2016 Construction and Demolition Debris Market Study

Final Report to MassDEP

May 2017

Prepared By:

DSM ENVIRONMENTAL SERVICES, INC.

Resource Economists
Environmental Scientists

Administered by:

NERC
NORTHEAST RECYCLING COUNCIL

DSM ENVIRONMENTAL SERVICES, INC.
Resource Economists
Environmental Scientists

2016 Construction and Demolition Debris Market Study

FINAL REPORT, APRIL 2017

Introduction 1

Tasks 2

Task 1A – Characterize the Quantities and Composition of C&D Materials 2

Task 1B – Characterization of Incoming and Outgoing Materials: 2

Task 2 – Assess Current and Future Capacity of Recycling End Markets 3

Task 3 – Processing Advancements 3

Task 4 – Barriers 3

Analysis 4

Task 1A – Quantities and composition of C&D waste processed in Massachusetts 4

Task 1B – Composition of incoming C&D materials and out-going residues 6

Applying the Visual Survey Data to Annual Facility Reported Data 7

Results 8

Task 2 – Current and Future Capacity of Recycling End Markets 13

Introduction 13

Waste Wood 14

Fines 16

Other Materials 16

Task 3 -Processing Advancements 19

Potential Processing Improvements 20

Task 4 – Barriers 23

Conclusions and Recommendations 24

DSM ENVIRONMENTAL SERVICES, INC.
Resource Economists
Environmental Scientists

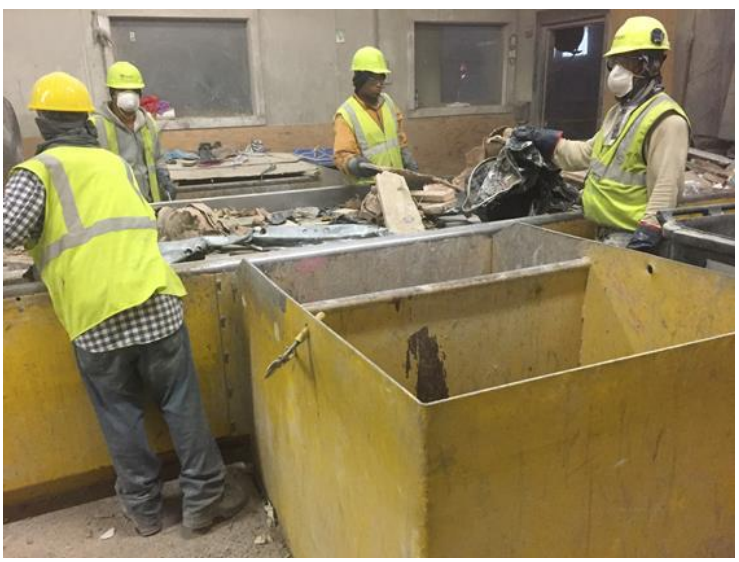
INTRODUCTION

The Massachusetts Department of Environmental Protection (MassDEP) contracted with the Northeast Recycling Council (NERC) and DSM Environmental Services (DSM) to evaluate the current and future status of construction and demolition (C&D) debris management in Massachusetts, and identify and recommend potential opportunities for the diversion of a greater proportion of recyclable materials to recycling markets.

NERC provided administrative functions for the project and DSM carried out the field work, analysis and report writing tasks.

MassDEP has established a goal of diverting 50 percent of C&D materials from disposal, but in recent years the actual diversion rate has plateaued at around 30 percent. The primary objective of the analysis undertaken by DSM was to first assess incoming and outgoing materials at Massachusetts C&D processors and handling facilities, and to determine what the opportunities and constraints are to increase materials diversion beyond 30 percent.

The project commenced in July 2016 with the field work undertaken between September and December, 2016.



TASKS

The analysis consisted of the following tasks summarized below.

TASK 1A – CHARACTERIZE THE QUANTITIES AND COMPOSITION OF C&D MATERIALS

MassDEP provided DSM with 2015 Solid Waste Facility Reports for each facility. These reports are required to be completed annually by C&D processors and transfer stations and are due February 15 of the following year.

These facility reports were used by DSM to quantify total C&D processing and disposal activity in Massachusetts in 2015 (the most recent reporting year from which MassDEP had compiled the data) as well as the recycling and disposition of the processed material by material type.

DSM also used the reports to track incoming and outgoing quantities by material type to better map material flow in the state, and more accurately represent materials recovery rates through processing mixed C&D wastes.

TASK 1B – CHARACTERIZATION OF INCOMING AND OUTGOING MATERIALS:

MassDEP arranged for DSM to visit five C&D processors and two C&D transfer stations to both interview owners/operators and to collect data on incoming and outgoing material/waste streams. These seven facilities handled roughly 40 percent of the total material sent to the 25 facilities operating in the Commonwealth in 2015.

At each facility, DSM conducted visual analyses of incoming loads of C&D (and other materials), and outgoing loads of residues (from the five processors only) with the goal of characterizing the incoming material and outgoing residue.

The visual samples for each facility were compiled by DSM and converted to weight based estimates of the composition of incoming C&D materials and out-going residues for each facility.

In addition to characterizing incoming and out-going loads, DSM also spent time with the facility owner/operator to tour the facility, observe the processing equipment in operation and to discuss processing and marketing issues that the owner/operator felt were important to gaining a more complete understanding of C&D processing in Massachusetts.

Task 2 – Assess Current and Future Capacity of Recycling End Markets

DSM discussed with the seven participating processing/transfer facility owner/operators where they believe the markets are today, and what they believe future markets will be. DSM then contacted identified markets directly to discuss current specifications and demand for materials that could be diverted from the incoming C&D materials.

Task 3 – Processing Advancements

DSM discussed with facility owners/manager, industry professionals and end user markets potential new technologies that might be available to increase recovery of C&D materials from processing facilities. This included conducting a literature review of certain technologies identified as potentially improving diversion of C&D materials.

Task 4 – Barriers

In addition to identifying potential opportunities for increased diversion at Massachusetts C&D facilities, DSM also attempted to identify specific barriers to increased diversion.

