National Biosolids Survey #2 (2018 Data)

LITERATURE REVIEW

AVAILABLE U. S. BIOSOLIDS DATA

Final Report

May 30, 2020

ACKNOWLEDGEMENTS

This report was funded by an Assistance Amendment to grant number 00D52017 from the U. S. EPA. Thanks to Kim Charick (Region 4, Atlanta), who served as EPA Project Officer, and Kenny Richardson (Region 4, Atlanta), who served as EPA Grant Specialist. The grant was administered by the Green Blue Institute (GreenBlue), and the Amendment was intended to "continue to assist with their ongoing national composting collaborative to increase organic material recovery from the municipal solid waste stream and reduce landfilling of organic materials." For the Amendment work, comprising Task 6 of the grant proposal, Green Blue was assisted by:

- Ned Beecher, Special Projects Manager, North East Biosolids and Residuals Association (NEBRA);
- Nora Goldstein, Editor, *BioCycle;*
- Maile Lono-Batura, Northwest Biosolids Association; and
- Greg Kester, California Association of Sanitation Agencies (CASA),

with special assistance from Tim Seiple, Pacific Northwest National Laboratories.

BACKGROUND

Task 4 of the original grant to GreenBlue — "State Food Waste Recycling Data Collection, Reporting Analysis" — analyzed state food waste recycling reporting and data collection methods and tools. The findings were intended to be used to help develop a national standardized data reporting tool and overall methodology for collecting state-by-state food waste recycling data. The desired goal was to have each state (and the jurisdictions that report data to that state) use the same methodology in order to present a more statistically robust national assessment. In addition, Task 4 findings were used to inform U.S. EPA about how it can close current organics recycling data gaps with a focus specifically on food waste recycling data. The scope of Task 4 provided a blueprint for the current Task 6 project.

The Task 6 project team thanks the following Advisory Group for their input and review. However, the project team is responsible for all final data and statements included in this report.

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INTRODUCTION

Biosolids are treated and tested solids (sludges) removed from water resource recovery facilities (WRRFs or wastewater treatment facilities[1]) that meet regulatory standards for application to land as

[1] The Water Environment Federation initiated widespread use of the term "water resource recovery facilities" or "WRRFs" in the 2010s. Until then, the terms most commonly used in the water quality profession to describe the same facilities have been "wastewater treatment plant" (WWTP) and "wastewater treatment facility" (WWTF). Other terms in use include "water reclamation facility" and "clean water plant." Terms originally used in U. S. EPA regulations that are not as commonly seen today include "treatment works treating domestic sewage" (TWTDS), and, more commonly, "publicly-owned treatment works" (POTWs). "TWTDS" designates facilities that are publicly-*or privately*-owned and treat *domestic* (as distinguished from commercial or industrial) sewage. "POTW"

soil amendments and fertilizers. Under federal and state regulations, biosolids can be beneficially land applied, disposed of in landfills or surface disposal units, or incinerated.

In 2004, U. S. WRRFs produced an estimated 7.18 million dry U. S. tons of biosolids, 55% of which were recycled to soils, according to *A National Biosolids Regulation, Quality, End Use & Disposal Survey* (NEBRA et al., 2007), which established the most comprehensive baseline data for U. S. wastewater solids management.

Since 2007, data on various aspects of biosolids management have been developed and reported, with different data sets developed for varying purposes; many have focused on the potential for anaerobic digestion (AD) and renewable energy production, and some have focused on phosphorus management. These various data sets are difficult to integrate. And they do not provide a comprehensive picture of biosolids management in the U. S. during the time period they cover.

Table 1
Historic estimates of wastewater sludge and biosolids production in the U.S.

Source	Tg/y (MT/y)	Material	Description
(NEBRA, 2007)	6.51 (7.18)	Biosolids	Used or disposed in 2004
(EPA, 1999a)	6.90 (7.61)	Biosolids	Used or disposed in 1998
(Bastian, 1997)	6.22 (6.86)	Biosolids	Used or disposed in 1997
(EPA, 1992)	7.05 (7.77)	Sludge	Generated in 1988
(EPA, 1992)	5.36 (5.91)	Biosolids	Used or disposed in 1988
(EPA, 1988)	4.56 (5.03)	Biosolids	Used or disposed in 1988. (

Source: Seiple et al. , 2017

SOURCES OF U. S. BIOSOLIDS DATA AVAILABLE IN 2020

This literature review summarizes these existing recent U. S. biosolids data, their focus and quality, and the methods used to compile them. Key national biosolids data reports prior to 2007 are noted in Table 1 (excerpted from Seiple et al., 2017).

In addition, this report:

- Identifies data gaps that, if filled, would be useful to policy-makers, researchers, and managers of biosolids; gaps to be filled were identified through input from the project Advisory Group and recommendations from the literature and other sources (the resulting final list of data fields will be delivered separately);
- Recommends next steps for implementing an updated, comparable national biosolids regulation, quality, end use, and disposal survey focused on 2018 data.

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distinguishes *public* ownership. These distinctions are important, but all of the terms above are loosely used to describe the same facilities. The current term "WRRF" is used in this report, except where more precise designation is needed, in which case "TWTDS" is used for consistency, because that is the set of facilities included in the first national biosolids use and disposal report (NEBRA et al., 2007). As noted in that report, "in reality, as shown by USEPA (1999), the difference in numbers between the larger group of TWTDS and the subset of POTWs is relatively small."

