Starting with a Product in Mind – Biosolids Design Based on Beneficial Use Goals

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ABSTRACT

Biosolids generators across the United States are beginning to reevaluate their biosolids processing and management programs to consider new technologies and products. As part of this process, generators are considering new regulatory requirements, more flexible outlets, and the concept of biosolids as a product. The focus of these evaluations is no longer technology centered, but rather focused on the quality of the product and the best use for the biosolids product. As part of their Long-Term Biosolids Master Planning effort, Howard County Department of Public Works (DPW) fulfilled their goal to select a solids processing technology that reduces volume and generates a Class A Exceptional Quality biosolids product that could be use locally in both agricultural and non-agricultural markets. In this case, product quality characteristics were important in entering local markets. Key aspects of the processing technology selection process will be discussed, including establishing County goals, identifying and surveying local beneficial use markets, selecting a solids management alternative, and ultimately selecting the dryer technology which fulfills the County’s established objective.

KEYWORDS: Changing regulatory environment, biosolids product quality, market preferences, management alternatives

INTRODUCTION

Howard County DPW owns and operates the Little Patuxent Water Reclamation Plant (LPWRP), an enhanced biological nutrient removal wastewater treatment facility located in Savage, Maryland in a highly developed area, landlocked by the Little Patuxent River, two major highways, and an industrial park. The LPWRP has an average daily flow of 20 mgd with an ultimate build-out design capacity of 28.5 mgd. The LPWRP wastewater treatment processes include raw wastewater influent screening and pumping, grit removal, primary clarification, three-stage activated sludge biological nutrient removal, secondary clarification, denitrification filters, ultra-violet (UV) disinfection, and post-aeration. Solids handling processes include gravity thickening for primary solids, dissolved air floatation thickening for waste activated solids, centrifuge dewatering, and Class A pathogen and vector attraction reduction using an advanced lime stabilization process (the RDP process).

The RDP EnVessel Pasteurization process uses supplemental heat and lime to generate a product that meets Class A exceptional quality (EQ) standards. The LPWRP installation currently uses lime at the rate of 40% on a dry weight basis to process biosolids. Approximately 880 wet metric tons (~50 truckloads) of stabilized EQ biosolids are land-applied as fertilizer to agricultural fields in Maryland, Virginia, and occasionally in Pennsylvania each week.
Maryland’s phosphorus site index regulations are pushing a growing number of farmers to reduce or eliminate land application of biosolids (and all fertilizers containing P) due to elevated soil P levels. Typically biosolids (and other organic forms of fertilizer) are applied to meet the crop’s nitrogen needs, but when applied at this rate, these fertilizers provide crops with substantially more P than needed if applied at the nitrogen-application rate. Moreover, as Maryland’s P-index is expected to become more restrictive, it is anticipated that many farms currently land applying biosolids in Maryland will be prohibited from any additional application of biosolids, which would at minimum increase costs for the program by forcing the LPWRP to transport a larger portion of their biosolids into other states, or it would completely eliminate land application as a viable outlet if neighboring states adopt similar restrictions.

When the RDP process was first installed, the plant’s minimal on-site storage was not a principal consideration because land application of biosolids in Maryland was available year-round. However, as a result of the “winter ban” implemented by Maryland’s Department of Agriculture (MDA) in 2012, the LPWRP is prohibited from sending biosolids to direct land application from November 16 to March 1 (105 days) and must send biosolids to long-term storage in Maryland, or land application in Virginia or Pennsylvania, or to landfill. Meanwhile, Maryland’s’ Department of Environment limits on-farm biosolids “staging” to 90 days and longer storage requires permits and public notices associated with a permanent “storage” facility. This set of regulatory requirements results in a period of time each year when beneficial use options are not available, and the LPWRP must pay a large tipping fee for landfill disposal. For the LPWRP, the seasonal biosolids application restrictions are compounded by loss of land area due to high soil pH and P content. For the farms involved with the program for many years, the repeated application of lime-amended biosolids has increased soil pH and/or P above the crops’ optimal range, which has reduced the frequency of biosolids application or, in some cases, has terminated biosolids application at these locations.

Until recently, Class A/EQ agricultural land application has provided Howard County with a cost effective and environmentally responsible alternative for the beneficial use of the produced biosolids. However, based on the current regulatory environment in Maryland, Howard County decided to engage HDR Engineering, Inc. and Material Matters, Inc. (the Team) and proceed with development of a biosolids Master Plan to provide a framework for a reliable, cost-effective treatment and use of their biosolids. At the outset of the project, the Team clearly identified the need to replace their current treatment process with a carefully selected alternative that would withstand the evolving regulatory environment. The alternative must be selected based on its long-term viability, and must align with the County’s social and environmental objectives for biosolids management.

