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Task 2.1 Project I

Commercial Lawn and Garden Emission Inventory

Technical Report

December 31, 2013

Prepared by:

Alamo Area Council of Governments

Prepared in Cooperation with the Texas Commission on Environmental Quality

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Abstract: The compilation of the commercial lawn and garden equipment emissions inventory (EI) required extensive research and analysis, and provided a vast database of regional pollution sources and emission rates. An extensive survey was conducted of all entities identified as operating commercial lawn and garden equipment in the San Antonio-New Braunfels MSA. Businesses and agencies that were surveyed for this task included commercial lawn and garden companies, universities/colleges, public school districts, golf courses, cemeteries, government facilities, federal and state parks, other businesses and employers, commercial and private airports, and military facilities. The results of the survey indicate significantly higher populations of commercial trimmers, front mowers, shredders, and rear engine mowers in the AACOG region than the populations developed for the TexN Model. Leaf blowers, turf equipment, lawn and garden tractors, and chainsaws are also under-predicted in the TexN Model. AACOG's 2012 survey results for total equipment were 280 percent higher than the existing equipment population in the TexN Model. Based on the results of AACOG's survey, commercial lawn and garden equipment was estimated to emit 3.6 tons of VOCs and 1.1 tons of NO_X per ozone season weekday. Trimmers were the largest source of VOC emissions, 0.65 tons per weekday, because of the large number and high activity rates of trimmers in the San Antonio New Braunfels MSA. The second largest source of VOC emissions was chippers/grinders (0.60 tons of VOCs per weekday), followed by chainsaws (0.46 tons), leaf blowers (0.45 tons), and rear engine mowers (0.44 tons). The largest source of NO_X emissions was chippers and grinders at 0.52 tons per weekday. Other sources of NO_X emissions included lawn and garden tractors, 0.19 tons per weekday and rear engine lawn mowers, 0.15 tons per weekday. A weekday versus weekend adjustment factor was calculated based on the hours of usage from the surveys for each facility type. The survey results show that commercial lawn and garden equipment usage was higher on weekdays compared to existing data in the TexN Model.

Related Reports:	**Distribution Statement:**	**Permanent File:**
Alamo Area Council of Governments, June 1, 2012. "Proposed Planning Process for the Emission Inventory". San Antonio, Texas.	Alamo Area Council of Governments, Natural Resources/Transportation Department	Alamo Area Council of Governments, Natural Resources/Transportation Department

EXECUTIVE SUMMARY

The Clean Air Act (CAA) is the comprehensive federal law that regulates airborne emissions across the United States.[1] This law authorizes the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment. Of the many air pollutants commonly found throughout the country, EPA has recognized six "criteria" pollutants, including ozone, which can injure health, harm the environment, and/or cause property damage. TCEQ operates three regulatory ozone monitors, CAMS23, CAMS58, and CAMS59, in the San Antonio area to determine compliance with the federal ozone standard. The annual fourth highest eight-hour average ozone concentrations, which are the values used in federal compliance calculations, have risen in recent years: from 75 ppb in 2009 to 83 ppb in 2013f.

Ozone is produced when volatile organic compounds (VOCs) and nitrogen oxides (NO_X) react in the presence of sunlight, especially during the warm days of summer time.[2] These ozone precursors can be generated by local processes and the majority of chemicals that form ground-level ozone originate from anthropogenic sources. To conduct analysis that determines emission reductions required to bring the area into compliance with the standards, local and state air quality planners need an accurate account of emissions and their sources in the region. The compilation of the commercial lawn and garden equipment emissions inventory (EI) required extensive research and analysis, and provided a vast database of regional pollution sources and emission rates.

Engines installed on commercial lawn and garden equipment that are regularly used by businesses and governmental agencies contribute to NO_X and VOC emissions. Documenting the scale of commercial lawn and garden equipment activities are essential steps in the emission inventory effort. An extensive survey was conducted of all entities that operate commercial lawn and garden equipment in the San Antonio-New Braunfels MSA. Having local survey data on commercial lawn and garden equipment usage improves emission estimates of these sources. Businesses and agencies that were surveyed for this task included commercial lawn and garden companies, universities/colleges, public school districts, golf courses, cemeteries, government facilities, federal and state parks, other businesses and employers, commercial and private airports, and military facilities. For every business/agency category, there was at least a 21 percent response rate with an overall 34 percent response rate to the surveys. A very high response rate was obtained for several business categories: a 100 percent response rate for military bases, a 78 percent response rate for cemeteries, a 72 percent response rate for local government facilities, and a 71 percent response rate for airports.

Once the lawn and garden equipment was tallied for all categories, a comparison was made between TexN Model data and the results from the AACOG survey. There were significantly more commercial trimmers, front mowers, shredders, and rear engine mowers in the AACOG survey than the TexN Model. Leaf blowers, turf equipment, lawn and garden tractors, and chainsaws are also under-predicted in the TexN Model.

[1] US Congress, 1990. "Clean Air Act". Available online: http://www.epa.gov/air/caa/. Accessed: 07/19/2010.
[2] EPA, Sept. 23, 2011, "Ground-level Ozone". Available online: http://www.epa.gov/air/ozonepollution/. Accessed: 10/31/2011.

