The Mass Sludge Survey 2018 v.1.1

Wastewater Solids Generation and Management in Massachusetts

Survey and Report by

North East Biosolids and Residuals Association (NEBRA)

for the

Massachusetts Clean Energy Center

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And our greatest appreciation goes to the water quality professionals at Massachusetts Water Resource Recovery Facilities (WRRFs) who manage wastewater and solids every day for protection of public health and the environment and took the time and effort to complete the Mass Sludge Survey 2018 and provide us insights into solids management in the state in 2018.

Note that data and information presented in this report and associated documents are the work of NEBRA, who is solely responsible for any errors or misrepresentations. Corrections and comments are welcome; send to info@nebiosolids.org. All photos by NEBRA, unless specified otherwise.

The only change in this Version 1.1 was to correct the annual wastewater flow for the Massachusetts Water Resources Authority (MWRA).

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ABBREVIATIONS & DEFINITIONS

biosolids = sludge (wastewater solids) that has been treated and tested and meets state and federal requirements for application on soils

BOD = biological oxygen demand, a measure of the strength of organic waste. A higher BOD means more energy and time is required to treat the wastewater. Chemical oxygen demand is a related measurement.

Class A biosolids = biosolids treated with a Process to Further Reduce Pathogens (PFRP) in accordance with the U. S. EPA 40 CFR Part 503 regulations; such processes include heat drying and composting and produce biosolids that have minimal to no pathogens that could convey diseases when used

Class B biosolids = biosolids treated with a Process to Significantly Reduce Pathogens (PSRP) in accordance with the U. S. EPA 40 CFR Part 503 regulations; such processes include mesophilic anaerobic digestion and alkaline stabilization which reduce pathogens significantly to levels similar or less than animal manures, allowing for minimal risk of disease transmission when land applied at non-public sites such as farms and mine reclamation sites

dmt = dry metric ton(s)

dt = dry U. S. ton(s)

exceptional quality ("EQ") biosolids = biosolids that meet both Class A standards and the lower (Table 3) contaminant (metal) ceiling values and appropriate vector attraction reduction (VAR) of the U. S. EPA 40 CFR Part 503 biosolids/sludge regulations

MassCEC = the Massachusetts Clean Energy Center

MassDEP = the Massachusetts Department of Environmental Protection

MGD = million gallons per day

Monofill = a landfill used to manage only one kind of material, such as wastewater solids

MWPCA = Massachusetts Water Pollution Control Association, the non-profit organization of the state's wastewater operators, managers, and engineers

NEBRA = North East Biosolids and Residuals Association, the non-profit regional biosolids group for New England and eastern Canada

NEWEA = New England Water Environment Association, the non-profit regional association of wastewater operators, managers, and engineers for the six New England states

NPDES = National Pollutant Discharge Elimination System, the federal regulatory structures for controlling water pollution; every WRRF has to have and abide by an NPDES permit

ppb = parts per billion

ppt = parts per trillion

preparer = by definition under federal regulations (40 CFR Part 503), a person or entity who takes wastewater solids and treats them further, creating a biosolids product

sludge = wastewater solids removed in the primary and secondary (and, in some facilities tertiary) wastewater treatment processes and not including grit and screenings; "sludge" is the official regulatory term used in MA law and regulation, although the term “biosolids” is used widely to differentiate those sludges that are further treated and applied to land

solids or wastewater solids = a more modern term for sludge

SSI = sewage sludge incinerator

Type I, II, or III sludge / biosolids = The MassDEP designations of biosolids treated to different degrees for pathogen reduction, as found in the Massachusetts 310 CMR 32.00 sludge regulations; these designations are similar to the U. S. EPA 40 CFR Part 503 classes of biosolids, such Class A and Class B. See definitions of Class A and Class B, above; Type I is similar to Class A and Type II is similar to Class B

WRRF = water resource recovery facility, also known as a “wastewater treatment plant” (WWTP) or “wastewater treatment facility” (WWTF) or “water pollution control facility” (WPCF)

EXECUTIVE SUMMARY

Wastewater solids – sludge – are the unavoidable byproducts of wastewater treatment. Wastewater solids – sludge – has to be managed, and, by law and regulation, there are only three options for doing so: landfill disposal, incineration, or recycling to soils (as biosolids, after treatment and testing).

In Massachusetts, where more than 120 water resource recovery facilities (WRRFs)[1] produce solids, all three options have been actively used for the past half-century and more. For several decades, Massachusetts has recycled 30% - 40% of the solids produced in the state, led by the Massachusetts Water Resources Authority (MWRA) Boston-area treatment facility. Incineration has been the other major, consistent option used by many Massachusetts WRRFs, and, in recent years, it has increased to be the leading outlet for the state's wastewater solids. Landfill disposal remains a regular option for some WRRFs and is a back-up option for many more.

What happens with wastewater solids is a major consideration for every WRRF, and the markets for solids management is a complex interplay of facilities that offer one of the three recycling or disposal options and are owned and/or operated by public municipal utilities and/or private companies. All of the options for wastewater solids management involve significant costs in terms of energy, WRRF staff attention, and money. Solids treatment and disposal is typically one of the largest expense items in a WRRF's capital and operating budgets.

In Massachusetts, the Massachusetts Department of Environmental Protection (MassDEP), in coordination with the U.S. Environmental Protection Agency (U. S. EPA), oversees the state's WRRFs and their operations and has occasionally compiled data on sludge production and management, most recently in about 2005. To understand the current management of wastewater solids and related trends in Massachusetts, the Massachusetts Clean Energy Center (MassCEC) contracted with North East Biosolids and Residuals Association (NEBRA) to conduct a survey, compile data, and evaluate the potential for regional facilities for solids processing.

The Mass Sludge Survey 2018 was conducted between March and July, 2019, using an online survey and direct communications with WRRF managers and operators. Eighty-five (85) responses were received, representing 96% of the average daily wastewater flows at MA WRRFs – including all of the largest facilities (greater than (>) 5 million gallons per day, or MGD).

Based on the survey responses and calculations using historic data to fill data gaps, NEBRA estimates the following for 2018:

- MA WRRFs treated total average daily flows of 823 million gallons (MGD).
- Half of the WRRFs have specialized advanced treatment systems for removing extra nutrients from their effluent.
- 93% of the solids produced in Massachusetts are from WRRFs with active industrial pretreatment programs, which helps protect the quality of the effluent, sludge, and biosolids.

[1] WRRF is the current term for what Massachusetts water quality professionals have called wastewater treatment plants (or facilities, WWTP or WWTF) or water pollution control facilities (WPCF). These terms are used interchangeably in this report. "WRRF" has been promoted by the Water Environment Federation as a way of recognizing that these facilities, which protect public health and the environment, are increasingly also focused on recovering resources – not just clean water, but also nutrients, organic matter, and energy.

- Septage receiving is an important service provided by at least 54 WRRFs around the state, with more than 173,600,000 gallons (from in and out of state) treated in 2018.
- Fifteen (15) MA WRRFs report taking in and treating other trucked-in liquid wastes, providing important help in managing these hard-to-manage materials.
- MA WRRFs produced a best estimate of 180,800 dry U. S. tons (dt) of wastewater solids, of which:
  - 43% was incinerated, from 77 WRRFs;
  - 38% was recycled/applied to soil, from 19 WRRFs;
  - 18% was sent to landfills (almost all out of state) or monofills[2], from 31 WRRFs; and
  - 1% was used or disposed of in other or unspecified ways, from 12 WRRFs.
- Beneficial use, or recycling, of biosolids involved:
  - 11 WRRFs sending solids to composting, totaling 4,217 dt;
  - 2 WRRFs heat-drying solids, totaling 40,644 dt;
  - 1 WRRF applying dewatered paper fiber as a soil amendment, totaling 19,186 dt; and
  - 5 WRRFs recycling biosolids to soils in other ways, totaling 4,694 dt.

The technologies being employed in Massachusetts to treat wastewater solids are typical of current trends in the region. There is a strong focus on thickening and dewatering, which reduces the moisture content of the solids and the associated costs of transportation and use or disposal. This is especially important for larger facilities that produce large amounts of solids. The most commonly-used technologies are belt filter presses, centrifuges, gravity belt thickeners, and simple gravity thickening and decanting. The resulting solids produced in Massachusetts are moved around and managed about half (on a weight basis) as liquid and half as dewatered "cake."

The management of Massachusetts wastewater solids is most commonly done by private contractors and public or private facilities that complete the end use or disposal of the solids. Only 8 of 79 survey respondents indicated that the WRRF staff managed the end use and disposal of their facility's solids in 2018. All the rest contracted with a private third party.

Solids management and disposal is one of the largest costs for a WRRF. The 71 WRRFs responding to the survey question about costs spent a reported total of $43,014,721 for solids disposal in 2018. The calculated costs per dry U. S. ton averaged $784, with a minimum of $35 and a maximum of more than $2000 (likely a figure incorporating treatment costs as well as transportation and use or disposal fees). The reported fees being paid to contractors, haulers, and facilities for each *wet* ton of solids moved from the WRRFs in 2018 were in the following ranges for the following end use or disposal options:

- incineration: $21 - $432 (mean of $144)
- landfill disposal: $35 - $608 (mean of $176)
- Class A and Class B[3] land application: $74 - $365 (mean of $180)
- Off-site preparer: $83 - $569 (mean of $270)

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2 A monofill is a landfill used to manage only one kind of material, in this case, wastewater solids.

3 See "Abbreviations & Definitions," above. Class A and Class B refer to levels of treatment for pathogens in biosolids, as designated by the U. S. EPA 40 CFR Part 503 regulations. Similarly, MassDEP designates sludges (biosolids) based on different degrees of pathogen reduction treatment (Massachusetts 310 CMR 32.00 sludge regulations); these designations are similar to the U. S. EPA classes of biosolids: Type I is similar to Class, A and Type II is similar to Class B.

Respondents to the Mass Sludge Survey 2018 were asked to consider whether or not the WRRF's solids treatment systems and costs will change in the next decade. A large majority expect to see new technologies in their facilities and the cost of solids management to increase by 20 – 100%.

The final part of the Mass Sludge Survey 2018 determined that there is considerable interest among WRRF staff in collaborating on regional wastewater solids management outlets. Fifty-one of the 74 respondents to this question (70%) said they are interested and 50 said it is somewhat to extremely important to them. Many noted the need for multiple solids management outlets, because options help keep costs under control and provide backup if a current option fails.

When survey respondents were asked if they would *host* a regional facility, all but six (8%) expressed little or no interest, and the plurality of responses was a strong "very unlikely." But those expressing interest in hosting a facility have already put in considerable work on the possibility, and only a few regional facilities are needed.

To be viable, a regional facility needs to have sufficient WRRF solids committed to the facility. Of the 74 WRRFs that responded to the Mass Sludge Survey 2018 question about whether or not they would send their solids to a regional facility, 12 (16%) said they would be "unlikely" or "very unlikely" to do so, while 40 (54%) said they would be "likely" (21) or "very likely" (19) to do so. (The remaining 30% were neutral.) Many of those showing interest in sending solids to a regional facility noted that cost would be the major driver in their decision.

With the information from the survey, three potential regional facility areas were identified: a Connecticut River Valley Regional Facility, a Southeast Regional Facility, and a Northeast Regional Facility.

These three areas present differing needs and challenges, but each of them has more than 15,000 dry tons of solids (equivalent to over 200,000 gallons per day at 5% solids) potentially available to take in from WRRFs whose staff have indicated they would "likely" or "very likely" send solids to a regional facility (as long as the price is right). For comparison, the Greater Lawrence Sanitary District, a moderately large, modern WRRF managing solids for renewable energy and beneficial use, processed less than 6,300 dry tons in 2018. Thus, regional solids treatment facilities in the identified areas would likely have adequate solids available for cost-efficient, modern resource recovery, similar to what GLSD is doing. (But it is important to note that response to a survey question is far from a commitment to any particular future solids management option.)

The Mass Sludge Survey 2018 is timely. Biosolids management in Massachusetts, in the region, and nationwide have been on a consistent trajectory of slow, steady growth and improvements in recycling to soils since the promulgation of the MassDEP sludge regulations (310 CMR 32.00) in the late 1980s and the federal 40 CFR Part 503 regulations in 1993. Now, in 2019, in a few states, including in New England, disruptions in wastewater solids (sludge) management markets are emanating from evaluations of a particularly challenging group of chemicals of emerging concern (CECs): PFAS (per- and polyfluorinated alkyl substances). Capturing a snapshot – 2018 data – of what has been the consistent state of practice for solids management for 25 years, provides a good baseline for comparison to past and future solids management data.

I. INTRODUCTION

Wastewater solids – sludges – are the unavoidable byproducts of wastewater treatment. Wastewater treatment is a critical part of protecting public health and the environment from such biological scourges as cholera and other water-borne diseases, as well as pollution caused by nutrients and wastes created by modern society. Wastewater solids – sludges – have to be managed, and, by law and regulation, there are only three options for doing so:

- landfill disposal,
- incineration, and
- recycling to soils, which is possible after treatment and testing and meeting state and federal regulations.

In Massachusetts, where more than 120 water resource recovery facilities (WRRFs)[4] produce solids, all three options have been actively used for the past half-century and more. Since the late 1980s, federal (40 CFR Part 503 and preceding regulations) and state regulations (310 CMR 32.00) have allowed for the beneficial use of treated solids – biosolids – on land as soil amendments and fertilizers, which puts to use the nutrients and organic matter in these materials. Since the major upgrades to the Deer Island Treatment Plant in the 1980s and 1990s, Greater Boston's wastewater solids have been mostly land applied - mostly out of state, but increasingly in state in recent years. This has led the state's biosolids recycling rate of 30% - 40% over the years. Incineration has been the other major, consistent option used by many Massachusetts WRRFs, and, in recent years, it has increased to be the leading outlet for the state's wastewater solids. Landfill disposal remains a regular option for some WRRFs and is a back-up option for many more.

What happens with wastewater solids is a major consideration for every WRRF, and solids/sludge production tends to increase over time, driven by increasingly stringent regulations on what can be discharged in wastewater effluent (for example, recent stringent nutrient limits imposed in wastewater discharge permits are causing increases in sludge production). The markets for solids management feature a complex interplay of facilities that offer one of the three options and are owned and/or operated by public municipal utilities and/or private companies. Added to this is the layer of public and private operations that generate, treat, transport, and recycle or dispose of solids. Sometimes, one batch of wastewater solids will be generated by one public entity, transported by a contracted private hauler to an off-site private treatment facility (a "preparer"), from which the treated material – biosolids – are then sold and distributed by another private contractor as part of the soil amendment and fertilizer markets. In contrast, some wastewater solids are treated minimally by the public WRRF that generates them and then transported, by that facility's staff, to a landfill (which might be a monofill in the same town) or incinerator, where they pay a tipping fee for disposal.

All of the options available for solids treatment, management, and end use or disposal involve significant costs in terms of energy, WRRF staff attention, and money. Solids treatment and disposal is

[4] WRRF is the current term for what Massachusetts water quality professionals have called wastewater treatment plants (or facilities, WWTP or WWTF) or water pollution control facilities (WPCF). These terms are used interchangeably in this report. "WRRF" has been promoted by the Water Environment Federation as a way of recognizing that these facilities, which protect public health and the environment, are increasingly also focused on recovering resources – not just clean water, but also nutrients, organic matter, and energy.

typically one of the largest expense items in a WRRF's capital and operating budgets – from 15% - 50% of annual operations, depending on how costs are calculated and the complexity of the operations.

Tracking wastewater solids generation and management is challenging and has not been routine or consistent over the decades of major centralized wastewater treatment, both at the federal and state levels. NEBRA led a national solids data collection effort focused on 2004 data (NEBRA et al., 2007), which remains the most comprehensive data set for the country, despite being 15 years old. In Massachusetts, the Massachusetts Department of Environmental Protection (MassDEP), in coordination with U.S. Environmental Protection Agency (U. S. EPA), oversees the state's WRRFs and their operations and has occasionally compiled data on sludge production and management. A concentrated MassDEP effort in 2005 assisted in the NEBRA et al. 2007 data set. U. S. EPA Region 1 also maintains data on WRRFs and their operations, with their latest major update having been completed in 2011. In addition, all but the smallest WRRFs are required to submit annual sludge reports to U. S. EPA. However, these data have been in paper format, uncollated, and virtually inaccessible over the years. Beginning in 2017, for data for 2016 and later years, federal regulations now require WRRFs to submit their annual sludge reports electronically, online. This now means that minimal basic data – including solids amounts – are becoming available through U. S. EPA's new biosolids section of the long-standing Enforcement and Compliance History (ECHO) online database. However, cooperation from WRRFs is growing slowly, and, only half of Massachusetts WRRFs provided 2018 data online.[5]

Therefore, to understand the current management of wastewater solids and related trends in Massachusetts, the Massachusetts Clean Energy Center (MassCEC) contracted with North East Biosolids and Residuals Association (NEBRA) to conduct a survey, compile data, and evaluate the potential for regional facilities for solids processing.