Table 2. U. S. Biosolids Data Sources and Reports

Source / Title	Year Published	Year(s) of Data	Description	Produced by / Author	Available from…
U. S. EPA Biosolids Annual Reports	2019	2018	Annual biosolids data electronic reporting required of certain biosolids generators and available in ECHO database.	U. S. EPA	https://echo.epa.gov/facilities/facility-search
Anaerobic Digestion Facilities Processing Food Waste in the United States in 2016	2019	2016	Second of 3 annual reports. This data from surveys of 134 U. S. facilities, including 72 WRRFs, about food waste digestion or co-digestion.	U. S. EPA, Region 3	https://www.epa.gov/anaerobic-digestion/anaerobic-digestion-facilities-processing-food-waste-united-states-survey
Anaerobic Digestion Facilities Processing Food Waste in the United States in 2015	2018	2015	Data from surveys of 137 U. S. facilities, including 72 WRRFs, about food waste digestion or co-digestion.	U. S. EPA, Region 3	Same as above.
Baseline Data to Establish the Current Amount of Resource Recovery from WRRFs	2018	2018		WEF / Carollo / CU Boulder	www.wef.org/.../03---resources/WSEC-2018-TR-003
Compendium of Biosolids Land Application Regulations	2018	2018	Focuses on regulations covering how nutrients – P in particular – are managed; includes agricultural regulations as well as biosolids-specific regulations	Sustainable Phosphorus Alliance	https://phosphorusalliance.org/
Modeling Wastewater Solids and Biosolids Generation	2017		Focused on advancing understanding of this potential for wastewater solids to provide renewable energy through emerging "waste-to-energy pathways"	Seiple et al.	https://www.sciencedirect.com/science/article/pii/S0301479717303808?via%3Dihub

NACWA 2017 Financing and Management Survey	2017	2017	Every 3 years, NACWA surveys its members – mostly large WRRFs in the U. S., including asking about biosolids management.	NACWA	https://www.nacwa.org/news-publications/financial-survey-nacwa-index
WEF Biogas Data: *Biogas Utilization: A Regional Snapshot in Understanding Factors that Affect Water Resource Recovery Facilities*	2015		Supplemented the prior report with additional data collected from WRRFs in U. S. EPA Region 4 and Texas.	WEF	https://www.resourcerecoverydata.org/
WEF Biogas Data: *Biogas Production and Use at WRRFs in the United States*	2013	2011	Targeted survey of municipal WRRF anaerobic digestion systems producing biogas, including wastewater flow data and basic information on biogas use. Does not include biosolids production or use data.	WEF	http://www.resourcerecoverydata.org/biogasdata.php https://americanbiogascouncil.org/resources/biogas-projects/
Clean Watershed Needs Survey (CWNS)		2012	Assessment of capital investment needed nationwide for publicly-owned wastewater collection and treatment facilities to meet the water quality goals of the Clean Water Act	U.S. EPA	https://www.epa.gov/cwns
A National Biosolids Regulation, Quality, End Use & Disposal Survey	2007	2004		NEBRA et al.	https://www.nebiosolids.org/about-biosolids

REVIEW OF BIOSOLIDS DATA COMPILATIONS, 2007 – 2020

A National Biosolids Regulation, Quality, End Use & Disposal Survey, NEBRA et al., 2007

The national biosolids end use and disposal report, providing data from 2004, remains the only data set with consistently compiled and reported nationwide and state-by-state data. It continues to be cited widely, despite being out-of-date. It found the following data for the U. S. in 2004:

- There were 16,583 treatment works treating domestic sewage (TWTDS), of which ~3,300 generated 92% of U. S. wastewater solids (sewage sludge).
- An estimated 7.18 million dry U. S. tons of wastewater solids were used or disposed of.
- 55% of these solids were treated, tested, and applied to soils in accordance with federal (and, where applicable, state) regulations. Of these beneficially-used biosolids…
    - …74% were applied to farmlands, 22% were treated to exceptional quality (EQ) standards and publicly distributed for various uses, and the remainder were used in land reclamation or silviculture or other uses.
- 45% of these solids were disposed of in municipal solid waste landfills, surface disposal units, or sewage sludge incinerators (SSIs). Of these solids,…
    - 63% were placed in MSW landfills, 4% were put in surface disposal units, and 33% were incinerated in SSIs.
- 23% of the U. S. solids were treated to Class A standards – mostly all EQ, with 34% treated to Class B standards.
- States with the highest levels of biosolids recycling to soils included Colorado, Florida, Maine, Maryland, New Mexico, Michigan, Nebraska, Oregon, Utah, Washington, and Wyoming.
- Most larger TWTDS have active industrial pretreatment programs (77% in one survey).
- Stabilization technologies used to treat biosolids were as follows (in order, treating the largest amount of solids to the least): anaerobic digestion > composting > alkaline stabilization > thermal (e.g. heat-dried) > lagoons & reed beds > aerobic digestion. However, aerobic digestion is the most common stabilization technology in use; it is common at small TWTDS.
- Dewatering technologies used to treat biosolids were as follows (in order, treating the largest amount of solids to the least): centrifuge > belt filter press > drying beds > plate & frame press > vacuum filter > screw press. However, there were more TWTDS using belt filter presses than any other technology, with drying beds second most common.
- Most states (29) regulate biosolids under their state water and wastewater regulatory programs. Other states regulate biosolids under their solid waste programs, or under both water and solid waste programs.
- Most states regulate biosolids more stringently than do the federal U. S. EPA 40 CFR Part 503 regulations.
    - 37 states require more stringent management practices.
    - 16 have adopted more stringent pollutant (e.g. metals) limits.
    - 7 have been delegated by U. S. EPA for their biosolids programs.
    - 9 states had no formal regulations addressing biosolids management, and biosolids in those states were managed in accordance with the federal Part 503 regulations.
- The number of full-time equivalent employees (FTEs) declined significantly from 2000 to 2006, from an estimated 146 in 2000 to an estimated 103.7 in 2006.
- Maine, Vermont, Wisconsin, and Washington had the highest number of biosolids program FTEs per million people in their states, more than two (2).
- To the question “Is beneficial use of biosolids increasing in your state?” 19 said “yes” and 26 said “no.”
- The top pressures on biosolids recycling programs were public involvement (e.g. concerns of neighbors) > declining available farmland and competition with manures > nuisance issues (odors, etc.) > environmental concerns (e.g. soils and public health) > environmental concerns regarding nutrient management > regulations.

