Executive Summary

The Arlington County Water Pollution Control Plant (WPCP) treats incoming wastewater flows for residents, businesses, and government agencies in the Arlington County sewer service area to protect public health and the environment. The residuals produced as a byproduct of the treatment process are currently stabilized using lime to produce Class B biosolids that are beneficially used through application on agricultural land. The previous Master Plan project (MP01) focused on implementing state-of-the-art technology for the liquid treatment processes. This Solids Master Plan focuses on planning for the future of solids processing at the facility.

The purpose of the Solids Master Plan is to provide a roadmap for Arlington County with long-terms goals and strategies to achieve those goals identified. The plan recognizes the potential for a regional solids management solution that might include partnership with other utilities. Potential partners including DC Water, Fairfax County, and others were contacted for interest; however, at the time of this report, no regional opportunity has emerged. The recommendations in this Solids Master Plan allow the County to proceed with the planning and implementation of a solids management strategy while continuing to explore potential regional opportunities that may arise.

ES.1 Solids Master Planning Background and Goals

The Arlington County WPCP is an advanced wastewater treatment plant located on South Glebe Road in Arlington, Virginia with capacity to treat up to 40 million gallons per day (mgd). The facility provides wastewater treatment for a service area that includes most of Arlington County plus areas of Falls Church, Alexandria, and Fairfax County. The area is densely populated with a mix of residential, institutional, and commercial customers. The service area includes over 220,000 residents plus landmarks including Reagan National Airport and the Pentagon.

The WPCP discharges treated wastewater effluent into Four Mile Run, part of the lower Potomac River sub-basin in the Chesapeake Bay watershed, under Virginia Pollutant Discharge Elimination System (VPDES) Permit No. VA0025143. The WPCP uses a combination of physical, chemical, and biological processes to treat wastewater to a high standard. Solids removed from the treatment processes receive additional treatment before being hauled off-site by trucks. Solids are thickened and dewatered prior to lime stabilization. Approximately 36,000 wet tons of lime-stabilized biosolids are hauled annually by truck from the site for beneficial use as Class B biosolids in bulk land application, which equates to about 30 dry tons per day.

Several goals for this Solids Master Plan were identified at the outset of the project. They include:

- Replacing failing and end of life equipment
- Mitigating the risk of potential future regulatory changes to the current practice of recycling Class B biosolids through application to agricultural land
- Providing a solution that reduces the energy and greenhouse gas footprint of the WPCP
- Achieving additional County-wide sustainability goals
- Developing a solids management strategy that offers long-term reliability
- Establishing an implementation plan compatible with County CIP funding

ES.2 Project Team and Communications

The master planning project team was comprised of representatives from multiple stakeholder groups including:

- Arlington County
  - Department of Environmental Services representatives from Management, Financial, Communications, and Energy teams
  - WPCP engineering and Bureau Chief
  - WPCP operations staff
  - WPCP maintenance staff
- CDM Smith consulting core team
- Technical advisory committee consisting of recognized industry experts
- Multiple subject matter experts
- External stakeholders including civic associations, financial commissions, and environmental groups

The team members met regularly over the project period to advance the project from initial goal-setting and technology screening, to developing and evaluating solids management alternatives, and ultimately to identifying a preferred alternative and developing an implementation plan.

The project team recognized the specific and direct impacts this project would have on WPCP customers, the community, and in particular, WPCP's closest neighbors. The team developed a communication plan early on and has been conducting community outreach since the project began in the fall of 2015. The purpose of this outreach was to ensure early, frequent and two-way communication with key stakeholders and residents throughout the multiple phases of the project. The communication plan and outreach facilitated an information exchange that allowed the project team to inform stakeholders of progress and recommendations of the Solids Master Plan. Additionally, the County received feedback from stakeholders that was valuable to the project.

WPCP hosted a series of workshops and presented information about the plan at several community meetings over a two-year period. Workshop attendance included representatives from the closest neighborhoods (Aurora Highlands, Arlington Ridge, Crystal City, and Long Branch), as well as members from the Arlington County Civic Federation, Neighborhood Conservation Advisory Commission, the Fiscal Advisory Affairs Commission, Arlingtonians for A Clean Environment and the Energy and Environment Conservation Commission.

