# FINAL REPORT: FOOD WASTE TO ENERGY AND FERTILIZER

MARCH 2010

Wisconsin Department of Natural Resources
Type A Project: Contracts with Non-Profits for Business Waste Reduction and Recycling Assistance

WasteCap Resource Solutions, Inc.
131 WEST SEEBOTH STREET, SUITE 220
MILWAUKEE, WI 53204-4300
P: (414) 961-1100 | F: (414) 961-1105
WWW.WASTECAP.ORG

# Final Report: Food Waste to Energy and Fertilizer

## WISCONSIN DEPARTMENT OF NATURAL RESOURCES TYPE A PROJECT: CONTRACTS WITH NON-PROFITS FOR BUSINESS WASTE REDUCTION AND RECYCLING ASSISTANCE

## TABLE OF CONTENTS

# ONE | PROJECT BACKGROUND

Food waste has a significant public health impact; it rots, smells bad, and attracts rodents and insects. Food waste drives municipal solid waste (MSW) collection frequency, the major cost of MSW management (from 75% to 80% of a MSW budget and around \$100/ton)[1]. Landfilling adds an additional \$30/ton. It also generates greenhouse gasses during decomposition, while the energy value and the soil nutrient value are lost when landfilling. Removing food waste from MSW has the potential to decrease greenhouse gas emissions, public health issues, MSW collection frequency and MSW management costs, increase renewable energy production in Wisconsin, and provide nutrients to our soils.

## Project Players

WasteCap Resource Solutions Food Waste Advisory Committee, in seeking alternatives to food waste in the municipal solid waste stream, concluded that anaerobic digestion of food waste to result in energy production and soil enhancement residuals has the potential to economically divert food waste from commercial sources, and may result in significant environmental benefits, including energy production and availability of the organic and nutrient value of food scraps to be utilized.

Veolia Water is the contracted operator of two wastewater treatment plants owned by the Milwaukee Metropolitan Sewerage District (MMSD). The South Shore Water Reclamation Facility has available capacity in its anaerobic digestion process. Veolia Water is seeking sources of organic wastes that are compatible with plant operations to fill some of this capacity. MMSD's anaerobic digestion process produces methane, which is harnessed as a renewable energy source to power electrical generators and air compressors, while the excess heat is used in boilers as the primary heating source for the digesters. At the onset of this project, 75% of the biosolids at MMSD produced from the anaerobic digestion process were turned into Milorganite and sold as a fertilizer, while 25% were applied to farm fields. Near the completion of the pilot project, however, MMSD shifted their focus to convert 100% of their biosolids into Milorganite.

Outpost Natural Foods Cooperative, an organic foods grocer with three Milwaukee locations, was interested in an environmentally-sustainable method of disposing of their food waste in congruence with their corporate values. At project start, 32 $yd^3$/wk of solid waste was collected from the Outpost Natural Foods Kinnickinnic Avenue (KK) location, with 30% of the waste comprised of food waste. An additional 32 $yd^3$/wk of solid waste was collected from the Outpost Capitol Drive location and 24 $yd^3$/wk of solid waste was collected from the Outpost State Street location, with both 30% of volume being food scraps. The waste required disposal 4 times/wk, due to space, odor, and health affects.

InSinkErator, the world's largest manufacturer of food waste disposers, has conducted or obtained numerous research studies around the world, which validate disposers as an environmentally responsible tool for transferring food waste into municipal sewerage systems and diverting from landfill disposal.

[1] Glysson, E.A. 1990. Chapter 8. "Solid Waste", *Standard Handbook of Environmental Engineering*, R.A. Corbitt, McGraw-Hill, Inc. p. 8.36.

## Acknowledgements

The Food Waste Committee would like to acknowledge a number of key individuals who helped to coordinate efforts of this project, for without their assistance this project would not have been possible:

- Wisconsin Department of Natural Resources – Cynthia Moore, Sarah Murray – for the financial support without which this project would not have been possible
- Outpost Natural Foods – Ed Senger, Tom Kneuppel, and Bob Wiroll
- Milwaukee Metropolitan Sewerage District - Peter Topczewski, Andy Walloch, and Elizabeth Stroik
- Veolia Environmental Services - Allan Luttinen and Ed Maki
- City of Milwaukee, Plumbing Inspector's Office – Foster Finco
- United Water Milwaukee LLC – Dennis Dineen, P.E. and Mike Link, P.E.
- WasteCap Resource Solutions – Susan Buchanan, Jenna Kunde, Alexis Stoxen, and Rob Sherman, P.E.
- InSinkErator, Division of Emerson Electric Company – Bill Strutz, P.E.


## Contributors

Members of the WasteCap Resource Solutions Food Waste Committee who guided the pilot project study and derived the findings for this final report are:

### STEVEN BRACHMAN | UNIVERSITY OF WISCONSIN-EXTENSION OF SOLID AND HAZARDOUS WASTE EDUCATION CENTER

Mr. Brachman serves as a Waste Reduction and Management Specialist and Distinguished Lecturer. He is primarily responsible for providing technical assistance and educational programs for pollution prevention, recycling, and solid and hazardous waste management projects for consumers, business and local governments in Wisconsin.

### CAROL DIGGELMAN, PH.D., MILWAUKEE SCHOOL OF ENGINEERING

Ms. Diggelman serves as a Professor in the Architectural Engineering & Building Construction (AE&BC) Department. She has a 1998 PhD in Environmental Engineering from UW-Madison; her advisor was Dr. Robert Ham and dissertation title was "Life Cycle Comparison of Five Engineering Systems for Managing Food Waste." Ms. Diggelman has over 30 years of teaching experience. She teaches and advises students in MSOE's Master of Science in Environmental Engineering (MSEV) Program. Environmental engineering research activities are in various aspects of solid waste management (municipal solid waste, food waste, waste electronics, and wood waste).

### MICHAEL GITTER, P.E., RACINE WATER & WASTEWATER UTILITIES

Mr. Gitter serves as the Chief of Operations. He holds a M.S. in Environmental Engineering from the Milwaukee School of Engineering. He is a certified water and wastewater operator for the State of Wisconsin, and has over 20 years experience in industrial and municipal wastewater operations. Currently, he reviews and evaluates overall water and wastewater utilities operations, systems, programs, and budgets for compliance with community needs, utility objectives, regulatory requirements, and mandates. Mr. Gitter is also a WasteCap Resource Solutions Board Member and Chair of the Food Waste Advisory Committee.

### MICHAEL KELEMAN, INSINKERATOR (DIVISION OF EMERSON ELECTRIC COMPANY)

Mr. Keleman serves as an Environmental Engineer in the Advanced Development Engineering Group of the R&D Engineering Department. He is working toward a M.S. in Environmental Engineering from the Milwaukee School of Engineering, and has a B.S. in Environmental Health Science from Purdue University. Currently, his main job focus is to provide internal support and outside expertise on the technical analysis of food waste disposers' impact on wastewater sewerage and septic systems, and solid waste disposal systems; and work with researchers on innovative food waste remediation technologies.

# TWO | PROJECT OBJECTIVES

## THE OBJECTIVES OF THE FOOD WASTE TO ENERGY AND FERTILIZER PROJECT WERE TO:

### A

Divert food waste from solid waste landfill disposal for beneficial recycling into an anaerobic digestion process, where methane could be utilized for a renewable energy source and residuals could be utilized as a fertilizer-like soil enhancement product.

### B

Provide MMSD with organic waste material to utilize existing plant capacity, which will increase its renewable energy generation, Milorganite production, and economic position.

### C

Provide Outpost Natural Foods with a more sustainable means of disposing of its food scraps, which is aligned to their corporate mission.

### D

Develop an environmentally friendly, sustainable, and cost effective strategy for food waste disposal, which could be expanded throughout the City of Milwaukee and provide a state-wide template. The strategy would categorize commercial and industrial food waste as a resource to encourage energy and nutrient recovery, minimize public health issues related to food waste management practices, and minimize fossil fuels and reduce process related emissions required to manage food waste.

# THREE | PROJECT OVERVIEW

The WasteCap Resource Solutions Food Waste Committee initiated the pilot project for food waste separation at Outpost Natural Foods in Milwaukee and hauling to the Milwaukee Metropolitan Sewerage District (MMSD) for waste energy recovery and landfill diversion in April 2007. For the pilot project, each of the three Outpost grocery locations utilized a different means to manage food scraps. The Capitol Drive location continued to haul food scraps with solid waste to landfill to serve as a baseline scenario. The State Street location utilized an InSinkErator food waste disposer to discharge ground food scraps to the sanitary sewer system and, thus, to MMSD. [Note: The State Street portion of the project was not funded through the DNR Type A Contract, but rather the entire funding was provided independently by InSinkErator.] The Kinnickinnic Avenue location utilized a food waste "slurry system," consisting of a food waste disposer to grind scraps into particles smaller than ½" and storage in an underground holding tank.

## A | Outpost Natural Foods, 100 East Capitol Drive in Milwaukee

This location served as a baseline scenario, as food waste continued to be hauled with the solid waste to landfill.

