Bryant University

HONORS THESIS

# Driving Towards Lower Emissions: Analyzing the Vehicle Usage of the Campus Management Department at Bryant University

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## ABSTRACT

In response to growing concern over the harmful impacts created by climate change and global warming, in addition to Bryant University's current focus on sustainability initiatives, this research project focuses on aiding the University to become a more environmentally aware and responsible institution through an analysis of the vehicle usage of the Campus Management Department at Bryant University. To begin, this project sets forth the basic issues of climate change and global warming and summarizes the harmful effects brought about by these phenomena. This information then illustrates how broad changes in human behavior will be necessary to address the negative impacts, including all aspects of transportation and vehicle use. Data regarding the department's current vehicle use was obtained from Assistant Vice President of Campus Management, Brian Britton. The operating efficiency of the Department's vehicles was determined using ecological footprint and carbon footprint calculations derived from the vehicle inventory data. The results of these calculations showed that the Campus Management Department's vehicles operations, are contributing to the atmospheric pollution by emitting carbon dioxide and other harmful compounds; despite the fact that this contribution is rather minimal. However, the department currently has no policies or procedures in place that support sustainable vehicle usage. Therefore, it is suggested that the Campus Management Department initiate changes within its current operating policies and procedure in an attempt to lower its ecological and carbon footprints, thus lowering its contribution to climate change and global warming. Specific areas for future change are also highlighted. In conclusion, this project demonstrates how small actions by an institution can create magnified results for the environment. Furthermore, this paper also argues that these small changes have the potential to encourage other universities and colleges to evaluate their current operations and implement more sustainable activities, resulting in a larger, more effective sustainability movement.

## INTRODUCTION

This research project aims to facilitate Bryant University in becoming a more sustainable campus. During a time in which global warming and climate change are recognized as major threats to the planet, the University is currently undertaking minimal initiatives to become more sustainable and lower its environmental impacts. As Gaytha A. Langlois, Professor of Environmental Policy, states in the 2009 Bryant University Sustainability Report,

> "Programs to improve energy efficiency on campus are a part of Bryant University's long standing strategic efforts to conserve consumption. Since 2008, there has been a concerted effort involving many stakeholder groups to boost the productivity of campus recycling. However, these and other efforts have not been adequately publicized and campus residents and staff are mostly unaware of these initiatives" (Langlois, 2009).

This research project also emphasizes the idea that it is important for the University to analyze its behaviors and determine what it can do to become more environmentally responsible. In the past, Bryant University has been a leader in sustainable initiatives, however in spite of extensive growth of the campus facilities, accompanied by increased energy consumption, the University has not maintained a concomitant expansion of its commitment to sustainable practices. Bryant University must take responsibility for all of its actions and begin to initiate processes to minimize the energy consumption and harmful emissions associated with its vehicle fleets. Thus, it is important for Bryant to create a strategy for addressing environmental issues in order to set an example for other universities as to how they too can become environmentally responsible. Thus, Bryant University can once again be recognized as a leader in campus sustainability.

Therefore, this paper will address how Bryant University can lower its impact on global warming and climate change through its Campus Management vehicle operations processes. Based on careful analysis of the current vehicle operations of the University, this paper will set forth recommendations of how the University can lower its emission of harmful compounds through more efficient vehicle operations. It was hypothesized that Bryant University's Campus Management Depart is contributing to the phenomena known as global warming and climate change, and that the department will be able to lower its ecological and carbon footprint through the implementation of an alternative fuel source for its campus management driving vehicle fleet; thus reducing its impact on global warming.

Climate Change and its Causes

Climate change is a phenomenon that is occurring worldwide and is often associated with the pattern of global warming; although these two phenomena are closely related, each term conveys a specific set of interactive factors. Climate change usually refers to "any significant change in measures of climate (such as temperature, precipitation, or wind), lasting for an extended period (decades or longer)" (Climate Change- Basic Information, 2009). Meanwhile, global warming is defined as "an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns" (Climate Change- Basic Information, 2009). Throughout the past few decades there has been much discussion as to the extent of climate change and the mechanisms underlying the changes; and further there has been extensive debate surrounding the extent of human interference and the likelihood that changes in human activity could actually intensify climate change trends. As Mike Hulme writes in his article, *Global Warming*, some researchers believe that climate change is the natural process of heating and cooling that the Earth goes through every few centuries (Hulme, 1998). However, other researchers, such as Ayhan Demirbas, believe that while it is true that the Earth goes through these periods of heating and cooling, human activity has caused the natural variances of Earth's temperature to fluctuate more irregularly and drastically (Demirbas, 2004). This project is based off of Demirbas' view of climate change. Nevertheless, climate change is being recognized as a major threat to the environment of the entire planet (Climate Change 2007: Synthesis Report, 2007).

Variation of the Earth's temperature is a common occurrence. "During the past 1,000 years, temperatures have naturally fluctuated by about one degree…", but due to global warming, a consistent increase in this temperature of approximately 2-5 Kelvin may be realized (Demirbas, 2004). This change in the Earth's atmospheric temperature can be attributed to several sources. Using Demirbas' view of climate change, the three main categories related to climate changing activities include natural factors, natural processes within the climate system, and human activity (Climate Change- Basic Information, 2009). Natural factors consist of slight changes in the Earth's orbit or the sun's intensity. Natural processes refer to changes in current environmental processes such as ocean currents or wind patterns. Finally, human activities refer to the numerous activities that humans carry out as they function on planet Earth, including the consumption of fossil fuels, deforestation, industrialization, and desertification (Climate Change- Basic Information, 2009).

This paper will focus on the third category of climate changing actions; the human activities that cause global warming to occur. In particular, this project will pay close attention to the consumption of fossil fuels to generate the energy needed to operate vehicles and its contribution to global warming.

Release of Greenhouse Gases into the Atmosphere

Fossil fuels are energy sources that were "formed over [millions of] years when once living organic matter was buried before it had a chance to decay" (Wolfson, 2008). These fuels are known as coal, oil and natural gas. Energy is obtained through the oxidation of these fuels. However, this human activity of consuming fossil fuels also produces greenhouse gases which contribute to the warming of the planet. Greenhouse gases are "atmospheric gases that absorb infrared radiation" (Wolfson, 2008). These gases have high heat holding capabilities and absorb the infrared radiation that otherwise would be emitted outward from the Earth in the form of heat (the albedo effect). The most common greenhouse gases are carbon dioxide, methane, ozone, nitrous oxide and chlorofluorocarbons. These compounds, once released into the Earth's atmosphere, absorb the infrared radiation that is coming up from the surface of the Earth, trap it, and prevent it from dissipating into the other layers of the atmosphere (Wolfson, 2008). Furthermore, this absorption of infrared radiation creates an energy imbalance in the Earth's atmosphere because the same level of infrared radiation is still coming into the atmosphere from the Sun. Therefore, the surface of the Earth begins to heat up because excess infrared radiation is being stored in its atmosphere, and the Earth's balance now occurs at a higher surface temperature (Wolfson, 2008).

The greenhouse gas carbon dioxide is most associated with global warming because it is emitted into the Earth's atmosphere at the highest percentage. For example, within the United States "carbon dioxide from fossil fuel combustion has accounted for approximately 79% of global warming potential weighted emission since 1990" (EPA, 2009). Therefore, the release of carbon dioxide into the atmosphere has the greatest potential for altering the Earth's surface temperature. Carbon dioxide can be released into the atmosphere through the consumption of all fossil fuels, however, this project will focus on the importance of reducing vehicle emissions of carbon dioxide on campus as a means of lessening the impacts of carbon dioxide overall, i.e., a carbon footprint reduction for the university.

### Release of Carbon Dioxide through the Burning of Gasoline

Gasoline is an energy fuel that is created through the refinement of the fossil fuel crude oil. This gasoline is then used in vehicles to fuel their movement. These vehicles, such as automobiles and trucks, are powered by an internal combustion engine which operates using fuel combustion to create pressures that produce mechanical motion. There are two main types of internal combustion engines, the continuous-combustion engine, and the intermittent combustion engine; the latter of which is more commonly found in automobiles and trucks (Wolfson, 2008).

Furthermore, there are several variations of the intermittent combustion engine that are still used today. The vehicles studied in this project operate using a variation known as a spark-ignition engine. This engine operates through the injection of gasoline into the cylinders at a certain point in their cycle and then at the optimum instant an electric spark ignites the fuel" (Wolfson, 2008). However, this type of energy is only "20% efficient at converting the energy content of gasoline into mechanical energy" (Wolfson, 2008).

Regardless of the type of engine, the end result is the same; carbon dioxide is emitted through the burning of gasoline or diesel fuel to operate the vehicle. It is this carbon dioxide that is increasing within the Earth's atmosphere, absorbing infrared radiation and warming the Earth's surface. In addition to the increased release of carbon dioxide emissions into the atmosphere, it is apparent that the common engines that are used today are highly inefficient.

### The Need to Limit Carbon Emissions

Based on this knowledge of the process by which carbon dioxide is emitted into the atmosphere through the use of automobiles, combined with the fact that, "from 1990 to 2007, transportation emissions rose by 29 percent", the need to limit these emissions becomes apparent (EPA, 2009). Furthermore, 28% of the greenhouse gases that were emitted in 2007, can be attributed largely to the use of light-duty trucks, which include sport utility vehicles, pickup trucks and minivans (EPA, 2009), all of which Bryant University use within their

Campus Management Department. Therefore, the rate at which carbon dioxide is being emitted into the atmosphere due to transportation activities is increasing drastically each year. Table I below shows this increase and is a summary of the Environmental Protection Agency's, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007*, this can be seen in its entirety in Appendix A.

