GEORGIA ENVIRONMENTAL FINANCE AUTHORITY

Biosolids Assessment and Prepared Study

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Acknowledgements

This Biosolids Assessment and Prepared Study reflects the contributions of the project team and stakeholder group. The stakeholder group volunteered their time, expertise, and talents before, during, and after numerous stakeholder meetings and conference calls during the preparation and review of this Biosolids Assessment and Prepared Study. GEFA and Project Manager, Amanda Carroll, gratefully acknowledges Jennifer Welte, Audra Dickson, Keith Stevens, William Cook, James Capp, and others of the Georgia Environmental Protection Division for their efforts to support the Black & Veatch project team. Amanda Carroll would also like to thank Danny Johnson with the Metro North Georgia Water Planning District, Mike Thomas with the Georgia Association of Water Professionals, and Rich Schoeck with Gwinnett County Department of Water Resources for their guidance and dedication throughout the entirety of this process.

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1.0 Executive Summary

Historically in Georgia, a large proportion of solids produced at publicly owned treatment works in the state has been disposed of in landfills. This proportion has grown over the last several decades as other disposal options, like incineration, became more expensive in comparison due to increased understanding of their environmental impact and subsequent regulatory changes. In recent years, landfill disposal of solids in Georgia has become much more challenging as the impact of high moisture content solids on landfill operations has become better understood. The potential for landfill disposal of high moisture content solids to precipitate slope failures and exacerbate other operational issues has led the industry to significantly increase tipping fees or restrict the acceptance of this material. Several slope failures have occurred in Georgia, including one at a major landfill in the metro Atlanta region in 2018. In response, the Board of Natural Resources has adopted regulations (via changes to Georgia's Solid Waste Management Rule 391-3-4) that require any landfill accepting more than 5 percent high moisture content waste (HMCW) to have a HMCW management plan in place to document mitigation measures for receiving this material. HMCW is classified as anything with a moisture content of greater than 40 percent by weight (i.e., less than 60 percent dry solids). Typical solids dewatering installations generate a product with a dry solids content between 15 percent and 25 percent, which is classified as HMCW.

While facing challenges with respect to landfill disposal, there are also significant potential opportunities to make use of biosolids as a resource. Biosolids contain valuable nutrients and organics, presenting potential opportunities for beneficial use as fertilizers, soil amendments, or for energy recovery.

Acknowledging the solids challenges faced by Georgia wastewater utilities, the Georgia Environmental Finance Authority (GEFA) commissioned Black & Veatch to perform a study to evaluate the challenges and opportunities related to biosolids management in the state and provide recommendations regarding strategies and funding for biosolids management going forward. A summary of the study scope and objectives is provided in Table 1-1.

Table 1-1 Summary of Biosolids Study Scope and Objectives

Task	Report Section	Objectives
Develop biosolids production estimates	Section 3.0	Review historical wastewater plant flows and future flow projections as well as solids production data from a previous survey conducted by the Georgia Association of Water Professionals (GAWP) to develop current and future solids projections across the state of Georgia.
Regulatory and emerging issues review	Section 4.0	Review and summarize existing state and national biosolids regulations and conduct a nationwide review of emerging issues and trends that could impact Georgia biosolids management.
Current management practice and regionalization opportunities survey	Sections 5.0 and 6.0	Conduct a survey to solicit input from wastewater utilities regarding current biosolids treatment and end use approach, processing costs, interest in regionalization, and for feedback on funding for biosolids projects. Review and analyze results.

Task	Report Section	Objectives
End use and market evaluation	Section 7.0	Conduct a review of potential market opportunities across the state for biosolids products, including in agriculture, silviculture, parks and recreation, sod farming, and golf courses. Identify market preferences and estimate market potential.
Technology review	Section 8.0	Prepare a technology review that summarizes available technologies for biosolids processing, including established and newer technologies. Prepare matrices summarizing technology status, product characteristics, and appropriateness for different facility sizes, complexity, and relative costs.
Technology cost evaluation	Section 9.0	Prepare concept screening capital, operating, and life cycle costs for two technology alternatives for biosolids treatment at large and small facility sizes.
Evaluate landfill and municipal solid waste (MSW) opportunities	Section 10.0	Estimate and summarize landfill capacity to accept sewage sludge and biosolids in Georgia based on data from Georgia EPD. Document potential MSW co-processing opportunities including co-digestion, combined composting and combined thermal conversion of blended biosolids/MSW feedstocks.
Develop regional biosolids management strategies	Section 11.0	Summarize opportunities and challenges related to regional biosolids management. Prepare a roadmap to document a potential pathway to develop a regional processing facility.
Develop recommendations	Section 12.0	Prepare a “gap analysis” to document the gap between current practices and future needs for biosolids management. Develop technology fact sheets for eight technologies to provide a convenient reference for utilities. Develop recommendations to document existing financial programs available through GEFA and to provide recommendations on how improvements can be made to better support biosolids projects.

Solids Production Estimates and Projections

Solids production estimates were developed on a regional basis for each Regional Commission in the state of Georgia. Solids production was estimated using a combination of data, including population projections, wastewater flow projections, information from a previous GAWP biosolids survey in 2018, and biosolids data reported to the United States Environmental Protection Agency (USEPA) in 2019. The geographical arrangement of the Regional Commissions is shown on Figure 1-1. Figure 1-2 shows the estimated current solids production for each Regional Commission for 2019 and the projected future production for 2060. As can be seen on Figure 1-2, most Regional Commissions are projected to see an increase in solids production from 2019 to 2060 as a result of population growth.

Figure 1-1 Georgia Regional Commissions

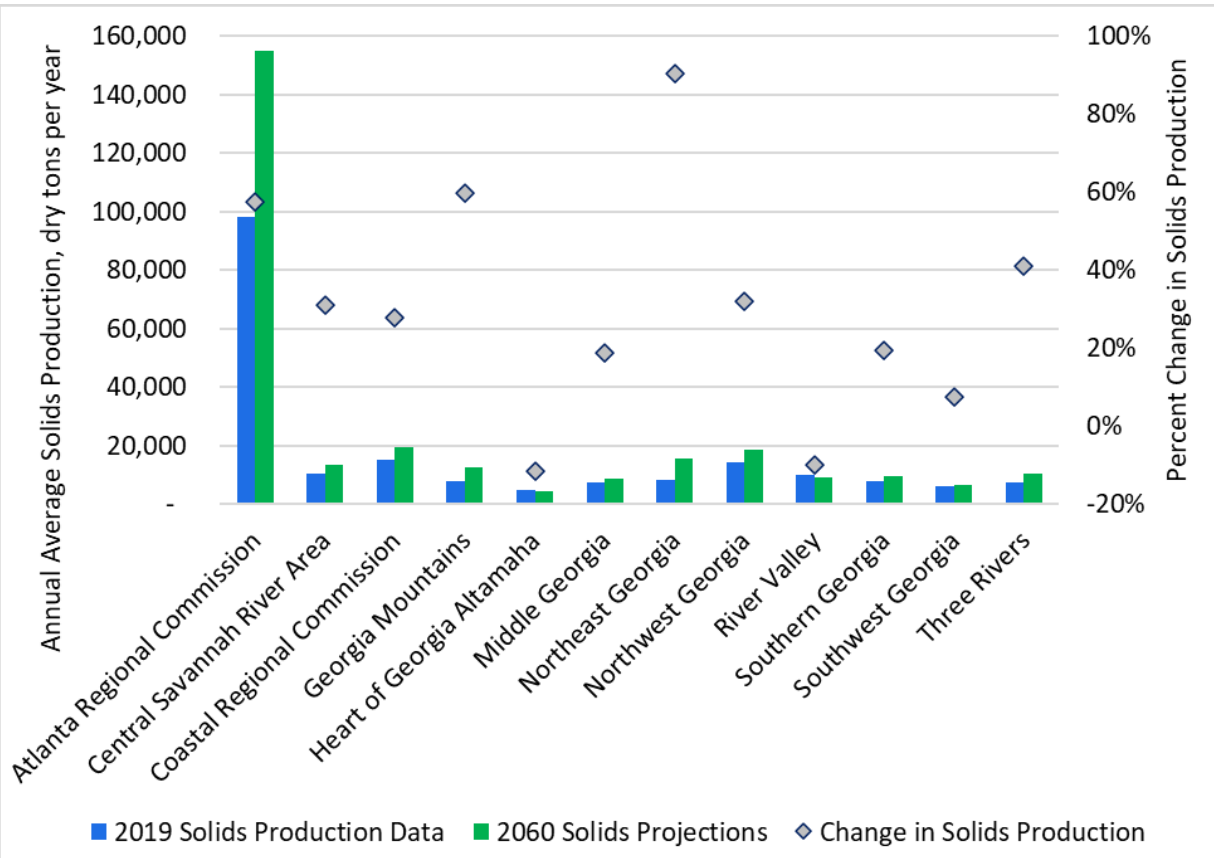


Figure 1-2 Solids Quantities in 2019 and 2060 by Regional Commission

Regulatory and Policy Frameworks

Regulatory and permitting frameworks can define the shape and trajectory of sewage sludge and biosolids management, and a clear understanding of their impacts is critical to develop and maintain resilient and sustainable solids management programs. This is especially true in Georgia, where pressures on landfilling are driving a move to alternative management practices.

A review of current regulations, upcoming changes, and regulatory trends (both in Georgia and nationwide) was undertaken as part of this study. Utilities should be aware of the following key issues:

Landfilling of sewage sludge and biosolids is regulated at a national and state level; historical requirements have generally been limited to passing toxicity and free moisture content requirements, which have been relatively easy for utilities to achieve.

The recent challenges with slope failures at several landfills has led Georgia EPD to implement additional requirements for landfills accepting more than 5 percent HMCW. To mitigate drainage issues that can lead to slope failure, an HMCW management plan will be required of any landfill where more than 5 percent of the total accepted waste is composed of HMCW.

Land application of biosolids is regulated at the federal and state level. Some states adopt the federal rules only, while other states include additional requirements beyond the federal rules. Biosolids are classified according to the level of pathogen reduction achieved as either Class B or Class A. Class A biosolids are treated to achieve a lower pathogen content and generally face fewer restrictions on use and application. Both classifications require demonstration of vector attraction reduction (VAR) to ensure that biosolids do not attract disease spreading pests. Class A biosolids that also meet certain metals limits are classified as Exceptional Quality. Exceptional Quality biosolids can be marketed as a soil amendment or fertilizer in Georgia based on product certification through the Georgia Department of Agriculture (GDA).

Recently, a November 2018 audit by the EPA Office of the Inspector General (OIG) raised concerns about EPA's obligations to review and update, as needed the federal biosolids rules and biosolids management program implementation, emphasizing the lack of information on unregulated contaminants. The EPA Office of Water raised concerns regarding the OIG findings, as did the National Institute of Food and Agriculture Research Committee. The audit's call to perform updated risk assessments for biosolids was viewed as a positive step to assuage public concerns and those assessments are now underway at EPA.

Regulatory trends in land application are driven by uncertainties regarding biosolids safety (especially with regard to per- and polyfluoroalkyl substances, or PFAS), odors at land application sites, and, in some areas, soil phosphorus and nitrogen and runoff concerns. While not yet a major focus, microplastics in biosolids are beginning to see increasing research and might have an impact on biosolids use in the future.

Incineration of biosolids in Sewage Sludge Incinerators (SSIs) is regulated at both the federal and state level by regulations that focus on air emissions and ash disposal requirements. In 2011 a change in the definition of solid waste meant that SSIs combusting wastewater sludges became subject to the Clean Air Act. The change required the development of Maximum Achievable Control Threshold (MACT) standards for SSIs and resulted in stringent emissions requirements for SSIs that have led to increasing costs in the operation of SSI facilities. As a result, operation of SSIs in Georgia (and elsewhere) has been in decline.

Current Management Practices

A biosolids management practice survey was issued to all Georgia municipal wastewater treatment permittees with the aim of capturing the following information:

- Current biosolids treatment and end use approach.
- Processing and disposal costs.
- Interest in regionalization opportunities.
- Alternative approaches that may be supported through GEFA's financial incentives.

Regarding biosolids treatment, survey responses showed that by far the most common stabilization technology employed at utilities in Georgia is aerobic digestion, which is a common approach for small to medium sized facilities. A smaller number of larger facilities utilize anaerobic digestion. Belt filter press dewatering was the most commonly used dewatering technology, followed by centrifuge dewatering, and then screw presses.

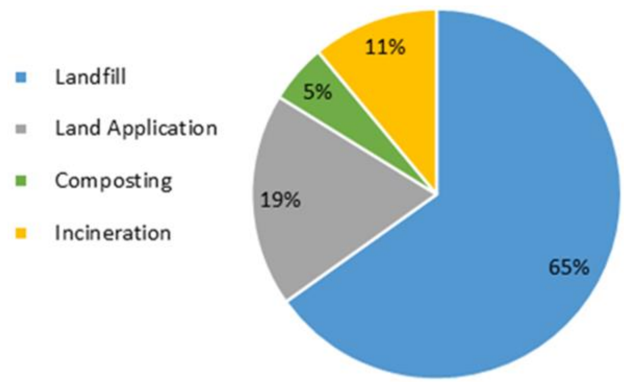


Figure 1-3 End Use Reported in State 2020 Survey (2019 data)

Feedback regarding end use approaches indicated that landfill disposal is still the dominant biosolids end use practice in the state. As show on Figure 1-3, 65 percent of biosolids produced by survey respondents was being sent to landfill in 2019. This is in contrast to national data which show that across the United States, around 22 percent of biosolids is landfilled (with the dominant practice being land application).

Responses relating to biosolids end use cost indicated that utilities continue to face rising end use costs. Figure 1-4 shows the range of third-party collection fees reported for 2018, 2019, and 2020, and clearly shows that costs have continued to rise over this period. This is unsurprising given the landfill stability challenges identified during this time..

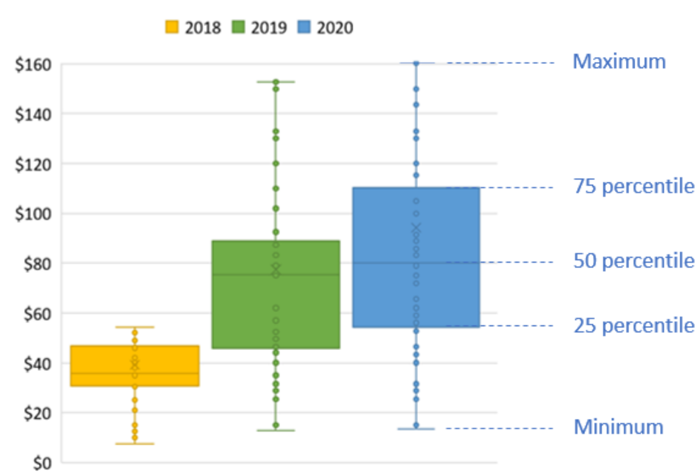


Figure 1-4 Reported Third-Party Collection Fees (Legend Shown for 2020 Data)

As shown on Figure 1-5, responses varied widely in terms of utilities' level of interest in a regionalized approach with responses ranging from utilities showing a strong interest to utilities indicating no interest whatsoever. As is discussed further below, some of this variation is likely to be related to geographical location and the proximity to other utilities that could potentially collaborate on a regionalized approach.

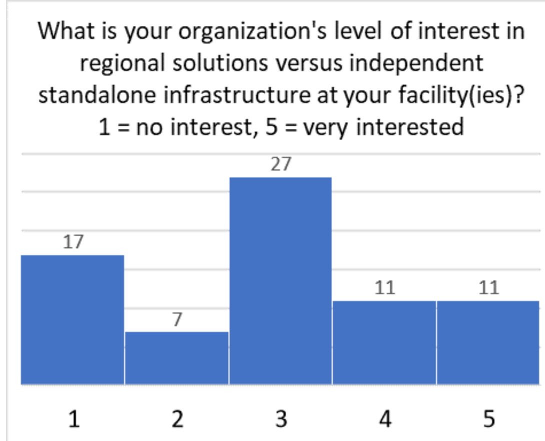


Figure 1-5 Interest in Regionalization

Utilities were also asked to rate their level of interest in different biosolids treatment technologies from a score of 1 (no interest) to a score of 5 (very interested) and the resulting feedback is summarized on Figure 1-6. There was a relatively strong level of interest in thermal drying and composting compared to other technologies, indicating a general preference for a higher quality product and/or greater volume reduction to improve end product marketability.

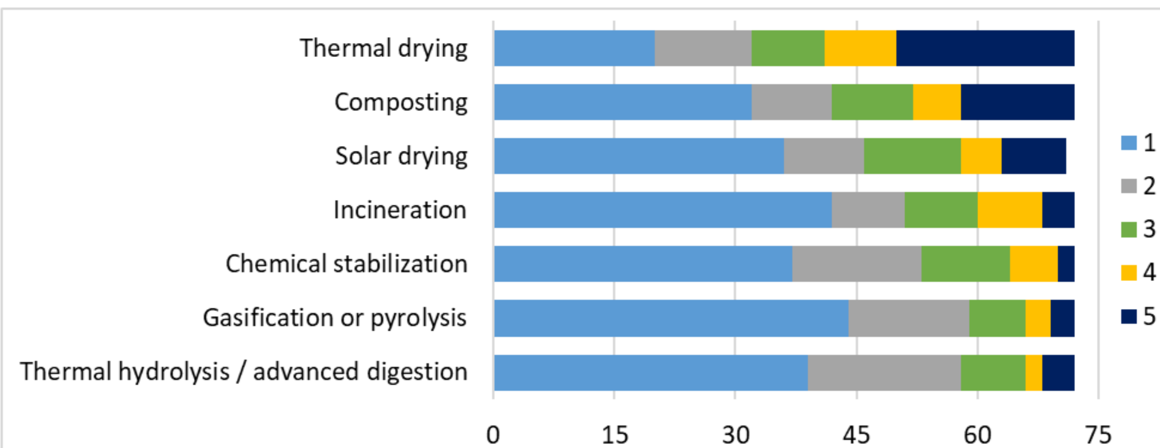


Figure 1-6 Utility Interest in Implementing Solids Treatment Processes

Utility managers identified a significant level of concern with the cost and availability of continued landfilling of biosolids. Utilities showed a varied level of interest in regionalized solutions and perceived obstacles to regionalization were also varied. For some utilities, lack of interest from or distance to other utilities was a barrier, whereas for others, concerns were more related to contractual issues. In general, there was a stronger interest in regionalization from utilities in urban areas where there is a greater proximity to other utilities. Overall cost was identified as the most highly ranked driver ahead of resiliency and sustainability issues.

In general, the survey showed that alternative (Class A) treatment approaches and (in some areas) regionalized solutions are of interest to utilities moving forward and that current GEFA and SRF funding opportunities are financially attractive to utilities, with many utilities having taken advantage of these funding avenues in the past.

End Use and Market Assessment

Whether transitioning from landfilling to beneficial use, or from one biosolids product to another, understanding biosolids market opportunities (and constraints) is critical. The size and location of biosolids markets, as well as user preferences within those markets, must be considered to ensure that reliable outlets are available for biosolids products. Toward this end, a biosolids market assessment was performed for this study.

The biosolids market assessment followed a structured approach that started with defining biosolids products that could be available, their characteristics, and potential uses. The next steps involved identifying target markets and then interviewing market "gatekeepers" (knowledgeable, involved, and influential market leaders) to determine market needs and preferences. A demand estimate was then produced for each market investigated to identify the potential demand for biosolids products. The final step was to estimate the market potential and the market penetration needed to provide an outlet for biosolids produced in the state. Figure 1-7 provides an overview of the process.

Figure 1-7 End Use and Market Assessment Approach

Markets investigated include agriculture, silviculture, sod farms, golf courses, parks and recreation, Georgia Department of Transportation, and general urban use (e.g., the sale of biosolids compost or dried product to the public through garden stores). Despite being common in other states, the Department of Transportation in Georgia is not a well-developed market for biosolids and is not expected to become so in the near future. Biosolids product preferences for the other markets, based on feedback from the market gatekeepers who were interviewed, is summarized in Figure 1-8.

General feedback was that high quality dried biosolids pellets are a preferred product for all markets, whereas dried biosolids from extrusion-type belt driers are less preferred because of concerns with spreadability, dust, and product density (note that there are many different types of belt dryers and that some produce a more uniform product than others). Biosolids compost was found to be an attractive product for agriculture, silviculture, sod farms, and for parks and recreation and urban uses; however, use on golf courses is more limited. Lime stabilized biosolids are a desirable product for agriculture and for sod farms, in part because of the additional alkalinity that the product provides. Digested biosolids that are dewatered to produce a cake of 15 percent to 30 percent total solids are generally only desirable for agricultural outlets.

Potential Target Market	Digested Biosolids Cake	Dried Biosolid Pellets	Dried Biosolids (Extruded)	Biosolids Compost	Lime Stabilized Biosolids
Agriculture	Preferred product	Preferred product	Product concerns or limited application opportunities	Preferred product	Preferred product
Silviculture	Product concerns or limited application opportunities	Preferred product	Product concerns or limited application opportunities	Preferred product	
Sod Farms		Preferred product	Product concerns or limited application opportunities	Preferred product	Preferred product
Golf Courses		Preferred product	Product concerns or limited application opportunities	Product concerns or limited application opportunities	Product concerns or limited application opportunities
Parks and Recreation		Preferred product	Product concerns or limited application opportunities	Preferred product	
General Urban Use		Preferred product	Product concerns or limited application opportunities	Preferred product	

Preferred product   Product concerns or limited application opportunities

Figure 1-8 Biosolids Product Preferences

Demand estimates for all of the markets other than general urban use were prepared based on the estimated acreage and typical biosolids application rate for each market. Results for the entire State of Georgia are presented on Figure 1-9. Agriculture was by far the largest potential market, followed by silviculture. Parks and recreation was found to be a significant market in urban areas but with limited potential in more rural areas. In general, the market potential was found to be extensive in relation to current solids production, with a minimal overall market penetration of only 2 percent required to provide an outlet for all of Georgia's biosolids. Beneficial use of biosolids in the state therefore presents an attractive opportunity to overcome the landfill challenges being experienced and to provide a more sustainable outlet for biosolids.

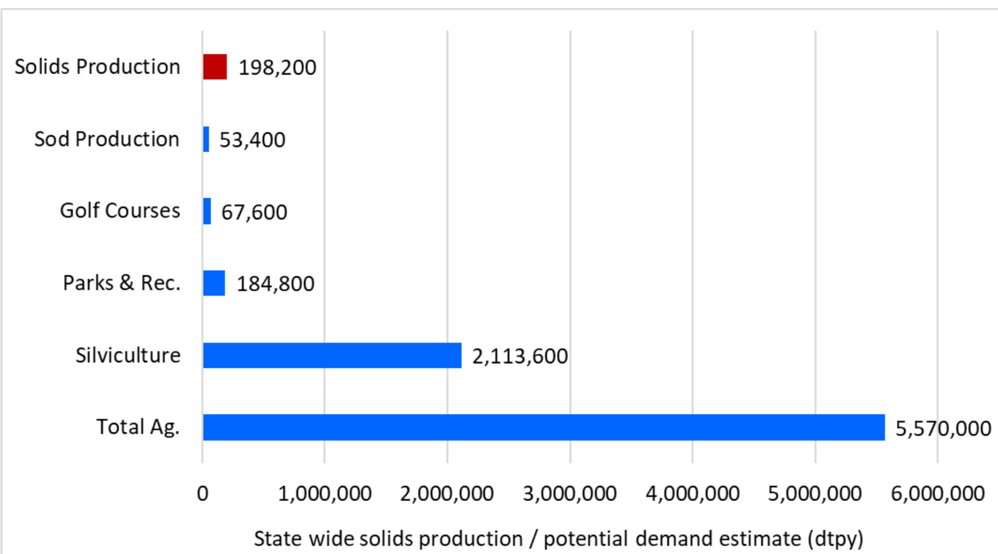


Figure 1-9 Current Solids Production Compared to Potential Demand Estimates for Biosolids Markets

Technology Review

A technology review was conducted to provide a reference for utilities when considering the implementation of the new biosolids handling processes. The technology review was grouped into three categories as shown on Figure 1-10.

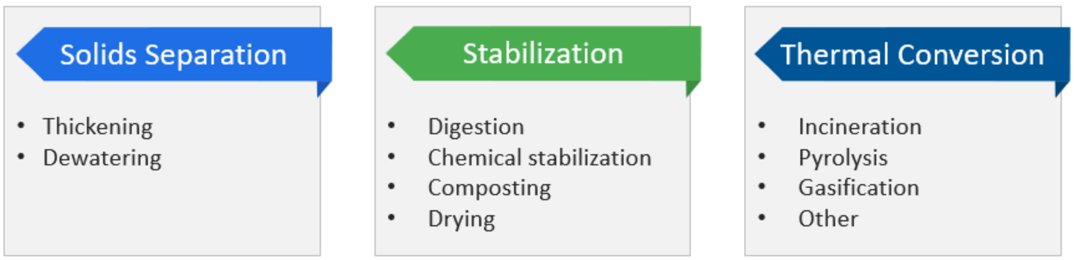


Figure 1-10 Technologies Reviewed

Thickening

Thickening technologies reviewed included gravity thickeners, gravity belt thickeners, rotary drum thickeners (RDTs), centrifuge thickeners, and dissolved air flotation thickeners. Figure 1-11 provides a comparison of these technologies along with comments regarding their typical application. As shown, some technologies, such as gravity thickeners, are more typically used for primary sludge (PS) thickening whereas others (such as gravity belt thickeners, RDTs, and dissolved air flotation) are more commonly used for waste activated sludge.

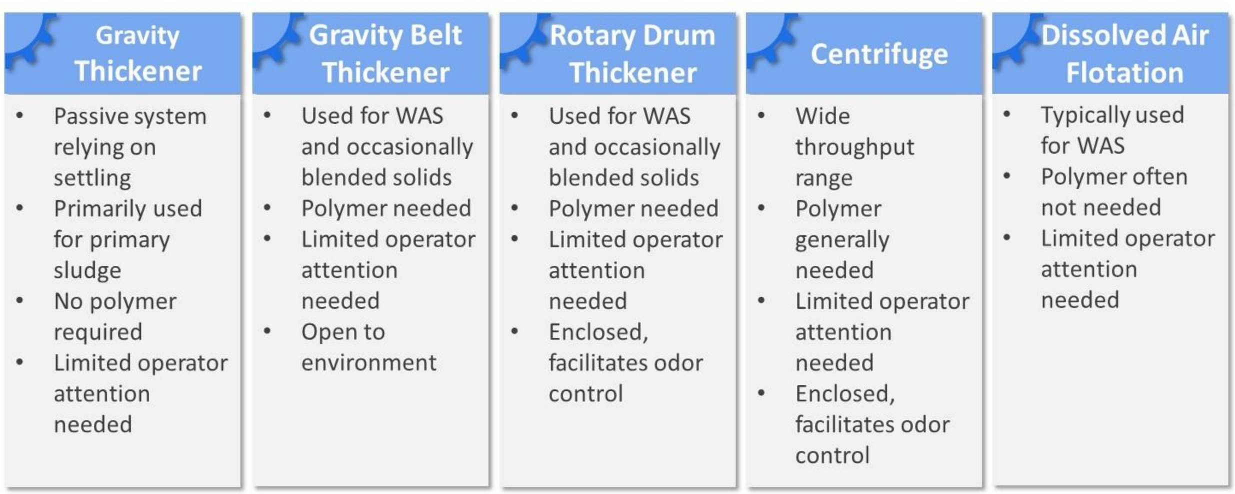


Figure 1-11 Thickening Comparison

Dewatering

Figure 1-12 provides a comparison of dewatering technologies that were reviewed. Important considerations for dewatering selection include the desired cake solids and solids capture performance, the polymer dosage, the degree of operator attention required, and the ability to control odors. Although power consumption differs between these technologies (centrifuges have a relatively high power consumption), power costs are typically a very small proportion of the life cycle cost of dewatering systems.

Belt Filter Press

- Lower cake solids than centrifuge
- Relatively high operator attention needed
- Open system, separate enclosure often needed for odor control

Centrifuge

- Generally highest cake solids
- Large range in throughput/capacity
- Relatively high power consumption
- Limited operator attention needed
- Enclosed, facilitates odor control

Rotary Press

- Generally modest throughput/unit
- Low power consumption
- Limited operator attention needed
- Enclosed, facilitates odor control

Screw Press

- Generally modest throughput/unit
- Low power consumption
- Limited operator attention needed
- Enclosed, facilitates odor control

Figure 1-12 Dewatering Comparison

Digestion

The review of biosolids stabilization systems was grouped into technologies based on digestion, chemical stabilization, composting, and drying. A comparison of digestion technologies is provided on Figure 1-13. In general, aerobic digestion systems are more commonly used for small to medium sized facilities whereas anaerobic digestion systems are more common for medium to large facilities. With both aerobic digestion and anaerobic digestion, options are available for producing a Class A biosolids cake; however, generally this requires a system with a higher degree of complexity than that required for a Class B product.

DIGESTION TECHNOLOGIES	Typical Facility Size	Technology Status in the U.S.	Class A Product	End Product	By-Products	Complexity L/M/H
Aerobic digestion	Small-medium	Established		Cake	N/A	L
Autothermal thermophilic aerobic digestion	Small-medium	Established	Y	Cake	N/A	M
Anaerobic digestion (mesophilic)	Medium-large	Established		Cake	Biogas	M
Acid phase digestion	Medium-large	Established		Cake	Biogas	M
Anaerobic digestion (thermophilic)	Medium-large	Established		Cake	Biogas	M
Temperature phased anaerobic digestion	Medium-large	Established	Y	Cake	Biogas	H
Thermal hydrolysis + digestion[1]	Medium-large	Established	Y	Cake	Biogas	H
Thermo-chemical hydrolysis + digestion (CNP Pondus™)	Medium-large	Innovative		Cake	Biogas	M
Thermo-chemical hydrolysis with pasteurization + digestion (e.g. CNP Pondus™)	Medium-large	Embryonic	Y	Cake	Biogas	H
Digestion + downstream thermochemical hydrolysis (e.g. Lystek™)[2]	Small-large	Emerging	Y	Liquid	Biogas	M
Enhanced enzymic hydrolysis	Medium-large	Emerging	Y	Cake	Biogas	H
Ultra-sonic hydrolysis + digestion	Medium-large	Emerging		Cake	Biogas	M

[1] Higher cake TS than conventional digestion (~30 percent TS)
[2] Class A requires soil incorporation for VAR. High solids liquid product (~14 percent TS)

Figure 1-13 Digestion Technology Comparison

Chemical Stabilization

Chemical stabilization using lime has been used in the industry for many years and is a proven process for producing either Class B or Class A biosolids cake, depending on the characteristics of the system, the chemicals added (some systems add additional chemicals to enhance pathogen reduction), and the conditions achieved in the process (particularly temperature and pH). One challenge with lime stabilization can be product odor and this must be taken into account when selecting application sites to avoid odor complaints.

Chemical stabilization using chlorine dioxide is a newer, innovative process that has emerged onto the market and now has multiple installations. Two different options are available to produce either Class B or Class A biosolids cake.

A comparison of chemical stabilization technologies is provided on Figure 1-14.

CHEMICAL STABILIZATION	Typical Facility Size	Technology Status in the U.S.	Class A Product	End Product	By-Products	Complexity L/M/H
Lime stabilization[1]	Any	Established	A or B	Cake	N/A	M
Chlorine dioxide stabilization - Class B (e.g. BCR CleanB™)	Small-medium	Innovative	N	Cake	N/A	M
Chlorine dioxide stabilization - Class A (e.g. BCR Neutralizer™)	Small-medium	Innovative	Y	Cake	N/A	M

[1] Lime content increases cake solids content

Figure 1-14 Chemical Stabilization Comparison

Composting

Several composting configurations are used for biosolids operations, with the most common including windrow composting, aerated static pile (ASP) composting, and in-vessel composting. Figure 1-15 illustrates each of these processes and their key features.

Figure 1-15 Composting Technologies

Although composting processes vary, they all share the same process needs, which include the addition of a bulking agent to provide porosity and a carbon source, aeration to promote aerobic decomposition, screening to recover bulking agent, curing to stabilize the product, and storage to balance demand. The need for a suitable bulking agent is a critical consideration and the type of bulking agent can have a significant impact on product quality. Another key factor with composting is odor control and the siting of composting systems is an important consideration. A comparison of composting systems is provided on Figure 1-15. Composting can produce a Class A product providing that time and temperature conditions are met and proper curing times are provided.

COMPOSTING	Typical Facility Size	Technology Status in the U.S.	Class A Product	End Product	By-Products	Complexity L/M/H
Windrow composting	Any size; often 3rd party/off site facility	Established	Y	Compost	N/A	L
Aerated static pile composting	Any size; often 3rd party/off site facility	Established	Y	Compost	N/A	L
In-vessel composting	Small-medium	Established	Y	Compost	N/A	M

Figure 1-16 Composting Comparison

Drying

Drying of biosolids involves the evaporation of moisture to produce a dried product which, because of the loss of the water, has a significantly reduced mass and volume, making distribution to end-use markets easier. Thermal drying systems use a fuel (e.g., natural gas, biogas) to dry the biosolids, whereas solar drying uses the sun's energy.

Thermal drying systems include drum dryers, belt dryers, disc or paddle dryers, and fluid bed dryers. As shown on Figure 1-17, product quality from thermal drying systems varies significantly, with some types of dryers producing a much more uniform product than others. Uniformity and density can be a very important factor for product marketing and should not be overlooked when selecting dryer technology. Thermal dryers are able to produce a Class A biosolids product provided temperature and time operating parameters are met.

Figure 1-17 Variations in Product Quality from Different Dryer Technologies

Solar drying involves spreading the biosolids on the floor of a greenhouse-like structure to allow the sun's energy to dry the biosolids. The solids are typically turned over using some type of mechanical device to aid in the drying process and break up the solids. Solar drying can produce a Class A product, but demonstration of pathogen reduction would typically require laboratory analysis for pathogens.

A comparison of drying technology is provided in Figure 1-18.

DRYING	Typical Facility Size	Technology Status in the U.S.	Class A Product	End Product	By-Products	Complexity L/M/H
Belt Dryer	Medium-large	Established	Y	Dried product	Waste heat	M
Rotary drum dryer	Medium-large	Established	Y	Dried product	Waste heat	H
Fluidized bed dryer	Medium-large	Innovative	Y	Dried product	Waste heat	H
Paddle / disc dryer	Any	Established	Y	Dried product	Waste heat	M
Drying beds	Small-medium	Established	N	Soil-like product	N/A	L
Solar dryer	Small-medium	Established	Potentially	Soil-like product	N/A	L

Figure 1-18 Drying Comparison

Thermal Conversion

Thermal conversion processes include incineration (in which there is sufficient oxygen present for complete oxidation), gasification (in which the oxygen supply is limited), and pyrolysis (in which there is no oxygen present). Incineration is established technology and has been used for many years for processing biosolids, including at several facilities in Georgia. Over recent years there has been a reduction in the quantity of biosolids incinerated in the state, driven at least in part by the cost of additional emissions controls compared to other disposal options. Gasification and pyrolysis are innovative technologies that are not yet widely applied for biosolids treatment (although they are more common with other feedstocks); however, use of these technologies are emerging in the national market.

Two technologies that are in the early (embryonic) stages of development for biosolids treatment are supercritical wet oxidation (which involves very high temperature and pressure and is in the early stages of being developed for biosolids treatment) and hydrothermal conversion (which converts biosolids into an organic liquid fuel). Wet air oxidation is a technology that has been applied for biosolids treatment but is now largely obsolete with most installations now having been shut down in favor of other alternatives.

A comparison of thermal conversion technologies is provided in Figure 1-19.

THERMAL CONVERSION	Typical Facility Size	Technology Status in the U.S.	Class A Product	End Product	By-Products	Complexity L/M/H
Multiple hearth incinerator	Large	Established	N/A	Ash	Waste heat	H
Fluidized bed incinerator	Large	Established	N/A	Ash	Waste heat	H
Pyrolysis	TBD	Innovative	Potentially	Biochar	Syngas	H
Gasification	TBD	Innovative	Potentially	Biochar	Syngas	H
Supercritical wet oxidation	TBD	Embryonic	N/A	Ash	Waste heat	H
Wet air oxidation (e.g. Zimpro)	Medium-large	Largely Obsolete	Y	Inert Cake	N/A	H
Hydrothermal conversion to organic liquid fuel (e.g. Genifuel)	TBD	Embryonic	N/A	Ash	Fuel	H

Figure 1-19 Thermal Conversion Comparison

Biosolids Treatment Costs

Capital costs for biosolids treatment technology vary significantly depending on the process. In general, capital costs for processing facilities that produce a less desirable product for landfill or land application have lower capital costs and costs increase with the selection of more mechanically intensive equipment required to produce a higher quality product or achieve thermal conversion of the volatile solids component of biosolids. A relative capital cost comparison is provided in Figure 1-20.

Operating costs and life cycle costs are very situation specific and require project-specific analysis to determine the expected cost ranges for a given application. The overall cost for biosolids management includes both the cost of treatment to produce a biosolids product for the desired end use and the cost of the final end use.

Low

Landfill

Land application

- Class B aerobic digestion
- Class B anaerobic digestion

Medium

Land application

- Chemical stabilization
- Advanced digestion (Class A)

Composting

High

Thermal drying

Incineration

Pyrolysis

Gasification

Figure 1-20 Capital Cost Comparison of Biosolids Management Strategies

Technology Cost Evaluation

The scope for this project included a cost evaluation of two different technologies for small and large facility sizes. Small and large facilities were selected to show the impact of facility size on the cost evaluation outcome. The technology choices were driven by the technologies receiving the most interest in the management practice utility survey. Following discussion with the project's core steering group, thermal drying and composting were selected as the technologies to evaluate and 1 million gallons per day (mgd) and 20 mgd were selected as the small and large facility sizes, respectively. The cost of treating biosolids using these technologies to produce Class A dried biosolids or compost was compared to ongoing landfill disposal and to Class B land application, assuming that the initial biosolids feedstock is dewatered cake at from a digestion system that already meets Class B land application requirements. Class B land application costs were assumed to include storage facilities. The approach is summarized on Figure 1-21.

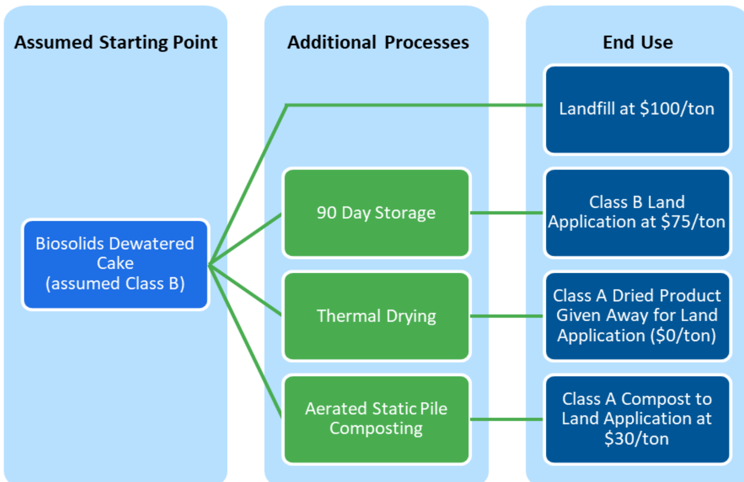


Figure 1-21 Cost Evaluation Approach and Baseline End Use Assumptions

Estimated life cycle costs for each alternative for both the small and large facility sizes are shown on Figure 1-22. For the small sized facility, the life cycle costs for composting and drying showed that these technologies are more expensive compared to either landfill disposal or Class B land application at this scale. For the larger facility size, the cost of implementing a composting system was found to be favorable compared to landfilling and Class B land application whereas the cost for drying was higher (assuming $100 per wet ton landfill cost). Sensitivity analysis (presented in Section 9.0) showed that, given other assumptions, thermal drying would become cost favorable compared to landfill at a landfill cost of $135 per wet ton. However, given the continued pressures on landfill disposal, tipping fees are likely to continue to increase, and utilities should consider additional factors beyond current cost in their future planning, including likely availability and long-term viability of the disposal method.

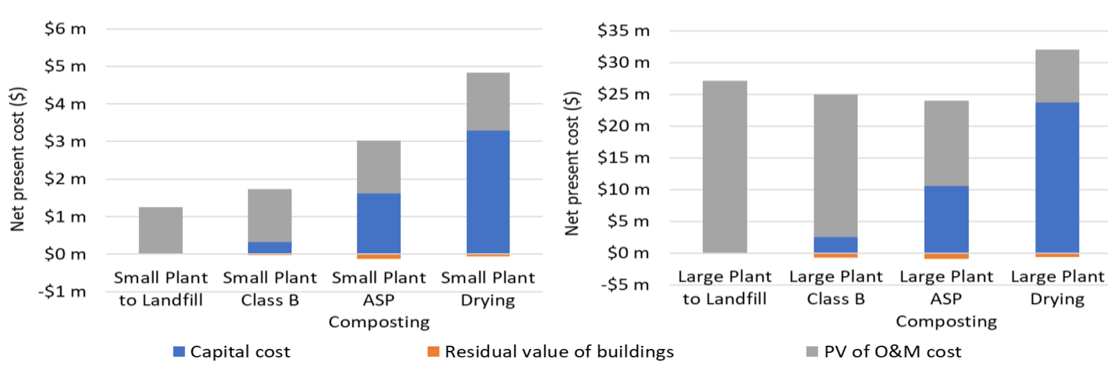


Figure 1-22 Net Present Costs for Each Alternative for both Small Facility (Left) and Large Facility (Right)

It should be noted that this concept screening analysis is intended to highlight trends and considerations in the implementation of these technologies. Project-specific cost analysis is recommended for utilities considering alternative biosolids processing approaches. The results clearly show the economies of scale associated with the implementation of composting and thermal drying. A regionalized approach to biosolids treatment is one way in which utilities could leverage these economies of scale.

Landfill and Municipal Solid Waste Opportunities

Landfill Capacity

A landfill capacity evaluation was performed based on historical data collected via a landfill survey conducted by Georgia EPD in 2018 as well as annual landfill tonnage reports, also provided by Georgia EPD. Projections were made regarding the potential landfill capacity for sewage sludge and biosolids based on the following three scenarios that were discussed with Georgia EPD:

- Municipal landfills accept 5 percent HMCW on a wet mass basis as a percentage of total waste received.
- Municipal landfills accept 10 percent HMCW on a wet mass basis as a percentage of total waste received.
- Municipal landfills accept 15 percent HMCW on a wet mass basis as a percentage of total waste received.

The capacity for receiving solids was then estimated assuming the same proportion of solids in HMCW as is currently observed. The estimated landfill capacity for solids was then compared to the actual estimated solids production in the state. Figure 1-23 shows the estimated amount of current solids production that exceeds the estimated landfill capacity for biosolids on a regional and statewide basis assuming all landfills accept only 5 percent HMCW. The results show that solids production is expected to exceed landfill capacity for solids assuming a statewide 5 percent HMCW acceptance rate. In the future, this constraint is expected to be intensified given other waste reduction and waste landfill diversion efforts.

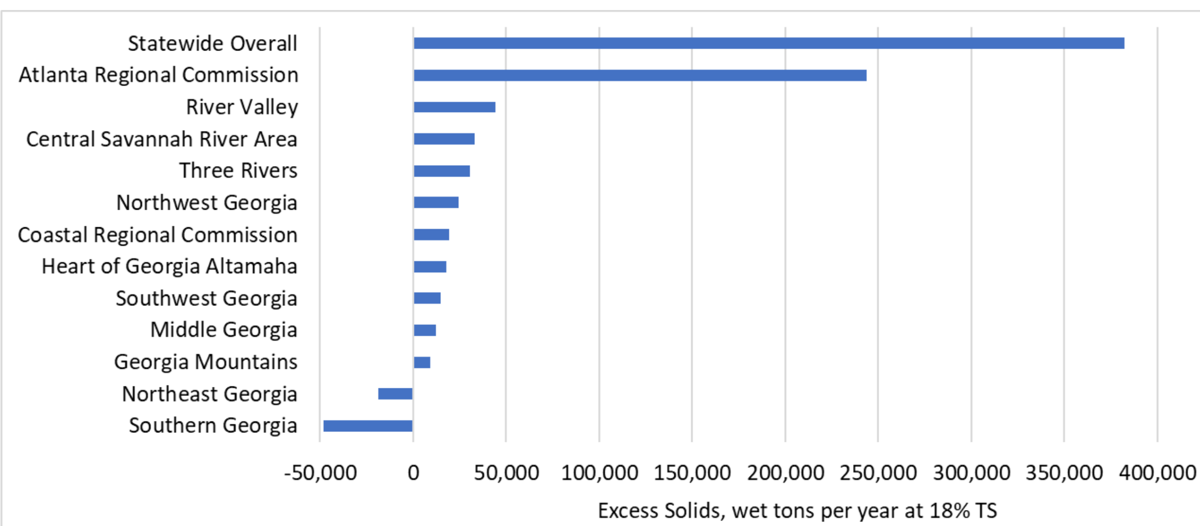


Figure 1-23 Estimated Amount of Currently Produced Wastewater Solids Exceeding Landfill Capacity at 5 Percent HMCW Acceptance Rate

Another issue with landfilling solids in the future is landfill closures as they fill. An analysis of remaining landfill capacity showed that half of the existing landfills in Georgia are expected to fill within the next 30 years.

The results presented on Figure 1-23 provide a useful overall comparison but may not be a realistic future scenario because not all biosolids are disposed of in landfills, and not all landfills currently accept biosolids. Furthermore, some landfills may continue to accept more than 5% HMCW. For this reason, an additional scenario where landfills currently accepting biosolids continue to do so at current ratios or limit to 5 percent HMCW if currently receiving more than this ratio was evaluated as a worst-case scenario in the gap analysis (see below). Within reasonable expected variations in assumptions, the results clearly point to the likelihood that alternative outlets will need to be used.

Municipal Solid Waste Co-Processing Opportunities

There are multiple potential options for either co-processing biosolids and MSW or for processing them separately at the same facility and taking advantage of operational synergies. Such opportunities include the following:

- **Co-digestion of biosolids with food waste** either in a low solids digester (as is common at wastewater facilities) or in a high solids digester. Treatment of food waste in a low solids digester requires pre-treatment to remove physical contaminants and liquification/blending to produce a uniform slurry that can be pumped into the digester along with the wastewater residuals. High solids digestion would involve the co-digestion of unstabilized biosolids cake with food waste. Typically, physical contaminant removal is achieved down-stream of high solids digesters.
- **Composting** of biosolids, food waste, and yard waste is a viable option, subject to achieving the right blend of feedstocks. Yard waste is a suitable amendment material if available in sufficient quantities, but food waste does not provide enough "structure" for composting without additional amendment.
- **Thermal conversion** of biosolids and thermal conversion of MSW are both commonly used, but they are typically separate processes. Co-incineration is viable and has been practiced for many years in Europe even though it is not typically practiced in the United States. Alternative thermal conversion technologies such as gasification and pyrolysis can potentially be used for combined thermal processing of biosolids and MSW organics; however, as noted above, biosolids experience is relatively limited with these technologies.
- **Treatment of biosolids and MSW using separate processes at the same facility** may offer potential synergies of operation, including optimization of the overall heat balance and the potential for combined flue gas treatment.

It is also noted that in other states, California as one specific example, regulation regarding organics diversion from landfills is driving the implementation of several projects involving low and high solids co-digestion systems.

Regional Management Strategies

One way in which smaller utilities can take advantage of economies of scale in biosolids management is to team together with other utilities to process residuals at a regional facility. There are several significant opportunities associated with a regionalized approach which may offset the potential barriers as depicted on Figure 1-24.

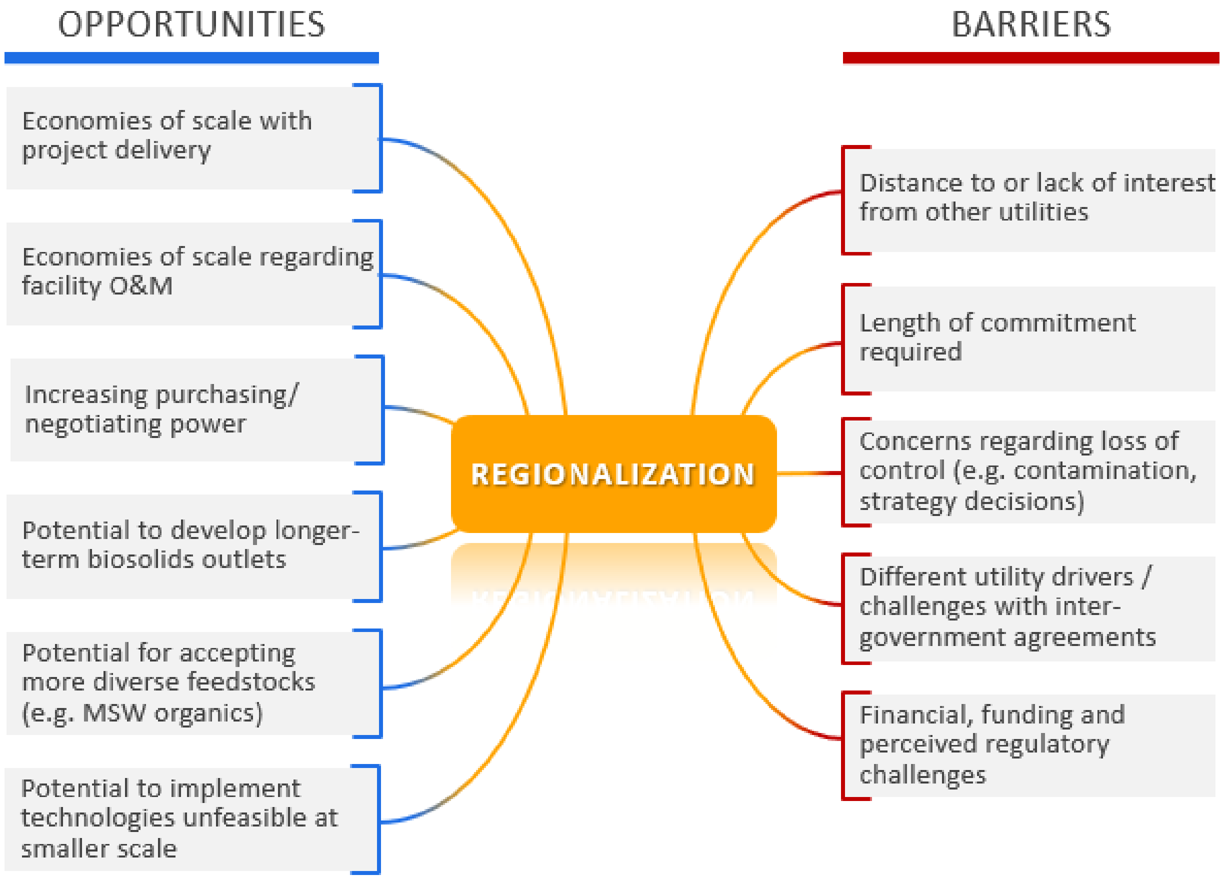


Figure 1-24 Opportunities and Barriers Associated with Regionalized Biosolids Processing

In terms of opportunities for and utility interest in regionalization, the greatest opportunities are in and around the urban areas. Figure 1-25 shows the average response by Regional Commission to the question asked in the State 2020 Survey about utilities' level of interest in a regionalized solution (where a score of 1 indicated that the utility was not interested and a score of 5 indicated it was very interested). As shown, the strongest interest was in the Atlanta Regional Commission, Northwest Georgia, Georgia Mountains, Southern Georgia, and Coastal Georgia.

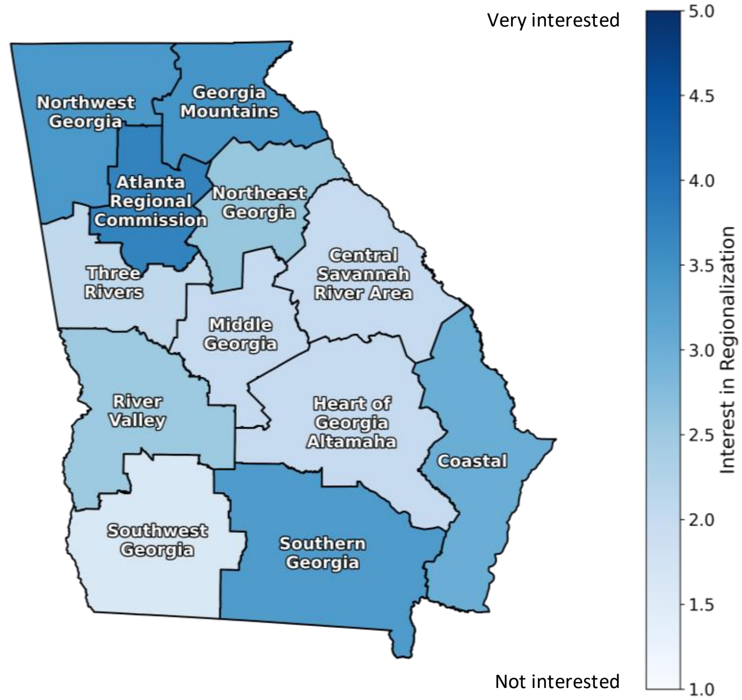


Figure 1-25 Map Showing Average Interest in Regionalization Score by Regional Commission

Given the pressures on current disposal methods and increased understanding of the dynamics of HMCW in landfills, utilities will likely have to make changes to current disposal strategies. Innovative approaches, including regional partnerships, will be needed to meet these challenges. To assist utilities with the development of regionalized biosolids systems, a road map was prepared to identify key steps required in the process. The road map is broken down into project stages and tasks required in key categories associated with project development, including partnering, design, project delivery mechanism, financing, market end use, regulatory requirements, and stakeholder engagement.

