Mattress Recycling Council®

Final Report

California Mattress Recycling Residue Composition Study

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MSW CONSULTANTS

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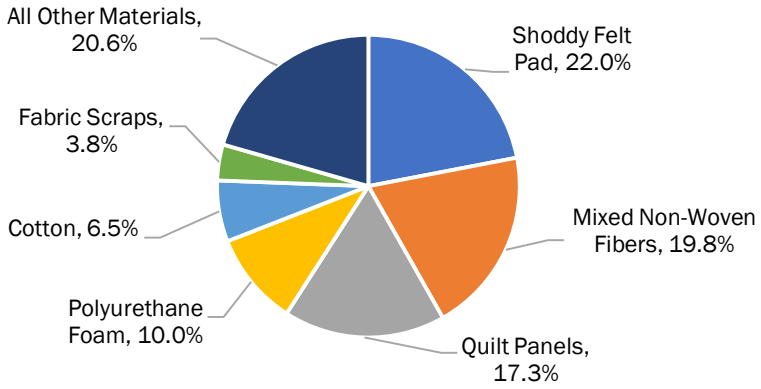
MATTRESS RECYCLING RESIDUE COMPOSITION STUDY

E. EXECUTIVE SUMMARY

The Mattress Recycling Council (MRC) is a 501(c)(3) organization formed by the mattress industry to operate recycling programs in several states. MRC contracts with qualified mattress recyclers, who are required to achieve a 75% by weight recycling rate. While this recycling performance reflects meaningful success in mattress and box spring recycling, MRC commissioned a composition analysis of the residual materials generated at two California mattress recyclers to identify what constituents are still going to landfills, and how it would be possible to incrementally improve mattress recycling rates.

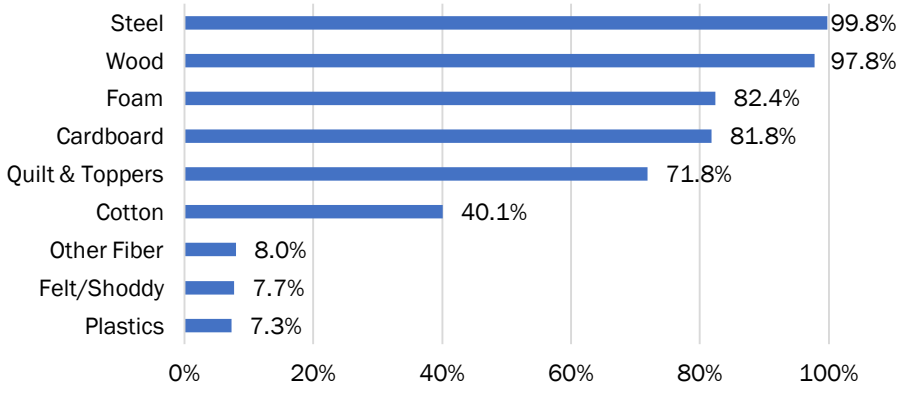
Over 19,000 pounds of residuals were sorted at the two participating recyclers. Figure E-1 summarizes the composition of the residuals as found in the study. The top three most prevalent waste categories as a percentage of total waste were shoddy felt pad (22.0%), mixed non-woven fibers (19.8%) and quilt panels (17.3%). Recyclers are disposing of these materials primarily because of a lack of end markets, or because the constituents contained contamination that impaired recovery.

Figure E-1 Composition of Mattress Recycling Residuals



The observed composition of residuals was also applied to reported annual (2020) mattress recycling and residual quantities to estimate the capture rate of various constituents from the mattress recycling process. Figure E-2 summarizes these estimated capture rates. The mattress recycling process is highly successful at capturing steel, wood, foam, and cardboard.

Figure E-2 Implied Capture Rates in California (2020)



1. INTRODUCTION

The Mattress Recycling Council (MRC) is a 501(c)(3) organization formed by the mattress industry to operate recycling programs (known as Bye Bye Mattress) in states which have enacted mattress recycling laws, including California, Connecticut, and Rhode Island. MRC educates the mattress industry and consumers about these mattress recycling laws and works closely with local governments, waste management professionals, recyclers, and others to create an accessible and efficient mattress collection and recycling network.