**Table I: Transportation Related Carbon Dioxide Emissions**

| | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| **Passenger Cars** | 656.9 | 644.1 | 694.6 | 705.8 | 678.3 | 664.6 |
| **Light-Duty Trucks** | 336.2 | 434.7 | 508.3 | 544.8 | 557.1 | 561.7 |
| **Medium-and Heavy-Duty Trucks** | 228.8 | 272.7 | 344.2 | 395.1 | 404.5 | 410.8 |
| **Buses** | 8.3 | 9.1 | 11.1 | 12.1 | 12.4 | 12.4 |
| **Motorcycles** | 1.8 | 1.8 | 1.9 | 1.6 | 1.9 | 2.1 |
| **Commercial Aircraft** | 136.9 | 143.1 | 167.8 | 159.8 | 155.5 | 155.2 |
| **Other Aircraft** | 44.4 | 32.3 | 32.9 | 34.5 | 33.8 | 34.2 |
| **Ships and Boats** | 46.9 | 56.5 | 65.1 | 50.7 | 54.1 | 56.3 |
| **Rail** | 38.6 | 44.1 | 50.1 | 56.7 | 58.9 | 58 |

These growing carbon dioxide emissions are not just increasing the occurrence of global warming however; they are also contributing to several harmful effects to the Earth in general, as well as the humans that inhabit it. The Intergovernmental Panel on Climate Change (IPCC) stated that "impacts of climate change will vary regionally but, aggregated and discounted to the present, they are very likely to impose net annual costs which will increase over time as global temperatures increase" (Parry, Canziani, Palutikof, van der Linden, & Hanson, 2007). Thus, the effects of climate change will be seen more in some areas of the Earth than others, but overall the effects that occur will negatively affect the planet.

Effects of altered climates include extreme temperature events, shifting weather patterns, flooding, drought, the intensification of storm activity, increased incidence of insect-borne diseases, coral reef damage, agricultural impacts, habitat alteration and sea level rise (Parry, Canziani, Palutikof, van der Linden, & Hanson, 2007). In terms of extreme temperature events, the warming of the Earth will cause more abnormally hot days that have higher maximum temperatures and fewer remarkably cold days with longer frost-free growing seasons. In addition, shifting weather patterns will create stronger and more intense tropical storms. These types of storms, such as hurricanes, cyclones and typhoons, gain in intensity from warmer surface water. Therefore, with an increase in the temperature of the surface water caused by gradual climate change, it is reasonable to predict that the intensity of these storms should increase (Parry, Canziani, Palutikof, van der Linden, & Hanson, 2007). Finally, it can also be predicted that there will be an increase in the sea level. This can be attributed to the "thermal expansion of water as it increases" (Wolfson, 2008). An increase in the sea-level is also caused by the melting of the polar ice caps from increased surface temperatures, as well as melting permafrost, and deposition of sediments by river flows (Parry, Canziani, Palutikof, van der Linden, & Hanson, 2007).

As the changes described above unfold, the balance of the Earth's ecosystem is greatly altered. A slight change of one habitat, whether as a result of extreme temperatures, increased storm intensity, or sea-level increases, could cause drastic and irreversible changes within the entire ecosystem. The organisms within an ecosystem are interdependent on each other. Therefore, if one organism is greatly affected by the warming of the Earth, the organisms that are dependent on that organism will also be affected. For example, the thawing out of the permafrost in the Arctic Tundra will greatly affect the migratory species that use the area for breeding and feeding (Polar Regions, 2009). The species that use this area for a breeding ground will no longer find the area ideal for breeding and thus migrate to another area more suitable. This will greatly affect the ecosystem of the area, as species that are vital to the stabilization of the ecosystem will leave, upsetting the food chain and hierarchy of the area.

In addition, these gradual climate changes also have the potential to affect humans. Specifically, the extreme temperature events just mentioned, have the ability to greatly hinder the well-being of humans. With more hot days at higher extreme temperatures, humans are at greater risks for heat waves, resulting in heat strokes; especially those with heart problems, asthma, the elderly, the very young and the homeless (EPA, 2009). Furthermore, the intensifying of tropical storms can lead to elevated levels of damage to coastal communities, as a result of these storms. With stronger storms, more businesses, homes and communities are at risk for being destroyed and the humans that habitat these areas are at a greater risk of being injured or killed by the destruction (EPA, 2009). And finally, warmer temperatures at higher altitudes can cause melting of mountain glaciers, which in turn affect sources of drinking water for coastal cities, and can result in expanding the territory of insects carrying human parasites.

As stated above, the gradual increase in the Earth's climate as a result of increased carbon dioxide emissions through the use of automobiles has the potential to greatly harm the Earth and its inhabitants. Therefore, Bryant University must review how it can reduce its carbon dioxide emissions from its Campus Management vehicle usage, in an attempt to reduce the university's contributions to this global problem.

Trends in College Campus Transportation Efficiency and Sustainability

Many other college campuses across the United States have already realized the need to reduce their carbon dioxide emissions in an attempt to reduce these harmful effects that climate change can create. These colleges have taken steps in all areas of their operations to reduce their carbon footprint and lower the impact that their operations have on the environment. Furthermore, many of these colleges have created sustainable transportation policies within their campuses in order to decrease the aggregate release of carbon dioxide from all vehicle operations.

The College Sustainability Report is an independent evaluation of the sustainability activities at colleges and universities within the United States and Canada (Executive Summary, 2009). The 2009 report analyzed the sustainability initiatives at 300 schools among the following categories: administration, climate change and energy, food and recycling, green building, student involvement, transportation, endowment transparency, investment priorities, and shareholder engagement (Executive Summary, 2009). Once the campus sustainability policies and activities are analyzed, the institution is given a grade depicting the level of sustainable actions and their effectiveness. Grades range from 'A' to 'F', with 'A' being the highest grade. Key findings are also reported for each category. "The Transportation category looks at how schools promote alternative transportation options through the policies and practices of facilities management and the administration" (Transportation, 2009). In addition, this category scores schools on their use of alternative fuel for campus vehicle fleets, the promotion of a pedestrian or bike friendly campus, incentives used to increase the use of these programs, and finally the use of public transportation (Transportation, 2009).

The following key trends for the Transportation category were found as a result of the 2009 College Sustainability Report Card:

- "Bicycle-sharing programs have been instituted at 31 percent of schools.
- Car-sharing programs are available at 35 percent of schools.
- Reduced-fare passes for public transit are offered at 50 percent of schools.
- Hybrid or other alternative-energy vehicles are used in 66 percent of school fleets (Transportation, 2009).
    - A summary of the grade distribution for this category is shown in Appendix B.

## <u>METHODOLOGY</u>

Based on this comparative information, it is valuable to see how Bryant University would compare with these trends in other institutions of higher education. Therefore, the current environmental impact of Bryant University's Campus Management Department vehicle operations was measured through an ecological and carbon footprint analysis. The data needed to complete these analyses was obtained from Brian Britton, Vice President of Campus Management. Information from Britton was obtained through several face-to-face meetings, and one questionnaire. The face-to-face meetings were used to familiarize Britton with the project, inform him as to what his role in the project would be, and request his support and participation. Later, a follow-up meeting was used to review the data that had been obtained and analyzed. The questionnaire that was sent to Britton is contained in Appendix C. This questionnaire was used in order to gain an understanding of the Campus Management Department's current vehicle use and policy. It was composed of open ended questions aimed at gathering information about current vehicle use, cost, replacement policy, etc.

Once the information was obtained from Britton, an ecological footprint analysis was completed. An ecological footprint analysis is "a measure of the load imposed by a given population on nature. It represents the land area necessary to sustain current levels of resource consumption and waste discharge by that population" (Wackernagel & Rees, 5). In other words, it is designed to calculate the "impact of humankind upon the productive land of our planet" (Juthe, 2005). The ecological footprint calculation typically sums up five categories of activities: carbon footprint, built-up land, forests, cropland and pastures, and finally fisheries. These numbers are converted to how many hectares of land per year are needed to sustain the equivalent current level of operation for an individual or organization. In comparison, one hectare of land is equal to approximately 2.74 acres of land.

Former Bryant University student Dana Juthe completed an ecological footprint analysis of the University in 2005 and wrote a report on the findings. The ecological footprint calculation that was used in this report was based on the calculations Juthe completed, in order to make logical comparisons. However, the calculation in this report focused solely on the transportation section of an ecological footprint analysis, using only information from the Campus Management Department's vehicles to calculate the ecological footprint. Essentially, the calculation was used to determine the equivalent hectares of land per year needed to continue the Campus Management Department's current use of its vehicles.

Furthermore, even though the ecological footprint analysis is comprised of several factors including a carbon footprint analysis, an independent carbon footprint analysis was calculated. This is due to the fact that a carbon footprint analysis has become commonplace when measuring the efficiency of vehicle usage. The carbon footprint analysis is a

> "measure of the impact our activities have on the environment, and in particular climate change. It relates to the amount of greenhouse gases produced in our day-to-day lives through burning fossil fuels for electricity, heating, transportation, etc." (What is a Carbon Footprint?, 2010).

This calculation determines how many metric tons of carbon dioxide are released into the Earth's atmosphere as a result of vehicle usage. Thus, a carbon footprint analysis was conducted to assess the amount of carbon dioixde that is emitted through the use of the Campus Management Department's vehicles.

This report focuses on the driving vehicles used by the Campus Management Department, excluding the department's golf carts. The other machines that run on gasoline, such as lawn mowers, leaf blowers, weed whackers, etc. were excluded due to the fact that there are more opportunities for improving vehicle efficiency for the driving vehicles within the department than any other types of machines.

## RESULTS

Questionnaire- Brian Britton

The questionnaire that Britton completed detailed several of the current Campus Management policies and procedures regarding their vehicle fleet. Britton's answers to these questions can be seen in Appendix D. In addition, Britton provided two Microsoft Excel spreadsheets along with the questionnaire that listed all of the current vehicles campus management uses, their make and model, and the mileage that was used in the ecological footprint and carbon footprint calculations. These spreadsheets are displayed in Appendix E.