When released in 2007, these data provided a useful indication of the scope of biosolids recycling and disposal in the U. S., the kinds of technologies and processes in use, and the pressures and trends at play in the biosolids management profession, which varies from state to state and are reflected in state regulations. Since 2007, there have been evaluations of the biosolids management sector and considerable interest in further data, including numerous economic and environmental metrics (e.g. biogas and renewable energy potential, recovery of other resources, greenhouse gas emissions, etc.), but only one comprehensive national data set: Seiple et al., 2017 and subsequent work by the same authors.

The recommendation, discussed at the end of this review, is to complete a second nationwide biosolids survey, to create 2018 data consistent with the 2004 data, allowing for comparisons and identification of trends. Additional data and metrics on aspects of new interest will also be collected, setting a baseline for those metrics.

Following are discussions of all known, significant, relevant sets of biosolids data compiled since 2007, presented in chronological order.

Clean Watershed Needs Survey, 2012

The Clean Watershed Needs Survey (CWNS) is required of U. S. EPA every four years by the Clean Water Act. It "is an assessment of capital investment needed nationwide for publicly-owned wastewater collection and treatment facilities to meet the water quality goals of the Clean Water Act. These capital investment needs are reported periodically to Congress" (U. S. EPA CWNS, 2020). The latest comprehensive data available is from 2012. These data cover pretty much all of the publicly-owned treatment works (POTWs, loosely called WRRFs today) in the U. S. The CWNS data on the actual wastewater flow produced by WRRFs serves to independently confirm the quality of estimates of wastewater solids production at the local, state, and national level. From U. S. EPA work by Robert K. Bastian since the 1990s to NEBRA et al., 2007 national biosolids use and disposal survey to Seiple's and Fillmore's recent work, the CWNS data have provided critical baseline data on WRRFs and wastewater flows, though not always tabulated electronically and thus difficult to navigate.

Anaerobic Digestion and Biogas Production & Use, WEF reports, 2013 and 2015

Anaerobic digestion (AD) and biogas production and use have gained increasing interest since the 1990s as renewable energy and landfill fugitive methane avoidance have become major policy goals. The methane that makes up 50% or more of biogas produced in WRRF AD systems is almost entirely from non-fossil-fuel sources; therefore, it is a consistent and continuously-produced alternative green fuel of considerable value for generating electricity, heat, and transportation fuels. Federal and state government agencies have created incentives and the water quality profession has invested extensively in AD and biogas systems at WRRFs throughout North America. This high level of interest in the potential of AD and biogas utilization has driven most of the data collection on WRRFs over the past decade.

In 2011, the Water Environment Federation (WEF) commissioned Black and Veatch and the North East Biosolids and Residuals Association (NEBRA), in collaboration with *BioCycle*, the Mid-Atlantic Biosolids Association (MABA), and other biosolids groups, to complete a survey of U. S. WRRF AD systems. That survey, which began with a large existing data set contributed by InSinkErator, was published in the July 2013 WEF report *Biogas Production and Use at WRRFs in the United States.*

The initial WEF AD and biogas use survey identified 1,238 WRRFs that were producing biogas in 2012. Many of the WRRFs identified in this national survey are large; such facilities tend to utilize AD because the capital investment is most easily justified at larger scales. However, the WRRFs included in the WEF AD and biogas survey represent only an estimated 48% of the wastewater flow processed by WRRFs in the U. S. (WEF, 2013).

In 2015, WEF and the National Biosolids Partnership (NBP) published *Biogas Utilization: A Regional Snapshot in Understanding Factors that Affect Water Resource Recovery Facilities (a report highlighting WEF Phase II Biogas Data Collection Results).* This supplemented the prior report with additional data collected from WRRFs in U. S. EPA Region 4 and Texas. It provided more information on small- and medium-sized facilities utilizing AD and some economic, financial, environmental, and regulatory details. The original data set, with these updates, remains publicly available at https://www.resourcerecoverydata.org/ (biogasdata.org leads to the same webpages).

These two WEF biogas data collection efforts utilized some of the same data collection techniques as used in the *National Biosolids Regulation, Quality, End Use & Disposal Survey* (NEBRA, 2007), that is, basic WRRF and flow data from the Clean Watersheds Needs Survey were combined with outreach to regional and local experts familiar with existing WRRFs and their systems and direct data collection from individual WRRFs.

The American Biogas Council (ABC), which formed in 2010, continues to track and advance AD and biogas information related to WRRFs in the U. S. As of 2018, it identified 1,269 WRRFs using AD for biosolids treatment and estimates that another ~3,500 WRRFs are “ripe for development” of AD and biogas systems (American Biogas Council, 2018).

The California Association of Sanitation Agencies (CASA) has tabulated anaerobic digestion at POTWs in California, including power, heat, and transportation fuel potential (2015) which estimated that 94% of the wastewater flow in the state is treated in AD systems. The CA State Water Resources Control Board commissioned Carollo Engineers to better quantify the CASA estimate and to evaluate excess capacity for co-digestion of organic waste (2020). The report is scheduled to be released in Spring 2020.

