Construction and Demolition Waste Characterization and Market Analysis

Prepared for:
The Department of Energy and Environmental Protection
Bureau of Materials Management and Compliance Assurance
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Provided by:

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in partnership with

SOVEREIGN CONSULTING INC.

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Background:

In conjunction with the development of the State of Connecticut's Comprehensive Materials Management Strategy (CMMS), Green Seal Environmental, Inc. (Green Seal) conducted a Construction and Demolition Waste Characterization and Market Analysis (C&D Study) for the Connecticut Department of Energy and Environmental Protection (CT DEEP). The first of its kind for the state, the purpose of the C&D Study was to provide information on the composition of this waste, flow patterns, market characteristics, recycling, and modes of disposal. This information will be used by CT DEEP to develop policies and strategies to recover more materials from the C&D waste stream and support businesses engaged in the recovery, processing, marketing, and use of such materials. For the C&D Study, Green Seal conducted the following tasks:

1. Gathered and analyzed data on waste types, origins/sources, quantities, and disposal. This analysis included determining the relative proportions of waste materials that compose the C&D stream, estimating total quantities of different materials in the C&D waste stream, estimating rates of recycling and reuse for each material, and for each material with significant potential for recovery, preparing a discussion of quality issues associated with the material as they may affect recovery for marketing, for example the hazardous nature of a material, or the need to aggregate a material through source-separation to make marketable. Materials of focus included:

    - Wood
    - Gypsum Wallboard
    - Asphalt Roofing Shingles
    - Metals
    - Major Packaging Waste
    - Asphalt, Concrete & Bricks
    - Ceramics
    - Other Wastes (Carpet, Carpet Pad, Mattresses/Box springs, Tires, Fines, Other oversized MSW)

2. Conducted interviews and waste "audits" (qualitative research) at the point of generation, management or disposal (e.g. general contractors for commercial projects, including large-scale housing construction).

3. Conducted targeted waste "sorts" (quantitative research) (e.g. waste sorts at volume reduction facilities)

4. Gathered market data, including rates and charges (i.e. tipping fees) for C&D services, and outlets (intermediate or end-users) for recovered materials.

5. Reviewed existing research data on the Connecticut and regional C&D waste stream.

6. Analyzed the flow of C&D wastes from generation to disposition, especially key categories/types of debris that is generated at different business sectors and processed at various types of facilities including:

    a. By business sector:
        i. Demolition – residential single-family; commercial (including multi-unit residential units)
        ii. Renovation/Remodeling – residential single-family; commercial (including multi-unit residential units)
        iii. New Construction - residential single-family; commercial (including multi-unit residential units)
        iv. Highway construction

    b. By processors/facilities:
        i. Landfills
        ii. Transfer Stations
        iii. Volume Reduction Facilities/C&D processors
        iv. Waste to energy facilities
        v. Recycling facilities, including scrap metal recyclers
        vi. Aggregate facilities

7. Prepared protocols and methodologies for waste sorts and audits.

8. Provided analysis and recommendations for the disposition of C&D derived wood, including clean dimensional lumber, clean oriented strand board (OSB), pallets and crates, plywood, manufactured wood, treated wood, painted/stained wood.

9. Identified generators/business sectors with the greatest potential for C&D recovery and made specific recommendations for areas of market growth in Connecticut and the Northeastern U.S., based on recoverable C&D materials that may be undervalued/underutilized in the present waste system.

10. Identified and assessed the economics, barriers and opportunities associated with the recovery or reuse of targeted C&D materials. Assessment included the identification of economic pressure points, opportunities, and potential policy issues, including methods used in other locales to foster increased recovery of C&D materials (e.g. regulations, financial incentives and disincentives, government involvement in facility development/operation).

11. Prepared specific recommendations for changes to current collection, transportation, and processing practices that could enable the recovery of greater quantities of materials for reuse, beneficial use, recycling, fuel production, and energy production.

12. Prepared specific recommendations for changes to current collection, transportation, and processing practices that would promote system efficiency, including decreasing system costs.

13. Prepared this Final Report.

Executive Summary:

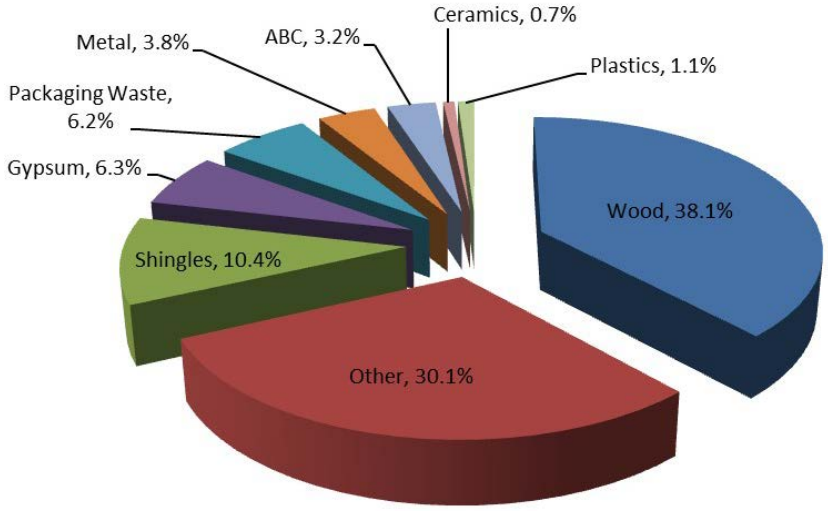
A summary of each section of the C&D Study is provided on the proceeding pages.

SECTION 1.0 – BASELINE RESEARCH SUMMARY

Green Seal conducted baseline research on C&D Generation, Composition/Characterization, Recycling, Reuse, and Disposal. Based on the research conducted:

- The per capita Connecticut C&D generation rate is approximately 0.29 tons per person per year, which is consistent with an average rate of approximately 0.30 tons per person per year developed from other regional state studies.
- Connecticut generated approximately 1,041,643 tons of C&D in 2013
- Green Seal performed a series of quantitative estimations of the different components of "typical" materials entering VRFs in CT. Inbound loads were observed for a total of 8 days at four different VRFs to obtain data on the typical percentages of the major inbound material makeup. The figure below presents the composition by weight that was observed during the assessment.

Inbound C&D and Oversized MSW Managed at CT VRFs
Waste Composition by Weight



- Based on 2013 facility data reports and interviews with VRFs and Recycling Facilities, with the estimated generation of 1,041,643 tons of C&D materials in 2013, and 71,181 tons recycled, CT achieved a C&D recycling rate of approximately 7%. According to CT DEEP, the rate was approximately 9% for the CY2013 data.
- Based upon the research conducted, very limited quantities of salvageable materials are extracted from CT C&D VRFs. It is worth noting that it is possible that a significantly larger amount of material could be salvageable if it were sorted at the point of generation versus after being loaded into a container with other non-salvageable items, being exposed to the elements and other contaminants within the mixed loads, and finally being dumped out of the container onto a tipping floor at a VRF.

- Based on 2013 CT facility data reports, interviews with VRFs, and when possible, verification with adjacent states' solid waste agencies, CT disposed of approximately 884,157 tons of C&D. Approximately 18 percent of the outbound materials disposed from VRFs were disposed in- state, with approximately 82 percent being disposed

out-of-state. Based on these statistics, CT relies heavily on out-of-state disposal. Of the 158,593 tons disposed within CT, approximately 94,784 tons or 59.8 percent was disposed at Resource Recovery Facilities (RRFs) aka waste- to-energy plants/facilities.

SECTION 2.0 – QUALITATIVE RESEARCH

Green Seal conducted research on the management of construction and demolition materials from the point of generation by conducting interviews with individual home builders, large-scale multifamily residential builders, large-scale commercial/industrial/institutional construction firms, deconstruction firms, and demolition contractors doing business within CT. The decision making process for recycling included numerous variables including:

- Whether it must meet the LEED certification and/or CT High Performance Building Standards
- Cost savings measures that would be realized through recycling
- Owner's preference (independent of cost savings)
- Company (builder's) policies
- Availability of recyclable commodity markets
- Project size

Based on the interviews conducted, there were perceived, economic and/or regulatory limitations associated with recycling and waste reduction at construction projects in CT including:

- The overall additional cost of recycling
- Access to local recycling outlets/aggregation sites
- The additional cost of labor for separating materials on-site and managing the waste streams
- The overall additional cost of achieving LEED certification on projects not subject to the CT high performance standards
- Weight limitations on the containers being hauled from construction sites
- A larger focus on energy efficiency with the CT state building code versus waste reduction and recycling.

In addition to the communication with the traditional construction, renovation, and demolition contractors, Green Seal conducted research on deconstruction and communicated with one identified deconstruction contractor within CT. Benefits associated with deconstruction include:

- Finding reuse that will allow for longer life spans for reused and repurposed construction materials,
- Creating a source of historic architectural components,
- Reducing the reliance on landfills and incinerators,
- Providing for a reduced carbon footprint by reducing the need for new building materials (manufacturing and transportation),
- Decreasing new building costs by providing discounted building materials,
- Providing for significant tax based incentives (donations of the salvaged building materials)
- Reducing damage that could occur if the materials were aggregated into a dumpster for shipment to a recycling facility, and

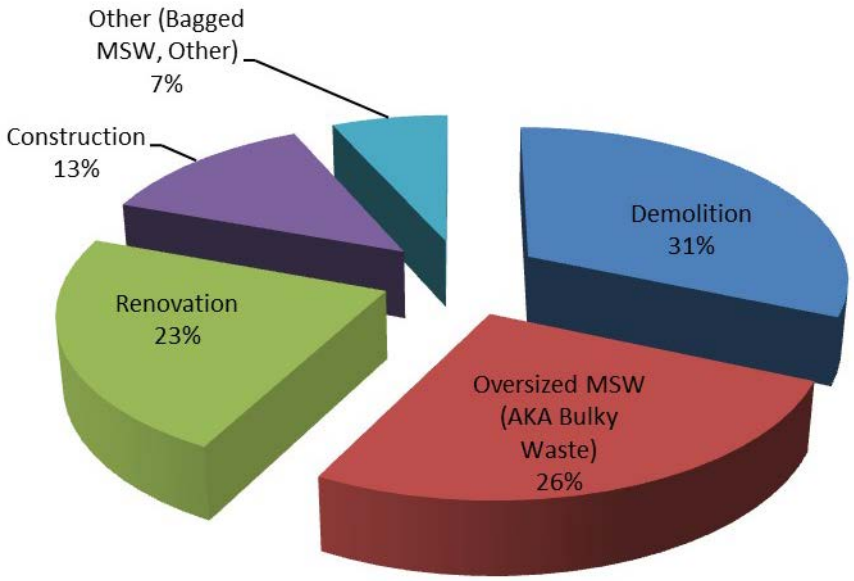
- Creating a secondary jobs market for repurposing the salvaged building materials (reuse store of manufacturing such as furniture).
- Using higher paid and skilled workers to perform the deconstruction

Presently, it appears that the main barrier to growing deconstruction in CT is finding and maintaining long term viable outlets for various materials. Based on interviews, deconstruction activities in CT have primarily consisted of residential and small commercial structures

SECTION 3.0 – QUANTITATIVE RESEARCH

Green Seal performed a series of quantitative estimations of the different components of "typical" materials entering VRFs in CT. Inbound waste loads were observed for a total of eight (8) days at four (4) separate VRFs. This task was performed in an effort to obtain data on the typical constituents found within the inbound waste material. The data collected was used to estimate the percentage of each material that could be available for subsequent recycling and/or disposal. As summarized in Section 1.0 above, Green Seal tabulated the data obtained, and developed the average "Inbound C&D and Oversized MSW Managed at CT VRFs Waste Composition by Weight." Additionally, Green Seal made the following observations:

Inbound Waste Loads Observed at CT C&D VRFs – By Category



Also, Green Seal conducted an additional analysis of the inbound waste received during the waste load observation exercises by removing from the data set, the loads that were primarily Oversized MSW. The resulting waste loads were 19% Construction, 34% renovation, and 47% demolition.

SECTION 4.0 – TIPPING FEES, RECYCLING, AND END MARKET RATES

Green Seal conducted research to gather market data, including rates and charges (i.e. tipping fees) for C&D/Oversized MSW disposal and recycling services, and outlets (intermediate and/or

end-users) for recovered materials. In addition to the current markets, Green Seal researched issues that would impact market longevity, and the potential impacts of market shifts for existing facilities as well as future siting. The research was conducted for the following:

- VRF Tipping Fees
- Landfill Tipping Fees
- Recycling Outlets for:
  - Metals
  - Recycled aggregates
  - Clean (unpainted, untreated) wood
  - Mixed wood
  - Asphalt shingles
  - Gypsum
- C&D "Fines" (fine material screened from mixed C&D materials) Outlets

Below is brief list of Green Seal's observations:

- C&D VRF owners/operators reported tipping fees in the range of $70 - $120 per ton.
- The overall average inbound price paid by haulers is approximately $70 - $80 per ton at the VRFs, with the higher end of the range being paid in more urban areas.
- Based on the research conducted, as of the date of this report, the twenty-nine (29) VRFs were owned by fourteen (14) different entities, with nine (9) facilities being affiliated with one entity/operator.
- Of the 29 permitted C&D VRFs in CT, eight (8) facilities have rail transportation capabilities for disposal of C&D/Oversized MSW and/or residuals from processing.
- Given the estimated generation of 1,041,643 tons of C&D materials in FY2013, with 71,181 tons recycled, CT achieved a C&D recycling rate of approximately 7%.
- According to facility interviews, currently, only five (5) of the twenty-nine (29) VRFs operate processing systems.
- Given the existence of only one viable market currently accepting mixed wood materials from CT, the longevity of the market is uncertain. The economics of transportation (namely the 80,000lb Gross Vehicle Weight restriction in CT) prevents additional access to out-of-state (namely Maine, New York & Canada) facilities that are currently accepting mixed wood for fuel.
- There is presently a strong market for metals, recycled aggregates and clean wood.
- The market for asphalt shingle is limited and is presently recycled at two facilities in CT. Based on the research conducted, the shingle recycling facilities accept materials for a tipping fee of approximately $60-$65/ton depending on quality and volume of materials received.
- Green Seal conducted a regional search for facilities accepting gypsum for recycling and found two active gypsum recycling operations in Pennsylvania. Based on interviews with the facilities, one of the two facilities, USA Gypsum, is accepting source-separated loads of gypsum materials from Connecticut and other parts of New England. According to the facility, tipping fees charged for materials at their facility are in the range of $15-$40/ton.
- Based on the research conducted, VRFs are not currently generating C&D fines for alternative uses other than disposal

SECTION 5.0 – EXISTING CT REGIONAL WASTE STREAM RESEARCH

Green Seal reviewed existing research and data on the Connecticut and regional C&D waste stream. This information was reviewed to compare regional data with CT data and to make comparisons regarding regional practices and policies. General observations included the following:

- Per capita generation rates in CT have remained similar since 2006
- Recovery/recycling rates have increased from approximately 6.2% in 2006 to 8.1% in 2013.
- Exportation remains the major source of disposal, with a significant percentage of the material destined for Ohio landfills via rail.
- Out of the materials mandated for recycling in CT, generally only scrap metal, corrugated cardboard and limited quantities of plastic containers are likely to be received in mixed loads of C&D/Oversized MSW at VRFs.
- In addition to the definitions of C&D, Green Seal noted differences in the definitions of recycling among states, as well as interpretations of the definitions, and how each state accounts for recycling. Most notably, two end uses relevant to C&D which are treated differently among states is wood that is sent to biomass facilities and C&D fines used as alternative daily cover.

SECTION 6.0 – C&D WASTE FLOW RESEARCH

Green Seal analyzed the flow of C&D waste from the point of generation including the types of debris created by the different construction activities (construction, renovation, or demolition), and how the types of materials generated by different activities influence their collection, transportation, recycling, and/or disposal. Several of Green Seal's observations for each category are presented below:

Construction Materials:

- Materials are typically transported commingled from the point of generation in roll-off containers.
- Based on the waste observations conducted for this study, the majority of construction materials are entering VRFs in 15-30 yard containers.
- Construction activities tend to generate smaller volumes of material than demolition projects and renovation projects, based on a square foot comparison.
- Construction materials are less likely to contain potential contaminants such as painted wood (Lead), creosote, PCBs, and asbestos containing materials.

Renovation Materials:

- Renovation comprises both demolition and construction activities, and thus materials generated are a combination of both waste streams.
- The majority of renovation materials are entering VRFs in 15-30 yard containers.
- Depending on the type of project and the age of the structure, prior to abatement, renovation materials are more likely than construction materials to contain contaminants such as lead based paint, asbestos, and or PCBs.
- Renovation projects on concrete or masonry (brick, block) structures may necessitate separated waste streams for the concrete and masonry materials versus the

construction materials.

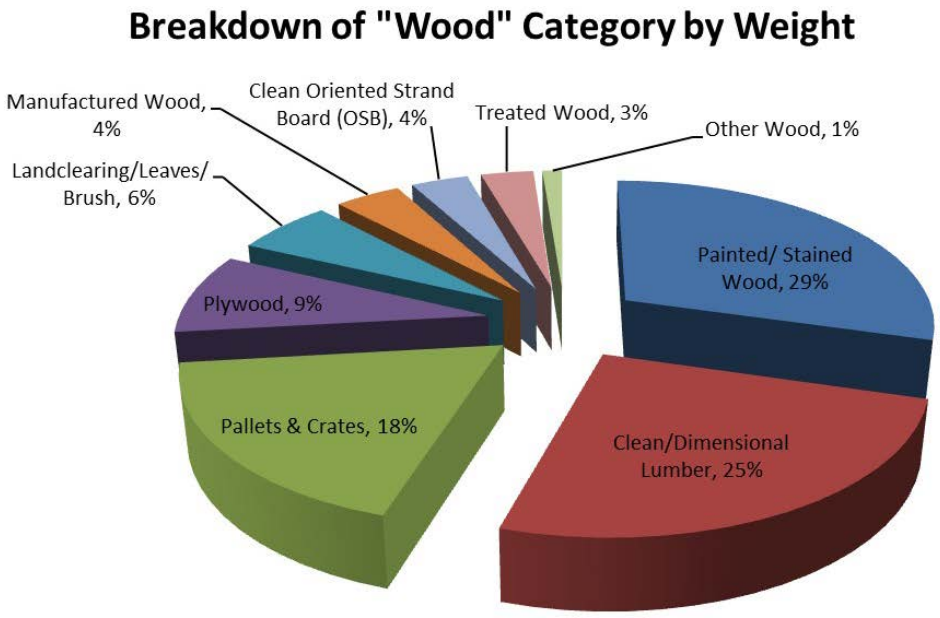
- In some cases, depending on site considerations, ABC materials may be reused directly on-site.

Demolition Materials:

- While limited quantities of demolition materials are directly re-used through deconstruction efforts presently, the majority of materials are transported to CT C&D VRFs.
- Based on the waste observations conducted for this study, the majority of demolition materials are entering VRFs in 30 CY containers and in some cases 100CY live-floor trailers loaded directly at the job sites
- Demolition materials tend to be the heaviest of the categories.
- Depending on the type of project and the age of the structure, prior to abatement, demolition materials can be more likely to contain contaminants such as lead based paint, asbestos, and or PCBs.
- Given the transportation efficiency of over-the-road "long-haul" with 100CY live-floor trailers, some demolition materials are transported directly from job-sites to out-of-state distant landfills versus entering a CT VRF. However, given CT's 80,000 GVW restriction, it is less common in CT than the rest of New England and New York.

SECTION 7.0 – C&D-DERIVED WOOD MARKETS ANALYSIS

Green Seal analyzed the current and potential markets for wood materials derived from C&D sources. Based on the waste observation exercise conducted for this study, which included the analysis of 267 loads of material accepted at CT VRFs, wood made up approximately 38% of the total inbound waste stream. The following is a breakdown of the wood categories by weight.



Mixed wood, which includes the wood from all categories except treated wood, there is

approximately 380,000 tons per year available. It should be noted that these volumes are "theoretical availability" figures only. It is not realistic to expect to be able to capture all wood via source separation and/or from separation of a mixed C&D waste stream

Based on the 2013 facility reporting data coupled with interviews of the VRFs operators, the most commonly used end markets for processed (separated, ground, and screened) clean wood include:

- Mulch (including bulk and bagged products, and also including dyed mulch), and
- Animal bedding

It should be noted that while some portion of the mulch and animal bedding is made from clean wood sorted from mixed loads of C&D debris, the majority of material is source separated clean materials such as pallets and crates, clean wood manufacturing scrap, and trees/stumps/brush.

Based on the research conducted, the only current end use for mixed wood is biomass fuel. It should be noted that mixed wood biomass fuel must be free of treated wood (I.e. CCA treated lumber and low in other contaminates such as lead). Although bulk biomass fuel is a "current" use in CT, it is generally limited to one outlet; Plainfield Renewable Energy based on over the road weigh restriction for long haul transportation.

Green Seal researched the potential for the use of C&D-derived wood in the manufacture of recycled-content wood products. Based on the research conducted, one manufacturer, Tafisa in Lac-Megantic, Quebec, Canada, is manufacturing post-consumer recycled-content wooden panels using a technology called Rewood™.

SECTION 8.0 – UNDERVALUED/UNDERUTILIZED C&D-DERIVED MATERIALS RESEARCH

Green Seal analyzed recoverable C&D materials that may be undervalued and/or underutilized presently. In general, recovery rates of all C&D-derived materials are presently fairly limited in CT. Based on 2013 facility reporting data, approximately 45% of all material managed by VRFs went to the five (5) VRFs that have processing systems. Furthermore, the recovery rates from the VRFs performing processing are relatively low, and in a majority of the cases are limited to source separated materials such as land clearing debris, pallets, metals, and aggregates (asphalt, brick, and concrete). Given this, a large majority of mixed C&D waste streams are "underutilized" with respect to extraction from the waste stream for subsequent recycling. Section 8.0 of the report includes analysis of each major component, including:

- Wood
- Asphalt roofing shingles
- Gypsum
- Oversized bulky waste components
- C&D fines
- Cardboard
- Plastics
- Aggregates, and
- Metals

SECTION 9.0 – ECONOMICS, BARRIERS, AND OPPORTUNITIES TO INCREASE C&D RECOVERY

Green Seal performed research to identify and assess the economics, barriers and opportunities associated with the recovery or reuse of targeted C&D materials. Research included the identification of economic pressure points, opportunities, and potential policy issues, including methods used in other locales to foster increased recovery of C&D materials (e.g. regulations, financial incentives and disincentives, government involvement in facility development/operation).

Based on Green Seal's research, the primary factors leading to low recovery at VRFs are attributable to the following variables:

- Inexpensive, rail accessed landfill disposal
- The additional costs of labor and equipment relative to the cost savings recovering additional materials
- The lack of mandatory recycling (for generators and/or processors)
- Lack of diversionary and/or recycled markets for materials (primarily C&D fines and mixed wood)

A number of other factors which are more site-specific include:

- Lack of space (indoor and/or outdoor storage and processing areas)
- Permit conditions (state, local) restricting operations
- Lack of local outlets for recovered materials

Section 9.0 includes a list of twenty-one potential options that could increase the recovery of C&D overall, and sixteen additional options to target specific components of C&D. Green Seal presented the options and recommendations in three categories:

- Short-Term Implementation and Study: Within 1-2 Years
- Longer-Term Implementation and Study: Within 2-4 Years
- "Contingency" Implementation and Study: Greater than 4 Years if the strategies developed in years 1-4 fail to make significant progress toward the 60% diversion goal

SECTION 10.0 – RECOMMENDATIONS FOR INCREASES IN THE QUANTITY OF C&D COLLECTED, TRANSPORTED, AND PROCESSED

Green Seal performed research to identify changes to the current collection, transportation, and processing practices that could enable the recovery of greater quantities of materials for reuse, beneficial use, recycling, fuel production, and energy production.

Currently, a majority of the mixed C&D generated in CT is transported from the point of generation to VRFs either with or without C&D processing systems. Locations are chosen primarily based on the proximity to the generator, roll-off container pricing, or the tipping fees at the VRF.

A current impediment for the efficient transportation of virtually all commodities is the 80,000lb GVW limit in CT which results in a higher cost per ton for transportation, and lower quantities of

recyclables being transported from CT facilities. A related impediment is the lack of local markets/economic factors for some materials including:

- Gypsum
- Mixed Wood
- C&D Fines

To increase quantities of materials transported from VRFs for recycling (versus disposal), additional economically viable local markets are needed for gypsum, mixed wood, and C&D fines.

It is Green Seal's opinion that in order to increase quantities of C&D recycled within CT, additional recycling facilities (and/or satellite collection sites) are also needed geographically to provide local access and reduce transportation inefficiencies.

Additionally, recovery rates are currently significantly lower than the facilities' capabilities due to inexpensive landfill disposal options, and marginal post-consumer markets when compared to the additional costs of labor to sort more materials from the mixed waste stream. Thus, the quantities of recyclables that the facilities can produce are not necessarily due to the limitations of the processing systems, but rather a function of the impact to profitability of increasing sorting and recycling without a mandate (permit condition and/or waste ban) and their need to remain competitive with disposal markets (in and out of state).

SECTION 11.0 – RECOMMENDATIONS FOR INCREASES IN THE EFFICIENCY OF C&D COLLECTED, TRANSPORTED, AND PROCESSED

In addition to researching methods for increasing quantities of C&D collected, transported, and processed in CT as discussed in Section 10.0, Green Seal performed research to identify changes to the current practices that could enhance efficiency.

Based on these considerations, Green Seal has recommended that the state determine the feasibility of providing source separated recyclable C&D materials "drop-off" sites for use by contractors to facilitate local access, and to increase the quantity of higher value recyclables before they are commingled. This could include state-owned/operated facilities at new or existing sites (such as the MIRA transfer stations), new sites, and/or privately owned and/or operated new sites or additions to existing VRFs and recycling facilities. Given that considerable infrastructure is already in place at the existing VRFs, and to prevent competing against the private sector which has invested heavily in the creation of the state's C&D recycling infrastructure, Green Seal recommends that working with existing facilities be given priority consideration.

To increase the efficiency of materials transported from VRFs for recycling (versus disposal), additional local markets and uses are needed for gypsum, mixed wood, asphalt shingles and C&D fines. Additionally, if room allows, baling of cardboard and plastics may increase recovery by reducing transportation inefficiencies.

As previously mentioned, recovery rates are significantly lower than the facilities' capabilities currently due to inexpensive landfill disposal options coupled with marginal markets when considering the additional costs of labor to sort more materials from the mixed waste stream. The

efficiency of the processing systems do not appear to be the limiting factor, but rather it is a function of economics and profitability as these facilities ultimately have to compete with the set barriers associated with straight disposal costs.

SECTION 1.0 – BASELINE RESEARCH SUMMARY

1.1 Introduction

Section 1.0 provides a summary of the results of the baseline research conducted for the study, including:

- Generation
- Composition and Characterization
- Reuse, Recycling, and
- Disposal

1.2 Generation

Green Seal Environmental, Inc. (Green Seal) conducted a review of available C&D waste generation studies, including a regional (northeast) study, and numerous state studies to estimate the quantities (tons) of C&D generated per year. The purpose of the literature review was to obtain a per capita average to compare against a per capita Connecticut C&D generation rate developed from facility reporting data and data obtained from adjacent states. The collection of data from adjacent states was performed to identify whether C&D materials are being directly hauled from point of generation and imported/exported to/from Connecticut. Below is a summary of the information obtained.

C&D Generation & Characterization Studies:

According to *Construction & Demolition Waste Management in the Northeast in 2006*, dated June 30, 2009, by Northeast Waste Management Officials' Association (NEWMOA), in 2006, approximately 1,466,371 tons of CT Construction and Demolition Debris, including some oversized MSW, passed through CT permitted C&D processing and transfer facilities; equating to approximately 0.42 tons per person per year [1]. This study calculated C&D generation based on the "Material Flows" method by reviewing reporting data from CT facilities, as well as reviewing import/export data from surrounding states. It is important to note that annual C&D debris generation rates can vary significantly based on occurrence of natural disasters, economic factors, trends in the housing market, etc.

The following Table, created with data from the 2009 NEWMOA Study, includes CT and seven other northeast states. Based on the data generated from the report, the states had an average per capita generation rate of C&D waste of 0.30 tons per person per year.

[1] http://www.newmoa.org/solidwaste/CDReport2006DataFinalJune302009.pdf

Table 1.1 - 2009 NEWMOA Report per Capita C&D Waste Generation

State	C&D Waste Generation (tons)	Per-capita (tons per person per year)
Connecticut	1,466,371	0.42
Maine	515,528	0.39
Massachusetts	1,858,151	0.29
New Hampshire	442,301	0.34
New Jersey	1,877,257	0.22
New York	5,530,655	0.29
Rhode Island	202,161	0.19
Vermont	147,222	0.24
Total	**12,039,646**	
Average		**0.30**

While there are a number of additional generation studies, including a national study completed by the US EPA, and numerous statewide studies including Florida, California, North Carolina, and Washington, Green Seal has the most confidence in this local (regional) study given the following:

- Similarities in the construction materials used in the northeast
- Similarities in construction activity (economic conditions) within the region
- Quality of data identifying importation and exportation of waste around the region
- Similarities in calculations using the "materials flow" methods versus other methods which estimate generation based on the amount of construction activity and multiplying those figures by the average waste generated per activity. In Green Seal's opinion, these types of studies typically have the highest potential variability and can be less accurate.