Recommendations

Gap Analysis

The gap between current practices and future needs related to biosolids management in the state is documented on Figure 1-26. Under this potential scenario, around 77,000 dry tons of biosolids would need to be diverted from landfills annually, with Georgia utilities needing to find an alternative outlet for this quantity of biosolids. Although this scenario may be pessimistic, its likelihood depends on the extent to which landfill operators are able to demonstrate sufficient engineering to allow for higher amounts of HMCW disposal while maintaining landfill stability.

Key constraints to implementing new biosolids management practices were identified through survey feedback and collection of other information. At present, these constraints include potential landfill acceptance of HMCW, existing landfill capacity, capital costs of new biosolids processing facilities, and utility interest in regionalization. Utilities are encouraged to evaluate long-term improvements in biosolids treatment to provide for disposal alternatives other than landfilling. However, landfills will continue to be an important part of biosolids management plans as a principal outlet or as a back up to other end uses.

The market evaluation conducted as part of this study (presented in Section 7.0) shows a huge potential opportunity for the beneficial use of biosolids products in Georgia, particularly in agriculture but also with significant potential in silviculture and, in some areas, in parks and recreation.

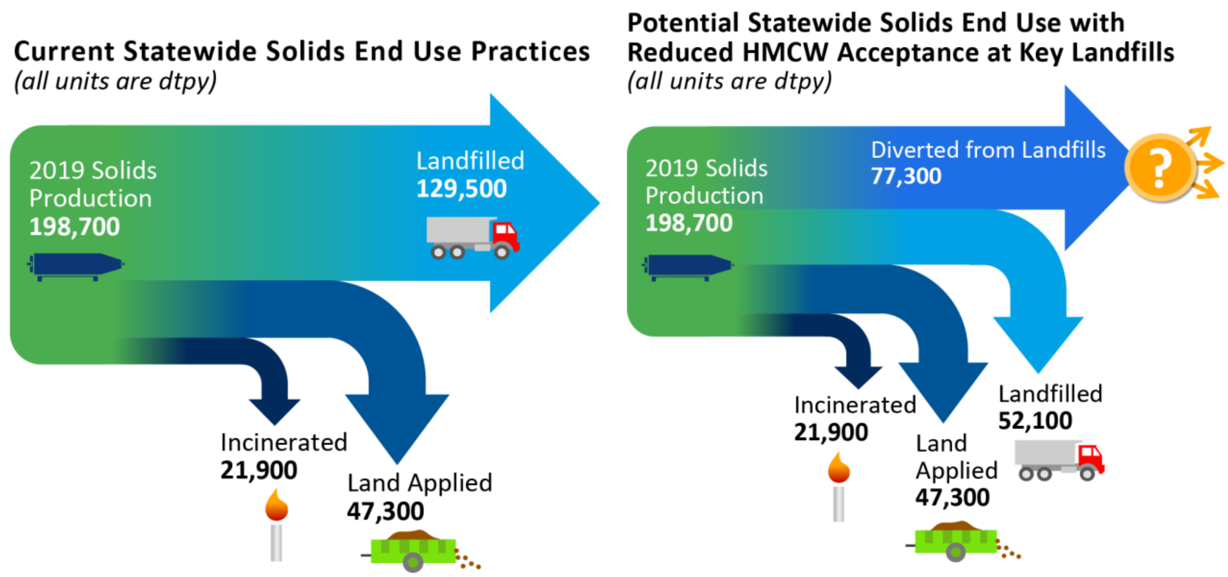


Figure 1-26 Current Solids Production and End Use Compared to a Potential Landfill Diversion Scenario (Values in Dry Tons Per Year)

Financial Recommendations

Several sources of funding are available through GEFA, including two that are available to support biosolids projects, the Georgia Fund and the Clean Water State Revolving Fund (CWSRF).

The Georgia Fund is for a limited amount of up to $3 million per year at a current interest rate of 1.63 percent for a 20-year loan; however, this amount is typically not sufficient to fund a major infrastructure project such as a new biosolids system, so projects would need to utilize multiple sources of funding.

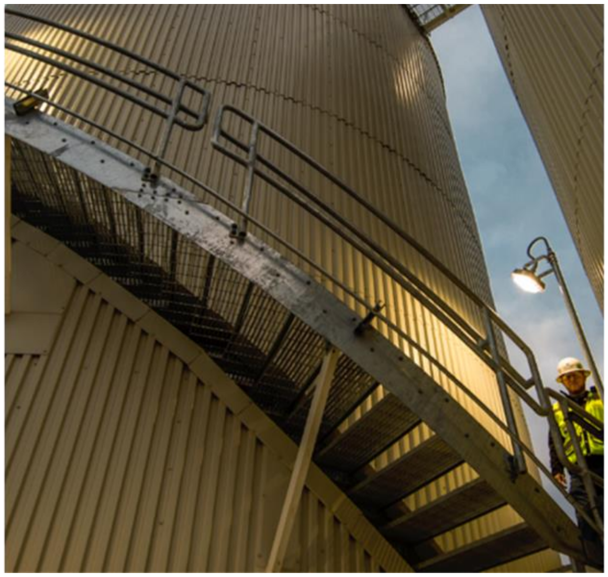
The CWSRF allows for a maximum loan amount of $25 million per year at a current interest rate of 1.13 percent (or 0.13 percent for conservation projects) over 20 years. However, although the CWSRF is available to support biosolids projects, the state administered scoring criteria for evaluating projects are not well suited to biosolids projects. Since the CWSRF scoring criteria are dictated by individual states, GEFA has the ability to determine what scoring criteria are used in the future and requested that this project make recommendations on funding to provide better support for biosolids projects. The following recommendations are made:

- Modify the CWSRF scoring criteria and/or guidance associated with the scoring criteria to either provide additional criteria more suited to biosolids projects, or to expand the current criteria to more sustainability-orientated criteria that would provide more equitable scoring for a wider range of projects, including those associated with biosolids. More specific recommendations are made in Section 12.0.

- Consider the development of a biosolids-specific funding initiative to overcome some of the barriers faced by utilities in developing biosolids projects. Funding could be targeted to prioritize support during the early phases of project development (in particular to assist with feasibility work and background work required for the CWSRF application). If GEFA decides to proceed with such an initiative, it is recommended that funds should prioritize utilities that have been most impacted by rising end use costs, those that are considering regional programs, and initiatives that support community education on biosolids matters with a view to expanding beneficial use of biosolids. This could include elected officials who are faced with making key decisions about biosolids management.
- It is recommended that GEFA add additional content to the GEFA website to provide resources for utilities facing biosolids challenges. This should include a web page or guidance document providing guidance for utilities seeking funding for biosolids projects, providing guidance on how biosolids projects can meet CWSRF criteria, and ensuring that reference is made to biosolids in both the Georgia Fund and CWSRF guidance documentation.

Moving forward, it is expected that Georgia utilities will continue to use a variety of biosolids end use and disposal options. Each utility's challenges are unique and will lead to alternative solutions, either individually or in collaboration with others.

2.0 Introduction



Georgia utilities are facing increasing pressures with respect to solids management and, in many cases, uncertainty regarding the path to resilient and sustainable programs that can weather market changes. This study provides a roadmap for utilities to optimize their solids programs and an understanding of the funding needed to do so.

Pressures on solids management in Georgia have been mounting, with limitations on disposal options resulting in increased costs for many utilities today and uncertainties regarding future costs. This has left many utilities having to identify new alternatives and a corresponding need to determine what might be required to move to a more resilient and sustainable approach.

The factors that must be considered in developing resilient and sustainable solids management strategies are varied and complex, as shown on Figure 2-1. The determination of a preferred strategy often involves balancing these sometimes competing factors and drivers that may be region-specific. Consequently, the ideal solution for one region or utility might not be the most appropriate choice for others.

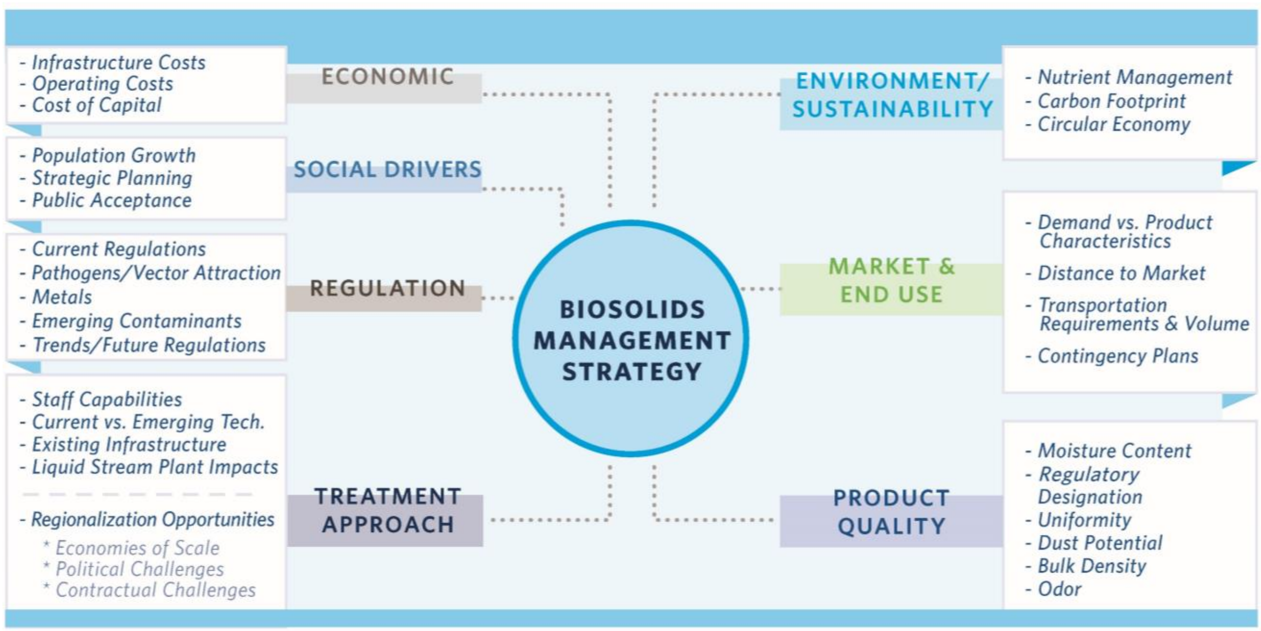


Figure 2-1 Factors Influencing Biosolids Strategies

To support utilities wishing to optimize their programs, the GEFA commissioned this study. Specifically, GEFA intends to use the study to identify the funding needs and develop programs that could beneficially serve the communities most impacted by the changing economic conditions and limited biosolids disposal options – reflecting the factors shown on Figure 2-1.

To meet that objective, the study does the following:

- Expands on existing information regarding solids production and management practices in the state.
- Defines both current and potential regulations that might impact solids management options.
- Explores market opportunities and constraints for solids management, reflecting regional variations.
- Includes a technology screening to identify those that might best meet Georgia utility needs.
- Defines high level costs for selected technologies.
- Identifies gaps between current practices and future needs.
- Documents GEFA financial assistance offerings for solids management improvements.
- Presents a strategic framework for solids improvement projects and provides recommendations for funding mechanisms, reflecting the elements above.

Regulatory Definitions

- "Sewage sludge" means solid, semi-solid, or liquid residue generated during the treatment of domestic sewage or a combination of domestic sewage and industrial wastewater in a treatment works.
- "Biosolids" means any sewage sludge that (fulfills regulatory requirements and) is used in a beneficial manner.

See Appendix C for more details.

3.0 Solids Production

Throughout Georgia, population trends are rapidly changing. Strategizing for long-term solids management starts with understanding how these changes and, correspondingly, solids production will change over time.

Solids production estimates for this project were developed and assessed on a regional basis, specifically reflecting the state's Regional Commissions. Figure 3-1 shows a map of the Regional Commissions.

To develop both current and future solids projections (for a planning year of 2060), data were obtained from a variety of sources. Data sources and the information gathered from each are summarized in Table 3-1.

Figure 3-1 Georgia Regional Commissions

Table 3-1 Solids Production Estimate Data Sources

Data Source	Description
Governor's Office of Planning and Budget	Residential population projections by county for the state from 2018 to 2063.
Georgia EPD	Annual average wastewater discharge flow data from facilities with National Pollutant Discharge Elimination System (NPDES) and Land Application Site (LAS) permits was provided for 2015 to 2019, where available.
2020 Wastewater Forecasts	Georgia EPD annual average wastewater discharge flow data from 2015 to 2019 was used with the most recent OPB population projections for wastewater flow forecasting through 2060. This was part of the regional water planning process for all regional water planning councils excluding the Metropolitan North Georgia Water Planning District.
2016 Wastewater Forecasts	The 2016 Wastewater Management Plan Update for the Metropolitan North Georgia Water Planning District included wastewater forecasting through 2050. Facility flow projections were extrapolated to 2060 for use in this study.
GAWP Survey	In 2019, GAWP surveyed utility members across the state to identify solids production, characteristics, and management practices for the previous year. A total of 52 communities responded, accounting for 99 facilities. Data provided by Georgia EPD for an additional 28 facilities were also included in the analysis and presentation of the GAWP survey results.

Data Source	Description
EPA ECHO Database	Biosolids Annual Reports were accessed for the state of Georgia for 2019. Available data only includes reports submitted electronically through EPA's NPDES eReporting Tool (NeT). For 2019, a total of 78 facilities in Georgia submitted Biosolids Annual Reports to the EPA.
EPD Annual Biosolids Reports	Data from Biosolids Annual Reports provided by Georgia EPD for 34 facilities were cross-checked against the EPA ECHO Database.

An overview of the approach used to develop 2019 and 2060 solids projections using these sources is shown on Figure 3-2.

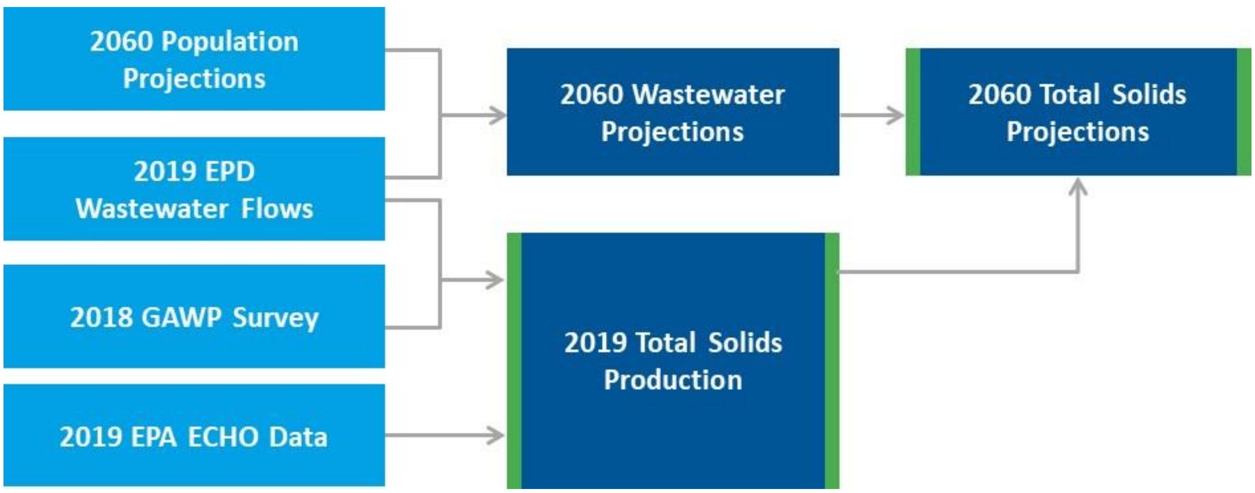


Figure 3-2 Methodology for Solids Production Estimates

As shown on the figure, several data sources were utilized to develop solids projections. The following methodology was used:

- Where available, current solids production rates (dry tons per mgd) were developed from 2019 EPA ECHO data and 2019 EPD flow data.
- Where 2019 solids production data were unavailable, the average unit solids production rate from the 2018 GAWP survey (dry tons per mgd) was used.
- Solids production for 2019 was estimated using the above unit solids production rates multiplied by actual 2019 flow data reported for that facility.
- Solids production for 2060 was estimated by applying a facility's assigned unit solids production rate to the facility's 2060 projected wastewater flow developed for the Regional Water Planning Councils. Wastewater forecasting was completed as part of the 2020 Regional Water Plans Update and the 2017 MNGWPD Integrated Water Management Plan Update.

Flow Estimates and Projections

Wastewater flow projections for 2060 were developed as part of separate projects for Regional Water Planning Councils. For counties in the MNGWPD, wastewater forecasts through 2050 had been updated as part of the District's 2017 Integrated Water Management Plan Update. These forecasts were extrapolated to 2060 for the purpose of this study. Wastewater forecasts for all other counties in the state were developed as part of the 2020 Regional Water Plans Update. Wastewater forecasting at the county level was informed by population projections from the Governor's Office of Planning and Budget on a county level.

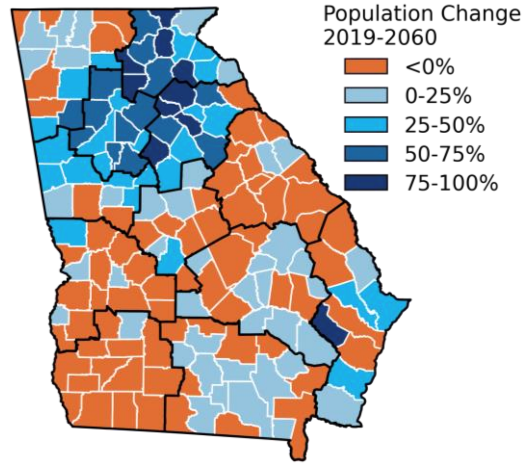


Figure 3-3 Population Change, 2019 to 2060

As shown on Figure 3-3, some regional commissions are expected to see significant changes in population between 2019 and 2060. The Georgia Mountains, Northeast Georgia, and Atlanta Regional Commission are each expected to see a population increase of more than 50 percent. Conversely, the River Valley and Southwest Georgia are forecasted to see a population decrease of 18 percent and 12 percent, respectively. Other regional commissions are forecasted to see little or no change in population over the next 40 years.

Projected wastewater flows for 2060 correlate with population changes; the impact of population change on wastewater flows is shown on Figure 3-4.

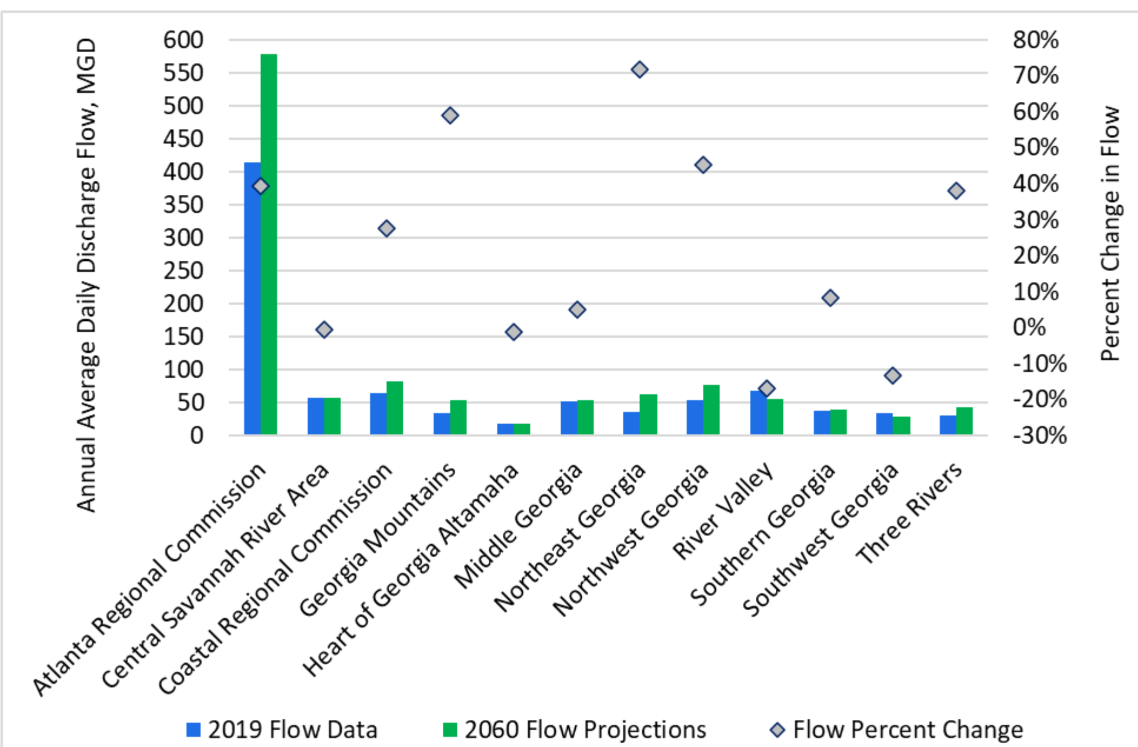


Figure 3-4 Current and Projected Wastewater Flows by Regional Commission

Solids Production Estimates and Projections

Based primarily upon the EPA's ECHO Database, total wastewater solids production estimated for 2019 in Georgia was approximately 201,000 dry tons on an annual average (AA) basis. The breakdown of this production by regional commission is summarized on Figure 3-5. As shown on the figure, solids production is dominated by counties in the Atlanta Regional Commission, which comprises 50 percent of the estimated solids produced in Georgia. The Coastal Regional Commission and Northwest Georgia are the next largest contributors at 8 percent and 7 percent of total solids produced, respectively. All other regional commissions each account for 5 percent or less of the total estimated 2019 solids production in Georgia.

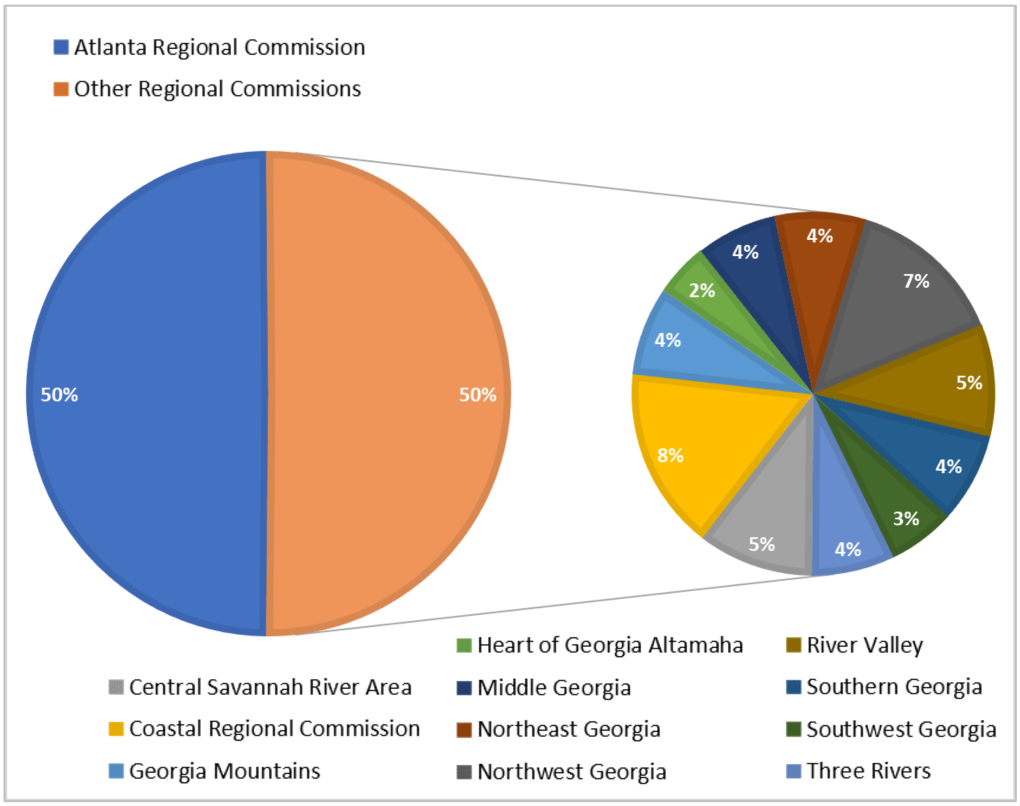


Figure 3-5 Estimated 2019 Solids Production by Regional Commission

2060 solids production was estimated by first calculating a unit solids production rate (dry tons per mgd) for each facility where 2019 solids production and 2019 flow data were available from EPA ECHO and EPD data, respectively. If this calculated value fell outside the expected range of 0.5 to 1.5 dry tons per mgd, the average unit solids production rate from the 2018 GAWP survey was used instead. The average solids production rate calculated from the GAWP survey results was 0.655 dry tons per mgd. Some facilities with large wastewater contributions from significant industrial users were expected to have solids production rates outside the expected range, which warranted further investigation. Follow up with the appropriate facility personnel confirmed the solids production rate and retained the calculated value for that facility's estimated 2060 solids production. Where 2019 solids production data were unavailable, the average unit solids production rate from the 2018 GAWP survey was used. Solids production for 2060 was estimated by applying a facility's assigned unit solids production rate to the facility's 2060 projected wastewater flow developed for the Regional Water Planning Councils.

Projected solids production for 2060 is assumed to follow the same trends as population projections. However, this assumption was used to provide a high-level estimate as some treatment systems do not remove residuals on a yearly basis. The Georgia Mountains, Northeast Georgia, and Atlanta Regional Commission are each expected to see an increase while the River Valley and Southwest Georgia are expected to see a decrease in solids production. Figure 3-6 shows the geographic distribution of the projected 2060 solids production, while Figure 3-7 compares 2019 and projected 2060 solids production for each regional commission. As expected, the majority of the solids production arises from urban areas, particularly the metro Atlanta region.

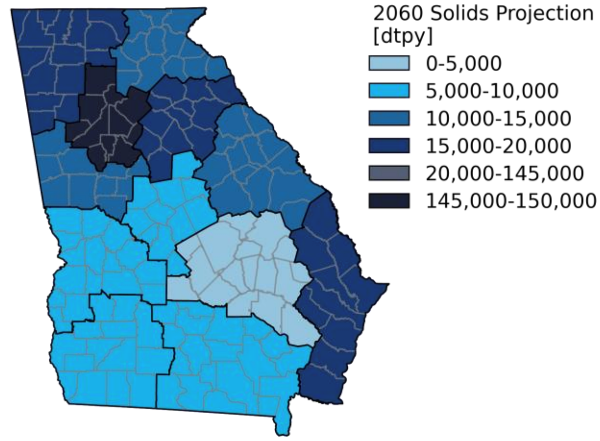


Figure 3-6 Geographic Distribution of Projected 2060 Solids Production

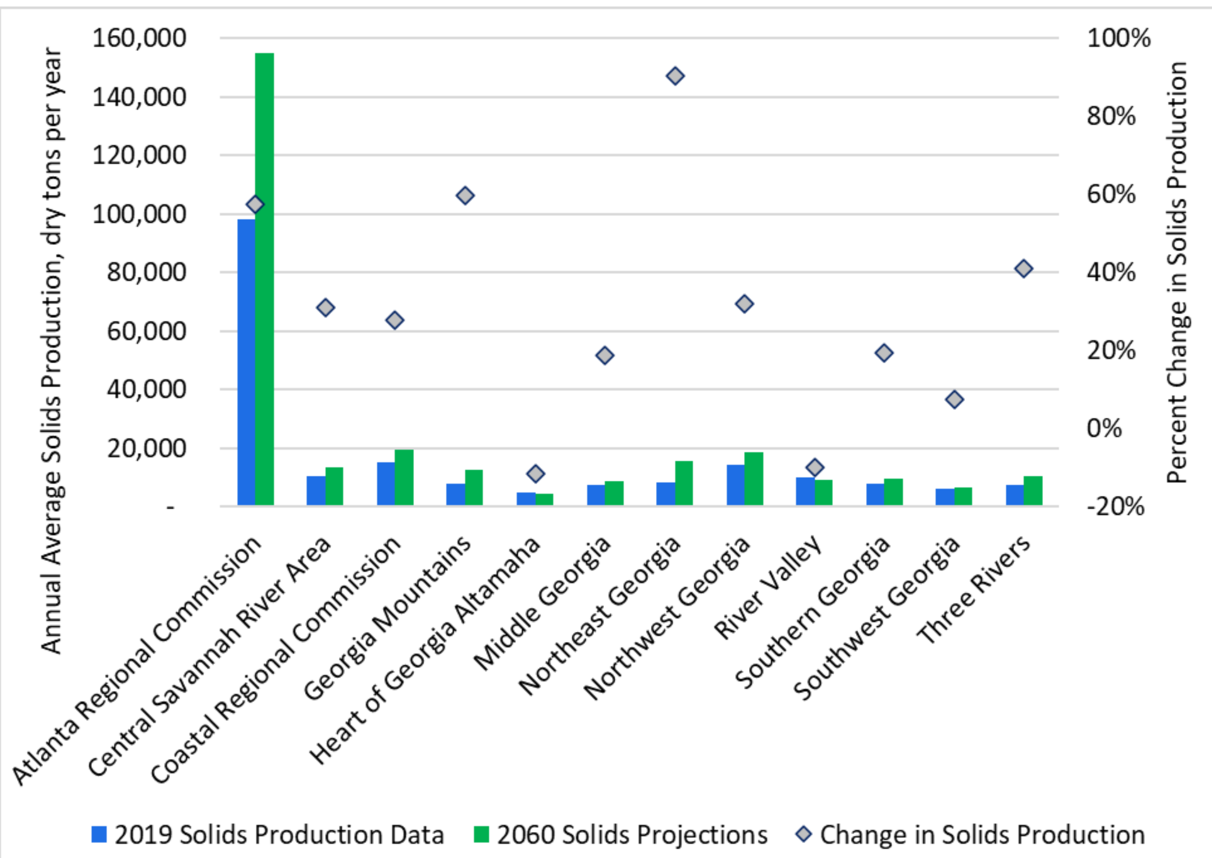
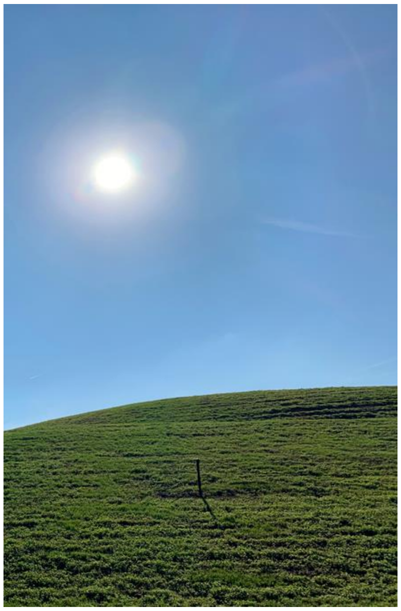


Figure 3-7 Solids Quantities in 2019 and 2060 by Regional Commission

4.0 Regulatory and Policy Frameworks



Regulatory and permitting frameworks can define the shape and trajectory of biosolids management, and a clear understanding of their impacts is critical to develop and maintain resilient and sustainable solids management programs. This is especially true in Georgia, where pressures on landfilling are driving a move to alternate management practices.

A variety of end use and disposal options are available for municipal wastewater solids, including landfilling, land application, the distribution of products such as compost, and incineration. In Georgia, predominant practices are landfilling and land application.

The strong reliance on landfilling in Georgia reflects the historically low cost of this practice, but costs have increased significantly because of a number of pressures and are expected to remain at elevated levels for the foreseeable future.

Going forward, beneficial uses for biosolids – through land application as an agricultural soil amendment or through distribution as a marketable product – are expected to play an increasing role for Georgia biosolids.

Incineration, an alternative disposal alternative to landfilling, is not expected to increase in the state because of cost and permitting complexity factors.

Both current regulations and regulatory trends that impact these practices are highlighted below. Note that highlights of existing regulations are not intended to be all-encompassing and rules discussed should be reviewed for additional detail.

Landfilling

Wastewater solids landfilled in Georgia are generally co-disposed with MSW, and so the following sections focus on regulations governing this practice at the federal and state levels.

Federal Regulations

Co-disposal of biosolids and MSW in landfills is regulated nationally by the EPA under Subpart I of 40 CFR Part 258, Criteria for MSW Landfills.

Key requirements for solids landfilling focus on solids characteristics. Solids must pass the Toxicity Characteristics Leaching Procedure (TCLP) to demonstrate the material is not hazardous. Wastewater solids typically do not have problems passing the TCLP. In addition to the TCLP, the waste solids must be dewatered sufficiently to pass the Paint Filter Test (EPA SW-846, Method 9095) to demonstrate no free-standing water in the solids.

Georgia Regulations

The co-disposal of wastewater solids and MSW in landfills is regulated by the EPD under Georgia's Solid Waste Management Rule 391-3-4, which incorporates the requirements of 40 CFR 258 by reference. Under this rule, solids from water treatment plants and water resource recovery facilities (WRRF) are defined as a solid waste. The rule includes requirements for design and operation of landfills.

Trends

There are no new federal regulations regarding the co-disposal of solids and MSW in landfills expected at this time, but a rule change has been made in Georgia. The changes to Rule 391-3-4, adopted by the DNR Board in May 2021 and effective on June 30, 2021, focus on HMCW – solids that have a moisture content greater than

Sludge Moisture Concerns Impact Landfilling

Concerns regarding the impact of sludges with high moisture content and low shear strength on landfill slope stability has reduced landfilling of biosolids in Georgia.

In May 2018, a slope failure at a landfill in Georgia resulted in the EPD developing a consent order that included a requirement that the operator limit the high moisture content material to the lesser of 5 percent of the waste received per day or 250 tons per day.

The Georgia EPD also accelerated the permit review schedule for any MSW landfill taking more than 10 percent sludge. Theses permit reviews will include a reevaluation of the waste stream each site receives and its impact on slope stability.

It is expected that the increased understanding of HMCW's impact on landfill stability may require some sites to make significant design and/or operational modifications, resulting in increased costs to landfill operators.

Uncertainty over costs and potential management requirements is impacting the current market for the disposal of wastewater solids.

40 percent. The changes reflect EPD's concerns regarding slope failures in landfills caused by HMCW acceptance and a lack of reporting requirements.

Specifically, the rule requires landfills that accept 5 percent or more (by weight) of wastewater solids to have an HMCW management plan. Part of this plan may include "solidification" of HMCW with lime or other bulking agents. EPD issued guidance for the rule in July 2021.

It is worth noting that some landfill operators outside of Georgia have restricted or prohibited wastewater solids acceptance because of concerns regarding physical characteristics, odors, and/or emerging contaminants. Of these, physical characteristics associated with "wet materials" appear to dominate.

For example, a large national operator placed restrictions on materials that (in addition to failing a paint filter test) have an average unconfined compressive strength less than 750 pounds per square foot (lb/sf). To be accepted at these landfills, materials that do not meet this criterion are to be solidified (stabilized with lime or other materials) to provide an average unconfined compressive strength of 1,000 lb/sf, or must be dewatered using a technology that meets both paint filter test and the 750 lb/sf compressive strength requirement.

A number of utilities in the southeastern United States indicate that solidification will be required for their plants and that landfilling costs will double or triple as a result.

Land Application

The land application of biosolids in Georgia is regulated on both federal and state levels. Additionally, local jurisdictions can restrict or ban some types of biosolids. Current regulatory requirements are described below, in addition to forces that have the potential to impact current regulations.

Table 4-1 lists federal and state requirements for biosolids land application in Georgia. Federal regulations require reporting to Region 4, since Georgia is not a delegated state. In addition to these requirements, some counties prohibit some or all land application activities. The regulations in the table and local restriction examples are briefly described in this section.

Table 4-1 Biosolids Land Application Regulations

Regulatory Body	Regulation	Relevance
USEPA	Title 40 CFR Part 503 (40 CFR 503)	Establishes minimum requirements for biosolids land application.
Georgia EPD	Rules and Regulations for Water Quality Control, Chapter 391-3-6.17 Sewage Sludge (Biosolids) Requirements. (GAC 391-3-6.17).	State rules to enact the requirements of 40 CFR 503, along with other state-specific requirements.
GDA	Georgia Soil Amendment Act, Section 2-12-73 and Georgia Fertilizer Act, Section 2-12-4.	Defines requirements relating to the registration of soil amendments and fertilizers marketed in Georgia.

Federal Regulations

The 40 CFR 503 regulation, also known as the "503 rule," was promulgated in 1993 and sets forth standards for the following three general use and disposal practices:

- Beneficial use through land application, distribution, or marketing;
- Disposal at dedicated sites or in sludge-only landfills; and
- Incineration in sludge-only incinerators.

With respect to land application, the existing rule sets forth risk-assessment-based standards for heavy metals, defines pathogen limitations in land applied materials, defines VAR requirements and establishes management standards to ensure that land application is protective of human health and the environment. It should be noted that the 503 rule uses the terminology "sludge" as opposed to "biosolids," which is an industry-accepted term for residuals that are suitable for beneficial use.

Figure 4-1 highlights key elements of the rule, excluding recordkeeping and monitoring. More specific requirements for the items shown on the figure can be found in Appendix A.

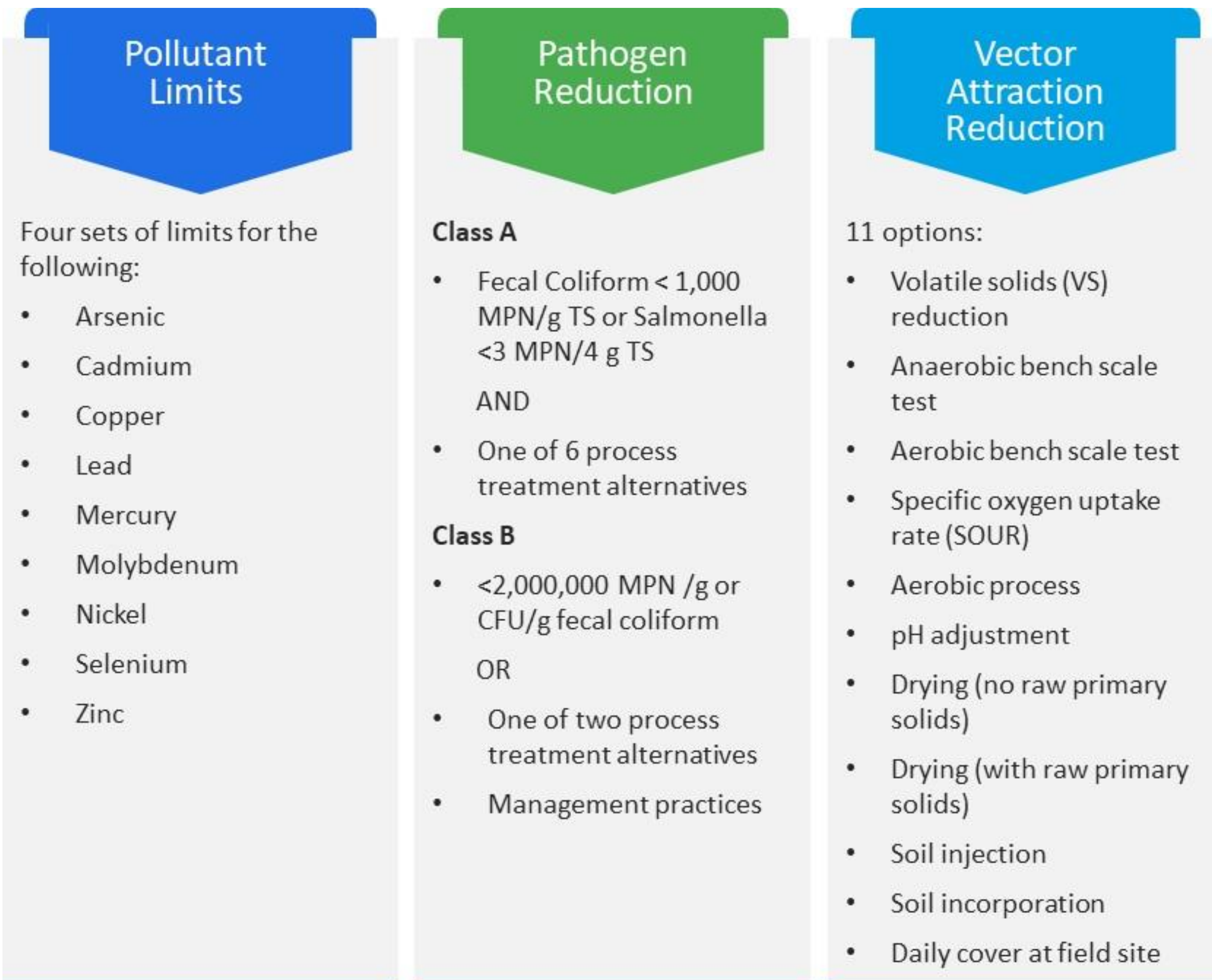


Figure 4-1 40 CFR 503 Key Biosolids Quality Elements

As shown on the figure, the 503 rule establishes two classifications based on the level of pathogen reduction achieved: Class A and Class B. With respect to pathogen content, Class A processes essentially reduce pathogens in biosolids to below detectable levels. Class B materials have a higher pathogen concentration (as measured by indicator organisms), but when managed in accordance with specific requirements in the rule, Class B limits are intended to provide the same level of protection as Class A limits. The EPA allows any one of six alternative methods to comply with Class A requirements and three alternatives for Class B biosolids. Additionally, Class A biosolids must meet fecal coliform (an indicator of the presence of pathogens) or Salmonella (one type of pathogenic bacteria) limits as well.

The pathogen classification can have a significant impact on end use options. The 503 rule imposes "general requirements" (such as access restrictions, setbacks, and prohibitions against applying material above an agronomic rate) on Class B materials and they can only be used for land application purposes. Class A biosolids that also meet metal and specific VAR requirements (also known as Exception Quality [EQ] biosolids) can be distributed in a bag and container and applied to lawns and gardens.

VAR criteria must also be met for all biosolid products; the 503 rule presents 11 options to meet this goal for wastewater treatment solids, as shown on Figure 4-1. The first eight VAR options are applicable for EQ classification.

The rule also requires that biosolids be applied in accordance with the agronomic rate for nitrogen.

Georgia EPD Regulations

As indicated in Table 4-1, two agencies have regulatory authority over biosolids use in Georgia: EPD regulates all biosolids use, and Class A or Exceptional Quality biosolids marketed as soil amendments or fertilizers come under the purview of GDA.

EPD generally adopted the 503 rule, as did many states. However, EPD has established additional requirements for land application. Requirements in GAC Rule 391-3-6-.17 are supplemented by the EPD *Guidelines for Land Application of Sewage Sludge (Biosolids) at Agronomic Rates* (the Guidelines).

As noted earlier, while EPD has adopted its own Rules, Georgia has not been delegated and reporting to EPA Region IV is still required.

Figure 4-2 shows requirements beyond the federal rule contained in the GAC rule and the Guidelines, each of which are briefly discussed below. Note that all facilities that generate sludge must have a permit (NPDES, LAS, and/or pretreatment) regardless of the method of handling sewage sludge.

Figure 4-2 Federal and Georgia Land Application Regulatory Comparison

Land Application Site Permits

When biosolids from more than one permitted entity – or from outside of Georgia – are land applied in the state, the owner or operator of the application site must obtain a LAS permit from EPD. The authorization to land apply biosolids may also be incorporated into an NPDES permit (EPD does not issue many individual LAS permits for the land application of sludge).

Sludge Management Plans

EPD requires that a Sludge Management Plan (SMP) be developed for any solids not destined for landfill disposal. This requirement includes sludges sent to another permitted facility (e.g., a sludge generator would require an SMP if sending their sludge to a regional facility for further treatment and subsequent land application – the SMP could be incorporated into their LAS or NPDES Permit and the regional facility may require a Sludge Only LAS Permit (depending on the ownership of the facility).

SMP requirements for Class A products destined for urban uses are minimal and include metals analyses, demonstration of pathogen and VAR compliance, the status of other EPD or GDA permits/approvals and, generally "sufficient details on the sludge treatment process to support the project."

For proposed agricultural and silvicultural Class B land application programs, EPD requires additional information in the SMP, including location and topographic map for application sites showing specific required features such as distances to wells, soil data, biosolids quality data including nutrient content, estimated land application quantities, cropping practices and nutrient uptake, application methods and operations, letter of agreement with site owner, biosolids transportation method and routes to site, Endangered Species Act evaluation, and proof of advertisement of a public meeting (the latter is only required the first time a facility land applies in a County). A site inspection is also required for Class B land application sites.

The EPD will issue a public notice for the proposed plan once review is complete and approve the plan if no significant negative comments are received. Once approved, the NPDES or LAS permit for the biosolids generator and/or processor will be amended to incorporate the approved plan.

Additional Setback/Buffer Requirements

For Class B biosolids setbacks, the 503 rule only stipulates a setback of 10 meters (33 feet) from water, but EPD Guidelines define additional setbacks for dewatered biosolids. Figure 4-3 shows these setbacks for unincorporated biosolids (setbacks for biosolids incorporated into the soil are similar, with the exception that the minimum distance to Waters of the state can be reduced from 50 feet to 35 feet).

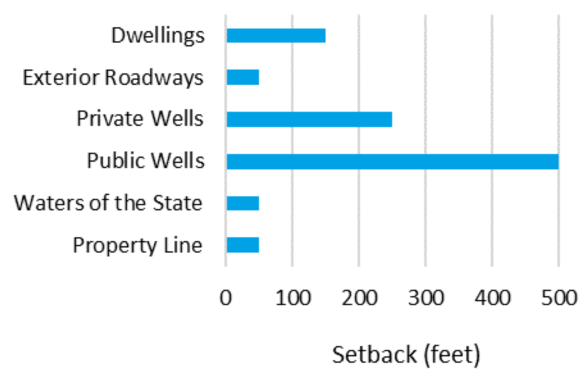


Figure 4-3 EPD Minimum Buffers for Unincorporated Biosolids

EPD additional requirements include the following:

- Additional buffer, up to a maximum of 150 feet, may be required if in a Watershed Protection Area or Protected River Corridor.
- All wells within a 500-foot radius of the site must be identified. Additional buffer areas may be required in accordance with the Wellhead Protection Act. Deviations may be approved by EPD on a case-by-case basis.

Buffers to individual private wells on the application site may be reduced to as low as 100 feet if the property owner's written consent is obtained.

Storage Requirements

EPD's *Guidelines for Land Application of Sewage Sludge (Biosolids at Agronomic Rates)* states that *"If the biosolids must be stored due to weather or operational concerns, it may be stored only on the wastewater treatment plant site or, if on the application site, in an enclosed tank or building for a period not to exceed 30 days."* EPD has advised that the limitation of 30 days applies to storage at both the wastewater facility and at the land application site.

The Guidelines also note that storage "must not result in runoff, odor complaints, or other environmental problems."

Based on feedback from biosolids management contractors operating in the state, the prohibition of field storage can be a major barrier to Class B land application. Securing additional land application sites may mitigate this barrier.

County Approvals

EPD requires county approval before allowing Class B land application, but at least one county (Dawson) has banned the land application of Class B biosolids and another (Lee) has banned biosolids land application completely.

The ban began with resistance to a proposed land application site in the county in 2012 and was enacted in 2013. Supporters of the ordinance believed that a statewide effort to provide other counties with jurisdictional control was needed, and so worked to change state rules. The resulting House Bill 741 set forth the county level approvals now required by EPD for Class B land application sites. EPD specifically requires that Class B land application must comply with a jurisdiction's land use plan and sets forth the requirements for public meetings.

Additional Permit Requirements

In addition to the above requirements, the sludge management rules include the following:

- Composting facilities are required to have a Solid Waste Handling Permit from EPD, unless the composting operation is part of a treatment works already regulated by an NPDES, LAS, or other permit from EPD.
- Heat-drying (thermal drying) or incineration facilities must obtain an Air Quality Permit from EPD,
- Additional requirements and approvals with the GDA.

Georgia Department of Agriculture Regulations

The GDA requires that biosolid-based soil amendments (such as compost) and fertilizer be registered with the agency prior to distribution. The department notes that only Exceptional Quality and Class A biosolids will be considered for registration under the Georgia Soil Amendment Act. EPD mirrors that requirement, stating in their land application rule that "preparers proposing to sell or give away sewage sludge in a bag or other container for application to the land, must first obtain approval from the Georgia Department of Agriculture."

Effective December 2019, GDA added new requirements for both industrial byproducts and biosolids-derived soil amendments. These additional requirements are reflected in Table 4-2, along with other requirements for both soil amendments and fertilizers.

Regulatory Trends

Regulatory trends in land application are driven by uncertainties regarding biosolids safety (especially with regard to per- and polyfluoroalkyl substances, or PFAS), odors at land application sites, and, in some areas, soil phosphorus and runoff concerns. While not yet a major focus, microplastics in biosolids are beginning to see increasing research and might have an impact on biosolids use in the future. Each of these issues is discussed below.

Table 4-2 Georgia Department of Agriculture Product Distribution Requirements

	Georgia Soil Amendment Act	Georgia Fertilizer Act
Applies to	Compost and other soil amendment distributors	Fertilizer distributors
Category	Soil amendments derived from sewage sludge	Fertilizer, specialty fertilizer (1)
General Requirements	• Annual registration • Application form submittal • $55/yr fee	• Annual licensing • Reporting (product sampling, tonnage) • Labelling (weight, brand, guaranteed nutrient analysis, licensee name, nutrient source, etc.) • $100/yr fee
Biosolids Submittal Requirements	• Product label information • Classification of source material • Identification of facilities contributing to product • Intended product use • Recommended application rates and frequency • Nutrient, mineral, and metal content • Total and volatile solids content • Fats, oils, and grease (FOG) content	• Product label (with nutrient content) • Macronutrient content • Secondary nutrient and/or micronutrient content (2) • Identification of secondary and micronutrient sources (2)

(1) Specialty fertilizer means a fertilizer distributed for nonfarm use, such as, but not limited to, home gardens, household plants, lawns, shrubbery, flowers, golf courses, municipal parks, cemeteries, greenhouses, and nurseries. The term also includes any fertilizer distributed in packages having a net weight of 10 pounds or less.
(2) Required for specialty fertilizers.

Biosolids Safety.

Over the years, the 503 rule has been assessed and a number of comprehensive studies and other federal rules have supported its protectiveness. Recently, a November 2018 audit by the EPA Office of Inspector General (OIG) raised concerns about EPA's obligations and responsibilities to assess and update regulations, as needed to ensure the rule has been properly reviewed and updated in accordance with the requirements of the Clean Water Act (CWA), emphasizing the lack of information on unregulated pollutants.

The EPA Office of Water raised concerns regarding the report (noted in Appendix D of the OIG Report), and following further discussion and correspondence with the OIG, agreed on a final resolved list of corrective actions and target completion dates. The OIG report, the EPA Office of Water Response and the final resolved list of corrective actions can be found here.

Key recommendations and actions relating to risk assessment arising from the OIG report are summarized in Table 4-3.

In July 2020, the U.S. Department of Agriculture's National Institute of Food and Agriculture Research Committee (known as the W4170 group) published a report referencing the OIG report with the objective of providing a science-based review of chemicals of concern. This report can be found here.

As part of EPA's response, a national biosolids meeting was held in December 2020 and the summary can be found here.

Table 4-3 OIG Risk Assessment Recommendations and Agreed Actions

OIG Recommendation	Action	Expected Completion Date
Complete development of probabilistic risk assessment tool and screening tool	Working to complete, screening expected first, followed by probabilistic modeling framework	12/31/21
Develop/implement plan to obtain data for risk assessments, promulgate regulations as needed	Will use screening tool to determine which pollutants warrant risk assessment	12/31/22

Per- and Polyfluoroalkyl Substances (PFAS)

The list of pollutants addressed by the OIG audit included a class of chemicals that have been an increasing focus for drinking water: per- and polyfluoroalkyl substances, or PFAS. These chemicals have been widely used for 50 years in consumer products, firefighting foams, and manufacturing. PFAS are characterized by a carbon molecule bonded to a fluoride molecule, one of the strongest chemical bonds in nature and so they are sometimes called "forever chemicals."

Figure 4-4 shows typical contributors to PFAS in WRRF influents as well as what is known with respect to fate and transport through wastewater treatment (based on limited information) and specific concerns regarding PFAS and biosolids land application.

Although the PFAS family includes thousands of individual chemicals, two dominant compounds – perfluorooctanoic acid (PFOA) and perfluoro octane sulfonate (PFOS) – have been a key focus of regulatory activities.

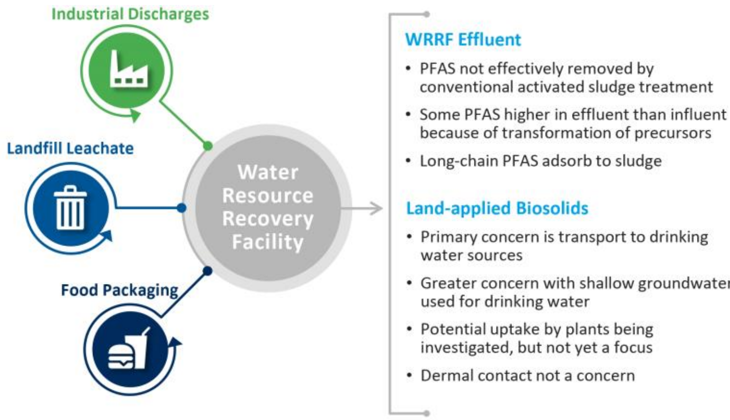


Figure 4-4 PFAS Sources and Concerns

A 2016 EPA drinking water advisory of 70 parts per trillion (ppt) for PFOA and PFOS (separately or combined) began a chain of events that expanded the focus on these contaminants – and has now impacted biosolids programs. Soon after the 2016 advisory, some northeastern states adopted the 70 ppt limit as a drinking water standard; in one case, a lower standard of 20 ppt was adopted, and the number of states establishing drinking water limits for PFOA, PFOS, and in some cases, other PFAS continues to increase. Since that time, some other states have established drinking water standards in the ppt ranges.

