CRLS Glocal Challenge: Anaerobic Digester Proposal

Date: August 18, 2017
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From: We8FoodWaste: Fosca Bechthold, Nusrat Lamisa Jahan, Michael Naughton-McWilliams, Sam Somerdin
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Interns For the Cambridge Community Development Department
Re: Proposal for the City of Cambridge Regarding Food Waste

Overview:

As a group of four incoming seniors attending Cambridge Rindge and Latin School, we participated in the Glocal Challenge this past school year. The prompt was to find a solution to reduce or re-purpose food waste significantly in Cambridge by 2018. We proposed installing an anaerobic digester at CRLS to convert the food waste produced by students and staff into energy to power the stoves, helping cook the next meal in a self-contained cycle. We chose the school as our location because the environment would support the technology as an educational opportunity for students and staff alike. Our project proposal, along with four other ideas, won the Glocal Challenge.

We dedicated this summer working as interns for the Cambridge Community Development Department, composing this report supporting the implementation of a Grind2Energy "food recycling" system at CRLS. For the past few years, "curbside composting," was a pilot program offered to North Cambridge residents as way to dispose organic food material in their homes. Due to its great success, the City of Cambridge worked to expand the curbside program. However, it will include some modifications: the waste collected will be sent to Lawrence, MA, to an anaerobic digester to create electricity and fertilizer. Unfortunately, after we shifted our research to purpose the Grind2Energy system, we were informed about the imminent curbside composting program, which will be expanded throughout the city effective in April 2018. The current pilot program in North Cambridge collects food waste to drop off at Rocky Hill Farm in Saugus, MA, where it is composted. Starting 2018, transportation of food waste to Rocky Hill Farm will cease. Instead, all city organic waste will be sent to the Waste Management Facility in Charlestown, MA, for processing.

Because the city of Cambridge refers to their curbside food waste program as "curbside composting," we will refer to that program as curbside composting throughout the paper.

Our initial purpose has changed from proposing an anaerobic digester be installed on-site at CRLS to commendation to the City for driving Cambridge to a common goal: repurposing food waste to benefit the community. However, we would like to stress the importance of creating educational material, as well as dedicating staff resources, to inform the student body on the issue of food waste. The benefits of education cannot be clearly quantified, but they are very real, and it combats the problem of food waste nearer to the source: the consumer.

The following is not a proposal, but a report. Despite some structuring and styling in the former manner, this paper is expository, rather than persuasive. There are also elements of a narrative, for we have included the evolution of our guiding thesis, and the gradual scaling-down when faced with practical realities. This paper includes all our research conducted throughout the past 6 weeks, as well as suggestions to educate both CRLS students and the general public about food waste.

We thank Jennifer Lawrence, who oversaw the creation of this report and helped us navigate through the city administration. We also thank Allie Koch, who edited and gave feedback to us on this report. Finally, we must thank everyone who helped us, many of whom taking the time to meet with us in person. Without them, we could not have written this paper.

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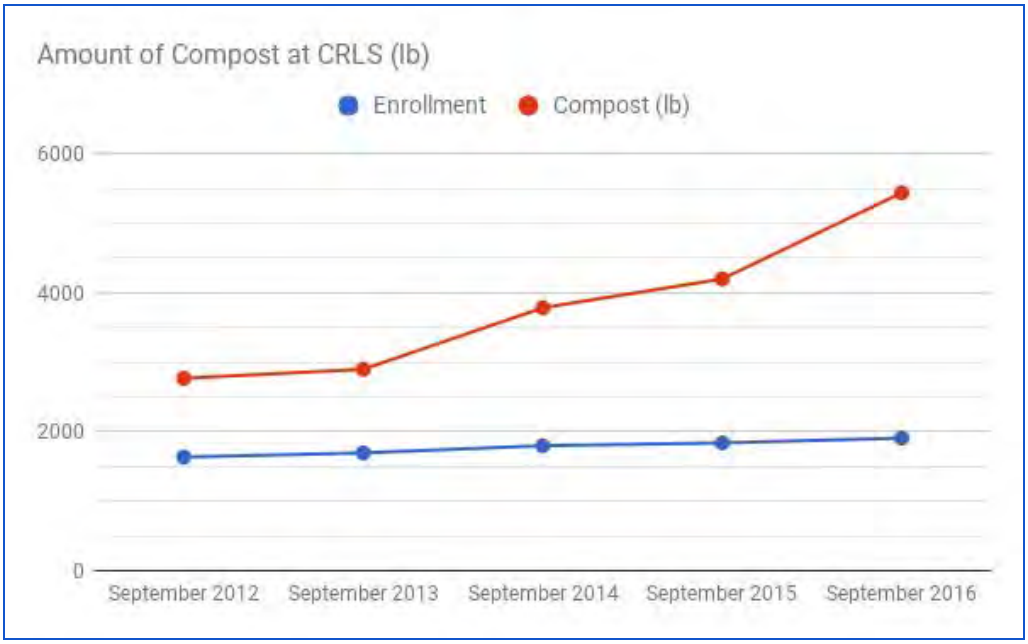
1. Introduction to Issue of Food Waste