The potential for AD and biogas utilization has driven further collection and modeling of U. S. wastewater and biosolids data by U. S. EPA (see EPA the Water Research Foundation (WRF) and the Pacific Northwest National Laboratories (Seiple et al., 2017 and Seiple and Fillmore, 2019, below)).

And, lastly, interest in AD coupled with state and U. S. EPA efforts to divert organic waste – especially source separated organics (SSO) / food waste – from landfills, spurred U. S. EPA Region 3 to conduct three years of surveying of WRRF AD systems accepting food waste for anaerobic digestion (see U. S. EPA reports, 2018 and 2019, below).

Baseline Data to Establish the Current Amount of Resource Recovery from WRRFs, WEF, 2018

The objectives of this WEF-funded study, completed by researchers at Carollo and University of Colorado, was to develop baseline data and start ongoing tracking of the recovery of resources – nutrients, energy, water (N.E.W.) – from WRRFs in the U. S. and Canada. Specifically, the study provides the following benefits to the industry:

1. "**Justify a standard level of resource recovery.** With quantitative metrics on resource recovery in North America, this database can help utility managers justify recovery goals and funding requests.
2. "**Benchmark resource recovery achievements among WRRFs.** The database allows WRRFs to compare their operation to the performance of other peer facilities and resource recovery industry leaders. This information can help set defensible quantitative facility objectives.
3. **"Track the progress of resource recovery objectives each year.** By documenting resource recovery metrics in the study's survey spreadsheet, WEF, policy makers, regulators, and WRRFs can track progress over time through regular updates."

Biosolids is one of the five major resources for which data are included in this baseline data report. The other resources for which specific data are compiled are:

- water reused;
- phosphorus (P) and nitrogen (N) applied to land as separated fertilizer, in biosolids, or in reuse water used for irrigation; and
- energy.

Data on biosolids are critical to the estimates for P, N, and energy recovery, which means that ongoing updates to the national biosolids data set are important for WEF to track trends in resource recovery.

The biosolids data in the WEF report are mostly the NEBRA et al. 2004 data (NEBRA et al., 2007), with more recent data from seven states integrated into this more recent compilation. The WEF report estimated that 51% of a total of 7.4 million dry U. S. tons (6.71 million metric dry tons) of biosolids produced in the U. S. are recovered. The report used the same assumptions as NEBRA et al., 2007, defining "recovered" as equivalent to the latter's "beneficial use." NEBRA et al., 2007, had estimated 55% recovery (beneficial use) of 7.18 million dry tons of biosolids produced in 2004.

Anaerobic Digestion Facilities Processing Food Waste, U. S. EPA reports, 2018 and 2019

U. S. EPA surveyed anaerobic digestion (AD) facilities around the U. S. that were willing to share data regarding their capacity to receive food waste and the amount of food waste actually processed. The surveys were conducted three years in a row, from 2017 – 2019, with many of the same facilities participating each year. The years of the data being reported were 2015, 2016, and 2017. Three kinds of AD facilities were included: stand-alone, farm, and municipal WRRF. The goal was to advance understanding of the capacity for diverting food waste to anaerobic digestion and produce renewable energy and reduce landfill disposal.

Specifically, the reports provide a (partial) picture of the current and potential management of food

waste via AD in the U. S., including:

- number and location of AD facilities processing food waste;
- total processing capacity at these AD facilities;
- growth of processing capacity over time;
- types of food and non-food wastes, and the sources of these wastes, that are accepted in AD facilities;
- how much food waste was processed;
- how much biogas was produced;
- end uses of AD products (biogas and digestate); and,
- additional information about AD facilities such as tipping fees, pre-processing/de-packaging, operational specifications, and gas cleaning systems.

There were 72 WRRF AD systems included in the 2015 and 2016 survey data. These facilities represent a fairly high percentage of the WRRFs processing food waste in the U. S. (Figure 1).[2] And it represents 6% of the WRRFs processing solids through AD in the U. S. (WEF, 2015).

Figure 1 – Operating WRRF Food Waste Co-Digestion Systems by State (U. S. EPA, 2018)

