

# **Achieving Economic and Environmental Benefit through Agricultural and Municipal Cooperation in Co-composting Green Waste with Animal Manure**

2003 OSWER Innovations Pilot Project  
Final Report: September 30, 2003 – March 31, 2005



San Joaquin Valley cows

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## **Project Overview**

Protecting groundwater from nitrate contamination is a major challenge for dairy producers in California's Central Valley, where approximately 1,600 dairies produce nearly 20% of the nation's milk supply. The California State Water Resources Control Board estimates that over 600 square miles of groundwater in the Central Valley are contaminated with nitrates.

Fortunately, research has demonstrated that if applied at agronomic rates, manure nutrients can be safely used to grow forage crops. Harter et al. (2002) showed that in just one year of using irrigation techniques for land application of lagoon nutrients according to crop uptake patterns, groundwater nitrate levels on a dairy with shallow groundwater and sandy soils were reduced by over 50%<sup>1</sup>. It is anticipated that before the end of the year, the Central Valley Water Resources Control Board, the regulatory agency responsible for permitting dairies in the Central Valley, will finalize regulations that require dairies to develop and implement nutrient management plans and keep records documenting that manure nutrients are applied at agronomic rates.

For many dairies, complying with nutrient management objectives results in a need to transport manure off the farm to avoid nitrate contamination of groundwater. Considering that manure is an excellent soil amendment and source of plant nutrients, the best case scenario for exported manure is for it to be used locally on nearby farms. When growers use manure for improving the soil, use of resources is optimized and groundwater impacts are minimized.

Currently, many producers export manure off the farm by contracting with manure hauling and spreading companies that acquire manure from dairies and resell it to other growers in the region. While some growers do land apply raw manure, others are concerned that pathogens associated with untreated animal waste can pose a public health problem. An outbreak of salmonella in the Spring of 2004 is one reason why the Almond Board of California recommends that almond growers avoid introducing raw manure into their orchards, as raw manure "dramatically increases the risk of contaminating your almonds with pathogens such as *E-coli* or *Salmonella*, which

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<sup>1</sup> Harter, Thomas, H. Davis, M. C. Mathews, R. D. Meyer. 2002. Shallow groundwater quality on dairy farms with irrigated forage crops, *Journal of Contaminant Hydrology* 55 (3-4), pp. 287-315.

could result in food-borne illness and possible death upon consumption.” For other producers, odors and weed seeds are also a concern.

However, when manure is composted properly, high temperatures result, producing a final product that is a good soil amendment and is free of pathogens, weed seeds and odors. Despite the benefits, currently only a small number of Central Valley dairies compost their manure. Dairy producers surveyed indicate that they don’t have the time, resources and/or technical know-how to properly compost and market their manure. There is also confusion about the State’s regulatory requirements. Consequently, little of the Central Valley’s dairy manure is composted on-farm.

Competing with manure and manure compost in regional markets, green waste (*i.e.* leaves, grass clippings and yard trimmings) are also being composted and sold to growers throughout the Central Valley. Because of state recycling mandates (such as AB 939), landfill managers are looking at green waste composting as a means to reduce the volume of waste disposed in landfills. Finding buyers is critical to the success of green waste recycling programs, and managers are interested in strategies that result in enhanced market value of the final compost product.

One potential method for increasing the value of green waste compost is to mix green waste with manure, which is higher in nutrients. This is feasible in the Central Valley because many dairies are in relatively close proximity to urban areas, particularly around the cities of Stockton, Visalia, Fresno, Merced, Modesto and Sacramento. Marrying the more urban generators of green waste with rural sources of manure are a natural convergence of interest, as there is a potential economic and environmental benefit for both sectors.

In 2003, the EPA awarded Sustainable Conservation a \$29,000 grant to demonstrate and evaluate the technical and economic feasibility of co-composting green waste and dairy manure in the Central Valley. Specific project tasks and strategies to achieve this goal were:

- 1) Identify dairy producers that would be interested in participating in the project;
- 2) Solidify partnerships;
- 3) Orchestrate contractual and other arrangements that allow the project to proceed to the implementation phase;
- 4) Develop budget detailing projected cost and revenues of each project phase encompassing:
  - Transportation – what are the costs of collection and hauling manure and what is the incremental cost for each additional mile traveled?
  - Processing – what are the marginal operational costs for adding dairy manure and what is the system capacity without significant new capital investment?
  - Reuse/marketing – what are the marketing and market delivery costs?
- 5) Compare projected to actual costs assessing unit cost of transport, processing and market delivery as well as new revenue sources and amounts. Compare with other alternatives;
- 6) Document and measure results;

- 7) Develop a communication plan;
- 8) Determine target geographical areas for possible expansion.