Food waste, a pervasive issue in Cambridge and around the world, is encountered every time we buy, prepare, or consume food. According to the United States Department of Agriculture, the United States wastes about 30-40% of its food supply, totaling to about 133 billion pounds.[1] On a global scale, the total amount of food thrown away is approximately ⅓ of all food produced.[2] Waste of edible food happens in both developing and developed countries; however, the point in the supply chain at which the loss occurs differs. In developing countries, most food is wasted at the production stage, due to suboptimal equipment and/or practices. In the developed world, most food is wasted by consumers—it is estimated that the average American wastes 243 pounds of food per year, or about 1500 calories per day.[3]

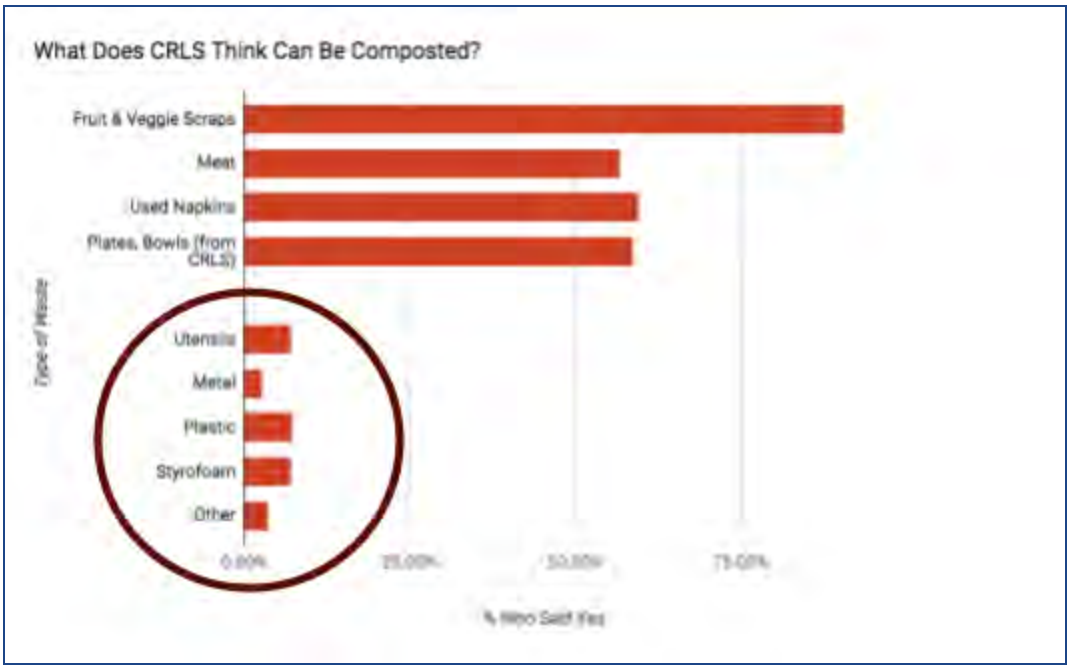
Thus, on September 16, 2015, the first national food waste reduction goal was initiated, calling for a "50-percent reduction by 2030."[4] Similarly, the City of Cambridge introduced the "Zero Waste Plan," aiming to reduce trash 30% by 2020 and 80% by 2050.[5]