## B | Outpost Natural Foods, 7000 West State Street in Wauwatosa

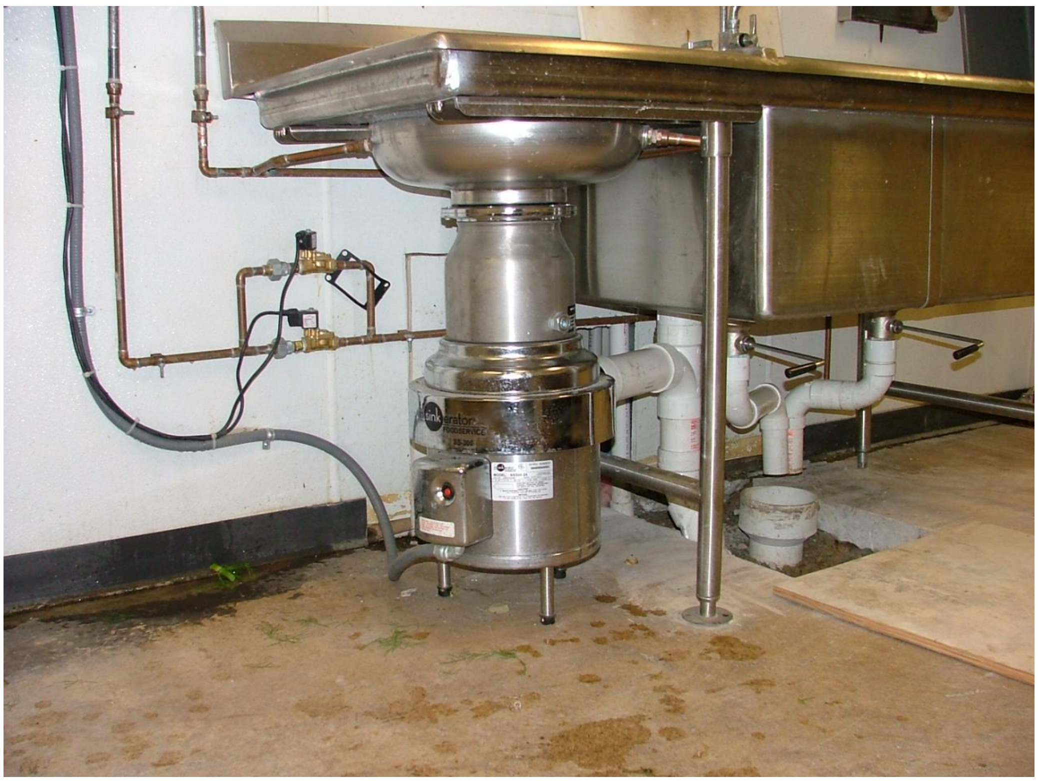
This location had installed an InSinkErator SS300 Food Waste Disposer with accompanying work table, bowl, and plumbing appurtenances for discharge to the City of Wauwatosa sanitary sewer system. All of the equipment, plus plumbing and electrical contractor installation costs, were funded by InSinkErator and not through the DNR Contract. The DNR did not support funding for this phase of the project because of initial concerns of potential grease problems developing in the sewer lateral or main from the disposal of food scraps. To assess the impact to the sewer system, the MMSD arranged for a private contractor, Visu-Sewer, to televise the local sanitary sewer system prior to disposer installation to determine the pre-project baseline condition. The televising was performed in September 2007. In addition, the Committee televised the sewer lateral in July 2008 when the disposer system was installed. Outpost employees were also provided training by the Committee at that time on the proper operation of the disposer, including proper grease management methods. Food waste grinding through the disposer was initiated in September 2008.

A water meter was installed on the disposer feed line to record gallons of water used to flush food scraps to sewer, and a run timer was installed to record the hours of disposer operation. By knowing the operation hours, an estimate of disposer electric usage can be determined. These meters were recorded consistently by the Committee through the term of the pilot.

MMSD personnel conducted composite sampling from the Outpost sewer manhole about twice per month. The samples were analyzed by the MMSD certified laboratory for heavy metals (arsenic, cadmium, chromium, copper, iron, lead, mercury, molybdenum, nickel, selenium, and zinc), FOG (fats, oils & grease), BOD (biochemical oxygen demand), TSS (total suspended solids), TKN (total kjeldahl nitrogen), and TP (total phosphorus). The sampling was initiated on October 6, 2008. Sampling for all but BOD, TSS, and TKN was suspended on March 4, 2009 after 10 samples showed no appreciable levels of the other pollutants of concern.

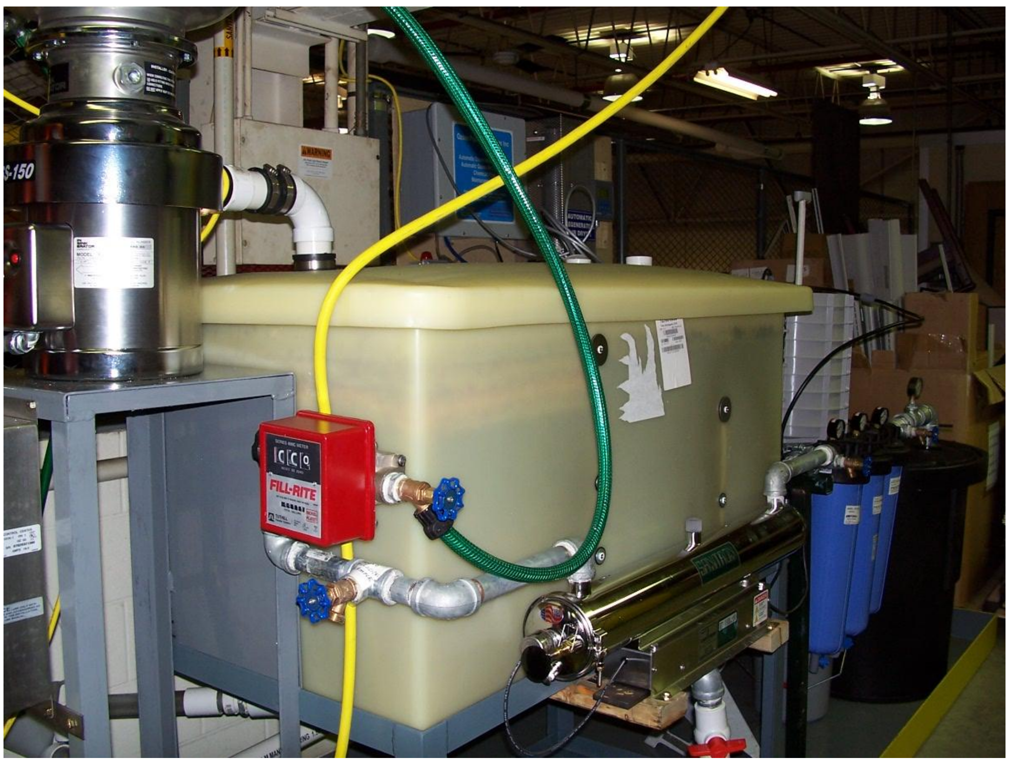
## C | Outpost Natural Foods, 2826 South Kinnickinnic Avenue in Bay View

This location had an InSinkErator SS300 Food Waste Disposer installed with accompanying work table, bowl, and plumbing appurtenances for discharge to an underground holding tank. The holding tank was a 2-tank design (i.e., 3,500 gal solids compartment and 1,250 gal water compartment). Because water gravity discharge was physically impossible at this location, a 1 hp submersible grinder pump was installed to discharge the water out of the system and into the sanitary sewer. Also, the tank was equipped with a Zabel 1/64 inch coarse filter and alarm system to maintain the food solids, while the carrier water flowed through the system and discharged to the sewer, resulting in a thickening of the holding tank contents. When full (as signaled by a tank filter alarm), the tank was then pumped by Veolia Environmental Services and hauled to MMSD for pumping directly into the anaerobic digesters, where its small particle size promoted rapid biological breakdown of the waste. As the waste breaks down, it is converted to gas (mainly methane), which can be harnessed as a renewable energy source.



KINNICKINNIC DISPOSER INSTALLATION

The Committee prefaced the full-scale installation by conducting a lab-scale (1/10$^{th}$ scale) test phase of the system in June 2007. The lab-scale system consisted of an InSinkErator SS150 commercial disposer grinding food waste collected from Outpost Natural Foods on a daily (Mon-Fri) basis. The food scraps were ground through the disposer and discharged into a 100-gal polyethylene storage tank (i.e., simulated holding tank), which was equipped with 2 baffles to maintain the bulk of the solids and a removable cover. A Zabel 1/64 inch coarse filter was connected externally to the tank piping, due to size constraints, to maintain solids from passing through the system, which was fitted with an audio control alarm to alert the operator for the need of manual filter cleaning. The water flowing through the coarse filter was collected in a second tank 50-gal compartment, which was also baffled and contained a submersible discharge pump. The pump was actuated by a solenoid when the disposer became operational, and returned water to the disposer inlet for flushing. The return line was equipped with 3 bag filters of reducing pore size (down to 1 um), followed by disinfection. Two mechanisms of disinfection were installed, including a 10 gal/min ozone unit (unit/injection/air dryer) and a 12 gal/min ultraviolet light (UV) unit, which could be run individually or in tandem. Water meters, pressure gauges, and sample ports were strategically located to provide testing data. Testing conducted included total solids (TS), pH, oxidation reduction potential (ORP), turbidity, heterotrophic aerobic bacteria (HAB), and total coliforms. ORP and pH monitored the development of septic conditions in the storage tank; TS determined the solids content of the solids fed into the system and the solids to be hauled from the tank for disposal; and turbidity, HAB and coliforms provided data on the quality of the return water.




