






Organic Waste Conversion Facility
Feasibility Study

Prepared for the City of Fort Bragg

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On behalf of The Noyo Food Forest

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Growing Power, Inc.
Sonoma Valley Worm Farm
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Cafe 1
Harvest Market
Headlands Coffeehouse
Living Light International
Piaci Pub and Pizzeria
Purity Supermarket
The Restaurant

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1. Executive Summary

The development of an Organic Waste Conversion Facility presents a multi-faceted opportunity for local economic growth and environmental sustainability within the City of Fort Bragg. Currently, significant natural resources, in the form of organic wastes, are literally being "thrown away" at a high cost to local business enterprises, while essentially the very same materials are being purchased from outside the region in the forms of composts and soil amendments.

Due to numerous factors including economic incentives and legislative requirements, private and municipal entities are finding new and innovative ways to divert these materials from the waste-stream to capitalize on their local conversion. In the process, organic wastes are being re-incorporated into the economic value stream, creating jobs, economic value, and other benefits (such as carbon emission reductions).

The primary benefits of capturing and converting locally-generated organic waste within the City of Fort Bragg include:

Local production of high value, marketable, and in-demand soil fertility products and related services.
Creation of meaningful jobs to staff and manage the facility and its associated departments.

Reduced disposal costs for area businesses that produce organic waste can result in increased profit margins.

Catalyzation of downstream enterprises that capitalize on the end and by-products of the conversion process (for example, high value micro-greens (pictured at left) could be produced for local restaurants).

Increased tax revenues as a result of the above.

In addition, the creation of high value, locally-marketable products by a conversion facility will strengthen the broad efforts currently underway to develop a healthy local food system in Mendocino County. Local farmers, gardeners, and food consumers will benefit greatly from having increased access to locally-produced, high quality, living soil amendments at competitive prices that enhance soil fertility and reduce dependence on expensive imported nutrients.

This project will also reduce carbon emissions and pollution due to the decreased export of organic waste from Fort Bragg as well as decreased imports of soil amendments and food. While outside the scope of this study, the carbon emissions savings is potentially significant, and worth investigation in an ancillary study.

From an economic development perspective, an Organic Waste Conversion Facility should be considered in context of the greater economy that can grow around it. While the total jobs created by the facility may seem small relative to the investment (fewer than ten jobs at full scale), the potential downstream products and services that could be catalyzed by this facility could be significant. The project will result in "Import Substitution"-- replacing sources of local consumption with local production-- in areas such as food, soil fertility, and waste management.

One excellent case study of converting organic waste to Vermicompost is Growing Power, Inc. in Milwaukee, Wisconsin. This "urban farm" accepts 70,000 pounds of food waste per week and utilizes vermicomposting to convert it into worm castings. This "Black Gold" is then sold through retail and wholesale channels; used to establish community and school gardens, and--perhaps most importantly for the farm as a business and supporter of its community--feeds the farm with available nutrients in order to produce micro-greens ("sprouts"), salad greens, and supplemental feed for aquaponics and poultry operations. From this perspective, the worms are the most important "workers" at Growing Power and the castings are its most important product.

The contributors to this study agree that the development of an Organic Waste Conversion Facility is a worthwhile endeavor that would benefit the City of Fort Bragg in a dynamic way. This project resonates with the local economic development strategies already in place and would tangibly demonstrate the City's commitment to building a restorative economy and a sustainable community. This study outlines various options and clearly determines that a small-scale vermicomposting operation is the most feasible and promising opportunity for an Organic Waste Conversion Facility in Fort Bragg.

2. Glossary*

* This section is provided in the beginning of this document as a convenience to the reader, and to describe terminology used throughout this report.

"Organic Wastes"

Organic wastes are defined in this document as a broad class of materials that include green, agricultural and putrescible (that is, rapidly decaying) "wastes." These materials range from landscape debris and wood chips to animal manures and food scraps from commercial enterprises. Additionally, paper products such as office paper and cardboard (including waxed) are included in this classification. Collectively, these materials are known as **feedstocks** for the conversion process.

“Conversion”

The process of diverting an organic waste stream and reincorporating it into the economic value stream is generally referred to as "conversion."

“Vermicompost”

The process of feeding organic waste to a population of worms to convert such feedstocks into worm castings and biomass. While commonly referred to as "vermicompost," **the by-product of the worms is actually a type of manure, not a compost,** and as such, "vermicompost" is in some ways a misnomer. This is an important distinction for regulatory and marketing purposes.

“Worm Castings”

The high value product of the conversion of organic waste via vermicomposting. High in available nutrients for plants, worm castings are also known as vermicast, worm humus, or worm manure.

“Active Compost”

Organic waste feedstock that is in the process of being rapidly decomposed and is considered unstable. Active compost, also known as thermophilic compost due to the type of bacteria involved in the process, generates temperatures of at least 50 degrees Celsius (122 degrees Fahrenheit) during decomposition and releases carbon dioxide at a rate of at least 15 milligrams per gram of compost per day, or the equivalent of oxygen uptake.[2]

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[2] Title 14, Chapter 3.1, Section 17852. http://www.calrecycle.ca.gov/Laws/regulations/title14/ch31.htm

“Point of Resource”

The producer of organic waste feedstock. For purposes of this study, Points of Resource are commercial enterprises that produce organic waste that is currently not utilized for any type of conversion.

“Downstream Endeavor”

A businesses that uses the product of a conversion facility as the feedstock for its operations. For example, worm castings may be used to grow micro greens with high nutrient value.

3. Key Findings

This feasibility study considers economic development in Fort Bragg through conversion of organic wastes into reclaimed resources for soil fertility, animal feed, and other downstream activities. Based on analysis of available regional organic waste feedstocks, regulatory considerations, and market opportunities, the key findings of this study include:

- **Vermicompost is the most viable and feasible option for Fort Bragg** and offers the best opportunity for economic development upon analysis of scale, regulations, access to organic waste feedstocks, and return on investment.

- **Collection of commercial food waste and agricultural wastes as a result of brewing and juicing operations are the most economic means of procurement of organic waste feedstocks.** With the North Coast Brewing Company located within Fort Bragg, a significant additional feedstock is available in the form of spent grains from the brewing process. Spent grains are considered an agricultural product and are not subject to the same regulatory limitations as food waste. Therefore, a mixture of food waste supplied by the Brewery's restaurant and other local food service providers, in combination with by-products of the brewery, could supply a small scale facility with sufficient organic waste for conversion.

- **Green waste (i.e. landscaping and tree trimmings) and residential waste are not recommended as potential feedstocks in Fort Bragg** due to regulatory constraints and the presence of existing disposal contracts.

- **Worm castings are the primary and most immediate product of the vermicompost process.** Many opportunities for downstream products and services exist to be developed as future phases of this endeavor.

- **Collection costs of food scraps, agricultural discards (e.g. brewery spent grains) and some types of manure are expected to be offset by contributions**

from the food service establishments. These collection fees are a potential secondary revenue stream for the enterprise.

- **An Organic Waste Conversion Facility in Fort Bragg should be designed to encourage and support the associated downstream businesses** that could produce goods such as fresh food, animal feed and soil amendments that are already being purchased from outside sources, thereby lowering costs for area businesses, creating jobs, and building local self-reliance and resiliency.

- **The Pilot Project should focus on developing a small scale facility** capable of converting the North Coast Brewing Company's (NCBC) organic waste from its restaurant and brewery operations. NCBC currently generates all of the organic waste feedstocks needed for a scalable project and has disposal systems and equipment in place that could feasibly shift towards conversion. See the *Organic Waste Conversion Facility Pilot Project* document for full discussion of the Pilot Project.

4. Methodology

4.1 Feasibility Study Framework

"Composting" versus "Conversion"

The City of Fort Bragg Request for Proposals (RFP) that framed this study[3] called for "a comprehensive compost feasibility analysis "focused on a vermicomposting model." However, vermicompost is not a composting process. The product of vermicompost is actually manure, not compost, and this technical distinction is significant for both regulatory compliance and marketing purposes. See Feasibility Analysis, Section 5 for more discussion. While vermicompost is closely related to compost, it is not a sub-type of composting, but a class of conversion unto itself.

This study considers the viability of the use of organic wastes as feedstocks to two conversion types: "***Active Compost*** " and "***Vermicompost.***" Each of these represents opportunities to divert materials from the organic waste stream into a value-added product that can be sold for other use. This study uses the term "Organic Waste Conversion Facility" to capture the variety of opportunities for conversion in the city of Fort Bragg.

Other conversion methods, such as co-generation (gasification and combustion) facilities, and other species of livestock (e.g. black soldier fly), were not evaluated by this report due to their relative capital costs and immature techniques.

4.2 Feasibility Study Steering Committee

A steering committee was established to advise and inform the various study tasks in order to encourage community participation and benefit from the business perspectives that would ideally participate in the Conversion Facility. The City Staff and Noyo Food Forest personnel agreed that a small and responsive team of community members from the business and non-profit sectors, representing the following stakeholders would best serve this function:

- Restaurants, groceries, and other commercial producers of food waste.
- Agricultural by-product producers (such as brewery and juicing companies).
- Nursery and garden supply stores.
- Other interested representatives of the public, including artists, gardeners, etc.
- City Staff.

[3] City of Fort Bragg Request for Proposals for Consultant Services for Preparation of Compost Facility Feasibility Study; released September 14, 2010.