ANALYSIS

TASK 1A – QUANTITIES AND COMPOSITION OF C&D WASTE PROCESSED IN MASSACHUSETTS

DSM used the individual 2015 facility reports submitted to MassDEP as the basis for our analysis of C&D processing and materials recovery in Massachusetts. While these reports are comprehensive, they do require some degree of manipulation to clearly map the flow of materials in Massachusetts.

Specifically, C&D processors (and transfer stations) receive several different streams of material, some of which they process directly, some which they transfer, either directly to disposal, or indirectly through another C&D transfer station for ultimate disposal, and some of which they process as mixed C&D to recover material for recycling. In addition, some transfer (of materials) is to another in-state C&D processing facility.

DSM tracked material flow between in-state facilities to eliminate double counting by removing material (from the totals) that is originally delivered to one facility – typically a processor - and then transferred either before processing or after processing to a second in-state facility – either a C&D transfer station for disposal (and therefore reported as incoming at that facility) or to a C&D processor (also reported as incoming at that facility). Material reported as bulky waste was also compiled and disaggregated to calculate processing of C&D materials only.

The revised material flow data were then used to calculate a state-wide recycling rate. The manipulated generation and recovery data are presented in Table 1, below. Table 1 illustrates the different recycling rates calculated depending on what is included in the denominator.

For example, Table 1 illustrates that roughly 25 percent of mixed C&D that was processed in-state (or roughly 219,000 of 865,000 tons processed in-state) was recovered for recycling in Massachusetts. Adding in source separated materials delivered to C&D processors (roughly 86,000 tons), the recycling rate is 27 percent for all C&D (in-state and out-of- state) or 32 percent if only C&D material that is processed in-state is included.[1]

[1] If bulky waste that is accepted by these facilities is included in the calculation of a C&D recycling rate, the rate would fall to 22%. And if materials recovered from mixed C&D sent out-of-state for processing were known and included, the rate would rise.

TABLE 1 - Calculation of C&D Recycling Rates for Massachusetts Using 2015 Facility Reports (1)

Generation & Recovery	Reported 2015 Tons	Description	From Total Generation	From Net C&D	From Net Instate C&D
Generation	1,379,994	Throughput to in-state facilities includes double-counting	100%		
Less Bulky Waste	250,133	Coded as incoming bulky waste	18%		
Net C&D:	***1,129,861***	***Generation minus bulky***	***82%***		
Source Separated Materials	85,997	Incoming separated recyclable materials	6%		
Mixed C&D	1,043,864	Net Mixed C&D	76%	100%	
Transferred OOS	178,955	Coded as transferred out of state for processing	13%	17%	
Net In-State C&D:	***864,909***	***Net Mixed In-State C&D to process***	**63%**	**83%**	**100%**
Recovered	***219,009***	***Recovered from mixed in-state C&D***	***16%***	***21%***	***25%***
Landfill Dependent Uses	323,687	Total landfill dependent uses from Instate C&D	23%	31%	37%
Disposed	322,213	Net disposed from Instate Mixed C&D	23%	31%	37%
Recycling Rate					
Net C&D (from above)	***1,129,861***	***Generation minus bulky***	***100%***		
Transferred OOS	178,955	Coded as transferred out of state for processing	16%		
Net In-State Managed:	***950,906***	***Includes source separated materials***	***84%***	***100%***	
Recycling Rate	***305,006***	***Recovered from processing, plus source separate material***	***27%***	***32%***	
Landfill Dependent Uses	323,687	Total landfill dependent uses reported from instate C&D	29%	34%	
Disposed	322,213	Net disposed from Instate Mixed C&D Only	29%	34%	

(1) This Table excludes any C&D that is generated in Massachusetts but sent directly out of state for processing and/or disposal or that is mixed with bulky waste and delivered directly to a MSW transfer station or disposal facility.

Table 1 also illustrates that diversion of material to landfill dependent uses totals roughly another 324,000 tons, which is 31 percent of C&D waste processed in-state, or 23 percent of all C&D waste.

Task 1B – Composition of incoming C&D materials and out-going residues

The data compiled in Task 1A above can then be disaggregated to investigate how well C&D processors are doing at recovering specific materials from the mixed loads which they process.

DSM devoted between 4 and 8 person-hours at seven C&D facilities (5 processing facilities and 2 transfer stations) conducting visuals of incoming mixed C&D loads and, for the five processing facilities, out-going residues. In all cases DSM conducted the visual analysis as described below.

The enumerator starts with a data-sheet listing eight primary material categories and roughly 44 secondary material categories

Primary categories are:

- Paper;
- Plastic;
- Glass;
- Organic;
- C&D;
- Metal;
- Special;
- Mixed MSW

Within each primary category there is a list of more detailed secondary categories. Examples include:

- Paper – OCC, Other
- Plastic – Buckets, Film, Foamed Insulation, Other
- Organic – Yard Waste, Carpet
- C&D – ABC, Asphalt Roofing, Clean Lumber, Plywood, Treated Wood, Etc.
- Special – Appliances, Electronics, Bulky Items, Etc.

The enumerator first observes the incoming truck and briefly interviews the driver in order to record the hauler name, vehicle number, and volume of material delivered on the data form.

After the load is tipped, the enumerator walks around pile and writes down the percent of each of the primary categories ***by volume***, with the sum of the primary categories equal to 100%.

The enumerator then walks back around the pile estimating the percent by volume of all secondary categories within each primary category – with the percent equal to 100% for each category.

Each visual survey is then entered into an excel spreadsheet with volumes converted to pounds/tons based on the density for each material. The total pounds are compared with the weight slip for that load and adjustments made as necessary so that the sum of pounds from the visual estimate is roughly equivalent to the net weight of the load.[2]

Because of the limited number of hours of observations at each facility the visuals are summed for each facility, and a single average percent composition calculated for that day of observations for the incoming loads, and separately for the out-going residue.

