

Report

Carbon Emission Analysis to Transport Recyclable Paper

Rock-Tenn, St. Paul, Minnesota

Project I.D.: 08R001

Ramsey/Washington Counties Resource
Recovery Project Board
Maplewood, Minnesota

May 2008



May 13, 2008

Mr. Zachary Hansen, R.E.H.S.
Ramsey/Washington County
Resource Recovery Project Board
2785 White Bear Ave. #350
Maplewood, MN 55109-1320

Dear Mr. Hansen:

RE: Carbon Emission Analysis to Transport Recyclable Paper

On behalf of Foth Infrastructure & Environment, LLC (Foth) we are pleased to submit this report comparing Green House Gas (GHG) emissions. The analysis compared the current GHG emissions produced from transporting recyclable paper to Rock-Tenn for processing to the GHG emissions produced from transporting this material to alternative locations.

As noted in the summary and findings, the potential change in GHG emissions would be significant.

Please contact Warren Shuros at (651) 288-8596 or Jessie Fenno at (651) 288-8586 if you have any questions.

Sincerely,

Foth Infrastructure & Environment, LLC

A handwritten signature in blue ink, appearing to read "Warren Shuros".

Warren Shuros
Senior Project Manager

A handwritten signature in blue ink, appearing to read "C. L. Hartog".

Curtis L. Hartog, P.E.
Senior Technical Consultant

Carbon Emission Analysis to Transport Recyclable Paper

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Project ID: 08R001

Prepared for
Ramsey/Washington County Resource Recovery Project Board

2785 White Bear Avenue, Suite 350
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Prepared by
Foth Infrastructure & Environment, LLC

May 2008

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Carbon Emission Analysis to Transport Recyclable Paper

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Carbon Emission Analysis to Transport Recyclable Paper

Executive Summary

The purpose of this study was to analyze the impact on Green House Gas (GHG) emissions if the Rock-Tenn facility in St. Paul no longer operated as a paper mill causing the 1,000 TPD of paper currently processed at their facility to be transported to other locations for processing. This study quantifies the change in GHG emissions produced from transporting this material to Rock-Tenn for processing to the GHG emissions produced from transporting this material to alternative locations.

A “base case” was developed to represent the existing GHG emissions related to transporting the fiber from various existing sources to Rock-Tenn. Likely alternative locations were identified where the fiber would be delivered by suppliers if it is no longer brought to Rock-Tenn. The GHG emissions generated from the base case were compared to the GHG emissions generated from the alternative scenario to provide a projection of the change in GHG emissions.

The average difference between the two scenarios is 16,950,083 kilograms of Carbon equivalent (C_e). This is the amount of additional GHG that would be emitted if the 1,000 TPD of fiber were no longer processed at the Rock-Tenn facility in St. Paul, Minnesota. This represents over a 750% increase in emissions versus continuing the current system. This is equivalent to the following emissions from the *Greenhouse Gas Equivalencies Calculator* on the EPA website¹:

- ◆ The CO₂ emissions of approximately 11,383 passenger cars in one year
- ◆ The CO₂ emissions from 7,054,518 gallons of gasoline consumed in one year
- ◆ The CO₂ emissions from the electricity from 8,232 homes for one year
- ◆ The C sequestered annually by 14,125 acres of pine or fir forests
- ◆ The C sequestered annually by approximately 433 acres of forest preserved from deforestation

¹ <http://www.epa.gov/cleanenergy/energy-resources/calculator.html> Accessed on 3/20/08.

List of Abbreviations, Acronyms, and Symbols

AZ	Arizona
C	Carbon
CAD	computer aided drafting
CA	California
CO	Colorado
COFC	Container on flat car
C _e	Carbon Equivalent
CO ₂	Carbon Dioxide
CO _{2e}	Carbon Dioxide Equivalent
CH ₄	Methane
DNR	Department of Natural Resources
ESRI	Environmental Systems Research Institute
Foth	Foth Infrastructure & Environment, LLC
Gal	Gallons
GHG	Green House Gas
GIS	Geographic Information Systems
IA	Iowa
ID	Idaho
IL	Illinois
IN	Indiana
KS	Kansas
Kg	Kilogram
LDI Fibres	LDI Fibres, Inc.
MI	Michigan
Mpg	Miles per gallon
MN	Minnesota
MO	Missouri
MP	Mixed Paper
MT	Montana
NV	Nevada
N ₂ O	Nitrous Oxide
ND	North Dakota
OH	Ohio
OCC	Old Corrugated Cardboard
ONP	Old newspaper
OR	Oregon
OTR	Over the road
R/W Counties	Ramsey/Washington Counties
SD	South Dakota
SPARS	State Permitting and Air Reporting System
TPD	Tons per day
U.S.	United States
VOC	Volatile Organic Compounds
WA	Washington
WI	Wisconsin

1 Introduction

This report provides an analysis of the projected potential increase in greenhouse gas (GHG) emissions if approximately 1,000 tons per day (TPD) of paper currently processed by the Rock-Tenn Company (Rock-Tenn) mill located in St. Paul, MN is transported to other locations to be recycled. Ramsey/Washington Counties Resource Recovery Project Board (R/W Counties) requested the study due to the Counties' role in promoting recycling as part of their comprehensive, integrated solid waste management programs. R/W Counties are very interested in maintaining the paper recycling processing capacity provided by Rock-Tenn for not only their Counties, but for many other recycling programs in Minnesota (as well as surrounding states and Canada). Further, R/W Counties are increasingly interested in understanding the GHG emission impact of its current policy and programs and to help guide its future decisions and recommendations.