II. METHODS

The Mass Sludge Survey 2018 was conducted between March and July, 2019. An online survey was created (Appendix B), tested initially by several WRRFs, edited, and finalized for use throughout the rest of the survey period. Invitations to complete the survey online were sent to all WRRFs in Massachusetts, as identified from several lists: U. S. EPA, 2011; Massachusetts Department of Environmental Protection (MassDEP) data; and Massachusetts Water Pollution Control Association (MWPCA) data.

Data collected by the online Mass Sludge Survey 2018 were reviewed for accuracy by comparing them to historic data sets (e.g. MassDEP sludge survey of 2005-2006, NEBRA reports, and U. S. EPA

[5] More specifically, according to MassDEP, WRRFs must comply with Massachusetts Operations & Maintenance and pretreatment standards (314 CMR 12.00) requiring O&M manuals to include, "Description, Operation and Control of Sludge Handling Facilities." And treatment plants with discharge to surface water (WRRFs) must meet the requirements of their National Pollutant Discharge Elimination System (NPDES) permit, issued and enforced by both U. S. EPA and MassDEP. There are no regulatory requirements to submit sludge reports to MassDEP. NPDES permits renewed over the past few years do not include a requirement to send sludge reports to MassDEP. While some older NPDES permits might include this language, upon renewal these permits are expected to include template biosolids language.

electronic sludge reports for 2016 and 2017). In addition, sludge masses reported were compared to estimated sludge generation based on average daily flow. Further details on methods and data quality are provided in Appendix A. The data themselves, and the analyses and calculations interpreting them, are available in spreadsheet format from the Massachusetts Clean Energy Center (MassCEC) and NEBRA.

The Mass Sludge Survey 2018 focused on obtaining data on the mass of solids[6] generated and how and where it was managed and at what cost. Some data were obtained related to sludge treatment processes, using some questions identical to the U. S. EPA electronic system for Biosolids Annual Program Reports (https://epanet.zendesk.com/hc/en-us/categories/204465328-Biosolids-Annual-Program-Report), which first became mandatory in 2017 for reporting of 2016 data.

Additional survey questions asked for estimates of future solids production and the costs of managing them. Lastly, respondents to the survey were asked about their interest in collaborating on a regional solids management facility option, such as a centralized anaerobic digestion facility that would take in solids from multiple WRRFs.

III. RESULTS, ANALYSIS, AND DISCUSSION

The Mass Sludge Survey 2018 received responses from 85 WRRFs. These responses represent 96% of the average daily wastewater flows at Massachusetts WRRFs, including all 28 of the WRRFs with wastewater flows over 5 million gallons per day (MGD) and 35 of 51 WRRFs with wastewater flows between 1 and 5 MGD.

Based on availability of historic data to fill gaps for those WRRFs that did not respond to the current survey, the final total list of WRRFs covered by this report includes 122 facilities.[7]

Data from the 85 survey responses are provided below. Also presented are estimates for the full set of 122 WRRFs, which better represent total Massachusetts sludge generation and management.[8]

The MWRA Deer Island Treatment Plant, serving Boston and area communities (MWRA photo).

[6] The terms "sludge" and "solids" are used interchangeably in this report to denote particulate matter, suspended material, and dissolved solids that are removed from wastewater in the wastewater treatment process. "Sludge" is the term used in Massachusetts regulations, but "solids" is the term increasingly used today in the wastewater management profession. These terms apply to material in the wastewater treatment facility and untreated material that is hauled away. "Biosolids" refers to solids (aka sludge) that have been treated and tested and meet standards for application to soils, in accordance with federal 40 CFR Part 503 regulations and the Massachusetts "sludge" regulations at 310 CMR 32.00. Raw, untreated untested solids cannot be and are not land applied.
[7] The WRRFs in Hardwick – Gilbertville and Wheelwright – were treated as one WRRF.
[8] Data provided in this report show appropriate numbers of significant figures/digits, reflecting the precision of the data. The complete data and analysis spreadsheet from this Mass Sludge Survey 2018 is available from Mass CEC and/or NEBRA.

Population served by Massachusetts WRRFs

It is estimated that the current survey captured data representing 83% or more of the sewered population of Massachusetts. By incorporating historic data into the final estimates of population served and sludge generation and end use or disposal, 96% of the sewered population is represented by the 2018 best estimates in this report.

Table 1. Sewered population served by Massachusetts WRRFs

2018 best estimate	5,000,000	
Adjusted total represented by the 85 survey responses	4,800,000	See note 1.
Historic data	4,365,705	1990 sewered population (Medalie, 1995)

Notes

1. The 85 WRRFs responding to the survey reported serving 6,623,993 people, which appears to be a significant overestimate, being close to the total current estimated population of the state (6,902,000). Likely some of the population estimates provided by survey respondents were for more than just the sewer users. It is difficult to define the sewered population, because…

- Septage from non-sewered households and businesses is usually delivered to WRRFs and it is reasonable to include those households and businesses in an estimate of the population served by a particular WRRF (but they are technically not sewered);
- Some facilities and engineering planning efforts track the "population equivalent" of industrial sewer users, since industrial wastewater is more concentrated than domestic wastewater; or
- Some respondents may have provided total town or city population estimates.

Use of historic data (Medalie, 1995), which indicates that about 27% of the state's population uses septic systems, resulted in the final estimated sewered population served by sewers and WRRFs shown above.

Wastewater flow

An estimated 823 million gallons of wastewater were treated daily, on average, at public WRRFs in Massachusetts in 2018. This recent estimate is higher than data reported to U. S. EPA in 2008 and 2012 (U. S. EPA, 2012). This is likely due to population and precipitation increases. But increases in flow can be offset by water-saving devices and behaviors (e.g. low-flow toilets and showerheads, etc.). There was a slight decline in wastewater flow between 2008 and 2012, possibly due to water conservation.

Table 2. Average Daily Wastewater Flow (million gallons per day or MGD) in 2018

2018 best estimate total	823	
85 survey responses	794	Representing 95% of the best estimate total
Historic data	750 /748[1]	Clean Watershed Needs Survey 2008 / 2012

Notes

1. The most comprehensive wastewater flow data appear in the U. S. EPA Clean Watersheds Needs Survey (CWNS, U. S. EPA, 2012), which has been conducted every four years in the past, with the most comprehensive recent data sets available for 2008 and 2012. The CWNS survey focuses on federal NPDES permits and includes many small facilities that are likely not producing any sludge. For example, Swampscott Public Works shows up in CWNS data (because they hold a NPDES permit), but there are no data from MassDEP or other sources indicating any sludge production; Swampscott wastewater is treated by the Lynn WRRF, according to that facility's information. Similarly, there are historic data for Northborough wastewater, but that wastewater is piped to the Marlborough WRRF and is, therefore, accounted for in that facility's wastewater flow and sludge

generation data. The best estimate total flow for the current survey's 122 WRRFs reported in 2008 by CWNS was 750 MGD, and in the 2012 CWNS, the equivalent total was 747.6 MGD. The current survey best estimate is significantly higher than the historic CWNS data. This may be explained, in part by population growth and in part by above-average precipitation in 2018.

Based on the 85 survey responses, the mean wastewater flow per person is 158 gallons per day, with a range of 10 to 675 gallons/day. These are typical wastewater flows.

Cleaned WRRF effluent

Specialized wastewater treatment systems

Wastewater treatment requirements, which include numerical standards in each WRRF's permit regarding the levels of specified contaminants allowed in the effluent, are set by U. S. EPA and the state environmental agencies and are increasingly stringent in order to protect the quality of surface waters that receive the effluent. In recent years, many effluent discharge permits around New England are being renewed with stricter limits on the amount of nutrients – nitrogen (N) and phosphorus (P). In order to meet these low limits, most WRRFs must install and operate specialized nutrient removal systems. The Mass Sludge Survey 2018 asked facilities if they have such systems, as well as industrial pretreatment programs. These systems can impact the generation and quality of wastewater sludges in a number of ways, including, but not limited to:

- *dewaterability*: When biological nutrient removal (BNR) is used to reduce P in effluent, the waste-activated solids/sludge (WAS) becomes more difficult to dewater and requires more polymer addition.
- *digestion chemistry*: Nutrient removal can change the carbon: nitrogen ratio in the anaerobic digestion process, which impacts volatile solids reduction (VSR) and biogas production. In some BNR systems, sludge carbon is diverted to the BNR process, which reduces biogas production in the anaerobic digestion process.
- *sludge retention time*: Some nutrient removal systems rely on longer solids retention times (SRT), which leads to reductions in energy in the solids entering anaerobic digestion.
- *sidestream quality*: Greater removal of nutrients from the effluent to the solids (especially P; much N is removed to the air), results in more concentrated nutrients in the side-stream flow from dewatering. Managing these nutrients requires additional attention and energy.

Dewatering wastewater solids (sludge) with a belt filter press.

Pretreatment is another important system that influences the quality of the wastewater solids. Potentially toxic chemicals and elements from industrial and other sources can inhibit, in particular, biological processes in WRRFs, including in anaerobic digestion.

For the above reasons, it is useful to know that about half of Massachusetts WRRFs operate advanced nitrogen and/or phosphorus removal systems. More than half (55%) of the WRRFs – including all the larger WRRFs that produce 93% of the state's solids – have active industrial pretreatment programs (Table 3).

Table 3. Specialized wastewater treatment systems, as reported by 85 survey respondents

Specialized treatment system at WRRF?	**Yes**	**Solids produced by these "yes" WRRFs** (U. S. dry tons)	**No**	**Solids produced by these "no" WRRFs** (U. S. dry tons)
Nitrification/denitrification [1]	43	65,500 / 39%	42	102,600 / 61%
Phosphorus (P) removal [2]	41	48,750 / 29%	44	119,300 / 71%
Active industrial pretreatment program	42	154,416 / 93%	35	11,394 / 7%

Notes

1. More than half (46) respondents reported specifics about the types of nitrification/denitrification processes in use; they include sequencing batch reactors, trickling filters, Bardenpho, Ludzack-Ettinger process (or modified: MLE), membrane bioreactors (MBR), and various semi-anoxic to anoxic and other sequenced zones in aeration tanks.
2. Phosphorus removal specifics were reported by 41 respondents. By far the most common was chemical (e.g. iron or alum) addition to physically remove P, followed by several WRRFs with biological P removal. Other P removal systems in place in Massachusetts facilities are sequencing batch reactors, anaerobic selector zones, and ballasted flocculation, as well as supplemental filtration (e.g. disk filters) at a couple of facilities.

Septage receiving

An estimated 27 percent of the population in Massachusetts rely on residential onsite septic systems for treatment of their wastewater (Medalie, 1995). Septic systems collect solids that must be pumped out every 1 - 3 years,[9] and the resulting septage must be managed. Most often, it is trucked to water resource recovery facilities (WRRFs) for treatment as part of the normal wastewater treatment process. Facilities that take in septage charge $100 or more per 1000 gallons, providing an essential public health service while generating some revenue to offset WRRF operations costs.[10]

Fifty-four (54) of the WRRFs responding to the Mass Sludge Survey 2018 indicated they receive and process septage. Many of them restrict septage receiving to septage generated locally or in neighboring towns. Others provide septage processing as a broader, regional service.

[9] Massachusetts regulation, Title 5, 310 CMR 15.00, does not specifically state how often septic systems must be pumped out, but it does state, "pumping frequency is a function of use, although pumping is typically necessary at least once every three years, and is recommended annually for a system with a domestic garbage grinder."

[10] For example, see Haverhill's septage receiving fee schedule: https://www.cityofhaverhill.com/departments/public_works_department/water_wastewater/index/index.php

The WRRFs that reported the largest totals of septage received and processed in 2018 are shown in Table 4. These facilities are regional service providers, some taking in septage from neighboring states as well as from Massachusetts, and collecting significant income from septage disposal fees. They are organizations already structured to manage outside wastes, with receiving systems and, in many cases, storage capacity. For example, the Lowell utility has storage and blend tanks for all outside waste, including septage, from which the material is fed at a steady rate into the headworks, to avoid disrupting the wastewater treatment process. The experience of such facilities (at handling outside wastes) can be expanded upon for processing other trucked-in waste and/or for organizing regional sludge processing centers.

Table 4. Major septage receiving WRRFs

Facility	Septage received in 2018 (gallons)
Greater Lawrence Sanitary Treatment District	24,667,750
Plymouth	19,563,768
Fitchburg (East)	11,355,645
Lowell Regional Wastewater Utility	10,903,551
Haverhill	9,052,850
Barnstable	9.048,000
Spencer	8,000,000
Charles River	6,650,000
Ipswich	6,622,000
Devens	5,589,425
MWRA sewer system	5,000,000
Bridgewater	5,000,000
Kingston	4,982,633
Palmer	4,154,675
North Brookfield	3,870,200
Westfield	3,500,000
Uxbridge	3,338,200
Erving Center	3,044,400
Springfield	3,003,738
Total of all reporting WRRFs (53)	**173,600,000**

Delivering septage to a WRRF

Other trucked-in waste

Only 15 Mass Sludge Survey 2018 respondents indicated they take in outside wastes other than septage. Sixty-four (64) specifically said they do not.

In addition to domestic wastewater, society produces other liquid organic wastes that are challenging – but necessary – to manage. Many are created by businesses and industries, such a food processors, and they are often treated, at least minimally, at the businesses' facilities. But, over the past decade, Massachusetts agencies (including MassCEC), non-governmental organizations (NGOs), businesses, and water quality professionals have advanced policies, regulations, and systems to provide better options for managing all types of organic wastes (especially food waste), promoting anaerobic digestion (AD) in particular for better treatment and gaining renewable energy.[11] At the same time, there has been a nationwide effort to see wastewater treatment facilities as "water resource recovery facilities" (WRRFs) that can expand their roles as vital local community services by managing challenging liquid wastes and extracting and recycling energy, nutrients, and organic matter from them, for greater sustainability.

Greater Lawrence Sanitary District (GLSD), a regional WRRF located in North Andover, is a leading example in the Northeast,[12] providing regional liquid organic waste management and generating some local revenue by taking in the following (data for 2018):

- 24,667,750 gallons of septage,
- 7,538,730 gallons of food waste pre-processed for anaerobic digestion (with an increasing volume expected to be received in the coming years as a new GLSD digester goes online), and
- 3.2 million gallons of sludge from other WRRFs.

The further advancement of efficiencies and energy benefits of regional solutions – as demonstrated by GLSD – was a major impetus behind the Mass Sludge Survey 2018 being reported here.

Rotary-drum heat drying of biosolids at Greater Lawrence Sanitary District

The specific outside wastes that survey respondents report taking in in 2018 include landfill leachate, a material that is commonly treated at WRRFs of all sizes. For example, the Lowell Regional Utility processed 12,241,730 gallons of landfill leachate through its headworks in 2018. Northampton processed 546,000 gallons, and the smaller facilities at Palmer and Warren took in 649,000 and 31,500 gallons, respectively.

WRRFs are often the only possible outlet for liquid wastes that landfills will not take. This includes industrial material (e.g. Lowell took in 14,469,462 gallons in 2018), sewer cleaning wastewater (e.g. as reported for 2018 by the South Essex WRRF); fats, oils, and grease (FOG, as Uxbridge and Wareham report), and brewery waste (an increasing volume of which is produced in communities of all sizes and taken in by all sizes of WRRFs, including, for example, at Spencer). The Erving Center WRRF, whose influent is dominated by Erving Paper mill wastewater, reports also receiving 3.7 million gallons of trucked-in soft-drink bottling wastewater. Some of the trucked-in wastes are particularly challenging for WRRFs to treat, because of the high biological oxygen demand (BOD) loadings or problematic

[11] See commercial food waste disposal ban information (https://www.mass.gov/guides/commercial-food-material-disposal-ban, AD and organics diversion information (https://www.mass.gov/lists/anaerobic-digestion-organics-diversion), organics-to-energy information (https://www.masscec.com/technology-programs/commonwealth-organics-energy), and food waste recycling guidance: https://recyclingworksma.com/how-to/materials-guidance/food-waste-2/.