**MASTER PLAN**

Biosolids management alternatives were evaluated for a 20-year planning period from 2015 to 2035. At the outset of the Master Planning process, it was important to establish goals and objectives, decision criteria, and constraints through a collaborative approach with Howard County personnel. The goals and objectives, in turn, would be the foundation for all decisions made throughout the project. During the initial planning workshop, the County developed a concise goal which summarized the overall approach to the Master Planning Project:
“Develop a Biosolids Master Plan that provides a framework for reliable, cost-effective treatment and beneficial use of LPWRP biosolids in a changing and uncertain future regulatory environment”

Based on the stated project goal, it was also necessary to develop specific, concrete objectives and decision criteria to guide the decisions made during the planning process. The six (6) objectives developed during the initial workshop include:

- Social and environmental responsibility – reduced truck traffic, preference for local/in-state beneficial uses, energy optimization, and greenhouse gas footprint.
- Biosolids end use – biosolids must be beneficially used, rather than disposed.
- Biosolids product – produce a versatile, high-quality, Class A/EQ product suitable for multiple uses.
- Volume reduction – reduce the volume of biosolids generated at the LPWRP, to reduce truck hauling and other operational costs associated with the beneficial use program.
- Optimize plant processes and facilities – biosolids processing must be compatible with other plant treatment processes, and maximizing use of existing facilities is a high priority.
- Reliability – proven processing technologies and end use markets are essential.

Screening of Management Alternatives

The evaluation of management alternatives started with the evaluation and screening of solids stabilization and processing technologies, biosolids products and associated markets, and product specifications.

In evaluating biosolids processing and stabilization technologies, it was decided at the initial project scoping workshop to consider only proven technologies with full-scale operating histories. Unproven technologies that have limited operating history beyond the pilot or demonstration scale would not be considered. The following technologies were evaluated during the initial screening step.

- Advanced alkaline stabilization (existing process, evaluation baseline)
- Mesophilic anaerobic digestion, with added processing for Class A stabilization
- Temperature-phased thermophilic anaerobic digestion
- Thermal hydrolysis (THP) plus mesophilic anaerobic digestion
- Thermal drying, including indirect dryers, direct drum dryers, direct belt dryers
- Composting (off-site only)

The six (6) processing technologies were combined with expected products, and target beneficial use markets to develop nineteen (19) management alternatives. Each alternative included unique combination of solids processing, product characteristics, and anticipated beneficial use market. The management alternatives were discussed in depth, and narrowed to a short list of management alternatives, summarized in Table 1, that would be considered for detailed evaluation. Note that the management alternatives selected for further evaluation included beneficial use options for bulk agricultural and specialty fertilizer, turf, and soil blending.
Table 1. Summary of biosolids management alternatives.

<table>
<thead>
<tr>
<th>No.</th>
<th>Anaerobic Digestion</th>
<th>Dewatering</th>
<th>Added Stabilization</th>
<th>Product</th>
<th>Energy Recovery</th>
<th>Beneficial Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None</td>
<td>Centrifuge</td>
<td>RDP</td>
<td>EQ cake</td>
<td>NA</td>
<td>Bulk agricultural</td>
</tr>
<tr>
<td>2</td>
<td>None</td>
<td>Centrifuge</td>
<td>Drying</td>
<td>EQ granule</td>
<td>NA</td>
<td>Bulk agricultural</td>
</tr>
<tr>
<td>5</td>
<td>Mesophilic</td>
<td>Centrifuge</td>
<td>RDP</td>
<td>EQ cake</td>
<td>CHP</td>
<td>Bulk agricultural</td>
</tr>
<tr>
<td>7</td>
<td>Mesophilic</td>
<td>Centrifuge</td>
<td>Drying</td>
<td>EQ granule</td>
<td>Dryer fuel</td>
<td>Specialty fertilizer, turf, soil blending</td>
</tr>
<tr>
<td>10</td>
<td>THP/Mesophilic</td>
<td>Centrifuge</td>
<td>None</td>
<td>EQ cake</td>
<td>THP, CHP</td>
<td>Bulk agricultural</td>
</tr>
<tr>
<td>13</td>
<td>THP/Mesophilic</td>
<td>Centrifuge</td>
<td>Drying/Screening</td>
<td>EQ granule</td>
<td>THP, Dryer</td>
<td>Specialty fertilizer, turf, soil blending</td>
</tr>
</tbody>
</table>

Beneficial Use Market Assessment

As a part of the detailed evaluation of each management alternative, it was important to conduct a market evaluation to understand the locally available markets, the product characteristics preferred/required by each market, and the available capacity to accept the LPWRP’s production volume.