In addition, the Noyo Food Forest was represented in dual roles, with Board Member George Reinhardt offering the public-advocacy perspective of the organization while consultant and project lead Chris Byrne facilitated the meetings on behalf of the project.

The committee met twice during the course of the study and has corresponded in one-to-one inquiries throughout the project. The Steering Committee has offered valuable input that has influenced the perspectives and findings of this report. A list of the committee members is on the Acknowledgements page of this report.

4.3 The Fort Bragg Organic Waste Database and Blog

An open-source database and collaborative website or "wiki" known as WAGN (www.wagn.org) was selected in order to collect and share information about the Organic Waste Conversion Facility Feasibility Study. This platform has facilitated many community collaboration projects[4]. WAGN represents a deliberate decision to leverage community knowledge and interest while minimizing staffing oversight and process bottlenecks, because it allows for direct community input into an online database and therefore facilitates the collection of survey data by multiple participants. Editing can be done by anyone with an account, which can be requested by interested parties and confirmed at the discretion of the site administrator. The current site administrator for the Fort Bragg Organic Waste Database is the Noyo Food Forest.

Early in the study, the Noyo Food Forest team determined that measuring available organic wastes in the region would not be possible on a broad scale. It would also be difficult for businesses to measure their organic waste streams, as they typically are not currently segregated from all trash. Consequently, the team conducted interviews to understand common practices, challenges, and when available, estimates of an establishment's organic wastes. Presently there is little data on the website. Once the Pilot Project is launched, more individuals and businesses will become interested and involved in the project and populate the database. See Appendix B for a sample database template.

[4] see: http://researchplanning.arb.wagn.org

4.4 Conversion Facility Site Visits

To include best practices from existing operations in the study, Chris Byrne visited a number of sites that are currently processing organic wastes, as described below:

Growing Power, Inc., Milwaukee WI

Chris Byrne visited Growing Power, Inc. in Milwaukee, Wisconsin in February, 2010, and participated in their "Urban Farming: From the Ground Up" workshop and conference series where he focused on Vermiculture, Aquaponics, and Micro-Greens production. At this event, he made the observation that the conversion of organic waste streams from breweries and various food waste sources (such as groceries and cafeterias) into high-value Vermicompost is the keystone in the accomplishments of Growing Power. The worm castings in turn become the feedstock for other "downstream" value creation, as the castings become the fertility and growing medium for plants (micro, salad and other greens) and animals (fish and chickens). Much of what Chief Executive Officer Will Allen and his team at Growing Power achieve would not be possible without the employment of the worms on what was once treated as "waste" and sent to landfills.

Sonoma Valley Worm Farm

Chris Byrne and Technical Assistance Consultant Ellen Hopkins made multiple visits to the Sonoma Valley Worm Farm to interview owner Jack Chambers and marketing director Amy Grimes. With over forty years of experience producing worms and worm castings for compost and feed, Sonoma Valley Worms (SVW) is an excellent example of a production operation. SVW purchases organic cow manure for conversion into high value castings for clients ranging from large scale, well-known wineries (where trials have been overwhelmingly positive for establishing new plantings), to retail internet customers. In addition, SVW manufactures Continuous Flow Vermicomposting "reactors" and Aerated Composters (for pre-processing materials) that are being evaluated for the Fort Bragg Pilot Project.

Cold Creek Compost, Potter Valley, CA

Located outside of Ukiah, California, Cold Creek Compost is a regional example of a scaled compost facility. Owner Martin Mileck was interviewed by Chris Byrne and Ellen Hopkins in order to gain a better understanding of the legal and logistical challenges of operating an Active Compost facility in Mendocino County. This visit confirmed that the active compost industry works within a complicated regulatory environment, and that these large scale business must produce high-volumes of compost due to the low relative value of the finished product in an already competitive market.

Sierra Nevada Brewing, Chico, CA

A well-known pioneer of craft beer brewing in the United States, Sierra Nevada has a long-standing commitment to environmental stewardship. It was the recipient of the 2010 CalRecycle Waste Reduction Awards Program[5]. One of the most recent additions to the facility is the "HotRot," an industrial scale, within-vessel composting system for brewery by-products and food discards from the restaurant. The unit was purchased at considerable cost (approximately $500,000) due to a lack of composting options in the region. Chris Byrne and Ellen Hopkins interviewed Sustainability Director Cherie Chastain. The takeaway from this interview was that while considerable intangible and indirect financial benefits would be realized from such an investment, the payback period and return on investment from the system may be long.

4.5 Interviews

4.5.1 State Regulatory Agencies

Chris Byrne conducted interviews with representatives from various California State agencies to determine the requirements for establishing a conversion facility in the Fort Bragg area. These agencies included:

- California Department of Resources Recycling and Recovery, including the Mendocino County Local Enforcement Agency (LEA) responsible for enforcement of California Code of Regulations Title 14 (CCR Title 14) concerning composting activities.
- The North Coast Regional Water Quality Control Board
- The California Department of Food and Agriculture

[5] see: http://www.ciwmb.ca.gov/wrap

4.5.2 Local Businesses

Carrie Gerard and George Reinhardt of the Noyo Food Forest conducted interviews with food service establishments within the Fort Bragg area. The purpose of these interviews was twofold:

i. To better understand the way food discards are handled by various local establishments; and

ii. To get a sense of the interest these establishments may have to participate in a food-waste-to-vermicompost project.

Fort Bragg businesses interviewed for this report include Cafe 1, Harvest Market, Headlands Coffeehouse, the North Coast Brewing Company, Piaci Pub and Pizzeria, Purity Supermarket, and The Restaurant.

In addition to the potential Points of Resources listed above, Scott Zeramby, owner of Dirt Cheap Garden Supply provided valuable information regarding potential product demand and end-user profiles.

5. Feasibility Analysis

The viability of any conversion endeavor depends on the availability and volume of the organic waste feedstock materials, the scale of the project, access to funding, federal, state and local regulations, and--perhaps most importantly--market demand and potential, among other factors. In the analysis below, these variables are described in depth.

5.1 Comparison of commercially viable organic waste conversion techniques and recommendations

A survey of commercially viable operations must consider technological, economic, and regulatory issues. For the purposes of this study, the two potentially feasible conversion operations identified for Fort Bragg include Vermicomposting and Active Composting.

Vermicompost versus Active Compost considerations

> **Regulatory:** Establishing a new, full scale Active Compost operation is a significant endeavor requiring tens of thousands of dollars for licenses and facility design costs to insure compliance with CCR Title 14 regulations[6].
>
> Establishing a new Vermicompost facility is significantly easier in terms of regulatory requirements and less expensive than an Active Compost facility. Vermicompost facilities are exempt from CCR Title 14 requirements.[7] While it is not explicitly stated in the regulations this may be because Vermicompost is not a composting process, but actually one whereby a livestock is fed organic material that is consumed and converted into manure. The manure can then be sold as a soil fertility amendment, and the worms can be sold as livestock feed or bait for recreational fishing.
>
> Thus, Vermicompost operations are subject to the same regulations that apply for livestock operations, rather than regulations applicable for an Active Compost facility, making for a more favorable regulatory environment. There are some considerations for the various types of feedstocks and the pre-processing needed before feeding to the worms, which are addressed in detail in the regulatory section below.

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[6] http://www.calrecycle.ca.gov/LEA/Regs/Review/FoodWastComp/FoodWastcomp.pdf

[7] See Appendix A: Title 14 Section 17855. Excluded Activities.

Operations: Active Compost operations require heavy machinery (windrow turners, front loaders, industrial chippers, etc.) to produce a product. This is a volume model, so an economy of scale is required to make a profitable endeavor. By contrast, energy and fuel requirements of a Vermicompost facility are low and produce a higher value product.

Land Use: The space requirements of an Active Compost production facility are significant. For example, Cold Creek Compost is a "smaller scale" facility and is almost six acres in size. By contrast, a great deal of value can be produced by a Vermicompost operation in a relatively small amount of space, such as vacant warehouse or semi-covered structure.

Scale: An economically-sustainable Active Compost operation would require a multi-acre facility, extensive permitting and ongoing monitoring for compliance, and would compete with established regional operations for already committed feedstocks and market share. By contrast, a Vermicompost facility produces a higher value product in a smaller area with less expensive equipment, while being designed to grow in a modular fashion to meet demand and investment access. Vermicompost activities also require limited Enforcement Agency Notifications for permitting with minor monitoring requirements.

Access to Feedstock: Most of the materials that could feed an Active Compost facility (e.g. residential yard waste and forestry by-products) are already committed in collection contracts and are provided to existing operations (e.g. residential green waste collection is currently shipped to Cold Creek Compost). The feedstocks that could be the keystone for a Vermicompost operation are diverse, widely available, and still represent a waste stream or low cost material without much competition for their use by existing operations. Examples are commercially produced food scraps, agricultural by-products of the brewing process, and animal manures from various livestock operations. Each of these feedstocks is addressed extensively in Section 5.2 of this document.

Capital Investment: Based on an assumption of limited availability of funding to establish a small scale pilot facility; a requirement of low investment relative to payback; and ease of establishment, a start-up Vermicompost facility facility is more feasible compared to an Active Compost Facility. As Vemicompost systems are modular, a Vermicompost Pilot Project could be scaled up to meet demand as the operation grows in proof of concept, organizational ability, and market demand.