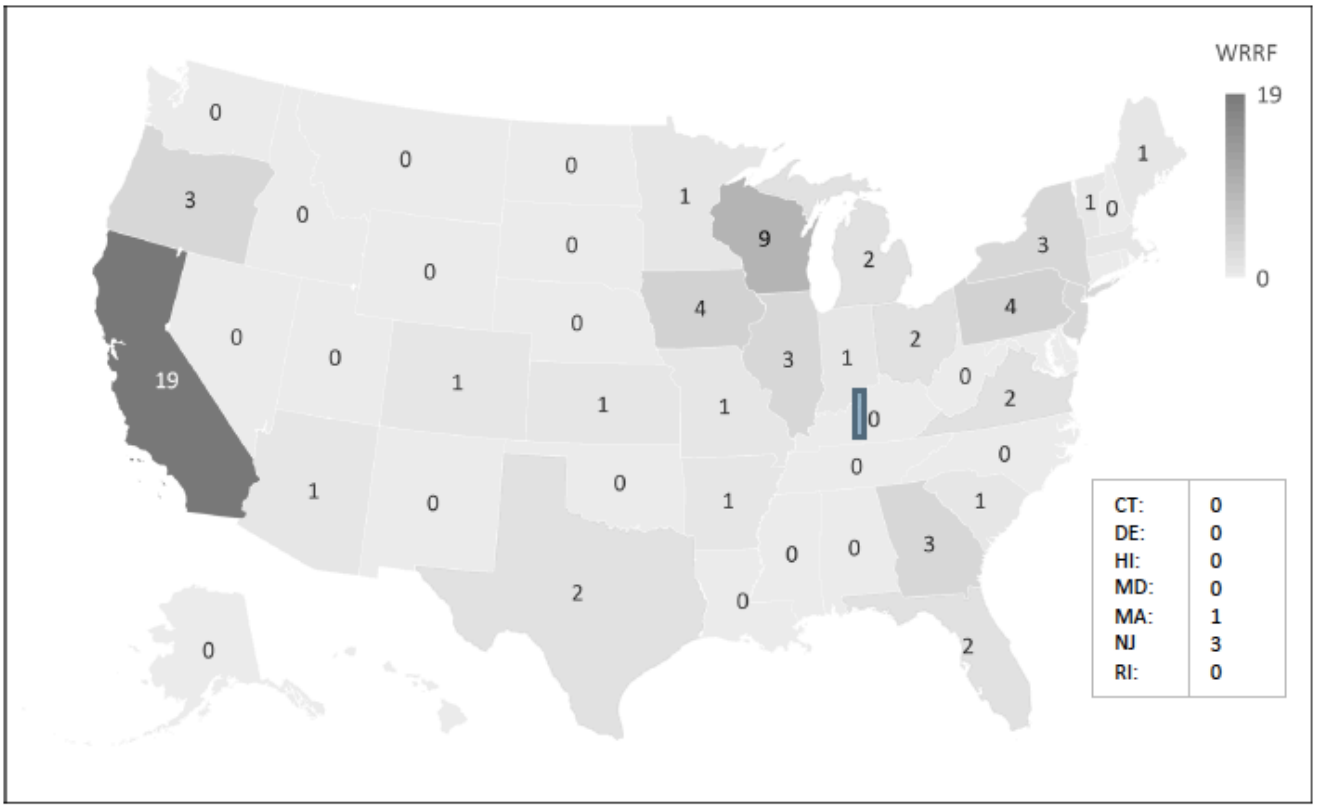

Figure 3: Operating WRRF Food Waste Co-Digestion Systems by State

[2] Biogas data work for WEF, 2015 found about 148 WRRFs with AD systems taking in outside waste, which is most commonly fats, oils, and grease (FOG), meaning that the total number taking in food waste is likely less than 100.

Modeling Wastewater Solids and Biosolids Generation, Seiple et al, 2017

The potential for production of energy from WRRF solids in the U. S. has also spurred initiatives by the U. S. Department of Energy (DOE) and other federal programs (e.g. DOE, 2015), sometimes in collaboration with national and state research organizations. For example, Timothy Seiple, PhD, and others at the Pacific Northwest National Laboratory (PNNL) have worked for several years, some in collaboration with Lauren Fillmore, PhD, of the Water Research Foundation (WRF), on modeling solids production and potential biogas and other options (e.g. bio-crude) for energy production at U.S. WRRFs. Seiple, Coleman, and Skaggs (2017) note that DOE is "working to accelerate the adoption of technologies that convert wet and gaseous renewable biomass into high-performance biofuels compatible with today's transportation infrastructure."

The Seiple et al. (2017) work was focused on advancing understanding of this potential for wastewater solids to provide renewable energy through emerging "waste-to-energy pathways" (e.g. biocrude production). The goal was to understand the masses of wastewater solids possibly available to envisioned regional biofuel production facilities. To quantify and locate all U. S. WRRFs, they relied on CWNS data from 2008 and 2012, along with more recent data from the Integrated Compliance Information System of the National Pollutant Discharge Elimination System (NPDES) program. This led to a database from which to calculate wastewater solids (sludge) production in the U. S., including Puerto Rico. As part of the database compilation, they completed the most thorough ever data quality validations of the WRRF data, using various independent data sources (e.g. WEF, 2013) – including validating many facility locations using aerial imaging. This resulted in a total of 15,014 WRRFs identified. The reported flows from these facilities (also checked for data quality) were used as the basis for modeling estimates of solids production (Table 3).

What is remarkable about the work by Seiple et al. (2017) is that it reached national estimate totals close to those reported in the national biosolids use and disposal survey of 2004 data (NEBRA et al., 2007). Although both studies based their WRRF and flow data on the same source, CWNS data, they reached their wastewater solids production and use and disposal numbers independently. NEBRA et al. (2007) compiled *reported* solids used or disposed, while Seiple et al. (2017) modeled solids production from flows, which advanced confidence in the estimates of biosolids end use and disposal.

Table 3. U. S. data, comparing 2004 (NEBRA et al., 2007) and 2016 (Seiple et. al. 2017)

	2004	**2016***
Number facilities for which solids use & disposal is estimated	16,583	15,014
Wastewater flow treated by these facilities, MGD	33,657	34,500
Total modeled solids (sludge) production from these facilities, million U. S. tons	N/A	13.84
Total biosolids use & disposed, million U. S. tons	7.18	N/A
Biosolids beneficially-used (land applied), million U. S. tons	3.93	3.95
Biosolids disposed**	3.25	6.97

*Seiple et al., 2017 developed their inventory "by synthesizing facility data catalogued in the EPA 2008 and 2012 CWNS and the EPA… Integrated Compliance Information System… (ICIS NDPES [sic.])."
**NEBRA et al., 2017 reported tons solids reported disposed; Seiple et al. estimated solids not treated by AD or land applied

Since 2017, Seiple and Fillmore have furthered their WRRF database, making additional data quality improvements and adding in liquid and solids process information for each facility. This allows more detailed estimates of solids generation and energy potential for each facility based on its specific treatment processes.

NACWA 2017 Financing and Management Survey

Every three years, the National Association of Clean Water Agencies (NACWA) surveys its members – mostly the largest WRRFs in the U. S. The most recent survey was completed for 2017. Some of the survey questionnaire includes biosolids production, use, and disposal information. The 126 WRRFs that provided data produced ~23% of the total biosolids used and disposed in the U. S (assuming a total of 7.4 million dry U. S. tons, as per WEF, 2018), of which ~29% were land applied, ~12% was composted, ~12 % was heat-dried, ~33% was landfilled, and ~19% was incinerated.

