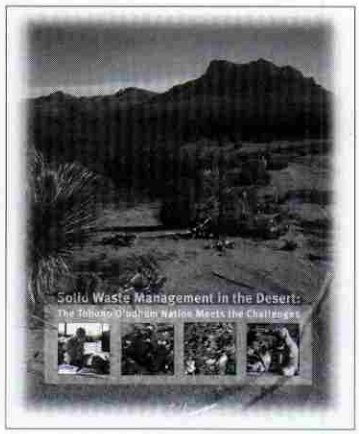

Characterization of the Solid Waste Stream of the Tohono O'odham Nation

Ann Marie A. Wolf, M.S.
Anna H. Spitz, Ph.D.
Gary Olson
Anita Závodská, Ph.D.
Mamoun Algharaibeh, Ph.D.

Abstract

The Tohono O'odham Nation's Solid Waste Management Program (SWMP) and the Sonora Environmental Research Institute, Inc. (SERI) completed a waste characterization study for the Tohono O'odham Nation (the Nation) to aid in the development of an effective waste management plan. The Nation has recently switched from open dumping and burning of waste to collection in dumpsters and transportation to regulated landfills. The study indicated that members of the Nation produce approximately one-third of the average amount of municipal solid waste produced per person per day in the United States. Far fewer hazardous materials and yard trimmings are found in the waste stream than is the U.S. average. Source reduction options are limited because much of the residential waste comes from packaging materials. Recycling opportunities exist but are hampered by the long distance to markets, which forces the Nation to look at innovative ways of utilizing materials on site. An education program focusing on the traditional O'odham lifestyle has been implemented to help reduce solid waste generation while improving people's health and the environment.

SERI research assistant Jamie Kern conducts the primary sort of the trash during the waste characterization.

Introduction

The Nation occupies 2,834,000 acres of land and extends from south of Casa Grande, Arizona, to the U.S./Mexico border. It is divided into 11 districts and 74 villages with a total population of about 8,906 (U.S. Census Bureau, 2000). The Nation as a whole believes that living in harmony with the earth is essential to its well-being. During the last 30 years, lifestyle changes have caused conflict with this belief. More and more, the population is using convenience items not used before. These new products are generating waste previously not dealt with by the O'odham people. Prior to 1996, most of the Nation's households disposed of their solid waste by open burning and dumping (Tohono O'odham Nation, 1996). Many residences had burn barrels, and each village had a community dump. Little maintenance was provided for these dumps once they were excavated. As trenches filled, the waste was burned to extend the useful life of the dump. With no controls, the dumps were a source of air and water pollu-

Previous solid waste disposal relied on community dumps consisting of trenches where trash was burned and more added.

The old community dumps had few controls. Windborne debris and ponding of water resulted.

tion, and windborne trash often covered the surrounding land.

The Nation recognized the need for a better method of handling solid waste and enacted the Solid Waste Management Code (Solid Waste Code) in 1997 (Tohono O'odham Nation, 1997). The Solid Waste Code addressed the Nation's desire to manage its solid waste in a manner that would protect the environment, the political integrity, and the economic security of the Nation and the health, safety, and welfare of its members. In creating this legislation, the Nation voluntarily decided to come into compliance with the U.S. Solid Waste Disposal Act, 42 U.S.C. 6901, as amended by the Resource Conservation and Recovery Act of 1976 (RCRA, 1976).

The Solid Waste Code created a collection system for nine of the 11 districts. The solid waste needs of the other two districts are met by private contracts at the district level. Those two districts are, however, still bound by the requirements of the Solid Waste Code. The open dumps were closed and replaced with waste dumpsters, and the Nation began hauling its waste to regulated landfills. In an effort to prevent pollution, the Solid Waste Code expressly prohibits the disposal in the waste collection system of liquids in amounts greater than 1 gallon and certain dangerous wastes, including household hazardous waste (HHW), biomedical wastes, asbestos, and tires (Tohono O'odham Nation, 1997). The response thus far to the adoption of the Solid Waste Code has been positive. In fact, Nation members recently voted for a five-dollar-per-month-per-household fee to support solid waste activities. One problem that persists is illegal dumping. SWMP is utilizing its outreach program to bring dumping under control while continuing to provide education about the Solid Waste Code.

