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Chapter 2

GREENHOUSE GAS EMISSIONS MODELING: A TOOL FOR FEDERAL FACILITY DECOMMISSIONING

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ABSTRACT

The Federal Aviation Administration (FAA) facility inventory is constantly changing as newer systems supplant older infrastructure in response to technological advances. Transformational change embodied by the FAA's Next Generation Air Transportation System (NextGen) will affect the replacement of thousands of ground-based air traffic control systems with satellite-based systems by 2025. NextGen alone will drive a massive facility decommissioning effort with the potential for major environmental impacts from demolition and disposal activities, including emissions of greenhouse gases (GHGs), criteria pollutants, and air toxics, erosion, runoff, noise, generation of solid waste, and the migration of contamination associated with historic releases of hazardous waste, fuel constituents, and hazardous building materials. The FAA and other federal agencies need effective environmental impact assessment tools to design mitigation strategies and ensure compliance with regulatory and policy drivers, including Executive Order (EO) 13514 Federal Leadership in Environmental, Energy, and Economic Performance, which establishes integrated strategies towards sustainability and greenhouse gas emissions reductions in the Federal Government. In this study we develop a model to facilitate the quantitative analysis of comprehensive GHG emissions inventories from demolition debris reuse, recycling, and disposal activities that accounts for scope 1, scope 2, and scope 3 emissions as defined by EO 13514. The results of the model are used to inform a trade-off analysis that compares the relative impacts of debris management alternatives. Data from the decommissioning of an air traffic control tower and an air route surveillance radar facility are used as case studies to refine and validate the model, which could be used as a tool to guide future

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decommissioning efforts at Federal facilities and to provide input to FAA's agency-wide GHG emissions inventory.

Keywords: greenhouse gas emissions, green house inventory, federal facilities, decommissioning, disposal, demolition

1. INTRODUCTION

The Federal Aviation Administration (FAA) facility inventory is constantly changing as newer systems supplant older infrastructure in response to technological advances. Transformational change embodied by the FAA's Next Generation Air Transportation System (NextGen) will necessitate the replacement of thousands of ground-based air traffic control systems with satellite-based systems by 2025. NextGen alone will drive a massive facility decommissioning effort with the potential for major environmental impacts from demolition and disposal activities, including emissions of greenhouse gases (GHGs), criteria pollutants, and air toxics, erosion, runoff, noise, generation of solid waste, and the migration of contamination associated with historic releases of hazardous waste, fuel constituents, and hazardous building materials.

In the United States, the federal government has focused considerable recent attention towards addressing GHG emissions. On December 7, 2009, the United States Environmental Protection Agency (EPA) Administrator Lisa Jackson signed a final action, under Section 202(a) of the Clean Air Act, finding that greenhouse gases constitute a threat to public health and welfare, and that the combined emissions cause and contribute to the climate change problem. If greenhouse gases continue to increase, climate models predict that the average temperature at the Earth's surface could increase from 3.2 to 7.2 ºF (1.8 to 4.0 C) above 1990 levels by the end of this century (EPA, 2010) with negative impacts to the biosphere. President Barack Obama signed Executive Order (EO) 13514, also in 2009, mandating federal agencies inventory and establish reduction goals for GHG. EO 13514 requires the federal government to report on GHG emissions directly linked to facility and vehicle fleet operation in what are known as scope 1 (direct fossil fuel combustion) and scope 2 (facility energy consumption via off-site fossil fuel combustion, e.g. electricity) sources. In addition, the executive order creates the first requirement in any nation to account for and set reduction targets for all other indirect sources of GHG, known as scope 3 emissions.

Currently, only scope 3 emissions related to Federal employee commuting, business travel, energy transmission and distribution losses, waste water, and solid waste are included in the federal inventory. Section 2(b)(i) of EO 13514 states that federal agencies shall consider reductions associated with "pursuing opportunities with vendors and contractors to address and incorporate incentives to reduce GHG…" It is anticipated, that remediation and deconstruction projects will fall under this requirement as GHG related regulatory updates are promulgated. The research team retro-actively calculated GHG emissions as a potential guidance approach for future scope 3 accounting and reduction opportunities related to site demolition projects.

In this study we develop a model to facilitate the quantitative analysis of comprehensive GHG emissions inventories from demolition debris reuse, recycling, and disposal activities that accounts for scope 1, scope 2, and scope 3 emissions as defined by EO 13514. The model is used to inform a trade-off analysis that compares the relative impacts of debris management alternatives using data from the decommissioning of two FAA facilities as case studies to refine and validate the model: the St. Albans Air Route Surveillance Radar (ARSR) facility (St. Albans, Vermont) and the former North Las Vegas Airport Air Traffic Control Tower (ATCT) located in Las Vegas, Nevada.

