WASTE REDUCTION MODEL (WARM)

TECHNICAL MEMORANDUM

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1. INTRODUCTION

The Environmental Protection Agency Waste Reduction Model (WARM) calculates the greenhouse gas (GHG) emissions from six different waste management practices for over 50 material types. Waste management practices include source reduction, recycling, composting, anaerobic digestion, combustion, and landfilling. WARM provides the annual GHG emissions as metric tons of carbon dioxide equivalent ($MTCO_2E$).

The City of Davis is assessing different disposal and processing options for its organic waste and is interested in understanding the GHG generation or reduction of each option. This technical memo evaluates three waste management scenarios:

1. All organic materials sent to landfill disposal;
2. All organic materials sent to composting;
3. All allowable organic materials sent to anaerobic digestion and the remainder sent to composting.

For the purposes of this report, the City of Davis (City) organic waste (12,672 tons per year) has been combined with the available organic waste (12,804 tons per year) from University of California, Davis (UCD). **Tables 4.5** and **4.6** in the *Organics Processing Facility Feasibility Analysis* (Report) show the breakdown of these organic feedstocks.

This revised Technical Memorandum incorporates the requests and comments from the City of Davis Natural Resources Commission (NRC). The revisions are primarily based on the preferred preferences selected within the WARM model.

2. ASSUMPTIONS OF THE WARM MODEL

To determine the GHG emissions from these three scenarios, the following assumptions were made in accordance with the WARM calculation method:

- The most recent available version of the WARM model was used (Version 15);

- All organic material is combined into one category which includes green material, food and commingled food/green material and other organics; the category used in the WARM model is "yard trimmings" per request of NRC;
- Assigns a value of 20 miles for transportation distances, when factoring in the emissions generated from the transport of materials to a disposal or processing site;
- The composting method is traditional windrow with no specified air quality best management practices;
- Anaerobic digestion utilizes dry digestion technology;
- Local (California) options were selected for electricity-related emission factors, and landfill gas recovery practices following California regulatory requirements;
- A "moderate" decay rate of k = 0.04 (between 20 and 40 inches of precipitation per year).

For each waste management scenario, WARM accounts for sources of emissions (e.g., combustion of fossil fuels) and emissions sinks (e.g., forest carbon storage, avoid fuel consumption). When the results in WARM show a negative value for GHG emissions or energy, this indicates that managing that material using the selected management practice results in overall avoided GHG emissions or energy from a life-cycle perspective.

3. <u>WARM RESULTS</u>

Three waste management scenarios were evaluated using WARM. The results of each scenario are summarized below in **Table 1.**

Table 1. Annual Metric Tons of Carbon Dioxide Equivalent ($MTCO_2E$) Generated or Reduced

WASTE MANAGEMENT SCENARIO	ANNUAL GHG EMISSIONS ($MTCO_2E$)		
Feedstock Generator	City	UCD	Combined
Landfill Disposal	-4,332.30	-4,377.43	-8,709.74
Composting	-1,854.07	-1,873.38	-3,727.45
AD with Composting	-	-	-2,735.98

<u>Landfill Disposal Scenario</u>

If all organic waste from both the City and UCD were sent to landfill for disposal, then roughly 8,700 $MTCO_2E$ of GHG emissions would be reduced each year. This is due to the Yolo County Central Landfill's landfill gas recovery system.

Composting Scenario

These combined organic wastes would yield an annual reduction of about 3,700 $MTCO_2E$ when sent to composting. When compared to landfill disposal, this is actually a GHG increase of about 5,000 $MTCO_2E$.

The difference in GHG emissions means this waste management practice results in overall increased GHG emissions or energy from a life-cycle perspective. This is primarily due to the assumed practice of landfill gas recovery. Additionally, the WARM model assumes windrow composting.

AD with Composting Scenario

For this scenario, only a portion of the organic wastes would be sent to the AD system (14,124 TPY), and the remainder would be sent to composting (11,352 TPY).

This waste management practice would result in a GHG reduction of about 2,700 $MTCO_2E$. The WARM considers carbon storage, avoided fertilizer offsets, and net electricity offsets.

4. CONCLUSION

Based on the WARM assumptions, both composting and AD with composting generate similar GHG reductions. Landfill disposal with a gas recovery system, however, generated the most significant GHG reductions. If no gas recovery system is utilized or there is a change is waste characterization (e.g., more than 50% foodwaste), then landfill disposal has the worst impact on GHG emissions.

It is important to note that the WARM model assumed windrow composting and dry anaerobic digestion which WARM identifies as the most commonly used technologies. However, in California and beyond there are more advanced systems such as aerated composting and high solids anaerobic digestion. Aerated composting systems have been shown to reduce emissions by 50 to 95% when compared to traditional windrow composting, but also require more energy than non-aerated systems. Similarly, high solids anaerobic digestion has been shown to produce more biogas than dry AD systems, which results in more renewable heat, electricity, or fuel generation.

While the WARM may not be up-to-date on current technologies, the results of this tool are meant to provide information on the GHG impacts from material management decisions.