TABLE 1

Selection of Dumpsters for Waste Characterization

Category	Subcategory	Characteristic	Number of Dumpsters
1. Residential			
	a) Population center (Sells)	Family owned	2
		Rental units	1
	b) Main road village (San Simon)	35 miles from Sells	1
	c) Rural villages		
	Pisinemo	32 miles from Sells	1
	Gu Vo	53 miles from Sells	1
	Menager's Dam	72 miles from Sells	1
2. Nonresidential			
	a) Supermarket		1
	b) Other commercial		
	Department of Education		1
	fire department		1
	commodities warehouse		1
	administration building		1
	legislative building		1
	judicial building		1

Current Disposal Procedures

SWMP collects waste from 600 residential dumpsters once a week and from most nonresidential sources twice a week. Nonresidential sources are limited primarily to the population center of Sells and include several government buildings, two schools, one jail, the Indian Health Services Clinic, the U.S. post office, the U.S. social security office, one supermarket, three convenience stores, one bank, one café,

TABLE 2

Waste-Sorting Categories

Paper	Plastic	Glass	Other	Metal	Organic	Durables	Non-construction Demolition Debris	Hazardous Waste
Newspaper Corrugated cardboard Glossy magazines Telephone books High-grade office paper Mail/paperboard Nonrecyclable paper	PET HDPE Polystyene Plastic film Nonrecyclable plastic	Clear Colored (amber, green) Nonrecyclable glass	Diapers Rubber Textiles Miscellaneous	Aluminum cans Aluminum foil Ferrous cans Ferrous scrap Nonrecyclable metal	Food Yard trimmings Other organic	Appliances Bulky waste		

and one video store. Nonresidential sources outside of Sells include three gas stations, four convenience stores, one casino, five schools, and two small health clinics.

Methods

Sampling Site Determination

In waste characterization studies, waste is usually divided into residential and nonresidential categories, with appropriate subcategories such as distance from a population center (Rathje & Murphy, 1992). Two categories were chosen for this study: residential and nonresidential. The residential category was further divided into three subcategories based on village location and socioeconomic status, and the nonresidential category was divided into the subcategories of "supermarket" and "other commercial" (Table 1). The residential subcategories are as follows:

1. Population center—Sells is the seat of government for the Nation and includes most commercial activities.
2. Main road village—San Simon is located within 35 miles of Sells and is on the main road.
3. Rural villages—Pisinemo, Gu Vo, and Menager's Dam are 32, 53, and 72 miles from Sells, respectively. They are off the main road and are considered rural villages. Menager's Dam is approximately 5 miles from Mexico.

For collection purposes, Sells was further divided into family-owned and rental units. The supermarket waste stream was assigned a subcategory of its own because it differed significantly from that of the other nonresidential entities.

Representative-Sample Collection

SWMP collected dumpsters for sorting on normally scheduled pickup days. To prevent compaction of garbage and mixture with other samples, the dumpsters were transported to the sorting area rather than being emptied into a garbage truck. Residents were not told that the study was being carried out, so no alteration of the typical waste streams was expected.

Waste Sorting

All residential samples consisted of one week's worth of waste, while nonresidential samples represented one-half week's accumulation. One dumpster at a time was sampled, sorted, and weighed, and all waste flowed in only one direction through the work area (primary sorting, secondary sorting, and weighing station). Rathje and Murphy (1992) have demonstrated that the accuracy of waste characterizations depends more on the accuracy of sorting than on the quantity of waste sorted; consequently, the procedures used by the Garbage Project at the University of Arizona were followed for this study.

Primary Sorting

Waste was placed on the primary sorting table, where the material was separated into 15 main categories—glass, plastic, paper, food, yard trimmings, metal, wood, durables, hazardous waste, diapers, textiles, rubber, miscellaneous, "other mixed inorganic," and "other mixed organic." These primary sorting categories were chosen to facilitate the sorting process.

Secondary Sorting

After primary sorting, the materials were passed to the secondary sorting crew and further sorted into 31 categories based on those used by the Garbage Project (Rathje & Murphy, 1992) (Table 2).

Weighing

After the secondary sort, the material was transferred into previously tared containers and weighed on an electronic scale. After each dumpster was sorted and weighed, the waste was disposed of, and the work area was cleared, swept, and prepared for the next sort.