1.1 St. Albans ARSR Site

In 1951, the United States Air Force (USAF) constructed the St. Albans Air Force Station as part of the Defense Early Warning System. During early operations, the USAF maintained an array of radar towers and extensive support facilities. With gradual improvements in radar technology and the Department of Defense (DoD) movement towards satellite-based tracking systems, radar operations were consolidated into smaller facilities and transitioned to the FAA in 1976 for use in tracking commercial aircraft within the National Airspace System (NAS). In 1979, the USAF departed from the installation, which was subdivided and transferred to the FAA and other parties. Beginning in 1991, the USAF, FAA, and others have been actively engaged in a variety of decommissioning-related activities, including site investigation and remediation to address legacy environmental contamination, removal and closure of fuel storage tanks, abatement of hazardous building materials, and the demolition and disposition of abandoned buildings and other infrastructure. In 2001, the FAA completed extensive decommissioning actions on its property (now known as the St. Albans ARSR site), including the demolition and disposal of a 16,159 ft^2 (1,500 m^2) concrete, steel-reinforced former Operations Building and two abandoned concrete radome foundations; data from this effort serve as our first case study. Demolition debris generated from this action included concrete and masonry that was crushed and reused onsite, asphalt, steel scrap, and non-ferrous metal shipped offsite for recycling, and construction debris, including wood, drywall, fasteners, lighting fixtures, fiberglass insulation, and other building materials disposed of at an offsite landfill. The duration of the demolition activities at the site was approximately 61 work days.

1.2 Former North Las Vegas Airport ATCT

In 2000, the FAA constructed a new ATCT at the North Las Vegas Airport, abandoning the original tower that was built in 1976 on land leased from the Clark County Department of Aviation (DOA). The FAA relinquished use of the property back to the DOA, but was required to remove demolish and dispose of the ATCT and other onsite infrastructure. The abandoned ATCT site was approximately 6,000 ft^2 (557 m^2) in size and included an eight story steel-frame control tower, an airport vault building, a pad-mounted transformer, and a paved parking area. Intermediate floors within the ATCT included offices and equipment rooms, with the 8th floor being the tower cab. The ATCT also included an elevator, with its motor and associated equipment located on the 1st floor. Following the abatement of asbestos and other hazardous materials and removal and disposal of building contents and furnishings, the abandoned ATCT was demolished and the concrete slab removed. Demolition debris included scrap metal and steel that was recycled offsite and construction debris that was disposed of at an offsite landfill. The demolition activities were completed in 2007 and the total duration of the effort was approximately 20 work days.

2. METHODS

Where possible, the model input data for the case studies were obtained directly from project record documents prepared by the vendors who performed the demolition work at each site. As discussed below, where data were not available, reasonable estimates were made to facilitate the GHG emissions analysis based on information from project planning documents, photographic records, interviews and the professional judgment of two of the coauthors who oversaw the demolition work in the field. Input data incorporated into the model was organized under scopes 1, 2, and 3 as shown in Table 1 and includes the following:

- Scope 1: Equipment used onsite, estimated percent equipment operating time, and its estimated average fuel consumption per hour.
- Scope 2: The area of facilities undergoing demolition
- Scope 3: The type and mass of demolition debris generated and its method of disposal and estimates of the distance traveled (business travel) in support to support the project.

*Table 1***.** GHG Model Input Data

St. Albans ARSR		
Scope 1		
Equipment (fuel type), Operating Time	**Avgerage Fuel Combustion/hour**	
	(gallons)	**(liters)**
Concrete Crushing (Diesel), 20%	9.91	37.51
Excavator / shear (Diesel), 20%	9.45	35.77
Excavator / universal processor(Diesel), 80%	9.45	35.77
Dozer D4 (Diesel), 100%	4.83	18.28
Excavator with bucket (Diesel), 100%	9.45	35.77
Loader track 2.5 (Diesel), 100%	2.66	10.05
Pick up 100% (Gas), 100%	1.23	4.66
Generator 100% (Gas), 100%	0.75	2.84
Scope 2		
Facilities	**Area**	
	ft^2	**m^2**
1020, 935, 925	16159	1501.22
Scope 3		
Demolition Debris Type	**Quanitity (Metric Tons)**	**Disposal Method**
Concrete	9183.67	On Site
Asphalt	56.7	Recycle
Lumber	65.05	Landfill
Clay	7.53	Landfill
Fiber Board	48.08	Landfill
Glass	35.47	Landfill
Paper	24.77	Landfill
Steel (landfill)	18.23	Landfill
Metal (recycled)	113.4	Recycle
Business Travel	**miles**	**km**
Air transport	3504	5639.14
Ground Transport	4544	7312.86

N. Las Vegas ATCT		
Scope 1		
Equipment (fuel type), Operating Time	**Avgerage Fuel Combustion/hour**	
	(gallons)	**(liters)**
120-Ton Crane (Diesel), 10%	12	45.42
Front loader/Backhoe John Deere 710 (Diesel), 25%	2.65	10.03
2 Small bobcat loaders (Diesel), 100%	5.31	20.1
Cat 966F (Diesel), 5%	3.55	13.44
Ten-wheeled truck (Diesel) 10%	1.7	6.44
2 JLG Variable reach Man-lift (diesel), 100%	1.96	7.42
Scope 2		
Facilities	**Area**	
	ft^2	**m^2**
ATCT	6000	557.42
Scope 3		
Demolition Debris	**Quanitity (Metric Tons)**	**Disposal Method**
Scrap Metal (mixed)	15.81	Recycled
Scrap Steel	24.49	Recycled
Lumber	1.72	Landfill
Fiberboard	2.3	Landfill
Paper	0.57	Landfill
Glass	2.3	Landfill
Mixed MSW	16.03	Landfill
Refrigerant	0.02	Recycled
Business Travel	**miles**	**km**
Air transport	9756	15700.76
Ground transport	3180	5117.7

To estimate scope 1 emissions we used an EPA method for calculating carbon dioxide (CO_2) emissions per volume of fuel consumed by the construction equipment used during demolition activities at each site (EPA Office of Transportation and Air Quality, 2005). The EPA method incorporates an oxidation factor of 0.99 as recommended by the Intergovernmental Panel on Climate Change (IPCC) in its guidelines for calculating emissions inventories (i.e., 99 percent of the carbon in the fuel is eventually oxidized, while 1 percent remains un-oxidized). Two separate CO_2 emissions values are given in the EPA method based on whether the fuel source is diesel or gasoline, with the combustion of diesel fuel generating greater CO_2 emissions than an equivalent volume of gasoline based on the higher carbon content of diesel (2,778 grams) compared to gasoline (2,421 grams) used by EPA (US Government Printing Office, 2007). The CO_2 emissions calculations also incorporate a multiplier (ratio of the molecular weight of CO_2 to the molecular weight of carbon (44/12)) to convert carbon to CO_2 equivalent.