In February 2019, the focus on PFAS culminated in a PFAS Action Plan issued by EPA and while the plan primarily addressed drinking water concerns, some elements of the plan could impact biosolids as well. EPA issued an update to the plan in February 2020. Elements that could impact biosolids are summarized in Table 4-4.

Table 4-4 EPA PFAS Action Plan Activities That Could Impact Biosolids

Topic	PFAS Investigations/Proposals
CERCLA inclusion	Will follow through on the regulatory development process for listing PFOA and PFOS as hazardous substances under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)
Toxics Release Inventory (TRI) inclusion	Issued advanced notice of proposed rulemaking that would allow the public to provide input on adding PFAS to the TRI toxic chemical list
PFAS manufacturing and importation restrictions	Proposal to ensure that certain persistent long-chain PFAS chemicals cannot be manufactured in or imported into the United States without notification and review under the Toxic Substances Control Act (TSCA) is currently undergoing interagency review at the Office of Management and Budget
CWA inclusion	Exploring data availability and research to support the development of Clean Water Act human health and aquatic life criteria for certain PFAS
Biosolids risk assessments	Developing risk assessments for PFOA and PFOS in biosolids, to better understand any potential public health or ecological impacts

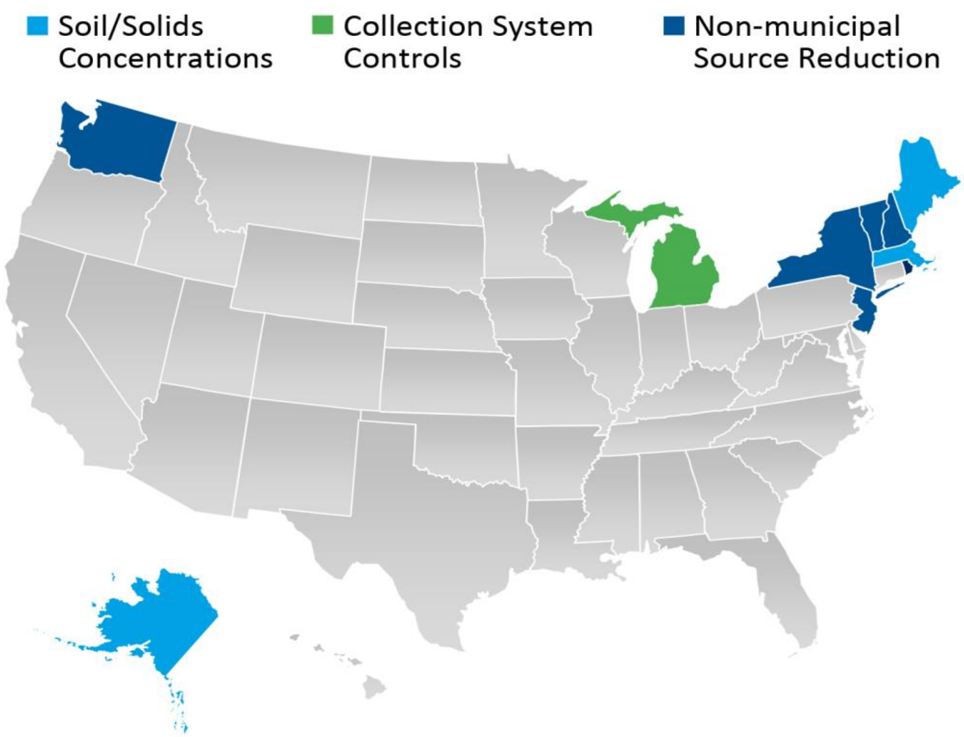


Figure 4-5 Non-Drinking Water State PFAS Control Approaches

The agency has also issued multiple PFAS guidance documents, including:

- Interim Strategy for NPDES Permits (November 2020) – Calls for incorporation of permit requirements for PFAS monitoring and best management practices. The guideline focuses on a "phased approach" to PFAS permit provisions, reflecting in part the current lack of approved analytical methods for non-drinking water matrices.
- DRAFT Interim Guidance on Destroying and Disposing of Certain PFAS and PFAS-Containing Materials That Are Not Consumer Products – This guideline was issued in December 2020 for public comment, and the comment period closed February 22, 2021. Land application is noted as being outside the document scope, but other language is somewhat ambiguous.

With the exception of the biosolids risk assessments now underway at EPA, the impact of the PFAS Action Plan is somewhat uncertain. For example, it is believed that should PFAS be included in CERCLA, that current exemptions (normal fertilizer use, recycling activity, etc.) might limit the impact on biosolids programs. And, to date, CWA efforts appear to focus on industrial discharges.

Going forward, the general focus on PFAS at EPA is intended to intensify, as the agency assesses these materials across multiple industries. The April 2021 formation of the EPA Council of PFAS reflects both the agency focus on these PFAS compounds and the need for coordination amongst multiple stakeholders. According to EPA Administrator Regan, the Council is to identify "pragmatic approaches to deliver critical protections" to the public. Key objectives of the program include development of the PFAS Strategic Roadmap which was released in October 2021. This multi-year strategy aims to address cross-media PFAS concerns, coordinate with other agencies, leverage funding support and expand engagement opportunities.

Efforts to control PFAS are not limited to the EPA – federal legislation efforts (highlighted in the text box at right) are underway and, while waiting for federal guidance, some states have moved forward with PFAS control measures for biosolids.

While the focus remains on drinking water, the impacts on biosolids programs in some areas has been profound. In March 2019, the state of Maine suddenly enacted what amounts to a biosolids land application ban in response to concerns regarding PFAS in milk from a dairy farm (though the state agency acknowledges that they cannot determine the source of the PFAS as many different types of residuals were applied on the farm). In Florida and a few other locales, biosolids have been turned away from landfills because of PFAS concerns. In Michigan, land application programs have been impacted while the state environmental agency determines a plan to address PFAS that appear to originate from some industrial discharges.

To date, approaches developed by states to address this concern fall into several categories, shown on Figure 4-5 and described below.

- **Soil/solids concentration limits**: Maine's land application limitation is based on low allowable biosolids PFAS screening concentrations that few biosolids are expected to pass. The state has established these standards for PFOA (2.5 parts per billion [ppb]), PFOS (5.2 ppb) and PFBS (1,900 ppb). For utilities whose biosolids exceed these standards, the state will require additional studies to determine the safety of biosolids applications.
  Alaska is an example of a state adopting a similar approach. Proposed regulations had called for soil clean up if soils exceed certain standards. The state utilized a risk-assessment-based approach to set ppb-level soil limits for several PFAS compounds. Though risk-based, there are grave concerns about key assessment assumptions that have a profound impact on allowable limits (such as soil organic matter content), as well as the enforceability of such limits in the absence of approved test methods.
- **Collection system controls:** Michigan implemented a tiered plan founded on sampling at a variety of WRRFs around the state and focused on WRRF effluent PFAS concentrations. This provided the basis for a state-wide industrial pretreatment program

PFAS Legislative Initiatives

The EPA focus on PFAS is echoed on Capitol Hill.

PFAS is a priority under the Biden Environmental Justice Plan, which supports the inclusion of these compounds in CERCLA. Additionally, legislative efforts in both the House and Senate that had faded during the pandemic are now being reintroduced. For example, in late April the House introduced the PFAS Action Act of 2021 (an update of the 2019 bill) which could impact CERLCA, Clean Air Act (CAA) and Clean Water Act (CWA) requirements. The recent reintroduction of the bicameral Clean Water Standards for PFAS Act provides another example of revisited PFAS legislation.

(IPP) initiative. Where effluent concentrations are low, i.e., less than 12 ppt, influents are assumed to be low as well (as PFAS are not effectively removed by conventional wastewater treatment processes) and no action is required. PFAS effluent concentrations between 12 and 50 ppt require quarterly monitoring and efforts to work toward source reduction. Facilities with effluent PFAS concentration greater than 50 ppt must implement source reduction, quarterly effluent monitoring, and biosolids monitoring. The Michigan Department of Environmental Quality has now set PFOA/PFOS surface water quality standards. Other states (California and Washington) are following the Michigan lead and initiating statewide PFAS surveys as a potential first step in addressing PFAS concerns.

- Non-municipal source reduction: Though limited, data suggests that PFAS are not effectively removed by wastewater or solids treatment processes. Thus, some states are focusing on source reduction to manage these compounds. For example, Washington state has passed bills eliminating PFAS in food packaging, and New York, Rhode Island, and New Jersey are considering similar measures. Additionally, Michigan and New York are banning PFAS in firefighting foams.

At this time, Georgia EPD is focused on drinking water with respect to PFAS. EPD has already conducted multiple sampling rounds in the state. Additional information on PFAS activities in the state can be found at https://epd.georgia.gov/pfoa-and-pfos-information.

As EPA moves toward Maximum Contaminant Limits (MCLs) for some PFAS compounds in drinking water, potential impacts on biosolids land application warrant continued attention.

With respect to biosolids, it is critical to note that EPA has not yet promulgated a Clean Water Act analytical method for PFAS. At the time of this report writing, EPA announced the first validated laboratory method, Draft Method 1633, to test for 40 PFAS compounds in wastewater, surface water, groundwater, soil, biosolids, sediment, landfill leachate, and fish tissue. EPA development of analysis methods for PFAS is ongoing at the time of writing and the latest information can be found on the EPA website here.

Michigan's PFAS Approach: Focus on Industrial Pretreatment Programs (EGLE, 2021)

- Identify industrial users in WRRF collection system that were potential sources of PFAS.
- Sample probable sources and WRRF effluent if sources were above screening criteria (12 ppt PFOS).
- Require source reduction at confirmed sources. Currently being accomplished through pollutant minimization plans, equipment/tank change/clean outs, product replacement, and installation of pretreatment to remove PFAS, specifically PFOS, prior to discharge.
- Monitor compliance of confirmed sources and ensure that they meet local IPP PFAS requirements.
- Submit reports and monitoring results as required by EGLE's Water Resources Division.
- Investigations are ongoing to determine "industrially impacted" biosolids and associated risks.
- More information about Michigan's IPP PFAS Initiative can be found at EGLE's website here.

Odors

Odor continues to drive regulations on both state and local levels.

Rule changes enacted in 2014 in Texas provide an example of state-level impacts. Odor complaints received for two biosolids products in Texas, both of which had lime added but used Alternative 4 to demonstrate Class A status, led to regulator concerns about the odor of products qualifying for Class A under Alternatives 2, 3, and 4. Based on these concerns, the state added a third tier for pathogen reduction: Class AB biosolids. When surface applied, these materials are subject to a host of requirements that are more stringent than Class A products, including signage at application sites, buffer zones, staging of biosolids away from odor receptors, and best management practices (BMPs) to address tracking of biosolids off-site. Class AB products do not require permits for use (permits are required for Class B applications), and, like Class A biosolids, are managed under the state's notification tier. With the new regulations, however, all biosolids (with the exception of value-added materials such as composts and heat-dried products) are also subject to additional "core requirements" that can include the development of an Odor Control Plan if deemed necessary by the Texas regulators.

On a local level (counties, cities), odors have been an initial driver behind biosolids bans. In Georgia, concerns regarding odor impacts at a nearby outlet mall were one of the reasons behind the Class B biosolids ban enacted in Dawson County and the City of Griffin withdrew a request to add additional sites because of concerns from citizens. More recently, two jurisdictions in Oklahoma also banned biosolids: the City of Choctaw banned Class B land application, citing odor and vector concerns, while the town of Luther enacted a total ban in 2020 in response to complaints regarding odors and environmental concerns.

Phosphorus

The increased focus on the environmental impacts of phosphorus (P) in land-applied manures from livestock operations has broadened in some regions of the United States to include biosolids. As is also true for manure nutrients, biosolids nitrogen (N) and P are unbalanced with respect to plant needs (the N:P ratio in biosolids is about 2:1 to 4:1, but crops need these nutrients at a ratio of about 8:1).

Consequently, some states require P-based management (statewide or in select areas). Figure 4-6 shows states that incorporate P management.

In general, the move toward P-based management poses a significant challenge to biosolids land application programs because it can lower application rates and, consequently, increase the land area required for such programs. The issue is exacerbated by the fact that most P risk tools (most commonly a "P Index") do not account for the relatively low P availability in most biosolids as compared to fertilizers and manures. The use of biosolid-specific parameters (specifically water extractable P, WEP) is increasing, however, somewhat mitigating expanded land requirements for P-based land application programs. In Georgia, as in many other states, land application rates are currently based on the agronomic plant uptake rates for nitrogen.

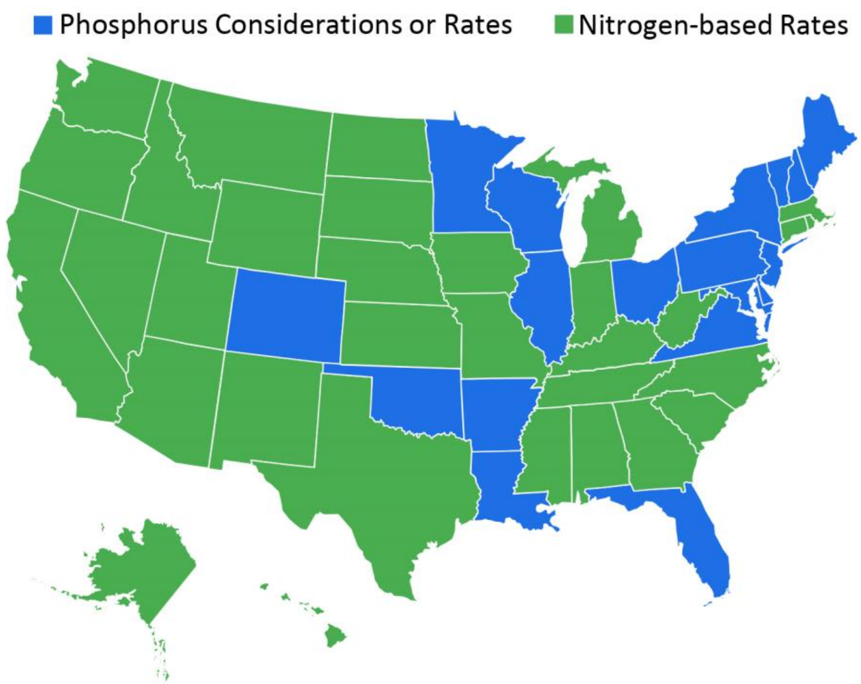


Figure 4-6 States with Biosolids P-Based Management

Microplastics

Though PFAS are commanding both regulatory and public discourse, microplastics have been raised as an increasing concern. Microplastics are small pieces of plastic (less than 5 mm in size) that may not be visible to the naked eye but can enter domestic wastewater through sources such as household dust, water from washing machines, and erosion of paints. Figure 4-7 shows microplastic types and typical sources for each.

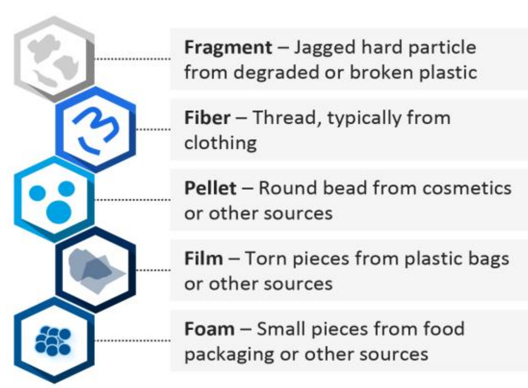


Figure 4-7 Microplastic Types and Sources

Research on microplastics in biosolids is limited, although a recent study provides some insights on both content and impacts of solids stabilization on microplastics content in biosolids. Mahon, et al. (2017) investigated the fate of these particles through different biosolids stabilization processes at seven WRRFs in Ireland. The researchers found that lime stabilization and thermal drying have higher particle counts (up to 13,675 particles per kg of dry matter) compared to anaerobic digestion (4,000 particles per kg of dry matter). The researchers postulated that the higher particle count in lime stabilized biosolids was because of shredding and flaking, while melting and blistering were potential contributors in thermal drying.

While there is limited scientific research documenting the effects of microplastics on soil (Nizzetto, Futter, & Langaas, 2016) and (Abel de Souza Machado, et al., 2018)), studies indicate that there are no adverse effects from the presence of microplastics in land applied biosolids. The benefits of organic matter and nutrients from biosolids improving the soil's microbial health are believed to outweigh the possible concerns from microplastics.

To date, there have been no federal or state regulations established regarding microplastics in wastewater or biosolids, although California has established strategic policies to explore microplastics in drinking water and the impact of these materials on the environment. Going forward, fundamental issues must be addressed before any detailed efforts to investigate these products are undertaken, not the least of which is standard methods for their measurement.

Incineration

Incineration is waning in Georgia, with only two SSIs in operation in the state. High costs, public resistance to new facilities, and other factors have contributed to the reduced reliance on this practice. Nonetheless, pressures on landfilling and uncertainties regarding the regulatory landscape for land application – particularly in areas where PFAS concerns dominate – have revived an interest in incineration.

For SSIs, regulations at both the federal and state levels focus on emissions and on ash disposal requirements.

Federal Regulations

Incineration in SSIs is regulated under both 40 CFR Part 503 and 40 CFR Part 60 *Standards of Performance for New Stationary Sources*. Table 4-5 shows key elements of the 503 rule.

In 2011, a change to the definition of solid waste had a profound impact on SSIs. Specifically, EPA ruled that all wastewater sludges that are combusted are "solid waste," and subject to the Clean Air Act (CAA) unless they meet the criteria for classification as a renewable fuel (including having a "meaningful heat value," among other criteria). This change required the development of MACT standards for SSIs.

The following rules were developed for SSIs:

- Subpart B - New Source Performance Standards, Adoption, and Submittal of State Plans.
- Subpart LLLL - Standards of Performance for New Sewage Sludge Incineration Units (§§ 60.4760 - 60.4930).
- Subpart MMMM - Emissions Guidelines and Compliance Times for Existing Sewage Sludge Incineration Units (§§ 60.5000 -60.5250).

The rule establishes emissions requirements for nine parameters, with requirements varying depending on SSI type (multiple hearth incinerator [MHI] or fluid bed incinerator [FBI]) and whether the unit is existing or new. The rule also includes testing, monitoring, reporting, recordkeeping, and operator training requirements.

Since the rule went into effect, few have attempted classification as a renewable fuel, with the result that many facilities have had to install costly emissions controls; others have found the costs to meet these new rules too high and have shut down their SSIs.

Table 4-5 40 CFR Part 60 SSI Requirements

Rule Element	Key Requirements
Emission pollutant limits	• Beryllium: 10 gallons per day (gpd) • Mercury: 3,200 gpd • Lead, arsenic, cadmium, nickel, and chromium: site-specific
Operational standard	• Emissions total hydrocarbon (THC) < 100 ppm
Management practices	• Continuous emissions monitoring for THC, oxygen, information to determine moisture content • Continuous process monitoring for furnace temperature • Maintain operating parameters specified by permitting authority
Frequency of monitoring, recordkeeping, and reporting	• Monitoring frequency for some parameters varies with solids throughput and may be reduced after 2 years operation • Records for emissions, process temperatures, sludge feed rate, and other parameters must be maintained for 5 years • Annual reports to permitting authority required

Georgia Regulations

The state promulgated Georgia Rule 391-3-1-.02 Air Quality Control Provisions to meet EPA requirements for SSIs, incorporating 40 CFR Part 60 by reference. Additionally, Georgia developed a State Plan for the Implementation of Existing SSI Guidelines (SSI Plan), which was submitted for EPA approval in June 2020. SSI owners and operators must comply with both requirements upon EPA approval of the SSI Plan. The SSI Plan includes emissions requirements for existing SSIs, as shown in Table 4-6.

Table 4-6 Existing SSI Emissions Limits

Pollutant	Units of Measurement (at 7% Oxygen)	Fluidized Bed Limit	Multiple Hearth Limit
Particulate Matter (PM)	mg/dscm	18	80
Hydrogen chloride (HCl)	ppmvd	0.51	1.2
Carbon monoxide (CO)	ppmvd	64	3,800
Dioxins/furans, total mass	ng/dscm	1.2	5.0
Dioxins/furans, toxic equivalency (TEQ)	ng/dscm	0.10	0.32
Mercury (Hg)	mg/dscm	0.037	0.28
Oxides of nitrogen (NOx)	ppmvd	150	220

Pollutant	Units of Measurement (at 7% Oxygen)	Fluidized Bed Limit	Multiple Hearth Limit
Sulfur dioxide (SO_2)	ppmvd	15	26
Cadmium (Cd)	mg/dscm	0.0016	0.095
Lead (Pb)	mg/dscm	0.0074	0.30
Fugitive emissions: ash handling	NA	5% or less of observation period	

In addition to components listed above in the federal rule and emissions limits, the SSI Plan also includes inventory requirements, compliance dates, performance testing requirements, operator qualification requirements, and other elements.

New SSI units must meet significantly more stringent standards than those shown in Table 4-6. The more stringent standards also apply if the cost of changes, over the life of the unit, excluding certain maintenance items, exceeds 50 percent of the original cost.

Implications for Solids Management

The impact of regulatory trends on solids management in Georgia varies by practice.

- Landfilling. As noted above, landfilling in Georgia remains under pressure. Slope failures at landfills that resulted in EPD reviewing landfill permits with respect to moisture content and biosolids to MSW ratios, have both limited the acceptance of solids and driven up landfill tipping fees – which are expected to exceed and remain above $70/wet ton. With the continued risk to landfill stability, the need for additional engineering and the rules requiring HMCW management plans for landfills receiving more than 5 percent HMCW in effect, this pressure is likely to continue. Moreover, history in the area (and in other areas of the United States) has shown the potential for sudden termination of service.
- Land application. Land application currently appears to be less limited than landfilling, with Class A biosolids use far less restricted than Class B use. As noted above, site-specific permitting needs, storage limitations, and the potential for county-level prohibitions are concerns with respect to the reliability of a program based on Class B land application. Conversely, regulatory restrictions on the distribution and use of Class A biosolids meeting EQ standards are minimal.

  This is not to say that the expansion of land application programs in the state is not without potential hurdles. In the immediate future, concerns (such as odors) driving local bans on land application should be considered and the generation of new biosolids products should reflect the relationship between product odor and public acceptance.

  In the near-term, potential indirect impacts from drinking water rules for PFAS may have an impact in select locations, though it is not certain whether EPA's upcoming screening assessment for some PFAS compounds in biosolids – and intensified research on PFAS fate and transport – will result in the establishment of a federal limit in biosolids for these compounds. A few states have set biosolids screening limits to protect water quality, but to date the primary state response has been focused on source reduction.

In addition, any given year there is also always a risk of legislative action impacting ongoing land application practices.

- Incineration. As noted earlier, pressures on landfilling and concerns regarding potential PFAS impacts on land application have renewed interest in this technology. Costs to construct new units are high, siting is typically an issue, and permitting requirements are stringent. Moreover, research to determine the fate of PFAS in SSIs is just beginning and potential impacts on emissions requirements uncertain.

5.0 Current Management Practices

The major methods of biosolids management in Georgia include landfilling, land application, and incineration. Each option has specific considerations and potential regulatory challenges that were discussed in detail in Section 4.0. Historically, the percentage of solids generated in Georgia and destined for beneficial use has been lower than national averages (Figure 5-1). In addition, EPA's promulgation of emissions guidelines for existing sanitary SSIs (76FR15371, (EPA, 2011)) effective May 20, 2011, affected the number of facilities in Georgia utilizing incineration, increasing the adoption of landfilling. The strong reliance on landfilling reflects the historically low cost of this practice, but costs have increased significantly and are expected to remain at elevated levels.

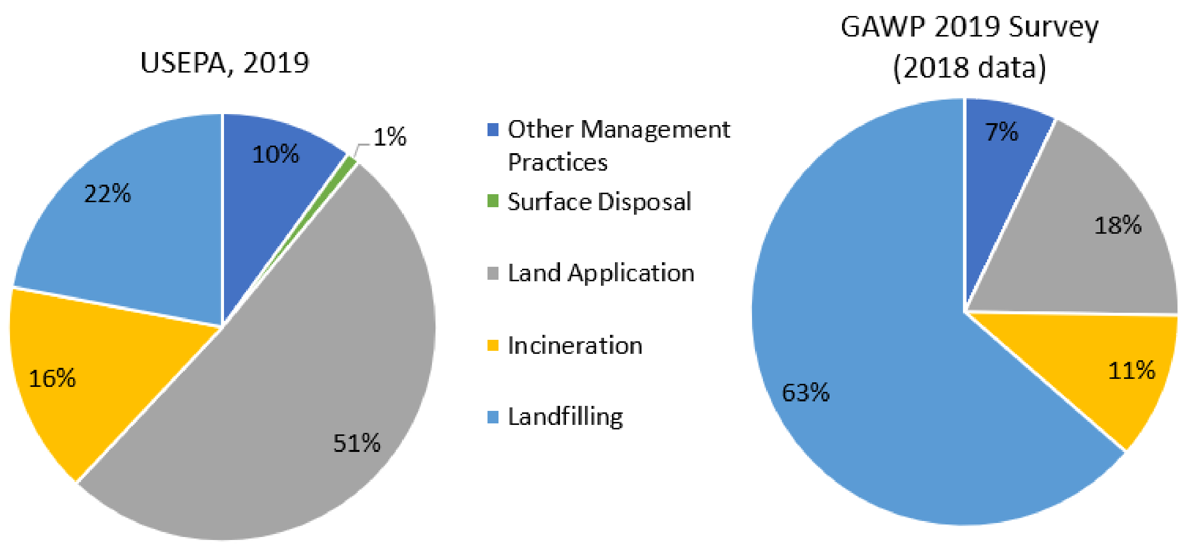


Figure 5-1 Solids Use and Disposal Practices Nationally and in Georgia

Going forward, beneficial uses for biosolids – through land application as an agricultural soil amendment or through distribution as a marketable product – are expected to play an increasing role for Georgia biosolids, with reduced reliance on landfilling.

Solids management practices in the state have been changing since 2018, when landfill slope failures resulted in industry and EPD reviewing landfill practices with respect to moisture content and biosolids to MSW ratios. This prompted many utilities to investigate and seek out alternative disposal and end use outlets. At that time, GAWP conducted a survey to better understand how this disruption was impacting solids management in the state.

Summary of Biosolids Surveys

The previous GAWP 2019 Survey was conducted in the fall of 2019 to compile 2018 permittee data. This survey was sent to all GAWP utility members and received responses from 52 communities, accounting for 99 facilities. Data were added to the survey results from EPD's Annual Biosolids Reports for 21 communities accounting for 28 facilities. In total, the GAWP 2019 Survey captured information regarding solids management practices in 2018 for 73 communities, accounting for 127 facilities. The results and findings were presented at the virtual GAWP Annual Conference in July 2020. Three other surveys were conducted prior to this in 1994, 2000, and 2006 by various entities. Landfilling in Georgia has remained under pressure since 2018 and so, as part of this study, an updated survey was conducted in 2020 to build upon the 2018 data collected in the GAWP 2019 Survey. Table 5-1 provides a summary of the recent and previous biosolids surveys that have been conducted.

The most recent State 2020 Survey conducted as part of this study aimed to capture the following information:

- Current biosolids treatment and end use approach.
- Processing and disposal costs.
- Interest in regionalization opportunities.
- Alternative approaches that may be supported through GEFA's financial incentives.

Table 5-1 Summary of Biosolids Surveys in Georgia[1]

Parameter	1994 Study	2000 UGA Study	2006 Survey Update	GAWP 2019 Survey (2018 data)	State 2020 Survey (2019 data)
Number of Facilities Considered	169	216	461 (~220 reporting)	127	122
Flow (mgd)	-	990	1,294	717[2]	720[2]
Solids Removed (dt/y)	151,875	175,221	220,854	183,133	169,022

[1] Previous survey results were obtained from Johnson & Thomas (2020)

[2] The 2000 and 2006 surveys recorded permitted flow whereas the 2019 and 2020 surveys recorded annual average flow (mgd) instead of permitted flow.

State 2020 Survey: Management Practice Results

The State 2020 Survey contained questions for both utility managers and facility personnel, which were separated into different sections. The facility questions inquired about treatment technologies currently used, flow treated, and solids produced in 2019, biosolids handling processes and final disposal methods, landfill tipping fees, hauling fees, and changes in end use or disposal contracts and practices. This section summarizes the responses from facilities and the next section describes the utility questions.

The survey responses indicate that the majority of WRRFs in Georgia (101 of 122 respondents) utilize an activated sludge process for liquid stream treatment; however, there is a large number of very small permitted facilities that likely utilize lagoons and ponds. Aerobic digestion was reported as the most common solids treatment, used by 78 of 122 respondents. For thickening or dewatering processes, 63 of 122 respondents reported using a belt press. This aligns with prior survey results, as many utilities have historically dewatered solids prior to disposal landfilling, and very few employ treatment processes that produce Class A biosolids. However, this trend appears to be changing in response to the regulatory and financial pressures on landfilling.

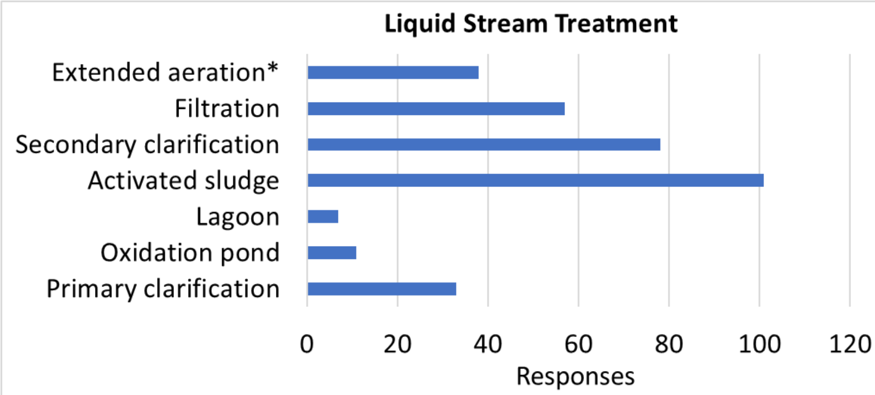


Figure 5-2 Liquid Treatment Processes Employed by State 2020 Survey Respondents (*Note: Extended Aeration Includes Oxidation Ditch)

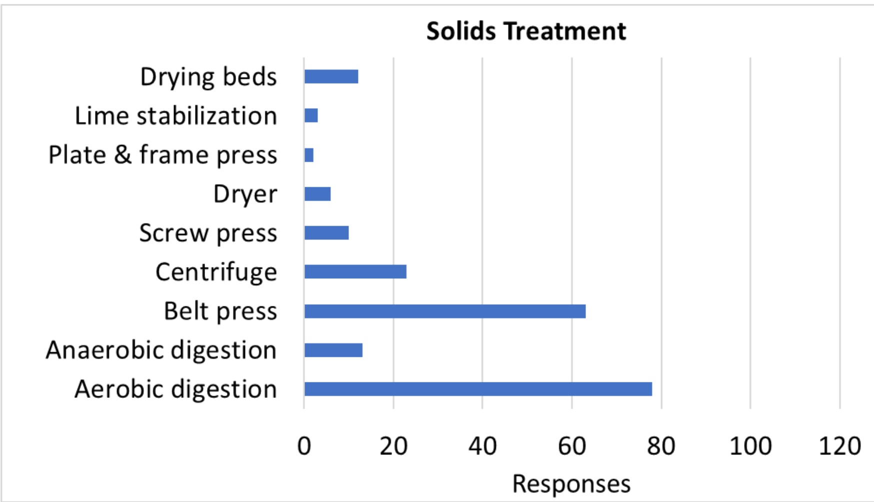


Figure 5-3 Solids Treatment Processes Employed by State 2020 Survey Respondents

In May 2021, changes to Georgia solid waste management Rule 391-3-4 were adopted. The rule change defines HMCW as "waste with a moisture content greater than 40 percent by weight (weight of liquid/total weight of sample), non-hazardous liquids, and bulk solidification agents" that includes wastewater solids with a total solids content of 60 percent or less, i.e., 40 percent moisture. As can be seen on Figure 5-4, only two facilities responding to the survey indicated producing solids at greater than 60 percent solids concentration (dryer facilities). All other WRRFs, whether utilizing dewatering processes or not, produce solids that would fall under the definition of "high moisture content waste."

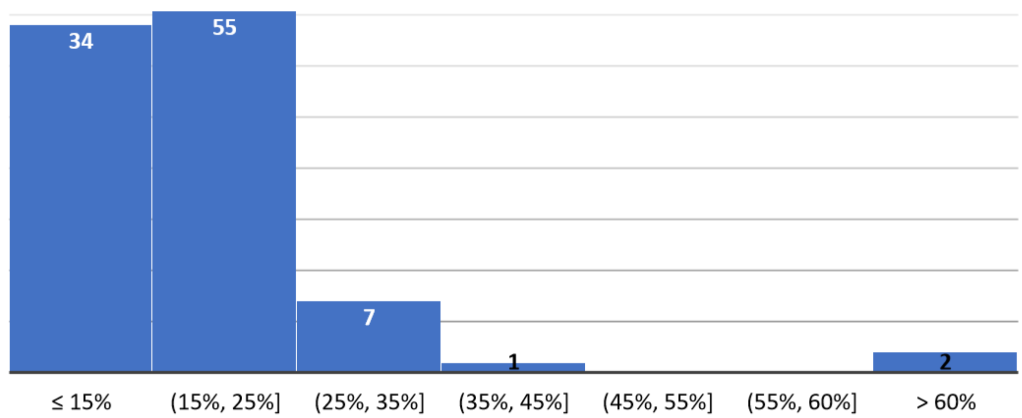


Figure 5-4 Range of % Total Solids (%TS) Reported in State 2020 Survey (2019 Data)

Most survey respondents reported no recent changes to their solids end use or disposal options. This is reflected on Figure 5-5 which shows a very little change to the results reported in the previous survey (refer to Figure 5-1).

Despite end use practices being similar to the previous survey, 14 respondents replied "yes" to having a landfill disposal or land application contract terminated by the vendor within the last 5 years because of the inability to continue under the contract terms and pricing. Several utilities commented that new projects or studies are underway to evaluate alternative solids management practices indicating that 2019 and 2020 are likely transition years for solids management practices in Georgia.

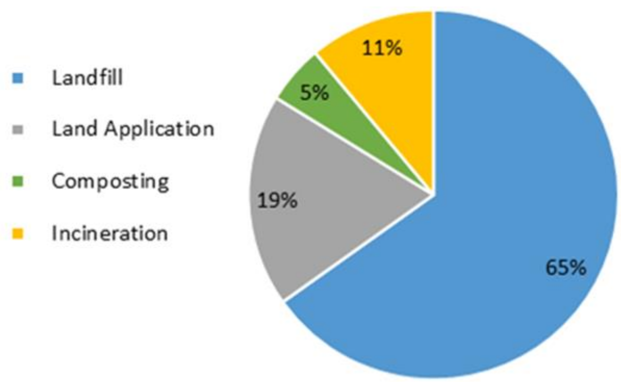


Figure 5-5 End Use Reported in State 2020 Survey (2019 Data)

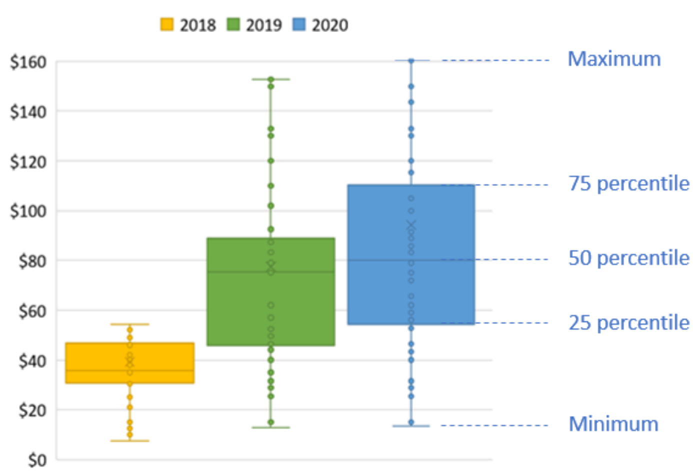


Figure 5-6 Reported Third-Party Collection Fees (Legend Shown for 2020 Data)

The State 2020 Survey also provided an opportunity to verify whether utilities are still experiencing cost increases associated with biosolids end use. Figure 5-6 shows reported third-party biosolids collection fees for 2018, 2019, and 2020. The results show a significant cost increase from 2018 to 2019 following the landfill slope failures around that time. The results also show that this pressure has continued, with results for 2020 showing higher costs than 2019. Note that some anomalous/outlying data were excluded from the chart (values greater than or less than 1.5 times the quartile range).

6.0 Future Opportunities

In addition to understanding the current solids management practices employed at WRRFs in Georgia, the State 2020 Survey aimed to gauge interest in future opportunities for biosolids management such as funding mechanisms, technologies, and regionalization opportunities.

To solicit the highest possible response rate, a request to complete a questionnaire was sent to every NPDES and LAS permittee in the state via email with contact information provided by EPD. GAWP and the Georgia Rural Water Association (GRWA) also shared the request with their utility members. Black & Veatch used LinkedIn to further amplify the message and the project team followed up with email and phone call reminders. This resulted in an overall response rate of 24 percent, which included 122 of 519 permitted facilities that reported 2019 wastewater flow data. Breaking this down further, 29 percent of NPDES permitted facilities (110 of 367) and 9 percent of LAS permitted facilities (13 of 152) responded to the State 2020 Survey. This is shown graphically on Figure 6-1.

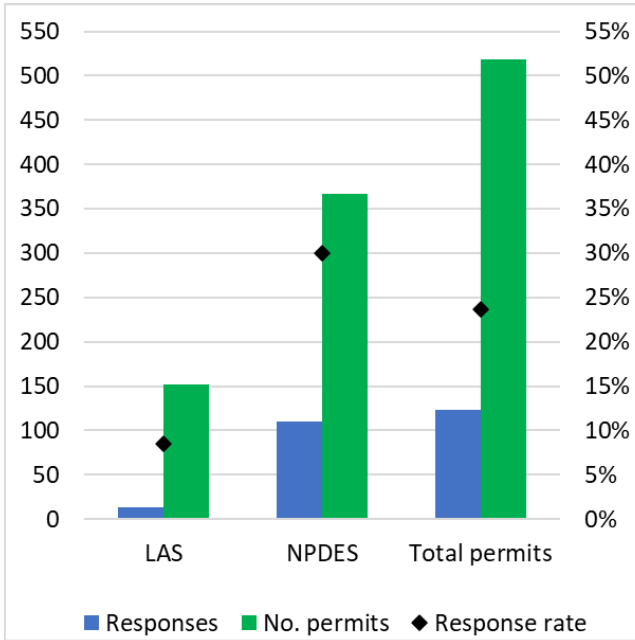


Figure 6-1 State 2020 Survey Response Rates

In addition to permit type, the responses were also analyzed by reported annual average flows for 2019. Described in Section 2.0, the estimated total annual average flow for permitted WRRFs in the state was 898 mgd. State 2020 Survey responses accounted for 720 mgd, or 80 percent of the estimated total 2019 annual average wastewater flow. The percent of 2019 estimated flow captured by State 2020 Survey respondents for each County is shown on Figure 6-2.

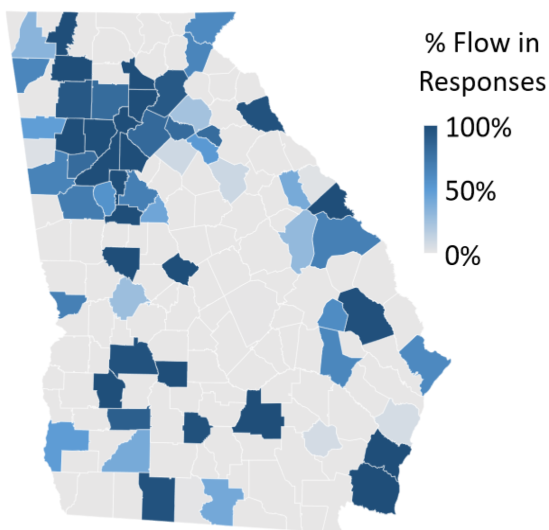


Figure 6-2 2019 Estimated Flow Captured by State 2020 Survey at County-Level

Figure 6-3 shows the permittee response rate and percent of wastewater flow captured by responses for the state and for each Regional Commission. Response rates from 10 of the 12 Regional Commissions captured 50 percent or more of the estimated wastewater flows in 2019. The Heart of Georgia Altamaha and Southern Georgia Regional Commissions had lower response rates.

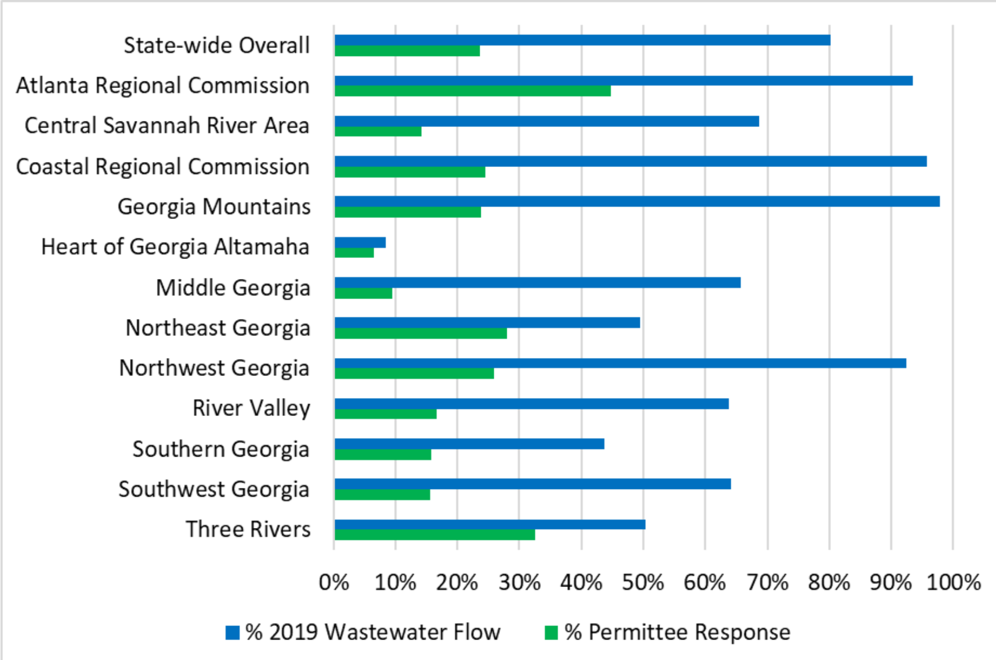


Figure 6-3 Permittee Response Rate and Percent of 2019 Wastewater Flow Captured

In general, the survey revealed a much lower response rate from facilities with LAS permits (9 percent response rate) compared to those with NPDES permits (30 percent response rate). This resulted in lower response rates from areas with a high proportion of LAS permits. Survey responses and phone conversations with LAS permit holders demonstrated that these facility types export solids infrequently. For example, LAS permittees that utilize lagoons for wastewater treatment typically only dredge the lagoon periodically (after several years of operation) to remove solids. For this reason, several LAS permittees responded that they do not produce biosolids and opted out of the survey, and it is likely that other LAS permittees did not respond for the same reason. A summary of the proportion of LAS permits by regional commission is provided on Figure 6-4.

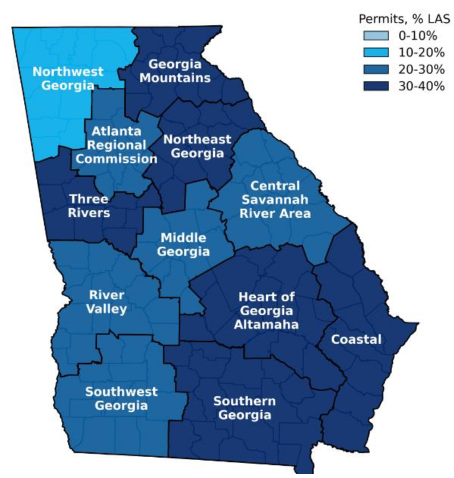


Figure 6-4 Proportion of LAS Permits by Regional Commission

The 2020 survey contained questions for both utility managers and facility personnel, as described in Section 5.0. Questions for utility managers were used to accomplish the following:

- Obtain feedback from utilities regarding potential GEFA/state funding for biosolids projects in GA.
- Gauge interest in potential regional solutions to biosolids management.
- Obtain feedback on drivers and preferences for different technological solutions to biosolids management.

Funding

Questions were posed to utilities regarding funding mechanisms to gauge current levels of participation in GEFA and State Revolving Fund (SRF) loans and to try to establish what barriers currently prevent utilities from utilizing these loans for biosolids projects.

Of the 78 utility respondents, 72 completed this section, 56 of which stated that they have obtained a GEFA or SRF loan before. Respondents indicated that the interest rates on these loans are highly attractive for potential funding of a biosolids project. Most responded that principal forgiveness is very important when making funding decisions. Less than 20 respondents stated that meeting the American Iron and Steel, Davis Bacon, and other requirements for federal funding make it difficult to utilize SRF loans. Less than 10 responded that annual funding caps negatively impact decisions to utilize GEFA loans.

Regionalization

With many utilities facing rising biosolids management costs, regionalized approaches to biosolids management may offer an opportunity to take advantage of economies of scale associated with processing biosolids from multiple facilities at one location. The survey included questions regarding regionalization to gain insight into utility managers' level of interest in regionalized solutions and potential barriers to their implementation. Specific questions and responses regarding regionalization are included below.

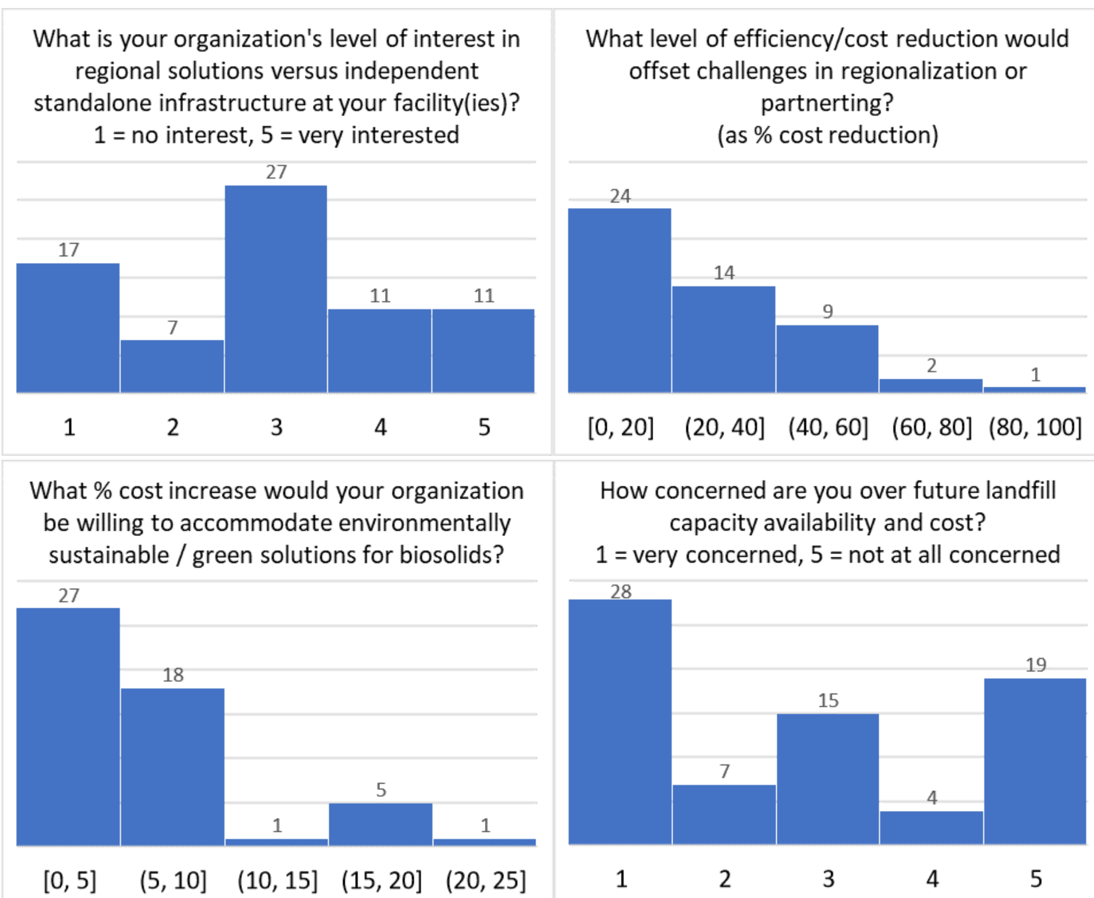


Figure 6-5 Selected Utility Questions and Responses to the State 2020 Survey

The responses show a varied level of interest in regionalized solutions from utilities that showed little interest to utilities that were very interested. A significant number of facilities (24) identified that a cost reduction of <20 percent would be sufficient to offset challenges associated with regionalization or partnering. A large number of utilities (28) responded that they were very concerned with future availability of landfill capacity and cost.

When asked "What obstacles do you foresee in 'partnering' with other similar entities and/or public-private partnerships in your geographic area?" responses provided by utilities generally fell into one or more of the following categories:

- Distance to other utilities.
- Perceived issues with cost control/cost sharing.
- Challenges with intergovernmental agreements.
- Regulatory approval.
- Financial obstacles/funding.
- Lack of interest from other utilities.

Treatment Alternatives

When asked to indicate interest of implementing various solids treatment processes, utilities showed favor toward thermal drying, composting, and solar drying over other options. Figure 6-6 shows the breakdown of responses with an answer of 1 being no interest and 5 being very interested.

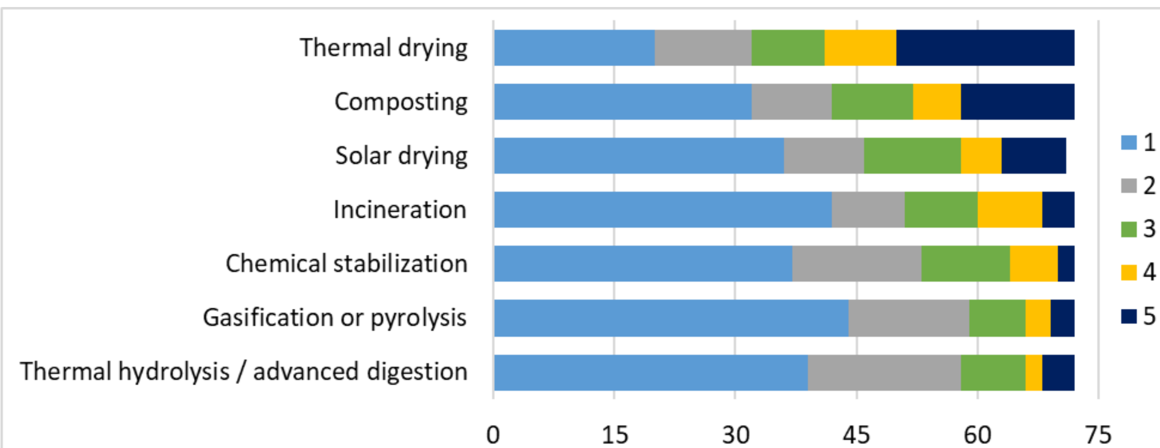


Figure 6-6 Utility Interest of Implementing Solids Treatment Processes (State 2020 Survey)

Similarly, utilities were asked how important overall cost, environmental sustainability, and resiliency of biosolids end use practice are to them on a scale of 1 to 5, 1 being of no importance and 5 being very important. The collected responses are shown on Figure 6-7 and overall cost for biosolids practices was ranked as the most important driver of the three. Resiliency of biosolids end use practice and environmental sustainability were ranked as moderately to highly important by utility respondents.

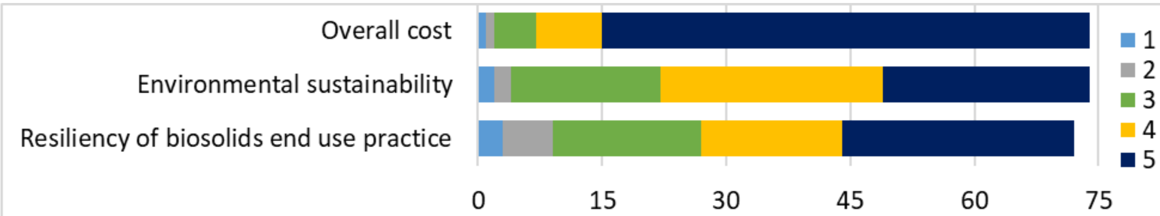


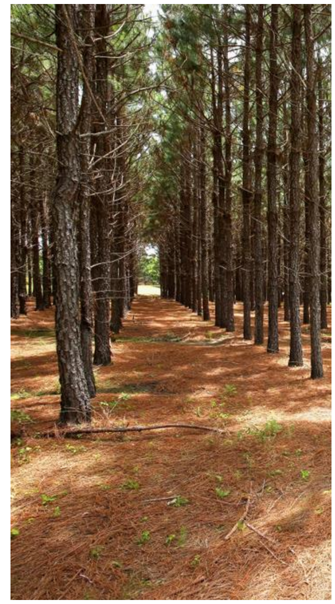
Figure 6-7 Importance of Program Drivers Related to Utility Biosolids Practices (State 2020 Survey)

Conclusions

Utility managers identified a significant level of concern with the cost and availability of continued landfilling of biosolids. As a result, there was a strong interest in technologies that are able to produce Class A biosolids, such as thermal drying and composting. Utilities showed a varied level of interest in regionalized solutions and perceived obstacles to regionalization were also varied. For some utilities, lack of interest from or distance to other utilities was a barrier, whereas for others, concerns were more related to contractual issues. In general, there was a stronger interest in regionalization from utilities in urban areas where there is a greater proximity to other utilities. Overall cost was identified as the most highly ranked driver relating to biosolids practices ahead of resiliency and sustainability issues.

In general, the survey showed that alternative (Class A) treatment approaches and (in some areas) regionalized solutions are of interest to utilities moving forward and that current GEFA and SRF funding opportunities are financially attractive to utilities, with many utilities having already taken advantage of these funding opportunities in the past.