In its role of managing state-wide mattress recovery programs, MRC contracts with qualified mattress recyclers, who are required to achieve a 75% by weight recycling rate. While this recycling performance reflects meaningful success in mattress and box spring (foundation) recycling, MRC is interested in identifying which post-consumer mattress materials are still landfilled and why, in order to increase its recycling rate.

MSW Consultants (MSW) performed a composition analysis of the residual materials (residuals) generated by two mattress recyclers in California. This report summarizes the methodology for characterizing mattress recycling residue, describes the composition of the residue streams, and offers observations about the capture rates and opportunities for incremental recycling improvements. MRC intends to use the report results to prioritize research projects that focus on currently landfilled mattress components to potentially increase statewide mattress recycling rates.

2. STUDY DESIGN

MRC publishes an annual report about mattress recycling progress in California. The most recent report[1] found that the statewide recycling rate currently is 77.1 percent. This study was performed to better understand the composition of the remaining 22.9 percent of material still going to landfill.

California recyclers manually deconstruct mattresses and foundations, and marketable materials are diverted for recycling. During this process, residuals are generated at various stages in the deconstruction process.

MSW collaborated with MRC and two recyclers to design a protocol to intercept residuals, and segregate and weigh the material into categories to determine the composition of this unique waste stream. Other details about the study design are contained in the following subsections.

2.1 RECYCLING FACILITIES

MRC selected two recycling facilities in California for the study. Data collected from both facilities has been aggregated to provide a larger representative sample which is indicative of the entire recycling network.

MRC and MSW conducted kick-off teleconferences with each recycler to investigate site layout, material flow, workspace, and material handling arrangements to develop a plan to intercept, sort, weigh, and discard residue. MSW then spent one day at each facility observing the mattress recycling process, tracking the flow of residue, meeting and interviewing key staff, and setting up the work area including specialized equipment needed for the study.

2.2 SORTING TARGETS

It was determined by MSW that intercepting all residue from a single day would provide a representative sample for determining composition of this material.

[1] Mattress Recycling Council 2020 California Annual Report, expected publication by August 2021.

Table 2-1 presents the estimated residue per day, and actual residue that was found from the study. As shown, the estimates were reasonably close to actual generation. It should be noted that a portion of residue from a second day was captured and sorted at one of the facilities.

Table 2-1 Sorting Targets (Lbs.)

Average Estimated Daily Generated Residue [1]	Actual Residue for One Day	Total Residue Sorted
15,750	16,977	**19,139** [2]

[1] Source: Estimates supplied by facilities during fieldwork

[2] Additional residue from second day was captured during study

2.3 MATERIAL CATEGORIES

All residual material was sorted into one of 16 material categories developed jointly by MRC and MSW based on what MRC considered to be most crucial to capture in the characterization data.

Table 2-2 Material Categories and Definitions

Cat #	Group	Material Category	Definitions
1	Paper	Cardboard	Corrugated cardboard layer occasionally found in mattress foundations used to separate wood and fabric layers
2	Plastic	Polyurethane Foam	Polyurethane-based conventional and memory foams in a variety of colors and densities
3	Plastic	Multi-Layered Foam	Mattress foam consisting of a mix of different polyurethane foams and/or latex foams that have not been separated in the mattress recycling process
4	Plastic	Loose Plastics	Rigid plastic mattress components such as corner guards and internal supports and plastic film used as mattress coverings during deliveries/disposal
5	Textile	Quilt Panels	Outermost layer of the mattress that is a composite of fabric, fiber batting, non-woven fabric, and/or foam; inconsistent material and construction
6	Textile	Cotton	Cotton padding or fill found in mattresses as additional construction layers
7	Textile	Shoddy Felt Pad	Fabric layer consisting of mixed, shredded post-industrial fibers usually placed between spring and foam layers as padding and insulation
8	Textile	Fabric Scraps	Fabric pieces or strips smaller than 1' by 1' which would be difficult to process and/or identify based on size
9	Textile	Mixed Non-Woven Fibers	Mattress and box spring components consisting of a mix of non-woven fibers such as polyester, rayon, and other synthetics; wool and other animal hairs
10	Textile	Coconut/Sisal/Plant Fibers	Mattress layer or fill consisting of either coconut, sisal, or another plant fiber
11	Metal	Scrap Metal	Ferrous and non-ferrous metal products such as wires and springs
12	Wood	Wood	Wood found in foundations
13	Other	Latex Foam	Mattress foam consisting of either natural or synthetic latex; typically a white or beige color with perforations throughout the material
14	Other	Pocketed Coils	Steel springs typically encased in polypropylene fabric
15	Other	Fines	Recyclable or non-recyclable materials and items that are smaller than a volleyball and therefore cannot be easily captured in the recycling process
16	Other	Other Material	All other materials not included in the other categories, or which cannot be identified