Applying the Visual Survey Data to Annual Facility Reported Data

The annual facility reports, when coupled with the visual survey data can be used to estimate the following:

- The average composition of incoming C&D materials, by volume and by weight;
- Materials potentially available for recovery;
- Current recovery rates at the participating facilities;
- Maximum, potentially achievable recovery rates; and,
- Recovery rates necessary to achieve 50 percent recycling rate.

It is important to note here that the visual data were obtained on a *single day* that may, or may not be representative of facility deliveries over time. However, the analysis provides a snapshot of the composition of incoming material at each of the facilities participating in the survey, and the relative effectiveness of these facilities at recovering materials from the incoming C&D waste.

DSM analysis of field survey data and reported data was as follows:

- Mixed C&D material accepted (*C&D Waste*) were separated from total reported deliveries for 2015 to help assure that the visual characterization data were applied only to the percent of total deliveries that were mixed C&D materials (see Task 1A above for a more complete description of the issue).

[2] There are several reasons why the total pounds estimated from the visuals and the net weight of the load can vary. First, the visuals are estimates only based on volume and then adjusted by standard densities and the actual density may differ. Second, C&D loads are typically not very heavy which means that in cases where the net weight is based on a pre-recorded tare weight of the truck, factors such as the amount of fuel in the tank, mud on the truck, and in some cases the empty weight of the roll-off container, can have a significant impact. Third, most C&D loads are left un-covered until they are transported so rain and snow can and do impact the weights. In general DSM strives to be within plus or minus 20 percent of the reported net weight, and we have adjusted density data accordingly.

- The material composition percent by weight based on the visual data were applied to reported *C&D waste* (Section 1, C&D Materials Accepted) at each participating facility for 2015 to estimate incoming tons by material type at each facility. This represents the theoretical maximum (tons) available by material type for recovery.
- The reported annual facility *materials recycled or used* (Section 2, C&D Materials Recycled or Used) data for each participating facility were divided into the total (theoretically available) *C&D Waste* received to estimate what percentage of incoming material (by material type) was actually recovered and sold. This represents the *recovery rate* by material type.
- Recoverable materials in most cases include the following;
    - Corrugated containers (OCC);
    - Rigid plastic and plastic film;
    - Asphalt (paving), brick and concrete (ABC);
    - Asphalt roofing;
    - Wood – clean wood, painted and stained wood, plywood, particle board and other engineered woods;
    - Clean Gypsum; and,
    - Metals – ferrous and non-ferrous.

Results

Table 2 (on the next page) presents the average composition (percent by weight) of incoming C&D waste based on the visual surveys of incoming C&D waste at all seven participating facilities.

Note that materials categories have been shaded to reflect targeted materials**.** Green is used for materials with good market potential (e.g., “A” wood, OCC and paper, and metals) and purple for materials that are either difficult to market, or for which there are no markets. Finally, light blue is used for materials that can be targeted for “B” wood, but are unlikely to end up as “A” wood. In most cases this means more highly contaminated wood that might be suitable for a bio-mass combustion facility but is not suitable for particle board production.

One further note concerning the material compositions reported in Table 2 is that carpet and padding is included in the “organic” category because that is the way DSM’s data collection forms have been organized for other C&D waste characterization studies, not because carpet is somehow bio-degradable.

TABLE 2 - Composition, by Weight, Visual Analysis at Seven Participating Facilities

INCOMING MATERIAL COMPOSITION		PERCENT BY WEIGHT							
	Sample ID#	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Average (1)**
	Material Category	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
	PAPER	**2%**	**1%**	**5%**	**1%**	**3%**	**2%**	**2%**	**2%**
1	OCC/Kraft	1%	1%	2%	1%	1%	2%	2%	**1%**
2	R/C and Other Paper	1%	0%	3%	4%	1%	0%	0%	**1%**
	PLASTIC	**2%**	**3%**	**2%**	**2%**	**2%**	**4%**	**1%**	**2%**
3	HDPE Buckets	1%	2%	0%	1%	0%	1%	0%	**1%**
4	Film	0%	0%	0%	0%	0%	0%	0%	**0%**
5	Foamed Insulation	1%	0%	0%	0%	0%	2%	0%	
6	R/C and Other Plastic	1%	1%	1%	1%	2%	1%	1%	**1%**
	GLASS	**3%**	**0%**	**3%**	**1%**	**4%**	**4%**	**0%**	**2%**
7	R/C and Other Glass	3%	0%	3%	1%		4%	0%	2%
	ORGANICS	**1%**	**1%**	**2%**	**2%**	**7%**	**0%**	**8%**	**3%**
8	Yard Waste	0%	0%	0%	0%	2%	0%	7%	**1%**
9	Carpet	1%	1%	2%	2%	3%	0%	1%	1%
10	Carpet Padding	0%	0%	0%	0%	0%	0%	0%	0%
11	R/C and Other Organics	0%	0%	0%	0%	0%	0%	0%	0%
	C&D	**75%**	**87%**	**78%**	**80%**	**71%**	**78%**	**82%**	**79%**
12	Concrete/Brick/Rock	0%	2%	5%	6%	1%	0%	1%	**2%**
13	Asphalt Paving	0%	0%	0%	0%	0%	0%	0%	**0%**
14	Asphalt Roofing	7%	15%	1%	24%	8%	13%	12%	**11%**
15	Wood Roofing	0%	3%	0%	0%	1%	1%	0%	1%
16	Ceiling Tiles	0%	1%	9%	0%	1%	1%	0%	2%
17	Vinyl Siding	0%	0%	0%	0%	0%	0%	0%	0%
18	Pallets and Crates	6%	4%	4%	10%	2%	0%	3%	**4%**
19	Clean Lumber	10%	12%	11%	5%	13%	6%	22%	**12%**
20	Plywood	5%	7%	6%	3%	9%	4%	10%	**6%**
21	Other Engineered Wood	6%	8%	6%	4%	4%	4%	6%	**6%**
22	Wood Furniture	1%	1%	1%	1%	2%	0%	0%	**1%**
23	Painted/Stained Wood	12%	11%	6%	9%	8%	14%	8%	**10%**
24	Treated Wood	0%	0%	1%	1%	2%	1%	0%	1%
25	Clean Gypsum Board	1%	0%	0%	5%	8%	3%	1%	**3%**
26	Printed/Papered Gypsum Board	11%	4%	1%	3%	3%	12%	0%	5%
27	Dirt, Sand and Gravel	0%	5%	11%	1%	0%	15%	3%	5%
28	Fiberglass Insulation	0%	0%	0%	0%	0%	0%	0%	0%
29	R/C and Other C&D	13%	13%	17%	8%	10%	5%	15%	11%
	METAL	**9%**	**1%**	**4%**	**10%**	**3%**	**2%**	**4%**	**5%**
30	HVAC Ducting	0%	0%	0%	0%	0%	0%	0%	**0%**
31	Wire Sheathing	0%	0%	0%	1%	0%	0%	0%	**0%**
32	Other Ferrous	3%	1%	4%	9%	4%	2%	3%	**4%**
33	Other Non Ferrous	5%	0%	0%	1%	0%	0%	0%	**1%**
	SPECIAL	**4%**	**7%**	**3%**	**3%**	**6%**	**9%**	**3%**	**5%**
34	Appliances	0%	0%	1%	1%	1%	0%	1%	1%
35	Electronics	0%	0%	1%	0%	1%	0%	1%	0%
36	Items with CRTs	0%	4%	0%	0%	0%	0%	0%	1%
37	Bulky Items	3%	2%	2%	2%	4%	9%	2%	3%
38	Tires	0%	0%	0%	0%	0%	0%	0%	0%
39	Lead Acid Batteries	0%	0%	0%	0%	0%	0%	0%	0%
40	Vehicle Fluids	0%	0%	0%	0%	0%	0%	0%	0%
41	Paint	0%	0%	0%	1%	0%	0%	0%	0%
42	Other Hazardous	1%	1%	0%	0%	0%	0%	0%	0%
43	Fines/Mixed Residue	0%	0%	0%	0%	0%	0%	0%	0%
	MSW BAGGED	**3%**	**1%**	**3%**	**1%**	**3%**	**1%**	**1%**	**2%**
44	MSW Bagged	3%	1%	3%	1%	3%	1%	1%	2%