However, as a check, Green Seal also reviewed the *2007 Massachusetts Construction and Demolition Debris Study, Final Report*, dated May 16, 2008, by DSM Environmental Services, Inc. (2008 DSM MA Study) [2]. According to this report, a literature review of eleven similar studies (including one national study and ten other statewide and/or local studies) produced an average of 1.7 pounds per day per capita. This translates into approximately 0.31 tons per capita per year, which is very similar to the average presented in Table 1 above.

CT C&D Generation:

Based upon a review of FY2013 data reported to DEEP by C&D Volume Reduction Facilities (VRFs) and Recycling Facilities, approximately 1,041,643 tons of C&D debris were processed through those Connecticut facilities. Almost all of the C&D originated from within CT, with only approximately 48,000 tons of C&D materials being identified as imported from other states. The 1,041,643 tons managed through the reporting facilities translates into approximately 0.29 tons per capita per year. The Table below is a summary for comparison of the current (FY 2013)

[2] http://www.mass.gov/eea/docs/dep/recycle/reduce/06-thru-l/07cdstdy.doc

figures against the other studies reviewed as part of the literature review.

Table 1.2 – 2013 Connecticut Facility Reporting Data Per Capita Comparison

Source	Per-capita (tons per person per year)
2013 Connecticut facility reporting data	0.29
2006 Connecticut facility reporting data (from the NEWMOA study)	0.42
2009 NEWMOA study including eight northeast state average	0.30
2008 Massachusetts study including eleven study average	0.31

A decrease in 2013 CT C&D generation is probable, given the significant decrease in construction activity compared to activity seven years prior. Additionally, where possible, Green Seal attempted to differentiate between C&D and Non-C&D Materials within the 2013 data; removing items such as "Oversized MSW" (house clean-out type materials), yard waste, brush, and stumps from the reported data. The total generation, with these additional "bulky" items added back into the generation estimate, would have been approximately 1,079,933 tons in 2013 (0.30 tons per capita per year). Given this, and similar correlation to the averages of multi-state studies above, Green Seal has a high level of confidence in the estimated per capita generation figure.

In addition, CT DEEP provided Calendar Year (CY) 2013 data for additional comparison. In CY2013 1,003,359.83 tons of CT C&D Debris was sent to disposal destinations and recycling destinations after being processed at CT C&D VRFs, CT asphalt recycling facilities, and CT scrap metal processors (scrap metal data reflects FY2014 data). 881,152.69 tons were disposed; 122,060.5 tons were recycled. With a population estimate of 3,596,080 that results in a per capita rate of 0.28 tons/person/year.

Limitations to Estimating C&D Generation:

Given the importance of obtaining an accurate baseline figure for generation in order to assist CT in its long term planning, and to be able to accurately compare generation versus recycling and waste reduction, Green Seal analyzed the limitations to estimating generation using the "material flows" approach. A discussion follows as to the limitations and the methods used to reduce the uncertainty as much as possible, within the limits of the research conducted.

The data used for calculating 2013 FY generation is based on quarterly reporting data from CT C&D VRFs and from CT asphalt roofing shingle recycling facilities provided to Green Seal by CT DEEP. In order to verify the accuracy of the data provided, and as part of the overall research completed for the study, Green Seal conducted a thorough review of the data, and also contacted all twenty-nine (29) of the permitted VRFs. Twenty-two (22) of the VRFs responded to Green Seal's request for interviews, representing the facilities that managed approximately 90% of all of C&D handled by VRFs in 2013. Most facility representatives were reluctant to verify reported data and referred us to their individual quarterly reports. However, based on the facility reporting data reviews conducted by CT DEEP, Green Seal's interviews

with the VRFs, and Green Seal's independent review of the data, Green Seal has a high level of confidence overall in the generation figures.

As part of the overall study effort, Green Seal requested data from adjacent states on imports and exports of C&D to and from CT. The goal of the research was to obtain data that might significantly increase (imports) or decrease (exports) the amount of C&D actually generated from within CT when using data from the CT VRFs to estimate C&D generation. Expressed as a formula, CT C&D Generation is:

CT C&D Generation =
C&D Inbound Reported Tonnage
+ C&D Exported Directly from CT Construction Sites to Out-of-state Facilities
– C&D Imported from Out-of-state Construction Sites to CT Facilities

Green Seal requested data from RI, MA, NY, and OH. While Ohio is not an adjacent state, Ohio received a large portion of C&D from CT VRFs in 2013. Data was received from MA, NY, and OH. RI did not respond to the request for the data. Based on the data received, Green Seal was able to verify some but not all materials reported being exported from and imported to CT, as reported in the VRF reports. A complicating factor for exports is the categorization of post-processed materials from CT VRFs. While inbound materials are treated as C&D at the VRFs, materials outbound post-processing are sometimes reported as "Bulky Waste", "Residuals", or "MSW" received in other states. Another complicating factor is the accounting for direct imports and exports which could include:

- Waste from out-of-state construction sites imported to a CT VRF
- Waste from an in-state construction site shipped directly to an out-of-state facility

While VRFs are required to report materials shipped out-of-state, individual generators (i.e. collectors) are not required to report to CT DEEP when directly hauling materials from a CT construction site to an out-of-state facility. Legislation passed in CT in 2010 (CGS Sec. 22a-220a(j)) requires collectors that haul solid waste from CT directly to out-of-state destinations to report annually to the CT DEEP [3]. If haulers hauling from construction and demolition sites meet the statutory definition of "collector" ("As used in this section, "collector" means any person who holds himself out for hire to collect solid waste on a regular basis from residential, business, commercial or other establishments") they are required to report. However, compliance with this requirement has been minimal per CT DEEP. For C&D imports (materials transported from an out-of-state construction site and/or transfer/processing facilities to CT VRFs), however, the data was obtained from reporting from the VRFs, and thus Green Seal was able to be exclude that quantity (47,230 tons in 2013) from the generation estimate. While direct exports (materials collected from CT construction sites and shipped to adjacent states without first going to a CT VRF) are an additional possible quantity of C&D generation, given the relatively similar tipping fees in adjacent states, it is not likely a large volume of material overall. Therefore, Green Seal did not adjust the generation to account for direct exports.

An uncertain quantity of C&D could also be added to the generation figures above by calculating the C&D materials accepted at Resources Recovery Facilities (RRFs, AKA waste-to-energy plants) in the state directly from the point of generation (construction sites), and not handled first

[3] http://www.ct.gov/deep/lib/deep/waste_management_and_disposal/solid_waste/wastecharstudy/ctcompositioncharstudymay2010.pdf

through a VRF. According to the Connecticut State-wide Solid Waste Composition and Characterization Study, Final Report, dated May 26, 2010, prepared by DSM Environmental Services, Inc., Cascadia Consulting Group, and MidAtlantic Solid Waste Consultants, C&D constituted approximately 14.1% (334,817 tons) of the total MSW waste stream in 2009. [4] These estimates were based on waste sorts conducted at five solid waste facilities including four RRFs and one transfer station. Green Seal reviewed the 2013 VRF reporting data on materials shipped out for disposal, and found that numerous facilities utilized the RRFs as a disposal option, and thus the materials are being accounted for in our generation calculations. In 2013, approximately 95,000 tons was sent from VRFs to CT RRFs and another approximately 40,000 tons was sent to MA RRFs. Given that the quantities of C&D/Oversized MSW shipped out to RRFs are being reported by the VRFs, there is the potential for double counting if RRF inbound quantities were also counted towards generation when attempting to determine inbound quantities of materials directly hauled from the point of generation versus a VRF. Additionally, based on Green Seal's research, there is the potential for materials which are C&D to be reported as Oversized MSW, and vice-versa. Given all of these limitations, and due to the fact that a large portion is already being reported by the VRFs as being managed by RRFs, Green Seal did not include additional RRF inbound C&D tonnage in the generation figures.

VRFs routinely transfer materials to other VRFs within CT. In 2013, VRFs transferred 211,119 tons of material to other VRFs, equating to approximately 16% of the total tons received at all VRFs. Based on the research, this is most commonly practiced when VRFs without processing systems and/or rail infrastructure ship to VRFs with the processing and/or rail infrastructure. Given that the amounts and destination are reported, Green Seal was able to reduce the quantity (211,119 tons) from C&D Generation to prevent double-counting.

Lastly, the generation figures do not include materials shipped from point of generation to non-reporting facilities such as scrap metal and asphalt, brick and concrete (ABC) recyclers. It is Green Seal's experience that significant quantities of ABC, given the weight and high recyclability of the material, are often recycled on-site or transported to recyclers from demolition projects. It's not feasible to accurately track all of the materials from point of generation to all of these facilities, and thus some quantity of generation is likely excluded. However, materials such as the aggregates (ABC) are traditionally not landfilled, and are typically excluded from generation in C&D studies. Also, materials from road and bridge construction, which are almost always excluded from mixed C&D generation studies since they've never traditionally been landfilled, are frequently handled at the same ABC recycling facilities. Thus, attempting to obtain annual volumes of materials accepted at these facilities would overinflate the generation figures as well by adding in road and bridge construction volumes. Given these accounting limitations, and the rationale for not including materials that are not typically landfilled, Green Seal did not include additional ABC managed outside of VRFs in the generation figures. Starting in FY2014 CT scrap metal processors as part of their amended annual solid waste reporting to CTDEEP, tried to estimate the amount of scrap metal they received direct haul from CT construction and demolition sites. Preliminary data indicated the tonnage to be approximately 19,609 tons in FY2014 (this estimate may include some road C&D scrap metal).

[4] http://www.ct.gov/deep/lib/deep/waste_management_and_disposal/solid_waste/wastecharstudy/ctcompositioncharstudymay2010.pdf

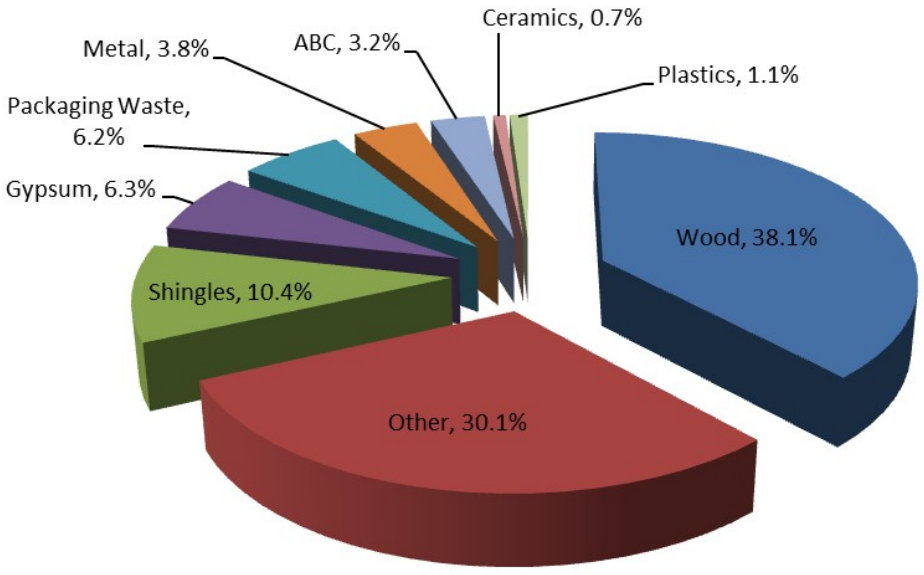
Given all of the limitations discussed above, it is possible that overall generation of construction and demolition debris is higher than the 1,041,643 calculated for this study. However, in terms of the importance and relevance of the data, Green Seal is confident that the figure represents the majority of the materials that are generated within CT that require management by CT VRF facilities. Additionally, as described above, the per-capita (tons per person per year) generation figure derived using this data (0.29) is very close to the average (0.30) of multiple state studies. Thus, for the purposes of developing a long term "Comprehensive Materials Management Strategy (CMMS)" strategy, the materials which are not already recycled directly from construction sites were approximately 1,041,643 tons in 2013 and should be the subject of the analysis provided herein.

1.3 Composition/Characterization

As part of this study, Green Seal performed a series of quantitative estimations of the different components of "typical" materials entering VRFs in CT. Inbound loads were observed for a total of 8 days at four different VRFs to obtain data on the typical percentages of the major inbound material makeup. Additionally, Green Seal performed a literature review to compare with the quantitative estimations. The goal of the quantitative estimations and literature review was to determine the average composition of C&D materials for determining the types and quantities of each category of material available for recycling and/or disposal in CT.

Section 3.0 – Quantitative Research provides a detailed description of the quantitative analysis performed, the results of the study, and an analysis of the overall effort. A summary of the average composition data generated from the analysis is provided in the chart below.

Figure 1.1 – Inbound C&D and Oversized MSW Managed at CT VRFs – Waste Composition by Weight



For comparison, Green Seal conducted a literature review on the composition of "typical" C&D materials. As part of the 2009 NEWMOA Report, which draws on data from the 2008 DSM MA Study, average composition figures were generated from numerous other studies, and an estimation of the major components of C&D materials was provided. Using the data from this study, Green Seal calculated the estimated quantity of the components based on the generation of 1,041,643 in 2013. The table below provides the estimated quantities of each material type.

Table 1.3 – 2009 NEWMOA Report Composition Applied to 2013 Connecticut Generation

Material	Percentage by Weight	Estimated Quantity Generated in CT (Tons – 2013)
Plastics	2.0%	20,833
Metals	5.0%	52,082
Concrete and Rubble (ABC)	9.0%	93,748
Drywall - Construction (clean)	6.0%	62,499
Drywall - Demolition/Renovation (dirty)	4.0%	41,666
Roofing	11.0%	114,581
Wood - Unadulterated (construction scraps and pallets)	11.5%	119,789
Wood - Adulterated (painted and engineered)	20.9%	217,703
Wood - Treated (pressure-treated)	1.6%	16,666
Other	29.0%	302,076
Total		**1,041,643**

Similarly, Green Seal applied the percentages obtained from the quantitative estimations to the baseline C&D Generation estimate of 1,041,643 tons in 2013.

Table 1.4 – 2015 C&D and Oversized MSW Quantitative Estimations Applied to 2013 Materials Managed at CT C&D VRFs

Material Category	Percentage	Tonnage
Wood	38.1%	397,204
Other	30.1%	313,110
Shingles	10.4%	108,131
Gypsum	6.3%	65,951
Packaging Waste	6.2%	64,831
Metal	3.8%	40,085
ABC	3.2%	33,398
Ceramics	0.7%	7,752
Plastics	1.1%	11,180
	100.0%	**1,041,643**

While the different categorization of materials prevents an apples-to-apples comparison between the two studies, the results of the study are very similar overall to those referenced above. A summary and comparison is as follows:

- The largest category is wood at approximately 38% (versus 34% in the comparison study).
- The second largest category in this study was the "Other" category at approximately 30% (versus 29% in the comparison study), which included items such as "Oversized MSW," more commonly referred to nationwide in the waste industry as "bulky waste." This can include items such as furniture, couches, mattresses, hard plastic toys, and miscellaneous materials generated from house clean-out activities. These materials, which are not associated with C&D activities, are nonetheless being managed by VRFs within the state, and were included in this study.
- The next largest category, roofing shingles (asphalt shingles) at approximately 10% (versus 11% in the comparison study), is a significant portion of the waste stream as well.
- These "top three" categories accounted for approximately 79% of the total materials observed in the study (versus 74% in the comparison study).

A detailed analysis of the quantitative estimates is provided in Section 3.0 – Quantitative Research. While there is significant inherent variability in the composition of inbound waste materials at VRFs, the study is based on a sample set of 267 loads of inbound materials observed at 4 different facilities, over 8 total days of analysis. Thus, Green Seal is confident that the data obtained includes an adequately large sample set and an adequate variety of receiving locations and waste sources to form an overall baseline composition of inbound materials at CT VRFs.

1.4 Recycling

Based on 2013 facility data reports and interviews with VRFs and Recycling Facilities, the table below provides a summary of recycling of C&D materials in CT. Given the estimated generation of 1,041,643 tons of C&D materials in 2013, with 71,181 tons recycled, CT achieved a C&D recycling rate of approximately 7%. According to CT DEEP, the rate was approximately 9% for the CY2013 data.

Table 1.5 – FY 2013 C&D and Oversized MSW Recycling in Connecticut Conducted at C&D VRFs and Asphalt Shingle Recyclers

C&D Material	Quantity Recycled (Tons - 2013)	Percentage of Total Recycling
Wood	23,831	33.5%
Metals	22,093	31.0%
Asphalt Shingles	13,377	18.8%
Asphalt Brick and Concrete (ABC)	6,267	8.8%
Old Corrugated Cardboard (OCC)	4,176	5.9%
Mixed Plastics	893	1.3%
Gypsum	544	0.8%
Total	**71,181**	

Based upon the research conducted and Green Seal's knowledge of the flow of materials from point of generation to recycling facilities, the recycling percentage is potentially higher than that calculated above. As discussed previously with regards to the generation estimates, there is an unknown volume of materials (ABC namely, but also metals, and in some cases clean wood, gypsum, cardboard, and plastics) that are removed directly from construction sites to non-reporting recycling facilities. As with generation, however, focusing on the relevance and importance of the data, the materials that remain after direct transport to recycling facilities and thus are in need of "management" is the focus of this research. With 1,041,643 tons entering VRFs and Recycling facilities in 2013, and approximately 71,181 tons being recycled, the C&D generated that requires recycling and/or disposal is approximately 970,453 tons.

1.5 Reuse

Based upon the research conducted, very limited quantities of salvageable materials are extracted from CT C&D VRFs. It is worth noting that it is possible that a significantly larger amount of material could be salvageable if it were sorted at the point of generation versus after being loaded into a container with other non-salvageable items, being exposed to the elements and other contaminants within the mixed loads, and finally being dumped out of the container onto a tipping floor at a VRF. Further, it should be noted that Green Seal did not attempt to identify potentially salvageable materials other than building materials. Items such as furniture, toys, and miscellaneous collectibles could also have potential value as well, but were not part of this study. Also, Green Seal did not consider pallets as a salvageable building material when determining whether a load had potentially salvageable materials.

1.6 Disposal

Based on 2013 CT facility data reports, interviews with VRFs, and when possible, verification with adjacent states' solid waste agencies, the table below provides a summary of the disposal of C&D materials generated within CT.

Table 1.6 – FY 2013 Connecticut VRF Outbound Disposal to Receiving States

Disposal Location by State	Total (Tons)	Percentage
Connecticut	158,593	17.9%
Ohio	494,633	55.9%
New York	122,357	13.8%
Massachusetts	52,985	6.0%
Pennsylvania	44,115	5.0%
Rhode Island	6,036	0.7%
Virginia	2,595	0.3%
Maine	2,824	0.3%
"Unidentified Location"	19	0.0%
Total	**884,157**	**100.0%**

Approximately 18 percent of the outbound materials disposed from VRFs were disposed in-state, with approximately 82 percent being disposed out-of-state. Based on these statistics, CT relies heavily on out-of-state disposal. Of the 158,593 tons disposed within CT, approximately 94,784 tons or 59.8 percent was disposed at Resource Recovery Facilities (RRFs) aka waste-to-energy plants/facilities. The Manchester Sanitary Landfill received the majority of the remainder of the tonnage with approximately 50,631 tons or 31.9 percent, with the remaining tonnage going to several small outlets including energy recovery and landfill cover.

Comparing the amount generated (1,041,643 tons in 2013), with the amount disposed (884,157 tons in 2013) and recycled (71,181 tons in 2013), there is a difference of approximately 86,305 tons that was either stored on site, was sent off site and not reported as disposal or recycling, or a combination of both on-site storage and non-reporting.

SECTION 2.0 - QUALITATIVE RESEARCH

Green Seal conducted research on the management of construction and demolition materials from the point of generation by conducting interviews with individual home builders, large-scale multifamily residential builders, large-scale commercial/industrial/institutional construction firms, deconstruction firms, and demolition contractors doing business within CT.

Green Seal inquired about recycling practices, decision making processes on what to recycle and where, and perceived or actual economic or regulatory limitations with respect to recycling and end usages. Additionally, Green Seal obtained information on the United States Green Buildings Council (USGBC) Leadership in Energy & Environmental Design (LEED) certified projects within CT.

2.1 Decision-Making Processes:

Green Seal spoke to numerous generators of C&D materials in CT, and based on the interviews conducted, the decision making process to determine whether to recycle and what the recycling goals are for projects varies by project type and size.

Large-scale Projects:

For large-scale projects, construction and demolition companies cited a combination of factors when deciding whether to recycle materials on large-scale projects, and what recycling goal to achieve, including:

- Whether the project is required to meet the LEED certification and/or CT High Performance Building Standards,
- Cost reduction if/when it can be achieved through reducing waste, reusing waste, and/or recycling (especially true for demolition contractors whose disposal/recycling costs is typically one of the largest cost components of their overall service),
- Design (architect) recommendations,
- Company (construction company's) policies relating to waste reduction and recycling,
- Ability to source separate materials at the job site (based on adequate room for multiple containers, economies of scale with the size of the job and amounts of materials generated to justify the multiple containers),
- Preferences of owners to recycle and/or reduce waste, including in some instances where the costs would be greater,
- Access to recycling markets as obtained through research by construction company employees (namely project managers), and
- Access to recycling markets as recommended by hauling companies.

Large-scale LEED Projects:

For larger projects, especially projects where they are attempting to achieve LEED certification, the decision is typically made by the designers (architects) and the owners. In some cases, high performance building standards (which include waste reduction for construction and renovation), are mandated by public law in CT. According to the CT DEEP's website, High Performance (Green) Building Standards for State Agency Buildings and School Buildings:

Public Acts 06-187 Section 70, 07-213 Section 5, 07-242 Section 10, and 07-249 Section 15 required the development of high performance building regulations for state agency buildings and school buildings. The regulations address the construction of:

- *A State agency facility projected to cost five million dollars or more and for which all budgeted bond funds are allocated by the State Bond Commission on or after 1/1/09;*
- *Renovation of a State agency facility projected to cost two million dollars or more and utilizing two million dollars of state funds approved and funded after 1/1/08;*
- *New construction of a facility projected to cost five million or more of which two million dollars or more is state funds and is authorized by the General Assembly pursuant to Chapter 173 on or after 1/1/09; and*
- *Renovation of a public school facility as defined in subdivision (18) of section 10-282 that is projected to cost two million dollars or more of which two million dollars or more is state funds and is authorized by the General Assembly pursuant to chapter 173 on or after 1/1/09; must comply with state regulations. (see Regulations below)*

These regulations were approved with technical corrections by the Regulation Review Committee on August 25, 2009 and submitted to the Secretary of State as required under the Connecticut General Statutes Sec. 4-172 on September 2, 2009. [5]

Based on the research conducted, the CT High Performance Building Standard is equivalent to that of the USGBC LEED Green Building Rating System-Silver certification. LEED projects are rated based on a scoring system where projects can obtain points by meeting certain design and construction standards in the following categories:

Category	Total Potential Points Earned
Integrative Process	1
Location and Transportation	16
Sustainable Sites	10
Water Efficiency	11
Energy and Atmosphere	33
Materials and Resources	13
Indoor Environmental Quality	16
Innovation	6
Regional Priority	4
Total =	**110**

According to LEED v4 for Building Design and Construction, Updated July 1, 2015, for new construction and major renovation, projects are required to meet a minimum of 50 points in order to obtain Silver certification.[6]

[5] http://www.ct.gov/deep/cwp/view.asp?a=4120&Q=481888
[6] http://www.usgbc.org/sites/default/files/LEED%20v4%20BDC_04.05.16_current.pdf

- The Materials and Resources Category with 13 total potential points, has a sub-category for Construction and Demolition Waste Management with 2 total potential points.
- Projects can achieve 1 point for at least 50% waste diversion, and 2 points for at least 75% waste diversion.
- Alternatively, projects that achieve a waste reduction goal of generating less than 2.5 pounds of construction waste per square foot of the building's floor area score 2 points.

Although it is a small portion of the rating system with only 1.8% of the total possible points (110), and 4% of the total possible points to achieve LEED Silver certification (50 points minimum), the use of the category does result in achieving a higher level of recycling and/or waste reduction.

Green Seal researched the number of LEED certified buildings in CT. According to *Green Building Wire*, as of August 2015, CT has 93 LEED certified buildings. [7] Given that it is a completely voluntary system for private commercial/industrial projects, and also not required for state agency buildings and school buildings which fall below the thresholds listed above, LEED certified projects likely represent only a small fraction of the overall construction projects undertaken in the state.

Small-scale Projects:

Construction companies and builders of smaller-scale projects had the following decision making considerations for choosing whether to recycle and the goals to achieve:

- Access to recycling markets if recommended by hauling companies (less likely to source separate materials for very small projects given the economies of scale required for multiple containers. More apt to choose a facility that can accept and recycle a mixed waste stream from one container),
- Cost reduction if/when it can be achieved through reducing waste and/or recycling (more efficient and cost effective for multi-family residential and commercial/industrial, and generally less efficient for individual residential projects),
- Company (builder's) policies relating to waste reduction and recycling (especially true for very small scale projects where the owner participates in construction and oversees waste management practices),
- Preferences of owners to recycling and/or reduce waste, including in some instances where the costs would be greater (less frequent with smaller scale projects such as individual residential projects), and
- Access to recycling markets (including local municipal drop off and recycling facilities) as obtained through research by construction company employees – namely owners and project managers.

2.2 Perceived and/or Actual Economic or Regulatory Limitations:

Based on the interviews conducted, the following were perceived and/or actual economic and/or regulatory limitations to recycling and waste reduction at construction projects in CT:

[7] http://greenbuildingwire.com/LEED-certified-building-CT

- The overall additional cost of recycling (especially for small-scale projects where space limitations and where economies of scale are hard to achieve given the limited quantities of materials generated at the job sites),
- Access to local recycling outlets/aggregation sites (Companies cited additional hauling costs in some cases to get materials to market themselves and/or with their hauling company. Companies cited difficulty accessing municipal recycling collection facilities as contractors),
- The additional cost of labor for separating materials on-site and managing the waste streams to prevent materials from being placed into the incorrect dumpsters (while some cited this as an ongoing problem at construction sites, other stated that it is generally only at the beginning of a new project),
- The overall additional cost of achieving LEED certification on projects not subject to the CT high performance standards (a lack of incentive to achieve LEED given the typically higher cost of construction),
- The economy and its impact on price sensitivity for construction projects (owners are less apt to look at waste reduction and more apt to look at the bottom line when poor economic conditions exist),
- Weight limits on the containers being hauled from construction sites (Companies cited CT's 80,000 Gross Vehicle Weight restriction as adding additional hauling costs to transport materials off-site to make multiple trips to end markets), and
- A larger focus on energy efficiency with the CT state building code versus waste reduction and recycling.

2.3 Deconstruction

In addition to the communication with the traditional construction renovation, and demolition contractors, Green Seal conducted research on deconstruction and communicated with one identified deconstruction contractor within CT. GSE researched several nationwide case studies with respect to deconstruction opportunities and/or programs. GSE researched how these opportunities are relevant with respect to reducing waste and finding higher value added uses for building materials that would otherwise be destined for disposal. In Connecticut, one full scale deconstruction contractor was identified and interviewed. Joe DeRisi of Urban Miners, LLC has grown their operations in CT since 2007 and has been involved with many successful deconstruction projects. According to Mr. Derisi, *"Deconstruction has many positive benefits when demolishing, remodeling and/or rebuilding structures. Deconstruction is an environmentally conscious choice that allows building materials such as cabinets, doors, hardware, fixtures, flooring, trim, and other traditional building elements to have an increased lifespan. Deconstruction can substantially reduce disposal fees and preserve higher value materials from being destined for lower value-added uses and/or disposal."*

<u>Benefits of Deconstruction Include:</u>

- Finding reuse that will allow for longer life spans for reused and repurposed construction materials,
- Creating a source of historic architectural components,
- Reducing the reliance on landfills and incinerators,
- Providing for a reduced carbon footprint by reducing the need for new building materials (manufacturing and transportation),
- Decreasing new building costs by providing discounted building materials,

- Providing for significant tax based incentives (donations of the salvaged building materials)
- Reducing damage that could occur if the materials were aggregated into a dumpster for shipment to a recycling facility, and
- Creating a secondary jobs market for repurposing the salvaged building materials (reuse store of manufacturing such as furniture).
- Using higher paid and skilled workers to perform the deconstruction

Additional Costs Associated with Deconstruction:

The cost of deconstruction is generally higher when compared to the cost of traditional demolition techniques using equipment to tear down a structure and transport it to a VRF for processing and recycling, or directly to a disposal outlet. The additional costs identified are:

1. Labor – Craft labor familiar with proper techniques to maintain the salvage value and integrity of the building component,
2. Transportation – Additional costs associated with transporting the materials to an outlet for resale and/or repurposing ,
3. Time (opportunity costs) – Deconstruction can take days if not weeks longer to employ, and
4. Marketing and reselling the materials (including space for storage or staging)

Salvageable Versus Non-salvageable Ratios:

It should be noted that deconstruction can be limited in nature, or comprehensive. In some instances, materials such are fixtures, doors, windows, etc. will be removed prior to demolition. In other instances additional materials will be deconstructed including, trims, flooring, sheathing, bricks, dimensional lumber, etc. As such, there can be a large variation in the amount of materials that will be salvaged through deconstruction activities. These factors are generally a result of the availability of post-consumer markets for each material. As post-consumer markets grow, the percentage of salvaged materials can increase.