Based on Britton's responses to the questionnaire, the Campus Management Department retains its vehicles until they are no longer functional. The official replacement policy outlines that vehicles be replaced once they reach 100,000 miles. However, this is uncommon because the vehicles only travel the three mile loop around the campus and usually become non-functional before they reach this mileage. The cost of maintenance for the vehicles that are not replaced averages around $85,000 per year.

The Campus Management Department purchases approximately two to three vehicles a year, as a result of replacing old vehicles or acquiring new vehicles for use. This estimate could be higher or lower each year depending on the need for vehicles. The cost of these replacements ranges between $17,000 and $26,000. These vehicles are purchased through a competitive bidding process.

Most of the vehicles used by the Campus Management Department operate with gasoline as a fuel. The cost of the gasoline for these vehicles can vary from year to year, and therefore, the department has an average for each year. For the 2009/2010 fiscal year, the department used an average of $2.50 per gallon for 18,000 gallons for their budget. However, this estimate includes all campus vehicles, not just those in the Campus Management Department. In addition, currently the department is paying $2.69 per gallon, a higher rate than what was originally budgeted.

Finally, the Campus Management Department does not currently use any vehicles that operate with alternative fuel sources. The two most common types of vehicles that the department operates were found to be the Chevrolet Astro Van and the Chevrolet Silverado; pictures of these two vehicles can be seen in Appendix F. The department is interested in the possibility of replacing some of its vehicles with alternative fuel sources, specifically hybrid and electric plug in vehicles. As a result, the department has done some primary research with other campus management departments to determine the feasibility of incorporating such vehicles. Nevertheless, the department has not included alternative use vehicles within its fleet because it cannot find a suitable vehicle that could perform the necessary tasks on and off campus.

Ecological Footprint Calculation Results:

The formula for the ecological footprint that was calculated for the campus management department vehicles was based on a standard approach as illustrated by Juthe's ecological footprint calculation. The ecological footprint was determined using the following formula:

Ecological footprint= Csr * I * Gm * Tm * M * EE

Where:

*Csr*- Carbon Sequestration Ratio- this measurement is the amount of land needed to sequester the carbon dioxide that is being emitted because of a certain process

Energy Intensity Ratio-this is a ratio depicting the rate of energy that is created by a fuel source

*Gm*- Gas Mileage - this factor illustrates the ratio of how many miles a vehicle can travel per gallon of gasoline

*Tm*- Total Miles Traveled

*M*- Metric Conversion Factor- this factor is used to convert the mileage of a vehicle into kilometers traveled

*EE*- Extra Embodied Energy for Car Manufacture and Maintenance- this factor adds in the additional energy, the additional carbon dioxide emissions, that were used in manufacturing and maintaining the vehicle

The values used for each of the factors, excluding the total miles traveled per vehicles were provided by Juthe's analysis and are as follows:

**Table II. Values for Factors Used in Ecological Footprint Calculation**

| | |
|---|---|
| Carbon Sequestration Ratio | 1.40845E-05 |
| Energy Intensity Ratio | 35.00 |
| Gas Mileage | 0.1893 |
| Total Miles Traveled (gathered from Table III) | 78,542 |
| Metric Conversion Factor | 1.6093 |
| Extra Embodied Energy Factor of Car manufacture and maintenance | 1.5 |

Thus, using the above formula and the data provided in Table III below, used to calculate the total miles traveled, the ecological footprint calculation for all Campus Management Department vehicles is:

*(1.40845E-05) * (35) * (0.18927206) * (78,542) * (1.6093) * (1.5) = 17.6899 ha/yr*

Thus, the total ecological footprint for the Campus Management Department vehicles is 17.6899 hectares per year. With one hectare equaling 2.74 acres, the ecological footprint in acreage equals 42.0079 acres.

*(17.6899) * (2.74) = 42.0079*

**Table III. Ecological Footprint Calculations for Campus Management Vehicles**

| Year | Make | Description | Mileage 12/08 | Mileage 12/09 | | Mileage added from 2008 | Ecological Footprint for Each Vehicle |
|---|---|---|---|---|---|---|---|
| 1994 | CHEVY | Pickup-3500-Yellow | 87,999 | 87,489 | | 2,909* | 0.6551824 |
| 2000 | CHEVY | Astro Cargo Van - Yellow | 84,194 | 87,125 | | 2,931 | 0.6601465 |
| 2001 | CHEVY | Astro Van - White | 55,293 | 57,222 | | 1,929 | 0.4344669 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2001 | CHEVY | Astro Van - White | 61,030 | 64,787 | | 3,757 | 0.8461857 |
| 2002 | CHEVY | Silverado-White | 33,199 | 37,884 | | 4,685 | 1.0551983 |
| 2003 | CHEVY | Astro Van - White | 19,271 | 20,887 | | 1,616 | 0.3639702 |
| 2003 | CHEVY | G1500 Express Van - White | 16,722 | 18,847 | | 2,125 | 0.4786118 |
| 2003 | CHEVY | Astro Express Van - White | 35,881 | 41,023 | | 5,142 | 1.1581280 |
| 2004 | CHEVY | Cargo Van-White | 45,876 | 46,808 | | 932 | 0.2099135 |
| 2004 | CHEVY | Cargo Van-White | 53,270 | 55,345 | | 2,075 | 0.4673504 |
| 2004 | CHEVY | Cargo Van-White | 49,185 | 48,692 | | 2,909* | 0.6551824 |
| 2005 | CHEVY | Express Van White | 10,265 | 13,563 | | 3,298 | 0.7428055 |
| 2005 | CHEVY | Express Van White | 4,663 | 6,487 | | 1,824 | 0.4108179 |
| 2005 | CHEVY | Express Van White | 5,412 | 6,541 | | 1,129 | 0.2542836 |
| 2005 | CHEVY | Express Van White | 8,417 | 11,629 | | 3,212 | 0.7234358 |
| 2005 | CHEVY | Silverado White | 28,724 | 37,267 | | 8,543 | 1.9241321 |
| 2006 | CHEVY | Express Cargo Van White | 9,000 | 11,790 | | 2,790 | 0.6283891 |
| | | | | | | | |
| 1990 | FORD | F600 Dump Truck - Yellow | 30,606 | 30,806 | | 200 | 0.0450458 |
| 1996 | FORD | E150 Econoline VAN-White | 109,283 | 110,607 | | 1,324 | 0.2982033 |
| 1999 | FORD | Taurus Wagon-Tan | 120,881 | 122,644 | | 1,763 | 0.3970789 |
| 2001 | FORD | F450 White | 60,351 | 61,894 | | 1,543 | 0.3475285 |
| 2003 | FORD | E-150 Econoline Van White | 45,178 | 48,692 | | 3,514 | 0.7914550 |
| | | | | | | | |
| 2003 | GMC | Sierra 3500 Dump Truck | 29,597 | 33,988 | | 4,391 | 0.9889809 |
| 2008 | GMC | Savana Van-White | 617 | 2,850 | | 2,233 | 0.5029365 |
| | | | | | | | |
| 1991 | INTERNATIONAL | Bucket Truck-Yellow | 4,289 | 4,408 | | 119 | 0.0268023 |
| | | | | | | | |
| 1998 | JEEP | Wrangler 4 WD-Yellow | 86,652 | 92,442 | | 5,790 | 1.3040764 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2008 | JEEP | Wrangler UT 4WD-Yellow | 3,556 | 9,415 | | 5,859 | 1.3196172 |
| | | | | | | | |
| | | | | **Total Vehicle Miles for 2009** | 78,542 | | |

*Average Added Mileage for 2009 = 2,909 miles. This average was used for 1994 Chevrolet 3500 Yellow Pick-up truck with the following serial number, 1GCHK34K5RE193854, and the 2004 Chevrolet White Astro Van with the serial number, 1GCFG15X141164858. This was done because the odometer on these vehicles is broken.

Carbon Footprint Calculation Results:

The total carbon footprint of the campus management driving vehicles was determined by using an online calculator provided by, www.carbonfootprint.com. This website calculates a vehicle's carbon footprint using the vehicles current mileage, and its year, make and model. The calculations that are completed are based on conversion factors from several government agencies throughout the world. A few of these agencies include the Environmental Protections Agency of the United States, the Department of Energy of the United States and Standards Association (CSA) GHG Registries of Canada (Carbon Footprint Calculator, 2010). Based on the limited data that was available for the vehicles in this study, this calculator was ideal. Furthermore, this calculator was used because once the carbon footprint was calculated, additional information about carbon footprints was provided to the user and even several suggestions as to how to lower the carbon footprint.

Therefore, the mileage, year, make and model of each vehicle were input into this calculator in order to calculate the carbon footprint of each vehicle. However, as stated earlier in the note above, two of the vehicles' odometers were broken and thus their accurate mileage was unknown. In this case, the average miles added from 2008 to 2009 was calculated and added to the two vehicles mileage from 2008. These vehicles were the 1994 Chevrolet Pickup 3500 and one of the 2004 Chevrolet Cargo Astro Vans. This calculation was done by simply averaging the "Mileage added from 2008" Table III.

The calculator then automatically calculated the amount of carbon dioxide emitted from the vehicles in metric tons of carbon dioxide. Once the total carbon footprint was calculated for each individual vehicle, the values were totaled. This data is shown in Table IV below. The total carbon footprint of Bryant University's Campus Management driving vehicles is 621.67

metric tons of carbon dioxide. The average carbon footprint per vehicle was also calculated and found to be 23.0248 metric tons of carbon dioxide; this is also shown is in Table IV.

