BOULDER COUNTY CONSTRUCTION AND DEMOLITION INFRASTRUCTURE STUDY, MATERIALS GENERATION ESTIMATE AND MARKET ANALYSIS

Prepared For:
Boulder County Resource Conservation Division

Prepared By:

CENTER FOR ReSource CONSERVATION
www.ConservationCenter.org
Logically Green™

UHG

Prepared by UHG Consulting

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1. Executive Summary and Background

At the request of the Boulder County Resource Conservation Division, this report was conducted to assess the generation of Construction and Demolition waste in Boulder County and to recommend a course of action based on an analysis of diversion potential, market viability, and facility design.

The report finds that Construction and Demolition (C&D) waste represents 20-40% of the total generated waste stream in Boulder County, or about 120,000 tons of material generated per year. Of this amount, the vast majority is currently sent to landfills outside of the County's borders, and only a small fraction is being diverted through recycling.

In accordance with its Zero Waste goals, the County called for an investigation into the potential markets for commodities produced by C&D activities, and the recycling potential for C&D waste materials. This report finds that there are established recycling options for many of the materials common in the C&D waste stream, and that the inconvenience and economic hardship of recycling these materials in separate locations across the Front Range often prevents industry professionals from taking advantage of available diversion alternatives. Considering the existing markets for many of these materials, it is within the realm of possibility for the County to economically provide infrastructural support to the C&D community in order to increase diversion rates.

One way that the County could provide this support would be to create a transfer station for C&D materials that would act as a centralized collection point for materials which would otherwise be sent to landfills. Given the strength of regional and local markets, the County should not seek to compete with private organizations. The facility considered and outlined in this report is a transfer station for source-separated C&D waste designed to make recycling C&D materials more convenient and economical than landfills, and to operate on a break-even basis by charging fees for the drop off of material.

Based on a preliminary analysis, a C&D transfer facility could initially expect to receive between 19-65 tons of material per day, would require a minimum of 7 acres to provide adequate space for its operations, and would ideally be sited on a 10-12 acre lot to allow room for expansion. Future development of the facility is examined below, and includes consideration of material processing on site as a viable option for future expansion.

A cost estimate places the total cost of constructing a facility of this type between $7,000,000-15,000,000, with annual operating expenses in the range of $300,000-550,000. Depending on the actual operating costs of the facility, as well as the waste diversion rate, an averaged, per-ton tipping fee could run $29-$47. An averaged fee would allow a flat rate across materials, where revenue from higher-value commodities offsets the losses incurred from recycling costly materials.

Such a facility could be owned and operated through a number of public/private partnerships, depending on the financial and logistical concerns of the County. It is the goal of this report to provide the information necessary to allow County officials to make an educated decision regarding whether or not to construct a facility for the transfer or processing of C&D wastes. Specific contractual arrangements will change the particulars of facility design, location, and operating model.

1.1. Background

The ongoing construction, remodeling, demolition and deconstruction of buildings is a fact of life in Boulder County. The generally healthy economy of the region has driven tremendous growth in the County's built environment over the past few decades – resulting in increased generation of waste from this ever-changing and dynamic community. As the County has grown in population and buildings in recent years, so too have citizens' desires to live in a sustainable community. In accordance with the County's Zero Waste Action Plan, adopted in 2010, the County has been investigating policies, programs, and facility options to help ensure that the County is building a sustainable infrastructure to address Construction and Demolition (C&D) wastes. This report provides an in-depth analysis of the feasibility of the County engaging in some type of infrastructure investment to facilitate C&D waste diversion. The report seeks to answer the question 'is a publicly-sponsored C&D waste recycling/processing/transfer facility conceptually viable for Boulder County?'

1.2. Basis for Analysis

The viability and design of a Boulder County C&D facility was assessed based on an analysis of the generation, diversion, and marketing potential of each material listed in Table 1-2.

The preliminary facility schematic developed for this report is designed based on the availability of end markets for each material considered. Upon examination, each material was assigned to a development phase depending on the strength of its markets and when it should be incorporated into the facility. The discussion of the facility's layout and construction is based on three phases of development:

- **Phase 1: Materials with existing markets:** Materials for which markets currently exist within reasonable transport distance from the County, or have otherwise viable recycling options are included in the initial phase of development.

- **Phase 2: Materials with developing markets:** Materials for which markets are under development are included in Phase 2 of the facility's build out. Phase 2 is designed as a flexible period to accommodate materials that cannot be reliably recycled now, but may be in the foreseeable future as markets develop. The secondary build out also includes options for expanded processing capabilities for materials that might develop more robust markets in the future from which the county could profit.

- **Phase 3: Materials for future market development:** The final phase of expansion includes materials for which recycling options are not available, and are not imminent. Due to unpredictability in the technological advances that may occur in the 20 year proposed lifespan of this facility, materials that have no recycling options today might be recyclable in the future. Phase 3 is meant to acknowledge this possibility.

When possible, materials that represent the largest fraction of the C&D waste stream are given greater influence on the design of the facility. The goal of designating materials to different developmental phases is to prioritize materials by fraction of the waste stream and marketability. Some materials that do not have robust markets, but make up a large fraction of the waste stream are included in Phase 2 in the hope that a market can be developed in the future. Table 1-2 lists the materials considered in this report, as well as the percent of the waste stream that each represents.

Table 1-1 Glossary of Acronyms

Acronym	Definition
C&D	Construction and Demolition
CDOT	Colorado Department of Transportation
CHaRM	Center for Hard to Recycle Materials
DOT	Department of Transportation
FTE	Full-Time Employee
GVW	Gross Vehicle Weight
HDPE	High-Density Polyethylene
HHW	Household Hazardous Waste
HMA	Hot-Mix Asphalt
LDPE	Low-Density Polyethylene
LEED	Leadership in Environmental Engineering and Design
MRF	Materials Recovery Facility
MSW	Municipal Solid Waste
OCC	Old Corrugated Cardboard
PET	Polyethlylene Terephthalate
PP	Polypropylene
PPCD	Pounds per Capita per Day
PVC	Polyvinyl Chloride
RAP	Recycled Asphalt Pavement
RAS	Recycled Asphalt Shingles
SDO	State Demographers Office
TPD	Tons per Day
TPY	Tons per Year
TS	Transfer Station
UBM	Used Building Materials
VCT	Vinyl Composite Tiles
VOC	Volatile Organic Compounds

Table 1-2 Material Market Status and Composition Percentages

Material	20 Year Low (% of total generation)[a]	20 year High (% of Total Generation)
Materials With Existing Markets		
Aggregates	30.0%	34.0%
Cardboard	1.3%	1.6%
Ceiling Tiles	0.1%	0.1%
Clean Wood	6.0%	6.0%
Durable Goods and Reusable Building Materials	3.0%	3.0%
Pallets	4.0%	4.0%
Plastics	0.5%	4.4%
Scrap Metal	6.0%	5.5%
Vinyl Composite Tiles	0.1%	0.1%
Materials With Developing Markets		
Asphalt Shingles	11.0%	16.0%
Carpet & Padding	1.0%	2.0%
Clean Gypsum Wallboard	4.0%	4.0%
Plate Glass	0.3%	4.0%
Materials For Future Market Development		
Cement Fiberboard	0.5%	0.5%
Commercial Roofing Membrane	0.2%	0.2%
Fiberglass Insulation	0.1%	0.3%
Painted Gypsum Wallboard	6.0%	7.5%
Painted/Stained/Treated Wood	8.0%	9.0%

[a] As much as possible, categories in this report are designed to match those in the 2010 Waste Composition study by MSW Consultants/Cascadia. Due to some differences, percentages in this table above do not add up to 100%

2. Materials Generation

Overview: Section 2 discusses the methodology used and findings of the materials generation projection conducted for this study. By combining industry knowledge with data from state and local organizations, the following projections were derived for use in assessing the viability of a Boulder County C&D infrastructure investment. This section projects the composition and quantity of generated C&D waste for the next 20 years, and goes on to discuss the various social, economic, and legislative factors that will affect both composition and quantity into the future.

Waste Categorization: Construction and Demolition waste is part of the broader category of solid waste, a category encompassing both municipal solid waste (MSW) and non-municipal solid waste. Construction and Demolition wastes are considered by the U.S. Environmental Protection Agency (EPA), the Colorado Department of Public Health and the Environment, and most waste/recycle managers to fall in to the non-MSW category, along with other miscellaneous industrial waste. When looking at all waste generated in Boulder County (as was done in the 2010 Boulder County Waste Composition by MSW Consultants/Cascadia), Construction and Demolition wastes comprise a significant fraction of the overall waste stream, between 20-40%. When seeking to achieve greater diversion of the entire solid waste stream, recycling and reusing Construction and Demolition wastes can provide some of the "biggest bang for the buck" (as can diverting commercial recyclables and organic wastes).

Typically, discussions of C&D waste split these materials into two categories:

- Materials created from road and bridge construction, repair and improvement
- Materials from constructing, deconstructing, and demolishing buildings.

Certain materials, namely concrete, asphalt, reinforced concrete and structural steel, are generated by both categories, and have similar handling and processing practices. Road and bridge construction represents a large fraction, by weight, of the total generated C&D waste stream, and is managed at larger scale facilities and is unlikely to flow into a general C&D facility.

Where the material will be generated: In the next 20 years, materials will be generated primarily in the larger population centers of the County: Boulder, Longmont, and then the east County towns of Louisville, Lafayette and Erie. Further, generation will primarily stem from the eastern part of the County rather than the western County border and the City of Boulder, as this region is both less developed and is targeted for future improvement by local municipalities.

Projections were not made for C&D wastes generated in adjacent urbanized areas of Weld, Broomfield, and Larimer Counties, though there is a possibility that C&D waste generators from those areas would use a Boulder County-based C&D facility for diverting their C&D materials if the economics (including transportation) were attractive enough. Due to a lack of data regarding the origin of materials, however, these areas are not factored into the material generation estimates.

The City of Boulder has strict limits on growth that will limit large new construction and deconstruction. C&D waste generation in the areas north and west of the City of Boulder to the County borders is expected to be relatively lower due to lower population density and lower potential for industrial, commercial, or institutional development. See Section 2.5 for a full discussion of factors influencing C&D waste generation, including the expectation of new

residential developments in the planning pipeline (e.g., a development near Erie) that will generate C&D waste, as well as the likelihood of other commercial developments.

2.1 Existing Data

Boulder County and its stakeholders have evaluated solid waste in the County on a regular basis in multiple studies over the last several years. Those evaluations that were useful in estimating C&D material generation included:

- "Recycling Material Data Reports" (prepared by Haul Away Recycling for the Center for Resource Conservation (CRC)'s ReSource Division in 2007)
  - Provided specific diversion and disposal quantities for residential deconstruction projects
  - Demonstrated that these projects can have diversion levels in excess of 80% by weight

- "Construction & Demolition Waste Diversion: Baseline Information & Gap Analysis" (prepared by Gracestone, Inc. as part of the Boulder County Zero Waste Effort, 2009)
  - Utilized waste composition results collected from other communities in Colorado and other states to estimate that as many as 168,000 tons of C&D could potentially be generated by 2017

- "Boulder County Zero Waste Model" (prepared by Skumatz Economic Research Associates, Inc. for the Boulder County Resource Conservation Division, 2009)
  - Estimated that the total solid waste generation rate for Boulder County is approximately 6.59 pounds/capita-day (ppcd)

- "2010 Waste Composition Study" (prepared by MSW Consultants/Cascadia Consulting Group for the Boulder County Resource Conservation Division, 2010)
  - Indicated that 25% of the total solid waste discards represented in the study were C&D tons[1]
  - Observed that the top five materials in the C&D discards waste stream (by weight) are "Concrete/Asphalt/Aggregate", "Asphalt Shingles/Backing", "Painted/Stained/Treated Wood", "Dirt/Sand" and "Demo/Painted Drywall"
  - With the exception of Dirt/Sand, the other top four materials are addressed in this report

- Boulder County Annual Hauler Reports (on-going, submitted by haulers) - including some residential deconstruction data from 2009

- Colorado State Demographers Office Preliminary Population Forecasts by County
  - Provided current population projections for the next 20 years.

[1] This study exclusively measured samples discarded for landfill disposal (as opposed to samples from the full, generated waste stream which would also include diverted materials). The full waste composition study included samples from the residential, commercial, mountain drop box and C&D waste streams - data referenced in this Section 2.0 pertain to the C&D samples only, with the exception of Section 2.6.2.

2.2 Challenges in Using Existing Data

Care must be taken when utilizing these sources to make future predictions as available data on generated, diverted and discarded C&D materials (especially non-residential waste) is limited. Two key examples include:

- C&D-related materials are generated by homeowners, commercial businesses, institutions, governments (especially highway departments), and even industries in addition to contractors, roofers, landscapers, and C&D roll-off and hauling service providers - however, the primary source of C&D materials (in terms of quantity) are generated by those involved in constructing, renovating and dismantling building, road and bridge projects

- Not all data is "apples to apples" - while residential deconstruction data provides some of the best information available on diverted and disposed material quantities, waste materials generated from dismantling single and multi-family homes can be very different from those resulting from roadway construction or renovation of a commercial property (additionally, deconstruction projects reflect diversion practices that are not typical of other types of demolition)

If information from the sources listed in Section 2.1 is applied judiciously, it is extremely helpful in beginning to assess the opportunity for diverting more C&D materials in the future. In the following sections, this information has been used to project material quantities that are specific to Boulder County.

2.3 Methodology

The materials generation analysis was conducted for both the 2010 baseline year and for four milestones over the 20-year planning period, i.e., 2015, 2020, 2025 and 2030.

The total solid waste stream (both MSW and non-MSW) generated in Boulder County was projected using the 6.59-ppcd generation rate estimated in the County's Zero Waste model (Skumatz, 2009), as well as current and projected population estimates developed by the Colorado State Demography Office (SDO). SDO data was selected as a population indicator as it has been updated to reflect the 2010 Census count.

Table 2-1 includes both the SDO population projections and the estimate of total waste stream for the baseline and milestone years.

The C&D waste stream was estimated by assuming that C&D wastes comprise a range of 20% to 40% by weight of the total waste stream. This reflects the general C&D ranges observed in other total waste streams in Colorado and other communities; note that the 2010 waste composition study also observed that the C&D samples measured represented about 25% of all samples studied. Table 2-1 estimates resulting C&D quantities[2] between 2010 and 2030.

Table 2-1 Estimated Boulder County Total MSW and non-MSW and C&D Waste Stream Generation (Tons/year, quantities rounded to nearest 1,000 tons)

	2010	2015	2020	2025	2030
Population [a]	294,889	312,847	332,025	350,433	364,112
Total Solid Waste Stream (tons) [b]	355,000	376,000	399,000	422,000	438,000
C&D Waste (tons)					
Low (20% of total)	71,000	75,000	80,000	84,000	88,000
Medium (30% of total)	106,000	113,000	120,000	126,000	131,000
High (40% of total)	142,000	151,000	160,000	169,000	175,000

[a] "Preliminary Population Forecasts by Region and County 2000-2040", prepared by the Colorado State Demography Office (prepared in 2011, based on 2010 Census count)
[b] Based on estimated waste generation rate of 6.59 pounds/capita-day (Skumatz, 2009)

2.3.1 C&D Waste Composition

In order to estimate current and future tons of generated C&D on a material-specific basis, waste composition data has been applied to the quantities shown in Table 2-1. Development of a working composition of the generated C&D stream was based on the 2010 Boulder County Waste Composition Study conducted on discarded waste stream samples only, deconstruction data collected by the CRC's ReSource Division and general knowledge about current diversion activities for local projects.

The 2010 Waste Composition study provides a valuable baseline and observed set of composition data for use in projecting actual generation figures. It is important to note that this study contains information about the discarded waste which was measured on site at local landfills. As such, this data does not encompass the portion of generated C&D waste

[2] These quantities correspond to the waste generated by building, demolition and deconstruction contractors; roofers; landscapers; and C&D roll-off and hauling service providers (they do not include miscellaneous C&D generated by homeowners and businesses, or material generated by road/bridge projects).

that would have been brought to recyclers or to other landfills nearby. The differences in the observed composition and the projected composition are meant to take into account these materials in order to forma clearer picture of the generated waste in the County.

Table 2-2 includes a suggested working composition for C&D materials generated in 2010 and the milestone years. To the extent possible, this analysis adheres to the materials definitions described in Appendix A of the 2010 Waste Composition Study. The following are either exceptions or clarifications to that document:

- White goods have been combined with "Ferrous Metals"
- Durable items are included in "Ferrous Metals", "Furniture/Bulky Items" and "Other C&D" (which includes all interior finish materials) as appropriate
- "Yard Waste" includes land-clearing debris
- "Untreated Wood" includes dimensional lumber and other clean wood
- "Hardwood/Laminated Flooring" has been added to reflect growing trends expected in the County's waste stream
- "Insulation" has been added (and includes blue board insulation materials)
- "Other C&D" includes all interior finishes (cabinets, doors, windows, lights, fixtures, hardware, ceiling tiles, etc.), cement fiber board and other miscellaneous materials

In generating composition estimates for future years, current and future building trends were taken into consideration to reflect the changing nature of the built environment. Short-term changes are meant to reflect changes to building trends that have already occurred, the results of which will be seen in the coming decade as these structures are torn down. The long-term changes described below are meant to reflect building trends that are likely to occur in the next few years. These changes are expected to be seen as buildings built in the near future are taken down in 10-20 years, and are included to account for the materials that a C&D facility will be receiving near the end of the projected term.

Short-Term (5 to 10 years)

- Over the past few decades non-ferrous metals (e.g. copper) have been replaced by low cost alternatives (e.g. PVC piping) in construction and therefore the quantities removed from construction sites will continue to decrease
- In the past decades, both residential and commercial projects have moved to more steel/glass construction for passive solar properties and general design considerations, causing these materials to increase in the coming 10 years
- Recently, carpeting has been replaced by hardwood floors, resulting in lower carpet generation and increased treated wood

Long-Term (10 to 20 years)

- As petroleum prices have risen, more alternatives have entered the market to compete with asphalt shingles. Assuming the trend continues more alternative roofing materials such as concrete roofing shingles and photovoltaic panels will enter the C&D stream in the long-term
- Electronics have continued to increase in buildings and will most likely continue that trend across the next 20 years[3]

Figures 2-1 through 2-5 illustrate the relative composition of the material categories observed for 2010 and the milestone years.

[3] While the use of electronics in new construction is anticipated to increase in the next 10-20 years, the unpredictability of this material resulted in its exclusion from this report.

Table 2-2 Observed Composition of C&D Discards and Suggested Composition For Boulder County's Projected C&D Waste Generation (% by Weight)

	C&D COMPOSITION IN DISCARDS 2010 [2]	GENERATED C&D WASTE STREAM ESTIMATES [3]				
		2010	2015	2020	2025	2030
MATERIALS						
Paper						
Uncoated OCC	0.1%	1.0%	1.0%	1.5%	1.5%	1.5%
Other Paper	0.4%	0.3%	0.3%	0.1%	0.1%	0.1%
Total Paper	*0.5%*	*1.3%*	*1.3%*	*1.6%*	*1.6%*	*1.6%*
Plastics						
Plastic Film Packaging	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%
Other Plastics	0.5%	0.4%	1.0%	1.7%	3.2%	4.3%
Total Plastic	*0.5%*	*0.5%*	*1.1%*	*1.8%*	*3.3%*	*4.4%*
Metals						
Ferrous Metal	1.7%	3.5%	4.5%	5.0%	5.5%	5.5%
Non-Ferrous Metal	0.4%	2.0%	1.5%	1.0%	0.5%	0.5%
Total Metals	*2.1%*	*5.5%*	*6.0%*	*6.0%*	*6.0%*	*6.0%*
Glass						
All Glass	0.3%	0.3%	1.0%	2.0%	3.0%	4.0%
Total Glass	*0.3%*	*0.3%*	*1.0%*	*2.0%*	*3.0%*	*4.0%*
Organics						
Yard Waste	1.2%	3.0%	3.0%	3.0%	3.0%	3.0%
Wood Pallets	2.0%	4.0%	4.0%	4.0%	4.0%	4.0%
Dirt/Sand	10.2%	3.4%	4.0%	4.0%	4.0%	4.0%
Total Organics	*13.4%*	*10.4%*	*11.0%*	*12.0%*	*11.0%*	*11.0%*
Problem Waste						
Electronics	0.0%	0.1%	0.1%	0.3%	0.3%	0.3%
Small Appliances	0.3%	0.2%	0.2%	0.3%	0.2%	0.2%
Carpet/Padding	0.3%	1.0%	1.5%	2.0%	1.5%	1.0%
Furniture/Bulky Items	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Total Problem Waste	0.7%	1.4%	1.9%	2.7%	2.1%	1.6%
C&D Materials						
Concrete/Asphalt/Rock/Brick	27.5%	34.0%	33.0%	32.0%	32.0%	30.0%
Asphalt Shingles/Backing	19.1%	16.0%	14.0%	12.0%	11.0%	11.0%
Painted/Stained/Treated Wood	12.7%	9.0%	9.0%	9.0%	8.0%	8.0%
Untreated Wood	3.7%	6.0%	6.0%	6.0%	6.0%	6.0%
Hardwood/Laminated Flooring	NA	0.5%	0.5%	0.6%	0.7%	0.6%
Clean/New Drywall	6.7%	4.0%	4.0%	4.0%	4.0%	4.0%
Demo/Painted Drywall	8.8%	6.0%	6.0%	6.0%	7.0%	7.5%
Insulation	NA	0.1%	0.2%	0.3%	0.3%	0.3%
Other C&D	*3.8%*	*5.0%*	*5.0%*	*4.0%*	*4.0%*	*4.0%*
Total Other	*82.3%*	*80.6%*	*77.7%*	*73.9%*	*73.0%*	*71.4%*
Total	99.8%	100.0%	100.0%	100.0%	100.0%	100.0%

Notes:

1 All percentages rounded to nearest 0.1% (some low-quantity materials may be presented as 0%)

2 Data on C&D samples only from "2010 Waste Composition Study" (prepared by MSW Consultants/Cascadia Consulting Grou

3 Based on ReSource data and understanding of future changes in construction practices/materials

4 Most materials defined in Appendix A of 2010 WCS report

Figure 2-1
2010 Estimated C&D Composition (% by Weight)

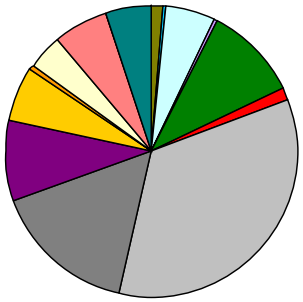


Figure 2-2
2015 Estimated C&D Composition (% by weight)

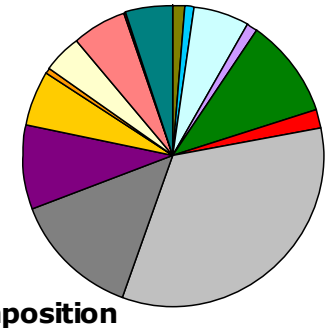


Figure 2-3
2020 Estimated C&D Composition (% by weight)

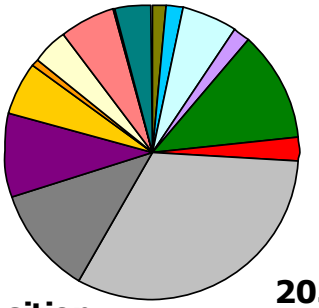


Figure 2-4
2025 Estimated C&D Composition (% by weight)

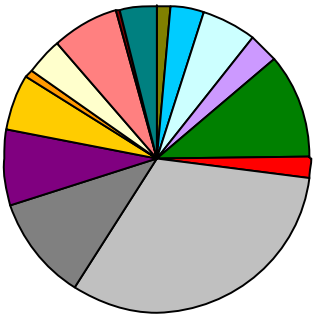
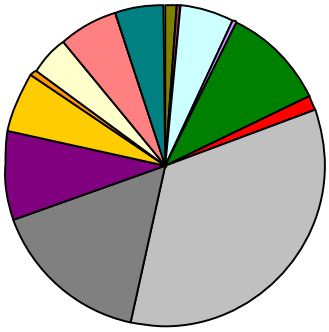


Figure 2-5
2030 Estimated C&D Composition (% by weight)



Legend

- Paper
- Plastics
- Metals
- Glass
- Organics
- Problem Waste
- Concrete/Asphalt/Aggregate
- Asphalt Shingles/Backing
- Painted/Stained/Treated Wood
- Untreated Wood
- Hardwood/Laminated Flooring
- Clean/New Drywall
- Demo/Painted Drywall
- Insulation
- Other C&D

2.3.2 Comments on Waste Composition Data

Several observations are pertinent to the suggested composition data provided in Table 2-2:

- It was assumed in this analysis that the 2010 Waste Composition Study data was the best basis for suggesting material percentages because it ostensibly sampled all types of construction, renovation and dismantling projects occurring in Boulder County during the study. These samples however, were only "snapshots in time" and the study may not necessarily have collected samples that were fully representative of the 2010 C&D waste stream. Therefore, the 2010 study numbers were used to guide the assumptions of low and high estimates, in order to capture the anticipated range of quantities generated

- While residential deconstruction data from the CRC's ReSource Division and the County's annual C&D hauler reports were considered in suggesting composition values, they were assumed to have more limited representation of the overall C&D stream (for example, the residential deconstruction projects were observed to have more clean wood, concrete and miscellaneous C&D than other projects)

- Table 2-2 and Appendix B organize the waste data such that "Paper", "Plastics", "Metals", "Glass, "Organics" and "Problem wastes" are not categorized as "C&D Materials" - this reflects an attempt to organize estimates and projections in a format similar to that established by the 2010 Waste Composition Study (but all materials included in this table represent waste generated during construction, renovation and/or demolition/deconstruction projects)

- With respect to the suggested composition values, it is noted that the percentage of "C&D Materials" may decrease slightly over the next 20 years - this should not be interpreted to mean that the overall C&D waste stream will decline (and in fact is expected to increase with population), but instead acknowledges marginal increases in "Paper", "Plastics", "Metals", "Glass, "Organics" and "Problem wastes" that off-set "C&D Materials" in a relative composition analysis

Finally, it is important to note that, because composition information is not available for the generated waste stream (only the discarded waste stream), these are suggested composition values only - they should be refined in the future when additional composition and/or deconstruction data is available

2.4 Materials Generation Results

The total waste stream quantities and suggested composition values (summarized in Tables 2-1 and 2-2, respectively) were used to project a range of generated materials in Boulder County's current and future waste streams.

2.4.1 Quantity Projection Results

Table 2-3 includes projected quantities over the next 20 years. The projections are presented in ranges that correspond to a low-to-high range of potential C&D generation within Boulder County's total waste stream[4]. Appendix B includes detailed projection quantities for low, medium and high potential generation levels.

As shown in Table 2-3, a mid-level estimate projects that C&D materials quantities could increase from 90,000 tons/year in 2010 to 130,000 tons/year in 2030[5]. This increase of nearly 36% reflects population projections by the Colorado SDO. The relative changes in specific material quantities over time, however, correspond to both population growth and the economic variables discussed in Section 2.5.3.

In 2010, the materials generated in highest quantity in the generated C&D waste stream are:

- "Concrete/Asphalt/Aggregate"
- "Asphalt Shingles/Backing"
- "Painted/Stained/Treated Wood"
- "Untreated Wood"
- "Demo/Painted Drywall"

By 2030, these top materials may shift slightly to include:

- "Concrete/Asphalt/Aggregate"
- "Asphalt Shingles/Backing"
- "Painted/Stained/Treated Wood"
- "Demo/Painted Drywall"
- "Untreated Wood"

These findings are consistent with the previous estimations in both the 2009 C&D Gap Analysis and the 2010 Waste Composition Study, 2010. The findings go beyond earlier studies, however, by providing estimations of material-specific generation over the 20-year planning period to consider possible changes in local construction practices that will likely impact Boulder County's waste stream.

[4] C&D waste has been estimated at 20% to 40% by weight of the total waste stream, and generated by contractors, roofers and landscapers, as described in Table 2-1.

[5] These quantities are based on the assumption that the "mid-level" estimate of the C&D waste generation range is approximately 30% of the total solid waste stream, and comprises C&D waste from contractors, roofers, landscapers, and roll-off and hauling service providers.

Table 2-3: Projected Composition for Boulder County's Generated C&D Waste [a,b] (Tons/year, rounded to nearest 100 tons and using mid-level projection)

MATERIALS	2010	2015	2020	2025	2030
Paper					
Uncoated OCC	1,000	1,100	1,800	1,900	2,000
Other Paper	300	300	100	100	100
Total Paper	1,300	1,500	1,900	2,000	2,100
Plastics					
Plastic Film Packaging	100	100	100	100	100
Other Plastics	400	1,100	2,000	4,000	5,000
Total Plastic	500	1,200	2,100	4,100	5,100
Metals					
Ferrous Metal	3,700	5,000	5,900	7,000	7,200
Non-Ferrous Metal	2,100	1,600	1,200	600	700
Total Metals	5,800	6,600	7,100	7,600	7,900
Glass					
All Glass	300	1,100	2,400	2,700	5,200
Total Glass	300	1,100	2,400	2,700	5,200
Organics					
Yard Waste	3,100	3,000	3,500	3,700	3,900
Wood Pallets	4,200	4,500	4,700	5,000	5,200
Dirt/Sand	3,600	4,500	4,700	5,000	5,200
Total Organics	10,900	12,000	12,900	13,700	14,300
Problem Waste					
Electronics	100	100	300	400	400
Small Appliances	200	200	300	200	200
Carpet/Padding	1,000	1,600	2,300	1,800	1,300
Furniture/Bulky Items	100	100	100	100	100
Total Problem Waste	1,400	2,000	3,000	2,500	2,000
C&D Materials					
Concrete/Asphalt/Aggregate	36,100	37,200	38,300	40,500	40,000
Asphalt Shingles/Backing	1,700	15,800	14,300	13,900	14,500
Painted/Stained/Treated Wood	9,500	10,100	10,700	10,100	10,500
Untreated Wood	6,300	6,700	7,100	7,600	7,800
Hardwood/Laminated Flooring	500	500	700	900	800
Clean/New Drywall	4,200	4,500	4,700	5,000	5,200
Demo/Painted Drywall	6,300	6,700	7,100	8,800	9,800
Insulation	100	200	300	400	400
Other C&D	5,300	5,600	4,700	5,000	5,200
Total Other	*70,000*	*87,300*	*87,900*	*92,200*	*94,200*
Total	90,200	111,700	117,300	124,800	130,800

[a] Projections are based on unverified suggested composition values in Table 2-2
[b] Rounding errors may cause apparent discrepancies in material totals

2.5 Factors Influencing C&D Waste Generation

A variety of factors impact the *generation* of C&D waste materials as quantified above in Sections 2.1-2.3. Factors influencing the *diversion* of C&D materials are discussed in Section 3.0.

2.5.1 Legislative Decisions Can Impact Generation

Several kinds of legislation and regulations could impact the increase of generation of C&D wastes. Examples include:

- Laws requiring the abatement of an environmentally hazardous material found in buildings (such as asbestos – replacing asbestos generated a great deal of C&D waste) could cause a spike in generation of the targeted materials
- Government use of tools such as tax incentives and economic development zones can drive construction which could increase C&D waste material generation.

2.5.2 Building Codes/ Standards

A variety of zoning and land use tools available to local governments can impact generation of C&D waste materials.

- **Zoning:** More stringent zoning and land use regulations have been used in the City of Boulder to control growth for decades; this has resulted in dramatically less new construction (especially residential) and thus more remodeling and teardown/new building on old sites. Should the rest of the County embrace these legislated limits to growth, it will influence the generation of C&D waste downwards, by the simple fact that there will be much less new construction going on.

- **EnergySmart:** The EnergySmart program is available to all homes and businesses in Boulder County. EnergySmart, a program developed from the Department of Energy's BetterBuildings program, strives to drive reduction in energy use through on-site assessments, microloans, and rebate incentives.[6] The program operates through 2013 and is designed to be self-supporting after that deadline. The program has caused an increase in the generation of scrap insulation, windows, and HVAC systems, due to replacement with more efficient equipment and materials.

- **SmartRegs:** The City of Boulder's SmartRegs program was approved in September of 2010 and went into effect in January 2011. SmartRegs refers to three separate ordinances that together update the city's housing and rental licensing codes. Because SmartRegs requires all rental housing to meet a basic energy efficiency standard by 2019, the City of Boulder provides subsidies and rebates to incentivize compliance by paying for upgrades that buildings will need to meet the requirements. Rental housing in the City of Boulder comprises nearly half of the existing housing stock; therefore the SmartRegs should result in increased generation of energy-related C&D waste materials such as windows, HVAC systems, and insulation from 2011-2018 as old housing stock is updated with more efficient materials and units to come into compliance.[7]

[6] Details at www.energysmartyes.com
[7] Details at www.bouldercolorado.gov/index.php?option=com_content&task=view&id=13982&Itemid=22

2.5.3 Economic Variables

Boulder County has historically been among the strongest economic regions in Colorado and the Rocky Mountain West, with a wide range of government facilities, industry, and commercial operations providing a diverse economic base. Over the past decade, Boulder County has tracked at a lower level of unemployment than the rest of Colorado,[8] making for a more stable local economy than other parts of the state. Local economic swings dramatically impact the generation of C&D wastes, because spending related to the built environment trends down as the economy weakens. The C&D waste generation forecasts provided in Sections 2.5 and 2.6 attempt to compensate for these swings by assuming C&D waste generation based upon the 20% to 40% range of total waste. The following trends can be expected:

In a **strong** economy, the:

- Residential sector will see increased new home construction and teardowns/deconstructed homes, resulting in a larger generated C&D waste stream with increased clean scrap materials (post-construction) and an increased generation of salvage, or used building materials (UBM) for reuse by others. (Conversely, interest in using UBM goes down as the do-it-yourselfers buy new items rather than used, lowering diversion).
- Commercial sector will see higher occupancy rates in office buildings County-wide, with increased generation of C&D waste from interior finish remodels. In a strong economic cycle, it is likely there would be more new business construction, such as major mall renovations in one or more of the large malls in the Boulder-Broomfield County/I-25 corridor.