Table 3 then presents the estimated average recovery rate for materials reported to be recycled from the surveyed facilities. Recovery rates have been averaged by type, first for the five processing facilities and then for the two transfer stations.

The recovery rates reported in Table 3 are calculated by multiplying the material composition percentages for each facility presented in Table 2 times the total C&D waste reported by that facility, and then compared against the same materials reported to be recycled for that facility. For example, if Facility 1 reported incoming C&D waste of 50,000 tons (hypothetical), then 27 percent of that incoming C&D waste (or 13,500 tons) was assumed to be recoverable “A” wood (6% pallets and crates; 10% clean lumber; 5% plywood; and, 6% other engineered wood – the green highlighted categories for Facility 1 in Table 2). The wood fuel reported to be sold from that facility is then divided into the 13,500 tons to calculate the recovery rate for these “A” wood materials.[3]

The recovery rates reported in Table 3 attempt to exclude source separated materials that were identified (on the annual reports) as delivered to each facility (e.g., C&D Wood, Metals, Asphalt/Brick/Concrete). These incoming material deliveries are subtracted from the total material recycled to represent a more accurate recovery rate from processing mixed C&D waste; or, in the case of transfer stations without processing lines, kick sorting.

However, there are still several estimated recovery rates of 100 percent in Table 3. This is the case because some relatively homogeneous loads of Asphalt/Brick/Concrete (ABC) and metals that arrive at the facility are not identified as incoming by material type on the annual reports. DSM did not conduct visuals of these types of loads, but they are included in the total material recycled in the annual reports to MassDEP, resulting in calculated recovery rates that may not reflect just the mixed C&D waste loads coming into the facility despite DSM’s best efforts to represent the data in this way.

Note that DSM has been able to deduct incoming loads of wood in most cases so the recovery rates for wood – the most critical C&D material – fairly closely reflect actual recovery rates of wood from mixed C&D loads.

[3] The percent composition reported in Table 2 are not shown converted to actual tons for each facility because showing those conversions would make it possible for the reader to identify the specific facility based on the Solid Waste Facility Reports.

TABLE 3 - Estimated Recovery Rates, By Material Type, for Mixed C&D Loads

Sorted Material	Processors (%)	Transfer Stations (%)	Overall (%)
OCC	31%	9%	22%
Plastic	6%	0%	3%
Metal	100%	49%	90%
Asphalt/Brick/Concrete	100%	100%	100%
Asphalt Roofing	12%	2%	7%
Clean Gypsum Board	9%	0%	4%
Wood	32%	4%	22%
Overall Materials Recovery Rate (1):	***48%***	***6%***	***33%***

(1) Overall rate is for all materials listed in Table 3 and does not include electronics, glass, mattresses, tires and other miscellaneous materials recovered in small quantities at some facilities.

Two important points are clear from Table 3. First, the recovery rates for transfer stations are much lower than they are for the processing facilities. This is the result of both a different mix of incoming materials, and less or no manual and mechanical sorting equipment.

Second, recovery rates for wood, which is the largest single component of C&D waste, average 32 percent for the five processors that DSM visited; ranging from a low of 15 to a high of 43 percent. These recovery rates would indicate that more wood could be recovered from these facilities depending on sorting technologies and market demand (see below).

Table 4, below compares the estimated average composition of residues for the five processing facilities with the estimated average composition of the incoming material from the same five processors. Table 4 confirms that significant amounts of potentially recoverable materials remain after processing. However, several cautions are necessary when reviewing Table 4.

First, observed residue piles do not coincide with incoming loads, they simply represent grab samples of residues taken off the end of the processing line.

Second, it is important to recognize that visual sampling of a limited number of incoming loads and residue grab samples necessarily results in relatively wide “confidence intervals” for the reported data.