While there are significant upfront costs to establish a continuous flow Vermicompost production facility as recommended by this study, the payback period can be as little as three years, depending on scale of the facility, amount of "tipping fee" (collection costs) revenue , and proper market development for the finished product. In contrast, Active Compost has a lower value per ton and would require a much longer payback period. The Operating Pro-Forma cost scenarios described in section 7.0 and illustrated in Appendix D of this document provide details of revenues and costs asosicated with a small-scale vermicompost facility.

Value of End Product : Worm castings, an end product provided through Vermicomposting, and compost, the end product of Active Compost activities, provide different functions in a garden or farm operation. Worm castings are a nutrient rich material that is easy for plants to assimilate. Furthermore, studies have shown that applications of castings are effective in helping plants withstand pests and disease. Compost provides soil conditioning and nutrients. Worm castings have a higher re-sale value than Compost ($75 to $400 per ton for Vermicompost, versus $12 to $50 per ton for Active Compost)[8].

Based on the above considerations and given the context of focus on economic development, this study has determined that **Vermicompost is the most viable model of organic waste conversion for the Fort Bragg region and is the primary focus of the remainder of this report.**

5.2 Identification and analysis of feedstocks

Of all the potential organic waste feedstocks to fuel a Vermicompost operation in Fort Bragg, some otherwise feasible feedstocs are committed elsewhere under existing contracts. In order to keep input costs to a minimum, this study identifies organic waste materials that are not yet committed to a conversion operation elsewhere.

As Vermicomposting is a mesophilic process, meaning the temperatures involved in the process are stable, a Vermicompost facility is not required to meet the permitting considerations that Active Compost facilities are required to address.[9] However, the organic waste feedstock inputs to *any* facility are required to address Title 14 considerations, and are discussed in the Food Scraps and Agricultural materials sections following.

Types and Viability of Organic Wastes considered for feasibility of Vermicompost in Fort Bragg:

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[8] For extensive discussion of these topics, see "Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management" by Clive A. Edwards, Norman Q. Arancon, Rhonda Sherman; Taylor & Francis US, 2010 ISBN: 1439809879

[9] See Appendix A: Title 14 Section 17855. Excluded Activities.

5.2.1 Organic Waste Type 1: Food Scraps

Points of Resource (suppliers): Commercial food service establishments, including restaurants, cafes, grocery stores, and cafeterias.

According to the California Department of Resources Recycling and Recovery's *Solid Waste Characterization Database*, an estimated 56% of the waste stream from restaurants in Fort Bragg is attributable to food discards[10]. This study assumes the more conservative benchmark of 50% of the restaurant waste stream as food discards. These food scraps are generally co-mingled in the solid waste collection bins and are disposed of at a cost to local business establishments.

Diverting and converting this waste stream provides the following benefits:

- Cost savings for local businesses (in the form of lower disposal/collection fees).
- Added revenue for the conversion facility (in the form of collection fees).
- Potential carbon emissions reductions (e.g. less waste transportation miles).
- Conservation of limited landfill space.

The collection of food scraps from restaurants will be funded through a fee which will support the vermicompost operation, while saving the food service establishment money as the fee will be less than what they presently pay for collection. The study assumes a collection fee of $100 per month for 1.5 yards of waste (picked up one or two times per week); the fee is based on a review of present rates (see table, below) and the estimated cost to provide local food

Calculation of Savings from Reduced Waste Collection Capacity Requirements		
Container Size	**Cost, per Month**	**Monthly Savings**
3 Cubic Yard	349.59	--
1.5 Cubic Yard	230.86	118.73
96 Gal Can	85.77	145.09
source: Fort Bragg Waste Management Price Sheet, 09/29/2011		

discard collection services. The collection fees could also offset the cost of additional feedstock needed for the Vermicompost facility.

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[10] http://www.calrecycle.ca.gov/WasteChar/wcabscrn.asp

Lastly, Points of Resource could participate in profit sharing arrangements. For example profit sharing could be based upon the proportion of volume contributed to final product. If the conversion facility is managed around shared equity, this would give the food service establishments a sense of ownership in the Vermicompost facility and its products, and this sense of joint ownership could also help to encourage quality-control to ensure high-quality feedstocks (see challenges, below).

Challenges:

***Regulatory Challenges*:** *Composting* food waste requires a Compostable Materials Handling Facility Permit. Ideally, a food-waste-to-Vermicompost operation would "pre-digest" (i.e. compost) the materials in order to remove some of the biological decomposition activity that results in heat in excess of ideal temperatures for the worms. The handling of this compostable material prior to and after use as a growth medium for the worms is not an excluded activity under Title 14. **Therefore, pre-treatment of food waste feedstocks is subject to California Code of Regulations Title 14 (CCR Title 14) concerning composting activities[11].**

However, **within-vessel composting process activities** (controlled environments as opposed to windrows or open piles) **with less than 50 cubic yard capacity are also excluded**. This means that a facility that processes food discards is limited to fifty cubic yards in process at any given time. North Coast Brewing Company (NCBC) has reported that its restaurant operations produce approximately 350 gallons, or 1.73 yards per week of food discards. With a two week processing time to stabilize the food scraps into an ideal feedstock for Vermicomposting, a facility would be able to accept 25 yards of food discards per week, or the equivalent of the food waste from approximately 14 similarly sized restaurants.

This 50 yard size would be ideal for a small scale facility. Sonoma Valley Worm Farm, one of the regional Vermicomposting operations visited to inform this study, utilizes a three-bin, forced-air system (shown here) to prepare their feedstock for the worms. This system has a capacity of 0.8 cubic yards per week[12] and could be scaled up to meet the capacity

[11] Title 14, Section 17854. see Apendix A

[12] This system presently processes cow manure and would require field trials with food scraps to determine actual process time.

demand of the pilot project and small scale facility. Furthermore, if local demand for processing capacity for food scraps is greater than the CCR Title 14 limitations, a decentralized approach to feedstock pre-processing could be taken. This design is beyond the scope of this study and is noted here for consideration in future phases.

From a technical perspective, stabilization (that is, composting prior to feeding the worms) may not be necessary according to a survey of other commercial Vermicomposting operations. It is conceivable that the feedstock could be kept below the “active” threshold of 122 degrees as defined by CCR Title 14, while being applied in thin layers to the Vermicompost reactors. However this would require close management of the process, as material that has not been stabilized could potentially become too hot and kill the worms. This could be considered for a future phase of the operation if demand supports expansion.

***Logistical Challenges*:**

***At Points of Resource*:** Food waste collection will require operational changes at individual restaurants. For example, restaurant bussing stations that only have one trash can would need to be re-configured to isolate feedstock from other waste, and staff and customers would require education as to how to use the dual-waste system and why the new system is a benefit. Quality assurance of the waste stream contents (e.g. ensuring that plastics or other non-organic wastes do not find their way into the containers) will also require staff training. However, the cost savings for the restaurant would offset these expenses.

***At a Vermicompost facility*:** The facility design will need to be scalable to accommodate the aggregate demand of all its clients. If businesses expect to dispose of their food wastes, the facility has to be able to meet and anticipate that demand without fail. Additionally, the generation of feed stocks by restaurants in Fort Bragg is highly seasonal, with significantly more food waste generated in the high tourism seasons of summer and fall. Coincidentally, this is the ideal time to scale up a vermicompost facility as the worms are more active during our moderate temperature summer and fall months.   In contrast, a facility solely focused on producing worm castings for market--such as Sonoma Valley Worm Farm--is a client of the feedstock producer (in their case, cow manure) and can simply order more as needed.

5.2.2 Organic Waste Type 2: Agricultural Materials

This study considers the feasibility of animal manures and the by-products of processing operations (such as breweries and juicing operations) as agricultural materials sources.

A. Manures

Points of Resource: Local dairies, stables, and other manure producers.

Benefits: Manure is the least regulated feedstock. Compost produced by an agricultural material composting operation that uses only agricultural material may be sold or given away in unrestricted quantities. These operations are subject to inspection at least once annually[13].

In addition, from the end user/value proposition perspective, this material provides the best growth-rate-to-cost ratio in academic research trials of this feedstock in application to greenhouse and field crops[14].

Challenges:

Horse Manure: High collection cost (labor and transportation) from small scale, individual stables.

Cow Manure: The only feedstock considered that is not treated by the producer as a waste stream. Compared to other feedstocks, cow manure is high cost due to its direct marketability ($50 per 20 cubic yard).

Poultry Manure: Is not suitable for vermicompost due to high nitrogen content (resulting in high heat and not suitable for worms).

B. Agricultural Materials Process By-Products

Points of Resource: Local breweries and juice companies.

Note: Trey Strickland, California Department of Resources Recycling and Recovery Local Enforcement Agency (LEA) for Mendocino County has stated that the by-product of the brewing process is an Agricultural material, and hence subject to (less restrictive) Agricultural composting standards[15].

Benefits: As these by-products are considered agricultural materials, they would not require within-

[13] Title 14, Section 17856, Agricultural Materials Composting Operations.

[14] "Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management" Chapter 10, The Use of Vermicomposts as Soil Amendments for Production of Field Crops. by Clive A. Edwards, Norman Q. Arancon, Rhonda Sherman; Taylor & Francis US, 2010 ISBN: 1439809879,

[15] Phone interview by author, 2011.09.27

vessel pre-composting as required for food scraps. The volume of this feedstock that could be accepted is limited only by the scale of the project and access to markets, not by regulations.