7.0 End Use and Market Assessment



Whether transitioning from landfilling to beneficial use, or from one biosolids product to another, understanding biosolids market opportunities (and constraints) is critical. The size and location of biosolids markets, as well as user preferences within those markets, must be considered to ensure that reliable outlets are available for biosolids products.

To meet this need, biosolids markets in Georgia were assessed for this study using the approach shown on Figure 7-1. This section summarizes both the assessment efforts and results.

Figure 7-1 End Use and Market Assessment Approach

Biosolids Products and Their Characteristics

While biosolids products – and their characteristics – vary, all share common benefits to soils that reflect both the nutrients and organic matter they contain. These benefits are shown on Figure 7-2.

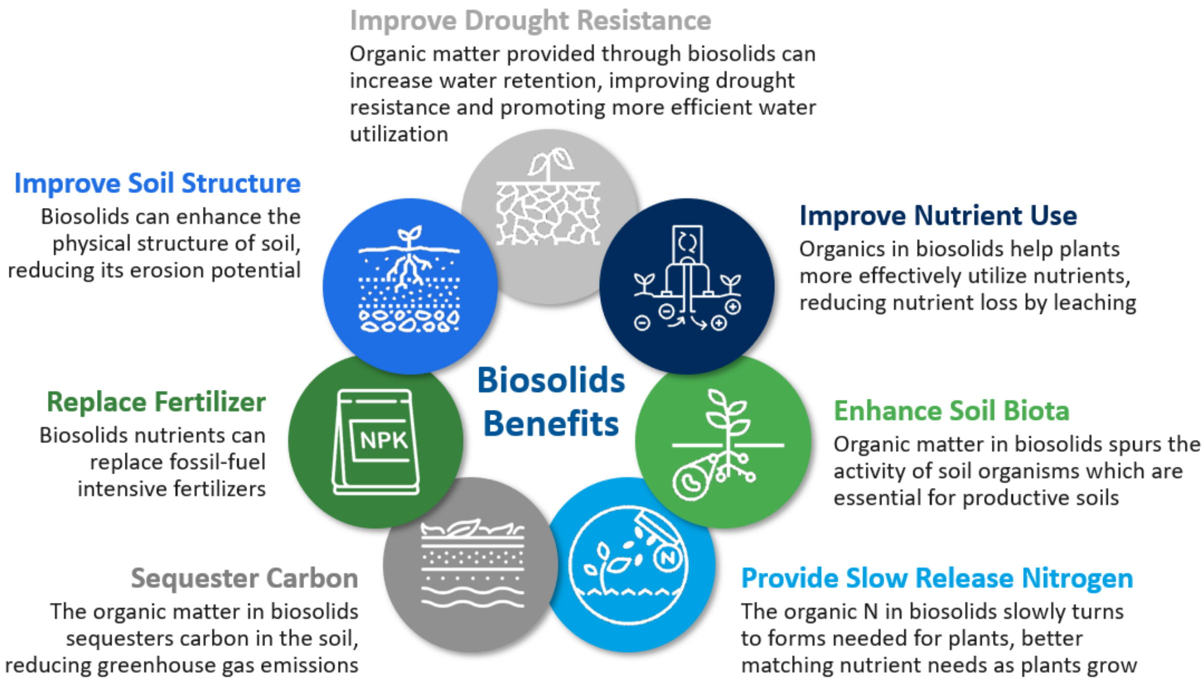


Figure 7-2 Benefits of Land-Applied Biosolids

To understand the potential markets for various biosolids products, it is important to understand how product characteristics differ. For this study, the following four general biosolids types were assessed:

- Class A or B digested and dewatered biosolids.
- Heat-dried biosolids.
- Compost.
- Lime-stabilized biosolids.

This section provides an overview of these products and sets the stage both for the identification of target markets and other market assessment activities.

Digested Cake

Digested and dewatered biosolids (aka "cake") typically have a low solids content (less than 30 percent total solids, TS) and are clay-like in appearance and consistency. This characteristic alone limits their use to agriculture or silviculture applications (without subsequent processing), as they are difficult for homeowners or other urban users to handle. Figure 7-3 shows a typical use for these products: biosolids spread on pasture fields.

Figure 7-3 Biosolids Cake Land Application for Agriculture

Cake products are differentiated by their pathogen content. Products meeting the strictest federal and state requirements are designated as Class A materials. The land application of Class B materials, on the other hand, is subject to comprehensive regulatory restrictions (discussed in Section 4.0).

In the United States, both Class A and Class B cake products are applied to agricultural or forested lands at a rate that meets the nitrogen (N) needs of growing crops. The application rate will vary, but typically ranges from about 4 dry tons/acres (dt/ac) to 8 dt/ac. Other uses include rapid vegetative establishment, erosion control, burn area restoration, and land reclamation. When applied to add organics for disturbed lands (e.g., for mine reclamation or to restore fire ravaged lands), application rates can be much higher (around 50 dt/ac).

Heat-Dried Biosolids

Dried biosolids meet Class A standards and have a TS concentration between 90 and 95 percent, depending on the drying system selected. Their shape (and use potential) varies widely, from uniform spheres (pellets, as shown on Figure 7-4), to irregular granules and large, irregular products that have been described as "Cheetos." The physical characteristics, including size, shape, hardness, and dust content, will also depend on the type of drying system used.

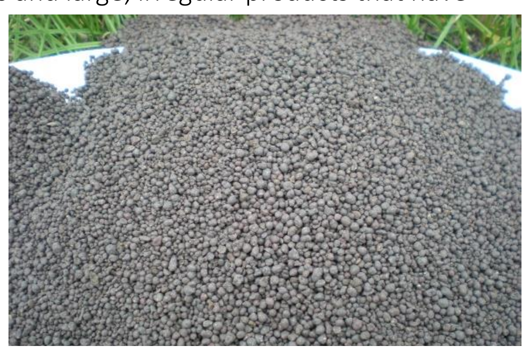


Figure 7-4 Heat Dried Biosolids Pellets

Drying has a minimal impact on product nutrient characteristics, and so the nutrient content of the dewatered cake can be used to estimate dried product nutrient content. N content is one of the most important factors in determining fertilizer value of the dried product. N content in biosolids varies, but generally ranges from 4 percent to 6 percent.

Dried biosolids have been manufactured and used for decades in the United States (a well-known product from Milwaukee, Milorganite, has been marketed nationally for nearly a century). In Georgia, the Clayton County Water Authority has manufactured a biosolid pellet for many years. The City of Savannah and City of Atlanta have installed dryers and other utilities are exploring this option as well.

Uniform, spherical pellets such as Milorganite, can be used to replace or supplement conventional fertilizer in agriculture, but can also access higher-value outlets such as golf courses and other urban markets, as well as commercial fertilizer blenders. Moreover, because of their higher N concentrations (and high-quality physical characteristics), they are highly transportable, commanding prices that can support the development of distant markets. For example, heat-dried biosolids from northern states are routinely marketed in the Sun Belt, and at least one Texas utility commanded prices "at the gate" (of the WRRF) of $35/ton for their product, which was sold throughout the mid-west. It should be noted, however, that markets take considerable effort (and time) to develop and maintain.

The typical target market for dried product from smaller operations is often regional agriculture. For example, both pellets and belt-dried material from Cary, North Carolina, are distributed to farmers in the region. Dried product made in Georgia is also currently applied to agricultural fields in the state. However, one exception to this general approach is Sumter, South Carolina where dried pellets have been produced since 1998. Sumter sells some dried product locally at a nursery and agricultural supply store, but most of it is shipped by rail to Florida for use on golf courses.

Pelletized product is typically sold in bulk or bags (depending on target market needs), while other dried products are typically marketed only in bulk form. Most producers will provide at least a portion of their product in bulk. Farmers and fertilizer blenders typically prefer the product in bulk form, so it can be loaded into spreaders or hoppers at the point of use. Homeowners typically prefer small bags, while commercial users may prefer totes or "super sacks" providing quantities of up to 2,000 pounds.

Compost

Compost is the product resulting from the controlled biological decomposition of organic waste. Biosolids composting requires a carbon source for processing (such as yard wastes, wood wastes and, in Georgia, peanut hulls). Of the products studied, compost is undoubtedly the most familiar to most consumers in the region and nationally. The product is relatively dry (generally with a TS content greater than 60 percent), and easily handled, which is attractive to users.

As a stand-alone product, compost is often used as topdressing by homeowners or turf managers (who typically spread the product at a depth of 1/4 inches to 1/2 inches on established lawns) or mixed directly into planting beds to improve poor soils (the compost provides nutrients and organic matter to the soil as it degrades). In Georgia, biosolids compost (including the well-known ERTH Food) can generally be purchased in bulk or bagged form by users; alternately, the compost can be spread with a hose by landscaping and maintenance services (Figure 7-5).

Figure 7-5 Compost Spreading via Sprayer

It is not uncommon, however, to see compost mixed with other materials, such as sand (to make a topdressing) and soil (manufactured topsoil). For example, ERTH Products includes biosolids composts in specialty mixes they prepare for bioretention ponds and other uses.

Composts are also used across the nation for erosion control and vegetative establishment in transportation projects. The Georgia Department of Transportation (GDOT) has developed specifications for compost applications, andthese specifications require that only Class A biosolids may be used to make the composts.

Lime Stabilized Biosolids

Lime stabilized biosolids can be Class A or Class B products, depending on the process used to generate them. The calcium hydroxide resulting from lime used in the stabilization process provides acid-neutralizing characteristics in these biosolids. Consequently, they are sometimes applied as “liming agents” to increase the pH of acid soils. While soils across Georgia vary, there are needs for liming in some parts of the state and in areas where soil pH has fallen because of conventional fertilizer use. Like other biosolids, lime stabilized materials also supply nutrients and organic matter, although the addition of lime reduces concentrations of these parameters compared to digested or dried materials.

Lime stabilized biosolids are typically used for agriculture only, and both the frequency and rate of application vary according to how they are used. When applied primarily for liming, both the frequency and amount of material applied is reduced compared to other biosolids. Liming may be needed only once every 3 to 5 years, depending on soil conditions, at application rates ranging from 2 to 8 dt/acre. Class B lime stabilized biosolids, which can have a lower lime content than some Class A materials, may be applied more for their nutrients and organic matter and so can be more frequently applied and at higher rates than liming materials.

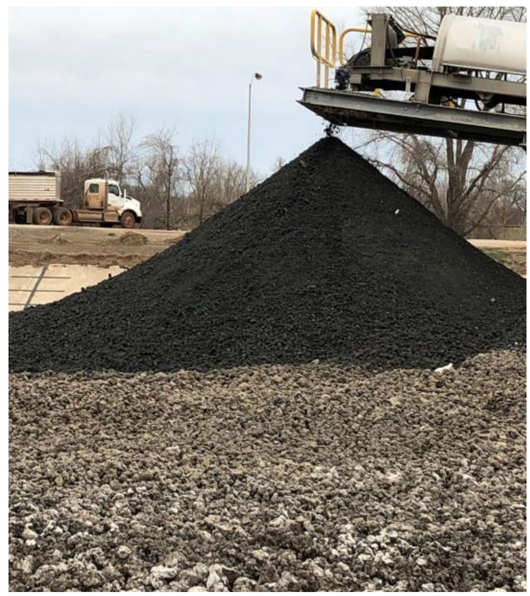


Figure 7-6 Class B Lime Stabilized Biosolids

The limitation of these products to primarily agricultural markets is a function of their typical pathogen content (Class B processes are more common), the handling characteristics of the material and, in some cases, product odor. Typical Class B limed biosolids are similar to dewatered cake but may be slightly drier because the lime addition (Figure 7-6). At least one proprietary Class A technology, however, dries its product to a soil-like consistency and markets the material beyond agricultural outlets.

Target Market Characterization

Biosolids products described in the previous section are used in a wide variety of markets. Table 7-1 lists target markets initially considered for each of the products assessed in this study. As shown on the figure, compost and dried biosolids provide the most flexibility. Although dewatered cakes and lime stabilized materials have the fewest potential markets, the markets they might access are vast in terms of available land for biosolids applications.

Most biosolids products can access markets within 50 miles of the facility where they are generated.

Table 7-1 Preliminary Target Markets

Potential Target Market	Digested Biosolids Cake	Dried Biosolids	Biosolids Compost	Lime Stabilized Biosolids
Agriculture	●	●	●	●
Silviculture	●	●	●	●
Sod Farms		●	●	
Golf Courses		●	●	
Parks and Recreation		●	●	
General Urban Use		●	●	
Georgia DOT			●	

Characterization Approach

Each of the remaining target markets were explored using a combination of land use databases and typical application rates to define potential market size, supplemented by interviews with gatekeepers to define market preferences, as shown on Figure 7-7.

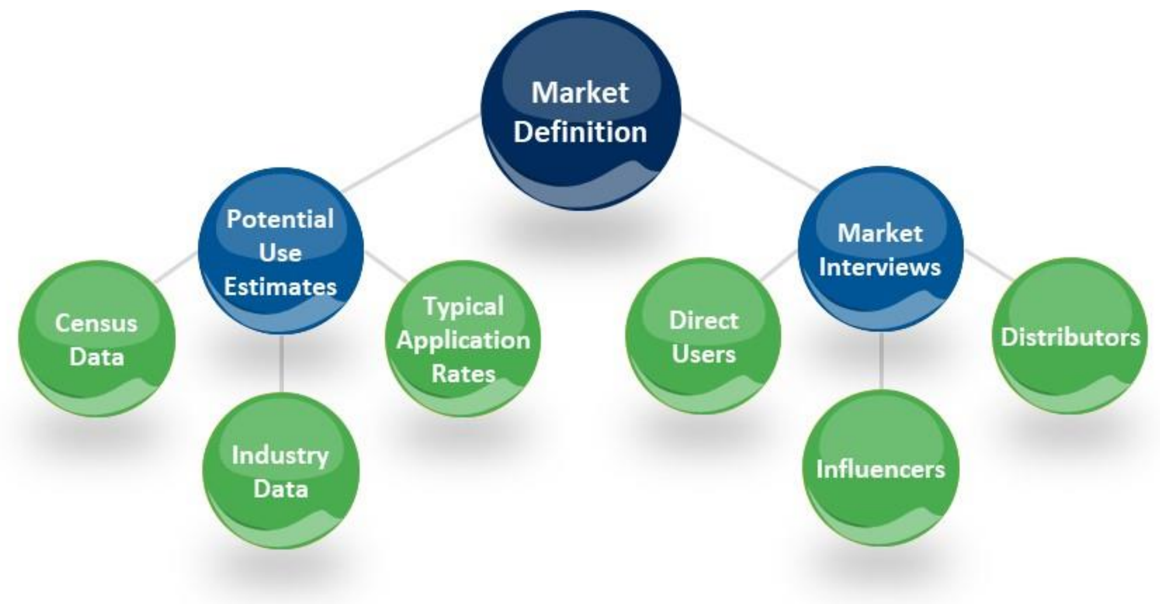


Figure 7-7 Market Characterization Approach

Potential use estimates relied on the databases and reports listed in Table 7-2 to quantify lands that might be available for biosolids land application.

Table 7-2 Land Base Estimate Sources

Target Market	Database/Report
Agriculture	2017 USDA Census of Agriculture
Silviculture	USDA Forest Service EVALIDator database
Sod Farms	2018 UGA Center for Agribusiness & Economic Development Farm Gate Value Report (FGVR)
	2021 Sod Producers Report (Urban Ag Council (UAC) of Georgia and a UGA Turfgrass Extension Specialist)
Parks & Recreation	USGS Protected Areas Database 2.0
Golf Courses	Golf Club Inventory, Georgia Chapter of the Golf Course Superintendent Association of America (GCSAA)

For market interviews, participants were selected to reflect not only target markets, but also different types of gatekeepers, including the following:

- Direct users – potential consumers of biosolids products.
- Influencers – this group includes gatekeepers (such as UGA staff and extension agents) that others rely on for guidance.
- Distributors – parties who collect treated biosolids and distribute them to potential users.

Table 7-3 lists gatekeeper interviews contributing to the project findings.

Table 7-3 Gatekeeper Contacts

Target Market	Company/Agency
Sod Producers	University of Georgia
	Southeastern Sod
Golf Courses	Golf Course Superintendent Association of America (GCSAA) Georgia Chapter
	The Landings Club
Parks and Recreation	City of Roswell
	Gwinnett County Parks and Recreation Department
General Urban Use	ERTH Products
	Urban Ag Council of Georgia
Agriculture	DFP Ag Services
	UGA Stripling Irrigation Research Center
	Denali Water Solutions
Silviculture	Georgia Forestry Commission
	University of Georgia

Photos and characteristics of potential biosolids products (shown on Figure 7-8) were shared with each interviewee to clarify the understanding of product differences.

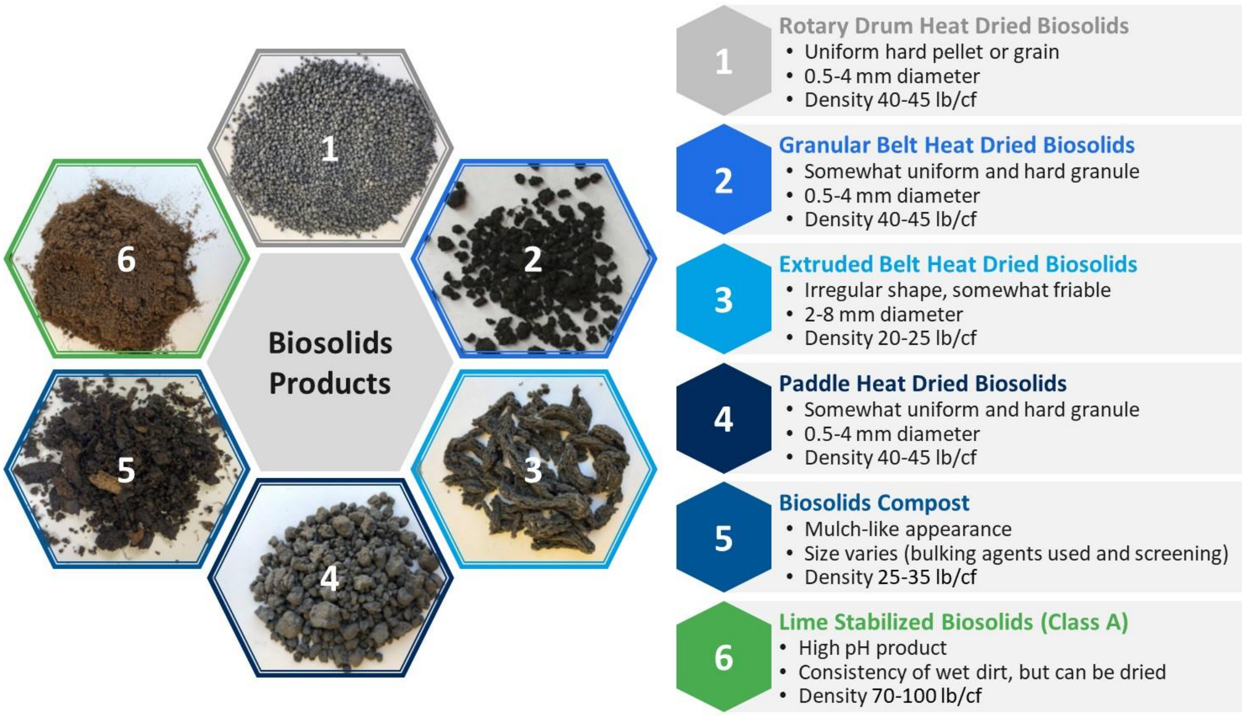


Figure 7-8 Biosolids Characteristics Summary

Agriculture

According to the USDA's 2017 Ag Census Report, approximately 10 million acres in Georgia are used as farmland, including cropland, pastureland, and woodland. Of these, biosolids are most often applied to pasture/forage lands, wheat, corn wheat, and soybeans. Note that another key Georgia crop, cotton, is not typically used for biosolids applications because of its low nitrogen needs.

Information in the 2017 Ag Census Report was used to estimate the number of agricultural acres available for biosolids application for each of the agricultural commodities listed above. The report is a comprehensive summary of agricultural activity and includes number of farms by size and type, inventory, and values for crops in each county. Figure 7-9 summarizes the total amount of land used historically for crops that are particularly suited to biosolids land application. In total, the categories shown represent about 1.1 million acres of land.

While the total acreage for each crop reflects the potential capacity for land application of biosolids, it is important to note that logistical considerations will impact potential biosolids use. For example, application windows and nutrient requirements vary by crop. Contractors typically target an approximate split of 70 percent grasses/pasture to 30 percent row crops for biosolids application because row crops have a limited window for application and pasture is more flexible.

Interviews with gatekeepers working in Georgia's agricultural sector revealed an interest in biosolids use. Biosolids are already applied in some areas, and reportedly the demand for heat-dried biosolid pellets exceeds supply. Additionally, Georgia soils tend to be acidic and the addition of a lime stabilized biosolid could be beneficial to maintain an optimum pH for agricultural productivity. Organic matter depletion is also an issue for state soils, and while some apply poultry litter to address that need, biosolids could supply needed organic matter as well.

Interviewees identified a number of preferences with respect to potential biosolids use, which are summarized on Figure 7-10. The two key issues were spreadability and cost. The ability to spread the material with farmers' existing equipment (conventional fertilizer spreaders or manure spreaders) was viewed as critical. Cost was also a driving concern, encompassing not only the product price, but also the labor required to spread the material. Profit margins for some agricultural practices can be relatively low, and so any product that can limit both time devoted to spreading and fertilization expenditures would be preferred.

With respect to preferred products, interviewees were generally receptive to all products except the extruded belt-dried material and compost. For all products, spreadability with existing equipment (primarily fertilizer spreaders in this area) was a concern and the density of the extruded product was deemed unfavorably with respect to labor requirements as well.

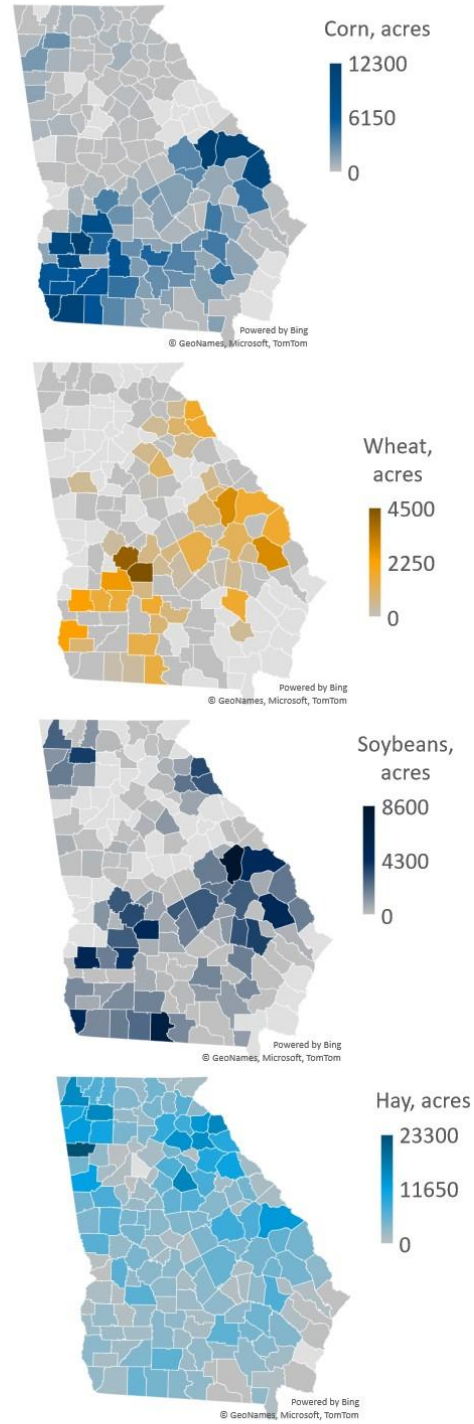


Figure 7-9 Acreage for Targeted Crops, USDA 2017

For biosolids cake, concerns included labor for spreading, so a third party may need to land apply the material (at a competitive price) to address these concerns. This approach has been successfully adopted for some lime stabilized products in the state, and these products are in high demand.

Discussions with contractors also found that Class B application programs can be more difficult to initiate because of field storage limitations, and therefore Class A products are preferred.

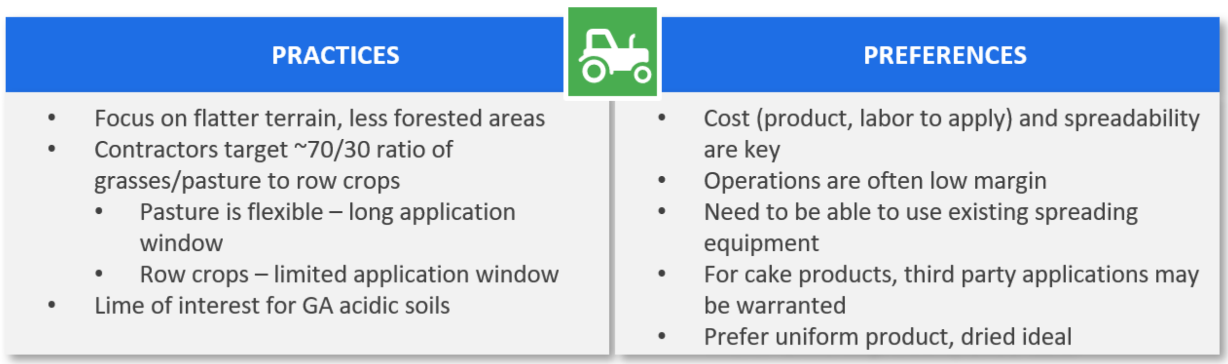


Figure 7-10 Agriculture Practices and Preferences

Silviculture

With an estimated 24.5 million acres of forest (USDA, 2018), Georgia is well known for its vast timberland that supports a thriving silviculture industry and production of pulp, paper, and many wood-based goods. According to the USDA, most forest land (approximately 89 percent in 2019) is owned by private landowners. Industrial owners include Timberland Investment Management Organizations (TIMOs) and Real Estate Investment Trusts (REITS) as well as paper companies and sawmills.

Most trees that are cultivated and harvested by the silviculture industry in Georgia are loblolly pine, which has shown a positive response in growth when fertilized with biosolids in both Virginia and Florida. Case studies conducted in Virginia, Florida, the Pacific Northwest, and New Zealand have shown biosolids fertilization leads to growth in height and diameter that outpaces that of trees fertilized with traditional, chemical fertilizers. However, this increased growth may not be ideal for higher quality products used for construction, as the slow growth is needed to provide wood strength.

Figure 7-10 provides a summary of the land base stocked with timberland in Georgia based on data from USDA's EVALIDator database.

Although there is a large land base of forestland for potential for biosolids fertilization, barriers to this market include the following:

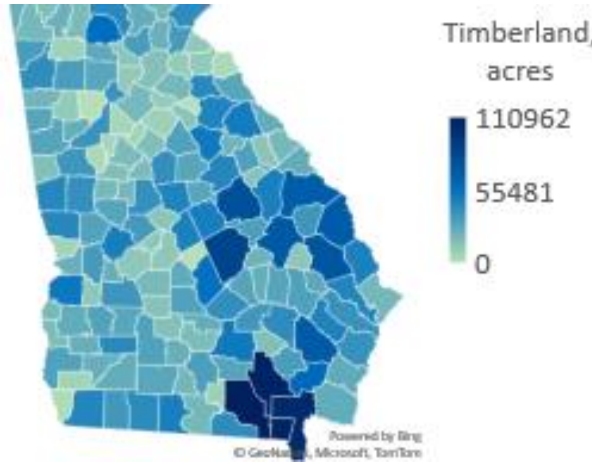


Figure 7-11 Stocked Timberland Acres, USDA 2018

- Land application methods that differ from the agriculture sector (forests may be hilly). Helicopters are sometimes used for fertilization. For both aerial and terrestrial spreading, a hard and uniform product (rotary drum or back-mixed dried biosolids) is preferred for even distribution. For terrestrial applications, the dried product is also preferred to minimize compaction from spreading equipment.
- Ownership patterns. Approximately 90 percent of Georgia's forests are privately-owned, of which 50 percent are family forest owners. Family-owned forests tend to be smaller, averaging 140 acres in size. Typically, these owners do not have the resources to invest in proactive forest management. Investor-owned or other large forests may have better resources to take on a fertilization program with biosolids.
- Timber markets. Currently, timber supply exceeds demand by 48 percent, and so owners may not be motivated to increase tree growth rates with biosolids.
- Fertilization frequency. Timber is not typically fertilized on an annual basis. Frequencies vary but might be limited to post-planting of new trees and possible applications every 5 to 10 years.
- Public perception. One researcher found that a landowner refrained from using biosolids as they planned to sell the land and had concerns about liability should the next landowner, or the public, view it negatively. If a utility moves forward in this market, a focus on large landowners with no intention to sell is recommended.

Interviewees described fertilization practices and identified a number of preferences with respect to potential biosolids use, which are summarized on Figure 7-12.

PRACTICES

- Trees fertilized post-planting of new trees and possibly every 5-10 years
- Applications can be terrestrial or aerial
  - Key: avoid tree damage
- Applications to family forests rare
  - Resource limited

PREFERENCES

- Dried product preferred (hard, uniform)
  - Even distribution
  - Minimize compaction from spreading equipment
- Gatekeepers advise focus on large forests with long-term ownership
  - Previous public perception concerns in SC drives recommendation

Figure 7-12 Silviculture Practices and Preferences

While barriers to development of a silviculture market for biosolids are relatively strong, the vast acreage of timber in the state is a basis for inclusion as a potential market. To develop this market, reliance on existing studies can help educate end users regarding the demonstrated productivity improvements, with a focus on the impact of biosolids on investment returns and tree health. University of Georgia Extension Offices could potentially help access and develop this market (as has been done in North Carolina).

Sod Farms

Biosolids products can be used as a sod establishment and top-dress fertilizer on turfgrass or sod. Producers typically apply fertilizer and harvest between one and three times per year, which may increase the demand for biosolids. Additionally, some of the soil is removed with the sod when it is harvested, depleting the organic and nutrient content of the farms over time; biosolids can address both of those issues.

An estimated 26,700 acres of turf grass were grown in Georgia in 2018 and production reports suggest that sod production will have increased by 3 to 4 percent per year between 2018 and 2021. Sod production is more prominent in south-central Georgia but is not limited to this region. The top 10 counties for turfgrass production in 2018 are shown by value according to the FGVR on Figure 7-11.

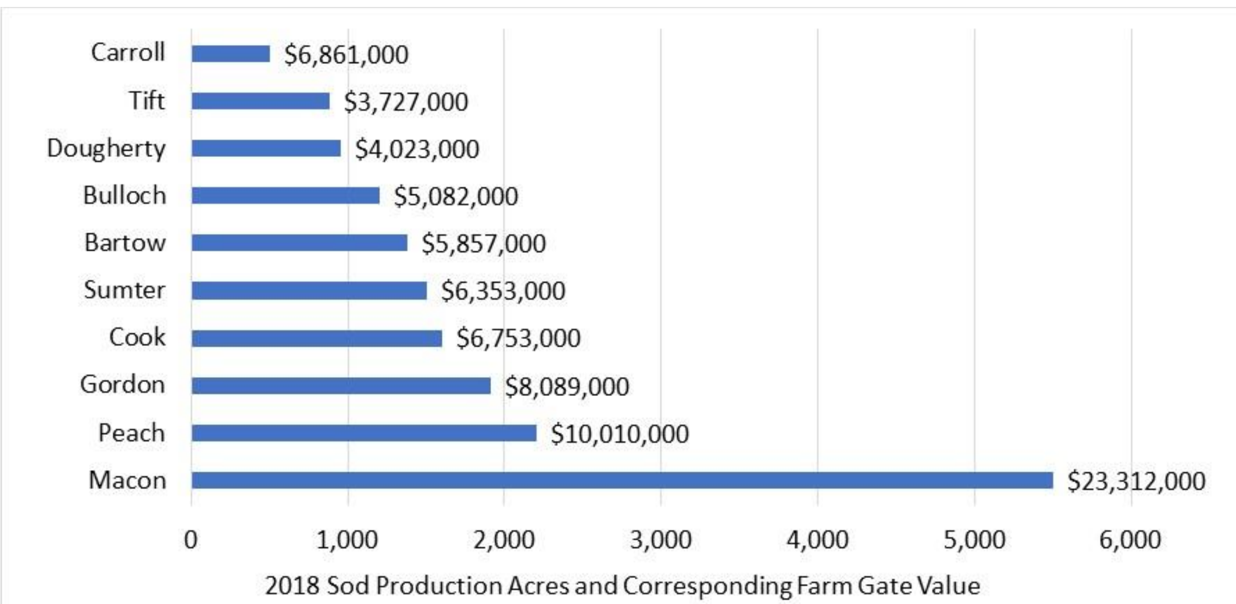


Figure 7-13 Top Ten Turfgrass Producing Counties by Acreage and Value, 2018 FGVR

Although the use of biosolids for sod production is limited, researchers have explored this application for a number of years. A 2013 study from Virginia Tech found that a Class A cake provided acceptable sod quality when compared to inorganic fertilizer, and a 2016 Wisconsin study found similar results with a Class B digested cake over time. Both studies noted, however, that the slow-release characteristics of biosolids needed to be considered with respect to application rates and timing.

Interest from the sod farming industry has been mixed, with some producers indicating a strong reluctance to explore biosolids products while others have shown a strong interest, including smaller producers. Sod production has long been a market for biosolids compost and, more recently, for lime stabilized Class A biosolids as well. Additionally, one Georgia producer is researching the efficacy of heat-dried biosolids for this market.

Information collected was insufficient to define clear product preferences but, based on the current information and previous studies, it is expected that a variety of biosolids products might be acceptable to Georgia sod producers. Practices and preferences of sod producers with respect to potential biosolids use are summarized on Figure 7-14. Considering the mixed reactions noted in previous studies and the relatively small sod production acreage in the state, this outlet will likely need to be considered as an outlet on a case-by-case basis for utilities in the proximity of sod producers.

PRACTICES	PREFERENCES

• Soil removed with sod harvests, depleting organics, N
  • Biosolids can replace
• Biosolids uses
  • Top dressing
  • Fertilizing for sod establishment
	• Products used in GA to date:
	  • Lime stabilized (good response)
	  • Compost
	  • Dried pellets (some concerns regarding adherence to applicator)
	• No other preferences noted

Figure 7-14 Sod Producers Practices and Preferences

Parks and Recreation

Parks and recreational facilities in the state included federal lands, as well as property owned by state agencies, counties, cities, and private entities. Federal lands have the most extensive acreage at about 2.4 million acres, while state land is also a significant share of Georgia's park land at 586,000 acres. Both federal and state parks tend to be dominated by natural landscapes that are not typically fertilized, and so this study focused on park acreage owned or operated by city and county governments.

Cities and counties manage an estimated 92,000 acres in the state. The relative density of these parks is shown on Figure 7-12.

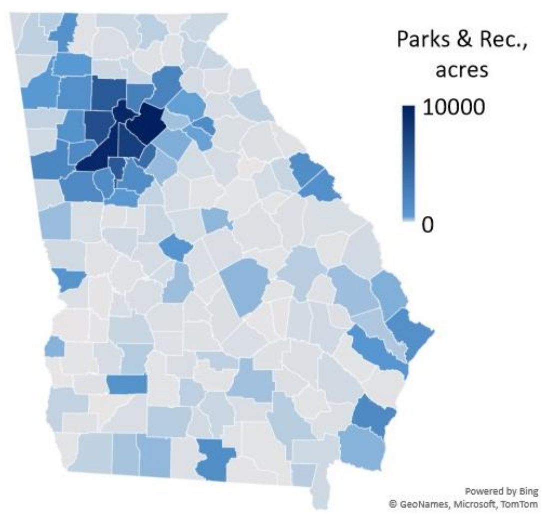


Figure 7-15 City and County Park Acreage

Parks and recreation department fertilization practices can vary significantly. Some organizations use very little fertilizers or soil amendments whereas others have robust multi-season programs. Most parks and recreation departments do not have extensive budgets that allow for fertilization of athletic fields (Figure 7-13) and other green spaces.

Feedback from interviews indicate that efficiency is a key focus for fertilization practices to maximize the value of each dollar spent on turf management and minimize labor needs. Black & Veatch has found in previous studies that many are reluctant to consider products that are not free (and transportation costs alone can limit market access).

Figure 7-16 Athletic Field Fertilization with Dried Biosolids

Similar to golf courses, gatekeeper interviews indicate a general familiarity and willingness to use biosolids products like Milorganite and composts, such as ERTH Food, that may be used for establishing new growth or maintaining existing areas. Slow-release N and organic content of biosolids are well suited to bolster soil types in Georgia and improve overall soil health and water drainage. In coastal areas, many parks have vast wetlands and coastline that are less suited for biosolids application.

Parks and recreation fertilization practices and preferences, with respect to potential biosolids use, are summarized on Figure 7-17.

PRACTICES

- Fertilize athletic fields, some turf, common areas (varies)
- Some familiarity with biosolids pellets and composts/use of both
- Could be used for establishment/maintenance of turf and other areas
- Note may not be suitable for coastal area parks (wetlands)

PREFERENCES

- “Free” preferred, if not, at least max value for dollar
- Relatively uniform
  - Ease of spreading with existing equipment
- Slow-release N and organics important
  - Improve soil health and drainage

Figure 7-17 Parks and Recreation Departments Practices and Preferences

Golf Courses

Georgia is host to 373 golf clubs, and Figure 7-14 shows the relative density of golf clubs in the state.

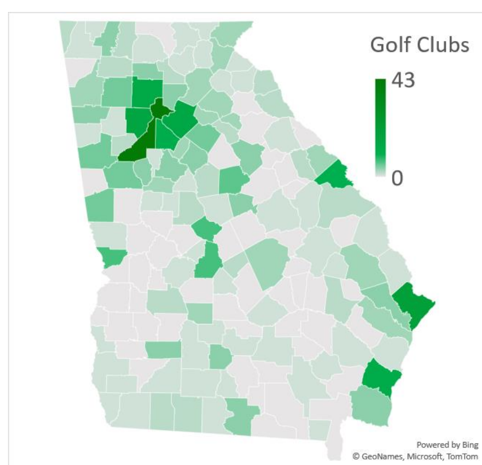


Figure 7-18 Golf Club Density

Both heat-dried biosolids and compost can be used at golf courses, with dried product used as a fertilizer and compost used as a top dressing that supplies nutrients to the turfgrass.

Discussions with golf course superintendents revealed a general familiarity with – and favorable responses to – dried biosolids pellets such as Milorganite, which has been sold in the area for a number of years. The interviews indicate that a uniform product such as a dried pellet is preferred for golf course applications, and that both public and private courses could consider (and some have used) dried biosolids as part of a multi-faceted fertilization program. Interviews show that dried product could be used in multiple locations across a golf course, including greens, tees, fairways, and roughs. Regardless of the location used, one of the key characteristics for dried biosolids is the slow N release rate, which prevents burning sometimes associated with high N, quick release products.

The key issues that would need to be addressed for market entry include price and odor, although price is of more concern for public courses than private. The relatively low N content of biosolids products was viewed as a potential barrier to widespread use.

Other products that might be considered for golf course use include compost and lime stabilized biosolids. Compost products would need to be both uniform, well screened, and fine because larger pieces of wood or bulking agent tend to remain on the surface of the tightly mown turf. Well screened material would likely only be considered for roughs. Lime stabilized products could potentially meet occasional liming needs but are not viewed as a consistent need. As with dried product, the odor of biosolids applied at golf courses could be a factor influencing their potential use.

Golf course fertilization practices and preferences with respect to potential biosolids use are summarized on Figure 7-19.

PRACTICES	PREFERENCES

• Near year-round applications, with some seasonal variation
• Some familiarity with/use of biosolids pellets
• Biosolids uses
    • Top dressing
    • Fertilizing
	• Uniformity
	    • Ease of spreading with existing equipment
	• Price
	• Slow-release N (avoids burning turf)
	• Composts must be FINELY screened (a concern)
	• Odor a concern
	• Delivery in bag and bulk

Figure 7-19 Golf Course Practices and Preferences

General Urban Uses

Both heat-dried biosolids and biosolids composts have been sold to the public through garden stores in Georgia for a number of years, but the number of products sold has been limited. For dried product, only the Wisconsin-based Milorganite has routinely been sold in Georgia retail stores, while the primary biosolids compost marketed in stores is the Georgia-based ERTH Food. ERTH Food is also used as a component of engineered soils used for bio-retention basins.

Discussions with ERTH Products revealed that they do not see the compost market increasing significantly in the near future and cited a lack of familiarity among UGA extension agents (who guide urban gardeners through Master Gardener and other programs) as a potential impediment to market expansion.

As with other markets, there was an interest expressed in dried product, with a preference to selling product in bags for homeowner use (bagging would also facilitate dried product storage during the cold season).

Georgia Department of Transportation

Use of composts containing biosolids by state DOTs is common for new highway construction, erosion and pollution control, and vegetation establishment. For example, in 2016, the Texas DOT boasted that it was the largest single user of compost in the United States. Although this can be a preferred target market, the regulations and use vary from state to state as well as the amount of highway miles under construction each year. GDOT specifications do allow for biosolids compost use, so long as the compost is made with Class A biosolids and has the USCC Seal of Testing Assurance (STA) Membership, as noted earlier. Use by DOTs is typically 7 cubic yards per highway mile.

Although this could be a market in the future, it is not currently well developed in Georgia and based on requirements for new road construction and typical application rates, the size of the market is likely to be small compared to other opportunities.

Potential Market Demand

The potential market demand for each product, market sector, and region is based on land use estimates and typical application rates and reflects the maximum potential biosolids product use if only biosolids are used to meet nutrient or liming needs. Market preferences are then used to further define market-specific needs and the expected availability of markets. The purpose of this effort is to generally identify potential market opportunities within each regional commission, recognizing that more extensive efforts would be required to both confirm the general findings here and explore opportunities that might be unique to each region.

Table 7-4 shows general assumptions used to assess potential demand.

Table 7-4 Target Market Potential Demand Assumptions

Market	Estimated Application Rate (dt/ac)	Assumptions
Agriculture	5	• Annual application rate for crops studied
Silviculture	0.8	• 4 dt/ac once every 5 years • Total acreage limited to non-family owned (larger) farms, 55 percent of total
Sod Farms	2	• Annual applications • Reflect fertilization needs of approximately 200 lb/ac
Parks and Recreation	2	• Applications limited to dried biosolids and compost • Reflect fertilization needs of approximately 200 lb/ac
Golf Courses	2	• One 18-hole course on average per golf club, with 90 acres of maintained turf (includes roughs) • Potential compost use can be estimated at 50 percent of total dried product demand (as it might be used predominantly on roughs)

Demand potential for biosolids products in the agriculture and silviculture markets are shown by region on Figure 7-15, while Figure 7-16 shows corresponding information for the smaller sod farm and urban markets.

As shown on the figures, agricultural outlets far outstrip others in terms of demand, with the notable exception of the Atlanta Regional Commission where parks and recreation dominates. It is important to note, however, that most products can be marketed outside of their generation area. For example, pelletized product can be distributed out-of-state, as their high density and low volume makes them more transportable than other products. Conversely, lower density products like compost and extruded dried biosolids are typically used closer to their generation point because of transportation costs.

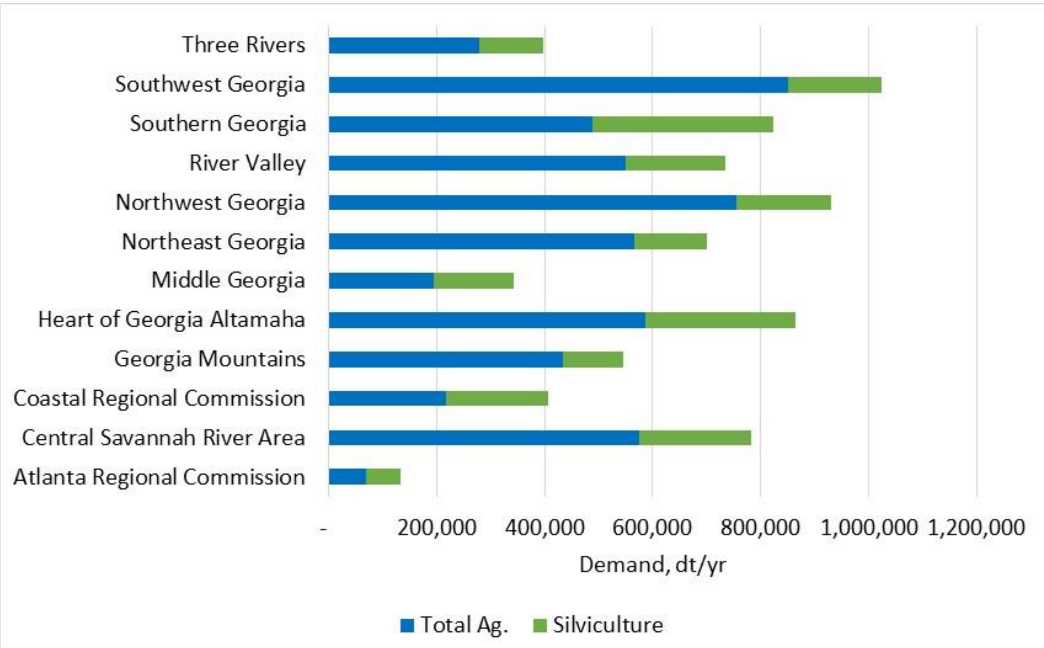


Figure 7-20 Potential Biosolids Demands for Agriculture and Silviculture

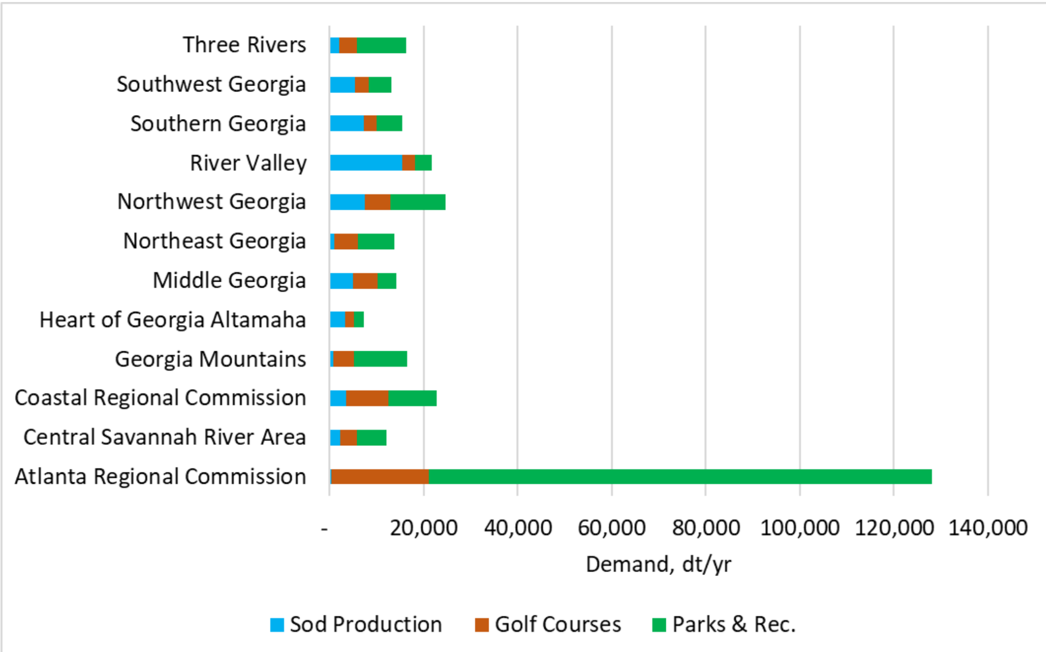


Figure 7-21 Potential Biosolids Demands for Sod Production and Urban Uses

Potential market demand must be viewed within the context of solids production to determine how much of the market share for fertilizers or soil amendments might be needed to accommodate biosolids production. This information is shown in Table 7-5, which indicates that the market penetration needed to manage biosolids in all regions is negligible, with the exception of the Atlanta Regional Commission. It is assumed, however, that agricultural markets outside of the Atlanta area would meet outlet needs.

Table 7-5 Market Penetration Needed for Solids Production

Regional Commission	2019 Annual Average Solids Production (dt/y)	Total Demand (dt/y)	Market Penetration Needed (% of Demand)
Atlanta Regional Commission	98,400	262,400	38
Central Savannah River Area	10,400	795,400	1
Coastal Regional Commission	15,300	430,200	4
Georgia Mountains	8,000	561,700	1
Heart of Georgia Altamaha	4,800	872,400	1
Middle Georgia	7,300	357,600	2
Northeast Georgia	8,300	713,500	1
Northwest Georgia	14,200	954,000	1
River Valley	10,000	755,300	1
Southern Georgia	8,000	837,700	1
Southwest Georgia	6,100	1,036,400	1
Three Rivers	7,400	412,800	2
TOTAL	198,200	7,989,400	2

The demand assessment must also consider preferences identified through gatekeeper interviews, which confirm that not all products are suitable for all markets. Figure 7-17 shows product preferences identified based on the interview discussions. Note that extruded dried product was not viewed favorably by any of the interviewees because of both its irregular shape and its low density. This product, however, could potentially be landfilled at a lower cost than biosolids cake because of its high solids content and low volume. It should also be noted that at least one utility in New York is mixing this product in with other residuals as part of a soil blend.

Potential Target Market	Digested Biosolids Cake	Dried Biosolid Pellets	Dried Biosolids (Extruded)	Biosolids Compost	Lime Stabilized Biosolids
Agriculture	🟢	🟢	🔵	🟢	🟢
Silviculture	🔵	🟢	🔵	🟢	
Sod Farms		🟢	🔵	🟢	🟢
Golf Courses		🟢	🔵	🔵	🔵
Parks and Recreation		🟢	🔵	🟢	
General Urban Use		🟢	🔵	🟢	

🟢 Preferred product 🔵 Product concerns or limited application opportunities

Figure 7-22 Biosolids Product Preferences

Target Market Summary

Opportunities vary for biosolids use in target markets. Agriculture offers a strong market potential across the state, given the land area suitable for biosolids applications, a general acceptance of various biosolids products in this sector and, for some products, strong demand among the farming community. As such, agriculture represents a high-volume market that is not likely to require significant market development.

Silviculture appears to offer an extensive land base for biosolids applications, but its potential might be tempered by market forces (more trees than needed, limited motivation to accelerate tree growth) and logistical concerns with respect to applications may limit the potential use of biosolids in this market. Nonetheless, silviculture is a market that has been developed in other regions (including Virginia) and lessons learned from others may improve the ability to use biosolids in some regions of Georgia. Research may be needed to help foresters understand potential benefits to tree health (as opposed to growth) and help build this market.

Sod farms may be of interest in some areas, though receptiveness to their use is mixed. While some sod producers have had success with biosolids, the largest producer in the state apparently eschews their use. Given the relatively small land base in sod production, concerns regarding reception, this market is expected to offer limited potential in general, albeit strong potential in some areas if producers can be convinced of the benefits of biosolids use.

Urban markets such as golf courses and parks are limited in size, but with market development could offer an outlet for some dried product offerings and for compost. General market familiarity with dried biosolids pellets, in particular, may help expand this market for biosolids. Providing a competitively priced product will be critical to market development for golf courses, but also for any materials applied to parks (as budgets and/or staff limitations can impact fertilization practices).

It is important to note that this market assessment was undertaken to identify general market opportunities (and constraints) within each Regional Commission. As such, it is not intended to supplant more extensive efforts undertaken to confirm the general findings presented here and explore opportunities that might be unique to each region.

8.0 Technology Review

A wide array of technologies is available to reduce the mass and volume of solids and/or convert solids into biosolid products that have value to end users.

This section explores a range of solids management technologies, including solids separation, stabilization, and thermal conversion processes (technologies in these categories are shown on Figure 8-1). The exploration includes detailed descriptions of established and newer technologies in the marketplace, a comparison of technologies with respect to a number of criteria, and a cost evaluation of selected technologies. Technologies selected for the cost evaluation reflect both input from project stakeholders and suitability for small and large WRRFs.

Figure 8-1 Technologies Reviewed

The technology comparison criteria for solids separation differed from criteria adopted for stabilization or thermal conversion technologies. The solids separation review focused on general application considerations. Stabilization and thermal conversion technologies, however, are more varied than separation technologies with respect to development status, application size, and end products. For this reason, these technologies were reviewed using the criteria shown in Table 8-1.

The technologies reviewed in this section require varied levels of staffing, operator expertise, and training. To highlight these differences, the technology comparison at the end of each section includes technology status in the United States and complexity as shown in Table 8-1.

Table 8-1 Technology Review Criteria and Rating Basis

Criterion	Rating Basis
Typical Facility Size	Small, medium, large
Technology Status in the United States	Emerging, innovative, established(1)
Class A Biosolid	Yes, no, or potentially
Typical Product Characteristics	Liquid, cake, dried product, soil-like product, compost, ash, biochar
Byproducts	Biogas, waste heat, syngas, fuel
Complexity	Low, medium, high

(1) Specific definitions for these criteria are presented in Appendix C.

The following sections provide an overview of technologies in each of the categories shown on Figure 8-1, focusing first on separation technologies (thickening, dewatering). Note that the descriptions focus primarily on established technologies or those that are of a particular interest (such as thermal conversion technologies that might reduce PFAS). Technology comparisons are presented at the end of each category. This section provides an overview of available technologies for solids thickening, dewatering, digestion, chemical stabilization, composting, drying, and thermal conversion.

Thickening

Solids thickening reduces the water content of sludge and increases the solids concentration to minimize the required volume of downstream equipment such as digestion systems. Thickening generally refers to an increase in solids concentration to around 4 to 8 percent TS (a concentration at which the sludge is still a liquid slurry). The suitability of thickening technologies varies depending on the type of solids (primary solids versus waste activated sludge [WAS]) and thickened solids requirements. Co-thickening of primary solids and WAS can be performed but is not as common as separate thickening for various reasons, including optimization of performance and reduced risk of odors.