Conversely, the TexN Model over predicted the number of tillers and commercial lawn mowers. AACOG's 2012 survey results for total equipment were 280 percent higher than the existing equipment population in the TexN Model.

The methodology used to estimate emissions from the operation of lawn and garden equipment incorporated information on equipment type, equipment population, horsepower, and activity data extracted from returned survey questionnaires. When specific data such as load or emission factors were not provided in the survey returns, existing data in the TexN Model was used. Based on AACOG's survey results, it was determined that commercial lawn and garden equipment emitted 3.6 tons of VOCs and 1.1 tons of NO_X per ozone season weekday. Trimmers were the largest source of VOC emissions, 0.65 tons per weekday, because of the large number and high activity rates of trimmers in the San Antonio-New Braunfels MSA. The second largest source of VOC emissions was chippers/grinders (0.60 tons of VOC per weekday), followed by chainsaws (0.46 tons), leaf blowers (0.45 tons), and rear engine mowers (0.44 tons). The largest source of NO_X emissions was chippers and grinders with 0.52 tons per weekday. Other sources of NO_X emissions included lawn and garden tractors, 0.19 tons per weekday and rear engine lawn mowers, 0.15 tons per weekday.

A weekday versus weekend adjustment factor was calculated based on the hours of usage listed in the completed surveys for each facility type. Universities/colleges, public schools, federal and state parks, other companies, and Stinson airport reported no equipment usage on the weekends. The only categories with significant usage on the weekends were small airports, military facilities, and golf courses. The survey results show that commercial lawn and garden equipment usage was higher on weekdays compared to existing data in the TexN Model.

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1.1. Background

The Clean Air Act (CAA) is the comprehensive federal law that regulates airborne emissions across the United States.[3] This law authorizes the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment. Of the many air pollutants commonly found throughout the country, EPA has recognized six "criteria" pollutants, including ozone, which can injure health, harm the environment, and/or cause property damage. Air quality monitors measure concentrations of these pollutants throughout the country.

Ozone is produced when volatile organic compounds (VOC) and nitrogen oxides (NO_X) react in the presence of sunlight, especially during the summer time.[4] These ozone precursors can be generated by local processes and the majority of chemicals that form ground-level ozone originate from anthropogenic sources. According to the EPA, "the health effects associated with ozone exposure include respiratory health problems ranging from decreased lung function and aggravated asthma to increased emergency department visits, hospital admissions and premature death. The environmental effects associated with seasonal exposure to ground-level ozone include adverse effects on sensitive vegetation, forests, and ecosystems."[5] Currently, the ozone primary standard, which is designed to protect human health, is set at 75 parts per billion (ppb). The secondary standard, which is designed to protect the environment, is in the same form and concentration as the primary standard.

To conduct analysis that determines emission reductions required to bring the area into compliance with the standards, local and state air quality planners need an accurate account of emissions and their sources in the region. Such sources include the small engines that power lawn and garden equipment. The compilation of the San Antonio-New Braunfels MSA commercial lawn and garden equipment emissions inventory (EI) required extensive research and analysis, and provided a vast database of regional pollution sources and emission rates. By understanding these varied sources that create ozone precursor pollutants, planners, political leaders, and citizens can work together to protect heath and the environment.

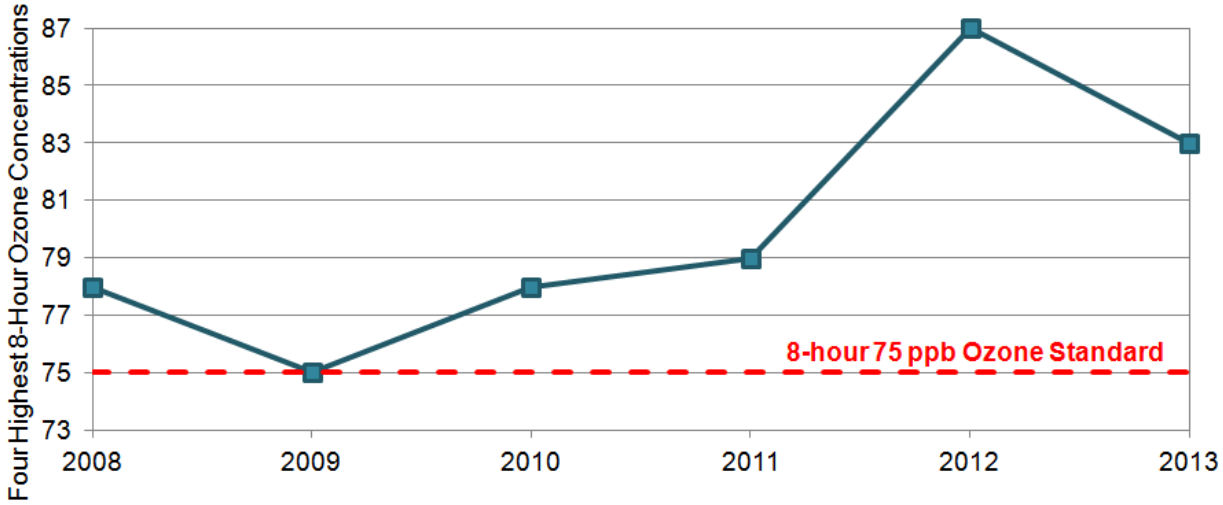
1.2. Local Ozone and Meteorological Conditions

