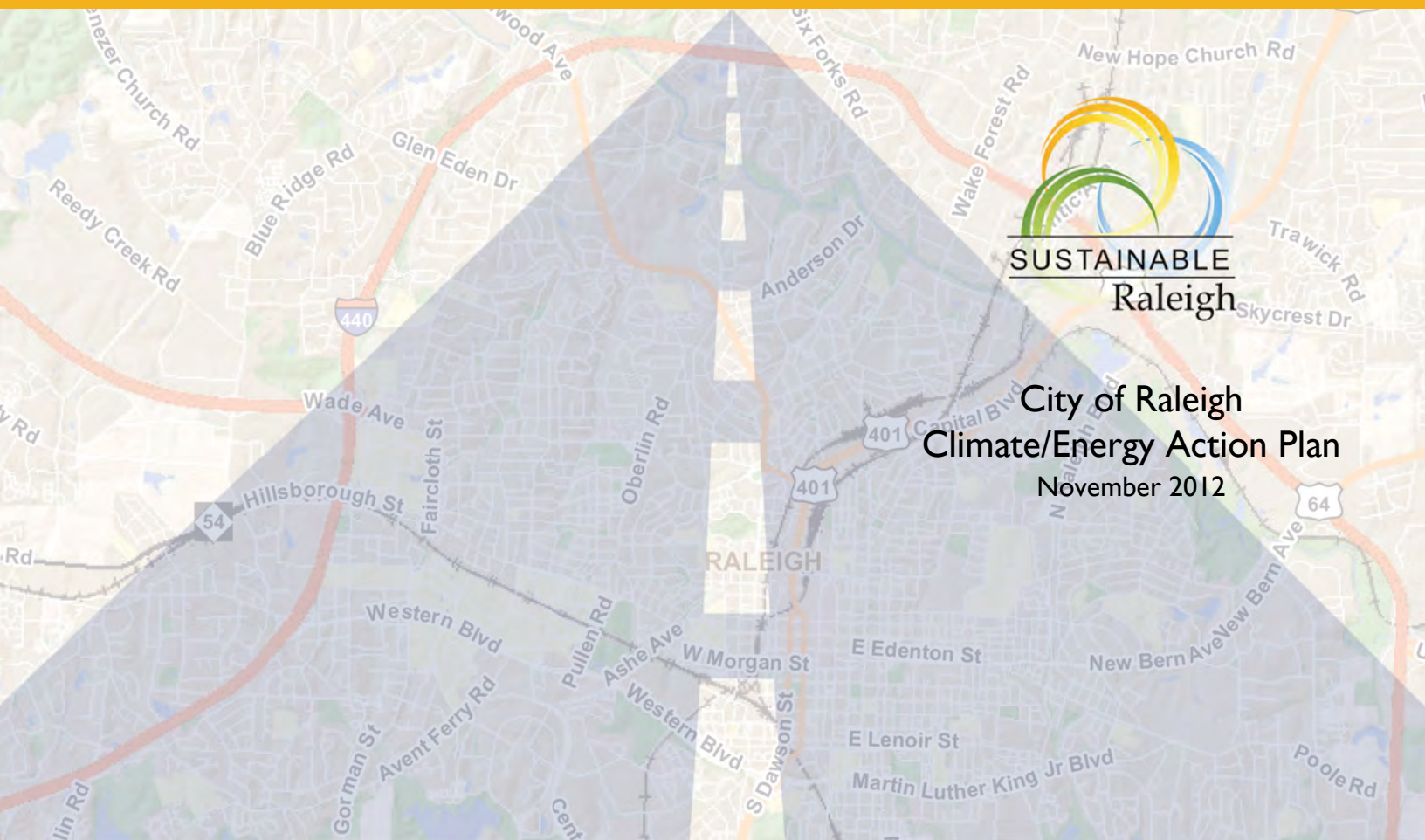




Technical Documentation – Volume Five
Baseline Emissions Inventory for Solid Waste



Technical Memorandum

Greenhouse Gas Baseline Emissions Inventory for City of Raleigh Solid Waste Disposed in Landfills – Years 2007 and 2010

Prepared for:

City of Raleigh

Office of Sustainability



October 2012

Greenhouse Gas Baseline Emissions Inventory for City of Raleigh Solid Waste Disposed in Landfills – Years 2007 and 2010

PREPARED FOR: City of Raleigh Office of Sustainability

PREPARED BY: CH2M HILL

DATE: October 2012

Background

In July 2010, the City of Raleigh developed the “City of Raleigh Greenhouse Gas Inventory: Municipal Operations” report. The purpose of the inventory was to quantify emissions from municipal operations and to identify the City’s emission sources for its operations. With respect to solid waste, the 2010 inventory included the collection of solid waste within the City, which is under the direct control of the City.