Third, because a significant amount of asphalt/brick/concrete, as well as wood (which are heavy materials) are removed during processing, it changes the relative volume (and weight) of the remaining material. For this reason, while OCC/Kraft may be a higher percentage of the outgoing residue that does not mean that the facility is not capturing marketable OCC/Kraft, only that some portion of the OCC/Kraft remains in the residue.

In many cases (and confirmed by our observations) this is because the remaining OCC/Kraft is too contaminated to be recycled.

Finally, visual sampling of residue may not be as accurate as visual sampling of incoming loads due to the difficulty of identifying processed materials which have been sized for sorting. Plastics (especially) which are not as easily broken by the excavators, and large pieces of corrugated are likely to be over represented in samples because they are easier to see and identify in the pile than small pieces of wood, as illustrated by the pictures of two residue samples that were visually characterized.

Given these qualifications, as illustrated by Table 4, it does appear possible to remove greater quantities of wood and metals, especially during sorting if the markets are capable of taking this material at a price that justifies increased sorting effort. And, as discussed below, increased recovery of plastics might also be possible.

TABLE 4 - Comparison, By Weight, of Incoming and Residual Composition for Marketable Materials (Potentially Marketable Materials Only) (1)

Material Category	INCOMING (%, By Weight)	Marketability	RESIDUALS (%, By Weight)
PAPER	2.3%		6.3%
OCC/Kraft	1.4%	H	3.3%
PLASTIC	2.5%		8.6%
Rigids	0.9%	M	4.5%
Film	0.1%	L	1.2%
ORGANICS	3.1%		3.9%
Yard Waste	1.3%	H	0.2%
Carpet/Padding	1.5%	L	3.7%
C&D	78.6%		74.5%
Concrete/Brick/Rock	2.1%	H	0.4%
Asphalt Roofing	11.3%	M	8.5%
"A Wood"	27.5%	H	22.3%
"B Wood"	10.6%	M	6.3%
Clean Gypsum Board	2.6%	L	3.0%
METAL	4.6%		2.5%
Ferrous	3.7%	H	1.2%
Non-Ferrous	1.2%	M	1.3%

(1) Does not include all material categories and subcategories, and therefore does not add to 100%.

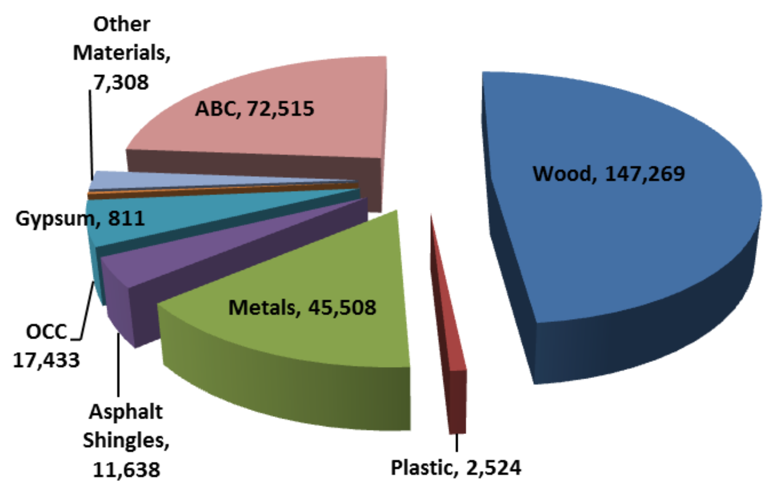
TASK 2 – CURRENT AND FUTURE CAPACITY OF RECYCLING END MARKETS

INTRODUCTION

Figure 1 below presents the composition (by weight) of the total material recycled from Massachusetts processors and transfer stations in CY 2015. This does not include material that may be recycled from construction or demolition sites and delivered directly to a buyer or end user (e.g. metal scrap yard, asphalt shingle or ABC waste recycling facility).

As illustrated by Figure 1, wood, metals and ABC were the primary materials diverted and sold from Massachusetts C&D processors and transfer stations.

Figure 1 - *Composition of the Recycled Materials Sold from C&D Facilities in CY 2015 (Tons by Material Type)*



The markets for each material illustrated in Figure 1 are reviewed below.

WASTE WOOD

At the time of DSM's 2007 C&D analysis for MassDEP, there was a robust market for waste wood – the most prevalent material available in mixed C&D waste. Below is a quote from the 2008 report by DSM to MassDEP:

"The Sappi/Westbrook, Maine paper mill should significantly increase demand for waste wood during 2008. Boralex is also expected to ramp up demand, although probably not to levels achieved a few years ago. In addition, the new partnership between Tafisa and Kruger in Quebec should significantly increase demand for waste wood, both as boiler fuel and, hopefully, as particle board".

As is often the case with future predictions, the situation eight years later is significantly different.

- Sappi/Westbrook, Maine purchases very little waste wood from Massachusetts processors.
- The Boralex (now ReEnergy) bio-fuels combustion facilities in Maine have all stopped accepting waste wood (except some from their own processing facilities) as a result of an unfavorable Connecticut ruling concerning Renewable Energy Credits.
- According to the buyer for Tafisa, the Tafisa/Kruger partnership has been terminated, which has meant the following for wood markets:

- First, the Quebec Ministry of Environment has tightened the combustion specifications for the Tafisa boiler and the Kruger paper mill boiler resulting in tighter specifications for waste wood;
- Second, because Tafisa no longer has a business relationship with Kruger, Tafisa has tightened its specification for the amount of fines it will accept because the fines can no longer be transferred to Kruger for combustion; and,
- Third, the specification for allowable levels of trace metals has been reduced at the Tafisa plant, also reducing the amount of fines Tafisa can accept in the "A" wood.