Results

Quantities of Solid Waste Generated

Workers sorted a total of 1,931.37 pounds of residential and 1,596.14 pounds of nonresidential waste. Approximations of the total generation of waste on the Nation were made with scaling factors to convert the sorted values to tons generated per week and per month and to pounds generated per person per day. For example, the three dumpsters from Sells residential neighborhoods constituted about 3 percent of the total number of dumpsters (93) in Sells neighborhoods. One week's worth of refuse from these three dumpsters was 683.44 pounds. Scaling this to the entire residential population of Sells gives 21,187 pounds of waste generated per week, or 1.04 pound per person per day (ppd). With seven-day weeks and four-week months as the basis for calculation, Sells residences generated 42.37 tons per month of waste. The amounts of daily waste generated

in the other villages were calculated in the same way and are shown in Table 3.

For the category "other commercial," each dumpster sorted was one of two picked up per week, so approximating the total waste generated required that the sorted quantities be doubled. The supermarket dumpster was one of three picked up per week, so the sorted quantities had to be tripled. In addition, the seven dumpsters of nonresidential waste constituted about 12 percent of the total number of nonresidential dumpsters (60). The scaling accounted for this fact as well, indicating 38.95 pounds of nonresidential waste generated per month (Table 4).

To find the total number of tons generated by the Nation per month, the calculated value for the sampling size was scaled for the total population of the Nation. The size of the population included in the waste characterization was 3,920. Given the Nation's population of 8,906, the scaled-value calculation is 98.85/3,920 x 8,906 = 224.58. The Nation's average tons per month for the months of October 1998 to May 1999 was 242, with a range of 193 to 368 tons per month. The scaled value is relatively close to the actual average and well within the range of monthly values.

TABLE 3

Quantities of Residential Solid Waste Generated

Waste stream	Generation Rate (pounds/person/day)			
	Total	Packaging	Ferrous Cans	Plastic
Sells residential	1.04	0.44	0.12	0.01
San Simon	0.50	0.09	0.05	0.01
Pisinemo	1.12	0.46	0.19	0.10
Gu Vo	1.29	0.57	0.16	0.12
Menager's Dam	1.93	0.46	0.22	0.07

TABLE 4

Generation Rates by Waste Stream

Waste Stream	Generation Rate (tons per month)
Supermarket	10.02
Other commercial	28.93
Sells	42.37
San Simon	0.96
Gu Vo	5.59
Pisinemo	6.17
Menager's Dam	4.81
Total	**98.85**

Characterizations of the Waste Streams

Residential Waste Streams

The daily waste generation rates in the residential areas ranged from 1.93 ppd in Menager's Dam to 0.55 ppd in San Simon (Table 3). In the rural villages, as the distance from Sells increased, the pounds per day increased. A common explanation of higher waste generation rates in rural areas is that people who live further away buy more food that is packaged than people who live in population centers, where more fresh food may be available (Dahab & Woldt, 1994). Table 3 gives the amount of packaging waste generated per day, with "packaging" defined as glass, plastic, and metal containers; plastic film; cardboard; and paperboard (U.S. Environmental Protection Agency [U.S. EPA], 2001). Sells, Gu Vo, and Pisinemo had similar rates of packing waste; Menager's Dam rates were higher. Looking specifically at ferrous cans (tin) and plastic containers, however, demonstrates that the most common storage containers actually were generated at a higher ppd rate. Gu Vo and Menager's Dam generated food waste at higher rates than did the other communities. Menager's Dam is a community with homes requiring modernization; spoilage of food may occur more easily.

The community of San Simon was expected to have a generation rate similar to or slightly higher than that of Sells, but instead had a significantly lower rate. As can be seen in Table 3, the amount of packaging waste is considerably lower in San Simon than in any of the other communities, which accounts for the overall lower rate. A visual inspection of San Simon identified several gardens, but the community is probably purchasing much of its food from the supermarket in Sells. Many of the residents work in Sells; perhaps some of the packaging waste is being disposed of there. At this time, no other specific explanation can be given for the low generation rate.

A profile of the Sells waste stream is given in Table 5 as an example of residential waste streams. The residential waste streams had a variety of materials but were dominated by food, metal, and glass containers. Few to no yard trimmings were found in the waste, probably because of the nonlandscaped desert environment surrounding the homes. A similar result was found for the Kaibab Paiute Nation at less than 2 percent by weight, compared with 19.7 percent for Tucson, Arizona (Hughes, Makowsky, Austin, & Johnson, 1998).