[12] For details on GLSD, see https://www.nebiosolids.org/greater-lawrence-sanitary-district

attributes (clogging by FOG, chemical contaminants that can impact effluent and biosolids quality, etc.). Many are better managed directly in anaerobic digesters rather than through the headworks of WRRFs.

As wastewater biosolids and sludge management advances and adapts in Massachusetts, there are competing pressures related to outside wastes and whether or not WRRFs will be able to continue to receive them. For example, current scrutiny on per- and polyfluorinated alkyl substances (PFAS) is bringing into question whether or not WRRFs should process landfill leachate. The kinds of liquid wastes currently managed by WRRFs must be dealt with in some way, and policy and regulation will drive how they are managed and whether or not they are managed as sustainably as possible.

Municipal wastewater solids generated in Massachusetts in 2018

In 2018, Massachusetts WRRFs generated an estimated 180,800 dry U. S. tons of sludge (wastewater solids). See Table 5.

Table 5. Wastewater solids / sludge generated in Massachusetts in 2018 – and where it went

Mass Sludge Survey 2018 Results	**Year of data**	**# of WRRFs/ WWTPs**	**# of facilities with total dt sludge data**	**Total sludge** (from # of facilities in prior column) **(dt)**	**Land applied Biosolids**	**Sludge disposed in landfill or monofill**	**Sludge incinerated**	**Sludge other disposal**
85 WRRFs that provided survey responses	**2018**	**85**	**83**	**167,150** (includes 19,644 dt Erving paper fiber)				
All 122 WRRFs	**2018**	**122**	**122**	**180,800** [1] (includes 19,644 dt Erving paper fiber)	**68,651** (from 19 WRRFs) (includes 34,345 dt from MWRA Deer Island, 19,186 dt Erving paper fiber, and 6,299 dt from Greater Lawrence)	**31,784** (from 31 WRRFs)	**78,353** (from 77 WRRFs)	**2,012** [2] (from 12 WRRFs)

Notes

1. This is a best estimate derived from the sum of all sludge generated and managed as reported to the Mass Sludge Survey 2018, plus estimates based on historic sludge generation data from facilities that did not complete the survey. It includes all identified WRRFs with average daily flows greater than 0.5 MGD. The 85 responses to the survey provided sludge generation totals that add up to 92% of the total best estimate of 180,800 dry U. S. tons generated in Massachusetts in 2018.
2. This includes sludge that was not accounted for in survey respondents' allocations of sludge to various dispositions, a total of 358 dry U. S. tons.

3. There is possible minimal double-counting of sludge from small facilities. For example, in 2018, South Deerfield transported its annual total of 24 U. S. tons of sludge to the Lowell WRRF, where a portion of it may have also been counted as part of Lowell's total sludge generated. This likely does not skew the totals significantly.

These current data are compared to historic data on sludge generation in Massachusetts in Appendix Table A-2. Beginning with 2016 data, WRRFs have been required to submit their biosolids annual reports online to the U. S. EPA Enforcement and Compliance History (ECHO) database. Those reports include sludge generated and how it was used or disposed of. But that sludge data reporting system only received data from 40 MA facilities for 2016 and 53 for 2017. Sixty-one (61) MA WRRFs reported 2018 data to ECHO, but the data were not yet publicly available for this current report. Thus, the data from ECHO remains incomplete – one half or fewer MA WRRFs are included – with data absent from several large facilities, such as Chicopee, Fitchburg, Lowell, Pittsfield, South Essex, and Taunton. Therefore, this current Mass Sludge Survey 2018 provides a far more complete picture and will likely do so for several years, up until all WRRFs are participating in the mandatory online reporting. And the ECHO database does not include many of details reported here.

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The relatively small amounts of solids from facilities with less than 0.5 MGD average daily flows are often not disposed of annually; some collect in lagoons that are only cleaned out every 5 to 20 years. Marion is an example of a lagoon system. In Marion in 2018, no solids were removed and 84 dry U. S. tons went into the lagoon where it breaks down further.[13] Examples of small facilities represented in the current survey include the following, showing the considerable range in sludge generation compared to the sizes of the facilities (from smallest to larger):

- For 2018, Northfield (.117 MGD) reported less than 2 dry U. S. tons of sludge, produced from long-term storage and decanting, which went to offsite incineration.
- Hatfield (0.218 MGD) has aerobic digestion and produced about 20 dry U. S. tons of sludge in 2018.
- Oxford-Rochdale (0.346 MGD) held its sludge in storage to thicken it before trucking 44 dry U. S. tons to incineration.
- Hadley (0.416 MGD) trucked 104 dry U. S. tons of raw sludge to incineration in 2018.


A wastewater solids (sludge) solids dewatering lagoon

[13] Research indicates that sludge lagoons that are not regularly aerated can be sources of methane emissions, similar to lagoons holding animal manures. Treatment of such sludges in anaerobic digesters would be an improved practice. Sludge lagoons – especially if unlined – can also contribute nutrient releases to the environment. Disposal of wastewater solids in unlined lagoons is now not allowed in MA, and, for example, new state and U. S. EPA requirements are ending Marion's use of two unlined lagoons and requiring lining of the town's third lagoon and subsequent reporting of all solids placed in that newly-lined lagoon.

Facilities and destinations receiving MA wastewater solids in 2018

In addition to the total mass of solids generated, the Mass Sludge Survey 2018 collected further data related to about 90% of the total estimated sludges generated, including from all of the WRRFs with flows greater than 5 MGD.

Mass. Water Resources Authority (MWRA) heat-dried biosolids is a valued, slow-release fertilizer.

The total estimated 180,800 dry U. S. tons (dt) generated were used or disposed of in the following ways:

- *43% was incinerated*, from 77 WRRFs, led by the Upper Blackstone facility, which serves the Worcester area (and, in addition, takes in solids from many smaller facilities). There are currently 11 sewage sludge incinerators (SSIs) operating in New England, three of which are in Massachusetts (and all three are publicly-owned municipal facilities). Of the 11 in New England, 8 (4 municipal and 4 private) take in outside sludges. See Table 7.
- *38% was applied to soil* at sites in Massachusetts and other states. These biosolids were from 19 WRRFs, with the majority being from the Massachusetts Water Resources Authority (MWRA) Deer Island facility, which produced 19% of the solids generated in MA. The total land applied includes 34,345 dt from the Deer Island facility, 19,186 dt of Erving paper fiber, and 6,299 dt from Greater Lawrence Sanitary District (Table 6). Deer Island and GLSD anaerobically digest solids and produce a dry pellet biosolids fertilizer that is used mostly in agriculture (for growing feed hay and corn for animal consumption) and for turf management. Erving paper fiber is used in soil mixes, especially for restoring healthy soils on barren, despoiled sites, such as gravel mines. The additional land-applied biosolids tallied in this survey were processed at the WRRFs that generated the solids (such as composting operations at Dartmouth, Hoosac, Ipswich, Marlborough, and Southbridge) or were managed by third-party private contractors who brought them to processing facilities in Massachusetts (e.g. Ipswich, Greater Lawrence, Marlborough) or Maine for composting or anaerobic digestion. Three facilities (Acton, Billerica, and Lowell) report having sent 1,322 U. S. dry tons to the anaerobic digesters (AD) at Greater Lawrence Sanitary District – an example of an AD facility currently providing some capacity for management of solids generated by other facilities.
- *18% was sent to landfills* (almost all out of state) or monofills, from 31 WRRFs. Solids processing and landfill disposal options in New England are summarized in Table 8.

- *1% was used or disposed of in other or unspecified ways*, from 12 WRRFs. This includes, for example, transport to another larger WRRF for disposal in the headworks, which several smaller facilities do (and which can result in unavoidable and unknowable minimal double-counting of some small amounts of solids).

Table 6. Tonnages of solids sent to land application options in 2018

	# of facilities [1]	**Solids** (U. S. dry tons)
Composting	11	4,127
Heat drying (making fertilizer pellets) [2]	2	40,644
Land applied paper fiber (Erving)	1	19,186
Other	5	4,694

Notes
1. These are facilities known to have treated their own solids as shown here or are known to have sent their solids to one of these treatments at another facility.
2. MWRA Deer Island and Greater Lawrence Sanitary Treatment District

Composting solids at Southbridge, MA.

Table 7. Sewage sludge incinerators (SSIs) operating in New England
(listed in order from ~north to ~south, revised from Beecher, 2016)

Sewage Sludge Incinerator (SSI) (operated by)	Capacity circa 2000 (dry U.S. tons/day	Capacity today (dry U.S. tons/day	Accepts Outside Solids?	Notes*
Manchester, NH (Manchester)	–	36	No	Fluidized bed
Lynn, MA (Veolia)	–	~15	No	Fluidized bed
Brockton, MA (Veolia)	18	18	No	Multiple hearth
Upper Blackstone WPCF, Worcester area (Upper Blackstone)	91	144	Yes, but more selective than before U. S. EPA air regulation	Multiple hearth; SSI permitted throughput is now limited by stack test.
Hartford WPCF (Metropolitan District Council)	60	120	Yes, but less than before U. S. EPA air regulation	3 multiple hearth units. Takes in less outside solids now because of new U. S. EPA air emissions regulation. Has energy recovery system.
New Haven, CT (Synagro)	–	42	Yes, but less than before U. S. EPA air regulation	Multiple hearth; takes in less outside solids now. Has had energy recovery system.
Mattabasset – Cromwell, CT (Mattabassett District)	–	36	Takes in only liquid outside solids and less than before.	Fluidized bed
Naugatuck, CT (Veolia)	54	84	Yes	Fluidized bed; provides significant capacity for regional solids disposal market.
Waterbury, CT (Synagro)	–	60	Yes	Fluidized bed; provides significant capacity for regional solids disposal market.
Cranston, RI (Veolia)	40	66	Yes	Multiple hearth; takes liquid solids only. Provides significant capacity for regional solids disposal market.
Woonsocket, RI (Synagro)	70	110	Yes	Fluidized bed; provides significant capacity for regional solids disposal market.

**Additional Notes:* All operating SSIs have completed or are completing upgrades to meet new U. S. EPA air emissions regulations. Those regulations and aging infrastructure led to the closing in recent years of SSIs in Fitchburg, MA; Fall River, MA; West Haven, CT; Glens Falls; NY; and Saratoga Springs, NY – facilities that used to accept solids from Massachusetts WRRFs. Thus, in the past half-decade, incineration capacity has been considerably reduced in the region.

Table 8. Regional solids processing and landfill disposal options in New England
(listed in geographic order from ~northwest to ~southeast; updated from Beecher, 2016).

Name	Location	Owner/Operator	Type	Capacity for Wastewater Solids from other WRRFs?
BENEFICIAL USE				
Englobe Facilities	Sherbrooke, QC area	Englobe	Bury compost, mine land reclamation sites	Possibly
Grasslands Facility	Chateaugay, NY	Casella Organics	Advanced alkaline stabilization producing Class A biosolids lime & fertilizer product	Possibly
Residuals Management Facility	New Hampton, NH	Resource Management Inc.	Alkaline stabilization producing biosolids for land application	Possibly
Merrimack Compost	Merrimack, NH	Town of Merrimack, NH	Composting local and some outside wastewater solids and leaf & yard waste	Uncertain
Hawk Ridge Compost Facility	Unity, ME	Casella Organics	New England's largest compost facility, producing Class A biosolids composts and other composts and mulches	Possibly
Lewiston-Auburn WPCA	Auburn, ME	Lewiston –Auburn Water Pollution Control Authority	Anaerobic digestion and composting of wastewater solids; accepting some liquid high-strength wastes into A.	Future compost and land application operations uncertain because of regulatory pressures
Genesis (formerly Village Green) anaerobic digester	Brunswick, ME	Genesis	850,000-gallon AD system taking area wastewater solids, food scraps, & other organic residuals	Possibly
Ipswich Compost	Ipswich, MA	Agresource & Town of Ipswich	Composting of local wastewater solids, leaf & yard waste, food scraps	Full

Name	Location	Owner/Operator	Type	Capacity for Wastewater Solids from other WRRFs?
SOLID WASTE LANDFILLS				
Waste USA Landfill	Coventry, VT	Casella	Accepts wastewater solids	Some
Bethlehem Landfill	Bethlehem, NH	Casella	Accepts wastewater solids	Some
Turnkey Landfill	Rochester, NH	Waste Management	Accepts wastewater solids, mostly from SE NH facilities	Some
Crossroads Landfill	Norridgewock, ME	Waste Management	Accepts wastewater solids	Some
Juniper Ridge Landfill	Old Town, ME	Casella	Accepts wastewater solids, but mostly only from Maine	Some
Central Landfill	Johnson, RI	RI Resource Recovery Corp.	Accepts wastewater solids, but only from RI	Possibly
MASSACHUSETTS SLUDGE-ONLY LANDFILLS (MONOFILLS)				
Attleboro	Attleboro, MA	Attleboro WRRF		Possibly; monofill expansion approved by MassDEP in 2017
MWRA Clinton	Clinton, MA	MWRA		Disposal of local wastewater solids
Fitchburg-Westminster	Fitchburg, MA	Fitchburg WRRF		Disposal of local wastewater solids
Gardner	Gardner, MA	Gardner WRRF		Possibly available for outside solids; currently working with MassDEP on permitting monofill expansion
Middleborough	Middleborough, MA	Middleborough WRRF		Disposal of local wastewater solids
Pittsfield	Pittsfield, MA	Pittsfield WRRF		Disposal of local wastewater solids in an emergency backup situation
Taunton	Templeton, MA	Taunton WRRF		Disposal of local wastewater solids; monofill likely closing in 2020, requiring hauling solids out of town
Templeton		Templeton WRRF		Disposal of local wastewater solids

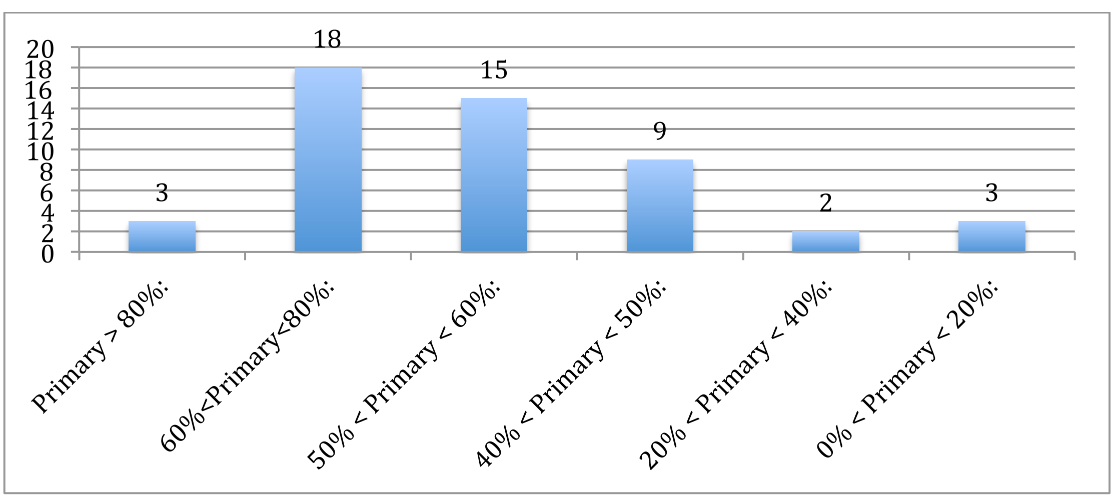
SLUDGE INCINERATOR ASH-ONLY LANDFILLS (MONOFILLS)				
Brockton	Brockton, MA	Brockton WRRF		Disposal of local incinerator ash
Lynn	Lynn, MA	Lynn WRRF		Disposal of local incinerator ash; monofill reaching capacity, requiring transporting ash elsewhere for disposal
Upper Blackstone	Worcester area	Upper Blackstone WPAD		Disposal of local incinerator ash

Notes: Southbridge Landfill, Southbridge, MA does not accept wastewater solids. Other landfills have been increasingly restrictive on accepting wastewater solids in recent years and have limited capacity for managing these challenging materials due to their wetness and odor issues. Most recently, PFAS concerns may limit or reduce the ability for any or all of these facilities to accept outside solids. In general, regional capacity for wastewater solids management has diminished and prices are rising.