R/W Counties interest in the Rock-Tenn facility's effect on the local recycling infrastructure, economy, environment, and public health peaked recently due to their recent loss of energy source. The source of Rock-Tenn's steam, the Xcel High Bridge Power Plant, recently closed due to circumstances outside Rock-Tenn's control. The loss of affordable energy had put Rock-Tenn's recycling operation at serious risk. While it appears this initial crisis has been averted largely due to an improved market price for Rock-Tenn, long-term viability is still a concern. Rock-Tenn needs to find a more affordable energy source to ensure competitiveness during potential future downturns in their market.

Several studies on options and approaches for alternative steam sources are underway separately from this project. R/W Counties asked to work with Rock-Tenn to evaluate GHG emissions in the hypothetical event that Rock-Tenn could be forced to discontinue mill operations which would require the 1,000 TPD of paper to be processed at other locations. Shipping this material to other locations would, in most instances, require an increase in transportation distances and a change in transportation methods leading to potential significant increases in GHG emissions.

1.1 Purpose

The purpose of this study was to analyze the transportation related GHG emissions related to paper collection and recycling at the Rock-Tenn facility in St. Paul. This report highlights the GHG emissions benefits of having the 1,000 TPD of paper currently recycled by a local resource rather than having it transported to other locations for processing. The study quantifies the change in GHG emissions produced from transporting this material to Rock-Tenn for processing to the GHG emissions produced from transporting this material to alternative locations. GHGs consist of carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. For this project the GHG emissions were quantified in kilograms of carbon equivalent emissions (C_e) produced by each type of transportation mode. Each of the GHGs has different impacts on the environment. The impacts of the different GHGs were considered when converting the GHGs to C_e .

1.2 Scope of Work

The focus of this GHG emissions project is on transportation related sources of emissions to transport the fiber to Rock-Tenn or an alternative location and not on the actual paper mill operations. The process included developing a “base case” of the existing GHG emission related to transporting the fiber from various existing sources to Rock-Tenn. Therefore, the base case included the following:

- ◆ Identifying the starting locations of the sources of fiber and distance transported to Rock-Tenn.
- ◆ Determining the annual quantities of material transported from each location and the number of trips each supplier makes to the Rock-Tenn facility on an annual basis.
- ◆ Identifying the likely transportation methods from each location.
- ◆ Identifying an appropriate carbon emissions modeling approach.

The scope included identifying the likely alternative locations for the fiber to be delivered if it is no longer brought to Rock-Tenn. Once this was completed, the same basic four steps were used (locations, tons, transport methods, and carbon emissions models) to calculate the total emissions of the alternative scenario.

The base case is then compared to the alternative scenario to provide a projection of the change in GHG emissions.

2 Background Information

2.1 Rock-Tenn

Rock-Tenn currently receives approximately 1,000 TPD of fiber including old corrugated cardboard (OCC), old newspaper (ONP), and mixed paper (MP). Sources include large and small suppliers; delivering baled and loose materials; originating from neighbors as well as surrounding states; arriving via semi-trailers, packer trucks or straight trucks, and pick-up trucks. Rock-Tenn receives fiber from between 600 to 700 different sources each year. Understandably, Rock-Tenn could not supply the names of suppliers for this project, but was very helpful in providing the location (city) of each as well as the tons delivered from each location and the average tons delivered per trip from each location (the key data required for the analysis).

Rock-Tenn indicated that even if they close the existing mill, they would likely continue to operate a waste paper collection plant at the facility. They would continue to seek and receive fiber from those suppliers who would choose to deliver directly to them. These would likely be from sources relatively close to Rock-Tenn who do not have their own baler and therefore no capability to attain “load limits” in a semi-trailer transport method. Rock-Tenn would continue to receive these deliveries, bale the material, and ship to another mill for processing.

2.2 Alternative Mills

Rock-Tenn believed the alternative domestic mill facilities that could potentially serve these suppliers in the United States would ultimately not have the capacity to handle the amount of material that would be diverted. If some of the suppliers were to deliver to other domestic mills, this would cause those mills to divert other suppliers away based on the economics associated with sourcing material. Eventually, all the diverted material (or equivalent amounts) would be trucked to the nearest rail yard, transported by rail to a sea port, and shipped overseas for processing.

Foth conducted research to determine where the diverted materials would be processed should the other local mills not have capacity. The research suggests that a large quantity of mixed fiber recovered in the United States (U.S.) is exported to China through the Los Angeles and San Francisco sea ports.

Below is a list of information detailed in the *2006 Annual Statistical Summary, Recovered Paper Utilization*²

- ◆ Since approximately the year 2000 the recovered mixed grade paper consumption has generally stabilized in the U.S.

² American Forest & Paper Association, Inc. 2007. *2006 Annual Statistical Summary, Recovered Paper Utilization*.