The "hazardous waste" category included any items that could be hazardous to people, animals, or the environment, such as sharps (primarily hypodermic needles) and hazardous chemicals. Sharps were found in all but one of the residential waste streams. As has been found in other studies of rural communities, the majority of sharps were deposited in the trash directly rather than placed in a container (U.S. EPA, 2001). Few containers of hazardous materials (including detergents) were found, and very little HHW. For all containers (bleach, detergent, nail polish, roofing material, and soaps/waxes), only a nail polish bottle in Sells contained more than a negligible amount of liquid. The total number of household batteries in the entire solid waste stream sort was under 30—not even 0.04 percent by weight, which is significantly lower than the percentage found in other studies (Wilson & Rathje, 1989). The weight fraction of HHW, at 0.11 percent, is also significantly lower than the percentage found in other studies. For the Kaibab Paiute Nation, the Garbage Project found 0.69 percent (Hughes et al., 1998). Over 10 years of sorts, the Garbage Project found that HHW ranged from 0.2 percent to 0.6 percent (Rathje, 1997).

TABLE 5

Waste Stream Characterization for Sells and the Legislative Building

Category	Percentage of Total Weight	
	Sells	Legislative Building
Paper		
newspaper	7.95	4.60
corrugated cardboard	4.98	5.15
glossy magazines	1.67	11.48
telephone books	0.00	2.14
office paper	0.32	37.98
mail/paperboard	5.01	11.48
nonrecyclable paper	8.99	8.95
Plastic		
PET	2.24	4.01
HDPE	1.41	0.00
polystyrene	1.92	1.10
plastic film	3.91	3.84
nonrecyclable plastic	1.65	0.00
Glass		
clear glass	7.49	3.75
colored glass	10.71	0.00
nonrecyclable glass	0.60	0.00
Metal		
aluminum cans	0.93	2.99
aluminum foil	0.79	0.50
ferrous cans (tin)	1.29	0.02
ferrous scrap	1.60	0.00
nonrecyclable metal	0.00	0.00
Organic		
food	19.71	1.61
yard trimmings	0.12	0.00
other organic	1.06	0.00
Construction and demolition	0.00	0.00
Durables		
appliances	1.51	0.00
bulky waste	0.00	0.00
Other		
rubber	1.93	0.00
diapers	7.47	0.00
textile	3.97	0.00
miscellaneous	0.00	0.00
Hazardous waste	0.70	0.44
Total	**100.00**	**100.00**

Nonresidential Waste Streams

Other Commercial. The waste stream from the legislative building is profiled in Table 5 as an example of nonresidential waste streams. The waste streams of the government buildings were dominated by paper categories. Several dumpsters had residential items such as diapers. These could be attributed to residential contamination or, more likely, to the prevalence of young children being taken to work. In commercial dumpsters, even fewer hazardous materials were found. Again, all containers, except one motor oil container, held only negligible amounts of liquid.

Supermarket. The supermarket's waste stream comprised primarily of food, paper, and plastic. The largest percentage of the waste was food, totaling 64.90 and consisting primarily of expired drinks such as milk and fruit juices. Over 90 percent of the food had expired within four days of the sorting. The percentage of paper, 11.67, was low because the supermarket already recycles cardboard. The waste that fell into the plastic category—13.24 percent—consisted primarily of plastic film and nonrecyclable plastics.

Comparison with the U.S. Average

Although dividing waste streams into residential and nonresidential categories is useful in the study of community waste generation, published data on municipal waste include commercial waste. The most recent U.S. EPA report on municipal solid waste generation includes waste from schools, businesses, institutions, and prisons in its calculations of municipal solid waste. HHW, industrial waste, biosolids, automobiles and construction debris are not included (U.S. EPA, 2001). A comparison of U.S. average waste generation and the waste generation of the Nation, following the definition given above for municipal solid waste and the categories given in the U.S. EPA report, is shown in Table 6. Similar trends are seen, except in the "food" and "yard trimmings" categories. The amount of food waste is disproportionately affected by the supermarket's waste, which represents over 26 percent by weight of the total nonresidential waste stream.