At each workshop stakeholders received a presentation about progress on the project and were able to provide input at key decision points. Meeting summaries, presentations and questions and answers were posted to a public project website (https://projects.arlingtonva.us/projects/water-pollution-control-plant-solids-master-plan/). Stakeholders' input provided along the way included participation in developing weightings for the evaluation criteria used in the alternatives analysis. Stakeholder participation resulted in an increased emphasis on social and

environmental impacts of the project; the importance of exploring regional solutions; and the need for an early evaluation of potential air emissions resulting from the technologies recommended for implementation. These priorities have been addressed as part of this study.

ES.3 Project Need and Basis of Planning

Much of the existing solids handling infrastructure at the WPCP is over 25 years old with some facilities over 40 years old. The equipment requires frequent attention from maintenance staff. A condition assessment was completed for the solids equipment early in the Master Plan project. The assessment reviewed both the criticality and condition of the equipment. The assessment identified numerous process equipment that was approaching or past its useful life. Frequent maintenance was noted for the equipment associated with the lime stabilization and truck loading process. Considerable improvements to the solids processes are needed.

The basis of planning for the master plan was determined by estimating future wastewater flows, influent loadings, and solids production for the WPCP. The projections, presented in Section 3 of the report, were based on conclusions from previous studies and adjusted based on recent plant operating records. On average, the solids projections reflect an increase of approximately 1.5% per year from current levels through year 2040.

- Facility improvements and capital costs described in the report are based on the WPCP's existing permitted capacity of 40 mgd.
- Annual costs and 20-year life cycle costs were developed using annual projections of solids for years 2021 – 2040.

ES.4 Evaluation Methodology

The evaluation methodology used in the master planning process includes multiple levels of evaluation to select a preferred solids management alternative from a list that initially included nearly 70 different potential technologies.

An initial review of technologies considered is presented in Section 5 of the report. The project team completed a screening exercise to identify preferred technologies that were appropriate for Arlington County based on a set of five criteria (**Table ES-1**).

Following an initial technology screening, the project team combined the preferred technologies into twelve (12) potential solids management alternative process trains. Ten of the process trains focused on processes that could be constructed at the WPCP. The remaining two process trains were developed around off-site solids management solutions. The potential for regional partnerships and/or third-party agreements were explored for these off-site management solutions.

Table ES-1. Screening Criteria Used to Identify Preferred Technologies

Criterion	Comparative Basis	Preferred
Development Status	Technical Development Level defined by WE&RF	Conventional/established technologies
Typical Application Scale	Typical solids production at wastewater treatment plants using the technology	10 - 100 dry tons per day
Site Requirements	Relative amount of land required, or off-site solution	Technologies that fit on site with minimal demolition; or technologies where solids would be processed elsewhere
Relative Costs	Compare to current solids management costs	Comparable to (or lower than) current biosolids management costs
Permitability	History of permitting technology	Technology has been permitted and/or no difficulty is anticipated

Due to the uncertainty associated with developing a regional partnership, the project team put this effort on its own parallel track and focused the master plan evaluation on solutions that Arlington County could construct and maintain long-term ownership. Arlington County will continue to consider any options for a regional solution; however, at this time, there are no feasible facilities or partners in place or anticipated in the near future.

Section 9 of the report presents the evaluation of the individual technologies and processes. Two project workshops were conducted to review the preliminary process evaluations with a focus on economics, space requirements, energy requirements, and end products. The outcome of the workshops resulted in the project team identifying four alternatives for detailed evaluations.

The four alternatives identified will result in either a Class A or a Class B biosolids product. Both classes of biosolids products are suitable for beneficial use in land application. Key differences between Class A and Class B biosolids are summarized below:

- Class A biosolids are treated for pathogen reduction to a level where pathogens cannot be detected. Class A biosolids can be distributed and applied with fewer restrictions than Class B biosolids. The result is that Class A biosolids can be distributed to additional markets outside of bulk agricultural land application.
- Class B biosolids are not treated to the same level for pathogen reduction as Class A biosolids. Regulators have developed management measures such as buffer requirements and access restrictions for Class B application sites to protect public health.