- ◆ Over that same time frame, the amount of recovered mixed grade paper exported each year from the U.S. has increased.
- ◆ In 2006, less than 0.01% of the total recovered mixed grade paper that was exported from the U.S. embarked from the West North Central Region (MN, KS, IA, MO). In other words, not much material is leaving through sea ports in these states (e.g., Duluth, MN or Mississippi River barges).
- ◆ In 2006, slightly over 1% of the total recovered mixed grade paper that was exported from the U.S. embarked from the East North Central Region (IL, IN, OH, MI, WI). Once again, minimal exports of this material via the Great Lakes sea ports.
- ◆ In 2006, 61% of the total recovered mixed grade paper that was exported from the U.S. embarked from the Mountain and Pacific Region (AZ, CO, ID, MT, NM, NV, CA, OR, WA). The primary shipping ports for paper are located on the west coast.
- ◆ There are 15 embarkation ports in the Mountain and Pacific Region. The two sea ports that export the most recovered paper material are in Los Angeles and San Francisco, California.
- ◆ In 2006, 40% of the U.S. recovered mixed paper that was exported embarked from Los Angeles, California.
- ◆ New York, New York was the second largest embarkation sea port; exporting 20% of the U.S. recovered mixed paper material to other countries in 2006.
- ◆ In 2006, 14% of the U.S. recovered mixed paper that was exported embarked from San Francisco, California.
- ◆ In 2006, 75% of the U.S. recovered paper (total) that was exported went to the Far East and Oceania countries. These countries include China, India, Indonesia, Japan, Korea, the Philippines, Taiwan, and Thailand. This trend has been increasing over time.
- ◆ In 2006, 88% of the U.S. recovered mixed grade paper that was exported went to the Far East and Oceania countries. This trend has been increasing over time.
- ◆ In 2006, 81% of the U.S. recovered mixed grade paper that was exported to the Far East and Oceania countries went to China.

The following information was also gathered from the *Recovered Paper Stock U.S. Exports and Import Shipments*.³

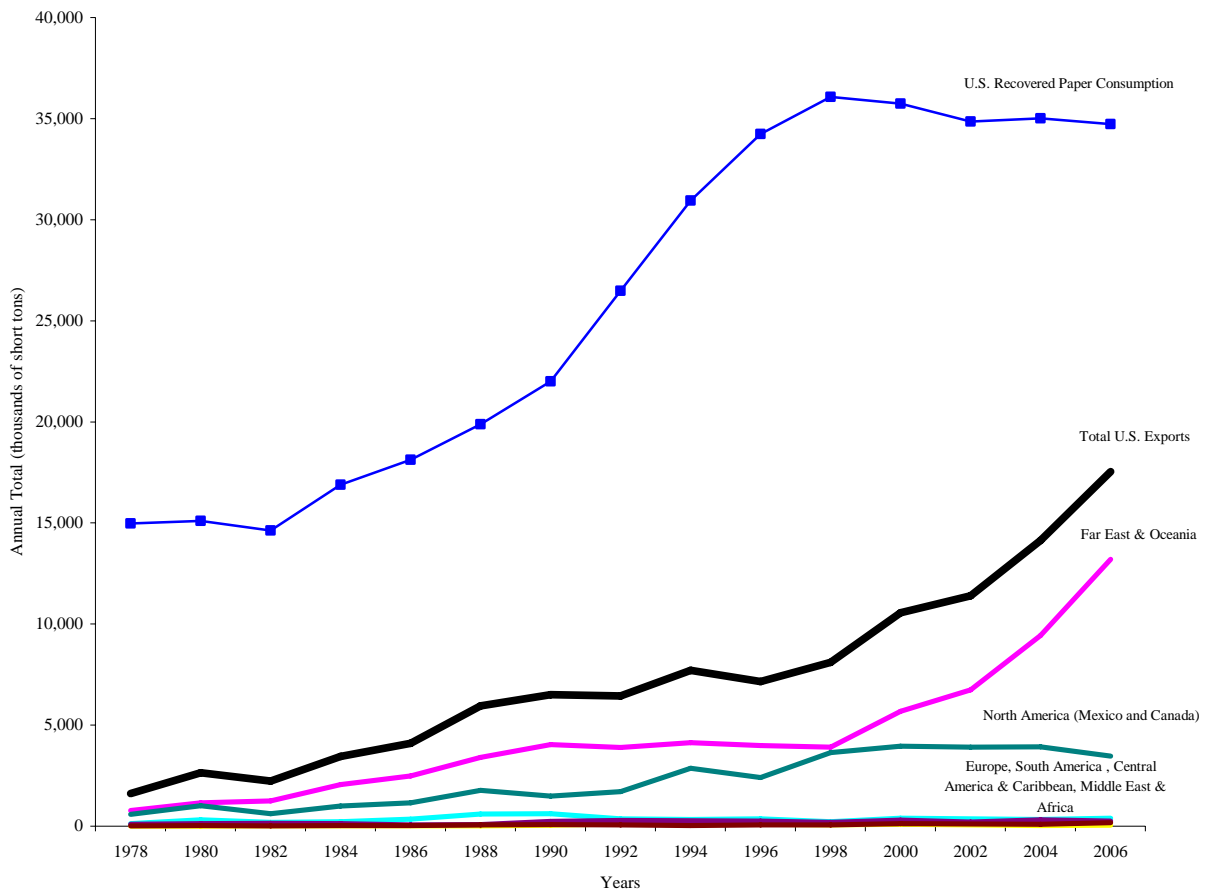
- ◆ The amount of recovered mixed grade paper sent to China increased from 1,107,710 short tons in 2000 to 4,231,090 short tons in 2006.

³ American Forest & Paper Association, Inc. 2008. *Recovered Paper Stock U.S. Exports and Import Shipments*.

- ◆ China received 72% of the recovered mixed grade paper exported from the U.S. in 2007 (up to November of 2007).
- ◆ Los Angeles and San Francisco are the two points of embarkation that ship out the most of the U.S. recovered paper stock. In 2007, as of November, these two sea ports shipped 55% of the mixed paper exported from the U.S.
- ◆ The majority of recovered mixed paper imported to China from the U.S. in 2007 came from Los Angeles, San Francisco, and New York sea ports. The Los Angeles and San Francisco sea ports exported 62% of the material received by China (through November).