The City’s solid waste is disposed in landfills that are owned and operated by Wake County. Solid waste generated within the City is transported by the City to transfer stations. Wake County then transports the solid waste from the transfer stations to its landfills. While Wake County has operational control over the disposal activities, the City can directly influence the volume of solid waste disposed through the implementation of policies, educational programs and choices of solid waste services offered to the community including recycling and composting.

This Technical Memorandum (TM) presents a baseline greenhouse gas (GHG) emissions inventory for the disposal of the City’s solid waste in Wake County landfills for the year 2007 and one subsequent year, 2010.

Inventory Boundary Conditions

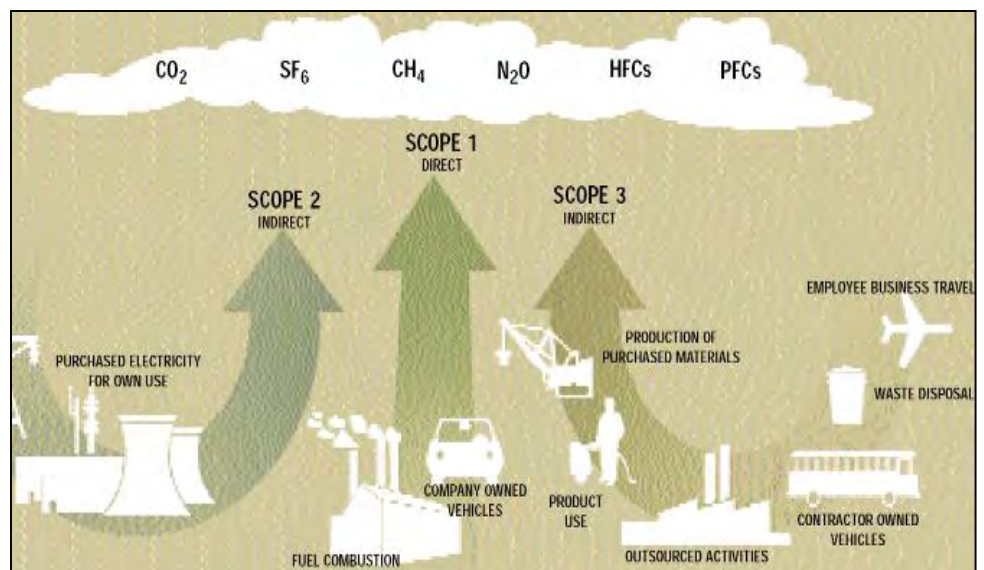
Operational Boundaries

Greenhouse gas emissions are defined by the three categories shown below and as depicted in **Exhibit 1**.

- Scope 1 - Direct emissions
- Scope 2 - Indirect emissions
- Scope 3 - Optional or other indirect emissions

The year 2007 and year 2010 landfilled solid waste inventory includes only Other Indirect Emissions (Scope 3) because an entity other than the City (Wake County) has operational control over the disposal activities.

EXHIBIT 1



Scope Included in this Emissions Inventory – Scope 3 Emissions

The Scope 3 emissions included in the City solid waste disposal GHG baseline inventory are:

- Mobile combustion sources used to transport the solid waste from the City to the Wake County landfills
- Solid waste emissions due to the decomposition of the City's solid waste in the Wake County landfills

Physical Boundaries

The geographical boundary for this inventory is the City of Raleigh jurisdiction within Wake County. The City occupies a 144-square-mile area and is home to over 400,000 citizens, as well as university and college campuses, and state and county government complexes.

Greenhouse Gases Evaluated

All six of the Kyoto GHGs – carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆) – were evaluated for inclusion. However, the solid waste disposal activities included in this analysis emit only CO₂, CH₄, and N₂O. There were no emissions of PFCs or SF₆ identified in this emissions analysis as these emissions are generally associated with the transmission and distribution of electricity from generation facilities and/or the manufacture of semi-conductors. Fugitive emissions of HFCs are associated with refrigerant usage and are not included in this emissions analysis.