Present Deconstruction:

As previously mentioned, it appears that the main barrier to deconstruction is finding and maintaining long term viable outlets for various materials. Based on interviews, deconstruction activities in CT have primarily consisted of residential and small commercial structures.

SECTION 3.0 – QUANTITATIVE RESEARCH

3.1 Introduction

Green Seal performed a series of quantitative estimations of the different components of "typical" materials entering VRFs in CT. Inbound waste loads were observed for a total of eight (8) days at four (4) separate VRFs. The task was performed in an effort to obtain data on the typical constituents found within the inbound waste material. The data collected was used to estimate the percentage of each material that could be available for subsequent recycling and/or disposal. The percentages were then applied to the total 2013 C&D Generation estimated from VRF facility reporting data to come up with an estimate of the statewide volume of each material.

With significant volunteer assistance from the host facilities, GSE conducted the targeted waste "observations" at the following locations:

#	Facility Name	Location	Observation Dates
1	CWPM	Deep River	8/4/15 – 8/5/15
2	Shoham Road	East Windsor	8/18/15 – 8/19/15
3	Circle of Life	New Haven	9/9/15 – 9/10/15
4	Winter Brothers	Danbury	9/22/15 – 9/23/15

GSE personnel were able to observe 267 inbound loads of C&D materials being tipped at VRFs over the course of eight days.

3.2 Waste Load Observation Procedures

Inbound waste load observation and quantitative estimation methods included the following procedures conducted at the VRFs:

1. Cordoning off an area separated from normal facility operations for quality control and safety.
2. Receiving random loads of all material types entering the facility regardless of source (i.e. construction sites [new construction, demolition and/or renovation], house clean-out projects, industrial bulky waste clients, etc.) or the volume of material (dump truck loads, 30-yard roll-off containers, etc.)
3. Generating a unique, sequential number for each load identifying the load for observation on the Waste Load Observation Sheet, and photographing the load with an identifier of the number (when allowed by the host facility).
4. Identifying the size of the container (i.e. 30 yard roll-off container).
5. Determining the volume of the contents of the container (i.e. 75% full) after the load was uncovered (tarpaulin removed) prior to tipping, and/or as the load is tipped upwards providing for enhanced visual observation.
6. Determining the likely source of the load based on the contents (i.e. Construction, Renovation, Demolition, Oversized MSW, Other, etc.)
7. Preparing independent estimates by two experienced personnel, of the volumes of the major material components of each load observed, and recording the information on a Waste Load Observation Sheet. Table 3.1 below shows the nine (9) targeted material categories and thirty-nine (39) individual materials documented for the quantification estimates.

Table 3.1 C&D/Oversized MSW Materials and Material Categories

Category #	Category	Material #	Material
1	Wood	1	Clean Dimensional Lumber
		2	Clean Oriented Strand Board (OSB)
		3	Pallets & Crates
		4	Plywood
		5	Manufactured Wood
		6	Treated Wood
		7	Painted/ Stained Wood
		8	Land Clearing/Leaves/Brush
		9	Other Wood:
2	Metal	10	Ferrous
		11	Non-Ferrous
3	Packaging Waste	12	Old Corrugated Cardboard (OCC)
		13	Plastic Film/Shrink Wrap
		14	Strapping
		15	HDPE Buckets
		16	Other Paper Packaging
		17	Other Plastic Packaging
		18	Other Packaging Waste
4	ABC	19	Asphalt/Brick/Concrete/Aggregates
5	Ceramics	20	Toilets
		21	Sinks
		22	Other:
6	Gypsum	23	Clean New Construction Gypsum Wallboard Scrap
		24	Renovation& Demolition Gypsum
7	Plastics	25	Plastic Pipe
		26	Vinyl Siding
		27	Other Plastics
8	Shingles	28	Asphalt Roofing Post-Consumer Tear Off Waste
		29	Asphalt Roofing New Construction Waste
9	Other	30	Carpet
		31	Carpet Pad
		32	Mattresses/Box Springs
		33	Tires
		34	Fiberglass Insulation
		35	Glass (Windows, Mirrors, etc.)
		36	Textiles
		37	Fines
		38	Other Oversized MSW (Furniture, Appliances, etc.)
		39	Other (To Be Listed As Applicable)

8. After the independent estimates were completed by the two personnel conducting the observations, the two personnel discussed their estimates and if necessary, re-examined the loads. If, based on the way the load was discharged from the container, materials were difficult to examine, facility operators were called upon to spread the loads out more within the tipping area.
9. Upon completion of the estimation procedure for each individual load, the personnel signaled the facility operators to completely remove the contents of that load prior to receiving and analyzing the next sample load.

3.3 Data Conversions – Volume to Weight

Once the data from the volume estimates were performed at the VRFs, the data from both individuals was entered into a spreadsheet. First, the data was averaged based on the two observers' independent estimations, and second, the resulting volume estimates were

converted into weight estimates based on industry standard conversion factors. The conversion factors for this study are detailed in Table 3.2.

Table 3.2 C&D/Oversized MSW Material Volume to Weight Conversion Factors

Material Category	Material	Conversion (lbs./CY)
Wood	Clean Dimensional Lumber	400
	Clean Oriented Strand Board (OSB)	400
	Pallets & Crates	400
	Plywood	400
	Manufactured Wood	400
	Treated Wood	400
	Painted/ Stained Wood	400
	Land clearing/Leaves/Brush	400
	Other Wood:	400
Metal	Ferrous	600
	Non-Ferrous	600
Packaging Waste	Old Corrugated Cardboard (OCC)	150
	Plastic Film/Shrink Wrap	50
	Strapping	50
	HDPE Buckets	50
	Other Paper Packaging	200
	Other Plastic Packaging	65
	Other Packaging Waste	50
ABC	Asphalt/Brick/Concrete/Aggregates	2,000
Ceramics	Toilets	860
	Sinks	860
	Other:	860
Gypsum	Clean New Construction Gypsum Wallboard Scrap	350
	Renovation& Demolition Gypsum	350
Plastic	Plastic Pipe	65
	Vinyl Siding	50
	Other Plastics	65
Shingles	Asphalt Roofing Post-Consumer Tear Off Waste	1,500
	Asphalt Roofing New Construction Waste	1,500
Other	Carpet	900
	Carpet Pad	62
	Mattresses/ Box Springs	250
	Tires	350
	Fiberglass Insulation	100
	Glass (Windows, Mirrors, etc.)	600
	Textiles	240
	Fines	1,200
	Other Oversized MSW (Furniture, Appliances, etc.)	250
	Other	250

3.4 Data Analysis

With data from all samples converted to weight measurements, Green Seal then compiled all 267 data sets for analysis. The analysis conducted was as follows:

1. All 267 data sets were compiled, and Green Seal computed the percentages by weight for each material in each sample set, relative to the total weight of each sample load.
2. Green Seal then computed the mean (average) weight by percentage, of each material using all 267 data sets.

3. Finally, Green Seal conducted statistical analysis of the data including:
    a. Standard Deviation
    b. Variance
    c. 90% Confidence Interval

Table 3.3 below presents a summary of the output of the analysis conducted. The 90% confidence interval column provides the range around the mean (+/-) that would provide 90% confidence that the material's percentage by weight would fall within that range. For example, with Material # 1, Clean Dimensional Lumber, we are 90% confident that the average percentage of that material is 9.6% +/- 1.6% (within the range of 8.0% - 11.2%).

Based on the data obtained from the waste observations, and a review of the statistical analysis conducted, it is clear that the composition of the VRF inbound waste stream is highly variable, as expected. There is significant inherent variability in the composition of inbound materials at VRFs, including the variety of materials accepted at any given point in time. For illustrative purposes, examples of highly differential loads of inbound materials could include:

- a re-roofing project producing a load of almost 100% asphalt shingles,
- a manufacturing facility producing a load of almost 100% pallets,
- a house clean-out of a foreclosed property producing a load with highly variable contents such as furniture, appliances, mattresses, hard plastic children's play furniture and other toys, boxed items such as books, clothes, and miscellaneous accumulated items,
- a demolition project of a painted masonry school building with a mainly gypsum interior, and drop ceiling tiles,
- a container half full of renovation debris and half full of leaf and yard waste generated at a residential site in the fall, and
- the demolition of a wooden deck with almost 100% pressure treated wood.

Unlike traditional municipal solid waste (MSW), C&D derived wastes are generally "temporary" in nature. Temporary means that waste is generated from one particular site at one or more particular times/events. Once activities are completed, it may be an undetermined amount of time before C&D derived waste is generated from that particular site again. Therefore, not only can the waste constituent be heterogeneous in nature, but the point of generation can be as well.

Table 3.3 Statistical Analysis of Waste Load Quantitative Estimates

Material Categories	Material #	Material Components	Mean Weight of All Samples (%)	Standard Deviation (%)	Variance (%)	90% Confidence Interval +/- (%)
Wood	1	Clean Dimensional Lumber	9.6%	19.4%	3.8%	1.9%
	2	Clean Oriented Strand Board (OSB)	1.3%	6.6%	0.4%	0.7%
	3	Pallets & Crates	7.1%	20.4%	4.2%	2.0%
	4	Plywood	3.4%	9.9%	1.0%	1.0%
	5	Manufactured Wood	1.5%	6.7%	0.4%	0.7%
	6	Treated Wood	1.2%	4.5%	0.2%	0.5%
	7	Painted/ Stained Wood	11.2%	21.7%	4.7%	2.2%
	8	Land Clearing/Leaves/Brush	2.3%	12.4%	1.5%	1.2%
	9	Other Wood:	0.5%	3.5%	0.1%	0.3%
	Subtotals		38.1%	36.1%	13.0%	3.6%
Metal	10	Ferrous	1.8%	7.0%	0.5%	0.7%
	11	Non-ferrous	2.1%	7.1%	0.5%	0.7%
	Subtotals		3.8%	10.9%	1.2%	1.1%
Packaging Waste	12	Old Corrugated Cardboard (OCC)	5.1%	14.0%	2.0%	1.4%
	13	Plastic Film/Shrink Wrap	0.4%	2.1%	0.0%	0.2%
	14	Strapping	0.0%	0.1%	0.0%	0.0%
	15	HDPE Buckets	0.1%	0.3%	0.0%	0.0%
	16	Other Paper Packaging	0.2%	0.7%	0.0%	0.1%
	17	Other Plastic Packaging	0.2%	0.8%	0.0%	0.1%
	18	Other Packaging Waste	0.2%	1.5%	0.0%	0.2%
	Subtotals		6.2%	15.8%	2.5%	1.6%
ABC	19	Asphalt/Brick/Concrete/Aggregates	3.2%	13.4%	1.8%	1.3%
	Subtotals		3.2%	13.4%	1.8%	1.3%
Ceramics	20	Toilets	0.2%	1.0%	0.0%	0.1%
	21	Sinks	0.1%	0.9%	0.0%	0.1%
	22	Other:	0.5%	2.6%	0.1%	0.3%
	Subtotals		0.7%	3.4%	0.1%	0.3%
Gypsum	23	Clean New Construction Gypsum Wallboard Scrap	2.2%	10.3%	1.1%	1.0%
	24	Renovation& Demolition Gypsum	4.1%	13.3%	1.8%	1.3%
	Subtotals		6.3%	16.9%	2.9%	1.7%
Plastics	25	Plastic Pipe	0.4%	5.3%	0.3%	0.5%
	26	Vinyl Siding	0.3%	1.7%	0.0%	0.2%
	27	Other Plastics	0.4%	2.2%	0.0%	0.2%
	Subtotals		1.1%	6.1%	0.4%	0.6%
Shingles	28	Asphalt Roofing Post-Consumer Tear Off Waste	9.6%	26.1%	6.8%	2.6%
	29	Asphalt Roofing New Construction Waste	0.8%	8.5%	0.7%	0.9%
	Subtotals		10.4%	27.2%	7.4%	2.7%
Other	30	Carpet	3.6%	11.2%	1.3%	1.1%
	31	Carpet Pad	0.1%	0.5%	0.0%	0.1%
	32	Mattresses/ Box Springs	0.8%	3.7%	0.1%	0.4%
	33	Tires	0.1%	0.7%	0.0%	0.1%
	34	Fiberglass Insulation	0.6%	6.2%	0.4%	0.6%
	35	Glass (Windows, Mirrors, etc.)	0.9%	4.0%	0.2%	0.4%
	36	Textiles	0.8%	3.3%	0.1%	0.3%
	37	Fines	1.0%	5.5%	0.3%	0.5%
	38	Other Oversized MSW (Furniture, etc.)	16.0%	28.9%	8.3%	2.9%
	39	Other	6.2%	18.3%	3.3%	1.8%
	Subtotals		30.1%	36.5%	13.3%	3.6%

In essence, variability is the “standard condition” of the materials entering these facilities, and thus high variability found in the quantitative estimate data is also expected. However, as discussed in the following sections, significant quality control procedures used in data gathering and dissemination, as well as comparison checks against similar studies confirms that the study produced the desired quality data.

3.5 Quality Control

To produce quality data, Green Seal followed strict quality control procedures for gathering and disseminating the data obtained from the study, including the following:

1. Evaluating materials at multiple facilities, including rural and urban facilities.
2. Evaluating materials over multiple days at each location.
3. Evaluating a large number of samples (267 loads in total) using volumetric estimates. Hand sorting and weighing waste loads over 8 days would have resulted in a much smaller data set and increased statistical variability.
4. Evaluating random loads of materials regardless of their size (dump truck versus a 30-yard roll-off container).
5. Using a unique numbering system to differentiate between loads, as well as photographing the loads (when facilities would allow).
6. Using multiple, experienced waste stream evaluators to provide independent estimates of each sample load.
7. Using Waste Load Observation Sheets for each sample.
8. Conducting random data entry checks of sample sets.
9. Conducting a review of all data by the Program Manager to ensure that all the data is logical and likely without error based on the individual and compiled data.
10. Conducting statistical analysis to determine the variability of the data.
11. Using the mean (averages) of the percentages (by weight) of the components of a large data set (267 samples) to reduce variability.
12. Comparing the data to other similar studies.

3.6 Waste Composition

Green Seal used the average composition data obtained from the quantitative estimates and applied the percentages to the 2013 CT C&D Generation (1,041,643 tons) in order to obtain estimates of the total volume of each category and material that is theoretically available for recycling and/or disposal. It should be cautioned that even though a constituent is theoretically “available,” extraction methodologies and economics can and will be a driver for recycling based decisions. Table 3.4 below presents the summary of quantities of the categories and individual materials based on the percentages obtained from the quantitative estimates.

Table 3.4 Connecticut C&D/Oversized MSW Waste Stream Composition

Material Categories	Material #	Material Components	Mean (Average) % by Weight	Estimated Tons (Materials)	Estimated Tons (Categories)
Wood	1	Clean Dimensional Lumber	9.6%	100,187	
	2	Clean Oriented Strand Board (OSB)	1.3%	13,997	
	3	Pellets & Crates	7.1%	73,439	
	4	Plywood	3.4%	35,037	
	5	Manufactured Wood	1.5%	16,024	
	6	Treated Wood	1.2%	12,840	
	7	Painted/ Stained Wood	11.2%	117,118	
	8	Land clearing/Leaves/Brush	2.3%	23,789	
	9	Other Wood:	0.5%	4,773	
	Subtotals		38.1%		397,204
Metal	10	Ferrous	1.8%	18,376	
	11	Non-Ferrous	2.1%	21,708	
	Subtotals		3.8%		40,085
Packaging Waste	12	Old Corrugated Cardboard (OCC)	5.1%	53,250	
	13	Plastic Film/Shrink Wrap	0.4%	4,368	
	14	Strapping	0.0%	52	
	15	HDPE Buckets	0.1%	577	
	16	Other Paper Packaging	0.2%	2,161	
	17	Other Plastic Packaging	0.2%	2,276	
	18	Other Packaging Waste	0.2%	2,146	
	Subtotals		6.2%		64,831
ABC	19	Asphalt/Brick/Concrete/Aggregates	3.2%	33,398	
	Subtotals		3.2%		33,398
Ceramics	20	Toilets	0.2%	1,727	
	21	Sinks	0.1%	1,304	
	22	Other:	0.5%	4,721	
	Subtotals		0.7%		7,752
Gypsum	23	Clean New Construction Gypsum Wallboard Scrap	2.2%	22,929	
	24	Renovation& Demolition Gypsum	4.1%	43,022	
	Subtotals		6.3%		65,951
Plastics	25	Plastic Pipe	0.4%	4,192	
	26	Vinyl Siding	0.3%	2,715	
	27	Other Plastics	0.4%	4,273	
	Subtotals		1.1%		11,180
Shingles	28	Asphalt Roofing Post-Consumer Tear Off Waste	9.6%	99,696	
	29	Asphalt Roofing New Construction Waste	0.8%	8,435	
	Subtotals		10.4%		108,131
Other	30	Carpet	3.6%	37,319	
	31	Carpet Pad	0.1%	1,304	
	32	Mattresses/ Box Springs	0.8%	8,308	
	33	Tires	0.1%	725	
	34	Fiberglass Insulation	0.6%	6,540	
	35	Glass (Windows, Mirrors, etc.)	0.9%	9,521	
	36	Textiles	0.8%	8,710	
	37	Fines	1.0%	9,923	
	38	Other Oversized MSW (Furniture, etc.)	16.0%	166,202	
	39	Other	6.2%	64,559	
	Subtotals		30.1%		313,110

As discussed in Section 1.0, for comparison, Green Seal conducted a literature review on the composition of "typical" C&D materials. As part of the 2009 NEWMOA Report, which draws on data from the 2008 DSM MA Study, average composition figures were generated from a number of studies, where an estimation of the major components of C&D materials was provided. Although differences in materials and material categories prevent apples-to-apples comparisons of all of the categories and materials investigated as part of this quantitative estimation exercise, the "top three" categories were able to be compared.

Table 3.5 below provides a comparison of these categories.

Table 3.5 – Top Three Material Categories Comparison

Material(s)	2009 NEWMOA Report	2015 Quantitative Estimates
Wood	34.0%	38.1%
Other	29.0%	30.1%
Shingles	11.0%	10.4%

Based on the comparison above, the results of our study were similar in composition, with the highest variation being in the wood category (approximately 38% in our study versus 34% in the NEWMOA study).

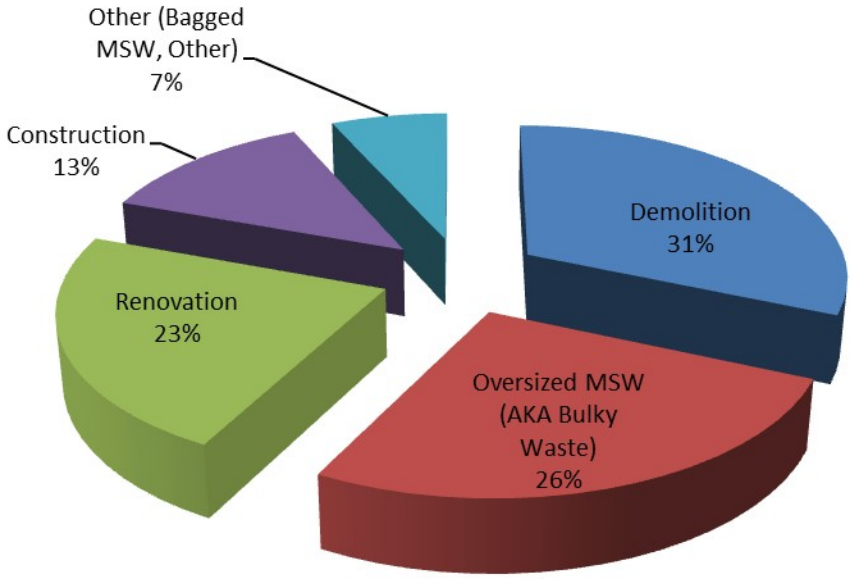
3.7 Waste Category Observations

In addition to compiling data on the breakdown of constituents within the waste loads, GSE also characterized the loads into the following categories: Construction, Renovation, Demolition, Oversized MSW, or Other. Figure 3.1 below provides a summary of the percentage of each load type received.

Of significance is the volume of "Oversized MSW" that enters the VRFs, with 26% of the loads being characterized as this type of material. These materials were observed to contain items that would typically be derived from a house clean-out and included materials such as furniture, children's toys, clothes/textiles, etc., as well as materials that might be found coming from industrial clients such as pallets and other large crates, cardboard, plastic film, and other packaging materials.

While these sources of material would not be considered construction, renovation, or demolition related projects (from which C&D materials by definition are generated), these "Oversized MSW" materials nonetheless are being received and handled by VRFs. Thus, the materials require management, including recycling when possible at the VRFs.

Figure 3.1 Inbound Waste Loads Observed at CT C&D VRFs – By Category



To conduct a comparison exercise, Green Seal conducted an additional analysis of the inbound waste received during the waste load observation exercises by removing from the data set, the loads that were primarily Oversized MSW. The resulting waste loads were 19% Construction, 34% renovation, and 47% demolition. The comparison of the composition is presented in the Figures below.

Figure 3.2 Composition of both C&D and Oversized MSW Loads

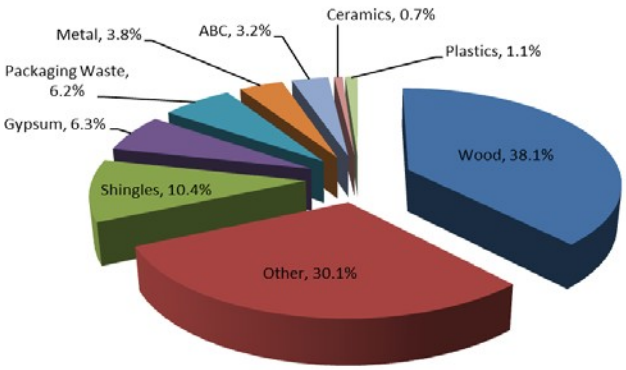
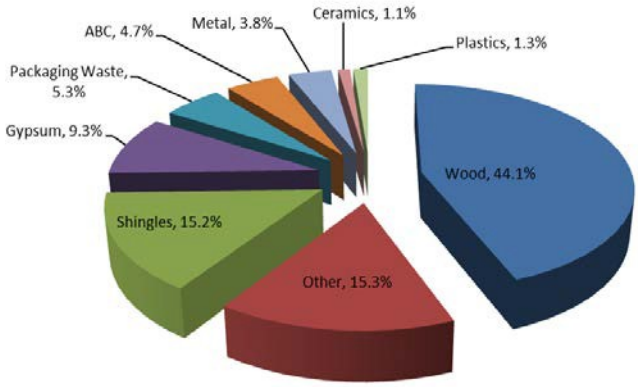


Figure 3.3 Composition of Predominately C&D Materials Only



3.8 Reuse/Salvage Observations

While observing loads being tipped, GSE made notes when potentially salvageable materials were observed within the loads. GSE noted, that of the 267 loads of materials observed, there were only six 6 loads that had potentially reusable/salvageable building materials found within the loads (windows, doors, cabinets, etc.). It is worth noting that it is possible that a significantly larger amount of material could be salvageable if it were sorted at the point of generation versus after being loaded into a container with other non-salvageable items, being exposed to the elements and other contaminants within the mixed loads, and finally being dumped out of the container onto a tipping floor at a VRF.

It should be noted that Green Seal did not attempt to identify potentially salvageable materials other than building materials. Items such as furniture, toys, and miscellaneous collectibles could also have potential value as well, but were not part of this study. Also, Green Seal did not consider pallets as a salvageable building material when determining whether a load had potentially salvageable materials.

SECTION 4.0 TIPPING FEES, RECYCLING, AND END MARKET RATES

4.1 Introduction

Green Seal conducted research to gather market data, including rates and charges (i.e. tipping fees) for C&D/Oversized MSW disposal and recycling services, and outlets (intermediate and/or end-users) for recovered materials. In addition to the current markets, Green Seal researched issues that would impact market longevity, and the potential impacts of market shifts for existing facilities as well as future siting. The research was conducted for the following:

- VRF Tipping Fees
- Landfill Tipping Fees
- Recycling Outlets for:
    - Metals
    - Recycled aggregates
    - Clean (unpainted, untreated) wood
    - Mixed wood
    - Asphalt shingles
    - Gypsum
- C&D "Fines" (fine material screened from mixed C&D materials) Outlets

4.2 Tipping Fees – Disposal/Transfer

GSE conducted research on the tipping fees for transfer/recycling at VRFs, as well as disposal at landfills that receive CT-generated C&D/Oversized MSW.

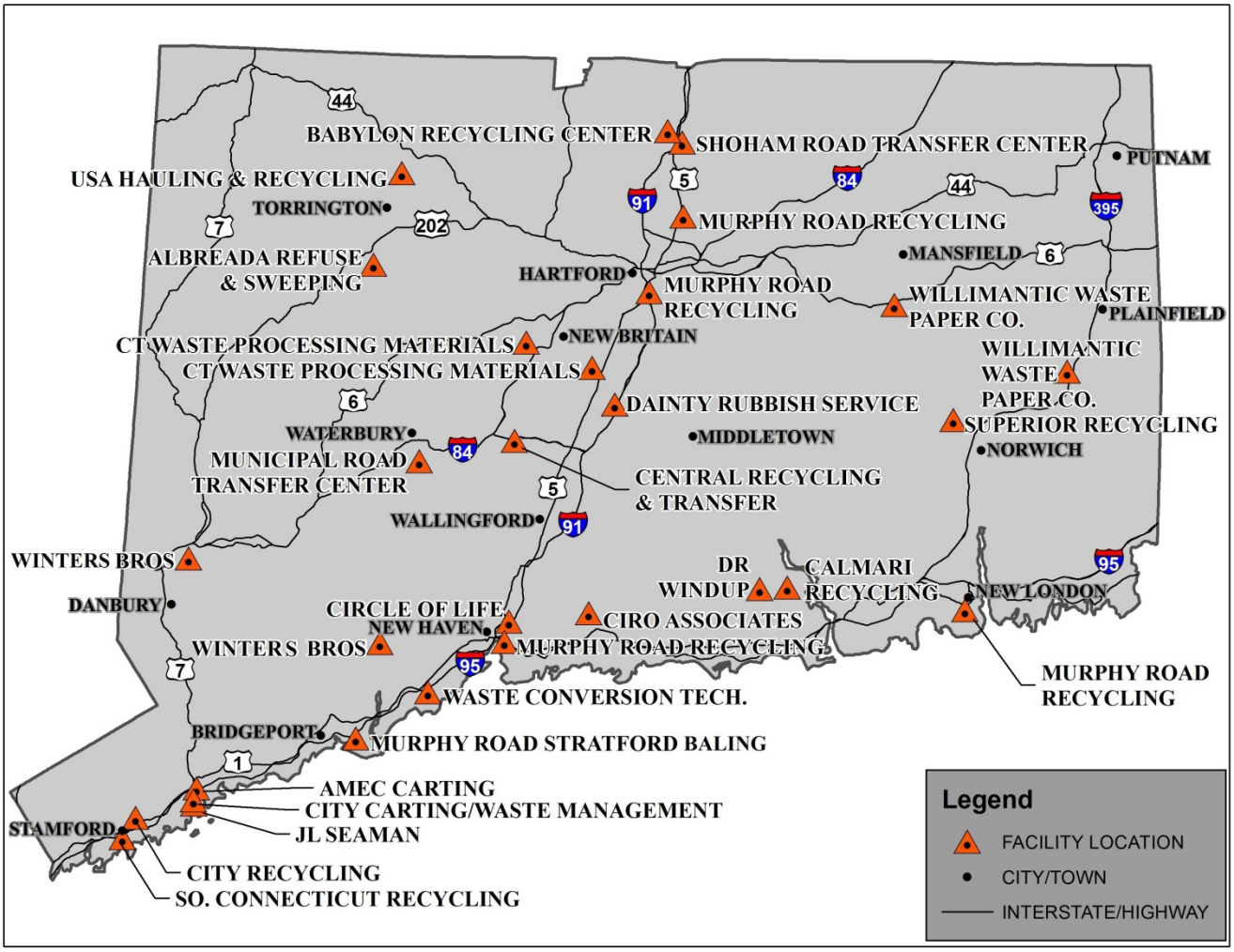
VRF Tipping Fees:

Mixed loads of C&D/Oversized MSW are predominately transported to VRFs within CT for recycling and/or transfer. All of the VRFs in CT are operated by private entities, and thus the actual rates charged to customers are proprietary. During interviews, C&D VRF owners/operators reported tipping fees in the range of $70 - $120 per ton depending on the following factors:

- The facility location,
- The volume of the material being received,
- Customer credit, and
- Other limiting factors.