In a **weak** economy, the:

- Residential sector will see little new home construction and more teardowns/deconstructed homes, and more remodeling. Generation will go down, and the C&D waste stream will comprise fewer new (post-construction) materials and more lower-value tear-out materials. (On the diversion side, interest in using used building materials (UBMs) goes up as do-it-yourselfers buy used items.)
- Commercial sector will see lower occupancy rates in office buildings, with less C&D waste generated such as from interior finish remodels. The industrial/commercial/ governmental C&D waste stream will shrink as new construction is deferred.
- Transportation improvements by governments may be reduced to mostly maintenance efforts, lessening road and bridge-related C&D wastes.

[8] USDA Economic Research Service, County-Level Unemployment and Median Household Income for Colorado, at www.ers.usda.gov/data/unemployment/RDList2.asp?ST=CO. Accessed 9/13/2011.

2.5.4 Independent Large Generators

Finally, as the large institutions in the County build new properties and/or expand/renovate their existing buildings, there will be large quantities of C&D waste generated in relatively short periods of time. Although such projects are not always easy to predict 5, 10, 15 or 20 years out, it is important to understand that one-time building projects can result in significant temporary increases in materials generation. These spurts will also cause peak load stresses on waste transfer or processing infrastructure, as well as on end markets.

On the horizon, large independent projects include building by the University of Colorado Boulder campus, renovation/expansion of NOAA facilities, the deconstruction of the Twin Peaks Mall in Longmont, as well as the redevelopment of the Daily Camera building in Boulder. Countywide, several large-scale residential developments are planned for development in Erie. The potential for large corporations moving to the area (such as a projected Conoco Philips campus in Louisville) suggests that along with the County's population growth, its economic progress will spur additional generation of C&D materials in the future. It should be noted that large-scale Construction and Demolition projects generate material in high enough volumes that it would be more economical to send directly to end markets, rather than a transfer station. Although a Boulder County C&D facility should expect to receive some of this material, these temporary and unforeseen fluctuations in input will not drastically alter the design of the facility.

3. Market Analysis

Overview: The market analysis presented below discusses current recycling practices and related end markets for C&D materials in and around the County. Information on end markets and market players was gathered through a series of interviews and meetings with local, regional, and national businesses and organizations. Research also identified new recycling techniques and end markets under development. Based on this research, the current state of each market has been analyzed, and potential avenues for market development were identified when appropriate. Section 3 first discusses materials with existing markets that are included in the Phase 1 build out (3.2), materials with developing markets that are included in the Phase 2 expansion (3.3), and materials for future market development and consideration in Phase 3 (3.4). Within each section, materials are discussed in alphabetical order.

Diversion: The actual ability of a C&D transfer station to capture material from the waste stream varies depending on the material in question. Contractor and public education, the location of and fees charged by a facility, as well as numerous other factors (see Section 3.1) will contribute to whether or not material is actually brought to the proposed facility. The diversion estimates given for each material in Section 3 are derived from industry knowledge gained through conversations with local Construction and Demolition professionals. The high and low ranges of diversion are meant to provide a general idea of what tonnages any local facility could reasonably expect to receive.

Based off of current high and low diversion estimates for each material, Phase 1 of the facility could expect to receive between 19 and 65 tons per day, or about 4-14% of the generated C&D waste from Boulder County each year.

Hauling Costs: A per-ton hauling cost has been provided for each end market. For purposes of estimation, these round-trip costs consider the facility to be sited at 63rdst and Arapahoe Ave in Boulder, as this is close to the waste centroid of the County, and is an area with existing recycling infrastructure. The calculation is based on total fuel cost, and does not take into account driver salary or maintenance costs, as it has yet to be determined who would operate the hauling element. All fuel costs are based off 2011 prices and are subject to change. The costs provided are meant to give a reasonable "ballpark" estimate of hauling costs and will likely differ depending on the particular contracts worked out when and if a facility is constructed.

Hauling capacities take in to account the density of the material in question as well as the maximum hauling capacities of the vehicles cited for each material. Density conversions are based off of the US EPA's "Standard Volume-to-Weight Conversion Factors"[9].

[9] http://www.epa.gov/osw/partnerships/wastewise/pubs/conversions.pdf

3.1 Factors Influencing Diversion of C&D Waste Materials:

While this section discusses the end markets for C&D wastes, it should be acknowledged that a variety of factors influence both the diversion of C&D materials and the growth of end markets. These supply and demand factors should be taken into consideration to understand the markets for C&D diversion. For a discussion of factors that influence generation of C&D wastes, see Section 2.5.

3.1.1 Legislation

Laws and ordinances at the level of local jurisdictions can cause an increase in the diversion of C&D materials when diversion codes like the BuildSmart and GreenPoints programs are put in place or expanded.

- **BuildSmart:** Boulder County's BuildSmart residential green building code, instituted in May, 2008, sets requirements and recommendations for a variety of areas of environmental impact, and applies to all new residential construction in unincorporated Boulder County requiring a building permit per the currently adopted building code. Demolition of residential buildings is no longer permitted – they must be deconstructed. Likewise, reusable or recyclable materials generated during remodeling or new construction must be directed to a recycling center and proof of diversion provided to the County.[10]

- **GreenPoints:** Both the City of Longmont, and the City of Boulder have adopted GreenPoints programs to their building codes, which address the recycling of C&D materials. Both ordinances include number of requirements (filing a deconstruction plan, recycling of specified materials, reaching certain recycling goals, etc.) linked to the building permit, which can lead to increased C&D recycling and use of recycled C&D materials.[11] Such jurisdiction-level building codes can greatly increase C&D waste diversion.

Opportunities to strengthen these programs include:
- Expanding coverage to commercial facilities;
- Requiring diversion of more materials, as markets expand and new materials come into widespread use;
- Increasing the size and type of projects covered by local diversion policies. E.g., requiring minimum diversion rates for projects too small to qualify under current regulations (perhaps by dollar value or square footage).
- Increasing enforcement of existing codes.
- Annual documentation of diversion successes.

Waste-Related Legislation: Policies that would drive increased C&D diversion could be impactful at both the local and state level. At the state level, legislative options include:
- Setting targeted recycling goals for local jurisdictions to meet (perhaps as part of solid waste planning work and diversion data reporting requirements);
- Enacting landfill bans of materials found in C&D (OCC, clean and/or treated dimensional lumber, aggregate fraction, etc.)

[10] County program details at www.bouldercounty.org/live/property/build/pages/buildsmarthome.aspx
[11] City program details at: www.bouldercolorado.gov/index.php?option=com_content&task=view&id=208&Itemid=489

- Landfill-level surcharges on specific C&D waste not segregated from mixed waste for diversion;
- Reduced compliance requirements and tax incentives to encourage new businesses that reuse and/or use diverted materials as feedstock; or
- Specific funding for research and pilot projects that increase C&D diversion.

At the local level, legislative options include:

- Replicating existing building code models in additional jurisdictions within the County.
- Partnering with neighboring counties and municipalities to develop similar building codes, increasing diversion across the Front Range.

Economic Factors: A variety of other economic factors can drive increased C&D diversion, such as:

- Increased tip fees at both C&D and MSW landfills along Front Range, whether driven by state policy or operator increases;
- Rising costs of specific fractions of new construction materials such as:
    - Dimensional lumber prices go up, which could lead to substitution of different kinds of framing (metal, composites) yielding materials in the waste stream that are harder to recycle or do not have any outlets.
    - As the cost of virgin plastics/oils goes up, the cost of new PVC piping, asphalt shingles, carpet, etc. would also rise, driving demand for products made from recycled/recovered plastics/oils, and in turn increasing the demand for diversion of those materials from the C&D waste stream
- Finally, as revenues from sales of diverted C&D materials increase, normal market factors should stimulate the growth of more end markets located in Colorado.

3.1.2 Mixed vs. Sorted Loads

Recycling facilities of all kinds must make the decision whether or not to accept loads of mixed materials as part of a single-stream recycling process or to require that materials be sorted at the source prior to entering the facility.

- **Single Stream:** Accepting mixed loads of C&D waste would allow contractors and haulers to simplify the demolition and deconstruction process significantly by placing all recyclable materials into a single container for hauling to the facility. These mixed loads would then be tipped onto a large common tipping floor and loaded onto a sorting line to be separated out by a series of screens, magnets, and manual pickers.

  This option could increase the amount of material that the facility is able to divert by simplifying the recycling process on the part of the generator. The added ease for generators, however, translates to increased complexity on the facility end. Modern sorting lines for C&D materials cost $1,000,000-$2,000,000 and increase the need for both personnel (manual pickers) and maintenance. Furthermore, mixed loads are more likely to contain refuse material and dirty recyclables, increasing the cost of residual disposal and lowering the market value of recyclable commodities.

- **Source-Separated:** Requiring that incoming material be brought to the facility in distinct, single-material loads could decrease total diversion, as it is much easier for contractors to throw all materials into the same container and take it to the landfill. The end market value of commodities, however, is likely to be higher for separated materials than mixed loads, as there is less chance of contamination.

  The infrastructure needed for source-separated recycling is significantly less costly and labor intensive than that required for single-stream. If acting as a transfer station for separated materials, the facility would only require a series of storage bays/tipping floors for different materials, and a way to haul them to end markets.

Most C&D sorting lines are designed to handle several hundred tons of material per day. Current diversion estimates for a Boulder County facility are between 30-115 tons per day, based on current and projected diversion estimates. For the purposes of this report, source-separated materials will be considered for the proposed facility.

3.2 Materials with Existing Markets

The following section discusses materials generated in Boulder County's C&D waste material stream that have mature existing markets – generally within a 50-60 mile radius from the population centers of the County. Existing markets are defined as entities that accept material for reuse or processing/manufacture into new products. End markets may pay for material, charge a fee to accept it, or accept material free of charge. The materials discussed below are factored in to the Phase 1 transfer station design of the C&D facility.

The materials with existing markets, to be included in the Phase 1 Design are:

- Aggregates
- Cardboard
- Ceiling Tiles
- Clean Wood
- Durable Goods and Reusable Building Materials
- Pallets
- Plastics
- Scrap Metal
- Vinyl Composite Tiles

3.2.1 Aggregates

Table 3-1 Aggregate High Level Generation Projections, With Low and High Diversion Estimates, in Tons Per Year*

	Generation	5% Diversion	15% Diversion
2010	48,000	2,400	7,200
2015	49,000	2,450	7,350
2020	51,000	2,550	7,650
2025	54,000	2,700	8,100
2030	52,500	2,625	7,875

*The full generation projection can be found in Figure 2.5

Overview: Aggregates generated from Construction and Demolition activities are primarily composed of concrete and asphalt, as well as concrete blocks, brick, and stone. In 2010, aggregates represented about 27% of the disposed C&D waste stream[12], though it is likely that the percentage of aggregates in the total generated C&D waste stream is larger. Increasing the diversion of aggregate materials would significantly reduce the total weight of C&D waste being sent to landfills.

Generated post-use aggregates can be split into two groups:

- Large generators such as those creating waste from industrial/commercial/municipal projects such as parking lots, roadways, and large foundations
- Smaller generators such as those creating waste from single-family residential or light commercial projects such as driveway or sidewalk repair.

Diversion Potential: During Construction and Demolition, concrete and other aggregates are often removed more or less simultaneously, allowing contractors to easily separate this material from the general C&D waste stream. Furthermore, aggregate processors charge higher fees for disposal of mixed material, and it is in the interest of the contractor to source separate this material. It is therefore well-recycled on the Front Range.

Due to the high cost of handling aggregates and relatively high quantity generated, it is likely that large generators will haul material directly to processing facilities near Denver rather than bring them to an intermediary County transfer station.

Most Construction and Demolition jobs that generate aggregates, even simple residential deconstructions, do so upwards of 100 tons at a time. When it is recycled, this quantity of material is hauled in large end-dump tractor-trailer rigs, each with a capacity of about 20 tons. Without a transfer vehicle larger than a tractor-trailer, there is no added efficiency from the transfer process.

As aggregate materials are heavy and costly to transfer/process, the County facility's tip fees could be set to discourage the drop-off of aggregates in order to encourage contractors to take them directly to end market processors. Such a facility, therefore, would likely receive material in smaller loads from smaller sized jobs; though it should be prepared to accept material from large generators should the case arise. Aggregate diversion by the proposed Boulder County C&D transfer station can be expected to range between 5% and 15%, as it will only be competing for smaller jobs and not the majority of the generated total.

[12] A full composition estimate and projection can be found in section 2.6.

Markets: Mixed aggregates can be processed to produce feedstock for reuse. Aggregate processing operations typically accept material from contractors for a fee of about $2/ton, though the price increases, up to around $15/ton, if the material is heavily contaminated with reinforcing steel. Materials are crushed and screened to specification for use in a variety of road and construction applications, including road base, backfill, paver bedding, drainage medium, and landscaping. In turn, processors sell processed material to end-users, which in this case includes contractors, consumers, and transportation departments who may also have been the original material generators. Processed material typically sells for about $7/ton.

Market Status: There are established markets for aggregate materials on the Front Range, and several processors in the greater Denver area. There are currently no aggregate processors active in Boulder County; the closest is in Weld County near Erie. The market for processed aggregates is currently over-supplied in the Front Range, as a glut of material from the teardown of the Stapleton airport has left large stockpiles. The main users of crushed aggregates are government departments of transportation; however the Boulder County Transportation Department has indicated that they produce sufficient material internally to suit their needs.

Table 3-2 Aggregate Market Sample

End Market-Company Name	Location	Materials/ Condition Accepted	End Markets Price Paid/Fee Charged to Customer (per ton)	Distance from Boulder County[a]	Round Trip Hauling Cost (per ton)[b]
Recycled Materials Company	Erie, CO	Concrete, Asphalt	-$2.00	14 miles	-$1.37
Oxford Recycling	Englewood, CO	Concrete, Asphalt	-$2.00	36 miles	-$3.51
Allied Recycled Aggregates	Commerce City, CO	Concrete, Asphalt	-$3.25/ton Concrete Asphalt Free	28 miles	-$2.73

[a] For estimation purposes, distances are calculated assuming a facility located at 63rd and Arapahoe in Boulder

[b] Based on a 20 ton end dump haul, 4 mpg, $3.90/gallon fuel cost prices are based on 2011 research

3.2.2 Cardboard

Table 3-3 Cardboard High Level Generation Projections, With Low and High Diversion Estimates, in Tons Per Year*

	Generation	5% Diversion	10% Diversion
2010	1,400	70	140
2015	1,500	75	150
2020	2,300	115	230
2025	2,500	125	250
2030	2,600	130	260

*The full projection can be found in Figure 2.5

Overview: Cardboard is a common material in the C&D waste stream. This material has established recycling infrastructure in Boulder County and healthy local end markets. As noted in Section 2.4 (Table 2-2), cardboard may comprise 1% or less (by weight) of the C&D waste stream generated in Boulder County over the next 20 years, though the effectiveness of recycling this material provides ample recycling infrastructure in and around the County.

Cardboard segregated by generators for recycling is typically sold to processors, who provide screening for contaminates and baling to reduce storage and transportation costs. The baled product is in turn sold to end-market mills, where it is used as a raw material in the production of new fiber products.

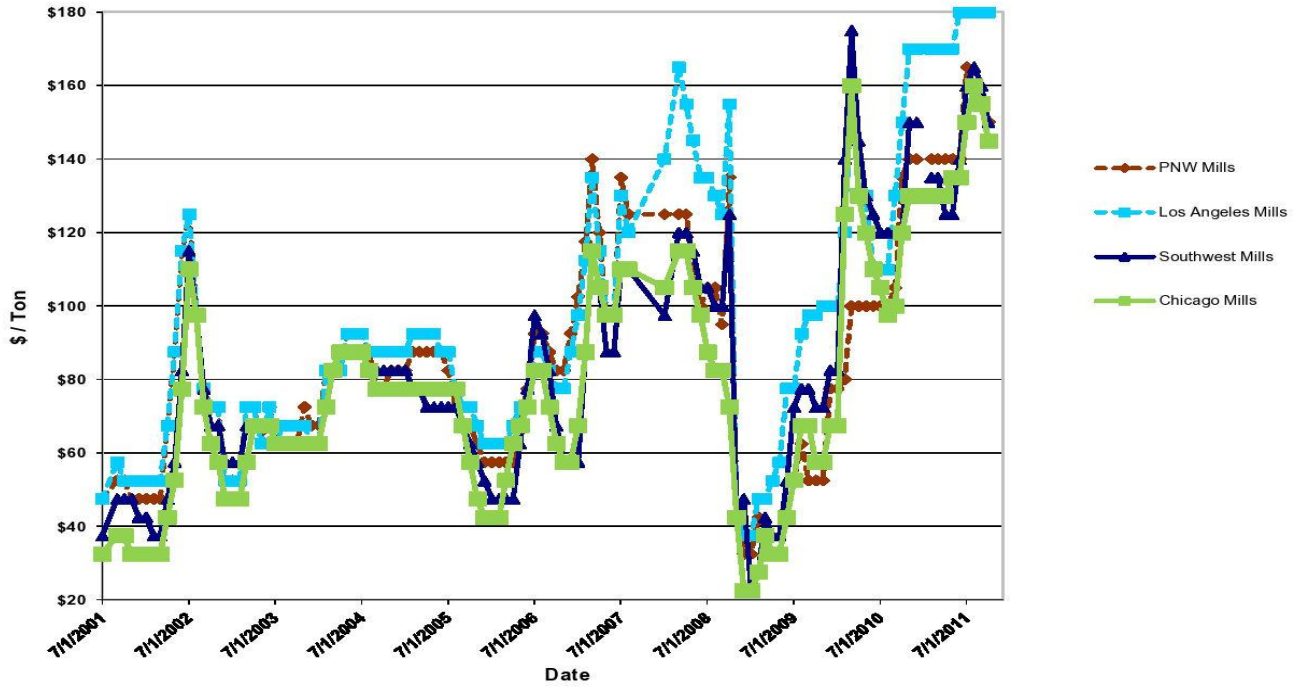
Issues associated with cardboard recycling include the generation of enough material to warrant diversion, space requirements (cardboard is a high volume/low weight material) and contamination (ideally, cardboard is collected in a container or location protected from weather). Some MRFs pay less for cardboard with high moisture content.

Diversion Potential: Although cardboard has a relatively high value when sold in bulk to brokers and mills, most MRFs recycling cardboard do not pay for small drop-offs of material. Most accept it free of charge, however. Cardboard at C&D jobsites is most often landfilled, as, due to its low density, it is not cost effective to haul to recyclers. A facility accepting segregated C&D materials should not expect to receive a large fraction of the generated waste stream, and could see an estimated 5%-10% of the generated cardboard entering the facility.

Current Markets: Given its relatively high revenue potential, MRFs will typically accept any cardboard that is relatively well sorted and mostly dry. Minimum/maximum quantity limits are not typical.

Cardboard is currently accepted at several local MRFs, as noted in Table 3-4. The Boulder County Recycling Center (BCRC) is the closest facility to most county projects, with the greatest earnings potential for cardboard generators. It is also the only publicly owned facility in this table. Other facilities include two multi-materials MRFs and a paper manufacturer/recycler, all located in north Denver. Table 3-4 includes the prices paid by each local processor for spot loads of cardboard delivered to their site. These prices do not distinguish between loose and baled loads (i.e., no pricing preference for compacted material).

Figure 3-1 Historic Cardboard Pricing by Region



Market Status: Prices paid by processors to generators is determined by both the cost of processing operations and the revenue or fees associated with selling processed material to fiber mills for re-manufacture. Figure 3-1 reflects 15-year mill pricing trends in areas of the country where Colorado-generated cardboard is likely to be sold[13]. These are gross prices that reflect mill pricing for cardboard delivered to their locations (i.e., pricing has not been modified to consider transportation costs between processors and mills).

As noted, mill pricing currently ranges from $145 to $180/ton (gross). Over the course of this data base (July 2001 to present), these prices have been as low as $25/ton (Chicago mills) and as high as $180/ton (Los Angeles mills). For late 2011/early 2012, market experts are expecting a correction in fiber markets that could lead to a drop in mill prices for cardboard by as much as $50 to $75/ton[14]. Although the prediction also includes a return towards current pricing for late 2012, any pricing fluctuation will undoubtedly be passed on by mills to both processors and generators.

Overall, cardboard will continue to be one of the most efficient means for packaging goods for transport and as such, widely used in nearly every industry. Cardboard generation is unlikely to change dramatically in the foreseeable future. Market fluctuations may impact recycling levels, however. In terms of future processing needs, it is expected that cardboard will generally be separated and recycled by contractors at a fairly high level (i.e., 50% to 75%), and hauled directly to processing facilities such as those identified in Table 3-12. A County C&D facility should expect to receive some cardboard in loose, mixed loads, which may be

[13] The data source for these mill prices is the Official Board Markets (OBM) publication that has been provided for the purpose of tracking historical pricing trends since 2001 by Boulder County and the City of Denver.

[14] Recycling Today, October 21, 2011.

separated and sold to local processors depending on contamination levels. The C&D facility could also bale and store cardboard separated from mixed loads for direct shipment to mills, although these quantities are expected to be low and accumulation of full loads will occur slowly (especially as no other fiber material is expected on a regular basis from the C&D waste stream).

Table 3-4 Cardboard Market Sample

End Market-Company Name	Location	Materials/ Condition Accepted	End Markets Price Paid/Fee Charged to Customer (per ton)	Distance from Boulder County[a]	Round Trip Hauling Cost (per ton)[b]
Boulder County Recycling Center	Boulder, CO	Cardboard, loose	$150/ton	0 miles	-$.24
Altogether Recycling	Denver,CO	Cardboard, loose	$150/ton	24 miles	-$5.85
Waste Management	Denver, CO	Cardboard, loose	Unavailable	25 miles	-$6.09
International Paper	Denver, CO	Cardboard, loose	$100/ton	31 miles	-$7.56

[a] For estimation purposes, distances are calculated assuming a facility located at 63rd and Arapahoe in Boulder

[b] Based on an 8 ton compactor load, 4 mpg, $3.90/gal fuel cost, prices based off 2011 research

3.2.3 Ceiling Tiles

Table 3-5 Ceiling Tile High Level Generation Projections, With Low and High Diversion Estimates, in Tons Per Year*

	Generation	10% Diversion	25% Diversion
2010	70	7	18
2015	75	8	19
2020	62	6	16
2025	67	7	17
2030	70	7	18

*The full projection can be found in Figure 2.5

Overview: Acoustic ceiling tiles are primarily made of either fiberglass or mineral fibers and have limited recycling options nationwide. These materials are most often generated during the deconstruction of large commercial buildings, and because of this are likely to enter the C&D waste stream in large, infrequent loads. Ceiling tiles were not broken out in the 2010 waste composition study, and precise data for this material is not available. Presumably, any ceiling tiles counted in the study would be classified as "Other C&D", a category that comprised about 3.8% or 4,000-7,000 tons of the generated C&D waste in 2010. Ceiling tiles comprise an estimated 1% of the Other C&D category, or about 60-70 tons per year.

Diversion Potential: Diversion of this material would require educational outreach to the construction/ deconstruction community to inform professionals of a diversion option. Furthermore, requiring contractors to palletize tiles on the job site may decrease diversion, and the facility should consider accepting material both loose and palletized. Due to the low cost of recycling ceiling tiles, however, it is feasible that they could be diverted by around 10%-25% with minimal impact on space and equipment requirements at the C&D facility, this would amount to about 6-19 tons per year.

Markets: The only company currently recycling ceiling tiles is Armstrong, a building materials manufacturer that operates a nationwide recycling program to collect material for use as raw material in the production of new products.

Armstrong provides asbestos testing free of charge, requiring that a sample of the material to be recycled is sent to Armstrong's facility for testing prior to any material leaving the jobsite. The results of the test generally take 2-3 days to receive. Once the tiles have been approved by Armstrong, they are deconstructed and either loaded onto pallets or brought loose to the transfer center. Individual projects must be kept together with proper documentation throughout the process to ensure product quality.

Once the ceiling tiles have been stacked 4' tall on 4'x4' pallets and wrapped for shipment, they are stored until 30,000 sqft (44 pallets or about 1 ton) of material has accumulated. Armstrong then sends a truck to haul away this material free of charge.

Market Status: Ceiling tile recycling is a new process that is currently only being implemented by one company, although the success of the program has led to expansion. As raw materials of all types become more expensive, product stewardship and industry recycling programs are likely to increase, potentially providing a stable market for materials such as ceiling tiles.

Table 3-6 Ceiling Tile Market Sample

End Market-Company Name	Location	Materials/ Condition Accepted	End Markets Price Paid/Fee Charged to Customer (per ton)	Distance from Boulder County[a]	Round Trip Hauling Cost
Armstrong Recycling	Lancaster, PA	Ceiling Tiles, Palletized	$0/ton	1500 miles	Free when hauled in full tractor trailer loads

[a] For estimation purposes, distances are calculated assuming a facility located at 63rd and Arapahoe in Boulder

3.2.4 Clean Wood

Table 3-7 Clean Wood High Level Generation Projections, With Low and High Diversion Estimates, in Tons Per Year*

	Generation	15% Diversion	30% Diversion
2010	12,750	1,913	3,825
2015	13,500	2,025	4,050
2020	14,250	2,138	4,275
2025	15,250	2,288	4,575
2030	15,750	2,363	4,725

*The full projection can be found in Figure 2.5

Overview: Clean wood waste is includes dimensional lumber, woody land-clearing debris, and engineered wood products (such as plywood and particleboard). Used pallets can be treated as clean wood waste, and a thorough discussion of pallet recycling can be found in Section 3.2.6. As noted in Section 2.3, clean wood comprises an estimated 6% of the generated C&D waste stream, a significant portion of the C&D waste in Boulder County, and has several methods for recycling.

Diversion Potential: The prevalence of wood in the built environment means that it is frequently separated out from the general waste stream on site by contractors. Unless the wood is being deconstructed, however, this material is unusable and is sent to either the landfill or one of several wood waste processors in the region.

Currently, local and County building codes mandating deconstruction of buildings are not sufficient to incentivize C&D professionals to properly deconstruct wood elements for reuse. Currently, an estimated 10% of the wood waste stream being thrown away or recycled could be reused as is, a figure that could rise with increased awareness and enforcement of deconstruction practices.

Unless diversion regulations are expanded or enforced with greater efficiency, the diversion of wood waste is unlikely to increase dramatically. A Boulder County C&D transfer station would be able to capture about 10%-30% of the total wood waste generated in the County.

Markets: In Boulder County, the largest users of clean wood waste are mulch and compost producers. These companies accept clean wood, including engineered products, for a fee and grind the material for use as either landscaping mulch or compost, which is then sold to consumers.

Wood is sometimes taken off job sites in reusable condition, in which case it can be brought to a used building materials yard for resale to consumers and contractors. When clean wood is not in good enough condition to be reused as is, the primary processing option is to grind it into material that can be used by several end markets.

Ground wood can also be used as alternate daily cover for landfills, although as this practice results in material going to landfill, this report does not consider it as a diversion alternative. In addition, clean ground wood can be used as fuel for biomass burners used to heat buildings. Currently, Boulder County's Open Space and Correctional facilities operate biomass burners using ground wood from land-clearing activities conducted by the County.

Market Status: Local mulch and compost companies accept material on a large scale, and anticipate doing so for the foreseeable future. These markets, however, report that they

have at times had difficulty moving all of the finished mulch and compost that they produce, and that additional consumers and markets for these materials are needed to ensure that supply does not outstrip demand.

The open space and correctional departments of Boulder County, which operate biomass burners, report that they can use appropriately sized clean, non-engineered C&D wood waste as fuel. Typically, land clearing projects throughout the year supply enough wood to fuel these two burners. There has, however, been need for these departments to purchase additional fuel in the past. Currently, County biomass burners are not a reliable end market, though the addition of more biomass burners in government or commercial buildings would provide additional demand for this material.

Table 3-8 Clean Wood Market Sample

End Market-Company Name	Location	Materials/ Condition Accepted	End Markets Price Paid/Fee Charged to Customer (per ton)	Distance from Boulder County[a]	Round Trip Hauling Cost (per ton)[bc]
Western Disposal	Boulder, CO	Clean wood, loose	-$24/ton	2 miles	-$.65
A1 Organics	Denver,CO	Clean wood, loose	-$12.50/ton	30 miles	-$9.75
Oxford Recycling	Englewood,CO	Clean wood, loose	-$17.50/ton	36 miles	-$11.70
Center for Resource Conservation's ReSource Yard	Boulder, CO	Reusable Wood	$0/ton	1 mile	$0.33

[a] For estimation purposes, distances are calculated assuming a facility located at 63rd and Arapahoe in
[b]Based on a 6 ton roll-off haul, 4 mpg, $3.90/gallon fuel cost. Prices are based on 2011 research and are subject to change
[c]Prices are based on 2011 research

3.2.5 Durable Goods and Reusable Building Materials

Table 3-9 Durable Goods and Reusable Building Materials High Level Generation Projections, With Low and High Diversion Estimates, in Tons Per Year*

	Generation	1% Diversion	5% Diversion
2010	3,850	39	193
2015	4,000	40	200
2020	4,300	43	215
2025	4,500	45	225
2030	4,750	48	238

*Estimates based on this fraction as 2.7% of the total C&D waste stream

Overview: Durable goods, consisting of appliances, cabinets, doors, lighting, building hardware, architectural features, and windows, as well as reusable building materials such as wood, bricks, pavers and stone, have an existing market with a number of reuse stores in the County and Front Range, and are often salvaged from job sites and brought directly to one of several outlets in the region. Reusable durable goods should be sent to dedicated sales yards, though it is likely that a facility accepting C&D waste will receive some reusable building materials that can be separated from the waste stream for reuse by consumers.

Diversion Potential: Although this category was not specifically broken out in the 2010 waste composition study, it could represent as much as 2.7% of C&D waste based on the categories used in the study. Recycling options for this material are growing on the Front Range, with several local non-profits providing diversion opportunities and already capturing an estimated 25-50% of the total generated reusable C&D material. A C&D transfer station would not be likely to receive much of this material, particularly if it were located near one of the used materials yards. Given that some incoming material, such as wood, may be reusable, however, such a facility could expect to receive an estimated 1%-5% of the generated reusable goods.

Markets: Several organizations that purchase or accept durable goods and reusable building materials operate in and around Boulder County. Facilities that resell durable goods typically sell to do-it-yourself remodeler/carpenter consumers and to some building contractors. The CRC's ReSource yard in Boulder and the St. Vrain Habitat for Humanity ReStore in Longmont are two local non-profits that accept materials as donations and resell them to consumers and contractors. Both non-profit organizations offer tax deductable receipts in exchange for donations.

There are also several commercial operations in the Denver metro area that sell reusable durable goods and architectural salvage materials. These markets effectively are in competition with the two local non-profits, and will pay modest fees for items of value that they can sell at a profit. Some Boulder County contractors will send recovered items to the Denver markets if the time and money is worth it to them.

Market Status: The salvage and reuse of building materials through organized sales yards is a growing practice across the country. As these outlets have been operating for fewer than ten years, it remains to be seen what the longevity of these markets will be. Nevertheless, considering the rise in awareness of the value of reusable building materials, as well as

support from governmental deconstruction policy, these markets are likely to remain active as a viable option for reusable goods.

Table 3-10 Durable Goods and Reusable Building Materials Market Sample

End Market-Company Name	Location	Materials/ Condition Accepted	End Markets Price Paid/Fee Charged to Customer (per ton)	Distance from Boulder County[a]	Round Trip Hauling Cost[b]
ReSource	Boulder, CO	Reusable durable goods and building materials	None, Donation receipts available	0 miles	$0.00
St. Vrain Habitat for Humanity ReStore	Longmont, CO	Reusable durable goods and building materials	None, Donation receipts available	15 miles	-$4.88
Bud's Warehouse	Denver, CO	Reusable durable goods and building materials	None, Donation receipts available	25 miles	-$8.13
Habitat for Humanity Building Outlet	Denver, CO	Reusable durable goods and building materials	None, Donation receipts available	31 miles	-$10.08

[a] For estimation purposes, distances are calculated assuming a facility located at 63rd and Arapahoe

[b] Based on a 6 ton truck load, 4 mpg, $3.90/gal fuel cost, prices based off 2011 research

3.2.6 Pallets

Table 3-11 C&D Pallet High Level Generation Projections, With Low and High Diversion Estimates, in Tons Per Year*

	Generation	5% Diversion	10% Diversion
2010	5,500	275	550
2015	6,000	300	600
2020	6,250	313	625
2025	6,750	338	675
2030	7,000	350	700

*The full projection can be found in Figure 2.5

Overview: Wooden pallets are the standard method of shipping goods in the United States, and are often generated at Construction and Demolitions sites. Many "used" pallets are in good enough condition to reuse again without repair. For gently damaged pallets, it is less costly to rebuild them than to build new ones. Pallets damaged beyond repair can be easily recycled by grinding the wood into mulch. These three end uses have created the stable secondary market for wood pallets.

Diversion Potential: Although pallets are sometimes brought to C&D job sites as a way to transport supplies and building materials, they are most often associated with commercial activity. Although commerce is not strictly speaking a Construction and Demolition-type activity, a great many pallets are currently landfilled in Boulder County as a result of inadequate pallet recycling options. If accepted by a conveniently located facility, pallets may well be recycled at a rate of 5%-10%.

Markets: There are several pallet recycling companies on the Front Range, located primarily in the Denver area. These processors accept and refurbish pallets, and may pay for undamaged, well constructed pallets, delivered in relatively high quantities (100 or more pallets). Non-salvageable pallets (e.g., roofing pallets) are not accepted. Those pallets in greatest demand are the standard grocery pallets (48" by 40" raised, called "four-way," meaning a pallet jack or forklift can lift the loaded pallet from all four directions). For sizeable loads, when demand is good, processors may pay up to $2.50/pallet for completely reusable loads, though prices in the long run tend to be about $1 - $2/pallet. Pallets are either reused, repaired, dismantled so the lumber can be reused, or sent to a wood grinder for mulch production.