**Table IV. Carbon Footprint Calculations for Campus Management Vehicles**

| *YEAR* | *MAKE* | *DESCRIPTION* | *MILEAGE 12/09* | Carbon Footprint for Each Vehicle in Metric Tons of CO2 Based on 2009 Mileage |
|---|---|---|---|---|
| 1994 | CHEVY | Pickup-3500-Yellow | 90,398 | 49.79 |
| 2000 | CHEVY | Astro Cargo Van - Yellow | 87,125 | 18.91 |
| 2001 | CHEVY | Astro Van - White | 57,222 | 30.88 |
| 2001 | CHEVY | Astro Van - White | 64,787 | 34.96 |
| 2002 | CHEVY | Silverado-White | 37,884 | 24.28 |
| 2003 | CHEVY | Astro Van - White | 20,887 | 11.27 |
| 2003 | CHEVY | G1500 Express Van - White | 18,847 | 11.37 |
| 2003 | CHEVY | Astro Express Van - White | 41,023 | 24.74 |
| 2004 | CHEVY | Cargo Van-White | 46,808 | 26.66 |
| 2004 | CHEVY | Cargo Van-White | 55,345 | 33.38 |
| 2004 | CHEVY | Cargo Van-White | 51,601 | 29.39 |
| 2005 | CHEVY | Express Van White | 13,563 | 8.18 |
| 2005 | CHEVY | Express Van White | 6,487 | 3.91 |
| 2005 | CHEVY | Express Van White | 6,541 | 3.95 |
| 2005 | CHEVY | Express Van White | 11,629 | 7.01 |
| 2005 | CHEVY | Silverado White | 37,267 | 23.88 |
| 2006 | CHEVY | Express Cargo Van White | 11,790 | 7.11 |
| | | | | |
| 1990 | FORD | F600 Dump Truck - Yellow | 30,806 | 16.97 |
| 1996 | FORD | E150 Econoline VAN-White | 110,607 | 60.92 |
| 1999 | FORD | Taurus Wagon-Tan | 122,644 | 59.87 |
| 2001 | FORD | F450 White | 61,894 | 37.33 |
| 2003 | FORD | E-150 Econoline Van White | 48,692 | 31.2 |
| | | | | |
| 2003 | GMC | Sierra 3500 Dump Truck | 33,988 | 18.72 |
| 2008 | GMC | Savana Van-White | 2,850 | 1.72 |
| | | | | |
| 1991 | INTERNATIONAL | Bucket Truck-Yellow | 4,408 | 2.43 |
| | | | | |

| | | | | |
|---|---|---|---|---|
| 1998 | JEEP | Wrangler 4 WD-Yellow | 92,442 | 37.16 |
| 2008 | JEEP | Wrangler UT 4WD-Yellow | 9,415 | 5.68 |
| | | | | |
| | | **Total Carbon Footprint** | | 621.67 |
| | | **Average Carbon Footprint per Vehicle** | | 23.0248 |

**DISCUSSION OF RESULTS**

These results illustrate that the Campus Management Department's current use of its vehicles contributes to global warming, and that there are ample opportunities to make changes in this pattern.

Ecological Footprint Analysis:

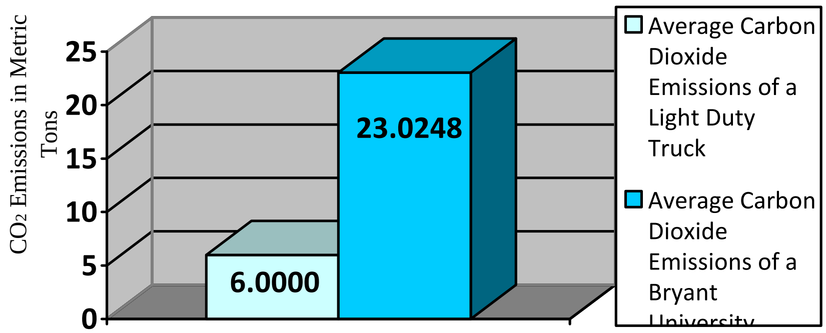
In total, Bryant University is a 420 acre campus (Directions to Campus, 2009). The vehicles analyzed in this study travel a three mile loop around this campus. Based on Table III, it can be determined that it would take the equivalent of 17.6899 hectares each year to sustain the current operation of these driving vehicles. In acres the department would need 42.0079 acres of biologically productive land, the equivalent of nearly 10% of its total acreage, to sustain its operations for one year (Hectares to Acres Conversion, 2010). Even further, at this rate the Campus Management Department would essentially need the entire acreage of the University to sustain itself for ten years before it would need additional acreage ranging outside of the school. This current rate of use for the entire department, results in an ecological footprint calculation that is almost double the average ecological footprint of an average American citizen. It is estimated that the average American has an ecological footprint of 9.0 hectares, or 23 acres (National Footprint Accounts 2009 - Key Findings and Graphs, 2009). As a result, it is important to take proactive measures to maintain or lower this ecological footprint in order to limit the overall harmful effect of operating fossil fuel burning vehicles. In addition, by addressing these concerns Bryant University will motivate and encourage other universities across the nation to do the same, resulting in a magnified effect that lowers the dangers associated with consuming fossil fuels, as well as setting an overall good example for the Bryant community.

Carbon Footprint Analysis:

To reiterate, the carbon footprint was calculated because of the growing use of this calculation in measuring the efficiency of vehicle usage. Furthermore, since the carbon footprint is a subcategory within the ecological footprint, it is important to determine methods by which the carbon footprint can be decreased in an effort to decrease the total ecological footprint. Thus, the independent carbon footprint calculation, shown in Table IV, determined that the department's current vehicle use emitted 621.67 metric tons of carbon dioxide into the atmosphere. Again, as shown in Table I, the total amount of carbon dioxide emitted into the atmosphere by medium to heavy duty trucks in the United States in 2007 was nearly 407.4 million metric tons of carbon dioxide. Even though the University's Campus Management Department is contributing a very small percentage to the total carbon dioxide emissions of the United States, the department is still a contributor by emitting this harmful compound into the atmosphere. Furthermore, in 2005 the Environmental Protection Agency (EPA) department of the U.S. Government, stated that the average level of carbon dioxide emissions of a light duty truck is approximately six metric tons of carbon dioxide (Emission Facts: Greenhouse Gas Emissions From a Typical Passenger Vehicle, 2005). The average amount of carbon dioxide emitted for a vehicle within the Campus Management Department's driving fleet was calculated at approximately 23.0248 metric tons of carbon dioxide; almost four times the average stated by the EPA in 2005. This comparison can be seen in Figure 1 below. Thus, this is further evidence that the University should enact policies and take actions to lower this average in an attempt to lower its environmental impact through vehicle use.

When Bryant University's Campus Management Department's carbon footprint is compared to other universities, it is apparent that the department itself has a low carbon footprint. In 2006, Harvard University in Cambridge, Massachusetts had a total carbon footprint of just over 300,000 metric tons of carbon dioxide (The GHG Reduction Goal, 2009). However, this was a calculation that was based on all departments of the University and not just one.

**Figure 1: Average Carbon Dioxide ($CO_2$)Emissions**




Therefore, while it appears at first that Bryant University's Campus Management Department's carbon footprint of approximately 621.27 metric tons of carbon dioxide is rather small, it must be remembered that this is the footprint of only one department within the entire university. Furthermore, Harvard University has recognized the need for it to lower its entire carbon footprint, and has begun a campaign entitled, Harvard's Greenhouse Gas Reduction Commitment (The GHG Reduction Goal, 2009). This commitment outlines how Harvard hopes to lower its Greenhouse Gas emissions 30% by 2016, and the means by which this will be done. Thus, other schools have already taken the initiative to calculate their total carbon footprints and implement methods of change to reduce these footprints; something that Bryant University has yet to accomplish.

<u>Questionnaire and Face-to-Face Interview Analysis:</u>
In terms of Bryant University's current vehicle use policies and procedures for vehicle use and life within the Campus Management Department, there are not any policies dealing with the environmental impact of the operating vehicles. Furthermore, it appears that the Campus Management Department has no current methods for tracking the carbon footprint and ecological footprint of its vehicle operations. Therefore, with no method of tracking these calculations, and no policies in place to rectify the damage being done by these vehicles to the environment, the department is allowing the harmful effects of its vehicle to take over and add to the permanent damage of the Earth.

## IMPLICATIONS FOR CHANGE AT BRYANT UNIVERSITY

Based on the questionnaire that was completed by Brian Britton, and the results of the ecological footprint and carbon footprint analyses, it is recommended that the Campus Management Department of Bryant University address the following areas to maintain or reduce its current environmental impact.

As a first step, the Campus Management Department should develop a policy to calculate and monitor its current carbon and ecological footprints, as a result of driving vehicle use. This policy will allow the department to track the impact that its current use has on the environment in terms of how much carbon dioxide the department is emitting through the use of fossil fuels, as well as the equivalent amount of land and sea that is required to support its vehicle operations. Currently, the state of Rhode Island operates under the federal Clean Air Act of 1970, which among other things, restricts carbon emissions from vehicles across the United States. In addition, Rhode Island is one of the many states that have adopted California's Motor Vehicle Greenhouse Gas Emission Standards; a law that sets stronger regulations and restrictions for carbon emissions in attempts to reduce the nation's overall rate of carbon emissions. Finally, Rhode Island's transportation sector operates under its own law titled the Air Pollution Control Regulation No. 34, which outlines vehicle maintenance and inspections standards. Therefore, Bryant University's Campus Management Department should initially check to ensure that its current vehicle operations fall within all of the appropriate standards and restrictions. Then, the department should create its own standards and restrictions to lower its carbon emissions and the size of ecological footprint.

The Campus Management Department could easily track its own emission against the standards it sets by using the calculations used in this project as a model for future calculations. Additionally, some online sources are provided in Appendix G. Even more, for this suggestion to be truly beneficial the department should create policies to enforce the standards and restrictions implemented, that describe what actions would take place should a vehicle not meet the standards. It is suggested that this policy include either repairing the vehicle so that it runs within the standards, or replacing it altogether; whichever is more cost beneficial to the department. Again, these standards and policies will allow the department to track and control its current environmental impact. In order to remedy the situation, the department must first make itself aware of the issue and its standing, and then it will be able to make the necessary changes.