The four alternatives are:

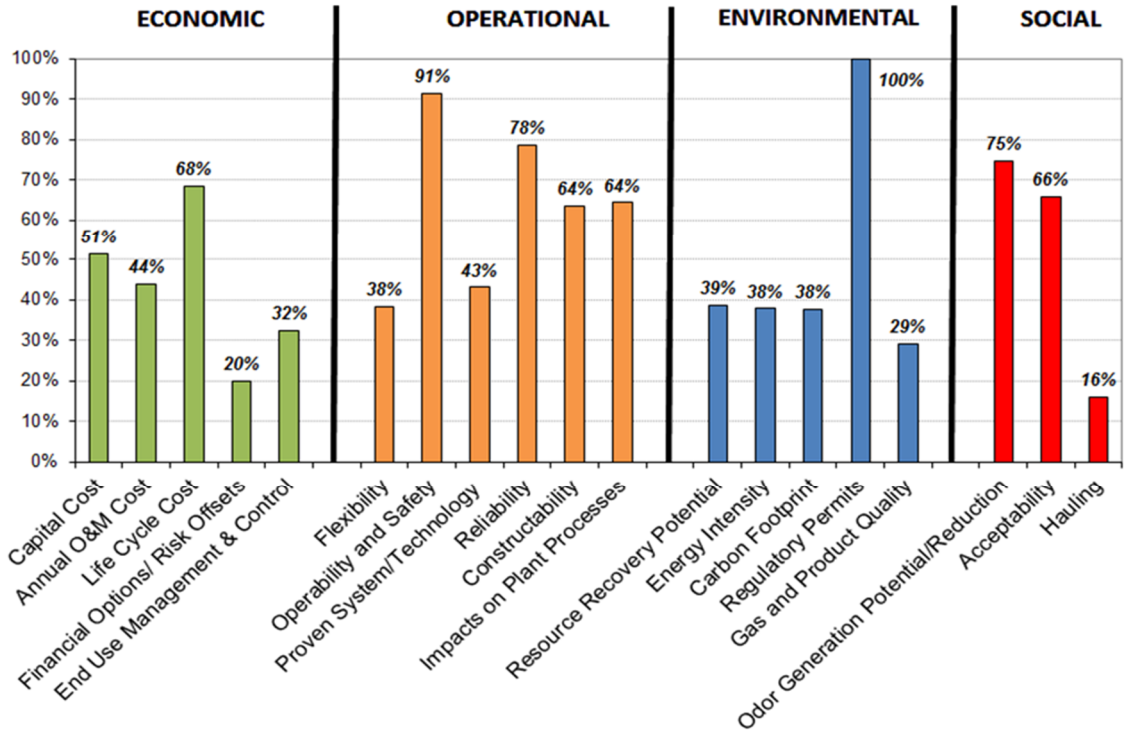
- **Alternative 1: Lime Stabilization.** Lime stabilization represents the current process employed at the WPCP and is used as a baseline for comparison of other alternatives. The current process produces Class B biosolids.
- **Alternative 2: Mesophilic Anaerobic Digestion.** Anaerobic digestion was identified as a preferred process for stabilization of WPCP solids at the screening level and preliminary process evaluations. The process includes thickening solids ahead of digestion, anaerobic digestion, and dewatering of the final product. The process will produce Class B biosolids and biogas that can be captured and utilized as fuel. Phosphorus recovery is also potential for all digestion options.

- **Alternative 3: Thermal Hydrolysis Pretreatment + Anaerobic Digestion.** THP combined with anaerobic digestion will produce Class A biosolids and biogas that can be captured and utilized as fuel. The process involves pre-dewatering of solids, thermal hydrolysis pretreatment, anaerobic digestion, and dewatering of the final product.
- **Alternative 4: Anaerobic Digestion + Drying.** Similar to Alternative 2, the mesophilic digestion process of this alternative will produce a biosolid that can be dewatered. The dewatered material can then be thermally dried to produce a Class A product with significant volume reduction compared to other alternatives.