Total emissions for the GHG inventory are expressed as carbon dioxide equivalents (CO₂-eq). Carbon dioxide equivalents represent the universal unit for comparing emissions of the various GHGs to one unit of CO₂ based upon their global warming potential (GWP) value. GWPs indicate the degree of warming to the atmosphere that would result from the emission of one unit of a given GHG compared to one unit of CO₂. To obtain CO₂-eq emissions, the mass rate of emissions for each GHG is multiplied by its respective GWP. The GWP values for the six Kyoto GHGs are shown in **Exhibit 2**.

EXHIBIT 2

Greenhouse Gas Global Warming Potentials

Greenhouse Gas (GHG)	Global Warming Potential (GWP) ^(a)
Carbon Dioxide (CO ₂)	1
Methane (CH ₄)	21
Nitrous Oxide (N ₂ O)	310
Hydrofluorocarbons (HFCs)	1300 (for R-134a)
Perfluorocarbons (PFCs)	varies
Sulfur Hexafluoride (SF ₆)	2600

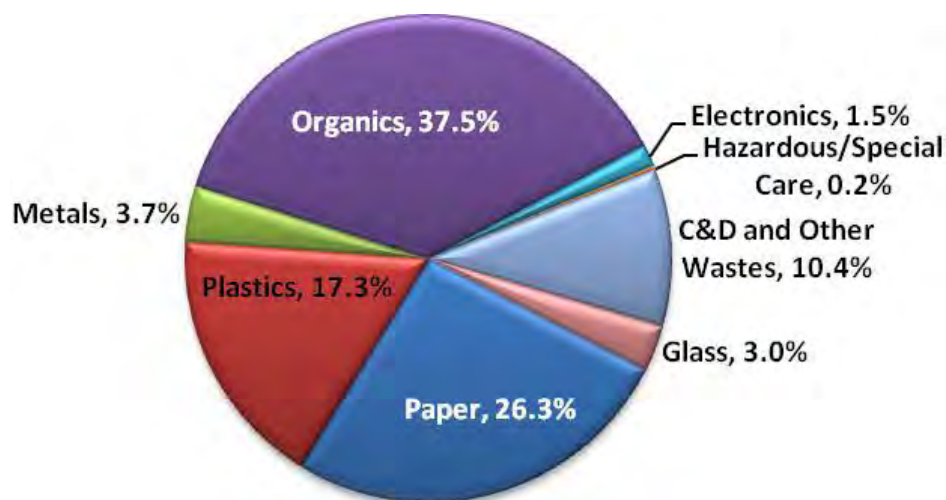
^(a) Based upon the Second Assessment Report (SAR) of the Intergovernmental Panel on Climate Change

Municipal Solid Waste Stream Characterization

In May 2011, Wake County developed the “Wake County Waste Characterization Study” report. The purpose of the study was to identify the composition of residential and commercial waste generated in Wake County. The percentages of different types of solid waste are presented in **Exhibit 3**. According to the City, while there has been no specific analysis of the City’s municipal solid waste, the results of the Wake County study should provide a close approximation of the contents of Raleigh’s municipal solid waste.

EXHIBIT 3

Overall Waste Stream Composition (from May 2011 Wake County Waste Characterization Study)



Recycling & Composting Programs, Landfill Diversion Rates, and Construction & Demolition Waste Management

City of Raleigh Recycling

The City of Raleigh Recycling Division is responsible for the collection of recyclable materials which are then received, sorted, baled and marketed by a private enterprise. The City collects recyclable materials at the curbside which include the following primary items:

- Glass and can food and beverage containers
- Plastic items No. 1 through 5 and No. 7
- Gable top cartons
- Newspaper and inserts
- Magazines and catalogs
- White and colored paper
- Corrugated cardboard

In 2010, Raleigh residents began participating in a pilot program that replaced the use of small 18 gallon recycling bins with 95 gallon roll carts. Recycle collection service was also decreased from weekly to bi-weekly. As a result of the pilot program, the City has seen increased materials recycling and is proceeding with replacing the small bins with roll carts throughout the City. Note that increasing the size of the recycling containers is one of the top future potential projects identified in the City’s Climate/Energy Action Plan (CEAP) to reduce energy and GHG emissions.