2.4 HEALTH AND SANITATION

Every member of the sorting team received a safety briefing conducted by MSW which covered safe handling of sample material. MSW complied with all PPE requirements identified by both facilities, and additionally required the use of chemical and puncture-resistant gloves for sorting.

2.5 MANUAL SORTING

Constituents were sorted into 30-gallon barrels and/or piles over the course of the shift. High-volume residue was accumulated on pallets or other platforms for transporting and weighing material, while low-volume residue was hand delivered to the scale. Each platform was subtracted from the material weigh-out process. Figure 2-1 shows photographs of the sort areas at the recycling facilities.

Figure 2-1 Sorting Areas

Indoor Sort Area

Outdoor Sort Area

2.6 DATA RECORDING AND ANALYSIS

Once a sufficient amount of residue had accumulated on the category piles, the weigh-out was performed. Each platform or barrel containing sorted residue was carried or driven by forklift over to the scale where it was weighed (net of tare weight). The Crew Chief recorded all data with a rugged tablet computer using MSW's *WasteInsight* material composition app.

The tablet allowed for samples to be tallied in real time to best inform the field team. The tablet synchronizes with the cloud via internet, providing excellent data security. The real-time data entry offered several important advantages:

- The template contains built-in logic and error checking to prevent erroneous entries.
- The template sums sample weights in real time.

3. RESIDUE COMPOSITION

The composition of residue was calculated as the percentage by weight of all outbound residue intercepted and sorted at both facilities.

The combined composition was calculated two ways. The first method combined weight data from both recyclers and calculated the percentage by weight of residue per category based on the sum of total residue. However, this method does not account for the fact that one of the host facilities deconstructs significantly more mattresses per day than the other. MSW employed a second method of calculating the composition using weighting factors to combine the two data sets. Using MRC-provided annual residue generation amounts for the two recyclers, MSW calculated weighting factors to adjust the composition percentages of the sorted residue. The weighted averages calculated using this second method are used throughout the rest of this report.

Table 3-1 compares the unweighted and weighted average composition of residue based on the two facilities participating in this study. As shown, the methods produce similar results, which suggests that the residue stream composition is similar at both facilities. These calculations also show that shoddy felt pads, mixed non-woven fibers, and quilt panels are the predominant items being landfilled.

Table 3-1 Unweighted vs Weighted Residue Composition

	Unweighted Average	Weighted Average
Material Group & Category	**% of Total**	**% of Total**
Shoddy Felt Pad	21.6%	22.0%
Mixed Non-Woven Fibers	19.4%	19.8%
Quilt Panels	17.5%	17.3%
Polyurethane Foam	10.4%	10.0%
Cotton	6.6%	6.5%
Loose Plastics	4.9%	4.8%
Fines	4.8%	4.7%
Fabric Scraps	3.7%	3.8%
Latex Foam	3.2%	3.0%
Coconut/Sisal/Plant Fibers	2.6%	2.7%
Other Material	1.9%	2.0%
Multi-Layered Foam	1.7%	1.6%
Wood	1.1%	1.2%
Pocketed Coils	0.4%	0.3%
Cardboard	0.1%	0.1%
Scrap Metal	0.0%	0.0%
	100.0%	**100.0%**

4. OBSERVATIONS

MSW was asked to observe the mattress deconstruction process and take note of the state of material being discarded into the residue stream. Observations about the discarded materials, potential for additional recycling, and other factors are itemized in the subsections below.