There are currently 11 air quality monitors, CAMS, in the San Antonio region that record ozone air pollution measurements. The data collected at these sites is processed for quality assurance by the Texas Commission on Environmental Quality (TCEQ) and is accessible via the Internet.[6] The CAMS network in the San Antonio region includes both regulatory and non-regulatory monitors. Regulatory monitors meet EPA's requirements for equipment type, site location criteria, and quality assurance. TCEQ operates three regulatory monitors in the San Antonio area: CAMS23, CAMS58, and CAMS59. The annual fourth highest eight-hour average ozone concentrations, which are the values used in federal compliance calculations, have risen

[3] US Congress, 1990. "Clean Air Act". Available online: http://www.epa.gov/air/caa/. Accessed: 07/19/2010.
[4] EPA, Sept. 23, 2011, "Ground-level Ozone". Available online: http://www.epa.gov/air/ozonepollution/. Accessed: 10/31/2011.
[5] EPA, September 16, 2009. "Fact Sheet: EPA to Reconsider Ozone Pollution Standards", p. 1. Available online: http://www.epa.gov/air/ozonepollution/pdfs/O3_Reconsideration_FACT%20SHEET_091609.pdf. Accessed: 06/28/2010.
[6] TCEQ, "Select a Monitoring Site in Region 13 (San Antonio)". Austin, Texas. Available online: http://www.tceq.state.tx.us/cgi-bin/compliance/monops/select_summary.pl?region13.gif. Accessed: 10/28/2013.

significantly in recent years: from 75 ppb in 2009 to 83 ppb in 2013f. Furthermore, the fourth highest eight-hour ozone average in the San Antonio region has exceeded 75 ppb for the last four years (Figure 1-1).

Figure 1-1: San Antonio-New Braunfels MSA's 4th-highest 8-Hour Ozone Value, 2008 - 2013



1.3. Inventory Pollutants

Ozone is a secondary pollutant because it forms as the result of chemical reactions between other pollutants, namely:

- Nitrogen oxides (NO_X)
- Volatile organic compounds (VOC)

Emissions were calculated for an average ozone season weekday and weekend by county and by type of facility that uses commercial lawn and garden equipment.

1.4. Geographic Area

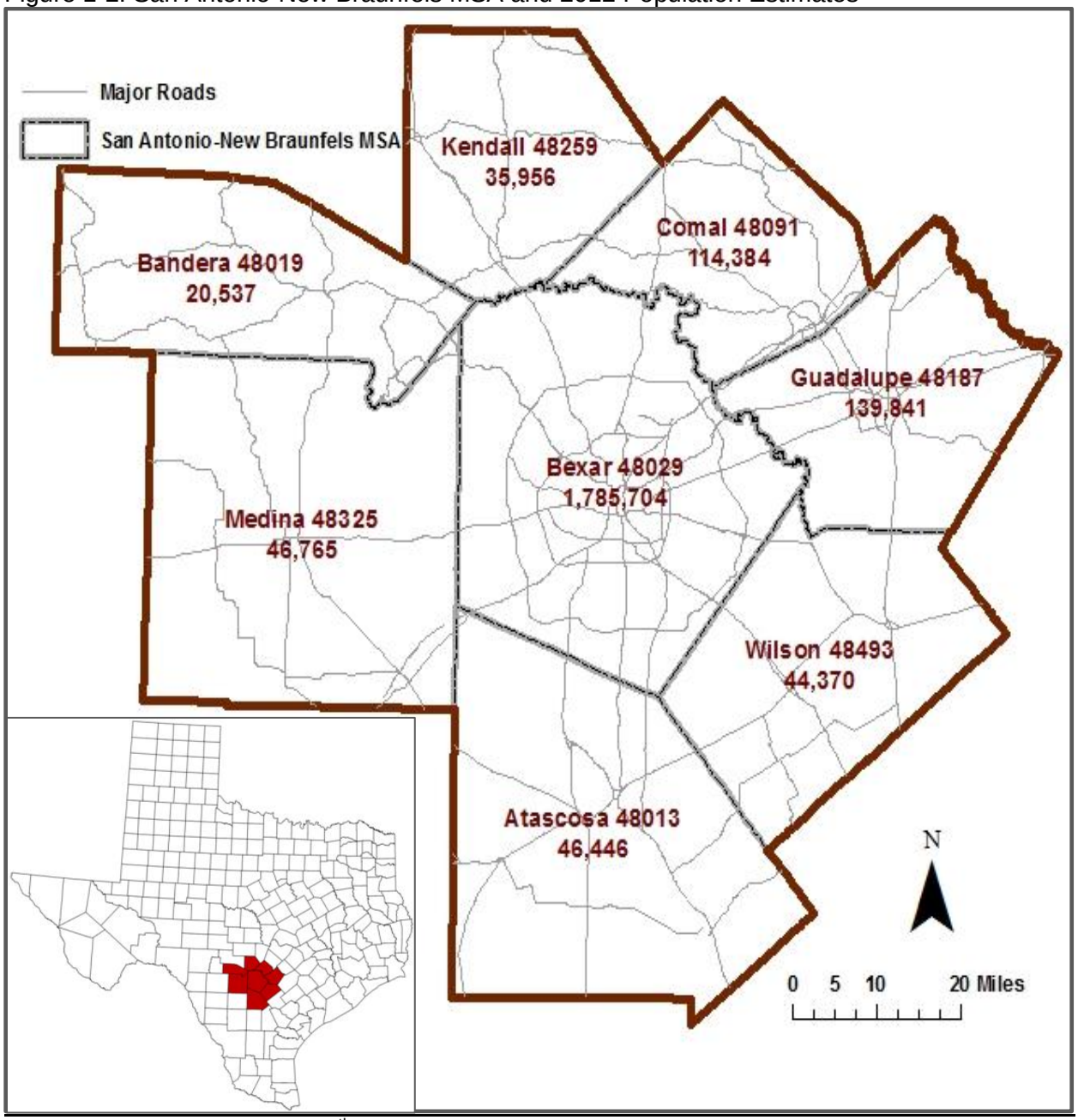
The emission inventory includes all identified business/agency sources in the San Antonio-New Braunfels MSA, consisting of eight counties located in South Central Texas and part of the Hill Country. These counties are: Atascosa, Bandera, Bexar, Comal, Guadalupe, Kendall, Medina, and Wilson counties (figure 1-2).