The 2017 NACWA biosolids production, use, and disposal data hint that the rate of beneficial use of biosolids in the U. S. since 2004 remains about the same, at about 53% (NACWA) versus 55% (NEBRA et al. 2007) (Table 4). However, the percentage of facilities surveyed is too small for reliable extrapolations.

Table 4. Biosolids use & disposal percentages from recent studies

	Beneficial use	**Disposal**
NEBRA et al. 2007	55%	45%
WEF, 2018	51%	49%
Seiple et al., 2017	50%	50%
NACWA, 2017	53%	51%

While the estimates of percentages of use and disposal of biosolids presented in Table 4 have some shared sources (e.g. WEF 2018 data relies heavily on NEBRA et al., 2007 data), there is some independence that provides confidence that these percentages, clustered in narrow ranges, are accurate. In addition, these data represent the efforts of four independent teams of experts, providing further confidence in the data.

U. S. EPA Electronic Biosolids Annual Reports, U. S. EPA, 2016, 2017, and 2018

Beginning in 2017, certain biosolids generators and programs have been required to electronically submit their biosolids reports required by 40 CFR Part 503, beginning with 2016 data submitted by February 19, 2017, and continuing annually. This new electronic biosolids reporting provides data for biosolids use and disposal in the U. S. for 2016, 2017, and 2018. Participation in the new program has been increasing year over year. EPA reports that for 2018, it received 2,290 electronic submissions

and only 52 paper submissions, making 2018 the first year for which the electronically compiled data in the Enforcement and Compliance History Online (ECHO) database is potentially useful for understanding biosolids use and disposal in most states and nationwide.

The NPDES entities – about 2,500 – that are required to submit their annual Part 503 biosolids reports electronically are:

- Class 1 sludge management facilities, and/or
- POTWs (as defined in 40 CFR 501.2) with a design flow rate equal to or greater than 1 MGD, and/or
- POTWs that serve 10,000 people or more, and
- Are in one of the 42 states *not* delegated by EPA for the administration of biosolids (the delegated states are AZ, MI, OH, OK, SD, TX, UT, WI) or are operated by tribes or are in territories.

The data collected by the EPA electronic reporting system are focused on ensuring compliance with Part 503 and are limited in scope. Eventually, when there is participation of all or nearly all biosolids programs that should be reporting, these EPA ECHO biosolids data will be useful for understanding state and national biosolids use and disposal year by year.

The data included and available in the EPA ECHO database are:

- Total sewage sludge produced at the POTW (dry metric tons)
- Treatment processes (pathogen reduction, vector attraction reduction (VAR), etc.
- Analytical methods
- Analytical results for regulated elements (metals), fecal coliform and/or Salmonella, and total nitrogen
- Biosolids/sewage sludge management practices: land application, surface disposal, incineration (with subcategories such as reclamation site application, bagged product, etc.) and masses (dry metric tons) directed to each management practice

The EPA ECHO biosolids data are limited in their usefulness for developing a national picture of U. S. biosolids use and disposal. Specifically:

- While it is supposed to include all of the POTWs / treatment facilities with flows greater than 1 MGD, the managers of the ECHO biosolids database and reporting system mention only about 2,500 such facilities. The 2012 Clean Watershed Needs Survey data set shows 3,211 facilities greater than 1 MGD, and a more recent compilation puts the number at about 3,600 (including territories, however). Based on EPA data and the 2008 CWNS, NEBRA et. al, 2007 estimated 3,322 facilities with flows greater than 1 MGD.
- Data quality is dependent on consistent understanding of the online data entry forms and the meaning of all terms used on the part of the ~2500 data submitters. This is still a work in progress.
- As of now, there are significant WRRF data missing in at least several states, eliminating the ability to rely on this source of data for compiling complete state numbers.

The EPA ECHO biosolids data sets for 2016, 2017, and 2018 are useful, however, for data quality control in any effort to compile national data. They allow for:

- independent checks on state biosolids production totals
- data on biosolids quality (metals) that should provide a reasonable national picture of quality; and
- 3 years of biosolids production numbers that address concerns about the variability from year to year and, thus, whether or not a one-year snapshot approach to data compilation is representative.

Figure 2 displays ECHO biosolids data for 2016 and 2017.

Figure 2. Comparison of 2016 and 2017 Biosolids End Uses in the U. S., from ECHO database

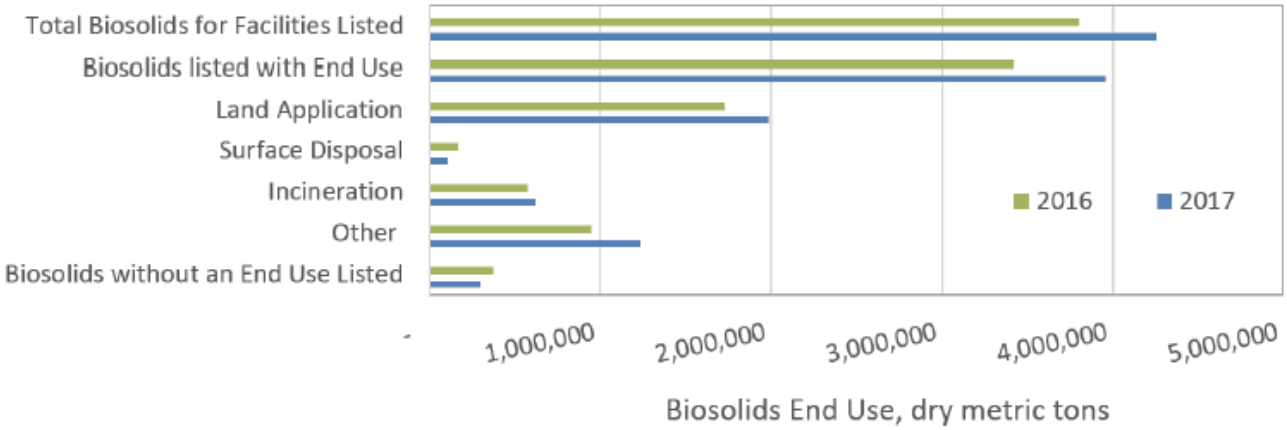

Figure 15 Comparison of 2016 and 2017 Biosolids End Uses in the U.S. (ECHO database, 2018)