Secondly, the Campus Management Department should adhere to the following driving techniques and tips from www.carbonfootprint.com that will allow it to lower its carbon footprint. The website lists several tips for general drivers, however those that are most applicable include:

- Keep the vehicle properly serviced
- Check tire pressure at least once a week
- Avoid carrying unnecessary weight in the vehicle
- Avoid sudden acceleration, engine revving, and sudden breaking-all which can use up to 30% more fuel and increase wear and tear on the vehicle
- Avoid using the air conditioner
- Accelerate slower
- Switch the engine off if the vehicle will be stationary for more than two minutes
- When replacing your vehicle, look for the most carbon efficient, or a vehicle with a high mile per gallon rate (Car Travel, 2010).

All of these tips will result in using less fuel while operating the vehicle. Thus, if less fuel is being used, less carbon dioxide is being emitted because less of the fossil fuel is being consumed.

However, if these driving tips still do not reduce vehicles carbon emissions, or a vehicle cannot be repaired to meet college, state and federal standards, the University should implement this third recommendation. The Campus Management Department should replace the vehicles that no longer meet these standards with more efficient alternative use vehicles. There are many types of alternative fuel use available, but based on the questionnaire completed by Brian Britton, the Campus Management Department is most interested in electric and hybrid alternative use vehicles. However, currently, there are few options available for hybrid and electric vans and trucks; the type of vehicles most commonly operated by the department. Nevertheless, the department still has some options. Chevrolet already manufactures a Hybrid model of its Silverado truck, and the Ford Motor Company is planning to offer a hybrid commercial van in 2010. These two suggestions can be seen in Appendix H. The van is a fore-runner in electric and hybrid cargo vans and is known as the Ford Transit Connect Van. Ford has had success with this electric van in many European countries (O'Dell, 2009). The main features of this van model are compared to the Department's current van model below in Table V.

**Table V: Suggested Van Model Features Versus Current Van Model**

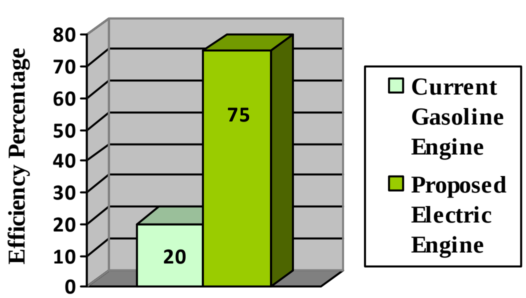
| | | Type of Fuel | Carrying Capacity | Mileage | Fuel Efficiency |
|---|---|---|---|---|---|
| **Suggested Van Model** | **Ford Transit Connect Van** | Lithium Ion Battery | 1600 lbs | 100miles per charge | 75% |
| **Current Van Model** | **Chevrolet Astro Van** | Gasoline | 1500lbs | 16-21miles per gallon of gasoline | 20% |

As seen in this table, the cargo van is designed to run on a lithium-ion battery pack and can hold up to 1,600 pounds of cargo. Furthermore, this van can travel up to 100 miles on one charge of its battery (O'Dell, 2009). This electric van is a more efficient alternate than simply replacing an older vehicle with a new model because it uses no gasoline and converts nearly 75% of the chemical energy created in the battery to the wheels (Electric Vehicles, 2010). As stated earlier, the current engine that is being used in the Campus Management Department's vans are only around 20% efficient at converting gasoline to energy; and thus this new engine is 55% more efficient than the current methods being used. This efficiency improvement can be seen in Figure 2.

Furthermore, the use of this energy produces no tailpipe air pollutants. In addition, no extra embodied energy, or the entire amount of energy to produce the vehicle, is used in using an electric vehicle. In other words, the Campus Management Department would not cause any extra energy to be utilized by purchasing an electric vehicle, because it was going to purchase a new car that was created with energy anyway. Finally, the last benefit of an electric

**Figure 2: Engine Efficiency**

vehicle is that it tends to run quieter and smoother and requires less overall maintenance than a traditional internal combustion engine (Electric Vehicles, 2010). This suggestion does have a cost however. Currently, the University spends approximately between $17,000 and $26,000 on each replacement vehicle. While the Ford Transit Connect Van's cost is within this range, at a cost of $22,000 (2010 Ford Transit Connect Styles, 2010), the Chevrolet Silverado Hybrid model is a bit more with a cost of about $39,000 (2010 Silverado Hybrid, 2010). This cost is obviously significantly higher than the average that the department spends on replacing vehicles. However, as previously stated, hybrid and electric vehicles require less overall maintenance, and thus it is believed that the department would spend less money each year in maintenance on this vehicle. Furthermore, because the truck operates on a hybrid motor using both gasoline and electricity, it is assumed that the truck would require less gasoline to fuel its operation; as the electric motor would be used in replace of the gasoline in certain driving circumstances. Thus, even though the 2010 Chevrolet Silverado Hybrid model is more expensive, the department would be spending less money servicing and fueling the vehicle overall, making up for the price differential. To conclude, by replacing vans or trucks that do not meet set standards or restrictions with electric vans or trucks, the Campus Management Department would be able to lower its carbon and ecological footprint by reducing its carbon dioxide emissions and maintaining a level embodied energy for vehicle production.




Finally, the Campus Management Department can engage in carbon offsetting. Carbon offsetting is the process of funding or supporting a renewable energy or reforestation project in a different location in order to balance out the carbon dioxide emissions that one is producing (How Carbon Offsets Work, 2010). Carbon offsetting is a great alternative that allows individuals or organizations to account for the carbon emissions they cannot reduce or eliminate. Therefore, with a simple donation to a sanctioned renewable energy project or reforestation effort, the Campus Management Department will be able to count the reduced carbon emissions from the project as its own, and thus reduce its total carbon dioxide emissions. In addition, the Campus Management department could partake in carbon offsetting by maintaining the forest area of the 420-acre campus and by planting additional trees around campus, as trees that uptake carbon dioxide are commonly known to offset carbon emissions. Further, the department could also explore if its extensive open space on campus could be counted toward the reduction of our carbon footprint.

By following these recommendations, Bryant University's Campus Management Department will be able to reduce its overall negative environmental impact. By creating strict emission standards, using better driving techniques, replacing inefficient vehicles with viable electric or hybrid alternatives and finally by carbon offsetting, the department will be able to monitor and reduce its overall carbon footprint. In addition, with a lowered carbon footprint, the department's ecological footprint will be reduced because less land and sea equivalent will be needed to operate the more efficient vehicles. As a result, the Campus Management Department will be able to reduce its contribution to the harmful effects of global warming and climate change by continually monitoring its carbon dioxide emissions and the alternatives available for reducing and eliminating those emissions. The department must make reducing its environmental impact a priority and not just a passing fascination in order to truly have an effect on the global phenomenon that is occurring.

## FUTURE RECOMMENDATIONS

There are many future opportunities that the Campus Management Department could realize in order to control its environmental impact and reduce its contribution to global warming and climate change.

The Campus Management Department could research and consider alternative fuel sources for the other machinery and vehicles that it operates on a daily basis. The department could potentially replace its current golf carts, lawn mowers, leaf blowers, etc. with machines that use alternative fuels instead of gasoline. This will aid the department in lowering its overall carbon footprint.

In addition, Bryant University in its entirety could eventually realize a decreased environmental impact by first completing an ecological and carbon footprint analysis of its current vehicle operations overall, and enacting similar policies outlined. There are a larger array of alternative use vehicles available for small passenger vehicles; the type of vehicle most used by other university departments. Therefore, the University could potentially lower its contribution to global warming and climate change by completing a thorough university wide study of vehicle operations and implementing the previously suggested activities, as well as replacing the vehicles with a more varied array of alternative use vehicles.

Overall, Bryant University has many opportunities to lower its environmental impact. However, none of these opportunities will be realized until the Bryant population is made aware of the environmental issues such as global warming and climate change that are occurring today. Therefore, in order for the University to move ahead and become a leader within the sustainability movement among college campuses, it much first educate and gain support from its population.

## CONCLUSION

By undertaking the suggestions provided for reducing the Campus Management Department driving vehicles operations, Bryant University will be able to greatly reduce its impact on the phenomena known as global warming and climate change. Furthermore, by contributing less to these global issues, Bryant will be able to help in decreasing the harmful effects that result from these unnecessary emissions. In addition, Bryant University has the potential to benefit from reducing its carbon and ecological footprints by once again being recognized as a leader within the sustainability division. The University can once more be seen as one of the fore-runners of this movement and be acknowledged for its dedication and concern for these issues. As a result of this recognition, Bryant also has the potential to influence other Universities and Colleges to become more environmentally aware of their operations and their implications; possibly expanding this movement and its followers. Finally, be making a commitment to sustainability by implementing the suggested recommendations, Bryant will be able to better market itself to prospective students as sustainability and green initiatives are becoming a major factor of student's decisions in choosing a University.

There is no reason that Bryant University should not be examining the impact that its operations have on the world. The issues that are relevant today affect every individual on the planet and cannot be ignored. Therefore, it is imperative that Bryant recognizes the need to reduce carbon emissions, in hopes of starting a trend that will span world-wide and result in a sustainable, healthier world to live in for everyone. These small changes and actions that Bryant University should implement are not meaningless and they have the potential to influence others, resulting in an even larger sustainability movement. Even the smallest actions can bring more awareness to the issues of climate change and global warming and encourage others to take a stand and do their part to reduce the harmful impact of these two phenomena. In fact, this one project began as an opportunity to share with the Bryant University community some of the larger issues that are plaguing the world, in hopes that individuals would be motivated into action on this campus. Finally, it must be remembered that it is these small actions, these risks, which often create the largest result.