1.5. Modeling Domain Parameters

Development of input files and/or spatial surrogates for photochemical model emission processing was based on a grid system consistent with EPA's Regional Planning Organizations (RPO) Lambert Conformal Conic map projection with the following parameters:

- First True Latitude (Alpha): 33°N
- Second True Latitude (Beta): 45°N
- Central Longitude (Gamma): 97°W
- Projection Origin: (97°W, 40°N)
- Spheroid: Perfect Sphere, Radius: 6,370 km

Figure 1-2: San Antonio-New Braunfels MSA and 2012 Population Estimates[7]



Plot Date: Dec. 16th, 2013
Map Compilation: Dec. 16th, 2013
Source: US Census Bureau

[7] United States Census Bureau, June 27, 2013. "State & County QuickFacts". Available online: http://quickfacts.census.gov/qfd/states/48/4801600.html. Accessed 12/16/13.

1.6. Data Sources

Specific emission input data was calculated by AACOG based on protocols provided by EPA and TCEQ. Emission calculations are based on the local activity data collected through surveys and application of data developed for the TexN Model[8]. Other data sources include US Census County Business Patterns,[9] Federal Aviation Administration,[10] and U.S. Department of Education[11]. All current federal and state regulations, including TxLED diesel fuel, were taken into account when calculating emissions.

1.7. Quality Check/Quality Assurance

"An overall QA program comprises two distinct components. The first component is that of quality control (QC), which is a system of routine technical activities implemented by inventory development personnel to measure and control the quality of the inventory as it is being developed. The QC system is designed to:

1. Provide routine and consistent checks and documentation points in the inventory development process to verify data integrity, correctness, and completeness;
2. Identify and reduce errors and omissions;
3. Maximize consistency within the inventory preparation and documentation process; and
4. Facilitate internal and external inventory review processes.

QC activities include technical reviews, accuracy checks, and the use of approved standardized procedures for emission calculations. These activities should be included in inventory development planning, data collection and analysis, emission calculations, and reporting."[12]

Routine QA procedures, such as verification of equations, data sources, and methodologies were conducted throughout the development of the emission inventory. As recommended by the Eastern Research Group, "More comprehensive procedures targeted:

- Critical points in the process;
- Critical components of the inventory; and
- Areas or activities where problems are anticipated"[13]

Special emphases were put on critical components, such as equipment counts, activity rates, and reported horsepower, for quality checks. Commercial lawn and garden equipment data developed through the emission inventory process were compared to previous data sets from other emission inventories.

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[8] Assessment and Standards Division Office of Transportation and Air Quality U.S. Environmental Protection Agency, July 2009. "NONROAD2008a Model". Available online: http://www.epa.gov/otaq/nonrdmdl.htm. Accessed 06/13/11.

[9] U.S. Census Bureau, April 2013. "County Business Patterns". Available online: http://www.census.gov/econ/cbp/index.html. Accessed 12/19/13.

[10] Federal Aviation Administration, June 2, 2005. "Air Quality Procedures for Civilian Airports and Air Force Bases, Appendix D: Aircraft Emission Methodology". Office of Environment and Energy. Washington, DC. p. D-5. Available online: http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/airquality_handbook/media/App_D.PDF. Accessed 08/05/11.

[11] U.S. Department of Education. "Search for Public School Districts". National Center for Education Statistics, Washington, DC. Available online: http://nces.ed.gov/ccd/districtsearch/. Accessed 10/03/11.

[12] Eastern Research Group, Inc, Jan. 1997. "Introduction: The Value of QA/QC'. Quality Assurance Committee Emission Inventory Improvement Program, U.S. Environmental Protection Agency. p. 1.2-1. Available online: http://www.epa.gov/ttn/chief/eiip/techreport/volume06/vi01.pdf. Accessed 06/04/2012.

[13] *Ibid*., p. 1.2-2.

When errors were identified they were immediately corrected and documented. All emission inventory calculation methodologies were documented and described in detail so external parties can replicate the results. For every emission inventory category, documentation was consistent and contained details on data sources, methodology, formulas, and results. When the emission inventory was completed, documentation and spreadsheets were sent to TCEQ and other interested parties for review.