An article titled “Recovered Paper Markets: A Global Commodity”⁴ highlighted China’s growth in the paper mill industry. The article indicated that in the year 2000 North America comprised 80% of the imported recovered paper in China. Figure 1 shows the history of U.S. paper consumption and exports (all grades of paper).

Figure 1 U.S. Recovered Paper Consumption (Domestic) and Exports



⁴ Moor, Bill. 2007. “Recovered Paper Markets: A Global Commodity.” *Resource Recycling*. 26 (11), pp. 14-19.

The source of the data for Figure 1 was the *2006 Annual Statistical Summary, Recovered Paper Utilization*⁵. Figure 1 shows the changes in the amount of recovered paper collected and processed at domestic paper mills. The figure shows an increasing trend in the U.S. paper consumption up to 1999. After 1999 domestic consumption begins to decrease. The *American Forest and Paper Association 48th Annual Capacity Survey Synopsis*⁶ reported that the U.S. capacity to produce paper and paperboard decreased by 1.6% in 2006 and decreased by 0.6% in 2007. The domestic paper and paperboard consumption has decreased at an average annual rate of 0.7% for the period of 2000 to 2007. The American Forest & Paper Association predicts that the domestic consumption will decline by 0.7% in 2008.

An article titled “Grading the Global Trade”⁷ reported that China has built and is continuing to build several large paper mills. The Chinese have been integrating themselves into the U.S. recovered paper market to help supply material for these mills. Shipping containers are used to transport imported goods from China and export recovered paper from the U.S. to China.

Figure 1 shows that amount of recovered paper exported has increased significantly in the last 10 years. This graph also shows that a majority of that material is exported to the Far Eastern and Oceanic countries, which includes China.

An article titled “Recovered Paper Exports Break Record”⁸ stated that the monthly quantity of exported recovered paper material hit an all time high in December 2007. The monthly quantity of exports of this material increased by 43.3 percent from November to December of 2007. This increase is attributed mainly to China which increased their demand of recovered paper by over 700,000 metric tons.

Based on the research, the alternative scenario for this project will model the diverted material as being transported by rail to either the Los Angeles or San Francisco sea port (whichever is closest) and then shipped to China for processing.

⁵ American Forest & Paper Association, Inc. 2007. *2006 Annual Statistical Summary, Recovered Paper Utilization*.

⁶ American Forest & Paper Association News. March 31, 2008. *AF&PA 48th annual Capacity Survey Synopsis*.

⁷ Stafford, Brian. 2008. “Grading the Global Trade.” *Resource Recycling*.27 (2), pp.17-22.

⁸ Arzoumanian, Mark, ed. 2008. “Recovered Paper Exports Break Record.” *Official Board Markets* 84 (9), p.4.

3 Base Case Scenario

3.1 Locations, Quantities, and Distance

To model the base case scenario, Rock-Tenn supplied Foth with each supplier's location (city and state), the total quantity of material (tons) brought to Rock-Tenn by the supplier in the first 11 months of 2007, and the average tons the supplier transported with each trip to Rock-Tenn.

The data was provided as total tons and average tons per shipment over an 11 month period. This was used to calculate the number of shipments per supplier the first 11 months in 2007. If the calculated number of shipments was not a whole number then the low number and high number of shipments was reported (representing rounding down and rounding up the calculated number of shipments, respectively – e.g., if a total 31 tons were delivered through November of 2007 with an average of 15 tons per delivery, a low of 2 and a high of 3 trips were used to create a range of the number of deliveries).

Using the supplier locational data provided by Rock-Tenn, Foth determined the roundtrip mileage for each supplier bringing materials to Rock-Tenn using the Google Map⁹ website. For suppliers located in St. Paul, Minnesota, the average roundtrip mileage was assumed to be 7 miles. Rock-Tenn indicated that these suppliers are in close proximity to the facility, ranging between 2 and 5 miles away (average 3.5 miles).

Three of the suppliers are “route suppliers.” This means that they travel to several different locations prior to unloading material at Rock-Tenn. The three routes were described by Rock-Tenn to be (1) Minnesota, the Dakotas (North and South), and Wisconsin, (2) Minnesota and the Dakotas, and (3) the Twin Cities area. For the Twin Cities area route, the roundtrip mileage was assumed to be an average of 10 miles to match the distance for suppliers located in Minneapolis, MN. The roundtrip mileage for the Minnesota, the Dakotas, and Wisconsin route was estimated to be an average of 800 miles based on the average distance from the middle of the Dakotas and Wisconsin to the Rock-Tenn facility. For the Minnesota and Dakotas route, the roundtrip mileage was assumed to be 1,000 miles based on the average distance from the middle of the Dakotas to the Rock-Tenn facility.

Using each supplier's roundtrip mileage and the range of number of visits to Rock-Tenn, a range for the total annual mileage was calculated.

3.2 Transportation

A type of vehicle was chosen to represent the transportation for each supplier based on the average tons the supplier transported with each trip to Rock-Tenn. The types of vehicles assumed to transport material to Rock-Tenn include semi-trailers, packer trucks or straight

⁹ <http://www.maps.google.com/maps?hl=en&tab=wl>. Accessed on 12/24/2007.

trucks, and pick-up trucks. Any supplier that transferred 12 tons per trip or more to the facility was assumed to be transporting the material in a semi-trailer. For loads between 2 and 11 tons, the mode of transportation was assumed to be by a packer or straight truck. For loads 1 ton or less, it was assumed to be transported by a pick-up truck.