Market Status: The market for pallets is steady, although it is subject to swings in demand in relation to the health of the economy. For example, at the time of this writing, one pallet company was not purchasing pallets due to several-months overstock. Because pallets are widely used across multiple industries, the market for their reuse can be expected to remain generally stable for the foreseeable future. As long as the cost of manufacturing new pallets increases, pallet recycling will continue to be an economical choice. The market for top-quality pallets is naturally healthier than broken pallets, although unwanted broken pallets can be treated as clean wood waste and ground into reusable mulch.

Table 3-12 Pallet Market Sample

End Market-Company Name	Location	Materials/ Condition Accepted[c]	End Markets Price Paid/Fee Charged to Customer (per ton)	Distance from Boulder County[b]	Round Trip Hauling Cost[a] (per ton)
Frisco Pallet, LLC	Denver,CO	Repairable Wood Pallets	$1-$2/pallet for quantities > 100 pallets	22 miles	-$21.45
Waste-Not	Loveland, CO	#1: Reusable #2: Repairable #3: Damaged stacked, lg. quant.	#1: $1.50-$2.50/pallet #2: $.50-$1.00/pallet #3: charge to receive	41 miles	-$39.98
L&R Pallet	Denver, CO	Repairable Wood Pallets: stacked, > 150 at a time	$.50-$1.50/pallet	30 miles	-$29.25

[a] Based on a 2 ton haul of 100 pallets in a tractor-trailer, 4 mpg, $3.90/gal fuel cost, prices based off 2011 research

[b] For estimation purposes, distances are calculated assuming a facility located at 63rd and Arapahoe in Boulder
[c] Pallet recyclers only will take the 48x48 or 48x40 "four-way" pallets (can be accessed by forklift from all 4 directions)

3.2.7 Plastics

Table 3-13 Plastic High Level Generation Projections, With Low and High Diversion Estimates, in Tons Per Year*

	Generation	5% Diversion	20% Diversion
2010	700	35	140
2015	1,500	75	300
2020	3,000	150	600
2025	5,500	275	1,100
2030	7,750	388	1,550

*The full projection can be found in Figure 2.5

Overview: Plastics from Construction and Demolition activities are primarily rigid PVC (polyvinyl chloride), high density film (such as Tyvek®) and low density polyethylene (LDPE) stretch plastic film. These materials have existing markets on the Front Range, though prices for material are volatile.

Diversion Potential: While plastics are highly recyclable, they are often heavily soiled by the time they come off of a C&D jobsite. Both post-consumer scrap such as PVC piping, as well as used LDPE stretch film pick up contaminants easily such that they may not be acceptable for recycling. Furthermore, these materials are costly to haul based on their low density and low market value in small quantities. For these reasons, a Boulder County C&D transfer station would only receive an estimated 5%-20% of the total generated C&D plastic waste.

Markets: Several end markets for stretch wrap in the Front Range accept this material free of charge. PVC and high-density film plastics currently have recycling markets on the Front Range, but at the time of this writing, one end market notes that generally prices are too volatile to offer firm quotes. One recycler will receive clean, undamaged, bundled PVC pipes in 4' lengths for $.00-$.12/lb., and will pay $.00-$.16/lb. for HDPE/LDPE (high-density and low-density polyethylene, respectively) plastic film, with range based on cleanliness and mixed vs. sorted. It will not receive dirty plastic film such as is found in a mixed roll-off of C&D materials. Note that a plastics manufacturer near Denver is developing the capacity to accept these plastic materials for recycling (likely coming online in 2012), and has estimated that it might pay between $.05-$.15/lb.

Market Status: The market for C&D plastics can has developed well in the Front Range over the past few years. Stretch wrap can be recycled through a specialty, non-profit market, with PVC and HDPE/LDPE film plastic recycling options growing steadily in the area.

Table 3-14 Plastic Market Sample

End Market-Company Name	Location	Materials/ Condition Accepted	End Markets Price Paid/Fee Charged to Customer (per ton)	Distance from Boulder County[a]	Round Trip Hauling Cost(per ton)[E]
Hi-Tec Plastics	Commerce City, CO	High Density and PVC Scrap	$.05-$.15/lb	30 miles	-$8.36[B]
Altogether Recycling	Denver, CO	Pre-/post-consumer industrial scrap	Market too volatile to quote at this time	24 miles	-$6.69[B]
Eco Cycle Boulder, CO	Boulder, CO	Stretch Plastic	$0/ton	3 miles	-$1.95[C]
Waste-Not Loveland, CO	Loveland, CO	Plastic films (HDPE & LDPE) baled, truckload	$.00-.16/lb. Prices less on mixed, contaminated loads	41 miles	-$3.63[D]
		PVC pipes (4' lengths, bundled, clean, undamaged)	$.0-$.12/lb.		-$11.42[B]

[A] For estimation purposes, distances are calculated assuming a facility at 63rd and Arapahoe Ave. in Boulder
[B] Assumes a 4 ton haul, 4 mpg, $3.90 per gallon fuel cost
[C] Assumes a 3 ton, compacted haul, 4 mpg, $3.90 per gallon fuel cost
[D] Assumes a full trailer load of baled LDPE, 4 mpg, $3.90/gallon fuel cost
[E] Prices are based on 2011 research

3.2.8 Scrap Metal

Table 3-15 Scrap Metal High Level Generation Projections, With Low and High Diversion Estimates, in Tons Per Year*

	Generation	1% Diversion	5% Diversion
2010	7,850	79	393
2015	9,000	90	450
2020	9,500	95	475
2025	10,000	100	500
2030	10,500	105	525

*The full projection can be found in Figure 2.5

Overview: Scrap metal is classified as either ferrous (containing iron, such as steel) or non-ferrous (aluminum, brass etc.). Material can be further classified by metal type, and when separated allows material to be sold at much higher rates than as a mixed load.

Scrap metals are the most mature market of all the recyclables, as humans have reused, re-refined, and recycled metals for as long as we have been extracting them. It is highly likely that there will be markets for all scrap metals recovered at a Boulder County C&D transfer facility. As noted in section 2.3, scrap metal comprises some 6% of the total C&D waste stream, and although it is highly recycled already, any facility accepting C&D materials is likely to receive some scrap metal.

Diversion Potential: Due to the high value of scrap metal, nearly all valuable material is separated out at the job site by contractors. This material can amount to significant revenue for building professionals and haulers alike, and the likelihood of much scrap metal being brought in separated loads to a County C&D transfer station is very low. Therefore, although the total diversion rate for all generated scrap metal is most likely about 75-80%, a Boulder County C&D transfer station is only likely to receive an estimated 1%-5%.

Markets: Scrap metal recyclers process, sort, and consolidate incoming metals to be sent to foundries, refiners, and smelters who produce specific metal outputs used in the production of new metal products. Numerous scrap metal recyclers throughout the Front Range pay market prices for material. Local processors will accept both sorted and unsorted material, though metals that are sorted by type command significantly higher prices.

Market Status: The market for scrap metal on the Front Range is healthy and well established. There is, historically, almost always a market for these materials; however, scrap metal prices can vary greatly depending on swings in the market. Nevertheless, scrap metal remains a valuable material and can be expected to remain as such into the foreseeable future.

Table 3-16 Scrap Metal Market Sample

End Market-Company Name	Location	Materials/ Condition Accepted	End Markets Price Paid/Fee Charged to Customer (per ton)[c]	Distance from Boulder County[a]	Round Trip Hauling Cost (per ton)[b]
Iron and Metals Co.	Denver, CO	Ferrous and Non-Ferrous Scrap Metal, loose	$190/ton mixed metal	25 miles	-$4.88
Atlas Metal and Iron	Denver, CO	Ferrous and Non-Ferrous Scrap Metal, loose	$195/ton mixed metal	30 miles	-$5.85
Wise Recycling	Longmont, CO	Non-Ferrous Scrap Metal, loose	Market prices, $.53/lb for aluminum	33 miles	-$6.44
Western Aluminum	Boulder, CO	Non-Ferrous Scrap Metal, loose	Market prices, $.43/lb for aluminum	3 miles	-$0.59

[a] For estimation purposes, distances are calculated assuming a facility located at 63rd and Arapahoe in Boulder
[b]Based on a 10 ton roll-off haul, 4 mpg, $3.90/gallon fuel cost
[c]Prices are based on 2011 research

3.2.9 Vinyl Composition Tile (VCT)

Table 3-17 Vinyl Tile High Level Generation Projections, With Low and High Diversion Estimates, in Tons Per Year*

	Generation	10% Diversion	25% Diversion
2010	140	14	35
2015	150	15	38
2020	125	13	31
2025	135	14	34
2030	140	14	35

*The full projection can be found in Figure 2.5

Overview: Vinyl composition tiles are commonly used in large commercial or public buildings as cheap, durable flooring. These materials are most often landfilled at the end of their life, although in recent years one company has begun recycling vinyl tiles for use as raw materials in the manufacture of new products. This material was not broken out in the 2010 Waste Composition Study, and generation estimates are not currently available. Presumably, however, any vinyl tiles found during the study would have been classified as "Other C&D" a category that makes up an estimated 3.8% of generated C&D waste. VCTs represent an estimated 2% of the Other C&D category, or between 125-150 tons per year.

Diversion Potential: Diversion of this material would require educational outreach to the Construction and Demolition community, though the low cost of testing and recycling this material should allow for diversion rates of 10%-25%, amounting to between 13-38 tons per year. Due to limited infrastructural requirements, recycling this material at a C&D facility would have little impact on the cost and layout of the site.

Markets: Armstrong is the only recycling market for vinyl tiles. Based out of Pennsylvania, they operate a nationwide recycling program for vinyl tiles very similar to their ceiling tile recycling operation. Materials are screened for contaminants and loaded into large cardboard boxes for transport to a processing facility, where they are melted down for use as raw material.

Market Status: Vinyl tiles are a material without established recycling protocols, and the market for these materials can be described as experimental. In recent years, however, the Armstrong vinyl tile recycling program has been growing and has met with success. Representatives from Armstrong have indicated that they are expanding their operation and are looking for new sources of material.

Table 3-18 Vinyl Composite Tile Market Sample

End Market-Company Name	Location	Materials/ Condition Accepted	End Markets Price Paid/Fee Charged to Customer (per ton)	Distance from Boulder County[a]	Round Trip Hauling Cost
Armstrong Recycling	Lancaster, PA	Vinyl Tiles, Boxed	$0.00	1500 miles	Free when hauled in full tractor trailer loads

[a] For estimation purposes, distances are calculated assuming a facility located at 63rd and Arapahoe in Boulder

3.3 Materials with Developing Markets

This section discusses materials for which markets are either inactive or developing, and should be considered for inclusion during the Phase 2 period of expansion depending on the strength of each market in the future. Inactive markets were once viable, but have stalled in recent years. These markets may become viable in the future, and individual circumstances are noted where appropriate. Developing markets are either new programs or hypothetical recycling options that have not yet come online.

The materials with developing markets, to be considered for Phase 2 expansion are:

- Asphalt Shingles
- Carpet
- Clean Gypsum Wallboard
- Plate Glass

3.3.1 Asphalt Shingles

Table 3-19 Asphalt Shingle High Level Generation Projections, With Low and High Diversion Estimates, in Tons Per Year*

	Generation	10% Diversion	25% Diversion
2010	22,750	2,275	5,688
2015	21,000	2,100	5,250
2020	19,000	1,900	4,750
2025	18,500	1,850	4,625
2030	19,200	1,920	4,800

*The full projection can be found in Figure 2.5

Overview: Asphalt shingles can be ground to specification for use as part of hot mix asphalt (HMA) for paving projects. Many states allow the use of ground asphalt shingles in HMA, and the Colorado Department of Transportation (CDOT) is currently supporting test projects to determine the viability of using recycled asphalt shingles in its road paving projects. These tests should be complete by 2013, at which point CDOT may be in a position to make a firm ruling on the use of recycled asphalt shingles (RAS) in its projects. As the leading figure in Colorado's transit industry, CDOT's ruling will greatly influence how municipalities and private entities view and use RAS in the future, and positive ruling would increase the use of recycled asphalt shingles dramatically.

Diversion Potential: It is difficult to estimate the diversion potential of this material due to the developing and uncertain nature of its recycling opportunities. Due to the success of recycling asphalt shingles in other parts of the country, however, it is likely that the use of RAS will increase in the region over the next 20 years, and that a C&D transfer station could expect to divert an estimated 10%-20% of the total generated asphalt shingles.

Markets: The primary market for recycled asphalt shingles are local paving companies, who can use this material to supplement virgin binder in paving projects. Private asphalt contractors are hired by private companies and municipalities to manage the paving of roads, paths and parking lots. Some asphalt companies own grinders capable of processing this material, and can accept sorted shingles; other companies must purchase ground material or use virgin asphalt instead.

Market Status: The market for asphalt shingles on the Front Range can be classified as stalled. Over the past few years, several companies have begun accepting asphalt shingles, and the Departments of Transportation of Boulder County and its municipalities have used the material in several test paving projects. Currently, there is a large excess of material and little demand, as local DOTs wait for the results of CDOT's test projects to come in. Given the long-term nature of road-building projects, it is important that adequate time be given for the tests to complete, generally 2-3 years. The growth of this market depends on the success of the material tests currently underway. Nevertheless, asphalt shingles have been used for years in other states and may be found a suitable material for use in Colorado roads.

Table 3-20 Asphalt Shingle Market Sample

End Market-Company Name	Location	Materials/ Condition Accepted	End Markets Price Paid/Fee Charged to Customer (per ton)	Distance from Boulder County[a]	Round Trip Hauling Cost (per ton)[bc]
Asphalt Specialties	Erie, CO	Asphalt Shingles	Free	13 miles	-$2.54
Brannan Sand And Gravel	Denver, CO	Asphalt Shingles tested for asbestos	-$10 to -$30/ton	10 miles	-$1.95

[a] For estimation purposes, distances are calculated assuming a facility located at 63rd and Arapahoe in Boulder

[b]Based on a 10 ton roll-off haul, 4 mpg, $3.90/gallon fuel cost. Prices are based on 2011 research and are subject to change

[c]Prices are based on 2011 research

3.3.2 Carpet

Table 3-21 Carpet Generation/Diversion Projection, High level estimate in Tons Per Year*

	Generation	3% Diversion	10% Diversion
2010	1,400	42	140
2015	2,250	68	225
2020	3,000	90	300
2025	2,500	75	250
2030	1,750	53	175

*The full projection can be found in Figure 2.5

Overview: Carpet can be recycled by shearing the plastic fibers off of the backing and reusing the plastic in the manufacture of new products. The process requires specialized testing equipment to identify different carpet types and, for the end processor, shearing technology.

Diversion Potential: Carpet recycling is in its infancy in the US, with about 4% of all scrap carpet generated nationwide in 2010 being recycled. Considering the developing markets for recycled carpet along the Front Range, and the significant population in the region, a successful carpet recycling program at a Boulder County C&D facility could expect to receive an estimated 3%-10% of the carpet generated in the County.

Markets: There are several end markets for recycled carpet, depending on the composition of the material.

Clean carpet tiles can be recycled through direct reuse. Re:Volve in Broomfield accepts clean Nylon 6 and Nylon 6,6 tiles for reuse free of charge.

Using a fiber analyzer tool ($20,000) carpet can be sorted by fiber grade (PET; Polypropylene; Nylon 6; Nylon 6,6; and wool) and shipped to end markets for recycling, currently Natural Transitions in Colorado Springs is accepting Nylon 6,6 and carpet pad for recycling.

Carpet can be used as fuel for certain industries, most notably in cement-plant furnaces. A company called GeoCycle operates a plant in Florence, CO, and is in the process of integrating scrap carpet into its fuel mix. This transition is currently in the permitting stage, and the process is expected to take between 12-18 months and to displace 15-20% of the coal that it currently uses. Geocycle has indicated that they would be interested in taking carpet from a Boulder County transfer facility, and that they might charge $30-$50 per ton depending on how the carpet is packaged.

The current LEED (Leadership in Energy and Environmental Design) green building ranking system gives points to remodels for carpet diverted from landfill, including carpet used as fuel. While this is not recycling as defined for the purpose of this study, it is noteworthy that this specific LEED point has been enough to generate significant feedstock for several carpet "recycling" businesses in other major metropolitan areas, and might do so in the Front Range.

Market Status: There are emerging options for recycling carpet on the Front Range. Natural Transitions (Colorado Springs) is currently collecting and baling Nylon 6,6 and carpet pad, and paying $.01-.02/pound. Re:Volve (Broomfield) collects carpet tiles and resells them as used. Rocky Mountain Recycling (Denver) is investigating its options for entering carpet recycling. There was a failed attempt to recycle carpet in Colorado in the past few years; its failure is thought to be due to bad business practices. Experts in the carpet recycling field note that the Front Range, with a population of 2-3 million, should be able to support a viable carpet recycling operation.

Table 3-22 Carpet Market Sample

End Market-Company Name	Location	Materials/ Condition Accepted	End Markets Price Paid/Fee Charged to Customer (per ton)	Distance from Boulder County[a]	Round Trip Hauling Cost (per ton)[b]
GeoCycle's UT plant (may have CO plant in 2013)	Devils Slide, UT, Florence, CO, Colorado Springs, CO	Rolled, free of debris (& flooring nails if possible). Prices vary by how shipped	$30/ton baled $40/ton pallets $50/ton loose	100 miles (To CO Springs Facility)	-$114.71
Re:Volve Broomfield, CO	Broomfield, CO	Carpet tiles, clean (nylon 6 or 6,6)	Receives for free	13 miles	-$14.91
Natural Transitions	Colorado Springs, CO	Nylon 6,6 and Carpet pad	$20-$40/ton	100 Miles	-$114.71

[a] For estimation purposes, distances are calculated assuming a facility located at 63rd and Arapahoe in Boulder
[b] Based on a 1.7 ton roll-off haul, 4 mpg, $3.90/gallon fuel cost. Prices are based on 2011 research

3.3.3. Clean Gypsum Wallboard

Table 3-23 Clean Gypsum Wallboard Generation/Diversion Projection, High level estimate in Tons Per Year*

	Generation	1% Diversion	5% Diversion
2010	5,750	58	288
2015	6,000	60	300
2020	6,250	63	313
2025	6,750	68	338
2030	7,000	70	350

*The full projection can be found in Figure 2.5

Overview: Gypsum wallboard, commonly known as Drywall, is composed of sheets of gypsum covered by paper on two sides. The gypsum inside wallboard is a valuable commodity and has many uses in agriculture, cement manufacture, and the construction of new wallboard. As noted in Section 2.3, clean (unpainted, pre-install and manufacture scrap) wallboard comprises roughly 4% of the C&D waste stream. Although clean wallboard scrap is a common material at construction sites, it is largely in the form of trimmings and small pieces of wasted material. Gypsum wallboard is commonly considered a difficult material to recycle, although markets are currently developing for this material.

Diversion Potential: Although gypsum wallboard can be used for a variety of purposes when recycled, the markets for these materials on the Front Range have not yet spurred significant recycling efforts. Currently, this material is almost exclusively landfilled, so the potential for diversion is high. Nevertheless, clean drywall scraps are not a high value material, and do not represent a large quantity on individual jobsites. It is unlikely that contractors will readily separate out this small-fraction material for individual recycling as this would be labor intensive to haul individually to a C&D transfer facility. Therefore, a Boulder County C&D transfer station could expect to receive an estimated 1%-5% of the total generated clean drywall scrap.

Markets: Currently, clean (or pre-consumer) wallboard can be brought to local composter A1 Organics, where it is used to add body to compost products. This market charges about $12.50/ton to receive this material for recycling. Gypsum recovered from wallboard can also be used to supplement raw gypsum in the production of Portland cement.

Market Status: The market for gypsum wallboard is developing, with additional research remaining to determine the viability of using this material as a raw material for cement production. This process should continue to evolve over the course of the next few years. Clean wallboard can currently be composted by local composter A1 Organics, although the amount that this operation can accept is on the order of only a few thousand tons per year.

A proprietary technology is in use in the Northeast and Europe that allows painted wallboard to be recycled by shearing off the paper from either side, leaving only the gypsum core. The company using this technology is aiming to expand into other regions, but currently has no plans to start operating near Colorado.

Table 3-24 Clean Gypsum Wallboard Market Sample

Material	End Market-Company Name	Location	Materials/ Condition Accepted	End Markets Price Paid/Fee Charged to Customer (per ton)	Distance from Boulder County[a]	Round Trip Hauling Cost (per ton)[bc]
Clean Gypsum Wallboard	A1 Organics	Denver,CO	Clean wallboard scrap, new	-$12.50/ton	30	-$9.75

[a] For estimation purposes, distances are calculated assuming a facility located at 63rd and Arapahoe in Boulder
[b]Based on a 6 ton roll-off haul, 4 mpg, $3.90/gallon fuel cost
[c]Prices are based on 2011 research and are subject to change

3.3.4 Plate Glass

Table 3-25 Plate Glass High Level Generation Projections, With Low and High Diversion Estimates, in Tons Per Year*

	Generation	15% Diversion	30% Diversion
2010	425	64	128
2015	1,500	225	450
2020	3,000	450	900
2025	5,000	750	1,500
2030	7,000	1,050	2,100

*The full projection can be found in Figure 2.5

Overview: Plate glass, due to chemical composition differences, cannot typically be mixed with container glass for recycling, and thus is often landfilled in the Front Range. Plate glass for recycling is generally defined as all window glass, architectural glass, and flat glass broken or in sheets or window panes, generally free of other types of glass and foreign material (including free of window putty and caulking). This category can include safety glass at the discretion of the recycler, as some processors accept this material and others do not, namely, Dlubak Glass will accept this for recycling.

Diversion Potential: Options for individual contractors looking to recycle plate glass are limited in the Boulder County area. Nevertheless, glass is fully recyclable, as well as relatively dense, and there may be significant potential to increase diversion of this material with the construction of an easy C&D drop-off point. A Boulder County C&D transfer station could expect to receive an estimated 15%-30% of the plate glass generated in the County.

Markets: Currently there are several markets for consideration for managing plate glass from the area's C&D waste stream:

- For a fee, the plate glass spot-market prices are available. Market prices are given for daily, weekly, monthly, and a quarterly periods, as well as for less-than-truckload (LTL) and Truck-Load (TL) quantities.[15]

- Dlubak Glass, a Texas-based glass recycler, has been in operation for about 30 years and accepts plate glass at both its Texas and Oklahoma facilities. Dlubak accepts both clear and mixed-color plate glass, as well as metal, vinyl, and wooden window frames, which it can separate and recycle..

- Plate glass cullet (crushed glass) meeting specifications can be melted in a furnace to make fiberglass insulation. Johns Manville, a manufacturer of fiberglass insulation, is interested in purchasing plate glass cullet (meeting its specifications) for use in its production line, although representatives indicate that a furnish of about 4,500 tons per year is needed to make the relationship financially feasible.

Market Status: Several of the end markets mentioned above will accept plate glass from the Front Range. Dlubak's end markets are stable, although they are considered proprietary information and no further details are available. The use of plate glass to make fiberglass insulation represents a fairly stable end market over time. The market for plate glass is likely to continue, although it is subject to swings in market prices, just as any commodity.

[15] See House of Glass at www.glasschange.com and the Global Recycling Network www.grn.com.

Table 3-26 Plate Glass Market Sample

End Market-Company Name	Location	Materials/ Condition Accepted	End Markets Price Paid/Fee Charged to Customer (per ton)	Distance from Boulder County[a]	Round Trip Hauling Cost(per ton)[bc]
Johns Manville	McPhearson, KS	Plate glass cullet	$.09/lb	422 miles	-$41.15
Dlublak Glass	Okmulgee, OK	Plate glass, sorted	$40/T clear $30/T mixed colors	750 miles	-$73.13
Dlublak Glass	Waxahachie, TX	same as above	same	820 miles	-$79.95

[a]For estimation purposes, distances are calculated assuming a facility located at 63rd and Arapahoe in Boulder

[b]Assumes a 20 ton end dump haul, 4 mpg, $3.90/gallon fuel cost

[c]Prices are based on 2011 research

3.4 Materials for Future Market Development

Overview: This section discusses materials for which no recycling options currently exist within reasonable transport distance of Boulder County, and/or for which efficient recycling technology is still under development. The materials listed here should be considered for future market development if viable opportunities arise in the next 10-15 years.

The materials that require further market development, and should only be considered for acceptance if new opportunities arise are:

- Cement Fiberboard
- Commercial Roofing Membrane
- Fiberglass Insulation
- Painted Gypsum Wallboard
- Painted/Stained/Treated Wood

3.4.1 Cement Fiberboard

Table 3-27 Cement Fiberboard High Level Generation Projections, With Low and High Diversion Estimates, in Tons Per Year*

	Generation	1% Diversion	5% Diversion
2010	350	4	18
2015	375	4	19
2020	313	3	16
2025	338	3	17
2030	350	4	18

*The full projection can be found in Figure 2.5

Overview: There are currently no facilities in place or good methods for recycling cement fiberboard. Fiberboard can be pulverized and used as fill at construction sites, but currently no true recycling end markets are available in the Front Range. Cement fiberboard was not broken out in the 2010 waste composition study on which the materials generation estimates were based; though presumably cement fiberboard would have been counted in the Other C&D category (see Section 2). As a relatively new material, it is unlikely to be present in great quantities until 10 to 15 years from now. This material could reasonably approach 5% of the "Other C&D category".

Diversion Potential: The diversion potential for this material is almost nonexistent at this point, and although recycling options may develop in the next 20 years, any expectation of such would be speculative. However, for estimations sake, a nascent recycling program for this material could expect to divert about 1%-5% of the generated material.

3.4.2 Commercial Roofing Membranes

Table 3-28 Commercial Roofing Membrane High Level Generation Projections, With Low and High Diversion Estimates, in Tons Per Year*

	Generation	5% Diversion	15% Diversion
2010	70	4	11
2015	75	4	11
2020	62	3	9
2025	67	3	10
2030	70	4	11

*The full projection can be found in Figure 2.5

Overview: Commercial roofing membranes are primarily made of PVC and EPDM (ethylene propylene diene Monomer "M-class" rubber – an elastomer) plastics, and are used to provide a watertight barrier across large areas of roof such as those found on large commercial buildings. This material can be deconstructed and sold as a reusable building material through local reuse yards, and some manufacturers of the material are looking into developing recycling programs. Although this material was not broken out in the 2010 waste composition study, presumably any roofing membrane would have been categorized as "Other C&D" Due to the common use of this material, as well as its relative weight, it could reasonably approach 1% of the "Other C&D" category.

Diversion Potential: Due to the developing nature of any recycling markets for this material, it is difficult to estimate what the diversion rate would be. Given the experimental nature of any new program, however, it is unlikely that recycling would start off at a robust rate. Nevertheless, this material is quite dense, and due to its largely commercial applications, would likely be generated by large jobs requiring significant deconstruction, and thus materials recovery. A Boulder County C&D facility with a well-advertised recycling program could expect to divert an estimated 5%-10% of the total generated material.

Market: Currently the only market for this material is for resale at reusable building material yards. Manufacturers of the material have indicated that they are interested in developing programs to collect and process this material into a form reusable as raw material for new products.

Market Status: The market for recycling commercial roofing membranes is experimental. Currently, deconstruction and reuse is the best option for recycling this material, though in the next several years manufacturers may develop programs to provide product stewardship recycling.

3.4.3 Fiberglass Insulation

Table 3-29 Fiberglass Insulation High Level Generation Projections, With Low and High Diversion Estimates, in Tons Per Year[1]

	Generation	1% Diversion	5% Diversion
2010	7	0	0
2015	15	0	1
2020	18	0	1
2025	20	0	1
2030	21	0	1

[1]The full projection can be found in Figure 2.5

Overview: Currently, the only market for fiberglass insulation is the reusable building materials industry. Good condition insulation can be bagged and donated to reusable materials yards for resale to do-it-yourselfers and contractors. Contaminated or dirty insulation is currently landfilled. At least one insulation manufacturer, however, is interested in developing a program to collect and reuse fiberglass insulation as raw material for new fiberglass products.

Diversion Potential: It is difficult to speculate on the diversion potential for this material as the markets are currently under early development. Nevertheless, considering that any developing program would be in its infancy, and that a large amount of the generated insulation could be deemed unusable depending on its composition/condition, a Boulder County C&D transfer station could be expected to receive an estimated 1%-5% of the fiberglass insulation generated in the County. Considering, however, the extremely low density of this material, it is not likely that annual accumulation would rise above one ton.

Markets: Aside from resale as a building material through local reuse yards, there are no recycling options for fiberglass insulation along the Front Range, at present. Representatives from Johns Manville, an insulation manufacturer, have indicated that they are currently in the research and development stage on a technology to reclaim fiberglass from used insulation.

Market Status: The market for fiberglass insulation is in development. Good condition material can be reused, and manufacturers are currently developing stewardship programs that would allow this material to be recycled. Due to the increasing cost of raw materials, there is an economic incentive for these companies to develop a successful recycling program, but tentative estimates indicate that there are still 1-2 years of research and development remaining before such a program would be realized.

3.4.4 Painted/Stained/Treated Wood and Wallboard

Table 3-30 Painted/Treated Wood Generation/Diversion Projection, High level estimate in tons per year*

	Generation	5% Diversion	10% Diversion
2010	12,750	638	1,275
2015	13,500	675	1,350
2020	14,250	713	1,425
2025	13,500	675	1,350
2030	14,000	700	1,400

*The full projection can be found in Figure 2.5

Treated Wood: Occasionally, painted and otherwise treated wood can be donated to a reusable building materials yard, however it cannot typically be recycled due to risks of contamination from lead or other potentially hazardous chemicals. Painted wood can be planed on all sides and reused if the resulting wood is in good enough condition; however, the vast majority of this material cannot be recycled and currently must be landfilled.

Table 3-31 Painted/Treated Wallboard Generation/Diversion Projection, High level estimate in tons per year*

	Generation	5% Diversion	10% Diversion
2010	8,500	425	850
2015	9,000	450	900
2020	9,500	475	950
2025	11,800	590	1,180
2030	13,000	650	1,300

*The full projection can be found in Figure 2.5

Treated (post-consumer) Wallboard: A proprietary technology is in use in the Northeast and Europe that allows painted wallboard to be recycled by shearing off the paper from either side, leaving only the gypsum core. The company using this technology is aiming to expand into other regions, although currently has no plans to start operating near Colorado.

Diversion Potential: Although there are currently no recycling options available for these materials, they are a large fraction of the total C&D waste stream, and a successful recycling program could expect to divert as much as 5%-10% of the generated material.

4. Operational Feasibility Analysis

Overview: This section discusses operational models available for handling the materials discussed in Section 3. For each material, this analysis explores the economics of different processing and transfer scenarios, and recommends the option with the greatest opportunity to operationally break even and increase diversion of C&D waste.

Analysis of each handling model considers the costs associated with hauling, equipment operation, maintenance, and replacement, as well as the prices paid or fees charged by end markets for material in various stages of processing. Consideration is given to the current state of the market, past trends, and future development opportunities.

This analysis aims to provide an understanding of the costs and potential revenue streams for each material, and to facilitate decision-making based on the ability to operationally break even. As such, it does not account for capital costs of land, building construction or equipment purchase, nor does it account for operational matters such as equipment needs and costs such as utilities and labor. These costs are considered in Section 6, which provides a detailed breakdown of capital and other variable costs.

The operational feasibility of a Boulder County C&D facility is assessed on a break-even basis in order to provide the County, or other operator, with greater flexibility with regard to the costs and revenue generated by each material. If the operator is only concerned with covering operational costs, it increases the ability of the facility to accept low-revenue materials, by covering the expense through revenue-generating materials. Furthermore, the facility operator would have greater flexibility to negotiate with potential markets, potentially allowing the facility access to otherwise unavailable diversion opportunities.

Tables: For each material, a table presents the break-even analysis for the different handling models available. The information presented by each column is described below:

- **Low/High Input Range in tons per year:** Using the diversion percentages presented in Section 3, this column outlines the amount of each material that is likely to enter the facility, using the lowest and highest annual tonnages as the probable range.
- **Cost of Processing and Transportation per ton:** Using an average of the hauling estimates and fees charged by end markets presented in Section 3, this column indicates the cost per ton of both transporting the material to its market, and any fee that the end market might charge to accept the material.
- **Annual Equipment Cost:** For materials that require equipment to process, this column indicates the annual cost of a replacement fund for the equipment, with the idea that the tip fees from each material will cover the cost of its equipment.
- **Annual Cost to Recycle:** This column presents the total cost to the facility to recycle the projected tonnages of each material. It takes into account transportation costs, fees charged by end markets, equipment operation, maintenance, and replacement.
- **End Market Price:** This column presents the per-ton revenue for each material based on the current price that material sells for in the market.
- **Net $ per ton:** This column considers both the total cost per ton and total revenue per ton for each material and handling model. It is the amount of money that the facility will either lose or gain from each ton of material handled.

- **Tip Fee per ton to Break Even:** This column presents the fee that a C&D facility would need to charge per ton in order to cover the expense of handling each ton of material.

Recommendations: For each material, a recommendation is provided based on the material's economics. For the purpose of planning a facility, materials are discussed with regard to the phase of development during which they should be accepted.

- Phase 1 materials should be included in the initial construction of the facility. Phase 1 focuses on transferring materials for which there are stable existing markets.

- Phase 2 materials are to be included in the future, as the markets for these materials are currently developing. Additionally, Phase 2 development allows for some processing of materials to take place depending on the viability of the markets for these materials.

- Phase 3 materials are those for which no diversion solutions are available or on the horizon and are unlikely to be accepted at a facility for the foreseeable future.

It is important to note that the prices quoted are in 2011 US Dollars, and are subject to change over time and through individual contract negotiation.

Table 4-1 details the materials to be included in each Phase of development, as well as the 20-year low and high diversion tonnages as estimated in Section 3.