City of Raleigh Composting

When the State of North Carolina banned the disposal of yard waste debris from landfills, the City began weekly collection of yard waste at the curbside for its residents. In 1991, the City opened the Yard Waste Recycling Center to recycle the collected yard waste into usable products such as compost. Composting is completely handled by City Operations and includes only the yard trimmings and branches collected by the City.

City of Raleigh Landfill Diversion Rate

Landfill diversion rate is defined as the ratio of materials not sent to a landfill to the total amount of waste collected. Based on information provided by the City of Raleigh regarding the solid waste that is recycled and composted, and the material landfilled by Wake County, the diversion rate was calculated for the years 2007 and 2010 as shown in **Exhibit 4**. Overall, the City of Raleigh diversion rate is increasing which means more materials are being recycled or composted instead of landfilled. The difference in material being recycled or composted between 2007 and 2010 was over 1,500 tons, which represents an increase of 3%.

EXHIBIT 4

Baseline Year 2007 and Year 2010 Solid Waste Diversion Data

Disposal Method	Year 2007 (tons)	Year 2010 (tons)	Percent Increase/Decrease
Total Waste Landfilled, Recycled, and Composted	140,890	142,830	1.4%
• Total Waste Landfilled ^(a)	85,090	85,510	0.5%
• Total Waste Recycled and Composted	55,800	57,320	2.6%
Diversion Rate	39.6%	40.1%	

^(a) Composition as shown in Exhibit 3

Proposed guidelines for federal facilities include a diversion rate of 50% for mixed solid wastes. By comparison, the City of Raleigh is achieving a diversion rate of over 40%. As a result of using the new large roll carts, the City has seen the following benefits:

- Increased diversion of solid waste to recycling
- Increased tons recycled reduces landfill costs and increases revenues from the sale of recyclables
- Biweekly collection from roll carts uses fewer trucks resulting in GHG mitigation and energy savings
- Improved safety for recycling crews; reduces workman compensation claims

Based on other North Carolina communities that have implemented the large roll carts, recycling tons are expected to continue to increase.

Construction and Demolition Waste Management

In February 2004, Wake County stopped accepting construction and demolition (C&D) waste materials at its landfills. These materials which include asphalt, cardboard, carpeting, concrete, drywall, paint, scrap metal, vinyl siding and wood/lumber/pallets, can be disposed/recycled at nearly 30 private recycling companies in the County. Some gently used and salvaged materials are also accepted by the Habitat for Humanity for resale: lumber, windows, doors, cabinets, flooring, lighting, hardware, appliances, electrical and architectural items. C&D waste is not included in this Scope 3 GHG emissions inventory due to the difficulty in obtaining information from nearly 30 independent facilities.

Greenhouse Gas Emissions Inventory Data and Results

For this analysis, Scope 3 emissions (Other Indirect Emissions) were calculated according to the *International Local Government GHG Emissions Analysis Protocol (IEAP), v1.0, 2009*. Scope 3 emissions include those from activities over which the City of Raleigh exerts significant control or influence and that occur within and sometimes outside of City boundaries, but are not owned or operated by the City. A major source of Scope 3 emissions are contracted services such as solid waste transport and disposal at landfills outside of the City. Mobile source emissions are generated from equipment and vehicles operated by contracted businesses performing these services for the City.

Solid waste generated within the City is transported by the City to transfer stations; these activities were included in the 2010 inventory. Wake County then transports the solid waste from the transfer stations to landfills owned and operated by Wake County. The GHG inventory described in this TM is comprised of the two primary sources of Scope 3 emissions from the City's solid waste that is disposed in Wake County landfills as described below.

Mobile Combustion Emissions

Mobile combustion emissions result from the combustion of fossil-fuels in transportation sources. For the solid waste transport to the Wake County landfills, GHG emissions are based on the total miles traveled and the amount of fuel used derived from the number of trips required to dispose of the total tons collected.

According to data provided by Wake County, the tractor trailers used for solid waste transport average a fuel economy of four (4) miles per gallon of diesel fuel used, and hold an average of 22 tons of solid waste per trip. The estimated round-trip mileage of the tractor trailers to and from the landfill is 52 miles per trip. The number of trips was estimated by dividing the total tons of solid waste disposed by the tons per trip. To determine the total miles traveled, the number of estimated trips was multiplied by the estimated miles to the landfill. Total fuel usage was estimated by dividing the miles traveled by the fuel economy. The resulting GHG emissions based on miles traveled and fuel usage are shown in **Exhibit 5**.