The average fuel economy (in mpg) was determined for three “types” of trucks: (1) semi-trailers, (2) packer trucks or straight trucks, and (3) pick-up trucks. The average fuel economy for semi-trailers was determined by evaluating the average fuel economy of various makes and models of semi-trailers. Most data found pertaining to fuel economy for semi-trailers was collected over a 3-6 month period, had various drivers, and included both in-city and over the road (OTR) driving. Also, the vehicles were monitored with empty and fully loaded cargos to try to determine a representative average to use in this study (Fuel Charger¹⁰ website). The average fuel economy for a semi-trailer was determined to be 5.72 miles per gallon (mpg).

The average fuel economy for packer and straight trucks was more difficult to determine. The Fuel Charger website had fuel economy information for a street sweeper truck and a sanitation truck in addition to the semi-trailers. Also, two Alternate Fuel Truck Evaluations Projects were found on-line. These studies were performed by UPS delivery trucks¹¹ and Waste Management packer trucks¹². These two studies each monitored three vehicles for fuel economy for approximately one year. The average fuel economy of the four studies is 4.9 mpg. This value was used to represent the fuel economy for packer and straight trucks. It may be noted that packer trucks when actually on collection routes have been reported to get less than 3 mpg. The higher mpg (4.9 mpg) used for this study is appropriate to represent the fuel economy associated with packer trucks from the end of the collection route to the unloading location.

The average fuel economy for a pick up truck was determined by looking at 16 different pick up trucks with different engines and transmissions found on the Fuel Economy¹³ website. The average fuel economy for this type of vehicle was determined to be 16.7 mpg.

3.3 Carbon Emissions Modeling

After assigning fuel economy and vehicle types to each supplier, the range for the total annual fuel consumption was calculated. Using the annual fuel consumption, annual mileage, and GHG emissions modeling equations, the carbon dioxide emissions equivalent (CO_{2e}) was calculated for each supplier. The formula for this calculation also takes into account the methane (CH₄) and nitrous oxide (N₂O) produced with emissions. In the formula, the CH₄ and N₂O components were converted to CO_{2e}. Then the CO_{2e} was converted to C_e. Below is a more detailed explanation of how the GHG emissions were determined for the vehicle traffic.

The *Direct Emissions from Mobile Combustion Sources*¹⁴ was used as the basis for calculating GHG emissions from truck traffic. Tables provided in the reference were used to estimate

¹⁰ <http://www.fuelcharger.cc/ftindex.htm>. Accessed on 12/27/07.

¹¹ http://www.pressroom.ups.com/statisticfiles/case_studies/19.pdf. Accessed on 12/28/2007. (*UPS CNG Truck Fleet – Final Results, Alternate Truck Fuel Evaluation Project*. 2002.

¹² http://www.eere.energy.gov/afdc/pdfs/waste_lng-final.pdf. Accessed on 12/28/2007. (*Waste Management LNG Truck Fleet – Final Results – Alternative Fuel Truck Evaluation Project*. 2001.

¹³ <http://www.fueleconomy.gov>. Accessed on 12/27/07.

emissions for carbon dioxide (CO₂), N₂O, and CH₄ for the different truck types based on the fuel used.

Table 3, “*Weighted Average Model Year CH₄ and N₂O Emission Factors for Highway Vehicles*” from the reference document contained modeling information for gasoline and diesel fueled vehicles. To calculate emissions from vehicles that burn gasoline (pick-up trucks only) emission factors of 0.501 grams/mile for N₂O and 0.0535 grams/mile for CH₄ were used. For diesel powered vehicles (straight trucks, packer trucks and semi-trailers) emission factors of 0.0483 grams/mile for N₂O and 0.0644 grams/mile for CH₄ were used. To obtain the CH₄ and N₂O emissions, these constants were multiplied by the total annual mileage traveled for each supplier.

CO₂ emissions were calculated using the factors presented in Table B-1. “*Factors for Calculating CO₂ Emissions from Motor Gasoline and Diesel Fuel Use*” in the reference document. For gasoline powered vehicles (pick-up trucks), CO₂ emissions were calculated using the factor 8.78 kg CO₂/gallon. For diesel powered vehicles, CO₂ emissions were calculated using the factor 10.04 kg CO₂/gallon. The assumptions and methods to determine fuel economy were discussed previously.

Once the emissions for CH₄, N₂O and CO₂ were determined, CH₄ and N₂O emissions were provided by the International Panel on Climate Change¹⁵. CH₄ emissions were multiplied by 23 to obtain CO_{2e} emissions. N₂O emissions were multiplied by 296 to obtain CO_{2e} emissions. CO₂ emissions do not require conversion to CO_{2e}. The CO_{2e} emission values and the CO₂ emission values were added together to get a total annual CO_{2e} value for each supplier.

The C_e emissions were calculated using EPA methods to convert CO_{2e} emissions to C_e emissions. To convert CO_{2e} emissions to C_e, the CO_{2e} emission values were multiplied by a ratio of their molecular weights (12/44). The spreadsheets showing these calculated values for each supplier for the base case scenario are provided in Appendix A.

4 Alternative Scenario

Foth met with Rock-Tenn to discuss the base case scenario development and results for the GHG emissions associated with supplier transportation. Discussion also addressed likely approaches to developing the alternative scenario. Rock-Tenn determined that suppliers who deliver on average 15 tons or more per load would likely seek alternative recycling methods if the mill was no longer available in St. Paul. Suppliers whose loads average 14 tons and lower each were assumed to continue to come to Rock-Tenn operating as a baling facility. To model GHG emissions associated with the alternative scenario, Foth divided the supplier list into two separate categories as noted above. One category represents suppliers that would continue to bring their recyclable material to Rock-Tenn for baling. The other category represents the suppliers who for purposes of this GHG analysis would no longer bring their recyclable material to Rock-Tenn. These suppliers would likely seek the next closest mill to take their recyclable paper.

