APPENDIX C

Final Report

Conversion Factors for Individual Material Types

Submitted to

California Integrated Waste Management Board

by

CalRecovery
INCORPORATED

Tellus Institute

ACT...now

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RESULTS

Table 5 is the master table that presents conversion factors for weight-to-volume and volume-to-weight for individual material types and forms. The information in this table is derived from field studies, a literature search, and mail survey. Tables 1, 2, 3, and 4 present the results of various data collection efforts from which data for Table 5 were selected. Selection and incorporation of data from Tables 1, 2, 3, and 4 into the master table (i.e., Table 5) was based on the following hierarchy in descending order of reliability: field studies, literature search and telephone communication, and mail survey.

At the top of the hierarchy of selection is the use of field study data. Field studies were conducted under controlled conditions and where possible were replicated in order to provide statistically valid densities of materials. These studies also allowed, in some cases, the selection of sub-groups for measurements within a specific material type. For example, previously published densities for whole glass containers do not distinguish density of containers as a function of color. The field studies conducted for this project enabled this distinction to be studied.

In those cases where collection of field data for field data for certain material types or forms was not feasible, data was utilized from the literature survey and telephone communication where such data were available and judged to be reliable.

For this study the least reliable density data were judged to be supplied by the mail survey. Confirmation of measurement data and other uncertainties are reasons for relegating the density results of the mail survey to the lowest level of the hierarchy of data reliability. Lacking data from field measurements or from the literature search, data was used from the mail survey where the data were judged by CalRecovery to be reliable.

Table 5. Densities and Conversion Factors for Various Material Types

Material Type	Form a)	Special Notes b)	California Field Studies			Conversion Factors from Literature Review			Out of State Field Studies			California Mail Survey Results		
				Conversion Factors			Conversion Factors			Conversion Factors			Conversion Factors	
			lb/cu yd	Tons to cu yd	cu yd to Tons	lb/cu yd	Tons to cu yd	cu yd to Tons	lb/cu yd	Tons to cu yd	cu yd to Tons	lb/cu yd	Tons to cu yd	cu yd to Tons
PAPER														
Old Corrugated Cardboard/ flattened boxes	loose		50.08	39.93	0.03									
Old Corrugated Cardboard/ whole boxes	loose		16.64	120.19	0.01									
Old Corrugated Cardboard/ recycling center	baled	73"x42"x32"	713.00	2.81	0.36									
Old Corrugated Cardboard/ resource recovery facility	baled	87"x40"x29"	742.00	2.70	0.37									
Old Corrugated Cardboard	baled low density	48"x42"x32"										378.00	5.29	0.19
Kraft (Brown) Bags/Paper	baled low density	69"x42"x40"										2221.71	0.90	1.11
Brown Paper Bags	loose		34.43	58.09	0.02									
Mixed Paper	loose								484.00	4.13	0.24			
Mixed Paper/supermix	baled	76"x38"x34"	635.00	3.15	0.32									
Newspaper	baled	80"x42"x32"	748.00	2.67	0.37									
Newspaper: w/o inserts	loose		322.77	6.20	0.16									
Newspaper	low compaction truck											421.88	4.74	0.21
Mags. Glossy/In.coated	baled high density	3'x4'x5'										1082.70	1.85	0.54
Glossy inserts	loose		570.37	3.51	0.29									
High Grade White Ledger	baled	76"x34"x38"	644.00	3.11	0.32									
High Grade Ledger/w/o CPO	loose		363.51	5.50	0.18									
Books/hardback	loose		529.29	3.78	0.26									
Books/paperback	loose		427.50	4.68	0.21									
Telephone Directories/books	whole	stacked							944.91	2.12	0.47			
Computer Printout	loose		519.40	3.85	0.26									
Computer Printout	baled	75"x40"x30"	578.00	3.46	0.29									
Other Paper/trims (white fly)	baled high density	84"x32"42"										495.92	4.03	0.25
Other Paper/trims (white fly)	baled high density	66"x45"x28"										408.40	4.90	0.20
Bleached HWD & SWD Paper	baled high density	35"x30"x17"										1254.62	1.59	0.63
Paperboard/Boxboard/Chipboard	whole		21.50	93.02	0.01									
PLASTIC														
HDPE/colored (black nursery pots)	baled	81"x44"x31"	573.00	3.49	0.29									
HDPE/milk,water	whole		22.10	90.50	0.01									
HDPE/mix color	whole		47.05	42.50	0.02									
HDPE/natural	baled	91"x43"x32"	576.00	3.47	0.29									
HDPE (mixed colored)	baled	84"x44"x32"	511.00	3.91	0.26									
HDPE (mixed colored)	pelletized	3 to 4 cu in.										857.14	2.33	0.43