EXHIBIT 5

Baseline Year 2007 and Year 2010 GHG Emissions for Mobile Combustion Sources for Solid Waste Transport by Wake County

Year	Amount Solid Waste Landfilled (Tons)	Solid Waste Transported/ Trip (Tons)	Number of Trips	Miles/ Trip	Total Miles Traveled	Fuel Usage at 4 miles/gal (Gal)	Total Mobile Combustion CO ₂ -eq (tonne/yr) ^(a)
2007 (Baseline)	85,090	22	3,870	52	201,123	50,280	511
2010	85,510	22	3,890	52	202,116	50,530	513
Percent Increase	0.5%	-	0.5%	-	0.5%	0.5%	0.4%

^(a) Tonne = metric ton

Solid Waste Decomposition-Related Emissions

The emissions resulting from the decomposition of solid waste in landfills are included in this Scope 3 GHG emissions inventory. The following data – provided by the City of Raleigh Solid Waste Services personnel and the Wake County Solid Waste Management personnel – were used to calculate the GHG emissions for solid waste disposal:

- Types of material collected
- Total volume or weight collected, by material type
- Method of disposal, by material type

The resulting GHG emissions from solid waste disposal are shown in **Exhibit 6**.

EXHIBIT 6

Baseline Year 2007 and 2010 GHG Emissions for Decomposition of City of Raleigh Solid Waste Disposed in Wake County Landfills

Year	Total Waste Landfilled, Recycled, and Composted from Exhibit 4 (tons)	Total Waste Landfilled from Exhibit 4 (tons) ^(a)	Total Solid Waste Decomposition CO ₂ -eq (tonne/yr) ^(b)
2007 (Baseline)	140,890	85,090	80,230
2010	142,830	85,510	80,630
Percent Increase/Decrease	1.4%	0.5%	0.5%

(a) Composition as shown in Exhibit 3

(b) Tonne = metric ton

Conclusions and Considerations

Conclusions

Exhibit 7 shows the comparison between the 2007 and 2010 solid waste disposal GHG emissions for the City of Raleigh. It is important to note that while the overall increase in GHG emissions is less than 1%, the population of the City has increased by approximately 6.8% during the same period of time. Detailed calculations are included in Attachment 1.

EXHIBIT 7

Comparison of Baseline Year 2007 and Year 2010 GHG Emissions Inventory for City of Raleigh Solid Waste Disposed in Landfills Owned and Operated by Wake County

Year	Total Mobile Combustion CO ₂ -eq (tonne/year) ^(a)	Total Solid Waste Decomposition CO ₂ -eq (tonne/yr) ^(a)	Total Scope 3 Total CO ₂ -eq (tonne/year) ^(a)	City of Raleigh Population
2007 (Baseline)	511	80,230	80,741	378,180
2010	513	80,630	81,143	403,890
Percent Increase	0.4%	0.5%	0.5%	6.8%

(a) Tonne = metric ton

Considerations for Developing Future Inventories

In future inventories, the City could include materials disposed at private construction and demolition (C&D) landfills, as well as those materials recycled for reuse by entities such as the Habitat for Humanity. Note that with nearly 30 private recycling companies located within Wake County, gathering this information may be time consuming.

Attachment 1

GHG Emissions Quantification Tool Results

Mobile Combustion Sources

Enter Data into the Yellow Shaded Cells Only

Data	
Emission Factor/Constant	
Results	

Quantification Methodology: Emissions = Activity Data x Emission Factor x Conversion Factor
CO2 (tonnes/yr) = fuel usage gal/yr x CO2 kg/gal x tonne/1000 kg = tonne/yr OR veh. miles/yr x gal/mi x CO2 kg/gal x tonne/1000 kg = tonne/yr
CH4 and N2O (tonnes/yr) = veh. mile/yr x CH4/N2O g/mile x 1 tonne/1000000 g = tonne/yr OR fuel gal/yr x miles/gal x CH4/N2O g/mile x 1 tonne/1000000 g = tonne/yr