One source, the North Coast Brewing Company, generates eight to sixteen dump trucks per week (at 7 cubic yards per truck) of spent grains that are currently not utilized for conversion. This is a significant amount of available organic waste material that could supply a full scale facility. Annually, this represents between 1440 and 2880 yards of finished Worm Castings per year assuming a two-to-one conversion of feedstock to product. Composting agricultural material “on farm” to be fed to livestock (worms) is an excluded activity under CCR Title 14.

Challenges: Considering the significant volume of material generated, accommodating all NCBC by-products would require either large capital outlays for equipment (continuous flow, reactor systems) or significant land use (batch/ windrow and/or wedge systems). Either system would require investment in rolling stock (e.g. front loader).

If a system is designed primarily around the feedstocks from NCBC, the system is left vulnerable to supply issues if availability changes. A contract could mitigate some of this risk.

5.2.3 Organic Waste Type 3: Paper Products

Points of Resource: Waxed cardboard from grocery stores and farms and paper pulp from local businesses, schools and other organizations.

Benefits: Use in a Vermicompost facility would divert these materials from landfills and would provide suitable supplemental feedstocks. Waxed cardboard is an excellent way to accept produce spoilage from grocery stores in carton without concern for generating additional waste. Paper products assist with moisture control in a Vermicomposting operation and often act as “bedding” for the worms.

Challenges: Vermicompost produced with paper products as primary feedstock produces a lesser quality product than a feedstock produced from resources such as food scraps or agricultural materials that have higher nutrient content.

5.2.4 Organic Waste Type 4: Green Waste

Points of Resource: Yard debris and forest products, including wood chips and tree trimmings.

Benefits: In a facility that accepts agricultural materials (described in Section 5.2.2 Type 2, above), up to 12,500 yards of green waste materials could be on site and in Active Composting at any given time[16]. The Georgia-Pacific Corporation is looking for opportunities to dispose of significant quantities of ground redwood bark (hundreds of thousands of cubic yards) from the highway 20 bark dump. These materials, already finely ground to a mulch like consistency, would potentially be a good feedstock (though field trials would be required, see: Challenges, below).

Challenges: Other than the GP ground redwood barks, the bulk of these materials (e.g. yard debris and tree trimmings) are already collected per existing contracts (e.g. residential green bins). Some of this material may be difficult for worms to break down and would require chipping or pre-composting.

The effects of Redwood in a vermiculture system has not been significantly tested and will require trials to determine suitability as a feedstock.

5.3 Estimate of organic waste collection and distribution cost and issues

The costs presented below are relevant to a pilot small scale facility. As market demand grows and local capacity allows many of these costs may actually decrease through lower per unit costs (e.g. capital expenditures on equipment; operations costs with optimized vehicle fleet, staff, and regularity of pickup).

5.3.1 Collection services of food scraps, agricultural discards and (potentially) some types of manure are expected to become a revenue stream.

Preliminary estimates prepared for this report anticipate an operations margin of up to 50% or more for collection of food scraps, depending on the option selected.[17] This report assumes the value of food waste collection at $20 per cubic yard, and for agricultural wastes (e.g. spent brewery grains) $10 per cubic yard. This may or may not be the pricing structure adopted. However--for commercial food waste--this is consistent and competitive with the present option in Fort Bragg, offered by Waste Management, which charges for *potential hauling capacity per month* ($18.54/yard) rather than per actual hauled material.[18].

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[16] Title 14, Section 17856. Agricultural Material Composting Operations.

[17] See Estimated Collection Costs Table, below, and for greater detail see also “Collection Costs” in the digital version of the associated spreadsheet for this report, listed in the Resources Appendix C

[18] Fort Bragg Waste Management Price Sheet, 09/29/2011

Estimated Collection Costs for Feedstocks

Material Type		Margin or (Cost) per Yard
Commercial Food Waste, Truck Pickup*		$ 17.48
Commercial Food Waste, Pedal/Electric Hybrid Pickup*		$ 12.68
Brewery By-products (spent grains)*		$ 8.71
Cow Manure**		$ (12.50)
Horse Manure		$ (21.30)

*Food waste collection services @ $20 per cubic yard; Brewery Grains @ $10 cubic yard.
**Cost of Manure @ $50 per 20 yards.
All except Cow Manure assume collection; Cow manure delivery fee of $200 per 20 yards.
These estimates include the cost of transportation (labor + fuel), materials (if any) and the contribution of collection service ("tipping") fees (if applicable) from the point of resource.

Source: Prepared by Chris Byrne for this report.

The typical restaurant that participates in this program could expect to reduce trash collection bins by 50 percent.[19] Savings could be redirected from trash disposal to feedstock collection. Additionally, many of the benefits listed throughout this report would be directly realized by participating establishments. For example, even if the collection costs for a restaurant were equal to its previous disposal arrangement, a client that values waste stream reductions, composting, home gardening, etc., would associate these values with the restaurant that participates in this program, adding marketing value where once there was only trash pickup. "I put your food scraps on my roses!"

5.3.2 A Note on the Electric / Pedal Hybrid Option

A Pedal/Electric hauler has many financial and other benefits, including: avoid pollution; gained carbon offsets; healthy workers with more work time (employing people, not fuel), and enhanced tourism (to see the model collection system). In a small, relatively flat city such as Fort Bragg, this hauler could be used for food scrap collection, even as the project moves to full scale.[20] Larger scale inputs such as spent brewery grains would likely require a vehicle such as a dump truck.

[19] see section 5.2.1 of this document, and http://www.calrecycle.ca.gov/WasteChar/wcabscrn.asp

[20] For an excellent example of pedal power municipal services, see: http://pedalpeople.com

5.4 Market issues and trends in compost products

According to a recent comprehensive study, *Trends in Organic Lawn and Garden Products, 2nd Edition,* the Organic Lawn and Garden sector reached $460 million in retail sales in 2008, a gain of 12% over 2007.[21] This report examined past, current and future trends and finds that the Organic Lawn and Garden product sector, though still small, has “taken root”. Furthermore, the report found that despite weak general economic trends, significant indicators point to strong future growth. According to the report, the worsening economy could contribute to a strong organic sector, as increasing petroleum prices could result in a price advantage for organic fertilizers over synthetics.[22]

Residential consumers are increasingly aware of the health benefits of using organic fertilizers near homes and recreational areas. Commercial agriculture and landscaping operations continue to transition to organic practices due to economic benefits of lower costs and higher performance, regulatory compliance and reporting, and in response to consumer demand. Worm castings meet the needs of these commercial operations for an organic source of fertilizer.

Additionally, there is a strong local market on the Mendocino Coast for organic fertilizer as inputs into agriculture and home gardening, as shown by the rapidly increasing sales of local soil and agricultural suppliers.

5.4.1 Market Potential

Regional retailers and wholesalers of worm castings are the most immediate markets for worms and worm castings. As the project grows in scope and scale, it could develop a national or state-wide retailing strategy and product line (via web and resellers).

Additionally, the conversion of organic wastes into high value worm castings and worms provides an opportunity to develop downstream businesses that use this resource as an input of their products and services. For example, new businesses might convert castings into other types of garden amendments or extracts (liquid fertilizers) and the worms into protein feed for chickens and fish.

An excellent case study of the role that a vermiculture facility played in developing downstream businesses is urban farm Growing Power Inc., of Milwaukee, Wisconsin. Run by 2010 MacArthur Fellow Will Allen, Growing Power processes more than 70,000 pounds of food wastes per week received from regional groceries, restaurants, cafeterias and breweries. These wastes are converted to castings and worms, both of which are used to feed micro-greens, aquaponics (aquaculture + hydroponics), community gardens, retail sales of castings and a host of other downstream endeavors.

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[21] http://www.reportlinker.com/p099456/Trends-in-Organic-Lawn-and-Garden-Products-2nd-Edit

[22] http://www.reuters.com/article/2009/01/15/idUS144023+15-Jan-2009+BW20090115

The worms could be called the keystone, or the economic engine of the whole Growing Power endeavor[23].

Potential downstream businesses, in Fort Bragg, could include:

- Production of Micro (“sprouts”), salad, and field greens (e.g. beets), and other produce
- Aquaponics (high value greens and fish production)
- Production of protein feed (for chickens and aquaculture)
- Worm casting “tea” extract production
- Consulting services for nutrient capture and fertility enhancement (for garden and broad-acre applications)
- Vocational and fee-for-services workshops and education

The primary function of Vermicompost is to increase the fertility of the soil or growth medium by the addition of both available nutrients and beneficial microbial life. Worm Castings are an excellent source of nutrients and beneficial microbes, and should be considered as competing with fertilizers and pesticides for market share, especially in organic agricultural and lawn and garden applications. As demand for organic and sustainable sources of fertilizer and pest control increases at the expense of market share of synthetic chemicals with long and energy intensive supply chains, locally-produced products such as worm castings are expected to see a marked demand increase.

5.4.2 Market Research: Pricing

Local Market

Presently, Dirt Cheap sells a one cubic foot bag of paper pulp vermicompost for $10 per bag. Owner Scott Zeramby estimates that Dirt Cheap could sell between 500 to 750 bags per year of a locally-produced vermicompost at a similar price, with 10% to 15% growth for three years.

Regional Market

According to their price sheet, *Sonoma Valley Worms* (SVW) sells worm castings (produced from organic cow manure) for $32 per cubic foot and for $395 per cubic yard. Worms are sold for $25 per pound (retail) or $13 per pound for ten pounds or more. SVW provides bulk worm castings to regional wineries and sells nationally by mail order and other local channels.