The detailed evaluation of the four alternatives was based on nineteen (19) criteria that were developed by Arlington County at the beginning of the project. The criteria were weighted based on input from numerous project stakeholders, including Arlington County staff and the external stakeholder group.

The evaluation criteria were distributed between four categories: economic, operational, environmental, and social. These categories and criteria support a "Quadruple Bottom Line" approach to the evaluation. Figure ES-1 is a representation of the criteria in each category with weightings.

Figure ES.1. Evaluation Criteria Weighting



ES.5 Alternative Evaluations

A detailed engineering evaluation of the alternatives was completed. Sections 10 and 11 of the Master Plan report provide additional information on the development of the alternatives and the results of the evaluation.

ES.5.1 Economic Criteria Evaluation

The project team considered multiple economic criteria as part of the analysis. Capital cost, annual cost of operations & maintenance, and 20-year life cycle costs were developed for each alternative using vendor information, utilities rates, County contracts, and solids quantity projections. Annual costs were adjusted for inflation as part of the cost development. A sensitivity analysis, comparing the impacts of cost increases or decreases, was also completed.

Alternative 2 (Mesophilic Anaerobic Digestion) received the highest score and was viewed most favorably under the economic criteria. Other digestion based alternatives (Alternative 3 and Alternative 4) also scored favorably compared to the existing lime stabilization process. The factors influencing the more favorable scores include:

- Moderate capital cost and reduced annual O&M cost resulting in comparable life cycle costs
- Reduced quantity of product hauling associated with digestion based alternatives
- Reduced life cycle cost sensitivity to variables such as changes in hauling costs or energy costs, resulting in reduced risk

ES.5.2 Operational Criteria Evaluation

Operational criteria evaluations focused on the impact to the operations of the WPCP. The criteria considered the number of hours projected to operate and maintain equipment, the reliability of the process and equipment to meet performance goals, the impact on other treatment plant processes, and operator safety.

Alternative 1 (Lime Stabilization) and Alternative 2 (Mesophilic Anaerobic Digestion) scored the highest (most favorable) in this category. In general, the scores are more favorable for these alternatives due to the following:

- Operability of systems that show a lower staffing requirement to operate and maintain (i.e., fewer processes and equipment)
- Processes that are more established with a longer operating history and more installations
- Processes that require smaller footprints based on preliminary layouts
- Alternative 1 (Lime Stabilization) scored slightly higher than Alternative 2 (Mesophilic Anaerobic Digestion) when considering the impact of the solids process on plant operations. Digestion-based alternatives will produce a dewatering sidestream with increased nutrient loading when compared to the lime stabilization process. The potential impacts of returning the nutrient-rich sidestream to the liquid process will need to be addressed.

The trend in the mid-Atlantic region for treatment facilities similar in size (and larger) than Arlington County's WPCP has been to move towards processes capable of producing a Class A biosolids product. Many of the facilities similar in size to Arlington County are either currently producing a Class A biosolids or have plans to produce a Class A product in the future. **Figure ES-2** presents a map of most Mid-Atlantic wastewater treatment facilities located in urban areas. For clarity, the map does not include all biosolids sources in each state; however, the size of treatment plants presented covers 2 mgd to 370 mgd. The map indicates the type of biosolids product or management process relied upon to manage solids produced at the facility.