2007

Entity/Facility	Vehicle ID	Make	Model	Vehicle Description	Year	2007 Miles Traveled	2007 Fuel Usage	Units	Fuel Economy (miles/gal)	Data Source	Percent Equity (%)	Fuel Type	Vehicle Classification	CO2 Emission Factor	CO2 Emission Factor Units	CH4 Emission Factor	CH4 Emission Factor Units	N2O Emission Factor	N2O Emission Factor Units	CO2 tonne/yr	CH4 tonne/yr	N2O tonne/yr	Total CO2-eq (tonne/year)	
Contracted Services																								
COR				Trailors going to landfill	2007	201,123.47	50,280.87	Gallon	4.0	Wake County	100	Diesel Fuel No.1 and 2	Diesel Heavy-Duty Vehicles (All Model Years)	10.15	kg/gallon	0.0051	g/mile	0.0048	g/mile	5.10E+02	1.03E-03	9.65E-04	510.67	
					Total	201,123.47	50,280.87	Gallons												Total	510.35	1.03E-03	9.65E-04	510.67

2010

COR				Trailors going to landfill	2010	202,116.44	50,529.11	Gallon	4.0	Wake County	100	Diesel Fuel No.1 and 2	Diesel Heavy-Duty Vehicles (All Model Years)	10.15	kg/gallon	0.0051	g/mile	0.0048	g/mile	5.13E+02	1.03E-03	9.70E-04	513.19
					Total	202,116.44	50,529.11	Gallons											Total	512.87	1.03E-03	9.70E-04	513.19

Indirect Emissions - Municipal Solid Waste Exports to External Landfill

Enter Data into the Yellow Shaded Cells Only

Data	
Emission Factor/Constant	
Results	

Quantification Methodology: Emissions = Activity Data x Emission Factor

CO2, CH4, and N2O (tonnes/yr) = Tons/yr x tonnes/tons = tonne/yr

Landfilled/Incinerated/Composted

2007

2007						CO2 Emission Factors			CH4 Emission Factors			N2O Emission Factor					
Entity	Description	Material	Quantity to Landfill (tons)	Quantity to Incinerator (tons)	Quantity Composted (tons)	Landfill (tonne/ton)	Incinerator (tonne/ton)	Composting (tonne/ton)	Landfill (tonne/ton)	Incinerator (tonne/ton)	Composting (tonne/ton)	Incinerator (tonne/ton)	Biogenic CO2 (tonne/yr)	CH4 (tonne/yr)	N2O (tonne/yr)	Total CO2-eq (tonne/yr)	
COR	From Wake County 2007 calender year data	Mixed MSW	85,091.00	0.00	0.00	0.3437	0.1867	0.0000	0.0449	0.0001	0.0000	0.0001	29,245.78	3,820.59	0.0000	80,232.30	
		Total	85,091	tons									Total	29,245.78	3,820.59	0.0000	80,232.30

NOTE: Biogenic emissions of CO₂ are not included in the total CO₂-eq.

2010

2010						CO2 Emission Factors			CH4 Emission Factors			N2O Emission Factor				
Entity	Description	Material	Quantity to Landfill (tons)	Quantity to Incinerator (tons)	Quantity Composted (tons)	Landfill (tonne/ton)	Incinerator (tonne/ton)	Composting (tonne/ton)	Landfill (tonne/ton)	Incinerator (tonne/ton)	Composting (tonne/ton)	Incinerator (tonne/ton)	Biogenic CO2 (tonne/yr)	CH4 (tonne/yr)	N2O (tonne/yr)	Total CO2-eq (tonne/yr)
COR	From Wake County 2010 calendar year data	Mixed MSW	85,511.00	0.00	0.00	0.3437	0.1867	0.0000	0.0449	0.0001	0.0000	0.0001	29,390.13	3,839.44	0.0000	80,628.32
		Total	85,511	tons								Total	29,390.13	3,839.44	0.0000	80,628.32

NOTE: Biogenic emissions of CO₂ are not included in the total CO₂-eq.