Ratio of primary solids to WAS

The energy potential of primary wastewater solids is greater than the energy potential in waste activated solids (WAS). When planning for anaerobic digestion (AD), the ratio of primary solids to WAS provides a rough sense of the relative amounts of energy that may be extracted from one sludge compared to the same mass of another sludge. Of the 50 WRRFs that provided data on the ratio of primary solids to WAS (primary:WAS), more than two thirds (36) indicated that their solids are made up of greater than 50% primary solids (Figure 1).

Figure 1: Number of WRRFs producing solids with the percent of primary in the ranges shown



Solids treatment technologies in use in 2018

Seventy-three (73) of the respondents to the Mass Sludge Survey 2018 indicated the kinds of solids treatment systems used at their WRRF (Table 9).[14] The survey focused particularly on thickening and dewatering, in order to provide a sense of how much sludge is currently being transported in thickened liquid form and how much is dewatered and, in some cases, processed further (e.g. composted or heat dried, Table 10). Survey responses related to Vector Attraction Reduction (VAR) treatments were limited and not useful; they are not included in this report.

Table 9: Solids treatment processes & technologies reported in use by MA WRRFs

WRRF uses preliminary sludge treatments	**WRRF uses thickening**	**WRRF uses aerobic digestion**	**WRRF uses anaerobic digestion**	**WRRF uses biogas (CH4) recovery**	**WRRF uses high T (Class A) composting**	**WRRF uses heat drying**	**WRRF uses some other sludge treatment(s)**
40	**59**	**13**	**6**	**5**	**5**	**2**	**12**

Dewatering technologies

belt filter press	**plate and frame press**	**screw press**	**centri fuge**	**vacuum filter**	**drying beds**	**gravity belt thickener**	**gravity thickener tanks**	**dissolved air flotation (DAF) units**	**none or N/A**	**Other[1]**
24	**0**	**1**	**14**	**0**	**0**	**14**	**19**	**3**	**12**	**16**

Notes:
1. Other dewatering technologies mentioned include rotary drum thickener (6 WRRFs reported using this technology), decanting (5 WRRFs), rotary press (2 WRRFs), and gravity drum thickener (1 WRRF).

As is typical in the solids management field nationwide, most smaller MA WRRFs minimally treat their solids. Such liquid sludges (with 3 – 5% solids content) are fine for processing in anaerobic digesters. And this option is cost-effective if the digester is not too far from the WRRF; longer distances are more costly because mostly water is being transported. For small facilities producing just a few truckloads a year, the cost of transporting mostly liquid to a disposal option does not add up to a lot of money. Larger facilities however, save significant money if they transport solids with higher solids content, so those are the facilities that usually have advanced thickening and dewatering systems and further solids treatments. Thus, in Massachusetts, about 80% (59 of 73) of WRRFs – including many small facilities – go as far as to thicken their solids in some way. Regarding other sludge treatment steps, only about 18% (13 of 73) have aerobic digestion and about 5% (6 of 122) have anaerobic digestion. Composting and heat drying are employed by only about 10% (about 13 of 122) of WRRFs. But these facilities with advanced solids treatments account for the large majority of sludges in the state.

The masses of liquid sludges and dewatered sludges generated in 2018 are shown in Table 10.

[14] These data on types of treatment systems are consistent with those collected by U. S. EPA in annual sludge reports required by 40 CFR Part 503 and now reported online and included in the ECHO database.

Table 10: Masses of liquid sludge and dewatered sludge produced at MA WRRFs in 2018

	Liquid (<10% solids) sludge	Dewatered sludge
Number of facilities	42	38
Average size of facilities producing this form of sludge (MGD average daily flow)	1.3	8.8[1]
Mass (U. S. dry tons in 2018)	19,371[2]	161,260 (includes 34,345 MWRA Deer Island)

Notes
1. Does not include the MWRA Deer Island Treatment Plant, which is much larger than any other. 13.9 MGD is the average size if MWRA Deer Island is included. The Deer Island reported 2018 average daily flow was 204 MGD.
2. What was actually produced and moved on site or transported off site was 90% or more water, which means that the actual liquid mass being moved and managed was approximately 10 times greater – nearly 200,000 liquid U.S. tons. Some of the dewatered solids also contain water and the total mass of material managed is also somewhat higher than the 161,260 dry tons shown. Thus, approximately equivalent actual masses of liquid and dewatered solids were managed in Massachusetts in 2018.

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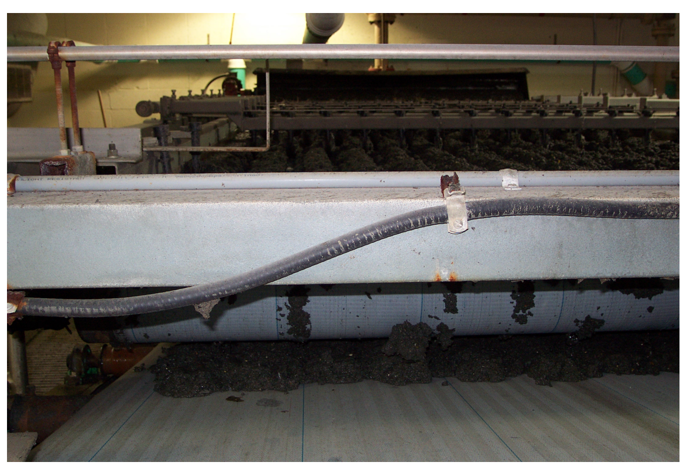
Who manages end use and disposal?

The large majority of WRRFs in Massachusetts contract with someone else to manage the end use and/or disposal of their wastewater solids (sludge). Of 79 survey respondents answering this question, only 8 reported managing the full solids end use and disposal themselves, with WRRF staff. The rest contracted with a third party, either someone who took the solids as they were to their final end use or disposal site (36 WRRFs did this) or someone who further treated ("prepared") the biosolids (35 WRRFs; this is likely an overestimate due to misunderstanding of the term "preparer," because most MA WRRFs send solids to incinerators or landfills, and those solids are not further prepared).



Gravity belt thickener

Biosolids products

Almost all Massachusetts solids are managed in bulk – transported in bulk in large trucks to disposal or land application sites. Only MWRA's Deer Island Treatment Plant bags a small portion of its biosolids fertilizer for local sales and distribution.

The solids from the large majority of Massachusetts WRRFs are not classified as

"Exceptional Quality"[15] ("EQ"), or Class A or B with respect to pathogen reduction – they are untreated and untested, because they are disposed of through incineration or at landfills. Further treatment and testing are unnecessary to meet requirements for those disposal options.

For 2018, survey respondents reported that 45,660 dry U. S. tons of Massachusetts wastewater solids (sludge) were treated to Class A (mostly EQ) standards (known as "Type 1" designation under MassDEP sludge regulations). The resulting products are marketed, distributed, and applied to soils with few restrictions, but in accordance with label instructions and best management practices (Table 11).

Table 11. WRRF solids used to produce Class A / Type 1 biosolids products in Massachusetts[1]

Generator / WRRF / Facility	**Process**	**Mass of sludge to process** (U. S. dry tons)	**Where used**
Amesbury WWTP (off site)	Composting	246	Class A sites – fields, parks, gardens, landscaping, etc.
Bridgewater WWTP	Composting	380	Class A sites – fields, parks, gardens, landscaping, etc.
Dartmouth WWTF	Composting	589	Class A sites – fields, parks, gardens, landscaping, etc.
Greater Lawrence San. Dist.	Anaerobic digestion & heat drying	6,299	Agriculture, Class A sites, & land reclamation sites
Hoosac Water Quality Dist.	Composting	381	Class A sites – fields, parks, gardens, landscaping, etc.
Ipswich WWTP	Composting	475	Class A sites – fields, parks, gardens, landscaping, etc.
Marlborough East WWTP	Composting	85	Class A sites – fields, parks, gardens, landscaping, etc.
Mass. Water Resources Auth. Deer Island Treatment Plant	Anaerobic digestion & heat drying	34,345	Agriculture, Class A sites, & land reclamation sites
Nantucket WWTP	Composting	320	Class A sites – fields, parks, gardens, landscaping, etc.
Newburyport WWTP	Composting (at Ipswich)	739	Class A sites – fields, parks, gardens, landscaping, etc.
Somerset WPCF	Composting (off site)	150	Class A sites – fields, parks, gardens, landscaping, etc.
Southbridge WPCF	Composting	665	Class A sites – fields, parks, gardens, landscaping, etc.
Total		**45,660**[2]	

[15] Exceptional quality ("EQ") biosolids means biosolids that meet both Class A standards and the lower (Table 3) contaminant (metal) ceiling values and appropriate vector attraction reduction (VAR) of the U. S. EPA 40 CFR Part 503 biosolids/sludge regulations. Other definitions and abbreviations are provided after the Table of Contents at the beginning of this document.

Notes:
1. This list is of biosolids products confirmed in the Mass Sludge Survey 2018. Other MA WRRF solids were land applied as well, bringing the total recycled to soil to 68,651 dt, which includes 19,186 dt of Erving paper mill residuals (short paper fiber) and 3,689 dt of Lowell sludge that were sent to an anaerobic digestion facility in Maine that land applies its digestate/biosolids.
2. Gloucester, Merrimac, and Rockport WRRFs did not respond to the current survey. In the past, their solids were sent to composting (e.g. at Ipswich or in Maine); these solids, an estimated 312 dt, 74 dt, and 600 dt, respectively, are included in the total here, but not shown in the table.

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Costs of solids management in 2018

Solids management and disposal is one of the largest costs for a WRRF. The 71 WRRFs responding to this survey question spent a reported total of $43,014,721 for solids disposal in 2018. This includes $15 million spent by MWRA Deer Island Treatment Plant (Table 12). These reported costs are estimates developed through different processes and are likely inconsistent, one to another. This is because:

- some respondents to the survey may track and report the full solids management costs from somewhere in the treatment process (e.g. from thickening onward), while others report only the costs for end use and disposal, and
- some respondents can only estimate full treatment and end use or disposal costs (e. g. MWRA's $15 million is a round estimate).

However, most of the estimates provided in the Mass Sludge Survey 2018 are likely based on what it costs the WRRF to move the solids/biosolids to its final destination(s) and pay any associated tipping or end use fees. That was what was asked in the survey question. For many facilities who pay a contractor to remove the solids or biosolids from the WRRF, the total paid to the contractor is what was requested in the survey question.

The cost per dry ton was calculated from the data provided by survey respondents (total solids management cost reported / tons solids produced in 2018) and varies considerably, likely for the same reasons discussed above. For 2018, the calculated maximum cost per dry U. S. ton was $4,165 (So. Deerfield; their reported total annual cost likely includes all solids treatment, trucking, and disposal costs) and the minimum was $35, with a mean of $784.

Table 12. Highest and lowest totals spent on solids/biosolids removal and disposal in 2018.

Facility	Wastewater solids produced in 2018 (dry U. S. tons)	Total paid for solids use/disposal in 2018	Total calculated annual cost per dry U. S. ton
MWRA Deer Island Treatment Plant	34,345	$15 million	$437
Springfield	10,604	$4,138,284	$390
South Essex	6,968	$3,510,294	$504
Fall River	3,263	$2,300,000	$705
Lowell	6,530	$2,079,605	$318

Haverhill	3,978	$1,217,459	$306
Charles River	2,303	$1,023,000	$444
Hardwick	16	$20,000	$1,250
Huntington	4	$9,650	$2,350
Otis	2.5	$6,000	$2,400
Russell Village	9	$3,435	$380
Northfield	1.5	$2,000	$1,330

In the wastewater solids management market, where contractors compete for multi-year contracts from WRRFs, the common pricing metric is either dollars (or cents) per gallon or dollars per wet ton transported away from the WRRF or preparation facility. However, a contractor moving compost to market may price it in dollars per cubic yard. These prices provide the clearest sense of the market pricing for solids management (Table 13) in Massachusetts and the New England region.

Lowell is an example of a common situation: a private company is contracted by the WRRF to remove all of the WRRF's solids. That contractor determines, on a day-to-day basis, where each truckload goes, depending on availability of capacity at use or disposal facilities, current tipping fees being charged by the receiving use or disposal option, and transportation distance. In 2018, different loads of Lowell solids went to incinerators, landfills, and anaerobic digestion facilities where the solids were eventually applied to land. The per-wet-ton costs, paid to the contractor for taking the treated solids from the WRRF and transporting and disposing of them, were about $319 for each of these options, according to Lowell's response to the survey.

Table 13. Per-WET-ton cost for transportation and end use or disposal of solids from WRRFs in 2018

Solids end use or disposal option	**Mean cost** per wet U. S. ton [1]	**Range of costs** per wet U. S. ton
Incineration (n = 28) [2]	$144	$21 - $432
Landfill disposal (n = 15)	$176	$35 - $608
Class A and Class B land application (n = 3)	$180	$74 - $365
Off-site preparer (n = 5)	$270	$83 - $569

Notes
1. Some respondents to the survey provided per-dry-ton costs; these were converted to per-wet-ton estimates assuming solids content of 22%. Some of the high-end per-wet-ton costs may include more than transportation from the WRRF and tipping fees, such as some treatment steps at the WRRF or planning and legal costs.
2. "n" refers to the number of WRRFs used to calculate the mean; anomalous responses that likely represented total per-ton costs for treatment and disposal were removed from the data set.

Expected equipment changes for solids management in the next 10 years

The Mass Sludge Survey 2018 received information from 56 WRRFs regarding their plans for changes to solids management looking forward to the next 10 years. The large majority of responses focused on plans for improving thickening and dewatering (33 survey responses). Reasons for this high level of attention on thickening and dewatering include:

- *optimizing operations* with "newer higher throughput equipment" (Acton) and a "bigger GBT" (gravity belt thickener, Amherst) and changing polymer (Hardwick) and improved

centrifugation for higher cake solids (Lowell), the goal usually being to reduce the volume of solids and associated hauling costs (noted by Northampton and Pepperell);
- *upgrades to more efficient equipment*: for example, Concord is considering upgrading to a filter press and Pittsfield (which has GBTs) and South Deerfield are considering adding drum thickeners and Rockland may "separate WAS from primary and pre-thicken;"
- *permit requirements*: for example, Hoosac (Williamstown) noted that changes in thickening may be driven "with renewed NPDES;"
- "*may add dewatering* to become more versatile and possibly increase disposal options" (Barnstable) and "landfill closing in 2020 - could be trucking liquid sludge out" (Taunton) and "because incineration is limited and has prices increasing" (Wareham).

South Deerfield's use of a sludge-reduction technology (which, they report, has reduced solids production by 30%) and their plan to install dewatering equipment is representative of the widespread interest in the wastewater management profession in reducing solids and producing drier (dewatered) solids, thus reducing the amount of water being hauled offsite and associated costs. At the same time, they are hoping that Greenfield will build anaerobic digestion (AD) that can take South Deerfield's solids – which has to be introduced to AD in a liquid (low-solids) form. Thus, there is a tricky balance between the costs of:
- dewatering at the sludge-generating WRRF,
- the costs and hassle of hauling a lot of water (liquid sludge), and
- the needs of an off-site anaerobic digester to receive liquid material (or having to add water to dewatered solids before feeding it to the digester).