LAB SCALE SLURRY SYSTEM AT INSINKERATOR IN RACINE, WI

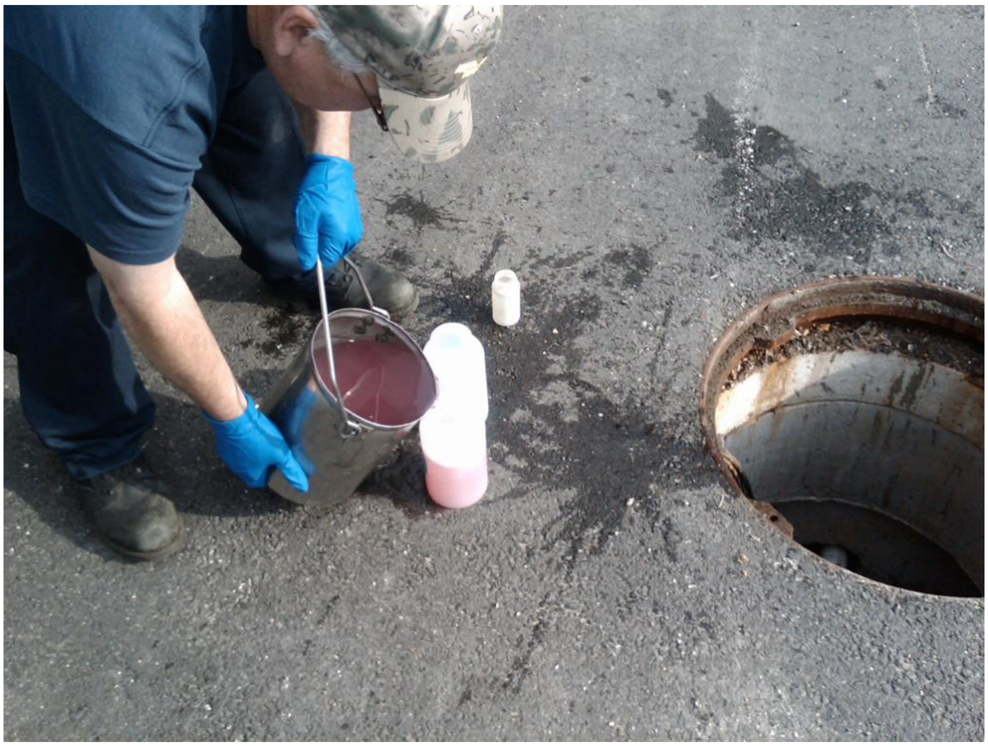
The lab-scale system functioned well to segregate food waste solids and separate the large solids from the disposer discharge, as a sample collected on July 2007 showed 22,300 mg/L TSS (2.2% solids), 7,720 mg/L BOD and 61.4 mg/L FOG. However, the quality of the re-use water was not acceptable for a kitchen setting with the bag filter/UV disinfection scheme (odors and pathogens were high, due to suspended particles smaller than 1 micron and dissolved organics leaching through the filters). The return water was detected with turbidity at about 300 NTU, BOD greater than 2,000 mg/L and high bacteria levels (HAB 16,000,000 CFU). With this data obtained, the lab-scale system was ended in November 2007. The solids concentration in the tank gave promise that a full-scale system would work, with the lab-scale system maximum feed of food waste about 2 lb/gal of water to allow the consistency of the waste to remain "pumpable."

As a result of the lab test, the full-scale system was designed without water reuse. Instead, an InSinkErator "Aqua-Saver" water control unit was installed on the disposer water feed line to reduce water usage for flushing food waste to sewer. The Aqua-Saver works to restrict flow to a pre-determined flow rate (i.e., 1 or 3 gpm) and to shut flow off completely after a set time frame when the disposer is not in use. A water meter was installed on the disposer feed line to record gallons of water used to flush food scraps to sewer, and a run timer was installed to record the hours of disposer operation. By knowing the operation hours, an estimate of disposer electric usage can be determined. These meters were recorded consistently by the Committee through the term of the pilot.

Full-scale system design was complicated by the existing plumbing configuration at the Outpost Kinnickinnic store. This factor, along with the approaching winter, pushed the full-scale slurry system installation to the spring of 2008. Additional delays were realized when the MMSD contract operations changed from United Water to Veolia Water in February 2008, bringing a new project partner into the pilot. In order to confirm participation by all new and existing project partners, a Memorandum of Understanding (MOU) was signed in September 2008. The MOU provided a written letter of support for all parties involved. Included in this support is that MMSD would waive all analytical costs associated with the project, and Veolia Water would waive the tipping fees and reimburse Veolia Environmental for the hauling fees for the 1-year project duration. MMSD would also compile all of the analytical data and provide it to the Committee for assessment. Thus, the project received outstanding partner support, including donation of the disposer and Aqua-Saver by InSinkErator. Construction of the slurry system was completed by Lagina Plumbing in September 2008, through a competitive bidding process.

KinnickiNnic Slurry Tank Installation

MMSD personnel conducted composite sampling from the slurry tank solids compartment and water compartment every time the tank was pumped and hauled to MMSD. Hauling was initially scheduled to occur every 3-4 weeks, but was extended to about 8 weeks as the project progressed. The samples were analyzed by the MMSD certified laboratory for heavy metals (arsenic, cadmium, chromium, copper, iron, lead, mercury, molybdenum, nickel, selenium, and zinc), FOG (fats, oils & grease), BOD (biochemical oxygen demand), TSS (total suspended solids), TKN (total kjeldahl nitrogen), and TP (total phosphorus). The sampling and first tank hauling was initiated on October 3, 2008. Sampling for all but BOD, TSS, and TKN was suspended on March 2, 2009 after 4 samples showed no appreciable levels of the other pollutants of concern.



MMSD Sampling Crew Collecting Slurry Tank Effluent

# FOUR | PROJECT FINDINGS

## A | Outpost Natural Foods, 100 East Capitol Drive in Milwaukee

This location served as a baseline scenario, as food waste continued to be hauled with the solid waste to landfill. Currently, this facility generates about 10 $yd^3$/wk of food waste (30% of the solid waste total), as it did at project start. For the pilot, this waste continued to be placed in dumpsters and hauled to landfill (4 times/wk). Prior to installation of the disposer, Outpost solid waste was collected 4 times per week for a total of 32 $yd^3$/wk. At the conclusion of the 1-year pilot project, Outpost solid waste collection remained the same.

### Advantages:

Solid waste disposal is advantageous because it is a convenient and established method.

### Disadvantages:

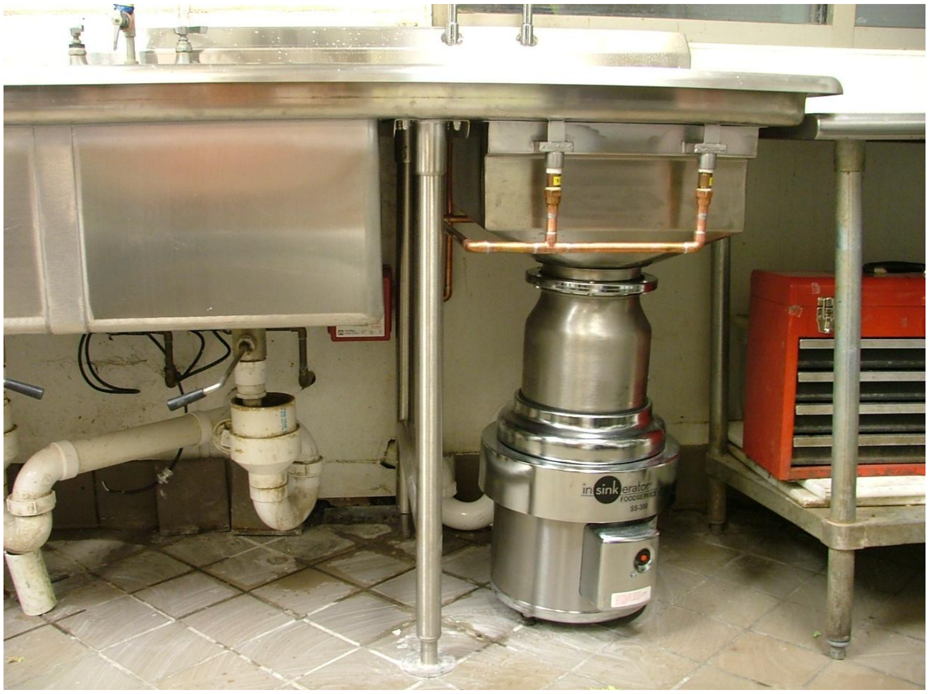
The disadvantages to solid waste disposal of food scraps are transportation costs will be the highest of the 3 scenarios used in the pilot (highest frequency). Labor costs will also be the highest, due to the necessity of physically handling the waste at both the source and removal. Outpost will also have storage space and odor issues associated with the waste. Landfill capacity will continue to be used for this recyclable waste and the energy and nutrient value of the waste is essentially lost. Leachate and greenhouse gas residues at the landfill are also environmentally negative, as well as greenhouse gas emissions and fuel costs from the trucks. Finally, the energy value of the waste is lost as methane will escape the landfill prior to the cap being placed.

## B | Outpost Natural Foods, 7000 West State Street in Wauwatosa

The food waste disposer worked effectively to grind food scraps and discharge to the sanitary sewer and to MMSD for biological treatment. Currently, this facility generates about 7.2 $yd^3$/wk of food waste, as it did at project start. The facility did experience some issues with plugging of the discharge line, which was determined to be caused by a 2" pipe size that should have been 3" in diameter. As a result, the committee changed the procedure to increase the flushing rate from 3 to 7 gpm during grinding, and instructed the operators to not grind in bulk. The staff at Outpost Natural Foods was inclined to feed scraps to the disposer in bulk and additional training was needed to space the feeding, so the disposer could more effectively clear the discharge line and convey the waste. These changes appear to have improved conditions.

### Water Usage:

Water usage was found to average about 181 gal/day, for a cost of $180/yr. The disposer run time was found to be 23 min/day on average, for an electrical equivalent of $59/yr. Approximately 800 lbs of food scraps were ground through the disposer daily on average, and grinding occurred in 30-45 minute daily intervals. The sampling data for the facility total wastewater discharge (shown in Appendix 1) resulted in average values over the 1-yr pilot of 45 mg/L of FOG; 562 mg/L of BOD; and 328 mg/L of TSS. These numbers are only slightly higher than MMSD normal domestic strength waste values of 310 mg/L BOD and 370 mg/L TSS. Thus, the ground food waste did not appreciably change the characteristics of the wastewater discharge at the grocery store. In addition, grease was not found to be a problem in terms of sewer conveyance. The Committee had planned to televise the sewer main at pilot project completion. However, since MMSD did not detect any issues in the main during pre-project televising; and since MMSD personnel inspected the sewer main visually throughout the project on a weekly basis and found no evidence of food waste accumulation; and since MMSD received no sewer complaints from the City of Wauwatosa of sewer backup problems at the State Street address, the televising at project end was not performed. Also, a televising of the lateral to about 120 feet did not reveal any obvious debris in the line.