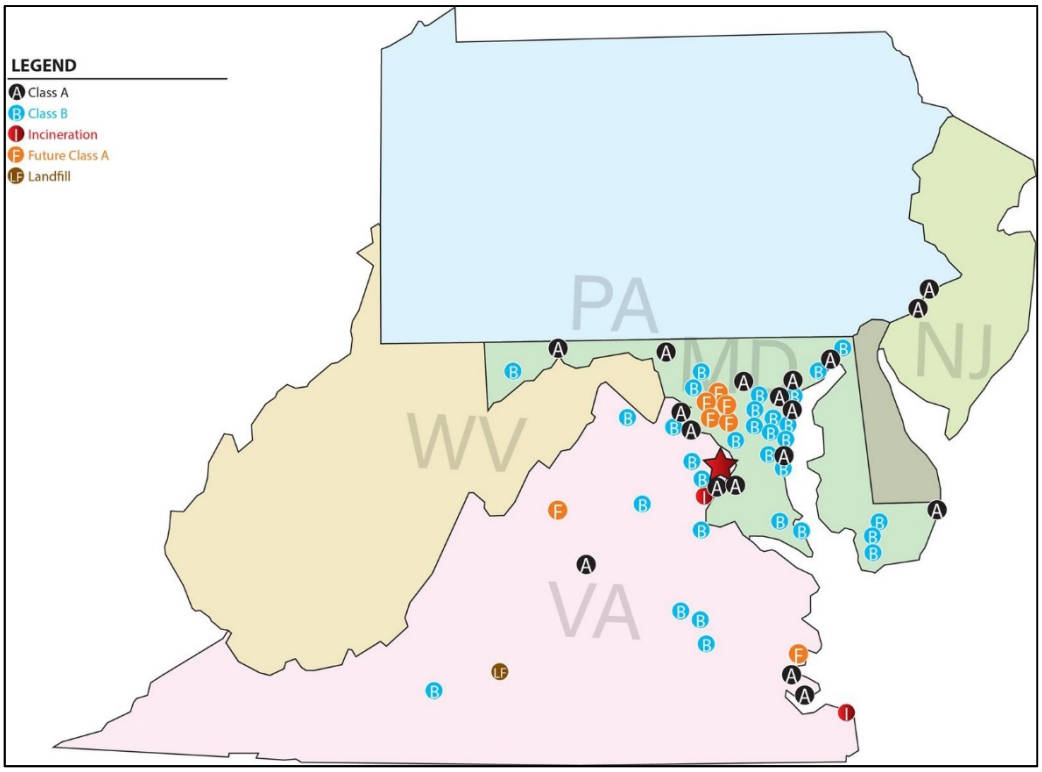


Figure ES-2. Map of Solids Management Practice at Mid-Atlantic Wastewater Treatment Facilities

Land application programs have successfully been used to manage biosolids for many years. Since Class B biosolids are not treated to the same level for pathogen reduction as Class A biosolids, regulators have developed management measures such as buffer requirements and access restrictions for Class B application sites to protect public health. Class A biosolids are treated to a higher level and can be distributed and applied without the same restrictions. The result is that Class A biosolids can be distributed to additional markets outside of bulk agricultural land application.

The added flexibility of processes that produce Class A biosolids was reflected in the evaluation of this criterion. While the criteria rankings reflect a low weighting for 'flexibility,' the project team recognized the value of Class A biosolids in increasing operational flexibility, even noting the County's long-term objective was to move towards a process that could produce Class A biosolids.

ES.5.3 Environmental Criteria Evaluation

For the environmental criteria, Alternative 3 (THP with Anaerobic Digestion) scored the highest (most favorable) of the alternatives considered. Other digestion based alternatives (Alternative 2 and Alternative 4) also scored favorably compared to lime stabilization.

Biogas production as a resource to be recovered favored all options with anaerobic digestion. Multiple biogas utilization opportunities were identified, including on-site combustion in a combined heat and power (CHP) system, local use of a cleaned biogas as CNG fuel, and pipeline injection of biomethane produced from cleaning of the biogas. Utilization of biogas locally aligns with Arlington County's Community Energy Plan to reduce carbon footprint along with generating and utilizing local, renewable energy.

As the project team considered the process that would produce a Class A biosolid, the reduced energy intensity and carbon footprint required to achieve Class A were key differentiators of the THP alternative.