2. Commercial Lawn and Garden Equipment Survey

Engines installed on commercial lawn and garden equipment contributes to tropospheric ozone formation because they emit NO_X and VOCs. Therefore, determining and documenting the scale of lawn and garden equipment activity is essential for regional emission inventory efforts. Having local survey data on commercial lawn and garden equipment usage improves the emission estimates of these sources. Businesses and agencies in the San Antonio-New Braunfels MSA that were surveyed included the following 10 categories of commercial lawn and garden equipment owners:

- Golf Courses
- Universities/Colleges
- Public School Districts
- Commercial Lawn and Garden Companies and Land Clearing Companies (both for residential properties and commercial properties)
- Cemeteries
- Commercial and Private Airports
- Local Government Facilities
- Federal and State Parks
- Other Companies
- Military Facilities

2.1. Survey of Commercial Lawn and Garden Equipment Activity

The preferred method for calculating emissions from the use of commercial lawn and garden equipment is a "bottom-up" survey approach that documents the characteristics of equipment operated by each category of users, e.g. golf courses, within the region. The survey collected the following data:

- Activity Rates (HRS) – total annual hours of use by type of equipment
- Temporal Profiles – equipment use on weekdays and equipment use on weekend days for all types of equipment
- Population of each equipment type
- Engine Characteristics:
  - Fuel Type – gasoline 2-stroke, gasoline 4-stroke, diesel, LPG, electricity
  - Engine Horsepower – rated power of the engine

A sample of both the survey cover letter and the survey form used in the process of developing the commercial lawn and garden equipment inventory are shown on the following pages.

AACOG
Alamo Area Council
Of Governments

Date

[COMPANY NAME]
[STREET ADDRESS]
[CITY] [STATE] [ZIP]

ATTENTION: OPERATIONS MANAGER

Re: San Antonio Regional Emissions Inventory

The Alamo Area Council of Governments (AACOG) requests your assistance in the development of the air quality emission inventory. This inventory is especially significant because the San Antonio region is close to violating federal air quality standards, the National Ambient Air Quality Standards.

AACOG will calculate equipment emissions from information submitted by local organizations involved in landscaping and lawn and garden activities in the San Antonio region using the enclosed survey. With this survey, we are requesting information on lawn and garden equipment used in Atascosa, Bandera, Bexar, Comal, Guadalupe, Kendall, Medina, and Wilson counties. The purpose of this survey is to provide better information and services to the region. Your input is vital to this process and will serve to achieve a true and correct emissions inventory. Please provide your responses on the attached survey and return it to us in the self-addressed envelope by the date indicated. Please submit your response by October 20th, 2012.

Thank you for your time and participation. If you have any questions or comments please feel free to contact Steven Smeltzer, Environmental Manager, at (210) 362-5266.

Sincerely,

Peter D. Bella

Peter Bella,
Natural Resource Director
AACOG

Survey for Equipment used in Commercial Lawn & Garden Service

Equipment Type	Number of Equipment	Models (if known)	Approximate Horse-power for Each Unit	Fuel Type (Gasoline 2-stroke, Gasoline 4 stroke, LPG, Diesel, Electric)	Mon-Fri Average Daily Hours of Use for Each Unit	Sat –Sun Average Daily Hours of Use for Each Unit
Riding Rear Engine Mowers						
Riding Front Engine Mowers						
Push Lawn Mowers						
Tow Behind Cutters & Turf Mowers						
Tractors						
Trimmer Edger Dethatcher						
Tillers & Aerators						
Blowers, Vacuums & Sweepers						
Shredder						
Chainsaw						
Chipper & Splitter						
Other Lawn & Garden Equipment (specify type)						

2.2. Second Survey of Commercial Lawn and Garden Equipment

After analyzing survey results, aerial photographs, district appraisal data, and other data sources, a second survey was sent to the local businesses that did not respond to the first survey. This second set of surveys differed from the first because it included estimations of the businesses' equipment populations, horsepower, and activity rates. Otherwise, the second survey used the same format as the initial survey. Companies and facilities were asked to correct estimations and send the surveys back to AACOG.

In order to make a general conclusion about the targeted population, the number of returned surveys required for an accurate representation is an important concern. Since determining a suitable sample size is not always clear-cut, several major factors must be considered. Due to time and budget constraints, a 95% level of confidence, which is the risk of error the researcher is willing to accept, was chosen. Similarly, the confidence interval, which determines the level of sampling accuracy, was set at +/- 6%. Since the population is finite, the following equation was used to select the sample size.[14]

Equation 2-1, Suitable sampling size for commercial lawn and garden equipment

$$RN = [CLV^2 \times 0.25 \times POP] / [CLV^2 \times 0.25 + (POP - 1)\ CIN^2]$$

Where,

RN = Number of survey responses needed to accurately represent the population
CLV = 95% confidence level (1.96)
POP = Population size (634 facilities)
CIN = ± 6% confidence interval (0.06)

The number of surveys needed for a 10% confidence interval:

$$RN = [(1.96)^2 \times (0.25) \times 634] / [(1.96)^2 \times (0.25) + (634 - 1) \times (0.06)^2]$$

= 186.4 facilities that use commercial lawn and garden equipment

Thus, local data was needed for 187 facilities that used lawn and garden equipment in order to meet the 95% level of confidence, and the ±6% confidence interval for equipment population. Survey response rates by sub-category of commercial lawn and garden equipment users are presented in Table 2-1. Since 221 facilities responded to the survey, the sample size meets the required confidence level and confidence interval.