2. Food Waste Issue at CRLS

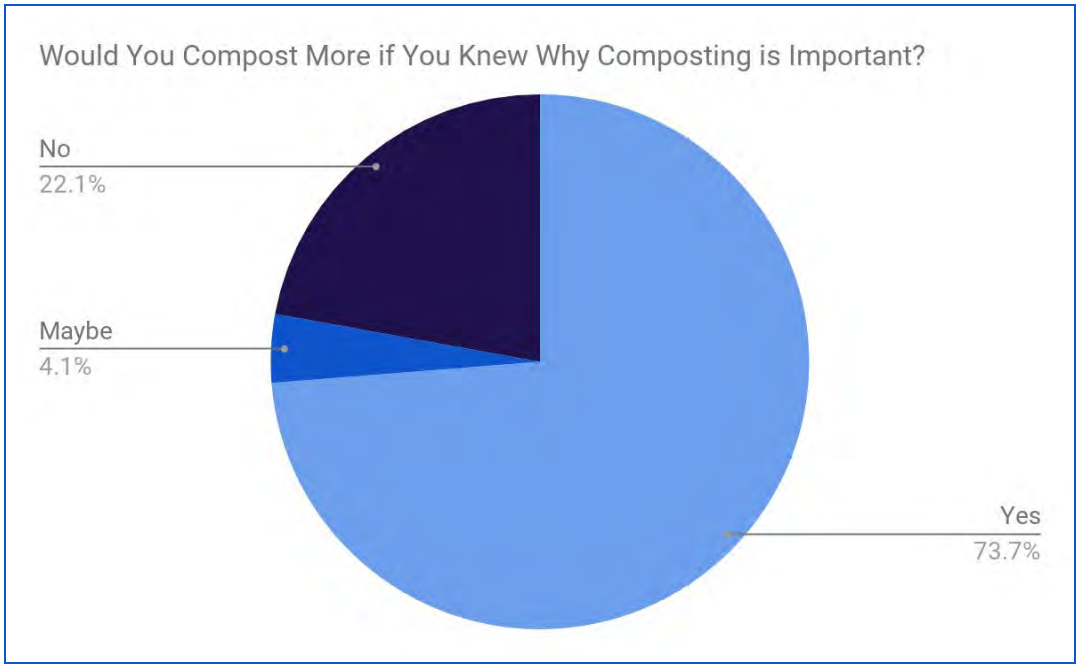
In our own cafeterias at CRLS, there was an average of 8,680 lbs of food waste per month in the 2016-2017 school year. Below is a graph showing the amount of food wasted at CRLS for September over five years consecutive years.



We also surveyed 495 random students throughout all four grades from different homerooms. The graph below depicts the opinions on what material can be composted. However the material in the circled area cannot be composted, revealing the need for food waste education in school.



Below is a chart showing students' opinion regarding the effectiveness of food waste education.



Based on the graph, 73.7% of the students would compost if they were given exposure to the benefits and importance of composting. However, 22.1% would not compost given more education. These results show students' perceived readiness to perform the tasks, which precede the actual composting, given enough impetus—namely, putting their waste into the appropriate receptacle at school. Of course, whether more diligence would be practiced with better education is not guaranteed. This being said, we believe it a matter of principle to put some faith in students' responses. The responses reveal an apathy among the student body about food waste—an apathy which might be turned into proactivity. Most of us are accustomed to an abundance of food. We live in a culture where food is disposable, which is the harmful idea that needs to be targeted. Education around the issue of food waste might help us to look beyond our own fortunate circumstances and help curb food waste.

3. Progression of Our Project

Over the past year, our project has completely changed. The initial goal of the summer research was to figure out how to to install an anaerobic digester on school grounds. However, through research, we explored other options to reach the same goal of repurposing food waste. For example, we considered a service called Grind2Energy as a viable alternative. After researching the system in depth, we met with Michael Orr, director of Recycling for the City of Cambridge and he informed us of the expansion of the curbside composting program . In the fall of 2017, when the curbside composting program is integrated into the school systems, CRLS food waste will be transported to an outside digester facility.

a. <u>Anaerobic Digester</u>

To address the challenge of "significantly reducing or repurposing food waste in Cambridge by 2018," our original solution was to install an anaerobic digester on school grounds. Food waste generated by the student body would be diverted to this digester, rather than compost facilities, and the biogas produced by this process would be utilized by the school kitchens in their appliances.

Anaerobic digestion is a biological process in which microorganisms break down biodegradable materials in the absence of oxygen. The principal result of anaerobic digestion is the production of methane-rich biogas by bacteria. The primary constituent of biogas is methane gas, and the chemical energy latent in the methane can be harnessed for an array of different purposes. It can be combusted directly to provide heat, put through a boiler, generating electricity, which can even be compressed to fuel vehicles. The secondary product of the process is digestate, a nutrient-rich fertilizer which can be used to supplement compost.