Even with commercial waste included, the generation rate of the Nation is only 1.66 ppd, compared with 4.62 ppd for the United States in 1999 (U.S. EPA, 2001). This disparity can be attributed to several factors. The Nation is not a throwaway society. Items are often reused several times. The traditional lifestyle emphasizes living in harmony with the environment. Part of the SWMP education program consists of elders speaking to children and young adults about the traditional lifestyle and respecting the land. Another contribution to the low generation rate may be the low average income on the Nation compared with the U.S. average and, hence, a decreased spending power that leads to less purchasing and less waste (U.S. Census Bureau, 2000).

Recyclables

The recyclables category includes newspaper, cardboard, magazines, mail/paperboard, polyethylene terephthalate (PET), high-density polyethylene (HDPE), polystyrene, clear and colored glass, aluminum cans and foil, plastic film, ferrous cans, and ferrous scrap. Only items reasonably likely to be recycled are considered recyclable; the category does not include items that are potentially recyclable but in practice are not recycled. Recyclables constituted from 24.88 percent

to 52.23 percent (by weight) of the residential waste streams, with Sells having the highest percentage, and from 9.31 percent to 88.97 percent in the nonresidential waste, with the legislative building having the highest percentage (Table 7).

Table 7 gives the top three recyclable materials found in each waste stream. All nonresidential waste streams except the supermarket stream had a paper product as the top recyclable item. Gu Vo and Sells had mixed colored glass as the most common recyclable (12.09 percent and 10.71 percent, respectively). Menager's Dam and San Simon had paper as the most common recyclable—magazines at 5.12 percent and newspaper at 8.96 percent, respectively. Pisinemo had ferrous cans as its top recyclable, at 11.19 percent. All of the villages except Sells had ferrous cans as a top recyclable, probably reflecting the distance from the supermarket.

Discussion

Because waste disposal is such a costly business, the Legislative Council feels the first and best line of defense is to reduce waste generation. SWMP has taken several steps toward that goal by implementing a traditional-living education program. The Nation has made a strong commitment to building new housing and modernizing bathrooms in existing homes. The population is moving from dirt-floor homes, in which few convenience cleaning items are used, to modern houses, in which there is a great potential for reliance on convenience items. The traditional-living program includes traditional methods for performing household cleaning activities in hopes of reducing the use of cleaners and the generation of containers. SWMP's pollution prevention program also emphasizes simple ways to reduce the waste stream, such as reusing containers, using both sides of a piece of paper, and buying only what is needed. Unfortunately much of the waste in the residential waste stream is due to packaging provided by manufacturers. For many of these items, recycling is the most viable option.

Recyclable Materials

The majority of the commercial waste is generated in Sells, facilitating collection of recyclables. An office paper recycling program has recently been implemented, and the cardboard program expanded. The supermarket now collects grocery bags (a plastic film). Institution of these programs is reducing the commercial waste stream. SWMP is currently looking into other recycling opportunities. Metal recyclers exist in Tucson, approximately 70 miles from Sells. Newspaper and glass must be transported to Phoenix, while the only market for plastic is in southern California. The most feasible option at this time is the institution of aluminum-can dropoff centers. Since a buy-back value is attached to this material, the endeavor may be economically viable. A collection program for ferrous cans and glass would further reduce the residential waste stream. The necessity of transportation to Tucson and Phoenix limits the profitability of such programs; however, the reduction in tonnage fees paid and operation and maintenance costs of waste collection vehicles may offset collection and transportation costs.

The best approach is to find potential end uses for the materials on the Nation. Because of the current upgrading of bathrooms and the installation of septic systems, ground glass could be reused on the Nation. A septic-system leachfield consists of a series of trenches that contain perforated pipe packed in a grav-

TABLE 6

Make-up of Waste Stream—U.S. Average Compared with Tohono O'odham Nation

Category	Percentage of Weight	
	U.S. Average	Tohono O'odham Nation
Paper and paperboard	38.06	31.73
Glass	5.48	8.02
Steel	5.78	2.88
Aluminum	1.35	1.51
Other nonferrous	0.61	0.00
Plastics	10.52	11.90
Rubber and leather	2.70	0.63
Textiles	3.96	5.49
Wood	5.35	0.24
Food	10.96	27.22
Yard trimmings	12.05	0.17
Miscellaneous inorganic	1.48	5.60
Other	1.74	3.74
Hazardous waste	NA	0.87
Total	**100.04***	**100.00**

*The value above 100% is attributable to rounding-off errors.