For each user category, there was at least a 21 percent response rate with an overall 35 percent response rate. A very high response rate was obtained for several business categories: a 100 percent response rate for military bases, a 78 percent response rate for cemeteries, a 76 percent repose rate for local government facilities, and a 71 percent response rate for airports. The lowest response rate was for commercial lawn and garden companies at 21 percent.

[14] Rea, L. M. and Parker, R. A., 1992. "Designing and Conducting Survey Research". Jossey-Bass Publishers: San Francisco.

Table 2-1: Commercial Lawn and Garden Survey Response Rates

Facility Type	Survey Response	Total Number Surveyed	Percent of Total
Golf Courses	16	46	35%
Universities/Colleges	9	16	56%
Public Schools Districts	22 School Districts (representing 426 Schools)	45 School Districts (representing 624 Schools)	47%
Commercial Lawn and Garden Companies	77	374	21%
Local Government Facilities	44	58	76%
Parks (State and Federal)	4	7	57%
Cemeteries	14	18	78%
Commercial and Private Airports (including SAIA)	12	17	71%
Other Businesses and Employers	16	44	36%
Military Facilities	5	5	100%
Total	221	634	35%

2.3. Determine Equipment Specification for Facilities that Lack Local Data

Missing equipment population and activity rates for facilities that did not respond to the surveys were determined by calculating equipment ratios from the survey responses of similar facilities. Either the total acreage or population size of the survey respondents was used to determine equipment ratios for those that did not respond to the survey. Data sources for the surrogate factors included aerial imagery, U.S. Department of Education[15], and U.S. Census County Business Patterns[16]. Surrogate factors are listed in table 2-2 and the formulas used to calculate the surrogates are detailed in Equation 2-2 and Equation 2-3.

[15] U.S. Department of Education. "Search for Public School Districts". National Center for Education Statistics, Washington, DC. Available online: http://nces.ed.gov/ccd/districtsearch/. Accessed 10/03/11.
[16] U.S. Census Bureau, April 2013. "County Business Patterns". Available online: http://www.census.gov/econ/cbp/index.html. Accessed 12/19/13.

Table 2-2: Lawn and Garden Equipment Surrogate Factors by Sub-category

Facility Type	Allocation Method	Data Source	Year
Golf Courses	Acres per Golf Course	Aerial Imagery, Golf course Book of Lists	2013
Universities/Colleges	Acres per University	Aerial Imagery	2013
Public Schools	Number of Schools	U.S. Department of Education	2013
Commercial Lawn and Garden Companies	Number of Companies	US Census County Business Patterns	2010
Government Facilities*	None	-	-
Parks*	None	-	-
Cemeteries	Acres of Cemeteries	Aerial Imagery	2013
Small Airports	Number of Airports	Aerial Imagery	2013
Other Businesses and Employers*	None	-	-
Military Facilities	None (100% response Rate)	-	-

*If a government facility, park and other business did not respond to the survey, no emissions were calculated

Equation 2-2 describes how collected survey data was used to determine the ratio of equipment per acre or facility.

Equation 2-2, Survey-based equipment ratios

$RATIO_{AB} = EQ_{AB} / TOTAL_{B}$

Where,

$RATIO_{AB}$ = Ratio of equipment type A used per acre or per facility at facility type B

EQ_{AB} = Total pieces of equipment type A used by facilities that responded to the survey for facility type B

$TOTAL_{B}$ = Total acres or number of facilities used by facilities that responded to the survey for facility type B

Sample Equation: Equipment ratio for 4-stroke riding fairway deck & rough mowers (SCC Code 2265004041) used at Golf Courses in hp bin 25-40.

$RATIO_{AB}$ = 11 gasoline 4-stroke engine riding fairway deck & rough mowers at Golf Courses that responded to the survey / 2,503 Acres total area for respondents

= 0.00439 gasoline 4-stroke engine riding fairway deck & rough mower per acre at golf courses in hp bin 25-40

This ratio was used in Equation 2-3 to determine the equipment population at facilities that did not respond to the survey.

Equation 2-3, Estimated equipment population for facilities that did not respond to the survey

$GPOP_{AB} = ACRES_B \times RATIO_{AB}$

Where,

$GPOP_{AB}$ = Population of equipment type A for facility type B

$ACRES_B$ = Number of acres or facilities for facility B

$RATIO_{AB}$ = Ratio of equipment type A per acre for facility type B (from equation 2-2)

Sample Equation: 4-stroke gasoline riding fairway deck & rough mower (SCC Code 2265004041) used at Golf Courses B in hp bin 25-40

$GPOP_{AB}$ = 250 Acres for Golf Course B x 0.00439 4-stroke gasoline riding fairway deck & rough mower per acre at golf courses in hp bin 25-40 hp

= 1.2 4-stroke gasoline riding fairway deck & rough mower in hp bin 25-40 hp at golf courses B

2.4. Golf Courses

Survey questionnaires were mailed to a list of golf courses' addresses compiled from the Internet and other publically available sources. In all, 46 golf courses in the San Antonio-New Braunfels MSA were identified and contacted, of which 5 responded to the first survey and 9 responded to the second survey, although 2 of the 9 responded as closed businesses. The survey responses covered 39 percent of the golf courses in the San Antonio-New Braunfels MSA and 30 percent of the total acres (Table 2-3). The second survey included a general estimation of equipment data for each local golf course based on their individual acreages and the data received in the first survey. The contacted golf courses were asked to make corrections if they found the data attributed to them incorrect and send back the survey questionnaires.