In our case, the objective with this was two-fold; first, using a closed-system loop to potentially minimize the energy loss, which occurs when waste processing occurs off-site. More

importantly, by dint of the tangible nature of the device and its proximity to students, the digester might act as a centerpiece, which would capture the attention of both students and the general public. We intended to increase awareness through education surrounding this pressing issue of food waste.

b. Grind2Energy System

We soon realized there were too many complications involved in such an undertaking. First was the nature of the site, which was not a suitable place to hold the machinery. An anaerobic digester would take up significant amount of space that CRLS cannot capacitate and the allowing the formation of flammable methane and hazardous byproducts, necessary parts of digestion, would be imprudent considering its proximity to such a densely populated building. Finally, there was the economic barrier, which proved insuperable. Anaerobic digesters are expensive, and the scale of operation was insufficient to render the use of one practical. We searched for alternatives similar to anaerobic digestion and discovered the Grind2Energy service, a food waste recycling system that installs a tank on the grounds of any given insitute, hauling out the slurry at timely intervals throughout the year.

c. Curbside Composting

After speaking to Michael Orr, we realized that contracting with Grind2Energy to handle the high school's food waste specifically does not offer enough of a palpable benefit over the future curbside composting program. Although economically better than our proposed installation of a Grind2Energy system, the educational opportunity is lost with curbside composting. Creating educational material—such as videos on what happens to food waste in Cambridge, or redesigning compost signs to clarify confusion for students and staff —would fortify the program as a whole. The following explains the evolution of our idea through our research. We recommend making education for residents in Cambridge about food waste and food waste recovery a priority. This should include integrating such topics in classroom curriculums to stoke interest in related careers.

4. Site Visits

Throughout this summer, we did three site visits to enhance our understanding of the stages of the anaerobic digestion process. We visited the Whole Foods on River St., where we met with Matthew Keller, Cambridge Community Liaison. Several days later, we were given a tour of the wastewater treatment facility on Deer Island by Nadia Caines Thomas. The last place we visited was the Waste Management facility in Charlestown, where we spoke to Brendan Kuhn, Boston CORe Facility Manager. The following details information about each site visit and the technicalities of their systems.

a. Whole Foods

Our first trip was to observe the Grind2Energy machinery that processes the food waste at the Riverside Whole Foods in Cambridge. Once the food scraps are received at the end of each

day, an employee sorts through the food to ensure that it was mixed with wet and dry foods—an important step in the process. Once the foods are sorted and the non-compostable materials, such as bones and shells, are removed, the food goes down the drain into an agitator, which pulverizes the food into a slurry. This slurry is then pumped through pipes into the holding tank in the adjacent room. When the machine becomes filled with the slurry, there is an automatic system, notifying the Grind2Energy company to come and pick up the material.

b. Deer Island

In addition to visiting Whole Foods, we visited the wastewater treatment facility on Deer Island. The wastewater goes through a series of different processes to clean the water. First, undergoing a primary sedimentation process, then the secondary reactions, and finally the secondary sedimentation. The so-called primary sludge is then pumped to several digesters. Each digester can hold 60 million gallons of sludge and to increase efficiency, are egg-shaped. The digesters themselves are 140 feet tall structures and have a mixer attached at the top of the digester, keeping the contents mixed. The material spends about 20 days inside the digesters and continuous mixing ensures that the digestion process is done well. The microbes used in the digesters are grown on the plant and are separated out in the secondary process. 50 tons of gas are produced; about 70% is methane and about 30% is carbon dioxide. The leftover sludge is sent to a facility, which creates fertilizer pellets. The gas is trapped at the top of the digester and moved via gas compressors and finally boiled to be used as heat for turbines on the plant. About 98% of the gas created is re-used in the plant and the rest is flared for an equivalent of about 6 days in a year. Recently, the wastewater treatment facility on Deer Island looked into trying to bring food waste slurry from the system at Waste Management (for more information read the below section) to their facility, but for unspecified reasons, the deal fell through.