Based on discussions with generators, GSE's knowledge of the local tipping fee rates, and knowledge of the disposal fees charged by the ultimate disposal locations (namely out-of-state landfills), GSE can conclude that these ranges are accurate. According to multiple industry sources, the overall average inbound price paid by haulers is approximately $70 - $80 per ton at the VRFs, with the higher end of the range being paid in more urban areas (particularly higher in the southwest portion of the state). Below is a map of the existing permitted C&D VRFs in CT.

Figure 4.1 – Connecticut Permitted C&D Volume Reduction Facilities (VRFs)



The market longevity of VRFs for recycling/transfer of C&D/Oversized MSW is not likely to change significantly given that the facilities are not landfills and can theoretically operate in perpetuity. The market rates for these facilities will be impacted primarily by the following factors:

1. The cost of disposal given that the vast majority (approximately 93% of FY2013 Generation) of material entering VRFs is ultimately disposed.

2. The availability of outlets for recyclable components of the waste stream.

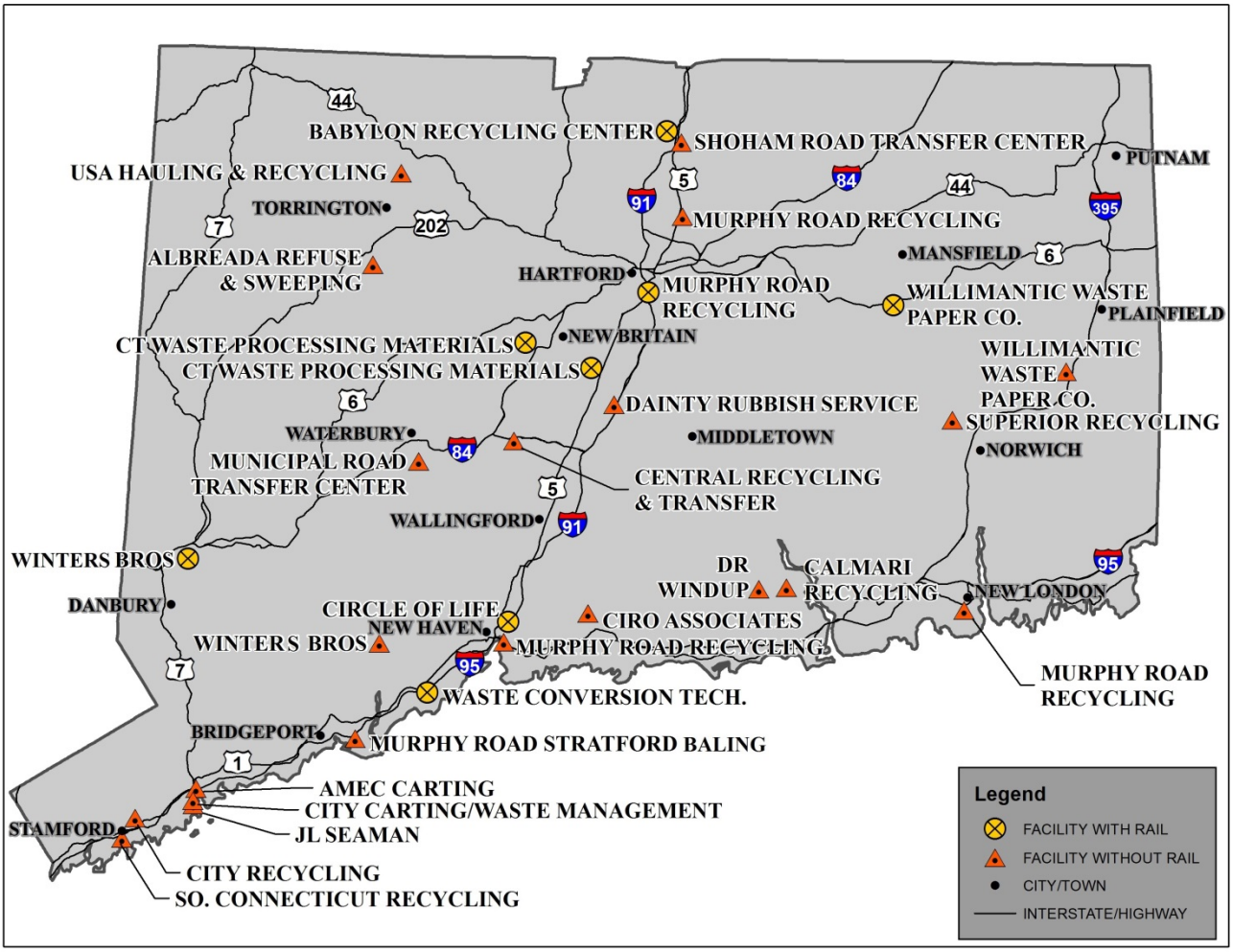
3. The amount of waste generation based on the amount of construction activity and overall health of the economy

4. Competition among VRFs, including consolidation within the industry. Based on the research conducted, as of the date of this report, the twenty-nine (29) VRFs were owned by fourteen (14) different entities, with nine (9) facilities being affiliated with one entity/operator.

Landfill Tipping Fees:

Based on a review of the FY2013 facility data, the majority of outbound C&D/Oversized MSW and residual materials remaining after processing was shipped by rail to several large landfills in OH. Green Seal conducted tipping fee research by directly contacting major landfills and by interviewing haulers, CT VRFs, and others in the industry familiar with tipping fees being paid by the landfills receiving waste from CT sources. Based on the research conducted, the overall average price paid by VRFs to transport and dispose of C&D/Oversized MSW by rail is approximately $55/ton. Of the 29 permitted C&D VRFs in CT, eight (8) facilities have rail transportation capabilities for disposal of C&D/Oversized MSW and/or residuals from processing. The figure below shows the VRFs with rail.

Figure 4.2 – CT C&D VRFs with Rail Transportation



The longevity of the landfill disposal market is dependent upon the current and future availability of airspace at the landfills accepting materials from CT. While performing an exhaustive search for existing, pending, or planned new and/or expanding landfills in the northeast region was not part of the research conducted for this study, Green Seal did nonetheless obtain data on the largest existing landfills in the region. Information was obtained from interviews conducted with VRFs and other industry experts, and by contacting regional state solid waste departments.

Based on FY2013 CT VRF reporting data, the landfills receiving the largest volume of waste from VRFs were the Sunny Farms Landfill in Fostoria, OH (receiving approximately 255,000 tons in 2013 or 29% of all C&D disposed), and Lordstown Construction Recovery landfill (AKA Lafarge) in Warren, OH (receiving approximately 150,000 tons or 17% of all C&D disposed). Both facilities receive waste by rail. Based on a review of available permitting documents, and direct communication with these facilities, the approximate remaining permitted capacities at these landfills in years are:

- Sunny Farms: Approximately twenty (20) years
- Lordstown: Approximately twelve (12) years

The actual timeframe for the remaining capacity in years is dependent on many factors, including but not limited to the actual fill rates (determined by construction activity, competition from new or expanding landfills, etc.) and changes in regulations or policies at the receiving facilities.

In addition to these two large capacity landfills that receive materials by rail, the Seneca Meadows Landfill in Seneca Falls, NY is contemplating integrating rail receiving capability and has already received permitted approval to do so. The facility recently expanded its capacity and increased its daily permitted tonnage to approximately 6,000 tons per day. The facility has a remaining capacity of approximately seven (7) years

Given the remaining permitted capacity of the large rail served landfills, the longevity of landfill disposal is not likely to be impacted in the near future. Additionally, should the Seneca Meadows landfill integrate rail, it is possible that the rates for landfill disposal could be reduced further based on increased competition and/or a reduction in transportation costs given its closer distance.

4.3 Recycling Conducted at VRFs in CT

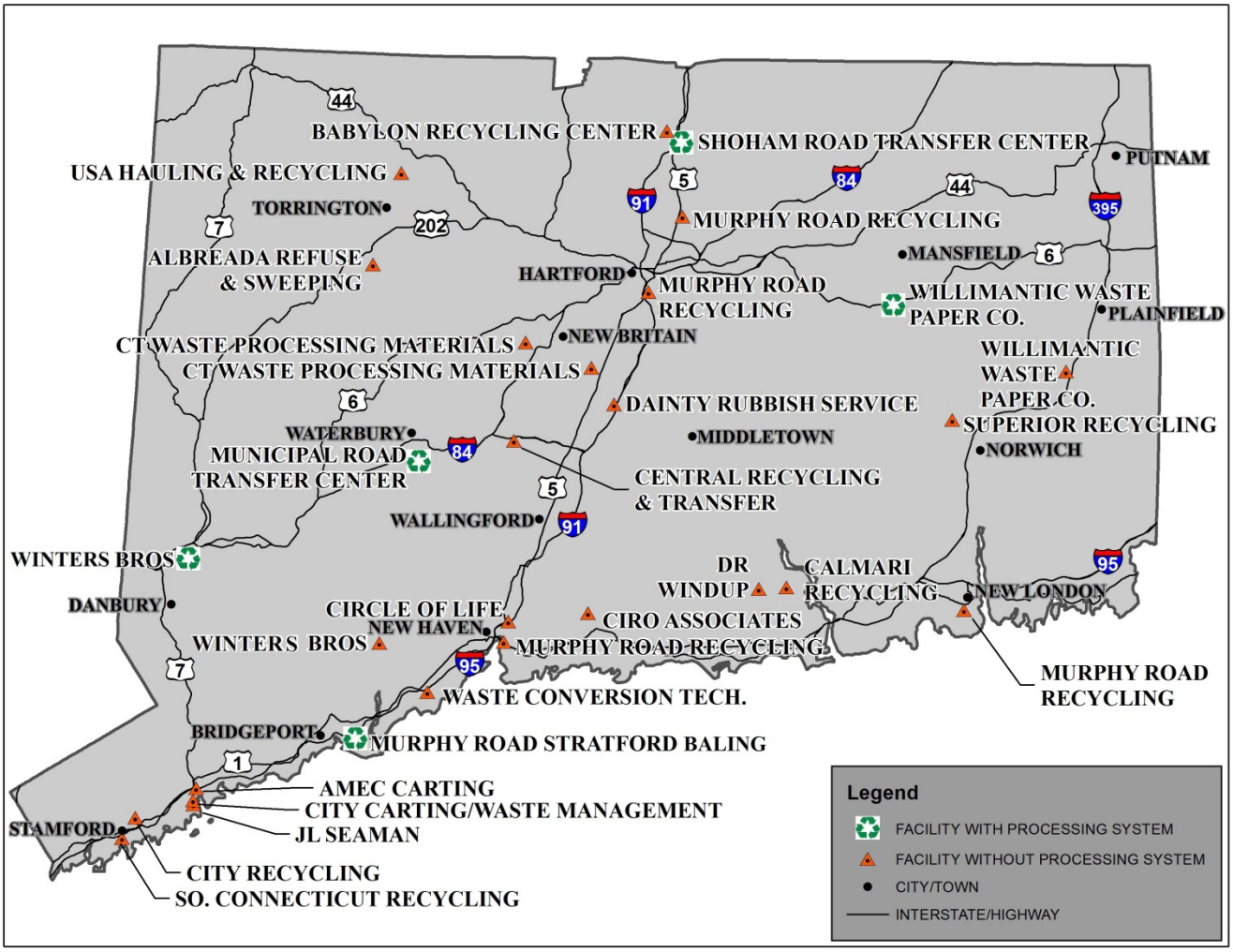
Green Seal researched the recycling activity performed at CT VRFs by obtaining data from:

- FY2013 Facility reporting data provided by CT DEEP (presented in Section 1.0)
- Conducting interviews with VRF representatives
- Conducting interviews with the recycling markets receiving materials from the VRFs
- Reviewed all current CT DEEP C&D VRF operating permits

As discussed in Section 1.0, given the estimated generation of 1,041,643 tons of C&D materials in FY2013, with 71,181 tons recycled, CT achieved a C&D recycling rate of approximately 7%. According to facility interviews, currently, only five (5) of the twenty-nine (29) VRFs operate processing systems. For purposes of this study, Green Seal considers a facility to have a "processing system" if it operates picking stations where materials can be sorted by hand. The other VRFs may perform "kick-sorting" using mechanized rolling stock such as excavators, loaders, bobcats, etc. However, this practice is less likely to achieve significant recycling rates for mixed loads of C&D/Oversized MSW.

It should be noted that is only a snapshot of the facilities' current processing practices. During interviews with VRFs, several facilities indicated their intentions to incorporate fixed processing infrastructure into their facilities in the future.

Figure 4.3 VRFs with Processing Systems



4.4 End Markets and Rates for Recyclables:

Green Seal conducted research on the recycling outlets for:

- Metals
- Recycled aggregates
- Clean (unpainted, untreated) wood
- Mixed wood
- Asphalt shingles, and
- Gypsum.

Green Seal also researched outlets for C&D fines.

Metals:

Based on the research conducted, the metals markets are currently at historic lows for the past 10+/- years. Some facility operators noted that while metals used to be a significant revenue generator to help off-set the costs of processing and/or disposal, it is not currently the case. However, metals are still typically sorted from mixed C&D/Oversized MSW at CT VRFs given the following:

- The material still has enough value to at least pay for the costs of transportation to an intermediate scrap metal processor (approximately $90/ton for mixed ferrous scrap and $850/ton for mixed non-ferrous scrap paid at receiving metals yards). Please note that there are multiple metal grades of ferrous and non-ferrous metals (e.g. #1 prepared, # 1 unprepared, #2, light iron, aluminum, copper [multiple grades], brass, etc.) which, depending on the degree of sorting, facilities may be receiving higher rates.
- The large number of scrap yards available to receive materials around the state providing access and keeping transportation costs lower compared to out-of-state markets for some materials.
- The net savings of recycling the material versus disposal costs which are between $55/ton – $120/ton, and thus the reduction in the overall disposal costs of outbound materials. This is particularly true for facilities using sorting lines and magnets, since the infrastructure is already set up to hand sort as well as mechanically sort the metals from the mixed waste streams.

Unlike some materials for which a small number of end markets determine the market price, the scrap metal prices are determined by international supply and demand for the raw and scrap materials. While market longevity is unlikely to change significantly (there will always likely be a large number of local or at least regional scrap metals outlets), economic shifts could impact the VRFs' propensity for removing more metals from the waste stream.

Recycled Aggregates:

Based on the research conducted, asphalt, brick, and concrete (ABC) entering VRFs within mixed loads of C&D/Oversized MSW is sorted at a small number of VRFs. Some VRFs that are permitted to accept source-separated loads of ABC keep the materials separated from the mixed C&D/Oversized MSW. ABC recycling from mixed waste loads is limited given the following:

- The material is a relatively small portion of the waste stream (approximately 3.2% of the weight on average based on the quantitative estimations performed for this study).
- The material generally has a negative value to ship to other recyclers (approximately $12-20/ton charged at the receiving facilities, with the higher end of the range being in urban areas) if it's delivered unprocessed, and only a limited value if processed at the VRFs and made into a substitute material for natural aggregates (approximately $14-20/ton, with the higher end of the range being paid in urban areas where aggregates are more scarce).
- ABC processing cannot be accomplished using the same processing equipment as mixed C&D/Oversized MSW and/or wood processing. Specialty rock crushing equipment (e.g. cone and jaw crushers) must be used, and is not standard equipment for the facilities with processing systems at the VRFs.
- If ABC crushing is conducted at the VRFs, the practice of processing the ABC for re-sale is typically accomplished using vendors that temporarily stage processing equipment and process large stockpiles of materials (typically 4,000+ yards at a time). Thus, the need for significant storage space is an additional limiting factor, and more often results in the VRFs shipping materials to other ABC recyclers instead.
- Recycled ABC materials are generally marketed as a gravel sub-base, which is a substitute for virgin aggregates. Market longevity is not likely to be impacted as the need for aggregates is not likely to change in the long term, and there are a large number of facilities that recycle the ABC. Aggregate sales are of course closely tied to construction

activity. As such, a reduction in construction spending directly impacts the demand for the recycled ABC.

Clean (unpainted/untreated) Wood:

Based on the research conducted, clean (unpainted/untreated) wood such as dimensional lumber (2 x 4s, etc.), pallets and crates, and trees/stumps/brush is being recycled from mixed loads of C&D/MSW at some CT VRFs currently. Some VRFs are also permitted to accept clean wood materials separately and keep the materials separated from the mixed loads of C&D/Oversized MSW. Presently, there is a problematic definition in statute that has been interpreted to prohibit the separation of clean wood from mixed C&D. It is suggested that the definition be clarified through future legislation. Clean wood is predominately being ground into wood chips and either being marketed as mulch, animal bedding, or biomass fuel. The wood and the market prices paid by the customers (or tipping fees charged) are highly variable depending on numerous factors including:

- The size of the product (i.e. unprocessed, ground, double-ground)
- The quality of the product including removal of any paper/plastic contaminants, metals (nails), screening for the removal of fines, and blending with other sources of wood like trees, stumps, and brush.
- The product being produced ("regular" wood mulch, colored mulch, etc.)
- The seasonal demand for competing materials (namely seasonal mulch markets)
- The periodic reduced demand for alternative sources of wood caused by natural disasters such as wind and flooding events (i.e. Hurricane Sandy) which result in an overstock of vegetative debris.
- The demand from biomass facilities

A description of the major categories and general market rates for clean wood is as follows:

- Unprocessed Clean Wood: For facilities without grinding equipment, or that do not obtain vendors for periodic on-site processing, clean wood materials are transported off-site to other VRFs or wood recycling facilities. These other facilities charge highly variable rates to receive the materials. Based on Green Seal's research, an average tipping fee being charged for these materials is approximately $35-$40/ton at Organic VRFs (wood recycling facilities).

- Processed Clean Wood: Wood that is ground into wood chips by the VRFs is generally sold directly from the VRFs (either in bulk or retail in some cases) as animal bedding, mulch, or biomass fuel, or sold to mulch distributors for retail. As discussed above, wood chip pricing is highly variable, ranging from as low as $6/ton for biomass fuel and bulk mulch markets off-season (paid at the receiving facilities), to as high as $112/ton ($28/yard) for retail colored mulch. Based on the research conducted and Green Seal's knowledge of the regional wood markets, the overall average price being paid for these materials is closer to the lower end of the range. It should be noted, however, that impacting the overall average price is the fact that CT VRFs and other C&D processors throughout the northeast are typically producing a mixed wood product that includes some portion of clean wood along with the mixed wood.

The market longevity for clean, ground wood is unlikely to change significantly for mulch and animal bedding markets. However, seasonal demand and other factors discussed above will always impact market pricing. Another unlikely but potential market influence could be the use of wood chips for mortality composting in the event of the Avian flu. In this instance, there would

likely be a brief but significant increase in demand for clean wood chips, thus impacting the supply and the pricing.

The longevity of the market for biomass fuel is very uncertain with only one local market in CT (Plainfield Renewable Energy), and unfavorable economics for transporting fuel to out-of-state facilities (namely Maine) and other biomass facilities in New York and Canada. Given the uncertainty of relying on one market, market longevity and market pricing for that one outlet category is unpredictable. A more detailed analysis of the current and potential markets for wood is provided in Section 7.0 – C&D-Derived Wood Markets Analysis.

Mixed Wood

Based on the research conducted, mixed wood including clean wood, painted wood, and engineered wood (plywood, Oriented Strand Board [OSB], Medium Density Fiberboard [MDF], etc.) is being recycled from mixed loads of C&D at some CT VRFs currently. Based on the research conducted, the only current, economically viable outlet for mixed wood (excluding treated wood materials which must be sorted from the mixed wood) is for biomass fuel at Plainfield Renewable Energy. As discussed above, the economics of transportation (namely the 80,000lb Gross Vehicle Weight restriction in CT) prevents additional access to out-of-state (namely Maine, New York & Canada) facilities that are currently accepting mixed wood for fuel. Based on the research conducted, prices being paid by Plainfield Renewable Energy range from $6-$15/ton for materials received at their facility.

The market longevity for mixed wood is uncertain with only one local market in CT (Plainfield Renewable Energy) currently, and unfavorable economics for transporting fuel to out-of-state facilities as identified above. Given the uncertainty of relying on one market, market longevity and market pricing for that one outlet category is unpredictable. A more detailed analysis of the current and potential markets for mixed wood is provided in Section 7.0 – C&D-Derived Wood Markets Analysis.

Asphalt Shingles

Green Seal researched current practices for the recycling of asphalt shingles in CT. Given the nature of how the materials enter VRFs mixed with other materials, and the difficulty of hand sorting shingles, the VRFs are not typically sorting the materials from the mixed loads of C&D/Oversized MSW. However, it was indicated as well as witness during the site visits, that source separated shingles do enter the VRFs. These materials could be separated from the other inbound waste stream. Presently, asphalt shingle recycling in CT is primarily conducted at two facilities which accept source-separated loads of the material:

- Asphalt Roof Recycling Center, Stratford, CT
- Incorporated Industries, Bloomfield, CT

Based on the research conducted, the shingle recycling facilities accept materials for a tipping fee of approximately $60-$65/ton depending on quality and volume of materials received.

Given that the number of markets is mainly limited to two primary receiving facilities in CT, and the inability to economically haul loads of unprocessed shingles over long distances, the longevity of the market is relatively uncertain. Generally, shingle recycler tipping fees are based on a discount off of the regional VRF tipping fees, and thus market pricing variations in VRFs will result in similar variations for the shingle recyclers.

Gypsum

Green Seal researched current practices for the recycling of gypsum in CT. Based on the research conducted, no gypsum recycling facilities exist within the state currently. Given the fact that gypsum materials are broken up into pieces too small to sort from mixed loads of C&D/Oversized MSW, it is not feasible to recover significant amounts of gypsum from mixed C&D recycling operations. Significant recovery of gypsum requires source separation at the point of generation.

GSE conducted a regional search for facilities accepting materials, and found two active gypsum recycling operations in Pennsylvania. Based on interviews with the facilities, one of the two facilities, USA Gypsum, is accepting source-separated loads of gypsum materials from Connecticut and other parts of New England. According to the facility, tipping fees charged for materials at their facility are in the range of $15-$40/ton. While another facility is reportedly in operation in Worcester, MA, facility representatives did not return multiple phone calls from Green Seal. According to several industry sources, that facility is not currently in operation.

Given the existence of only one viable market currently accepting materials from CT, the longevity of the market is uncertain. Additionally, the market pricing is also potentially variable given only one outlet.

C&D Fines

Green Seal researched current practices for the processing of mixed C&D/Oversized MSW materials, and the production of C&D fines from processing. Based on the research conducted, VRFs are not currently generating C&D fines for alternative uses other than disposal. While historically C&D fines were used throughout New England as alternative daily cover materials at landfills, the markets are now very limited and most CT C&D processing facilities are sending the materials out with other residuals for landfill disposal. Therefore, the market prices paid for disposal of C&D fines by VRFs are the same as disposal (approximately $55-$75/ton). If, as some other processers in New England are currently doing, CT facilities were to market C&D fines as ADC, regional landfills (namely MA and NY) are charging a discounted rate off of disposal “gate-rates” for the alternative daily cover materials.

The market longevity will be impacted by the following:

- Final closure of the already limited landfill facilities within the New England region.
- The lack of acceptance in unregulated/unrestricted applications (i.e. outside of landfills) due to the potential for contaminants (i.e. lead)
- The historic issues with the generation of hydrogen sulfide gas in some landfills that accepted large quantities of C&D fines without proper blending and management protocols.
- The regular availability of other sources (i.e. urban soils, street sweepings, contaminated soils, etc.).

However, given the importance of obtaining reduced tipping fee outlets for C&D Fines for C&D processors, in Green Seal’s opinion, it is likely that new outlets and new procedures for using the materials as alternative daily cover will be created in the future. However, it is not likely in the near term.

SECTION 5.0 - EXISTING CT REGIONAL WASTE STREAM RESEARCH

5.1 Introduction

Green Seal reviewed existing research and data on the Connecticut and regional C&D waste stream. This information was reviewed to compare regional data with CT data and to make comparisons regarding regional practices and policies.

5.2 Existing Regional C&D Studies

As referenced in Section 1.0, the most recent multi-state study on Construction and Demolition Debris management was completed in 2009 by the Northeast Waste Management Officials' Association (NEWMOA). This report, which used 2006 generation data, included participants and data from Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. Highlights from the study include:

- Connecticut generated approximately 1,466,371 tons of Construction and Demolition Debris, which equates to approximately 0.42 tons per person per year.
- For the New England states only, 484,698 tons of material was recovered, which equates to 10 percent of the estimated total C&D waste generated (4,657,670 tons) in 2006 for this geographical area.
- In 2006, the majority of C&D waste processed was ultimately landfill disposed. Of the remaining "recycled", a large percentage was used in landfill applications such as ADC (alternative daily cover) or as a grading and shaping material.
- In 2006, C&D wood processed into wood fuel chip was the main material recovered for energy by facilities in Maine and New Hampshire. In addition, wood fuel was a significant percentage of the extracted recyclables from facilities in Massachusetts, New York, and Rhode Island. Clean wood was the primary material recovered by C&D processing facilities in Connecticut.
- The definitions of C&D vary considerably among the states.

5.3 Comparing Generation

As presented in Section 1.0, based upon a review of 2013 data reported to the CT DEEP by VRFs and Recycling Facilities, CT generated approximately 1,041,643 tons of C&D. Comparing 2013 data to the 2006 data, this represents a significant reduction in generation. However, it should be noted that the 2006 NEWMOA study data likely represents C&D and Oversized MSW (AKA Bulky Waste), whereas in the 2013 generation figure, when feasible, Green Seal removed the bulky waste quantities from the data. In addition, GSE was able to identify areas where double counting of waste may have occurred (e.g. Resources Recovery Facilities and movement of materials among VRFs).

Further, a decrease in 2013 CT C&D generation is probable, given the significant decrease in construction activity compared to the amount of activity seven years prior, which was at the peak of the housing and real estate market. As presented in Table 1.1, the average per-capita (tons per person per year) generation of C&D using data from the 2009 NEWMOA Study is .30 tons. This figure is in line with the per capita generation figure obtained from using 2013 data of 0.29 tons.

5.4 Comparing Recovery and Disposal

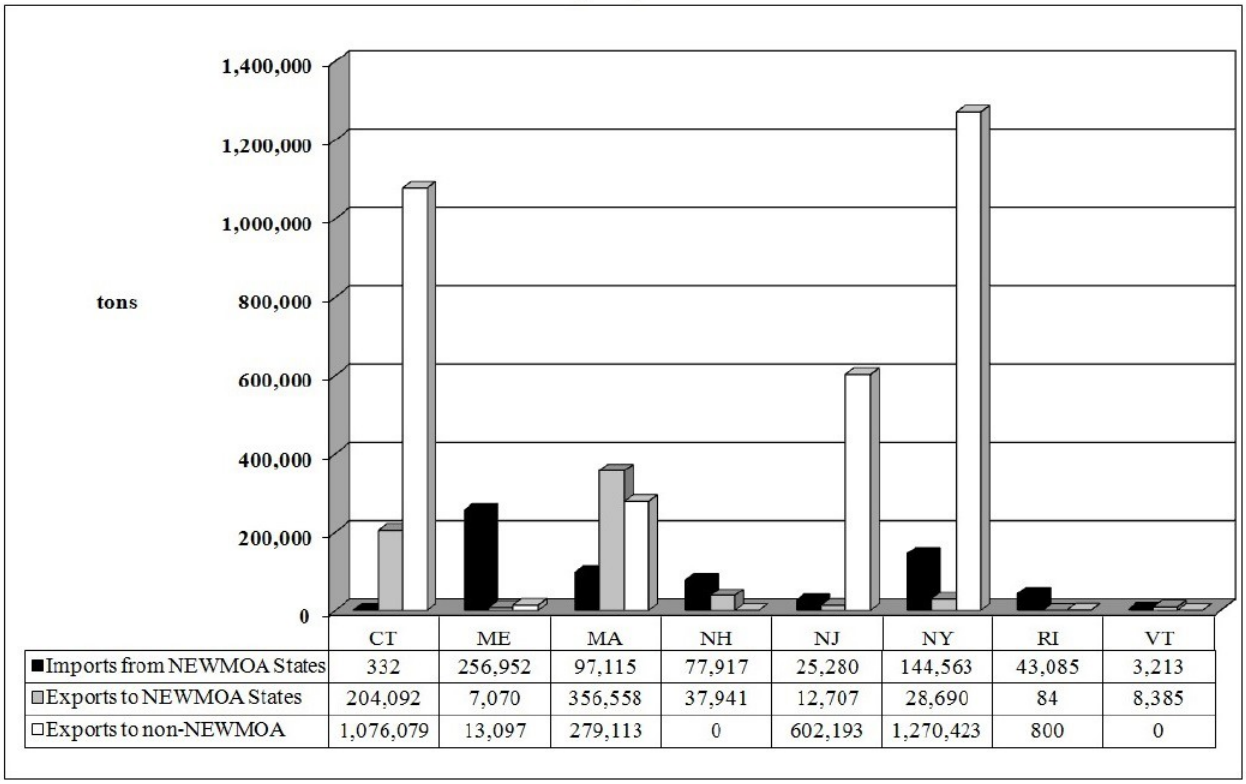
Green Seal conducted a comparison of the materials recovered in 2006 versus 2013. The NEWMOA report shows a 2006 disposal quantity of 1,139,723 tons and a recovery of 71,062

tons (6.2% of disposal) from CT VRFs. Comparing that to 2013 data, the CT VRFs accounted for 884,157 tons of C&D disposed (1,092,243 tons if you add in Oversized MSW), and reported 71,181 tons recycled (8.1% of disposal).