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[23] For more information about Growing Power, see: www.growingpower.org

National Market

"*Vermicompost Technology"* quotes pricing of $200 to $1000 per ton depending on quality, unit size, and packaging.[24] One ton of castings is typically between two and three yards.

Unco Technologies, located in Racine, Wisconsin, sells its Wiggle Worm Soil Builder™ brand Certified Organic fertilizer via various channels, both direct on its website, through third party resale over the internet, and in "brick and mortar" garden supply stores. The average selling price is $20 for 15 pounds and $35 for 30 pounds.[25]

Value Assumptions

One cubic foot of worm castings is approximately 30 pounds. Based on the above, a wholesale price of $100 per yard is used in Scenario A (with no retail sales). For Scenario B values are assumed at $75 per yard and $12 per cubic foot (bagged) wholesale and $150 per yard (bulk) and $20 per yard (bagged) retail, (as shown in the Product Mix appendix D-4).

5.4.3 Distribution Costs

Most of the anticipated sales of the finished product for the first phases are direct, within the Fort Bragg region and Mendocino County. Exporting to other regional and individual markets could be developed if warranted by production capacity and demand. In both cases, delivery costs are expected to be offset by additional charges or by customer pickup.

5.4.4 Marketing

Highly effective, low cost marketing in the age of social media is a good strategy and a fit for this type of endeavor. Exposure will also be supported by word of mouth, regional media coverage and public-advocacy groups sharing the story of Fort Bragg Made Worm Castings. The marketing budget includes a small advertising allocation to allow for select focus in some local media outlets.

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[24] "Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management" by Clive A. Edwards, Norman Q. Arancon, Rhonda Sherman; Taylor & Francis US, 2010 ISBN: 1439809879. pg. 318.

[25] http://www.vermiculture.com

6. Roadmap to Establish an Organic Waste Conversion Facility in the Fort Bragg Region

6.1 Develop and Implement Pilot Project

In order to demonstrate the potential to establish a full scale Organic Waste Conversion Facility and to incorporate regionally appropriate practices, the next phase (Major Task 2) of this study is a Pilot Project. Noyo Food Forest (NFF) and the North Coast Brewing Company (NCBC) have expressed the desire to participate in a Pilot Project, with NFF proposing to provide operations oversight and NCBC proposing to provide the feedstocks from its restaurant and brewery operations.

The Organic Waste conversion Facility Pilot Project document prepared for Major Task 2 to this feasibility study consists of a design and implementation plan for the Pilot.

Next Steps:

- *Secure Capital and Operations Budget Funding.* The City and Project Partners will be responsible for identifying and securing funding from various sources in order to implement the Pilot phase of the project.
- *Conversion of NCBC Brewery and Restaurant discards into Worm Castings for re-sale.*
- *Marketing of "Fort Bragg Made Worm Castings" by wholesale and retail sales.*
- *Documentation of accomplishments, challenges, and takeaways.*

6.2 Moving to Full Scale

Moving to a full scale facility is the anticipated next phase in this project. While Development Cost Estimates and Operating Cost Pro Forma analyses have been include in the Study (see Section 7.0 and Appendix D), the full scale facility design and implementation plan is outside the scope of this report. Building on a solid foundation of experience from the Pilot Project as described in the *Organic Waste Conversion Facility Pilot Project*, a full scale facility design will be informed by the following:

- Anticipated markets based on feedback and further takeaways from the Pilot Project
- Final facility design and technology selection
- Identification of available feedstocks
- Economic and regulatory considerations

6.2.1 Facility Design Requirements

While there is some promise regarding the potential for "low-technology" systems such as windrows and wedge systems for large batch feedstocks[26] (e.g. spent brewery grains), the prevailing academic opinion is that a continuous flow, within-vessel reactor system is the ideal system for commercial production facilities[27]. This is due to the nature of worm migration through a feedstock. This system optimizes capital investment in equipment rather than labor over time in order to address the separation of worms from castings for marketing. In addition, the land use requirement with a reactor system is much less than the windrow/wedge systems and hence better suited for an investigatory Pilot Project to small scale facility.

Below are general guidelines for development of the small scale facility. This should not be considered an exhaustive implementation plan. Lessons from the Pilot Project will inform the design of the small scale facility.

6.2.2 Zoning and Permits

From the investigations detailed in this report, the best legal description for a Vermicompost facility is a "Worm Farm" and would be compatible with Agricultural Land Use Zoning. Vermiculture is an "excluded activity" and is permissible without Title 14 considerations[28].

However, food scrap composting does require a full composting facility permit, unless the process is within-vessel and does not exceed 50 yards per facility at any given time[29]. The 50 yard limitation results in a workable size for a small scale facility; however, it is smaller than the potential of the commercial food discard feedstocks available in the area. As described in Section 5.2.1 Type 1: Food Scraps, if this feedstock type proves significant and beneficial to both the endeavor and regional businesses, the "pre-processing" of food scraps could be off site from the main Vermicompost facility in clusters near the Points of Resource. For example, collection containers that would be eliminated due to reduced waste could be replaced with within-vessel composting systems, from which stabilized material could be transported to the centralized Vermicompost facility. This could increase the capacity of the conversion facility's ability to process commercially produced food discards. This strategy is referred to as "decentralized processing of feedstocks" and should be noted for future development phases.

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[26] See Chapter 8 "Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management" by Clive A. Edwards, Norman Q. Arancon, Rhonda Sherman; Taylor & Francis US, 2010 ISBN: 1439809879, pg 307

[27] See Chapter 9, ibid.

[28] See Appendix A: Title 14 Section 17855. Excluded Activities. (2) Vermicomposting

[29] See Appendix A: Title 14 Section 17855. Excluded Activities. (8) Within-vessel composting

In addition to these considerations, the California State Water Resources Control Board stated in an interview with this author that impermeable surfaces for leachate and a storm water mitigation plan would be required for a small scale or larger Vermiculture facility. However a small Pilot Project could be implemented with less restrictive conditions.

6.2.3 Physical Site Requirements

Covered structures for all processes. This could consist of a vacant warehouse or other converted building. Minimal (if any) retrofits would be required. A poly-tunnel or greenhouse could also suit a pilot project.

Vehicle Access for delivery of feedstocks, shipping, and customer pickup.

An impermeable surface would be required for both water leachate and materials collection purposes. A storm water mitigation plan would be required by the California State Water Resources Control Board.

Standard 110v/220v electrical access. Energy use for system operation is minimal.

A concrete pad or other impermeable surface will be required of the small scale facility. Each unit / module footprint is approximately 1,320 square feet. A five reactor facility would require 6,600 square feet for reactors. This does not include paths, roads, or ancillary equipment which will be site specific considerations.

6.2.4 Equipment

Equipment requirements for a full-scale facility are categorized for purposes of this study as general equipment that is commonly in use and readily available; specialized equipment available from industry manufacturers or on a custom-build basis; livestock (worms), and rolling stock.

General equipment requirements: Equipment such as compost chopping, grinding, and mixing machinery and moving belts to facilitate continuous flow of product through the system are necessary for a full scale facility in order to maximize feedstock use and vermicomost production. Storage bays for protection of finished product prior to distribution are also necessary. This type of equipment is commonly used in agricultural and manufacturing operations and may be procured as a new or used product.

Specialized equipment requirements [30]. Equipment manufactured for limited or specialized use for vermicomposting activities includes Pre-digesters, continuous

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[30] For a detailed description of Continuous Flow Reactor Systems and related equipment, see Chapter 8 “Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management” by Clive A. Edwards, Norman Q. Arancon, Rhonda Sherman; Taylor & Francis US, 2010 ISBN: 1439809879,

flow reactors, mobile (multiple reactor) gantry; trommel (worm separator), and liquid waste separation equipment.

- **Pre-digesters** facilitate storage and preparation of feedstocks prior to entry into the vermicomposting system. As explained in Section 5.2.1 above (Food Scraps – Challenges), pre-digesters that provide “within-vessel” composting process activities are easily scalable as processing needs grow, and these can be used in a decentralized feedstock collection and composting approach. Smaller systems are available from Sonoma Valley Worms, and larger systems could be built to suit faclity needs. Medium to large scale within-vessel composters such as are available from Green Mountain Technologies and observed at Sierra Nevada Brewing (see Section 4.4 Conversion Facility Site Visits) are beyond the needs of a Vermicompost facility.

- **Continuous flow reactor(s)** are equipment used as a method of producing worm castings with reduced labor costs than traditional “low-technology” systems such as windrows. Feedstocks are applied in thin layers (approximately one to two inches) multiple times a week to the top of the reactor bed. Worms in the system migrate “up” to fresh feedstock, while leaving behind worm castings. The bottom of the system is a wire grating, a foot or so above the floor. A mechanized “cutting bar” is run across the bottom of the reactor one to two times per week, freeing the available castings onto the floor or other collection surface. Total retention time of the feedstock material is 30 to 60 days. Production systems are available, as are detailed fabrication plans from the work of Clive A. Edwards and others.

- **Mobile (multiple reactor) Gantry** is a semi-automated vessel that rolls over the continuous flow reactors in order to apply thin layers to the reactor beds. This is a labor saving system, and allows for greater control of the required thin layer of material. A well designed and functional gantry may eliminate the need for pre-digesters, as the latter are required to eliminate biological heat (from composting organisms) and the former applies material in such thin layers that minimize this heat.