Table 4-1 Material Diversion Estimates (In Tons)[a]

Material	20 Year Low tons per year	20 year High tons per year
Phase 1		
Aggregates	2,400	8,100
Cardboard	70	260
Ceiling Tiles	6	19
Clean Wood	1,913	4,725
Durable Goods and Reusable Building Materials	39	238
Pallets	275	700
Plastics	35	1,550
Scrap Metal	79	525
Vinyl Composite Tiles	13	38
Total Tons - Phase 1	4,830	16,155
Tons per Day	19	62
Phase 2		
Asphalt Shingles	1,850	5,688
Carpet & Padding	42	300
Clean Gypsum Wallboard	58	350
Plate Glass	64	2,100
Total Tons - Phase 2	2,014	8,438
Tons per Day	8	32
Phase 3		
Cement Fiberboard	3	19
Commercial Roofing Membrane	3	11
Fiberglass Insulation	0	1
Painted Gypsum Wallboard	425	1,300
Painted/Stained/Treated Wood	638	1,425
Total Tons - Phase 3	1,069	2,737
Tons per Day	4	11
Total Tons - All Phases	**7,913**	**27,330**
Total Tons per Day - All Phases[b]	**30**	**105**

[a]Quantities are based off estimated diversion percentages and total generation estimates.

[b]Assumes one 8-hour shift per day, 5 days per week, 52 weeks per year for a total of 260 work days.

4.1. Phase 1 Materials

Overview: This section discusses materials that a County C&D facility could accept during the initial build out given a site of sufficient acreage and a sufficient budget. Materials included in Phase 1 are those which the facility could accept due to the presence of mature end markets and recycling opportunities in the region.

The materials with existing markets, to be included in the Phase 1 Design are:

- Aggregates
- Cardboard
- Ceiling Tiles
- Clean Wood
- Durable Goods and Reusable Building Materials
- Pallets
- Plastics
- Scrap metal
- Vinyl Composite Tiles

4.1.1. Aggregates

Overview: Aggregates can be crushed and screened to uniform size with heavy equipment. Several large aggregate recycling companies in the Boulder County vicinity accept material for a fee. Processing aggregates creates dust and noise, increasing the need for air quality control and a higher level of OSHA (U.S. Occupational Safety and Health Administration) compliance assurance in operations.

- **Transfer Model:** Under this model, the transfer station accepts material for a fee, and stores it onsite in containment bunkers until enough material has accumulated to warrant hauling it to aggregate processors in the area, most likely using 20 ton end-dump trailers. Local processors accept clean concrete for about $2/ton, with prices increasing as high as $15/ton based on the degree to which the concrete is contaminated with rebar. This model will also incur hauling charges, which would run an average of $2.50/ton.

- **On-Site Third-Party Processing:** In this model, material is accepted for a fee, and stored on site in large piles until enough material has accumulated to justify having a third-party processor bring mobile processing equipment on site to crush the material. Local processors have indicated that they would charge around $7.50/ton for this service.

- **County Processing Model:** The County could invest in a heavy material processing line which would crush and screen material to specification for reuse in landscaping, road building and construction applications. A processing line of this type would cost around $400,000, based on dealer estimates and although it would incur significant maintenance costs, would enable the County to generate revenue through the sale of crushed aggregate products on site, roughly $8/ton for a standard road base. It should be noted that any retail sales of materials from a County C&D facility would

require specialized zoning measures and dedicated areas for retail operations in order to keep customers off of the tipping floor and away from dangerous equipment.

Table 4-2 Aggregate Analysis Using High and Low Diversion Estimates

Model	Low/High Input Range, Tons Per Year[a]	Cost of Processing and Transportation[b] per ton	Annual Equipment Costs[c]	Annual cost to recycle	End Market Price	Net $ Per Ton	Tip fee per ton to break even
Transfer	2,400-8,100	-$4.94	$0	-$11,856 to $38,902	$0	-$4.94	$4.94
On Site Third Party Processing	2,400-8,100	-$7.50	$0	-$18,000 to $59,062	$0	-$7.50	$7.50
County Processing	2,400-8,100	Low: -$29.10 High: -$8.60	-$40,000[d]	-$70,000	$8	Low: -$21.10 High: -$.60	Low:$21.10 High:$.60

[a]Based off 20 year low/high diversion estimates
[b]Based on the average cost to transfer and the average hauling cost, per ton
[c]Assumes $30,000 annual O&M costs, spread among high/low tonnage
[d]Assumes a $400,000 processing line, paid off over 10 years

Recommendation: As aggregates are the largest contributor to C&D waste, they represent a significant opportunity to increase diversion. There are, however, several large aggregate processors outside of Boulder County that provide both crushing services and retail sales of processed material. A glut of supply in the crushed aggregate market means that sales of processed material would be unreliable.

Until the market for crushed aggregate can be better established, the most economical option for handling aggregates is to serve as a transfer station during Phase 1. In order to encourage private haulers to take their larger loads directly to aggregate processors, a differential tipping fee should be charged to discourage bringing large (20 ton) loads to the facility, in favor of providing a place for loads from smaller jobs, such as sidewalk and driveway demolition, to be recycled.

In the future, if a processor interested in crushing the material with mobile equipment approaches the County, this could provide a more economical option depending on viability of such an operation, costs, and contract terms. Crushing aggregates on site would incur additional considerations with regard to noise and air pollution, as this operation produces large volumes of dust. Such a processing line would require additional landscape buffers between the facility and its neighbors, and would make the permitting process more difficult.

4.1.2 Cardboard

Overview: Most MRFs will accept loose cardboard without any additional processing, as they typically bale the material on site to prepare it for shipment to end markets. Baling the material consolidates it for increased shipping efficiency, as cardboard is a low density material and is costly to haul without compaction. Considering the low volume of cardboard that a County C&D facility is likely to receive, a baler, which can process several tons in a matter of hours, would not be a cost effective way to consolidate cardboard. The remaining options for cardboard collection and transfer are to transport loose cardboard in a roll-off container, or to use a stationary compactor.

- **Roll-Off Container:** Using a large roll-off container (e.g., a 40-cy roll-off unit with cover to control moisture) would allow customers to drop off material into the bin. Once full, the container can be hauled to a recycling center for baling and shipment to end markets. Depending on the operational details of the facility, the roll-off truck could be owned and operated by either the County, a private facility operator, an independent hauling company, or the end market MRF.

- **Stationary Compactor:** Using a stationary compactor greatly reduces the space required for equivalent amounts of cardboard. The compacting unit of the machine is anchored to a concrete pad in the facility, and a large receiving container is attached to it. Material is loaded into the charge box of the compacting unit, which holds up to 2-cy at a time. From this box, the cardboard is pressed into the storage container by a hydraulic ram, compacting up to about 1.5 tons into the transport box. A stationary compactor requires electrical power from a utility, requiring that the facility have electricity running to the material handling area.

Table 4-3 Cardboard Analysis Using High and Low Diversion Estimates

Model	Low/High Input Range, Tons Per Year	Cost of Processing and Transportation[a] per ton	Annual Equipment Costs[b]	Annual cost to recycle	End Market Price[c]	Net $ Per Ton	Tip fee per ton to break even
Roll-Off Container	70-260	-$19.74	$0	Low:-$1,381 High:-$5,132	Market Prices, about $100/ton	$80.26	Any
Stationary Compactor	70-260	-$4.90	-$1,200	Low:-$1,543 High:-$2,474	Market Prices, about $100/ton	$95.10	Any

[a]Based on the average cost to transfer and the average hauling cost, per ton

[b]Assumes Purchase of $12,000 compactor, 10 year replacement period

[c]Prices vary greatly over time, see Figure 3-1 for historic data

Recommendation: Although the amount of cardboard likely to come into a C&D facility is small, it is a high value material when sold in bulk, and should be accepted for transfer from the initial Phase 1 build out. Due to the large gain in transportation efficiency associated with a cardboard compactor, this option will be the most economical in the long run. Some cardboard recyclers will pay individual customers for material, due to its high value. As the facility will not be purchasing a baler, however, it will not be requiring large volumes to cover that cost, and would not need to pay for material.

Given the County's existing cardboard recycling operation at the Boulder County Recycling Center, there may be efficiencies to be gained by partnering with that facility to process C&D cardboard. This partnership opportunity would be subject to contract negotiation depending on the eventual operator of the C&D facility.

4.1.3 Ceiling Tiles

Overview: The options for recycling ceiling tiles are limited, though they can be recycled through Armstrong's program if they meet contaminant and material specifications. Due to the nature of the recycling program, transferring this material is the only viable recycling option.

If accepting this material, the County should undertake education of contractors and deconstruction professionals to ensure testing compliance and awareness of this recycling option.

- **Transfer Model:** Based on end-market specifications, the material can only be transferred by a County C&D facility. Properly documented and acceptable material should be accepted at the facility, where it can be palletized (if not already) and stored until sufficient stock has accumulated to fill a tractor-trailer.

All material must be tested for asbestos and recyclability prior to entering the C&D facility. Undocumented or unacceptable materials should not be accepted and would represent contamination in the material stream. The facility should require proof of testing to receive materials, but should not bear the direct cost of testing.

Table 4-4 Ceiling Tile Analysis Using High and Low Diversion Estimates

Model	Low/High Input Range, Tons Per Year	Cost of Processing and Transportation per ton[a]	Annual Equipment Costs	Annual cost to recycle	End Market Price	Net $ Per Ton	Tip fee per ton to Break Even
Ceiling Tile Transfer	6-19	$0	$0	$0	$0	$0	Any

[a] Assumes a full tractor-trailer load of 44 pallets

Recommendation: As recycling using the Armstrong program is currently free of charge when materials are shipped by full tractor-trailer loads, this is an economically feasible option that will require limited investment or labor, at least as long as the program remains free. The C&D facility should accept ceiling tiles, with proper testing and documentation, in Phase 1. Although this material is a small portion of the waste stream, there are currently no centralized recycling opportunities for contractors to consolidate loads and take advantage of shipping economies. Providing such a service would have minimal cost as long as enough material (about 44 pallets) could be gathered to fill a full truckload.

4.1.4 Clean Wood

Overview: Clean wood entering a C&D transfer station should first be sorted into usable and unusable items. Reusable lumber makes up a about 10% of the total wood waste stream, and the facility should have procedures in place to separate out this material for transfer to a used building materials yard.

- **Transfer Model:** Under this model wood is brought on site and stored in either a containment bunker or a roll-off container prior to being hauled to a processing facility. Local processors charge between $12.50 and $24 per ton to recycle untreated clean wood waste. Additional hauling costs increase this by up to $11.70/ton depending on the end market to which material is being hauled.

- **On-Site Third-Party Processing:** In this model, wood waste is stored in larger containment bunkers or in piles until sufficient stock has accumulated to justify having a third-party processor bring mobile equipment on site to grind material and haul away chips. A local processor has indicated that they would charge about $12.50/ton for this service.

- **Processing:** To process wood waste requires a wood grinder, typically about $450,000, to turn wood into mulch. These machines can be upgraded with attachments such as colorizers and screens to increase the quality of the end product. Mulch can be sold on site to end markets such as landscapers and homeowners. Wood grinders can come in a wide range of prices, generally $80,000-$600,000 depending on condition, capability and age. The wood grinder used in this analysis is capable of grinding asphalt shingles with an additional $15,000 attachment. It is considered here in case the County should decide to grind shingles during Phase 2 or 3.

Table 4-5 Clean Wood Analysis Using High and Low Diversion Estimates

Model	Low/High Input Range, Tons Per Year	Cost of Processing and Transportation per ton[a]	Annual Equipment Costs[b]	Annual cost to recycle	End Market Price[c]	Net $ Per Ton	Tip fee per ton to Break Even
Transfer	1,913-4,725	-$25.30	$0	High:-$48,398 Low: -$119,542	$0	-$25.30	$25.30
On Site Third Party Processing	1,913-4,725	-$12.50	$0	High:-$23,912 Low:-$59,062	$0	-$12.50	$12.50
County Processing	1,913-4,725	-$7.00	-$45,000	High:-$13,391 Low:-$33,075	$12.50	$5.50	Any

[a]Based on the average cost to transfer and the average hauling cost, per ton

[b]Cost of equipment ($450,000) annualized over 10 year lifespan to provide a replacement fund

[c]Based on single-grind, untreated mulch

Recommendation: Due to the slow market for ground wood mulch, the County facility should not begin processing this material unless additional markets can be developed. Given the large amount of wood waste in the waste stream, however, the transfer station should accept clean wood waste on site to recycle with local processors. Additionally, due to the abundance of reusable wood in the waste stream, the facility should have a separate area to set aside reusable pieces of lumber for transferring to reusable building materials outlets.

Depending on the development of markets for wood mulch in the next decade, the operator of the facility may consider purchasing a wood grinder, particularly if the market for ground asphalt shingles becomes viable, as the same grinder can be used for both materials.

4.1.5 Durable Goods and Reusable Building Materials

Overview: Reusable durable goods have established markets in the area and are not likely to be brought to a County transfer station in any great numbers. Reusable building materials, however, will likely be brought in with general C&D waste and should be picked out of the waste stream whenever possible for transfer to a resale facility. Unless enough area is sited to include a retail outlet, with the necessary parking, roadways and public access, selling materials on side would not be desirable.

- **Transfer Model:** Reusable goods are likely to enter the facility as both a part of the clean wood waste stream and as individual items. Under a transfer station model, these items would be removed from the greater stock of material once identified, and set aside in a roll-off container to await transfer to one of several local non-profits specializing in resale of these materials. Depending on the location of the C&D facility, and the end market that material is being brought from, the hauling costs for these materials could run as high as $11.50 per ton.

Table 4-6 Reusable Durable Goods and Building Materials Analysis High and Low Diversion Estimates

Model	Low/High Input Range, Tons Per Year	Cost of Processing and Transportation per ton	Annual Equipment Costs	Annual cost to recycle	End Market Price	Net $ Per Ton	Tip fee per ton to break even
Transfer	39-238	$0	$0	$0	Varies	$0	Any

Recommendation: Reusable material should be collected from the waste stream starting in Phase 1, and either a bunker or storage container should be present to store material until it can be brought to its end market. Picking reusable material out of the waste stream will require staff trained to identify suitable items, and the facility could feasibly contract with local non-profits to operate the collection of reusable materials, possibly having weekly drop-off days or a staff member on site to oversee collection. Under such a model, the non-profit organization would be responsible for transportation costs, saving the facility the cost of transferring these materials.

4.1.6 Pallets

Overview: Standard wooden pallets can be handled easily by forklift and take up relatively little room when stacked. Quality pallets that can be refurbished or reused have both practical and market value. Unusable waste pallets can be treated as clean wood waste and ground into mulch either by a grinding company secured by the County or through one of the pallet markets.

- **Transfer Model:** Some pallets can be sold to pallet refurbishers for as much as $2.50/pallet, though the price will vary depending on the quality of the pallet, the number of pallets sold, and current market saturation in the region. Pallet refurbishers will typically only purchase "four-way" pallets that are accessible by forklift from four sides, and typically measure 48"x40".

- **Reuse Model:** A small number of pallets that are in good condition can be used on site for storage and transport of recycled materials.

Table 4-7 Pallet Analysis Using High and Low Diversion Estimates

Model	Low/High Input Range, Tons Per Year	Cost of Processing and Transportation[a] per ton	Annual Equipment Costs	Annual cost to recycle	End Market Price, per ton[b]	Net $ Per Ton	Tip fee per ton to break even
Transfer	275-700	-$30	$0	Low:-$8,250 High:-$21,000	$100	$70	Any

[a]Based on the average cost to transfer and the average hauling cost, per ton

[b]Based on 2011 research, subject to change based on the strength of the market

Recommendation: Given that pallets are readily reused, easily stored, and can be resold or ground up if need be, a C&D facility should have space set aside to store incoming pallets if they are in good condition. It should be noted, however, that at the time of writing, the pallet market is stalled, and both prices and demand will be subject to the strength of the market.

4.1.7 Plastic

Overview: C&D plastics are mostly composed of PVC and film plastics such as Tyvek® (high density) and stretch plastic (low density). Post-consumer plastics need to be ground or melted before they can be made into a plastic pellet that can compete with virgin pellets. Receiving clean material and hauling it efficiently are the two primary operational efficiencies. Because buyers for these plastic grades accept plastic unprocessed, transferring material without processing is the most economical option.

- **Transfer Model:** Transferring C&D plastics requires several dumpsters or roll-off containers for storage of material prior to shipment. Film plastic can be compacted to increase transport efficiency, though PVC scrap (such as pipes) cannot, and should be bundled or stored in a roll-off container.

Table 4-8 Plastic Analysis Using High and Low Diversion Estimates

Model	Low/High Input Range, Tons Per Year	Cost of Processing and Transportation per ton	Annual Equipment Costs	Annual cost to recycle	End Market Price[a]	Net $ Per Ton	Tip fee per ton to break even
Transfer	35-1550	-$5	$0	Low: -$175 High:-$7,750	$200	$195	Any

[a]Prices for post consumer plastics are highly volatile, current analysis is based on 2011 research

Recommendation: Given regional end markets, clean low-density film plastic should be received and stored in Dumpsters or polyethylene "Super Sacks" during Phase 1 for transfer. PVC and high-density plastic film should also be received in Phase 1.

4.1.8 Scrap Metal

Overview: Scrap metal recycling has the potential for significant revenue. Due to the highly involved nature of processing scrap metals, however, a transfer station is the only feasible option available in any phase for diverting scrap metals. Scrap metals can be transferred to end markets either as mixed scrap or sorted by material type.

Transfer can occur either by a third-party processor or by the County. Local processors will place their roll-offs at a facility and pick them up when full, swapping out full containers for empties. The cost of hauling is then subtracted from the price paid per ton. Alternately, the County could have its own trucks haul material to processors, incurring fuel and maintenance costs, but receiving higher prices for material.

- **Mixed Load Model:** Under this model several large (40-50-cy) roll-off containers would be kept on site to be filled with any incoming scrap metal. Once filled, roll-offs would be hauled off-site by local processors who pay for the material. Loads of mixed metal are priced as steel, and do not take into account any non-ferrous metals that may be present.

- **Separated Load Model:** Under this model, one large roll-off container is present on site for accepting steel, with smaller, 10-cy containers available to collect non-ferrous metals, which garner higher prices per pound.

Table 4-9 Scrap Metal Analysis Using High and Low Diversion Estimates

Model	Low/High Input Range, Tons Per Year	Cost of Processing and Transportation[a] per ton	Annual Equipment Costs	Annual cost to recycle	End Market Price	Net $ Per Ton	Tip fee per ton to break even
Mixed Scrap Metal	79-525	-$6	$0	High:-$474 Low:-$3,150	$170	$164	Any
Scrap Metal Sorted - Steel	79-525	-$6	$0	High:-$474 Low:-$3,150	$170	$164	Any
Scrap Metal Sorted - Non Ferrous	79-525	-$6	$0	High:-$474 Low:-$3,150	$1,000/ton[b]	$994	Any

[a]Based on the average cost to transfer and the average hauling cost, per ton
[b]Based on a $.50/lb quoted market price in 2011, all prices subject to change over time

Recommendation: Although scrap metal recyclers are well established, and most pay for incoming material, a C&D transfer station is still likely to receive enough scrap metal to make the limited investment worthwhile. While the vast majority of valuable scrap metal is picked out by haulers, and other contractors for sale to recycling facilities, the limited investment required to accept this material would allow for some revenue from recycling scrap metal. Given the small amount of metal likely to come to the facility, as well as an already significant diversion rate for the total generated amount, paying for material is not recommended as very little scrap metal is currently landfilled.

Scrap metal may also enter the facility indirectly, as rebar in concrete or aluminum window frames. Recycling capabilities for scrap metal should be present at the facility in Phase 1, as

having the capability to handle scrap metal would allow the facility to expand this operation in the future should the opportunity arise

4.1.9 Vinyl Composite Tile (VCT)

Overview: Recycling opportunities for vinyl tiles are limited, though not out of the question. Armstrong operates a recycling program for this material (see sec. 3.1.10). The program calls for transfer of the material, which can be accomplished with limited investment. As with ceiling tiles, recycling vinyl tiles will require increased education of remodelers, contractors, and deconstruction professionals to ensure compliance with Armstrong's testing requirements prior to deconstruction.

- **Transfer Model:** Vinyl tiles must be tested for asbestos and other contaminants prior to deconstruction or removal from the job site. This lab test, administered by Armstrong, ensures acceptability of materials and typically takes two or three days to complete. Due to increased labor costs, VCTs should only be accepted at the facility after they have been approved by the recycler, and have been boxed and palletized, thus they can be loaded directly to the storage area.

Once approved, tiles can be packaged in gaylord boxes and consolidated at a central location. Batches of tile must be kept together with appropriate documentation throughout the recycling process. Once 24 gaylords of material have accumulated, Armstrong will send a truck to haul away material free of charge. Because VCTs are typically found in commercial buildings, they are likely to be received in large, infrequent loads, and generators could be required to schedule an appointment in order to accept their materials.

Table 4-10 Vinyl Composite Tile Analysis Using High and Low Diversion Estimates

Model	Low/High Input Range, Tons Per Year	Cost of Processing and Transportation per ton[a]	Annual Equipment Costs	Annual cost to recycle	End Market Price	Net $ Per Ton	Tip fee per ton to Break Even
VCT Transfer	13-38	$0	$0	$0	$0	$0	Any

[b] Assumes a full tractor-trailer load

Recommendation: Although a County C&D facility is unlikely to see a steady stream of vinyl tiles, the ease and low cost of recycling this material suggests that the initial Phase 1 facility should be equipped to accept VCTs and store them until sufficient material has accumulated. As these materials will most likely be generated by large commercial projects, the operator of the facility could decide to accept VCTs by appointment only, and ensure that they meet specifications prior to being accepted.

4.2 Phase 2 Materials

Overview: In order to best operate on a break-even basis, the facility should not accept all materials immediately, as some of these materials are in need of further market development. The materials presented in Section 4.2 have markets that are currently developing and should be considered for acceptance case by case as these markets reach maturity.

The materials with developing markets, to be considered for Phase 2 expansion are:

- Asphalt Shingles
- Carpet
- Clean Gypsum Wallboard
- Plate Glass

4.2.1 Asphalt Shingles

Overview: Asphalt shingles can be ground up for use in hot mix asphalt (HMA) paving projects. The Departments of Transportation of Boulder County as well as its constituent municipalities have conducted tests of this material that are currently under review. Pending approval of RAS use in local and regional projects, the market for this material is stalled and most processors are not accepting this material at the time of writing. In the past, several private companies have accepted asphalt shingles for processing.

- **Transfer Model:** Asphalt shingles are typically stored in large piles until they can be processed. Due to the large amount of this material available, if the facility were to engage in transferring shingles, it should not store large quantities on site as this could lead to an unwanted surplus. If transferring, the facility should make an effort to transfer shingles off site to processors when truckload quantities are generated to avoid a stockpile.

- **Processing Model:** When processing asphalt shingles, the material is stored in piles on site. State regulations require that any material to be used in HMA is tested for asbestos, which is done by pulling samples from each pile in order to verify that there is no contamination. Asphalt shingles can last, but the piles must be "stirred," or shifted in order to prevent decay of the material and hazardous conditions. Furthermore, storage and grinding shingles requires air quality testing and would most likely require additional landscaping and screening.

Under this latter model, asphalt shingles would be processed using a shingle grinder which reduces material to a coarse powder. The grinder factored in to this analysis is a $450,000 wood grinder (the same used for the clean wood analysis) outfitted with a $15,000 attachment. As there is some overlap between the cost of this machine, there are efficiencies to be gained by grinding both clean wood and asphalt shingles once a machine is purchased. Ground shingles would then be hauled to asphalt companies for use in new HMA.

Table 4-11 Asphalt Shingle Analysis Using High and Low Diversion Estimates[a]

Model	Low/High Input Range, Tons Per Year	Cost of Processing and Transportation[b] per ton	Annual Equipment Costs	Annual cost to recycle	End Market Price	Net $ Per Ton	Tip fee per ton to break even
Transfer	1,850-5,688	-$2.24	$0	Low:-$4,162 High:-$12,741	$0	-$2.24	$2.24
Processing	1,850-5,688	-$7	-$47,500	Low:-$60,450 High:-$87,316	$30	Low:-$2.60 High:$15	Low:$2.60 High: Any

[a] Prices are based on 2010 numbers, as of the time of writing this market is stalled and its return is uncertain.

[b]Based on the average cost to transfer and the average hauling cost, per ton

Recommendation: Considering that the market for asphalt shingles is currently stalled, it would not be wise to accept asphalt shingles during Phase 1. If the market returns, then the facility should begin accepting shingles for transfer or processing during Phase 2 or 3. This is only recommended if the market stabilizes and becomes economically viable.

4.2.2 Carpet

Overview: The intermediate processing procedures to ready carpet fiber for final end markets are cost-prohibitive for a C&D Phase 1 facility to take on. Transferring carpet to different end markets is the most economical way to divert the material, although recycling operations on the Front Range are still immature.

- **Transfer to Processing:** Under this model carpet is collected and sorted by material type using a fiber analyzing tool ($20,000) to distinguish between materials. The carpet is then hauled to processors to be separated into its component parts. One carpet processor in Colorado Springs has indicated that it will pay $.01-$.02/lb for nylon carpet and carpet pad.

- **Transfer to Be Used As Fuel:** Under this model, carpet is consolidated at a facility prior to being hauled to manufacturers for use as an alternative fuel source. Geocycle's cement plant in Florence, CO is in the process of being approved to use this material as fuel, and has indicated that they would charge between $30-$50/ton to take this material, depending on whether it is baled, palletized, or loose. This may come online in late 2012 – early 2013.

Table 4-12 Carpet Analysis Using High and Low Diversion Estimates

Model	Low/High Input Range, Tons Per Year	Net Cost of Processing and Transportation[ab] per ton	Annual Equipment Costs	Annual cost to recycle	End Market Price	Net $ Per Ton	Tip fee per ton to break even
Transfer for Processing	42-300	-$94	-$2,000	Low:-$3,948 High:-$28,200	$0	Low:-$141 High:-$100	Low:$141 High:$100
Transfer for Fuel	42-300	-$154	$0	Low:-$6,497 High:-$46,200	$0	-$154	$154

[a]Based on the average cost to transfer and the average hauling cost, per ton
[b]Fees vary depending on condition, $30/ton baled, $40/ton Palletized, $50/ton Loose, this analysis uses the median

Recommendation: Because carpet recycling in Colorado is still in its infancy, the market for carpet recycling should be monitored, as more opportunities are likely to arise in the region during the 2012-2014 period.

4.2.3 Clean Gypsum Wallboard

Overview: Recycling gypsum wallboard requires that the material be ground to specification depending on the end market. Until more research is done into the material's usefulness in the manufacture of Portland cement, its primary market is as a bulking agent in compost. In the future, however, there may be opportunities to process this material, which represents about 6% of the C&D waste stream.

For both transferring and processing, any wallboard stored on site at a C&D facility will need to be kept indoors and unexposed to elements to prevent off-gassing of odors.

- **Transfer Model:** In this model, clean wallboard scrap is taken in at the C&D facility and stored under cover until sufficient material has accumulated to warrant hauling it to local compost manufacturers or other wallboard processors. In order to consolidate material prior to shipping, material can be "wheel rolled," a procedure where rolling stock equipment is run over the wallboard in order to break it up for more efficient hauling.

- **Processing Model:** The County could grind its own gypsum wallboard using a large grinder and trommel screen, thus preparing the material for end use itself. The viability of this option would vary greatly depending on the specifications for the end use of the material and the price paid for the ground gypsum product.

Table 4-13 Gypsum Wallboard Analysis Using High and Low Diversion Estimates

Model	Low/High Input Range, Tons Per Year	Cost of Processing and Transportation per ton[a]	Annual Equipment Costs	Annual cost to recycle	End Market Price	Net $ Per Ton	Tip fee per ton to Break Even
Transfer	58-350	-$22.25	$0	Low: -$1,290 High:-$7,787	$0	-$22.25	$22.25
Processing	58-350	Undetermined	Undetermined	Undetermined	Undetermined	Undetermined	Undetermined

[a]Based on the average cost to transfer and the average hauling cost, per ton

Recommendation: Currently, local compost manufacturers will accept clean wallboard scrap for use in their products. At present, however, the amount of material that they can take is very small and can not be considered a mature market. As new markets for recycled gypsum come online, it might become economical to begin accepting and either transferring or grinding wallboard on site during a future expansion.

4.2.4 Plate Glass

Overview: Plate glass has current markets (fiberglass industry and other end markets). Most markets accept material when it meets certain specifications and has been pre-processed to a degree, although the quantities required by these industries are on the order of several thousand tons per year.

- **Transfer Model:** Under a transfer model, plate glass is accepted by the facility and stored in gaylord boxes on pallets, supersacks, or roll-off container – breakage is fine and accepted. Sorting the glass by color will garner higher end-market prices. Once a container is full, it is then transported to a glass processing facility to be ground into cullet as a feedstock for other industrial uses.

- **Processing Model:** Under this model, a $20,000 processing line would be used to crush glass down to cullet of a specified composition. This material would then be sold to end markets for use as a raw material.

Table 4-14 Plate Glass Analysis Using High and Low Diversion Estimates

Model	Low/High Input Range, Tons Per Year	Cost of Processing and Transportation[a] per ton	Annual Equipment Costs[b]	Annual cost to recycle	End Market Price per ton	Net $ Per Ton	Tip fee per ton to break even
Transfer	64-2100	-$97	$0	Low:-$6,208 High:-$203,700	$40	-$57	$57
Processing	64-2100	-$97	-$2,000	Low:-$8,208 High:-$205,700	$180	$83	Any

[a]Based on the average cost to transfer and the average hauling cost, per ton

[b]Based on a $20,000 processing line, 10 year replacement period

Recommendation: While not a large quantity in the C&D waste stream, plate glass has viable end markets and should be considered for Phase 2 if a contract can be worked out between the operator of the facility and an end-market glass processor.

4.3 Phase 3 Materials

Overview: This section discusses materials for which no recycling options currently exist on the Front Range, and should only be considered if new recycling opportunities arise.

These materials include:

- Cement Fiberboard
- Commercial Roofing Membrane
- Fiberglass Insulation
- Painted Gypsum Wallboard
- Painted/Stained/Treated Wood

4.3.1. Cement Fiberboard

Overview: The only opportunity currently available for recycling cement fiberboard is as a reusable building material. If reusable sizes of this material come to a Boulder County C&D facility, they should be set aside for transfer as a reusable material (in Phase 1). Unusable cement fiberboard should not be accepted until recycling opportunities arise.

Recommendation: At the time of writing, there are no recycling options available for cement fiberboard, and this material should not be accepted at a C&D facility. In the coming decade, however, this material is likely to increase in the waste stream and recycling opportunities may develop. In the case of a viable recycling option, the operator of the C&D facility could consider accepting this material.

4.3.2 Commercial Roofing Membrane

Overview: Currently the only market for recycling commercial roofing membranes is reuse. Large pieces of this material can be deconstructed from job sites and brought to building material reuse yards for sale to contractors and homeowners. Manufacturers of PVC and EPDM membrane have indicated a desire to start a recycling program in the future. This recycling program, however, is years of research and development away from implementation. Transfer of this material to used building material yards is currently the only viable means to increase its rate of diversion.

Recommendation: A C&D transfer station should be prepared to accept this material as a used building material for transfer to resale yards during Phase 1. Due to its high durability, this material is easily stored indoors or out, and can be transferred easily on a pallet.

4.3.3 Fiberglass Insulation

Overview: Currently, good condition insulation can be donated to used building materials yards for reuse by homeowners. Insulation manufacturer Johns Manville has indicated that they may be interested in developing a recycling program for this material, though this is still in research and development and any viable option is still 5-10 years from implementation.

- **Transfer Model:** Under this model the facility would accept material, consolidate and store it until sufficient stock had accumulated to warrant transfer to either a reuse yard or to a fiberglass recycling facility to be turned into new products.

- **Processing Model:** In the event that a recycling process is developed that pre-processes fiberglass insulation, a C&D facility could process material prior to shipment. Note that processing fiberglass insulation may pose a significant health hazard for handlers, particularly if any processing (such as shredding) is involved.

No operational analysis table has been included in this sub-section because no data is currently available on costs of such an operation.

Recommendation: Due to the health and air quality hazards associated with processing fiberglass insulation (i.e. shredding, etc.), as well as the lack of current processing technology at present, it is not recommended that processing insulation be an option in Phase 1. Some insulation could be accepted as a reusable durable good if sufficient quality controls were implemented. Given the difficult nature of handling this material, the best option during Phase 1 is to accept only reusable fiberglass insulation for transfer as a used building material. If an arrangement can be worked out with a private entity to have them accept, handle, and manage this material, such a diversion alternative might be beneficial considering the County's Zero Waste goals.

4.3.4 Painted/Stained/Treated Wood and Wallboard

Overview: Painted and otherwise treated wood and wallboard cannot be recycled along with other clean items due to risk of contamination by chemical treatments. Some reusable pieces of material can be transferred to used building material yards, but the majority of this material –including all treated wood- should not be accepted by a C&D facility during Phase 1.

It is possible to plane painted wood and wallboard to remove the painted material from each piece. Given demand for quality lumber, this may become a viable opportunity in the future, but should be saved for future expansion of the facility.

Recommendation: At the time of writing there are no recycling options available for this material, and it should not be accepted by a C&D facility. In the future, if markets develop and recycling alternatives come online, the facility could consider accepting treated wood.

5. Conceptual Site Plan

Overview: This section presents one possible arrangement for a C&D transfer facility based on the handling models presented in Section 4. There are many forms that a facility of this type could take, and the design presented below is intended to establish a basic

understanding of the capabilities, size, operational flow and physical requirements of a transfer station for C&D materials.

5.1 Assumptions

Section 5.1 discusses the assumptions that inform the conceptual site plan. Several assumptions underlie the design of the facility:

- During the first phase of development, the facility will only accept material for transfer, with processing capabilities to come during later development.
- The transfer station will accept material as source separated loads, and will not have equipment on site to accept or to sort mixed loads of C&D wastes.
- Ideally, all materials handled by the facility would be kept under cover and protected from the elements in order to protect the commodities and minimize storm water pollution.
- The ideal design of the facility would accommodate large end-dump trucks, with a ceiling about 40ft-high, however actual limitations on roof height may preclude this option.
- The preliminary site plan is designed to illustrate the minimum space required to transfer all of the materials included in Phase 1, as well as provide the minimum amount of space for a Phase 2 expansion.