5.5 Comparing Disposal – Exports

Green Seal conducted a comparison of 2006 versus 2013 exports of C&D. Based on the NEWMOA study, in 2006, CT exported approximately 1,280,171 tons, with the majority of the materials going to landfills in Ohio. Based on the 2013 VRF facility reporting data, CT exported approximately 884,157 tons of C&D materials with the majority (approximately 56%) going to landfill in Ohio.

Figure 5.1 NEWMOA Report - 2006 Regional C&D Waste Imports and Exports for Disposal



	CT	ME	MA	NH	NJ	NY	RI	VT
■Imports from NEWMOA States	332	256,952	97,115	77,917	25,280	144,563	43,085	3,213
▒Exports to NEWMOA States	204,092	7,070	356,558	37,941	12,707	28,690	84	8,385
□Exports to non-NEWMOA	1,076,079	13,097	279,113	0	602,193	1,270,423	800	0

5.6 Comparing Regional C&D-related Policies

Green Seal researched C&D-related policies, regulations, and practices among states within the region to conduct a comparison with CT.

5.6.1 Comparing Definitions of C&D

Green Seal reviewed the definitions of C&D and bulky waste from around the region. Figure 5.2 presents a summary by state. Green Seal observes several key differences including:

- Land clearing debris, such as trees, stumps, and brush is considered C&D debris in some states and not in others. In Green Seal's opinion, land clearing debris is more likely to be managed separately from mixed C&D debris, is not typically landfilled, and should not be considered C&D debris.

- Asphalt, brick, and concrete (ABC) materials from paving, roadways, and bridge work (infrastructure construction) is considered C&D debris in some states but not in others. In Green Seal's opinion, ABC materials from infrastructure-related projects is more likely to be managed separately from mixed C&D debris, is not typically landfilled, and should not be considered C&D debris.

Figure 5.2 C&D Definitions in Northeast States

Definitions of Bulky Waste and/or C&D Waste by State	
CONNECTICUT	***"Construction and Demolition"*** *waste* means building materials and packaging resulting from construction, remodeling, repair and demolition operations on houses, commercial buildings and other structures, excluding asbestos, clean fill, as defined in regulations adopted under section 22a-209, or solid waste containing greater than de minimis quantities, as determined by the Commissioner of Environmental Protection. ***"Bulky Waste"*** means land clearing debris and waste resulting directly from demolition activities other than clean fill. (Section 22a-208a-1 (10) of the Regulations of Connecticut State Agencies (RCSA)).
MAINE	***"Construction and Demolition"*** means solid waste resulting from construction, remodeling, repair, and demolition of structures. It includes but is not limited to: building materials, discarded furniture, asphalt, wall board, pipes, and metal conduits. It excludes: partially filled containers of glues, tars, solvents, resins, paints, or caulking compounds; friable asbestos; and other special wastes.
MASSACHUSETTS	***"Construction and Demolition"*** is defined as building materials and rubble resulting from the construction, remodeling, repair or demolition of buildings, pavements, roads or other structures. Construction and demolition waste includes but is not limited to, concrete, bricks, lumber, masonry, road paving materials, rebar, and plaster. ***"Bulky Waste"*** is defined as items of unusually large size, including but not limited to, large furniture, rolls of fencing, insulation, carpets, mattresses, box springs, large plastic toys, and plastic pools.
NEW HAMPSHIRE	***"Construction and Demolition"*** is defined as non-putrescible waste building materials and rubble which is solid waste resulting from the construction, remodeling, repair or demolition of structures or roads. The term includes, but is not limited to, bricks, concrete and other masonry materials, wood, wall coverings, plaster, dry wall, plumbing, fixtures, non-asbestos insulation or roofing shingles, asphaltic pavement, glass, plastics that are not sealed in a manner that conceals other wastes, and electrical wiring and components, incidental to any of the above and containing no hazardous liquid or metals. ***"Bulky Waste"*** means large items that cannot be handled by normal solid waste processing, collection or disposal methods, such as appliances, furniture, large auto parts, tires, and, when they are not buried on-site in accordance with RSA 149-M:4, XXII, tree stumps.

Definitions of Bulky Waste and/or C&D Waste by State	
NEW JERSEY	***"Construction and Demolition"*** is defined as building materials and rubble resulting from construction, remodeling, repair, and demolition operations on houses, commercial buildings, pavements and other structures. The following materials may be found in construction and demolition waste: treated and untreated wood scrap; tree parts, tree stumps and brush; concrete, asphalt, bricks, blocks and other masonry; plaster and wallboard; roofing materials; corrugated cardboard and miscellaneous paper; ferrous and nonferrous metal; non-asbestos building insulation; plastic scrap; dirt; carpets and padding; glass (window and door); and other miscellaneous materials; but shall not include other solid waste types. ***"Bulky Waste"*** is defined as large items of waste material, such as appliances and furniture. Discarded automobiles, trucks and trailers and large vehicle parts, and tires are included under this category.
NEW YORK	***"Construction and Demolition"*** is defined as uncontaminated solid waste resulting from the construction, remodeling, repair and demolition of utilities, structures and roads; and uncontaminated solid waste resulting from land clearing. Such waste includes, but is not limited to: bricks, concrete and other masonry materials, soil and rock, wood (including painted, treated and coated wood and wood products), land clearing debris, wall coverings, plaster, drywall, plumbing fixtures, non-asbestos insulation, roofing shingles and other roof coverings, asphaltic pavement, glass, plastics that are not sealed in a manner that conceals other wastes, empty buckets ten gallons or less in size and having no more than one inch of residue remaining on the bottom, electrical wiring and components containing no hazardous liquids, and pipe and metals that are incidental to any of the above. Excludes waste (including what otherwise would be construction and demolition debris) resulting from any processing that renders individual waste components unrecognizable, such as pulverizing or shredding, at a facility that is not a department-approved C&D debris processing facility.

Definitions of Bulky Waste and/or C&D Waste by State	
RHODE ISLAND	***"Construction and Demolition"*** waste means non-hazardous solid waste resulting from the construction, remodeling, repair, and demolition of utilities and structures; and uncontaminated solid waste resulting from land clearing. This waste includes, but is not limited to, wood (including painted, treated and coated wood and wood products), land clearing debris, wall coverings, plaster, drywall, plumbing fixtures, non-asbestos insulation, roofing shingles and other roof coverings, glass, plastics that are not sealed in a manner that conceals other wastes, empty buckets ten (10) gallons or less in size and having no more than one (1) inch of residue remaining on the bottom, electrical wiring and components containing no hazardous liquids, pipe and metals that are incidental to any of the previously described waste, and concrete if and when the debris is transported to a construction and demolition debris processing facility. Specifically excluded from the definition of Construction & Demolition debris is solid waste (including what otherwise would be construction and demolition debris) resulting from any processing technique, other than that employed at a department-approved C&D debris processing facility, that renders individual waste components unrecognizable, such as pulverizing or shredding.
VERMONT	***"Construction and Demolition"*** means waste derived from the construction or demolition of buildings, roadways or structures including but not limited to clean wood, treated or painted wood, plaster, sheetrock, roofing paper and shingles, insulation, glass, stone, soil, flooring materials, brick, masonry, mortar, incidental metal, furniture and mattresses. This waste does not include asbestos waste, regulated hazardous waste, hazardous waste generated by households, hazardous waste from conditionally exempt generators, or any material banned from landfill disposal under 10 VSA §6621.

5.6.2 Comparing Mandatory Recycling

Green Seal conducted a review of CT's recycling regulations as well as regional states' policies and regulations pertaining to mandatory recycling. Currently, the following materials are "Items Designated (i.e. Mandated) for Recycling" in CT:

- Glass & Metal Food & Beverage Containers
- Plastic Containers (PET or PETE #1)
- Plastic Containers (HDPE #2)
- Old Corrugated Cardboard (OCC)
- Boxboard
- Newspaper
- Magazines
- White & Colored Office Paper
- Scrap Metal Including Appliances
- Ni-Cd Rechargeable Batteries
- Used Motor Oil
- Leaves

- Lead Acid Battery or Motor Vehicle Batteries
- Grass Clippings
- Commercially Generated Source Separated Organic Materials

Out of the materials mandated for recycling, only scrap metal, corrugated cardboard and limited quantities of plastic containers are likely to be received in mixed loads of C&D/Oversized MSW at VRFs. Based on a review of other regional states' waste bans, Massachusetts is the only state to ban additional components of the C&D waste stream. In addition to scrap metal and cardboard, Massachusetts has implemented a waste ban on the following materials:

- Asphalt Pavement, Brick & Concrete
- Clean Gypsum Wallboard, and
- Treated & Untreated Wood & Wood Waste (Banned from Landfills Only)

While CT doesn't have a ban on C&D disposal or disposal of individual components of C&D (other than scrap metal and cardboard), there are permit requirements for recycling at some but not all VRFs in the state. Based on a review of all twenty-nine (29) current operating permits for the CT VRFs, some facilities are being required to implement recycling following a phased approach, for items not already "designated" for recycling in CT. For example, one facility permit requires the following:

Table 5.1 – Sample VRF Permit Condition for Recycling

Recovery Rate for Non-Designated Recyclable Items (by weight)	
Year of the Permit	**Percent of Total Waste Received**
First Year	10%
Second Year	20%
Third Year	30%
Fourth Year	35%
Fifth Year	40%

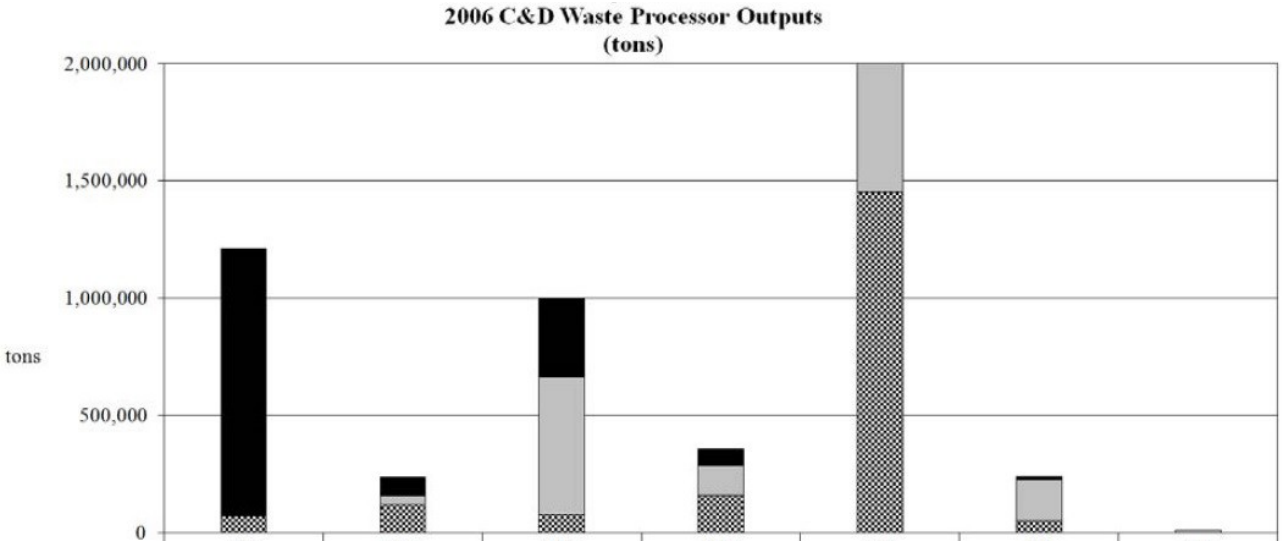
5.6.3 Comparing Definitions and Interpretations of Recycling, Diversion, and Beneficial Use

In addition to the definitions of C&D, Green Seal noted differences in the definitions of recycling among states, as well as interpretations of the definitions, and how each state accounts for recycling. Most notably, two end uses relevant to C&D which are treated differently among states are:

- Wood extracted from mixed C&D debris, and sent to biomass facilities for fuel, is counted towards recycling (or diversion, or non-landfill "uses") in some states, but not in others. As indicated in VRF reports submitted to CT, wood sent out for biomass fuel does not count towards recycling, and is considered a waste-to-energy option.
- C&D fines and in some cases C&D residuals can be permitted in some states as a beneficial use material for use as Alternative Daily Cover (ADC) or other regulated uses within landfills, and count towards recycling (or diversion). In CT, ADC does not count towards recycling and is considered landfill disposal.

Figure 5.3 below copied from the NEWMOA study highlights the relevance of the above definitions and interpretations of landfill uses in particular. Significant volumes of C&D-derived materials were used in landfill applications in 2006 in most states. It should also be noted that the recovery quantities are largely influenced by whether states include road and bridge materials such as asphalt, brick, and concrete. New York, for example includes these materials in their generation and recovery calculations, resulting in a disproportionally higher recovery rate than most other states.

Figure 5.3 – NEWMOA Report 2006 C&D Waste Processor Outputs



	CT	ME	MA	NH	NY	RI	VT
■Disposal	1,139,723	79,204	334,224	71,196	2,125,442	10,592	0
▫Landfill Uses	0	38,094	584,371	125,850	622,504	176,159	12,598
⊠Recovered	71,062	121,327	79,537	159,904	1,452,670	52,868	0

It should be noted that Connecticut's disposal tonnages in the NEWMOA graph above include waste used as alternative daily cover material and waste incinerated with energy recovery. In other states that tonnage may have been categorized as "landfill uses" or as "recovered".

SECTION 6.0 - C&D WASTE FLOW RESEARCH

6.1 Introduction

Green Seal analyzed the flow of C&D waste from the point of generation including the types of debris created by the different construction activities (construction, renovation, or demolition), and how the types of materials generated by different activities influence their collection, transportation, recycling, and/or disposal. Additionally, Green Seal analyzed the current practices of waste flow from CT VRFs to the point of disposal.

6.2 Waste Flow from Point of Generation

Based on the research conducted and Green Seal's knowledge of construction, renovation, and demolition materials, the following provides a summary of the typical flow of waste from the point of generation at construction, renovation, and demolition sites.

Construction Materials:

- Materials are typically transported commingled from the point of generation in roll-off containers.
- Based on the waste observations conducted for this study, the majority of construction materials are entering VRFs in 15-30 yard containers.
- Construction activities tend to generate smaller volumes of material than demolition projects and renovation projects, based on a square foot comparison.
- Roll-off containers with construction materials tend to be lighter than those containing renovation and demolition materials.
- Packaging materials can be a very large percentage of material by volume for construction projects, but are a relatively small percentage by weight.
- Construction materials are less likely to contain potential contaminants such as painted wood (Lead), creosote, PCBs, and asbestos containing materials.
- Recycling of C&D materials is not mandatory in CT, and thus recycling practices are most commonly decided based on cost and availability of the services. In some cases, company policies and/or preferences of project managers determine whether recycling occurs at construction sites. As discussion in Section 2.0, if projects are subject to the CT high performance building standards, generators either use multiple containers on construction sites to source separate materials, or send the materials to CT VRFs that recycle mixed loads of materials. Source separated materials typically include:
    - Wood
    - Cardboard
    - Gypsum
    - Metals
    - Aggregates (Brick, block, concrete, etc.)

Renovation Materials:

- Renovation comprises both demolition and construction activities, and thus materials generated are a combination of both waste streams.
- Based on the waste observations conducted for this study, the majority of renovation materials are entering VRFs in 15-30 yard containers.
- The weight of renovation materials tend to be heavier than construction materials.

- Materials are typically transported commingled from the point of generation in roll-off containers for renovation projects on wooden structures.
- Depending on the type of project and the age of the structure, prior to abatement, renovation materials are more likely than construction materials to contain contaminants such as lead based paint, asbestos, and or PCBs.
- Renovation projects on concrete or masonry (brick, block) structures may necessitate separated waste streams for the concrete and masonry materials versus the construction materials. As discussed in Section 4.0, aggregate recyclers typically charge between $12-20/ton on average to receive asphalt, brick, and concrete (ABC) materials for recycling, versus mixed loads of materials entering VRFs at $70-$120/ton. Thus, depending on the volume of ABC created on a renovation project, it may be more cost effective to keep the materials separate, despite having to pay a separate hauling fee to a separate location.
- When ABC materials are transported off-site, given the weight of the materials, they are often transported in smaller containers (15CY), or transported in dump trucks. Transportation is often to local markets given the inefficiency of transporting small volumes.
- In some cases, depending on site considerations, ABC materials may be reused directly on-site.
- For roofing renovation projects which typically consist of removing the old shingles and placing new shingles on the roof, the materials produced are predominately shingles (90+/-%) by weight, with packaging materials, flashing, and some wood (depending on whether repairs are also conducted to the wooden structure) making up the remainder of the load. Asphalt shingles are typically being sent either shingle recyclers or VRFs depending on the proximity to the recyclers and generators knowledge of recycling options.
- Recycling rates for renovation materials are highly variable and depend on many factors including but not limited to the type of project (a re-roofing project versus bathroom renovation for example), the age of the structure, and the recyclability of the material components.

Demolition Materials:

- While limited quantities of demolition materials are directly re-used through deconstruction efforts presently, the majority of materials are transported to CT C&D VRFs. Based on GSE's research, reused materials are predominantly derived from residential deconstruction, and transported to salvage resale businesses. In some cases, salvaged lumber is reused directly by manufacturers of wood products (i.e. wood flooring and furniture).
- Based on the waste observations conducted for this study, the majority of demolition materials are entering VRFs in 30 CY containers.
- Demolition materials tend to be the heaviest of the categories.
- Depending on the type of project and the age of the structure, prior to abatement, demolition materials can be more likely to contain contaminants such as lead based paint, asbestos, and or PCBs.
- Depending on the size of the structure, demolition of wooden structures can sometimes justify the use of larger (40-50CY) roll-off containers, and in some cases 100CY live-floor trailers loaded directly at the job sites.
- Given the transportation efficiency of over-the-road "long-haul" with 100CY live-floor trailers, some demolition materials are transported directly from job-sites to out-of-state

distant landfills versus entering a CT VRF. However, given CT's 80,000 GVW restriction, it is less common in CT than the rest of New England and New York.

- As with renovation, if demolition projects are conducted on concrete or masonry structures, the materials will typically be kept separate from other mixed debris to save on disposal costs.
- In some cases, depending on site redevelopment considerations, ABC materials may be reused directly on-site.
- Diversion rates on projects with demolition of concrete and masonry structures are typically very high, given that the concrete/masonry and metals are typically the largest components of the structures. Source separation of materials (ABC & metal) at the job site is standard practice on almost all sizeable projects given the cost savings over mixed disposal/recycling.
- Diversion rates on projects with demolition of wooden structures are highly variable depending on the availability (proximity and tipping fees) of mixed demolition recycling markets. Source separation is seldom practiced given the difficulty of separating the components and the site, and the marginal (if any) cost savings of separating wood, metal, gypsum, or other components, and the lack of end markets for sources separated demolition-derived materials (with the exception of metals).

6.3 Waste Flow from VRFs

As discussed in previous sections, based on the FY2013 VRF facility reporting data, CT exported approximately 884,157 tons of C&D materials with the majority (approximately 56%) going to Ohio. While some disposal took place with over-the-road long-haul live floor trailers and flatbed (bales), the vast majority of materials were transported from VRFs to out of state disposal outlets via rail. Based on the research conducted, eight (8) VRFs currently have rail infrastructure integrated into their operations. Haulers and facility operators cited the following as the primary factors for the development of rail infrastructure at CT VRFs:

- A lack of in-state disposal capacity.
- CT's 80,000lb GVW weight restriction impacts the efficiency of over-the-road long-haul via 100CY live-floor /flatbed (bales) trailers.
- The presence of landfills with rail infrastructure with large capacity and relatively inexpensive tipping fees.
- The efficiency of transporting heavy materials in high capacity containers (100-ton capacity rail cars).

6.4 The Economics of Rail Haul

The following observations are made based on the research conducted on the economics of rail haul:

- The overall disposal cost for CT VRFs with existing rail infrastructure to transport and dispose of waste via rail is approximately $50-$60/ton.
- The largest and most widely used landfills are located in the northeast corner of Ohio. These landfills are charging approximately $15-$25/ton for disposal at their facilities.
- Rail cars used for C&D disposal typically hold between 70-100 tons per car. Materials with aggregates and/or fines removed are typically at the lighter end of the range. Thus, removing heavy materials from the rail cars results in a higher cost per ton for disposal, and facility operators must weigh the financial benefit of recycling/reuse of fines and aggregates against the financial loss of potentially increasing the cost per ton per rail

car. In some cases, CT VRFs are putting C&D fines on top of mixed loads in order to achieve higher weights per car and to act as cover to contain loose materials. It should be noted that the cost of transportation remains static and is not dependent upon the weight.

- The two large landfills in OH accepting the majority of the materials from CT differ in their ability to accept C&D waste streams. The Sunny Farms Landfill in Fostoria, OH is an MSW landfill and may accept either MSW or C&D materials. The Lordstown Construction Recovery landfill (AKA Lafarge) in Warren, OH is a C&D-only landfill. A regulation in OH prevents C&D landfills from accepting “pulverized debris”. As defined by Ohio Revised Codes (ORC) Chapter 3714.01, *Construction and demolition debris definitions*, (I): "Pulverized debris" means a load of debris that, after demolition has occurred, but prior to acceptance of the load of debris for disposal, has been shredded, crushed, ground, or otherwise rendered to such an extent that the load of debris is unidentifiable as construction and demolition debris. This is relevant to the economics of C&D disposal and recycling because the VRFs performing processing (including recycling) may cause the materials to be classified as “pulverized debris” and limit the disposal of their materials to an MSW landfill in OH, or a different-out-state C&D landfill other than those in Ohio. Based on the research conducted, however, the tipping fees are currently similar at both locations.

SECTION 7.0 - C&D-DERIVED WOOD MARKETS ANALYSIS

7.1 Introduction

Green Seal analyzed the current and potential markets for wood materials derived from C&D sources.

7.2 Wood Composition

Based on the waste observation exercise conducted for this study, which included the analysis of 267 loads of material accepted at CT VRFs, wood made up approximately 38% of the total inbound waste stream. A breakdown of the make-up of the identified wood components is provided below. The figures present the breakdown of wood from all loads inbound including C&D and oversized MSW, as well as the breakdown of just the predominantly C&D loads.

Figure 7.1 – Breakdown of "Wood" Category by Weight of C&D and Oversized MSW Loads

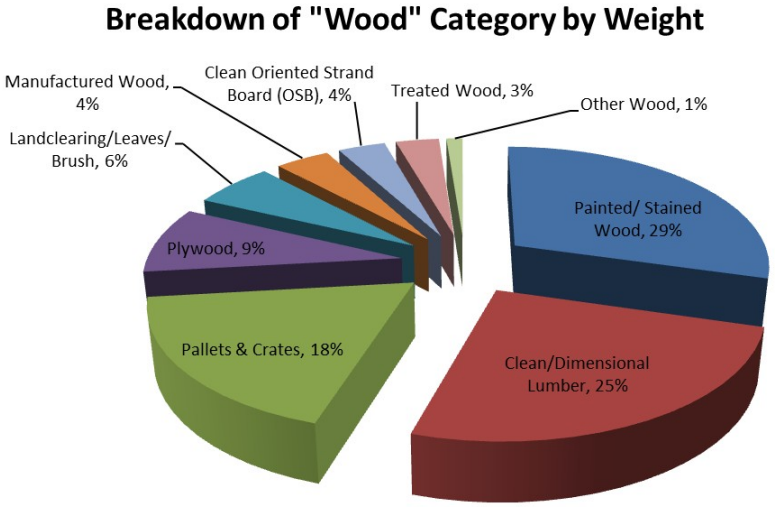
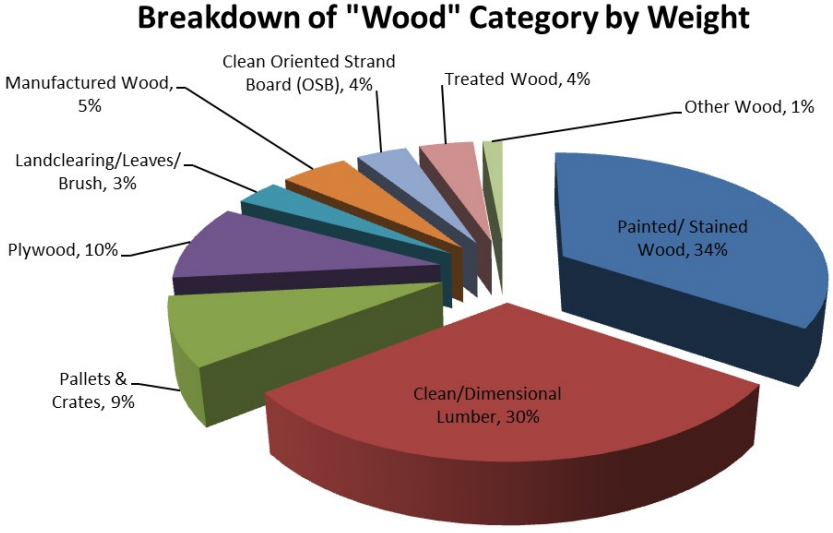


Figure 7.2 – Breakdown of "Wood" Category by Weight of Predominantly C&D Loads



Furthermore, Green Seal applied the 2013 generation (1,041,643 tons) to the "Wood" category in order to calculate the estimated volume of each of the wood components available for recycling or disposal. Based on the estimate, there is approximately 200,000 tons per year of "Clean Wood", consisting of Clean Dimensional Lumber, Pallets & Crates, and Land clearing/Leaves/Brush sources, available for recycling. For Mixed Wood, which includes the wood from all categories except Treated Wood, there is approximately 380,000 tons per year available. It should be noted that these volumes are "theoretical availability" figures only. It is not realistic to expect to be able to capture all wood via source separation and/or from separation of a mixed C&D waste stream. The table below provides a summary of the calculations.

Table 7.0 Estimated Tons of Wood Components

Material Components	Mean (Average) Percentage by Weight of Each Material Per Sample	Estimated Tons (Components)
Painted/Stained Wood	11.20%	117,118
Clean Dimensional Lumber	9.60%	100,187
Pallets & Crates	7.10%	73,439
Plywood	3.40%	35,037
Land Clearing/Leaves/Brush	2.30%	23,789
Manufactured Wood (Particle Board)	1.50%	16,024
Clean Oriented Strand Board (OSB)	1.30%	13,997
Treated Wood	1.20%	12,840
Other Wood:	0.50%	4,773

7.3 Current Uses of Wood

As discussed in Section 4.0, the current uses for wood materials are broken down generally into two categories; clean (unpainted/untreated) wood, and mixed wood.

Clean Wood

Based on the 2013 facility reporting data coupled with interviews of the VRFs operators, the most commonly used end markets for processed (separated, ground, and screened) clean wood include:

- Mulch (including bulk and bagged products, and also including dyed mulch), and
- Animal bedding

It should be noted that while some portion of the mulch and animal bedding is made from clean wood sorted from mixed loads of C&D debris, the majority of material is source separated clean materials such as pallets and crates, clean wood manufacturing scrap, and trees/stumps/brush.

The markets for these materials and prices paid (or tipping fees charged depending on the size/quality of the product) are discussed in Section 4.0.

Mixed Wood

Based on the research conducted, the only current end use for mixed wood is biomass fuel. It should be noted that mixed wood biomass fuel must be free of treated wood (I.e. CCA treated lumber). Although bulk biomass fuel is a "current" use in CT, it is essentially limited to one outlet; Plainfield Renewable Energy. Additionally, based on interviews with the VRFs, at the current time, only limited volumes of C&D-derived wood are being sent from CT VRFs to Plainfield Renewable Energy. It should be noted, however, that the Plainfield facility recently (July 2015) changed ownership. Based on discussions with facility representatives, CT VRFs, and other out-of-state processors supplying materials to the plant, in Green Seal's opinion, the facility is increasing their efforts to procure wood from C&D sources. Therefore current consumption (fall 2015) is not necessarily indicative of future consumption from this facility.

One additional outlet that was identified was the acceptance of processed C&D wood at RRFs. These facilities may accept processed C&D wood as special waste but are limited by the SWDA Plans tonnages. Additionally, given that the prices charged to accept the wood at the RRFs are the same as disposal, this outlet is minimally used.

7.4 Potential Uses of Wood

Wood Heating Pellets

Green Seal researched the potential for using C&D-derived wood materials for the manufacture of wood residential/commercial heating pellets. The Pellet Fuels Institute, a non-profit association that serves the pellet industry has developed a quality standard and voluntary certification program that is becoming widely adopted within the industry. According to the *Pellet Fuels Institute Residential/Commercial Densified Fuel QA/QC Handbook*, Section 4.5, Chemically Treated Materials: "With the exception of de minimis levels, any feed stock material (cellulosic or otherwise) that contains any bonding agent, resin, preservative, surface coating or other finish, or any other chemical compound that has been added to the material is not acceptable." [8] To meet this standard, C&D-derived wood used for pellet manufacturing would likely have to be limited to clean dimensional lumber and clean pallets and crates only. Also, based on communication with manufacturers, in addition to the issue of potential chemical contamination, it is also important to prevent materials other than clean wood, pallets, and crates from entering the manufacturing process in order to maintain the proper physical characteristics of the required feedstock.