¹⁴ United States Environmental Protection Agency. Office of Air and Radiation. *Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance – Direct Emissions from Mobile Combustion Sources*. 2004.

¹⁵ <http://www.ipcc.cn/> Accessed on 02/14/2008.

Foth conducted some on-line research to verify the assumption that local alternative paper mills were at capacity. The two mills targeted included LDI Fibres, Inc. (LDI Fibres) in Becker, Minnesota and Weyerhaeuser in Cedar Rapids, Iowa. These two mills are conveniently located to several of Rock-Tenn's paper scrap suppliers and could be an alternative location for them to bring their recyclable material. It was difficult to obtain information on the operating capacity of these two facilities. Both facilities have Title V air permits. However, the air permits do not contain operating capacity information. The permits contain Title V emission potentials (outline in the Title V permit) and actual emission values. The MPCA is the regulatory body for the Title V air permits in Minnesota. LDI Fibres Title V air permit was available for the public to view at the Minnesota Pollution Control Agency (MPCA)¹⁶ website. The Volatile Organic Compounds (VOC) emission potential for LDI Fibres was reported as 184 tons per year. The actual VOC emission was reported as 116 tons per year. However, this does not necessarily indicate the mill is operating below capacity. While the emission potentials and actual emissions were available for LDI Fibres, they were not easily located for Weyerhaeuser. The DNR is the regulatory body for the Title V air permits in Iowa. The DNR utilizes a program called State Permitting and Air Reporting System (SPARS) to manage the Title V air permits and submittals of emission information. Foth does not have access to this database for the Weyerhaeuser site.

In addition, it was determined that the majority of LDI Fibers material is OCC, not mixed paper. On the MPCA website, LDI Fibres was not listed as a facility that accepted residential or office mixed grade paper, only OCC. This implies that any material (which may contain mixed paper) diverted from Rock-Tenn would not be accepted at LDI Fibres.

As noted in Section 2, paper mill capacity in the domestic market (U.S.) has been flat to declining while mill capacity overseas has been expanding rapidly. Therefore, for purposes of completing this analysis, the assumption was made that an additional 1,000 TPD of paper would be shipped to China.

4.1 Alternative Scenario – Continuing Rock-Tenn Suppliers

As mentioned previously, any supplier delivering less than 15 tons per load would continue to bring materials to the Rock-Tenn Facility for baling. The Twin Cities route supplier would likely continue to bring material to Rock-Tenn.

To model this alternative, the base case scenario was slightly modified. These suppliers would continue to transport their material to Rock-Tenn in the same manner and frequency as in the base case scenario. Rock-Tenn would likely bale the material, however it would be shipped overseas (assumed to be China) for processing. For this model, the Nine Dragons paper mill paper was chosen as the mill that would process this material. Nine Dragons is located in Dongguan, China approximately 50 miles from the Hong Kong sea port (100 miles roundtrip).

4.2 Alternative Scenario – Alternative Delivery Locations

Suppliers whose loads averaged at least 15 tons were believed most likely to seek a different delivery destination due to the basic economics of the recycling industry. End market pricing is

¹⁶ <http://www.pca.state.mn.us> Accessed on 02/11/2008.

likely to be more attractive than a baling facility at Rock-Tenn. Their paper is most likely already baled and ready for market. The two other route suppliers (the Minnesota & Dakotas route and the Minnesota, Wisconsin, & Dakotas route) would likely seek an alternative delivery destination. With the assumption that all 1,000 TPD would eventually be shipped to China, the logical assumption was to have each of the suppliers deliver their loads to the closest railyard with capability to handle ocean containers. The material would then be transported from these railyards, to the nearest sea port (either Los Angeles or San Francisco, CA) and shipped to the China for processing at the Nine Dragons paper mill.

4.2.1 Geographic Information System (GIS) Analysis and Methods

GIS was utilized to help determine the most likely routes (from generation point to end point) for the transportation of material for this alternative scenario.

The first task for GIS analysis was to geocode locations of all current supplier cities that supply the Rock-Tenn facility with recycling materials. Geocoding is the process of calculating geographic locations based on address information. In this case, only the supplier city and state was used to pin-point the supplier locations. (see Figure 1 at the end of the report for current supplier locations). The basemap source data used to geocode the supplier cities, and all network analysis, was Environmental Systems Research Institute (ESRI)¹⁷ which consists of nationwide transportation, demographic, and various cultural data, based on GIS data compiled by Navteq, a world leader in transportation data production.

The next step was to acquire data for locations of railyards that handle truck to COFC (container on flat car), and ports that handle COFC to ship intermodal shipping. The COFC railyard and port GIS data was acquired from the United States Department of Transportation's Bureau of Transportation Statistics¹⁸ website. Then a GIS network dataset was created in GIS which combined the COFC railyard locations, major highways for the roadway network, and the supplier cities. The ESRI's Network Analyst extension was used to calculate the shortest routes from each supplier city to the closest COFC railyard (see Figure 2 at the end of the report). This process provided the total roundtrip mileage traveled by suppliers to the railyards.