- **Trommel (worm separator):** This is typically a rotating wire mesh cylinder on a slight incline. Worms and castings are fed into the front and as they tumble throughcastings are separated by the gauge of the mesh in each section, with worms coming out the end. Applied Fabrication Technologies makes what appears to be an excellent trommel.

Applied Fabrication Technology’s Worm Trommel

Livestock (worms) are the “engine” of the system. New reactors require one pound of worms per square foot, at bulk rates typically between $10 to $13 per pound. These can be acquired from existing vermiculture operations just prior to beginning operations.

Rolling stock. Vermicompost operations rolling stock tasks include remote (off site) collection of feedstocks; movement of feedstocks and product at the facility site; and distribution of final product to points of sale. A front loading, wheeled tractor is recommended as an efficient and nimble means to move feedstocks and product on site. For feedstock collection and product distribution, a truck is required for large-scale inputs. As described in Section 5.3.2 above, an electric/pedal hybrid vehicle may be a workable solution for smaller loads, such as those that would be collected from restaurants and other smaller scale points of resource, and decentralized (off-site) pre-digesters.

7.0 Development and Operation Cost Estimates

Development and operation costs estimates for a Fort Bragg Organic Waste Conversion Facility are detailed in Appendix D The cost estimates in Appendix D are described as “Small Scale Facility” estimates in order to differentiate Fort Bragg’s feasible capacity and capabilities from those of much larger existing facilities that were used as models and references.

The Small Scale cost estimates include the following worksheets:

- Appendix D-1: Small Scale Development Assumptions and Estimated Costs
- Appendix D-2: Small Scale Facility Operating Costs Pro Forma – Scenario A
- Appendix D-3: Small Scale Facility Operating Costs Pro Forma- Scenario B
- Appendix D-4: Sales Scenario B Product Mix Assumptions and Calculations

A Small Scale Facility Schematic that includes calculations and assumptions for facility capacities and requirements is included in the Digital Resources Appendix to this report at the following link:

http://fortbraggcompost.wagn.org/wagn/report+resources

Information and analysis from each of these worksheets follows.

7.1 Development Assumptions and Estimated Costs

The total estimated cost of development for a Small Scale Organic Waste Vermicompost Facility is presented using a “low” estimate” and a “high” estimate in Appendix D-1. The “low” estimate of total development cost is $531,163 and the “high” estimate is $758,846. The “high” estimate is used for Operating Pro Forma cost estimates, and Operating Pro-Formas assume that all development costs will be financed and repaid over a thirty-year term. Components of development cost estimates are described below.

Land. Estimates for the 10,000 square foot facility range from $20,000 (low end) to $100,000 (high end) based on marginal land requirements. Lease arrangements could also be pursued.

Facility cost estimates. As described in Section 6.2.3 “Physical Site Requirements” above, facility needs include covered structures, concrete pads, and access to water and other utilities. Development costs include six “retrofit” (converted use) or semi-covered structures at $7,000 each for the “high” estimate (none are included in the “low” estimate, assuming existing structures are available). Based on input and collection capacities, six concrete pads to cover a total area of 9,108 square feet are budgeted at $40,986 ($4.50 per square foot) for the “high” estimate. No concrete pad cost is estimated for “low” costs, assuming an existing impermeable surface may be available. Water system and other utility connections or enhancements are estimated at $9,760 for both the “high” and “low” estimates. Total facility costs are estimated at $92,746 for the “high” estimate and $9,760 for the “low” estimate.

Equipment cost estimates. Equipment needs are detailed in Section 6.2.4 above. The following cost estimates are included in the development cost totals:

▪**General equipment**: One combination chopping/grinding/mixing machine is included with an estimated cost of $20,000. A moving belt system is estimated to be available at $8,000. Four storage bays are recommended at a cost of $2,500 each or $10,000. These equipment needs and costs are the same for both the “high” and “low” estimates.

▪**Specialized equipment**: Five pre-digesters are recommended for efficient, continuous feedstock preparation, budgeted at $5,000 each; total investment $25,000. The largest system investment is the recommended procurement of five continuous flow reactors at $40,000 each, which are necessary to accommodate available feedstocks; total $200,000. One mobile (multiple reactor) gantry is recommended at an estimated cost of $12,000. Two Trommels (worm separators) are needed at $5,000 each; total $10,000. A Liquid Waste Separation machine is recommended at $35,000 (excluded from the “low” estimate).

▪**Rolling stock**. Cost of a front-loading tractor is estimated at $15,000. Budget for a truck and a hybrid pedal vehicle is $20,000.

Total equipment costs are estimated at $359,936 for the “low” estimate and $394,936 for the “high” estimate.

Other development costs. Other costs include a contingency budget; an escalation budget; start-up training budget; and cash-flow allowance equal to year-one operations costs.

▪**Contingency budget**. A contingency budget calculated at ten percent of total development costs ($38,970 for the “low” estimate and $58,768 for the “high” estimate” is included for unforeseen costs.)

▪**Escalation budget**: The escalation budget is included to accommodate unexpected price increases and is calculated at five percent of total development costs ($19,485 for the “low” estimate and $29,384 for the “high” estimate).

▪**Start-up training**: Because the vermicompost operation is a new industry in the Fort Bragg region, start-up training is assumed to be necessary under both the “low” and “high” scenarios. Start-up training is expected to include forty hours of consulting time at $100 per hour and 40 hours of staff time at $20 per hour (including 20% staff fringe benefits)

7.2 Operating Pro-Forma, Scenarios A and B

Operating Pro-formas are presented for two different Vermicompost product mix scenarios. Operating Pro-Forma components are described below, and detailed costs are presented in Appendices D-2 and D-3. Appendix D-4 provides detailed calculations supporting the Scenario B product mix sales figures.

Net cash flow after debt service and reserves is positive under both sales scenarios beginning in Year 1 and continuing through the seven-year period presented.

7.2.1 Revenues

Operating Pro-Formas includes revenues derived form Collection Services and from Vermicompost Sales.

- **Collection Service revenues** are projected at $20 per cubic yard based on annual process capacities for Scenario A, and at $12 per yard for Scenario B. Scenario A assumes the CCR Title 14 cap of 50 yards for collection of food discards from local food service establishments at a competitive rate of $20 per yard. Scenario B values all materials collections (food scraps plus brewery and other agricultural discards) at a rate of $12 per yard. Both of these are baseline assumptions and could be developed into greater revenue amounts (e.g. by also charging in Scenario A for brewery discards.)

- **Vermicompost revenues** are assumed as bulk only, retail and wholesale, for Scenario A, at a rate of $100 per cubic yard of product sold. For Scenario B, the following product mix is projected:

Product	**Percent of Total**	**Price**
1-cubic foot bag, retail	10%	$20 per bag
1-cubic foot bag, wholesale	15%	$12 per bag
Bulk, retail	30%	$150 per yard
Bulk, wholesale	45%	$75 per yard

The Scenario B product mix results in higher overall revenues than the Scenario A bulk sale-only model. Scenario B also results in higher labor, distribution and marketing costs and higher overall profits as described below and exhibited in the Operating Pro Formas.

7.2.2 Cost of Sales.

Cost of sales under both Scenario A and Scenario B includes Feedstock Collection costs (non-labor costs) and direct labor. Feedstock collection costs are based on annual process capacities at a rate of $10 per yard, per industry analysis[31]. Under Scenario A, direct labor to perform collection, processing, and production tasks for bulk sales only is assumed to require 1.5 Full Time Equivalent employees at a rate of $17 per hour plus fringe (estimated at 20%). For Scenario B, direct labor with the addition of the more complex product mix is expected to require 2.5 Full Time Equivalent employees at $17 per hour plus 20% fringe rate.

7.2.3 Operating Expenses.

Operating expense line items include administrative and other indirect labor; sales and marketing costs; utilities; equipment repair and maintenance; insurance, and supplies. Under Scenario A, administrative and indirect labor is estimated to require a half-time employee at $17 per hour plus fringe. Under Scenario B, due to additional administrative and marketing tasks associated with the expanded product mix, administrative labor is anticipated to require one Full Time Equivalent employee at the same rate of pay. Sales and marketing expenses, projected at ten percent of gross revenues for Scenario A, are increased to 20% of gross revenues for Scenario B for increased efforts due to the Scenario B product mix. Other expenses are the same for both scenarios and are based on industry and/or regional averages.

7.2.4 Debt Service and Reserves.

- **Debt service** is the same for Scenario A and Scenario B. The data assumes that full development cost of $758,846 is financed for a 30-year term at 5.25% interest, resulting in a monthly principal and interest payment of $4,190 or annual payment of $50,284. The debt service amounts represent a conservative estimate, since it is unlikely that one hundred percent of development costs would be realized or financed.

- **Cash Reserves** are calculated at 10% of total operating expenses. Scenario A reflects lower total operating expense than Scenario B, as described above. Cash Reserves are projected to be set aside for emergency or unusual cash needs in each of the seven years presented in the Pro Formas. However, if sufficient cash flow is generated from operations, this amount may be reduced within the seven-year period.