CO_2 emissions from a gallon of gasoline:

= 2,421 grams carbon/gallon gasoline x 0.99 x (44/12)
= 8.8 kg CO_2/gallon gasoline
= 19.4 pounds CO_2/gallon gasoline

CO_2 emissions from a gallon of diesel:

= 2,778 grams carbon/gallon diesel x 0.99 x (44/12)
= 10.1 kg CO_2 /gallon diesel
= 22.2 pounds CO_2/gallon diesel

The actual volume of fuel used during the execution of each project was not recorded and had to be estimated. Since an inventory of equipment actually used during the demolition work at each site was not available, the equipment included in Table 1 was estimated from cost estimates and project work plans that were prepared in advance of the work, which identified proposed construction equipment (Marcor Remediation Inc, 2000, 2001, MWH Americas Inc 2006). The percentage of the time each piece of equipment was in operation at each site was also estimated and is included in Table 1 to the right of the equipment description. The type of fuel (diesel or gasoline) and an average volume of fuel consumption per hour of operating time were determined or estimated based on equipment manufacturer's published data. An eight hour work day was assumed for each site for the duration of each project: 61 work days for the St. Albans ARSR site and 20 work days for the N. Las Vegas ATCT site.

Scope 2 emissions were estimated using EPA's Emissions & Generation Resource Integrated Database (eGRID), a comprehensive inventory of environmental attributes of electric power systems. eGRID is based on available plant-specific data for all U.S. electricity generating plants that provide power to the electric grid and report data to the U.S. government and integrates many different federal data sources on power plants and power companies, from three different federal agencies: EPA, the Energy Information Administration (EIA), and the Federal Energy Regulatory Commission (FERC). Emissions data from EPA are carefully integrated with generation data from EIA to produce useful values such as mass of CO_2 emissions per megawatt-hour of electricity usage. Each region and sub-region has a corresponding mix of GHG emissions based on the range of different types of power plants (e.g. nuclear, coal-fired, hydro-power, etc.). For this study, we used the EPA's web-based eGRID interface to tailor the electricity-related GHG emissions to each project's geographic region. Project total building area and/or project area, area code, and total project duration were inputted into eGRID and the tool calculated the regional GHGs associated with each project. The total area of buildings undergoing demolition was used for the St. Albans site, while the total project site area was used at the N. Las Vegas site (because it was a very compact site and the total building area was not available). eGRID estimates electricity generation based on an average commercial building of the size entered into the tool. It is recognized that the ARSR and ATCT facilities are not average commercial buildings and the overall approach is expected to overestimate the electricity usage at both sites neither facility was fully active for the project duration.

Scope 3 GHG emissions estimates incorporate the embodied energy in the waste generated from demolition activities as well as business travel to and from the project sites. EPA has derived GHG emissions factors for a variety of waste materials from life-cycle analysis work, which can be applied as multipliers to estimate GHG emissions based on metric tons of waste generated and the method of disposal (EPA, 2006, EPA, 2003). Our case study source data included project close-out reports that documented types and quantities (either volume of mass) of demolition debris that was generated at each site and whether that debris was reused, recycled, or disposed of at an offsite landfill (Marcor Remediation Inc, 2002, MWH Americas Inc, 2007). Conversion of waste volumes to mass was based on average density factors found in common estimating guides (Spradlin, 1986). For the St. Albans ARSR site, four general categories of demolition debris were reported: concrete and masonry (reused onsite), asphalt (offsite recycle), construction debris (offsite landfill), and scrap metal (offsite recycle). Four general categories of demolition debris were also reported for the N. Las Vegas ATCT site and included refrigerants (offsite recycle), scrap tin (offsite recycle), scrap steel (offsite recycle), and other inert construction and demolition waste (offsite landfill). Where necessary to facilitate use of EPA's GHG emissions factors, which are listed for more specific categories of waste, the general categories of debris generated at each site were further subdivided into more