ES.5.4 Social Criteria Evaluation

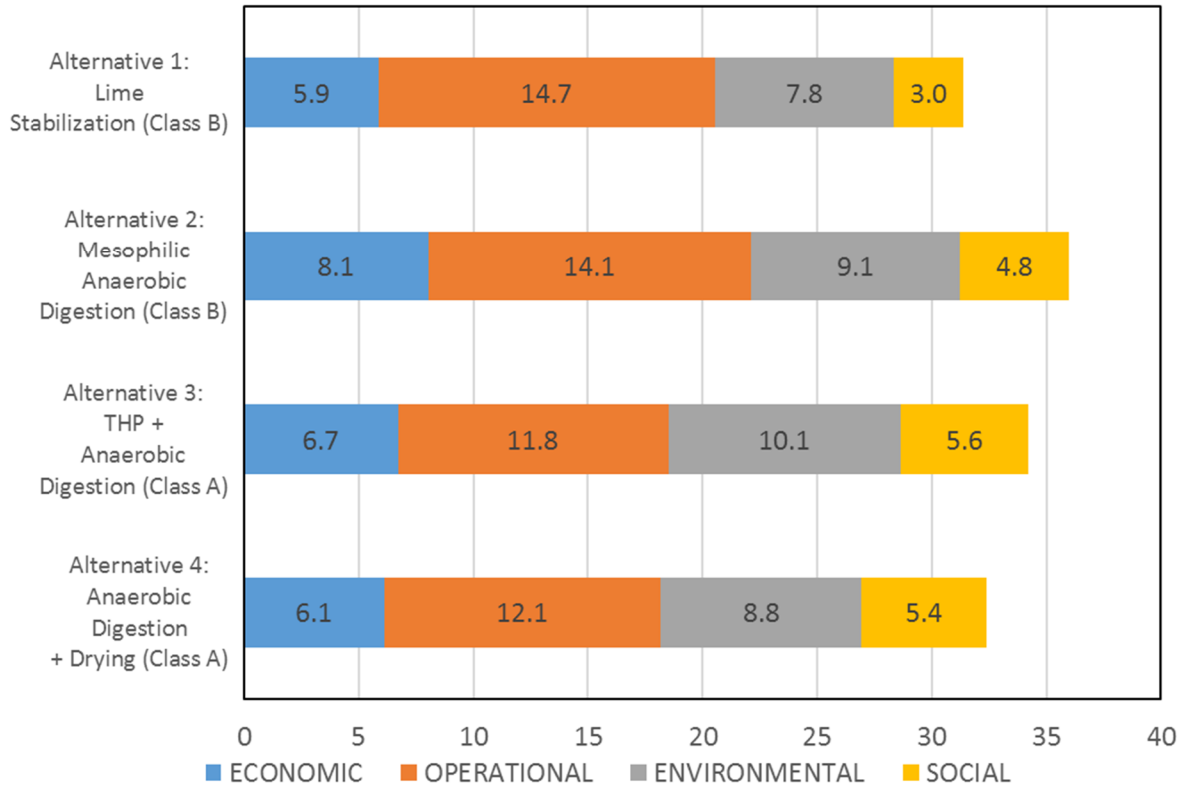
Alternative 3 (THP with Anaerobic Digestion) received the highest score in the social criteria evaluation. Alternative 4 (Anaerobic Digestion with Drying) also received a high score. The acceptability of Class A biosolids suitable for distribution with fewer restrictions was a key differentiator for the two highest scoring alternatives. Concerns with thermal dryer (Alternative 4) potential emissions, in particular odors, led to a preference for THP.

Concerns with process and product odors, lower acceptability of a Class B product, and higher traffic associated with product hauling all contributed to Alternative 1 (Lime Stabilization) receiving the lowest score in the social criteria evaluation.

ES.5.5 Results of Evaluation

The individual scoring results for each criterion are presented in Section 11. **Figure ES-3** presents the overall results of the scoring evaluation graphically. The ranking of the end results indicates that Alternative 2, Mesophilic Anaerobic Digestion, scored the best against the evaluation criteria. Alternative 3, THP pretreatment followed by anaerobic digestion, was the second ranked alternative based on the scoring. Alternative 4 (Anaerobic Digestion + Drying) ranked third and Alternative 1 (Lime Stabilization) ranked last.

Figure ES-3. Results of Alternative Scoring



ES.6 Recommended Alternative

The project team reviewed the final rankings and considered these rankings in determining the recommended alternative. The Quadruple Bottom Line analysis was not the definitive means of determining the preferred alternative, but did help the team clarify their thinking about what was important and helped move the discussion forward as described below.