Transportation was also an area of some interest for survey respondents: 10 of 56 (18%) of respondents commented on it. Their comments illuminate typical, ongoing concerns widely expressed in the solids management profession:
- "hopefully a shorter commute to an end [use or disposal] facility" – Barnstable
- "contract is bid every 3 years" – Edgartown
- "Different sludge hauling contractor" – Great Barrington, North Brookfield
- "Getting more expensive as the contracts are renewed. Haulers are becoming scarcer" – South Deerfield
- "Incinerator ash will need to be transported to offsite landfill" – Lynn
- "Changes in lagoon design may lead to periodic removal of biosolids in the near and remote future." - Marion

Chicopee faces a unique sludge "transportation" concern: because of aging infrastructure, limited space, and anticipated upcoming permit requirements to remove nutrients (nitrogen), serious consideration is being given to converting this WRRF to a major pump station diverting almost all of its incoming wastewater to Springfield. Minimal wastewater treatment and sludge generation would occur at the current Chicopee facility.[16]

[16] According to MassDEP, it is expected that the Chicopee facility will still need to function as a primary treatment facility for wastewater-related combined sewer overflows (CSOs, caused by big precipitation events). In such situations with large combined sewer and stormwater flows, there would still be sludge generated at the Chicopee site, but, on an annual basis, only a fraction of the sludge currently produced.

Survey responses suggest that few facilities (just 5 survey respondents, or 9% of WRRFs) are planning significant changes to pathogen treatment or stabilization. Such changes are generally driven by efforts to recycle biosolids to soils, and the survey indicates that only a few Massachusetts WRRFs that don't currently recycle biosolids are thinking of moving toward recycling (including Greenfield, Northfield, Rockland, South Essex, and Springfield):

- Greenfield is "currently undertaking a project to build an anaerobic digester and composting facility."
- Springfield's plans are representative of actions at mid-size and larger WRRFs in the region: reduce solids production (e.g. through anaerobic digestion, which Springfield is seriously considering) and expand options for end use or disposal of solids by installing heat-drying / pelletizing, producing biosolids that can be land applied or combusted as an alternative fuel (e.g. in cement kilns). Currently, MWRA (Boston area) and Greater Lawrence Sanitary Treatment District are the only WRRFs in the state that produce heat-dried biosolids.

Over the past several years, MassCEC has funded and received studies regarding the upgrading of existing or addition of new anaerobic digestion facilities for Springfield, Rockland, Pittsfield, and Holyoke (Brown and Caldwell, 2019; Brown and Caldwell, 2018; Kleinfelder, 2018; and CDM Smith, 2019; respectively).[17] Fitchburg has also evaluated the option of creating anaerobic digestion at the old – now closed – "wastewater West Plant." According to MassCEC, a common finding of studies about adding new systems at small WRRFs was that anaerobic digestion was not a clear financial benefit at the scale of a small individual facility, with various uncertainties factored in; generally, the more feedstock that can be assumed, the better the predicted financial viability and performance.

Of the relatively few Massachusetts WRRFs that currently recycle biosolids, two – Hoosac (Williamstown) and Southbridge expressed some uncertainty, as they looked forward to the next 10 years, about whether their composting operations, which have been successful for decades, will continue. Southbridge notes that they anticipate "compost will remain unless odor issues or stricter regulations will not allow land application, etc. PFAS [per- and polyfluorinated alkyl substances] is something new on the horizon." Hoosac notes that their composting operation "depends on MA DEP Approval of Suitability," which, based on new MassDEP requirements introduced in January 2019, will include testing for PFAS, for which there is currently no EPA-approved analytical method and no numerical screening level or enforcement standard against which to compare test results – all of which raises uncertainty. Hoosac has been planning to increase the capacity of their compost operations in order to provide an outlet for other solids in the region. Whether or not this happens will depend on regulatory developments.

MWRA Deer Island and Greater Lawrence, the two largest producers of recycled biosolids, have evaluated many options for improvements during the past several years. GLSD has built additional anaerobic digestion and new engine generator capacity; these will allow expansion of its food waste receiving program, which began in 2018, making that WRRF a regional resource for managing liquid wastes, advancing diversion of organics from landfills, and generating renewable energy. Deer Island is interested in similar advances, but is stymied by the challenge of conveying food waste to the Island.

[17] In the past decade, MassCEC has helped facilitate and fund many other feasibility studies related to wastewater solids management; see https://www.masscec.com/.

In the meantime, however, they produce large amounts of renewable energy that is used on site and are planning to expand their biosolids product markets by producing more bagged product.

Comments on potential changes over the next decade in how solids are managed also included the following:

- "[Our local sludge-only] landfill is expected to reach its life expectancy within 10 years" – Fitchburg
- "[Our solids/sludge management] contractor currently exploring other uses" - Marlborough

The Mass Sludge Survey 2018 also asked whether or not WRRFs are expecting to change their practices related to taking in septage or other outside liquid wastes. Thirty responses were provided.

Regarding septage receiving, 11 said they intend to take in more septage – including Northfield's plans to start a septage-receiving program and South Deerfield considering it as part of their first upgrade "in 45 years!"

Five facilities expect to decrease and three expect to keep constant the amount of septage they receive. The reasoning?

- "Less as our sewage system expands" – Barnstable, Westfield
- "We are hoping to take in less over the next few years or make more money. We will hopefully be increasing prices to reflect how hard it is to manage septage" – Lowell
- "Unknown: it has its challenges" – Southbridge

Regarding other outside wastes and plans for the future, the few comments received indicate that several facilities will continue to take in other WRRF solids (e.g. Lowell) or are considering doing so. For example, Hoosac may take in outside solids for composting. Lowell explained the future of its program this way, which is an apt presentation of the concerns WRRFs have to consider: "We will continue to take in our current waste on wheels and keep expanding, as long as the wastes do not have a negative impact on the process or affect us meeting [our NPDES] permit."

Additional survey comments further illuminate the spectrum of concerns WRRF managers and operators are considering as they look ahead to the next ten years of solids management:

- *Additional treatment to improve effluent quality, such as nutrient removal, leads to greater solids production*:
    - "Sludge production will increase due to adding chemicals to remove phosphorus and copper in the near future." – Warren
    - "The Town will be building an upgrade to include nitrogen removal, so there will be some as of yet unknown changes depending on the process that is chosen." - Fairhaven
- *Stable, predictable outlets for solids are needed*, and at least some WRRF staff are worried about the current uncertainties and increasing prices:
    - "Due in large part to our new NPDES permit (and probably the one to follow), many operational changes, including solids handling, will be occurring. While I can't predict all the results in 10 years, at the least, they will (in my opinion) depend heavily on the affordable availability of regional biosolids processing and handling facilities. The biosolids will probably be transported elsewhere, and possibly thickened beforehand to

reduce shipping costs. Then again, it may be possible that end users will be paying Marion… for their Grade A biosolids." - Marion

- "Massachusetts BADLY NEEDS two REGIONAL solids handling facilities run by the state or contracted out, but owned by the state. There needs to be one just outside the 495 corridor in the east, and another one in Franklin County for the western part of the state. They should be large, have twin incinerators, digesters, and indoor composting. The digester gas would offset energy use and also would provide surplus energy to be sold to the utilities. This would reduce overall costs to everyone. The hauling would be to and from smaller distances, they would incorporate all the types of sludge receiving needed, and would be self-sustaining from the energy production. It would be cleaner, more efficient, less polluting, and do less harm to the roads in our state. At the very least build one huge solids handling facility right in the middle of the state for everyone in our state to use…." – South Deerfield
- "With the increase in cost, we will take a look at other options for disposal in the near future" – Haverhill
- "We are limited by the area of our site and are limited with our options on sludge management. We always are monitoring new technologies to see if anything can help improve the situation" – Lowell
- "We will always be looking at more cost effective ways to treat our residuals and the best way to utilize those residuals." – Northampton, Lee

Expected changes in costs for solids management in the next 10 years

Seventy-four survey respondents estimated changes in the amount of solids generated at their WRRFs and the associated costs of managing those solids (Table 14). Most striking was that, of the 18 who said they expected no change in solids production, only one said they did not expect cost increases. Pretty much everyone is expecting the cost of solids management to increase by up to 30% in the next ten years, with 5 respondents (68%) thinking their costs will double. Current pressures and uncertainties in the solids management markets have already sent prices higher. Haverhill notes that "sludge cost for FY20-22 has jumped to $120 per wet ton!!!!!"

Table 14. Anticipated increases (decreases) in solids generation and the costs of solids management

Percentage of increase (decrease) anticipated	**Do you expect the amount of solids to increase (decrease) in the next 10 years?** (number of survey respondents / percentage of survey respondents)	**Do you expect the cost of solids management to increase (decrease) in the next 10 years?** (number of survey respondents / percentage of survey respondents)
(Decrease by 15% or 20%)	(2 / 3%)	(2 / 3%)
No change	18 / 25%	1 / <1%
Increase by 1% – 30%	45 / 62%	36 / 49%
Increase by 31% - 99%	7 / 9%	30 / 41%
Increase by 100%	1 / <1%	5 / 7%

Interest in collaborating on a regional facility

Of 74 responses to the question of whether they are interested in collaborating on a regional solids management facility, 51 (70%) said they are interested and 50 said it is somewhat to extremely important to them. Many noted the need for multiple solids management outlets, because options help keep costs under control and provide backup if a current option fails. Billerica noted "As costs rise, we need to find a solution to handling our biosolids. Right now there are few options and we pay more because there is no competition in this field."

When survey respondents were asked if they would *host* a regional facility, all but six (8%) expressed little or no interest (Table 15) and the plurality of responses was a strong "very unlikely."

However, Springfield and Holyoke specifically expressed interest in hosting a facility, with Springfield noting that hosting a regional facility would allow them to "control our own destiny." Northampton appears willing to consider it too, but said "this would have to be discussed with the community to see how receptive they are to such a facility." South Deerfield noted that they had had discussions with a composting company about building a regional facility in their area, but that the company thought there is not enough feedstock close to South Deerfield. Southbridge, which is currently one of the few biosolids compost operations in the state, notes that the community will decide soon if composting will continue and, depending on that, if expanding to take in some solids from other communities should be considered. Greenfield expressed perhaps the greatest level of commitment: "We intend to be a regional disposal destination once we get up and running and will expand to fill the need."

Table 15. How likely would you be to host a regional solids handling facility at or near your WWTP?

Very likely	Likely	Neither likely nor unlikely	Unlikely	Very unlikely
2	4	20	18	30

Respondents gave the following reasons for *not being interested* in collaborating in a regional solids management option:

- it would depend on what the cost would be for their facility;
- they are extremely busy and, thus, unlikely to be able to help with a regional facility option;
- their upper management, their communities, or their contracted solids management company would be the ones to decide whether or not to collaborate in a regional solution; and their current solids management system is fine as is ("We are fortunate to be close to multiple incinerators," noted Uxbridge).

The following reasons were given for *not likely hosting* a regional solids management facility:

- About 10 respondents noted that their facilities or sites have space limitations that they see as precluding hosting a regional facility. [18]
- Somewhat related, several facilities noted that they are small and not wanting to take on larger operations. [19]
- Several facilities said that their neighbors would not accept their facility becoming a regional facility, a couple citing NIMBY (not in my back yard) attitudes.

[18] Billerica, Charlton, and Chicopee note they "have no space for a facility."

[19] For example, Hardwick-Gilbertville notes that their facility is too small, echoing the expected response from smaller facilities that would not want to take on larger operations.

- Concerns about impacts on facility operations and meeting permit requirements; for example, Great Barrington noted concerns about "nutrient loads and nutrient removal."
- Several respondents noted that the question about whether or not to host or participate in a regional facility was a decision for policy-makers at the highest levels in their organizations.

Creating a few regional facilities to manage solids does not require many WRRFs to be interested. However, to be viable, there must be widespread interest from area WRRFs in sending solids to a regional facility. Of the 74 WRRFs that responded to the Mass Sludge Survey 2018 question about whether or not they would *send their solids* to a regional facility, 12 (16%) said they would be "unlikely" or "very unlikely" to do so, while 40 (54%) said they would be "likely" (21) or "very likely" (19) to do so. (The remaining 30% were neutral.) Many of those showing interest in sending solids to a regional facility noted that cost would be the major driver in their decision.

IV. THE POTENTIAL FOR NEW REGIONAL ANAEROBIC DIGESTION FACILITIES

Markets for wastewater solids processing, end use, and disposal are already active and regional in Massachusetts and New England (even into New York and New Jersey), having developed extensively since the 1980s, when the Commonwealth promulgated its current sludge regulations and the federal Part 503 rule was created. Massachusetts WRRFs currently avail themselves of a variety of in-state options, as well as outlets for solids end use and disposal in CT, ME, NH, and RI. Southern New England especially is served by regional wastewater solids processing facilities: sewage sludge incinerators (SSIs) at Upper Blackstone (Worcester area) and throughout CT and RI – and at least 77 Massachusetts WRRFs send solids to these SSIs. The market for managing wastewater solids is dynamic and is dominated by private enterprise and competition. Currently it is stretched thin, with concerns about adequate capacity and prices rising.

Significant obstacles to creation of regional wastewater solids processing facilities are present in Massachusetts and around New England, including:

- political and social challenges related to cooperation amongst municipalities;
- siting of centralized facilities, which tends to trigger local objections because of real and perceived unequal distributions of nuisances and risk;
- complex economics; and
- new, emerging regulatory issues (further discussed in a Section V, below).

On the other hand, the potential for municipalities to cooperate on wastewater management has been recently demonstrated. In southeast Massachusetts, for example, Mansfield, Foxborough, and Norton (MFN) are collaborating on a shared wastewater treatment facility (Galvin, 2018):

> "The communities involved in the MFN district saw the opportunity to increase tax bases by expanding the commercial and industrial development along the Route 495 corridor, providing additional revenues to pay for needed infrastructure, including new schools. But nitrogen removal was also a component as the Taunton River Watershed empties in Narragansett Bay.

> "Mansfield built its treatment plant in 1985 on land in Norton and eventually the towns of Norton and Foxborough purchased treatment capacity from Mansfield through an intermunicipal agreement. District negotiations began in 2008 and special legislation was approved in 2010 establishing the district. It took 30 meetings over four years to put an agreement in place."

The MFN collaboration – and other long-standing inter-municipal agreements (Oxford-Rochdale, Wayland-Sudbury) that require complicated governance and financing arrangements – are currently illuminating a path forward for the Cape Cod towns of Harwich, Dennis, and Yarmouth, who are negotiating a three-town wastewater management system, with some newly-sewered wastewater from Harwich to be treated at the existing Chatham WWTF.[20]

Similar inter-municipal agreements may be necessary for regional solids management facilities. But shared ownership and operations are not always required. Because solids are readily transported, the range of solids management system options extends from a purely market-driven set of separate generators and outlets – which is what dominates the situation today – to formal intergovernmental agreements, ownership, and/or operations of a regional solids management facility, perhaps including public-private partnerships. The challenge for those attempting to plan for more efficient, beneficial regional wastewater solids processing facilities is to determine how to leverage the power of the current markets while supporting the considerable investment needed to create a regional facility and managing the considerable risk involved.

A Connecticut River Valley Regional Facility

The Connecticut River Valley, from Springfield at the south to Northfield at the New Hampshire line, is a geographically connected region with robust transportation corridors. It contains numerous WRRFs. Springfield's Bondi's Island WRRF and Holyoke's facility are central to the greatest mass of solids in the Valley, although the facilities are not geographically centered. But Northfield, at the New Hampshire border, is still within about 50 miles of either, not far off of Interstate 91, an efficient transportation route for the Valley. It is reasonable to assume that one regional solids management facility could serve the Valley, as well as WRRFs scattered to the east and west, some of which are not far from I-90 / the Mass Pike (Figure 2).

Both Springfield and Holyoke have recently completed feasibility studies for anaerobic digestion, and there has been discussion of one or the other being a regional resource, most likely offering anaerobic digestion as an outlet for the Valley's wastewater solids and other liquid organic residuals (e.g. food scraps). Ample quantities of wastewater solids in the area improve the likelihood that such a facility would be economically viable.

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[20] An additional example: The "Tri-town" septage treatment facility, which served the Cape Cod towns of Brewster, Eastham, and Orleans, has been shut down as the communities react to the need to reduce nitrogen pollution. Large percentages of homes in the area are being connected to new collection systems, and Orleans, for one, will soon have a new wastewater treatment plant to remove nitrogen (Eldred, 2018). These communities also have experience with regional solutions.