STATE STREET DISPOSER INSTALLATION

Due to a reduction in solid waste disposal and no evidence of sewer line problems, the food waste disposer method of food scraps disposal was continued after the project was completed. Prior to installation of the disposer, Outpost solid waste was collected 4 times per week for a total of 24 $yd^3$/wk. After installation of the disposer, Outpost solid waste collection dropped to 3 times per week for a total of 18 $yd^3$/wk.

### Advantages:

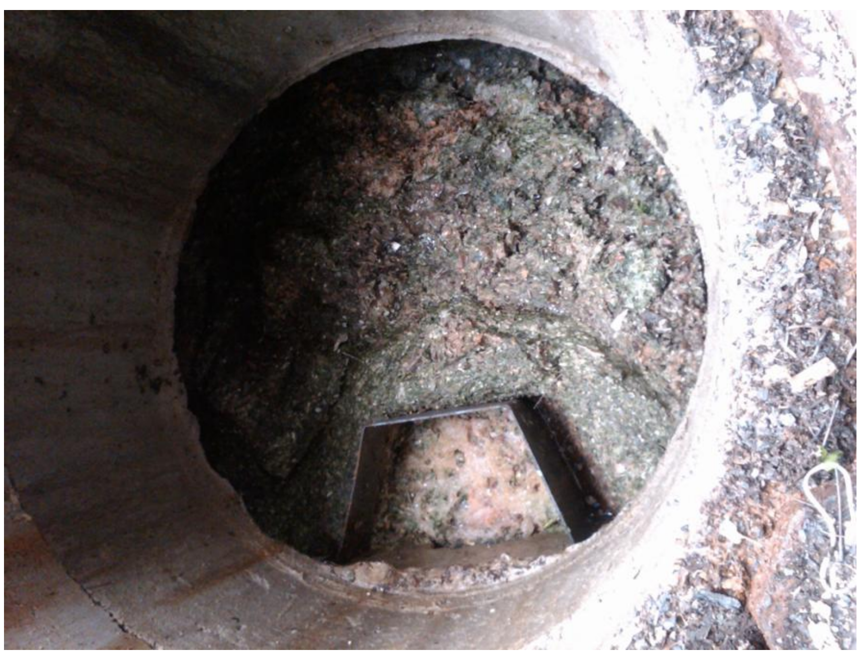
The advantages to direct sewer disposal of food scraps through a food waste disposer are for renewable energy value at MMSD, and enhanced organic/nutrient value in the Milorganite biosolids product. Other advantages are no labor is involved, as there is no waste handling or storage, other than running the waste through the disposer. Also, there is no transportation needed and, thus, no hauling cost. Health and odor issues are also eliminated as the waste is immediately removed from the site.

### Disadvantages:

The disadvantages to direct sewer disposal of food scraps through a food waste disposer are that the waste will need to go through the entire MMSD treatment plant process, which may increase overall treatment costs. [However, this can also be an advantage as more carbon will be available to the biological treatment nutrient removal processes, in lieu of the need for a chemical carbon source.] Another negative is the need for carrier water and its associated cost. There may also be a need for some additional sewer maintenance, from any grease generation, although Outpost waste was mostly fruits and vegetables and not of grease origin. As the waste passes through the entire MMSD plant process, less methane energy will be realized in the anaerobic digester, and a higher overall treatment cost is likely, compared to the slurry disposal (which is pumped directly into the digester). There is also the capital cost of the disposer and installation. A final point is that MMSD does not “surcharge” for excess discharges of conventional pollutants above typical domestic waste values. Some municipal wastewater utilities do surcharge for excess discharges of pollutants such as BOD, TSS, and Phosphorus, of which food waste can cause an increase.

## C | Outpost Natural Foods, 2826 South Kinnickinnic Avenue in Bay View

The food waste disposer worked effectively to grind food scraps and discharge to the slurry tank and for hauling to MMSD for biological treatment. Currently, this facility generates about 12 $yd^3$/wk of food waste, as it did at project start. The facility did experience some issues with plugging of the discharge line, which was determined to be caused by a 2" pipe size that should have been 3" in diameter. As a result, the committee changed the procedure to increase the flushing rate from 3 to 7 gpm during grinding, and instructed the operators to not grind in bulk. In addition, staff was inclined to feed scraps to the disposer in bulk and additional training was needed to space the feeding, so the disposer could more effectively clear the discharge line and convey the waste. These findings will help in design of future installations.
Ground food scraps tended to congeal at the inlet of the slurry tank, although the increased flow rate did distribute the solids better throughout. Slurry hauling (3,500 gal) occurred on the following dates: 10/3/08, 11/14/08, 12/18/08, 1/27/09, 3/26/09, 5/29/09, 7/24/09, and 10/9/09; for a total of 8 hauled loads. Originally, the tank was to be pumped every month or so, but the hauling was extended to 2 months, as the tank solids were about 0.6% total solids, with the highest concentration of 0.96% total solids on the last hauled load. MMSD prefers to pump organic waste at about 5% solids into the digesters. A thicker waste is desired for anaerobic digestion so excess water does not waste energy needed to heat the digester, and treatment capacity is reserved for organic wastes. Due to the dilute nature of the waste, the MMSD and the Committee concluded that direct sewer disposal through a food waste disposer is the best disposal option for the waste.

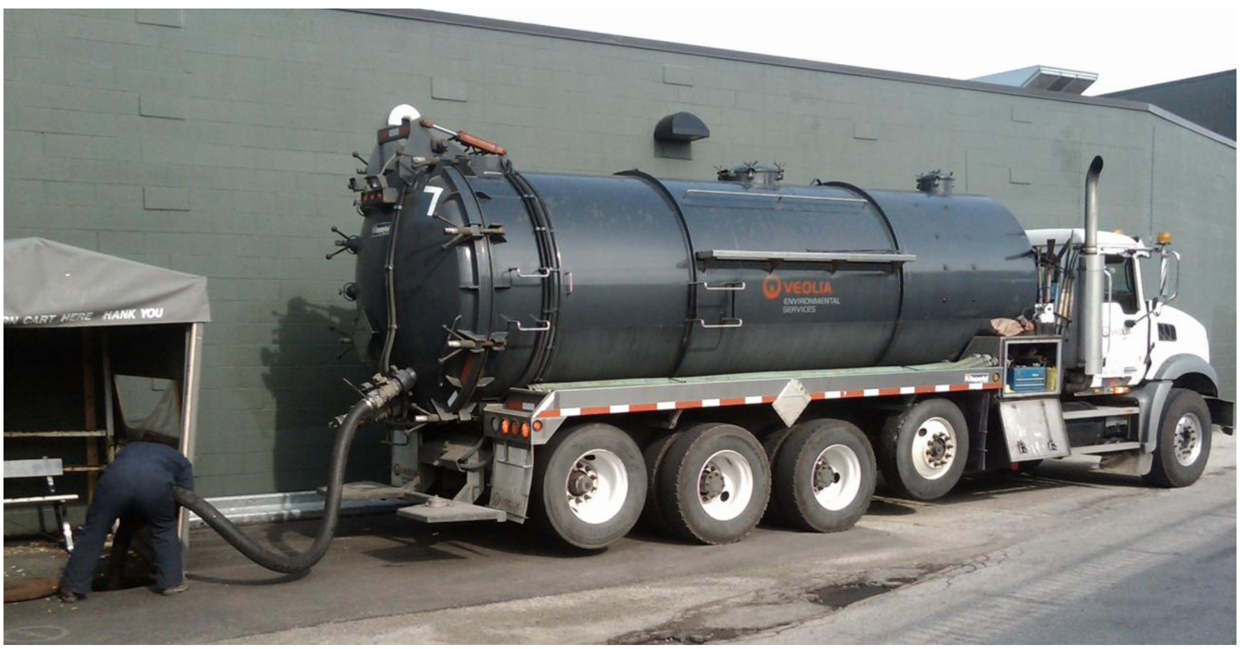


SLURRY TANK MANHOLE WITH SOLIDS BUILDUP CONCENTRATING NEAR THE INLET

The lab-scale slurry system found the quality of the reuse water to be too poor for a food prep area. In order to improve the quality for water reuse, the Committee reviewed alternative filtering systems and found ceramic membranes (nanofiltration) to be a good application for food waste. However, the cost of these systems (i.e., $30,000 to $50,000) makes them cost-prohibitive for use in a waste disposal scheme, unless a facility was impacted by strict water rationing regulations. The payback period based on median water and sewer rates of 0.5% to 1% per gallon would result in payback of 10 to 30 years for median or large sized food service establishments. Thus, discharging the flush water to sewer was the most economical solution.

**Water Usage:**

Water usage was found to average about 159 gal/day, for a cost of $104/yr. The disposer run time was found to be 20 min/day on average, for an electrical equivalent of $59/yr. Outpost was very pleased to reduce its food waste from 6-7 containers per day to 1 container per day through the use of the disposer and slurry tank (about an 85% reduction). Approximately, 1,058 lbs of food scraps were ground through the disposer daily on average, and grinding occurred in 30-45 minute daily intervals. The solids compartment sampling data (shown in Appendix 1) resulted in average values over the 1-yr pilot of 39 mg/L of FOG; 6,550 mg/L of BOD; 6,100 mg/L of TSS; and 7,967 mg/L TS. It was very difficult getting representative samples, due to the lack of mixing in the tank. This was offset in later samples by pumping the waste out and back into the tank as a mixing means. Thus, the BOD and TSS data is from the average of the last 4 samples only (most representative). The flow-through water compartment sampling data (shown in Appendix 1) resulted in average values over the 1-yr pilot of 5.3 mg/L of FOG; 2,257 mg/L of BOD; and 80 mg/L of TSS. Thus, about 34% of the BOD (mainly dissolved) flowed through the tank to the sanitary sewer, while about 98% of the solids remained in the tank. Very little FOG escaped the slurry tank, as expected, although grease levels were quite low in the wastestream overall (mainly fruits and vegetable waste).