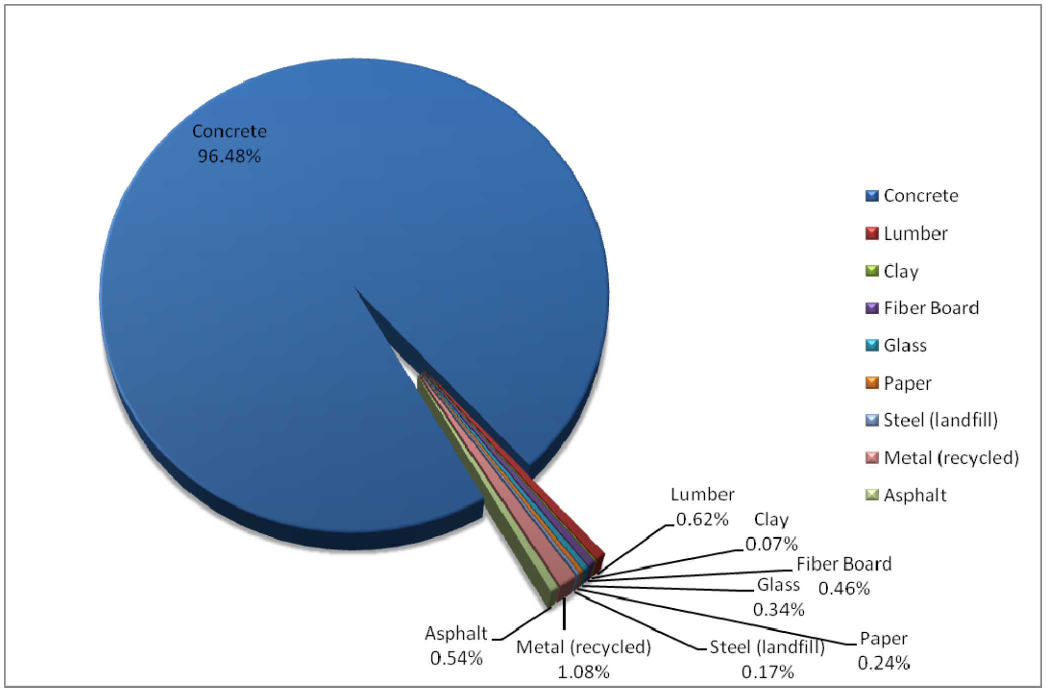

Figure 1a. Waste composition at the St. Albans ARSR site

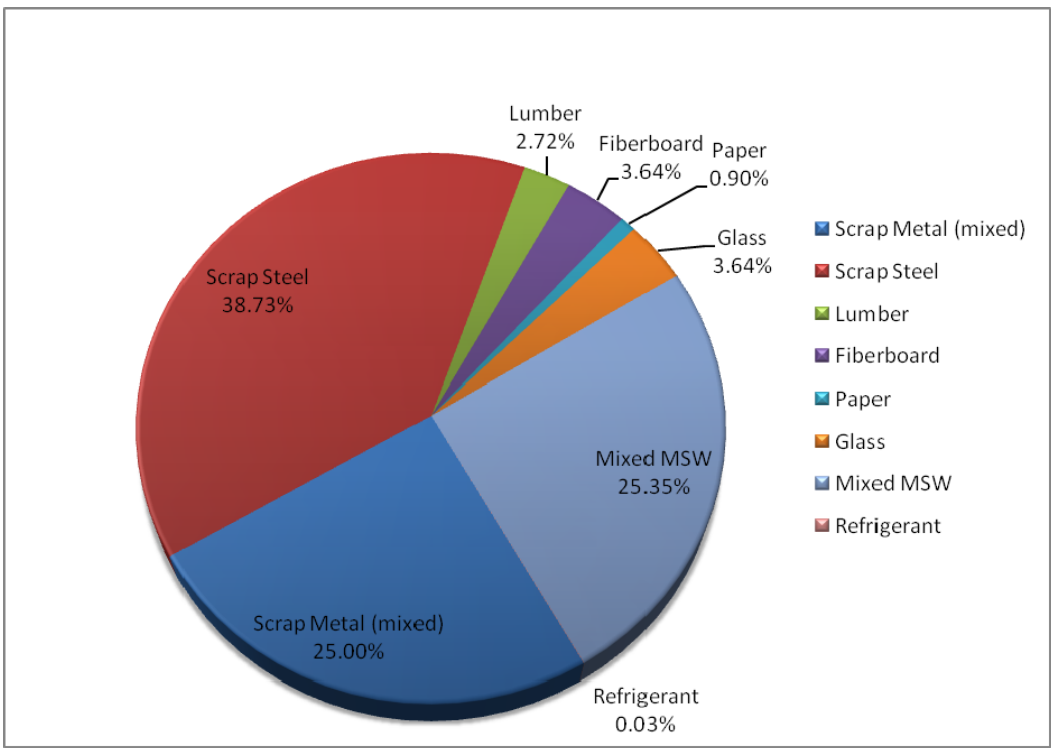

Figure 1b. Waste composition at the N. Las Vegas site

specific categories listed in Table 1 (and shown graphically in figures 1a and 1b) based on percentage distributions deemed reasonable for the purpose of this exercise.

GHG emissions for business travel were estimated using the Greenhouse Gas Protocol Initiative's Mobile Combustion GHG Emissions Calculation Tool, which calculates metric tons of CO_2 equivalent GHG emissions from distance traveled (Greenhouse Gas Protocol Institute, 2010). Since business travel data were not available, the distance traveled to and from the site by air or ground transport was estimated based on estimates of the composition and location of the work crews and work schedules based on input from the coauthors who oversaw field work at the sites (Table 1).

To help understand the relative impacts on GHG emissions of reuse and recycling that was performed at each site (the *actual scenario*), we evaluated an *alternate scenario*, under which all of the demolition debris generated at each site was assumed to have been landfilled. As such, the two scenarios differed only in the scope 3 emissions relating to the embodied energy in the waste generated, and the quantity of GHG related to waste transport avoided through reuse and/or recycling.