Indirect Emissions - Municipal Solid Waste Exports to External Landfill

Enter Data into the Yellow Shaded Cells Only

Data

Emission Factor/Constant

Results

Quantification Methodology: Emissions = Activity Data x Emission Factor

CO2, CH4, and N2O (tonnes/yr) = Tons/yr x tonnes/tons = tonne/yr

Recycled

Wastes Characterization																				
	FY07									FY10										
Material	Qty Generated (lbs or tons)	Qty Recycled (lbs or tons)	Percent Recycled (%)	Qty Landfilled (lbs or tons)	Percent Landfilled (%)	Qty Incinerated (lbs or tons)	Percent Incinerated (%)	Qty Composted (lbs or tons)	Percent Composted (%)	Qty Generated (lbs or tons)	Qty Recycled (lbs or tons)	Percent Recycled (%)	Qty Landfilled (lbs or tons)	Percent Landfilled (%)	Qty Incinerated (lbs or tons)	Percent Incinerated (%)	Qty Composted (lbs or tons)	Percent Composted (%)		
Aluminum Cans		217									214									
Steel Cans		397									411									
Glass		3,755									3,832									
HDPE		235									247									
LDPE																				
PET		353									371									
Corrugated Cardboard		4,256									4,896									
Magazines/Third-class Mail		237									250									
Newspaper		11,500									12,128									
Office Paper																				
Phonebooks											13									
Textbooks																				
Shred/Recycle Events											21									
Medium-density Fiberboard		6									-									
Food Scraps																				
Yard Trimmings		28,612									28,612									
Grass																				
Leaves		6,041									6,041									
Branches																				
Mixed Paper (general)		5									-									
Mixed Paper (primarily residential)		119									125									
Mixed Paper (primarily from offices)																				
Mixed Metals		33									58									
Mixed Plastics																				
Mixed Recyclables																				
Mixed Organics																				
Mixed MSW *		85,091									85,511									
Other Metal		34									11									
Electronics		5									94									
Total (recycled and composted)		55,805									57,323									
Total waste generated		140,896									142,834									
Diversion Ratio		39.61%									40.13%									

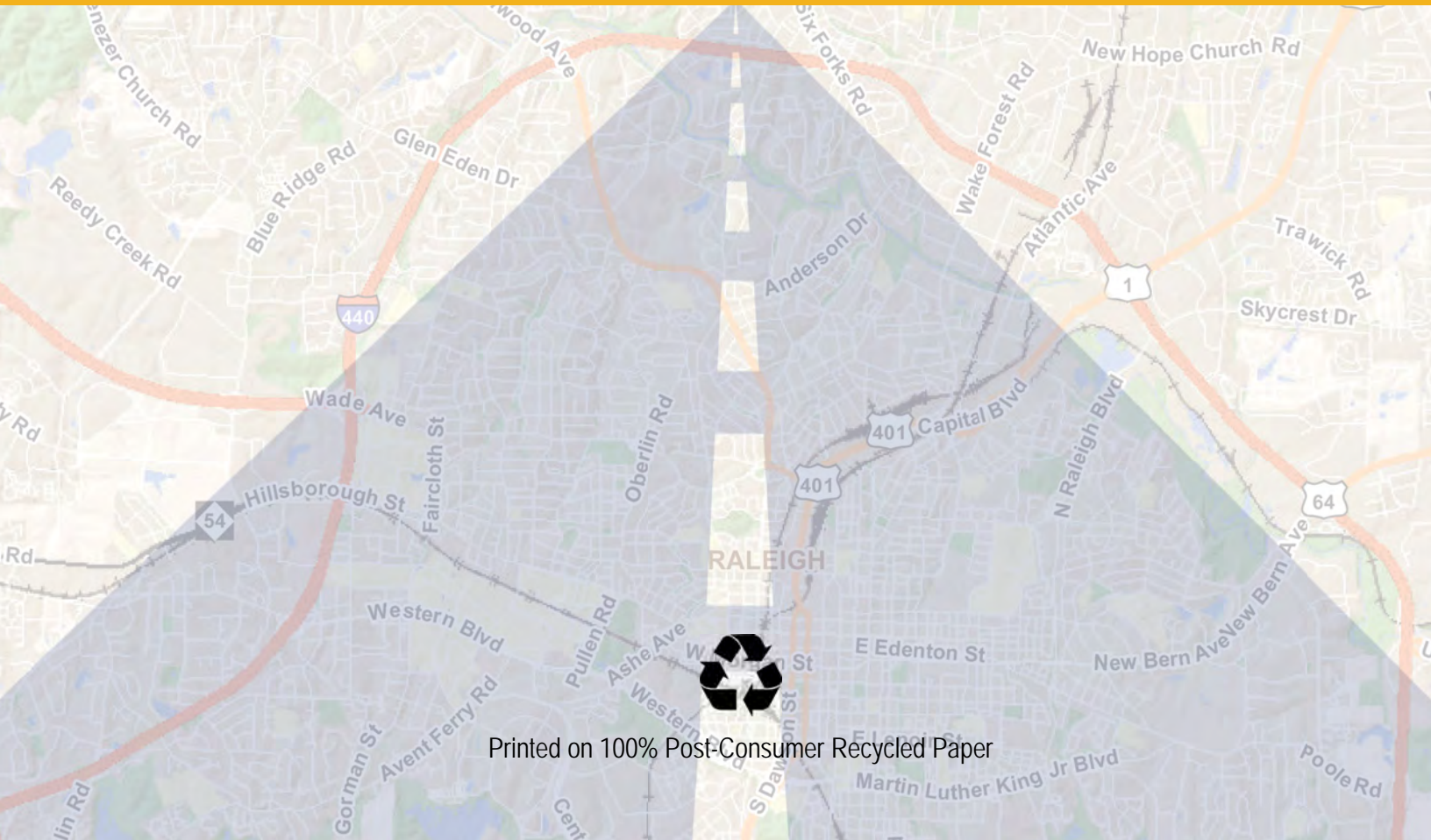
Indirect Emissions - Municipal Solid Waste Exports to External Landfill