5.1.1 Materials Accepted

As discussed, the design of the transfer station can be divided based on phases of development. The materials that are considered for the initial build out, Phase 1, are:

- Aggregates
- Cardboard
- Ceiling Tiles
- Clean Wood
- Durable Goods and Reusable Building Materials
- Pallets
- Plastic Film
- Scrap Metal
- Vinyl Composite Tiles

Phase 2 of the facility build out is meant to incorporate consideration for materials that may develop markets within the next 5-10 years. While some materials may develop viable markets in this time, it is possible that not all of them will, or that materials not discussed here may become a priority. Phase 2 is meant to account for additional expansion as it becomes necessary. The materials targeted for future inclusion based on market growth are:

- Asphalt Shingles
- Commercial Roofing Membrane
- Fiberglass Insulation
- Plate Glass
- Clean Gypsum Wallboard

Phase 2 considerations also include adding processing capabilities for some materials depending on the market demand.

Phase 3 materials are not directly addressed in this conceptual plan, although space is provided to accommodate unexpected expansion and new materials in the event that this becomes necessary.

5.1.2 Site Assumptions

The conceptual site plan does not take into account the topographical and geographical particulars that are inherent to any actual parcel of land. For simplicity, and to make the site plan generally applicable, the site used in this model makes the following assumptions:

- The parcel is a North/South oriented rectangle approximately 430ft x 710ft or 300,000sqft (6.8 acres)
- The building is covered by a pre-engineered steel canopy tall enough to accommodate dump and roll-off trucks (30ft), and wide enough to provide a slight eave (10ft) over the walls.
- The building has concrete walls on four sides to keep out storm water, while leaving openings to accommodate trucks entering and leaving. This design also provides air flow between the walls and roof in order to improve interior air quality and reduce construction costs. Note that the building could also be designed as a fully enclosed steel, wood, or concrete structure.
- The building rests on a reinforced concrete slab.
- The area of the building is approximately 375' x 260', or 97,500 sq ft.

5.2 Preliminary Schematic

Figure 5.1 illustrates one possible site layout for the initial Phase 1 build out of the transfer station and is meant to provide a basic understanding of the traffic and operational flow of a facility with the capabilities discussed in Section 4.

The diagram below is not meant to be an architectural drawing, and the actual engineering, architecture, and site design will vary greatly depending on the realities of both budget and site specifics.

5.2.1 Site Layout and Operational Flow

Upon entering the facility, all incoming traffic is weighed in at the scale house, where it will be weighed again upon exiting to determine appropriate dumping fees. If different materials are charged at different rates, trucks might need to be weighed additional times between loads. The transfer station building is serviced by roadways on site that direct incoming traffic to one of three areas:

1. Contractor/Hauler Material Drop Off: The main structure contains a series of concrete bunkers which are dedicated to each material accepted by the facility. These bunkers are arranged along the outer walls of the structure, with room enough in between rows for roll-off and similar sized trucks to back into each bay. The bunkers are constructed out of concrete blocks that are moveable by a number of different rolling stock machines equipped with lifting forks. As such, the bays can be altered to accommodate the evolving needs of the transfer station throughout its operation.

Each bay is equipped with additional space for 1-2 roll-off containers. Incoming material is dumped into the bay, where it is transferred to roll-offs to await hauling to its end market.

2. Loading Dock: The facility is equipped with pallet storage area and an elevated loading dock to facilitate the transportation of palletized goods to end markets, as well as receiving materials and supplies for the transfer station when necessary.

3. Public Material Drop Off: An optional amenity that is shown in this rendering is a parking lot with small dumpsters to accommodate smaller, residential material drop off. The aim of this area is to provide a separate area for small vehicles to drop off C&D waste material in small quantities, avoiding the potential hazard of having these customers occupy the same space as larger commercial operators. The parking area also provides space for facility staff to park their vehicles.

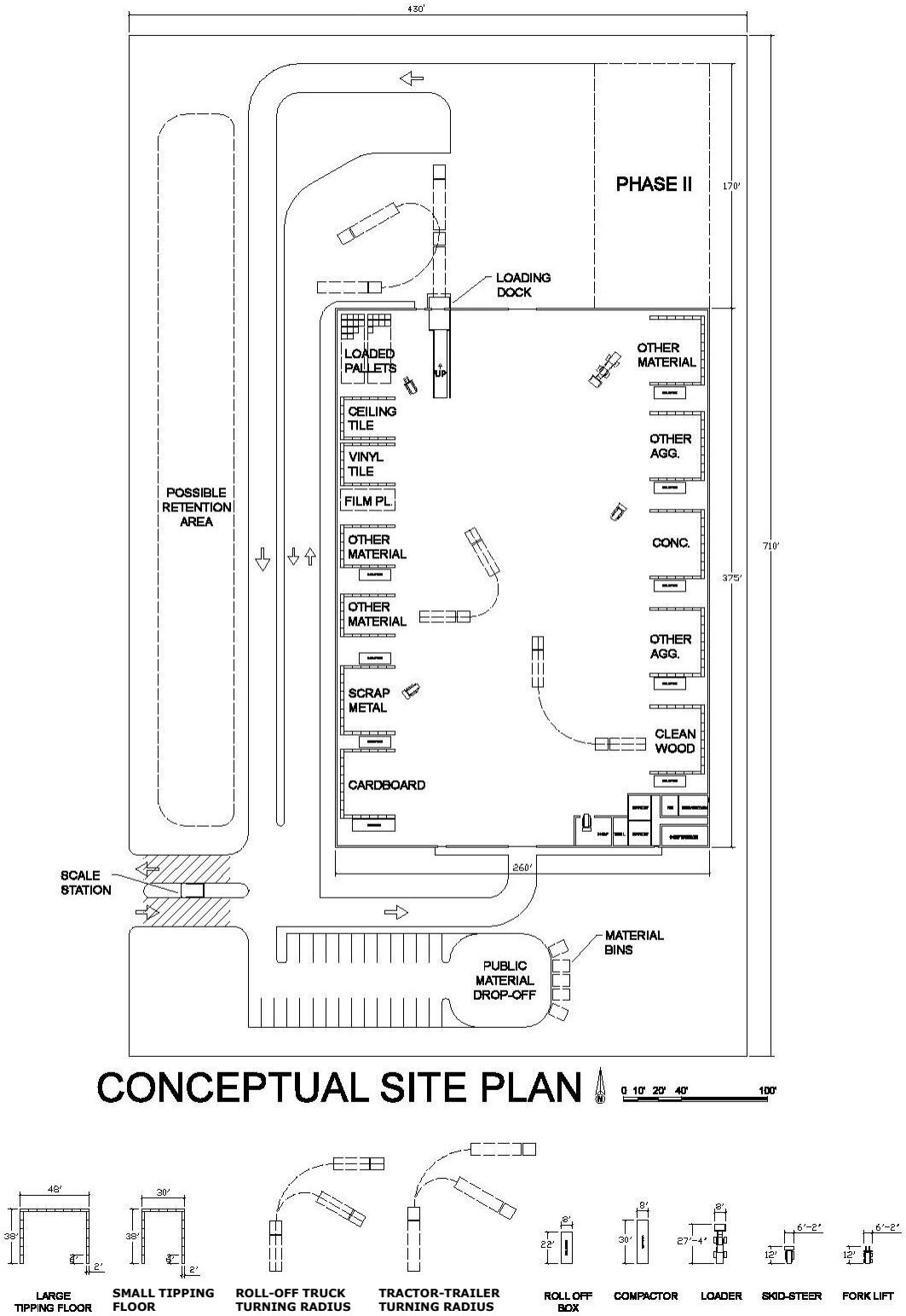
5.2.2 Additional Site Features

Offices and Support Building: The site design incorporates an administrative support area into the design of the main building, with approximately 1500 sq ft of office space for administrative operations. The support area also includes room for restrooms, a break room, and a maintenance area to provide support for the daily operations of the facility.

Further Expansion: The conceptual site plan includes space to expand the operations of the transfer station depending on the future needs of the facility. An area of about .3 acres is set aside to accommodate Phase 2 development should the need arise. Furthermore, the use of concrete block in the design of material holding bays will allow increased flexibility during expansion.

The area designated for Phase 2 expansion is designed to fit a wood/shingle grinder if it becomes economically viable to add processing capabilities to the facility. It is also designed to accommodate additional material bays, either to hold new materials or processed materials post-grinding.

Figure 5-1 Conceptual Site Plan



5.2.3 Site Requirements

Siting the C&D transfer station will require careful attention to the land use codes of Boulder County, as well as its incorporated municipalities. The County and its municipalities all have comprehensive development plans that will limit the number of viable sites significantly due to a limited selection of industrially zoned properties. Ideally, the facility would be sited on a parcel that offers convenient access for both contractors bringing in material, and haulers taking material away to end markets.

Zoning: The proposed facility would be considered either a large recycling collection center or a solid waste transfer station as described in the Boulder County code, Section 4-112. As such the facility will need to be sited in an area that is zoned for General Industrial use. Currently, each municipality, as well as the unincorporated County, has land designated for industrial use, though finding an available and desirable parcel of land may still pose a challenge.

Utilities: The facility will require access to water, electrical, and sewer utilities, and may need to be sited in an incorporated municipality in order to have access to these resources. In order to accommodate the offices on site, the facility should also have telephone and internet access. The location of utility lines will bear on the orientation of the building on the selected site, and it should be noted that if the scale house is located separately from the administrative office, communications cable will need to be run to connect the scale to the facility.

Setbacks: Industrially zoned properties will likely require additional setbacks than those illustrated in the conceptual site plan. Boulder County's code defines industrial setbacks to be 60' in front, 12' to the side, and 20' from the rear of the property border. Additionally, industrially zoned land has a building height limit of 50'.

Pollution: The main pollution concerns for the proposed facility are light, sound, storm water, and dust. Both Boulder County and the City of Boulder, have light pollution ordinances requiring new construction to maintain its light on site through the use of cut-off lighting fixtures. Any outdoor, nighttime lighting on the facility will need to comply with the appropriate regulations depending on the municipality it is sited in.

Noise pollution generated by truck traffic, processing equipment, and rolling stock will need to be mitigated through additional fencing and landscape barriers between the site and its neighbors.

Dust is likely to be produced by dumping, moving, and loading C&D materials, and will certainly be produced during Phase 2 if processing occurs on site. Dust control measures include forced-air circulation and water-mist suppression systems. The facility floor will also accumulate dust throughout the course of each day, and should be cleaned each night with a sweeper. Materials may track out of the facility after being picked up by truck tires and the roadways around the facility should be swept regularly, with the interior being swept as needed.

Fully enclosing the building, rather than leaving open space under the roof would significantly reduce pollution concerns, though it would raise concerns regarding interior air quality, and would likely increase construction costs.

Storm water: Storm water run-off from concrete, asphalt, and other hardscape surfaces must be diverted from running directly into streams, rivers, and other public waterways. Depending on the siting of the facility, water could be channeled to the public storm sewer system, however retention ponds will need to be constructed to store and release storm water at a controlled rate and to monitor water quality.

The preliminary site schematic calls for all materials to be stored under a roof and protected from the elements with bunker walls, reducing the likelihood of storm-water contamination. Nevertheless, it may become necessary to test the cleanliness of stored water, and possibly clean it, prior to releasing the water into public waterways. The specifications for the size and placement of a retention pond will depend on a site review once a location and final design have been chosen.

Traffic: The preliminary schematic places the scale and scale house at the edge of the parcel. This placement is meant to illustrate that a scale must be placed prior to any dumping area. The realities of scale traffic will require a driveway or run-up to accommodate a queue line in front of the scale in case multiple trucks are entering at the same time. Furthermore, the roadways leading to/from the facility must have acceleration/deceleration lanes to accommodate large trucks entering and leaving the facility without disturbing normal traffic.

The designer of the final building must decide what types of vehicles the facility is going to accept material from. Specifically, end-dump tractor-trailers can pose problems for a roofed facility since they require a roof some 40ft high in order to provide sufficient clearance during dumping. While roll-off trucks and dump trucks can maneuver and dump efficiently under a roof of about 30ft, end dump trailers will not be able to dump in such a building, though they could be loaded with material to be hauled to end markets.

Furthermore, both the interior roadways as well as those surrounding the facility along transit routes must be rated to hold large vehicles. If the facility is to be exporting material on fully-loaded end-dump trailers, the maximum vehicle weight is likely to be about 40 tons.

The size and type of vehicles that the facility accepts material from will determine the traffic pattern in and around the transfer station. Whether or not material is accepted from tractor trailers, it is likely that some materials will need to be hauled away to end markets using larger trucks. The site schematic presented above is designed to accommodate the larger turning radius of tractor-trailers as well as smaller trucks; however the siting of the facility must also take this into account.

Efficiencies: Depending on the way that material will be exiting the facility, accepting material from end dump trailers may not be desirable. The material being accepted by this facility will be hauled to processors and end markets using roll-off containers and, at most, 22 ton end-dump or other tractor-trailer rigs. Accepting loads from these large trucks (20-22 ton) will not allow for any added efficiencies, since the same type vehicles (or smaller) will be hauling the material away.

5.3 Rolling Stock and Equipment

Table 5-1 Details the estimated equipment needs for the proposed facility.

Table 5-1 Rolling Stock and Equipment Needs

Equipment	Example Manufacturers	Example models	Quantity		Primary Uses	Purchase Price	Operating Costs	Average Life Span	FTE's to Operate
			Low	High					
Loader	John Deere	544K	1	1	Heavy duty material handling and loading	$240K-$265K	$5-$6K (Fuel) $2-$3K (Maint.)	10-15 years	1
	Caterpiller	IT38H							
Skid Steer	Bobcat	S-650	1	2	Medium duty material handling and loading	$38K-$45K (w/attach.)	$3-$4K (Fuel) $2-$3K (Maint.)	8-10 years	1
	Caterpiller	252B Series 3							
Forklift	Toyota	5K# 8S	1	1	Light duty material handling and pallets	$28K-$32K	$1K-$1.5K(Fuel) $400-$500 (Maint.)	6-8 years	0.5
	Hyster	H50FT							
Parking Lot Sweeper	Schwarze	S235	1	1	Debris removal from hardscape	~$55K(New) ~$25K (Used)	$3K-$4K (Fuel and Maint.)	5-6 years	0.25
	Tymco	210							
Stationary Compactor	Marathon	RJ-400	0	1	Increase hauling capacity for OCC	$9K-$12K (w/box)	$400-$600 (Elec.) $400-$600 (Maint.)	5-6 years	--
	Wastecare	ST-31							
Roll-Off Box	May Mfg.	Tub-style	Numerous		Material storage and transport	$3.5-$4K	$100-$200	10-15 years	--
	Troth Ent.	Square							

The proposed equipment needs are designed to accommodate the materials present in Phase 1 and 2. As the facility ages, it may accept more material, different kinds of material, or handle materials differently. Additional equipment will likely be required to accommodate processing capabilities, and is included in the cost estimate for each material, respectively.

5.4 Personnel Requirements

Table 5-2 Details the Estimated Personnel required for the proposed facility.

The following proposed staffing solution is designed with the Phase 1 build out in mind. In the future, the transfer station may add processing capabilities, in which case additional personnel will be required. The facility will almost certainly receive more material as it ages, and personnel requirements should increase according to operational needs. The low estimate for personnel needs represent the bare minimum staff that would be required to operate a facility. Operational efficiencies would decrease with understaffing, and this estimate is meant to illustrate the cheapest amount of employees possible. The high estimate would be the ideal staffing from an operational standpoint, as it provides ample employees to handle both materials and customer service.

The personnel requirements take in to account the staff that would be needed to operate each piece of equipment on site, as well as administrative support staff. The Scale House Attendant and "Other Yard Staff" positions are flexible designations, and are meant to represent staff who could serve multiple roles. For example, under the minimum staffing situation, the scale house attendant might be available to operate a forklift as needed. Finally, the Marketing/Outreach Coordinator is responsible for developing market relationship with potential purchasers as well as increasing diversion through education and outreach to the community.

The County might choose to outsource the operation of the C&D facility to a private organization, a full discussion of which can be found in Section 6.6.

Table 5-2 Personnel Requirements

Title	FTE's	Job Description	Quantity	
			Low	High
Site Supervisor	1	Supervises equipment operators and general operations	1	1
Heavy Equipment Operators	0.5	Operates rolling stock equipment	2	4
Other yard Staff	0.5	Fills various roles as needed	1	2
Mechanic	0.25	Repairs heavy equipment as needed	0	1
Scale House Attendant	0.5	Processes incoming traffic and provides weight tickets	1	1
Marketing/Outreach Coordinator	1	Finds and maintains markets, increases diversion through education and outreach	0	1

5.5 Air Quality and Hazardous Materials Concerns

Air Quality: The site design presented in this report calls for a building that is partially enclosed, with space between the outer walls and roof to allow air to circulate through the structure. Due to commercial traffic and rolling stock exhaust generation, adequately ventilating the structure is important for worker safety. In a fully enclosed facility, adequate ventilation systems should be included in the design to minimize interior air pollution.

Dust Control: Materials such as aggregates, wood, wallboard, and asphalt shingles can all produce dust when they break apart, causing air quality concerns. Phase 1 of site development does not call for any processing to take place on the site, and concerns over hazardous dust are limited. Phase 2, however, suggests that some processing may in the future become a viable option at this facility, and consideration should be given to air quality control should this become a reality. Water-misting dust control systems can reduce the spread of dust off site, and should be considered along with any proposal to begin grinding material at the transfer station. It should be noted, however, that as the proposed building is not heated, water-based dust control systems will be subject to freezing temperatures and may not be able to operate in the winter.

Hazmat: Hazardous materials should be considered contamination in the waste stream and penalties should be charged for loads that are found to be contaminated after acceptance. If hazardous materials are visibly present in incoming loads, the loads should not be accepted to minimize worker exposure to harmful materials. Materials that should be considered hazardous include but are not limited to:

- Toxic chemicals or chemical residue
- Household hazardous materials
- Moldy or wet materials
- Asbestos
- Contaminated soils

Fire Suppression: Included in the design of the facility, and in the Section 6 cost estimate, is a fire-control system required to prevent flammable materials from catching fire and spreading flames.

6 Financial Analysis

Overview: This section discusses the capital and ongoing operating and maintenance costs associated with the C&D transfer station outlined in Section 5. The discussion below is intended to serve as a basis for understanding the costs involved in one possible arrangement of the facility, and uses the conceptual site plan as an archetype for this analysis. This analysis considers the site preparation, building and construction costs, as well as rolling stock capital costs. It goes on to consider the operational costs of the proposed schematic including equipment operating and maintenance costs, personnel salaries and benefits, as well as the operating reserve. The realities of building a facility will vary depending on the actual site and building plan chosen.

It is important to note that all cost estimates are in 2011 US Dollars, and that prices are subject to change over time and through contract negotiations.

6.1 Capital Costs

Section 6.1 discusses the estimated cost of building the facility described in Section 5. The capital cost analysis does not take into account interest that would need to be paid on any loans taken out to fund the construction of the facility, as it was understood that the County would have sufficient capital to cover the initial investment.

Furthermore, the cost of land on which to build the facility is not included here. Additional site research is required before accurate estimations can be made, and for the purpose of this model the cost of land is not factored in.

6.1.1 Rolling Stock

Table 6-1 presents the estimated cost of purchasing the rolling stock equipment called for in the Phase 1 build out.

Table 6-1 Rolling Stock Capital Costs

Rolling Stock Capital Costs				Total Cost	
Equipment	Low Estimate	High Estimate	Quantity	Low Estimate	High Estimate
Loader	$240,000	$265,000	1	$240,000	$265,000
Skid Steer	$38,000	$45,000	2	$76,000	$90,000
Forklift	$28,000	$32,000	1	$28,000	$32,000
Sweeper	$25,000	$55,000	1	$25,000	$55,000
Roll-Off Box	$3,500	$4,000	6	$21,000	$24,000
Compactor	$9,000	$12,000	1	$9,000	$12,000
Totals					
			Subtotal	$399,000	$478,000
			Sales Tax	4.90%	4.90%
			Total Equipment Cost	**$418,551**	**$501,422**
			Annual Debt Service	$54,698	$65,528

6.1.2 Building and Site Construction

Table 6-2 details the costs behind the planning and construction of the transfer station buildings and site infrastructure. The construction cost estimate presented below was compiled from a series of interviews with contractors, manufacturers, and suppliers in order to determine the possible price range of each facility component.

Table 6-2 Building and Site Construction Costs

Building and Site Construction Costs					
Item/Service	**Amount**	**Unit**	**Cost Per Unit**	**Low Estimate**	**High Estimate**
Design Costs					
	Estimate Basis			**Low Estimate**	**High Estimate**
Permitting, Fees, Entitlements				$300,000	$500,000
Engineering	8%	%		$390,960	$853,288
Total Design Costs				$690,960	$1,353,288
Site Preparation Costs					
	Estimate Basis			**Low Estimate**	**High Estimate**
Mobilization				$50,000	$75,000
Earthwork				$50,000	$100,000
Water/Sewer Systems				$25,000	$100,000
Paving	39,000	sq ft.	$3-$25/sq ft.	$119,700	$997,500
Detention Pond				$30,000	$100,000
Fencing	2,200	ft	$6/sq ft.	$13,000	$15,600
Landscaping	30,000	sq ft.	$5-10/sq ft.	$150,000	$300,000
Site Lighting				$50,000	$100,000
Total Site Prep				$487,700	$1,788,100
Building Costs					
	Estimate Basis			**Low Estimate**	**High Estimate**
Warehouse	96,000	sq ft.	$55-88/sq ft. enclosed,	$4,224,000	$8,448,000
Large Bunkers	7@ 30x30	sq ft.	$1,500-$8,000	$10,500	$56,000
Small Bunkers	4@ 30x30	sq ft.	$1,200-$6,000	$4,800	$24,000
Loading Dock				$35,000	$50,000
Warehouse Doors	2	ea.	$10,000-$50,000	$20,000	$100,000
Total Building Costs				$4,294,300	$8,678,000
Support Costs					
	Estimate Basis			**Low Estimate**	**High Estimate**
Offices	1,500	sq ft.	$40-$60/sq ft.	$60,000	$90,000
Scale	2	ea.	$15,000-$40,000	$30,000	$80,000
Scale House	50	sq ft.	$100-$200/sq ft.	$5,000	$10,000
Technology				$10,000	$20,000
Total Support Costs				$105,000	$200,000
Totals					
	Estimate Basis			**Low Estimate**	**High Estimate**
Subtotal				$5,577,960	$12,019,388
GC/Project Management	7%	%		$390,457	$841,357
Contingency	20%	%		$1,115,592	$2,403,878
Total				**$7,084,009**	**$15,264,623**
Annual Debt Service	6%	%		$609,024	$1,312,326

6.1.3. Funding Assumptions

In order to cover the costs of constructing the proposed facility, it is assumed that the project will be funded using public-sector debt. The costs of annual debt service are included in each capital cost table and are meant to provide a conservative estimate of the annual costs of financing a facility such as the one proposed in section 5. The terms of the debt considered here account for a 20 year facility lifetime and repayment period, with an annual rate of 6%. While it is unlikely that the entire cost of the facility's construction will come from public debt, the current cost estimate considers this option in order to provide a conservative estimate of the annual debt service.

6.2 Operating Costs

Section 6-2 discusses the variable operating costs associated with the initial Phase 1 build out described in Section 5. The actual costs are subject to change depending on the realities of material intake, and will likely rise or fall depending on how busy the facility is.

6.2.1 Equipment Operating and Maintenance

Table 6-3 details the operating and maintenance costs for the rolling stock equipment in use at the C&D transfer station. O&M costs are based off fuel and maintenance costs, as well as the capital cost of each machine annualized over its expected lifetime. A full listing of individual equipment costs and lifetimes can be found in Table 5-1.

Table 6-3 Annual Equipment Operating and Maintenance Costs

Equipment Operating and Maintenance Costs		
Equipment	**Low Estimate**	**High Estimate**
Loader	$31,000	$36,500
Skid Steer	$19,500	$25,250
Forklift	$6,067	$7,233
Sweeper	$8,000	$15,000
Roll-Off Box	$2,700	$3,600
Compactor	$2,200	$3,000
Totals	$69,467	$90,583

[a] O&M costs are based off fuel and maintenance costs, as well as the capital cost of each machine annualized over its expected lifetime.

6.2.2 Personnel

Table 6-4 presents an estimate of employee salaries, including benefits and overtime pay as a percentage of the total salary cost. The current employee estimate is based on a facility open five days per week. The low and high estimates presented below are meant to account for variability of staffing due to fluctuations in the amount of material entering the facility. The more material the facility receives, the more employees will be required to properly staff it. A more complete discussion of labor needs for the proposed facility is found in Section 5.4.

Table 6-4 Annual Personnel Salary Costs

Personnel Costs				Total Salaries	
Title	Salary Estimate	Low Quantity FTE's	High Quantity FTE's	Low Estimate	High Estimate
Site Supervisor	$55,000	1	1	$55,000	$55,000
Equipment Operator	$45,000	1	2	$45,000	$90,000
Other Yard Staff	$45,000	0.5	1	$22,500	$45,000
Mechanic	$45,000	0	0.25	$0	$11,250
Scale House Attendant	$45,000	0.5	0.5	$22,500	$22,500
Marketing/Outreach Coordinator	$45,000	0	1	$0	$45,000
		Salary Total		$145,000	$268,750
		Benefits and Overtime	40.00%	$58,000	$107,500
		Salary and Benefits Total		**$203,000**	**$376,250**

6.2.3 Other Variable Operating Costs

Table 6-5 details the estimated costs of additional services and site maintenance requirements that should be accounted for in the yearly operating budget, in this table the low and high estimates are not directly related to variation in tonnage-per-year. Rather, Table 6-5 is meant to account for a range of costs that will vary depending on the specifics of the facility when it is designed.

Table 6-5 Other Variable Operating Costs

	Low Estimate	High Estimate
Utilities	$1,500	$4,800
Supplies	$1,500	$3,000
Training	$2,000	$2,500
Site Maintenance	$3,000	$5,000
Professional Services	$2,400	$5,000
Total	**$10,400**	**$20,300**

6.2.4 Administrative Costs

There are numerous administrative costs, such as accounting, payroll, scheduling, and other clerical work, that must be accounted for when considering the operational costs of a facility such as this. As the final operational scenario of the facility has yet to be decided, it is unclear at this point what administrative resources would be available to the facility operator. In order to account for administrative costs, therefore, an additional 15% has been applied to the total operating costs, as illustrated in Table 6-7.

6.2.5 Operating Reserve

The operating reserve is designed to provide the facility with a financial safety net that covers unforeseen costs that are likely to arise over the course of the facility's lifetime. A typical operating reserve to keep on hand is the equivalent of three months' operating expenses. In the case of the schematic facility, this would equate to between $70,716 and $121,783. In order to ease the burden of saving these funds, the reserve can be developed over the first 3 years of the facility's operation, and the annual contribution would amount to between $23,572 and $40,594.

6.3 Total Expenses

Tables 6-6 through 6-9 present the estimated total costs for the construction and operation of the facility described in Section 5 as well as those costs annualized over the proposed 20 year lifespan of the facility.

Table 6-6 Total Capital Costs

Capital Costs

	Low Estimate	High Estimate
Building and Site Construction	$7,084,009	$15,264,623
Rolling Stock	$418,551	$501,422
Total Capital Costs	**$7,502,560**	**$15,766,045**
Annual Debt Service	$663,723	$1,377,854

Table 6-7 Annual Operating Costs

Annual Operating Costs

	Low Estimate	High Estimate
Personnel	$203,000	$376,250
Equipment O&M	$69,467	$90,583
Other Variable Costs	$10,400	$20,300
Operating Reserve	$23,572	$40,594
Administrative Costs (15%)	$45,966	$79,159
Total Annual Costs	**$352,405**	**$606,887**

6.4 Tipping Fees

For the facility to operationally break even, it must charge tipping fees for incoming material that are sufficient to cover both the cost of recycling each material, as well as operational costs such as salary and utilities.

Material Costs: The first set of costs governing the tip fee are the costs to recycle each material. In Section 4, a cost analysis is given for each material, including the cost of transferring to an end market recycler. The total cost for each material is the sum of its hauling cost and the tipping fee charged by the end market. Table 6-10 summarizes the total costs described in Section 4 and included in the Phase 1 analysis. Actual prices negotiated by the operator will be subject to market conditions at the time and the information presented in table 6-8 is meant to give a general idea of 2011 prices for recycling these materials.

Table 6-8 Total Material Costs Using Low and High Diversion Estimates

Material	Low Annual Tonnage	High Annual Tonnage	Cost Per Ton	Low Annual Cost	High Annual Cost
Aggregates	2,400	8,100	$4.94	$11,856	$40,014
Cardboard	70	260	$4.90	$343	$1,274
Ceiling Tiles	6	19	$0.00	$0	$0
Clean Wood	1,913	4,725	$25.00	$47,825	$118,125
Durable Goods	39	238	$0.00	$0	$0
Pallets	275	700	$30.00	$8,250	$21,000
Plastics	35	1,550	$5.00	$175	$7,750
Scrap Metal	79	525	$6.00	$474	$3,150
VCT	13	38	$0.00	$0	$0
Totals	4,830	16,155		$68,923	$191,313

Operational Costs: The first set of costs that the tipping fee will need to cover are the variable operating costs described above and summarized in table 6-7, and range from about $352,405 and $606,887.

Material Revenue: Many of the materials represent valuable commodities when they are recycled properly. Table 6-9 summarizes a preliminary estimate of the revenue potential for the materials recommended for Phase 1. It is important to note that the contractual details to be negotiated with each end market will significantly affect the total revenue potential of these materials, as will the ability of the operator to achieve enough diversion to garner these amounts.

Table 6-9 Material Revenue Potential Using Low and High Diversion Estimates

Material	Low Annual Tonnage	High Annual Tonnage	Revenue Per Ton	Low Annual Revenue	High Annual Revenue
Aggregates	2,400	8,100	$0	$0	$0
Cardboard	70	260	$100	$7,000	$26,000
Ceiling Tiles	6	19	$0	$0	$0
Clean Wood	1,913	4,725	$0	$0	$0
Durable Goods	39	238	$0	$0	$0
Pallets	275	700	$100	$27,500	$70,000
Plastics	35	1,550	$100	$3,500	$155,000
Scrap Metal	79	525	$170	$13,430	$89,250
VCT	13	38	$0	$0	$0
Totals	4,830	16,155		$51,430	$340,250

Annual Tonnage: The amount of material that is handled by the facility each year will directly influence the amount of the per-ton tipping fee. For the purpose of estimation, this analysis uses the tonnages derived from the estimated diversion numbers. Based on current diversion estimates, the facility could expect a range of 5,000-16,000 (rounded) tons per year.

Annual tonnage not only determines how many tons of profitable commodities the facility is able to market, but also how many tons the annual operating costs can be spread over. Higher diversion rates, therefore, will significantly reduce the tipping fee required, while low rates and low tonnages will require a higher tipping fee.

Averaged model: Depending on the variables described above, the facility's tipping fee could range significantly. Of critical importance will be efficient management and staffing, beneficial contract negotiations with end recyclers and commodities markets, and the ability to divert sufficient quantities of high value materials to disburse the operating costs of the facility. Table 6-10 summarizes the range of tip fees possible for a Boulder County C&D transfer station.

The range of tipping fees is defined at the low end by pairing the lowest operating cost estimate with the low-tonnage scenario. The high end assumes the highest-cost operating scenario paired with a high tonnage.

Table 6-10: Operating Costs and Tipping Fees

	Low Cost Estimate	High Cost Estimate
Annual Operating Costs	-$352,405	-$606,887
	Low Tonnage	**High Tonnage**
Material Cost	-$68,874	-$189,614
Material Revenue	$50,430	$328,250
Tonnage	4,989	16,316
Tipping Fee Per Ton	$47	$29

Material-Specific Tip Fees: In order for the facility to succeed in its goal of diverting material from landfills and increasing the overall diversion rate of Boulder County's waste stream, the tipping fee must be competitive with the cost of dumping at a local landfill. Landfills in the area report that they charge around $13-$19/cy for C&D waste. Depending on the material, this translates to about $25/ton. As landfill pricing is based on mixed loads of C&D waste, the comparison to a facility which only accepts source-separated loads is not exact. Table 6-10 displays the tipping fee that would be required for each material based on the cost to recycle it.

Table 6-11 Material-Specific Tipping Fee

Material	Tipping Fee
Aggregates	$4.94
Asphalt Shingles	$2.24
Cardboard	Any
Carpet	$141.00
Ceiling Tiles	Any
Clean Wood	$25.30
Clean Wallboard	$22.25
Durable Goods	Any
Pallets	Any
Plastics	Any
Plate Glass	$57.00
Scrap Metal	Any
VCT	Any

As table 6-10 shows, some materials will be significantly more economical to accept at the facility than others. Through effective contracting, it would be possible for the revenue from higher-value materials to offset the costs of recycling for lower-value materials, which could lower the necessary tipping fees for these materials significantly. It is important to note that differential tipping fees will allow the operator of the facility to influence the diversion of materials, encouraging those materials that will turn a profit, or are high-priority to the County's Zero-Waste goals, and discouraging those that are either costly to recycle or low-priority.

6.5 Facility Ownership/Operating Scenarios:

It is possible for the facility to serve Boulder County in a variety of ownership-operating scenarios, which are presented below in Table 6-8.

Table 6-12: Ownership/Operating Scenarios

Scenarios		Considerations	
Ownership	**Operation**	**Typical Pro's**	**Typical Con's**
County	County	▪ High control ▪ Functionally a non-profit operating scenario, enabling receipt of low- and no-profit materials; greater diversion? ▪ Precedence elsewhere in country; HHW facility here ▪ County's lower initial capital costs reduce overall facility costs	▪ Marketing commodities includes inherent risk ▪ County fully responsible for all risks to suppliers and end-users ▪ Longer development time ▪ County site search may trigger price hikes in eligible parcels
County	For-profit operator	▪ County can set many operating parameters through contract, including revenue sharing ▪ Operational efficiencies associated with private sector especially where economies of scale can be achieved with other operations	▪ Operator's need for profit may mean less materials received ▪ County may not be able to "contract away" operating risks ▪ County site search may trigger price hikes in eligible parcels
County	Non-profit operator	▪ County can set many operating parameters through contract, including revenue sharing ▪ Non-profit may receive more materials, increasing diversion ▪ Non-profits historically engage in more education of generators	▪ County less likely to be able to "contract away" operating risks ▪ County site search may trigger price hikes in eligible parcels ▪ Little precedent nationwide of nonprofit operators of C&D Transfer Stations or MRFs
For-profit operator	For-profit operator (private development scenario)	▪ Can achieve diversion without County investment ▪ Least risk to County ▪ Private operator more likely to do full C&D MRF rather than a transfer station (higher potential profit with MRF)	▪ No County control ▪ "Cherry-picking" of materials ▪ May be low diversion

It should be noted that Boulder County currently operates its recyclable materials MRF under the public-ownership/non-profit operator, and the Center for Hard to Recycle Materials is also owned and operated by a non-profit, with City of Boulder operational and site subsidies.