Descriptive definitions for bulk agriculture and specialty fertilizer were established to clearly identify the target market for the surveys. The “bulk agricultural market” was defined as options where biosolids are marketed in bulk (large volume, truckloads only) to agricultural markets, including feed/fiber/food crops and where biosolids may be distributed to bulk agriculture customers via fertilizer brokers/dealers, contractors, or a self-managed program. The specialty fertilizer market was defined as options where biosolids are marketed to non-bulk agricultural use, soil blenders, turf farms, and wholesale/retail fertilizer distributors. In the specialty fertilizer market, biosolids may be distributed in bulk (small volume, truckload) or bagged (1 ton super sacks, 50 lb. bag, etc.) to specialty fertilizer customers via fertilizer brokers/dealers, contractors, or a self-managed program.

A detailed assessment of the product generated by each management alternative was necessary, as each product would have its own set of unique characteristics that would influence the viability within a given market. For example, while alternatives 2 (undigested dried granules) and 7 (digested dried granules) each generate a dried granular product, the product characteristics associated with alternative 2 (no anaerobic digestion) have been demonstrated to have a higher potential to generate nuisance odors. Therefore, alternative 7 is much more likely to be suitable for beneficial use markets with close public interaction (i.e. golf courses) than option 2. To accurately conduct the market assessment, therefore, each product’s anticipated nutrient content, percent total solids, production volumes, potential to generate nuisance odors, and dustiness were
established. The characteristics were summarized into User Information Sheets that were presented to potential customers during market interviews (Figure 1, below).

Figure 1. Example User Information Sheet developed for use in market survey.
Once the target markets and preferred product characteristics were established, local customers in each market were identified. Phone surveys were conducted to identify the customer’s current raw materials and feedstocks, products sold, on-site storage capacity, and typical transportation methods (i.e. are materials delivered to their site or do they pick them up?) to understand if any of the biosolids products could fit into their operation. Follow-up onsite interviews were pursued with the customers who showed interest in the product. During the onsite interviews, the customers were provided with samples of biosolids products representing selected processing technologies, and asked to evaluate the suitability to replace a raw material or feedstock currently being incorporated into the customer’s product. When possible, the biosolids samples provided to the customer were processed using the same digestion, dewatering technology, and/or drying technology being considered for LPWRP, as each step in biosolids processing can result in different product characteristics. An example of biosolids samples provided to customers is shown in Figure 2. Note the difference in grain size and consistency of the Exeter and OceanGro granules.

![Figure 2. Biosolids product samples provided to potential customers during interviews.](image)

**Bulk Agriculture** - The survey results concluded that the agricultural market, which is the appropriate beneficial use for management alternatives1, 2, 5, and 10, was an “established” market in Maryland; meaning biosolids are commonly used as an agricultural fertilizer and minimal marketing efforts are necessary. Additionally, agriculture will accept the widest range of products, and has capacity to accept the entire volume of product generated at the LPWRP. The agriculture market preferred products with low dust potential that would spread evenly on their fields with typical fertilizer or manure spreading equipment. However, due to Maryland’s evolving land application regulations, it is expected that most future agricultural application sites will not be local, but would be located in Virginia and Pennsylvania. It was also confirmed that distribution to the agriculture market is limited for portions of the year due to cropping and weather limitations, which means off-site storage must be considered for this market. In general,
the agriculture market is a lower-value option, meaning this option has low potential to generate revenue, and will likely require management fees for farming services.