In 2013, one pellet manufacturing facility, Inferno Pellets in Rhode Island, was using a mixture of source separated clean wood and clean wood sorted from mixed C&D sources in CT. However, the facility closed in 2013 after a dust explosion at the facility. According to the former facility owner, the use of C&D-derived wood for fuel pellets is very challenging both from a feedstock procurement standpoint and a manufacturing standpoint.

According to a representative of the company, the largest pellet manufacturer in the region, New England Wood Pellet, LLC, with manufacturing locations in Jaffrey, NH, Deposit, NY, and Schuyler, NY does not use C&D-derived wood in the manufacture of their pellets.

[8] http://www.pelletheat.org/assets/docs/2015/Standards/pfi_qa-qc_handbook_july_9_2015.pdf

According to Biomass Magazine, in a list last modified on October 6, 2015, there were no pellet manufacturing plants identified in CT.[9] Green Seal identified one manufacturer of compressed wood fuel "bricks", Biopellet Heating Systems, LLC, in Berlin, CT. Company representatives did not return Green Seal's phone and email inquiries. Green Seal is unaware whether the company's BioBricks™ product is manufactured with any C&D-derived clean wood.

Given the difficulty of obtaining consistent quality materials from C&D-derived wood, and the complexity of manufacturing pellets from this source, the potential end-use of pellets is uncertain. Green Seal is unaware of any future or planned pellet manufacturing facilities using C&D-derived wood in the region.

Bulk Biomass Fuel

Green Seal researched the potential for other markets in CT (aside from Plainfield Renewable Energy) for consumers of bulk biomass fuel. Based on the research conducted, in addition to Plainfield Renewable Energy, one other facility, ReEnergy Sterling, in Sterling, CT is currently permitted to accept C&D-derived wood materials. However, the facility is currently idled. According to *Written Comments of ReEnergy Holdings LLC March 27, 2015, Submitted Electronically to CleanEnergyRFP@gmail.com to the Specified State Agencies and Electric Distribution Companies in Connecticut, Massachusetts and Rhode Island Regarding the Draft Request for Proposals for Clean Energy and Transmission*, "ReEnergy and the Connecticut Municipal Electric Energy Cooperative (CMEEC) have signed a Memorandum of Understanding for the joint re-development and ownership of ReEnergy's Sterling, CT facility, and are contemplating making a significant investment to retrofit the facility to use woody biomass as its fuel if certain development milestones can be achieved, including securing a long-term contract for the sale of the renewable energy credits to be generated by the retrofitted facility." [10] Thus, should the existing facility be restarted, there would be significant additional demand for mixed wood for biomass fuel.

Green Seal also researched out-of-state markets for bulk biomass fuel. While other markets exist that currently accept mixed C&D-derived wood in Maine, New York, and Canada, there is presently little to no volume of wood fuel going to these facilities from CT sources. Based on interviews with VRFs and direct communication with the biomass facility representatives, the primary impediment to increasing demand for biomass fuel from generators in CT is the current 80,000 lb. GVW limit for over-the-road long-haul transportation. In addition to transportation restrictions, biomass plants cited the following:

- Loss and/or reduction of renewable energy credits for plants that burn larger volumes of C&D-derived wood versus green wood.
- Impacts to the boilers which are set-up to burn green wood, and require additional maintenance and repair when burning C&D-derived wood.
- Lower energy demand (and thus resulting lower fuel consumption), and increased competition from natural gas as well as lower crude oil prices. Stand-alone power generation facilities have greatly reduced consumption of biomass fuels in reaction to the lower energy demand and natural gas market competition. The impacts have been less dramatic at biomass facilities that generate power for on-site industrial uses (I.e. Paper mills).

[9] http://biomassmagazine.com/plants/listplants/pellet/US
[10] https://cleanenergyrfpdotcom.files.wordpress.com/2015/03/reenergy.pdf

- Increased ash disposal costs for facilities that burn mixed wood and have to landfill the ash versus land applying ash from green wood sources.

Manufactured Wood Products

Green Seal researched the potential for the use of C&D-derived wood in the manufacture of recycled-content wood products. Based on the research conducted, one manufacturer, Tafisa in Lac-Megantic, Quebec, Canada, is manufacturing post-consumer recycled-content wooden panels using a technology called Rewood™. According to the company's website, the facility manufactures decorative and particleboard products using approximately 50% of their feedstock from C&D-derived wood. [11] Based on discussions with the facility's feedstock procurement representative for the New England region, the facility accepts a combination of clean and mixed wood from within the region, but not in CT. CT's 80,000lb GVW was cited as the main reason for the inability to procure materials from CT VRFs. According to the representative, mixed wood materials are being procured from sources near CT (in MA), and the company is charging C&D processors approximately $5-$10/ton for materials picked up at their facilities.

Green Seal is unaware of any other entities in the region making other manufactured wood products from C&D-derived wood.

[11] http://www.tafisa.ca/rewood-en

SECTION 8.0 UNDERVALUED/UNDERUTILIZED C&D-DERIVED MATERIALS RESEARCH

8.1 Introduction

Green Seal analyzed recoverable C&D materials that may be undervalued and/or underutilized presently. In general, recovery rates of all C&D-derived materials are very limited presently in CT. As discussed in Section 4.0, of the twenty-nine (29) permitted VRFs, only five (5) facilities operate processing systems (e.g. systems that use equipment other than rolling stock). While some VRFs transfer materials to other VRFs with processing systems, the majority of materials are still not being processed. Based on 2013 facility reporting data, approximately 45% of all material managed by VRFs went to the five (5) VRFs that have processing systems. Furthermore, the recovery rates from the VRFs performing processing are relatively low, and in a majority of the cases are limited to source separated materials such as land clearing debris, pallets, and aggregates (asphalt, brick, and concrete). Given this, a large majority of mixed C&D waste streams are "underutilized" with respect to extraction from the waste stream for subsequent recycling.

8.2 Wood

Presently, wood recovery from mixed C&D-derived materials is very limited in CT, and has significant potential for increasing. Based on a review of facility reporting data and interviews with VRFs, the majority of wood recovered from VRFs is from land clearing debris, pallets/crates, and other sources where materials are arriving source separated (I.e. wood manufacturing scrap). Very little wood is being recovered from mixed C&D. The majority of wood materials are marketed as mulch and animal bedding in CT, with limited amounts also being marketed as bulk biomass fuel.

Both mulch and animal bedding uses are relatively high value uses/commodities derived from clean C&D wood. However, mulch is a seasonal commodity in the northeast United States, and according to mulch producers, only has strong demand for approximately 4 months of the year. The highest value of mulch from C&D-derived materials is with retail priced colored (dyed) mulch, as well as bagged products. However, both of these uses require a substantial amount of additional processing/handling and generally a significant amount of storage space on-site (e.g. staging, processing and finished product storage areas). Thus, making value-added products could add costs which may or may not increase the overall net revenue generated from the materials. More often, C&D-derived wood materials are sent to mulch producers in bulk who maintain larger storage areas for year-round acceptance and stockpiling of materials. In addition, their intermediaries have the fixed equipment (grinding, screening, dying, and bagging equipment) to refine the products (including blending with other wood feedstock) into a salable commodity. In addition, generally these intermediaries have the capabilities to wholesale and/or retail the end products more proficiently.

Bulk biomass fuel is a relatively low value end use for C&D-derived wood materials. However, the benefit for this market is that it can accept mixed wood materials (versus just the clean wood for mulch and animal bedding). As discussed in Section 7.0, due to the CT 80,000lb GVW weight restriction, this market is essentially limited to only one in-state market, Plainfield Renewable Energy. While only limited amounts of material are entering the facility currently (fall 2015), it is likely that the facility will increase the use of C&D-derived wood materials based on operating requirements of the facility which require the specific use of C&D-derived wood. The

facility has an annual maximum potential demand of approximately 250,000 tons per year at full operation.

Based on the research conducted, the highest value for mixed wood products is in the manufacturing of recycled content wood products. As discussed in Section 7.0, based on the research conducted, only one company, Tafisa, in Lac-Mégantic, Quebec, Canada (approximately 350 miles from Hartford, CT) is currently using C&D-derived wood for the manufacture of recycled-content wood products. Given the distance to this market, the low prices paid for the C&D-derived feedstock in this region (processors are paying $5-10/ton to Tafisa for materials picked up in MA), and the inefficiency of transporting bulk wood product from CT with the 80,000lb GVW weight restriction, this market is not currently utilized.

8.3 Asphalt Roofing Shingles (ARS)

Presently, asphalt roofing shingle recycling from either source separation or mixed C&D materials is relatively limited in CT, and has significant potential for being increased. Asphalt roofing shingles are a unique component of the C&D waste stream in that their generation generally results in a relatively homogenous source-separated waste stream consisting of 95%+ asphalt roofing shingles, with only limited amounts of other materials (metal flashing, packaging waste from the new shingles, etc.).

As discussed in Section 4.0, presently, asphalt roofing shingle recycling in CT is primarily conducted at two stand-alone facilities which accept source-separated loads of the material:

- SONO Investments, LLC aka Asphalt Roof Recycling Center, Stratford, CT
- Incorporated Industries, Bloomfield, CT

Shingles accepted and processed by these two facilities are used as either a recycled aggregate material, or as a feedstock for hot mix asphalt (HMA) pavement. HMA is an exceptional use for asphaltic based roofing material as the material contains 18%+/- asphalt emulsion and roadways generally need a 6%+/- asphalt emulsion. Thus, the use of shingles reduces the amount of emulsion required overall in the mixes.

Of the two uses, asphalt pavement arguably is the higher value product. CT DOT specifications currently limit the use of recycled asphalt shingles (RAS) in pavement mixes used for bottom (binder) course of pavement, and not top course products. [12] As described in the *General Permit for the Storage and Processing of Asphalt Roofing Shingle Waste For Beneficial Use and Recycling, Issuance Date: June 2, 2011, Expiration Date: June 2, 2021*, Binder Course and Top Course are defined as:

- "Binder course" means the layer of hot mix asphalt (HMA) that may contain RAS and is located between the top course and aggregate base in the construction of asphalt paving structures.
- "Top course" means the surface or wearing course of asphalt paving structures consisting of HMA and that may contain RAS.[13]

The market demand for top course is significantly higher than that of binder course given that re-paving of highways and other roadways typically only involves the removal and replacement

[12] http://www.ct.gov/dot/cwp/view.asp?a=1400&q=434650
[13] http://www.ct.gov/deep/lib/deep/Permits_and_Licenses/Waste_General_Permits/Asphalt_roofing_shingles_gp.pdf

of the top coat, where binder course is mostly only necessary for new roadways, driveways, and parking lots. Given the policy limiting its use to binder course only, and the lower demand for binder course, the material is significantly underutilized and undervalued.

8.4 Gypsum

Presently, gypsum recovery from source separation and/or mixed C&D materials is very limited in CT, and has a moderate potential for being increased. Based on the research conducted, no gypsum recycling facilities exist within the state currently. Given the fact that gypsum materials are broken up into pieces too small to sort from mixed loads of C&D/Oversized MSW, it is not feasible to recover significant amounts of gypsum from mixed C&D recycling operations. Significant recovery of gypsum would generally require source separation at the point of generation.

As discussed in Section 4.0, Green Seal was only able to identify one recycler of gypsum accepting materials from CT. USA Gypsum, in Denver, PA (approximately 270 miles from Hartford, CT) is accepting source-separated loads of gypsum materials from Connecticut and other parts of New England. According to the facility, the company manufacturers both bulk agricultural gypsum and bagged products. The bagged products are their highest value product.

Another high-value added use of gypsum is the use of post-consumer materials in the manufacture of recycled content gypsum. One regional facility in Newington, NH (Georgia Pacific; previously Domtar) had historically been using post-consumer gypsum but has since stopped accepting the materials.

8.5 Oversized MSW/Bulky Waste Components

Green Seal analyzed the potential for the recovery of components of bulky waste (AKA Oversized MSW). Although these materials are not generated from construction, renovation, and/or demolition activities, these materials are nonetheless being managed by all of the VRFs in CT. Based on the waste observation exercises conducted for this study, which included the observation of 267 loads of incoming materials at four separate VRFs over 8 days, approximately 26% of the loads entering the VRFs contained Oversized MSW/Bulky Waste. The loads accounted for an estimated 30% of the weight of the materials observed. A wide variety of materials make up this category of the waste stream, but some of the common materials observed included:

- Furniture
- Furnishings (Household decorations, shelving, etc.)
- Children's toys (Large plastic toys, play houses, etc.)
- Miscellaneous collectibles from house clean-outs (Yard-sale type items)
- Appliances (Vacuums, household electronics, etc.)
- Mattresses
- Carpet and carpet padding
- Building materials (Doors, windows, etc.)
- Textiles (Clothes, window dressings, etc.)
- Miscellaneous bagged waste

The highest value for the materials within this category is generally direct salvage and reuse prior to disposal. However, it's likely in at least some cases that the generator has disposed of

the material because it was at the end of its useful life (not repairable, beyond suitable condition for donation, etc.). Additionally, once received at the VRFs and comingled with mixed C&D debris, a large portion of the materials are generally beyond salvage. Thus, any significant increase in recovery of materials in this category will require source separation. Services that pick-up items for salvage/donation (I.e. Salvation Army, 1-800-GOT-JUNK, etc.), are available within CT. Additionally, drop-off facilities (donation facilities) are also generally available in most urban areas for used building materials, furniture, clothing, etc.

8.6 C&D Fines

In order to effectively process (sort) C&D materials, C&D fines are generally extracted prior to extracting other higher value commodities. As discussed within Section 4.0, based on the research conducted, VRFs are not currently generating C&D fines for alternative uses other than disposal. While historically C&D fines were used throughout New England as alternative daily cover materials at landfills, the markets are now very limited and most CT C&D processing facilities are sending the materials out with other residuals for landfill disposal. The highest value currently for C&D fines is in landfill applications such as cap/closure materials and alternative daily cover. It should be noted that there have been policies and procedures developed to effectively utilize these materials in landfill applications while reducing the potential for nuisance conditions such has hydrogen sulfide gas. Thus, their use in landfill applications has significant potential for being increased, and improving the overall viability of mixed C&D recycling.

8.7 Cardboard

Cardboard recovery from mixed loads of C&D materials at VRFs is limited currently in CT. Although a small percentage by weight, cardboard was observed to be a significant volume of some loads of inbound materials based on the observations conducted. Cardboard is traditionally recycled into new cardboard, which is a high value product. The recovery of cardboard at VRFs is limited due to the commingling of the materials with other C&D materials, and the difficulty with extracting it without excessive labor costs. Worker safety was also cited as a concern when considering the removal of cardboard on facility tipping floors prior to mixing with other C&D materials for further processing. Thus, significant removal of cardboard would likely require source separation from the point of generation, as is required by CT's mandatory recycling provisions

8.8 Plastics

Plastics recovery from mixed loads of C&D materials at VRFs is fairly limited currently in CT. Although a small percentage by weight, mixed plastics were observed to be a significant volume of some loads of inbound materials based on the observations conducted. The plastic materials were highly variable and included such items as:

- Plastic film
- Durable plastic goods (Children's toys, play houses, play furniture, appliances housed in plastics, etc.)
- Buckets
- Plastic pipe
- Vinyl siding
- Plastic composite lumber
- Styrofoam packaging materials

Mixed plastics are sent to plastics recycling companies, sorted, processed, and eventually made into high value new plastic products. Difficulties in sorting bulky plastics such as film, and the labor required to do so prevent larger amounts of plastics from being sorted currently at VRFs. However, based on the research conducted, markets are available for receiving the materials.

8.9 Aggregates

As discussed in Section 4.0, asphalt, brick, and concrete (ABC) entering VRFs within mixed loads of C&D/Oversized MSW is sorted at a small number of VRFs. Some VRFs that are permitted to accept source-separated loads of ABC keep the materials separate from the mixed C&D/Oversized MSW. The recovery of ABC materials from mixed loads of C&D materials is limited due to the labor costs of sorting the materials and relatively low value of the end products. Higher recovery rates would necessitate either source separation, additional labor for sorting, and/or additional processing equipment (I.e. addition of de-stoners to processing operations) to increase recovery appreciably.

Based on the research conducted, the highest value recovery of ABC materials in CT is in the sorting and processing of brick materials for use as decorative stone in landscaping applications. Some processors remove brick from mixed ABC regardless, in order to improve the quality of their sub-base product. More commonly, however, the combined ABC materials are size-reduced and marketed as a substitute for natural aggregates. The end use for these materials is a relatively low value, but well established and consistently demanded (relative to construction activity) market.

8.10 Metals

As discussed in Section 4.0, despite low prices currently being paid for recovered metals, metals continue to be sorted from mixed loads of C&D materials in CT. Metals markets are well-established and are made into new high value metal products. Given their current relatively low value (relative to historic prices paid for scrap), the ferrous metals recycling being conducted currently can best be described as “opportunistic” recovery when large enough scrap materials are able to be sorted efficiently by hand or small rolling stock, and/or when recovered by magnets at facilities with processing equipment. Higher recovery rates would necessitate either source separation, additional labor for sorting, and/or additional processing equipment (I.e. addition of traditional magnets [equipment or processing line mounted] or eddy current systems for non-ferrous metal removal) in order to increase recovery appreciably.

SECTION 9.0 ECONOMICS, BARRIERS, AND OPPORTUNITIES TO INCREASE C&D RECOVERY

9.1 Introduction

Green Seal performed research to identify and assess the economics, barriers and opportunities associated with the recovery or reuse of targeted C&D materials. Research included the identification of economic pressure points, opportunities, and potential policy issues, including methods used in other locales to foster increased recovery of C&D materials (e.g. regulations, financial incentives and disincentives, government involvement in facility development/operation).

9.2 Factors Influencing the Current Status of C&D Management in CT

Green Seal first reviewed the factors (economics and barriers) which influenced the development of the current C&D management infrastructure in the state, and the recovery of C&D materials as a whole. From a nationwide perspective, in the absence of regulatory driven waste diversion goals (placed on generators, processors, and/or landfills), the recycling of C&D debris is dependent primarily on the economics of recycling and waste diversion versus the economics of straight landfill disposal and/or incineration. Thus, regions of the country with abundant and inexpensive landfills generally have less recycling infrastructure and divert lower volumes of C&D materials.

Over the last 20-30 years, in reaction to the closing of CT landfills, VRFs were developed throughout the state to more efficiently process, size reduce, consolidate, and ultimately dispose of C&D materials and other bulky wastes. Given a lack of mandatory regulatory drivers for diversion, coupled with the lack of markets for end products (long and short term), the VRFs primarily acted as waste transfer facilities where materials were size reduced (compacted to some degree) and transported for disposal. According to communication with VRF operators and regional hauling companies, CT's 80,000lb GVW weight restriction is lower than the weight restriction around the adjoining New England states and New York. These restrictions have the effect of reducing the amount of waste per vehicle that can be transported via long-haul trailers (approximately 25% to 40% less). Within the last 10-20 years, some VRFs have been modified, and new VRFs constructed that have incorporated rail into their facility logistics in order to obtain more efficient access to long-distance, inexpensive, disposal outlets. Currently eight (8) CT VRFs have rail integration.

Also within the last 10-20 years, some VRFs have integrated recycling systems into their operations, and/or opened new VRFs with processing systems. With markets limited primarily to landfill applications approximately 10-15 years ago, CT processors mainly size reduced materials and marketed the screened and/or ground materials as alternative daily cover and or as a shaping and grading material used during landfill closure activities. In addition, some of the higher organic materials were used in alternative landfill applications (e.g. landfill roadway stabilization or sludge bulking material). With the closure of most of the large-scale landfill outlets since then and with fewer landfills going through the closure process, the markets for these materials have decreased so significantly as to make their use marginally economical to processors in CT. In addition, historical landfill protocols and procedures for using these alternative materials increased the production of hydrogen sulfide gases which can be attributed to the presence of gypsum in C&D materials. Presently, most processors are now turning to landfill disposal of screened C&D materials and residuals after processing. It should be noted

that there have been recent successful uses of these alternative materials in a number of active and inactive landfill applications.

At present, the majority of the recycling of mixed C&D materials is being conducted at the five (5) VRFs with fixed processing equipment. A number of VRFs also conduct recycling of source-separated materials; primarily clean wood (pallets, crates, land clearing debris, etc.) and asphalt, brick, and concrete (ABC). Some VRFs without processing equipment also conduct "opportunistic" recycling when items such as metals & cardboard can cost effectively and safely be removed from the waste stream. Recovery achieved from recycling of C&D is very low in CT. According to 2013 VRF reporting data submitted to CT DEEP, the facilities recovered only approximately 70,000 tons (approximately 7% of Generation).

The primary factors for the currently low recovery at VRFs are attributable to:

- Inexpensive, rail accessed landfill disposal
- The additional costs of labor and equipment relative to the cost savings of recovering additional materials
- The lack of mandatory recycling (for generators and/or processors)
- Lack of diversionary and/or recycled markets for materials (primarily C&D fines and mixed wood)

A number of other factors which are more site-specific include:

- Lack of space (indoor and/or outdoor storage and processing areas)
- Permit conditions (state, local) restricting operations
- Lack of local outlets for recovered materials

9.3 Policies and Goals Guiding Future C&D Recovery

Green Seal reviewed the drivers for implementation of C&D-related policies and programs within CT now and in the future, and the parameters within which decisions are being made. These include:

1) The State of Connecticut's current goal of diverting 60% of the solid waste generated in the state by January 1, 2024, by source reduction, reuse, and recycling (approximately 7.5 years from the date of the anticipated completion of the 2016 Update to the Solid Waste Management Plan aka CMMS).
2) According to the 2006 Connecticut Solid Waste Management Plan, the long-range vision for solid waste management is to:
    a. "Transform our system into one based on resource management through shared responsibility of everyone involved in the life-cycle of products and materials;
    b. Shift from a 'throwaway' society toward one that promotes a reduction in the generation and toxicity of trash, and that treats discards as valuable raw materials, feedstock, and energy resources; and
    c. Manage materials through a more holistic and comprehensive approach, resulting in the conservation of natural resources and the creation of less waste and less pollution, while supplying valuable recovered materials to revitalize economies."[14]

[14] http://www.ct.gov/deep/cwp/view.asp?a=2718&q=325482&deepNav_GID=1646%20#Current

3) According to The Report of the Modernizing Recycling Working Group Presented to Governor Dannel P. Malloy, dated December 27, 2012, key recommendations included:
    a. "Promote environmentally beneficial infrastructure
    b. Foster economic development and job creation
    c. Reduce burdens on municipalities
    d. Refine role of CRRA [aka MIRA]"[15]

Based on the guidance above, Green Seal offers the following observations regarding C&D/Oversized MSW management in CT relative to the state's goals and objectives:

1) Green Seal cannot estimate with any degree of accuracy, the current waste reduction volumes for C&D materials in CT as generators are not required to report these figures.
2) The recycling of C&D materials was approximately 7% of C&D debris processed through CT C&D VRFs and CT asphalt roof shingle recycling facilities based on FY 2013 facility reporting data, which does not add significant quantities to the overall goal of 60% diversion and recycling.
3) Approximately 93% of C&D being managed at CT VRFs is either disposed in landfills or incinerated at energy recovery facilities. Of that percentage, approximately 85% is landfilled, and approximately 15% is incinerated at CT and MA energy recovery facilities. Based on these statistics, the current C&D management practices are not in alignment with the CT's Solid Waste Management Hierarchy.
4) C&D materials and Bulky Waste (AKA Oversized MSW) are two different and distinct waste streams which are nonetheless being managed by VRFs. Based on waste observations conducted at four (4) different VRFs in CT over an eight day period resulting in the observation of 267 loads of inbound materials, Bulky Waste accounted for approximately 26% of the loads. The generation of a large amount of bulky waste, which typically includes a significant amount of durable goods, is a strong indication of the "throwaway society" habits as described in the 2006 Connecticut Solid Waste Management Plan. Furthermore, the acceptance of Oversized MSW with a low potential recyclability, potentially impacts facilities' recovery percentages. If for example, based on the observation of approximately 26% of materials being Oversized MSW, that same quantity were removed from the equation (and not be counted towards C&D recycling at the facility), then recovery would be closer to 10% versus the present recovery rate of 7%.
5) A review of the potential for additional job creation at C&D recycling businesses versus disposal was not conducted as part of the research, but Green Seal can state unequivocally that facilities that transfer waste for disposal without processing have much lower labor needs (internally and externally) than VRFs with recycling systems which rely heavily on labor.
6) Currently, the majority of C&D material that is handled within the state is managed at private VRFs. None of the C&D VRFs are municipal and/or state-owned.
7) Generators, with the exception of construction projects that fall under the CT High Performance Building Standards, are generally disconnected from the concept of "shared responsibility of everyone involved in the life-cycle of products and materials" and the need to reduce and/or recycle C&D waste in CT. The burden of recycling of

[15] http://www.ct.gov/deep/lib/deep/waste_management_and_disposal/solid_waste/transforming_matls_mgmt/gov_recycling_work_group/report_dec_27_2012.pdf

C&D is almost completely left to the private sector VRFs. It should be noted that the ultimate decision is likely economically driven by the generator and not the VRF.

8) Green Seal is not aware of any involvement of the Materials Innovation and Recycling Authority (MIRA, formerly Connecticut Resources Recovery Authority or CRRA) in recycling of C&D materials in CT.

9.4 Opportunities for Additional Recovery of C&D in CT

Green Seal investigated potential options for increasing recovery. Sources of information included interviews with VRF and recycling facility owners/operators, and a review of policies and programs in other states. In order to objectively present options to CT DEEP for achieving high levels of recovery, Green Seal looked into all potential options regardless of the ease of implementation, current regulations and policies, financial impacts to CT VRFs and municipalities, impacts to out-of-state facilities, etc. Green Seal first looked at actions that could be taken which would potentially increase recovery of all C&D materials, and then at actions that would impact individual components or groups of components. A summary of both are included below (not in order of preference), along with a brief analysis of the pros and cons associated with each option.