3. RESULTS AND DISCUSSION

Total GHG emissions estimates and the distribution among scopes 1, 2, and 3 for each case study are shown in Table 2 and displayed in Figure 2. The total estimated GHG emissions calculated for the St. Albans ARSR site (actual scenario) was 720.02 metric tons (MT), with the largest share 529.73 MT (73.6 %) of the total emissions attributable to scope 3, 175.73 MT (24.4 %) for scope 1, and 14.56 MT (2.0 %) for scope 2. The total estimated GHG emissions for the St. Albans alternate scenario (all demolition-generated debris landfilled) was 2,510.74 MT, 1,790.62 MT greater than the estimated GHG emissions for the actual scenario. This difference represents the estimated GHG emissions avoided by incorporating reuse and recycling into the project. For the alternate St. Albans scenario, the magnitudes of the scope 1 and scope 2 emissions are the same as the actual scenario, but their share of the total emissions is less; 175.73 MT (7.0 %) for scope 1 and 14.56 (0.6 %), with scope 3 emissions under the alternate scenario responsible for 2,320.44 MT (92.4 %).

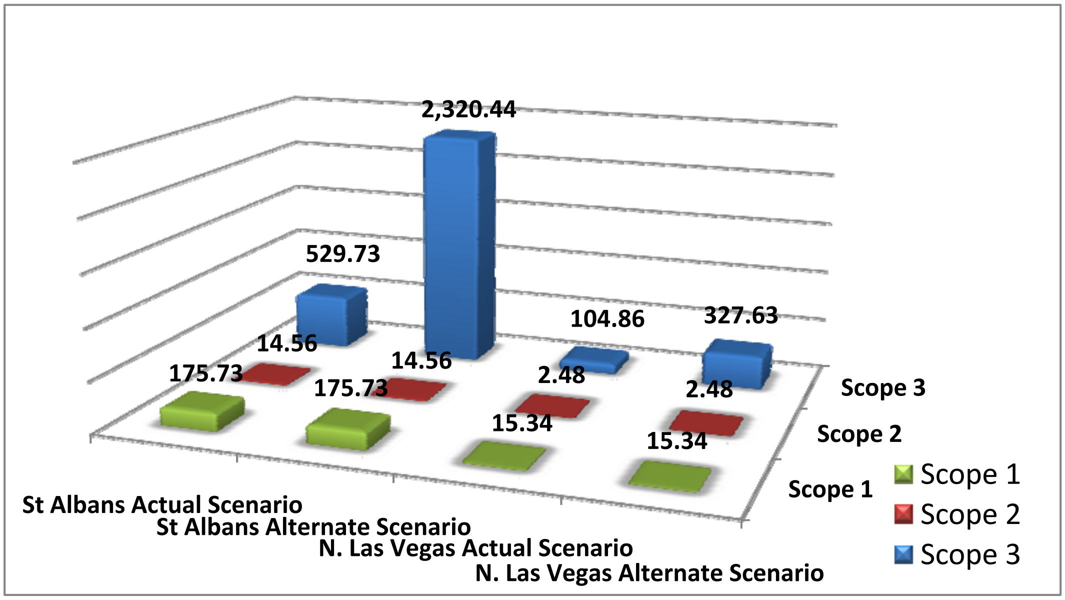

Figure 2. Comparison of greenhouse gas emissions estimates (metric tons)

The total estimated GHG emissions calculated for the N. Las Vegas ATCT (actual scenario) was 122.68 MT; 15.34 MT (12.5 %) for scope 1, 2.48 MT (2.0 %) for scope 2, and 104.86 MT (85.5 %) for scope 3. The total estimated GHG emissions for the N. Las Vegas alternate scenario was 345.45 MT, representing 222.77 MT GHG emissions avoided by incorporating reuse and recycling. Similarly, under the alternate N. Las Vegas scenario, the magnitudes of the scope 1 and scope 2 emissions are the same as the actual scenario and their share of the total emissions is also less; 15.34 MT (4.4 %) for scope 1 and 2.48 (0.72 %) for scope 2, with scope 3 emissions under the alternate scenario responsible for 327.63 MT (94.8 %).

The percent contribution of each type of demolition debris to the total GHG emissions for the actual and alternate scenarios for the St. Albans ARSR site and the N. Las Vegas ATCT site are shown in Figures 3a and 3b, respectively. These figures show the relative importance debris reuse and recycling efforts, especially concrete reuse at the St. Albans site and refrigerant recycling at the N. Las Vegas site. Under the St. Albans actual scenario, the top contributors to GHG emissions are metals (recycled offsite, 46.7 %), lumber (landfilled, 26.8 %), and steel (landfilled, 13.9 %), while the GHG emissions under its alternate scenario (all demolition debris landfilled) is attributable to concrete and asphalt disposal (70.4 %) and metals (18.3 %) (figures 3a and 3b). And, under the actual scenario at N. Las Vegas, the top contributors to GHG emissions are scrap steel (38.7 %), scrap metal (25.0 %), and mixed municipal solid waste (MSW) (25.4 %), while the