The only potentially significant positive development with respect to waste wood markets has been the opening of the Plainfield Renewable Energy (PRE) gasification facility in Plainfield, Ct. After several years of startup difficulties, Rob Crummett, their Fuel Director reports that they are now consuming roughly 1000 tons per day, of which 70% is waste wood, with a goal of increasing that to 80 to 90% in the next year.[4]

Several Massachusetts processors who deliver waste wood to PRE reported to DSM that PRE is not as consistent a market as Tafisa due to operational and storage constraints at the PRE facility, and tight specifications, especially for fines. Rob Crummett confirmed that their specification for fuel was tighter than Tafisa, but that the shorter distance, and therefore lower transport cost, made it attractive.

For these reasons the primary buyer of waste wood from Massachusetts processors is currently Tafisa in Lac Magentic in Quebec. According to Sylvain Martel, Tafisa consumed 216,000 tons in 2016, of which 60 percent were sourced from Massachusetts and New Hampshire. They would like to increase consumption of waste wood, but fines remain a problem.[5]

[4] Telephone conversation, April 17, 2017
[5] E-mail to DSM dated March 7, 2015.

Finally, in 2007, there was some hope that the cleaner waste wood could be used in other products such as animal bedding, mulch and commercial fuel pellets. While animal bedding and mulch are markets for green wood, essentially these markets do not exist for C&D wood except for source separate clean (unpainted, untreated) dimensional lumber cut offs and in some cases, pallets. However, most mulchers and end users of animal bedding do not want pallet wood as a source of their material due to the possibility it has come into contact with chemicals, bacteria or other agents.

Fines

As was the case in 2007 fines continue to be a significant issue for C&D processors. The outlet for fines as alternative daily cover (ADC) essentially disappeared because of concerns associated with gypsum and hydrogen sulfide emissions at landfills. The obvious alternative was to mix fines in with separated and ground wood waste for delivery to bio-mass combustion facilities. Unfortunately, the fines tend to have higher concentrations of trace metals and other contaminants and therefore the bio-mass combustion facilities that still accept wood waste have reduced the quantity of fines allowable in the wood waste.

Similarly, Tafisa has also reduced the amount of allowable fines in their material, in part because the fines also contain higher concentrations of lead which Tafisa needs to limit in its products.

The end result is that there are really no markets for fines, and fines are an inevitable by-product of processing mixed C&D waste; which involves dumping on a tipping floor, breakage of the incoming material by excavators,[6] in most cases, prior to introduction to the sort line, and then grinding of the resultant recovered wood, with screening to reduce fines, to meet end user specifications.

Other Materials

Corrugated Containers (OCC)

The market for OCC remains relatively stable. The most significant issue for C&D processors is that much of the OCC delivered in mixed C&D loads is contaminated by other C&D materials, and because many C&D containers are open top containers, the OCC can also be very wet. As a consequence, while OCC is often picked for recycling, the recovery rate is much lower than in a single stream MRF, and the value of the OCC is also lower. In addition, most C&D processing facilities do not have balers (due to the

[6] Most processors no longer use grinders at the front of the processing line, which reduces the amount of fines, instead preferring to break the incoming material into pieces that can be manually pulled off of the sorting line.

high capital cost and low usage time for this piece of equipment), making marketing OCC limited to selling to other processors who have balers.

Figure 2 below shows the typical quality of OCC sorted off of a processing line.

Figure 2 – *OCC Chute off Mixed C&D Processing Line*

METALS

There remain robust markets for both ferrous and non-ferrous metals, although there can be relatively large swings in the value of these metals. Much of the metal observed in the residue is either attached to wood (such as roofing) or is wire and wire sheathing which can be difficult to manually remove, and may not be captured by magnets.

PLASTICS

Markets for plastics are relatively stable, although Chinese restrictions on the import of recycled plastic have reduced the value of lower value plastics – which are the primary plastics available in mixed C&D. Bulky rigid plastics especially, including clean five gallon pails or other containers, have some value, although contaminants in the buckets significantly reduce their value.

And, like OCC, plastic film, while prevalent in the mixed C&D, is often relatively highly contaminated reducing its value. In addition, it can be difficult to pull film off the picking line because it tends to be tangled with all of the other mixed C&D.

Rigid plastics are often found in the bulky waste deliveries where large plastic toys, outdoor play equipment and furniture and broken laundry, waste and recycling containers are often found. These materials are more likely to be recovered at facilities that are also marketing other commercial (and residential) recyclables and have easier access to plastic recycling markets and can mix and bale rigid C&D plastics with other residential/commercial plastics.

Gypsum

At the time of preparation of this report DSM has learned that a gypsum recycling facility is supposed to open shortly in Raynham, MA. To date DSM has not been able to confirm the capacity and specifications for this facility. Gypsum that is recycled from Massachusetts facilities typically goes to Pennsylvania where it is made into an agricultural product.

The primary way to recycle gypsum, however, is not as a component of mixed C&D because it tends to break into small particles during collection, transport and mixing on the tipping floor.

Instead, it is typically necessary to manage it separately at the job site where it can be kept separate in large pieces, and remain relatively clean. In addition, most gypsum recycling facilities require new gypsum, not painted or wallpapered gypsum, which is typical of demolition debris.

Asphalt Roofing Shingles

While most asphalt roofing that is recycled is delivered directly to a facility designed to specifically handle this material, a fair amount of mixed C&D from roofing jobs or repairs contain asphalt shingles. The main market for facilities in Massachusetts is Carneys, located in Raynham. Other potential markets, although not as commonly reported to be used, are Rooftop Recycling in Boxborough, MA and RAS-Tech located in Brentwood, NH.

TASK 3 - PROCESSING ADVANCEMENTS

As presented in Table 1, the current recycling rate for Massachusetts C&D ranges from 27 to 32 percent, depending on how it is calculated. MassDEP has established a goal of recycling 50 percent of C&D, and therefore one of the tasks associated with this analysis was to investigate how/whether that goal could be met.

Table 5, below presents estimates of current recovery rates by recyclable material type, as well potentially high achievable rates (and tonnages) for the same materials.