Gravity Thickeners

Often, primary solids are removed from primary clarification at concentrations suitable for downstream processing, but in some instances additional thickening is warranted. When primary solids need to be thickened, gravity thickeners are ideally suited for this purpose. Sludge from primary clarifiers usually has a solids concentration of around 1 to 4 percent TS. This can be thickened using gravity thickeners without the addition of polymer to around 5 to 6 percent TS. The benefit of downstream volume reduction achieved through gravity thickening is greater at lower feed solids concentrations, as is often seen with rectangular clarifiers, although gravity thickeners are used following both rectangular and circular clarifiers. An example gravity thickener is shown on Figure 8-2.

Gravity thickeners are usually covered to reduce odor release, with the headspace under the cover vented to the aeration basins, eliminating the need for separate odor control. At large- and medium-sized plants, settled solids are typically withdrawn continuously from the gravity thickener whereas smaller facilities may have intermittent withdrawal.

Gravity thickeners are not recommended for co-thickening of primary solids and WAS because the solids retention time usually results in biological activity that produces odor and detrimentally impacts the thickening process.

Figure 8-2 Example Gravity Thickener Installation

There are a number of advantages and disadvantages associated with the use of gravity thickening as listed in Table 8-2.

Table 8-2 Gravity Thickening Advantages and Disadvantages

Advantages	Disadvantages
• Increased solids concentration reduces downstream capacity requirements. • Potential to generate volatile fatty acids for biological nutrient removal processes. • Provides some flow equalization and storage. • Simple operation.	• Odor concerns/management. • Additional treatment step increases process complexity. • Additional treatment step increases plant siting requirements.

Gravity Belt Thickeners

Gravity belt thickeners (GBTs) have widespread use for WAS thickening applications and may be suitable for selected co-thickening applications as well. Gravity belt thickeners separate free water from the solids by gravity drainage through a porous belt. Dilute solids are introduced at the head end of a horizontal filter belt. As the solids move along the belt, free water drains through the porous belt into a collection tray and is returned to the headworks. Plows in the gravity zone break up the solids and aid the release of water. Thickened solids are discharged at the end of the horizontal filter belt. Gravity belt thickeners are available in belt widths ranging from 1 to 3 meters. Figure 8-3 shows an example installation with gravity belt thickeners.

The feed solids are conditioned with a polymer to form a stable floc before introduction to the belt. With the use of a polymer, GBTs can achieve 4 to 6 percent TS and achieve 95 percent solids recovery or greater.

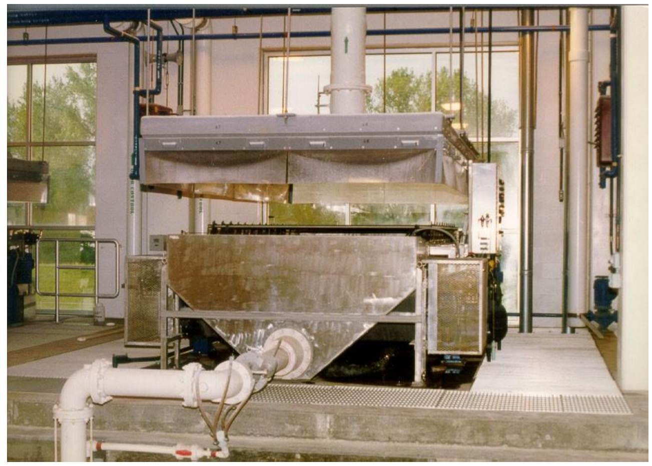


Figure 8-3 Example Gravity Belt Thickener Installation

Gravity belt thickeners have an open equipment design and it can be difficult to capture odorous emissions for treatment. Consequently, the whole area usually requires ventilation and perhaps odor control depending on the type of sludge being processed. The belt is usually washed continuously to avoid blinding. Gravity belt thickeners are available from several manufacturers, including Komline-Sanderson, BDP Industries, Alfa Laval, Andritz, and Charter Machine.

Advantages and disadvantages of GBTs are listed in Table 8-3.

Table 8-3 Gravity Belt Thickening Advantages and Disadvantages

Advantages	Disadvantages
• Moderate operational complexity; relatively low requirement for operator attention. • Relatively high unit capacity. • Relatively low initial capital cost. • Low power requirements.	• Odor concerns/management. • High wash water requirement. • Require continuous belt washing to avoid blinding – high wash water flows.

Rotary Drum Thickeners

RDTs use gravity to drain solids as they pass through a mesh or perforated basket. RDTs require polymer addition and some systems include a flocculation tank upstream. A system of spray nozzles operating intermittently are used to keep the media clean. An example is shown on Figure 8-4.

Figure 8-4 Example RDT Installation (Single Drum with Flocculator in Foreground)

RDTs have a rotating drum made of wire, polyethylene mesh, fabric, or perforated steel. The feed solids are pumped into the drum, where drum rotation continuously exposes the sludge to the porous media, which allows the filtrate to drain through the media into a collection trough. Some systems include flights inside the drum to help retain the solids and create a rolling effect to expose fresh material to the porous media. The mesh size increases toward the drum outlet to facilitate drainage of the more difficult to release water.

Polymer is required to condition solids in an RDT. In most cases, RDTs can produce 4 to 6 percent TS with 95 percent solids recovery. RDTs are typically enclosed to contain odors.

Having relative simplicity and good odor containment, RDTs have been gaining in popularity as a WAS thickening technology. Several design variations of RDTs are offered by suppliers of the technology. RDTs are available from several manufacturers, including Parkson (Hycor), Andritz, BDP Industries, Vulcan Industries, and Alfa Laval.

Advantages and disadvantages of rotary drum thickening are listed in Table 8-4.

Table 8-4 Rotary Drum Thickening Advantages and Disadvantages

Advantages	Disadvantages
• Moderate operational complexity. • Little operator attention. • Low power usage. • Good odor containment. • Lower wash water requirement as compared to GBT.	• Higher polymer consumption Relatively lower unit capacities as compared to GBT. • May have difficulty thickening WAS with feed concentrations less than 0.5 percent TS.

Dissolved Air Flotation Thickeners

Dissolved air flotation (DAF) thickening concentrates solids by attaching microscopic air bubbles to the suspended solids, increasing the buoyancy of the solids and causing them to float to the surface. A recycle stream from the DAF subnatant is saturated with air and discharged into the DAF influent. When this combined stream is released in the DAF, the entrained air comes out of solution, forming fine bubbles. A pressure tank (saturator) and compressor system has been typically used to create the air enriched solution; however, air handling recycle pumps that combine the pumping and air injection steps are available, eliminating the need for saturators and compressors. A DAF thickener is shown on Figure 8-5.

Figure 8-5 Example DAF Thickening Installation

While DAFs have been traditionally used to thicken WAS, a number of installations use co-thickening DAFs to thicken a combined feed of primary solids and WAS. Co-thickening DAFs can also help concentrate scum removed from the primary and secondary clarifiers. In a co-thickening DAF, the heavier solids settle to the bottom while the lighter solids float.

DAF thickeners are sized based on solids loading rate per unit area and can be operated with or without polymer conditioning. Loading rates can typically be significantly higher for polymer conditioned feed solids. The thickened solids concentrations typically range from 3 to 4 percent TS and capture efficiency will vary with sludge characteristics and use of polymer, but typically greater than 95 percent capture efficiency can be achieved when polymer is used. Co-thickened solids can reach concentrations of up to 7 percent TS. DAF thickening technology is available from a number of manufacturers, including Envirex, Tenco Hydro, Huber, Komline Sanderson, and WesTech.

Advantages and disadvantages of DAF thickening are presented in Table 8-5.

Table 8-5 DAF Thickening Advantages and Disadvantages

Advantages	Disadvantages
• Provides "wide spot" in line, minimizing need for storage. • Little operator attention. • Can be designed for low polymer consumption. • Relatively insensitive to hydraulic loading rate changes.	• Relatively high power use – varies depending on saturation technology. • Odor concerns/management. • Lower thickened solids concentration than other thickening technologies (WAS only DAFs). • Can have large footprint requirement.

Other Types of Thickeners

Several other types of thickeners are available that are not as common as the methods above for wastewater applications.

- Disc thickeners are an alternative to RDTs that operate on a similar principal but with the solids thickened using a perforated disc rather than a drum. Disc thickeners are available from Huber.
- Centrifuge thickening is used by some facilities, typically for WAS thickening applications at larger facilities. Centrifuge thickeners are available from the same manufacturers and operate on the similar principles to centrifuge dewatering (see below).

Thickening Comparison

Figure 8-6 compares the thickening technologies listed above (with the exception of disc thickeners). Loading rates will vary among systems based on manufacturer criteria and will vary based on feed.

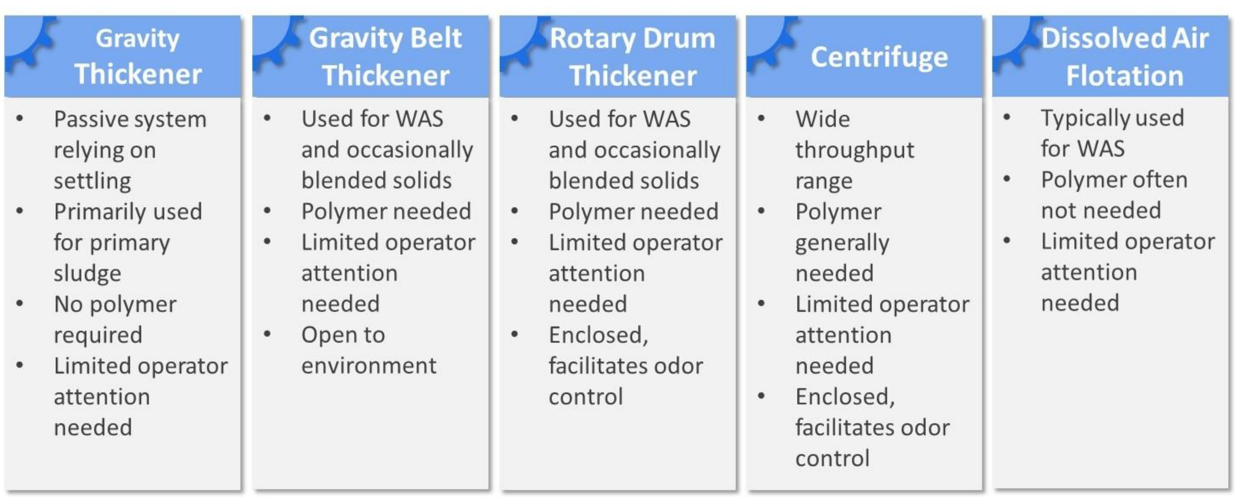


Figure 8-6 Thickening Comparison

Dewatering

Dewatering is a mechanical treatment process used in reducing the moisture content of biosolids. Dewatering typically refers to increasing the solids content of biosolids to between 15 to 40 percent TS and produces a product that is a cake rather than a liquid slurry. It should be noted that none of the dewatering technologies discussed below are capable of meeting the 40 percent moisture / 60 percent TS requirements to avoid classification as HMCW.

The capacity and cost of post-dewatering treatment steps, such as heat drying or incineration, are affected by the moisture content of the dewatered cake. Cake volume also decreases with decreasing moisture content, so the total cost of end use options that require cake hauling decrease with increased moisture removal. The effectiveness of dewatering technologies varies depending on the type of solids (WAS versus combined primary and WAS) and upstream processing (digested solids versus raw).

A number of solids dewatering technologies are available. The most widely used technologies are belt filter press dewatering and centrifuge dewatering; however, newer technologies such as screw press dewatering and rotary press dewatering are becoming increasingly popular. These dewatering technologies are discussed in the following sections.

Ancillary equipment for dewatering operation includes solids feed pumps, polymer storage and feed equipment, and cake conveyance equipment.

Belt Filter Press

The belt filter press dewaters solids through a continuous process of gravity drainage followed by compression. In standard units, polymer conditioned sludge is evenly distributed onto a moving porous belt where free water is drained from the sludge, followed by a zone of compression dewatering during which the solids are squeezed between two porous cloth belts to remove additional water. A photo of an installed BFP is presented on Figure 8-7.

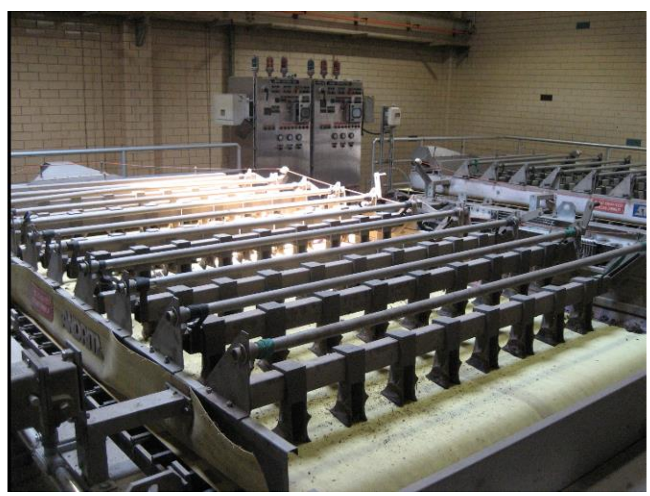


Figure 8-7 Example Belt Filter Press Installation

Depending on the characteristics of the feed solids, BFPs are capable of achieving cake solids concentrations typically ranging from 15 to 22 percent for digested solids and 25 percent or greater for raw solids. Capture efficiencies are typically greater than 95 percent. The variables affecting the performance of BFPs include the feed solids characteristics, polymer conditioning, and the belt tension and speed. Maintenance, which includes replacing belts, rollers, and bearings, can be performed by plant staff.

Belt filter press capacity requirements are based on both solids and hydraulic loading rates. Belt press equipment is typically limited to a hydraulic loading rate (HLR) of approximately 70 gpm/meter. Solids loading rates (SLRs) typically range from 600 to

800 pounds per hour of belt width (pph/meter) for digested solids; and 1,000 to 1,200 pph/meter for combined raw primary and WAS solids; however, loading rates can vary significantly.

The feed solids are conditioned with a polymer to form a stable floc before introduction to the belt. Consistent feed characteristics or feeding from a well-mixed tank is important for maintaining optimum performance.

Belt filter presses have an open equipment design and can be difficult to capture odorous emissions for treatment. Consequently, the whole area requires ventilation and possible odor control. The belt is continuously washed to avoid blinding. Belt filter presses are available from a number of vendors, including BDP, Alfa Laval, Komline-Sanderson, Andritz, and Charter Machine.

Advantages and disadvantages of BFP dewatering are listed in Table 8-6.

Table 8-6 Belt Filter Press Dewatering Advantages and Disadvantages

Advantages	Disadvantages
• Simple operation. • Low power requirements. • Maintenance can be performed by plant staff. • Relatively tolerant of grit and other inert material.	• Increased odors and housekeeping. • Large footprint for high-capacity systems. • High wash water flows. • Mid-range cake solids as compared to other dewatering technologies. • May require more operator attention than other dewatering technologies.

Centrifuge

Centrifuge dewatering is a shallow depth settling process enhanced by applying centrifugal force. While several types are available, the scroll-discharge, solid bowl centrifuge is most often used. The solids are pumped into the centrifuge, where the high-speed spinning action of the bowl forces the solids against the bowl surface. The heavier solids are conveyed by the scroll along the bowl to the solids discharge point. The centrate flows to the opposite end of the centrifuge and is discharged. Centrifuge equipment used for dewatering is similar to centrifuge thickening equipment; however, machine adjustments are different for the two applications. An example installation is shown on Figure 8-8.

Figure 8-8 Example Centrifuge Installation

Centrifuge cake solids are typically 2 to 3 percentage points dryer than belt filter press cake. Capture efficiencies are usually 95 percent or greater. Centrifuge dewatering typically requires greater polymer use than BFP dewatering. Centrifuge operations can be optimized by adjusting the feed rate, polymer dose, and the differential scroll speed. Consistent feed characteristics or feeding from a well-mixed tank is important for maintaining optimum performance. Centrifuges are subject to damage from trash in the feed solids; consequently, grinders or macerators are provided upstream of the centrifuge. Minor maintenance can be performed by plant staff, but major maintenance, such as repairing or refinishing the centrifuge scroll or bowl, must be performed by the manufacturer or specialized service company.

Similar to the belt filter press, centrifuge capacity is based both on hydraulic and solids loading rates. Centrifuges are available in a variety of sizes, with centrifuge sizing typically based on manufacturer recommendation. On a unit basis, centrifuges provide greater dewatering capacity than belt filter presses, making these machines more common in large facilities. Centrifuges are often difficult to install in an existing building because of the high vibrational loads generated by the centrifuge equipment. Structural renovations required to support the equipment can be cost prohibitive.

Advantages and disadvantages of centrifuge dewatering are listed in Table 8-7.

Table 8-7 Centrifuge Dewatering Advantages and Disadvantages

Advantages	Disadvantages
• Relatively low operator attention requirements. • High cake solids content. • Enclosed technology – good odor control and reduced housekeeping issues. • High capacity equipment. • High degree of operational flexibility.	• Often difficult to install in existing buildings due to need for structural reinforcement associated with vibration • High polymer requirement. • High power use. • Major maintenance on centrifuge rotating assembly needs to be performed by the vendor.Can be susceptible to high wear from grit and other inert materials. • Concerns for bacterial and pathogenic regrowth and reactivation following anaerobic digestion.

Rotary Press

Rotary press dewatering is a relatively new technology for the wastewater industry, but interest is growing because of its low energy requirement, simple operations, and odor containment. An example rotary press installation is shown on Figure 8-9.

Solids are fed into the dewatering channel and are moved along the channel by a rotating element on the central shaft. As the solids travel the length of the channel, the pressure builds and forces water from the cake. The filtrate passes through metal screens on either side of the channel and is discharged at the bottom of the press. Dewatered cake is discharged at the bottom of the press. A flocculation unit is included

Figure 8-9 Example Rotary Press Installation

upstream of the press to allow the solids to flocculate after polymer addition.

The press capacity is based on the number of channels attached to the central shaft, with a maximum of 6 channels. Rotary press capacity is a function of solids loading rate, not hydraulic loading rate. Dewatered solids concentrations from rotary press installations vary; high concentrations for raw sludges can be comparable to centrifuges, whereas digested solids and WAS cake solids can tend to be low. Since performance information is limited, pilot testing is recommended if this dewatering method is going to be considered.

Currently Fournier, Prime Solutions, and Evoqua market this technology.

Advantages and disadvantages of this technology are summarized in Table 8-8.

Table 8-8 Rotary Press Dewatering Advantages and Disadvantages

Advantages	Disadvantages
• Low operator attention required. • Enclosure improves odor control and reduces housekeeping. • Low energy consumption. • Expandable in modules. • High solids for raw sludges with high primary solids content.	• Relatively low throughput can increase capital cost. • Potentially high polymer demand. • Due to a more limited number of installations on a range of sludges compared to belt filter presses and centrifuges, pilot testing is recommended to establish expected performance

Screw Press

Screw press dewatering technology has been used in industrial applications for many years and has recently been promoted for dewatering municipal biosolids. There are several screw press technologies available, but all technologies operate on the same basic principles. Flocculated solids are fed into the press and are conveyed from the inlet to the outlet of the press by a rotating screw. As the sludge moves along the length of the press, it is squeezed between the screw and perforated screens surrounding the screw. Filtrate pressed from the sludge drains through the perforated screens. Figure 8-10 illustrates this technology in use at Fulton County, Georgia.

Reported cake solids concentrations generated by screw presses have widely varying concentrations, ranging from 14 to 25 percent TS. Reported polymer dosages also vary widely. Consequently, pilot testing would be recommended if this dewatering technology is considered.

Figure 8-10 Example Screw Press Installation

Screw presses have relatively low capacities compared to other dewatering technologies, so they would not be recommended for larger capacity facilities. Depending on the manufacturer, screw press technology can also require a significant footprint. Screw press dewatering has relatively low power consumption requirements. The enclosed construction reduces odor potential and improves housekeeping.

Advantages and disadvantages of screw press dewatering are shown in Table 8-9.

Table 8-9 Screw Press Dewatering Advantages and Disadvantages

Advantages	Disadvantages
• Simple operation. • Low power requirements. • Maintenance can be performed by plant staff. • Enclosed technology – good odor containment and housekeeping.	• Large footprint for high-capacity systems. • Variable cake solids • Variable polymer consumption • Due to a more limited number of installations on a range of sludges compared to belt filter presses and centrifuges, pilot testing is recommended to establish expected performance

Other Types of Dewatering

Several other types of dewatering equipment are available that are not as common as the methods above for wastewater applications. For example, the Dehydris Twist™ piston press technology has been used in Europe but has not seen acceptance in the United States because of its high cost. One older technology that still has applications in the wastewater industry is the pressure filter, which has also been known as the plate-and-frame-press. The pressure filter is widely used in industry applications and with some water treatment residuals, but it is a batch process and is generally more expensive than belt presses or centrifuges, and therefore has limited new applications in the municipal wastewater industry.

Dewatering Comparison

Figure 8-11 compares the dewatering technologies listed above. Loading rates can vary significantly based on sludge characteristics, machine size, and manufacturer.

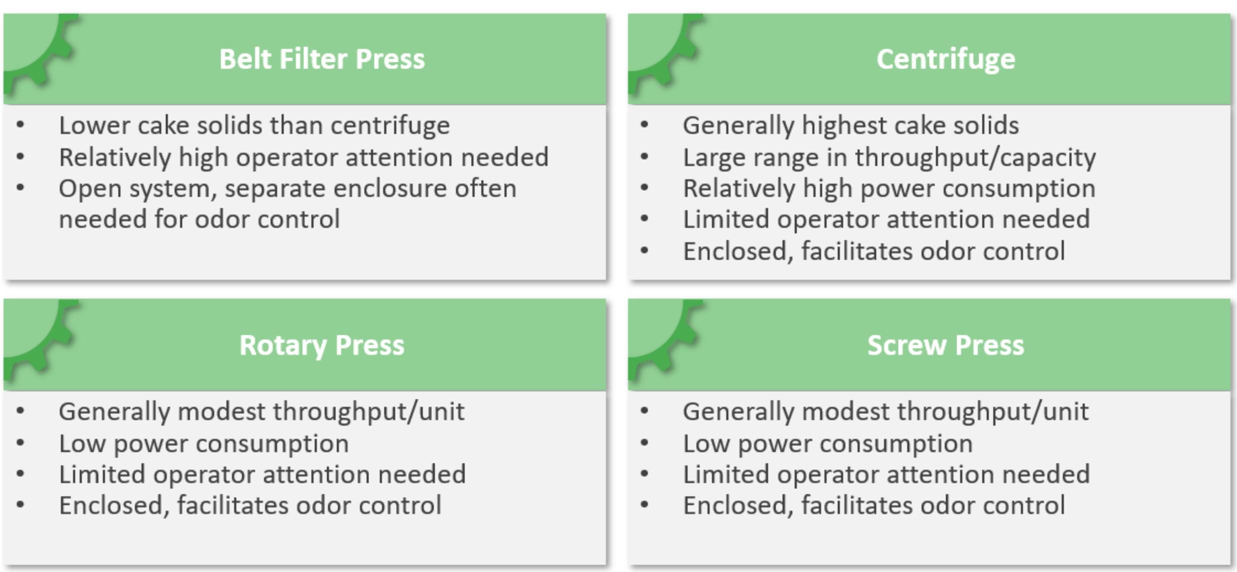


Figure 8-11 Dewatering Comparison

Digestion Technologies

Digestion technologies are used to reduce the volatile solids component in biosolids, reduce odor, and produce a more stable product that has a lower pathogen content and is less likely to attract birds, insects, rodents, and other potential disease carriers. Digestion processes may be either aerobic or anaerobic, with aerobic digestion being more common at smaller facilities processing only WAS, and anaerobic digestion being more common at larger facilities that have primary clarifiers.

Aerobic Digestion

Aerobic digestion involves the oxidation of biodegradable materials in the waste stream by microorganisms in the presence of oxygen. Typically, the process is used to stabilize WAS. Aerobic digestion of PS or a mixture of PS and WAS is generally not recommended for conventional aerobic digestion systems. There are multiple reasons for this, but all culminate in the point that the addition of primary solids will contribute to odor generation. More advanced systems, such as autothermal thermophilic aerobic digestion, which is addressed in the following section, can accommodate the higher total and organic solids loading from PS. Since the aerobic digestion process is very similar to the activated sludge process, the same concerns regarding variations in influent characteristics and levels of biologically toxic materials apply.

During the digestion process, the digester contents are aerated continuously to provide the required oxygen for the microorganisms (Figure 8-12 shows a digester during an aeration cycle). The solids concentration of the material entering the system is important in the design and operation of an aerobic digestion process. Thickening prior to aerobic digestion will result in longer solids retention times and smaller digester volume requirements. However, the thickened solids concentrations are typically limited to less than 3 percent to ensure efficient oxygen transfer in the digesters.

Figure 8-12 Aerobic Digester

The temperature of the digester contents is dependent on the ambient temperature and can fluctuate extensively. Lower temperatures retard the process while higher temperatures enhance the activity of the microorganisms. The default time-temperature criteria specified by EPA for Class B compliance are 60 days at 15° C (59° F) and 40 days at 20° C (68° F), but a 30 percent reduction in those times can be achieved with batch or series operation; the shortened retention time approach is noted in EPA's 2003 guidance document *Control of Pathogens and Vector Attraction in Sewage Sludge*. The EPA document has been used in some states to obtain regulatory approval for a shorter retention time.

Volatile solids reduction (VSR) in the digesters is a function of both liquid temperatures and the retention time in the digesters. Typically, VSR in the digesters can range from 10 to greater than 40 percent.

However, research suggests that the reduction in volatile solids during the digestion process may not be a valid indication of stabilization. For example, some activated sludge processes may produce a WAS that has a low volatile solids content prior to entering aerobic digestion. This could result in the digestion process not achieving the conventional 38 percent VSR needed for VAR requirements, but the biosolids are stable and VAR can be met through other parameters, such as measuring the Specific Oxygen Uptake Rate.

The advantages and disadvantages of aerobic digestion are shown in Table 8-10.

Table 8-10 Aerobic Digestion Advantages and Disadvantages

Advantages	Disadvantages
• Simple operation. • Low ammonia concentrations in sidestream (compared to anaerobic digestion).	• High energy costs. • Large footprint because of low feed TS and long retention time. • Cold temperature impacts. • Relatively poor dewatering characteristics. • Suitable for WAS only in most applications.

Autothermal Thermophilic Aerobic Digestion

Autothermal Thermophilic Aerobic Digestion (ATAD) has been used in the United States for nearly three decades to create Class A biosolids, but nearly all older facilities have been retrofitted to reflect significant technology evolutions addressing odor and dewaterability issues from first generation facilities; new facilities incorporate these modifications as well.

The ATAD system is a batch process that operates at thermophilic temperatures (about 130° F to 150° F). Thickened sludge is fed to one of two reactors, typically on alternating days and over a period of 4 to 24 hours. Solids are retained in the system for 12 days. Once sludge is fed into the ATAD reactor, the reactor is isolated, such that the system can meet Process to Further Reduce Pathogens (PFRP) requirements for batch operations. Figure 8-13 shows a schematic of an ATAD system, including ancillary processes.

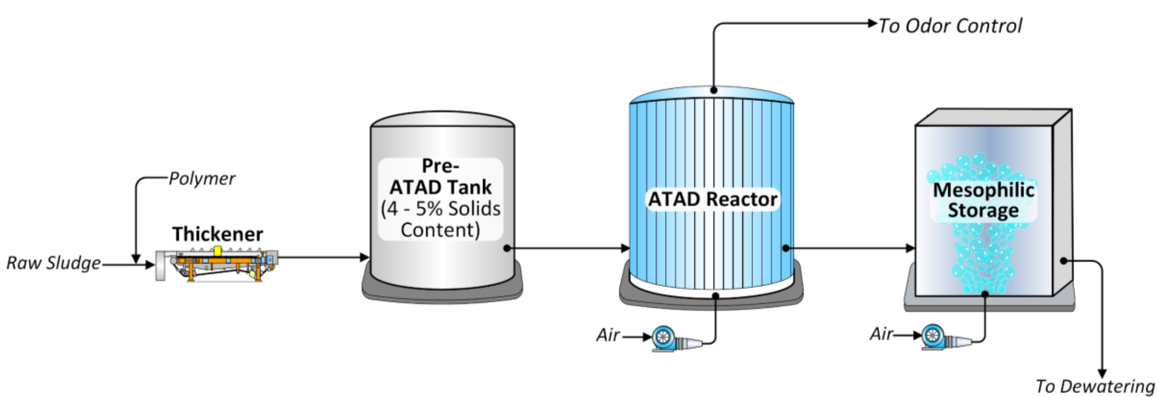


Figure 8-13 Autothermal Thermophilic Aerobic Digestion Schematic

Air injected into the tank via a floor mounted nozzle system (Figure 8-14) both meets oxygen demand and, via intense mixing, shears cell walls to enhance digestion. The aeration rate is controlled by Oxidation Reduction Potential (ORP) probes, which allow the system to better respond to varying oxygen demand than previous ATAD generations.

Stabilized solids leaving the ATAD reactor have temperatures in the thermophilic range, which experience has long shown adversely impacts dewaterability. Accordingly, stabilized solids are sent through a heat exchanger and then to aerated, mesophilic storage. The mesophilic storage serves multiple purposes, including cooling to mesophilic temperatures for improved dewatering performance, reduced chemical conditioning costs, and improved dewatering capture and filtrate quality.

Figure 8-14 Autothermal Thermophilic Aerobic Digestion Aeration System

Despite the improvements from mesophilic storage, conditioning with polymer alone is usually not sufficient for ATAD stabilized solids, and ferric chloride or alum are often used to enhanced conditioning. Operators of these systems have found, however, the costs for supplemental conditioning are generally offset by the lower sludge volume to be handled (as the system provides 50 to 70 percent VSR); and improved dewaterability (25 percent or so higher cake solids than raw sludge).

Table 8-11 summarizes advantages and disadvantages of ATAD systems.

Table 8-11 ATAD Advantages and Disadvantages

Advantages	Disadvantages
• Produces Class A biosolids. • Suitable for PS and WAS. • High VSR (50 to 70 percent). • Significant cake mass and volume reduction. • Relatively simple operations. • Low odor product.	• High energy requirements. • Dual conditioning required (coagulant and polymer). • Odor concerns/management.

Anaerobic Digestion

Anaerobic digestion involves the conversion of volatile solids in sludge under elevated temperature by acidogenic (acid forming) and methanogenic (methane forming) bacteria. Most anaerobic digesters are configured as conventional mesophilic digesters, operating in the 35 to 38° C (95 to 100° F) range. Thermophilic digestion is also used in some places but most commonly in combination with mesophilic digestion as part of a temperature phased system (see below). High-rate digesters are equipped with mixers and external heating to achieve shorter detention times (15 to 20 days) and more stable conditions than low-rate digesters, which have no mixing. The digestion system stabilizes the biosolids and reduces the mass of volatile solids, typically by 40 to 55 percent. Biogas is generated in the process by the methanogenic microorganisms. Anaerobic digesters at the F. Wayne Hill WRF in Gwinnett County are shown on Figure 8-15.

The digested biosolids are suitable for use in bulk application to agricultural land if requirements for Class B biosolids in 40 CFR 503 are met. Anaerobic digestion can meet Class B requirements by providing at least 15 days retention time at 35° C or above for pathogen reduction and demonstrate at least 38 percent VSR for VAR. Class B land application is the most commonly used practice for biosolids in the United States, as discussed in Section 4.0.

Figure 8-15 Anaerobic Digesters in Gwinnett County

Facilities practicing anaerobic digestion of WAS without PS present are not particularly common because WAS is not as readily digestible as PS.

Advantages and disadvantages of anaerobic digestion are summarized in Table 8-12.

Table 8-12 Anaerobic Digestion Advantages and Disadvantages

Advantages	Disadvantages
• Well proven. • Relatively simple operation. • Production of biogas that can be converted to electricity or renewable natural gas. • Compatible with future addition of add-on technology to meet requirements for Class A biosolids (e.g., thermal hydrolysis, thermal drying). • Potential to boost biogas production by accepting alternative feedstocks.	• Limited product volume reduction compared to other options. • Low VSR on WAS.

Biogas Utilization Options from Anaerobic Digestion Technologies

- Combust to generate heat (e.g., boiler)
- Combust to generate electricity and heat (e.g., cogeneration) for use on-site or export electricity to the grid
- Upgrade to biomethane for use as renewable natural gas (i.e., removing CO_2) and inject into the natural gas grid
- Upgrade to biomethane for use as vehicle fuel (i.e., removing CO_2 and compressing) for use in city fleet, buses, or garbage trucks
- If no beneficial use is identified, dispose of biogas by combustion

Temperature Phased Anaerobic Digestion

Temperature-phased anaerobic digestion (TPAD) involves the use of batch thermophilic digesters upstream of mesophilic digesters. Through the incorporation of a suitably designed batch thermophilic digestion step with a typical SRT of 6 to 8 days, the process has the potential to meet the time and temperature requirements for Class A biosolids required by the state and federal regulations. The downstream mesophilic digesters are usually operated in a flow through configuration, have a typical SRT of 8 days, provide additional process stability, and ensure that the final product is well digested with limited odor potential. Although the process will generate Class A biosolids, the product is still a liquid or cake that is best suited for bulk land application.

TPAD is able to meet requirements for Class A biosolids by meeting time and temperature requirements for pathogen reduction in the thermophilic batch digestion step and achieving at least 38 percent VSR for VAR. It should be noted that re-growth of *E. coli* has been observed with TPAD, particularly when centrifuge dewatering is used for dewatering (Higgins & Murthy, 2015).

Configurations for the process can vary, but a general schematic showing a typical configuration for the TPAD process is provided on Figure 8-16.

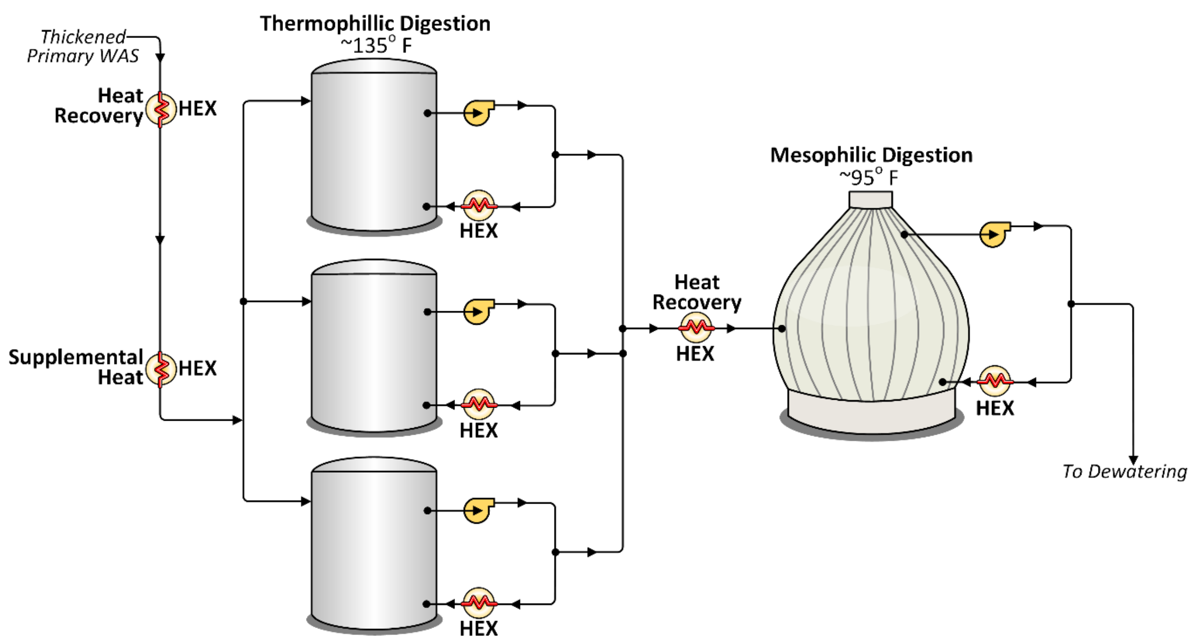


Figure 8-16 Temperature-Phased Anaerobic Digestion General Schematic

Advantages and disadvantages of TPAD are summarized in Table 8-13.

Table 8-13 Temperature-Phased Anaerobic Digestion Advantages and Disadvantages

Advantages	Disadvantages
• Produces a Class A product. • Established technology. • May achieve some additional VSR compared to conventional mesophilic digestion. • A steam boiler is not absolutely necessary (in contrast to the THP option discussed below); however, a steam boiler may still be preferred as an easier option for sludge heating (to achieve the higher temperature required for the thermophilic phase) than hot water heat exchangers.	• Significant additional tank volume required. • Complex system. • Multiple heat exchangers. • Challenging to operate. • Potential for fecal coliform regrowth – particularly with centrifuge dewatering. •

Thermal Hydrolysis

The thermal hydrolysis process (THP) consists of a high-temperature, high-pressure steam, solids pretreatment system that is generally applied upstream of anaerobic digestion. The process hydrolyzes the feed sludge, making it easier to digest. Hydrolyzing the sludge and resulting changes in the sludge viscosity allows digesters downstream of THP to be fed at much higher loading rates than conventional digesters. Additional pre-screening and pre-dewatering systems are required upstream of THP for minimizing the amount of debris fed to the pressure vessels and to feed the system at ideal solids concentrations for optimum performance and to minimize steam demand.

The market leader of THP technology is Cambi, who developed the original process and have the largest number of installations. Veolia (Kruger in the United States) have the second largest portfolio of systems. A number of other vendors also offer THP technology including Haarslev, Eliquo Stulz, and DMT Environmental.

Benefits of THP compared to conventional digestion include a higher VSR, better dewaterability, a reduction in the mass and volume of cake for hauling, and a Class A cake product with no demonstrated potential for regrowth of fecal coliforms.

As an alternative to being installed upstream of digestion, THP can also be used in an intermediate configuration (between two phases of digestion) or downstream of digestion with COD rich dewatering filtrate returned to the digesters for treatment. Intermediate THP, however, requires significant digester capacity, and post digestion THP does not meet 40 CFR Part 503 requirements for the order of occurrence of pathogen reduction and VAR. By far the most common configuration is with THP upstream of anerobic digestion.

Figure 8-17 Thermal Hydrolysis Process System at Davyhulme, UK

Pre-digestion THP can meet 40 CFR Part 503 requirements for Class A biosolids by demonstrating time and temperature for pathogen reduction (achieved in the THP reactors which typically heat to 165° C for a duration of 20 to 30 minutes) and meeting 38 percent VSR or greater for VAR.

Figure 8-17 shows the THP system installed at the Davyhulme treatment facility in Manchester, United Kingdom.

A schematic showing a typical configuration for a THP and anaerobic digestion system is provided on Figure 8-18. A key requirement of the system is steam supply for the THP unit. Steam can be generated directly by burning biogas (or natural gas), or by utilizing waste heat from an engine generator.

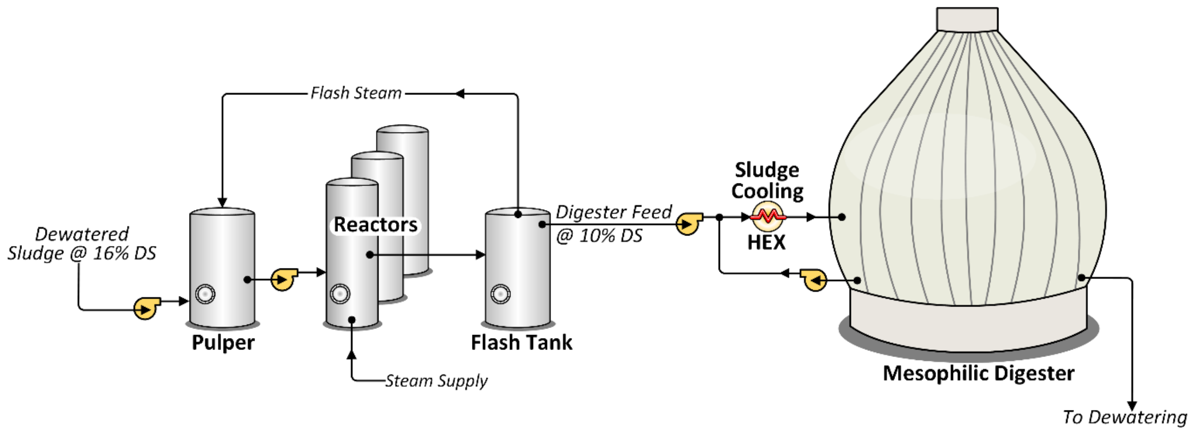


Figure 8-18 Thermal Hydrolysis Process Upstream of Anaerobic Digestion

Advantages and disadvantages of THP are summarized in Table 8-14.

Table 8-14 Thermal Hydrolysis Process Advantages and Disadvantages

Advantages	Disadvantages
• Produces Class A biosolids cake. • Well proven technology with 20 years installation history at full scale. • More throughput per unit digester volume (more than double that of conventional digestion). • High VSR (typically 55 to 60 percent). • Better dewaterability as compared to conventional digestion (typically around 30 percent TS). • Reduced wet mass for hauling. • No regrowth potential. • Good fit for cake receiving as a regional facility (i.e., could be configured to receive cake from other facilities).	• Additional mechanical equipment (screening, pre-dewatering, cake bin, THP). • Steam boiler operation (versus water boilers for conventional digestion). • Increased sidestream N and P loading, including recalcitrant components. • Reactors operate at high temperature/pressure requiring annual inspection and suitable operations and maintenance (O&M) procedures to ensure safe operation.

Thermo-Chemical Hydrolysis

Thermo-chemical hydrolysis is an alternative to thermal hydrolysis that involves the addition of chemicals (typically alkalis such as sodium or potassium hydroxide) as well as heat to achieve hydrolysis of solids either prior to or following anaerobic digestion. Examples include CNP's Pondus™ system and the Lystek™ process.

CNP Pondus™ involves pre-treating WAS in a hydrolysis reactor using sodium hydroxide and heat to hydrolyze the WAS and make it easier to digest. The hydrolyzed WAS is typically then blended with PS and anaerobically digested. The standard Pondus system uses a flow through reactor and does not produce a Class A product. However, the system can be configured to provide batch pasteurization to meet time and temperature requirements for Class A with additional cost and complexity.

Lystek™ involves thermo-chemical hydrolysis of dewatered biosolids downstream of digestion in a reactor using heat and potassium hydroxide. The process can operate in batch mode to meet time and temperature requirements for Class A in a similar manner to THP; however, because the pathogen reduction step occurs downstream of digestion it cannot use VSR across the digesters to meet VAR requirements and must meet VAR by injection below the soil surface within 8 hours after being discharged from the pathogen treatment process. Figure 8-19 shows a schematic of the Lystek™ system downstream of digestion.

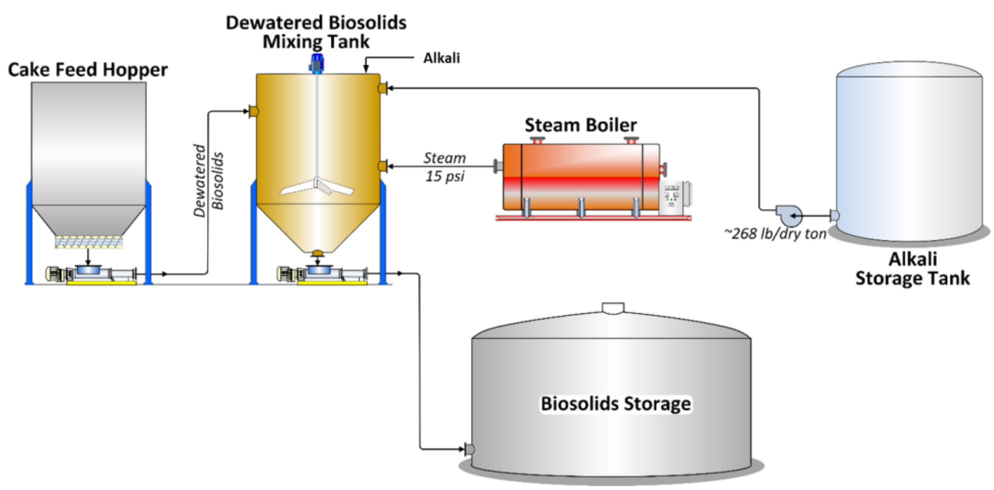


Figure 8-19 Lystek™ Thermo-Chemical Hydrolysis System Downstream of Digestion

Advantages and disadvantages of thermo-chemical hydrolysis are summarized in Table 8-15.

Table 8-15 Thermo-Chemical Hydrolysis Technologies Advantages and Disadvantages

Technology	Advantages	Disadvantages
CNP Pondus™	• Simple system, less complex than THP. • Lower capital cost than THP for standard configuration. • Pasteurization can be incorporated to produce Class A biosolids. • Higher digester loading than conventional digestion but less than THP (more throughput for existing digesters). • Some improvement in VSR/gas production but not as significant as THP. • Some improvement in dewaterability but not as significant as THP.	• Standard configuration will not meet Class A. • Pasteurization system adds cost and complexity if Class A is required. • Pasteurization configuration is unproven at full scale. • Limited use in the United States.
Lystek™	• Can produce a Class A liquid product. • Added potassium may increase commercial value as fertilizer. • Simple system, less complex than THP. • Potential for recycle of high COD supernatant either to BNR as supplemental carbon source or to digesters to increase gas production.	• Compliance with VAR requires injection into soil within 8 hours to meet regulatory requirements. • No increase in throughput of existing digesters. • Requirement for large liquid product storage tanks. • Limited use in the United States.

Other Hydrolysis Technologies

A number of other hydrolysis technologies have been used with the aim of improving VSR and gas production with anaerobic digesters. These include the use of ultrasound, microwaves, rapid pressure changes, and the application of electric fields. None of these technologies have gained widespread traction in the industry compared to thermal hydrolysis, which has been used successfully in many water reclamation facilities worldwide. Several examples are listed below:

- Biocrack™ – electric field.
- Sonolyzer™ – ultrasound.
- Crown™ disintegrator – pressure change/cavitation.
- Praxair Lyso – ozone.

Other previous examples include Microsludge™ and Opencel™; however, neither of these products appear to be currently marketed.

These technologies have limited successful experience at full scale for municipal solids treatment. As with the application of any technology, utilities are advised to carry out due diligence, seek references, and carry out pilot studies before applying technology that has not been widely and successfully demonstrated in the industry.

Digestion Comparison

Figure 8-20 compares available digestion technologies and those described above.

DIGESTION TECHNOLOGIES	Typical Facility Size	Technology Status in the U.S.	Class A Product	End Product	By-Products	Complexity L/M/H
Aerobic digestion	Small-medium	Established		Cake	N/A	L
Autothermal thermophilic aerobic digestion	Small-medium	Established	Y	Cake	N/A	M
Anaerobic digestion (mesophilic)	Medium-large	Established		Cake	Biogas	M
Acid phase digestion	Medium-large	Established		Cake	Biogas	M
Anaerobic digestion (thermophilic)	Medium-large	Established		Cake	Biogas	M
Temperature phased anaerobic digestion	Medium-large	Established	Y	Cake	Biogas	H
Thermal hydrolysis + digestion[1]	Medium-large	Established	Y	Cake	Biogas	H
Thermo-chemical hydrolysis + digestion (CNP Pondus™)	Medium-large	Innovative		Cake	Biogas	M
Thermo-chemical hydrolysis with pasteurization + digestion (e.g. CNP Pondus™)	Medium-large	Embryonic	Y	Cake	Biogas	H
Digestion + downstream thermochemical hydrolysis (e.g. Lystek™)[2]	Small-large	Emerging	Y	Liquid	Biogas	M
Enhanced enzymic hydrolysis	Medium-large	Emerging	Y	Cake	Biogas	H
Ultra-sonic hydrolysis + digestion	Medium-large	Emerging		Cake	Biogas	M

[1] Higher cake TS than conventional digestion (~30 percent TS)
[2] Class A requires soil incorporation for VAR. High solids liquid product (~14 percent TS)

Figure 8-20 Digestion Technology Comparison

Chemical Stabilization

There are several different methods for using chemical addition to achieve stabilization and pathogen reduction and VAR in biosolids, including traditional lime stabilization systems that have been used for many years as well as newer technology using different chemical treatment approaches.

Lime Stabilization

The most common form of chemical stabilization is lime stabilization, which involves the addition of lime to raise the temperature and pH of the sludge to kill pathogens. The process can meet regulatory requirements for pathogen reduction based on achieving operating criteria for time and temperature, or time, temperature, and pH. The elevated pH (typically 12 or higher) also meets requirements for VAR, and the end-product can achieve Class A status. Figure 8-21 shows an example lime stabilization installation.

Figure 8-21 Example Lime Stabilization Installation in Atlanta, Georgia

Lime stabilization generally requires a low capital investment but results in relatively high operating costs. It is most suited for small- to medium-sized facilities. It also results in an increase in the mass of solids produced because of the additional lime solids. There have also been odor issues with land application programs using lime stabilized solids.

Vendor supplied lime stabilization systems are available from companies such as Schwing Bioset™ and RDP Technologies, Inc.

A schematic showing a lime stabilization system is provided on Figure 8-22.

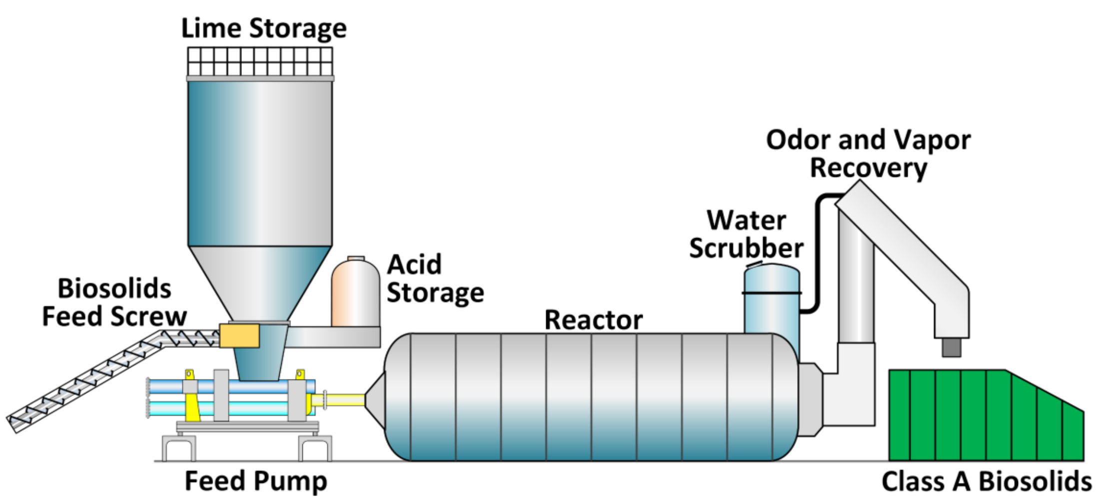


Figure 8-22 Lime Stabilization System (based on Schwing Bioset™)

The advantages and disadvantages of lime stabilization are summarized in Table 8-16.

Table 8-16 Lime Stabilization Advantages and Disadvantages

Advantages	Disadvantages
• Relatively low capital cost. • Simple process and operation. • Capable of handling a wide range of sludges. • The end product can be used as fertilizer and is potentially marketable if farmers need to supplement soil alkalinity.	• Relatively high operational costs. • Increases the volume of stabilized biosolids to be disposed. • Chemical handling and storage requirements. • The decrease in pH after treatment can contribute to odors and bacterial regrowth. • The process and product can generate dust that is corrosive to equipment and structure and makes for a poor work environment.

Chlorine Dioxide Stabilization

BCR Environmental offers proprietary processes to create both Class B and Class A products. The two processes, Clean B and Neutralizer, have been granted PSRP and PFRP national equivalencies by EPA for treating WAS when specified operational conditions are met. Clean B has been applied to combined primary and WAS sludges, however, with fecal coliform testing used to demonstrate compliance with Class B criteria.

Both processes incorporate on-site generation of chlorine dioxide, which is injected into solids prior to dewatering, but the processes differ significantly in other ways. Key differentiators between the two processes are summarized on Figure 8-23.

Parameter	 Clean B (Class B)	 Neutralizer (Class A)
Feed requirements	• 2% TS WAS at dissolved oxygen > 1 mg/l (air compressor required)	• 4 % TS
Chemicals/ application	• Sulfuric acid and sodium chlorite mixed to form chlorine dioxide • Chlorine dioxide added to feed sludge	• Ferric sulfate added to feed sludge to precipitate phosphorus • Sulfuric acid and sodium chlorite mixed to form chlorine dioxide • Chlorine dioxide added to feed sludge and held for 1 hour • Sulfuric acid and sodium nitrate added and held for 6 hours • Caustic added

Figure 8-23 Chlorine Dioxide Stabilization Comparison

Of the two, Clean B has been more widely adopted. Key process advantages and disadvantages are listed in Table 8-17.

Table 8-17 Chlorine Dioxide Stabilization Advantages and Disadvantages

Advantages	Disadvantages
• Relatively low capital cost. • Simple process and operation. • Improved dewaterability. • Reduced odors. • Small footprint.	• Chemical handling and storage requirements. • Relatively high operating costs.

Chemical Stabilization Comparison

Figure 8-24 compares the chemical stabilization technologies described above.