[31] A Small Scale Facility Schematic that includes detailed calculations and assumptions for facility capacities and requirements is included in the digital resources Appendix to this report at the following link: http://fortbraggcompost.wagn.org/wagn/report+resources

8. Conclusion

This study is the result of extensive research regarding the regulatory, economic, technological and associated issues that may be present in establishing an Organic Waste Conversion Facility in or around Fort Bragg California. While the authors have attempted to anticipate all of the related factors and issues that need to be addressed in establishing an Organic Waste Conversion Facility, this report should be considered extensive but not exhaustive. Regulations and economics change, and like any business, disruptive technologies and unforeseen challenges should be considered part of any risk of establishment. Every attempt has been made to mitigate these risks up front with solid research and reporting, and the recommendations made herein are offered with this understanding. Nonetheless, this consultancy provides this study with confidence that an Organic Waste Conversion Facility on the Mendocino Coast as outlined in the City of Fort Bragg Compost Facility Feasibility Study Request for Proposals and analyzed in this document is indeed feasible and advantageous for Fort Bragg. In addition to the financial and additional advantages to the Fort Bragg economic region and the downstream endeavors that would benefit from the creation of this product, this project could serve as a model for other communities to reclaim and reincorporate the organic waste stream into a valuable economic resource.

Appendix A: California Code of Regulations Title 14

(Excerpts)

Section 17852. Definitions: www.calrecycle.ca.gov—ch31.htm
(1) "Active Compost" means compost feedstock that is in the process of being rapidly decomposed and is unstable. Active compost is generating temperatures of at least 50 degrees Celsius (122 degrees Fahrenheit) during decomposition; or is releasing carbon dioxide at a rate of at least 15 milligrams per gram of compost per day, or the equivalent of oxygen uptake.

(5) "Agricultural Material" means material of plant or animal origin, which result from the production and processing of farm, ranch, agricultural, horticultural, aquacultural, silvicultural, floricultural, vermicultural, or viticultural products, including manures, orchard and vineyard prunings, and crop residues.

(39) "Vermicomposting" means an activity that produces worm castings through worm activity. The EA may determine whether an activity is or is not vermicomposting. The handling of compostable material prior to and after use as a growth medium is subject to regulation pursuant to this chapter and is not considered vermicomposting.

Section 17855. Excluded Activities.
(a) The activities listed in this section do not constitute compostable material handling operations or facilities for the purposes of this Chapter and are not required to meet the requirements set forth herein. Nothing in this section precludes the EA or the board from inspecting an excluded activity to verify that the activity is being conducted in a manner that qualifies as an excluded activity or from taking any appropriate enforcement action.

(2) Vermicomposting is an excluded activity. The handling of compostable material prior to and after use as a growth medium is not an excluded activity and is subject to the requirements of this chapter. Handling of agricultural material on the site of a vermicomposting activity, for use as a growth medium on that same site, is an excluded activity if it complies with section 17855(a)(1).

(8) Within-vessel composting process activities with less than 50 cubic yard capacity are excluded.

Section 17856. Agricultural Material Composting Operations.
(a) All agricultural material composting operations and chipping and grinding operations shall comply with the Enforcement Agency Notification requirements set forth in Title 14, California Code of Regulations, Division 7, Chapter 5.0, Article 3.0 (commencing with section 18100), except as otherwise provided by this Chapter. Agricultural Compostable Materials Handling Operations shall only be subject to the requirements of section 17863.4 if the EA makes a written determination that the operation has violated the requirements for odor impacts of section 17867.

(b) Compost produced by an agricultural material composting operation or chipping and grinding operation which uses only agricultural material may be sold or given away in unrestricted quantities. These operations shall be inspected by the EA at least once annually.

(c) Compost produced by an agricultural material composting operation which uses agricultural material and/or green material, as specified in section 17852 (a)(21), may be sold or given-away in accordance with the following restrictions.

(1) Those sites that do not sell or give-away more than 1,000 cubic yards of material per year shall be inspected by the EA at least once annually when actively composting. If more that 12,500 cubic yards of green material, including feedstock, compost, or chipped and ground material, is to be handled on-site of productive farmland as defined in Government Code section 51201, the operator shall give advance notice to the EA. The EA shall only prohibit the on-site storage of additional materials, or impose a greater inspection frequency, if the EA makes a written finding that it will pose an additional risk to public health and safety and the environment. The EA shall forward a copy of the request and approval to the Board.

(2) Those operations that sell or give-away more than 1,000 cubic yards of material per year, shall have not more than 12,500 cubic yards of green material, including feedstock, compost, or chipped and ground material, on-site at any one time and shall be inspected by the EA once every three (3) months.

(3) These sites shall record the quantity received of green material.

Appendix B: Fort Bragg Organic Waste Database Template

Example Database Template:

Points of resource are represented by a "card" in the WAGN database wiki. For each entity/card the following fields will be presented:

- Name of Establishment
- Contact Name
- Address
- Phone number
- Email
- Website
- Interest in participating in the pilot?
- Category [drop-down]
    - Grocery store
    - Cafeteria (school, hospital, etc.)
    - Café
    - Restaurant
    - Brewery / Juicing
    - Office
    - Residential *
    - Paper waste**
- Category and Weight / Volume*** of Organic Waste(s) [checkboxes]
    - Pre-Consumer
    - Prep Waste
    - Spoilage
    - Post-consumer
    - Plate "scrapes"
    - Soiled Paper and Cardboard
    - Waxed Cardboard
    - Other
- Is there meat presently in the co-mingled food waste stream? [Yes/No]
- Current method of disposing of organic waste
- Current cost of (organic) waste disposal: Size / Rate of container
- If co-mingled solids, % of organic/total solid waste (estimate or actual?)
- Estimated Volume of Food Waste / Week ____ in _____ (units: lbs; volume; other)

Appendix C: Resources and Contact Information

Resources

This report refers extensively to "Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management" by Clive A. Edwards, Norman Q. Arancon, Rhonda Sherman; Taylor & Francis US, 2010 ISBN: 1439809879

More information on the concept of Import Substitution can be found in: "Going Local: Creating Self-Reliant Communities in a Global Age" by Michael Shuman; Routledge, 2000 ISBN: 0415927684

Additional information on commercial composting technologies can be found at http://www.biosci.ohio-state.edu/~soilecol/CommercialTech.htm

This study refers to www.wastecapwi.org—foodwaste.pdf for case studies regarding redesign, financial considerations, and other program adoption challenges for commercial food waste collection.

Contact Information

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Fort Bragg Organic Waste Vermicompost Facility
Appendix D - 1
Small Scale Facility Development Assumptions and Estimated Costs

A. Assumptions Impacting Development: Conversion Unit Calculations:

Food Waste Conversion			
Inputs Capacity / Month (cubic yards)	107.14		
Inputs Capacity / Week (cubic yards)		25.00	
Conversion Units (Reactors) required			2.00
Agricultural By-products			
Inputs Capacity / Month (cubic yards)	240.00		
Inputs Capacity / Week (cubic yards)		56.00	
Conversion Units (Reactors) required for above			3.00
Total Inputs			
Inputs Capacity / Month (cubic yards)	347.14		
Inputs Capacity / Week (cubic yards)		81.00	
Total Facility Conversion Units "Reactors)			**5.00**

B. Development Cost Estimates

	Qty	Unit	Per Unit Cost	Low Estimate	High Estimate
1.0 Land Cost Estimates (10,000 square feet)				**$ 20,000**	**$ 100,000**
2.0 Facility Cost Estimates					
Retrofits or Semi-covered structures	6	each	$ 7,000	$ -	$ 42,000
Concrete Pads (6 @ 1320 sq ft. each, plus 15%)	9108.00	sq. ft.	$ 4.50	$ -	$ 40,986
Water System Installation/Expansion	600.00	linear feet	$ 4.60	$ 2,760	$ 2,760
Other utility improvements (contingency)				$ 7,000	$ 7,000
Total Facility Costs				**$ 9,760**	**$ 92,746**
3.0 Equipment Cost Estimates					
General					
Chopping / Grinding / Mixing Machine	1.00	each	$ 20,000	$ 20,000	$ 20,000
Moving Belts	1.00	each	$ 8,000	$ 8,000	$ 8,000
Storage Bays	4.00	each	$ 2,500	$ 10,000	$ 10,000
Specialized					
Pre-digester	5.00	each	$ 5,000	$ 25,000	$ 25,000
Continuous Flow Reactor(s)	5.00	each	$ 40,000	$ 200,000	$ 200,000
Mobile (Multiple Reactor) Gantry	1.00	each	$ 12,000	$ 12,000	$ 12,000
Trommel (Worm Separator)	2.00	each	$ 5,000	$ 10,000	$ 10,000
Liquid Waste Separation	1.00	each	$ 35,000	$ -	$ 35,000
Livestock (Worms) (for 3 reactors)	1,024.00	per reactor	$ 13.00	$ 39,936	$ 39,936
Rolling Stock					
Front Loader	1.00	each	$ 15,000	$ 15,000	$ 15,000
Truck	1.00	each	$ 20,000	$ 20,000	$ 20,000
Total Equipment Costs				**$ 359,936**	**$ 394,936**
4.0 Sub-total Development Costs				**$ 389,696**	**$ 587,682**
5.0 Other Development Costs:					
Contingency Budget (*as percentage of Development Costs)*			10%	$ 38,970	$ 58,768
Escalation Budget (*at percentage of Development Costs*			5%	$ 19,485	$ 29,384
Start-up Training		*Hours*	*Rate*		
Consulting		40.00	$ 100.00	$ 4,000	$ 4,000
Staff		40.00	$ 20.00	$ 800	$ 800
Year One Operations (for Cash Flow)-Scenario A, Appendix D-2				$ 78,212	$ 78,212
Total Other Development Costs				**$ 141,467**	**$ 171,164**
Total Development Costs				**$ 531,163**	**$ 758,846**