- The team agreed that all three digestion-based alternatives were preferred over lime stabilization.
- The team also noted master planning goals included mitigating regulatory and social acceptability risks by moving towards a Class A biosolids program. While there is no foreseeable regulatory risk on Class B land application, implementation of a process that produces Class A biosolids product will provide the County with added flexibility in seeking product outlets. Improving the level of treatment can also address potential public concerns related to product uses.

As the project team considered additional factors, such as the County's Community Energy Plan, Alternative 3 (THP followed by anaerobic digestion) was preferred over Alternative 4 (anaerobic digestion and drying). The Community Energy Plan identified goals for reducing the County's carbon footprint and developing/ utilizing renewable energy. Each of these goals aligns with the THP and anaerobic digestion processes.

THP provides Arlington County an opportunity to recover multiple resources suitable for use in the local area. These include a Class A biosolids product, biogas, and potentially recovered phosphorus.

- The Class A biosolids product is able to be distributed to the public as well as to other County departments and commercial entities. The biosolids will likely require additional processing if local distribution is desired. Additional processing could include blending with soil or bulking agent to create a soil amendment and developing a distribution center.
- Biogas can be used to generate steam for the THP process, heat process buildings, generate electrical power with heat recovery, cleaned and converted to compressed natural gas (CNG) for local use, or cleaned and injected into the natural gas grid. Initial review of biogas utilization opportunities has identified the Arlington Rapid Transit (ART) bus fleet as a potential CNG customer. The bus fleet has been converted to CNG with a fueling station located across the street from the WPCP.

Implementation of THP with anaerobic digestion aligns with the goals Arlington County established at the beginning of this project. Additionally, the recommendation to implement THP with Anaerobic Digestion aligns the WPCP Solids Master Plan with the County's Community Energy Plan.

A critical element of the recommended plan involves the beneficial use of biogas generated as part of the anaerobic digestion process. The potential impacts of various biogas uses on site to the air quality in the WPCP vicinity is a subject of concern to civic and neighborhood groups. An emission study was conducted to evaluate the potential contributions of air pollutants under various biogas use scenarios. The study concluded that with proper use of control technologies, biogas use on or off site will not significantly impact the air quality in the vicinity of the WPCP, and is fully protective of the health of sensitive populations bordering the facility site. Detailed evaluation results are presented in Appendix K.

While off-site options were considered early on in the project, the decision-making process in the master plan yielded top-ranked alternatives that Arlington could construct, own, and operate. The potential for regional partnerships remains an option for the County. For example, both DC Water and Fairfax County have existing solids treatment infrastructure, and both indicated early in the project that they might have available capacity to take some or all of the County's residuals. However, subsequent conversations indicated challenges to a long-term partnership such as capacity limitations and logistics of implementation. Opportunities for regional partnerships will be revisited during the next phase of the project.

ES.7 Community Input

Multiple meetings were held over the course of the project with the external stakeholder group. The recommended alternative was presented at the June 22, 2017 public meeting. During that meeting, external stakeholders provided feedback on the project. The general consensus was the group appreciated the sound engineering, clear presentations, and patience County staff showed through the master planning process. Most agreed that they enjoyed participating in thoughtful discussions. They also liked the concept of energy recovery from the biogas, that the process could be safely managed, and that the end result was a Class A product. They reported appreciating the opportunity to see the master planning process evolve, and one noted, "It was beneficial that the County set up the [stakeholder] group at such an early point in the process to get feedback so early on." Many of the stakeholders agreed that the recommended technology includes several potential environmental and social benefits like providing a safe, nutrient positive soil amendment product to the community, minimizing truck traffic into and out of the plant, and generating a sustainable energy source for use by the plant, County and/or the community.

ES.8 Implementation of Master Plan Recommendations

Figure ES-4 presents a simplified process flow for THP with anaerobic digestion. The two sources of solids (primary sludge and secondary sludge) are blended, screened, and pre-dewatered ahead of the THP reactors. Hydrolyzed solids from the THP reactors are digested and dewatered. The dewatered solids can be land applied in bulk as a Class A biosolid or distributed to other markets such as soil blenders.