c. Waste Management

The third site visit we did was to the food waste facility at Waste Management Charlestown, MA. At this site, they have machinery which sorts through the food waste in order to rid it of contaminants, and a 55,000 gallon tank to hold the slurry produced from the food waste. The slurry is created on-site and trucked to anaerobic digesters at the wastewater treatment facility in Lawrence, MA. Currently, about 200 tons are trucked to Lawrence per week, but in the future, they will ideally be sending about 130 tons per day, managing around 700 tons per week. This full implementation will begin within 6 months, as the digesters in Lawrence are acclimating to producing energy from food waste, after having only produced energy from the waste found in their wastewater. At the moment, about 200 tons of food waste are being processed at the facility. The sources of this food waste are places such as restaurants, hotels, grocery stores, hospitals, food manufacturers, conference centers and schools. About 9-10% of the material collected is not sent to the digester because it is made up of contaminants such as plastics, compostable trays, utensils, etc. Instead, these are incinerated. After going through

machinery which separates contaminants from food waste and creates the slurry, it is pumped through pipes into the 55,000 gallon tank in the adjacent room. Reused water in a separate tank is added to the slurry as necessary, in order to dilute it and assist in the making of the slurry needed for the digester. In order to prevent the digestion process from beginning, the slurry is continuously mixed and "pickled;" that is, the pH is regulated with a proprietary treatment process.

5. Grind2Energy System

a. Technical Details:

i. Specifications/Dimensions

- 3-Phase, 208/230V - 35A or 460/480V - 25A electric supply with NEMA 4 rated disconnect box.
- ½" cold water line for processing table
- Outdoor tanks with frost protection require two 120V electrical disconnect boxes
- 4500 gal tank capacity
- Tank dimensions: 95 in diameter; 158.75 in tall
- Maximum pipe length 60-70 ft

ii. Safety Hazards

The Grind2Energy system poses minimal safety hazard. The "InSinkerator," which is the sink component, is bladeless. Within the disposal chamber, there is a centrifuge that spins at a high rate, serving to pulverize and thoroughly mix the waste. The second component, the storage tank, is insulated and airtight. Because no methane or other gases are released, there is little to no odor, ensuring sanitary conditions around the tank. Additionally, there is an automatic notification when the tank reaches capacity, thereby preventing an overfill or waste backup.

iii. Finances

EMERSON

Preliminary Price Proposal

grind 2 energy

Prepared for

Cambridge Rindge and Latin School

We are pleased to provide the following Grind2Energy price proposal

Grind2Energy Monthly Equipment, Data and Service Package Includes

Installation/Start-up: Site Survey, 2D/3D CAD Drawings, professional installation of the processing table, holding tank, all necessary system components and start-up.
IoT technology: visibility into system operation, run times, performance data and metrics, remote tank monitoring and service, tonnage and sustainability reports.
Sevice & Support: 24/7 customer support line, routine and emergency service, as well as on-site training.

Hauling and Disposal Price per Pump-out

Pump-outs are based on the actual tonnage generated by facility and would be billed based on the previous month's activity.

Quotation Date (proposal valid for 60 days) 07/29/17	**Agreement Length** 4 years
Number of Installations 1	**Estimated Hauling and Disposal Rate** $ 650.00
Capital Expenditure Offset / Earnest Money $ 0.00 / $ 0.00	*7 - 8 pump-outs per year based on estimated tonnage of 1 ton/week to process*
Monthly Equipment, Data and Service Package $ 1,499.00	

Approved by:
Name & Title:

Signature: Date: / /

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The above document is a preliminary proposal given to us by Grind2Energy. It shows the estimated subscription cost and pickup fees for the school district. There would be no upfront cost besides the initial installation of necessary utilities: specifically, a cold water line, and a three-phase electrical power supply. The subscription is $1,500 per month; this covers all maintenance and repairs on the Grind2Energy system. There is also an additional hauling fee of $650 for every pickup, where the slurry in the tank is pumped out and transported to nearby digesters. This would occur 7-8 times in a school year. Altogether, the monthly average cost for the school year would be about $2,000 per month.

This is admittedly a steep price, compared to both the current composting program which handles the school's food waste, as well as the future curbside composting program. The most recent invoice from Rocky Hill Farm in Saugus, MA, which formerly received the school's organic waste, gave a total of $1,138.20 for the month of May 2017. This is almost half of the cost of Grind2Energy; a difference which is further compounded by the fact that the invoice is not only for collection from CRLS—it encompasses surrounding buildings and residences, as well (we do not have a determinate area).