County Costs - Each of these scenarios includes different development and operational costs for the County. For example, each scenario will require County resources on some level for permitting (land use/special use, environmental, and solid waste) and site zoning variances (if needed). For the County ownership and operation scenario, additional costs will be incurred for siting, facility design, construction (including site clearing/grading), construction quality assurance, equipment procurement and installation, facility start-up, operations and (eventually) facility decommissioning.

For the County ownership/for-profit or non-profit operation scenarios, these resources may be shared with the operator to a degree that varies with the contractual relationship. Additional County costs for these scenarios will include the contractor procurement process (development and issuance of a request for bids/proposals and negotiation of a contract) as well as the on-going contract administration, invoicing and payment activities. Depending on the negotiated contract term, the procurement process may need to be repeated several times during the life of the facility. Obviously, the private sector ownership/operation scenario will incur the least costs to the County, albeit at the loss of control over operations and diversion.

Land – The most significant additional cost for the construction of the facility will be the purchase of the land on which to build it. The current costs estimate does not account for this purchase, which will increase the total cost of the facility dramatically.

Insurance – Pollution Prevention and General Business Liability Insurance will be required of the facility operator. Additionally, if the facility is County-owned, the County's risk assessment personnel will need to review operations and the operator, and contractually require adequate insurance to protect the County's risk rating.

6.6 Future Considerations

Given the data provided in this report, the County is armed with the information it needs to decide if a C&D facility is a worthwhile investment in Boulder County. If the decision to proceed with a facility is made, the County may wish to consider performing the following analysis which fell outside the scope of this report:

- **Single Stream Analysis:** In order to design a facility with simple infrastructure and a lower investment on the part of the County, this report is concerned primarily with source-separated C&D recycling. It may be pertinent in the future, however, for the County to investigate the logistics and economics of constructing a single-stream recycling facility for C&D waste. Looking at the other C&D recycling facilities in the country, most of them accept mixed loads from contractors, and use sophisticated sorting lines to separate out different materials from the waste stream. This approach is easier for contractors and industry professionals to use, though it requires a significantly larger investment in both capital and operations. Nevertheless, the increased diversion possible with single-stream C&D recycling could be significant, and may warrant a further study at the discretion of the County.

- **Traffic Analysis**- For a site chosen, the County will have to provide an analysis of the traffic patterns and frequency of vehicles entering and exiting the facility. This analysis will not be able to be performed until a site is chosen, but given the heavy truck traffic of the facility, the traffic analysis will be required.

- **Architectural Facility Design**- This report provides a Preliminary Conceptual Site Plan. The County should consider honing the Site Plan through a more thorough analysis of the space design. It is possible that doing so may result is cost savings due to a more efficient building design. It may be wisest to do this though only after a particular site has been chosen for the facility.

- **Site Operation Schedule-** This report provides an analysis of the amount of materials expected to be delivered to the site. The next step would be to plan out the expected removal of materials from the site and how much material the County plans to stockpile before removal. This analysis would help the County more finely tune its storage space and convert the tonnage received numbers to cubic yard stored. Understanding the frequency of material pickup will be a necessary component of the traffic analysis report mentioned above.

- **Pricing Analysis**- This report provides all the data necessary to analyze the Boulder County C&D material markets as of Fall 2011. It purposefully stops short of recommending a set tipping fee price for item or per vehicle. Doing so allows Boulder County to:
    - prioritize what it wishes to accomplish with the facility
    - have some much needed flexibility in negotiation with potential vendors/markets
    - use 2011 market rates in consideration
    - choose an appropriate fee if and when a facility is in place without having anchored expectations based upon 2011 markets.

  Given the volatility of some markets, if the facility does not open prior to Spring 2013, it would be wise to perform another Market Pricing Analysis. This analysis will allow Boulder County to revisit markets and not only understand what market pricing is as

close to opening date as possible but also make decisions on materials accepted based upon current market conditions.

- **Consumer Survey**- For the purposes of this report an in depth consumer survey of potential customers of the Boulder County C&D facility was not performed. The analysis which assumes how much material will arrive in the facility is not scientific but rather is estimates based upon a small number of interviews and the feedback received in these interviews. The County should consider a more detailed analysis of its expected customer base to better hone its expectations of materials brought to its facility as opposed to other facilities such as local landfills as well as to better design the customer experience to maximize customer satisfaction.

Material	End Market-Company Name	Location	Materials/ Condition Accepted	End Markets Price Paid/Fee Charged to Customer (per ton)[a]	Distance from Boulder County[b]	Round Trip Hauling Cost per ton[c]
Aggregates	Recycled Materials Company	Erie, CO	Concrete, Asphalt	-$2.00	14 miles	-$1.37
	Oxford Recycling	Englewood, CO	Concrete, Asphalt	-$2.00	36 miles	-$3.51
	Allied Recycled Aggregates	Commerce City, CO	Concrete, Asphalt	-$3.25/ton Concrete Asphalt Free	28 miles	-$2.73
Asphalt Shingles	Asphalt Specialties	Erie, CO	Asphalt Shingles	Free	13 miles	-$2.54
	Brannan Sand And Gravel	Denver, CO	Asphalt Shingles tested for asbestos	-$10 to -$30/ton	10 miles	-$1.95
Cardboard	Boulder County Recycling Center	Boulder, CO	Cardboard, loose	$150/ton	0 miles	-$0.24
	Altogether Recycling	Denver,CO	Cardboard, loose	$150/ton	24 miles	-$5.85
	Waste Management	Denver, CO	Cardboard, loose	Not Available	25 miles	-$6.09
	International Paper	Denver, CO	Cardboard, loose	$100/ton	31 miles	-$7.56
Carpet	Re:Volve Broomfield, CO	Broomfield, CO	Carpet tiles, clean (nylon 6 or 6,6)	Receives for free	13 miles	-$14.91
	Geocycle	Colorado Springs, CO	Rolled, free of debris (& flooring nails if possible). Prices vary by how shipped	$30/ton baled $40/ton pallets $50/ton loose	100 miles (To CO Springs Facility)	-$114.71
	Natural Transitions	Colorado Springs, CO	Nylon 6,6 and Carpet pad	$20-$40/ton	100 Miles	-$114.71
Ceiling Tiles	Armstrong Recycling	Lancaster, PA	Ceiling Tiles, Palletized	$0/ton	1500 miles	Free when hauled in full tractor trailer loads
Cement Fiberboard	None	N/A	N/A	N/A	N/A	N/A
Clean Wood	Western Disposal	Boulder, CO	Clean wood, loose	$0/ton	2 miles	-$0.65
	A1 Organics	Denver,CO	Clean wood, loose	-$12.50/ton	30 miles	-$9.75
	Oxford Recycling	Englewood,CO	Clean wood, loose	-$17.50/ton	36 miles	-$11.70
	Center for Resource Conservation's ReSource Yard	Boulder, CO	Reusable Wood	$0/ton	1 mile	-$.33
Clean Gypsum Wallboard	A1 Organics	Denver,CO	Clean wallboard scrap, new	-$12.50/ton	30 miles	-$9.75
Durable Goods	Center for Resource Conservation's ReSource Yard	Boulder, CO	Reusable durable goods and building materials	None, Donation receipts available	1 mile	-$0.33
	St. Vrain Habitat for Humanity ReStore	Longmont, CO	Reusable durable goods and building materials	None, Donation receipts available	15 miles	-$4.88
	Bud's Warehouse	Denver, CO	Reusable durable goods and building materials	None, Donation receipts available	25 miles	-$8.13
	Habitat for Humanity Building Outlet	Denver, CO	Reusable durable goods and building materials	None, Donation receipts available	31 miles	-$10.08

[a]Market prices and charges are based off of 2011 research

[b]For estimation purposes, hauling distances are calculated based on a facility located at 63rd st and Arapahoe Ave in Boulder, CO

[c]Estimated hauling costs are based off of 2011 research

Material	End Market-Company Name	Location	Materials/ Condition Accepted	End Markets Price Paid/Fee Charged to Customer (per ton)[a]	Distance from Boulder County[b]	Round Trip Hauling Cost per ton[c]
Fiberglass Insulation	N/A	N/A	N/A	N/A	N/A	N/A
Painted/Treated Wood	None	N/A	N/A	N/A	N/A	N/A
Wood Pallets* Note - pallet recyclers will only take 48x48 or 48x40 "four-way" pallets (can be accessed by forklift from all 4 directions)	Frisco Pallet, LLC	Denver,CO	Repairable Wood Pallets	$1-$2/pallet for quantities > 100 pallets	22 miles	-$21.45
	Waste-Not	Loveland, CO	#1: Reusable #2: Repairable #3: Damaged stacked, lg. quant.	#1: $1.50-$2.50/pallet #2: $.50-$1.00/pallet #3: charge to receive	41 miles	-$39.98
	L&R Pallet	Denver, CO	Repairable Wood Pallets: stacked, > 150 at a time	$.50-$1.50/pallet	30 miles	-$29.25
Plastics	Hi-Tec Plastics	Commerce City, CO	High Density and PVC Scrap	$.05-$.15/lb	30 miles	-$8.36
	Altogether Recycling	Denver, CO	Pre-/post-consumer industrial scrap	Market too volatile to quote at this time	24 miles	-$6.69
	Eco Cycle Boulder, CO	Boulder, CO	Stretch Plastic	$0/ton	3 miles	-$1.95
	Waste-Not Loveland, CO	Loveland, CO	Plastic films (HDPE & LDPE) baled, truckload	$.00-.16/lb. Payments less on mixed or contaminated loads	41 miles	-$3.63
			PVC pipes (4' lengths, bundled, clean, undamaged)	$.0-$.12/lb.		-$41.15
Plate Glass	Johns Manville	McPhearson, KS	Plate glass cullet	$.09/lb	422 miles	-$73.13
	Dlublak Glass	Okmulgee, OK	Plate glass, sorted	$40/T clear $30/T mixed colors	750 miles	-$79.95
	Dlublak Glass	Waxahachie, TX	same as above	same	820 miles	-$4.88
Scrap Metal	Iron and Metals Co.	Denver, CO	Ferrous and Non-Ferrous Scrap Metal, loose	$190/ton mixed metal	25 miles	-$4.88
	Atlas Metal and Iron	Denver, CO	Ferrous and Non-Ferrous Scrap Metal, loose	$195/ton mixed metal	30 miles	-$5.85
	Wise Recycling	Longmont, CO	Non-Ferrous Scrap Metal, loose	Market prices, $.53/lb for aluminum	33 miles	-$6.44
	Western Aluminum	Boulder, CO	Non-Ferrous Scrap Metal, loose	Market prices, $.43/lb for aluminum	3 miles	-$0.59
Vinyl Composition Tiles	Armstrong Recycling	Lancaster, PA	Vinyl Tiles, Boxed	$0.00	1500 miles	Free when hauled in full tractor trailer loads

[a]Market prices and charges are based off of 2011 research

[b]For estimation purposes, hauling distances are calculated based on a facility located at 63rd st and Arapahoe Ave in Boulder, CO

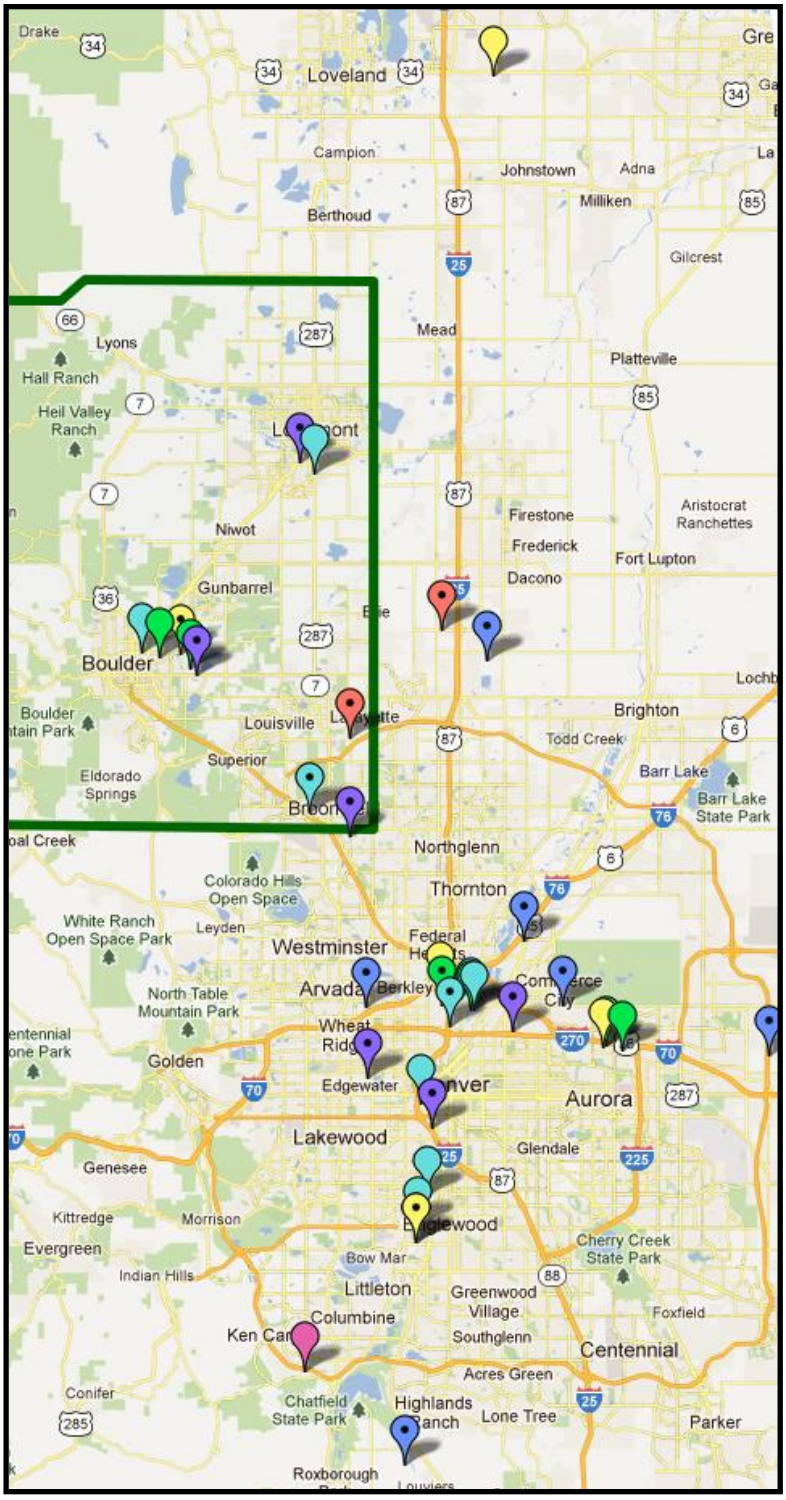
[c]Estimated hauling costs are based off of 2011 research

Appendix B: C&D Waste Generation Projection

	2010			2015			2020			2025			2030		
	low	med	hi	low	med	hi	low	med	hi	low	med	hi	low	med	hi
MATERIALS															
Paper															
Uncoated OCC	709	1,064	1,419	753	1,129	1,505	1,198	1,797	2,396	1,264	1,897	2,529	1,314	1,971	2,627
Other Paper	213	319	426	226	339	452	80	120	160	84	126	169	88	131	175
Total Paper	922	1,383	1,844	978	1,467	1,957	1,278	1,917	2,556	1,349	2,023	2,697	1,401	2,102	2,803
Plastics															
Plastic Film Packaging	71	106	142	75	113	151	80	120	160	84	126	169	88	131	175
Other Plastics	284	426	567	753	1,129	1,505	1,358	2,037	2,715	2,697	4,046	5,395	3,766	5,649	7,532
Total Plastic	355	532	709	828	1,242	1,656	1,438	2,156	2,875	2,782	4,172	5,563	3,854	5,780	7,707
Metals															
Ferrous Metal	2,483	3,724	4,965	3,386	5,079	6,773	3,993	5,990	7,986	4,636	6,954	9,272	4,817	7,225	9,634
Non-Ferrous Metal	1,419	2,128	2,837	1,129	1,693	2,258	799	1,198	1,597	421	632	843	438	657	876
Total Metals	3,901	5,852	7,802	4,515	6,773	9,030	4,792	7,188	9,584	5,057	7,586	10,115	5,255	7,882	10,510
Glass															
All Glass	213	319	426	753	1,129	1,505	1,597	2,396	3,195	2,529	3,793	5,057	3,503	5,255	7,007
Total Glass	213	319	426	753	1,129	1,505	1,597	2,396	3,195	2,529	3,793	5,057	3,503	5,255	7,007
Organics															
Yard Waste	2,128	3,192	4,256	2,258	3,386	4,515	2,396	3,594	4,792	2,529	3,793	5,057	2,627	3,941	5,255
Wood Pallets	2,837	4,256	5,674	3,010	4,515	6,020	3,195	4,792	6,389	3,372	5,057	6,743	3,503	5,255	7,007
Dirt/Sand	2,412	3,617	4,823	3,010	4,515	6,020	3,195	4,792	6,389	3,372	5,057	6,743	3,503	5,255	7,007
Total Organics	7,377	11,065	14,754	8,278	12,416	16,555	8,785	13,177	17,570	9,272	13,908	18,544	9,634	14,451	19,268
Problem Waste															
Electronics	71	106	142	75	113	151	240	359	479	253	379	506	263	394	525
Small Appliances	142	213	284	151	226	301	240	359	479	169	253	337	175	263	350
Carpet/Padding	709	1,064	1,419	1,129	1,693	2,258	1,597	2,396	3,195	1,264	1,897	2,529	876	1,314	1,752
Furniture/Bulky Items	71	106	142	75	113	151	80	120	160	84	126	169	88	131	175
Total Problem Waste	993	1,490	1,986	1,430	2,145	2,860	2,156	3,234	4,313	1,770	2,655	3,540	1,401	2,102	2,803
C&D Materials															
Concrete/Asphalt/Aggregate	24,117	36,175	48,233	24,833	37,249	49,665	25,556	38,335	51,113	26,973	40,460	53,946	26,275	39,412	52,549
Asphalt Shingles/Backing	11,349	17,023	22,698	10,535	15,803	21,070	9,584	14,375	19,167	9,272	13,908	18,544	9,634	14,451	19,268
Painted/Stained/Treated Wood	6,384	9,576	12,768	6,773	10,159	13,545	7,188	10,782	14,375	6,743	10,115	13,487	7,007	10,510	14,013
Untreated Wood	4,256	6,384	8,512	4,515	6,773	9,030	4,792	7,188	9,584	5,057	7,586	10,115	5,255	7,882	10,510
Hardwood/Laminated Flooring	355	532	709	376	564	753	479	719	958	590	885	1,180	525	788	1,051
Clean/New Drywall	2,837	4,256	5,674	3,010	4,515	6,020	3,195	4,792	6,389	3,372	5,057	6,743	3,503	5,255	7,007
Demo/Painted Drywall	4,256	6,384	8,512	4,515	6,773	9,030	4,792	7,188	9,584	5,900	8,851	11,801	6,569	9,853	13,137
Insulation	71	106	142	151	226	301	240	359	479	253	379	506	263	394	525
Other C&D	3,547	5,320	7,093	3,763	5,644	7,525	3,195	4,792	6,389	3,372	5,057	6,743	3,503	5,255	7,007
Total Other	*57,170*	*85,756*	*114,341*	*58,470*	*87,705*	*116,940*	*59,019*	*88,529*	*118,038*	*61,533*	*92,299*	*123,065*	*62,533*	*93,800*	*125,067*
Total	70,931	106,397	141,862	75,251	112,876	150,501	79,065	118,597	158,130	84,291	126,437	168,583	87,582	131,373	175,163

Appendix C Maps of Recycling Facilities Adjacent to Boulder County

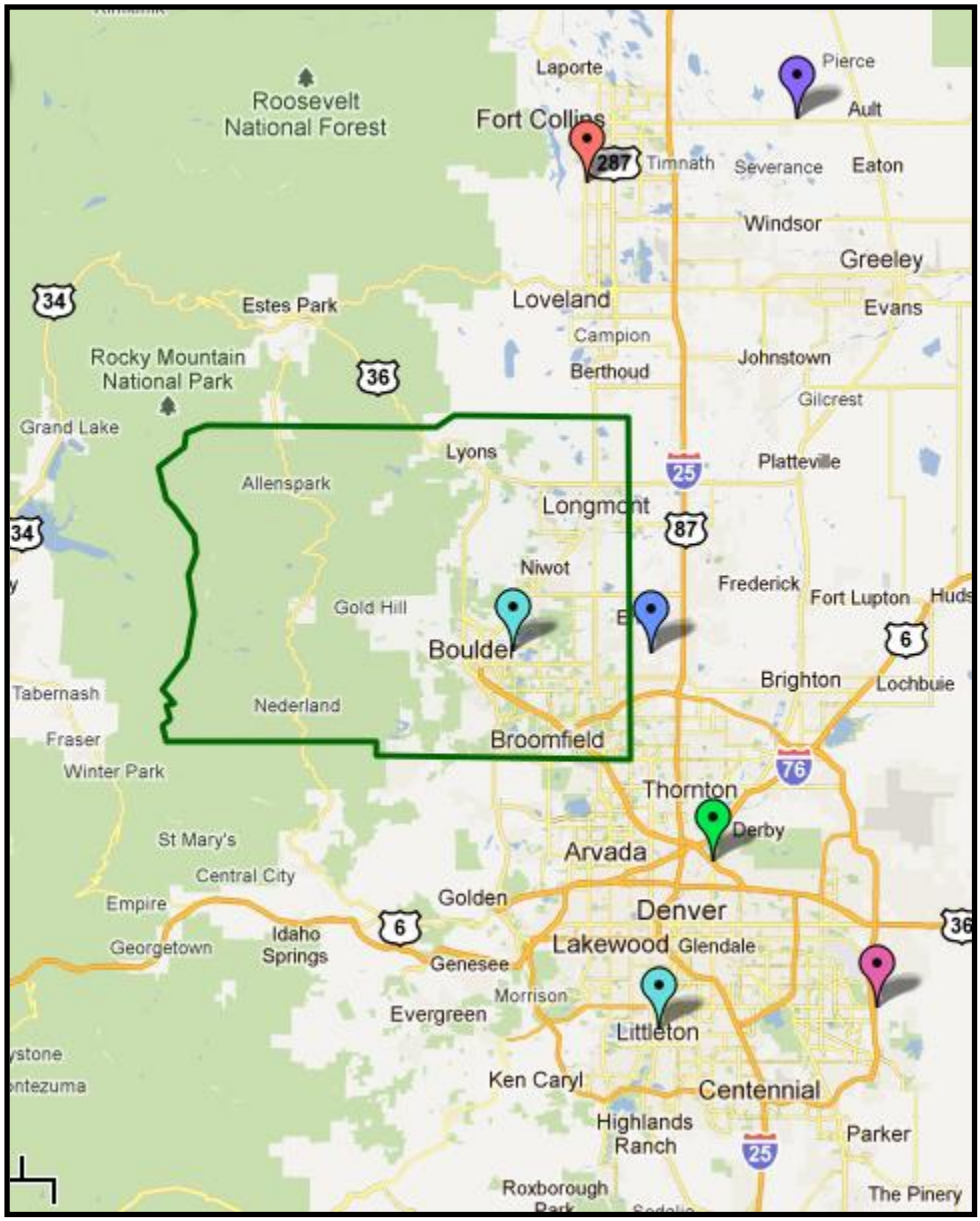
Map of Recycling End Markets Adjacent to Boulder County



- Boulder County
  Not an exact representation
- RMCI DADS Recycle Center
  3100 Gun Club Rd Aurora, CO 80019
- RMCI Arvada Recycling Center
  5500 Fenton St Arvada, CO 80002
- RMCI Titan Recycling Center
  9030 N Moore Rd Littleton, CO 80125
- RMCI Stapleton Recycling Center
  8200 E 56th Ave Denver, CO 80266
- RMCI Tri-City Recycling Center
  1688 County Road 11 Erie, CO 80516
- Oxford Recycling
- Allied Recycled Aggregates
  7901 U.S. 85 Commerce City, CO 80022
- Asphalt Specialties
  3220 County Road 8 Erie, CO 80516
- Brannan Sand and Gravel
  1240 Rock Creek Cir Lafayette, CO 80026
- Boulder County Recycling Center
  1901 63rd St Boulder, CO 80301
- Altogether Recycling
  645 W 53rd Pl Denver, CO 80216
- Waste Management
  5395 Franklin St Denver, CO 80216
- International Paper
  3900 Lima St Denver, CO 80239
- Geocycle
  1170 Transit Dr Colorado Springs, CO 80903
- Re:Volve
  3401 Industrial Ln Broomfield, CO 80020
- Mountain Trade Supply
  4840 Broadway Denver, CO 80216
- Western Disposal Services Inc
  5880 Butte Mill Road Boulder, CO 80301-2900
- A-1 Organics
  16350 County Road 76 Eaton, CO 80615-8705
- Oxford Recycling
  2400 W Oxford Ave Englewood, CO 80110
- Center For Resource Conservation's ReSource Yard
  6400 Arapahoe Rd Boulder, CO 80303
- Brothers Redevelopment Inc
  2250 Eaton St Denver, CO 80214
- Restore Home Improvement Outlet
  1351 Sherman Drive Longmont, CO 80501
- Flatirons Habitat for Humanity ReStore
  6900 W 117th Ave #400 Broomfield, CO 80020
- Habitat for Humanity Building Outlet
  70 Rio Grande Blvd Denver, CO 80223
- Bud's Warehouse
  4455 E 46th Ave Denver, CO 80216
- Johns Manville
  10100 West Ute Avenue Littleton, CO 80127-5000
- Frisco Pallet Services
  6100 Huron Street Denver, CO 80221-2459
- Waste-Not Recycling
  1065 Poplar Street Johnstown, CO 80534-4160
- L&R Pallet
  3855 Lima St Denver, CO 80239
- Hi-Tec Plastics
  12555 E 37th Ave Denver, CO 80239
- Eco-Cycle
  5030 Pearl Street Boulder, CO 80301
- Iron & Metals Inc
  5555 Franklin Street Denver, CO 80216-6215
- Atlas Metal and Iron Corp.
  1100 Umatilla Street Denver, CO 80204
- Wise Recycling LLC
  622 Missouri Avenue Longmont, CO 80501-6862
- Western Aluminum Recycling
  3280 Valmont Rd # C Boulder, CO 80301-2160
- C&M Iron and Metal
  2390 W Hampden Ave Sheridan, CO 80110
- Sims Metal Management Inc
  5601 York St Denver, CO 80216
- All Recycling
  1775 W Wesley Ave Englewood, CO 80110

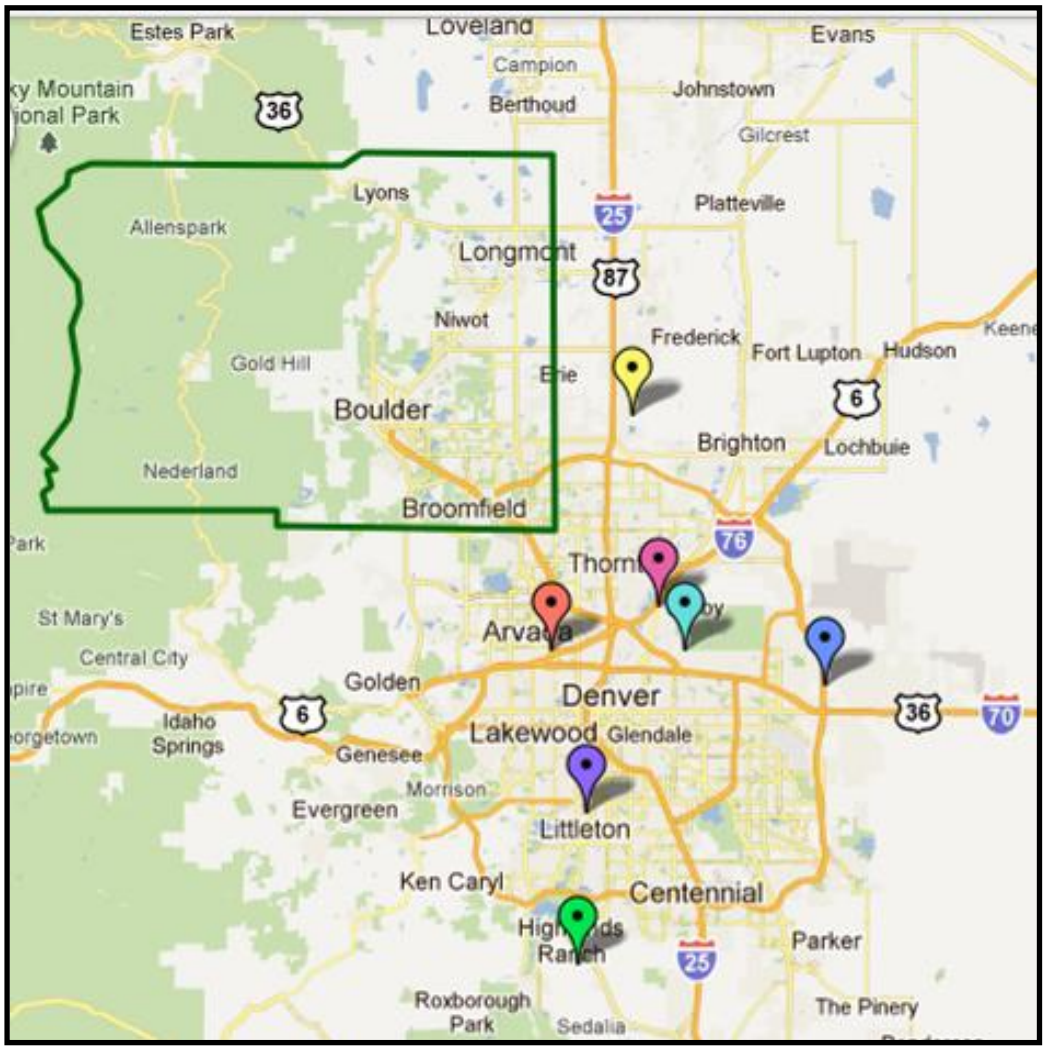
Landfills and Transfer Stations Adjacent to Boulder County

- Boulder County
- Denver Regional Landfill (Front Range)
  1441 County Road 6 Erie, CO 80516
- Larimer County Landfill
  5887 S Taft Hill Rd Fort Collins, CO 80526
- Denver D&R Transfer Station
  6091 Brighton Blvd Commerce City, CO 80022
- South Metro Transfer Station
  2400 W Union Ave Englewood, CO 80110
- Western Disposal Services Inc
  5880 Butte Mill Road Boulder, CO 80301-2900
- North Weld Landfill
  40000 County Road 25, Ault, CO 80610
- Denver Arapahoe Disposal Site (DADS) Landfill
  Denver Arapahoe Disposal 3500 South Gun Club Road



Aggregate Processing Facilities Adjacent to Boulder County

- Boulder County
- Oxford Recycling
  2400 W Oxford Ave Englewood, CO 80110
- Allied Recycled Aggregates
  7901 U.S. 85 Commerce City, CO 80022
- RMCI Tri-City Recycling Center
  1688 County Road 11 Erie, CO 80516
- RMCI Stapleton Recycling Center
  8200 E 56th Ave Denver, CO 80266
- RMCI Titan Recycling Center
  9030 N Moore Rd Littleton, CO 80125
- RMCI Arvada Recycling Center
  5500 Fenton St Arvada, CO 80002
- RMCI DADS Recycle Center
  3100 Gun Club Rd Aurora, CO 80019