An additional network dataset was created that consisted of the national railroad network and west coast shipping port locations. Again, the shortest routes were calculated from each COFC railyard to the closest west coast port (see Figure 3 at the end of the report). This process provided the total roundtrip mileage from each railyard to the Los Angeles and San Francisco sea ports.

The final route calculation involved generating a route from the resulting two west coast ports (San Francisco and Los Angeles) to the port of Hong Kong. The only shipping lane data that could be obtained for this route was provided by APL's¹⁹ (a global container shipping company)

¹⁷ Environmental Systems Research Institute, Street Map USA, Version 9.2. <http://www.esri.com/data/data-maps/overview.html> Accessed on 12/29/2008.

¹⁸ http://www.bts.gov/publications/national_transportation_atlas_database/2007/ Accessed on 02/29/2008.

¹⁹ http://www.apl.com/routes/html/asia_north_america.html Accessed on 02/29/2008.

website and was based on their Pacific South Express route from the Los Angeles and San Francisco ports to Hong Kong. The APL map route was heads-up digitized into GIS to create the route. A total shipping route distance of 9,471 miles was calculated (see Figure 4 at the end of the report).

4.2.2 Location, Quantities, and Distance Calculations

Knowing the distances (to railyards, sea ports, and China) determined by the methods described above, alternative routes (from generation point to end point) were created for both suppliers who would continue to utilize Rock-Tenn as a baling facility and other suppliers who would likely deliver to alternative locations.

The continuing Rock-Tenn suppliers will transport their recyclable material to Rock-Tenn using the same truck type and frequency as they did in the base case scenario. Rock -Tenn will transport the baled material to the St. Paul Midway Railyard via full semi-trailers (assumed to be 20 tons per load).

The other suppliers would transport their recyclable material to the nearest railyard using the same truck type and frequency as they did in the base case scenario. For example, a supplier delivering to Rock-Tenn 38 times in 2007 would make that same number of trips instead to the nearest railyard. Also, if that supplier transported their recyclable material to Rock-Tenn using a semi-trailer, they would use that same type of truck to transport the material to the railyard.

For both supplier types in the alternative scenario, the remaining transportation routes are modeled the same and are as follows:

- ◆ From the railyards, it is assumed that the material would be transported via rail to the nearest sea port (either Los Angeles or San Francisco, California).
- ◆ From the sea ports it would be shipped to the Hong Kong sea port in China.
- ◆ From the Hong Kong sea port it would be transported via full semi-trailers (assumed to be 20 tons per load) to the Nine Dragons paper mill in Dongguan, China (100 miles roundtrip).

4.2.3 Carbon Emissions Modeling

The GHG emissions for the truck traffic portions of the alternative scenario were determined using the same methods as the base case scenario. New methods were needed to model the rail and ship transportation in the alternative scenario.

GHG emissions from rail transport are not well studied or documented. In order to determine GHG emissions from rail, multiple public data sources were used to determine an estimate of GHG emissions per ton mile of freight by rail. Specific emission factors for rail assumed No. 2 diesel fuel. Emission factors for No. 2 diesel fuel were taken from *General Reporting Protocol*.²⁰ Specifically, CO₂ emissions were estimated at 10.05 kg/gallon, CH₄ at 0.0014 kg/gallon and N₂O at 0.0001 kg/gallon. These emission factors are slightly higher than diesel

²⁰ California Climate Action Registry. *General Reporting Protocol*. March 2007.

truck emission factors since rail emission controls are not as aggressive as “on road” emission controls. However, based on data provided in the *2003 Locomotive Emissions Monitoring Program*²¹ the emissions for CO₂ are comparable to the data gathered in Canada on locomotive emissions.

The Bureau of Transportation Statistics website provided information to determine the estimated fuel efficiency for rail. The Bureau of Transportation Statistics reports that in 2004 (the most current reporting year available) freight rail transportation used 4,059,000,000 gallons of diesel fuel to transport 1,684,461,000,000 ton-miles of freight. Therefore, freight transport via rail required 0.0024 gallons of diesel/ton-mile.

Emissions from freight rail were calculated for the specific GHG emitted (CO₂, CH₄, and N₂O), converted to CO_{2e}, and then converted to C_e. Conversion factors for CO_{2e} and C_e were the same as identified for vehicle transport as presented in Section 3.3.

To calculate GHG emissions from ocean transport, several sources were used to determine the potential emissions.

The primary equation used to determine the amount of CO₂ emitted as a result of shipping cargo via ocean liner was developed by using information from the *Business for Social Responsibility April 2004 presentation*²². CO₂ emission from ocean freight was quantified as:

$$1 \text{ km of ocean transport} = 114.5 \text{ g CO}_2/\text{TEU}$$

Where TEU = A container 20 feet long, 8 feet wide and 8 feet tall (1,280 cubic feet) that can transport 12 registered tons.

Registered tons = 100 cubic feet

Therefore a TEU has a capacity of 1,280 cubic feet and can transport 1,200 cubic feet of material.

Foth assumed the density of baled paper to be 1,000 pounds per cubic yard. This value was obtained from the *Business Guide for Reducing Solid Waste*.²³ The value represents the high-end density for baled OCC and ONP and a lower end density for baled MP. Therefore, one TEU of paper material, which contains 1,200 cubic feet, will have an estimated weight of 44,444 pounds. Using this information the ocean transport emissions was calculated. Each ton-mile of transport emits 8.29 grams of CO₂. This translates to about one-third of the emissions from rail transport.

²¹ 2003 Locomotive Emissions Monitoring Program. Environmental Canada. EPS/2/TS/11. December 2004.