VEOLIA ENVIRONMENTAL SERVICES PUMPING SLURRY TANK

Lab analysis indicates that the food waste slurry was received and assimilated by the MMSD treatment plant without incident; however, the waste in the tank was found to be very dilute (about 0.6% total solids). Only after the system was first put into use, an onsite observation determined that the two compartment sink was also plumbed into the slurry tank, and so the hydraulic loading to the tank was higher than intended. Thus, the tank was underloaded with food waste and could accept more. Increasing the loading would increase the hauling frequency from 8 weeks to closer to 3 weeks, as the project was initially conceived. Odors were not detected to be problematic while storing the waste for several weeks underground, but odor was quite noticeable when the tank cover was removed for pumping.

Due to a reduction in solid waste disposal and no evidence of sewer line problems, the food waste disposer method of food scraps disposal was continued after the project was completed. Prior to installation of the disposer, Outpost solid waste was collected 4 times per week for a total of 32 $yd^3$/wk. After installation of the disposer, Outpost solid waste collection dropped to 2 times per week for a total of 16 $yd^3$/wk. The solid waste disposal costs at this Kinnickinnic Avenue location is skewed higher than the other 2 sites, because Outpost Natural Foods pays a premium rate as the location requires a different hauler. This difference is an additional $8.25 per haul in comparison to the Capitol Dr location, which uses the same size dumpster.

### Advantages:

The advantages to disposal of food scraps through a hauled slurry tank are for MMSD renewable energy value, and organic/nutrient value in the biosolids. Also, transportation costs will be reduced (in comparison to solid waste transport) as the slurry tank was hauled once every 4-8 weeks (in comparison to 4 times/wk for solid waste hauling). Health and odor issues will also be minimized as the system was completely contained. The waste is thickened for anaerobic digestion, and the methane value of the waste is maximized because of direct digester injection. The system is also applicable to disposal at alternative organic processing facilities that may arise, as it solves the major problem of food waste segregation. It was noted in the lab-phase that the solid waste received from ONF contained plastic, wire ties, and wood pieces, although ONF personnel were vigilant in segregating the waste. Poor segregation and high transport costs are major obstacles toward composting food waste solids. Getting the slurry waste to a more concentrated state (i.e., about 2-5% solids) is the challenge to making the system amenable to direct disposal to a wastewater treatment plant.

### Disadvantages:

The disadvantages are the capital costs of the disposer and tank installation, and some maintenance will be needed for system upkeep. Also, as the waste is directly pumped to the digesters, any paper or other waste fragments will also go directly to the digesters. This may be a problem as paper wastes will not break down as readily as food waste and, thus, a portion of the waste may not be degraded if the detention time is too short [Note: Plastic, metal, or glass waste will not degrade at all and must be separated, thus, the use of the food waste disposer is a natural source separation device]. It should also be noted that the physical site location at Kinnickinnic Avenue required the installation of 2 septic tanks, whereas, a single tank with a secondary water compartment would have decreased capital costs.

# FIVE | PROJECT CONCLUSIONS

In analyzing the data generated through the course of the pilot project to the initial project objectives (Part II), a number of positive conclusions can be drawn. The project 10-year Life Cycle Costs are presented in Appendix 2. The conclusions are presented below the Part II objectives:

## A | Divert food waste from solid waste landfill disposal for beneficial recycling into an anaerobic digestion process, where methane could be utilized for a renewable energy source and residuals could be utilized as a fertilizer-like soil enhancement product.

### Conclusion:

This objective was attained by both the food waste disposer discharge to sewer scenario, and the food waste disposer discharge to the slurry tank with hauling to MMSD scenario. Landfill disposal provides little, if any, methane capture for renewable energy, as food waste degrades rapidly and before the final cap is placed. Instead, methane is lost to the atmosphere where it contributes to greenhouse gas. Methane gas is known to be 21 times more potent than carbon dioxide. In addition, landfilling of food waste does not provide a means to utilize the nutrient value as a soil enhancer. On the other hand, most of the modern municipal wastewater treatment plants are well equipped to utilize the methane value of anaerobic digestion gas, and recycle the nutrients into the soil through a fertilizer product or direct application to farm land. MMSD produces "Milorganite," a fertilizer-like product that is sold commercially.

## B | Provide MMSD with organic waste material to offset existing plant capacity shortages, which will increase its renewable energy generation, Milorganite production, and economic position.

### Conclusion:

As noted above, both alternative scenarios served to divert food waste from landfill into MMSD treatment processes. Food waste is the second largest contributor to Wisconsin's landfills by weight from the commercial sector. The *Wisconsin Statewide Waste Characterization Study* indicated that food waste at 95,241 tons food waste/year (2001) is the second largest category of institutional/commercial/industrial (ICI) waste going to landfill in SE Wisconsin[2]. And one can assume that this number is conservative; food waste liquids would have been absorbed by other components in MSW, such as paper. The Milwaukee Metropolitan Sewerage District (MMSD) serves 1.1 million people in a 420 square mile service area, 54% of the total population (2,045,554) in SE Wisconsin.[3] Assuming that food waste generation is based on population, the annual ICI food waste generation in this service area is 51,430 tons/year (.54 x 95,241 tons/year) that could potentially be diverted from landfill disposal.

As research has shown, food waste is approximately 30% dry solids, which are 95% decomposable, then 14,657 tons/year decomposable food waste solids are available in MMSD's service area from ICI sources (51,430 tons/year x 0.3 x 0.95). Decomposable food waste solids can be anaerobically digested to produce methane. As 1 kg of COD (chemical oxygen demand) of digested solids produces nearly 14 standard cubic feet of methane gas, then 14,657 tons/year of dry food waste will produce approximately 1,417,000

[2] http://dnr.wi.gov/org/aw/wm/publications/recycle/wrws-finalrpt.pdf. Page B-33.
[3] http://www.census.gov/popest/counties/tables/CO-EST2004-01-55.xls

therms/yr of gas energy with a value of nearly a million dollars per year.[4] As shown in Appendix 2, the 10-year Life Cycle value of the biogas generated is $35.80/ton at the State Street (direct sewer disposal) location, and $54.28/ton at the Kinnickinnic Avenue (slurry haul disposal) location. Direct hauling and feeding into the anaerobic digesters has the potential to generate higher levels of methane than sewer disposal because organics are lost through travel through the collection system and through the wastewater treatment process. In addition, the slurry method indicates that food scrap storage in the septic tank promoted the initial breakdown (hydrolysis) of the organic waste, which can reduce overall digestion time. Still, both disposal methods are much higher than landfilling in terms of renewable energy generation. It will be a challenge to the Food Waste Advisory Committee to develop the slurry hauling method to produce a final waste product that is higher in total solids content for direct anaerobic digestion.

## C | Provide Outpost Natural Foods with a more sustainable means of disposing of its food scraps, which is aligned to their corporate mission.

### Conclusion:

This objective was attained, as landfill diversion was achieved through both alternate scenarios. At both the State Street and Kinnickinnic Avenue stores, a diversion in solid waste disposal of food waste of about 85% was realized. This was noted through a decrease from about 7 bins per day of food scraps to the waste dumpster to 1 bin per day. In addition, overall solid waste volume decreased from 24 $yd^3$/wk to 18 $yd^3$/wk at State Street, and from 32 $yd^3$/wk to 16 $yd^3$/wk at Kinnickinnic Avenue. In addition, Outpost Natural Foods employees were noted to appreciate operating the food waste disposer instead of hauling waste to the dumpster.

## D | Develop an environmentally friendly, sustainable, and cost effective strategy for food waste disposal, which could be expanded throughout the City of Milwaukee and provide a state-wide template. The strategy would categorize commercial and industrial food waste as a resource to encourage energy and nutrient recovery, minimize public health issues related to food waste management practices, and minimize fossil fuels and reduce process related emissions required to manage food waste.

### Conclusion:

The project 10-year Life Cycle Cost summary (shown below in Table 1) clearly indicates that the project was a success in terms of economic and environmental impacts. Both the food waste disposer discharge to sewer scenario, and the disposer to slurry haul scenario, resulted in decreased net present value (NPV) costs than the food waste to landfill scenario. Landfilling had a NPV cost of $42.83/ton, slurry hauling was next at $40.68/ton, and the disposer to sewer scenario was found best with a NPV cost of 38.64/ton. In comparison to landfilling, capital payback periods were 6.6 years for the slurry option, and 1.3 years for the disposer to sewer scenario. However, when accounting for the value of the biogas at MMSD the spread becomes much greater with slurry hauling being the best choice; the NPV for the disposer to sewer method drops to $2.84/ton, and the slurry disposal option NPV decreases to a -$13.61/ton. This is due to the increased generation of methane by directly feeding food waste into the anaerobic digester, whereas, the sewer disposal option will lose organic value because some waste is lost in the sewer system or is assimilated into other MMSD treatment processes rather than the digesters. Finally, landfilling was found to create much

[4] Email message from Dennis Dineen, United Water Services, July 19, 2006.

higher levels of greenhouse gases (1.69 lb $CO_2$ equivalents/lb food waste) than the sewer disposal or slurry hauling scenarios (0.02 lb $CO_2$ equivalents/lb food waste).