## APPENDICES

Appendix A – Transportation-Related Greenhouse Gas Emissions (Tg CO2 Eq.)

| Vehicle Type/Gas | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| **Passenger Cars** | **656.9** | **644.1** | **694.6** | **705.8** | **678.3** | **664.6** |
| CO2 | 628.8 | 604.9 | 643.5 | 658.4 | 634.4 | 625.0 |
| CH4 | 2.6 | 2.1 | 1.6 | 1.1 | 1.0 | 0.9 |
| N2O | 25.4 | 26.9 | 25.2 | 17.8 | 15.7 | 13.7 |
| HFCs | + | 10.1 | 24.3 | 28.5 | 27.2 | 24.9 |
| **Light-Duty Trucks** | **336.2** | **434.7** | **508.3** | **544.8** | **557.1** | **561.7** |
| CO2 | 320.7 | 405.0 | 466.2 | 502.8 | 515.5 | 522.0 |
| CH4 | 1.4 | 1.4 | 1.1 | 0.7 | 0.7 | 0.6 |
| N2O | 14.1 | 22.1 | 22.4 | 13.7 | 12.6 | 11.1 |
| HFCs | + | 6.1 | 18.6 | 27.7 | 28.3 | 27.9 |
| **Medium- and Heavy-Duty Trucks** | **228.8** | **272.7** | **344.2** | **395.1** | **404.5** | **410.8** |
| CO2 | 227.8 | 271.2 | 341.3 | 391.6 | 401.1 | 407.4 |
| CH4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| N2O | 0.8 | 1.0 | 1.2 | 1.2 | 1.1 | 1.1 |
| HFCs | + | 0.3 | 1.6 | 2.1 | 2.2 | 2.2 |
| **Buses** | **8.3** | **9.1** | **11.1** | **12.1** | **12.4** | **12.4** |
| CO2 | 8.3 | 9.0 | 10.9 | 11.8 | 12.1 | 12.1 |
| CH4 | + | + | + | + | + | + |
| N2O | + | + | + | + | + | + |
| HFCs | + | + | 0.1 | 0.2 | 0.3 | 0.3 |
| **Motorcycles** | **1.8** | **1.8** | **1.9** | **1.6** | **1.9** | **2.1** |
| CO2 | 1.7 | 1.8 | 1.8 | 1.6 | 1.9 | 2.0 |
| CH4 | + | + | + | + | + | + |
| N2O | + | + | + | + | + | + |
| **Commercial Aircraft$_a$** | **136.9** | **143.1** | **167.8** | **159.8** | **155.5** | **155.2** |
| CO2 | 135.5 | 141.6 | 166.0 | 158.2 | 153.9 | 153.6 |
| CH4 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| N2O | 1.3 | 1.4 | 1.6 | 1.5 | 1.5 | 1.5 |
| **Other Aircraft$_b$** | **44.4** | **32.3** | **32.9** | **34.5** | **33.8** | **34.2** |
| CO2 | 43.9 | 32.0 | 32.5 | 34.1 | 33.4 | 33.9 |
| CH4 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| N2O | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| **Ships and Boats$_c$** | **46.9** | **56.6** | **65.1** | **50.7** | **54.1** | **56.3** |
| CO2 | 46.5 | 55.5 | 61.0 | 45.4 | 48.7 | 50.8 |
| CH4 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| N2O | 0.4 | 0.4 | 0.5 | 0.4 | 0.4 | 0.4 |
| HFCs | + | 0.6 | 3.4 | 4.7 | 4.9 | 4.9 |

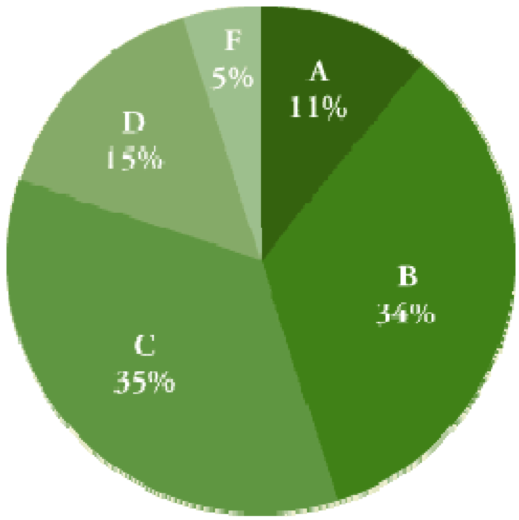
| | | | | | | |
|---|---|---|---|---|---|---|
| **Rail** | **38.6** | **44.1** | **50.1** | **56.7** | **58.9** | **58.0** |
| CO2 | 38.1 | 42.2 | 45.1 | 49.8 | 51.8 | 50.8 |
| CH4 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| N2O | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 |
| HFCs | + | 1.4 | 4.6 | 6.4 | 6.5 | 6.6 |
| Other Emissions from Electricity Generation$_d$ | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |

| **Vehicle Type/Gas** | **1990** | **1995** | **2000** | **2005** | **2006** | **2007** |
|---|---|---|---|---|---|---|
| **Pipelines$_e$** | **36.2** | **38.5** | **35.2** | **32.4** | **32.6** | **34.6** |
| CO2 | 36.2 | 38.5 | 35.2 | 32.4 | 32.6 | 34.6 |
| **Lubricants** | **11.9** | **11.3** | **12.1** | **10.2** | **9.9** | **10.2** |
| CO2 | 11.9 | 11.3 | 12.1 | 10.2 | 9.9 | 10.2 |
| **Total Transportation** | **1,546.7** | **1,688.3** | **1,923.2** | **2,003.6** | **1,999.0** | **2,000.1** |
| *International Bunker Fuels$_f$* | *115.6* | *102.7* | *100.0* | *112.7* | *111.7* | *109.9* |

+ Does not exceed 0.05 Tg CO2 Eq.
a Consists of emissions from jet fuel consumed by domestic operations of commercial aircraft (no bunkers).
b Consists of emissions from jet fuel and aviation gasoline consumption by general aviation and military aircraft.
c Fluctuations in emission estimates are associated with fluctuations in reported fuel consumption, and may reflect data collection problems.
d Other emissions from electricity generation are a result of waste incineration (as the majority of municipal solid waste is combusted in “trash-to-steam” electricity generation plants), electrical transmission and distribution, and a portion of limestone and dolomite use (from pollution control equipment installed in electricity generation plants).
e CO2 estimates reflect natural gas used to power pipelines, but not electricity. While the operation of pipelines produces CH4 and N2O, these emissions are not directly attributed to pipelines in the US Inventory.
f Emissions from International Bunker Fuels include emissions from both civilian and military activities; these emissions are not included in the transportation totals.
Note: Totals may not sum due to independent rounding. Passenger cars and light-duty trucks include vehicles typically used for personal travel and less than 8500 lbs; medium- and heavy-duty trucks include vehicles 8501 lbs and above. HFC emissions primarily reflect HFC-134a.

Source: EPA. (2009, April). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007*. Retrieved August 2009, from www.epa.gov: http://www.epa.gov/climatechange/emissions/usinventoryreport.html

Appendix B- Grade Distribution for Transportation Category in 2009 College Sustainability Report Card




*This chart shows that out of the three-hundred colleges whose sustainability policies were analyzed, only 11%, or around thirty-three colleges, received an "A" for their Sustainable Transportation Activities. In addition, only 34% of colleges received a "B", and the majority of colleges scored a "C" or worse when their sustainable transportation activities were analyzed.

Source*: Transportation*. (2009). Retrieved February 2010, from The College Sustainability Report Card: http://www.greenreportcard.org/report-card-2009/categories/transportation

Appendix C – Questions for Interview with Brian Britton

Thank you for your participation in my Senior Honors Thesis. The following questions will aid me in my research in analyzing the vehicle operations efficiency of Bryant University. The Microsoft Excel document that is also provided with these questions is for your responses. If you have any questions as to how to fill the document out, please feel free to ask. Finally, if for any of these questions you feel that there is a more appropriate person whom I should contact to gather the information needed, please list their name. Thank you.

- How many vehicles does Bryant University have in its operations?
- What are the make and models of these vehicles?
- What are the estimated miles per gallon rates of these vehicles?
- What is the average length of vehicle life?
- How often do you purchase new vehicles?
- What is the cost of these new vehicles?
- How do you acquire these new vehicles? Partnership, licensing, etc?
- What type of fuel do these vehicles operate from? New and old.
- What is the cost of the fuel for these vehicles?
- What is the cost of maintenance for these vehicles?
- Do any of the vehicles use alternative fuel sources?
- Are there currently any actions being taken to makes vehicles operations more sustainable?
- If so, why were these actions undertaken?
- What are the costs of these activities?
- Is there a cost savings? What is the cost savings?
- What are other benefits from these activities?
- Do you see any ways in which vehicle operations could become more sustainable?
- Do you think the university would be open to alternative fuel sources, such as:
- Biodiesel, Electric, Fuel Cell, Hybrid?

Appendix D: Questionnaire for Brian Britton- Completed with His Answers
Britton's responses to the questions are noted in red.

Questions for Interview

Thank you for your participation in my Senior Honors Thesis. The following questions will aid me in my research in analyzing the vehicle operations efficiency of Bryant University. The Microsoft Excel document that is also provided with these questions is for your responses. If you have any questions as to how to fill the document out, please feel free to ask. Finally, if for any of these questions you feel that there is a more appropriate person whom I should contact to gather the information needed, please list their name. Thank you.