**Specialty Market** - The surveys conducted within the specialty market concluded that the high-quality biosolids associated with management alternatives 7 and 13 provides flexibility to enter multiple markets, including soil blenders, fertilizer blenders, and turf producers. All three specialty markets are “novel” markets in Maryland, meaning that biosolids use within these markets is not commonly practiced in the region, and a greater level of marketing and pilot testing is necessary to demonstrate biosolids will benefit these markets. Each customer in the specialty market indicated that only the granular product would be suitable for their operation, and the product must meet strict specifications, unlike those required by the agricultural market: low nuisance odor, consistent, uniform in size, contain no inorganics, and produce little dust. Specialty markets indicated that they do not have storage capacity or structures available, and therefore storage at the LPWRP would be needed. Overall, the specialty markets are higher value, and distribution to these markets will likely generate revenue. Survey findings show that the fertilizer blending market would generate the most revenue per unit sold; however, because biosolids contain phosphorus, use in the fertilizer market is expected to be limited, as Maryland regulations limit fertilizers containing P. In contrast, the soil blending market is not subject to P regulations if biosolids are incorporated to a soil blend as a soil amendment (for micro nutrients, organic matter, etc.). Therefore, soil blending was found to be the most promising market, even though it would generate less revenue per ton.

**Selecting a Management Alternative**

The regulatory evaluation and market surveys completed during the Master Planning provided support for Howard County personnel to select management Alternative 7—Anaerobic Digestion and Heat Drying for long-term biosolids management for the LPWRP. Several alternatives met some of the County’s objectives and/or had a lower estimated cost than Alternative 7, but did not adequately fulfill the objective for a versatile, high quality product with local beneficial use options. For example, Alternatives 1, 2, and 5 with bulk agriculture as the only outlet had lower estimated cost, but they would expose the County to the risk of the increasing and uncertain regulatory restrictions on bulk land application in Maryland. The regulatory review and market survey results demonstrated the probability to meet the objectives for local use and reduced truck traffic would not be realized with this alternative. Similarly, Alternative 10—Thermal Hydrolysis and Anaerobic Digestion was a slightly lower estimated cost alternative for producing a Class A/EQ dewatered cake, but it Howard County felt this option provided too much risk to be pursued since thermal hydrolysis is new to the United States and feedback from the market surveys indicated little demand for the cake product.

Alternative 7 was selected because it met each of County’s six (6) objectives. This option significantly reduces the production volumes and truck traffic, and eliminates the lime system (social and environmental responsibility and volume reduction). Additionally, the technology is well-established in meeting the goal for reliability, and produces a high-quality, Class A/EQ biosolids. Alternative 7 also maximizes the use of existing infrastructure at the LPWRP including existing anaerobic pretreatment tanks, pumps, piping, etc. with manageable added process complexity and impacts to other plant processes. Ultimately, however, the decision to select this alternative was most influenced by the results of the market survey which proved local demand for the product. Potential customers in multiple local and regional markets supported a
low-dust, low-odor, dried granule product; confirming the product created by Alternative 7 has potential to be utilized locally and in high volume.

The results of the biosolids master planning effort set the stage for the Preliminary Engineering Report (PER), which refined the technology and process decisions made during the Biosolids Master Planning Efforts to a specific dryer type and manufacturer.

**PRELIMINARY ENGINEERING REPORT**

The selected management alternative includes mesophilic anaerobic digestion, centrifuge dewatering, and thermal drying to produce a granule for use in specialty markets. As the specialty markets are being developed, granules are planned to be beneficially used in bulk agriculture with the advantage of significant volume reduction from the existing process.

Howard County authorized the Team to proceed with a Preliminary Engineering Report (PER) to expand upon the Biosolids Master Plan and further refine the process and equipment concept plan.

As part of the PER, an evaluation of three (3) dryer technologies was conducted; one (1) rotary drum dryer and two (2) types of belt dryers: “Belt A” utilizing screening and product recirculation; and “Belt B” without product screening or recirculation. Of interest were the characteristics of the products that would be produced for each dryer type and manufacturer, and the suitability for the local beneficial use market.

![Drum dryer and typical product.](image)

**Figure 3.** Drum dryer and typical product.

Drum dryers (Figure 3) are a well-established technology which produces a hard, circular, relatively uniform product, and often have post processing oil sprays to reduce dust, making this a product preferred by fertilizer distributors and fertilizer blenders. Drum dryers utilize a product recirculation and screening process to achieve a highly uniform product. Drum dryers also have a high evaporation potential and, therefore, are the most common drying technology for large wastewater treatment plants (>15 mgd). Belt dryers (Figure 4, below), while widely used in Europe, are a relatively new technology in the United States. In general, belt dryers have a lower evaporation capacity than drum dryers, and therefore, are typically used for smaller wastewater treatment plants (<15 mgd). In the belt dryer system, biosolids are applied on a slow moving belt...
in a low-temperature vessel, resulting in a granular, friable, less uniform product than the product generated by the drum dryer. Recirculation and screening equipment can be added to belt dryers to improve uniformity.