### Table 1: 10-Year Life Cycle Cost Analysis Summary

**WASTECAP RESOURCE SOLUTIONS PROJECT SUMMARY**
**Type A Project - "Food Waste to Energy and Fertilizer"**

**Food Waste Disposal 10-Yr Life Cycle Cost Comparison**

| | Without Biogas | | | | | | | | With Biogas | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Vol Tons | Landfill Tons | Diverted Tons | 10-yr NPV $ Cost | 10-yr NPV $/Ton | Capital $ Cost | Payback Yrs | GHG[1] lb $CO_2$ Eq/lb | Biogas Value $ Total | Biogas Value $/Ton | 10-yr NPV $/Ton |
| Scenario 1 (To Landfill) | 2,323.2 | 2,323.2 | 0.0 | $99,494 | $42.83 | $0 | NA | 1.69 | $0 | $0.00 | $42.83 |
| Scenario 2 (To Sewer) | 1,782.3 | 267.3 | 1,514.9 | $68,867 | $38.64 | $9,512 | 1.3 | 0.02 | $63,802 | $35.80 | $2.84 |
| Scenario 3 (To Slurry) | 2,487.1 | 373.1 | 2,114.0 | $101,166 | $40.68 | $35,243 | 6.6 | 0.02 | $135,008 | $54.28 | -$13.61 |

[1]Skubal, Nicole L. November 2008. "Evaluating Greenhouse Gas Emissions During Commercial Food Waste Disposal," Milwaukee School of Engineering Capstone Project

At project end, Outpost Natural Foods maintained the operation of the food waste disposers at both the State Street and Kinnickinnic Avenue locations. The latter was replumbed to a sewer disposal and the slurry tanks were removed due to the dilute nature of this waste, which was not suitable for directly pumping into the MMSD anaerobic digesters. However, the increased value of biogas generation still makes the slurry haul scenario a viable option. The system could be improved by reducing the water usage and not installing as a flow-through system to the sanitary sewer. Instead, minimal water flow would carry the ground food scraps to the storage tank, which would be pumped as it becomes full with no water passing through. In this way, capital costs could be reduced significantly, water usage would decrease, the disposer could serve as a source separation device, the slurry would have higher solids content, and the most renewable energy value could be attained through direct digester feeding of the waste. In addition, with the noted substantial increase in biogas value, MMSD may be asked to consider financial incentives to offset some of the overall capital costs of the slurry equipment.

The project appears to prove that commercial food waste disposers are environmentally beneficial and cost-efficient for handling commercial food waste, and there are many potential policy and practical implications. Food waste disposers may be considered a complimentary alternative to home or on-site composting for food scraps diversion from landfills. Responsible businesses may install commercial food waste disposers. Wisconsin's renewable energy portfolio may grow. Food from commercial sources will have an alternative to landfilling. The state may consider regulation prohibiting food scraps disposal to landfill.

As a start, in a press release dated September 4, 2009, the City of Milwaukee urged residents to "grind up leftover food scraps in your garbage disposal" in an effort to minimize the impacts of higher landfill taxes imposed by the State of Wisconsin. As of October 1, 2009, tipping rates for Milwaukee increased 35%. The result could increase costs for city budgets by as much as $2 million annually. Although, Outpost Natural Foods contracts privately to haul their solid waste to nearby landfills, this media advisory by the City of Milwaukee underscores the rationale for considering such diversion strategies as the pilot project discussed within this report.

# APPENDIX 1: PILOT PROJECT LABORATORY RESULTS

**Outpost Natural Foods**
**Food Waste Pilot Study**
Laboratory Results (mg/L)

**Kinnickinnic Ave Slurry Tank Solids**

| | As | Cd | Cr | Cu | Fe | Pb | Mo | Ni | Se | Zn | Hg | HEM | P | TKN | BOD | TSS | TS | COD | VOA | VOS | Alk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10/3/2008 | <0.008 | <0.0036 | <0.0062 | 0.048 | 2.4 | 0.33 | 0.0046 | 0.019 | <0.036 | 0.29 | <0.0001 | 20 | 14 | 67 | 3,500 | 710 | 3,500 | 9,400 | | LA | 240 |
| 11/14/2008 | 0.064 | 0.0065 | 0.023 | 0.12 | 6.4 | <0.011 | 0.016 | 0.02 | 0.1 | 0.38 | <0.0001 | 51 | 20 | 180 | 4,100 | 690 | 4,600 | 7,800 | LA | LA | LA |
| 12/18/2008 | 0.0089 | <0.0036 | <0.0062 | 0.09 | 3.6 | <0.011 | 0.0094 | 0.011 | <0.036 | 0.2 | <0.0001 | 59 | 17 | 150 | 1,900 | 280 | NA | 4,300 | 2,100 | 1,600 | NA |
| 2/2/2009 | <0.008 | 0.005 | 0.011 | 0.074 | 3.1 | <0.011 | <0.004 | 0.017 | <0.036 | 0.23 | <0.0001 | 28 | 12 | 76 | 3,100 | 420 | 3,600 | 5,300 | LA | 2,900 | LA |
| 3/26/2009 | | | | | | | | | | | | | | 240 | 3,300 | 4,200 | 7,300 | | | | |
| 5/29/2009 | | | | | | | | | | | | | | 1.5 | 8,100 | 6,900 | LA | | | | |
| 7/24/2009 | | | | | | | | | | | | | | 380 | 8,100 | 5,500 | 7,000 | | | | |
| 10/9/2009 | | | | | | | | | | | | | | 320 | 6,700 | 7,800 | 9,600 | | | | |
| **AVG Overall** | **0.018** | **<0.0036** | **0.009** | **0.083** | **3.88** | **0.083** | **0.008** | **0.017** | **<0.036** | **0.275** | **<0.0001** | **39.5** | **15.8** | **177** | **4,850** | **3,313** | **5,933** | **6,700** | **2,100** | **2,250** | **240** |
| **AVG Most Representative** | | | | | | | | | | | | | | | **6,550** | **6,100** | **7,967** | | | | |

**KinnicKinnic Ave Slurry Tank Wastewater Discharge**

| | As | Cd | Cr | Cu | Fe | Pb | Mo | Ni | Se | Zn | Hg | HEM | P | TKN | BOD | TSS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10/3/2008 | <0.008 | <0.0036 | <0.0062 | 0.038 | 4.6 | 0.6 | 0.0066 | 0.021 | <0.036 | 0.23 | <0.0001 | 10 | 11 | 67 | 3500 | 130 |
| 11/14/2008 | 0.054 | <0.0036 | <0.0062 | 0.017 | 6.3 | <0.011 | 0.0049 | 0.01 | 0.045 | 0.082 | <0.0001 | 3.9 | 7.9 | 25 | 3300 | 30 |
| 12/18/2008 | <0.008 | <0.0036 | <0.0062 | 0.045 | 3.3 | 0.019 | <0.004 | 0.011 | <0.036 | 0.099 | <0.0001 | 5.8 | 6.4 | 21 | 1300 | 55 |
| 1/27/2009 | 0.018 | <0.0036 | <0.0062 | 0.034 | 1.8 | <0.011 | <0.004 | <0.0094 | <0.036 | 0.082 | <0.0001 | 1.6 | 6.4 | 29 | 1800 | 10 |
| 3/26/2009 | | | | | | | | | | | | | | 41 | 2100 | 56 |
| 5/29/2009 | | | | | | | | | | | | | | 56 | <600 | LA |
| 7/24/2009 | | | | | | | | | | | | | | 42 | 2500 | 170 |
| 10/9/2009 | | | | | | | | | | | | | | 32 | 1300 | 110 |
| **AVG** | **0.018** | **<0.0036** | **<0.0062** | **0.034** | **4.00** | **0.155** | **<0.004** | **0.011** | **<0.036** | **0.123** | **<0.0001** | **5.3** | **7.9** | **39** | **2,257** | **80** |

**State St Sanitary Sewer Discharge (combined with facility total sanitary flow)**

| | As | Cd | Cr | Cu | Fe | Pb | Mo | Ni | Se | Zn | Hg | HEM | P | TKN | BOD | TSS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10/6/2008 | 0.012 | <0.0036 | 0.0089 | 0.095 | 0.62 | <0.011 | <0.004 | <0.0094 | <0.036 | 0.16 | <0.0001 | 11 | 9.8 | 31 | <600 | 230 |
| 10/29/2008 | <0.008 | <0.0036 | <0.0062 | 0.058 | 0.82 | 0.012 | <0.004 | <0.0094 | <0.036 | 0.16 | <0.0001 | 50 | 8.7 | 49 | 270 | 270 |
| 11/12/2008 | <0.008 | 0.0098 | 0.013 | 0.068 | 0.81 | 0.045 | <0.004 | 0.012 | <0.036 | 0.19 | <0.0001 | 77 | 7.6 | 57 | 480 | 350 |
| 11/24/2008 | <0.008 | <0.0036 | 0.0073 | 0.066 | 1.4 | <0.011 | <0.004 | <0.0094 | <0.036 | 0.15 | <0.0001 | 60 | 8.2 | 43 | 520 | 470 |
| 12/3/2008 | <0.008 | <0.0036 | 0.0071 | 0.042 | 0.44 | <0.011 | <0.004 | <0.0094 | <0.036 | 0.087 | <0.0001 | 43 | 2.3 | 16 | 210 | 180 |
| 1/9/2009 | <0.008 | <0.0036 | <0.0062 | 0.059 | <0.34 | <0.011 | 0.0047 | <0.0094 | <0.036 | 0.034 | <0.0001 | 14 | 2.8 | 4 | 200 | 40 |
| 1/21/2009 | <0.008 | <0.0036 | 0.028 | 0.076 | 1 | 0.013 | 0.006 | 0.013 | <0.036 | 0.29 | <0.0001 | 96 | 12 | 54 | 680 | 430 |
| 2/5/2009 | <0.008 | <0.0036 | <0.0062 | 0.05 | <0.34 | <0.011 | <0.004 | 0.012 | <0.036 | 0.07 | <0.0001 | 30 | 3.8 | 26 | 350 | 250 |
| 2/16/2009 | <0.008 | <0.0036 | <0.0062 | 0.063 | 0.42 | <0.011 | 0.0091 | <0.0094 | <0.036 | 0.089 | <0.0001 | 44 | 3.3 | 22 | 330 | 180 |
| 3/4/2009 | <0.008 | <0.0036 | <0.0062 | 0.044 | 0.44 | <0.011 | <0.004 | <0.0094 | <0.036 | 0.065 | <0.0001 | 22 | 3.3 | 32 | 180 | 270 |
| 3/26/2009 | | | | | | | | | | | | | | 44 | <800 | 580 |
| 4/9/2009 | | | | | | | | | | | | | | 63 | 970 | 690 |
| 4/28/2009 | | | | | | | | | | | | | | 51 | <500 | 570 |
| 5/12/2009 | | | | | | | | | | | | | | 67 | <500 | 120 |
| 5/21/2009 | | | | | | | | | | | | | | 7.8 | <600 | LA |
| 7/14/2009 | | | | | | | | | | | | | | 68 | 1,100 | 630 |
| 7/27/2009 | | | | | | | | | | | | | | 36 | 620 | 220 |
| 8/3/2009 | | | | | | | | | | | | | | 13 | <500 | 110 |
| 9/24/2009 | | | | | | | | | | | | | | 89 | 1,400 | 320 |
| **AVG** | **<0.008** | **<0.0036** | **0.0064** | **0.062** | **0.595** | **<0.011** | **<0.004** | **<0.0094** | **<0.036** | **0.130** | **<0.0001** | **44.7** | **6.2** | **41** | **562** | **328** |