Source: https://www.wef.org/globalassets/assets-wef/direct-download-library/public/03---resources/WSEC-2018-TR-003 Page 44 of PDF, Section 3.4 Biosolids Resources Recovery Trends

Biosolids Regulation Survey and Database, Sustainable Phosphorus Institute, 2018

As discussed above, a major impetus of recent biosolids data compilations has been the interest in renewable energy potential from biosolids. Another strong impetus for biosolids data has been the potential for recovery and use of phosphorus (P), an essential element that is considered limited (e.g. from mined sources) and the management of which has enormous environmental implications (e.g. excess P causing surface water eutrophication). Academic researchers and regulators seek biosolids data to understand the potential impacts of biosolids-P in the environment, and technology inventors and vendors require biosolids data to understand the potential markets for removal of P from wastewater and biosolids.

The Sustainable Phosphorus Alliance (SPA, https://phosphorusalliance.org/) is the North American organization focused on phosphorus, similar to the European Sustainable Phosphorus Platform (www.phosphorusplatform.eu). In 2018, SPA completed a *Compendium of Biosolids Land Application Regulations.* A parallel compendium of manure regulations was done at the same time. The report states:

> "Title 40, Part 503 of the US Code of Federal Regulations establishes a set of minimum regulations that govern all land application of biosolids in the United States. These regulations constrain not just what is applied to land, but how it is applied. In doing so, they help protect our waters from nutrient pollution while setting the ground rules that enable nutrient recycling. States are free to augment these regulations with their own, and they do. In fact, states don't agree even on the definition of biosolids or classes of biosolids. The result is a patchwork of regulations that can be difficult to navigate. This compendium provides a state-by-state overview of these state-level regulations as they apply to the land application of biosolids. It is meant to provide regulators, biosolids producers, purveyors of biosolids products, researchers, and others with a handy guide." (Sustainable Phosphorus Alliance, 2018)

The *Compendium* focuses on regulations covering how nutrients – P in particular – are managed, so they include agricultural regulations as well as biosolids-specific regulations. It deliberately does not address administrative details, such as monitoring and reporting requirements. For each state, details are provided regarding:

1. Regulations and regulators;
2. Key definitions (e.g. related to classes of biosolids and agronomic rates); and
3. Specific regulations and requirements that extend beyond the federal Part 503 requirements.

Within the context of this current national biosolids data review, the SPA *Compendium* provides a comprehensive and useful update to those portions of the original national biosolids regulation, quality, end use, and disposal survey (NEBRA et al., 2007) that addressed state regulations.

SPA is currently working to provide localized data on manure production – tons of manure produced at local combined animal feeding operations (CAFOs). They would like to have similar local data on biosolids production, with the aim of understanding the total amounts of P in organic residuals being managed in any particular locale or watershed. SPA notes that there is far more manure generated than biosolids, and it would be helpful at the local level to have comparable numbers.

Biosolids Market Analyses, such as Greenwich Strategy, 2019

Another group of stakeholders seeking and compiling data on biosolids production and management is made up of business and market analysts, venture capital stakeholders, investors, consulting firms, and technologists. For example, in 2019, Greenwich Strategy interviewed NEBRA extensively regarding the U. S. biosolids marketplace – and this was only one of a dozen such interviews NEBRA has participated in over the past few years. Generally, the reports from these analyses are proprietary. However, they indicate a high level of interest in the sector. And while some are useless, thin assessments, others show considerable depth of knowledge and provide important insights into the biosolids management profession.

State Biosolids Management Data & Reports, 2010 – present

Some state regulatory agencies compile biosolids data annually or every few years. The following states are known to have comprehensive data on biosolids quantities, quality, end use, and disposal. In some cases, additional data, including on treatment processes, are also compiled. These states will be helpful in piloting a second national biosolids regulation, quality, end use, and disposal survey, as recommended below. Data will be collected from these states efficiently.

- **California, 2019 data**
  CASA has available an Anaerobic Digestion and Biogas Production & Use spreadsheet, which is based on 2015 data. They also have biosolids production and end use data from 2009 – 2019 (from USEPA Region 9). Other updated data include: the Bay Area Clean Water Agencies' "2016 Biosolids Trends Survey Report"; the Southern California Association of POTWs' (SCAP) 2018 survey, "Biosolids Biennial Trend Survey 2016-2018"; and the previously mentioned co-digestion capacity survey of California WRRFs.

- **New York, 2015 data**
  "Biosolids Management in New York State" was published in March 2018 and reports data from 2015. Its findings are consistent with – and presented in a similar way to – the NEBRA et al. national biosolids report of 2007. It reports a total of 377,663 dry tons of New York biosolids used or disposed in 2015, up from 353,300 reported for 2004 by NEBRA et al., 2007. Over the same time period, there was a dramatic shift from beneficial use to landfill disposal, in large part because the reduction in beneficial use of New York City's biosolids, from 48% in 2004 to 16% in 2015.