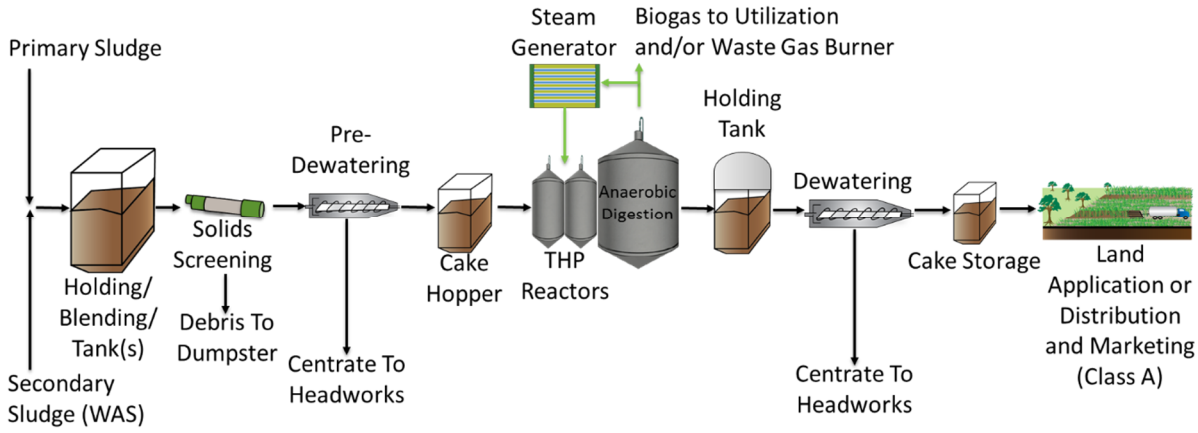


Figure ES-4. THP with Mesophilic Anaerobic Digestion Process Flow

Table ES-2 provides a summary of the capital cost associated with the implementation of THP with anaerobic digestion at the WPCP. The costs presented are planning level estimates which reflect the engineer's opinion of full implementation costs including project management, design, construction, and construction management. The FY17-26 Capital Improvement Program also included a sufficient contingency to account for changes in these costs over time.

Table ES-2. Capital Costs for THP with Anaerobic Digestion

Process	Capital Cost
Primary Solids Holding	$ 700,000
WAS Holding	$ 700,000
Blended Solids Holding	$ 700,000
Screening	$ 1,800,000
Pre-Dewatering	$ 10,100,000
THP	$ 17,900,000
Mesophilic Digesters and Building	$25,600,000
Digested Solids Holding	$ 3,400,000
Post-Dewatering	$ 25,600,000
Biological Solids Processing Building Demolition	$ 3,500,000
Allowance for Odor Control System Improvements	$ 5,000,000
Alternative Capital Cost	**$ 95,000,000**
Biogas Utilization	$ 10,200,000

Planning level costs representing an accuracy of -30%/+50% Costs are presented in 2017 dollars

Implementation of the recommendations from the Solids Master Plan is anticipated to occur over the next several years with completion targeted for 2027. The next phase in the process is engaging a Program Manager to serve as the owner's representative through the process. Section 13 presents a proposed implementation schedule that begins with Arlington County procuring a program manager in FY 2019. The program manager will prepare a Facility Plan that advances the project to a 15-20% design level. The Facility Plan should confirm assumptions used in the development of the Master Plan and determine whether a regional solution has become available and is worth considering. A more detailed biogas utilization study and a nutrient sidestream treatment analysis, including phosphorus recovery opportunities, are recommended components of the Facility Plan. Arlington should revisit the assumptions of the Solids Master Plan in the economic evaluation of biogas utilization as more information becomes available. Additionally, the Facility Plan should develop preliminary process flow schematics and identify pipe routing and other design details. Finally, the opinion of probable construction cost should be updated with the Facility Plan.

Implementation of thermal hydrolysis pretreatment with anaerobic digestion, as recommended in this Solids Master Plan, meets the goals and objectives established by Arlington County. The recommendations provide a roadmap for the County to implement a long-term solids management strategy that aligns with County energy goals, reduces greenhouse gas emissions, and reduces the County's risk associated with the continued land application of Class B lime stabilized biosolids.