CHEMICAL STABILIZATION	Typical Facility Size	Technology Status in the U.S.	Class A Product	End Product	By-Products	Complexity L/M/H
Lime stabilization[1]	Any	Established	A or B	Cake	N/A	M
Chlorine dioxide stabilization - Class B (e.g. BCR CleanB™)	Small-medium	Innovative	N	Cake	N/A	M
Chlorine dioxide stabilization - Class A (e.g. BCR Neutralizer™)	Small-medium	Innovative	Y	Cake	N/A	M

[1] Lime content increases cake solids content

Figure 8-24 Chemical Stabilization Comparison

Composting

Composting is an aerobic biological degradation process that can achieve Class A pathogen reduction and VAR. The process involves mixing dewatered biosolids with an amendment, typically a wood waste, to achieve adequate porosity to promote aerobic conditions and balance the Carbon to Nitrogen ratio for optimal decomposition.

Several composting configurations are used for biosolids operations, with the most common including windrow composting, ASP composting and in-vessel composting. Figure 8-25 illustrates each of these processes and their key features.

Figure 8-25 Composting Technologies

Each process is subject to slightly different requirements to meet Class A pathogen reduction needs. For ASP and in-vessel systems, the composting material must maintain a temperature at or above 55° C for a minimum of 3 days, while windrow material must maintain that temperature for a minimum of 15 days (during that 15-day period, the windrow piles must be turned at least 5 times).

Although the active composting process is slightly different for each of these technologies, all share the following needs:

- Bulking agent – Yard waste, wood chips, peanut hulls, or other materials are needed to provide both porosity in the composting mix and a carbon source to optimize microbial activity. Typically, two to three parts bulking agent for each part biosolids (volumetric basis) are blended to create a "feedstock mix" with about a 40 percent solids content before composting.
- Aeration – Air is required to maintain aerobic conditions in the composting material and prevent odors. Sufficient oxygen can be provided through natural convention, forced aeration with blowers, or by turning the compost pile (windrowing). The type of aeration method dictates the physical configuration of the compost operation.
- Screening – Screening is typically performed after the active composting period to recover bulking agent for reuse and/or meet customer requirements.
- Curing – This critical step, typically 30 to 90 days in duration, "finishes" the compost process, lowering temperatures and ensuring that the final product is stable.
- Storage – Storage is required to accommodate seasonal impacts on compost demand.

Composting systems require a large area for processing, materials storage, and to provide for odor mitigation. Windrow and ASP facilities require the largest amount of land. Even with aeration, odors from these methods can be problematic. Additionally, land may be required for biofilters to treat process odors from ASP or in-vessel systems and/or to provide a significant buffer for potential odors from windrow facilities or curing piles. In-vessel composting systems typically have a smaller footprint than the static pile or windrow methods; however, the capital cost is higher. ASP and in-vessel systems are often equipped with biofilters to treat odorous process exhausts; the biofilters themselves can be land-intensive.

Advantages and disadvantages of compost stabilization are listed in Table 8-18.

Table 8-18 Composting Advantages and Disadvantages

Advantages	Disadvantages
• Class A product suitable for diverse uses. • Relatively simple operation. • Windrow composting can offer low capital costs.	• Large footprint. • Odor concerns/management. • Need for bulking agent. • Significant transport needs because of bulking agent, low density of finished compost.

Composting Comparison

Figure 8-26 compares the composting technologies described above.

COMPOSTING	Typical Facility Size	Technology Status in the U.S.	Class A Product	End Product	By-Products	Complexity L/M/H
Windrow composting	Any size; often 3rd party/off site facility	Established	Y	Compost	N/A	L
Aerated static pile composting	Any size; often 3rd party/off site facility	Established	Y	Compost	N/A	L
In-vessel composting	Small-medium	Established	Y	Compost	N/A	M

Figure 8-26 Composting Comparison

Drying Biosolids

Thermal Drying

Thermal drying technologies remove moisture by raising the temperature of the incoming sludge cake to evaporate water, reducing the total volume and producing a stabilized end-product that retains its nutrient properties. Biogas, natural gas, or some form of waste heat is required as the energy source for thermal drying.

Thermal dryers can be categorized into direct drying systems such as rotary drum dryers, fluid bed dryers, and belt dryers where the biosolids are dried via direct contact with heated air, or indirect drying systems such as disc, paddle, or tray dryers where the biosolids are dried via contact with a surface that is in turn heated by a heated fluid.

Dryers are usually fed from feed bins receiving digested and dewatered cake. The final product, once cooled, is discharged to a product handling/storage system often consisting of silos with a truck loading station. Dryer systems incorporate air emissions and odor control for processing off-gas emissions.

Thermal dryers are able to meet state and national regulatory requirements for pathogen reduction (either by meeting time and temperature requirements or by designation as a "Process to Further Reduce Pathogens" and meeting associated requirements). VAR is met by achieving stipulated dryness criteria in the regulations, depending on the type of biosolids feed.

As mentioned above, various dryer types are available, and the product quality varies significantly depending on the technology and specifics of the vendor's equipment. Also, applicability of technology varies depending on throughput requirements.

Rotary drum dryers (e.g., Andritz DDS, Baker Rullman) produce a high-quality pelletized product and are a better fit for medium to large utilities. They work by coating recycle dried product with wet cake in a mixer and drying this material in a heated (typically multi-pass) drum. Dried product is separated from process air in a polycyclone separator. The dried biosolids are screened to produce the required granule size. Oversized particles are crushed and returned to the process via a recycle bin, along with under-sized particles/fines and a portion of recycled product.

Fluid bed dryers (e.g., Andritz FDS, Schwing/Bioset) produce a product of a similar quality to a rotary drum dryer. Similar to drum dryers, they are likely to be more suited to medium to large utilities. Fluid bed dryers work on a similar principle to drum dryers but with the pellets being dried in a fluidized bed rather than a multi-pass drum. These types of dryers are uncommon in the United States but have been used more commonly in Europe.

Belt dryers (e.g., Andritz BDS, Suez, Veolia, Huber) generally produce a lower quality product than rotary dryers with a lower density but can be a good fit for smaller to medium sized facilities. The product quality from these systems varies significantly with some systems producing a higher quality than others. Belt dryers work by passing heated air over or through a belt that transports biosolids through the unit. A number of methods for feeding biosolids onto the belt are available depending on the manufacturer, including systems with back mixing technology similar to drum dryers, extruders that squeeze the biosolids like spaghetti onto the belt, and systems that pass biosolids through a drum screen onto the belt. It should be noted that the product quality from belt dryers varies significantly depending on the method of delivering biosolids onto the belt.

Paddle/disc dryers (e.g., Komline-Sanderson, Andritz) produce a non-uniform granular product but the systems are relatively compact and may be suitable for smaller to medium sized utilities. They typically work by contacting biosolids with heated discs or paddles, which also serve to push biosolids through the unit as they rotate.

The most common types of dryers for municipal solids applications in the United States are rotary drum dryers, belt dryers, and paddle/disc dryers. Example schematics showing typical arrangements for drum, belt, and paddle dryers are provided on Figure 8-27, Figure 8-28, and Figure 8-29.

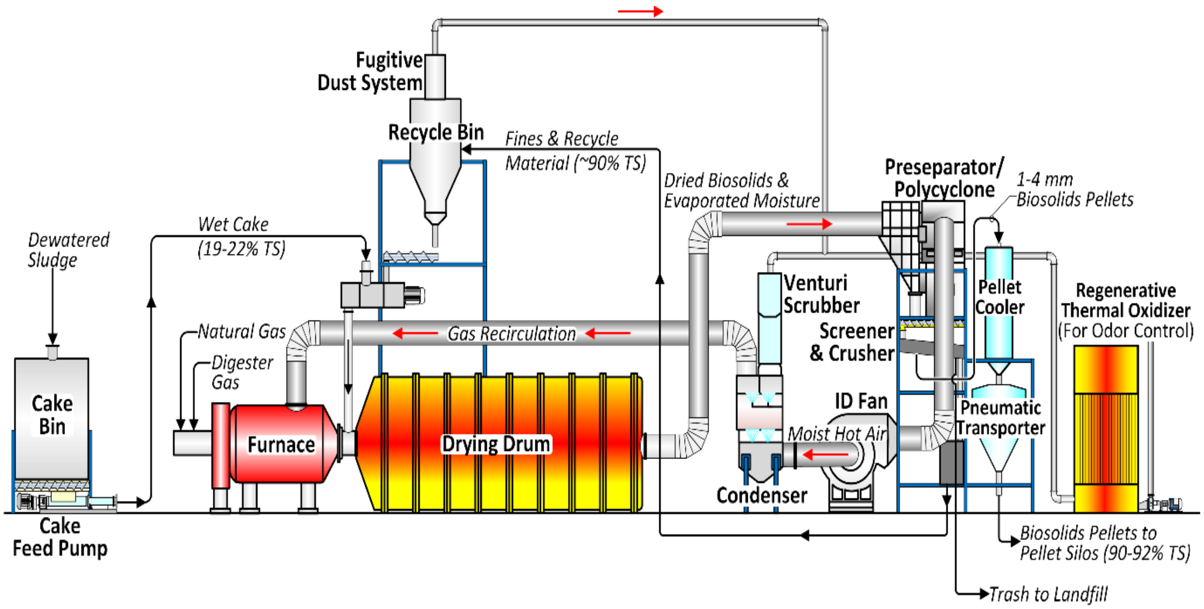


Figure 8-27 Rotary Drum Dryer Schematic Based on Andritz Technology

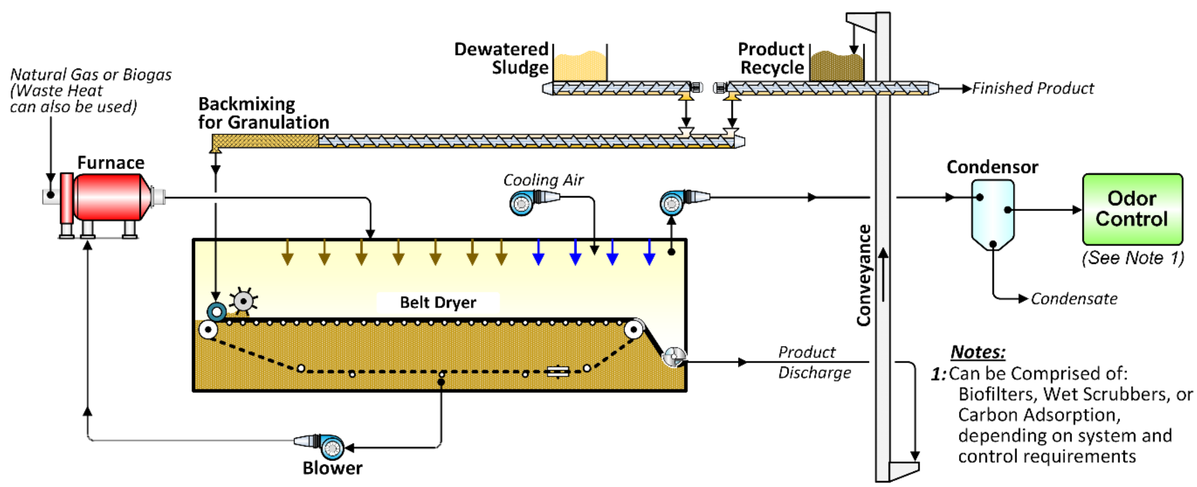


Figure 8-28 Belt Dryer Schematic Based on Andritz Technology

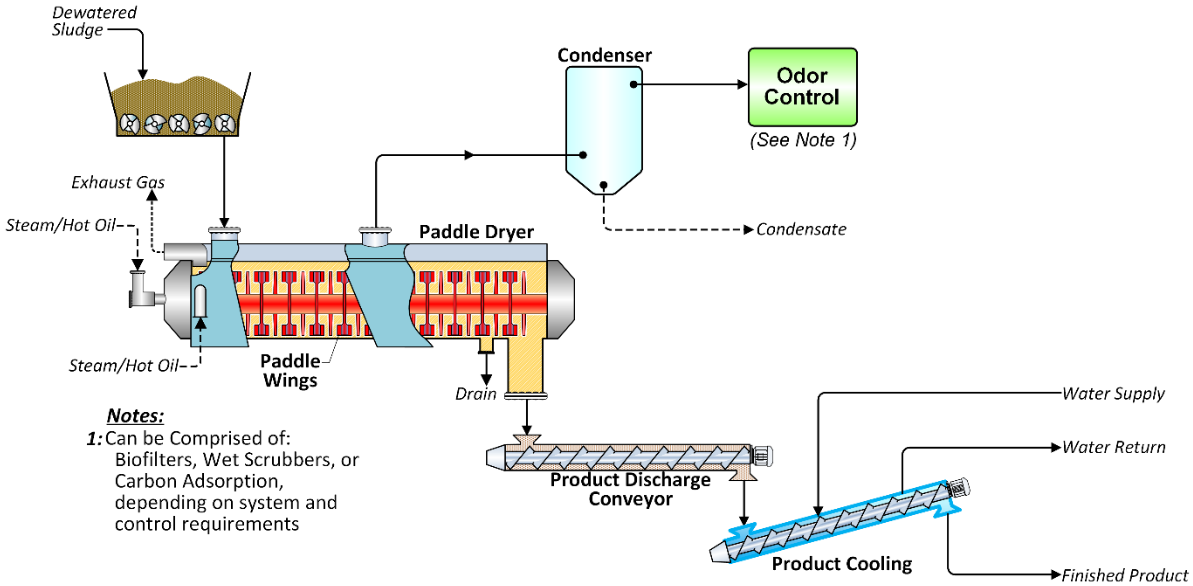


Figure 8-29 Paddle Dryer Schematic Based on Komline-Sanderson Technology

Some examples of product quality from different types of dryers are shown on Figure 8-30. Note the wide variation in product quality. It is strongly recommended that before choosing a drying technology, utilities consider the quality of product with respect to the intended end use to ensure that it will meet the needs of the intended market.

Drum dryer	Belt dryer (with back mixing)	Belt dryer (extrusion type)	Paddle dryer
			

Figure 8-30 Variations in Product Quality from Different Dryer Technologies

Thermal dryers are typically fueled using natural gas or digester gas (or a combination of the two) and lower temperature systems, such as belt dryers, are also able to make use of lower grade waste heat that may be available from reciprocating engine generators.

It is important to note that safety considerations are paramount in dealing with dryer systems. The dried product is combustible and will begin to smolder after some time (because of exothermic biochemical reactions) if allowed contact with moisture or condensate. Dust produced in drying systems will present an explosion risk if not properly managed. Safety systems as well as operational safety procedures are critical with these systems, as there have been some significant safety incidents.

Advantages and disadvantages of thermal drying are summarized in Table 8-19.

Table 8-19 Thermal Drying Advantages and Disadvantages

Advantages	Disadvantages
• Can produce a Class A product. • Some systems produce a high-quality product, which may be marketable. • Largest volume reduction for any technology other than thermal conversion, allows for a potential backup of landfill disposal without triggering HMCW management concerns.	• Highly mechanical systems requiring significant attention to operations and maintenance. • Requires stringent adherence to safety procedures to mitigate fire and explosion risks. • Large energy requirements (depending on availability of digester gas).

Solar Drying

This technology uses both radiant and convective heat in a greenhouse configuration (drying chambers) to dry solids.

Liquid or dewatered solids are spread in thin layers inside a large greenhouse-like structure and periodically agitated or turned to promote drying. The spreading and agitation method varies by technology vendor. For example, one system uses a small automatic mobile mixer to both spread and agitate the sludge on the bed to promote drying (Figure 8-31) . A microprocessor controls vents and fans to optimize the humidity level within the chamber to further enhance drying.

Figure 8-31 Example Solar Dryer Installation

Solar drying is typically used to dry solids to a TS content between 40 to 80 percent. Achieving solids concentrations on the high end of that range will require longer time in the drying chamber, especially in the winter months. Although a number of factors will affect drying time, it appears that typically 18 to 20 days is adequate to dry most sludges to an 80 percent solids content. The finished product can be land applied using a manure spreader.

The process can produce a Class A biosolids product, but it does not meet process-specific regulatory requirements. Instead, facilities using the process must rely on Class A Alternative 3, which establishes numeric criteria for helminth ova and enteric viruses.

Solar drying requires a very large footprint and the greenhouses require large volume odor control to avoid odor complaints.

Advantages and disadvantages of solar drying are summarized in Table 8-20.

Table 8-20 Solar Drying Advantages and Disadvantages

Advantages	Disadvantages
• Can potentially meet Class A. • Simple system. • Minimal energy requirements compared to thermal drying. • Significant solids volume reduction. • Soil-like product.	• Requires numeric pathogen testing to demonstrate Class A product. • Large footprint. • Large exhaust volume may require odor control. • Generally suitable for WAS only.

Drying Comparison

Figure 8-32 compares available drying technologies and those described above.

DRYING	Typical Facility Size	Technology Status in the U.S.	Class A Product	End Product	By-Products	Complexity L/M/H
Belt Dryer	Medium-large	Established	Y	Dried product	Waste heat	M
Rotary drum dryer	Medium-large	Established	Y	Dried product	Waste heat	H
Fluidized bed dryer	Medium-large	Innovative	Y	Dried product	Waste heat	H
Paddle / disc dryer	Any	Established	Y	Dried product	Waste heat	M
Drying beds	Small-medium	Established	N	Soil-like product	N/A	L
Solar dryer	Small-medium	Established	Potentially	Soil-like product	N/A	L

Figure 8-32 Drying Comparison

Thermal Conversion

The thermal conversion of organics in biosolids has been dominated for many years by incineration, which involves thermal conversion of biosolids with enough oxygen present to oxidize the organic matter. More recently, there has been a growing interest in alternatives to incineration such as gasification (thermal conversion with limited oxygen present) and pyrolysis (thermal conversion with no oxygen present).

Incineration

Incineration achieves complete combustion of the volatile organic component of biosolids in the presence of sufficient oxygen to provide complete combustion. This also results in the destruction of pathogens, the evaporation of moisture, and the production of a non-odorous ash consisting of inert solids that can be landfilled or beneficially used. Landfilling is the dominant practice in the United States, but some utilities have been able to use their product as a feedstock in fertilizer production.

In 2011, the EPA finalized the Sewage Sludge Incineration (SSI) Maximum Achievable Control Technology (MACT) rules that affect all sanitary sludge incinerators. These rules set emissions standards that incinerators at wastewater treatment plants must meet. Compliance with MACT standards has resulted in additional emissions control requirements, causing a substantial increase in the cost of incineration. Biosolids incinerators have also been associated with significant public objections in some areas of the country.

Two types of incinerators have been widely employed worldwide: multiple hearth incinerators (MHIs) and fluidized bed incinerators (FBIs). MHIs are less efficient than FBIs, which has led to their gradual phasing out. The MHI furnace consists of a cylindrical steel shell surrounding a number of solid refractory hearths, and a central rotation shaft to which rabble arms are attached. In FBI units, the reactor is a closed cylindrical vessel with refractory walls. Fluidizing and combustion air enters the unit and keeps silica sand particles in suspension and boiling motion for optimum contact of the cake with the combustion air. The sand bed retains the organic particles until they are reduced to ash.

In Georgia, the recent trend has been away from sewage sludge incineration with the closure or cessation of operation of facilities in the City of Atlanta, City of Savannah, and Cobb County. With the pressures on landfill disposal of biosolids, there has been some renewed interest in this technology; however, concerns over ease of permitting and potential public perception challenges remain.

A schematic showing a typical arrangement for a fluidized bed incinerator is provided on Figure 8-33.

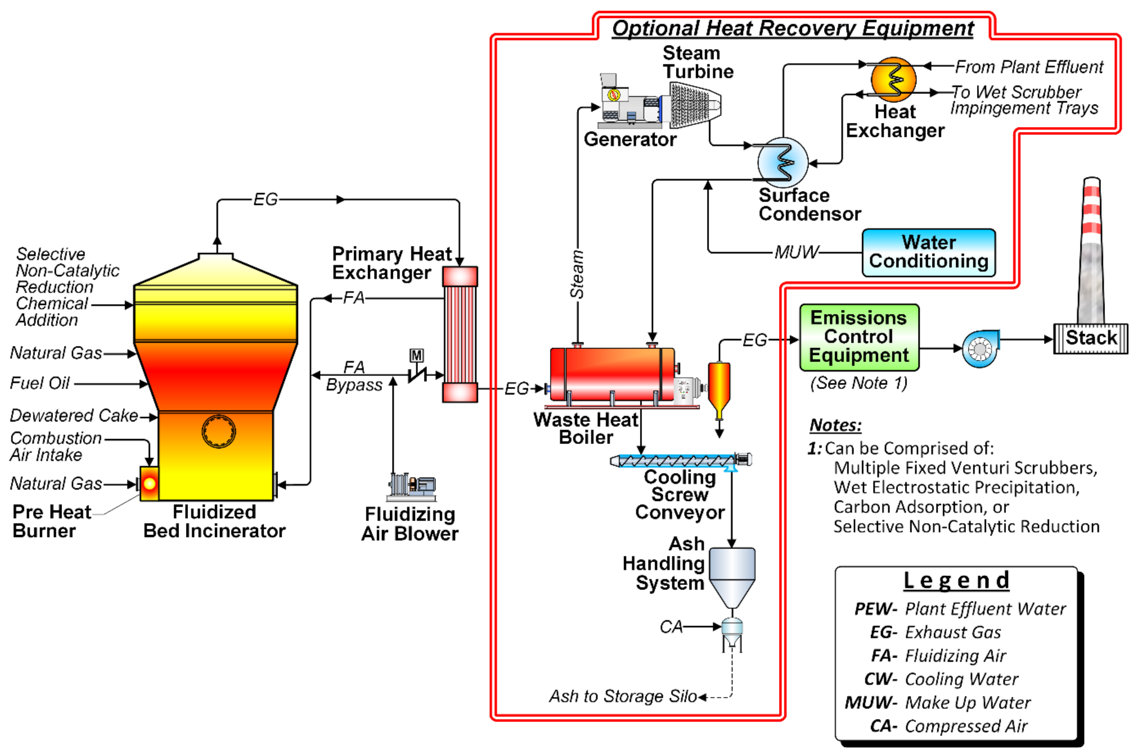


Figure 8-33 Fluidized Bed Incinerator Schematic

The advantages and disadvantages of incineration are summarized in Table 8-21.

Table 8-21 Incineration Advantages and Disadvantages

Advantages	Disadvantages
• Achieves maximum reduction in mass of final product for disposal (produces an inert ash). • Complete pathogen destruction. • Potential for energy recovery. • Less concern about emerging contaminants if ash is sent to landfill (compared to beneficial use of biosolids).	• Complex process from a mechanical and control perspective. • An auxiliary source of fuel is required for startup, and possibly for normal operation if the combustion process is not self-sufficient. • Odor concerns/management. • The process has a long startup time to reach operating temperature and needs to be run constantly for extended time periods. • The process requires a relatively uniform dewatered solids feed. • Extended periods of downtime are typically required for maintenance, requiring multiple streams, extended sludge storage, or an alternative biosolids outlet during this period.

Pyrolysis

Pyrolysis involves the thermal conversion of carbonaceous material in the absence of an oxidizing agent. The products of the reaction are a liquid bio-oil, a biochar, and some combustible gas. The bio-oil and combustible gases produced in the process can be cleaned and used to generate electricity and heat via gas engines, gas turbines or via a boiler and steam turbine. The bio-oil can also be refined and used to produce transportation fuels or chemicals; however, at present this does not appear to be economically favorable. The biochar can potentially be processed to recover metals and to produce carbon products (e.g., activated carbon) or can be used as a soil amendment.

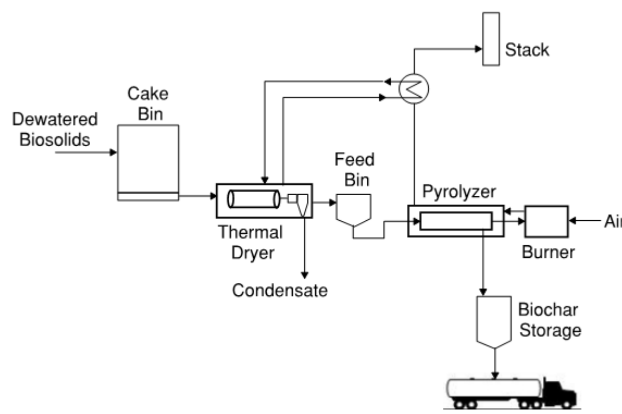


Figure 8-34 Pyrolysis (based on BioforceTech System)

The pyrolysis process can be classified as either fast or slow depending on the reaction time and temperature with faster reaction times producing a higher proportion of fuel products. Slow pyrolysis is also termed “carbonization.”

Pyreg Carbon Technology Solutions is a German company that has delivered multiple pyrolysis/carbonization solutions, including four installations on municipal, dried sewage sludge (two in Germany, one in Sweden). Silicon Valley Clean Water in Redwood California recently installed a pyrolysis system delivered by BioforceTech Corporation).

Some recent investigations have identified that pyrolysis has the potential to remove PFAS compounds from biosolids (Sazal Kundu, 2021), although questions remain regarding releases from and potential additional compounds formed in the process.

Gasification

Gasification is the thermal conversion of carbonaceous material into a combustible gas known as syngas, which is composed mainly of H_2, CO, CO_2, H_2O CH_4 (plus some longer chain hydrocarbons depending on the type of process used). This is an emerging technology that has seen substantial investment, although as yet there have been only a handful of commercial scale facilities operating on biosolids. It is, however, starting to gain more interest in the biosolids market.

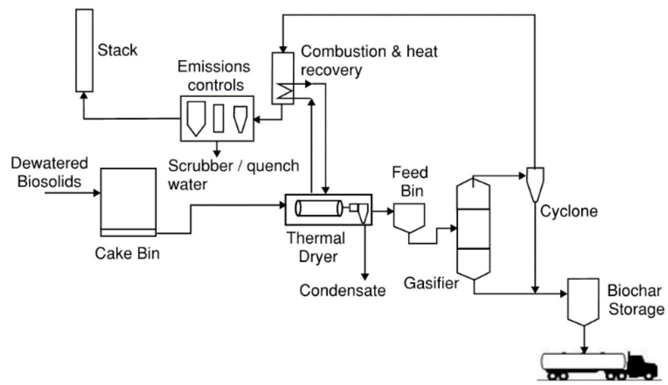


Figure 8-35 Typical Gasification System (Close Coupled)

The gasification process involves heating to high temperature (500 to 1,600° C) in the presence of a controlled supply of oxygen (with the air/fuel ratio typically controlled to between 25 percent and 35 percent of the stoichiometric requirement).

A variety of different types of gasifiers are available for processing including updraft, downdraft ad fluidized bed systems, with the choice of process having an impact on the quality/energy value of the syngas produced.

Close coupled gasification involves direct combustion of the syngas to provide heat for the dryer system, whereas two stage gasification involves combustion of the syngas for power production (e.g., in a reciprocating engine generator) with waste heat recovery for drying.

In the United States, Aries Clean Energy (formerly PHG Energy) acquired the intellectual property and an existing biosolids demonstration scale gasification facility (at Sanford FL) from Maxwest following bankruptcy of the company in 2014. This added Maxwest fluid bed gasification technology to their existing portfolio of downdraft gasification systems. Since then, Aries Clean Energy has been awarded and is currently constructing a new 400 (wet) ton per day biosolids gasification system for the City of Linden in New Jersey. The company also operates a facility at Lebanon, Tennessee, that processes predominantly wood waste but also receives biosolids as a portion of the feedstock. In Europe, Sülzle Kopf has three installed 2-stage fluidized bed gasification facilities in Germany in the Cities of Koblenz, Mannheim, and Balingen, with capacities ranging from 2,000 to 5,000 tons dry solids per year.

Other Thermal Conversion Technologies

Supercritical wet oxidation refers to the treatment of biosolids under supercritical conditions at which water is above its critical point (374.15° C, 22.1 MPa). Under these extreme conditions, the properties of water dramatically change making organic matter and oxygen extremely soluble with very low mass transfer resistance to chemical reactions. Supercritical wet oxidation of biosolids has been practiced at pilot scale but it cannot currently be considered mature enough for widespread full-scale application. Challenges include stringent requirements for pre-screening and grit removal of biosolids feedstocks as well as scaling and corrosion of the reactor materials. Examples of systems under development include Aquacritox® from H+E and AirSCWO from 374 Water. Both of these systems have yet to be proven for full scale operation on biosolids.

Hydrothermal processing converts organic materials to "biocrude" oil and methane gas at a temperature of 350° C and pressure of 20 MPa. An example is the Genifuel process developed by the Pacific Northwest National Laboratory. The process has been operated at pilot scale on wastewater residuals at Vancouver, Canada, and a 2 metric dry ton per day demonstration facility is planned for 2021 startup.

Thermal Conversion Comparison

Figure 8-36 compares available thermal conversion technologies and those described above.

THERMAL CONVERSION	Typical Facility Size	Technology Status in the U.S.	Class A Product	End Product	By-Products	Complexity L/M/H
Multiple hearth incinerator	Large	Established	N/A	Ash	Waste heat	H
Fluidized bed incinerator	Large	Established	N/A	Ash	Waste heat	H
Pyrolysis	TBD	Innovative	Potentially	Biochar	Syngas	H
Gasification	TBD	Innovative	Potentially	Biochar	Syngas	H
Supercritical wet oxidation	TBD	Embryonic	N/A	Ash	Waste heat	H
Wet air oxidation (e.g. Zimpro)	Medium-large	Largely Obsolete	Y	Inert Cake	N/A	H
Hydrothermal conversion to organic liquid fuel (e.g. Genifuel)	TBD	Embryonic	N/A	Ash	Fuel	H

Figure 8-36 Thermal Conversion Comparison

In addition to the technologies covered here, there are a number of technologies that are variations of the types covered and are in various stages of development, piloting, and implementation. As with the application of any technology, utilities are advised to carry out due diligence, seek references, and carry out pilot studies before applying technology that has not been widely and successfully demonstrated in the industry. Utilities' unique solids characteristics, circumstances, and local opportunities should be considered when selecting technologies for implementation.

Biosolids Management Costs

Overall biosolids management costs are driven by both capital and O&M costs. In general, alternatives such as landfilling and Class B land application offer the lowest capital cost alternatives that minimize up-front investment. However, as end use costs for these alternatives increase (as has been the case in Georgia with escalating landfill costs), it may become cost-effective to accept a higher up-front capital cost investment to save O&M costs associated with biosolids end use, resulting in a lower overall life cycle cost.

Technologies such as chemical stabilization, advanced digestion and composting will generally have a higher capital cost than landfilling or Class B land application and may save O&M costs associated with biosolids end use compared to these alternatives. Thermal drying and thermal conversion technologies such as incineration, gasification, and pyrolysis will generally result in capital costs that are higher than other alternatives, but these technologies may still be cost-effective over the long term if there are significant savings in end use costs.

Figure 8-37 shows typical capital cost categories for the most common biosolids management approaches to help utilities understand which alternatives are likely to involve the highest initial capital investment. Which alternative results in the lowest overall life cycle cost for a given facility or utility will be very situation specific. A detailed economic analysis is recommended for utilities to determine the best path forward given the utility's specific situation and cost drivers. To provide further information on how utility size and treatment approach can impact life cycle cost outcomes, an example technology cost evaluation is provided in Section 9.0.

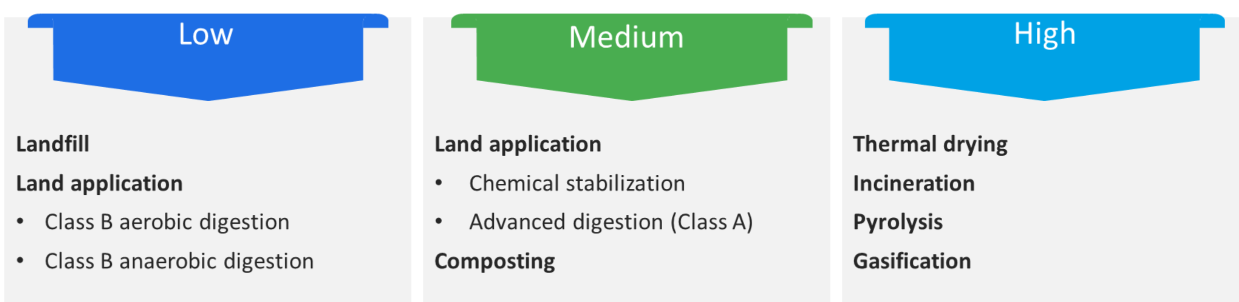


Figure 8-37 Biosolids Management Capital Costs

9.0 Technology Cost Evaluation

A technology cost evaluation was performed in order to determine the life cycle cost of technologies that offer an alternative to landfill disposal. To determine how facility size impacts economies of scale, costs were prepared for two different sizes of facilities. Based on an evaluation of typical plant sizes in Georgia and direction from the project steering group, a rated capacity of 1 mgd was chosen for the smaller facility and 20 mgd was chosen for the larger facility.

Based on feedback from the current management practice survey, the cost evaluation was prepared based on the following alternatives for both sizes of facilities:

- Landfill disposal.
- Class B land application (with construction of a storage barn for wet weather).
- ASP composting to produce a Class A compost.
- Thermal drying to produce a Class A thermally dried product.

For all alternatives, it was assumed that the facility in question already practices digestion and dewatering of biosolids. A summary of solids production used in the evaluation for each size of facility is provided in Table 9-1. The evaluation was prepared assuming that the plants are operating at capacity with the maximum average monthly flow equal to the rated capacity of the plant.

Table 9-1 Solids Production Assumptions for Two Facility Sizes Evaluated

Parameter	Units	Small Facility	Large Facility
Plant rated capacity	mgd	1	20
Maximum month to annual average peaking factor assumed	-	1.5	1.3
Raw solids production rate assumed	dt/MG	1	1
Maximum month raw solids production	dtpd	1	20
Annual average raw solids production	dtpd	0.67	15.4
Stabilization technology assumed present	-	Aerobic digestion	Anaerobic digestion
Maximum month digested solids production	dtpd	0.68	12.80
Annual average digested solids production	dtpd	0.45	9.85
Cake solids content assumed	%	18	18

Class B Land Application

The Class B land application was evaluated based on the cost of building cake storage to manage biosolids production during wet weather because field storage of biosolids is prohibited under the Georgia biosolids rules. A schematic for this alternative is provided on Figure 9-1.

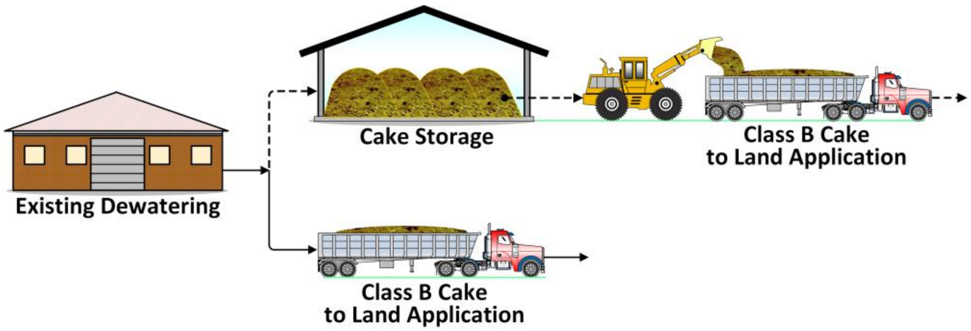


Figure 9-1 Class B Land Application

Aerated Static Pile Composting

ASP composting was evaluated based on the assumption that wood chips are purchased at $40/ton as the bulking agent for mixing with the biosolids to provide structure and as an energy amendment. It should be noted that a wide range of different bulking agents can be used, and the use of different bulking agents would have an impact both on cost and on the required materials balance. A general schematic for ASP composting is provided on Figure 9-2.

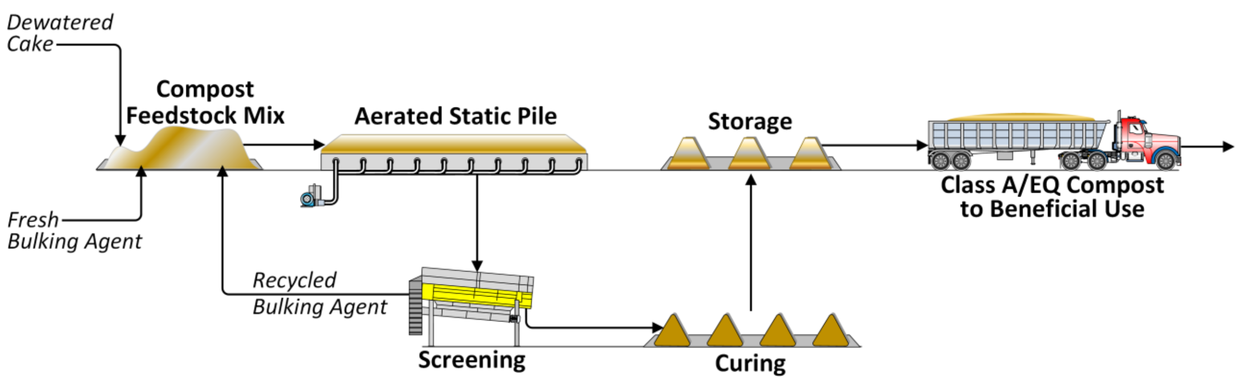


Figure 9-2 Aerated Static Pile Composting

Thermal Drying

Thermal drying to produce a dried biosolids product with a moisture content of at least 92 percent was evaluated. Dryer costs were determined from a cost curve which was based on a combination of previous quotations and some new quotations for smaller sized facilities. The evaluation is technology agnostic with respect to the dryer technology used. The technology for the larger facility could be either a drum or belt dryer given the size of facility. The technology for the smaller facility could be a belt dryer, screw dryer, or tray dryer. The analysis for thermal drying was based on the assumption that 80 percent of the fuel for the dryer would come from biogas for the larger facility (with the remainder from natural gas) and that 100 percent of the fuel for the smaller facility would come from natural gas (because anaerobic digestion is uncommon at this size). A schematic is provided on Figure 9-3.

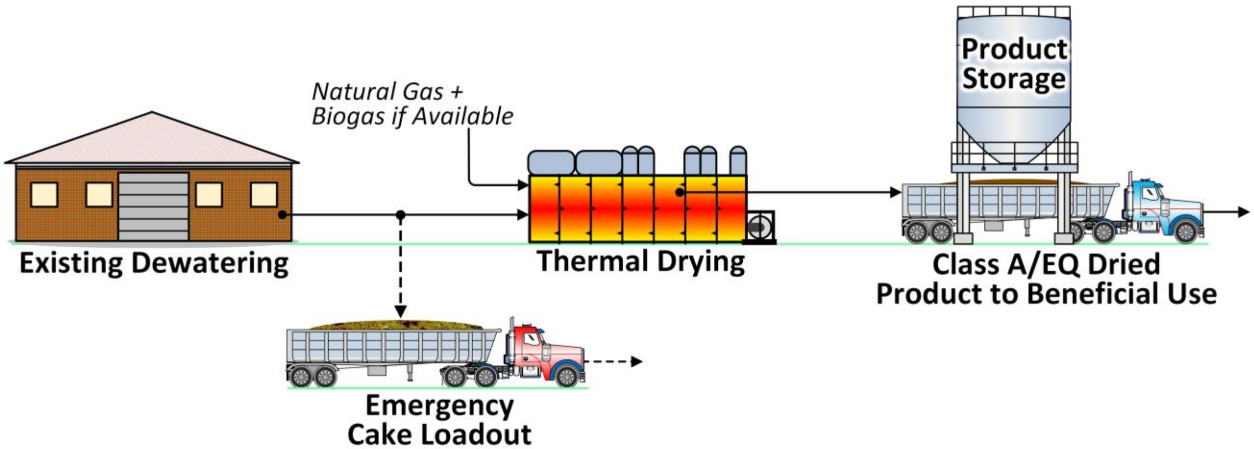


Figure 9-3 Thermal Drying

Cost Analysis

A summary of estimated capital costs for each alternative is provided on Figure 9-4 and Figure 9-5 for the small and large facility sizes, respectively.

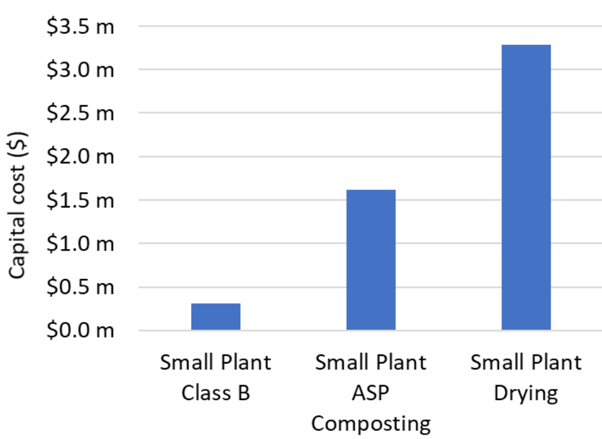


Figure 9-4 Capital Costs for Small Facility Alternatives

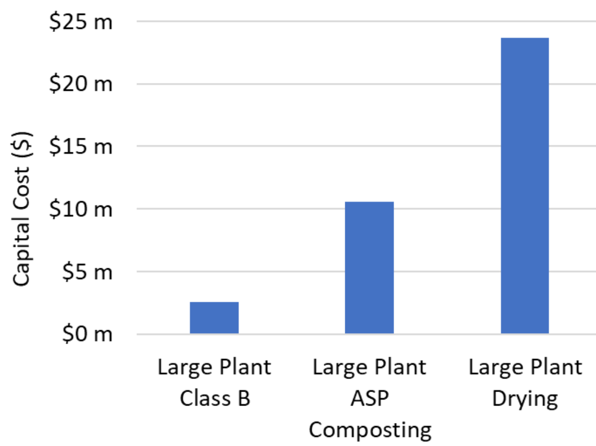


Figure 9-5 Capital Costs for Large Facility Alternatives

O&M costs were estimated for each technology alternative and each size of facility. Key O&M unit costs assumed for the baseline evaluation are summarized in Table 9-2.

Table 9-2 Operations and Maintenance Unit Costs

Parameter	Units	Value
Landfill disposal	$/wet ton	100
Class B land application	$/wet ton	75
Compost	$/ton	30
Dried product	$/ton	0

Parameter	Units	Value
Natural gas	$/mmBtu	8.0
Power	$/kWh	0.06
Fuel	$/gal	3
Maintenance	%	4%
Labor	$/hr	50

A number of other assumptions were made regarding both the capital and O&M costs and these are summarized further in Appendix B.

Sensitivity of the cost outcome to the cost of landfill disposal is further evaluated below.

Estimated O&M costs for each alternative for the smaller size facility and larger facility are provided on Figure 9-6. It is immediately evident from consideration of Figure 9-6 that there is a dramatic difference between the small and large facilities in terms of the O&M costs relative to landfill disposal. For the small facility, both composting and drying were more costly to operate than a continued landfill disposal, whereas for the larger facility these technologies resulted in cost savings relative to landfill disposal. The main reason for the lack of cost savings for the smaller facilities for these technologies was the cost of labor to operate the composting or drying facility.

The same is true but to a lesser extent for Class B land application, where some labor was assumed for management of the on-site storage barn.

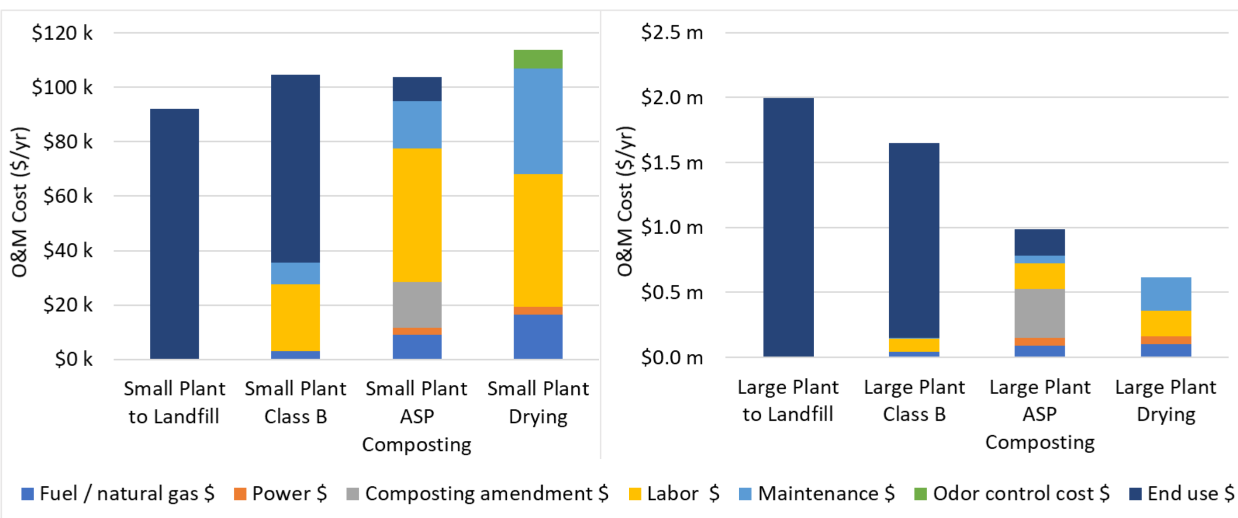


Figure 9-6 O&M Costs Per Year for Each Alternative for both Small Facility (left) and Large Facility (right)

Life cycle costs for each of the alternatives for the small and large facilities are summarized on Figure 9-7 (values shown are net present costs in 2021 dollars).

Life cycle costs were prepared based on a 20-year net present cost evaluation. A rebate at the end of the 20-year evaluation period was assumed for all buildings, based on a 30-year asset life.

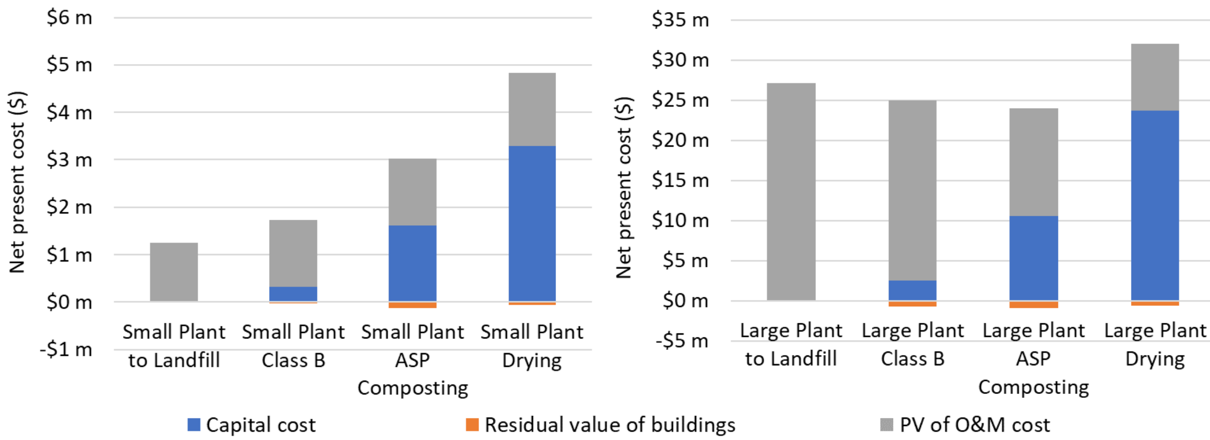


Figure 9-7 Net Present Costs for Each Alternative for both Small Facility (left) and Large Facility (right)

As would be expected for the small facility given the O&M costs for the alternatives, the life cycle costs for composting and drying showed that these technologies are not favorable compared to either landfill disposal or Class B land application at this scale. However, for the larger facility, costs for all alternatives were fairly similar, but with a slightly higher life cycle cost for the drying alternative.

The difference in the viability of composting and thermal drying between the small and the large facility size clearly demonstrates the economies of scale associated with these processing alternatives. In order to benefit from these types of technologies, smaller facilities may need to join regional partnerships with other utilities or third party biosolids management companies in order to make these processing options financially viable.

Sensitivity analysis was conducted in order to evaluate the impact of key variables on the estimated life cycle cost outcomes. Figure 9-8 and Figure 9-9 show the impact of the landfill disposal cost on the life cycle cost outcome of Class B land application, ASP composting and thermal drying for the small and large plants respectively.

It can be seen that composting and thermal drying appear to have a higher life cycle cost for the smaller facility across the range of landfill disposal costs evaluated. The small facility, Class B land application at $75 per ton appeared to be financially viable compared to continued landfilling at a landfill disposal cost of approximately $135 per ton, whereas for the larger facility, the breakeven point was more like $90 per ton.

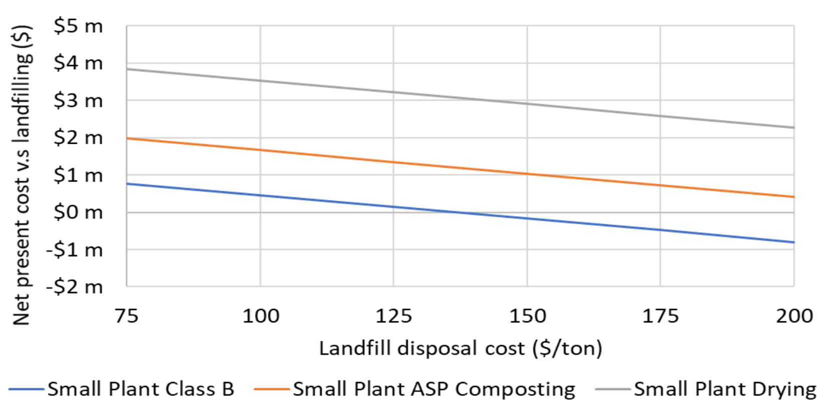


Figure 9-8 Net Present Cost Sensitivity to Continued Landfill Disposal Cost (Small Facility)

For the larger facility, ASP composting appears to be financially attractive at a landfill cost of around $85 per wet ton or greater and thermal drying appeared to be financially viable at a landfill cost of around $115 per wet ton or greater.

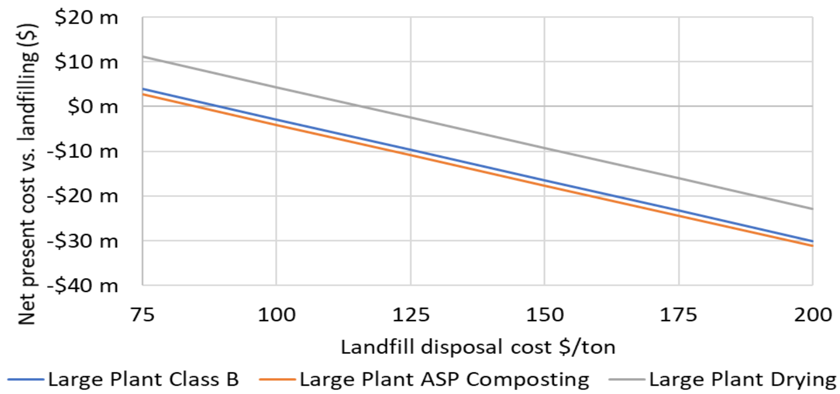


Figure 9-9 Net Present Cost Sensitivity to Continued Landfill Disposal Cost (Large Facility)

Conclusions

The following conclusions were reached in the technology cost evaluation:

- For a small facility with a capacity of 1 mgd, neither composting nor thermal drying appeared to be financially viable compared to continued landfilling across the range of landfill costs currently reported in Georgia.
- For a larger facility with a capacity of 20 mgd, composting appeared to be viable once landfill costs reach around $85 per ton and thermal drying at around $115 per ton.
- Differences between the results for the small and large facilities clearly show the significant economies of scale with these treatment approaches that make them more viable as facility size increases.
- For smaller facilities to take advantage of these economies of scale, some kind of regional partnership would be required, either teaming with other facilities for biosolids processing or engaging with a third-party contractor for solids processing.

10.0 Landfill & Municipal Solid Waste Opportunities

Landfill Capacity

Georgia EPD conducted a landfill Sludge Survey in 2018 to document the amount of sludge and HMCW currently disposed in landfills across the state. According to the survey, 42 of 51 MSW landfills accepted HMCW in 2017. The 2018 tonnage report indicates that four of these are unlined sanitary landfills that are not suitable for HMCW disposal and two are industrial landfills. Of the 51 MSW landfills, 12 are private commercial, one is commercial industrial, and all others are public.

Results from the 2018 Sludge Survey showed that 10 MSW landfills received more than 10 percent wet material by volume in 2017. After a significant slope failure in 2018, Georgia EPD accelerated the permit review schedule for these MSW landfills and asked that each conduct a rigorous site investigation to determine suitability for managing HMCW and identify any issues regarding HMCW disposal. One site investigation resulted in the landfill operator taking remedial action by constructing a berm and others established self-imposed limits on HMCW.

Potential scenarios were discussed with EPD's Solid Waste Permitting Unit to forecast available MSW landfill capacity for wastewater solids in Georgia. EPD expects that landfills will continue accepting more than 5 percent HMCW by volume and will proceed with HMCW management plans. However, some landfills may have stopped receiving or greatly reduced the amount of HMCW accepted because of concerns over recent slope failures. Given these uncertainties, EPD concurred with Black & Veatch's suggestion to evaluate three potential scenarios: HMCW acceptance at MSW landfills of 5 percent, 10 percent, and 15 percent of total wet tonnage disposed.

EPD provided 2018 Annual Tonnage Reports that summarized waste received at each landfill during each quarter of the year. EPD also provided a summary of the 2018 Sludge Survey that showed 7.3 percent of the waste disposed in MSW landfills in Georgia was HMCW and that 84 percent of the HMCW was sludge. EPD personnel stated that most of the sludge is wastewater solids although there are other sludge types included. Therefore, it was assumed that 84 percent of HMCW was wastewater solids.