Enter Data into the Yellow Shaded Cells Only
Data
Emission Factor/Constant
Results
Quantification Methodology: Emissions = Activity Data x Emission Factor
CO2, CH4, and N2O (tonnes/yr) = Tons/yr x tonnes/tons = tonne/yr

Recyclable Details:

PROGRAM

	FY07					FY10					
	CURBSIDE	DROP-OFF	INHOUSE	TOTAL	check	CURBSIDE	DROP-OFF	INHOUSE	OTHER	TOTAL	check
	& MF TONS	TONS	TONS	TONS		& MF TONS	TONS	TONS		TONS	
GLASS											
Clear	1362.04	213.73	na	1,576	1,576	1499.48	112.93	na		1,612	1,612
Brown	1342.67	196.31	na	1,539	1,539	1478.16	103.73	na		1,582	1,582
Green/Blue	522.87	117.68	na	641	641	575.63	62.18	na		638	638
Total	3227.57	527.72		3,755	3,755	3553.28	278.85			3,832	3,832
PLASTIC											
PETE #1	301.12	51.78	na	353	353	336.63	34.25	na		371	371
HDPE #2	200.75	34.52	na	235	235	224.42	22.84	na		247	247
Total	501.86	86.31		588	588	561.04	57.09			618	618
METAL											
Aluminum cans	174.77	42.43	0.00	217	217	187.01	26.51	-		214	214
Steel cans	338.20	58.33	na	397	397	374.03	36.47	na		411	411
*White Goods	32.83	na	na	33	33	57.67	na	na		58	58
Other metal	na	na	33.50	34	34	na	na	11.11		11.11	11
Total	545.80	100.76	33.50	680	680	618.71	62.98	11.11		692.79	693
PAPER											
ONP	10380.59	1119.82	na	11,500	11,500	11428.46	699.74	na		12,128	12,128
OCC	1,878.41	2203.33	174.59	4,256	4,256	2,244.17	2526.53	124.80		4,896	4,896
Paperboard/SBS	na	6.21	-	6	6	-	-	-		-	0
OMG	214.03	23.09	na	237	237	235.64	14.43	na		250	250
White Office	107.02	11.54	na	119	119	117.82	7.21	na		125	125
Mixed paper	na	na	5.23	5	5	na	na	0.00		0	0
Shred/Recycle Events							12.88			13	13
Ann'l Phone Books							21.12			21	21
Total	12580.05	3363.99	179.82	16,124	16,124	14026.09	3281.91	124.80		17,399	17,433
OTHER											
Alkaline Batteries						-	-	-	8	8	8
*Electronics	4.37	na	na	4	4	-	na	na	86	86.38	86
Cartridges, Cell Phones & Accessories	na	0.65	na	1	1	na	-	na	-	-	0
Total	4.37	0.65	-	5	5	-	-	-	94.34	94.34	94
TOTAL TONS:	16859.66	4079.43	213.32	21,152	21,152	18759.12	3680.82	135.91	94	22,636	22,670



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