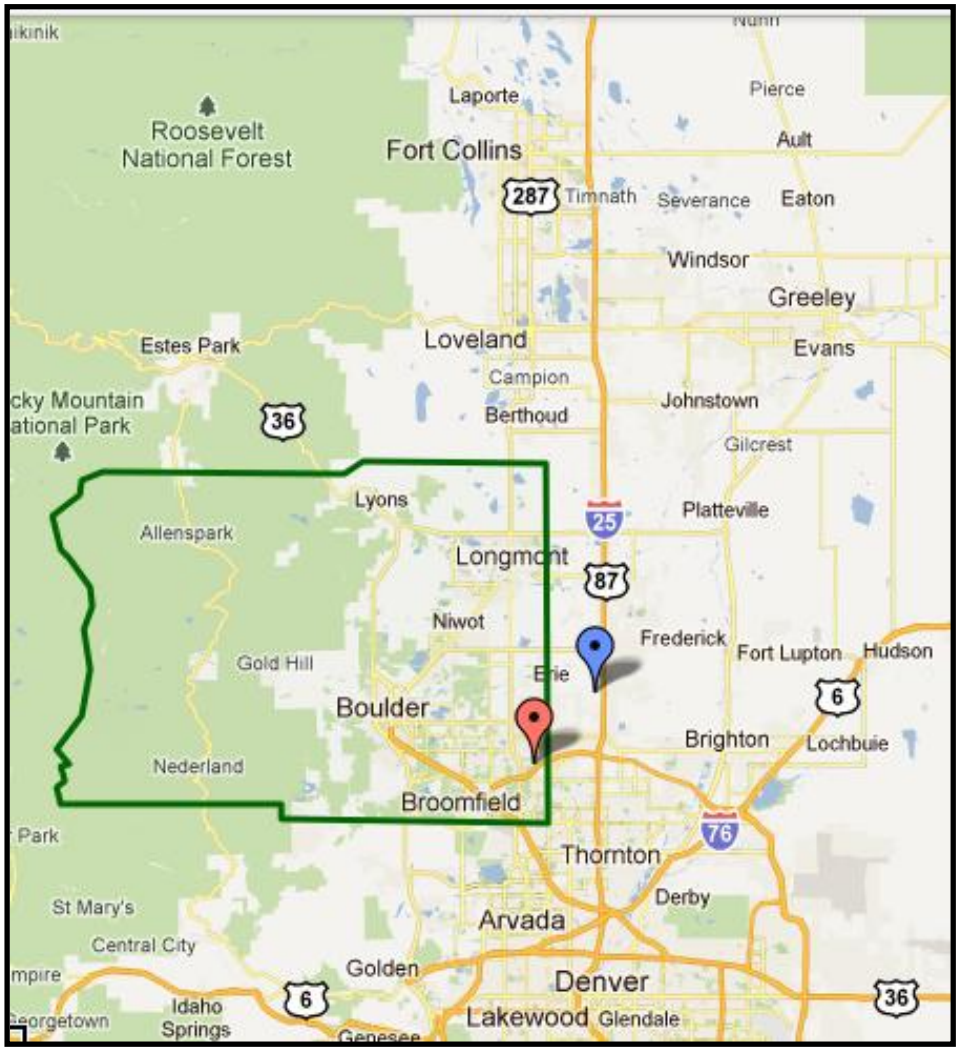


Asphalt Shingle Processors Adjacent to Boulder County

Boulder County

Asphalt Specialties
3220 County Road 8 Erie, CO 80516

Brannan Sand and Gravel
1240 Rock Creek Cir Lafayette, CO 80026



Cardboard Recyclers Adjacent to Boulder County

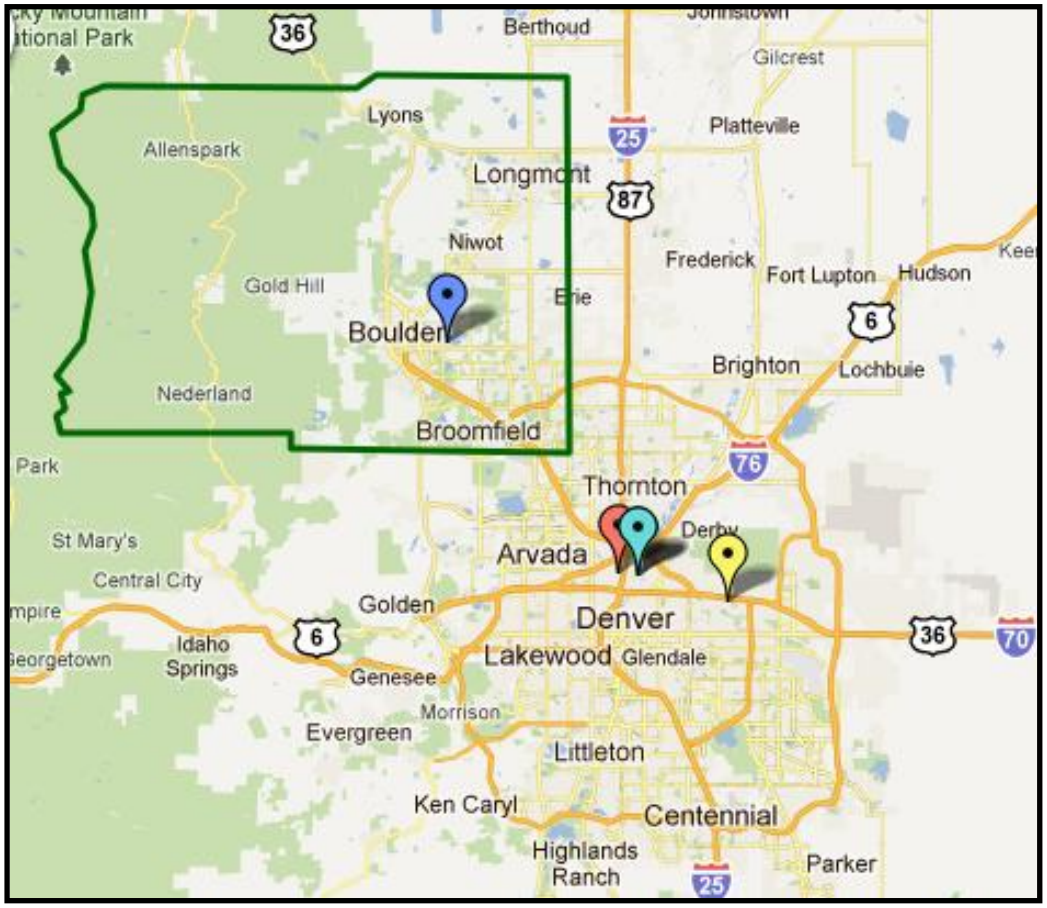
Boulder County

Boulder County Recycling Center
1901 63rd St Boulder, CO 80301

Altogether Recycling
645 W 53rd Pl Denver, CO 80216

Waste Management
5395 Franklin St Denver, CO 80216

International Paper
3900 Lima St Denver, CO 80239



Clean Wood Processors Adjacent to Boulder County

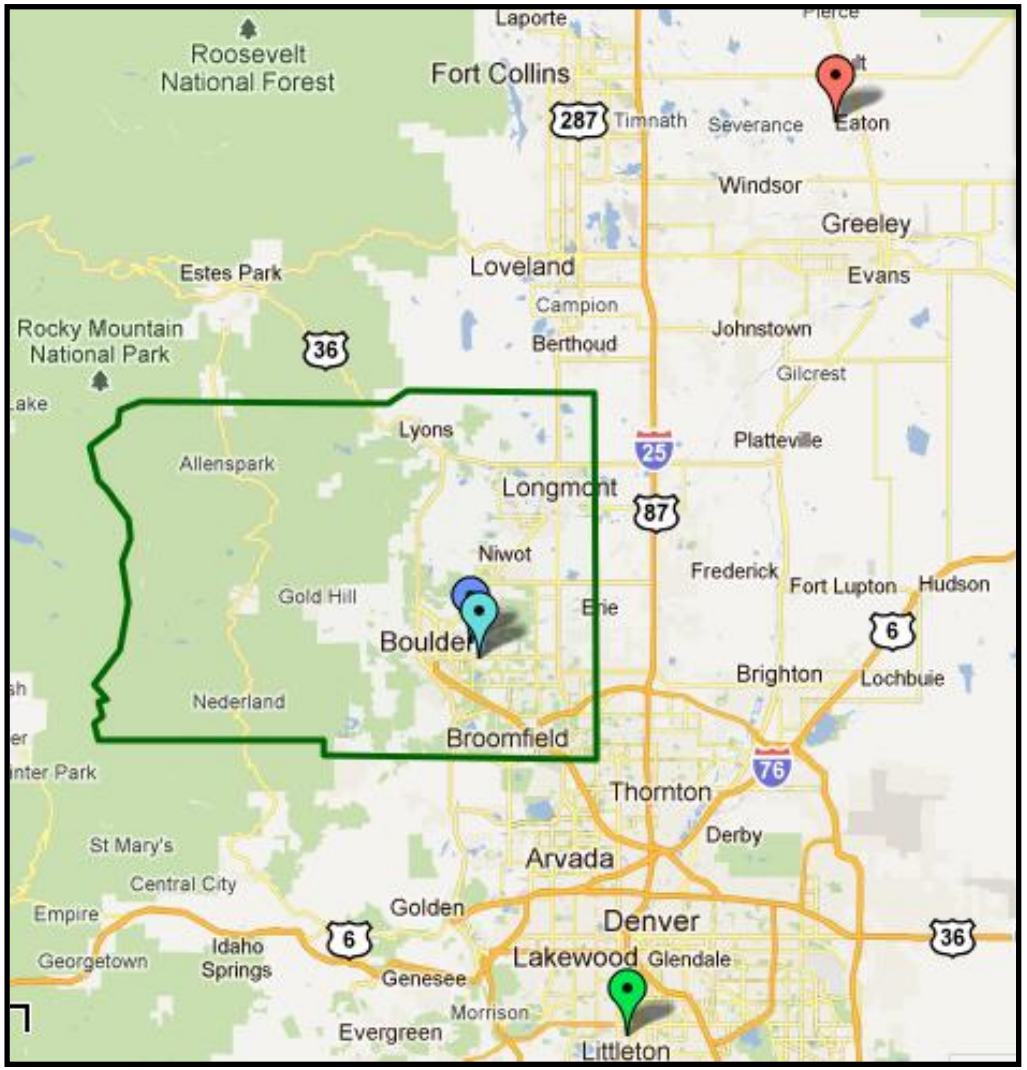
Boulder County

Western Disposal Services Inc
5880 Butte Mill Road Boulder, CO 80301-2900

A-1 Organics
16350 County Road 76 Eaton, CO 80615-8705

Oxford Recycling
2400 W Oxford Ave Englewood, CO 80110

Center For Resource Conservation's ReSource Yard
6400 Arapahoe Rd Boulder, CO 80303



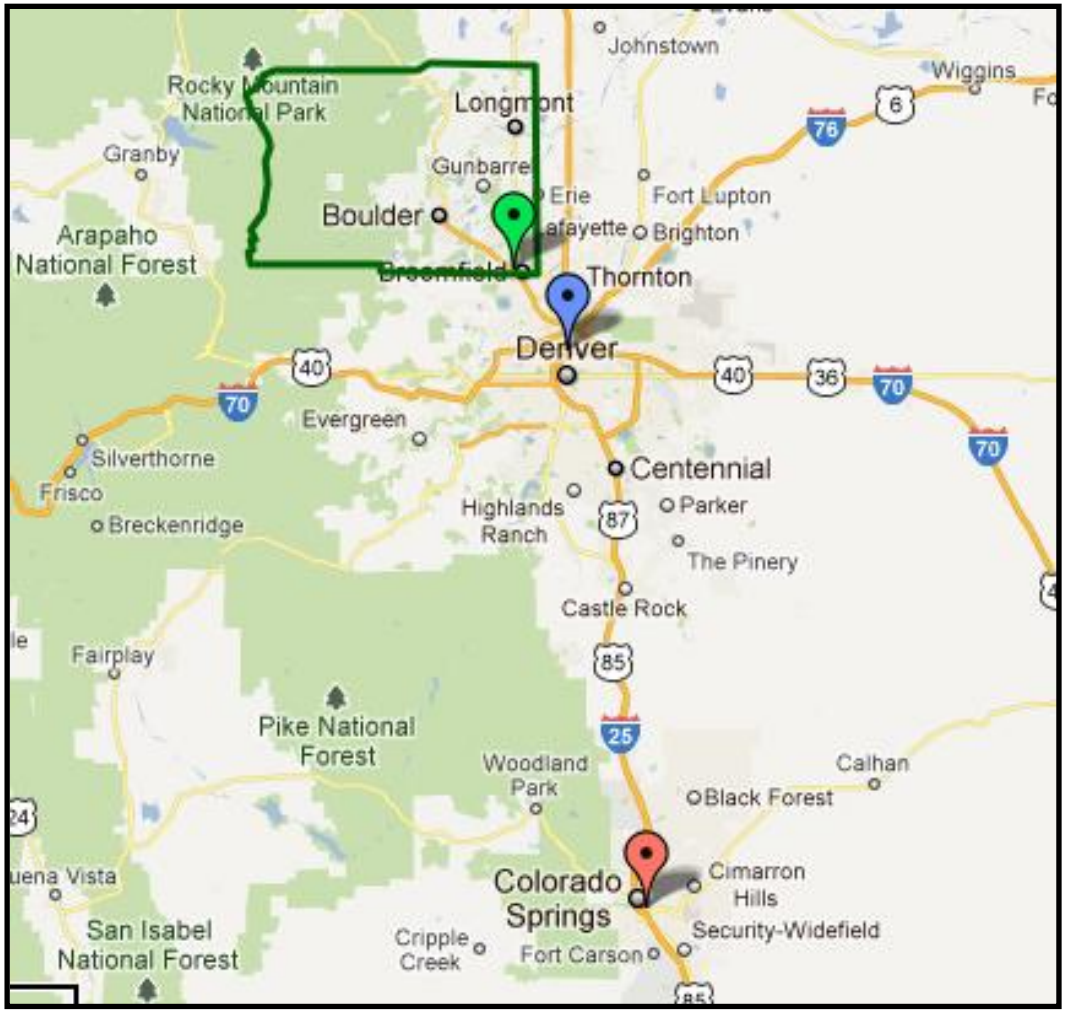
Carpet Recyclers Adjacent to Boulder County

Boulder County

Mountain Trade Supply
4840 Broadway Denver, CO 80216

Geocycle
1170 Transit Dr Colorado Springs, CO 80903

Re:Volve
3401 Industrial Ln Broomfield, CO 80020



Durable Goods and Reusable Building Materials Markets Adjacent to Boulder County

Boulder County

Center For Resource Conservation's ReSource Yard
6400 Arapahoe Rd Boulder, CO 80303

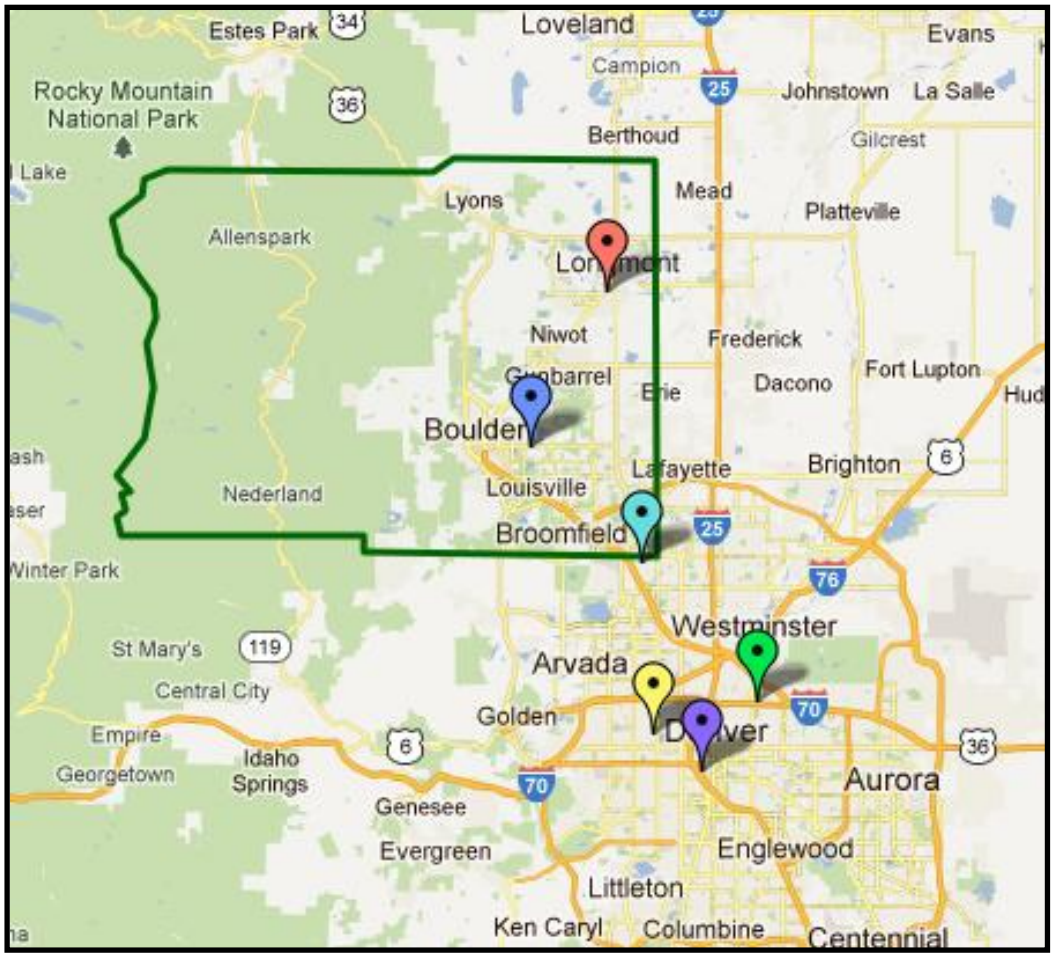
Restore Home Improvement Outlet
1351 Sherman Drive Longmont, CO 80501

Bud's Warehouse
4455 E 46th Ave Denver, CO 80216

Flatirons Habitat for Humanity ReStore
6900 W 117th Ave #400 Broomfield, CO 80020

Brothers Redevelopment Inc
2250 Eaton St Denver, CO 80214

Habitat for Humanity Building Outlet
70 Rio Grande Blvd Denver, CO 80223



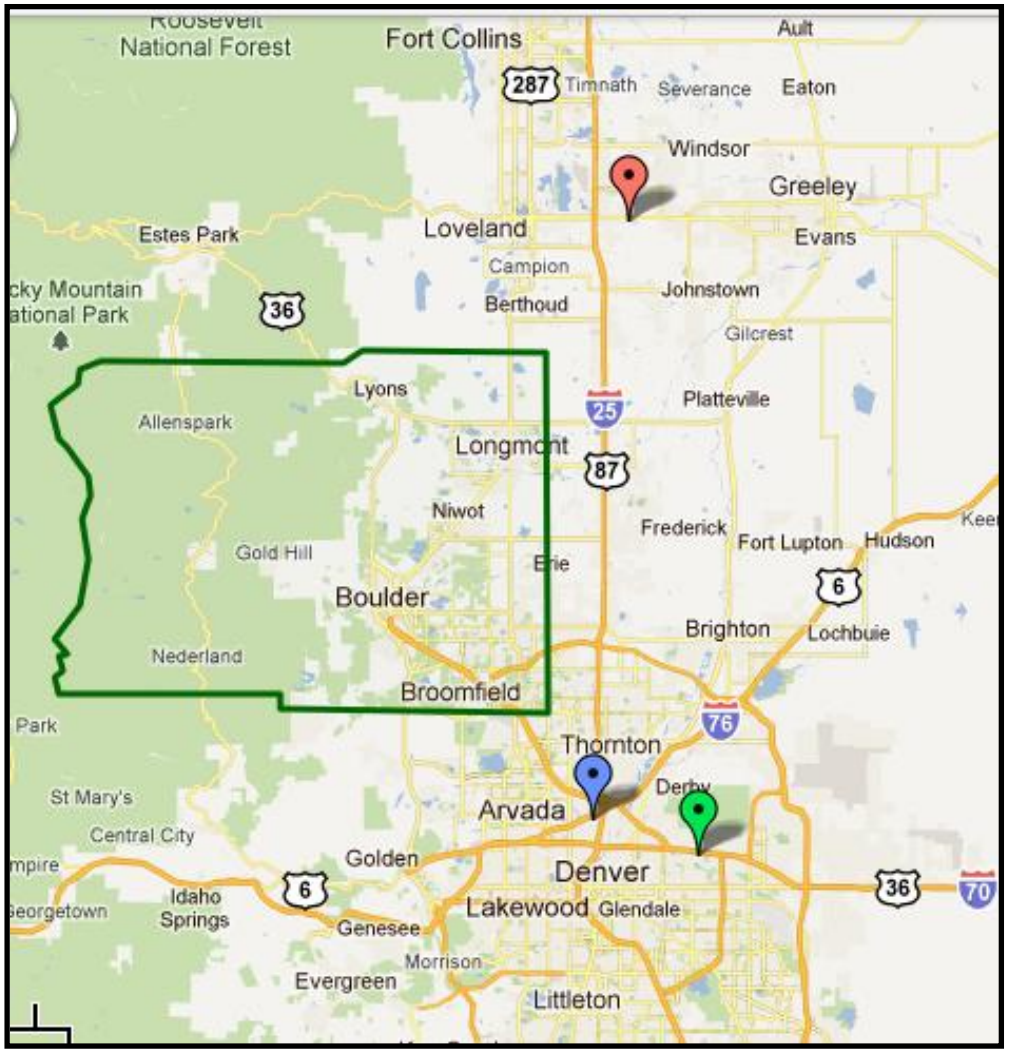
Pallet Recyclers Adjacent to Boulder County

Boulder County

L&R Pallet
3855 Lima St Denver, CO 80239

Waste-Not Recycling
1065 Poplar Street Johnstown, CO 80534-4160

Frisco Pallet Services
6100 Huron Street Denver, CO 80221-2459



Plastic Recyclers Adjacent to Boulder County

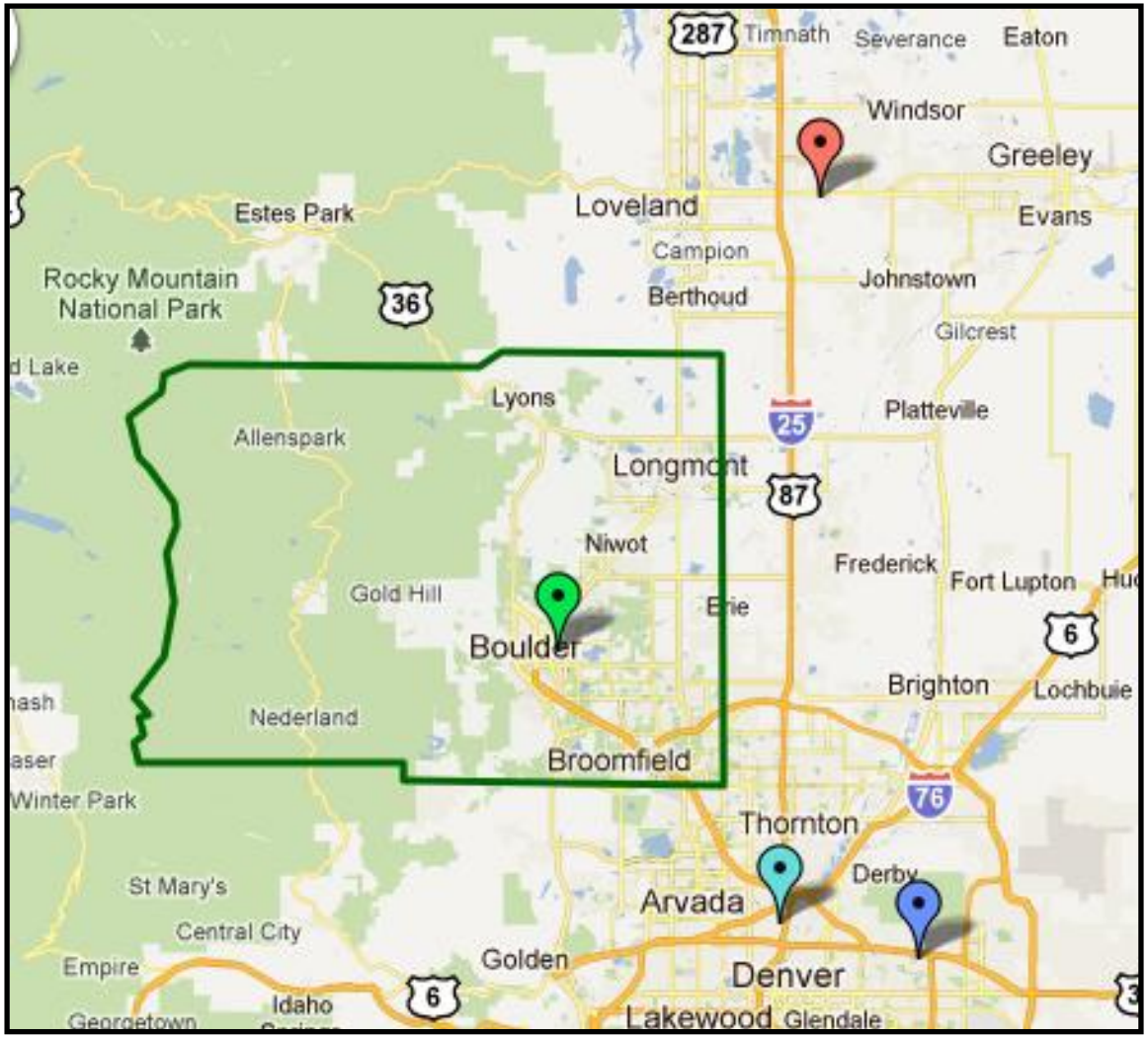
Boulder County

Eco-Cycle
5030 Pearl Street Boulder, CO 80301

Hi-Tec Plastics
12555 E 37th Ave Denver, CO 80239

Altogether Recycling
645 W 53rd Pl Denver, CO 80216

Waste-Not Recycling
1065 Poplar Street Johnstown, CO 80534-4160



Scrap Metal Recyclers Adjacent to Boulder County

Boulder County

All Recycling
1775 W Wesley Ave Englewood, CO 80110

Sims Metal Management Inc
5601 York St Denver, CO 80216

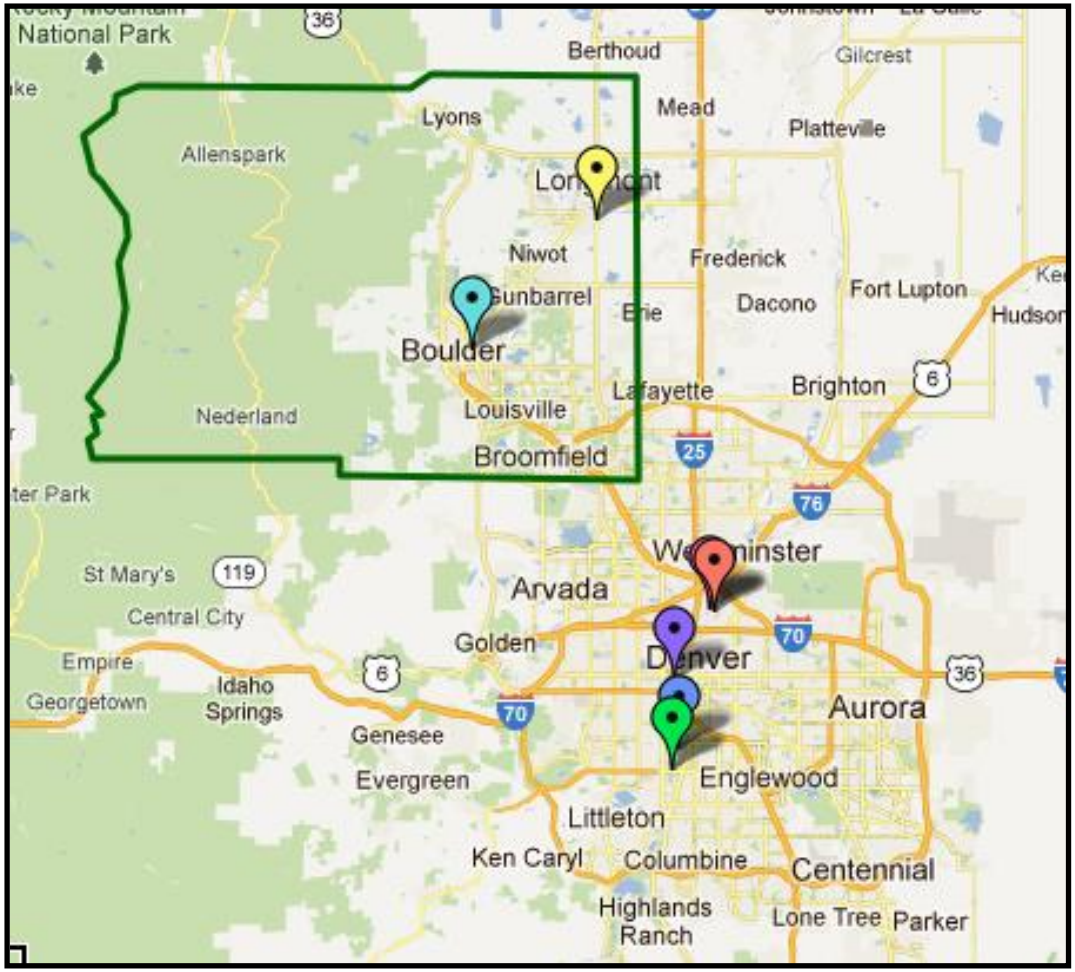
C&M Iron and Metal
2390 W Hampden Ave Sheridan, CO 80110

Western Aluminum Recycling
3280 Valmont Rd # C Boulder, CO 80301-2160

Wise Recycling LLC
622 Missouri Avenue Longmont, CO 80501-6862

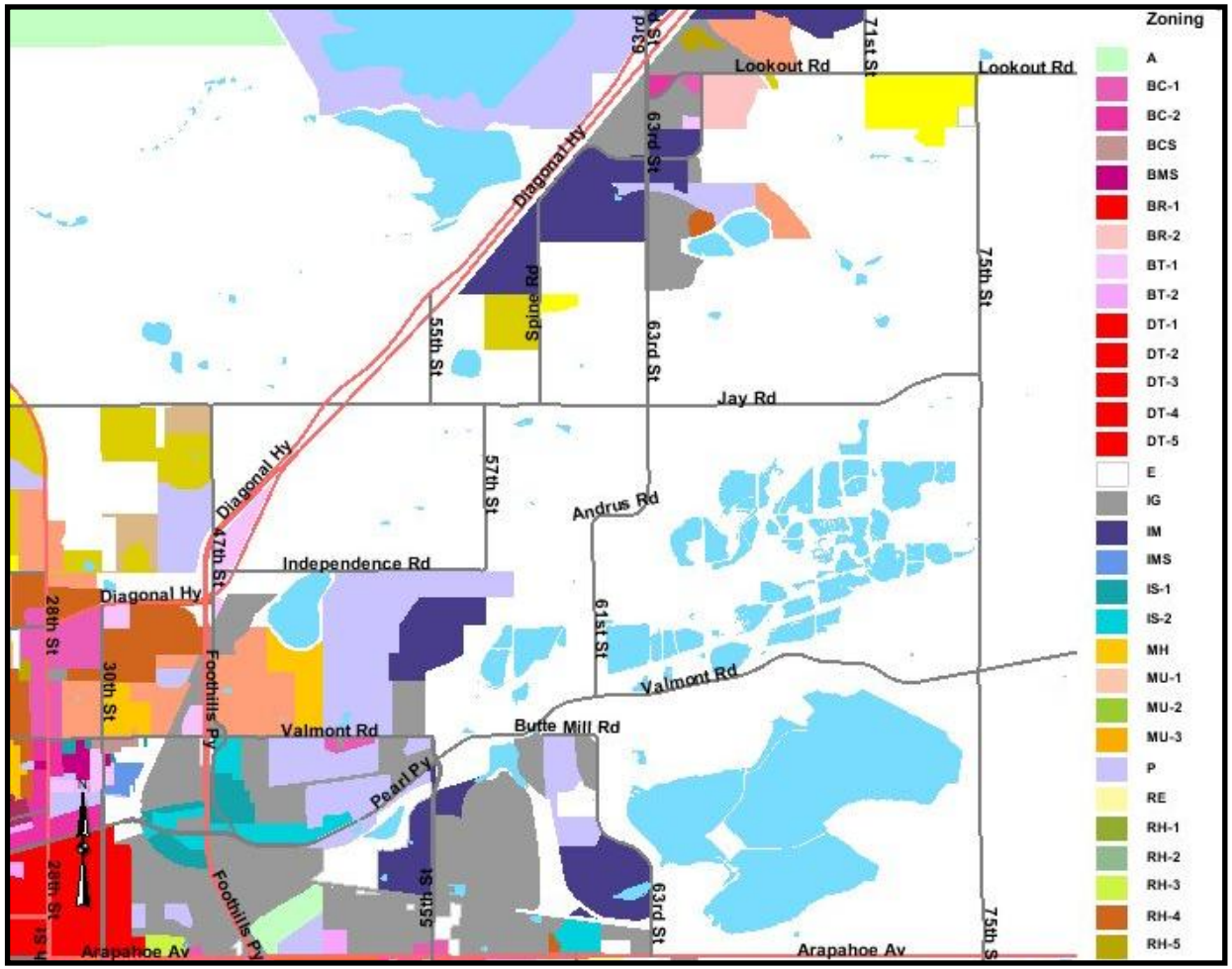
Atlas Metal and Iron Corp.
1100 Umatilla Street Denver, CO 80204

Iron & Metals Inc
5555 Franklin Street Denver, CO 80216-6215



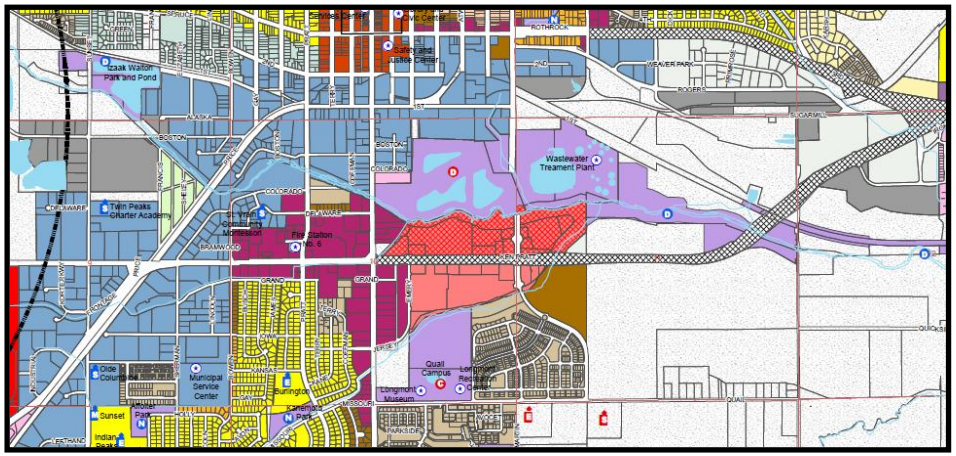
City of Boulder Industrial Zones[16]