a) Refer to Appendix B for an explanation of processed and unprocessed forms
b) < = less than

Table 5. Densities and Conversion Factors for Various Material Types (Continued)

Material Type	Form a)	Special Notes b)	California Field Studies			Conversion Factors from Literature Review			Out of State Field Studies			California Mail Survey Results		
			Conversion Factors						Conversion Factors					
			lb/cu yd	Tons to cu yd	cu yd to Tons	lb/cu yd	Tons to cu yd	cu yd to Tons	lb/cu yd	Tons to cu yd	cu yd to Tons	lb/cu yd	Tons to cu yd	cu yd to Tons
PET	baled	92"x43"x32"	414.00	4.83	0.21									
PET/clear w/o redemp	baled	79"x43"x32"	443.00	4.51	0.22									
PET/CRV	whole		34.58	57.84	0.02									
PET/mixed	whole		43.30	46.19	0.02									
PET	granulated	1/2"										771.43	2.59	0.39
PVC	loose								341.12	5.86	0.17			
Film Plastic/mixed	loose		22.55	88.69	0.01									
Other Plastic (SPI codes #3-7)	whole		49.76	40.19	0.02									
LDPE Film Plastics	semi-compacted	assorted bags							72.32	27.65	0.04			
HDPE Film Plastics	semi-compacted	assorted bags							75.96	26.33	0.04			
Polystyrene/rigid	whole	stacked sheets							21.76	91.91	0.01			
Polystyrene/blown formed foam	loose		9.62	207.87	0.00									
Styrofoam/kernels	loose		6.27	318.87	0.00									
Polypropylene/film	packed	can liners							9.26	215.98	0.01			
Polypropylene/strap	packed, coiled								371.62	5.38	0.19			
GLASS														
Other Non-Recyclable	size reduced	plate glass window, <4"							1415.00	1.41	0.71			
Glass/clear CRV	whole		466.49	4.29	0.23									
Glass/clear non-CRV	whole		437.77	4.57	0.22									
Glass/green	whole		456.71	4.38	0.23									
Glass/mix brown	whole		439.58	4.55	0.22									
Glass/mix clear	whole		476.26	4.20	0.24									
Glass/mix color	size reduced	<2"	1867.75	1.07	0.93							2187.00	0.91	1.09
Cal Redemp. Value	size reduced	5/8"										2187.00	0.91	1.09
Other Recyclable	size reduced	5/8"												
METAL														
Aluminum Foil	loose		48.10	41.60	0.02									
Aluminum Foil	baled	65"x42"29"	188.00	10.64	0.09									
Aluminum Cans	loose	uncrushed & crushed mix	91.40	21.88	0.05									
Aluminum Cans	baled	82"x41"x31"	399.00	5.01	0.20							49.00	40.82	0.02
Aluminum Cans	uncrushed											363.00	5.51	0.18
Aluminum Cans	shredded	2"												
Aluminum Scrap	cubed	34"x24"x20"	424.00	4.72	0.21							175.00	11.43	0.09
Aluminum Scrap	whole													

a) Refer to Appendix B for an explanation of processed and unprocessed forms

b) < = less than

Table 5. Densities and Conversion Factors for Various Material Types (Continued)