- Column 1 is derived from multiplying the average percent composition (by material type) in Table 2 by the total reported mixed C&D waste (in tons) processed in Massachusetts.
- Column 2 represents the sum of reported incoming source separated material.
- Column 3 is the sum of Columns 1 and 2.
- Column 4 represents the total reported material recycled.
- Column 5 divides Column 4 (Recycled) by Column 3 (Total Available) to calculate the current recovery rate by material.
- Column 7 is multiplication of the Total Available (Column 3) by the Potentially Achievable Recovery Rate shown in Column 6.

As illustrated by Table 5, based on DSM's visual analysis of mixed C&D loads, coupled with incoming source separated materials, roughly 55 percent of all of the C&D generated and processed in Massachusetts consists of materials that are currently recyclable (Column 1).

Massachusetts processors are currently recovering roughly 50 percent of these materials based on DSM's visual analysis (Column 5).[7] Column 6 presents what DSM would consider to be the high end of potentially achievable recovery rates for these same materials.

As illustrated in Column 7, applying these theoretical recovery rates would result in roughly 435,000 tons recovered (compared with roughly 306,000 tons currently) which would result in a maximum achievable recycling rate for in-state processed/transferred material of 46 percent.

---

[7] Some materials such as electronics, tires, mattresses and glass are not shown in column 3 because it would be difficult to estimate the total amount of these materials (as a group) found in mixed C&D, however DSM expects that the recovery rate is relatively low for these materials since not all facilities recover these materials.

Note that Table 5 only includes those materials processed in-state from Table 1 for which there are markets. For this reason, the *recovery rates* reported in Table 5 will be higher than the *recycling rate* reported in Table 1. Table 5 also does not include bulky waste or C&D material transferred out of state for processing in this calculation.

TABLE 5 - Current and Potentially Achievable Material Recovery Rates

Recyclable Material	Amount In Mixed C&D (tons) (1)	Delivered Source Separated (tons) (2)	Total Available (tons) (3)	Total Recycled (tons) (4)	Current Recovery Rate (%) (5)	Potentially Achievable Recovery Rate (%) (6)	Potentially Achievable (tons) (7)
Wood	318,372	21,377	339,749	147,269	43%	70%	237,824
ABC	18,022	35,807	53,829	72,515	135%	100%	53,829
Metals	39,721	3,137	42,858	45,508	106%	95%	40,715
Gypsum	22,859	61	22,920	811	4%	10%	2,292
Asphalt Shingles	97,760	8,909	106,669	11,638	11%	50%	53,335
Cardboard	12,003	0	12,003	8,717	73%	70%	8,402
Plastics	15,774		15,774	2,524	16%	50%	7,887
Other Recyclable Materials (1)	NA	16,706	NA	16,706	NA	NA	30,000
Total Material	524,512	85,997	610,509	305,687	50%		434,284
Percent of In-State Managed C&D	55%	9%	64%				
Recycling Rate:				*32%*			*46%*

(1) Includes Electronics, Tires, Mattresses, Glass and other miscellaneous materials recycled in smaller quantities.
(2) Recovery rates of over 100% represent source separated materials added to mixed C&D.

POTENTIAL PROCESSING IMPROVEMENTS

Based on the data presented above, **wood** remains the dominant incoming material with market value, and can be recovered at relatively high recovery rates depending on how rich in wood the input loads are, and what equipment is available to separate wood from other materials. However, as illustrated by Table 4, the percent of wood in the residue, while lower than in the incoming material is still significant, and “A” Wood (clean wood, pallets/crates, plywood, engineered wood) remains the largest single material type.

Based on DSM’s observations at the participating facilities, and discussion with the facility owners/operators, more wood is not recovered because of the difficulty in separating it from other materials (contaminants) including pressure treated wood, as well as the difficulty of meeting the Tafisa specification.

One solution may be to install additional equipment to recover this wood as “A” Wood for sale to Tafisa or to a bio-mass combustion facility. Several processors told DSM that they are evaluating additional equipment to recover more of this material. And, according to Lou Martin, Sales Manager for Van Dyke Recycling Solutions[8], at least one Massachusetts processor requested a preliminary design and cost estimate to install optical sorting equipment and the associated up-front equipment, but ultimately made a decision not to move forward.

Therefore, it is DSM's opinion that one possible way to increase C&D material diversion might be for MassDEP to assist with the capital cost of up-front conveyors, air separators, disc screens and optical sorters to recover more wood. One benefit of optical sorting is that the material does not touch the optical sorters which reduces wear on the equipment. But the optical sorters need a relatively clean material so there is a need to remove plastics and other non-wood materials before the wood is presented to the optical sorters.

In addition, according to Lou Martin, optical identification of pressure treated wood is really still in the development stage, with full scale application occurring over the next several years, so these facilities will still need to pull questionable pressure treated wood out manually, which will reduce the overall recovery rate for not pressure treated wood.

This is potentially another area where assistance from MassDEP in advancing the technology for optically identifying pressure treated wood might prove important in increasing recovery. DSM spoke with representatives from several companies who design and manufacture optical sorting equipment who said that they could conceive of ways to optically identify pressure treated wood if the demand for the equipment was there.

Another, lower cost approach to increase the recovery of wood might be to install more air separators and disc screens to remove contaminants from "B" wood lines.

Another option that MA DEP requested DSM investigate was the potential to install small scale gasification units at one or more of the processors to convert the "B" Wood into energy. Unfortunately, after conducting research on this issue, it is DSM's opinion that this option is not feasible for facilities in Massachusetts.[9] This is primarily the case because MA C&D processors do not need building heat, but primarily need electric power to run their sorting equipment. This requires that any bio-gas produced be run through an internal combustion engine to produce power for a generator set.

According to Ted Pytlar (see reference below) the resulting bio-gas contains tars and other impurities that make it very difficult to fuel an internal combustion engine without extensive gas clean-up, which puts the cost of the fuel significantly higher than for

[8] Telephone conversation, January 20, 2017

[9] See for example, *Status of Existing Biomass Gasification and Pyrolysis Facilities in North America,* Theodore S Pytlar, Divirka and Bartilucci Consulting Engineers, from the Proceedings of the 18th Annual North American Waste-to-Energy Conference, May 11 – 13, 2010. Also follow-up telephone conversation with Ted Pytlar, January 20, 2017.

conventional gasoline or diesel fuel. This was confirmed by a second source which compiled a list of small scale facilities around the world which were operating, but, in most cases have stopped operating.[10] Therefore it is DSM's opinion that it is unlikely that small scale gasification equipment designed to consume "B" wood generated at existing processor will be cost effective or feasible as a way to increase materials recovery.