- **Felt/Shoddy Pad**: This material category is landfilled largely due to lack of end markets.
- **Mixed Non-Woven Fibers**: The majority of mixed fibers consisted of foundation fabric covers, which have non-woven top and bottom sections, and non-woven fabric layers between other mattress layers. Virtually all foundations had similar construction therefore this material could be recovered if end markets existed for non-woven fabric.
- **Quilt Panels**: The majority of quilt panels found in the residue stream contained either metal staples or tacks on the edges and built-in foam or gels. Some were also soiled. It is surmised that the cost to separate the metal and foam would currently exceed the recovery value.
- **Cotton**: The cotton found in the residue stream consisted mostly of cotton padding, which may have been far from an end market or could not be stored until a truckload was collected.
- **Polyurethane Foam**: At one recycler, the majority of polyurethane foam found in the residue stream contained metal tacks and staples. The recycler was not able to further process this foam and therefore

sent it to disposal. The other recycler had almost no polyurethane foam in the residue stream as the processors dedicated extra time to removing metal tacks.

- **Plastic – Film:** Plastic film used as mattress coverings was mostly dusty with little to no moisture present. Clean film is highly recyclable if contamination stays at the level observed.
- **Plastic – Rigid/Foam**: Very few plastic mattress corner guards were found in the residue stream as facilities have found a market for them. Loose Plastics consisted mostly of expanded polypropylene support frames and inner layers with surface contamination.
- **Fines:** Fines consisted of a diverse mixture of small foam and wool chunks, fabric and felt scraps, and some plastic guards. The effort required to sort for recycling or locate end markets would likely exceed the potential recovered value. This residue may be attractive as a feedstock for various waste-based fuels, which could incrementally increase energy recovery and further reduce landfill disposal.
- **Fabric Scraps**: At the outset of the project, this category was amended to include fabric strips with metal tacks from the outside edge of mattresses. These strips were by far the most prevalent type of fabric scraps but are considered contaminated by end markets due to the metal tacks.
- **Latex Foam**: Less than twenty latex mattresses or individual layers were encountered across the two recyclers. Some secondary market foam buyers now accept latex foam.
- **Coconut/Sisal/Plant Fiber**: These material layers were often glued or sewn to wool and felt layers, which often fell apart when attempting to separate by hand.
- **Other Material**: The majority of material not elsewhere classified consisted of adjustable firmness mattress components such as air bladders, hoses, and pumps. While these items contained trace amounts of metal and electronic components, the required effort for further recycling would likely exceed the recovered value. Other instances of materials placed in this category included rebonded foam layers and miscellaneous unidentifiable materials.
- **Multi-Layered Foam**: At one recycler, all material placed into this category consisted of mixed layers of polyurethane and latex foam. For the second recycler, no material was placed into this category as the recycler had identified markets for both materials and was separating the layers.
- **Pocketed Coils**: A single, intact set of pocketed coils was observed which was glued to a structural piece of polymer. This was a single observation. One other string of pocketed coils was found and appeared to have been inadvertently disposed of rather than processed.

5. IMPLIED CAPTURE RATES

As a final exercise, MSW derived statewide capture rates using the residual material composition found during this study and applying it to MRC's statewide quantities of recoverable materials. The tables below outline the data and methodology used to estimate these capture rates.

Table 5-1 shows the commodities recovered from mattresses and foundations in 2020 based on MRC's 2020 California Annual Report. As shown, 74.95 percent of mattress components are diverted from disposal. (Additionally, a small percentage of whole mattresses are renovated, and a small percentage of residue is used as feedstock for energy recovery. These amounts are excluded from capture rate calculations.)