Material Type	Form a)	Special Notes b)	California Field Studies			Conversion Factors from Literature Review			Out of State Field Studies			California Mail Survey Results		
				Conversion Factors			Conversion Factors			Conversion Factors			Conversion Factors	
			lb/cu yd	Tons to cu yd	cu yd to Tons	lb/cu yd	Tons to cu yd	cu yd to Tons	lb/cu yd	Tons to cu yd	cu yd to Tons	lb/cu yd	Tons to cu yd	cu yd to Tons
Bi-Metal Containers	uncrushed								141.38	14.15	0.07			
Ferrous Food & Beverage Containers	loose		144.32	13.86	0.07									
Ferrous Food & Beverage Containers	cubed	29"x21"x24"	2093.00	0.96	1.05									
Brass/scrap	whole	<12"	906.43	2.21	0.45									
Lead Scrap	whole					1603.84	1.25	0.80						
Copper Scrap	whole					1093.52	1.83	0.55						
Copper Wire	whole											337.50	5.93	0.17
Copper Pipe	whole											210.94	9.48	0.11
Copper Fittings	loose								1047.62	1.91	0.52			
White Goods	cubed	30"x22"x23"	1907.00	1.05	0.95									
Dishwashers	whole					234.00	8.55	0.12						
Dryers	whole					224.00	8.93	0.11						
Refrigerators/freezers	whole					198.00	10.10	0.10						
Washers	whole					321.00	6.23	0.16						
Stoves/ovens	whole					300.00	6.67	0.15						
YARD WASTE														
Leaves/dry	loose		343.70	5.82	0.17									
Grass/clipping fresh	loose		280.22	7.14	0.14									
Prunings	shredded	2"										527.00	3.80	0.26
Prunings/dry	loose	<4"	36.90	54.20	0.02									
Prunings/green	loose	<4"	46.69	42.83	0.02									
Large Limbs & Stumps	loose	>4"				1080.00	1.85	0.54						
Garden Debris/flowers,plants	loose		182.81	10.94	0.09									
Pine Needles	loose	dry	74.42	26.88	0.04									
OTHER ORGANICS														
FOOD WASTE														
Produce Waste/cantelopes	loose								1000.00	2.00	0.50			
Produce Waste/mixed fruit	loose								1131.00	1.77	0.57			
Produce Waste/vegetable	loose								909.00	2.20	0.45			
Produce Waste/mixed	loose					1443.00	1.39	0.72						
MULCH/COMPOST														
Mulch/cedar	loose		381.96	5.24	0.19									
Mulch/redwood	loose	coarse	187.50	10.67	0.09									
Mulch/redwood	loose	fine	277.50	7.21	0.14									
Bark/fir	size reduced	1/4"	426.96	4.68	0.21									

a) Refer to Appendix B for an explanation of processed and unprocessed forms

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Table 5. Densities and Conversion Factors for Various Material Types (Continued)

Material Type	Form a)	Special Notes b)	California Field Studies			Conversion Factors from Literature Review			Out of State Field Studies			California Mall Survey Results		
				Conversion Factors			Conversion Factors			Conversion Factors			Conversion Factors	
			lb/cu yd	Tons to cu yd	cu yd to Tons	lb/cu yd c)	Tons to cu yd	cu yd to Tons	lb/cu yd	Tons to cu yd	cu yd to Tons	lb/cu yd	Tons to cu yd	cu yd to Tons
Bark/fir	size reduced	3/4"	438.75	4.56	0.22									
Bark/fir	size reduced	2"	492.86	4.06	0.25							240.00	8.33	0.12
Wood Chips	shredded	2"	463.39	4.32	0.23									
Compost	loose					1400.00	1.43	0.70						
Compost/MSW	loose	40-50% moisture				474.00	4.20	0.24						
Compost/sludge	loose								1739.75	1.15	0.87			
Compost/yard waste	loose	unscreened												
Compost/mushroom	loose		827.68	2.42	0.41									
TIRES														
Tires/auto	whole	stack of 3 tires							221.57	9.03	0.11			
Tires/truck														
Radial	whole	individual tire							476.00	4.20	0.24			
Bias	whole	individual tire							362.00	5.52	0.18			
Tires/heavy equip.	whole	bias ply individual tire weight only				316.00	NA d)	NA						
Rubber Products	loose					1200.00	1.67	0.60						
WOOD WASTE														
Furniture	whole					166.00	12.05	0.08						
Pallets	whole	4/sample	200.98	9.95	0.10									
Saw dust	loose		375.00	5.33	0.19									
Wood scrap	loose	<2"	329.53	6.07	0.16									
Particle board	loose		425.14	4.70	0.21									
Shavings	loose					440.00	4.55	0.22						
Roofing/shake shingle	bundle		435.30	4.59	0.22									
Plywood	sheet	2'x4'	776.30	2.58	0.39									
AG CROP RESIDUE														
Field Residues														
Spent barley	loose					450.00	4.44	0.23						
Corn silage	loose					480.00	4.17	0.24						
Dried corn stalks	loose					30.00	66.67	0.02						
Almond shell/hulls	loose		642.86	3.11	0.32									