It was anticipated that this project would demonstrate an economically viable and technically practical strategy for capturing manure nutrients and safely utilizing them for agricultural production in the Central Valley.

## **Project Methods**

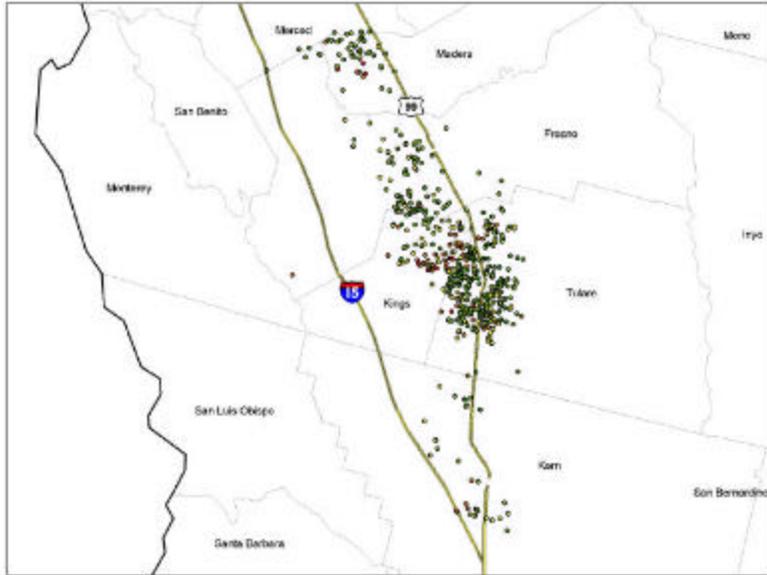
### **Site Selection**

Given its proximity to dairies (Figure 1), and their successful green waste composting program (Figure 2), the Merced County Highway 59 Landfill was selected for the project demonstration site. According to Jerry Lawrie (the Integrated Waste Program Manager for Merced County), the Highway 59 Landfill green waste composting program currently diverts approximately 30,000 tons of organic waste from the landfill per year - the equivalent of 3,000 to 7,000 refuse truck loads. Regionally, the dairy industry and agriculture features prominently in the Merced County landscape. According to the National Agricultural Statistics Service, there were 532,000 acres of cropland, 339 dairy farms, and approximately 400,000 cows and calves residing in Merced County<sup>2</sup> In 2003, the value of agricultural production in Merced County approached 2 billion dollars, and the sale of milk products (the largest source of agricultural revenue in the county) accounted for 553 million of that total (California Agricultural Statistics Service, 2004)<sup>3</sup>. In California, Merced is second only to Tulare County in milk production.

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<sup>2</sup> <http://www.nass.usda.gov/census/census97/highlights/ca/cac024.txt>

<sup>3</sup> California Agricultural Statistics Service, 2004. Summary of County Agricultural Commissioners' Reports: Gross values by commodity groups - California 2002-2003. Sacramento, CA. Available online at: <http://ucce.ucdavis.edu/counties/common/countvagreports.pdf>



**Figure 1.** Geo-coded locations of dairies in the San Joaquin Valley of California. From Mansell and Roe (2002).



**Figure 2.** Dry season green waste composting site at the Highway 59 Landfill in Merced, California. A calf rearing farm is visible in the distant background.

### Project Partners

Our project partners: Jerry Lawrie (Integrated Waste Program Manager, Merced County), Marty Yerrick (Highway 59 Landfill Supervisor), Steve Stone (Stone Family Manure Hauling), Jeff Palsgaard (Merced County Department of Public Health), Ron Lew (California Integrated Waste Management Board), and Adrienne Priselac (EPA OSWER), and Paul Martin and Joe Ramos (Western United Dairymen).