As = Arsenic
Cd = Cadmium
Cr = Chromium
Cu = Copper
Fe = Iron
Pb = Lead
Mo = Molybdenum
Ni = Nickel
Se = Selenium
Zn = Zinc
Hg = Mercury
HEM = Oil & Grease (hexane extracted)
P = Phosphorus
TKN = Total Kjeldahl Nitrogen
BOD = Biochemical Oxygen Demand
TSS = Total Suspended Solids
TS = Total Solids
COD = Chemical Oxygen Demand
VOA = Volatile Organic
VOS = Volatile Organic
Alk = Alkalinity

LA = Lab Accident
NA = Not Analyzed
NS = Not Started

# APPENDIX 2: LIFE CYCLE COST ANALYSIS

**Type A Project - "Food Waste to Energy and Fertilizer"**
**WasteCap Resource Solutions**
**Project Life Cycle Cost Analysis**

Food Waste Hauled to Landfill by Outpost Natural Foods

PROJECT START:

1) Solid waste hauled in dumpsters 4 times/week with food waste 30% of the total
2) Commercial food waste bulk density = 910 lb/yd$^3$
3) Hauled food waste volume:

| | | | | |
|---|---|---|---|---|
| ONF: | KK Site: | 32 yd$^3$/wk x 910 lb/yd$^3$ x 1 ton/2000 lb x 0.3 x 52 wk/yr = | 227.1 | wet tons/yr |
| | Capitol Site: | 32 yd$^3$/wk x 910 lb/yd$^3$ x 1 ton/2000 lb x 0.3 x 52 wk/yr = | 227.1 | wet tons/yr |
| | State Site: | 24 yd$^3$/wk x 910 lb/yd$^3$ x 1 ton/2000 lb x 0.3 x 52 wk/yr = | 170.4 | wet tons/yr |
| | | Total: | 624.6 | wet tons/yr |

4) Solid waste hauling costs:

| | | | | |
|---|---|---|---|---|
| ONF: | KK Site: | $375/mo x 12 mo = | $4,500 | per yr |
| | Capitol Site: | $350/mo x 12 mo = | $4,200 | per yr |
| | State Site: | $284/mo x 12 mo = | $3,408 | per yr |
| | | Total: | $12,108 | per yr |

PROJECT END:

1) Solid waste hauled in dumpsters 4 times/week with food waste 30% of the total at Capitol site
2) Commercial food waste bulk density = 910 lb/yd$^3$
3) KK and State sites food waste hauled reduced 85% (decreased from 7 to 1 bin of food waste/day)
4) Hauled food waste volume:

| | | | | |
|---|---|---|---|---|
| ONF: | KK Site: | 227.1 tons/yr x 0.15 = | 34.1 | wet tons/yr |
| | Capitol Site: | 32 yd$^3$/wk x 910 lb/yd$^3$ x 1 ton/2000 lb x 0.3 x 52 wk/yr = | 227.1 | wet tons/yr |
| | State Site: | 170.4 tons/yr x 0.15 = | 25.6 | wet tons/yr |
| | | Total: | 286.8 | wet tons/yr |

5) Solid waste hauling costs:

| | | | | |
|---|---|---|---|---|
| ONF: | KK Site: | $32/haul x 2 hauls/wk x 52 wks/yr = | $3,328 | per yr |
| | Capitol Site: | $23.75/haul x 4 hauls/wk x 52 wks/yr = | $4,940 | per yr |
| | State Site: | $21/haul x 3 hauls/wk x 52 wks/yr = | $3,276 | per yr |
| | | Total: | $11,544 | per yr |

Scenario 1: Solid Waste Disposal (Outpost Natural Foods Capitol Dr Site to Landfill)

Assumptions:

1) Solid waste stored by ONF personnel @ $15/hr, and hauled by waste contractor
2) Labor requirement to store waste = 0.5 hr/day

COSTS

| | | | | | |
|---|---|---|---|---|---|
| Labor: | ONF: | Storage: | $15/hr x 0.5 hr/d x 365 d/yr = | $2,738 | per yr |
| Disposal: | Hauling: | Contractor: | $23.75/haul x 4 hauls/wk x 52 wks/yr | $4,940 | per yr |
| | WI Generator Tax: | | $83.45/mo x 12 mo/yr = | $1,001 | per yr |
| | | | Total O&M Costs | $8,679 | per yr |

Scenario 2: Food Waste Disposer to Sewer (Outpost Natural Foods State St Site to MMSD South Shore)

Assumptions:

1) ONF prep operations 0.75 hrs/day with disposer at no-load for 0.25 hrs/day and full-load for 0.5 hrs/day
2) Disposer (3 hp) draw at no-load = 1,000W, full-load = 3,000W
3) Disposer power draw = ((1000W x 0.25hr/day) + (3000W x 0.5hr/day)) x 1kW/1000W = 1.8 kWh/day
4) Disposer water use = metered 181 gal/day
5) Wauwatosa water cost = $2.04/100 $ft^3$ x 100 $ft^3$/748 gal = $0.0027 per gal
6) Wauwatosa wastewater treatment rates = $3.025 per 1000 gal
7) Solid waste food waste portion hauling cost = solid waste cost x 30% (food waste) x 85% (reduction)
8) Food waste disposed through disposer to sewer = 170.4 tons/yr - 25.6 tons/yr = 144.8 wet tons/yr
9) 5% of food waste is lost to sewer or grit removal, primary settling is 65%, food waste is 95% volatile
10) Digester volatile solids reduction is 60% and 13 $ft^3$ of gas is generated per lb of food waste

COSTS

| | | | | | |
|---|---|---|---|---|---|
| Capital: | Disposer/Work Station: | | $6,562 | | |
| | Installation: | | $2,950 | | |
| | Total Capital Costs: | | $9,512 | | |
| Labor: | ONF: | $15/hr x 0.75 hr/day x 365 days/yr = | | $4,106 | per yr |
| Disposal: | Solid Waste | $3,276 x 0.3 x 0.15 = | | $147 | per yr |
| | WI Generator Tax: | $68.05/mo x 12 mo/yr = | | $817 | per yr |
| Utilities: | Disposer: | Electricity: 1.8 kWh/day x $0.09/kWh x 365 days/yr = | | $59 | per yr |
| | | Water: $0.0027/gal x 181 gal/day x 365 days/yr = | | $180 | per yr |
| | Wastewater: | Treatment: $3.0253/1,000 gal x 181 gal/day/1000 x 365 days/yr = | | $200 | per yr |
| | | Total O&M Costs | | $5,509 | per yr |
| Biogas: | MMSD: | 144.8 tons/yr x 0.95 x 0.65 x 0.95 x 0.6 x 2000 lb/ton x 13 $ft^3$ gas/lb = | | 1,325,108 | $ft^3$/yr |
| | | 1,325,108$ft^3$/yr x 600 BTU/$ft^3$gas x 1therm/0.1M BTU x $0.70/therm = | | $5,565 | per yr |

Scenario 3: Liquid Slurry Disposal (Outpost Natural Foods KK Site to MMSD South Shore)

Assumptions:

1) ONF prep operations 0.75 hrs/day with disposer at no-load for 0.25 hrs/day and full-load for 0.5 hrs/day
2) Disposer (3 hp) draw at no-load = 1,000W, full-load = 3,000W
3) Disposer power draw = ((1000W x 0.25hr/day) + (3000W x 0.5hr/day)) x 1kW/1000W = 1.8 kWh/day
4) Disposer water use = Metered 159 gal/day
5) Milwaukee water cost = $1.34/100 $ft^3$ x 100 $ft^3$/748 gal = $0.0018 per gal
6) Veolia Water wastewater treatment rates = $1.561 per 1000 gal
7) Solid waste food waste portion hauling cost = solid waste cost x 30% (food waste) x 85% (reduction)
8) Food waste disposed through disposer to slurry = 227.1 tons/yr - 34.1 tons/yr = 193.1 wet tons/yr
9) Slurry hauled by contractor @ $75/hr (plus 15% fuel surcharge)/haul every 8 weeks = $345 per haul
10) Veolia Water treatment cost = septic tank hauled waste rate = $32.030 per 1000 gal
11) 98% of food waste remains in the tank with minimal degradation, food waste is 95% volatile
12) Digester volatile solids reduction is 60% and 13 $ft^3$ of gas is generated per lb of food waste

Scenario 3: Liquid Slurry Disposal (Outpost Natural Foods KK Site to MMSD South Shore) - Continued