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c) Except for individual items (e.g., each) in which case the units are pounds (lb).

d) NA means not applicable because data are reported on a unit basis.

Table 5. Densities and Conversion Factors for Various Material Types (Continued)

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Rice Hulls	loose					220.00	9.09	0.11						
Straw	loose					60.00	33.33	0.03						
Prunings	loose	<4"	46.69	42.83	0.02									
Cannery Waste						350.00	5.71	0.18						
Beet pulp	loose													
Tomato pumice	loose	wet	827.14	2.42	0.41									
Grape pumice	loose	wet	1240.18	1.61	0.62									
Grape pumice	loose	dry	781.61	2.56	0.39									
MANURE														
Poultry														
Ricca hen aged	loose	wet				1406.00	1.42	0.70						
Ricca hen fresh	loose	wet				1376.00	1.45	0.69						
Turkey	loose					734.00	2.72	0.37						
Broiler	loose	dry				756.00	2.65	0.38						
Hen	loose	wet				1796.00	1.11	0.90						
Livestock														
Horse Manure	loose	w/ wood chips							1252.00	1.61	0.63			
Cattle	loose					1628.00	1.23	0.81						
TEXTILES														
Carpet & Padding	loose		84.40	23.70	0.04									
Scrap Leather	semi-compacted	1/8"x7"x33" pieces							243.00	8.23	0.12			
Scrap Leather	semi-compacted	1/8"x6"x18" pieces							303.00	6.60	0.15			
Scrap Leather	semi-compacted	1/8"x6"x18" pieces-flat							470.00	4.26	0.24			
Leather Remnants	semi-compacted	apron leather							383.60	5.21	0.19			
Leather Remnants	semi-compacted	shoe leather							363.40	5.50	0.18			
Leather Remnants	semi-compacted	hide scraps							514.90	3.88	0.26			
Shoes/men's	loose								224.00	8.93	0.11			
Used Clothes/winter coats	loose								241.00	8.30	0.12			
Used Clothes/jeans	loose								285.00	7.02	0.14			
Used Clothes/T-shirts	loose								260.00	7.69	0.13			
Used Clothes/mixed	loose								225.00	8.89	0.11			
Used Clothing	compacted					540.00	3.70	0.27						