Table 2. GHG Emissions Inventory

St. Albans ARSR						
	Actual Scenario - Direct Fossil Fuel Combustion			Alternate Scenario - Direct Fossil Fuel Combustion		
Scope 1	Fuel burned per day (diesel)	272.30 gallons	1030.75 liters	Fuel burned Per day (diesel)	272.30 gallons	1030.75 liters
	Fuel burned Per day (gas)	15.84 gallons	59.96 liters	Fuel burned Per day (gas)	15.84 gallons	59.96 liters
	Total GHG emissions per day		6352.27 lbs.	Total GHG emissions daily		6352.27 lbs.
	Total Scope 1 GHG Emissions (20 days)		**175.73 MT**	**Total Scope 1 GHG Emissions (20 days)**		**175.73 MT**
	Actual Scenario - Energy Consumption Via Off-Site Fossil Fuel Combustion			Alternate Scenario - Energy Consumption Via Off-Site Fossil Fuel Combustion		
	NO emitted	29.58 lbs.	13.42 kg	NO emitted	29.58 lbs.	13.42 kg
Scope 2	SO2 emitted	81.39 lbs.	36.92 kg	SO2 emitted	81.39 lbs.	36.92 kg
	CO2 emitted	32000.93 lbs.	14515.38 kg	CO2 emitted	32000.93 lbs.	14515.38 kg
	Total Scope 2 GHG Emissions		**14.56 MT**	**Total Scope 2 GHG Emissions**		**14.56 MT**
	Actual Scenario - Embodied Energy in Waste			Alternate Scenario - Embodied Energy in Waste		
	Total MTCE		143.29	Total MTCE		631.62
Scope 3	Total MTCO2E		525.43	Total in MTCO2E		2316.14
	Total GHG Lbs. for Waste		148,131.31	Total GHG Lbs. for Waste		192559.78
	Actual Scenario - Bussiness Travel			Alternate Scenario - Bussiness Travel		
	Total GHG Emission MTCO2E		4.35	Total GHG Emission MTCO2E		4.35
	Total Scope 3 GHG Emissions		**529.73 MT**	**Total Scope 3 GHG Emissions**		**2320.44 MT**
	Total GHG Emissions Actual Scenario		**720.02 MT**	**Total GHG Emissions Alternate Scenario (metric tons)**		**2510.74 MT**
Total	Scope 1 %:		24.41	Scope 1 %:		7.00
	Scope 2 %:		2.02	Scope 2 %:		0.58
	Scope 3 %:		73.57	Scope 3 %:		92.42

Table 2. GHG Emissions Inventory (con't)

	N. Las Vegas ATCT					
	Actual Scenario - Direct Fossil Fuel Combustion			Alternate Scenario - Direct Fossil Fuel Combustion		
Scope 1	Fuel burned per day (diesel)	76.18 gallons	288.37 liters	Fuel burned Per day (diesel)	76.18 gallons	288.37 liters
	Fuel burned Per day (gas)	0 gallons	0 liters	Fuel burned Per day (gas)	0 gallons	0 liters
	Total GHG emissions per day		1691.20 lbs.	Total GHG emissions daily		1691.20 lbs.
	Total Scope 1 GHG Emissions (20 days)		**15.34 MT**	**Total Scope 1 GHG Emissions (20 days)**		**15.34 MT**
	Actual Scenario - Energy Consumption Via Off-Site Fossil Fuel Combustion			Alternate Scenario - Energy Consumption Via Off-Site Fossil Fuel Combustion		
	NO emitted	8.77 lbs.	3.98 kg	NO emitted	8.77 lbs.	3.98 kg
Scope 2	SO2 emitted	4.49 lbs.	2.04 kg	SO2 emitted	4.49 lbs.	2.04 kg
	CO2 emitted	5447.84 lbs.	2471.1 kg	CO2 emitted	5447.84 lbs.	2471.1 kg
	Total Scope 2 GHG Emissions		**2.48 MT**	**Total Scope 2 GHG Emissions**		**2.48 MT**
	Actual Scenario - Embodied Energy in Waste			Alternate Scenario - Embodied Energy in Waste		
	Total MTCE		67.18	Total MTCE		631.62
Scope 3	Total MTCO2E		246.35	Total in MTCO2E		2316.14
	Total GHG Lbs. for Waste		148,131.31	Total GHG Lbs. for Waste		192559.78
	Actual Scenario - Bussiness Travel			Alternate Scenario - Bussiness Travel		
	Total GHG Emission MTCO2E		7.40	Total GHG Emission MTCO2E		7.40
	Total Scope 3 GHG Emissions		**104.86 MT**	**Total Scope 3 GHG Emissions**		**327.63 MT**
	Total GHG Emissions Actual Scenario		**122.68 MT**	**Total GHG Emissions Alternate Scenario**		**345.45 MT**
Total	Scope 1 %:		12.50	Scope 1 %:		4.44
	Scope 2 %:		2.02	Scope 2 %:		0.72
	Scope 3 %:		85.48	Scope 3 %:		94.84