Figure 4. Belt dryer with single-pass (no recirculation) and typical product.

Numerous samples of dried products from the three (3) types of dryers being considered were obtained from wastewater treatment plants across the United States. Additionally, samples of “Belt B” with post processing options “crushed” and “crushed/pelletized” were obtained from the belt dryer representative (Figure 5). The samples were provided to the same potential customers who were surveyed during the Biosolids Master Planning Phase to detail and confirm the product characteristics preferred by each industry. Potential customers were also asked to rank by preference the products from each dryer / post processing technology.

Figure 5. The Belt B dryer products from left to right are: dried/non-pelletized, dried/pelletized /not cut, dried/pelletized/cut, and dried/non-pelletized/crushed.
The results of the final market study revealed that although the drum dryer produces a product that has proven successful in the high value, bagged fertilizer market in other regions of the country, local P-fertilizer regulations limited interest in local markets to Howard County, Maryland. The local soil blending market, which has the ability to beneficially use a large volume of product and is not impacted by the P-fertilizer regulations, preferred the granular / irregular qualities of the product generated by the belt dryer over the spherical pellets generated by the drum dryer. It was also determined that the product generated by the belt dryer was suitable for the bulk agriculture market, which will likely continue to be available during some portions of the year.

A summary of the market preferences and market availability is summarized in Table 2. Potential customers were provided with samples from each dryer / post processing combination and asked to (1) identify what product(s) could be used in their business and (2) rank the products in preference order. It should be noted that no Belt B product with digestion was available for the analysis but it is expect that digestion would only improve the product and thus increase market acceptance.

Table 2. Product and market preferences.

<table>
<thead>
<tr>
<th>Product</th>
<th>Market</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soil Blender</td>
</tr>
<tr>
<td>Drum</td>
<td>Anaerobic</td>
</tr>
<tr>
<td>Belt A</td>
<td>Aerobic</td>
</tr>
<tr>
<td>Belt B</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Ranking of Maryland Market Availability</td>
<td>1</td>
</tr>
<tr>
<td>Key: ++ = preferred; += usable, but not preferred; - = not usable</td>
<td></td>
</tr>
</tbody>
</table>

Selecting a Dryer

The results of the PER final market survey resulted in Howard County selecting the belt dryer technology. During the PER evaluation, Howard County continued to focus on accomplishing the objectives defined at the start of the Biosolids Master Planning process. Once again, Howard County personnel recognized the local market demands when deciding which dryer technology was most suitable for the LPWRP. The PER market survey showed the Maryland soil blending market to have significant interest in and capacity for dried biosolids, and therefore, is the most suitable primary target market for the LPWRP to pursue. The survey also indicated interest for agriculture land application in adjacent states. In contrast, Maryland fertilizer blenders, which indicated a preference for products similar to the spherical pellets produced by the drum dryer, had minimal interest for any biosolids products due to regulations limiting P application. Therefore, Howard County selected a belt dryer to meet their goals to produce a high-quality product that would be demanded locally by multiple markets that will remain viable despite Maryland’s evolving regulatory environment.
DISCUSSION

The methodology used to complete the Howard County project is distinctive due to the strong focus on connecting the technology decisions with the long-term viability of the biosolids product in the local marketplace. Throughout the project, regional regulations and local market demands were demonstrated to be critical when considering solids processing technology. For example, Howard County determined that, due to Maryland regulations, the management alternatives associated with bulk land application of cake to be cost prohibitive or unavailable in the long term. However, a regulatory review and market survey conducted in a different state may find bulk land application to be cost-effective, locally available, and highly demanded by the local farming community.

Additionally, this project highlights the significance of establishing concrete objectives, and focusing on product quality, which sets the foundation for decisions made throughout the process. Every decision made during the project considered the goal established at the outset of the project to: “Develop a Biosolids Master Plan that provides a framework for reliable, cost-effective treatment and beneficial use of LPWRP biosolids in a changing and uncertain future regulatory environment”. Whereas solids processing technology has historically not considered the product or beneficial use outlet, Howard County consistently focused on an entire management alternative, from the start of the solids processing step to the beneficial use outlet. By identifying the final product generated by each management alternative and presenting the product to the potential customers in the area, the County reduced the risk associated with poor product quality and identified a likely demand for the product. This project serves as an excellent example to demonstrate that evaluating regulatory pressures and market availability is critical to identifying reliable and sustainable biosolids management solutions.