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OTHER WASTES														
INERT SOLIDS														
Rock	loose	2-12"							2570.96	0.78	1.29			
Rock/red lava	loose	5/16"	1325.89	1.51	0.66									
Concrete Scrap	loose	<8"	1855.18	1.08	0.93									
Brick	whole					3024.00	0.66	1.51						
Brick/red (broken)	loose	<8"	1614.11	1.24	0.81									
Ceramic Tile	loose	6"x6"	1213.93	1.65	0.61									
Sand	loose		2441.25	0.82	1.22									
Contaminated Soil	loose					2600.00	0.77	1.30						
Soil/sandy loam	loose		2391.96	0.84	1.20									
Soil/via self haul	loose		2385.54	0.84	1.19									
Fines	loose					2700.00	0.74	1.35						
Asphalt/paving	crushed					1380.00	1.45	0.69						
Asphalt/tar roofing						2918.92	0.66	1.51						
Asphalt/shingles comp	loose		418.53	4.78	0.21									
Gravel	loose					2565.00	0.78	1.28						
Stone/crushed	size reduced					2700.00	0.74	1.35						
Sheetrock Scrap	loose	<2'	393.57	5.08	0.20									
Fiberglass Insulation	loose					17.00	117.65	0.01						
Soiled Disposable Diapers	loose		540.00	3.70	0.27									
Aseptic Packaging	whole		56.70	35.27	0.02									
Televisions	whole					343.00	5.83	0.17						
Stereo Equipment	whole					763.00	2.62	0.38						
Stuffed Furniture	whole					80.00	25.00	0.04						
Empty Discarded HHW Containers	whole		117.26	17.06	0.06									
Antifreeze	liquid					1653.00	1.21	0.83						
Auto Batteries	whole	4/sample	3027.18	0.66	1.51									
Auto Oil Filters	loose		834.40	2.40	0.42									
Enamel Paint	liquid					1653.00	1.21	0.83						
Latex Paint	liquid					1836.00	1.09	0.92						
Flammable Liquids						1653.00	1.21	0.83						
Flammable Liquids						550.00	3.64	0.28						
Aerosol Cans						918.00	2.18	0.46						
Oxidizers						92.00	21.74	0.05						

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Poisons						550.00	3.64	0.28						
Waste Oil						1524.94	1.31	0.76						
SPECIAL WASTES														
Ash/Incinerator		50% solids				1350.00	1.48	0.68						
Ash/Incinerator		15% water				1957.00	1.02	0.98						
Ash/wood		50% solids				1100.00	1.82	0.55						
Ash/other		dry				1110.00	1.80	0.56						
Baghouse						810.00	2.47	0.41						
Sewage Sludge/dewatered		20.4% solids	1293.75	1.55	0.65									
Sewage Sludge/dewatered		95.5% solids	1935.54	1.03	0.97									
Sludge/chem fix		55% solids				2025.00	0.99	1.01						
Industrial Sludge/apple waste		41% solids				1411.00	1.42	0.71						
Industrial Sludge/papermill		34-38% solids				1425.00	1.40	0.71						
Industrial Sludge/dewatered	landfill high compaction	50% solids										1500.00	1.33	0.75
Asbestos Bags	semi-compacted					376.50	5.30	0.19						
Auto Shredder Fluff	loose					800.00	2.50	0.40						
Auto Bodies	baled					1215.00	1.65	0.61						
Auto Bodies	flattened					579.20	3.45	0.29						
Auto Bodies	compacted					450.00	4.44	0.23						
Cement Kiln Dust	loose					1404.00	1.42	0.70						
Slag	loose	broken				2970.00	0.67	1.49						
Slag	crushed					1998.00	1.00	1.00						
Slag/furnace	granulated					1620.00	1.23	0.81						
Slag/screenings	loose					2495.00	0.80	1.25						
Dead Animals/small	each	individual				20.00	NA d)	NA						
Dead Animals/large	each	individual				1150.00	NA	NA						
Dead Animals/turkey	bulk					600.00	3.33	0.30						
Transformer/100 kva	whole					1798.00	1.11	0.90						
Transformer/15 kva	whole					1008.00	1.98	0.50						
Transformer/167 kva	whole					1828.00	1.09	0.91						
Transformer/25 kva	whole					1096.00	1.82	0.55						
Transformer/37.5 kva	whole					1254.00	1.59	0.63						
Transformer/50 kva	whole					1326.00	1.51	0.66						
Transformer/75 kva	whole					1385.00	1.44	0.69						

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Street Sweepings	loose		1145.36	1.75	0.57									
Drilling Mud		25% moisture				2222.00	0.90	1.11						
Septic Tank Pumpings						1655.56	1.21	0.83						
Chemical Toilet Wastes						1655.56	1.21	0.83						
Grease Trap Pumpings						1594.90	1.25	0.80						
Intact Red Bags of Treated Medical Waste						166.15	12.04	0.08						
Drinking Water/wastewater treatment residue (Diatomaceous Earth)		55% moisture	967.00	2.07	0.48									
		air dry	479.80	4.17	0.24									

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