- How many vehicles does Bryant University have in its operations?
  I have included a spreadsheet with this information.
  - What are the make and models of these vehicles?
  - What are the estimated miles per gallon rates of these vehicles?
- What is the average length of vehicle life?
  In Facilities we generally keep vehicles as long as they are functional and until they are too costly to keep in good repair. The actual policy states that vehicles are replaced once they reach 100,000 miles, however that is usually not used because the vehicles do not gain that mileage around campus.
- How often do you purchase new vehicles?
  It varies according to the condition of the vehicles and the functional needs of the operation but I would estimate that we may buy on average 2 to 3 per year.
  - What is the cost of these new vehicles?
    The cost of varies with the type of vehicle but the most common purchase is a cargo van at somewhere around $18,000 to a heavy duty pickup with plow for $26,000.
  - How do you acquire these new vehicles? Partnership, licensing, etc?
    Vehicles, new and used, are typically purchased outright through competitive bidding process.
- What type of fuel do these vehicles operate from? New and old.
  Typically, Regular Unleaded Gas, however some equipment runs on diesel fuel.
- What is the cost of the fuel for these vehicles?
  For FY 2009/10 we budgeted $2.50 per gallon for an estimated usage of 18,000 gallons per year. However this also includes fuel for all campus equipment as well as public safety vehicles. Lately we have been paying around $2.69.
- What is the cost of maintenance for these vehicles?
  We spend about $85,000 per year on vehicle and equipment parts and labor.
- Do any of the vehicles use alternative fuel sources?
  No

- Are there currently any actions being taken to makes vehicles operations more sustainable?
    - If so, why were these actions undertaken?
    - What are the costs of these activities?
    - Is there a cost savings? What is the cost savings?
    - What are other benefits from these activities?

    Generally we are open to alternative fuels and special purpose vehicles. We have looked at alternatives and compared notes with other facility departments but so far have not found vehicles that can serve a variety of on-campus needs and also be able to double for off campus errands. I would be grateful to learn of any examples of suitable alternatively powered vehicles that you encounter in you research.
- Do you see any ways in which vehicle operations could become more sustainable?
  I have hopes that we will be able to acquire hybrid or plug in- hybrid working vehicles like panel vans. I would also like to see our small fleet of golf carts go electric but first cost has been an obstacle. Currently we buy most of our golf carts used for $2,000 to $2,500 each.
- Do you think the university would be open to alternative fuel sources, such as:
    - Biodiesel
    - Electric
    - Fuel cell
    - Hybrids

      At this point it seems that electric and hybrid technology is most promising.

## Appendix E: Microsoft Excel Spreadsheets Provided by Brian Britton

1.) Vehicle Inventory List

| *DEPARTMENT* | *CONTACT* | *YEAR* | *MAKE* | *DESCRIPTION* | *DRIVER* | *SERIAL #* | *REG. #* | *INS* | *MILEAGE 12/09* | *PURCHASED* |
|---|---|---|---|---|---|---|---|---|---|---|
| FACILITIES-CARP-206601-75131 | Katie C X6050 | 2005 | CHEVY | Express Van White | Dean Carlson | 1GCFG15X851124097 | 13516 | Y | 13,563 | 5/19/2005 |
| FACILITIES-CARP- 206601-75131 | Katie C X6050 | 2005 | CHEVY | Express Van White | Barry Frechette | 1GCFG15X051198291 | 13466 | Y | 6,487 | 5/19/2005 |
| FACILITIES-CARP-206601-75131 | Katie C X6050 | 2005 | CHEVY | Express Van White | Greg Borges | 1GCFG15X651166638 | 13517 | Y | 6,541 | 5/19/2005 |
| FACILITIES-CARP-206601-75131 | Katie C X6050 | 2003 | CHEVY | Astro Van - White | Al Forget | 1GCDM19X13B104596 | 251-898 | Y | 20,887 | 11/2/2004 |
| FACILITIES-CARP-206601-75131 | Katie C X6050 | 2003 | CHEVY | G1500 Express Van - White | Derek Munschy | 1GCFG15X631201613 | 166-869 | Y | 18,847 | 11/2/2004 |
| FACILITIES-CARP-206601-75131 | Katie C X6050 | 2003 | FORD | E-150 Econoline Van White | Brian McCarthy | 1FTRE14253HB26807 | 16624 | Y | 48,692 | 11/1/2004 |
| FACILITIES-LK-206601-75131 | Katie C X6050 | 2006 | CHEVY | Express Cargo Van White | Nate Perrino | 1GCFG15X861115417 | 55539 | Y | 11,790 | 5/18/2006 |
| FACILITIES-HVAC-206601-75131 | Katie C X6050 | 2004 | CHEVY | Cargo Van-White | multiple drivers | 1GCFG15X741164492 | Unregistered-on campus | N | 46,808 | 8/18/2006 |
| FACILITIES-HVAC-206601-75131 | Katie C X6050 | 2004 | CHEVY | Cargo Van-White | multiple drivers | 1GCFG15X941164722 | Unregistered-on campus | N | 55,345 | 8/18/2006 |
| FACILITIES-HVAC-206601-75131 | Katie C X6050 | 2001 | CHEVY | Astro Van - White | multiple drivers | 1GCDM19W81B120895 | 16699 | Y | 57,222 | 11/1/2004 |
| FACILITIES-HVAC-206601-75131 | Katie C X6050 | 2003 | CHEVY | Astro Express Van - White | Bruce Shepard | 1GCDL19X63B124281 | 16648 | Y | 41,023 | 11/2/2004 |
| FACITITIES-PT-206601-75131 | Katie C X6050 | 2004 | CHEVY | Cargo Van-White | Painters | 1GCFG15X141164858 | Unregistered-on campus | N | 48,692 | 8/18/2006 |
| FACILITIES-PLUM-206601-75131 | Katie C X6050 | 1996 | FORD | E150 Econoline VAN-White | Jim McGee | 1FTHE24Z4THA88548 | 48155 | Y | 110,607 | Donated |
| FACILITIES-ELEC-206601-75131 | Katie C X6050 | 2000 | CHEVY | Astro Cargo Van - Yellow | Felix Corpuz/Victor Vargas | 1GCDM19W3YB190248 | 12032 | Y | 87,125 | 4/11/2003 |
| FACILITIES-ELEC-206601-75131 | Katie C X6050 | 2001 | CHEVY | Astro Van - White | Mike Forget | 1GCDM19W51B149321 | 52940 | Y | 64,787 | 11/2/2004 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| FACILITIES-ELEC-206601-75131 | Katie C X6050 | 2005 | CHEVY | Express Van White | Roger Adam | 1GCFG15X151200534 | 13506 | Y | 11,629 | 5/19/2005 |
| FACILITIES-ELEC-206601-75131 | Katie C X6050 | 1991 | INTERNATIONAL | Bucket Truck-Yellow | Electricians | 1HTSDNSN0MH374847 | Unregistered-on campus | N | 4,408 | |
| FACILITIES-HSKP-206601-75131 | Katie C X6050 | 1999 | FORD | Taurus Wagon-Tan | multiple drivers | 1FAFP58S4XG292851 | ZD 992 | Y | 122,644 | |
| FACILITIES-HSKP-206601-75131 | Katie C X6050 | 2008 | GMC | Savana Van-White | multiple drivers | 1GTGG25C481108264 | 175-952 | Y | 2,850 | 7/31/2008 |
| FACILITIES-HSKP-206601-75131 | Katie C X6050 | 2002 | CHEVY | Silverado-White | multiple drivers | 1GCEC14W22Z171400 | 114-502 | Y | 37,884 | 9/16/2004 |
| FACILITIES-GRND-206601-75131 | Katie C X6050 | 1990 | FORD | F600 Dump Truck - Yellow | multiple drivers | 1FDNF60H3LVA18511 | 43778 | Y | 30,806 | |
| FACILITIES-GRND-206601-75131 | Katie C X6050 | 1998 | JEEP | Wrangler 4 WD-Yellow | multiple drivers | 1J4FY19S5WP796719 | QS 379 | Y | 92,442 | |
| FACILITIES-GRND-206601-75131 | Katie C X6050 | 2009 | GMC | Sierra 2500HD 4WD-White | multiple drivers | 1GTHK44K99F176734 | 106-042 | Y | 50 | 1/25/2010 |
| FACILITIES-GRND-206601-75131 | Katie C X6050 | 2003 | GMC | Sierra 3500 Dump Truck | multiple drivers | 1GDJK34U73E342884 | 127-652 | Y | 33,988 | 4/9/2003 |
| FACILITIES-GRND-206601-75131 | Katie C X6050 | 2001 | FORD | F450 White | multiple drivers | 1FDXF47S71EB88589 | 34191 | Y | 61,894 | 11/1/2004 |
| FACILITIES-GRND-206601-75131 | Katie C X6050 | 2008 | JEEP | Wrangler UT 4WD-Yellow | multiple drivers | 1J4FA24138L575719 | 806-865 | Y | 9,415 | 1/28/2008 |
| FACILITIES-GRND-206601-75131 | Katie C X6050 | 2005 | CHEVY | Silverado White | multiple drivers | 1GCHK24U25E159036 | 13465 | Y | 37,267 | 5/19/2005 |
| FACILITIES-GRND-206601-75131 | Katie C X6050 | 1994 | CHEVY | Pickup-3500-Yellow | multiple drivers | 1GCHK34K5RE193854 | 49729 | Y | 87,489 | |
| | | | | | | | | | | |
| ***GROUNDS EQUIPMENT*** | | | | | | | | | | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 1974 | JACOBSEN | MOWER | multiple drivers | 94502500548 | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 1982 | CUSHMAN | REFUSE UNIT | multiple drivers | 560671 | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 1986 | TENANT | STREET SWEEPER | multiple drivers | | not required | N | N/A | |