Using the total annual tonnage disposed at each landfill and the assumptions regarding wastewater solids and HMCW, Figure 10-1 shows the estimated sludge tonnage that could be accepted in each Regional Commission and statewide at the various HMCW acceptance rates. This is compared to the estimated 2019 solids production and predicted 2060 solids production at 18 percent TS, which is typical for dewatered cake from belt filter presses (the most commonly used dewatering technology in the state based on the utility survey responses). Figure 10-2 shows the estimated amount of currently produced wastewater solids (at 18 percent TS) that exceeds the landfill capacity in each Regional Commission if the acceptance rate of HMCW is only 5 percent. In this scenario, the Atlanta Regional Commission would produce nearly 250,000 wet tons per year (tpy) of solids that could not be disposed by landfilling at landfills located within the counties that make up the Atlanta Regional Commission. Other Regional Commissions would lack landfill capacity by 9,000 to 44,450 wet tpy and only the Northeast Georgia and Southern Georgia Regional Commissions would have sufficient capacity to dispose all solids by landfilling. Overall, at an acceptance rate of 5 percent HMCW, the statewide capacity would be exceeded by 382,300 wet tons of wastewater solids annually.

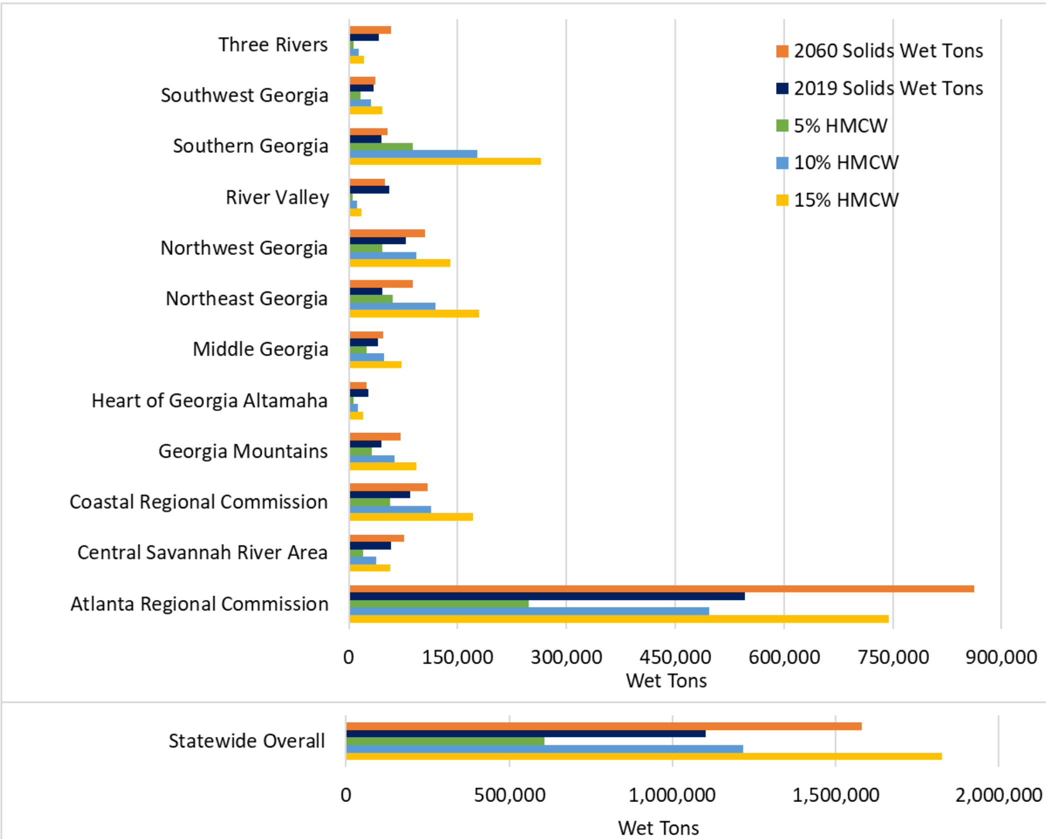


Figure 10-1 Comparison of Estimated Wastewater Solids to Sludge Tons at Various HMCW Acceptance Rates

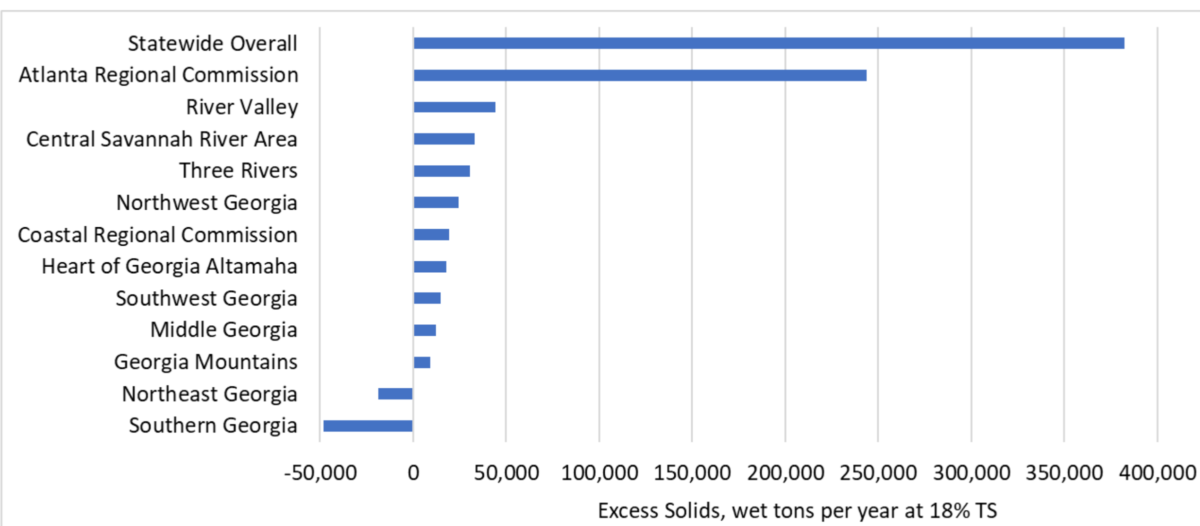


Figure 10-2 Estimated Amount of Currently Produced Wastewater Solids Exceeding Landfill Capacity at 5 Percent HMCW Acceptance Rate

Table 10-1 shows the number of landfills and provides the estimated amounts of sludge tonnage at various HMCW acceptance rates and the estimated solids produced in each Regional Commission in 2019. There are several Regional Commissions where the estimated amount of solids produced in 2019 exceeds landfill capacity at both 5 percent and 10 percent HMCW. For the Central Savannah River Area, Heart of Georgia Altamaha, River Valley, and Three Rivers Regional Commissions, the amount of solids produced in 2019 may exceed landfill capacity even at 15 percent HMCW acceptance.

Table 10-1 Landfill Location, Estimated Sludge Accepted, and 2019 Solids Produced by Regional Commission

Regional Commission	No. Landfills	Sludge Tons at 5% HMCW	Sludge Tons at 10% HMCW	Sludge Tons at 15% HMCW	Estimated Solids, dry tons	Estimated Solids, wet tons (18% TS)
Atlanta Regional Commission	7	248,300	496,700	745,000	98,400	546,700
Central Savannah River Area	3	19,100	38,200	57,300	10,400	57,800
Coastal Regional Commission	7	57,100	113,900	171,000	15,300	85,000
Georgia Mountains	4	31,100	62,300	93,400	8,000	44,400
Heart of Georgia Altamaha	4	6,500	12,700	19,200	4,800	26,700
Middle Georgia	3	24,000	48,100	72,300	7,300	40,600
Northeast Georgia	4	60,000	119,900	179,900	8,300	46,100
Northwest Georgia	5	46,500	93,200	139,600	14,200	78,900
River Valley	2	5,700	11,400	17,100	10,000	55,600
Southern Georgia	6	88,600	176,900	265,400	8,000	44,400
Southwest Georgia	4	15,500	30,900	46,400	6,100	33,900
Three Rivers	2	6,700	13,500	20,200	7,400	41,100
TOTAL	51	609,100	1,217,700	1,826,800	198,200	1,101,700

EPD provided 2019 landfill data that contains the remaining volume capacity at each landfill. Additionally, EPD calculated the rate of fill and corresponding estimated years of remaining life and predicted a fill date of each landfill based on this data. As shown on Figure 10-3, more than half of the existing MSW landfills in Georgia are expected to fill within the next 30 years.

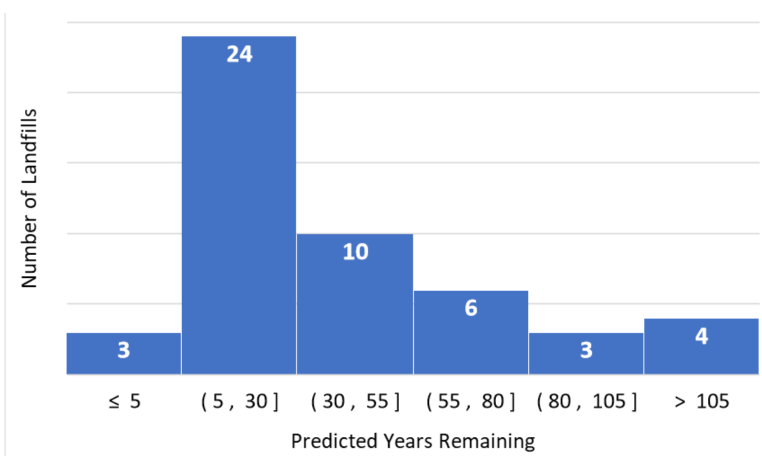


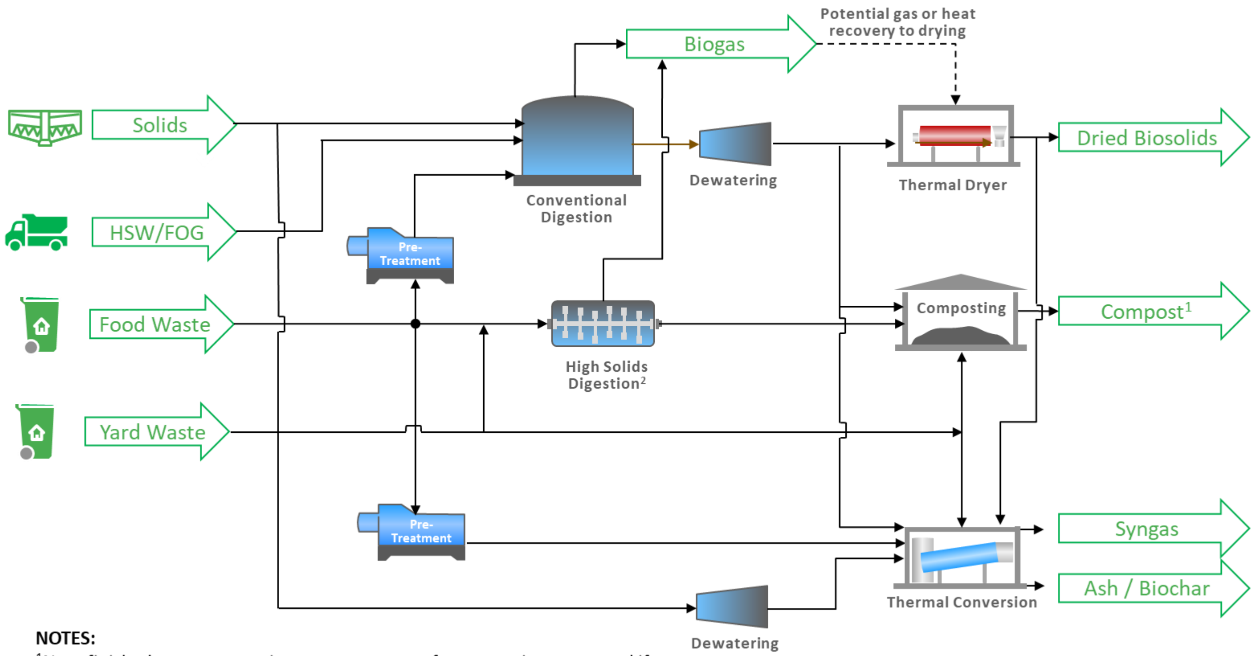
Figure 10-3 Estimated Years of Remaining Landfill Use, EPD 2019

In general, the landfill capacity evaluation confirmed the need for utilities to continue efforts to provide alternative outlets for biosolids. However, it is worth noting that as utilities develop alternative strategies for biosolids management they may still require landfill as a backup. Although there may be challenges given the pressures on landfills, one approach may be for utilities to work together when negotiating contracts for backup disposal at landfills. Further, EPD recently determined the requirements for HMCW management plans that will be required of landfills accepting more than 5 percent HMCW.

Municipal Solid Waste Co-Processing Opportunities

Most of the biosolids produced in Georgia are currently disposed in landfills that process MSW. Some technologies that are used for biosolids processing may also be used for processing some fractions of MSW and vice-versa. Even with separate processing trains, there may be benefits to co-locating biosolids and MSW processing. For these reasons, there may be potential opportunities for synergistic processing of biosolids and MSW at the same facility.

Figure 10-4 provides an overview of various potential pathways for combined MSW and biosolids processing for beneficial use. The various pathways available and key considerations are discussed in the following sections.



NOTES:
[1]Note finished compost requires post-treatment for contaminant removal if fed from high solids digestion with minimal pre-treatment
[2]High solids digestion requires a feed with >30% total solids

Figure 10-4 Some Key Potential Municipal Solid Waste and Biosolids Processing Pathways

Co-Digestion

Figure 10-5 FOG and HSW Receiving at F. Wayne Hill WRC in Gwinnett County

Conventional anaerobic digesters that are currently in use at many water reclamation facilities can potentially be used for digestion of MSW organics. Digestion of restaurant grease trap waste (containing FOG) and other high strength waste (HSW) from industry is already practiced at multiple water reclamation facilities across the United States, including the one shown on Figure 10-5 at Gwinnett County's F. Wayne Hill Water Reclamation Center (WRC).

Digestion of source separated food waste is also possible with pre-processing of the food waste to remove physical contaminants and to produce a homogenized slurry that can be fed to low solids digestion systems.

Figure 10-6 Processing to Remove Impurities and Homogenize Feedstock

Organic solid waste contains many different physical impurities such as plastics, textiles, glass, bones, cardboard, batteries, soda cans, and other materials. For low solids digestion (which is typical at water reclamation facilities), pre-processing is required to remove these impurities and to provide a suitable homogenous feedstock for the digester (refer to Figure 10-6). Various different mechanical technologies are available for this purpose including pulpers, hammermills, and separation presses. Processing of organic waste in this manner would require either the MSW processing facility to be co-located with the wastewater facility, or the MSW processing facility could be remote with trucking of liquid slurry to a wastewater facility for co-digestion. Potential benefits of co-digestion include additional biogas production at the wastewater facility, a reduced volume of waste for landfilling, and the avoidance of methane production from landfills (methane is a potent greenhouse gas). Biogas can be converted to electricity using engine generators or converted to renewable natural gas by removing CO_2 and other contaminants. These technologies can also be used for landfill gas; however, the efficiency of methane recovery is much better at dedicated digestion facilities and the waste heat from electricity generation can be used for digester heating. The main challenge with this type of approach is the potential for contamination of biosolids with residual contaminants in the MSW.

High Solids Digestion

Figure 10-7 Continuous/Plug Flow Digester (Courtesy of Hitachi Zosen Inova)

High solids digestion refers to the anaerobic digestion of organics at high solids concentrations (typically 30 percent solids by weight or greater). Two types of high solids digestion are possible as follows:

- Continuous/plug flow systems – in which organics are fed and removed continuously from a plug flow reactor. Refer to Figure 10-7.

- Discontinuous/batch processes – in which organics are fed to a digester, then digested and then removed (typically done manually using a front loader). These systems typically require a feed with greater than 40 percent TS.

A typical processing approach for high solids digestion is outlined on Figure 10-8. The product from high solids digestion can be composted/cured before contaminant removal. In contrast to low solids/liquid digestion systems, physical contaminant removal in high solids digestion systems occurs after the digestion process, with minimal mechanical pretreatment prior to digestion.

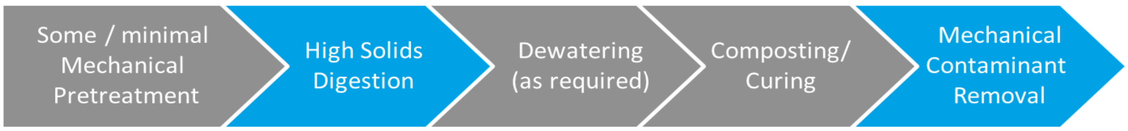


Figure 10-8 Key Steps in High Solids Digestion

Composting

Composting of biosolids, food waste, and yard waste is viable, subject to achieving the right blend of feedstocks. Yard waste can be used as amendment material for composting of biosolids and food waste (which do not alone provide enough structure) subject to achieving the correct proportion of amendment to provide porosity and correct carbon to nitrogen ratio for a good finished product quality. Any of the composting technologies discussed in Section 8.0 can potentially be used. Challenges with combined composting include large footprint requirements, potential odor concerns and combustion risks. Proper siting of facilities is key for odor and noise management.

An example of a large composting facility that processes municipal solid waste and biosolids is the Sevier Solid Waste Inc. facility in Sevierville, Tennessee. It was successfully rebuilt in 2010 after a fire in 2007 and reportedly processes 275 tons of mixed MSW and 60 wet tons of biosolids per day and uses windrow composting.

Thermal Conversion

Thermal conversion of MSW is widely practiced with many MSW incinerators in operation worldwide. Co-incineration of MSW and biosolids is practiced in Europe but not typically practiced in the United States.

Alternative thermal conversion technologies such as gasification and pyrolysis can potentially be used for combined thermal processing of biosolids and MSW organics; however, as noted above, biosolids experience is relatively limited with these technologies.

Lamar County Regional Solid Waste Authority

- Formed in 1993
- Successful reclamation and recycling of 20 acres of old, unlined landfill to state-of-the-art Subtitle-D (lined) landfill with 80 years projected disposal life
- 50 ton per day demonstration pyrolysis system to convert municipal solid waste to biochar and syngas
- Ongoing project to install three 70 ton per day pyrolysis trains for municipal solid waste processing
- Syngas production to be used for leachate evaporation
- Future plans to consider incineration for biosolids processing

An alternative to co-mingling biosolids and MSW organics for processing is to process both feedstocks at the same facility but with separate process lines, for example using a grate fired boiler for MSW incineration with a fluidized bed incinerator for biosolids. This approach may offer several potential synergies relating to the beneficial use of waste heat for and management of vapor from sludge drying and commonalities associated with flue gas treatment (Schuttenhelm, 2019).

At Lamar County in Georgia, the Regional Solid Waste Authority which was formed in 1993 has piloted a pyrolysis system to process MSW to biochar and syngas and is in the process of installing a full-scale system with three 70 ton per day pyrolysis units. The Authority also has considered installing incineration for wastewater biosolids if it can enter into suitable long-term contracts with donor utilities.

Experience from Other States

Several states in the United States have initiatives or mandates to divert organics from landfills or reduce food waste in their state. The map on Figure 10-9 summarizes current state-level policies. Program drivers and legislative goals are state-specific and are critical to determine which generators must comply. Experience from California is highlighted below:

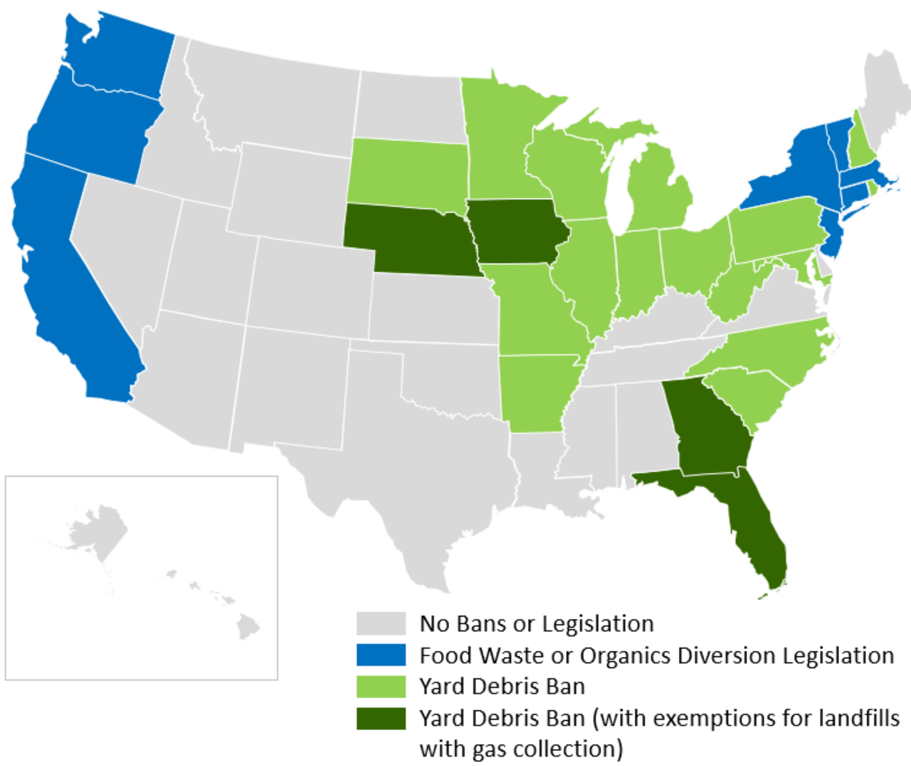


Figure 10-9 States with Organics Diversion Mandates or Legislative Goals

Currently, California is at the leading edge of organics diversion from landfills through ambitious legislation requiring 75 percent diversion by 2025. As a result, several infrastructure projects have been implemented in the state which could serve as useful references for Georgia utilities when considering co-locating biosolids and MSW processing. The California legislation means that over 20 million tons of organics (including food scraps and biosolids) need to be processed for beneficial use. In response, the following projects have been brought online, with many more expected to follow:

- As part of a phased approach, the waste management firm EDCO in Southern California brought online two high-solids plug-flow digesters in February 2021 capable of processing up to 93,000 tpy of source separated organics comingled with yard waste. The throughput will be doubled through the installation of two more digesters in a second phase. The produced biogas will be upgraded to renewable natural gas (RNG) for pipeline injection and use as CNG vehicle fuel.
- Since 2018 the Los Angeles County Sanitation District has been processing around 100 tons per day (tpd) of commercial organics into a bioslurry at their Puente Hills material recovery facility. The bioslurry is then transported to their Joint Water Pollution Control Plant in Carson, California, for co-digestion targeting a future expansion of 550 tpd of organics for co-digestion. The produced biogas has been used on-site for power and heat production via internal combustion engines (ICE). A new biogas upgrading system will produce RNG for vehicle fuels. The tail gas from the upgrading system is blended with digester gas to fuel the ICEs.
- The company Anaergia is currently commissioning a Bioenergy Facility in Rialto, California, which is projected to be the largest food waste diversion and energy recovery facility in North America targeting to process 700 tpd of source separated organics and organic faction of MSW (both produced off-site). The facility began export of RNG in March 2021. The process uses low-solids anaerobic digestion technology and is projected to produce up to 985,000 MMBTU/year of renewable natural gas. The facility is also designed to process 170 tpd of biosolids brought in from regional wastewater treatment plants for on-site drying. A pyrolysis system will be brought in a later stage to produce biochar from the dried biosolids.

11.0 Regional Management Strategies

As with many processes, biosolids processing generally exhibits economies of scale whereby processing costs typically become more economical (on a unit throughput basis) at larger facilities. This was clearly demonstrated in Section 9.0 which showed both drying and composting costs were lower on a unit throughput basis at a larger facility than a smaller facility.

One way in which smaller utilities can take advantage of these economies of scale is to team together with other utilities to process residuals in a regional biosolids processing center. Other potential advantages to a regionalized approach include greater purchasing and negotiating power and the potential to diversify and accept a wider range of feedstocks.

There are also barriers to regionalized treatment and many of these were reflected in the utility responses to the management practice survey. Committing to a long-term contract can be a challenge for public utilities to make a regionalized biosolids center viable. Utilities may be concerned over the lack of control over potential contamination of a combined biosolids project from another utility's biosolids. There may also be differences in the political or philosophical mindset of organizations that make it difficult to reach consensus on a strategy, or utilities may be concerned over a lack of control of their own destiny. Challenges with intergovernmental agreements, distance to or lack of interest from other utilities, financial obstacles and perceived challenges with regulatory approval were also cited in utilities' biosolids survey responses as other barriers. The regionalized biosolids processing opportunities and barriers are depicted on Figure 11-1.

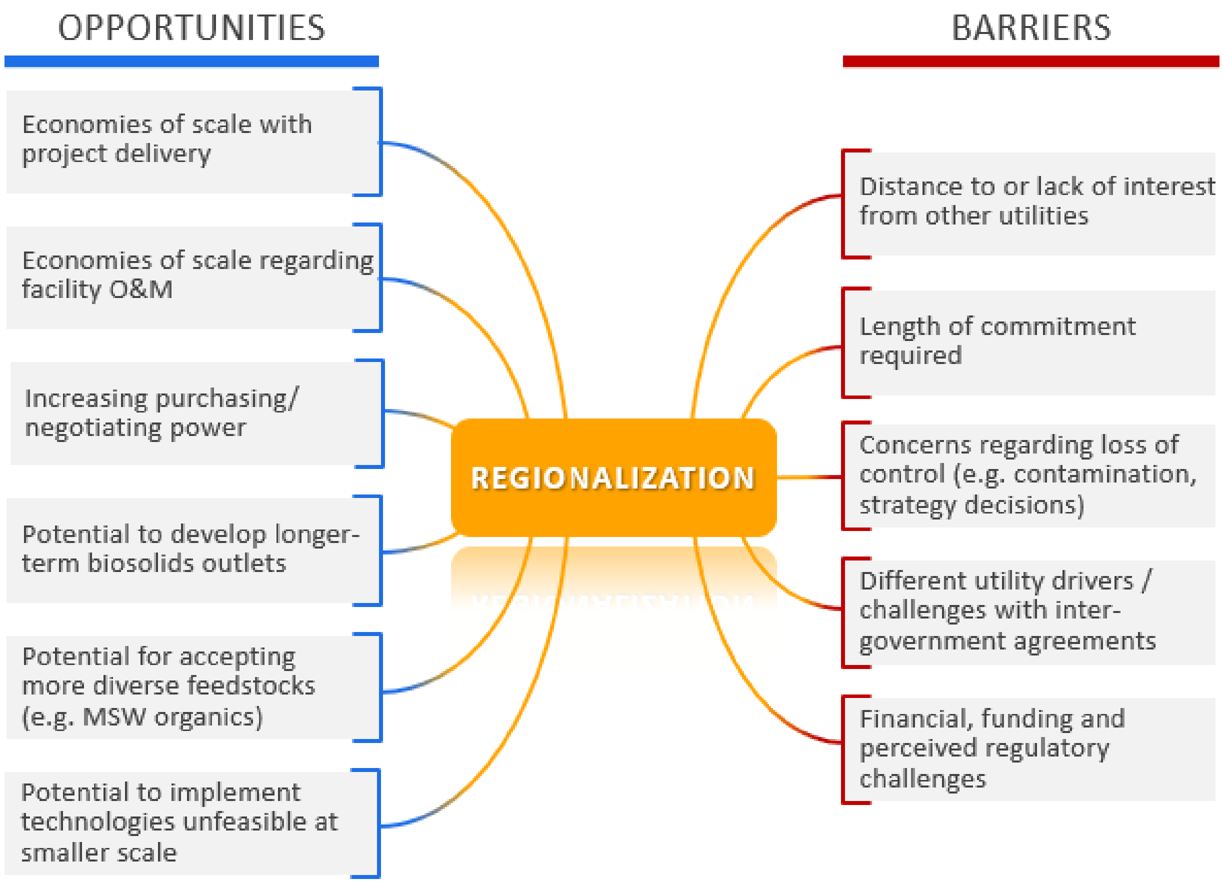


Figure 11-1 Opportunities and Barriers Associated with Regionalized Biosolids Processing

Regionalization Opportunities in Georgia

The solids production estimates detailed in Section 3.0 confirmed that, as expected, solids production is concentrated in the urbanized areas of the state including in the Atlanta and Coastal regional commissions in particular. In terms of biosolids outlets, opportunities in agriculture and silviculture were predominantly located in southern Georgia; however, there were also some significant opportunities in parks and recreation which tended to be concentrated in the same urban areas as biosolids production.

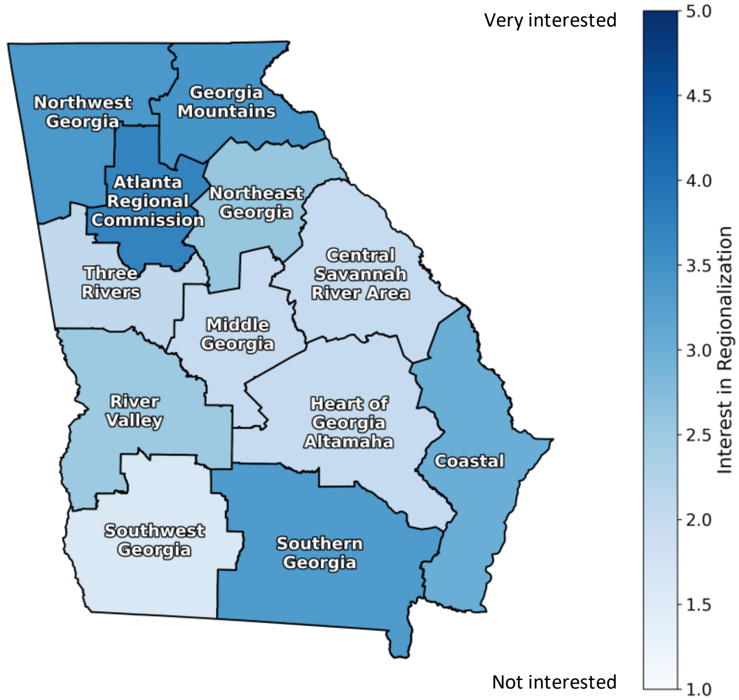


Figure 11-2 Map Showing Average Interest in Regionalization Score by Regional Commission

For regionalized processing, the most attractive opportunities to capture a high quantity of biosolids to maximize economies of scale are in and around the urban areas where biosolids production is concentrated. This was also reflected in the utility responses to the biosolids survey. Figure 11-2 shows the average score by Regional Commission for responses to the question asking about utilities level of interest in a regionalized solution (where a score of 1 indicated the utility was not interested and a score of 5 indicated it was very interested). As can be seen from the map, the strongest interest was in the Atlanta Regional Commission, Northwest Georgia, Georgia Mountains, Southern Georgia, and Coastal Georgia.

In terms of processing technologies, for a large regional facility that could be developed in one of these areas, it is likely that mechanically intensive processes such as drying or thermal conversion will be most viable because of the volume reduction achieved and the beneficial impact on transportation costs, either to biosolids markets or to landfill in the case of incinerator ash.

Even though the most impactful opportunities for regional processing are likely to be for larger utilities in urban areas, there are likely to be many opportunities for smaller regional processing facilities elsewhere in the state, in areas where utilities are close enough to one another to be able to collaborate. In these cases, a wider range of technologies may be considered, including the following:

- Smaller drying facilities and potentially newer thermal conversion technologies as these become more well proven.
- Processing alternatives that do not achieve a large volume reduction but result in a product that has value for agricultural outlets may be viable, including chemical stabilization and composting.

For technologies that do not achieve significant volume reduction, proximity to the market outlet will be an important factor in relation to project economics.

To assist utilities in evaluating and planning for a potential regional biosolids facility, Figure 11-3 provides a roadmap that identifies key tasks required at various stages of project development. These tasks are described in more detail in the following sections.

Feasibility

The first stage in project development is to determine project feasibility. At this stage, utilities would gauge interest from other utilities in the region to determine if a regionalized approach may be viable. If there is interest from other utilities, a feasibility and preliminary siting assessment should be prepared. At this stage, there could also be some preliminary information gathering regarding potential project delivery mechanisms and sources of funding. It is also important to begin thinking about end use opportunities at an early stage as this can impact project feasibility, so a high-level market evaluation can be useful at this state to identify potential uses and outlets for biosolids products. An initial review of regulations should also be prepared and preliminary discussions with potential stakeholders can be carried out if a project appears viable.

Alternatives Evaluation

If the feasibility study indicates that a regionalized project is potentially viable, then the next phase in project development will be to carry out a more rigorous alternatives evaluation. This would either require commitment of funds from participating utilities, or for a 'lead utility' to step forward and spearhead the project development with the expectation that other utilities would participate at a later stage. This stage in project development would involve a screening evaluation and then a detailed cost evaluation of alternatives. Alternatives may include various combinations of treatment technology and facility location. A full biosolids market study should also be carried out at this stage to determine likely end use cost ranges that can be used in the evaluation of alternatives. Regulatory requirements for different alternatives should also be identified so that any requirements can be incorporated into the alternatives analysis.

As a preferred alternative becomes better defined, a more thorough funding evaluation can be carried out to determine a preferred approach to funding the project. This should go hand in hand with an evaluation of project delivery mechanisms, since the funding approach would be very different for a utility-led facility, compared to a privately funded and operated facility.

Once a preferred approach has been identified, partners should agree on a preliminary design concept to take forward to preliminary design. Key aspects of a regional facility and contractual agreement that should be discussed at this stage include: establishing minimum treatment requirements for solids accepted for processing at the regional facility, risks, costs, and community impact associated with the transportation of solids to the regional facility, and responsibility for product final end use. The risks of combining solids from various plants and how this may impact the final end use should also be evaluated. At this stage, it is recommended to conduct more formal community engagement and stakeholder workshops to ensure that the community understands the drivers for the project and the benefits to the community.

Preliminary Design

During the preliminary design phase, the preliminary design will be developed for the chosen solution to a level of detail that is suitable to progress to detailed design, dependent on the project delivery method. Typically, conventional design-bid-build project delivery would involve development of the preliminary design to a level of completion of around 30 percent. However, if an alternative delivery method is chosen, such as design-build, then a 10 percent preliminary design may be more appropriate to allow the design-builder more flexibility to provide innovation and cost savings as the design develops.

The first step in this process is for the participating utilities to provide feedback and agree on the scope of the concept design. The selected design consultant can then move forward with preliminary design. The preliminary design should incorporate any regulatory requirements that were identified during the alternatives evaluation. The preliminary design phase should include a thorough preliminary design and basis of design document, development of an opinion of probable cost for construction, and a final business case evaluation for the project (including operating, maintenance, and life cycle costs). This will allow the partnering utilities to confirm the financial viability of the project so that they can determine whether or not to commit to participation in the project on a contractual basis. Providing there is agreement to proceed, a formal partnering agreement should be prepared and signed by all parties.

Also, during this phase, providing that there is commitment to proceed, a procurement contract should be developed for delivery of the project. The content of this will obviously depend on the delivery method and may or may not include financing of the project and a contract for marketing of the final product.

If the project is not being financed by a third party, the utility partners will need to finance the project and funding applications should be prepared at this stage. For CWSRF funding, this will require the preparation of an Environmental Review for Georgia EPD.

If end use of the biosolids product is to be managed by the utility partners rather than contracted to a third party, then at this stage, markets and/or land application sites should be identified and confirmed.

At this stage, a design development report should be prepared and submitted to Georgia EPD for approval.

Once the preliminary design has been completed, a community/stakeholder workshop can be conducted to educate the community on the project and obtain feedback. This would include presentation of renderings of the preliminary design and address other potential community concerns such as traffic, noise, and odor.

Contractual Buy-In

During preliminary design, the design basis solids load will have been developed based on the quantities of solids from participating utilities. Before the project moves to detailed design, it will be necessary to get contractual buy-in from participating utilities and potential other partners so that the detailed design can proceed. Although this would be the ideal time to get contractual commitment from all participating utilities, a phased approach could also be implemented where some utilities commit for the first phase with a potential for the plant to be expanded at a later date if more utilities utilize the regional facility.

Detailed Design

The first step in this stage is to select the organization responsible for delivering the detailed design. Depending on the project delivery method, the detailed design will either be prepared by a separately procured design consultant, or by the selected design-build contractor (or other alternative delivery entity). The design should also include planning for commissioning to ensure that any commissioning requirements are included in the design.

If the facility is to be operated by a utility-led O&M team, then planning, organization of and/or recruitment of the O&M team should be done at this stage.

With respect to funding, if a loan is being obtained from GEFA, then this will require submission of plans and specifications to Georgia EPD.

On the marketing front, if management of the end product is to be done in-house by a utility led entity, then marketing outreach should continue and be stepped up during detailed design to ensure that outlets will be available for the biosolids product after commissioning. If management of the product is to be done by a third party, then the contract for this should be procured at this stage (unless it is already part of an overall third-party contract for project delivery and operation).

Once the detailed design is complete, construction approval should be obtained from Georgia EPD and any other local development authority approvals required (e.g., land disturbance permit, erosion, and sediment control, etc.).

It would also be appropriate at this stage to conduct a final stakeholder workshop to present the final design and plans for commencement of operation.

For conventional project delivery, the detailed design phase will culminate in the procurement of a construction contractor. For alternative delivery, construction may begin part way through the detailed design process.

Construction and Commissioning

For conventional delivery, typically the design consultant will provide construction phase services including supervision of construction and site inspections. It is also important to begin training during construction to ensure that following commissioning, the O&M team is ready to operate the facility.

If the facility is to be operated by a third party and the contract for operations is not already incorporated into the project delivery contract, then a third-party O&M contractor would need to be procured at this stage. This could potentially be coupled with a contract for management of the biosolids product as outlined above.

Regarding financing, loan repayments will need to commence at the appropriate time dependent on the specific requirements of the loan.

During commissioning, mobilization of the outlet program for the biosolids product will need to take place so that there is an outlet for biosolids as the facility is commissioned and starts operation. This may need to include an emergency outlet (e.g., landfill) for any “out-of-specification” product that is generated during the commissioning process.

Prior to operation, any necessary permits to operate will need to be obtained from Georgia EPD.

Prior to construction, it may be beneficial to conduct a groundbreaking ceremony involving key stakeholders and community leaders and to hold a ribbon cutting event prior to commencement of operation.

Operating and Maintaining the Facility

Finally, it is important to recognize that the long-term success of a regional facility is heavily dependent on the successful management of the facility to meet the following requirements:

- Ensure adequate funds are available for ongoing operations and in particular, preventive maintenance to ensure the facility remains in good working order.
- Ensure protocols are in place for dealing with unplanned downtime and that alternative outlets are available for biosolids (or sufficient redundant equipment is in place).
- Maintain a supply chain for parts and ensure that any parts with long lead times are kept in stock if needed.
- Make an ongoing commitment to staffing for the facility.
- Perform ongoing management and development of the biosolids product market.
- Plan for expansion and growth or to accommodate additional partners.
- Monitor regulations changes and emerging issues that could impact operations.

	PARTNERING	DESIGN	PROJECT DELIVERY MECHANISM	FINANCING	MARKET END USE	REGULATORY	STAKEHOLDER ENGAGEMENT
FEASIBILITY	Gauge interest from potential participants	Prepare feasibility study Conduct Initial siting assessment	Gather Information	Perform Initial funding review Canvas private contractors	Conduct initial market study	Complete initial review	Initiate stakeholder discussions
ALTERNATIVES EVALUATION	Define approach Commit study funds Agree on preliminary design concept	Evaluate technologies Perform siting and transportation study	Determine preferred project delivery approach	Evaluate funding opportunities Determine funding strategy	Determine biosolids end use cost ranges	Identify regulatory requirements	Conduct community engagement / stakeholder workshops
PRELIMINARY DESIGN	Solicit partner feedback on design concept Develop partnering contract – establish minimum treatment requirements	Prepare preliminary design and opinion of probable cost Complete final business case evaluation	Develop procurement contract if using DB, DBO, DBOM, DMFOM etc.	Perform environmental review Prepare funding applications Negotiate 3rd party contract (if applicable)	Identify end use markets/ application sites (if managing in-house)	Incorporate regulatory requirements into design Prepare and submit design development report to GA EPD	Conduct community engagement / stakeholder workshops
CONTRACTUAL BUY-IN FROM PARTICIPATING UTILITIES / OTHER PARTNERS							
DETAILED DESIGN	Organize O&M team (if utility operated)	Prepare detailed design Begin commission planning	Selection of design build contractor (alternative delivery) Bid construction contract (conventional delivery)	Submit plans and specifications to GA EPD	Continue market outreach (if managing in-house) Solicit/procure end use contract (if using 3rd party)	Obtain construction and other regulatory approvals	Conduct final stakeholder workshop
CONSTRUCTION & COMMISSIONING	Mobilize O&M team (if utility operated)	Supervised construction Train staff Support commissioning/ optimization	Select 3rd party O&M contract if not already part of selected project delivery approach	Coordinate loan repayments as applicable	Mobilize end use program (in-house or 3rd party contractor)	Obtain permits from GA EPD Obtain approval to operate	Provide community progress updates Host community event(s)

Figure 11-3 Regionalization Road Map

12.0 Recommendations

Based on the challenges being experienced in the state of Georgia regarding solids management, it is evident that wastewater utilities will need to be proactive in planning going forward. The Gap Analysis section below provides a summary of the current situation regarding biosolids treatment and management compared to future potential needs based on a scenario of decreased landfilling of biosolids in future. Recommendations are made regarding how utilities can plan for such potential future scenarios.

The Financial Recommendations section provides a summary of the funding mechanisms that are currently available to support biosolids projects and recommendations are made regarding how access for funding of biosolids projects could be improved or encouraged going forward.

Gap Analysis

Disposal of solids to landfill remains the current dominant practice in Georgia with 65 percent of wastewater solids generated in the State estimated to have been disposed to landfill in 2019. Two key factors are likely to negatively impact the ability to dispose solids to landfill in Georgia in the future:

1. The history of landfill slope failures in the state where HMCW was determined to be a precipitating factor. This has caused industry to reevaluate the amount of HMCW they may take without impacting landfill stability and resulted in implementation by EPD of a rule requirement for landfills to put a HMCW management plan in place if they receive greater than 5 percent HMCW on a wet mass basis as a percentage of total waste. Landfills that continue to accept high amounts of HMCW may need additional engineering and experience additional costs to accommodate that waste stream.
2. The fact that existing landfills are filling up and few new landfills are being commissioned.

- To appreciate the potential impact of the HMCW rule, Figure 12-1 provides a summary showing the estimated 2019 solids production for the state and the current outlets, alongside a potential near-term scenario that is based on the following assumptions:Any landfill currently accepting HMCW continues to do so at current ratios if currently receiving less than 5 percent HMCW.
- Any landfill accepting more than 5 percent HMCW limits their acceptance rate to 5 percent to avoid possible operational changes.

Under the potential scenario on Figure 12-1, around 77,000 dry tons of biosolids would need to be diverted from landfills each year, with utilities needing to find an alternative outlet for this quantity of biosolids. Although this scenario may be pessimistic, its likelihood depends on the extent to which landfill operators are disincentivized to receive HMCW by the requirements of the HMCW rule.

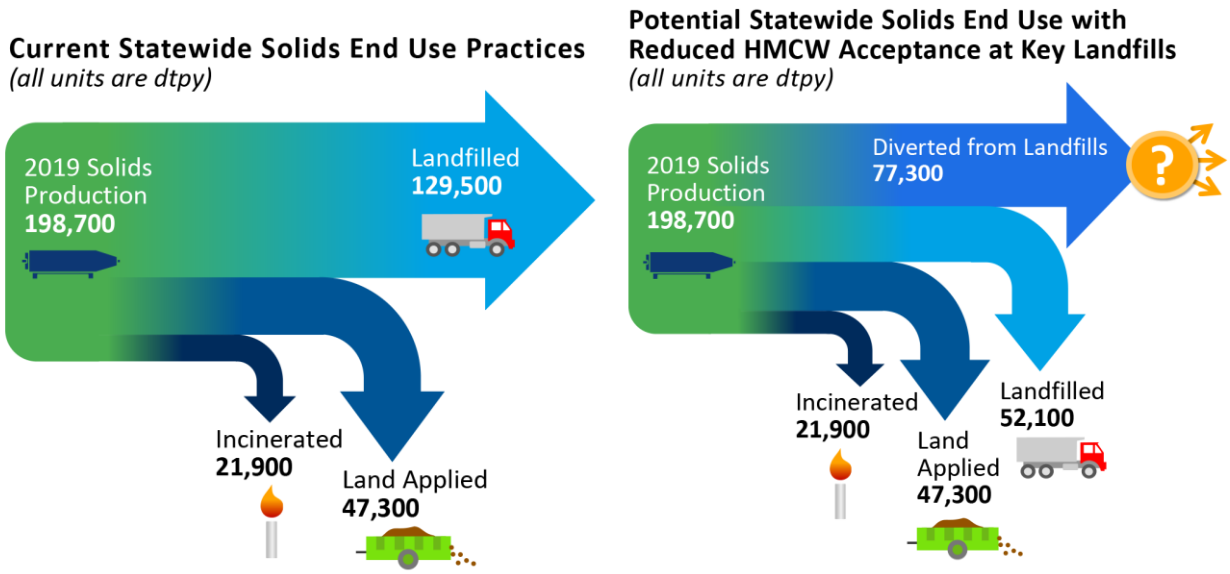


Figure 12-1 Current Solids Production and End Use Compared to a Potential Landfill Diversion Scenario (Values in Dry Tons Per Year)

To evaluate the potential impact of landfill closures, Figure 12-2 provides projections of potential landfill acceptance of biosolids given the following assumptions:

- The overall solids acceptance ratio at landfills remains constant at the current ratio..
- Landfills are closed based on fill dates estimated by Georgia EPD and no new landfills are commissioned.

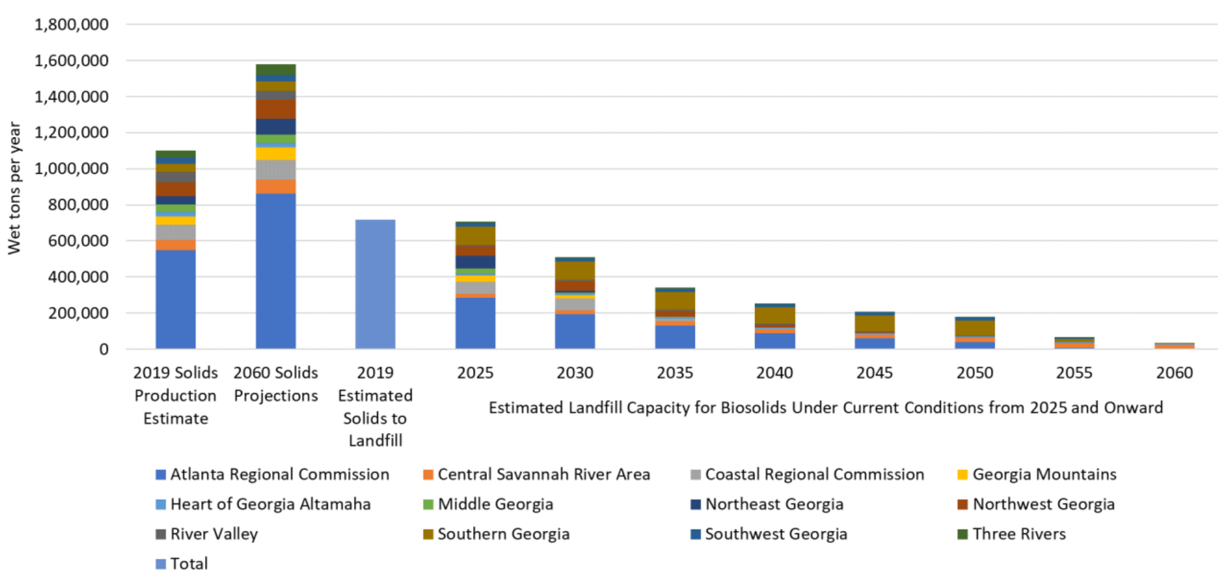


Figure 12-2 Current and Future Solids Production Estimates Alongside Landfill Capacity for Biosolids Based on Estimated Closure Dates from Georgia EPD Assuming Biosolids Acceptance Ratios Remain Constant

Figure 12-2 shows that even if landfill biosolids acceptance ratios continue at the current rate, if landfill closures are in-line with projections from Georgia EPD and no new landfills are commissioned, an increasing quantity of solids will need to be diverted from landfills in the future.

Considering the potential impacts of both HMCW on landfill design and stability and the expected closure of landfills as they fill, it is starkly evident that utilities need to plan for the diversion of a significant quantity of solids from landfill to alternative outlets in the future. Utilities are encouraged to evaluate long-term improvements in biosolids treatment to provide for disposal alternatives other than landfilling.

The market evaluation conducted as part of this study (presented in Section 7.0) shows a huge potential opportunity for the beneficial use of biosolids products in Georgia, particularly in agriculture but also with significant potential in silviculture and, in some areas, in parks and recreation.

The lowest capital cost alternative to landfill disposal will be a Class B land application program. While many facilities reported having either aerobic digestion or anaerobic digestion in the utility survey, the presence of systems to achieve Class B biosolids will depend on the facility. Utilities should pay close attention to the time and temperature requirements for Class B biosolids that are discussed in Section 4.0 and should also consider on-site storage requirements with respect to seasonal impacts on land application or consider the type of application (ie. Injection).

There are several alternatives for producing Class A biosolids that will generally result in higher initial capital costs but can provide more flexibility in terms of beneficial use outlets and may result in a lower overall life cycle cost, depending on the specific situation. A summary of key considerations is provided on Figure 12-3 with ratings from a score of 1 (lowest/bad) to a score of 5 (highest/good).

	Class B Land Application of Digeted Biosolids	Chemical Stabilization	Advanced Digestion & Class A Land Application	Solar Drying	Composting	Thermal Drying	Thermal Conversion
Capital cost & infrastructure	5	4	2	2	2	1	1
End-use market / flexibility	1	3	3	3	4	5	4
Siting & footprint	4	4	4	1	1	3	3
Commodity costs	5	1	4	5	2	2	3
Staffing requirements	5	4	3	4	2	2	2
Maintenance requirements	5	3	2	4	3	1	1
Permitting challenges	2	5	5	3	4	5	2
Capital cost & infrastructure	• Low invesment if existing digestion meets Class B. • Can existing infrastructure meet time / temperature requirements or is additional capacity needed? • Is additional dewatering equipment needed for a cake program?	• Generally low up-front investment • Purchase or rent equipment • Permanent or temporary equipment	• Significant investment for Class A digestion	• Significant investment for solar drying facility	• Significant investment for composting facility	• High investment	• High investment
End-use market / flexibility	• Low end-use flexibility / challenges of managing Class B program	• Good end use flexibility for Class A product • Alkalinity may be desirable for soil pH (lime stabilized products)	• Good end use flexibility for Class A product	• Good end use flexibility for Class A product	• Very good end use flexibility for composted product	• Excellent end use marketability for pelletized products	• End use not important for processes producing ash (e.g. incineration) • Marketability for biochar may vary
Siting & footprint	• No additional footprint if existing systems meet Class B • Footprint required for additional tanks if needed	• Small footprint for chemical stabilization systems	• Generally small additional footprint if existing digesters in place but requirements vary	• Very large footprint • Siting is key given odor challenges	• Very large footprint • Siting is key given odor challenges	• Medium footprint requirements	• Medium footprint requirements
Energy / chemical costs / amend	• Low energy and chemical costs	• Significant costs for chemicals	• Generally low energy and chemical costs	• Low energy and chemical costs	• Significant potential costs for purchase and transport of amendment. Confirming availability and suitability of amendment is a key success factor	• Potentially high energy requirements • Energy demand can be significantly reduced if biogas is available	• Energy demands are dependent on combustion value of cake • Process can be autothermic or can have significant energy demands for low energy feedstocks
Staffing requirements	• Generally low staffing requirements	• Some additional staffing to operate system	• Significant additional staffing to operate system	• Passive system, generally lower staffing requirement	• Relatively high staffing requirement (dependent on type of system)	• Relatively high staffing requirement (dependent on type of system)	• Relatively high staffing requirement (dependent on type of system)
Maintenance requirements	• Maintanance similar to existing systems if already operating digestion technology	• Some maintenance for processing equipment but systems	• Relatively high maintenance requirements (depending on technology)	• Relatively low maintenance requirement / simple system	• Some maintanance for processing equipment	• High maintenance / mechanically intensive system	• High maintenance / mechanically intensive system
Permitting challenges	• Significant permitting effort to maintain Class B program	• Relatively straightforward permitting for Class A system	• Relatively straightforward permitting for Class A system	• Generally straightforward however additional burden of proving pathogen reduction by sampling for pathogens	• Relatively straightforward permitting for Class A system	• Relatively straightforward permitting for Class A system	• Permitting may be a challenge given public perception issues around incineration. Potentially easier with other thermal conversion alternatives

Figure 12-3 Key Considerations for Alternative Strategies to Produce Class A Biosolids

Financial Recommendations

Several sources of funding are available through GEFA, including two that are available to support biosolids projects: the Georgia Fund and the CWSRF.

The Georgia Fund is a state-funded loan program for water, wastewater, and solid waste infrastructure. It is available to fund eligible projects which include projects associated with treatment plant infrastructure, including biosolids treatment. Loans are available at a low interest rate for a maximum period of 20 years. At the time of writing, the maximum loan amount is $3 million per year at an interest rate of 1.63 percent for a 20-year loan.

The CWSRF is a federally funded loan program for wastewater infrastructure and pollution prevention projects. Eligible CWSRF projects include construction of new wastewater treatment plants or expansion of existing plants, including biosolids treatment. Loans are available at a low interest rate for a maximum period of 30 years. The program also supports renewable energy projects such as combined heat and power systems to provide power at publicly owned treatment plants. At the time of writing, the maximum loan amount is $25 million per year at an interest rate of 1.13 percent for a 20-year loan.

In addition to funding available through GEFA, there are also federally administered programs such as the Water Infrastructure Finance and Innovation Act of 2014 (WIFIA) that can potentially provide funding for biosolids projects. This is a federal credit program administered by EPA for eligible water and wastewater infrastructure projects.

There is no specific scoring mechanism for prioritizing projects for the Georgia Fund and it is typically only used for projects that would not qualify for CWSRF funding. Loan applications for both funds are made using the same application form available from the GEFA website. CWSRF loans also require a pre-application to be submitted.