Options that could potentially impact C&D recovery overall:

#	POTENTIAL OPTION	PROS	CONS
1	Providing state government funding (through grants and/or loans) to public and private entities to develop end markets for C&D components through: • Funding for the construction of new and/or expanded operations • Funding for research on the development of recycling technologies	• Creation of additional recycling infrastructure • Development of more sound, higher value end products • Could work with or through existing grant programs such as The RecycleCT Foundation	• Funding required for the grants and/or loans • Funding required for administration of the program • May require additional staff resources from CT DEEP
2	Facilitating the siting and development of new recycling facilities and end market users in conjunction with the CT Department of Economic and Community Development.	• Higher likelihood of successful business recruitment • Uses an existing state agency's resources and knowledge	• May require additional staff resources from CT DEEP
3	Establishing stand-alone government-owned/ operated and/or private sector operated regional source-separated C&D materials recycling drop-off centers.	• Creates access to recycling markets for small construction jobs that otherwise wouldn't have affordable, local access • Increases the material quality and recyclability over mixed C&D materials	• Potentially competes with private sector. In particular, the VRFs that have substantial investments in mixed C&D processing equipment • Cost to fund the permitting, development, operation, and maintenance of the facilities ***(Continued next page)***

Options that could potentially impact C&D recovery overall:

#	POTENTIAL OPTION	PROS	CONS
3 *(Cont.)*			• Cost of the marketing campaign required to educate generators of the availability of the programs • Cost to generators for source separating the materials on the job sites (can be more expensive on smaller jobs)
4	Assisting with establishing regional source-separated C&D materials recycling drop-off centers at existing VRFs.	• Creates access to recycling markets for small construction jobs that otherwise wouldn't have affordable, local access • Increases the material quality and recyclability over mixed C&D materials • Uses existing infrastructure • Easier than permitting, developing, and operating new sites • Prevents government competition compared to # 3 above.	• May conflict with the VRFs that have substantial investments in mixed C&D processing equipment • Cost to generators for source separating the materials on the job sites(can be more expensive on smaller jobs) • Increased potential for out-of-state transport from generator when/if less expensive. In these cases it may financially impact VRFs, and ultimately impact jobs • Potential impacts to current operations (traffic flow, etc.) • Potential site limitations (adequate storage, queuing areas, etc.) • Permit limitations
5	Integration of C&D recycling operations at the state-owned Resources Recovery Facility (RRF) and Transfer Stations, to include either source separated drop-off facilities and/or mixed C&D materials recycling and/or transfer to other recyclers.	• Could be accomplished via an RFP process similar to the MIRA, (formerly CRRA) solicitation of proposals for redevelopment of the Connecticut Solid Waste System Project. [16] • Creates better access to recycling markets • Uses existing infrastructure • Easier than permitting, developing, and operating new sites	• Potentially competes with private sector. In particular, the VRFs that have substantial investments in mixed C&D processing equipment • Cost of implementation • Potential impacts to current operations (traffic flow, etc.) • Potential site limitations (adequate storage, queuing areas, etc.) • Permit limitations • Potentially competes with private sector
6	Creation of targeted waste reduction and recycling educational programs for generators of C&D materials.	• Results in waste reduction (resulting in less material requiring recycling and/or disposal) • Results in more recycling	Costs of implementing the campaign

[16] http://www.ct.gov/deep/lib/deep/waste_management_and_disposal/solid_waste/MIRA_RFP/CSWSP_RFP.pdf

Options that could potentially impact C&D recovery overall:

#	POTENTIAL OPTION	PROS	CONS
7	Incentivize and promote deconstruction.	• Results in higher value reuse of building materials • Tax incentives for reuse of materials • Additional job creation compared to standard building demolition practices	• Lack of significant outlets for reusable materials • Additional time required for planning, deconstruction, and reuse/donation
8	Requiring mandatory recycling of C&D materials (or individual components) by generators.	• Results in more recycling • More likely to result in source separated recycling and increasing the material quality versus mixed C&D recycling • Appropriately places the burden (and cost) on the generator of the waste versus the processors	• Still not likely to achieve 60% goal unless energy recovery and landfill applications are considered diversion. A similar program in MA, having been in place for 7 years has increased recycling from approximately 14% to 25%. Adding energy recovery (~13%) and landfill uses (~20%) the total diversion achieved in MA is approximately 58%. • Costs for implementing and administering the program state-wide • Likely increase in regional (CT-wide) tipping fees at least temporarily for the service given the low recovery rates achieved under non-mandatory "open" market • Current lack of processing for some materials (namely gypsum), and limited end markets for some materials (namely mixed wood, asphalt shingles) • Potential additional cost for accessing markets (depending on location within the state and current markets for components of C&D) • Could potentially lead to an increase in illegal dumping
9	Requiring mandatory recycling of C&D materials (or individual components) by VRFs.	• Results in more recycling • Provides a "level playing field" for all VRFs versus the current status of permits with varying recycling goals which may have the effect of driving materials from recycling facilities to facilities that transfer for disposal	• Still not likely to achieve 60% goal unless energy recovery and landfill applications are considered diversion • May require modification to the existing regulations for facilities "grandfathered" in with existing permits not seeking expansions and/or modifications ***(Cont.)***

Options that could potentially impact C&D recovery overall:

#	POTENTIAL OPTION	PROS	CONS
9 *(Cont.)*		• Uses existing regulatory authority • Ease of implementation on 29 permitted VRFs versus statewide implementation on all generators for # 7 above	• Likely increase in cost for the service given the low recovery rates achieved under non-mandatory "open" market, and the relatively low disposal costs being afforded to the VRFs from out-of-state landfills for disposal currently. • Places the burden on the VRFs versus the generators • Results in mixed materials with lower value being recovered from mixed waste streams. • Potentially could result in C&D materials being transported from CT construction sites to out-of-state facilities unless requirements for tracking are also implemented • Could potentially lead to an increase in illegal dumping
10	Requiring mandatory waste diversion/recycling programs for generators implemented at the local (municipal) level in conjunction with building permit approval processes.	• Results in additional recycling • Requires proof of recycling, and thus less likely to result in illegal dumping and/or direct out-of-state transfer for disposal	• Costs for municipalities to implement the programs and administer it. • Potential cost to generators depending on the availability of local markets for recyclable materials
11	Establishing a tax on C&D materials transferred for disposal from CT.	• Results in additional recycling • Creates a financial incentive for recycling without implementing a waste ban • Creates a funding mechanism for additional recycling programs	• Increase in cost to generators and processors • Implementation of the program • May increase direct out-of-state transportation & disposal, thus impacting the existing in-state infrastructure and jobs • May require a review for potential federal interstate commerce conflicts
12	Modifying permitting procedures and regulations to expedite the regulatory timeframes for modifying operations to add recycling at VRFs and other regulated facilities (i.e. RRFs).	• Results in additional recycling	• Requires modifications to existing regulations • May require additional CT DEEP staff for implementation
13	Creation of a General Permit system for the addition of C&D picking stations at VRFs.	• Results in additional recycling • Simplifies permitting procedures	• Requires modification to the existing regulations • May require additional CT DEEP staff for implementation

Options that could potentially impact C&D recovery overall:

#	POTENTIAL OPTION	PROS	CONS
14	Reducing financial assurance requirements placed on VRFs and recycling facilities for materials with proven market value.	• Lessens the financial burden of recyclers • Facilitates the development of new recycling facilities and end markets	• Requires development of a new system including modifying and/or phasing out portions of the current system • Requires established, stable markets for recyclable materials
15	Obtaining a regulatory exemption for the transportation of recyclable materials from the 80,000lb GVW weight limit.	• Would result in additional recycling	• Potential impacts to roadways from increased vehicle weight • Environmental impacts of hauling materials greater distances
16	Implementing multi-state planning efforts for the establishment of regional end uses for recycled C&D components.	• Would result in more efficient regional systems • Could be accomplished through the existing NEWMOA program	• Requires multi-state coordination among states with varying recycling/waste diversion goals, definitions, policies, and regulations
17	Implementing a fee on individual difficult to manage materials (durable goods such as carpet, carpet padding, couches, furniture, etc.) similar to the "Bye Bye Mattress" take-back program implemented in CT.	• Would result in increased recycling • Would result in a funding mechanism for implementing recycling programs • Would improve the efficiency of VRFs who are currently receiving large and difficult to manage oversized MSW along with traditional C&D materials	• Costs of implementation of the program • Increased cost to the consumer for those products • Requires development of markets for the used materials
18	Expanding requirements similar to those required of large state funded projects in CT with the CT High Performance Building Standards, to cover all or some portion of the projects not currently subject to the standard (i.e. making LEED mandatory for all projects).	• Uses existing systems (i.e. LEED, CT High Performance Building Standards, etc.) • Requires proof of recycling, and thus less likely to result in illegal dumping and/or direct out-of-state transfer for disposal	• Costs of implementing and administering the program • Potential additional costs for recycling services based on the currently low levels of recovery under "open" market conditions presently
19	Incentivize C&D recycling through the creation of a Recycling Credit system similar to the Renewable Energy Credits for the energy sector.	• Creates an incentive program for facilities to recycle more and dispose less, versus a "penalty" system • Allows the option of disposal through the purchase of "Recycling Credits" from recyclers • Could be a phased implementation of recycling percentages (similar to the increase in percentages for renewable energy)	• Additional cost added to disposal • Costs to implement and monitor the program

Options that could potentially impact C&D recovery overall:

#	POTENTIAL OPTION	PROS	CONS
20	Provide tax exemptions and/or credits for purchases of recycling equipment.	• Provides an incentive versus a "penalty"	• Loss of revenue from taxes
21	Provide a designated C&D permitting "liaison" from CT DEEP to assist recyclers with permitting issues and/or applications.	• Facilitates permitting activity	• May require additional DEEP staff resources

Options that could potentially impact individual material components (or groups of materials):

#	COMPONENT	POTENTIAL OPTION	PROS	CONS
1	Wood	Categorizing the use of C&D-derived wood for biomass fuel as recycling/diversion.	• Would result in higher diversion/recycling rates • Results in the increased use of a relatively low value wood product for energy production, replacing higher value wood waste and/or green wood materials.	• Energy recovery is not consistently considered diversion/recycling • Potentially reduces feedstock for other higher value uses of mixed wood that may be developed in the future.
2	Wood	Create additional and/or maintain the existing Renewable Energy Credits (RECs) for uses of C&D-derived wood at energy facilities in CT.	• Results in maintaining or increasing recovery of wood and reduces demand on higher value wood waste and/or green wood materials. • Maintains/improves the financial viability of the wood market	• Costs to implement the program • Costs of the renewable energy credits to energy rate payers
3	Wood	Modify/implement reporting requirements for wood processing facilities to break down materials from C&D-derived sources versus land clearing debris, urban tree waste, etc.	• Results in more accurate accounting of C&D versus non-C&D materials	• May require a change in regulations and/or policy to implement
4	Wood	Add land clearing debris generation and recycling in the calculations for C&D recycling.	• Results in a higher quantity of recycling	• Results in a significantly larger generation quantity • Difficulties in tracking materials at non-regulated facilities

Options that could potentially impact individual material components (or groups of materials):

#	COMPONENT	POTENTIAL OPTION	PROS	CONS
5	Wood	Remove or lessen the feedstock certification procedures for suppliers of biomass to the Plainfield Renewable Energy and/or newly proposed facilities (and possibly replace with implementation of "back-end" regulations on stack emissions similar to other states).	• Increases the likelihood that more wood producers will supply material to the facility by removing or reducing the complex and costly sampling and inspections program required of its suppliers • Increases Plainfield Renewable Energy's or future facilities and existing RRFs ability to accept from spot markets to supplement major supplies periodically when needed • Reduces the demand for higher value wood waste and green wood	• Potential impacts to air quality would require additional study. • Would require a modification of the facility's solid waste permit • Special waste limits at RRFs, and tipping fees charged
6	Wood	Add land clearing debris and pallets to the list of "Designated Recyclables".	• Well-established existing markets for these materials • Adds a high value clean wood material to the recycling market versus disposal	• May decrease wood entering VRFs
7	C&D Fines	Categorize the use of C&D fines in landfill applications as recycling/diversion.	• Would increase recycling quantities	• Is not consistently considered recycling
8	C&D Fines	Create additional outlets for fines at stand-alone residual landfills and/or in conjunction with ash landfills for RRF ash materials.	• Would increase recycling quantities • Would decrease disposal costs and increase the profitability of the processors	• Need to establish proper SOPs to reduce hydrogen sulfide gas issues associated with gypsum • Difficulty of permitting new/expanding existing landfills • Costs to permit, design, and operate facilities
9	C&D Fines	Provide grants for research on the prevention of hydrogen sulfide gases releases from the use of C&D fines in landfill disposal and/or alternative uses.	• If successful, would increase recycling quantities • Would decrease disposal costs and increase the profitability of the processors	• Cost of the grants

Options that could potentially impact individual material components (or groups of materials):

#	COMPONENT	POTENTIAL OPTION	PROS	CONS
10	Asphalt Shingles	Modify the existing policies on the use of asphalt shingles to include top coat hot mix asphalt in addition to binder coat.	• Would result in increased recycling	• Would require modification of existing policies/regulations • May require additional research on material performance
11	Asphalt, Brick, Concrete	Modify/implement reporting requirements for aggregate recycling facilities to break down materials received from C&D-derived sources versus roadway and bridge infrastructure materials.	• Results in more accurate accounting of C&D versus non-C&D materials	• May require a change in regulations and/or policy to implement
12	Asphalt, Brick, Concrete	Add Asphalt, Brick, and Concrete generation and recycling in the calculations for C&D recycling.	• Results in a higher quantity of recycling	• Results in a significantly larger generation quantity • Difficulties in tracking materials at non-regulated facilities
13	Oversized MSW/Bulky Waste	Modify/implement reporting requirements for VRFs to account for Oversized MSW/Bulky Waste materials separately.	• Results in more accurate accounting of C&D versus non-C&D materials	• May require a change in regulations and/or policy to implement
14	Oversized MSW/Bulky Waste	Education/Promotion of recycling/reuse options.	• Results in a higher quantity of reuse/recycling	• Cost of the program; use of staff resources to conduct the educational programs
15	Oversized MSW/Bulky Waste	Conduct a composition study of Oversized MSW/Bulky Waste.	• Would provide better knowledge of components, and thus assist in developing reuse/recycling options	• Cost of the study
16	Oversized MSW/Bulky Waste	Create policy to require separate handling of C&D waste and Oversized MSW at CT C&D VRFs.	• Would provide better data for quantities of Oversized MSW managed at CT VRFs • Could improve the condition of potentially recoverable materials at the VRFs	• Cost of creating and maintaining separate acceptance areas at the CT C&D VRFs • Potential for less recovery if it is diverted to a disposal only-area.

9.5 Recommendations for Implementation

Given the status of CT's current C&D management practices, and the state's goals and objectives, drastic measures will be required to meet the goal of 60% diversion in the next 8 years. Based on the options presented above, and the need for significant changes, Green Seal has the following recommendations, laid out in the three categories:

- Short-Term Implementation and Study: Within 1-2 Years
- Longer-Term Implementation and Study: Within 2-4 Years
- "Contingency" Implementation and Study: Greater than 4 Years if the strategies developed in years 1-4 fail to make significant progress toward the 60% diversion goal

9.5.1 Short-Term Implementation and Study (Within 1-2 Years)

1) Conduct a review of the solid waste permitting regulations in order to enable the timely buildout of the C&D recycling infrastructure to expand toward the 60% goal. Modify permit review timelines to include definitive review and response times, and final decision times.
2) Assess the implementation of a General Permit for C&D recycling at existing VRFs to add basic sorting operations (i.e. picking stations) to existing facilities, to reduce permitting and regulatory burden.
3) Designate a CT DEEP C&D facility permitting liaison to assist C&D recycling businesses (either from within the permitting group, or outside of the group)
4) Develop a funding mechanism to be used for the development of C&D end markets and/or intermediate processors. Options include but are not limited to:
    a. Obtaining funding as part of the DEEP annual operating budget
    b. Creating a disposal fee (tax) levied on all C&D/bulky waste transferred for disposal. May require a review for potential federal interstate commerce conflicts.
5) Institute the grant and/or recycling loan programs using the revenue from the funding mechanism above for C&D materials; potentially in conjunction with The RecycleCT Foundation. Grants could include:
    a. Research and development for recycling and processing technologies (including all C&D components and the management of fines and residuals from recyclers)
    b. Targeted materials for undervalued/underutilized materials such as gypsum and asphalt shingles
    c. Purchases of recycling equipment
    d. Development of regional consolidation facilities to "feed" existing recycling operations
    e. Investments in alternative energy such as solar to augment power for their energy-intensive processing equipment
    f. Development of facilities to warehouse and market salvaged building materials
6) Conduct a feasibility assessment for the siting of satellite drop-off facilities for consolidation of source-separated C&D materials; potentially through the issuance of an RFP for potential developers/operators. Options for analysis may include:
    a. Public ownership and operation of facilities
    b. Private ownership and/or operation of facilities

c. Using existing public infrastructure (similar to the RFP for the MIRA RRF and Transfer Stations)
d. Using existing Transfers Stations, VRFs, and Recycling Facilities

7) Leverage knowledge and resources of other state agencies (I.e. CT Department of Economic and Community Development) for siting and/or expanding businesses and creating jobs in CT. Should a grant/loan program be implemented as described above, it can be used as an additional recruitment tool.
8) Implement an educational program aimed at reducing disposal through reuse and donation of potentially reusable durable goods that are often disposed as bulky waste (AKA Oversized MSW) such as used building materials, furniture, furnishings, children's plastic toys, etc.
9) Modify the "Items Designated (i.e. Mandated) for Recycling" in CT to include land clearing debris and pallets, provided that materials can still be accepted and recycled at VRFs.
10) Modify VRF reporting to categorize Oversized/MSW separately from Mixed C&D, and/or modify the policies for separate management of the materials at CT C&D VRFs.
11) Modify VRF reporting and/or related policies on the categorization of C&D-derived wood used for energy production to allow it to be categorized as a management option given that it is a renewable energy source and is directly substituting other higher value wood wastes and/or green wood.
12) Maintain and/or expand the current RECs program for renewable energy from wood waste.
13) Modify the existing policies on the use of asphalt shingles to include top coat hot mix asphalt in addition to binder coat.
14) Conduct a composition study for Oversized MSW managed at CT VRFs

9.5.2 Longer-Term Implementation and Study (Within 2-4 Years)

1) Create additional outlets for C&D fines and/or other residuals to be used at stand-alone residual landfills, landfill closure projects and/or in conjunction with ash landfills for RRF ash materials.
2) Remove or lessen the feedstock certification procedures for suppliers of biomass to the Plainfield Renewable Energy and/or newly proposed facilities (and possibly replace with implementation of "back-end" regulations on stack emissions similar to other states)
3) Revise financial assurance requirements to account for recyclable commodity values in calculating facility closure costs
4) Implement a tax incentive program for CT recycling businesses to potentially include:
    a. Property tax exemptions
    b. Income tax credits
    c. Sales tax exemptions for purchases of recycling and recycling-related equipment
5) Implement a fee or product stewardship program for additional individual difficult to manage materials (durable goods such as carpet, carpet padding, couches, furniture, furnishings, etc.) similar to the "Bye Bye Mattress" take-back program implemented in CT.
6) Implement multi-state planning efforts for the establishment of regional end uses for recycled C&D components. Could be accomplished through NEWMOA.
7) Expand waste reduction and recovery requirements similar to those required of large state funded projects with the CT High Performance Building Standards (LEED Silver equivalent), to cover all or some portion of the projects not currently subject to the standard, but that are state and/or municipal-funded projects.

8) Conduct a feasibility assessment for obtaining a regulatory exemption for recyclable materials from the 80,000lb GVW weight restriction in CT.
9) Conduct a feasibility assessment for the creation of a recycling credits program similar to the renewable energy credits (RECs) program to incentivize recycling over disposal.

9.5.3 "Contingency" Implementation and Study (4 Years+)

1) Implement a ban on disposal and/or add mixed C&D materials and/or components to the Items Designated for Recycling in CT. Include: clean wood, mixed wood, clean gypsum, ABC, and asphalt shingles. Conduct enforcement at the generator level versus the VRF level. Simultaneously develop an educational C&D recycling campaign targeting generators, coupled with a system mandating municipalities to create and institute recycling "deposit" systems as part of their building permit processes to comply with the ban.

SECTION 10.0 RECOMMENDATIONS FOR INCREASES IN THE QUANTITY OF C&D COLLECTED, TRANSPORTED, PROCESSED, AND RECOVERED

10.1 Introduction

Green Seal performed research to identify changes to the current collection, transportation, and processing practices that could enable the recovery of greater quantities of materials for reuse, beneficial use, recycling, fuel production, and energy production.

10.2 Collection Practices

Mixed C&D is mainly collected in roll-off containers in CT. As described in Section 6.0, the types of materials produced (construction, renovation and/or demolition) and specific building materials used (wood framed versus masonry construction) can dictate the containers used for the collection of materials as well as where the material is shipped.

Based on the research conducted, the size of the collection containers used is generally determined by the customers with guidance from the hauling companies. Additionally, unless specified by the generator (and typically only when required of the generator), the hauling companies generally will not suggest multiple containers for source separated recycling, and/or recommend transporting mixed materials specifically to VRFs with recycling systems.

As discussed in Section 9.0, Green Seal recommends the state determine the feasibility of providing source separated recyclable C&D materials "drop-off" sites for use by contractors to facilitate local access, and to increase the quantity of higher value recyclables before they are commingled. This could include state-owned/operated facilities at new or existing sites (such as the MIRA transfer stations), new sites, and/or privately owned and/or operated new sites or additions to existing VRFs and recycling facilities.

10.3 Transportation Practices

Currently, almost all mixed C&D generated in CT is transported from the point of generation to VRFs either with or without C&D processing systems. Locations are chosen primarily based on the proximity to the generator, roll-off container pricing, or the tipping fees at the VRF. In order to increase quantities of the materials transported to VRFs with recycling systems, one or some of the following would have to occur:

1) Implementation of a waste ban mandating generators to have their waste transported to a VRF with recycling,
2) More of the existing VRFs would have to integrate recycling systems into their operations in order to provide local receiving facilities,
3) New VRFs would need to be sited with recycling systems, and/or
4) Materials would need to be consolidated at local VRFs without recycling systems, and transported to locations with recycling systems.

For outbound recyclable materials transported from VRFs to end markets, the transportation practices depend on the commodities being transported, as well as the size and configuration of the facility. Considerations that can impact transportation practices can include:

- Use of 100-CY live-floors (either from the tipping floor or in recessed loading areas),
- Rail integration,
- Loading docks for fork lifts,

- Automated conveyance systems (screw augers, conveyors, etc.) for direct loading of containers and/or trailers
- Compactors and balers

Some of the most common commodities recycled at VRFs and their transportation methods include:

Commodity (ies)	Transportation Systems
Mixed and/or Clean Wood	Bulk unprocessed and processed wood from VRFs is typically transported out in 100CY live-floor trailers.
Metals	Metals (both ferrous and non-ferrous) are typically transported from VRFs loose (not baled), in roll-off containers varying from 10-50 CY.
Aggregates	Unprocessed and processed aggregates are typically transported from VRFs to processing facilities in dump trucks.
C&D Fines	When markets are available locally (within the New York/New England Region), C&D fines are typically transported from VRFs in 100CY live floor, and transported out by rail if being shipped to OH for disposal.
Plastics	Mixed plastics are typically being shipped out in 30-40 CY roll-off containers when not baled. Baled plastics are transported in box trailers and loaded/unloaded by fork lift.
Cardboard	Cardboard is either transported in large (30 CY or 100CY live containers or trailers) when not baled. Baled cardboard is transported in box trailers and loaded/unloaded by fork lift.
Gypsum	Gypsum is transported from VRFs in 100 CY live-floor trailers.

A current impediment for the efficient transportation of virtually all commodities is the 80,000lb GVW limit in CT which results in a higher cost per ton for transportation, and lower quantities of recyclables being transported from CT facilities. A related impediment is the lack of local markets for some materials including:

- Gypsum: The closest market currently accepting gypsum is outside of Philadelphia, PA.
- Mixed Wood: While one local market exists with enough capacity to handle a large portion of CT's recoverable Mixed Wood (Plainfield Renewable Energy), all other markets are significant distances, and include Maine, Canada, and upstate New York.
- C&D Fines: Almost no local markets exist and materials are being transported for disposal either in over-the-road long-haul trailers or in rail cars.

To increase quantities of materials transported from VRFs for recycling (versus disposal), additional local markets are needed for gypsum, mixed wood, and C&D fines.

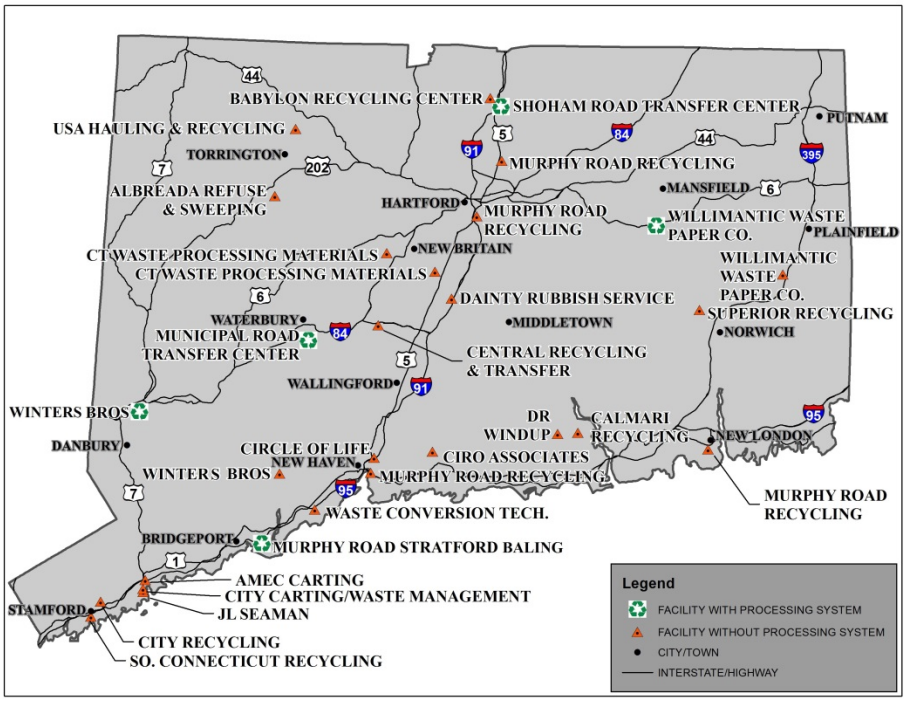
10.4 Processing Practices

As discussed in Section 4.0, only five (5) of the twenty-nine (29) VRFs operate processing systems. For purposes of this study, Green Seal considered a facility to have a "processing system" if it operated a picking station where materials can be visually sorted by hand. Many of

the VRFs perform “kick-sorting” using mechanized rolling stock such as excavators, loaders, skid steers, etc. However, this practice is less likely to achieve significant recycling rates for mixed loads of C&D/Oversized MSW. It should be noted that during interviews with VRFs, several facilities indicated their intentions to incorporate fixed processing infrastructure into their facilities in the future. As shown previously in Section 4.0 and provided again below, Figure 4.3 shows the locations of VRFs with recycling systems. These facilities provide fair coverage geographically and based on population, with the exception of “pockets” without local access in:

- Central/Southern Hartford
- New Haven
- Torrington
- Stamford
- Norwich/New London

Figure 4.3 CT C&D VRFs with Processing Systems



As discussed above in the Transportation Practices section, in order to increase quantities of C&D recycled within CT, additional recycling facilities are needed geographically to provide local access.

In addition to reviewing the geographic coverage and need for new facilities, Green Seal also assessed the existing facilities and the current and future potential for increasing recycling quantities. Based on a review of facility permits, site visits, interviews conducted with VRF operators, and Green Seal’s knowledge and experience with similar processing systems throughout the northeast and other parts of the country, it is Green Seal’s opinion that the existing VRFs with recycling systems are realistically capable of achieving 30-40% or greater recycling/recovery by weight of mixed C&D materials with the following conditions/assumptions:

- Recovered metals, OCC, and other “designated” recyclables count toward overall recycling.
- Integrated facility/hauling companies can take credit for recyclable materials collected separately at the source as well as what is sorted at the facility.
- Source separated loads of land clearing debris and other “green” waste such as trees, stumps, and brush is not counted towards generation and recycling.
- Source separated loads of road and bridge materials (ABC) are not counted towards generation and recycling.
- The lack of markets for C&D fines continues to result in their disposal, and/or fines are not counted towards recycling or diversion.
- The markets for clean wood (pallets, clean dimensional lumber, etc.), metals, aggregates, cardboard, and plastics continue to be accessible and at least relatively stable.
- The market for mixed wood (biomass fuel) remains stable, and biomass fuel is counted toward recycling/recovery.
- The market demand for recycled asphalt shingles continues to be limited due to the approved usages.
- VRFs continue to accept and transfer at least limited amounts of gypsum and asphalt shingles to other recycling facilities.

Recovery rates are currently significantly lower than the facilities’ capabilities due to inexpensive landfill disposal options, and marginal post-consumer markets when compared to the additional costs of labor to sort more materials from the mixed waste stream. Thus, the quantities that the facilities can produce are not necessarily due to the limitations of the processing systems, but rather a function of the impact to profitability of increasing sorting and recycling without a mandate (permit condition and/or waste ban) and their need to compete with disposal markets (in and out of state).

10.5 Sorting Technologies and their Impact on Recycling Quantities

Generally, mixed C&D waste streams are handled in either one of two methods:

- Positive sorting where materials are hand sorted from mixed materials. This is typically accomplished by picking stations where laborers remove materials that have value. The materials that remain on the sorting line after valuable materials are removed are then discarded. This technique represents the majority of the systems in CT and throughout the northeast.
- Negative sorting where a predominately homogenous waste stream has components removed from it to produce a “cleaner” product. Given that wood is a large percentage of the inbound waste stream of mixed C&D, the negatively sorted material is always wood, from which all other materials are removed. Facilities with negative sorting systems often either “pre-sort” large non-wood materials prior to their being processed in mixed C&D systems, and/or accept only loads with high wood content. Of the CT VRFs interviewed, none are currently performing a negative sort for wood material, and negative sorting is only performed at a few facilities in the northeast. The facilities that maintain these systems are highly mechanized systems with many additional sorting and size reduction processes integrated.

Both positive and negative sorting systems typically include screening systems (trommel screens, disc screens, finger screeners, vibratory shaker pans, etc.) to remove fines and make

materials easier to sort by hand. In addition to the common screening/sorting system components, a variety of technologies are employed based on the end markets and design preferences of the facility owners/operators. Some of these technologies include:

- Size reduction equipment (pre-shredders and crushers),
- Magnets (both ferrous [head pulley, drum and overband] and non-ferrous [eddy current])
- De-stoning equipment to sort heavy from light fractions
- Float tanks to sort heavy from light fractions (the goal being aggregates from wood), and/or
- Air knife/Air Classification systems (to remove lighter paper and plastics from other materials – generally coupled with destoners)
- Grinders (high speed mills used for size reduction of wood and residuals)

Similar to single stream recycling versus curb-sorted materials, and the arguments for and against, the issues that arise when comparing positive and negative sorting systems include:

- Significantly higher quantities of wood material can be generated through negatively sorted, predominantly wood waste streams
- Higher quality recyclables are obtained from positive sorting materials by hand
- Negative sorting systems generally only produce one category of mixed wood, and thus higher value markets are not an option for negatively sorted wood
- Mixed C&D waste streams can overwhelm negative sorting systems with excessive contamination (meaning non-wood materials), and can impact the quality of the wood product at the end of the sorting system.
- Some facilitates in the northeast producing negatively sorted mixed wood do not currently meet quality standards and/or preferences of consumers of biomass fuels.

Given the above, while negative sorting systems do generally produce higher quantities of wood for recycling, the quality of the product may prevent its use. Further, creating a negatively sorted wood material prevents clean wood from being used for higher value products.