Table 5-1 Annually Recycled Mattress Components in California (2020)

Materials	Pounds	% of Total
Commodities		
Steel	29,365,968	34.88%
Foam	13,201,620	15.68%
Quilt & Toppers	8,502,147	10.10%
Wood	10,193,344	12.11%
Cotton	842,317	1.00%
Other Fiber	442,113	0.53%
Felt/Shoddy	352,791	0.42%
Cardboard	120,474	0.14%
Plastics	72,947	0.09%
Subtotal - Commodities	*63,093,271*	*74.95%*
Whole Mattress Reused/Renovated	*1,777,160*	*2.11%*
WTE	*26,845*	*0.03%*
Residue Landfilled	*19,286,140*	*22.91%*
Total	**84,183,866**	**100.00%**

Source: MRC 2020 California Annual Report

Table 5-2 applies the percentage of material residue calculated in this study to the total amount of material landfilled by all MRC recyclers in 2020.

Table 5-2 Annual Landfilled Material Composition Based on Sorted Categories

Material	Weighted Percent	Total Disposed
Shoddy Felt Pad	22.0%	4,238,710
Mixed Non-Woven Fibers	19.8%	3,823,400
Quilt Panels	17.3%	3,333,553
Polyurethane Foam	10.0%	1,925,807
Cotton	6.5%	1,260,711
Fabric Scraps	3.8%	740,588
Loose Plastics	4.8%	929,689
Fines	4.7%	900,735
Latex Foam	3.0%	584,474
Coconut/Sisal/Plant Fibers	2.7%	517,656
Other Material	2.0%	390,580
Multi-Layered Foam	1.6%	309,484
Wood	1.2%	230,744
Pocketed Coils	0.3%	67,011
Cardboard	0.1%	26,799
Scrap Metal	0.0%	6,198
Total	**100%**	**19,286,140**

The categories used in this study were then mapped into the commodity types reported in the 2020 California Annual Report. The commodity mappings are shown in Table 5-3 and the resulting quantities in Table 5-4 are listed in order of most to least prevalent.

Table 5-3 Composition Study Material Category vs MRC 2020 California Annual Report Category Mapping

Composition Study Categories	2020 Annual Report Categories
Shoddy Felt Pad	Felt/Shoddy
Mixed Non-Woven Fibers	Other Fiber
Quilt Panels	Quilt & Toppers
Polyurethane Foam	Foam
Cotton	Cotton
Fabric Scraps	Other Fiber
Loose Plastics	Plastics
Fines	Other Non-Recoverable
Latex Foam	Foam
Coconut/Sisal/Plant Fibers	Other Fiber
Other Material	Other Non-Recoverable
Multi-Layered Foam	Foam
Wood	Wood
Pocketed Coils	Steel
Cardboard	Cardboard
Scrap Metal	Steel

Table 5-4 Estimated Annual Residue Composition, Recast to 2020 Annual Report Commodity Categories

Material	Pounds	Percent
Other Fiber	5,081,644	26.3%
Felt/Shoddy	4,238,710	22.0%
Quilt & Toppers	3,333,553	17.3%
Foam	2,819,765	14.6%
Other Non-Recoverable	1,291,315	6.7%
Cotton	1,260,711	6.5%
Plastics	929,689	4.8%
Wood	230,744	1.2%
Steel	73,209	0.4%
Cardboard	26,799	0.1%
Total	**19,286,140**	**100.0%**

Combining the 2020 Annual Report commodities with the estimated composition of the residuals stream allows the calculation of estimated California capture rates for each recoverable commodity. These capture rates are shown in Table 5-5.