Currently, there is available capacity to fund biosolids related projects. CWSRF loans may be eligible for principal forgiveness with projects prioritized based on affordability and project scoring criteria. GEFA also uses these scoring criteria to rank applicants for funding priority. Each state sets its own scoring criteria based on general priorities that are outlined at a federal level.

A further 1 percent discount in the interest rate for CWSRF loans is available for eligible water and land conservation projects, resulting in a current interest rate of 0.13 percent for a 20-year loan. GEFA guidance currently states the eligible projects are as defined in the CWSRF program literature. USEPA program literature identifies a number of eligible projects for both water and land conservation but makes it clear that eligibility varies by state.

Affordability criteria are applied to prioritize disadvantaged communities for principal forgiveness. The following criteria are used with up to 4 points available in each category to give a maximum score of 40 points:

1. Median household income.
2. Unemployment percent.
3. Percentage not in labor force.
4. Poverty rate.
5. Percentage on social security.

6. Percentage on supplemental security income.
7. Percentage with cash public assistance.
8. Percentage with supplemental nutrition assistance program.
9. Age dependency ratio.
10. Population trend.

At the time of this study, projects are ranked based on factors including readiness to proceed, compliance benefits, and project benefits using the scoring structure outlined below. GEFA lists projects in priority order for funding based on these criteria. Currently, the program has sufficient capacity to fund all eligible projects and the ranking is used to prioritize projects for principal forgiveness. If the capacity of the fund in the future is not sufficient to fund all eligible projects, then the ranking would also be used to prioritize projects for funding.

1. **Readiness to proceed (40 points)** - Projects can score up to 40 points for readiness to proceed based on completion of either the State Environmental Review process or State Non-point Source Management Plan.
2. **Compliance benefit (40 points)** - Projects can either score 40 points if the project is needed to address deficiencies in an emergency or administrative order from EPA or EPD, 30 points if the project will support implementation of a total maximum daily load (TMDL), or 20 points if the project is required for compliance with a discharge permit.
3. **Project benefits (20 points)**
   a. Stormwater management, nonpoint source, and source water protection benefits (8 points).
   b. Energy conservation, efficiency, and production benefits (6 points).
   c. Wastewater collection, conveyance, and treatment benefits (6 points).

A full breakdown of funding criteria and assignment of points is provided in the 2021 CWSRF Call for Projects solicitation letter, which is duplicated in Appendix D.

While the current CWSRF evaluation criteria do a good job of prioritizing disadvantaged communities and projects that are ready to proceed and are needed for compliance, the current scoring structure makes it difficult for biosolids projects to score points compared to liquid stream projects where compliance benefits are more obvious.

GEFA requested that the Black & Veatch project team provide recommendations to enable future funding of biosolids projects in Georgia to meet the following requirements:

- Recommendations for modification of the CWSRF scoring criteria to make it easier for biosolids projects to qualify for funding at beneficial interest rates.
- Recommendations regarding the potential for a biosolids-specific funding initiative.
- General recommendations regarding guidance and support for funding of biosolids projects.

Recommendations for Modifying GEFA CWSRF Scoring Criteria

As noted above, the current GEFA scoring mechanism for CWSRF funding is not well matched to typical criteria that are important drivers for biosolids projects. With many utilities facing biosolids challenges in the State, it is important that utilities are not discouraged from seeking funding because it appears difficult for them to receive a high score from the above criteria. Table 12-1 provides specific recommendations regarding how the current scoring and ranking criteria could be modified to rectify this issue.

Table 12-1 Comments on Current CWSRF Scoring Criteria and Recommendations

Criterion	Comments/Challenges	Recommendations
1. Readiness to proceed	Biosolids projects will typically go through the State Environmental Review Process administered by EPD. This may be a potential barrier, particularly for smaller communities with limited funds.	Consider providing more direct funding support for smaller communities and utilities for feasibility studies and preparation for the State Environmental Review Process. This could be incorporated into the biosolids-specific funding initiative discussed below.
2. Compliance benefit	It is difficult for biosolids projects to meet the compliance benefit criteria which include addressing an administrative order from EPA or EPD, implementation of a TMDL plan or compliance with a discharge permit.	Consider either rewriting the criteria to include criteria specific to biosolids (e.g., *"project is needed to provide an outlet for biosolids to avoid permit compliance issues"*) or provide additional guidance and clarification that biosolids projects required to secure an outlet for biosolids will be deemed to satisfy the existing permit compliance criterion (i.e., since not wasting solids would lead to permit failure).
	Assigning higher points to addressing deficiencies documented in an emergency or administrative order does not encourage a pro-active approach to avoid permit failure.	Consider reassigning points to score preventive measures equal to emergency measures.

Criterion	Comments/Challenges	Recommendations
3. Project benefits	The current distribution of points seems to dramatically favor readiness to proceed and compliance benefits over project benefits.	Consider reassigning points to consider project benefits more equally alongside readiness to proceed and compliance benefits.
	The categories listed under project benefits are focused on source water protection, energy conservation and wastewater management and there is no mention of residuals management. As a result, it is difficult for biosolids projects to score points. The existing criteria are also very specific and could be expanded to provide better access to a wider range of projects (including, but not limited to, biosolids projects).	Two potential options are recommended for consideration as follows: **1. Adding to the existing criteria to provide better access to biosolids projects.** Examples of additional biosolids-specific criteria that could be added are as follows: *Project will secure a more sustainable outlet for biosolids, mitigating future risk of permit failure.* *Project will divert biosolids organics from landfill, resulting in a lower carbon footprint.* *Project will result in beneficial use of nutrients and/or energy in biosolids.* **2. Rewriting the criteria to bring them more in-line with modern sustainability goals** This option would open up the scoring mechanism to include a wider range of sustainability criteria. This would benefit biosolids projects but also potentially other clean water projects that achieve sustainability benefits. Examples of categories that could be considered include the following: **Environmental benefits:** protecting source water, reducing greenhouse gas emissions, protecting air quality. **Resource benefits:** reducing water consumption or reusing water, reducing energy consumption or producing energy, producing fuel or bioproducts, recycling nutrients, diverting waste from landfills. **Resiliency benefits:** providing flood protection, providing backup power, diversifying operations or improving redundancy. **Community benefits:** enhancing public space, enhancing public health and safety, developing local skills and capabilities.

Recommendations for a Biosolids-specific Funding Initiative

Given the significant biosolids challenges being experienced by utilities in Georgia, GEFA is interested in considering if there would be a benefit to providing a more targeted funding initiative that would be specific to biosolids projects.

Should GEFA provide funding opportunities specific to biosolids projects, the following general recommendations for guiding principles are made:

- Funding should prioritize support during early stages of project development that are likely to secure access to larger funding initiatives such as CWSRF in the future. This could include funding for initial feasibility studies to determine biosolids project viability as well as assistance with preparation of the environmental protection plan and CWSRF application.
- Allocation of funds should prioritize utilities that have been most impacted, in relative terms, by increasing end use costs.
- Funding could potentially prioritize (or provide a higher level of funding to) regional programs that have the potential to benefit a wider range of utilities.
- Funding could be made available to support activities that serve to educate the community regarding biosolids management in order to expand access to beneficial outlets for biosolids.
- Another alternative would be to offer a reduced interest rate for loans for biosolids projects. This could either be permanent or be a temporary measure lasting for several years to assist utilities as they transition biosolids management strategies.

General Recommendations

The following general recommendations are made to improve guidance and support for utilities seeking funding for biosolids projects:

- Consider adding a web page or guidance document to the GEFA website that provides guidance about funding that is available for biosolids projects.
- Provide guidelines on how biosolids projects can meet CWSRF criteria.
- Ensure reference is made to biosolids projects in Georgia Fund and CWSRF guidance documentation so that it is clear that biosolids projects are eligible for funding.
- Coordinate with state groups such as GAWP and Georgia Rural Water to ensure that GEFA biosolids initiatives and any guidance developed is referenced and linked from the websites of these groups.

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Appendix A
40 CFR 503 Supplemental Information

Table A-1 summarizes 40 CFR 503 requirements for pollutant limits, pathogen reduction, and VAR. regulation, also known as the “503 rule” was promulgated in 1993 and sets forth standards for three general use and disposal practices. Table A-2 and Table A-3 provide 40 CFR 503 alternatives and options.

Table A-1 40 CFR 503 Pollutant Limits (Dry Weight Basis)

Pollutant	Ceiling Concentration (Mg per Kg)	Pollutant Concentration (Mg per Kg)	Cumulative Loading Rate (Kg per Hectare)	Maximum Annual Loading Rate (Kg per Hectare per Year)
Arsenic	75	41	41	2.0
Cadmium	85	39	39	1.9
Copper	4,300	1,500	1,500	75
Lead	840	300	300	15
Mercury	57	17	17	0.85
Molybdenum	75	--	--	--
Nickel	420	420	420	20
Selenium	100	100	100	5.0
Zinc	7,500	2,800	2,800	14

Application Notes:

1. If biosolids are applied to land, the cumulative pollutant loading rates and the pollutant ceiling concentrations must not be exceeded.
2. If biosolids are applied to a lawn or home garden, the pollutant concentrations must not be exceeded (Note: only Class A biosolids can be used for this purpose).
3. If sludge is sold or given away in a bag, the material must meet the pollutant concentration limits (Column 3) or the application rate may not exceed the maximum annual pollutant loading rate. (Note: only Class A biosolids can be used for this purpose).

Table A-2 40 CFR 503 Pathogen Reduction Alternatives

Class	Numeric Limit		Alternative
Class A	Fecal Coliform < 1,000 MPN/g TS **or** Salmonella <3 MPN/4 g TS	AND	• No. 1: time and temperature • No. 2: pH elevation • No. 3: numeric criteria, clean sludge • No. 4: numeric criteria, normal sludge • No. 5: PFRP (1) • No. 6: PFRP (1) equivalent
Class B	Alt. No. 1: <2,000,000 MPN /g or CFU/g fecal coliform	OR	• No. 2: PSRP (2) • No. 3: PSRP (2) equivalent

(1) PFRP = Process to Further Reduce Pathogens: Composting, Heat Drying, Heat Treatment, Thermophilic Aerobic Digestion, Pasteurization, Irradiation.

(2) PSRP = Process to Significantly Reduce Pathogens: Aerobic digestion, air drying, anaerobic digestion, composting, lime stabilization.

Table A-3 40 CFR 503 Vector Attraction Reduction Options

VAR Option	Requirement
1. Volatile Solids (VS) Reduction	> 38% VS reduction during solids treatment
2. Anaerobic Bench Scale Test	< 17% VS loss, 40 days at 30° C to 37° C (86° F to 99° F)
3. Aerobic Bench Scale Test	< 15% VS reduction, 30 days at 20° C (68° F)
4. Specific Oxygen Uptake Rate (SOUR)	SOUR at 20° C (68° F) is < 1.5 mg oxygen/hr/g TS
5. Aerobic Process	> 14 days at > 40° C (104° F) with an average> 45° C (113° F)
6. pH adjustment	pH > 12 measured at 25° C (77° F)*, and remain at pH > 12 for 2 hours and > 11.5 for 22 more hours
7. Drying (no raw primary solids)	> 75% TS prior to mixing
8. Drying (with raw primary solids)	> 90% TS prior to mixing
9. Soil Injection	No significant solids on land surface 1 hour after injection Class A: inject within 8 hours after pathogen treatment
10. Soil Incorporation	Class B: incorporate < 6 hours after land application Class A: incorporate < 8 hours after pathogen treatment
11. Daily Cover at Field Site	Cover biosolids placed on a surface disposal site with soil or other material at the end of each operating day

* Or corrected to 25° C

Appendix B
Technology Cost Evaluation

The technology cost evaluation represents general costs for biosolids management in Georgia at the time this report was written; however, there are many variables and this evaluation may not be representative of every utility's biosolids management costs. All inputs and assumptions are listed for each scenario that was evaluated.

APPENDIX B - TECHNOLOGY COST EVALUATION

INPUTS AND ASSUMPTIONS

1.0 GENERAL COST INPUTS	UNITS	VALUE
Life cycle costs		
Cost of capital	%	4%
Inflation	%	2%
Equipment cost adders		
Installation	%	25%
Piping & valves	%	10%
Site work	%	10%
Electrical / I&C	%	20%
Building	$/SF	250
Hoist System	EA	-
Indirect cost adders		
Engineering, legal & admin	%	25%
General conditions	%	12%
Contractor overhead & profit	%	10%
Contingency	%	30%
O&M Costs		
Landfill disposal	$/wet ton	100
Class B land application	$/wet ton	75
Compost	$/ton	30
Dried product	$/ton	0
Natural gas	$/mmBTU	8.0
Power	$/kWh	0.06
Fuel	$/gal	3
Maintenance	%	4%
Labor	$/hr	50

2.0 SOLIDS PRODUCTION INPUTS	UNITS	SMALL PLANT	LARGE PLANT
Peaking factor	-	1.5	1.3
solids production	dt/MG	1	1
Volatile solids content	%	80%	80%
Volatile solids conversion	%	40%	45%
Solids content	%	18%	18%

3.0 CLASS B INPUTS	UNITS	SMALL PLANT	LARGE PLANT
Cake barn sizing			
Number of days storage (average throughput)	days	90	90
Cake bulk density	lb/ft^3	55	55
Cake average stacking height	ft	4	4
Area reserved for access / vehicle movement	%	40%	40%
Site work			
Grading cost	$/CF	0.19	0.19
Barn Cost			
Cost per unit area	$/ft^2	40	40
O&M			
Fuel	gal/yr	1000	15000
Labor FTE (for intermittend cake barn use)	-	0.25	1

4.0 COMPOSTING INPUTS

4.0 COMPOSTING INPUTS	UNITS	VALUE
Energy to evaporate water	BTU/lb	1500
Biodegradable volatiles	%	50%
Energy in VS	BTU/lb	10000
Bulk density	lb/CF	55

Amendment

Total solids conc amendm	%	70%
Volatile solids	%	75%
Biodegradable volatiles	%	60%
Energy in VS	BTU/lb	7490
Bulk density	lb/CF	26

Product

TS out	%	60%
Bulk density	lb/CF	33.5

Recycle

Initial mix	%	43%

		SMALL PLANT	LARGE PLANT
Bulking agent storage			
Storage required	days	30	30
Height	ft	8	8
Biosolids storage			
Storage required	days	3	3
Height	ft	3	3
Active composting			
Retention time	days	21	21
Height	ft	6	8
Curing area			
SRT required	days	30	30
Height	ft	8	8
Area for recycled amendment			
SRT required	days	14	14
Height	ft	8	8
Outside storage			
SRT required	days	90	90
Height	ft	8	8

Capital costs

		SMALL PLANT	LARGE PLANT
Site purchase			
Site purchase	$/acre	5000	5000
Site work			
Grading cost	$/CF	0.19	0.19
Paving	$/SF	4.0	4.0
Covered composting area inc floor & electr	$/SF	50	50
Office unit cost	$/SF	200	200

Equipment

No. front loaders	-	1	2
Front loader cost/unit + spare bucket for 1MGD	$/unit	$205 k	$200 k
Rotomix	-	0	2
Rotomix cost/unit	$/unit	$340 k	$340 k
Trommel screen	-	1	2
Trommel screen cost/unit	$/unit	$225 k	$225 k
Trommel screen cost	$	$225 k	$450 k

O&M Costs

Fuel consumed	gal/yr	3000	30000
Fuel cost	$/gal	3	3
Power cost	$/kWh	0.06	0.06
Power required	kWh/dt	100	100
Amendment cost/CY	$/CY	40	40
Operational labor	$/hr	50	50
Labor FTEs	FTE	0.5	2

5.0 DRYING INPUTS		**SMALL PLANT**	**LARGE PLANT**
Dried product solids	%	92%	92%
Operating days per week	days/wk	5	5
Operating hours per day	h/d	24	24
Dried product solids	%	92%	92%
Hoist System	EA	-	$100,000
Dryer building footprint	SF	1,000	10,000
Natural gas	$/mmBTU	8	8
Power	$/kWh	0.06	0.06
Operational labor	$/hr	50	50
Product cost collected from site	$/ton	0	0
Specific energy demand	BTU/lb	1400	1600
% from biogas	%	0%	80%
Power demand all trains average	kWh/lb H2O	0.03	0.03
FTE	%	0.5	2
Odor control CFM	CFM	610	N/A RTO
Odor control cost	$/CFM/yr	11	N/A RTO
Covered storage cost	$/SF	50	N/A - product silo inc.

NET PRESENT COST EVALUATION

Alternative	Units	Small Plant to Landfill	Small Plant Class B	Small Plant ASP Composting	Small Plant Drying	Large Plant to Landfill	Large Plant Class B	Large Plant ASP Composting	Large Plant Drying
Dry solids in	dtpd	0.67	0.67	0.67	0.67	15.4	15.4	15.4	15.4
End product									
End use tons (average)	wtpd	2.52	2.52	0.83	0.49	54.7	54.7	18	10.7
End use cost	$/ton	100	75	30	0	100	75	30	0
Capital costs									
Initial project cost	$	-	$0.31 m	$1.62 m	$3.29 m	-	$2.56 m	$10.56 m	$23.65 m
Residual value of buildings after 20 years	$	-	-$0.07 m	-$0.26 m	-$0.12 m	-	-$1.51 m	-$1.90 m	-$1.24 m
Residual value of building (todays dollars)	$	-	-$0.03 m	-$0.12 m	-$0.06 m	-	-$0.69 m	-$0.87 m	-$0.57 m
O&M costs									
Fuel / natural gas	$	-	$3 k	$9 k	$17 k	-	$45 k	$90 k	$103 k
Power	$	-	-	$1 k	$3 k	-	-	$22 k	$58 k
Composting amendment	$	-	-	$17 k	-	-	-	$380 k	-
Labor	$	-	$25 k	$49 k	$49 k	-	$98 k	$196 k	$196 k
Maintenance	$	-	$8 k	$17 k	$39 k	-	$8 k	$61 k	$261 k
Odor control cost	$	-	-	-	$7 k	-	-	-	-
End use	$	$92 k	$69 k	$9 k	$0 k	$1,997 k	$1,497 k	$201 k	$0 k
O&M total	$	$92 k	$105 k	$102 k	$114 k	$1,997 k	$1,649 k	$949 k	$617 k
NPV									
Capital cost	$	$0.00 m	$0.31 m	$1.62 m	$3.29 m	$0.00 m	$2.56 m	$10.56 m	$23.65 m
Residual value of buildings	$	$0.00 m	-$0.03 m	-$0.12 m	-$0.06 m	$0.00 m	-$0.69 m	-$0.87 m	-$0.57 m
PV of O&M cost	$	$1.25 m	$1.42 m	$1.39 m	$1.55 m	$27.13 m	$22.41 m	$12.90 m	$8.39 m
Net present cost	$	$1.25 m	$1.70 m	$2.89 m	$4.77 m	$27.13 m	$24.27 m	$22.59 m	$31.47 m
O&M cost / dt	$/dt	$257	$292	$285	$317	$242	$200	$115	$75
Capital cost / dt	$/dt	$0	$58	$308	$664	$0	$17	$86	$206
Total / dt	$/dt	$257	$350	$594	$981	$242	$216	$201	$280

Appendix C
List of Acronyms and Definitions

AA	Annual average
ATAD	Autothermal Thermophilic Aerobic Digestion
BFP	Belt Filter Press
Biosolids	"Biosolids" means any sewage sludge that (fulfills regulatory requirements and) is used in a beneficial manner.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CWA	Clean Water Act
CWSRF	Clean Water State Revolving Fund
DAF	Dissolved Air Flotation
Dscm	Dry standard cubic meter
dt/ac	Dry tons per acre
Dtpd	Dry tons per day
Emerging Technology	Technologies in the development stage and/or tested at laboratory or bench scale. New technologies that have reached the demonstration stage overseas, but cannot yet be considered to be established there, are also considered to be emerging with respect to North American installations.
EPA	Environmental Protection Agency
EPD	Environmental Protection Division
EQ	Exceptional quality
Established Technology	Technologies widely used (i.e. generally more than 25 facilities throughout the United States) are considered well established.
FBI	Fluidized Bed Incinerators
FGVR	Farm Gate Value Report
FOG	Fats, oils, and grease
GAWP	Georgia Association of Water Professionals
GBT	Gravity Belt Thickener
GCSAA	Golf Course Superintendent Association of America
GDA	Georgia Department of Agriculture
GDOT	Georgia Department of Transportation
Gpm	gallons per minute
HLR	Hydraulic Loading Rate
HMCW	High moisture content waste
IPP	Industrial Pretreatment Program
Innovative Technology	Technologies meeting one of the following qualifications: (1) have been tested at full-scale demonstration site in this country; (2) have been available and implemented in the United States for less than 5 years; (3) have some degree of initial use (i.e. implemented in less than 25 utilities in the United States; and (4) are established technologies overseas with some degree of initial use in the United States.
LAS	Land application site
lb/sf	pounds per square foot
MACT	Maximum Achievable Control Technology

Mgd	Million gallons per day
MHI	Multiple Hearth Incinerators
MNGWPD	Metropolitan North Georgia Water Planning District
MPa	Mega Pascals
MSW	Municipal solid waste
N	Nitrogen
NIFA	National Institute of Food and Agriculture
NPDES	National Pollutant Discharge Elimination System
OIG	Office of the Inspector General
OW	Office of Water
ORP	Oxidation Reduction Potential
P	Phosphorus
PM	Particulate matter
Ppb	Parts per billion
Pph	Pounds per hour
Ppm	Parts per million
Ppmvd	Parts per million by volume, dry
Ppt	Parts per trillion
PFAS	Poly- and per-fluoroalkyl substances
PFBS	Perfluorobutanesulfonic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
PFRP	Process to Further Reduce Pathogens
PS	Primary sludge
PSRP	Process to Significantly Reduce Pathogens
RDT	Rotary Drum Thickener
SLR	Solids Loading Rate
Sewage Sludge	Solid, semi-solid, or liquid residue generated during the treatment of domestic sewage or a combination of domestic sewage and industrial wastewater in a treatment works.
Sludge	Generally used before applicable beneficial recycling criteria have been achieved, which normally occurs at the outlet of the stabilization process (WEF, 2021).
SMP	Sludge Management Plan
Solids	Used for general description of residuals derived from water and wastewater treatment processes (WEF, 2021). May be used interchangeably with the term “residuals”.
SOUR	Specific oxygen uptake rate
SRF	State Revolving Fund
SSI	Sewage Sludge Incineration
STA	Seal of Testing Assurance (from USCC)
TCLP	Toxicity Characteristics Leaching Procedure
THC	Total hydrocarbon
TPAD	Temperature-phased anaerobic digestion
TS	Total Solids
UAC	Urban Ag Council
UGA	University of Georgia
USCC	United States Composting Council

USDA	United States Department of Agriculture
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
VAR	Vector attraction reduction
VS	Volatile solids
WAS	Waste activated sludge
WRRF	Water Resource Reclamation Facility

Appendix D 2022 CWSRF Call for Projects Solicitation Letter

Georgia Environmental Finance Authority

Brian P. Kemp
Governor

Kevin Clark
Executive Director

September 1, 2021

Re: 2022 Clean Water State Revolving Fund (CWSRF) Call for Projects

To Whom It May Concern:

The 2022 CWSRF Intended Use Plan (IUP) call for projects is now open. The CWSRF provides low-interest financing for publicly-owned wastewater systems. Types of projects eligible for CWSRF funding include, but are not limited to, projects that:

- Maintain compliance with wastewater rules and regulations, and
- Improve water quality.

To be eligible for funding, submit a CWSRF pre-application via GEFA's website by 5:00 p.m. Monday, February 28, 2022. Pre-applications received after this time will not be scored for principal forgiveness. A pre-application does not obligate you to apply or guarantee funding. The pre-application and additional guidance are available at gefa.georgia.gov/call-for-projects.

Please note the following:

- The architecture and engineering qualifications-based selection requirements are on page 5;
- The affordability criteria are on pages 7 and 8; and
- The new project scoring criteria are on pages 9 and 10.

Please contact the Water Resources Division at 404-584-1000 or waterresources@gefa.ga.gov if you have any questions.

Sincerely,

Kevin Clark

Enclosures

233 Peachtree St NE | Ste 900
Atlanta, GA 30303

P: 404-584-1000 | F: 404-584-1069
gefa.georgia.gov

Georgia Environmental Finance Authority
2022 CWSRF Call for Projects
Project Submission Guidelines and Program Requirements

Deadline	Pre-application Website	Questions
5:00 p.m., February 28, 2022	gefa.georgia.gov/call-for-projects	404-584-1000

Who Can Apply for CWSRF Loans?
- Georgia cities
- Georgia counties
- Georgia water and sewer authorities
- Community Improvement Districts (CID)
- Any state or local authority created by the Georgia General Assembly

Minimum Criteria for Eligibility
- Only those counties and municipalities certified as Qualified Local Governments by the Georgia Department of Community Affairs (DCA) and the water and sewer authorities within those certified governments may receive funding.
- Only applicants within counties that have current DCA-certified Service Delivery Agreements (HB 489) may receive funding and the proposed project must be consistent with the verified strategy.
- Applicants must be in compliance with state audit requirements. Compliance questions can be answered at audits.ga.gov.
- Applicants within the Metro North Georgia Water Planning District (MNGWPD) must be certified by the director of the Georgia Environmental Protection Division (EPD) as complying or making a good faith effort to comply with all MNGWPD plans and/or enforcement measures.
- Project must conform to applicant's regional water plan, once adopted.
- All applicants must adopt and enforce the state minimum standard plumbing code provisions outlined in O.C.G.A. Section 8-2-3 to be eligible to receive funding.

Eligible CWSRF Projects
- Construction, renovation, or expansion of a publicly-owned treatment works;
- Installation of sewer systems;
- Combined sewer overflow (CSO) projects;
- Construction, repair, or replacement of decentralized wastewater treatment systems that treat municipal wastewater or domestic sewage;
- Construction and rehabilitation of municipal storm sewer systems (MS4s);
- Purchase of street and storm sewer cleaning equipment;
- Landfill closure and landfill leachate collection and treatment;
- Projects to increase the security of publicly-owned treatment works; and
- Implementation of measures to manage, reduce, treat, reuse, recycle, or recapture stormwater.

CWSRF Water, Energy, or Nonpoint Source Projects
- Constructing, renovating, or expanding wastewater recycling and reuse facilities that replace potable sources with non-potable sources;
- Installing or retrofitting water efficient devices, such as plumbing fixtures and appliances;
- Implementing incentive programs to conserve water such as rebates for water efficient fixtures;
- Reducing energy consumption at publicly-owned treatment works, such as correction of infiltration/inflow problems, lighting upgrades, pump and motor replacement projects, and energy efficiency upgrades in the treatment process;
- Power producing projects via wind, solar, and biogas that directly serve the publicly-owned treatment works;
- Acquisition of buffer zones and/or wetlands;
- Streambank restoration projects;
- Purchasing land for land conservation purposes; and
- Eliminating faulty septic tanks.

Project Priority and Rank

Project ranking is based on factors including A/E procurement, readiness to proceed, compliance benefits, and project benefits. Projects will be listed in priority order on the CWSRF Fundable Priority List and incorporated into the IUP and submitted to U.S. Environmental Protection Agency (EPA). GEFA will score all pre-applications and rank projects in descending order. It is important that applicants complete the pre-application in its entirety, including all supplemental attachments, to ensure the project is accurately scored.

CWSRF Interest Rates

Projects funded through the CWSRF program can borrow with various terms and interest rates. Please see page 4 for GEFA's current loan interest rates, loan terms, and project-based interest rate concessions.

Georgia Environmental Finance Authority

Loan Program Interest Rates

GEFA charges the following interest rates by loan program. Six amortization periods are offered. A loan with an amortization period between the tiers receives the interest rate for the next highest amortization tier, e.g., a seven-year loan receives the 10-year rate.

Program	5-Year Loan	10-Year Loan	15-Year Loan	20-Year Loan	25-Year Loan	30-Year Loan	Annual Borrowing Maximum
Benchmark Rate	**0.21%**	**0.52%**	**1.22%**	**1.63%**	**2.06%**	**2.36%**	
Georgia Fund	0.21%	0.52%	1.22%	1.63%	N/A	N/A	$3,000,000
Georgia Fund - Conservation or WaterFirst	0.08%	0.15%	0.22%	0.63%	N/A	N/A	$3,000,000
Georgia Fund - PlanFirst	0.15%	0.43%	0.72%	1.13%	N/A	N/A	$3,000,000
Clean Water State Revolving Fund (CWSRF)*	0.15%	0.43%	0.72%	1.13%	1.56%	1.86%	$25,000,000
CWSRF - Conservation or WaterFirst	0.00%	0.04%	0.07%	0.13%	0.56%	0.86%	$25,000,000
CWSRF - PlanFirst	0.08%	0.24%	0.47%	0.63%	1.06%	1.36%	$25,000,000
Drinking Water State Revolving Fund (DWSRF)*	0.15%	0.43%	0.72%	1.13%	1.56%	1.86%	$25,000,000
DWSRF - Conservation or WaterFirst	0.00%	0.04%	0.07%	0.13%	0.56%	0.86%	$25,000,000
DWSRF - PlanFirst	0.08%	0.24%	0.47%	0.63%	1.06%	1.36%	$25,000,000

* Loans with repayment terms up to 40 years available for disadvantaged communities as defined by the U.S. Environmental Protection Agency provided the terms do not exceed the useful life of the project.

Effective September 2020

GEFA

gefa.georgia.gov

Federal Requirements

Architectural/Engineering Qualification-Based Selection Process
Borrowers must comply with Section 602(b)14 of the Federal Water Pollution Control Act, which requires competitive procurement for architectural and engineering (A/E) services through a Qualifications-Based Selection (QBS) procedure. This applies to contracts for program management, construction management, feasibility studies, preliminary engineering, design, engineering, surveying, mapping, or other engineering-related services.

To be eligible for financing from the 2022 Clean Water State Revolving Fund, all borrowers must comply with the following A/E selection requirement:

- If the anticipated project cost is less than $1,000,000 and A/E services are less than $100,000, a QBS procedure is not required.
- If the anticipated project cost is $1,000,000 to $3,000,000 and A/E services are more than $100,000, a **ONE-STEP procurement** is required for selecting an A/E firm. In a one-step procurement, the borrower selects a consultant based on the scoring methodology that has been published in a Request for Qualifications for A/E Services.
- If the anticipated project cost is more than $3,000,000 and A/E services are more than $100,000, a **TWO-STEP procurement** is required for selecting an A/E firm. In a two-step procurement, the borrower uses the scoring methodology published in its RFQ to narrow down the candidates to three to five "finalist" firms. Then, the borrower interviews the "finalist" firms to select the most qualified candidate.

Guidance and templates for a one-step and two-step QBS process can be found on the GEFA website at gefa.georgia.gov/architectural-and-engineering-services.

Davis-Bacon Wage Rate Requirement
The provisions of the Davis-Bacon Act apply to all "treatment works" projects financed in whole or in part from the CWSRF. These requirements apply to projects for the construction, alteration, maintenance, or repair of a treatment works. In all contracts in excess of $2,000, the Borrower shall insert in full the document entitled "Supplemental General Conditions for Federally-Assisted State Revolving Fund." This document is located on the GEFA website at gefa.georgia.gov/loan-documents.

American Iron and Steel
The American Iron and Steel (AIS) requirements apply to all "treatment works" projects financed in whole or in part from the CWSRF. These requirements apply to projects for the construction, alteration, maintenance, or repair of a treatment works. In all contracts, the Borrower shall insert in full the document entitled "AIS Special Conditions." This document is located on the GEFA website at gefa.georgia.gov/loan-documents.

State Environmental Review Process
Projects funded by the CWSRF must undergo an environmental review via the EPA-approved State Environmental Review Process (SERP). This environmental review is conducted by EPD through either a Categorical Exclusion (CE) or Notice of No Significant Impact (NONSI) process. This process addresses issues such as environmental impact, potential historical preservation issues, potential endangered species concerns, and permit compliance. Borrowers should review the "Guidance Document for Project Requirements" document, which is located on the GEFA website at gefa.georgia.gov/loan-documents.

Disadvantaged Business Enterprise (DBE)
As a part of GEFA's loan agreement, loan recipients are required to encourage the participation of minority- and women-owned businesses in all project subcontracts. The state's CWSRF percentage goals through September 30, 2022, are four percent for Minority Business Enterprises (MBE) and four percent for Women Business Enterprises (WBE). Borrowers should review the "Supplemental General Conditions for Federally-Assisted State Revolving Fund," which are located on the GEFA website at gefa.georgia.gov/loan-documents.

Fiscal Sustainability Plans
Borrowers from the CWSRF that will repair, replace, or expand "treatment works" with CWSRF funds must certify that it has developed and implemented a fiscal sustainability plan that includes:

1. An inventory of critical assets that are a part of the treatment works;
2. An evaluation of the condition and performance of inventoried assets or asset groupings;
3. A certification that the recipient has evaluated and will be implementing water and energy conservation efforts as part of the plan; and

4. A plan for maintaining, repairing, and, as necessary, replacing the treatment works and a plan for funding such activities.
5. Loan agreements signed between GEFA, and the borrower will contain certification language pertaining to this Fiscal Sustainability requirement.

Proposed Timeline for Funding

September 1, 2021 – The 2022 call for projects opens

February 28, 2022 – Deadline to submit pre-application via GEFA's website at gefa.georgia.gov

April 22, 2022 – Fundable Priority list posted on GEFA's website

May 31, 2022 – *Tentative* public meeting for the 2022 CWSRF IUP and Fundable Priority List

June 17, 2022 – IUP submission to EPA for approval

Georgia Environmental Finance Authority
2022 CWSRF Affordability Criteria

GEFA's affordability criteria uses data on median household income (MHI), unemployment rate, percentage not in labor force, poverty rate, percentage on Social Security, percentage on Supplemental Security Income (SSI), percentage with cash public assistance, percentage with Supplemental Nutrition Assistance Program (SNAP), age dependency ratio, and population trend from the U.S. Census Bureau's 2019 American Community Survey. The applicant's data is categorized in percentiles. GEFA will use the affordability criteria to rank applicants for funding priority for the Assistance for Small and Disadvantaged Communities Drinking Water Grant. **Please note that the affordability percentiles may change based on updated census data.**

1. Median Household Income (MHI)

State Percentiles	25th Percentile (4 points)	50th Percentile (3 points)	75th Percentile (2 points)	100th Percentile (1 point)
MHI	$32,699	$42,444	$54,555	$54,556 or higher

2. Unemployment Percent

State Percentiles	25th Percentile (1 point)	50th Percentile (2 points)	75th Percentile (3 points)	100th Percentile (4 points)
Unemployment Percent	2.0%	3.1%	4.6%	4.7% and higher

3. Percentage Not in Labor Force

State Percentiles	25th Percentile (1 point)	50th Percentile (2 points)	75th Percentile (3 points)	100th Percentile (4 points)
Percentage Not in Labor Force	36.9%	43.5%	50.3%	50.4% and higher

4. Poverty Rate

State Percentiles	25th Percentile (1 point)	50th Percentile (2 points)	75th Percentile (3 points)	100th Percentile (4 points)
Poverty Rate	12.3%	20.0%	27.4%	27.5% and higher

5. Percentage on Social Security

State Percentiles	25th Percentile (1 point)	50th Percentile (2 points)	75th Percentile (3 points)	100th Percentile (4 points)
Percentage on Social Security	29.2%	36.1%	43.3%	43.4% and higher

6. Percentage on SSI

State Percentiles	25th Percentile (1 point)	50th Percentile (2 points)	75th Percentile (3 points)	100th Percentile (4 points)
Percentage on SSI	3.9%	6.8%	10.4%	10.5% and higher

7. Percentage with Cash Public Assistance

State Percentiles	25th Percentile (1 point)	50th Percentile (2 points)	75th Percentile (3 points)	100th Percentile (4 points)
Percentage with Cash Public Assistance	0.2%	1.3%	2.3%	2.4% and higher

8. Percentage with SNAP

State Percentiles	25th Percentile (1 point)	50th Percentile (2 points)	75th Percentile (3 points)	100th Percentile (4 points)
Percentage with SNAP	10.8%	18.8%	25.2%	25.3% and higher

9. Age Dependency Ratio

State Percentiles	25th Percentile (1 point)	50th Percentile (2 points)	75th Percentile (3 points)	100th Percentile (4 points)
Age Dependency Ratio	58.6	67.4	77.3	77.4 and higher

10. Population Trend

The following categories will be used to determine scoring for change in population from 2011 to 2019.

- Positive growth or no growth (1 point)
- Between -0.01% to -1% (2 points)
- Between -1.01% and -2% (3 points)
- Greater than -2% (4 points)

Georgia Environmental Finance Authority
2022 CWSRF Call for Projects
Project Scoring Criteria

Projects will be rated in three categories to determine eligibility and selection for funding through the CWSRF Program.

CLEAN WATER SRF

Clean Water State Revolving Fund Scoring System (maximum 100 points)

1. A/E procurement (10 points)
2. Readiness to proceed (30 points)
3. Compliance benefit (30 points)
4. Project benefits (30 points)

CWSRF Scoring System – Detailed Breakdown

1. A/E Procurement (only one option can be selected)

a.	Developed a Request for Qualifications (RFQ) for engineering services and/or posted an RFQ for engineering services.	5 pts
b.	Contracted with an engineering consulting firm in accordance with the qualifications - based selection (QBS) policy discussed on page 5.	10 pts
c.	Contracted with an engineering firm for projects with construction costs less than $1,000,000 and engineering costs less than $100,000.	10 pts

2. Readiness to Proceed (only one option can be selected)

a.	Project description submitted to GEFA to request a loan number.	10 pts
b.	State Environmental Review Process (SERP) package submitted to EPD.	15 pts
c.	SERP issued (Categorical Exclusion or Notice of No Significant Impact determination published in a letter from EPD).	20 pts
d.	SERP approved (EPD published a final approval letter).	30 pts

3. Compliance Benefits (only one option can be selected)

a.	Project will support implementation of a Total Maximum Daily Load (TMDL) plan (provide applicable TMDL, water body name, and water body ID).	20 pts
b.	Project is needed to **fully address** deficiencies documented in Emergency or Administrative Order from EPA or EPD (provide the order number and a brief narrative on how deficiencies are fully addressed).	30 pts

4. Project Benefits (select all that apply)

a.	Project will provide a redundant power supply (e.g., generators with an automatic transfer switch or alternative energy sources) to prevent interruption of operations during an emergency.	5 pts
b.	Project will contribute to the de-listing of a stream segment currently listed as "non-attaining of designated use" on either the 303(d) list or the 305(b) list. (provide the specific stream segment ID)	5 pts
c.	Project will reduce combined sewer overflows or sanitary sewer flows. This may include correction to significant infiltration and inflow problems that have caused sewer backups or flooding issues.	10 pts
d.	Project will address faulty septic systems.	10 pts

***** GEFA reserves the right to verify any information submitted within the pre-application.

Please contact the Water Resources Division at 404-584-1000 or waterresources@gefa.ga.gov if you have any questions about the 2022 Clean Water State Revolving Fund Call for Projects.

Appendix E Technology Fact Sheets

These technology fact sheets are available as a reference for utilities to use when discussing available biosolids treatment technologies.

Composting

BLACK & VEATCH

TECHNOLOGY VARIATIONS

Windrow

- Solids/amendment placed in long piles (windrows)
- Windrows turned by specialized machines to aerate/ "fluff"
- Often outdoors
- Process control limited to compost mix selection, turning schedule and climate protection

Aerated Static Pile (ASP)

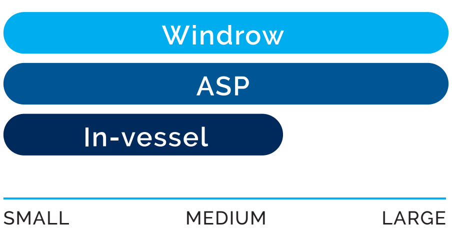
- Solids/amendment piles not moved during composting
- Piles aerated by blowers
- Air pulled through pile sent to odor control
- Blower operation manual or thermocouple-driven
- Can be covered with geomembrane to mitigate odors

In-vessel

- Amendment/solids mix loaded into bays
- Bays aerated with blower
- Specialized machine moves material along bay and "fluffs"
- Air pulled through pile sent to odor control
- Process PLC-controlled based upon temperature

APPLICATION CONSIDERATIONS

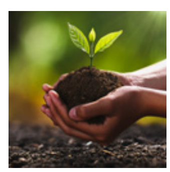
Plant Size



Use Opportunities

PRODUCT: CLASS A COMPOST

AGRICULTURE



URBAN

Development Status

EMERGING INNOVATIVE ESTABLISHED

ADVANTAGES & DISADVANTAGES

Advantages

- Class A product suitable for diverse uses
- Relatively simple operation
- Low capital costs for windrow composting

Disadvantages

- Large footprint
- Odor concerns/management
- Energy/aeration costs for ASP and in-vessel
- Need for bulking agent
- Significant transport needs because of bulking agent, low density of finished compost

Aerobic Digestion (AD)

BLACK & VEATCH

TECHNOLOGY VARIATIONS

Mesophilic AD

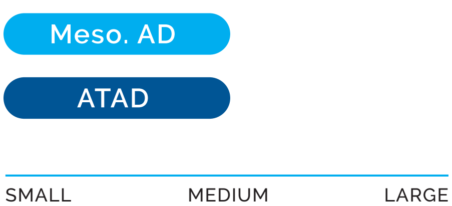
> Class B process
> Not well suited for primary sludge
> Air added to mix/aerate liquid sludge (<3% solids content) in tanks with long solids retention times (typically 40 to 60 days depending on temperature)
> Aeration intermittent – air turned off to allow settling before decanting

Autothermal Thermophilic AD (ATAD)

> Class A process
> WAS or blended P and WAS thickened, fed to batch reactors with SRT of 12 days
> ORP-based aeration control ensures aerobic conditions maintained
> Post-digestion aeration required to cool solids for dewatering and reduce recycle stream strength
> Dual conditioning (polymer and flocculant) required

APPLICATION CONSIDERATIONS

Plant Size



Use Opportunities

PRODUCT: CLASS B or CLASS A CAKE

AGRICULTURE

Development Status

ADVANTAGES & DISADVANTAGES

Advantages

> Relatively simple operation
> High volatile solids reduction/ cake solids/volume reduction (ATAD)
> Low odor cake (ATAD)
> Low ammonia sidestream compared to anaerobic digestion (mesophilic AD)

Disadvantages

> High energy requirements
> Large footprint (mesophilic AD)
> Limited to WAS (mesophilic AD)
> Relatively poor dewaterability (mesophilic AD)
> Dual conditioning required (ATAD) for dewatering

Anaerobic Digestion

BLACK & VEATCH

TECHNOLOGY VARIATIONS

Conventional

- > Anaerobic microorganisms convert volatile solids to biogas under anaerobic conditions
- > Can be mesophilic (35 to 38°C) or thermophilic (55 to 65°C), most systems are mesophilic
- > Can be single stage or multiple stage (e.g., acid phase)
- > Produces class B biosolids with >15 days retention at >35°C

Temperature Phased (TPAD)

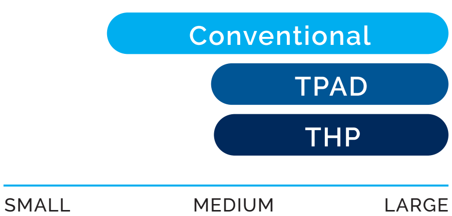
- > Thermophilic digestion followed by mesophilic digestion
- > Produces Class A biosolids if batch thermophilic tanks used to meet time and temperature
- > Some fecal coliform regrowth observed with centrifuge dewatering

Thermal Hydrolysis Process (THP)

- > Batch hydrolysis of digester feed solids by 'pressure cooking' with steam injection
- > Meets time & temperature requirements to produce Class A biosolids
- > Increased digester loading, improved VS conversion and better dewaterability

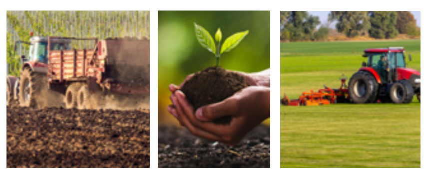
APPLICATION CONSIDERATIONS

Plant Size



Use Opportunities

PRODUCT: CLASS B or CLASS A CAKE



AGRICULTURE URBAN SOD PRODUCTION

Development Status

EMERGING INNOVATIVE ESTABLISHED

ADVANTAGES & DISADVANTAGES

Advantages

- > Reduces mass and volume of biosolids
- > Low energy use
- > Produces biogas which can be converted to electricity and heat or renewable natural gas
- > Established and well-proven
- > Potential for co-digestion of multiple feedstocks for additional tipping fees and additional biogas
- > Potential for nutrient recovery

Disadvantages

- > Biogas systems require rigorous attention to safety to mitigate explosion risk
- > Relatively large footprint
- > Generally, not suitable for smaller facilities
- > Not efficient for waste activated sludge-only systems (except potentially with THP)
- > Results in sidestream with high N & P loads returned to liquid stream plant

Thermal Conversion

BLACK & VEATCH

TECHNOLOGY VARIATIONS

Incineration

- Thermal combustion of organics with enough oxygen present for full oxidation
- Produces ash
- New installations are generally fluidized bed systems (older units may be multiple hearth)
- Fed with dewatered cake

Gasification

- Thermal conversion of organics under limited oxygen conditions
- Products include biochar and syngas
- Requires dried product feed

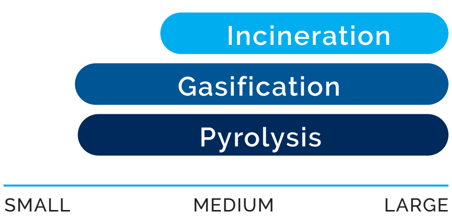
Pyrolysis

- Thermal conversion of organics with no oxygen present
- Products include biochar, liquid bio-fuel and some combustible gas
- Requires dried product feed

Courtesy of Aries Clean Technologies

APPLICATION CONSIDERATIONS

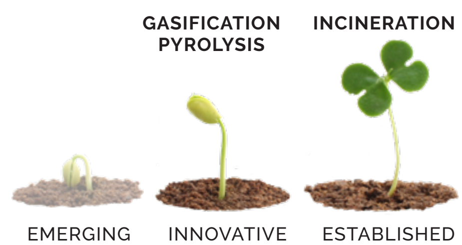
Plant Size



Outlets

- Ash to landfill
- Biochar to landfill or beneficial use
- Potential for metals recovery
- Syngas to energy recovery

Development Status



ADVANTAGES & DISADVANTAGES

Advantages

- Incineration provides complete conversion of volatile solids to ash providing large mass/volume reduction
- Gasification and pyrolysis produce a biochar which may be beneficially used
- Incineration is well-proven

Disadvantages

- Limited operating experience with gasification and pyrolysis on wastewater residuals compared to incineration
- Permitting is a challenge for incineration facilities
- Emissions control requirements

Chemical Stabilization

BLACK & VEATCH

TECHNOLOGY VARIATIONS

Class B Lime

> Lime added at 0.2 to 0.5 ton/dry ton dewatered solids
> Plug mill or similar mixers blend lime and solids
> Generally, Class B product

Class A Lime

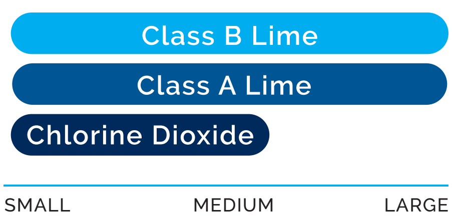
> Typically proprietary
> Adds lime and heat or heat of lime and acid to achieve Class A
> Lime dose 0.2 to 0.8 tons/dry ton dewatered solids

Chlorine Dioxide

> Sulfuric acid and sodium nitrite mixed to form chlorine dioxide
> Chemical injected into unthickened sludge before dewatering
> Class B product
> Class A/PFRP process for thickened sludge available, additional chemicals needed

APPLICATION CONSIDERATIONS

Plant Size

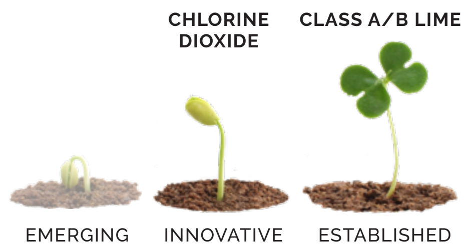


Use Opportunities

PRODUCT: CLASS B or CLASS A LIMING AGENT OR CAKE

AGRICULTURE | URBAN | SOD PRODUCTION

Development Status



ADVANTAGES & DISADVANTAGES

Advantages

> Relatively low capital cost
> Relatively simple operation
> Class B or Class A product achievable
> Low odor for chlorine dioxide processes
> Small footprint

Disadvantages

> High chemical costs
> Chemical handling requirements
> Odor concerns for lime products
> No cake volume reduction

Drying

BLACK & VEATCH

TECHNOLOGY VARIATIONS

Rotary Drum

- Feed cake mixed with recycled dried pellets
- Cake 'coats' pellets in mixer
- Wet pellets pass through rotary drum, dried using heated air (direct drying)
- Dried pellets screened for size
- Product is spherical and uniform, spreads easily

Belt

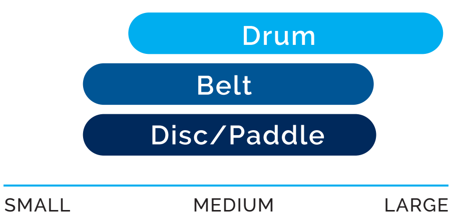
- Feed cake spread or extruded onto drying belt
- Solids conveyed through dryer on belt and dried using heated air (direct drying)
- Wide variation in product quality, dependent on vendor
- Some products are non-uniform / friable and difficult to spread

Disc/Paddle

- Cake fed into dryer vessel
- Cake dried via contact with discs / paddles which also push solids through the dryer (indirect drying)
- Non-uniform granular product

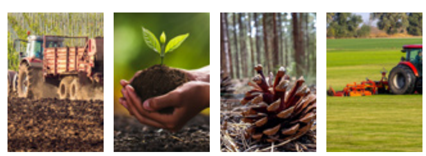
APPLICATION CONSIDERATIONS

Plant Size



Use Opportunities

PRODUCT: CLASS A DRIED



AGRICULTURE URBAN SILVICULTURE SOD PRODUCTION

Development Status

EMERGING INNOVATIVE ESTABLISHED

ADVANTAGES & DISADVANTAGES

Advantages

- Class A product with large diversity of end uses
- Large volume reduction minimizes transport costs / maximizes distribution opportunities
- Biogas can fuel dryer (if available)

Disadvantages

- High energy requirements (less so if biogas available)
- Mechanically intensive equipment requires significant maintenance
- Safety concerns related to process and combustible product

Solar Drying

BLACK & VEATCH

TECHNOLOGY OVERVIEW

Drying Mechanism

> Solar energy used, convective and radiative drying process at ambient temperature

> Dewatered cake spread in 6 to 8-inch layer, left for ~20 days or more

> Variety of turning devices used

O&M

> Simple operation and few components

> Batch or continuous processes

> Equipment failure won't critically impact operation

> Can be fully automated

> Odor control for large volume of exhaust air

Product

> Soil-like, typically 40-80% TS

> Potential for Class A dependent on system design and operation

> May meet VAR by achieving specific TS levels based on sludge feed type

APPLICATION CONSIDERATIONS

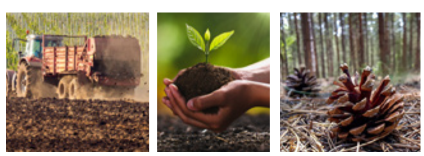
Plant Size

Solar Dryers

SMALL MEDIUM LARGE

Use Opportunities

PRODUCT: CLASS A OR B



AGRICULTURE URBAN SILVICULTURE

Development Status

EMERGING INNOVATIVE ESTABLISHED

ADVANTAGES & DISADVANTAGES

Advantages

> Can potentially meet Class A

> Simple system

> Minimal energy requirements compared to thermal drying

> Significant solids volume reduction

> Soil-like product

Disadvantages

> Requires numeric pathogen testing to demonstrate Class A product

> Large footprint

> Large exhaust volume may require odor control

> Generally suitable for WAS or digested solids

Dewatering

BLACK & VEATCH

TECHNOLOGY VARIATIONS

Generally Decreasing Cake Solids Concentration

Centrifuge

Scroll-discharge, solid bowl centrifuges are most common: solids are pumped into the centrifuge, where the high-speed spinning action of the bowl forces the solids against the bowl surface. Heavier solids are conveyed by the scroll along the bowl while centrate flows in the opposite direction.

Level of Operator Attention:
Low

Enclosed:
Yes

Major Maintenance Performed by:
Vendor

Capacity:
High

Power Requirements:
High

Polymer Use:
Yes

Belt Filter Press

Free water drains from sludge evenly distributed onto a moving porous belt followed by compression between two porous cloth belts. Press capacity requirements are based on both solids and hydraulic loading rates.

Level of Operator Attention:
High

Enclosed:
No

Major Maintenance Performed by:
Plant Staff

Capacity:
Varies

Power Requirements:
Low

Polymer Use:
Yes

Rotary Press

Solids fed into the dewatering channel are moved along it by a rotating element on the central shaft. As solids travel the channel length, pressure builds and forces water from the cake. Filtrate passes through metal screens on either side of the channel.

Level of Operator Attention:
Low

Enclosed:
Yes

Major Maintenance Performed by:
Plant Staff

Capacity:
Low

Power Requirements:
Low

Polymer Use:
Yes

Screw Press

Solids fed into the press are conveyed from the inlet to the outlet by a rotating screw. As the sludge moves along the length of the press, it is squeezed between the screw and perforated screens surrounding the screw. Filtrate pressed from the sludge drains through the perforated screens.

Level of Operator Attention:
Low

Enclosed:
Yes

Major Maintenance Performed by:
Plant Staff

Capacity:
Low

Power Requirements:
Low

Polymer Use:
Yes