**Figure 3.** Steve Stone (Kenneth Stone and Family Spreading Service, left), Marty Yerrick (Highway 59 Landfill Supervisor, center), and Jerry Lawrie (Merced County Integrated Waste Program Manager, right) at the Highway 59 Landfill site.

### Co-Composting Methods

Sustainable Conservation contracted with the Kenneth Stone and Family Spreading Service to deliver dairy manure (490 yd<sup>3</sup> or 313 tons) from two nearby farms to the Highway 59 Landfill green waste composting site (Figure 4), where it was mixed with Highway 59's Wildcat Windrow Turner with 960 yd<sup>3</sup> (183 tons) of screened and chipped green waste (Figure 5). As trucks delivered the manure, and as the manure was unloaded, the material was sprayed with water to minimize dust (Figure 6).



**Figure 4.** Delivery of dairy manure trucks (front) mixed with green waste truck (back) to form windrows.



**Figure 5.** Highway 59 Landfills' Wildcat Windrow Turner mixing manure and green waste.



**Figure 6.** Water was sprayed on compost pile rows before mixing to reduce dust formation and

increase moisture content to promote the composting process.

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### Sample Analysis

Samples of green waste, manure and finished compost were analyzed for nutrient content by A & L Western Agricultural Laboratories (1311 Woodland Ave., Modesto, CA), using industry standard analysis for organic amendments. This facility was selected because they routinely analyze the Highway 59 Landfill's green waste compost, hence results from analysis of the co-compost could be compared with results typical of green waste-only compost.

### Economic Analysis

Economic feasibility of this project was evaluated by interviewing project partners to identify appropriate market rates for manure and compost, quantifying actual costs of composting, and factors that affect costs, such as nutrient content and distance transported.

## **Project Results**

### Compost Quality

The green waste and dairy manure co-composting demonstration at the Highway 59 Landfill in Merced County demonstrated that green waste co-composted with dairy manure increased the nutrient content, and therefore should increase the market value, of the green waste compost. Table 1 lists laboratory analysis results for manure, green waste and the finished co-compost product. The addition of manure to green waste (50% by volume) increased the final nitrogen concentration of the green waste by 13%, while phosphorus, potassium and sulfur concentrations doubled. Organic matter concentrations increased by over 25%, and calcium concentrations increased by a third. While nutrients and minerals increased in the co-compost compared to typical green waste compost, so did the sodium concentrations, although the final value was less than 0.5 percent of the total mass, well within the range for land application. Not only did the addition of manure to the green waste improve nutrient concentrations, there was no detectable salmonella, fecal or total coliforms found in the final product.

**Table 1.** Lab analysis results for nutrients, carbon to nitrogen (C:N) ratio, total and fecal coliforms and salmonella from green waste and dairy manure (pre-composting), finished co-compost and typical finished green waste compost.

Report of Analysis	Green Waste Pre-Compost	Dairy Manure Pre-Compost	Finished Co-compost	Typical Finished Green Waste Compost
% Concentration				
Nitrogen	1.69	2.02	1.46	1.29
Phosphorus	0.23	0.46	0.52	0.27
Potassium	1.21	2.21	2.12	1.05
Sulfur	0.20	0.35	0.54	0.20
Magnesium	0.70	0.45	0.89	0.64
Calcium	1.50	1.75	3.21	2.05
Sodium	0.10	0.57	0.45	0.09
Organic Matter	62.55	55.57	34.02	27.08
Moisture	32.18	61.17	29.17	-
(PPM)				
Iron	7061	5,267	7,412	15,345
Aluminum	6,993	6,011	4,368	16,915
Manganese	239	139	359	388
Copper	23	86	83	42
Zinc	104	175	219	131
Boron	60	67	92	71
C:N Ratio	21:1	16:1	14:1	13:1
Total Coliform (MPN/1g)	-	-	Below Detectable Limit	Below Detectable Limit
Fecal Coliform (MPN/1g)	-	-	Below Detectable Limit	Below Detectable Limit
Salmonella (MPN/4g)	-	-	Negative	Negative

### Economic Analysis

Costs and estimated project revenues are detailed in Table 2. Critical factors in determining the economic feasibility of mixing dairy manure with green waste compost at the Highway 59 Landfill include:

- 1) Cost for delivery of manure, which is dependent on distance hauled and moisture content (*i.e.* the weight and density).
- 2) Tipping fee for green waste - because it is owned by all jurisdictions within Merced County and thus serves the public, the Highway 59 Landfill charges a lower-than-average tipping fee for receiving curbside collected green waste originating anywhere within the County. Typical values are \$16-\$20/ton, while the Highway 59 Landfill only charges \$8/ton.
- 3) Sale price of finished product, which varies according to volume purchased. The Highway 59 Landfill sells finished green waste compost for approximately \$10.00 / ton (bulk) to \$30.00 / ton (smaller volumes). Kenneth Stone & Family Manure Hauling and Spreading also composts and sells manure, and their sale price for composted manure is typically \$20/ ton at the pile, with an additional delivery charge.
- 4) Cost of regulatory compliance (not included in Table 2).

**Table 2.** Preliminary direct and net costs of green waste compost and green waste co-composted with dairy manure at the Highway 59 Landfill in Merced County, CA.

**Direct Production Costs**

<b>Processing Costs at the Highway 59 Landfill</b>	<b>Green Waste Compost Cost (\$ / ton)</b>	<b>Green Waste + Manure Co-Compost Cost (\$ / ton)</b>
Material Preparation: (receiving, cleaning, grinding and hauling to windrow area)	8.30	3.00*
Windrow composting	3.00	3.00
Screening	1.50	1.50
Storage (curing prior to sale)	2.00	2.00
Loading	.50	.50
<b>Total Direct Costs</b>	<b>15.30</b>	<b>10.00</b>
<b>Adjusted for Expected Tonnage Loss After Screening**</b>	<b>18.00</b>	<b>12.00</b>

\* Manure does not need to be cleaned and ground and is delivered directly to the windrow area, hence material preparation costs are lower.

\*\*Typically about 10 to 20% on a weight basis

**Net Costs**

<b>Costs and Revenues</b>	<b>Green Waste Compost Cost (\$ / ton)</b>	<b>Green Waste + Manure Co-Compost Cost (\$ / ton)</b>
Adjusted direct production costs	(18)	(12)
Tipping fee***	8	
Manure purchase and delivery****		(8)
<b>Total Net Costs</b>	<b>(10)</b>	<b>(20)</b>

\*\*\* The Highway 59 Landfill charges less than average for tipping fees. Most operations charge between \$16 and \$20 per ton.

\*\*\*\*This delivery price (\$8/ton) for manure is contingent on local sources. Above 15 miles, delivery charges increase. Also, manure for this project was requested at higher moisture content to facilitate composting. Delivery costs would have been less if dry manure were used and water added on site, although the savings would need to be countered by the added processing cost.

Production and net costs from Table 2 indicate that if the co-compost could be sold for \$20/ton in bulk (the same price that Kenneth Stone & Family Manure Hauling and Spreading charges for composted dairy manure), the project would ‘break even’. If this price could be achieved and manure delivery costs were reduced, the co-compost could potentially generate a profit.

It is important to note that time required to satisfy permitting requirements was not included in Table 2. Permitting details are discussed in the next section, however when assessing the economic viability of co-composting, time required to gain approval to accept dairy manure as a compost feed stock can be significant.

Also, the distance that manure needs to be transported, both to the composting site and to the market destination, is also a factor in determining economic feasibility. Jerry Lawrie (Integrated Waste Program Manager, Merced County) indicated that most of their green waste compost is sold to customers within a 15 mile radius from the composting site. Kenneth Stone and Family charges a delivery fee for their compost based on distance traveled. Incremental costs for delivery based on mileage are detailed in Table 3. For co-composting to be cost effective, sources of dairy manure and compost buyers should be within close proximity (approximately 15 miles) from the composting site.