Table 5-5 Implied Capture Rates in California (2020)

Material	Recovered	Disposed	Total	Capture Rate
Steel	29,365,968	73,209	29,439,177	99.8%
Wood	10,193,344	230,744	10,424,088	97.8%
Foam	13,201,620	2,819,765	16,021,385	82.4%
Cardboard	120,474	26,799	147,273	81.8%
Quilt & Toppers	8,502,147	3,333,553	11,835,700	71.8%
Cotton	842,317	1,260,711	2,103,028	40.1%
Other Fiber	442,113	5,081,644	5,523,757	8.0%
Felt/Shoddy	352,791	4,238,710	4,591,501	7.7%
Plastics	72,947	929,689	1,002,636	7.3%
Other Non-Recoverable	*0*	*1,291,315*	*1,291,315*	*0.0%*
Total	**63,093,721**	**19,286,140**	**82,379,861**	**76.6%**

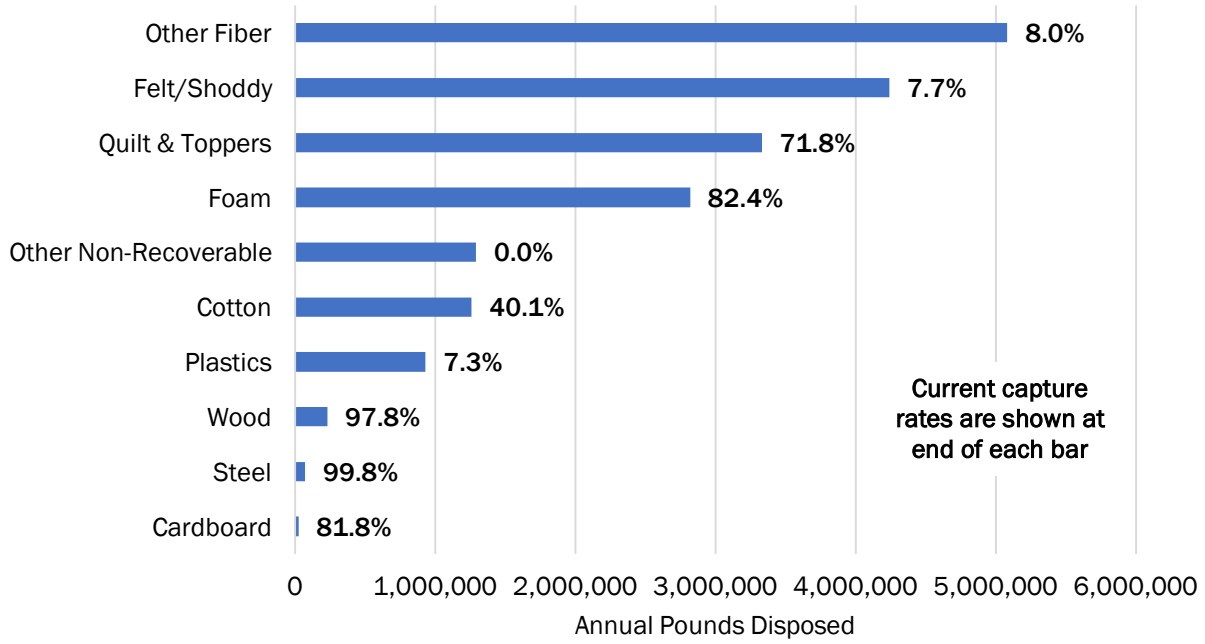
MSW makes the following observations about Table 5-5.

- **Excellent Capture of Steel, Wood, Foam, and Cardboard**: Mattress recycling is highly effective at recovering steel, wood, foam, and cardboard, which makes sense as these materials are more easily separated and have value in the recycling markets.
- **Effective Capture of Quilt and Toppers**: Quilt and toppers are captured at 71.8 percent, which should be considered effective performance.

6. CONCLUSIONS

Figure 6-1 re-orders the most prevalent materials in the mattress recycling waste stream from highest to lowest quantity regardless of capture rate.

Figure 6-1 Annual Pounds Disposed and Implied Capture Rates by Commodity



As shown, incremental recycling rate increases could be achieved by finding recycling solutions to the top four most prevalent residues. However, this residual material represents either "hard to recycle" material due to processing time and commensurate operating cost, or material without an end market.

This report assumes that the residue composition of mattress recycling operations across California are reasonably comparable to the composition of the facilities that hosted this study. In the future, it would be useful to conduct additional residue composition studies at other facilities to assess the changing composition of discarded mattresses over time.