The interest in supporting a regional facility in the Connecticut River Valley seems to be high. Respondents from many of the WRRFs in that region said they would be "likely" or "very likely" to send solids to a regional facility (as long as the cost was acceptable). Those WRRFs – including Springfield – generate more than 17,000 dry U. S. tons of solids per year, the equivalent of more than 200,000 gallons per day of 5% solids. (Compare this to the 6,300 dry U. S. tons that Greater Lawrence Sanitary District generated and digested in 2018.) As Brown and Caldwell (2019) noted, only a portion of the solids generated in the region would be needed to make a Springfield regional digestion operation cost-efficient. Based on conservative assumptions, their report indicated no significant increase in costs to the Springfield WRRF if they built AD and energy generation. If the facility was built as a regional resource, the cost efficiencies could provide net benefits to the host community.

A full-service resource recovery facility in the Connecticut River Valley would also be supported by:

- proximity of small northern Connecticut WRRFs, who might buy into a regional option;
- possible back-up incineration, with Hartford about 40 miles and Upper Blackstone about 55 miles away;
- a mix of agricultural and urban/suburban markets for biosolids soil amendments and fertilizers;
- the north-south (I-91) and east-west (I-90) transportation corridors (and possible rail options) for reaching more distant markets with biosolids products and other recovered resources.

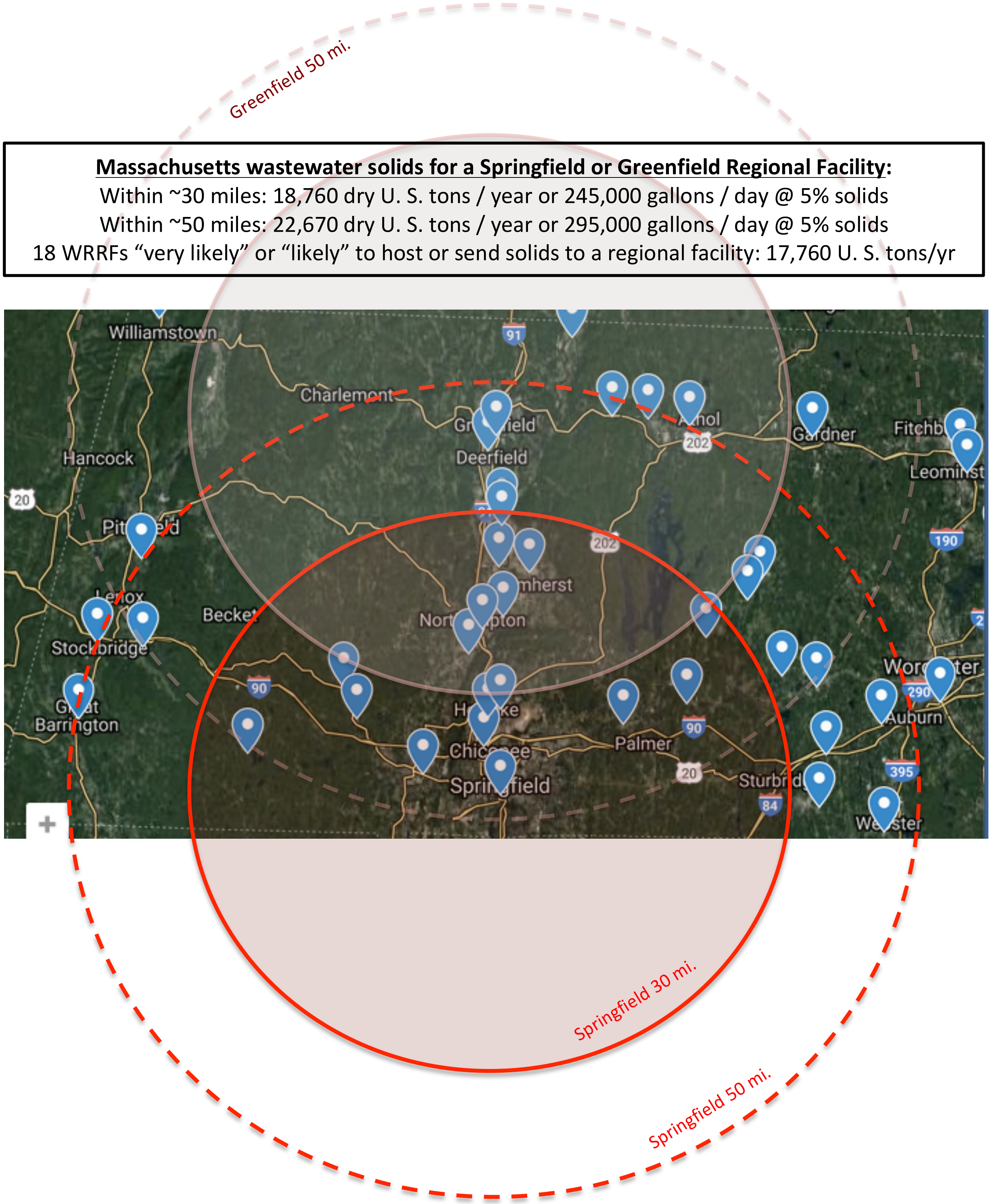
With ample Massachusetts WRRF solids within 30 to 50 miles from facilities who have expressed interest in contributing to a regional solution, a Springfield regional resource recovery facility – or one at Holyoke or Greenfield – appears to be a reasonable and feasible option.

Greenfield has expressed considerable interest, and has taken local steps toward hosting a regional AD facility. Although at the northern end of the Valley, it could still provide service to Springfield (39 miles south on the interstate) and WRRFs in between and some communities across the border, including Keene, NH (35 miles away). (Brattleboro, VT, just 21 miles north, has its own advanced digestion system and would be unlikely to send solids to another facility.) Greenfield might also draw solids from the east-west corridor of Route 2, including WRRF solids from Charlemont and possibly Williamstown to the west and Orange, Athol, Gardner, and even Fitchburg to the east. All are within about 50 miles of Greenfield. Space constraints and other factors may limit how much material Greenfield could accept from other WRRFs. Northfield also expressed possible interest in hosting a regional facility, but is more remote.

Biosolids and other organic residuals have provided great benefits to farmers and landowners in central and western Massachusetts, creating productive topsoils on disturbed sites (e.g. gravel mines) while recycling nutrients and sequestering carbon in the soil.

Figure 2. A Springfield or Greenfield Regional Facility

<u>Massachusetts wastewater solids for a Springfield or Greenfield Regional Facility</u>:
Within ~30 miles: 18,760 dry U. S. tons / year or 245,000 gallons / day @ 5% solids
Within ~50 miles: 22,670 dry U. S. tons / year or 295,000 gallons / day @ 5% solids
18 WRRFs "very likely" or "likely" to host or send solids to a regional facility: 17,760 U. S. tons/yr

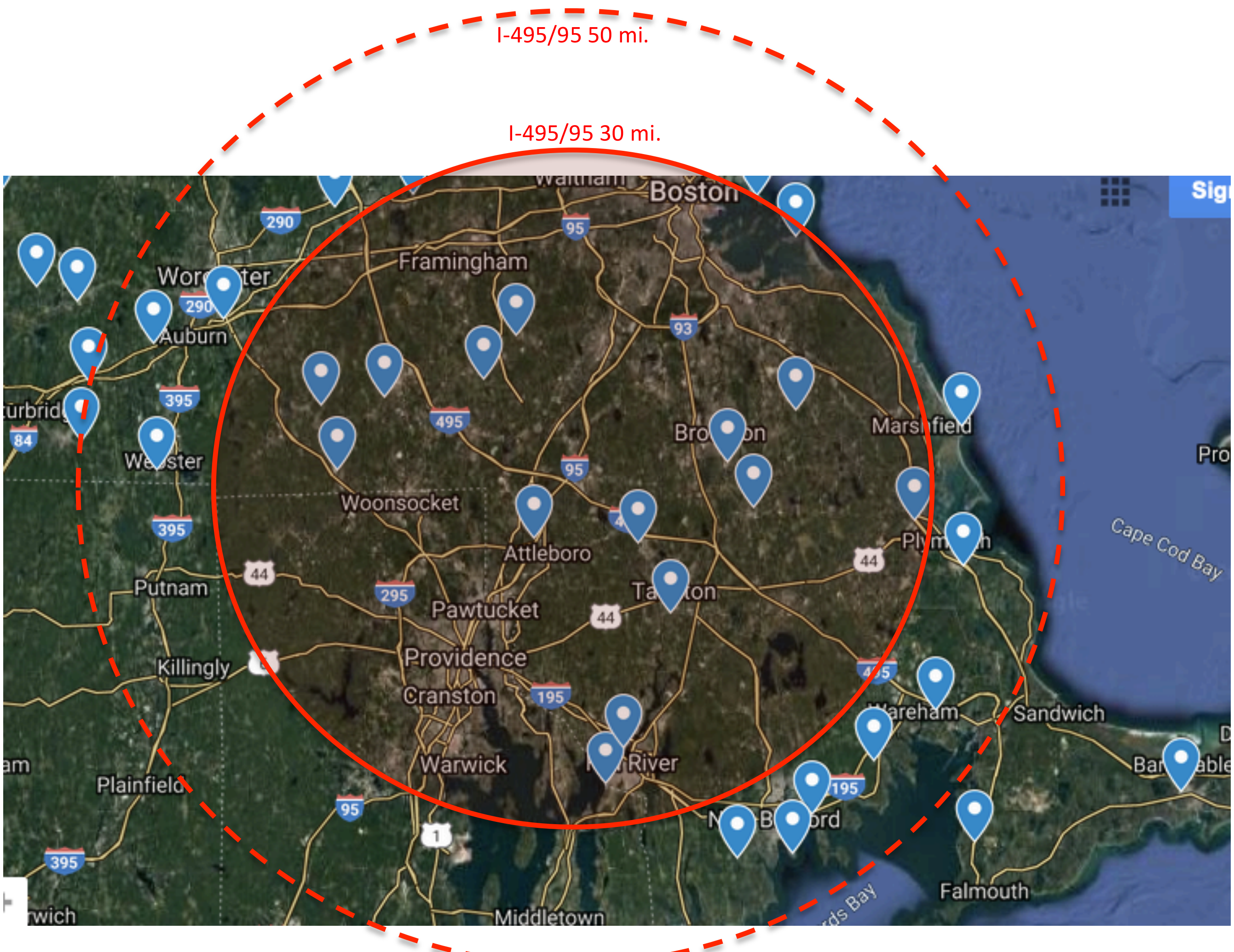


A Southeast Regional Facility

The other part of Massachusetts where there appears to be considerable interest in collaboration on a regional wastewater solids processing system is in the southeast. Nineteen of the 51 survey respondents who said "yes" to the idea of collaboration on a regional facility are within 50 miles of the intersection of I-495 and I – 95 (Figure 3). A regional facility in that area would service facilities from Marlborough on the northwest to Plymouth and Wareham on the southeast (Figure 3). Easy transportation is provided by Interstates 495, 95, and 93. Rhode Island WRRFs would also have easy access. For WRRFs on Cape Cod and the Islands, several of whom expressed interest in a regional solution, this southeast facility would be 60 miles or more, one way. Rockland, which is farther east than the I-495 – I-95 junction, has an older anaerobic digestion system that it may upgrade, but, in the survey, did not express interest in becoming a regional facility. In any case, shifting a southeast regional facility eastward toward the Cape would reduce its usefulness to central Massachusetts communities, which have larger solids production.

Figure 3. A Southeast Regional Facility

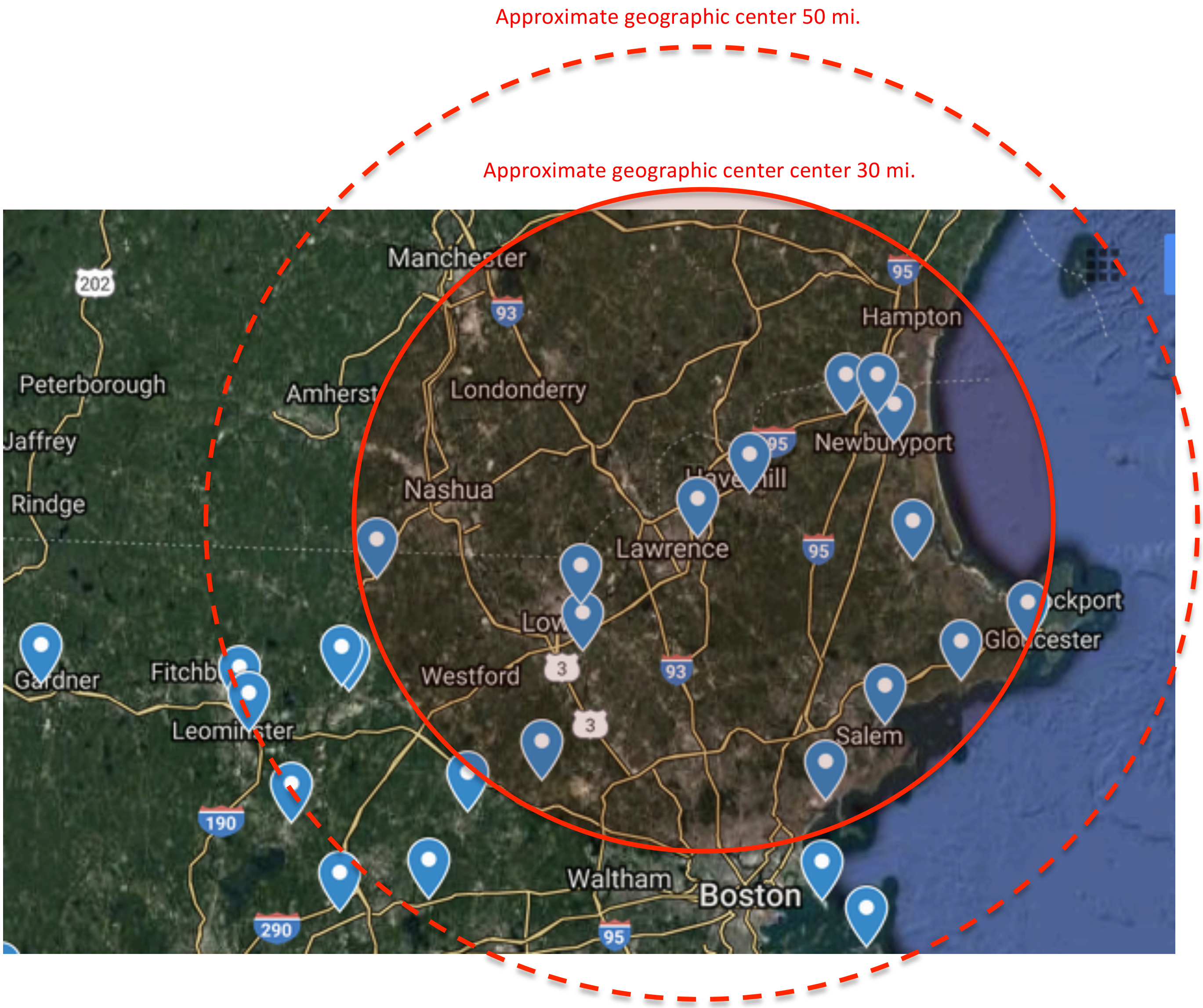
Massachusetts wastewater solids for a Southeast Regional Facility:
17 area WRRFs within ~50 miles are "very likely" or "likely" to send solids to a regional facility:
15,750 dry U. S. tons/year or 206,000 gallons / day @ 5% solids



A Northeast Regional Facility

The third region of the state in which there is interest in a regional solids management option is north of Boston, especially in the Merrimack River Valley. Eight WRRF survey respondents from this region expressed strong interest in collaboration on a regional facility - they include some large facilities: Haverhill, Lowell, and South Essex on the east, and Fitchburg on the west. Greater Lawrence Sanitary District, which is close to the geographic center of this area, already manages some outside wastes, but will likely be at capacity soon, with a new digester and renewable energy system and a focus on taking in pre-processed, slurried food scraps. The survey suggests that if it, or another nearby facility had capacity, there could be up to 20,000 dry U. S. tons of solids whose owners are seeking a regional option.