It is important to note here that the Plainfield Energy Recovery Facility in Plainfield, CT is a large-scale bio-mass gasification facility. Many of the issues cited above with respect to small scale gasification appear to also be a problem with large scale gasification of waste wood. For this reason, if Massachusetts wants to encourage more recovery of waste wood in Massachusetts, outlets other than gasification should be considered – such as source separated clean wood applications and combustion.

The second material to target with potential market value is **metal**. While the C&D processors that DSM evaluated are using magnets to remove ferrous metals, there remain non-ferrous metals in the residue that might be valuable. When compared to wood, additional recovery of metal will probably not have much of an impact on the overall recycling/recovery rate, but could potentially improve the economics of processing though greater recovery of higher value materials.

Recovery of non-ferrous metals in most cases would involve the addition of eddy current separators. As with optical sorting, it is likely that some additional clean-up of the material would be necessary in front of the eddy current separator, but the cost and complexity is probably significantly less than for clean-up prior to an optical sorter.

The third material that might be targeted is **bulky, rigid plastic.** As illustrated by Table 4, plastic is estimated to represent roughly 9 percent of the weight of outgoing residue at the five processing facilities where DSM has observational data. And, based on DSM's observations, roughly 80 percent of this plastic might be bulky rigid plastic (bulky rigids plus an estimated 50 percent of the "other plastics" category). In most cases this represents a mix of resins, and would be of low value. However, if the processing facility has room to create a separate bunker to collect this material it might make sense to recover it. This is especially the case if the facility is accepting a significant amount of bulky waste, which also contains bulky rigid plastics. But without a baler, the net value to the processor is relatively low and therefore without significant extra space, it may continue to not be economical to recycle this material.

Another significant material is **carpet**. While in the past this material might also have had value, the move away from nylon based carpet to PET based carpets has significantly reduced the value of dirty carpet. As such, DSM is not convinced that investing in recovery of carpet will make financial sense.

---

[10] https://energypedia.info/wiki/Electricity_Generation_from_Biogas

Two other materials for which limited markets exist in Massachusetts are asphalt shingles and gypsum. There are currently several markets for asphalt shingles in Massachusetts and New Hampshire; and efforts are being made to revive gypsum recycling. To the extent possible, MassDEP should work with these markets to help ensure their success.

Task 4 – Barriers

Barriers to increasing the recycling rate for C&D materials in Massachusetts fall into five categories:

- Market specifications for waste wood;
- Relatively low cost landfill and rail transfer and disposal of waste wood;
- Lack of a uniform definition of "processing" for C&D waste leading to low recovery rates at facilities without mechanized processing equipment;
- Distance between where the majority of C&D is generated and availability of processing capacity; and,
- Low value for commodities such as mixed plastics, dirty OCC, vinyl siding and other materials where the additional processing and transport costs far outweigh the value even when a market can be found

As discussed above, the market for waste wood has shrunk since DSM last conducted this study in 2007. In addition, specifications have been tightened. This makes it difficult for processors to invest in more labor or technology to recover more "A" Wood, primarily for the single particle board market in Quebec.

The economics also are difficult because it is so inexpensive to load C&D onto a rail car and ship it to low cost landfills – especially in Ohio. As such, the incentive will always be there to process the recyclable rich loads and to transfer for disposal loads that contain smaller quantities of recyclables, or that are more heavily contaminated.

While DSM cannot quantify how much C&D waste is actually run through a processing line; based on our observations, a greater percentage of C&D appears to be processed now than in 2007/08. However, a significant amount of material arriving at transfer stations or at crowded processing facilities may not be processed at all because it is low in recyclables of any value and the cost to transfer to process the material outweighs any benefit.

Finally, C&D waste generation is cyclical with the economy and the majority is generated in locations where the economy is doing well. This means that C&D waste generation may be the largest in the greater Boston area where facilities are harder to get to, or where trucks may experience longer wait times. In some cases, this C&D waste may make its way to other transfer stations and bypass processing facilities or be direct hauled out of state where processing may or may not occur.

CONCLUSIONS AND RECOMMENDATIONS

It is DSM's opinion that processors in Massachusetts are doing a relatively good job of recovering materials from mixed C&D waste – currently recovering roughly 50 percent of marketable materials, resulting in a 32 percent recycling rate for C&D waste managed in Massachusetts (As shown in Table 1 and 5). This is despite the fact that the market for wood waste - the most prevalent material in mixed C&D is more limited now, in terms of both capacity and tighter specifications – than it was in 2007.

Recovering greater amounts of material will require continued investment in new processing equipment at existing processing facilities. These investments will be constrained by the relatively low tipping fee to dispose of mixed C&D waste at Massachusetts landfills, and of rail shipment of mixed C&D waste to out-of-state landfills. This low cost alternative makes it difficult for processors to justify running low value C&D through their processing facilities, and constrains investment in new, capital intensive processing technologies.

Based on DSM's analysis of incoming and outgoing materials, MassDEP should consider providing assistance to C&D processors to invest in additional processing equipment targeting the following materials:

- Recovery of additional "A" wood through additional investments in new processing equipment, and investments in research necessary to prove the potential to optically sort pressure treated wood from non-pressure treated wood;
- Recovery of additional metals through investments in eddy current separators and other equipment necessary to recover non-ferrous metals;
- Conversion of more "B" wood to "A" wood through systems designed to sort smaller pieces of wood, and to remove contaminants and fines form this wood; and,
- Potential investments in recovery of bulky plastics through dedication of sorting space for bulky plastics and, potentially, film, with baling of the resulting separated materials at high throughput facilities.