Table 2-3: Golf Courses Survey Response Ratios, 2012

Survey Results	Number of Golf Courses		Acres	
	Total	Percent of Total Golf Courses	Total	Percent of Total Acres
Responded to First 2012 Survey	5	11%	1,167	14%
Responded to Second 2012 Survey	7	15%	666	8%
Responded to 2005 Survey	4	9%	670	8%
Closed	2	4%	-	0%
Total for all Golf Courses	46	100%	8,384	100%

Aerial photography and appraisal district data were used to determine the improved acres for each golf course that did not respond to the survey. Bexar County had the most acreage, 4,698 acres or 56 percent of the total, followed by Kendall County, 1,080 acres or 13 percent (Table 2-4). The equipment to acre ratio was then calculated for golf courses by dividing the total pieces of equipment counted for each category in the first survey by the total number of acres for these golf courses. This ratio was used to calculate estimated equipment populations for the other golf courses.

Table 2-4: Allocation of Golf Courses by County, 2012[17]

FIPS	County	Total Number of Golf Courses*	Percentage	Total Acres of Golf Courses*	Percentage
48013	Atascosa	1	2%	142	2%
48019	Bandera	1	2%	395	5%
48029	Bexar	28	61%	4,698	56%
48091	Comal	5	11%	767	9%
48187	Guadalupe	4	9%	669	8%
48259	Kendall	3	7%	1,080	13%
48325	Medina	3	7%	297	4%
48493	Wilson	1	2%	336	4%
Total (San Antonio – New Braunfels MSA)		46	100%	8,384	100%

*Military Golf Courses are not included (lawn and garden equipment from these golf courses are included in the military facilities emission inventory)

The information provided in the survey returns, indicates a wide variety of commercial lawn and garden equipment is used at golf courses. Table 2-5 shows golf course commercial lawn and garden equipment ratios per 100 acres. The most common types of equipment used at golf courses were diesel riding fairway deck and rough mowers (0.6 per 100 acres), 4-stroke golf carts used for lawn maintenance (0.5 per 100 acres), 2-stroke chainsaws (0.3 per 100 acres), and 4-stroke riding greens and tee mowers (0.3 per 100 acres).

A narrow confidence interval was determined for survey responses regarding horsepower ratings and hours of activity for the common commercial lawn and garden equipment used at golf courses. Diesel riding fairway deck and rough mowers had an average horsepower of 34.8 and were used 971 hours per year, while 2-stroke chainsaws had an average horsepower of 3.8 and were used 65 hours a year. The horsepower and activity rates for 4-stroke riding greens and tee mowers was 18.1 horsepower and 1,052 hours of operation per year (Table 2-6). Commercial lawn and garden equipment used at military bases' golf courses are included in the Military Facilities category.

[17] U.S. Department of Education. "Search for Public School Districts". National Center for Education Statistics, Washington, DC. Available online: http://nces.ed.gov/ccd/districtsearch/. Accessed 10/03/11.

Table 2-5: Golf Courses Lawn and Garden Equipment Ratio per 100 Acres

Equipment Type	SCC	n (survey)	Standard Deviation*	Low*	Mean	High*	Confidence Level*
Blowers, Vacuums & Sweepers	2260004031	19	1.9	-0.6	0.2	1.1	0.9
Blowers, Vacuums & Sweepers	2265004031	6	1.2	-0.9	0.1	1.0	0.9
Chainsaw	2260004021	22	1.2	-0.2	0.3	0.7	0.5
Chainsaw	2265004021	2	0.0	0.0	0.0	0.0	0.0
Gator/Cart	2270001060	3	0.5	-0.5	0.0	0.6	0.5
Gator/Cart	2265001060	40	3.9	-0.7	0.5	1.7	1.2
Greens Rollers	2265004056	11	0.8	-0.3	0.1	0.6	0.5
Push Lawn Mowers	2260004011	7	2.0	-1.4	0.1	1.6	1.5
Push Lawn Mowers	2265004011	16	2.2	-0.9	0.2	1.3	1.1
Riding Fairway Deck & Rough Mower	2270004041	54	1.6	0.2	0.6	1.1	0.4
Riding Fairway Deck & Rough Mower	2265004041	18	1.2	-0.3	0.2	0.8	0.6
Riding Greens & Tee Mowers	2270004041	12	0.4	-0.1	0.1	0.4	0.2
Riding Greens & Tee Mowers	2265004041	25	2.0	-0.5	0.3	1.1	0.8
Sprayers	2270004071	4	0.4	-0.4	0.0	0.5	0.4
Sprayers	2265004071	7	0.2	0.0	0.1	0.2	0.1
Tillers & Aerators	2265004016	11	1.0	-0.5	0.1	0.7	0.6
Tractors	2270004056	29	1.5	-0.2	0.3	0.9	0.6
Trimmer	2260004026	18	2.1	-0.7	0.2	1.2	1.0
Turf top dresser & Spreaders	2265004071	18	1.9	-0.7	0.2	1.1	0.9
Turf top dresser & Spreaders	2270004071	1	-	-	0.0	-	-
Tow Behind Cutters & Mowers	2265004071	4	-	-	0.0	-	-
Chippers/ Stump/ Grinders/ Mulchers	2270004066	1	-	-	0.0	-	-
TOTAL		328					

n*: Denotes number of observations, or population.
[#]Statistics only calculated for equipment with more than 4 survey responses