Massachusetts wastewater solids for a Northeast Regional Facility:
8 area WRRFs within ~50 miles are "very likely" or "likely" to send solids to a regional facility:
21,290 dry U. S. tons/year or 279,000 gallons / day @ 5% solids



V. BIOSOLIDS MANAGEMENT CONTEXT AND CHALLENGES

Over the past 30 years, solids management and the markets servicing this critical function have become steadily more sophisticated in Massachusetts and around the country. This progress has involved advances in, for example (not an exhaustive list):

- research and demonstration of biosolids recycling to soils for agronomic and environmental benefit;
- best management practices for land application, landfill disposal, and incineration of biosolids;
- treatment technologies and management systems tailored to the selected biosolids use or disposal outlet (e.g. improved dewatering systems for biosolids headed to disposal or recycling on soils);
- the diversity of biosolids uses (e.g. land reclamation, forestry, landfill caps, leachate treatment, bioenergy cropping, cement kiln fuel, etc.);
- energy efficiency of wastewater treatment and biosolids management, including capturing the energy potential in biosolids through anaerobic digestion (AD) and combined heat and power (CHP) or energy recovery from incineration; and
- understanding the net greenhouse gas emissions and other environmental impacts of wastewater and biosolids management, and how to best reduce any potential negative impacts (e.g. soil nutrient imbalances, conveying trace contaminants of concern, etc.) while maximizing benefits (e.g. recycling local nutrients and organic matter, providing cost-effective solutions for local farms and landscapes, improving crops, and cost-efficiently advancing community sustainability).

Even as these advances have occurred, regulations have become stricter, mostly driven by state regulatory agencies:

- The federal Part 503 regulations have not changed significantly since their inception in 1993, but other federal standards have had influence on biosolids management, including the U. S. Department of Agriculture (USDA) organics rule (precluding use of biosolids in certified organic agriculture), the U. S. Food and Drug Administration regulations under the Food Safety Modernization Act, and the U. S. EPA air office's new air emissions regulations for sewage sludge incinerators.
- At the state level, management issues, nuisance concerns, and public pressures have led to a wide variety of additional requirements for management of land applied biosolids, making most states' (including all of New England's states') biosolids recycling regulations far stricter than the federal minimum standards. Particularly challenging in recent years in New England and Massachusetts has been integrating biosolids and other organic residuals (e.g. composts) into the regulations aimed at reducing phosphorus (P) in fertilizers, even as wastewater discharge permits have become stricter on allowable P discharges, meaning more P end up in wastewater solids. For example, the MWRA Clinton WRRF reported to the current survey that they have just recently started running a new phosphorus-reduction system.

At the same time, in the past decade, there has been pressure to advance the recycling of organic residuals (although biosolids are not often emphasized). Massachusetts policies and investments have increasingly focused on mitigating climate change through greenhouse gas emissions reductions, which has included diversion of organic materials from landfills, to reduce harmful methane emissions.

The state has also set aggressive goals to reduce greenhouse gas emissions associated with use of fossil fuels, incentivizing renewable energy, including anaerobic digestion (AD) and combined heat and power (CHP). The WRRF sector has increasingly adopted these goals and put considerable effort into realizing the goal of having WRRFs serve as resource centers for managing a variety of materials and producing valuable products – including renewable energy – that reduce emissions and create more sustainable communities.

All of the above policy and regulatory developments have led to important further protection of the environment, but they also create competing challenges for wastewater solids management, especially related to recycling to soils, with the regulations sometimes acting as disincentives. In the past 15 years, the rate of biosolids recycling in Massachusetts has increased only marginally from 35% to 38% (Table 16), although landfill disposal (where methane emissions are a concern[21]) has decreased more, by 9%. Incineration has taken up most of the difference, including most of the increase in overall solids production.

Table 16. Trends in end use and disposal of Massachusetts wastewater solids, 2004 vs. 2018

	2004 (NEBRA et al., 2007)			2018 (current survey)		
	# of WRRFs	Dry U.S. tons	% of tons	# of WRRFs	Dry U.S. tons	% of tons
Beneficial use (application to soil)	17	53,513	35%	19	68,651	38%
Landfill disposal	21	41,588	27%	31	31,784	18%
Incineration	89	57, 558	38%	77	78,353	44%
Totals	127	153,235		122 [1]	180,800	

Notes:
1. The current survey of solids management in 2018 included 122 WRRFs. Ten of the facilities report sending solids to two or three outlets, as follows: Brockton, Chicopee, Devens, Fall River, and Holyoke sent solids to both landfill and incineration. Erving sent solids (paper mill residuals) to landfill and land application. Somerset and Ware sent solids to land application and incineration. Concord and Lowell sent solids to all three options.

The market for managing wastewater solids was challenged in 2016 by the shake-out caused by incinerators closing in response to new U. S. EPA air emissions regulations (Beecher, 2016). Today, the challenge comes from the uncertainty around a particularly challenging set of chemicals of emerging concern (CECs): per- and poly-fluorinated alkyl substances (PFAS). PFAS concerns related to biosolids recycling center on one issue: the potential for traces of some of these widely-distributed commercial chemicals, which are found in wastewater and biosolids in ng/g or parts per billion (because they are ubiquitous in our daily lives and we wash them into sewers), to leach and impact groundwater (and, perhaps, surface water) in low ng/L or parts per trillion levels. These low part-per-trillion (ppt) levels are in the range at which a few states are regulating them in drinking water and groundwater. Considerable uncertainty surrounds PFAS concerns, stemming from developing understanding of their toxicity and fate and transport and how widely they are already dispersed after having been in commerce since the mid-1900s. Such uncertainty is commonly addressed with regulatory caution,

[21] Most modern landfills have methane capture and treatment or utilization systems. However, landfills are inefficient at capturing methane from sludge in comparison to anaerobic digesters. Methane gas leaks more easily from the large areas of a landfill, and, when sludge is landfilled some of the methane is produced before the particular landfill cell can be closed and the gas collection system becomes operational.

which, in this case, has resulted in significant disruptions to biosolids use on soils in Maine and New Hampshire, with perturbations already affecting wastewater solids management in Massachusetts.

Beginning in January 2019, MassDEP initiated PFAS-related regulatory actions that add hurdles to recycling of biosolids to soils:

- MassDEP now requires the testing for PFAS of all land-applied biosolids and residuals under the Approval of Suitability permit program. Each biosolids recycling program must test its product during the first year of its new AOS permit (permit terms are 5 years).
- Site cleanup regulations for PFAS are being finalized with numerical standards that could (unintentionally perhaps) reduce the possibility of recycling biosolids to soils.
- Maximum contaminant levels (MCLs) for drinking water are being developed, and some proposed levels are low enough that wastewater and biosolids management activities – along with other activities – may well be unable to meet associated groundwater and surface water standards.

These regulatory steps create considerable uncertainty for WRRFs, including regarding potential liability and future costs. Wastewater and solids management professionals are wrestling with all the uncertainty, including:

- no screening or enforcement standards to which to compare biosolids PFAS test results,
- gaps in research on potential impacts of wastewater and biosolids management with relation to PFAS, and
- considerable public upset about PFAS that is driving quick regulatory actions in surrounding states, and, to a lesser degree, in Massachusetts.

These actions have led to the current mid-2019 wastewater market disruptions and price increases that are impacting WRRFs and their communities and rate-payers. Anecdotal reports indicate costs for solids management for some utilities have jumped from the range of $70 - $80 per wet ton to $120 to $130 per wet ton, driven by uncertainty around the potential disruptive impacts of PFAS concerns. Wastewater solids management has never before seen this level of disruption and uncertainty, driven by state regulatory actions, with potential liability and risk concerns facing private wastewater solids management contractors and public utilities.

The PFAS issue and other regulatory developments in recent years (e.g. phosphorus fertilizer regulation) are slowing progress on maximizing the beneficial uses of biosolids. Wastewater contains water, nutrients, organic matter / carbon (C), energy, and rare elements – along with traces of contaminants. Whether or not wastewater treatment operations in Massachusetts can recover some or all of these resources in the coming years has become uncertain. Returning clean water to the environment will remain the primary mission of WRRFs; in the presence of PFAS, this may require costly new systems for PFAS removal from effluent. Use of biosolids on soils, which recovers nutrients and organic matter from wastewater, seems likely to diminish in the coming years, down from the current 38% recycling rate. Already, some biosolids are being diverted to landfills and incinerators because of regulatory actions and uncertainty related to PFAS. While landfills provide little resource recovery (except some potential energy recovery from methane generation and capture), incineration can recover some energy, some phosphorus, and, possibly, other elements. Sustainably managing wastewater solids – recovering the resources in them – appears to be getting more difficult than ever.

Concurrently, there has been growing public interest and communications around biosolids and wastewater management; the media and public are more involved in environmental and public health matters than ever before. Biosolids recycling programs have always had challenges communicating the necessities and benefits of what they do. It is expected that those challenges will continue.

In the midst of these challenges facing current wastewater solids management markets, anaerobic digestion (AD) remains a solution with several benefits. AD recovers renewable, green energy from wastewater solids and reduces their mass and volume. It retains nutrients and some organic matter (a benefit if the biosolids are eventually recycled to soils) and does not close many options for the final use or disposal of the resulting biosolids. However, if anaerobically digested biosolids are subsequently incinerated, they require the addition of more fossil fuel (e.g. natural gas) to burn than undigested solids. AD also provides the benefit of reducing many trace chemical contaminants; but those that are most persistent, such as PFAS, are just conveyed forward into the final biosolids. Thus, exploration of new AD facilities continues to make sense, even as solids use and disposal options are under review and in flux.

VI. CONCLUSION

This Mass Sludge Survey 2018 is timely. Biosolids management in Massachusetts and the region and nationwide have been on a consistent trajectory of gradually increased recycling to soils since the promulgation of the MassDEP sludge regulations (310 CMR 32.00) in the late 1980s and the federal 40 CFR Part 503 regulations in 1993. Now, in 2019, in a few states, including in New England, new perspectives on wastewater solids (sludge) management are emanating from evaluations of a particularly challenging group of chemicals of emerging concern (CECs): PFAS (per- and polyfluorinated alky substances). Capturing what has developed, as shown in 2018 data, provides a good baseline for comparison to future solids management data.

Regional collaboration may be one way to help strengthen the wastewater solids (sludge) management markets. But such collaborations will need clear direction regarding what the regulations for solids management will be. Municipal and WRRF managers find it hard to plan with the levels of uncertainty currently pervading wastewater and solids management (in 2019, mostly related to PFAS).

As this survey indicates, there is considerable interest in regional wastewater solids management solutions. Anaerobic digestion can advance without PFAS questions being fully answered. A few districts are exploring hosting a regional facility. State policies and incentives could be valuable now, as they have been in the past, in creating long-term, reliable inter-municipal partnerships and contracts, which would ensure reliable economics for all parties over periods of a decade or more. Currently, the markets for sludge management are highly competitive, with most municipalities and utilities considering short-term lowest cost above all other factors. And sludge management contracts reflect this, some with time periods of 5 years or less. Many WRRFs are served by contractors for 5 – 10 year contract terms, but those contractors play the spot market, using the least expensive of available outlets for each load of solids. Incentives could encourage longer-term planning and contracting and would help create stable sludge distribution and end use or disposal structures that would warrant municipal, utility, and private investment. An important concept to recognize in the markets for wastewater solids management is the fact that this is a business that will not go away and can be reliably planned for in units of decades. This suggests that WRRFs should be discouraged from using simple payback time periods as a basis for decision-making (WERF, 2013) and encouraged to use 20-year or longer NPV cost analyses. Almost all of the current WRRFs in MA are likely to be producing solids 100 years from now.

In the Connecticut River Valley, a new or expanded regional solids management facility makes a lot of sense, and the interest is there.   In southeast Massachusetts, pressures are being felt by WRRFs, and regionalization and collaboration are increasingly embraced, creating an opportunity for developing a regional solids management facility, but perhaps requiring a different approach tailored to the local situation. Likewise, solids management in northern Massachusetts, including in the Merrimack River Valley, provides an opportunity for collaboration.

Applying biosolids compost enhances the durability and resilience of turfgrass on quality sports fields (Agresource photo).

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APPENDIX A: METHODOLOGY AND DATA QUALITY

Methodology

- **Identifying facilities, contacts, and contact information**

To identify water resource recovery facilities (WRRFs) to be included in the Mass Sludge Survey 2018, NEBRA relied on lists compiled by U. S. EPA Region 1 (2011), MassDEP, and the Massachusetts Water Pollution Control Association (MWPCA). These were compared with lists from U. S. EPA sources: the Clean Watershed Needs Surveys of 2008 and 2012 and data from the online ECHO database.

- **Creating the survey**

After consultation with MassCEC staff, NEBRA drafted the online survey (hosted on Survey Monkey under NEBRA's account) for review by MWPCA and MassCEC. After edits were completed, several facilities were asked to complete it and provide suggestions. Further edits were made to clarify questions and ensure consistent, reliable data would be collected.

- **Conducting the survey**

Beginning in mid-March, Ned Beecher (NEBRA) and Mickey Nowak (MWPCA) began concerted efforts to invite all Massachusetts WRRFs to complete the online survey. Outreach included individualized emails to every treatment plant, with follow-up phone calls and new emails, sometimes to different contacts at WRRFs that did not respond promptly. General notices and invitations were provided in NEBRA and MWPCA newsletters. By the end of May, there were about 70 responses, and a last push began, with the goal of increasing the participation rate to meet the stated goals for strong statistical representation:

  - participation by all of the 30 largest WRRFs (greater than 5 MGD);
  - data from at least 70% of the WRRFs with wastewater flows of 1 – 5 MGD;
  - data from at least 30% of the smaller facilities (< 1 MGD);
  - and, overall, data representing at least 90% of the wastewater solids generated in MA.

By July, after further outreach efforts by NEBRA's Janine Burke-Wells and Ned Beecher, the participation goals were met (with 68% rather than 70% of WRRFs with flows of 1 – 5 MGD). About 92% of the wastewater solids generated in Massachusetts were represented by survey responses.

- **Filling data gaps with historic data.**

In order to provide best estimates for total, state-wide wastewater solids production, treatment, and end use and disposal, the remaining data gaps were then filled with historic data gleaned from the MassDEP sludge management data compilation of 2005 and data reported to U. S. EPA's online reporting system (ECHO) for 2016 and/or 2017. Historic data introduced in this way to the Mass Sludge Survey 2018 (almost entirely from small facilities) are identified in different colors in the project's master data spreadsheet (see spreadsheet key for details) and were left the same, no matter their age (e.g. 2005); they were not extrapolated or updated in any way.

- **Data analysis**

Data quality was assessed (see below) as analysis was conducted. The master spreadsheet of data from this project is a compilation of WRRF and contact information from several historic data sets, presented alongside the results of the Mass Sludge Survey 2018, which were downloaded electronically. Once the master data compilation of relevant historic and current data was complete, all further data manipulation and analysis were worked within iterative versions of that one spreadsheet. All calculations and summary data appear in the spreadsheet, from which they were transferred to this report.

Data quality

Different data sets identify different numbers of water resource recovery facilities (WRRFs) or wastewater treatment plants/facilities in Massachusetts. The most comprehensive list can be gleaned from lists of National Pollutant Discharge Elimination System (NPDES) permits (e.g. https://eeaonline.eea.state.ma.us/DEP/NPDESePublicViewer/), which includes large facilities such as the Deer Island Treatment Plant and small package plants serving small housing developments. The latter and other small public wastewater treatment operations produce minimal solids. Some store solids in lagoons for many years and only clean them out and dispose of them occasionally.

The more useful data sets are focused on staffed facilities treating 100,000 gallons per day or more. Historic data sets discovered and used for data verification, quality, and reference in this current Mass Sludge Survey 2018 project are included in Tables A-1 and A-2, below.

Table A-1. Data sets reporting wastewater flow by facility size, for comparison

Data set	Year(s) of data	# of WRRFs/ WWTPs listed	Design flow <0.5 (MGD)	Design flow .5<Q<1 (MGD)	Design flow 1<Q<5 (MGD)	Design flow 5<Q<10 (MGD)	Design flow 10<Q<20 (MGD)	Design flow >20 (MGD)
U. S. EPA Region 1 [1]	2011	116	26	12	48	15	6	9
Mass Sludge Survey 2018 (current report – 84 responses	2018	84	12	10	34	13	4	11
Mass Sludge Survey 2018 (current report – 122 WRRFs	2018	122	29	14	51	13	4	11

Notes

1. U. S. EPA Region 1, 2011. Municipally-owned wastewater treatment facilities in New England. Includes how solids were managed at the time, but not solids volumes.