10.6 Accounting and Reporting Practices and their Impact on Recycling Quantities

Although not an impact on the actual amount of recycling that takes place, differences in accounting and reporting practices could result in a “reporting increase” in the quantity of materials recycled, if not properly tracked. Given the need to accurately account for materials at all facilities consistently, Green Seal researched the various possible reporting scenarios and how that could impact (increase or decrease) reporting quantities.

If VRFs also accept source separated loads of ABC and those materials are added to their recycling totals (and inbound waste totals), then the total recovery rates of the VRFs would be higher. This is particularly significant with aggregates given that the materials weigh approximately 1 ton or more per cubic yard. However, given that these materials aren’t typically landfilled and therefore aren’t typically counted in C&D generation and recycling figures, it would have the effect of artificially “boosting” their recycling quantities.

Similarly, if source separated loads of land clearing materials are accepted at VRFs, and their generation and recycling were added to the totals, the recovery rates of the VRFs would be higher. However, land clearing debris is not typically landfilled, isn’t typically considered a component of C&D materials, and therefore isn’t typically counted towards generation and recycling. As with road and bridge materials, accounting for the materials would also have the effect of artificially “boosting” recycling numbers.

Given that ABC materials (particularly road and bridge materials) and land clearing materials are already recycled at high rates under an "open market" without a waste ban (likely 95%+ recycling currently), in Green Seal's opinion it would be illogical to include these materials in the generation and recycling numbers for VRFs. Looking at an example for comparison to other commodities, when calculating solid waste generation and recycling in CT, metals received at all CT scrap yards are not included in generation/recycling calculations. It would be illogical and impractical to calculate the annual generation of post-consumer durable metal goods (automobiles, structural I-beams, etc.) and then count their recycling since they're seldom disposed.

Taking a closer look at how this may impact "reported recycling" versus actual recycling activity, and potentially have a negative impact on the recycling of mixed C&D materials, Green Seal offers the following scenario:

> *If CT VRF Facility XYZ obtains a permit with the condition to recycle 60% of all inbound materials regardless of the types of materials, and the facility has no existing processing equipment for mixed C&D, the facility would have to adapt by either adding processing equipment, transferring materials to processors for recycling, or by shifting their percentages of inbound materials to include more recyclable materials. The facility could theoretically replace some portion of their inbound tonnage or add new tonnage by accepting and transferring for recycling large quantities of ABC materials in order to meet the recycling goal. Under this scenario, ABC materials which were already being recycled at other locations were brought in to compensate for the more difficult recycling of mixed C&D. The mixed C&D materials could then be disposed while still meeting the facility's goal of 60% diversion. For example, if CT VRF Facility XYZ has a permit for 300 tons per day, but normally takes in an average of 100 tons per day of mixed C&D, the facility could theoretically meet the goal by taking in an additional 150 tons per day of ABC. However, under this scenario, no additional recycling actually occurred.*

While this example takes it to the extreme, in Green Seal's opinion it is likely that if source separated ABC materials and/or land clearing debris is counted towards recycling, then at least some amount of mixed C&D recycling will be "displaced" by accepting a higher percentage of those materials which would already otherwise be recycled elsewhere.

For this reason, Green Seal recommends that facilities with recycling requirements be required to report these materials separately in order to obtain "credit" for recycling. As an example, a possible method could be as follows:

- <u>ABC:</u>
  - Report inbound source separated loads of ABC materials separately
  - Report outbound ABC materials from source separated materials separately
  - Report outbound ABC materials sorted from mixed loads of C&D separately. Once materials are sorted from mixed C&D, weigh the materials prior to transporting them off-site or stockpiling with other source separated materials. Consider the ABC materials recycled when they either leave the site directly without being mixed with other source separated materials, or, if they're combined with other source separated materials as follows:

- After the combined materials are consolidated and/or processed, and transported off-site, calculate the total quantity of material transported off site for that period. Call that quantity A for purposes of this example, and assume a weight of 100 tons.
- Then, subtract the amount of ABC separated from the mixed loads that was weighed prior to being consolidated (call that quantity B, with an assigned value of 25 tons), to obtain the quantity of Source-separated ABC sent out for recycling (call that quantity C with a value of 75 tons).
- For reporting, report the outbound quantities separately with:
  - Outbound Sources Separated ABC (C) = 75 tons
  - Outbound Mixed C&D-derived ABC (B) = 25 tons
- When determining facility recycling quantities, only count value B, 25 tons

o As a check, compare the recycling quantities to the percentages of materials typically found in mixed loads of inbound materials. Based on the waste load observations of mixed materials entering VRFs, ABC materials represented approximately 3% of inbound materials. Quantities reported above 5% may indicate problems with accounting for source-separated versus mixed C&D materials.

- <u>Wood:</u>
  - o Report inbound source separated loads of land clearing debris separately.
  - o Report outbound land clearing debris materials separately.
  - o Report outbound mixed wood or clean wood separately from land clearing debris. Once materials are sorted from mixed C&D, weigh the materials prior to transporting them off-site or stockpiling with other source separated materials. Consider the wood materials recycled when they either leave the site, or are combined with the other stockpiled source-separated materials.
  - o Report outbound wood materials sorted from mixed loads of C&D separately. Once materials are sorted from mixed C&D, weigh the materials prior to transporting them off-site or stockpiling with other source separated materials. Consider the materials recycled when they either leave the site directly without being mixed with other source separated materials, or, if they're combined with other source separated materials, in the same manner as ABC.
  - o As a check, compare the recycling quantities to the percentages of materials typically found in mixed loads of inbound materials. Based on the waste load observations of mixed materials entering VRFs, wood materials represented approximately 38% of inbound materials (the theoretically available percentage of wood if it were all extractable). Quantities reported above 40% may indicate problems with accounting for source-separated land clearing materials versus mixed C&D materials.

10.7 End Market Capacity Quantities

Green Seal researched the end market capacities of the commonly recycled C&D materials, to determine whether capacity is preventing larger quantities of materials from being recycled. As presented in Section 3.0, based on the waste load observations of inbound materials at CT VRFs, Green Seal estimated the quantities of materials available for recycling by category. It should be noted that these are "theoretical quantities" based on averages of the loads observed, and materials entering VRFs vary considerably. Additionally, it is not realistic to assume that all or even high percentages of individual materials can be recovered as most are entering VRFs in mixed loads.

Table 10.1 Theoretical Quantities of C&D Materials Available for Recycling

Material Category	Percentage	Tonnage
Wood	38.1%	397,204
Other	30.1%	313,110
Shingles	10.4%	108,131
Gypsum	6.3%	65,951
Packaging Waste	6.2%	64,831
Metal	3.8%	40,085
ABC	3.2%	33,398
Ceramics	0.7%	7,752
Plastics	1.1%	11,180
Totals	**100.0%**	**1,041,643**

Based strictly on a comparison of the quantities of C&D materials theoretically available to the current capacity of the end markets available (regardless of markets prices, etc.) to consume these materials, Green Seal offers the following observations:

- The markets for clean wood, metals, aggregates, cardboard, and plastics are well established and the materials are not currently restricted by market capacity limitations.
- The market capacity for mixed wood is limited to two end uses currently:
    - Biomass fuel consumed by facilities in CT, ME, NY, and Canada
    - Feedstock for the manufacture of recycled content wood products (particle board and decorative wood panels)
- Comparing mixed wood generation (~400,000 tons if all materials were extractable, and none was removed for clean wood markets), to the capacity of the end markets above, the current markets could theoretically manage all C&D-derived wood materials from CT sources. It should be noted, however, that Treated Wood (approximately 3% of the wood category or approximately 1% of all C&D materials) cannot be accepted at the current outlets for mixed wood.
- Looking closer at "local" capacity, mixed wood is only currently marketable to one outlet, Plainfield Renewable Energy. Based on discussions with company representatives, the capacity of the facility is approximately 250,000 tons per year at full operation. This equates to approximately 63% of the total theoretically available wood in CT.
- The market capacity for gypsum is relatively difficult to determine given that it is currently limited to only one outlet located in Pennsylvania. However, given the relative size of the waste stream at only approximately 6% or roughly 60,000 tons, and the fact that it is mostly unrecoverable unless its source separated, it is likely that the one existing market could handle the majority if not all of the quantity of recoverable gypsum. Additionally, according to a company representative, USA Gypsum recently moved into an expanded facility.
- The market capacity for asphalt shingles is also relatively difficult to determine based on the given that there are only two stand-alone facilities in CT. Based on communication with representatives with both companies, and their current storage limitations, it is likely that additional recycling facilities, expansion of the existing facilities, and/or the creation of satellite storage yards would be required to meet the demand from the theoretically available approximately 110,000 tons per year of asphalt shingles.

SECTION 11.0 RECOMMENDATIONS FOR INCREASES IN THE EFFICIENCY OF C&D COLLECTED, TRANSPORTED, AND PROCESSED

11.1 Introduction

In addition to researching methods for increasing quantities of C&D collected, transported, and processed in CT as discussed in Section 10.0, Green Seal performed research to identify changes to the current practices that could enhance efficiency.

11.2 Collection Practices

As described within Section 10.0, mixed C&D is mainly collected in roll-off containers in CT, and the types of materials produced (construction, renovation, and/or demolition) and specific building materials used (wood framed structures versus block or brick construction) can dictate the containers used for the collection of materials. “Commingled” C&D collection and transportation to one mixed C&D recycling facility is arguably the most efficient system, strictly from an on-site labor (waste generator’s labor) and transportation efficiency standpoint. However, as discussed previously, mixed C&D collection impacts the quality of the potentially recyclable materials. Among the materials impacted are the following:

- Gypsum, especially new construction cut off is relatively easily source separated at construction sites and renovation projects. Typically the gypsum work is completed during one phase of construction and the materials can be sorted at that time. Demolition projects involving gypsum produce a lower quality material that may be too difficult to remove or efficiently sort. Additionally, renovation related gypsum may have coatings (e.g. paint) that may preclude the material for certain post-consumer uses. If/when construction and renovation materials are mixed with other C&D and sent to a recycling facility, the materials are of lower quality, potential contaminated with other components, and fractured to the point where they may be too small to be efficiently sorted from mix materials.
- Asphalt shingles are relatively easily source separated. The materials generated from re-roofing are typically 95%+ asphalt shingles with limited flashing and other wood materials. Mixing the materials at a C&D recycling facility greatly reduces the efficiency of recycling the shingles.
- Packaging materials are relatively easily sorted prior to commingling. Plastic wrap is generally too light, bulky, and intertwined with mixed materials to remove efficiently after it enters a mixed C&D recycling facility. Similarly, cardboard is easily source separated during generation and may have a reduced quality once it reaches a mixed C&D recycling facility. While a small weight of the overall C&D makeup, cardboard was observed to be a substantial volume of material entering VRFs based on the waste observation exercises conducted.
- Asphalt, brick, and concrete materials are relatively easily source separated. Mixing with materials at a C&D recycling facility greatly reduces the efficiency of removal, and if using a mechanized sorting methodology (e.g. de-stoner) may get contaminated with other materials such as ceramics, glass and metal.
- As witnessed during the waste observation exercises, potentially salvageable materials such as used building materials and other durable goods are likely to be damaged beyond salvage when transported commingled and dumped on a tipping floor.

The efficiency of source separation can be impacted by the size of a project. With larger construction projects, there are economies of scale that improve the efficiency of source separation. For example, the large projects subject to the CT high performance building standards produce a much larger quantity than say, the construction of a single-family house. Therefore the larger quantities and lower tipping fees for source separated materials can justify having multiple containers on-site and the transportation costs of going to multiple markets. Regardless of the size of the project (I.e. square feet of construction), the amount of available space for on-site logistics can always play a role in the amount of source separation that can occur on a site (e.g. highly urbanized areas may not have ample staging areas for multiple containers).

In addition to the size of the project, the type of construction activity and the materials produced can dictate the efficiency of source separation. Based on the research conducted, and Green Seal's knowledge of the industry, source separation is more likely to take place on construction projects than with renovation and/or demolition of wooden structures. Separating items such as gypsum from wood framing materials is generally cost prohibitive during demolition. On the other hand, concrete and masonry demolition projects almost always result in the source separation of these materials from the other construction materials due to their weight and the significant cost savings over mixed C&D recycling services.

Based on these considerations, and as discussed in the previous sections, Green Seal recommends the state determine the feasibility of providing source separated recyclable C&D materials "drop-off" sites for use by contractors to facilitate local access, and to increase the quantity of higher value recyclables before they are commingled. This could include state-owned/operated facilities at new or existing sites (such as the MIRA transfer stations), new sites, and/or privately owned and/or operated new sites or additions to existing VRFs and recycling facilities. Given that a lot of the infrastructure is already in place at the existing VRFs, and to prevent competing against the private sector which has invested heavily in the creation of the state's C&D recycling infrastructure, Green Seal recommends that working with existing facilities be given priority consideration.

11.3 Transportation Practices

As discussed in Section 10.0, currently almost all mixed C&D generated in CT is transported from the point of generation to VRFs either with or without recycling systems. Locations are chosen primarily based on the proximity to the generator, roll-off container pricing, or the tipping fees at the VRF. Similar to increasing quantities, to increase efficiency of the materials transported to VRFs with recycling systems, one or some of the following would have to occur:

5) More of the existing VRFs would have to integrate recycling systems into their operations in order to provide local receiving facilities,
6) New VRFs would need to be sited with recycling systems, and/or
7) Materials would need to be consolidated at local VRFs without recycling systems, and transported to locations with recycling systems, which presently occurs in several instances.

Section 10.0 described the transportation practices for outbound recyclable materials transported from VRFs to end markets. Historically in CT, the creation of VRFs was to improve the efficiency of the consolidation and management of C&D and bulky waste materials. Not surprisingly, transportation practices of materials from the VRFs are highly efficient. However,

the practices are set up for a combination of disposal and recycling, and currently under "open market" conditions, the VRFs are recovering only small amounts of materials.

Transportation via rail is likely the most efficient transportation system available for waste and/or C&D fines given the 80,000lb GVW limit in CT which results in a higher cost per ton for transportation for over-the-road transport. Based on the research conducted, no facilities were found to be transporting outbound recyclable commodities by rail. The reasons given varied by commodity, and include:

- Wood: Sorted wood is too light to efficiently transport via rail. Additionally, no mixed or clean wood end-markets exist via rail currently. Local markets (mulch, Plainfield Renewable Energy, etc.) would not justify transportation via rail intrastate.
- Packaging Waste (cardboard, etc.) and Other Plastics: Materials are too light for efficient rail transport. Baled cardboard and/or plastics could be a commodity shipped by rail, however, overall volumes of packaging waste and other plastics are too small to justify stockpiling and rail transport generally. Local markets exist for these materials and would not justify rail transport intrastate.
- Gypsum: No end markets for gypsum via rail. Volumes of gypsum are too small to justify stockpiling and rail transport.
- Aggregates: End markets may exist for aggregates, however, volumes are too small to justify stockpiling and rail transport and local use and infrastructure is already adequate.
- Asphalt Shingles: No end markets for asphalt shingles currently available by rail. One facility did report sending processed shingles out for recycling via rail at one point. Local markets are available for unprocessed shingles.

All materials not transported by rail are generally transported using long-haul over-the-road trailers (100CY live floor trailers); however, some more dense materials such as aggregates are transported in dump trucks and/or roll-off containers due to their weight per cubic yard.

To increase the efficiency of materials transported from VRFs for recycling (versus disposal), additional local markets and uses are needed for gypsum, mixed wood, asphalt shingles and C&D fines. Additionally, if room allows, baling of cardboard and plastics may increase the efficiency of their recovery.

11.4 Processing Practices

As discussed in Section 10.0, recycling facilities provide fair coverage based on geography and population. However, there are exceptions of "pockets" without local access. In order to increase the efficiency of C&D recycled within CT, additional recycling infrastructure or facilities are needed geographically to provide local access.

In addition to reviewing the geographic coverage and need for new facilities and/or infrastructure to increase efficiency, Green Seal also assessed the existing facilities and the current and future potential for increasing efficiency. Based on a review of facility permits, site visits, interviews conducted with VRF operators, and Green Seal's knowledge and experience with similar processing systems throughout the northeast and other parts of the country, in Green Seal's opinion, the existing VRFs within CT are operating in a manner that is highly efficient for disposal, but not recycling. This is due to the fact that recycling is limited to only five (5) facilities currently, and rail facilities transfer large amounts of material for disposal. As described in Section 10.0, the existing facilities are realistically capable of achieving 30-40% or greater recycling/recovery/diversion by weight of mixed C&D materials.

Recovery rates are significantly lower than the facilities' capabilities currently due to inexpensive landfill disposal options coupled with marginal markets when considering the additional costs of labor to sort more materials from the mixed waste stream. The efficiency of the processing systems do not appear to be the limiting factor, but rather it is a function of economics and profitability as these facilities ultimately have to compete with the set barriers associated with straight disposal costs.

11.5 Sorting Technologies and their Impact on Recycling Efficiency

As discussed in Section 10.0, mixed C&D waste streams are handled in either one of two methods:

- Positive sorting where materials are hand sorted from mixed materials.
- Negative sorting where a predominately homogenous waste stream has components removed from it to produce a "cleaner" product.

Similar to the discussion of how each impacts the quantities of recovered materials, while negative sorting systems are arguably more efficient, the quality of the product may prevent its use as such. Further, creating a negatively sorted wood material prevents clean wood from being used for higher value products.

11.6 End Market Efficiencies

Similar to the research conducted on end-market capacity (quantities), Green Seal researched whether the acceptance practices of the current end markets are impacting the efficiency of recovery. Green Seal offers the following observations by material (or group of materials), and recommendations for efficiency improvements (as discussed in Section 9.0):

- Commonly Recycled Materials: The end markets for clean wood, metals, aggregates, cardboard, and plastics are well established and the materials are not currently impacted by end market acceptance inefficiencies.
- Mixed Wood: Given transportation limitations, mixed wood markets primarily consist of one local outlet at this time. An improvement in the efficiency would therefore be the creation of additional outlets for the mixed wood materials. The limitations on the one market itself (Plainfield Renewable Energy) are also potentially impacting the efficiency of the use of mixed wood for biomass fuel in CT. The facility is currently limited to acceptance from VRFs and other out-of-state processors with approved fuel supply protocols only. Storage limitations for feedstock, and for ash (which must be tested on-site prior to disposal) are also limitations for the facility itself. These facility limitations can impact the efficiency of the market for recovered mixed wood in CT. Green Seal recommends the following:
    - A review of the existing wood fuel certification processes and procedures. The focus would be:
        - Streamlining the sampling procedures where feasible
        - Consideration of a phased reduction of facility-based and/or generator-based sampling over time. This reduction would be premised on an assessment of chemical and physical trends coupled with facility emissions data.
    - A review of the financial assurance requirements and consideration of a phased reduction in requirements over time based on the proven end use for the material and market longevity, given that there are existing outlets for this prepared fuel in

Maine, New York and Canada. Since this material is already properly prepared, loading and transportation costs are the underlying variables versus “disposal” costs associated with other regulated solid waste facilities in CT.

  - A review of the ash stockpiling and/or disposal requirements and consideration of a phased reduction of these requirements based on historical trends. A phased reduction would likely involve the need for a risk based statistical analysis that assesses the chemical characteristics of the ash (e.g. hazardous under RCRA).

- Gypsum: The end market for gypsum is currently limited to only one outlet located in Pennsylvania. Thus, the efficiency of end markets would be improved by the creation of additional end markets in or near CT. Based on the research conducted, the one facility itself does not appear to have an impact on the efficiency of the acceptance of the materials. Green Seal recommends that as part of the grant programs and economic development (job creation and business recruitment) programs described in Section 9.0, gypsum end uses be targeted.
- Asphalt Shingles: The processors of asphalt shingles do not appear to be impacting the efficiency of the end use, except that the facilities have limitations for on-site storage and financial assurance requirements which necessitate smaller stockpile volumes. The end use itself, namely the use of shingles in asphalt pavement mixtures is currently less efficient than it could be given that it is not currently widely used at hot-mix asphalt plants. This is due to a current lack of demand given that recycled shingles are only allowed in base courses of pavement which are significantly lower in demand that top course products. Green Seal recommends a modification to the acceptance policies to include asphalt shingles in top course. Also, Green Seal recommends that as part of the grant programs and economic development (job creation and business recruitment) programs described in Section 9.0, asphalt shingle end uses be targeted.
- C&D fines: There are currently no alternative uses (end markets) for C&D fines. Thus, the lack of local markets is the inefficiency for the end market. C&D fines are created in large quantities through the processing of mixed C&D materials, and discounted disposal prices are an important factor in the viability of mixed C&D recycling. Green Seal recommends that through grant funding or other programs, additional research is conducted on the end uses for C&D fines in regulated applications (landfill applications) and their safe use. Green Seal also recommends the study of co-disposal of incinerator ash from RRFs and C&D fines through MIRA or some other effort.

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ADDENDUM - RELEVANT DEFINITIONS [i]

TERM	DEFINITION
BULKY WASTE	"Bulky Waste" means land clearing debris and waste resulting directly from demolition activities other than clean fill. [Note: the CT Solid Waste Management Regulations definition is meant to define "bulky" or large volume waste streams such as Construction and Demolition Waste (dimensional lumber, metals, gypsum, concrete, brick, etc.) and Land Clearing Debris (trees, stumps, brush, etc.), and is not to be confused with what is typically referred to as Bulky Waste outside of CT, to mean large items such as furniture, carpets, couches, tires, appliances, mattresses, hard plastic toys, and other miscellaneous "large" materials often found incidental to Construction and Demolition Waste].
CONSTRUCTION AND DEMOLITION WASTE	"Construction and Demolition Waste" means waste building materials and packaging resulting from construction, remodeling, repair and demolition operations on houses, commercial buildings and other structures, excluding asbestos, clean fill, as defined in regulations adopted under section 22a-209, or solid waste containing greater than de minimis quantities, as determined by the Commissioner of Environmental Protection, of (A) radioactive material regulated pursuant to section 22a-148, (B) hazardous waste as defined in section 22a-115, and (C) liquid and semiliquid materials, including, but not limited to, adhesives, paints, coatings, sealants, preservatives, strippers, cleaning agents, oils and tars. [Note: as described above, in CT, Construction and Demolition Waste is considered a component of "Bulky Waste"].
CONSTRUCTION AND DEMOLITION WASTE PROCESSING FACILITY	"Construction and Demolition Waste Processing Facility" means a volume reduction plant, the operations of which involve solely the reduction in volume of construction and demolition waste generated elsewhere.
DECONSTRUCTION	"Deconstruction" refers to technique practitioners are using to salvage valuable building materials, reduce the amount of waste they send to landfills, and mitigate other environmental impacts. It is the disassembly of a building and the recovery of its materials, often thought of as construction in reverse.
DESIGNATED RECYCLABLE ITEM	"Designated Recyclable Item" means an item designated for recycling by the Commissioner of Environmental Protection in regulations adopted pursuant to subsection (a) of section 22a-241b, or designated for recycling pursuant to section 22a-208v or 22a-256
MUNICIPAL SOLID WASTE (MSW)	"Municipal Solid Waste" [aka MSW] means solid waste from residential, commercial and industrial sources, excluding solid waste consisting of significant quantities of hazardous waste as defined in section 22a-115, land-clearing debris, demolition debris, biomedical waste, sewage sludge and scrap metal.
OVERSIZED MSW	"Oversized MSW" – undefined by CT State Statutes, Chapter 446d Secs. 22a-207 to 22a-256ee Solid Waste Management. Term commonly used by CT DEEP to refer to large waste and/or recyclable items found incidental to Construction and Demolition Waste. Often referred to outside of CT within the waste industry as "Bulky Waste" and/or "Difficult to Manage (DTM)" materials, and may include furniture, carpets, couches, tires, appliances, mattresses, hard plastic toys, and miscellaneous "large" materials often found incidental to Construction and Demolition Waste. While not included in the CT Solid Waste Management Regulations definitions, CT DEEP commonly refers to these incidental items as "Oversized MSW", and thus Green Seal has used this term within the study to describe these materials].
RECYCLING	"Recycling" means the processing of solid waste to reclaim material therefrom.
RECYCLING FACILITY/CENTER	"Recycling Facility" or "recycling center" means land and appurtenances thereon and structures where recycling is conducted, including but not limited to, an intermediate processing center as defined in section 22a-260.

TERM	DEFINITION
RESOURCES RECOVERY FACILITY (RRF)	"Resources Recovery Facility" (aka RRF) means a facility utilizing processes to reclaim energy from municipal solid waste.
SOLID WASTE	"Solid Waste" means unwanted or discarded solid, liquid, semisolid or contained gaseous material, including, but not limited to, demolition debris, material burned or otherwise processed at a resources recovery facility or incinerator, material processed at a recycling facility and sludges or other residue from a water pollution abatement facility, water supply treatment plant or air pollution control facility
SOLID WASTE FACILITY	"Solid Waste Facility" means any solid waste disposal area, volume reduction plant, transfer station, wood-burning facility or biomedical waste treatment facility.
TRANSFER STATION	"Transfer Station" means any location or structure, whether located on land or water, where more than ten cubic yards of solid waste, generated elsewhere, may be stored for transfer or transferred from transportation units and placed in other transportation units for movement to another location, whether or not such waste is stored at the location prior to transfer
VOLUME REDUCTION FACILITY (VRF)	"Volume Reduction Facility (VRF) – see "Volume Reduction Plant"
VOLUME REDUCTION PLANT	"Volume Reduction Plant" means any location or structure, whether located on land or water, where more than two thousand pounds per hour of solid waste generated elsewhere may be reduced in volume, including but not limited to, resources recovery facilities and other incinerators, recycling facilities, pulverizers, compactors, shredders, balers and composting facilities. (Commonly referred to as volume reduction facilities or VRFs.)

WOOD-RELATED TERMS AND DEFINITIONS

TERM	DEFINITION
BIOMASS GASIFICATION PLANT	"Biomass Gasification Plant" means a biomass gasification plant that qualifies as a Class I renewable energy source, as defined in section 16-1.
CLEAN WOOD	"Clean Wood" means any wood which is derived from such products as pallets, skids, spools, packaging materials, bulky wood waste, or scraps from newly built wood products, provided such wood is not treated wood as defined in section 22a-209a of the General Statutes or demolition wood.
LAND CLEARING DEBRIS	"Land Clearing Debris" means trees, stumps, branches, or other wood generated from clearing land for commercial or residential development, road construction, routine landscaping, agricultural land clearing, storms, or natural disasters. [Note: definition is not included within the CT State Statutes, Chapter 446d Secs. 22a-207 to 22a-256ee Solid Waste Management: https://www.cga.ct.gov/current/pub/chap_446d.htm, but is included within the CT DEEP Glossary of Recycling & Solid Waste Terms, Abbreviations and Acronyms: http://www.ct.gov/deep/cwp/view.asp?a=2714&q=438548 , and the Connecticut Solid Waste Permit Fee Regulations: http://www.ct.gov/deep/lib/deep/regulations/22a/22a-208a-1.pdf]
LAND CLEARING/CLEAN WOOD PROCESSING FACILITY	"Land Clearing/Clean Wood Processing Facility" (aka "Organic VRFs") means a volume reduction plant, the operations of which involve solely the reduction in volume of land clearing debris or clean wood generated elsewhere.
MULCH	''Mulch'' means a protective cover of organic material placed over soil to preserve soil moisture, prevent erosion, or promote the growth of plants.

TERM	DEFINITION
ORGANIC VRFS	"Organic VRFs" – see "Land Clearing/Clean Wood Processing Facility"
PROCESSED CONSTRUCTION AND DEMOLITION WOOD	"Processed Construction and Demolition Wood" means the wood portion of construction and demolition waste which has been sorted to remove plastics, plaster, gypsum wallboard, asbestos, asphalt shingles, regulated wood fuel as defined in section 22a-209a and wood which contains creosote or to which pesticides have been applied or which contains substances defined as hazardous waste under section 22a-115.
RECYCLED WOOD	"Recycled Wood" means any wood or wood fuel which is derived from such products or processes as pallets, skids, spools, packaging materials, bulky wood waste or scraps from newly built wood products, provided such wood is not treated wood.
TREATED WOOD	"Treated Wood" means wood which contains an adhesive, paint, stain, fire retardant, pesticide or preservative.
PROCESSED WOOD	"Processed Wood" means recycled wood or treated wood or any combination thereof which has been processed at a volume reduction facility permitted under this chapter.
REGULATED WOOD FUEL	"Regulated Wood Fuel" means processed wood from construction and demolition activities which has been sorted to remove plastics, plaster, gypsum wallboard, asbestos, asphalt shingles and wood which contains creosote or to which pesticides have been applied or which contains substances defined as hazardous under section 22a-115.
WOOD-BURNING FACILITY	"Wood-burning Facility" means a facility, as defined in section 16-50i, whose principal function is energy recovery from wood for commercial purposes. "Wood-burning facility" does not mean a biomass gasification plant that utilizes land clearing debris, tree stumps or other biomass that regenerates, or the use of which will not result in a depletion of, resources.

[i] CT DEEP Glossary of Recycling & Solid Waste Terms, Abbreviations and Acronyms: http://www.ct.gov/deep/cwp/view.asp?a=2714&q=438548, and CT State Statutes, Chapter 446d Secs. 22a-207 to 22a-256ee Solid Waste Management: https://www.cga.ct.gov/current/pub/chap_446d.htm