- **Massachusetts, 2018 data**
  NEBRA completed a thorough survey of almost all WRRFs in Massachusetts, receiving data from 85 WRRFs representing 96% of the state's annual flow (NEBRA, 2019).

Additional states with recent quality data include Florida, Maine, New Hampshire, and Washington.

RECOMMENDATIONS

As noted in the introduction of this Literature Review, this report includes recommendations — based on the literature surveyed — regarding biosolids data collection methods; and the need for a 2nd National Biosolids Regulation, Quality, End Use & Disposal Survey (2018 data).

Biosolids Data Collection Methods

The 2007 *National Biosolids Regulation, Quality, End Use & Disposal Survey* collected data following techniques developed by *BioCycle* in its surveys of recycling and biosolids management trends published in the 1990s. The key techniques that ensure the most efficient compilation of high quality data are as follows:

1. Rely on the people in each state or region who are most knowledgeable about local biosolids management. In most states, this includes the biosolids coordinator(s) in the state regulatory

agency, as well as a few key consultants and/or biosolids management professionals and, in a few instances, a biosolids regional group and/or EPA regional staff person.

2. Review existing data and reports in order to understand the challenges that are encountered in compiling consistent, comparable data. For example, different WRRFs and states use different units for measuring the amount of biosolids produced, and unit conversions must be addressed.
3. Rely on a small trained team of biosolids experts to conduct the survey in each state using one consistent survey document. This ensures consistent interpretations of survey questions and responses.
4. Compile data, manipulating it as needed to create consistency amongst all states, complete internal quality checks, and then *reflect the data back to the state expert(s)*, for their review and acceptance.
5. Conduct:
    a. online survey(s) of WRRFs to obtain independent data that helps quality check and validate the state and national data sets; and
    b. model estimates of solids production using existing wastewater flow data.

Other approaches to collecting state, regional, and national data on biosolids management have been relied on before and after the 2007 report, including, most extensively, modeling of solids production using wastewater flow data. U. S. EPA estimates of solids production in the 1990s relied on this technique, and the work of Seiple and Fillmore have advanced this considerably (see below). In contrast, the Mid-Atlantic Biosolids Association (MABA) and the California Association of Sanitation Agencies (CASA) have relied on collecting solids production and use data directly from the WRRFs in their regions. And a fair number of states obtain such data from their WRRFs.

All of these data collection techniques are time consuming. For 20+ years, there has been discussion about some easier way. For example, an Internet-based data system has been suggested as a solution. But that is a difficult system to create. As part of its new electronic reporting regulation for the NPDES program, U. S. EPA began to require WRRFs to enter biosolids production and management data electronically beginning with data from 2016. All larger WRRFs must electronically file – by February 19th each year – the annual biosolids reports required by 40 CRF Part 503. As discussed below, this system has the potential to provide annual data that track biosolids production, use, and disposal. However, as of 2020, the data from the first three years of electronic reporting remain incomplete and of somewhat uncertain quality. And their focus on compliance with the Part 503 regulations means the ECHO data lack key data important to biosolids management professionals.

Need For 2nd National Biosolids Regulation, Quality, End Use & Disposal Survey (using 2018 data)

Useful data paint a picture of an activity. Biosolids management is an activity and a profession, and well-devised data provides understanding of not only masses and disposition of products, but also indicators of activity on the part of regulators, technology providers, and other stakeholders.

In the modern economy, every major commercial activity is tracked and evaluated with data collected routinely and repeatedly, so that the state of the profession and the market and their impacts are

visible at particular moments and in trends. Biosolids are products, and their management is a tens-of-millions-of-dollars activity in the U. S. But data are scant. And it is not because of lack of interest in the biosolids management sector: over the past decade, scores of venture capital and investment evaluations have been conducted to assess the value of the biosolids management marketplace, with its technologies, consultants, management, and public contracts. The kinds of data being sought are those found in the National Biosolids Regulation, Quality, End Use & Disposal Survey (NEBRA, 2007). But people also want far more data, including data on economics, jobs, environmental impacts (e.g. nutrients, greenhouse gas emissions), and energy recovery. Those continually seeking data on biosolids management include:

- Regulatory agencies
- Legislators / policy makers
- WRRF owners, managers, and operators
- Engineering firms and consultants
- Academic researchers (e.g. Lu et al. 2012)
- Technology inventors and vendors
- Venture capitalists, investors
- Business and market analysts
- News media
- Other stakeholders and the general public.

Despite effective organizations at the national level involved in biosolids (e.g. WEF, NACWA) and active regional biosolids groups (CASA, MABA, NEBRA, NW Biosolids, SEBA), the biosolids profession has scant data to offer these stakeholders. It's hard to guide an activity and a profession without data.

The 2nd National Survey will address not only the need for data, but also attempts to advance understanding of the usefulness of particular metrics for particular purposes and stakeholders. Therefore, we recommend a repeat of the National Biosolids Regulation, Quality, End Use & Disposal Survey — *and* recommend adding additional data fields to meet the demands for data from the expanding universe of stakeholders. For example, there is an obvious high level of interest in anaerobic digestion (AD), biogas, and renewable energy production, as reflected in the majority of the biosolids data reports discussed earlier. Adding carefully chosen data fields to the next national biosolids survey will help satiate this growing appetite for AD and biogas data. Similarly, biosolids groups receive an increasing number of requests for cost and economic data, so adding data fields on those becomes critical.

Through the current literature review and planning process, suggestions for potential additional data fields have been collected from reports and an Advisory Group of leading biosolids management experts with diverse roles and perspectives. Their input has been distilled and will be incorporated into the final steps to complete Task 6.

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