Table A-2. Historic data sets reporting solids (sludge) mass and use or disposal, compared to current Mass Sludge Survey 2018

Data set	Year of data	# of WRRFs/ WWTPs	# of facilities with total dt sludge data	Total sludge (from # of facilities in prior column) (dt)	Land applied biosolids	Sludge disposed in landfill or monofill	Sludge incinerated	Sludge other disposal
NEBRA et al., 2007 national survey, based on MassDEP Survey 2005 [1]	2005 - 2006	128	127	153,235 (includes 42,192 dt Erving paper fiber)	53,513 (includes 22,776) dt Erving paper fiber)	41,588	57,558	576
U. S. EPA ECHO electronic solids data reporting [2]	2016	40	40	120,974	55,201	3,463	38,467	17,744
U. S. EPA ECHO electronic solids data reporting [3]	2017	53	53	148,742	58,457	52	55,230	26,609
85 survey responses only, Mass Sludge Survey 2018 (current report)	**2018**	**85**	**83**	**167,150** (includes 19,644 dt Erving paper fiber)				
122 WRRFs, Mass Sludge Survey 2018 (current report)	**2018**	**122**	**122**	**180,800** (includes 19,644 dt Erving paper fiber)	**68,651** (from 19 WRRFs) (includes 34,345 dt from MWRA Deer Island, 19,186 dt Erving paper fiber, and 6,299 dt from Greater Lawrence)	**31,784** (from 31 WRRFs)	**78,353** (from 77 WRRFs)	**2,012** (from 12 WRRFs)

Notes

1 .This data source also provides septage intake gallons for 128 facilities and where sludge was disposed. Includes very small facilities, such as Templeton Developmental Center, which, for example, reported disposing 10.5 dry tons in the Templeton WPCF landfill in 2005.

2. The sum of 2016 ECHO sludge use and disposal numbers equal 114,875 dry U. S. tons, which is lower than the reported total of 120,974 dry U. S. tons. Some reporting facilities did not account for all of their sludge when reporting where it went.

3. The sum of 2017 ECHO sludge use and disposal numbers equal 140,348 dry U. S. tons, which is lower than the reported total of 148,742 dry U. S. tons. Some reporting facilities did not account for all of their sludge when reporting where it went.

____

Data were provided directly to this survey by staff at 85 Massachusetts water resource recovery facilities (WRRFs). Local staff and managers at WRRFs are considered the most reliable sources for treatment operations data. However, to further ensure data quality, data sets from other sources were compiled and compared to the current survey data (Table A-2). During data analysis and the writing of this report, when questions arose regarding particular data, one or more of the following processes were used to ensure accuracy:

1. Compare data of concern to data in a historic data set
2. Contact the survey respondent or someone else at the WRRF to check on the accuracy of the data
3. If unresolved, discard data and/or create an estimated as a placeholder in data compilations and analyses (e.g. for calculating averages).

Note that summary totals provided in this report show appropriate numbers of significant figures/digits, reflecting the approximate precision of the data. Other data reported are based on sums and calculated means using the data provided; they do not properly represent the level of accuracy and should be assumed to be approximate.

APPENDIX B: THE MASS SLUDGE SURVEY 2018

Following is a copy of the online Mass Sludge Survey 2018, hosted by the online survey company Survey Monkey, under NEBRA's account.

Massachusetts Wastewater Solids (Sludge) Management 2018

1. Welcome

This survey will provide MWPCA, NEBRA, and Mass CEC with up-to-date information on wastewater solids (sludge) management in Massachusetts. For information only. Not for compliance.

25 minutes to fill in.
Provide data for 2018.
Only one survey response per WWTP please.
To enter data for a 2nd WWTP, use a different computer and just click to the survey link again.

You will need: Your 2018 EPA Part 503 Sludge Report (completed & filed for Feb. 19, 2019) or similar reporting on solids/sludge management in 2018.

Want help filling in the data by phone? Or have questions?
Call Mickey Nowak at 774-276-9722 or Ned Beecher at 603-323-7654.

Details
– Please follow directions carefully. If you are unsure of something, call us (numbers above).
– For numerical answers, please provide your best estimate as one number, no text or commas.
– If you need to explain something, please use the comment boxes found at the end of each page.

Run out of time? If you need to leave in the middle of completing the survey, that's okay. When you return, use the same computer, and you can pick up where you left off. This also means you can go back in and correct something later, if you wish. However, this also means that you can only complete *one survey from any single computer*. Use another computer to enter data from a 2nd WWTP.

What will be done with the data you provide?
We will not share your contact information. The sludge management data you provide will become part of a report for MassCEC and will be publicly available. Your WWTP will be listed along with about 120 others, all providing the same data.

Want to see the results?
The results from this survey will be available to you. If you provide your email address (at the end of the survey), we will send you a copy. We will not share your email address.

Thank you for helping with this survey!

Massachusetts Wastewater Solids (Sludge) Management 2018

2. Facility Information

* 1. Enter your facility name (e.g. Lowell Regional Wastewater Utility)

[ ]

* 2. Enter your name.

Enter data below for the facility named above.
MGD = millions of gallons per day

* 3. Average daily flow in 2018 (MGD). Enter just a number.

4. Permitted (or design) capacity (MGD). Enter just a number.

* 5. What is the actual RESIDENTIAL POPULATION served by your facility?
(Don't include commercial population equivalents.)
Enter just a number (your best estimate).

* 6. Nitrification/Denitrification - Does your WWTP have nitrification/denitrification processes?

- ○ Yes
- ○ No

Please describe:

* 7. P removal - Does your WWTP have phosphorus (P) removal?

- ○ Yes
- ○ No

Please describe the P removal process:

8. Does your facility have an active industrial pretreatment program?

- ☐ Yes
- ☐ No
- ☐ Don't know
- ☐ Not applicable

9. Please add any comments or explanations:

Massachusetts Wastewater Solids (Sludge) Management 2018

3. QUANTITY of solids (sludge, biosolids) leaving your WWTP...

* 10. Indicate the units used in the answers below regarding quantities of solids/sludge/biosolids:

- ◯ DRY U. S. tons
- ◯ DRY METRIC tons
- ◯ WET U. S. tons
- ◯ WET METRIC tons
- ◯ Cubic yards
- ◯ Gallons

* 11. What was the TOTAL QUANTITY of solids/sludge/biosolids that left your facility for use and/or disposal in 2018?
PLEASE USE THE FORM OF MEASUREMENT INDICATED ABOVE AND ENTER IT IN THE PROPER LINE BELOW.
Put a zero in every other box; do not include commas or text.

DRY U.S. tons per year	
DRY METRIC tons per year	
WET U. S. tons per year	
WET METRIC tons per year	
CUBIC YARDS per year	
GALLONS per year	

* 12. % Solids - What is the average percent solids of the final solids (biosolids) leaving your WWTP (2018 data)?

0 % solids 100

* 13. Please indicate the QUANTITY of the solids/sludge/biosolids from your WWTP used or disposed in the following ways in 2018. Enter just numbers. PLEASE USE THE SAME UNITS AS ABOVE (e.g. wet U. S. tons). The totals here should add up to the total above.

The amount land applied (beneficially used on land) in 2018	
The amount incinerated in 2018	
The amount landfilled in 2018	
The amount disposed in a surface disposal unit / sludge monofill in 2018	
The amount put in storage for use/disposal after 2018	
The amount managed some other way in 2018	

14. Please add any comments or explanations:

Massachusetts Wastewater Solids (Sludge) Management 2018

4. Septage & Other Trucked-in Waste

* 15. Septage - Does your WWTP take in septage?

- Yes
- No

Please clarify, if needed:

16. In 2018, how many GALLONS of septage did your WWTP receive?
Enter just a number.

* 17. Does your WWTP take in trucked-in waste other than septage?

- Yes
- No

Please clarify, if needed:

18. Please indicate what trucked-in waste other than septage.
For 2018, show how many GALLONS of each:

landfill leachate put into anaerobic digesters

landfill leachate put into headworks

food waste put into anaerobic digesters

food waste put into headworks

industrial waste put into anaerobic digesters

industrial waste put into headworks

slaughterhouse &/or farm waste put into anaerobic digesters

slaughterhouse &/or farm waste put into headworks

19. Please add any comments or explanations:

Massachusetts Wastewater Solids (Sludge) Management 2018

5. Solids/Sludge PROCESSING & HANDLING

* 20. What is the ratio of primary solids (sludge) to WAS (waste activated sludge) typically generated at your WWTP (in 2018)?
Example: 60% primary / 40% WAS.
Move the slider to show the % of PRIMAY solids.

0% — % of primary solids — 100 %

* 21. What processes are used for processing solids/sludge at your WWTP?
Check all that apply.

- [ ] Preliminary Operations (e.g., Sludge Grinding, Degritting, Blending)
- [ ] Thickening (Gravity and/or Flotation Thickening, Centrifugation, Belt Filter Press, Vacuum Filter, etc.)
- [ ] Aerobic digestion
- [ ] Anaerobic digestion
- [ ] Methane or biogas capture and recovery
- [ ] Lower temperature composting (Class B)
- [ ] Higher temperature composting (Class A)
- [ ] Lime stabilization
- [ ] Heat drying (e.g., Flash Dryer, Spray Dryer, Rotary Dryer, etc.)
- [ ] Temporary solids/sludge storage (Sewage Sludge Stored on Land 2 Years or Less, Not in Sewage Sludge Unit)
- [ ] Other treatment process (please specify)

* 22. What processes are used for THICKENING solids/sludge at your WWTP? You must make a choice in each of the three columns/menus.

	primary	WAS	combined primary & WAS
Thickening			

Please explain (optional):

* 23. Who manages the end use and/or disposal of solids/sludge/biosolids from your WWTP?

- [ ] On-Site Owner or Operator (WWTP / municipality staff)
- [ ] Off-Site Third-Party Handler or Applier (that person does not further treat the solids)
- [ ] Off-Site Third-Party Preparer (that person further treats the solids)

* 24. Are the solids or biosolids distributed or disposed in BULK and/or in BAGS/CONTAINERS?

- [ ] Bulk
- [ ] Bags/containers

* 25. Indicate the percentage of biosolids quantity distributed by each:

0% in bags/containers	percentage distributed in bags/containers	100% in bags/containers	

* 26. Pathogen treatment - What CLASS are the biosolids from your facility? Indicate the percentage of each:

Class A EQ	
Class A (not EQ)	
Class B	
Not applicable / not treated for pathogens	

* 27. Vector attraction reduction (VAR) - If biosolids are land applied or disposed, what VAR process is used?

- [ ] VR1 - Volatile Solids Reduction
- [ ] VR2 - Bench-Scale Volatile Solids Reduction (Anaerobic Bench Test)
- [ ] VR3 - Bench-Scale Volatile Solids Reduction (Aerobic Bench Test w/ Percent Solids - 2% or Less)
- [ ] VR4 - Specific Oxygen Uptake Rate
- [ ] VR5 - Aerobic Processing (Thermophilic Aerobic Digestion/Composting)
- [ ] VR6 - Alkaline Treatment
- [ ] VR7 - Drying (Equal to or Greater than 75 Percent)
- [ ] VR8 - Drying (Equal to or Greater than 90 Percent)
- [ ] VR9 - Sewage Sludge Injection
- [ ] V10 - Sewage Sludge Timely Incorporation into Land
- [ ] V11 - Sewage Sludge Covered at the End of Each Operating Day

* 28. Dewatering technology(ies) used at your facility (check all that apply):

- [ ] belt filter press
- [ ] plate and frame press
- [ ] screw press
- [ ] centrifuge
- [ ] vacuum filter
- [ ] drying beds
- [ ] gravity belt thickener
- [ ] gravity thickener tanks
- [ ] dissolved air flotation (DAF) units
- [ ] none or N/A
- [ ] Other dewatering/thickening (please specify)

29. Please add any comments or explanations:

6. Biosolids End Use Locations & Costs

* 30. In 2018, where did the solids/sludge/biosolids from your WWTP end up?
Check all that apply. Indicate the percentage of your WWTP's solids/biosolids sent to each type of site. Should total 100%.

Class A sites - home & city parks, yards, gardens, landscaping, sports fields

Agricultural sites (farms, Class A or B)

Land reclamation sites (Class A or B)

Incinerator(s)

Landfill(s)

Off-site preparer(s) (composter, other further processing for land application)

Other (please describe)

* 31. What is the COST to your WWTP for each option (2018 prices)?
Enter the net $ per as-is wet ton for:

transport from the WWTP
+ (plus) disposal fee
- (minus) any per-ton revenue from sale of the biosolids.

Give your best estimate. If a contractor takes the solids, all you need to enter is the per-ton cost (as is/wet ton) they charge you for each option.

Class A sites - home & city parks, yards, gardens, landscaping, sports fields	
Agricultural sites (farms, Class A or B)	
Land reclamation sites (Class A or B)	
Incinerator(s)	
Landfill(s)	
Off-site preparer(s) (composter, other further processing for land application)	
Other (please describe)	

* 32. How much did your WWTP pay TOTAL for all solids/sludge/biosolids disposal or use in 2018? If a contractor manages the solids, all you have to enter is the total paid to them. If WWTP staff transported the solids, estimate your transport costs and add any tipping fees.

33. Please add any comments or explanations:

Massachusetts Wastewater Solids (Sludge) Management 2018

7. Looking to the FUTURE...

Your answers to the questions on this page will not be quoted. They will be compiled with about 120 others' responses and a summary of all responses will be presented in the final report. You will be anonymous on these questions.

* 34. Do you expect the QUANTITY of solids/sludge produced at your WWTP to increase or decrease in the next 10 years?
Indicate the percentage change you expect for 2028 (compared to 2018 data reported above).

estimated increase (+) or decrease (-) in solids/sludge generation as of 2028, compared to 2018

-100% +100%

* 35. Do you expect the TOTAL ANNUAL COST of solids/sludge management to increase or decrease in the next 10 years?
Indicate the percentage change you expect for 2028 (compared to 2018 data reported above).

estimated increase (+) or decrease (-) in total annual costs for solids/sludge management as of 2028, compared to 2018

-100% +100%

* 36. At your WWTP, do you expect the solids/sludge treatment & handling processes will be changed in the next 10 years? Describe any changes you expect:

Thickening

Pathogen reduction

Stabilization (VAR)

Dewatering

Transportation

A change in who manages end use or disposal (i. e. by a contractor or by WWTP staff)

How sludge/biosolids are used or disposed (e.g. shift from land application to incineration or landfilling or vice versa)

Septage receiving (will you take in more or less?)

Outside/trucked-in waste receiving (will you take in more or less?)

Other (please explain)

37. Explain further any plans for changes in solids/sludge management in the next 10 years:

8. Final questions...

Your answers to the questions on this page will not be quoted. They will be compiled with about 120 others' responses and a summary of all responses will be presented in the final report. You will be anonymous on these questions.

* 38. Are you interested in collaborating or participating on a REGIONAL FACILITY located in MA for solids/sludge management?

- ◯ Yes
- ◯ No

If not, why not?

[ ]

39. If yes, how important to you is a regional facility option?

◯ Extremely important ◯ Very important ◯ Somewhat important ◯ Not so important ◯ Not at all important

Please explain:

[ ]

* 40. How likely would you be to HOST A REGIONAL SOLIDS HANDLING FACILITY at or near your WWTP?

- ◯ Very likely
- ◯ Likely
- ◯ Neither likely nor unlikely
- ◯ Unlikely
- ◯ Very unlikely

Please explain:

[ ]

* 41. How likely would you be to SEND SOLIDS/SLUDGE to a regional facility somewhere else?

- ◯ Very likely
- ◯ Likely
- ◯ Neither likely nor unlikely
- ◯ Unlikely
- ◯ Very unlikely

Please explain:

[ ]

42. Please add any comments or explanations:

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9. Thank You!

Thank you for completing this Survey!

43. A final report, including results and analysis from this survey, will be available from NEBRA, MWPCA, and/or Mass CEC.
To request a copy, check the box below and provide your email address.

☐ Please email me a copy of the report when it is done. I have provided my address below.

44. We ask for your contact information to help us assure only one response from each facility and to allow us to contact you if we have any questions. Your contact information will not be shared with anyone. Completing this information is optional.

Your Name

Email

Phone number

45. Additional comments: Please add further explanations or clarifications here. For comments that apply to a specific question, please begin with the question number.