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|---|---|---|---|---|---|---|---|---|---|---|
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 1990 | SCAG | WALK BEHIND | multiple drivers | 541100 | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 1994 | O T R | UTIL.TRAILER 2 WHEEL | multiple drivers | 409U51219R2022010 | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 1994 | | PAINTER MACHINE | multiple drivers | | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2004 | STEINER | TRACTOR/SWEEPER/MOWER/SNOW | multiple drivers | 75700400118 | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | | HUSTLER | MOWER | multiple drivers | 4010851 | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | | TENANT | DRIVE VACUUM | multiple drivers | 4300 1677 | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2001 | JCB 214 | TRACTOR/LOADER/BACKHOE | multiple drivers | SLP214TC1U0901081 | not required | N | N/A | 3/24/2003 |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2004 | SCAG | WALK BEHIND | multiple drivers | 8080098 | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2004 | KUBOTA | L5030 Tractor | multiple drivers | 24593 | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2005 | JOHN DEERE | WALK BEHIND | multiple drivers | TC-2653D081494 | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | | HMT | UTIL.TRAILER 2 WHEEL GREEN | multiple drivers | BLKVIN000003132 | 39559 | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2006 | NILFISK | RS 1300 W/3RD BROOM PACKAGE | multiple drivers | 61306144 | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2006 | TORO | TRACTOR SPRAYER | multiple drivers | 260000475 | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2006 | JOHN DEERE | GATOR | multiple drivers | MOHP4GX044231 | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2006 | MULTIPRO | 300 GAL SPRAYER | multiple drivers | | | | | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2007 | KUBOTA | F3680 with accessories | multiple drivers | 10459 | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2007 | VERTIDRAIN | Deep Tine Aerator | multiple drivers | | not required | N | N/A | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2007 | VERTI TOP | Turf Debris Remover | multiple drivers | | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2007 | PROSEED | PROSEEDER 6000 | multiple drivers | | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2007 | REDEXIM | TURF TIDY 60612 | multiple drivers | | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2007 | TROWEL | 2 1/2 YD SANDER | multiple drivers | | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2007 | JOHN DEERE | AERCORE | multiple drivers | | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2007 | KABOTA | UTILITY VEHICLE | multiple drivers | | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2007 | TYCROP | TOPSEEDER | multiple drivers | | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2008 | REDEXIM | VERTIDRAIN CHARTERHOUSE | multiple drivers | | not required | N | N/A | |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 2008 | TORO | INFIELD PRO 5040 TRACTOR | multiple drivers | | not required | N | N/A | |
| ***SOLD,TRADED OR JUNKED*** | | | | | | | | | | |
| FACILITIES-PLMB - 206601-75131 | Katie C X6050 | 2000 | CHEVY | ASTRO CARGO VAN - WHITE | | 1GCDM19W3YB114223 | 195499 | totaled 12/08 | 56,489 | 4/11/2003 |
| FACILITIES-GRND - 206601-75131 | Katie C X6050 | 1984 | CHEVY | High Lift Bucket Truck | multiple drivers | 1GBM7D1E0EV144354 | not required | Junked 2/09 | not useable | 11/8/2006 |
| FACILITIES-GRND-206601-75131 | Katie C X6050 | 2000 | CHEVY | Pick Up-Yellow | multiple drivers | 1GCGK24U7YE194400 | 106-042 | traded 1/25/10 | 87,222 | |

2.) Vehicle Inventory-Purchase Cost List

| DEPARTMENT | YEAR | MAKE | DESCRIPTION | SERIAL # | REG. # | INS | Cost New | Driver |
|---|---|---|---|---|---|---|---|---|
| FACILITIES | 1984 | CHEVY | UTILITY TRUCK | 1GBM7D1EOEV144354 | | N | | on campus use |
| FACILITIES | 1994 | CHEVY | YELLOW PICKUP-3500 | 1GCHK34K5RE193854 | 49729 | Y | $ 22,000.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2000 | CHEVY | ASTRO VAN | 1GCDM19W3YB190248 | 12032 | Y | $ 10,000.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2000 | CHEVY | ASTRO VAN | 1GCDM19W3YB114223 | 195499 | Y | $ 10,000.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2000 | CHEVY | PICK UP - | 1GCGK24U7YE194400 | 106042 | Y | $ 26,125.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2001 | CHEVY | ASTRO VAN | 1GCDM19W81B120895 | | Y | $ 11,500.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2001 | CHEVY | ASTRO VAN | 1GCDM19W51B149321 | | Y | $ 8,500.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2002 | CHEVY | SILVERADO | 1GCEC14W22Z171400 | 114502 | Y | $ 13,500.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2003 | CHEVY | ASTRO VAN | 1GCDL19X63B124281 | | Y | $ 15,800.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2003 | CHEVY | ASTRO VAN | 1GCDM19X13B104596 | | Y | $ 14,991.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2003 | CHEVY | G1500 EXPRESS VAN | 1GCFG15X631201613 | | Y | $ 15,700.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2004 | CHEVY | Cargo Van | 1GCFG15X941164722 | | N | $ 12,620.00 | on campus use |
| FACILITIES | 2004 | CHEVY | Cargo Van | 1GCFG15X741164492 | | N | $ 12,620.00 | on campus use |
| FACILITIES | 2004 | CHEVY | Cargo Van | 1GCFG15X141164858 | | N | $ 12,120.00 | on campus use |
| FACILITIES | 2005 | CHEVY | SILVERADO | 1GCHK24U25E159036 | | Y | $ 25,696.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2005 | CHEVY | EXPRESS VAN | 1GCFG15X851124097 | | Y | $ 18,589.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2005 | CHEVY | EXPRESS VAN | 1GCFG15X051198291 | | Y | $ 18,689.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2005 | CHEVY | EXPRESS VAN | 1GCFG15X651166638 | | Y | $ 18,709.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2005 | CHEVY | EXPRESS VAN | 1GCFG15X151200534 | | Y | $ 18,689.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2006 | CHEVY | EXPRESS CARGO VAN | 1GCFG15X861115417 | | Y | | on campus use occasional off-campus maintenance |
| FACILITIES | 1982 | CUSHMAN | REFUSE UNIT | 560671 | | * | on campus use | |
| FACILITIES | 1987 | FORD | E152 CARGO VAN CMD | 1FTDE14Y4HHA47022 | 175952 | Y | $ 4,500.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 1990 | FORD | F600 DUMP TRUCK - YELLOW | 1FDNF60H3LVA18511 | 43778 | Y | $ 35,000.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 1996 | FORD | ECONOLINE | 1FTHE24Z4THA88548 | | Y | $ 2.00 | donation |
| FACILITIES | 1999 | FORD | TAURUS WAGON | 1FAFP58S4XG292851 | ZD 992 | Y | $ 16,700.00 | on campus use occasional off-campus maintenance |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FACILITIES | 2001 | FORD | F450 | 1FDXF47S71EB88589 | | Y | $ 19,300.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2003 | FORD | E-150 | 1FTRE14253HB26807 | | Y | $ 14,500.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2003 | GMC | SIERRA 3500 DUMP TRUCK | 1GDJK34U73E342884 | 127652 | Y | $ 30,313.00 | on campus use occasional off-campus maintenance |
| FACILITIES | | HMT | UTILITY TRAILER 2 WHEELS GREEN | BLKVIN000003132 | 39559 | * | on campus use | |
| FACILITIES | 1991 | International | Bucket Truck | 1HTSDNSN0MH374847 | | * | $ 15,000.00 | on campus use |
| FACILITIES | 1974 | JACOBSEN | MOWER | | | * | | on campus use |
| FACILITIES | 2001 | JCB 214 | TRACTOR/LOADER/BACHOE | SLP214TC1U0901081 | | * | $ 40,000.00 | on campus use |
| FACILITIES | 1998 | JEEP | WRANGLER 4 WD | 1J4FY19S5WP796719 | QS379 | Y | $ 32,000.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 2008 | JEEP | WRANGLER 4 WD | 1J4FA24138L575719 | | Y | $ 20,991.00 | on campus use occasional off-campus maintenance |
| FACILITIES | 1987 | JOHN DEERE | WALK BEHIND | | | * | on campus use | |
| FACILITIES | 2004 | Kubota | L5030 Tractor | | | * | | on campus use |
| FACILITIES | 1980 | NATIONAL | MOWER | | | * | on campus use | |
| FACILITIES | 1990 | SCAG | WALK BEHIND | | | * | on campus use | |
| FACILITIES | | STEINER | TRACTOR | 75700400118 | | * | | on campus use |
| FACILITIES | 1986 | | STREET SWEEPER | | | * | on campus use | |
| FACILITIES | 1994 | | PAINTER MACHINE | | | * | on campus use | |
| * On campus vehicles insured for liability only as mobile equipment. | | | | | | | | |
| FACILITIES | | | RS1300 W/3rd BROOM PACKAGE | 61306144 | | N | $ 91,126.04 | on campus use |
| | | | | | | | $ 605,280.04 | |
| * Denotes on campus use only. Vehicle is insured for liability only as mobile-equipment on the University's CGL policy. | | | | | | | Automobiles over 5 years old do not have collision coverage. | |
| | | | | | | | | |

Appendix F: Pictures of The Two Most Common Types of Vehicles Used by The Department

Chevrolet Astro Van


Chevrolet Silverado

Appendix G: Suggested Online Resources for Tracking Carbon Footprint Analysis and Software for Carbon Footprint Calculators

ERA Environmental Consulting:

http://www.era-environmental.com/software/green-house-gas-emissions/?gclid=CP2IwZzDkaECFclM5QodNwJWPw

HARA Environmental and Energy Management Solution:

http://www.hara.com/solutions_overview.html?gclid=CK2xyvfDkaECFclM5QodNwJWPw

EPA'S Greenhouse Gas Management Programs:

http://www.epa.gov/climatechange/wycd/businesses.html

Software for Carbon Footprint Calculations:

http://wareseeker.com/free-carbon-footprint/

http://www.carbonfootprintsoftware.com/

http://carbon-footprint-calculator.smartcode.com/info.html

Appendix H: Pictures of The Suggested Vehicle Models

*2010 Ford Transit Connect Van*

Source: *2010 Ford Transit Connect Van*. (2009). Retrieved March 2010, from Google.com: http://www.tinyhouselover.com/wp-content/uploads/2009/11/2010-ford-transit-connect.jpg

*2010 Chevrolet Silverado Hybrid*

*Source: 2010 Chevrolet Silverado Hybrid*. (2010). Retrieved March 2010, from Google.com: http://image.trucktrend.com/f/23451188+w750+st0/163_news0910_09z+2010_Chevy_Silverado_hybrid+front_view.jpg

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