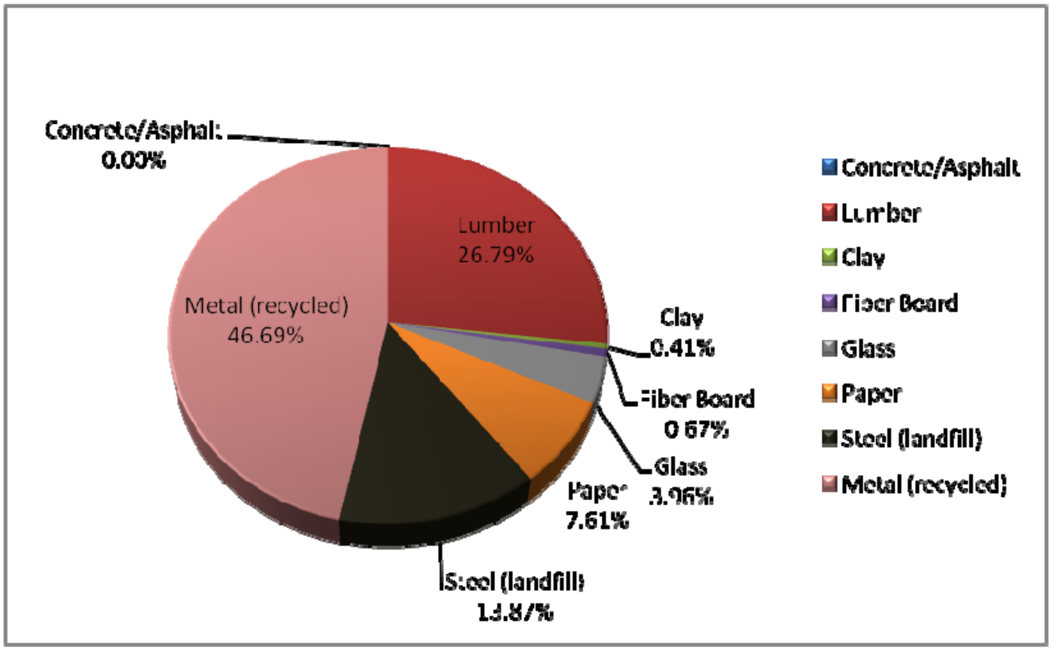

Figure 3a. Percent contribution to total GHG emissions by waste type– St. Albans actual scenario

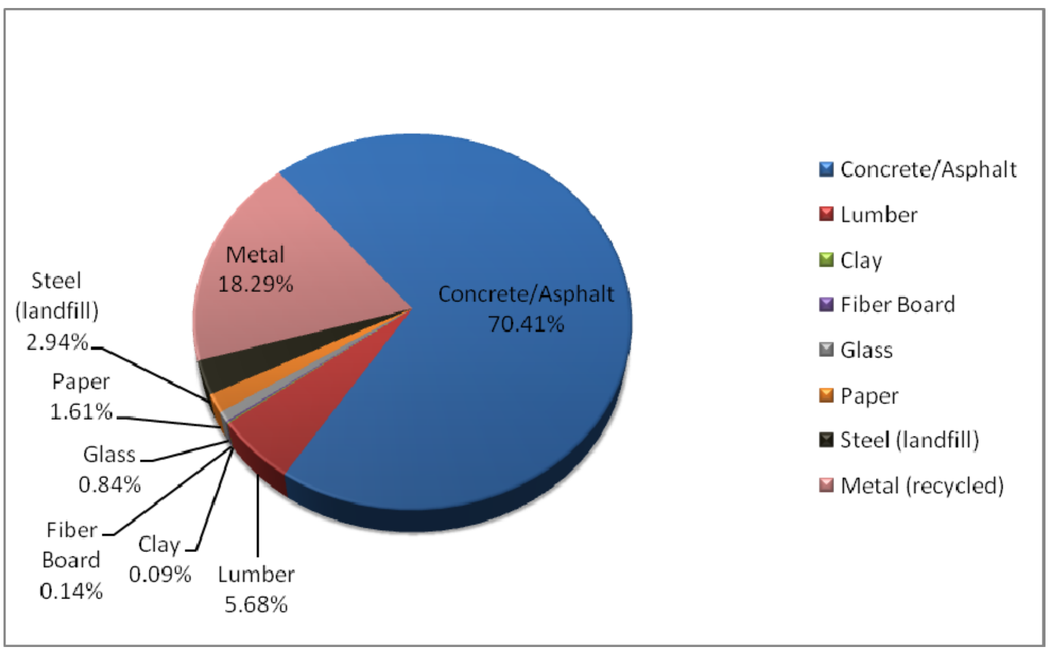

Figure 3b. Percent contribution to total GHG emissions by waste type– St. Albans alternate scenario

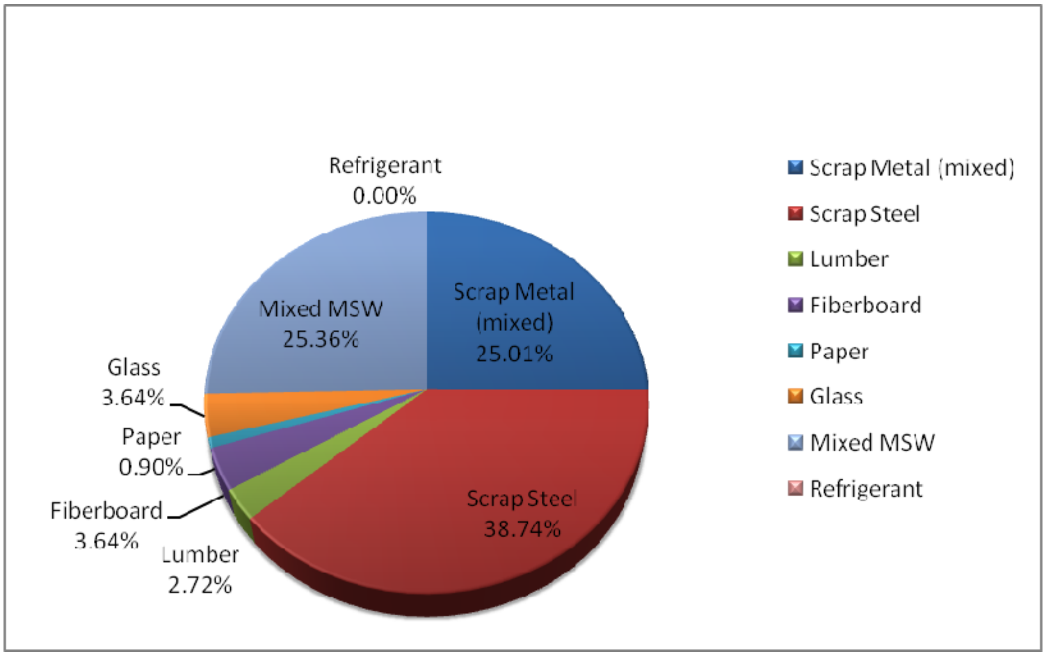

*Figure 4a. P*ercent contribution to total GHG emissions by waste type– N. Las Vegas actual scenario