The above model is adapted from Table 19.3 of "Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management" by Clive A. Edwards, Norman Q. Arancon, Rhonda Sherman; Taylor & Francis US, 2010

Fort Bragg Organic Waste Vermicompost Facility
Appendix D - 2
Small Scale Facility Operating Costs Pro Forma - Scenario A

Scenario A Description: Bulk Sales Only; No Product Mix

A. Scenario A Assumptions:

Annual Escalation:

	Percent	Multiplier
Revenues	5%	1.05
Cost of Sales	5%	1.05
Operating Expenses	5%	1.05

Facility Size	Per unit	Total	Unit
Process Capacity (Annual	986.07	4,930.37	cubic yards
Product Output (Annually)	493.04	2,465.19	cubic yards
Number number of Reactors		5	

B. Operating Pro-Formas

	Qty	Unit	Rate	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Revenue	Qty	Unit	Rate							
Collection Services	1,972.15	cubic yards	$ 20.00	$ 39,443	$ 41,415	$ 43,486	$ 45,660	$ 47,943	$ 50,340	$ 52,857
Vermicompost Sales (bulk only, no mix)	2,465.19	cubic yards	$ 100.00	246,519	258,844	271,787	285,376	299,645	314,627	330,358
Total Revenues - Scenario A				**285,961**	**300,260**	**315,273**	**331,036**	**347,588**	**364,967**	**383,216**
Cost of Sales	Qty	Unit	Rate							
Feedstock Collection	4,930.37	cubic yard	$ 10.00	49,304	51,769	54,357	57,075	59,929	62,925	66,072
Direct Labor and 20% Fringe	1.50	FTE	$ 17.00	63,648	66,830	70,172	73,681	77,365	81,233	85,294
Total Cost of Sales				**112,952**	**118,599**	**124,529**	**130,756**	**137,294**	**144,158**	**151,366**
Gross Profit				**173,010**	**181,660**	**190,743**	**200,280**	**210,294**	**220,809**	**231,850**
Operating Expenses	Qty	Unit	Rate							
Administrative payroll and 20% fringe	0.5	FTE	$ 17.00	21,216	22,277	23,391	24,560	25,788	27,078	28,431
Sales and Marketing	*% of Total Revenues*		10%	28,596	30,026	31,527	33,104	34,759	36,497	38,322
Utilities (water, sewage, electricity)	1	Annual	5,000.00	5,000	5,250	5,513	5,788	6,078	6,381	6,700
Equipment Repair and Maintenance	1	Annual	6,000.00	6,000	6,300	6,615	6,946	7,293	7,658	8,041
Insurance	1	Annual	$ 12,000	12,000	12,600	13,230	13,892	14,586	15,315	16,081
Office supplies	12	Per month	$ 100	1,200	1,260	1,323	1,389	1,459	1,532	1,608
Postage	12	Per month	$ 100	1,200	1,260	1,323	1,389	1,459	1,532	1,608
Travel & entertainment	12	Per month	$ 250	3,000	3,150	3,308	3,473	3,647	3,829	4,020
Total Operating Expenses				**78,212**	**82,123**	**86,229**	**90,540**	**95,067**	**99,821**	**104,812**
Net Operating Revenues				**$ 94,798**	**$ 99,538**	**$ 104,514**	**$ 109,740**	**$ 115,227**	**$ 120,988**	**$ 127,038**
Debt Service and Reserves										
Debt Service - full development cost (5.25%, 30-year term)		Monthly P&I:	$ 4,190	50,284	50,284	50,284	50,284	50,284	50,284	50,284
Cash Reserves (as percentage of Operating Expenses)			10%	7,821	8,212	8,623	9,054	9,507	9,982	10,481
Net Cash Flow After Debt Service and Reserves				**$ 36,692**	**$ 41,041**	**$ 45,607**	**$ 50,402**	**$ 55,436**	**$ 60,722**	**$ 66,273**

Source: Adapted by Chris Byrne from Vermicompost Technology (see Appendix C - Resources and Contact Information)

Fort Bragg Organic Waste Vermicompost Facility

Appendix D - 3
Small Scale Facility Operating Costs Pro Forma - Scenario B

Scenario B Description: Includes Vermicompost Product Mix including retail & wholesale bags; and retail and wholesale bulk sales

A. Scenario B Assumptions:

Annual Escalation:	Percent	Multiplier
Revenues	5%	1.05
Cost of Sales	5%	1.05
Operating Expenses	5%	1.05

Facility Size	Per unit	Total facility	Unit
Process Capacity (Annual	986.07	5,916.44	cubic yards
Product Output (Annual)	493.04	2,958.22	cubic yards
Number of Reactors		6.00	

B. Operating Pro-Formas

	Qty	Unit	Rate	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Revenue										
Collection Services	5,916.44	cubic yards	$ 12.00	70,997	74,547	78,275	82,188	86,298	90,613	95,143
Vermicompost Sales-mix	2,958.22	cubic yards	See App.D-4	536,474	563,297	591,462	621,035	652,087	684,691	718,926
Total Revenues - Scenario B				**607,471**	**637,844**	**669,737**	**703,224**	**738,385**	**775,304**	**814,069**
Cost of Sales	Qty	Unit	Rate							
Feedstock Collection	5,916.44	Cubic yards	$ 10.00	59,164	62,123	65,229	68,490	71,915	75,510	79,286
Direct Labor and 20% Fringe	2.50	FTE	$ 17.00	106,080	111,384	116,953	122,801	128,941	135,388	142,157
Total Cost of Sales				**165,244**	**173,507**	**182,182**	**191,291**	**200,856**	**210,898**	**221,443**
Gross Profit				**442,226**	**464,338**	**487,555**	**511,932**	**537,529**	**564,406**	**592,626**
Operating Expenses	Qty	Unit	Rate							
Administrative labor and 20% fringe	1.0	FTE	$ 17.00	42,432	44,554	46,781	49,120	51,576	54,155	56,863
Sales and Marketing	% of Gross Revenues		20%	121,494	127,569	133,947	140,645	147,677	155,061	162,814
Utilities (water, sewage, electricity)	1	Annual	$ 5,000	5,000	5,250	5,513	5,788	6,078	6,381	6,700
Equipment Repair and Maintenance	1	Annual	$ 6,000	6,000	6,300	6,615	6,946	7,293	7,658	8,041
Insurance	1	Annual	$ 12,000	12,000	12,600	13,230	13,892	14,586	15,315	16,081
Office supplies	12	Per month	$ 100	1,200	1,260	1,323	1,389	1,459	1,532	1,608
Postage	12	Per month	$ 100	1,200	1,260	1,323	1,389	1,459	1,532	1,608
Travel & entertainment	12	Per month	$ 250	3,000	3,150	3,308	3,473	3,647	3,829	4,020
Total Operating Expenses				**192,326**	**201,942**	**212,040**	**222,642**	**233,774**	**245,462**	**257,735**
Net Operating Revenues				**249,900**	**262,395**	**275,515**	**289,291**	**303,755**	**318,943**	**334,890**
Debt Service and Reserves										
Debt Service - full development costs (5.25%, 30-year term)		Monthly P&I	4,190.35	50,284	50,284	50,284	50,284	50,284	50,284	50,284
Cash Reserves (as percentage of Operating Expenses)			10%	19,233	19,233	19,233	19,233	19,233	19,233	19,233
Net Cash Flow After Debt Service and Reserves				**$ 180,383**	**$ 192,878**	**$ 205,998**	**$ 219,774**	**$ 234,239**	**$ 249,426**	**$ 265,373**

Source: Adapted by Chris Byrne from Vermicompost Technology (see Appendix C - Resources and Contact Information)

Fort Bragg Small Scale Organic Waste to Vermicompost Facility
Appendix D-4
Operating Cost Pro-Forma Scenario B - Product Mix Assumptions and Calculations for Revenue Calculations

Assumptions:

Feedstock (per reactor) per year:	986.07	cubic yards
Conversion to cubic feet multiplier:	27	
Equivalent in cubic feet		26,624.00
Product (per reactor) per year:	493.04	cubic yards
Conversion to cubic feet multiplier:	27	
Equivalent in cubic feet		13,312.00
Reactors per Facility	6.00	
Feedstock (per facility) per year:	5,916.44	cubic yards
Product (per facility) per year:	2,958.22	cubic yards
Product (per facility) per year, cubic feet:	79872.00	cubic feet

Product Mix and Revenue Calculations:		Year One	Year Two	Year Three	Year Four	Year Five	Year Six	Year Seven
1 Cubic Foot Bags: RETAIL								
Price per Bag	$ 20.00							
% of total product mix	10%							
Retail revenue		$159,744	$175,718	$193,290	$212,619	$233,881	$257,269	$282,996
1 Cubic Foot Bags: WHOLESALE								
Price per Bag	$ 12.00							
% of total product mix	15%							
Wholesale Revenue		$143,770	$158,147	$173,961	$191,357	$210,493	$231,542	$254,697
BULK / WHOLESALE								
Price per Yard	$ 75.00							
% of total product	45%							
Revenue		$99,840	$109,824	$120,806	$132,887	$146,176	$160,793	$176,873
BULK / RETAIL								
Price per Yard	$ 150.00							
% of total product	30%							
Revenue		$133,120	$146,432	$161,075	$177,183	$194,901	$214,391	$235,830
Total Revenue		**$536,474**	**$590,121**	**$649,133**	**$714,046**	**$785,451**	**$863,996**	**$950,396**