TABLE 7

Percentage of Recyclables, by Weight, in Waste Streams

Waste Stream	Percentage of Recyclables	Top Three Recyclable Commodities		
Supermarket	9.31	Plastic film	Cardboard	PET
San Simon	24.88	Newspaper	Clear glass	Ferrous cans
Menager's Dam	28.30	Magazines	Plastic film	Ferrous cans
Pisinemo	39.82	Ferrous cans	Plastic film	Clear glass
Gu Vo	47.92	Colored glass	Ferrous cans	Newspaper
Judicial building	48.90	Mail/paperboard	Plastic film	PET
Sells residential	52.23	Colored glass	Newspaper	Clear glass
Fire department	54.34	Cardboard	Mail/paperboard	Colored glass
Department of Education	78.22	Office paper	Newspaper	Mail/paperboard
Commodities warehouse	81.13	Cardboard	Plastic film	Ferrous scrap
Administration building	87.48	Mail/paperboard	Cardboard	PET
Legislative building	88.97	Office paper	Magazines	Mail/paperboard

el bed. A standard leach field requires 33 cubic yards of gravel, which the Nation proposes to replace with ground glass. A glass grinder is available at low cost for pilot testing and eventual implementation. The reuse of the glass would have a twofold impact: 1) The material would be recycled and diverted from the waste stream. 2) Resources would be saved because the Nation would not be shipping the material elsewhere and would not have to ship in or mine gravel for the septic-system upgrades.

Food Waste

Composting is not widely practiced on the Nation. The only place where some indication of composting was seen was on the hospital grounds next to a small vegetable garden, where several wooden boxes of garden trimmings were set apart from other materials. It did not look like a very active project, however. While composting would ideally be a way to reduce the amount of food waste, it is not at present a very practical option. The desert environment does not easily lend itself to composting, and little demand for composted material is evident.

In the United States, supermarkets often send food to local food banks (Heumann, 1999). The supermarket in Sells throws away significant quantities of food. The waste characterization carried out in this study suggests that the main reason for food being thrown away was expiration date rather than spoilage. One of the goals of SWMP is the donation of this food to families on the Nation. The main issue will be timely donation with respect to the expiration dates. Preliminary contacts with the supermarket indicate a willingness to attempt some type of cooperative effort. SWMP also is trying to see if anyone who raises livestock would be interested in taking the food to feed to animals.

Hazardous Waste

Very little hazardous waste was found in the waste streams. Previous reconnaissance of the open dumps also found few HHW containers. Zeiss (1994) found the weight fraction of HHW disposed of by rural communities to be 3.6 percent, compared with 0.87 percent (including containers) found for the Nation. In 1999, because the percentage of HHW was low, a dropoff station for antifreeze, batteries, oil, and paint was set up instead of a full HHW collection facility. In January 2002, a grant from U.S. EPA enabled the Nation to purchase necessary equipment, set up outreach sites in other districts, and provide education. After the waste characterization, SWMP had established an education program focused on alternatives and the proper use and disposal of hazardous materials. The U.S. EPA grant has allowed SWMP to expand its outreach program, with a focus on presentations to schools and at community events and meetings.

Conclusion

The Nation has made a successful transition from open dumps and burning of waste to collection of waste in dumpsters. Residents are concerned about solid waste management and are committed to a successful program. The Nation produces far less solid waste per person than most U.S. communities—it appears to be far less of a "throw-away" society. This study provided valuable data for setting solid waste management goals and for tracking progress toward those goals. It highlighted opportunities for recycling and provided information on special management issues that should be addressed, such as reducing food waste. The long distance to markets limits the kinds of programs that can be adopted, and the Nation must develop innovative ways to divert materials from the waste stream. Currently, a viable way of reusing glass in the installation of septic systems is promising. The transition has helped to preserve and protect the health of the Nation's members and the integrity of its land.

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Corresponding Author: Anne Marie A. Wolf, Sonora Environmental Research Institute, Inc., 3202 E. Grant Rd., Tucson, AZ 85716. E-mail: aawolf@seriaz.org.

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