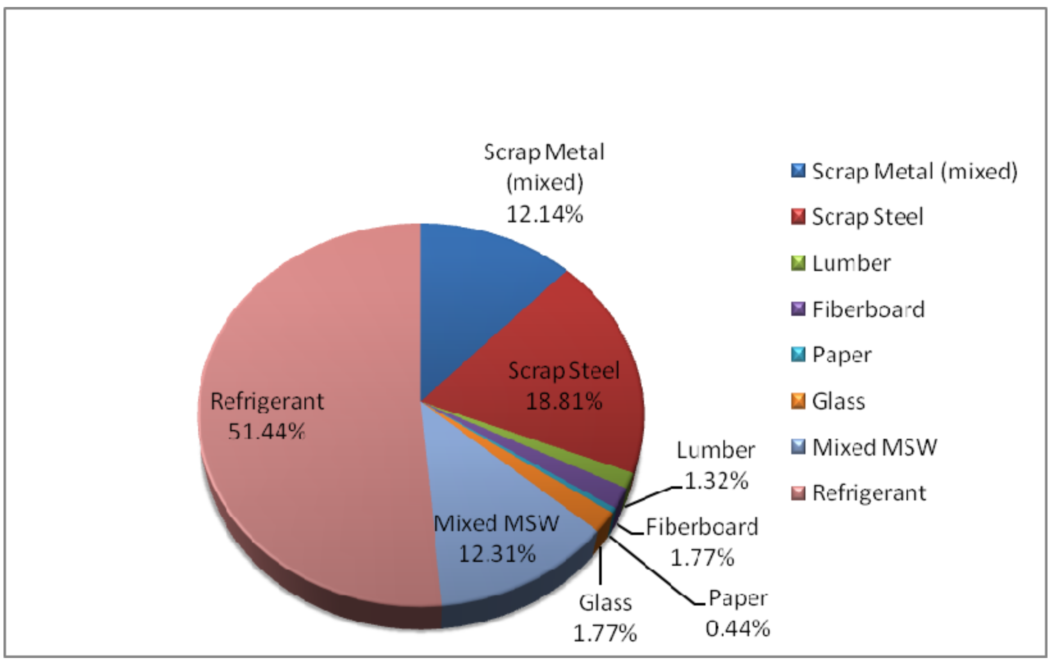

*Figure 4b. P*ercent contribution to total GHG emissions by waste type– N. Las Vegas alternate scenario

GHG emissions under the N. Las Vegas alternate scenario, is dominated by refrigerant (51.4 %) followed by scrap steel (18.8 %), mixed MSW (12.3 %), and scrap metal (12.1 %) (figures 4a and 4b). The significance of the impact of refrigerant recycling was surprising given that it comprises just 0.03 % of the total quantity of demolition debris generated.

4. CONCLUSIONS AND RECOMMENDATIONS

The largest share by far of the total GHG emissions estimates under all scenarios we evaluated was attributable to scope 3 emissions and driven primarily by the embodied energy in the waste generated from demolition activities. This suggests that for decommissioning projects involving demolition activities, a more comprehensive accounting of scope 3 GHG emissions may be warranted under future reporting updates that could be issued in association with EO 13514 mandates and could improve the ability of federal agencies such as the FAA to assess and mitigate the environmental impacts of major initiatives such as NextGen.

The comparison of actual scenarios to an alternate (all demolition debris landfilled) scenario suggests that there are significant opportunities for reducing GHG emissions through reuse and recycling. For many materials such as metals, recycling is commonplace due to market forces or is governed by regulation (e.g., refrigerants). However, we can see from our analysis that the consequences of overlooking such opportunities or requirements can be significant, even for a relatively small amount of material as would have been the case had refrigerants not been recovered at one of our case studies. For other materials, such as concrete and masonry debris, our analysis showed that there are tremendous additional opportunities for reducing GHG emissions through onsite reuse.

The accuracy of our analysis was limited by our reliance on a number of assumptions as discussed above where actual data was not available. However, as a first order approximation to understand the general impacts facility disposition activities could have on GHG emissions in the federal sector and to prepare agencies for more comprehensive GHG emissions accounting mandates that may arise in the future, the results of this study are instructive. For more accurate accounting, it is recommended that agencies maintain logs of onsite fuel consumption (scope 1), meter electrical usage (scope 2), and provide detailed accounting of commuting and business travel (scope 3) during project execution. Since the federal government typically hires contractors to perform demolition work, it is recommended that a GHG emissions analysis be incorporated as a technical evaluation factor when selecting contractors for award. Contractors would ideally provide both their GHG estimate and their calculation methodology. Fostering competition to minimize GHG emissions would likely help to accelerate the development of new and innovative emissions reduction strategies.

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