**Table 3. Manure delivery costs compared to distance traveled.**

<b>Delivery Distance (miles)</b>	<b>Dry Manure Delivery Cost \$/ton (~23 tons/load)</b>	<b>Moist Manure Delivery Cost (\$/ton) (~17 tons/load)</b>
0 - 15	3.78	5.12
16 - 20	4.13	5.59
21 - 25	4.48	6.06

#### Targeted Areas for Geographical Expansion

This project demonstrated that the addition of manure to green waste compost increases the nutrient value of the final product, and if a higher price can be obtained, the production of co-compost can be economically feasible. The proximity of green waste to dairy manure, and the high levels of agricultural production in the region, makes the Central Valley an ideal place to recycle manure and green waste nutrients via co-composting. There are three primary areas where co-composting occurs in the Central Valley –at municipal composting facilities, at commercial composting facilities, or on farms. Preliminary research indicated that many dairy farmers are not interested in composting on-farm. Further, an earlier demonstration of co-composting with turkey litter on-farm brought to light that where significant volumes of compost are exported off the farm, the composting operation is subject to state regulations. Therefore, it seemed logical to locate the co-composting demonstration on a municipal or commercial facility that has the infrastructure, equipment and permits needed to produce, sell and transport compost.

For this project the CIWMB suggested that the Highway 59 Landfill operator apply for a ‘Research Permit’ to allow for the project to proceed. This was agreed to by the operator, who applied for and received a research permit specifically for this project.

There are currently 16 permitted municipal or commercial green material composting facilities in the Central Valley that could conceivably improve their final product via the addition of dairy manure. State regulations allow green material composting facilities to also handle manure. The CIWMB’s website has information and resources on how to obtain approval to operate a co-composting facility ([www.CIWMB.ca.gov/permittoolbox](http://www.CIWMB.ca.gov/permittoolbox)).

Through the course of this project, we heard from dairymen and producer organizations that some dairy farmers were interested in producing compost on-farm, but uncertain of regulatory requirements. To clarify what these requirements are for on-farm composting of manure and/or agricultural green waste, we consulted with Robert Holmes, a Senior Integrated Waste Management Specialist with CIWMB. According to Holmes, the CIWMB does not require a permit, regardless of volume produced, if all of the compost produced is used on-farm. However, accepting green waste and selling or giving away more than 1000 yd<sup>3</sup> of compost does require enforcement agency notification, and in some case filing requirements, minimum standards and annual or quarterly inspections as described in Table 4.

**Table 4.** Summary of Integrated Waste Management Board regulatory requirements for on-farm composting and manure and green waste co-composting (prepared by Robert Holmes, CIWMB).

Material Source	Amount Sold or Given Away Annually	Material Type		On-Site Green Material Volume	Regulatory Tier	Subject to Minimum Standards	Inspection Frequency
		Agricultural Material <sup>a</sup>	Green Material <sup>b</sup>				
Own material <sup>c</sup>	< 1000 yd <sup>3</sup>	X		NA	Excluded	No	NA
	> 1000 yd <sup>3</sup>	X		NA	EA Notification <sup>d</sup>	Yes <sup>e</sup>	Annual
Combination: own and off-site material	< 1000 yd <sup>3</sup>	X		NA	EA Notification <sup>d</sup>	Yes <sup>f</sup>	Annual
	> 1000 yd <sup>3</sup>	X		NA	EA Notification <sup>d</sup>	Yes <sup>e</sup>	Annual
	< 1000 yd <sup>3</sup>	X	X	No limit <sup>h</sup>	EA Notification <sup>d</sup>	Yes <sup>g</sup>	Annual <sup>i</sup>
	> 1000 yd <sup>3</sup>	X	X	Limited to 12,500 yd <sup>3</sup>	EA Notification <sup>d</sup>	Yes <sup>g</sup>	Quarterly