As for the planned curbside composting program, the cost differs by nearly an order of magnitude. While we do not have not done or received any sort of cost analysis, Michael Orr, Recycling Director, gave us his own estimate: according to him, the monthly cost for CRLS alone would be about $250 per month, a clear disparity.

c. Advantages over Curbside Composting

There are a multitude of economic, environmental, and educational benefits to installing a Grind2Energy system compared to the current composting program. Unlike composting, which only produces a product, anaerobic digestion is an energy net-positive process, which can directly generate heat and/or electricity. The system is able to create green energy from waste, which repurposes food waste to benefit the community. In fact, a single 4,500 gallon tank of slurry provides about 2,100 kilowatt-hours of electricity, which is enough to power the average Massachusetts household for over 100 days.[6]

The physical technology would be an opportunity to educate the student body, working as a visual reminder of how food waste affects our community. The machinery would create interest in technology/food sustainability, increase the association students have with food waste, and establish an opportunity to raise awareness about food waste. To explain the process of anaerobic digestion, students can gain an understanding of organic chemistry, environmental science, biology, culinary, and chemistry through lessons integrated into a curriculum.

6. Conclusion

Because the City of Cambridge has plans in the near future for food waste to be sent to anaerobic digesters, the Grind2Energy proposal is not an economically sound one. The main benefit in opting to use the Grind2Energy service is in the educational opportunities it provides. Part of the reason for the apathy among students about food waste is a result of a detachment from its disposal site. Garbage is thrown into receptacles, out of sight and mind, and often travels vast distances. A Grind2Energy system could be used as a focal point, in order to integrate the issue of food waste in various curriculums. It could also be a point of pride and distinction for the school community.

However, it would be somewhat disingenuous to neglect the many educational possibilities which the forthcoming program brings to the school district. School field trips to the Waste Management facility might be equally beneficial. Students could see in person the machinery employed in preparing the food waste for digestion, as well as receive explanations from specialists about the processes involved and day-to-day functions.

As it stands, Cambridge is at the vanguard of food sustainability initiatives; and more broadly environmental sustainability. Therefore, it is plausible that the impact of the Grind2Energy system would be somewhat diluted, as compared to its introduction in places without the infrastructure within and around Cambridge which underlies such programs. Any possible advantage this union offers is superseded by the drastically lesser expense and labor in sending CRLS organic waste to Waste Management, as a part of the collective City waste. For this reason, we cannot recommend a partnership between CRLS and Grind2Energy as the best course of action.

7. Future Related Projects

We want to push the importance of education because even though it will be our last year at CRLS, we want the classes after ours to take initiative in designing innovative ways to tackle the pressing issue of food waste. For example, students can develop learning material for an x-block, an 80 minute homeroom/community meeting period to raise awareness about issues in the community. The following explores possible talking points for the x-block regarding food waste:

1. Differences of compost, recycling, and trash
2. Food waste journey from kitchens to digester
3. Student impact locally and globally
4. Clarifying compost signs to reduce confusion

8. Contacts of Experts

- Christine Beling – Project Engineer, Assistance and Pollution Prevention Unit – Environmental Protection Agency – 617-918-1792 – beling.christine@epa.gov
- Meryl Brott – Recycling Program Manager – Cambridge Department of Public Works – <mbrott@cambridgema.gov>
- Jerry Friedman, P.E. – Supervising Engineer – Cambridge Department of Public Works – 617-349-9720 – <jfriedman@cambridgema.gov>
- Vedad Konjic – Director of Facilities – Cambridge Public Schools – 617-201-6054 – <vkonjic@cambridgema.gov>
- Brendan Kuhn – CORe Facility Manager – Waste Management – 617-483-5990 – <bkuhn2@wm.com>
- Sarah Levinson – Planner – Environmental Protection Agency – 617-918-1390 – <levinson.sarah@epa.gov>
- Michael Orr – Recycling Director – Cambridge Department of Public Works – 617-349-4815 – <morr@cambridgema.gov>
- Maria Reuter – Business Development Manager – Emerson – 262-366-5672 – <maria.reuter@emerson.com>
- Jeffrey Roberts – Senior Manager for Zoning and Development – Cambridge Community Development Department – 617-349-4639 – <jroberts@cambridgema.gov>
- Wendy Robinson – Wastewater Engineer – Cambridge Department of Public Works – <wrobinson@cambridgema.gov>

9. References

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