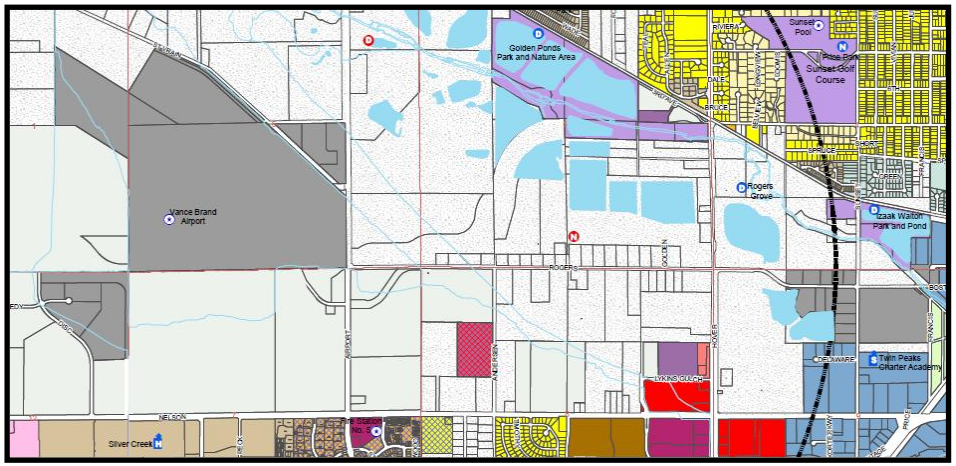
General industrial (IG) shown in gray



[16] The complete City of Boulder zoning map can be found at http://www.bouldercolorado.gov/index.php?option=com_content&task=view&id=1415&Itemid=507

City of Longmont Industrial Zones[17]



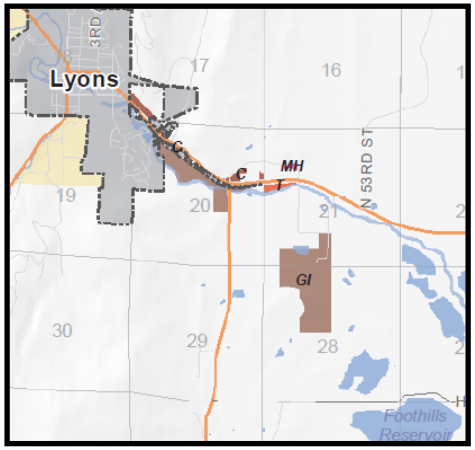


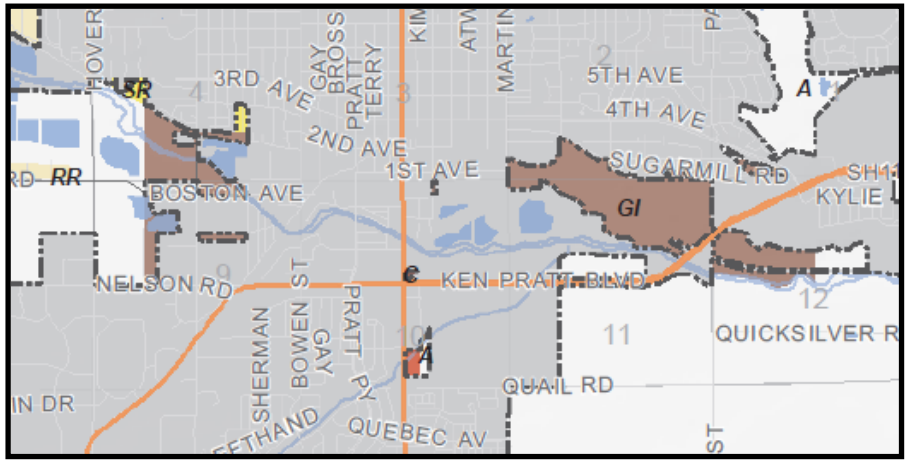
ZONING DISTRICT LEGEND

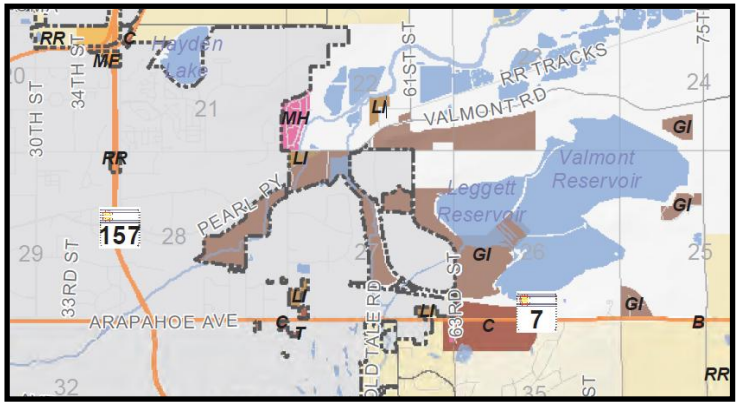
E1	Estate Residential - Very Low Density	G	Existing Community Park
E2	Estate Residential	D	Existing District Park
RLE	Residential Low Density Established	N	Existing Neighborhood Park
R1	Residential Low Density	E	Existing Elementary School
R2	Residential Medium Density	H	Existing High School
R3	Residential High Density	M	Existing Middle School
RMD	Residential Mixed Density	S	Existing Special School
MH	Mobile Home Development		Existing Other Facility
PUD-R	Residential Planned Unit Development	G	Proposed Community Park
PUD-C	Commercial Planned Unit Development	D	Proposed District Park
PUD-I	Industrial Planned Unit Development	N	Proposed Neighborhood Park
PUD-MU	Mixed Use Planned Unit Development	E	Proposed Elementary School
C	Commercial	H	Proposed High School
CBD	Central Business District	M	Proposed Middle School
CR	Commercial - Regional	S	Proposed Special School
BLI	Business / Light Industrial		Proposed Other Facility
GI	General Industrial		General Improvement District
MI	Mixed Industrial		Airport Influence Zone Overlay FAR Part 77 Airspace - Refer to Vance Brand Airport Master Plan
P	Public		*Floodway / Floodway Fringe Overlay -Refer to Title 20 of the Longmont Municipal Code
A	Agricultural		
	Unincorporated Boulder County		
	Unincorporated Weld County		
	Planned Unit Development Overlay		
	Medical Overlay		
	Terry Lake Overlay		
	Scenic Entryway Overlay (overlay standards apply to all annexed lots within 500 feet of a roadway designated as a scenic entryway)		
	Properties include special use or density restrictions on approved concept plans		

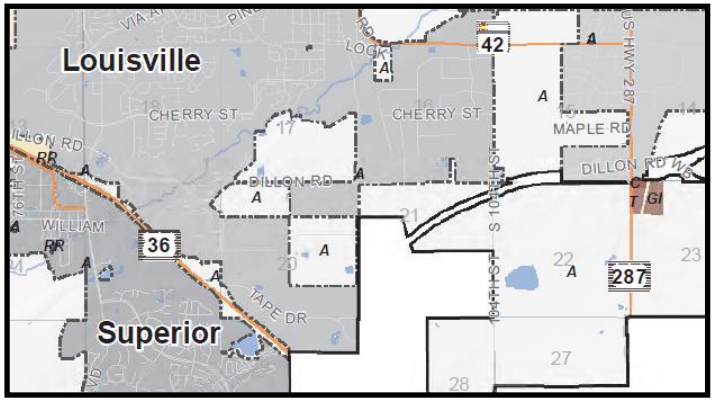
[17] The complete City of Longmont zoning map can be found at http://www.ci.longmont.co.us/planning/maps/documents/zoning_revised_112011.pdf

Unincorporated Boulder County Industrial Zones[18]







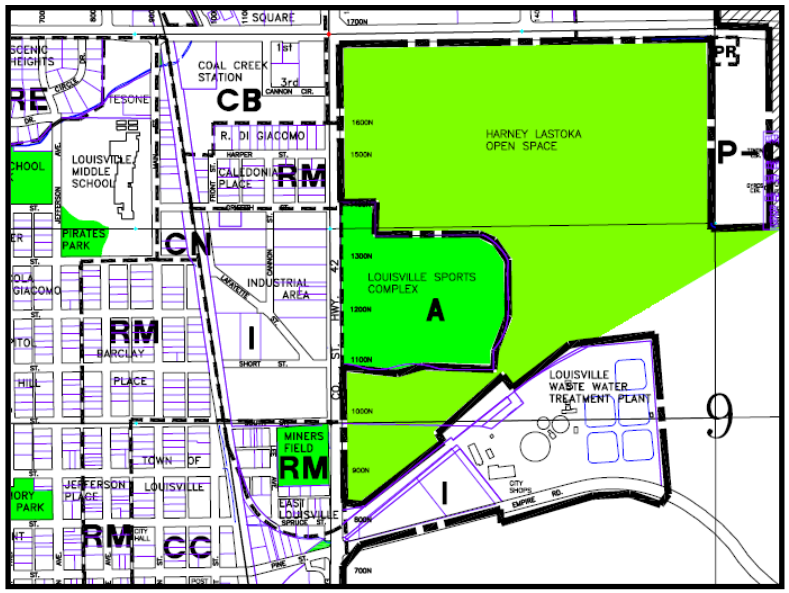


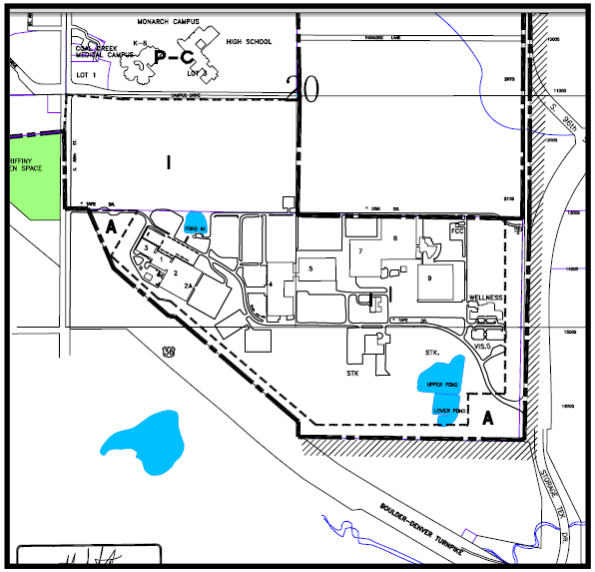
ZONING
- Municipalities
- Agricultural
- Business
- Commercial
- Economic Development
- Estate Residential
- Forestry
- General Industrial
- Historic
- Light Industrial
- Multiple Family
- Manufactured Home
- Montain Institutional
- Rural Community
- RC II
- Rural Residential
- Suburban Residential
- Transitional

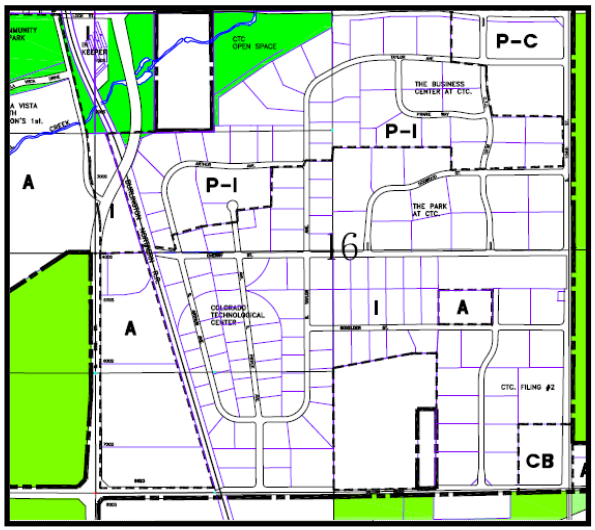
[18] The complete Boulder County zoning map can be found at http://www.bouldercounty.org/government/dept/pages/bczoning.aspx

City of Louisville Industrial Zones[19]

Industrially zoned parcels are indicated with an "I"



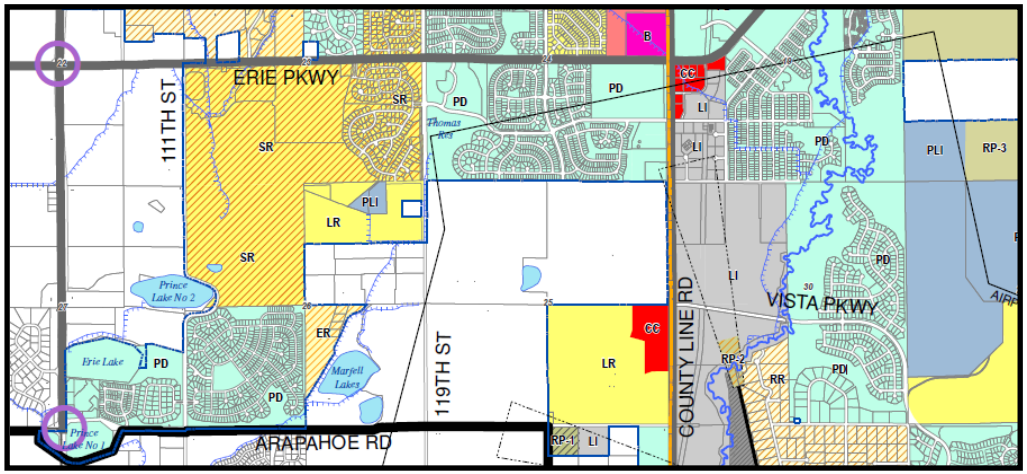




[19] The complete City of Louisville zoning map can be found at http://www.louisvilleco.gov/SERVICES/PlanningZoning/ZoningInformation/tabid/306/Default.aspx

City of Erie Industrial Zones[20]

- Rural Preservation 1 (RP-1)
- Rural Preservation 2 (RP-2)
- Rural Preservation 3 (RP-3)
- Rural Residential (RR)
- Estate Residential (ER)
- Suburban Residential (SR)
- Low Density Residential (LR)
- Medium Density Residential (MR)
- High Density Residential (HR)
- Old Town Residential (OTR)
- Planned Development (PD)
- Regional Commercial (RC)
- Community Commercial (CC)
- Business (B)
- Downtown District (DT)
- Neighborhood Mixed-Use (NMU)
- Community Mixed-Use (CMU)
- Light Industrial (LI)
- Public Lands & Institutions (PLI)
- Airport (AP)
- Agriculture/Open Space (AG/OS)



City of Lafayette Industrial Zones[21]

Map Legend

Zoning Classification

- RE1 Rural Estate Residential District
- R0 Low Density Residential District
- R1 Medium Density Residential District
- R2 Single-Family & Two-Family Residential District
- R3 Multi-Family Residential District
- RSR Senior and Special Residential District
- OTR Old Town Residential District
- T1 Transitional Business District
- B1 Community Service Business District
- C1 Regional Business District
- M1 Industrial District
- C1-M1 Regional Business - Industrial District
- P Public District
- DR Developing Resource District
- Planned Unit Development

County & Corporate Boundaries

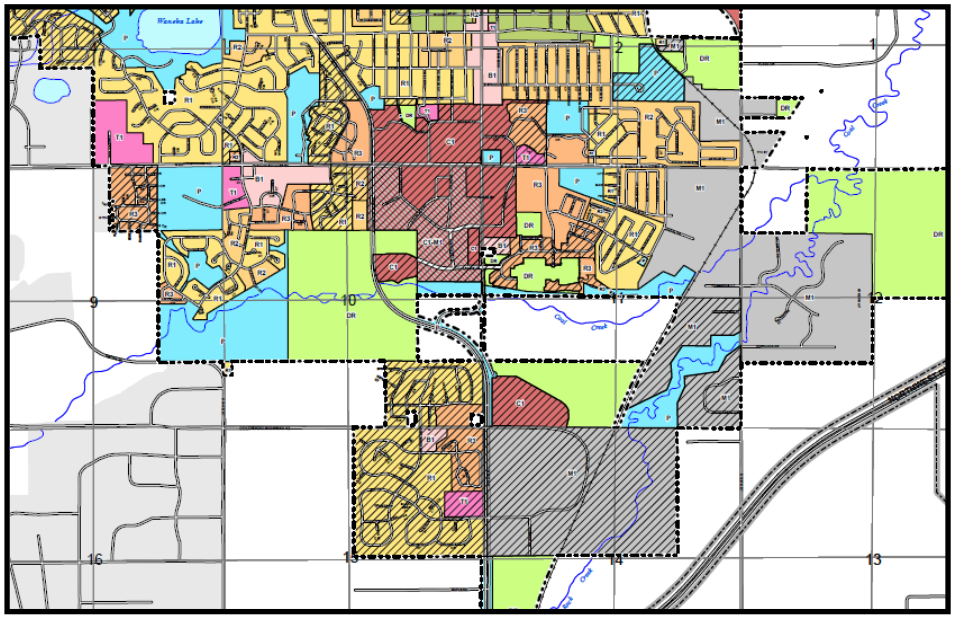
- County Line
- Lafayette Corporate Boundary
- Neighboring City, Town

Surface Water

- Lake, Pond
- River, Stream, Ditch

Additional Features

- Railroad



[20] The complete City of Erie zoning map can be found at www.**erieco**.gov/DocumentView.aspx?DID=334
[21] The complete City of Lafayette zoning map can be found at **cityoflafayette**.com/Page.asp?NavID=391

Appendix E: Stakeholders Contacted in Researching this Study

UHG would like to thank those who provided input into this project.

Amy Ferryman	Johns Manville
Anita Comer	Waste-Not Recycling
Anne Peters	Gracestone Inc.
Bill Meretz	Colorado Springs Department of Transportation
Bob Kiepe	Boulder County Department of Transportation
Bryce Isaacson	Western Disposal
Carey Merrill	The Carpet Recyclers
Charlie Kamenides	City of Longmont
Chris Meschuk	City of Boulder Planning Department
Chris Pyke	US Green Buildering Council
Dave Coddington	3R Roofing
Deb Kleinman	US Green Buildering Council
Denise T Arthur	Cemex
Dennis Pino	Cheyenne County Solid Waste Department
Doug Parker	Boulder County Land Use Department
Elena Barakos	Armstong Recycling
Elizabeth Vasatka	City of Boulder Office of Environmental Affairs
Gary DeWitt	Colorado Department of Transportation
Gary Horton	Western Disposal
Gerry Guard	Messersmith Manufacturing
Jack Debell	University of Colorado at Boulder
Jaimie Harkins	City of Boulder Business S
Jan Hard	Hi-Tech Recycling
Jeff Callahan	Boulder County Resource Conservation Division
Jeff Shock	Johns Manville
Jennifer Shriver	Roofs to Roads Colorado
Joel Ripmaster	Colorado Landmark Realty
John Anderson	Recycled Materials Company
Keith Mullen	Armstrong Recycling
Kelle Boumansour	City of Boulder Environmental Action Division
Kent Pendley	A1 Organics
Kent Pugsley	Asphalt Recovery Specialists
Kurt Buss	Center for Resource Conservation
Lance Johnson	Recycled Aggregate Products Co.
Laurie Batchelder-Adams	LBA Associates
Lisa Friend	Boulder County Comissioners Office
Liz Williams	St. Vrain Habitat for Humanity
Louis Hard	Hi-Tech Recycling
Marjorie Griek	Colorado Association For Recycling
Mike Dorsey	Fauquier County, VA Solid Waste Department
Mike Gnewkowski	Rockford Construction
Mike Smaha	Owens-Illinois Glass
Mike Stewart	Recycled Materials Company
Mike Thomas	Boulder County Department of Transportation
Mira Panek	US Green Buildering Council
Murray Cohen	Iron and Metals Inc.
Murray Mcintyre	Rotochopper
Nancy Paul	Marpan Recycling
Noel Critchlow	Armstrong Recycling
Patrick Manning	Gypsum Recycling USA
Paul Bennet	Repsco, Inc.
Pete Michell	Rockford Construction
Richard Clark	Johns Manville
Rick Huston	A1 Organics
Roberto De Dios	Colorado Department of Transportation
Roger Williams	American Baler
Russ Callas	Haul Away Recycling
Ryan Yoch	LaFarge
Samantha Stegenga	Johns Manville
Sean Foley	LaFarge
Shane Allen	Cemex
Shaun LaBarre	Center for Resource Conservation
Spencer Villwock	US Green Buildering Council
Stephen Gillette	Larimer County Solid Waste Division
Steve Cruise	Aggregate & Mining L.L.C
Susan Moratelli	Wells Fargo
Tara Nichols	St. Vrain Habitat for Humanity
Therese Glowacki	Boulder County
Tim Towndrow	International Paper
Todd Loose	Waste-Not Recycling
Tom Chesney	AMG National Bank
Ty Romijn	Diversion Connection
Vince Porreca	Porreca and Associates

4-112 General Industrial (GI) District

A. Purpose: Areas for the development of general industrial, manufacturing, commercial, and/or retail uses.

B. Principal Uses Permitted

1. Agri-business Uses (see 4-501)
   a. Agricultural Products Processing and Storage
   b. Custom Meat and Poultry Processing Facility (S)
   c. Keeping of Nondomestic Animals (S)
2. Agricultural Uses (see 4-502)
   a. Commercial Nursery
   b. Farm Stand
   c. Intensive Agricultural Uses
   d. Open Agricultural Uses
3. Commercial/Business Service Uses (see 4-503)
   a. Building Contracting Shop
   b. Carpentry, Woodworking, or Furniture Making Facility
   c. Car Wash
   d. Commercial Bakery
   e. Commercial Laundry and Dry Cleaning
   f. Machine Shop
   g. Printing and/or Publishing Establishment
   h. Vehicle Sales/Rental Lot
4. Community Uses (see 4-504)
   a. Adaptive Reuse of a Historic Landmark (I)
   b. Church
   c. Educational Facility (S)
   d. Membership Club
   e. Reception Halls and Community Meeting Facilities
   f. Use of Community Significance (I)
5. Forestry Uses (see 4-505) None Permitted
6. Industrial Uses (see 4-506)
   a. Composting Facility (S)
   b. General Industrial (S)
   c. Light Industrial
   d. Outside Storage
   e. Recycling Collection Center, Large
   f. Recycling Processing Facility (S)
   g. Saw Mill
   h. Solid Waste Disposal Site and Facility (S)
   i. Solid Waste Transfer Facility (S)
7. Lodging Uses (see 4-507)
   a. Overnight Lodging
   b. Resort Lodge, Conference Center, or Guest Ranch
   c. Short-Term Dwelling Rental 4-39
8. Mining Uses (see 4-508)

a. Limited Impact Open Mining (I)
b. Oil and Gas Drilling and Production, on subdivided land
c. Oil and Gas Drilling and Production, on unsubdivided land
d. Open Mining (S)
e. Subsurface Mining (S)
f. Subsurface Mining of Uranium (S)

9. Office Uses (see 4-509)
   a. Professional Office
10. Recreation Uses (see 4-510)
   a. Indoor Recreation
   b. Outdoor Recreation, for day use
   c. Outdoor Recreation, for night use (S)
11. Residential Uses (see 4-511)
   a. Boarding House
   b. Single Family Dwelling
12. Retail and Personal Service Uses (see-4-512)
   a. Bank
   b. Building Materials or Garden Store
   c. Convenience Store
   d. Day Care Center
   e. Emergency Care Facility
   f. Eating or Drinking Place, with drive through (S)
   g. Eating or Drinking Place, without drive through
   h. Indoor Theater
   i. Medical Marijuana Center
   j. Mortuary
   k. Outdoor Theater
   l. Recycling Collection Center, Small
   m. Retail or Personal Service Facility
   n. Vehicle Service Center
   o. Veterinary Clinic, with outdoor holding facilities
   p. Veterinary Clinic, without outdoor holding facilities
13. Transportation Uses (see 4-513)
   a. Airport (S)
   b. Heliport (S)
   c. Helistop (S)
   d. Park and Ride Facility (S)
14. Utility and Public Service Uses (see 5-514)
   a. Central Office Building of a Telecommunication Company (R)
   b. Community Cistern (I)
   c. Fire Barn (I)
   d. Fire Station (S)
   e. Large Solar Energy System (S)
   f. Major Facility of a Public Utility (S) (R) (L)
   g. Medium Solar Energy System or Solar Garden (S)
   h. Public or Quasi-public Facility other than Listed (S)

i. Public Safety Telecommunication Facility (I)
j. Sewage or Water Transmission Line (R) (L)
k. Sewage Treatment Facility (S) (R) (L)
l. Small Solar Energy System or Solar Garden (SPR) (I)
m. Small Wind-Powered Energy System (see 4-514.M.)
n. Telecommunications Facility, existing structure meeting height requirements
o. Telecommunications Facility, new structure or not meeting height requirements (S)
p. Utility Service Facility
q. Water Reservoir (S) (R) (L)
r. Water Tank or Treatment Facility (S) (R) (L)

15. Warehouse Uses (see 5-515)
    a. Personal Storage Facility
    b. Warehouse and Distribution Center

C. Accessory Uses Permitted (see 4-516)
1. Accessory Agricultural Sales
2. Temporary Accessory Community Meeting Facility
3. Accessory Concrete or Asphalt Batch Plant (S)
4. Accessory Dwelling (I)
5. Accessory Outside Storage
6. Accessory Solar Energy System
7. Accessory Structure
8. Grading of more than 500 Cubic Yards (I)
9. Home Events
10. Home Occupation
11. Household Pets
12. Noncommercial Telecommunication Site, one structure which meets setback and height requirements
13. Noncommercial Telecommunication Site, multiple structures and/or not meeting setback or height requirements (I)
14. Small Wind-Powered Energy System, Roof-Mounted

D. Temporary Uses Permitted (see 4-517)
1. Emergency Noncommercial Telecommunication Site (A)
2. Garage Sales or Occasional Sales
3. Group Gathering (A)
4. Temporary Batch Plant (A)
5. Temporary Construction or Sales Office (A)
6. Temporary Dwelling Unit (A)
7. Temporary Farm Stand
8. Temporary Fireworks Stand (I)
9. Temporary Special Use (nonconforming use under Section 4-1004(A)(2)) (S)
10. Temporary Weather Device Tower

E. Lot, Building, and Structure Requirements
1. Minimum lot size
    a. In a community service area on subdivided land where the principal structure is not a single family dwelling and is connected to public water and sewer facilities…no minimum requirement
    b. On any other land…35 acres

2. Minimum setbacks
   a. Front yard...60 feet from the centerline of the ROW
   b. Side yard...Zero or 12 feet
   c. Rear Yard...20 feet
   d. From an irrigation ditch...50 feet from the centerline of the ditch. This requirement only affects structures built after October 10, 1996. The setback may -with County concurrence- be reduced in accordance with a letter from the applicable ditch company establishing a different setback, but in any event shall not be less than 20 feet from the ditch centerline.
   e. Supplementary requirements may apply, refer to Article 7-1400.
3. Maximum building height...50 feet

F. Additional Requirements
1. Animal units...Four animal units per acre
2. Special review is required for any use which:
   a. generates traffic volumes in excess of 150 average daily trips per lot, as defined by the Institute of Transportation Engineers;
   b. has an occupant load greater than or equal to 100 persons per lot;
   c. has a wastewater flow greater than or equal to 2,000 gallons per day per lot; or
   d. has a total floor area greater than 25,000 square feet (35,000 square feet in a community service area).
3. Limited Impact Special Review is required for any use which is:
   a. a parking area associated with a trail of a governmental entity on publicly acquired open space land, which parking area is in accordance with an open space management plan approved by the Board of County Commissioners, and which generates traffic volumes in excess of 150 average daily trips per lot as defined by the Institute of Transportation Engineers;
   b. grading involving the movement of more than 500 cubic yards of material as defined and provided in Section 4-516(I).
4. An exemption plat is required for any single family residential development on vacant land proposed for subdivided land with a final plat approved prior to March 22, 1978.
5. No parcel shall be used for more than one principal use, except for allowed open agricultural uses, forestry uses, mining uses, or any combination thereof unless approved through special review, or for multiple principal uses on properties that have been designated as historic landmarks by Boulder County where the Boulder County Commissioners and Historic Preservation Advisory Board determine that the multiple uses serve to better preserve the landmark.
6. Small Wind-Powered Energy Collectors Systems, and Small Solar Energy Collectors Systems or Solar Gardens, Medium Solar Energy Systems or Solar Gardens, and Large Solar Energy Systems can be approved on parcels with existing principal uses without Special Review approval, however, these uses shall be reviewed using the process and standards described in the Utility and Public Service Uses classification in this Code.

Appendix G: End Market Contact Information

Material	End Market- Company Name	Address	Contact Person	Email Address	Phone Number
Aggregates	Recycled Materials Company	6425 West 52nd Ave., Ste #1 Arvada, CO	Mike Stewart	Mstewart@rmci-usa.com	303-431-3701
	Oxford Recycling	2400 West Oxford Avenue Englewood, CO	N/A	details@oxfordrecycling.com	303-762-1160
	Allied Recycled Aggregates	7901 Hwy 85 Commerce City, CO	N/A	alliedsales@alliedrecycle.com	303-289-3366
Asphalt Shingles	Asphalt Specialties	3220 Weld County Rd. 8 Erie, CO	Gary Stillmunkes	garys@asphaltspecialties.com	303-289-8555
	Brannan Sand And Gravel	1240 Rock Creek Circle Lafayette, CO	N/A	materialsales@brannan1.com	303-534-1231
Cardboard	Boulder County Recycling Center	1901 63rd St. Boulder, CO	N/A	resourceconservation@bouldercounty.org	720-564-2220
	Altogether Recycling	645 W 53rd St. Denver, CO	Brent Hildebrand	bhildebrand@alpinewaste.com	N/A
	Waste Management	5395 Franklin St. Denver, CO	Scott Hutchins	shutchin@wm.com	N/A
	International Paper	3900 Lima St. Denver, CO	Tim Towndrow	tim.towndrow@cbpr.ipaper.com)	N/A
Carpet	GeoCycle	1170 Transit Drive Colorado Springs, CO	Joe Collard	joe.collard@geocycle.com	719-227-9860
	Mountain Trade Supply	4840 Broadway Denver, CO	Shirley Beliveau	shirley@mountaintradesupply.com	303-294-0226
	Re:Volve Broomfield, CO	3401 Industrial Lane Broomfield, CO	Vaughn Miller	revolve.recycling@gmail.com	720-212-9375
Ceiling Tiles	Armstrong Recycling	Lancaster, PA	Keith D. Mullen	KDMullen@Armstrong.com	877-276-7876
Clean Wood	Western Disposal	5880 Butte Mill Road Boulder, CO	Bryce Isaacson		303-444-2037
	A1 Organics	16350 County Road 76 Eaton, CO	Kent Pendley	kentpendley@a1organics.com	970-454-3492
	Oxford Recycling	2400 West Oxford Avenue Englewood, CO	N/A	details@oxfordrecycling.com	303-762-1160
	Center for Resource Conservation's ReSource Yard	6400 Arapahoe Ave Boulder, CO	Shaun LaBarre	slabarre@resourceyard.org	303-419-5418
Clean Gypsum Wallboard	A1 Organics	16350 County Road 76 Eaton, CO	Kent Pendley	kentpendley@a1organics.com	970-454-3492

Appendix G: End Market Contact Information

Material	End Market-Company Name	Address	Contact Person	Email Address	Phone Number
Durable Goods	Center for Resource Conservation's ReSource Yard	6400 Arapahoe Ave Boulder, CO	Shaun LaBarre	slabarre@resourceyard.org	303-419-5418
	Brothers Redevelopment Inc.	2250 Eaton St. Denver, CO	N/A	info@brothersredevelopment.org	303-202-6340.
	St. Vrain Habitat for Humanity ReStore	1351 Sherman Dr Longmont, CO	Liz Williams	Lwilliams@stvrainhfh.org	303-776-3334
	Bud's Warehouse	4455 E. 46th Ave Denver, CO	N/A	bud@budswarehouse.org	303-296-3990
	Flatirons Habitat for Humanity ReStore	6900 W. 117th Ave Suite 400 Broomfield, CO	Theresa Donahue	tdonahue@flatironshabitat.org	303-404-2008
	Habitat for Humanity Building Outlet	70 Rio Grande Blvd Denver, CO	Jerry Arnold	Jerry@habitatoutlet.org	303-722-5863
Fiberglass Insulation	Johns Manville	10100 West Ute Avenue Littleton, CO	Amy Ferryman	Amy.Ferryman@jm.com	303-978-5238
Painted/Treated Wood	N/A	N/A	N/A	N/A	N/A
Wood Pallets* Note - pallet recyclers will only take 48x48 or 48x40 "four-way" pallets (can be accessed by forklift from all 4 directions)	Frisco Pallet, LLC	6100 Huron St Denver, CO	N/A	friscopallet@msn.com	303-428-1344
	Waste-Not	1065 Poplar Street Loveland, CO	Anita Comer	acomer@waste-not.com	970-669-9912
	L&R Pallet	3855 Lima Street Denver, CO	N/A	N/A	303-355-5083

Appendix G: End Market Contact Information

Material	End Market-Company Name	Address	Contact Person	Email Address	Phone Number
Plastics	Hi-Tec Plastics	12555 East 37th Aveue Denver, CO	Jan Hard	Jan@HTPRecycling.com	720-644-2460
	Altogether Recycling	645 W 53rd St. Denver, CO	Brent Hildebrand	bhildebrand@alpinewaste.com	N/A
	Eco Cycle Boulder, CO	5030 Pearl Street Boulder, CO	Eric Lombardi	Eric@ecocycle.org	303-444-6634
	Waste-Not	1065 Poplar Street Loveland, CO	Anita Comer	acomer@waste-not.com	970-669-9912
Plate Glass	Johns Manville	10100 West Ute Ave Littleton, CO	Amy Ferryman	Amy.Ferryman@jm.com	303-978-5238
	Dlublak Glass	Okmulgee, OK	Rick Carr	rcarr@dlubak.com	918-752-0226
	Action Recycling	7610 W 42. Ave Wheatridge, CO	N/A	N/A	303-424-1600
Scrap Metal	Iron and Metals Co.	5555 Franklin St Denver, CO	Murray Cohen	mcohen@ironmetals.com	303-292-5555
	All Recycling	1775 W. Wesley Ave. Englewood, CO	Matt Alvarez	scott@allrecycling.com	303-922-7722
	Atlas Metal and Iron	1100 Umatilla Street Denver, CO	N/A	N/A	720-256-2305
	Sims Metal Manangement Inc.	5601 York St Denver, CO	Dan Woltmann	Dan.Woltmann@Simsmm.com	303-295-2911
	Wise Recycling	622 Missouri Ave. Longmont, CO	N/A	gemock@wiserecycling.com	303-485-0064
	C&M Iron and Metal	2390 West Hampden Avenue Sheridan, CO	N/A	N/A	303-780-6779
	Western Aluminum	3280 Valmont Rd, #C, Boulder, CO	N/A	N/A	303-447-0252
Vinyl Composition Tiles	Armstrong Recycling	Lancaster, PA	Noel Critchlow	NLCritchlow@Armstrong.com	717-396-5731