- a. Agricultural Material means material of plant or animal origin, which results from the production and processing of farm, ranch, agricultural....products, including manures, orchard and vineyard prunings, and crop residues. [14 CCR 17852(a)(5)]
- b. In order to be considered Green Material must meet the definition of 14 CCR 17852(a)(21) and requirements of 14 CCR 17868.5.
- c. Agricultural Material derived from agricultural site, and similar amount of the material produced returned to that same agricultural site, or an agricultural site owned or leased by the owner, parent, or subsidiary. [14 CCR 17855(a)(1)]
- d. No permit required. Operator is required to notify enforcement agency of intent to operate. [14 CCR 17856] Filing requirements contained in 14 CCR 18103.1.
- e. Operational requirements, including: General Design Requirements (14 CCR 17866), General Operating Standards (14 CCR 17867), Training (14 CCR 17867.5), Sampling Requirements (14 CCR 17868.1), Maximum Metal Concentrations (14 CCR 17868.2), Pathogen Reduction (14 CCR 17868.3), General Record Keeping Requirements (14 CR 17869), and Site Restoration (14 CCR 17870). Note: Odor Impact Minimization Plan (per 14 CCR 17863.4) required if enforcement agency finds violation of odor impact requirements of 14 CCR 17867.
- f. Operational requirements, including all of the above [in (e.)] except Sampling Requirements (14 CCR 17868.1), Maximum Metal Concentrations (14 CCR 17868.2), and Pathogen Reduction (14 CCR 17868.3).
- g. Operational requirements, including Green Material Processing Requirements (14 CCR 17868.5) plus all of the above [in (e.)] except Sampling Requirements (14 CCR 17868.1) and Pathogen Reduction (14 CCR 17868.3).
- h. Unless enforcement agency finds risk to public health, safety, or the environment, in which case enforcement agency could reduce the on-site storage of green material. [14 CCR 17856(c)(1)]
- i. Unless enforcement agency finds risk to public health, safety, or the environment, in which case enforcement agency could require more frequent inspections. [14 CCR 17856(c)(1)]

## Communicating Results

To communicate our results to the solid waste, regulatory and dairy communities, on Friday, October 15<sup>th</sup>, 2004, a site tour and luncheon meeting was held in Merced. The event was attended by over 30 people from regulatory agencies such as U.S. EPA Region 9, Cal-EPA, California Integrated Waste Management Board, California Air Resources Board, San Joaquin county Solid Waste Division, Merced County Public Works, and Kings County Environmental Health. Representatives from commercial composting operations and dairy farms also attended (Figure 7).



**Figure 7.** Co-compost project overview at the Highway 59 Landfill.

The meeting began at the Highway 59 Landfill, where Jerry Lawrie (operations manager) gave the group a tour of the composting operations and participants were able to observe the co-compost directly (Figure 8). The conference then had a meeting in Merced to discuss aspects of the project such as: (1) the environmental benefits of co-composting dairy manure and urban green waste, (2) operational considerations and co-composting logistics, (3) economic feasibility of co-composting, (4) market opportunities for dairy manure and green waste co-compost, (5) regulatory requirements, and (6) how to make co-composting happen in California. Specific agenda items were:

1. ***Composting Dairy Manure for Improved Water Quality:*** Allen Dusault, Sustainable Conservation, Adrienne Priselac, U.S. EPA
2. ***Logistics of Co-Composting of Dairy Manure and Urban Green Waste:*** Jerry Lawrie, Merced County Public Works
3. ***Project Economic Feasibility:*** Kristen Hughes, Sustainable Conservation, Jerry Lawrie,

Merced County Public Works, Steve Stone, Ken Stone and Family Spreading Service

4. ***Market Opportunities for Manure/Green Waste Co-Compost in the Central Valley:*** Joe Mullinax, Denele Agri-Link Agricultural Laboratories

5. ***Dairy Manure Composting and Regulatory Compliance:*** Robert Holmes, Integrated Waste Management Board

6. ***How to Make Co-Composting Happen:*** Matt Cotton, Integrated Waste Management Consulting

The CIWMB also posted information about the project on their website, including project objectives and photos from the field day: <http://www.ciwmb.ca.gov/Organics/Farming/AgDemos/Manure.htm>.

Allen Dusault also wrote an article about the project published in the September 2004 issue of BioCycle titled “Digesting and Composting Team Up in California”.

The project final report will also be posted on Sustainable Conservation’s website: [www.suscon.org/dairies/index.asp](http://www.suscon.org/dairies/index.asp)



**Figure 8.** Field day attendees examine finished dairy manure and green waste co-compost at the site.

## **Conclusion**

The proximity of green waste to dairy manure and the high levels of agricultural production in the region make the Central Valley an ideal place to recycle manure and green waste nutrients via co-composting. This project demonstrated that the addition of manure to green waste compost increases the nutrient value of the final product, and if a higher price can be obtained, the production of co-compost can be economically feasible if manure and green waste sources are in close proximity to the landfill. Located just outside of the city of Merced, the Highway 59 Landfill is an excellent example of the geographic proximity of source and markets.

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