COSTS

| | | | | | |
|---|---|---|---|---|---|
| Capital: | Slurry System (ie, install disposer, septic tank, table, etc) = | | | $29,840 | |
| | Disposer, table, Aqua-Saver control = | | | $5,403 | |
| | | | Total Capital Costs: | $35,243 | |
| Labor: | ONF: | $15/hr x 0.75 hr/day x 365 days/yr = | | | $4,106 per yr |
| Disposal: | Solid Waste | $3,328 x 0.3 x 0.15 = | | | $150 per yr |
| | WI Generator Tax: | | $43.51/mo x 12 mo/yr = | | $522 per yr |
| | Slurry: | $345/haul x 1 haul/8 wks x 52 wks/yr = | | | $2,243 per yr |
| Utilities: | Disposer: | Electricity: | 1.8 kWh/day x $0.09/kWh x 365 days/yr = | | $59 per yr |
| | | Water: | $0.0018/gal x 159 gal/day x 365 days/yr = | | $104 per yr |
| | Pump: | Electricity: | 1hp x 0.746 kW/hp x $0.09/kWh x 0.75hr/day x 365 = | | $18 per yr |
| | Slurry: | Treatment: | $32.03/1000gal x 1haul/8wks x 3500gal/haul x 52 = | | $729 per yr |
| | Wastewater: | Treatment: | $1.56091/1,000 gal x 159 gal/day/1000 x 365 days/yr = | | $91 per yr |
| | | | | Total O&M Costs | $8,021 per yr |
| Biogas: | MMSD: | 193.1 tons/yr x 0.98 x 0.95 x 0.6 x 2000 lb/ton x 13 $ft^3$ gas/lb = | | | 2,804,008 $ft^3$/yr |
| | | 2,804,008$ft^3$/yr x 600 BTU/$ft^3$gas x 1therm/0.1M BTU x $0.70/therm = | | | $11,777 per yr |

Food Waste Volume at Outpost Natural Foods

Assumptions:

1) 10 yr life cycle

2) 2%/yr waste volume growth for KK, 1% waste growth for State, 0.5% waste growth for Capitol

| | KK Ave | Capitol Dr | State St |
|---|---|---|---|
| Year | tons/yr | tons/yr | tons/yr |
| 1 | 227 | 227 | 170 |
| 2 | 232 | 228 | 172 |
| 3 | 236 | 229 | 174 |
| 4 | 241 | 231 | 176 |
| 5 | 246 | 232 | 177 |
| 6 | 251 | 233 | 179 |
| 7 | 256 | 234 | 181 |
| 8 | 261 | 235 | 183 |
| 9 | 266 | 236 | 184 |
| 10 | 271 | 238 | 186 |
| Total | 2,487 | 2,323 | 1,782 |

Outpost Natural Foods Food Waste Disposal Options Present Value Costs

| | Scenario 1 | | Scenario 2 | | Scenario 3 | |
|---|---|---|---|---|---|---|
| Year | Item | Cost | Item | Cost | Item | Cost |
| 1 | O&M | $8,679 | Capital | $951 | Capital | $1,535 |
| | | | O&M | $5,509 | O&M | $8,021 |
| | | | (Dep Tax) | ($380) | (Dep Tax) | ($614) |
| | | | (Biogas) | ($5,565) | (Biogas) | ($11,777) |
| | Total | $8,679 | Total | $6,080 | Total | $8,942 |
| 2 | O&M | $8,939 | Capital | $951 | Capital | $1,535 |
| | | | O&M | $5,675 | O&M | $8,262 |
| | | | (Dep Tax) | ($380) | (Dep Tax) | ($614) |
| | | | (Biogas) | ($5,732) | (Biogas) | ($12,130) |
| | Total | $8,939 | Total | $6,245 | Total | $9,183 |
| 3 | O&M | $9,207 | Capital | $951 | Capital | $1,535 |
| | | | O&M | $5,845 | O&M | $8,510 |
| | | | (Dep Tax) | ($380) | (Dep Tax) | ($614) |
| | | | (Biogas) | ($5,904) | (Biogas) | ($12,494) |
| | Total | $9,207 | Total | $6,416 | Total | $9,431 |
| 4 | O&M | $9,484 | Capital | $951 | Capital | $1,535 |
| | | | O&M | $6,020 | O&M | $8,765 |
| | | | (Dep Tax) | ($380) | (Dep Tax) | ($614) |
| | | | (Biogas) | ($6,082) | (Biogas) | ($12,869) |
| | Total | $9,484 | Total | $6,591 | Total | $9,686 |
| 5 | O&M | $9,768 | Capital | $951 | Capital | $1,535 |
| | | | O&M | $6,201 | O&M | $9,028 |
| | | | (Dep Tax) | ($380) | (Dep Tax) | ($614) |
| | | | (Biogas) | ($6,264) | (Biogas) | ($13,255) |
| | Total | $9,768 | Total | $6,772 | Total | $9,949 |
| 6 | O&M | $10,061 | Capital | $951 | Capital | $1,535 |
| | | | O&M | $6,387 | O&M | $9,299 |
| | | | (Dep Tax) | ($380) | (Dep Tax) | ($614) |
| | | | (Biogas) | ($6,452) | (Biogas) | ($13,653) |
| | Total | $10,061 | Total | $6,958 | Total | $10,220 |
| 7 | O&M | $10,363 | Capital | $951 | Capital | $1,535 |
| | | | O&M | $6,579 | O&M | $9,578 |
| | | | (Dep Tax) | ($380) | (Dep Tax) | ($614) |
| | | | (Biogas) | ($6,645) | (Biogas) | ($14,062) |
| | Total | $10,363 | Total | $7,149 | Total | $10,499 |
| 8 | O&M | $10,674 | Capital | $951 | Capital | $1,535 |
| | | | O&M | $6,776 | O&M | $9,865 |
| | | | (Dep Tax) | ($380) | (Dep Tax) | ($614) |
| | | | (Biogas) | ($6,845) | (Biogas) | ($14,484) |
| | Total | $10,674 | Total | $7,347 | Total | $10,786 |
| 9 | O&M | $10,994 | Capital | $951 | Capital | $1,535 |
| | | | O&M | $6,979 | O&M | $10,161 |
| | | | (Dep Tax) | ($380) | (Dep Tax) | ($614) |
| | | | (Biogas) | ($7,050) | (Biogas) | ($14,919) |
| | Total | $10,994 | Total | $7,550 | Total | $11,082 |
| 10 | O&M | $11,324 | Capital | $951 | Capital | $1,535 |
| | | | O&M | $7,189 | O&M | $10,466 |
| | | | (Dep Tax) | ($380) | (Dep Tax) | ($614) |
| | | | (Biogas) | ($7,262) | (Biogas) | ($15,366) |
| | Total | $11,324 | Total | $7,759 | Total | $11,387 |

Assumptions:
1) Capital depreciated over useful life of 10 yrs (except septic tank = 30 yrs)
2) Inflation rate = 3%/yr
3) Tax rate = 40%
(i.e, depreciated tax savings = depreciated capital x 0.4)

| Outpost Natural Foods Food Waste Disposal Options Present Value Annual Cost Comparison | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Scenario 1 | | | Scenario 2 | | | Scenario 3 | | |
| | NPV | Waste | Biogas | NPV | Waste | Biogas | NPV | Waste | Biogas |
| Year | Cost | Tons/Yr | $ Value | Cost | Tons/Yr | $ Value | Cost | Tons/Yr | $ Value |
| 1 | $8,679 | 227 | $0 | $6,080 | 170 | $5,565 | $8,942 | 227 | $11,777 |
| 2 | $8,939 | 228 | $0 | $6,245 | 172 | $5,732 | $9,183 | 232 | $12,130 |
| 3 | $9,207 | 229 | $0 | $6,416 | 174 | $5,904 | $9,431 | 236 | $12,494 |
| 4 | $9,484 | 231 | $0 | $6,591 | 176 | $6,082 | $9,686 | 241 | $12,869 |
| 5 | $9,768 | 232 | $0 | $6,772 | 177 | $6,264 | $9,949 | 246 | $13,255 |
| 6 | $10,061 | 233 | $0 | $6,958 | 179 | $6,452 | $10,220 | 251 | $13,653 |
| 7 | $10,363 | 234 | $0 | $7,149 | 181 | $6,645 | $10,499 | 256 | $14,062 |
| 8 | $10,674 | 235 | $0 | $7,347 | 183 | $6,845 | $10,786 | 261 | $14,484 |
| 9 | $10,994 | 236 | $0 | $7,550 | 184 | $7,050 | $11,082 | 266 | $14,919 |
| 10 | $11,324 | 238 | $0 | $7,759 | 186 | $7,262 | $11,387 | 271 | $15,366 |
| Total | $99,494 | 2,323 | $0 | $68,867 | 1,782 | $63,802 | $101,166 | 2,487 | $135,008 |
| NPV/Ton | $42.83 | | $0.00 | $38.64 | | $35.80 | $40.68 | | $54.28 |

# APPENDIX 3: LIFE CYCLE COST ANALYSIS SUMMARY

**WASTECAP RESOURCE SOLUTIONS PROJECT SUMMARY**
**Type A Project - "Food Waste to Energy and Fertilizer"**

| | Food Waste Disposal 10-Yr Life Cycle Cost Comparison | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Without Biogas | | | | | | | | With Biogas | | |
| | Total Vol Tons | Landfill Tons | Diverted Tons | 10-yr NPV $ Cost | 10-yr NPV $/Ton | Capital $ Cost | Payback Yrs | GHG1 lb CO2 Eq/lb | Biogas Value $ Total | Biogas Value $/Ton | 10-yr NPV $/Ton |
| Scenario 1 (To Landfill) | 2,323.2 | 2,323.2 | 0.0 | $99,494 | $42.83 | $0 | NA | 1.69 | $0 | $0.00 | $42.83 |
| Scenario 2 (To Sewer) | 1,782.3 | 267.3 | 1,514.9 | $68,867 | $38.64 | $9,512 | 1.3 | 0.02 | $63,802 | $35.80 | $2.84 |
| Scenario 3 (To Slurry) | 2,487.1 | 373.1 | 2,114.0 | $101,166 | $40.68 | $35,243 | 6.6 | 0.02 | $135,008 | $54.28 | -$13.61 |

[1]Skubal, Nicole L. November 2008. "Evaluating Greenhouse Gas Emissions During Commercial Food Waste Disposal," Milwaukee School of Engineering Capstone Project

# APPENDIX 4: KINNICKINNIC AVE SLURRY SYSTEM DIAGRAM