²² *Business for Social Responsibility*; April 2004 presentation.

²³ United States Environmental Protection Agency. *Business Guide for Reducing Solid Waste*. EPA/530-K-92-004. November 1993.

Appendix B provides the detailed spreadsheet calculations of GHG for suppliers assumed to deliver materials to alternative locations. Appendix C provides the detailed spreadsheet calculations for suppliers who continue to deliver materials to Rock-Tenn.

5 Summary & Findings

All the data for the two scenarios was calculated based on the total tonnage received during the first 11 months of 2007. This data was adjusted to represent a full year (12 months) after determining the total GHG emissions (C_e) for both the base case and alternative scenarios.

The annual GHG emission for the base case scenario was calculated to be between 2,529,882.72 kilograms and 2,584,698.93 kilograms of C_e (Appendix A – Base Case Scenario). This range represents the amount of GHG emissions produced by supplier vehicles transporting material to the Rock-Tenn facility. There is a range because of the range of number of trips each supplier was assumed to make to the Rock-Tenn facility within the year (described earlier in section 3.1).

The annual GHG emissions associated with the alternative scenario was calculated to be between 19,490,188.23 kilograms and 19,524,559.30 kilograms. The range was calculated by adding the GHG produced by the transportation of material from suppliers who continue to utilize Rock-Tenn and the GHG produced from alternative transportation utilized to deliver to alternative locations. This represents an over 750% increase in GHG emissions versus the base case.

Table 5-1 summarizes the GHG emissions associated with each step of the transportation process for the suppliers that continue to bring material to Rock-Tenn for baling. Table 5-2 summarizes the GHG emissions associated with each step of transportation for suppliers who may seek alternative recycling methods.

Table 5-3 shows the comparison of the base case and alternative scenarios. The average difference between the two scenarios is 16,950,082.95 kilograms of C_e . This is the amount of additional GHG that would be emitted if the 1,000 TPD of fiber were no longer processed at the Rock-Tenn facility in St. Paul, Minnesota. This is equivalent to the following emissions from the *Greenhouse Gas Equivalencies Calculator* on the EPA website²⁴:

- ◆ The CO₂ emissions of approximately 11,383 passenger cars in one year
- ◆ The CO₂ emissions from 7,054,518 gallons of gasoline consumed in one year
- ◆ The CO₂ emissions from the electricity from 8,232 homes for one year
- ◆ The C sequestered annually by 14,125 acres of pine or fir forests
- ◆ The C sequestered annually by approximately 433 acres of forest preserved from deforestation

²⁴ <http://www.epa.gov/cleanenergy/energy-resources/calculator.html> Accessed on 3/20/08.

Table 5-1 Alternative Scenario: Total Carbon Generated from Continuing Rock-Tenn Suppliers

Description	Low Total C _e (kg C _e)	High Total C _e (kg C _e)	Total C _e (kg C _e)	Adjusted 12 Month Low - Total C _e (kg C _e)	Adjusted 12 Month High - Total C _e (kg C _e)	Adjusted 12 Month - Total C _e (kg C _e)
Supplier transports material by truck to Rock-Tenn	374,095.20	387,808.09	NA	408,103.85	423,063.37	NA
Rock-Tenn transports material by semi truck to St. Paul Midway Railyard	7,166.96	7,169.16	NA	7,818.50	7,820.91	NA
Transport material by rail to San Francisco sea port	NA	NA	1,872,123.70	NA	NA	2042316.765
Transport material by ship to Hong Kong sea port	NA	NA	1,394,109.74	NA	NA	1520846.991
Transport material by semi truck to paper mill	157,170.22	157,218.52	NA	171,458.42	171,511.11	NA
			TOTAL (kg)	4,150,544.54	4,165,559.15	

Table 5-2 Alternative Scenario: Total Carbon Generated By Delivery to Alternative Locations

Description	Low Total C _e (kg C _e)	High Total C _e (kg C _e)	Total C _e (kg C _e)	Adjusted 12 Month Low - Total C _e (kg C _e)	Adjusted 12 Month High - Total C _e (kg C _e)	Adjusted 12 Month - Total C _e (kg C _e)
Supplier transports material to railyard	1,110,779.67	1,128,474.78	NA	1,211,759.64	1,231,063.40	NA
Transport material by rail to sea port	NA	NA	7,122,682.25	NA	NA	7,770,198.81
Transport material by ship to Hong Kong sea port	NA	NA	5,228,950.44	NA	NA	5,704,309.57
Transport material by semi truck to paper mill	598,927.70	598,976.00	NA	653,375.67	653,428.36	NA
			TOTAL (kg)	15,339,643.69	15,359,000.15	

Table 5-3 Difference in Carbon Emissions between Base Case & Alternative Scenario

Description	Adjusted 12 Month Low - Total C _e (kg C _e)	Adjusted 12 Month High - Total C _e (kg C _e)	Average Total C _e (kg C _e)
Alternative Scenario - Rock-Tenn Suppliers	4,150,544.54	4,165,559.15	
Alternative Scenario – Alternative Delivery Locations	<u>15,339,643.69</u>	<u>15,359,000.15</u>	
Total for Alternative Scenario	19,490,188.23	19,524,559.30	19,507,373.77
Total for Base Case Scenario	<u>2,529,882.72</u>	<u>2,584,698.93</u>	<u>2,557,290.83</u>
Average Difference			16,950,082.95

Figures

Appendix A

Base Case Scenario

Appendix B

Alternative Scenario – Alternative Delivery Locations

Appendix C

Alternative Scenario – Rock-Tenn Suppliers