Table 2-6: Confidence Interval at 95% for Golf Courses Lawn and Garden Equipment

Equipment Type	SCC	Horsepower				Hours/Year			
		n* (survey)	Mean	Confidence Interval*	Percent of Mean*	N* (Survey)	Mean	Confidence Interval*	Percent of Mean*
Blowers, Vacuums & Sweepers	2260004031	19	2.2	0.2	8%	19	433	218	50%
Blowers, Vacuums & Sweepers	2265004031	6	17.8	7.2	40%	6	517	302	58%
Chainsaw	2260004021	22	3.8	2.7	71%	22	65	28	42%
Chainsaw	2265004021	2	2.0	12.4	622%	2	78	523	667%
Gator/Cart	2270001060	3	21.7	0.7	3%	3	539	222	41%
Gator/Cart	2265001060	40	13.2	0.8	6%	40	1,108	138	12%
Greens Rollers	2265004056	11	16.1	4.1	26%	11	595	261	44%
Push Lawn Mowers	2260004011	7	5.5	1.2	22%	7	378	182	48%
Push Lawn Mowers	2265004011	16	4.9	0.5	9%	16	793	198	25%
Riding Fairway Deck & Rough Mower	2270004041	54	34.8	2.9	8%	54	971	100	10%
Riding Fairway Deck & Rough Mower	2265004041	18	25.0	4.5	18%	18	1,627	388	24%
Riding Greens & Tee Mowers	2270004041	12	17.8	1.6	9%	12	1,045	281	27%
Riding Greens & Tee Mowers	2265004041	25	18.1	0.6	4%	25	1,052	284	27%
Sprayers	2270004071	4	30.4	6.4	21%	4	613	556	91%
Sprayers	2265004071	7	21.4	2.2	10%	7	209	59	28%
Tillers & Aerators	2265004016	11	14.8	3.9	26%	11	63	43	69%
Tractors	2270004056	29	39.2	3.3	8%	29	684	218	32%
Trimmer	2260004026	18	1.9	0.3	18%	18	415	86	21%
Turf top dresser & Spreaders	2265004071	18	18.3	2.0	11%	18	2,538	754	30%
Turf top dresser & Spreaders	2270004071	1	34.0	-	-	1	261	-	-
Tow Behind Cutters & Mowers	2265004071	4	6.0	-	-	4	1,095	-	-
Chippers/ Stump/ Grinders/ Mulchers	2270004066	1	141.0	-	-	1	131	-	-
TOTAL		328				328			

n*: Denotes number of observation, or population.

[#]Statistics only calculated for equipment with more than 4 survey responses

2.5. Universities/Colleges

A list of universities and colleges was compiled from the Internet and other publically available sources and survey questionnaires were mailed to those within the San Antonio region. In all, 16 addresses were identified and contacted, of which 3 responded to the first survey and 2 responded to the second survey. The data provided by 4 facilities that responded to a 2005 survey was also included in the calculations. The facilities that responded to the surveys represented 51 percent of the total acreage of university and college campuses in the San Antonio-New Braunfels MSA (Table 2-7).

Table 2-7: Universities and Colleges Survey Response Ratios, 2012

Survey Results	Number of Universities/Colleges		Universities/Colleges Acres	
	Total	Percent of Total Universities/ Colleges	Total	Percent of Total Acres
Responded to First 2012 Survey	3	19%	268	11%
Responded to Second 2012 Survey	2	13%	91	4%
Responded to 2005 Survey	4	25%	906	36%
Universities/Colleges Operating in 2012	16	100%	2,541	100%

The numbers of lawn and garden equipment owned by universities and colleges have a direct correlation with the size of their campuses. Therefore estimations for those institutions that did not respond to the survey were made based on the ratio of equipment populations to the total acres covered by the college campuses that responded to the survey. Most of the large universities and colleges, 91 percent of total acres, are in Bexar County (Table 2-8) with small campuses in Guadalupe and Atascosa counties.

Table 2-8: Number of Acres for University and Colleges by County, 2012

FIPS	County	Total Acres	Percentage
48013	Atascosa	9	0.4%
48019	Bandera	0	0.0%
48029	Bexar	2014	91.3%
48091	Comal	0	0.0%
48187	Guadalupe	184	8.3%
48259	Kendall	0	0.0%
48325	Medina	0	0.0%
48493	Wilson	0	0.0%
Total (San Antonio – New Braunfels MSA)		2,207	100.0%

As shown in Table 2-9, the most common types of commercial lawn and garden equipment used at universities and colleges were 2-stroke trimmers/edgers/brush cutters (4.3 per 100 acres), 2-stroke leaf blowers (2.8 per 100 acres), and 4-stroke rear engine riding mowers (2.5 per 100 acres). The confidence interval for horsepower and annual hours was low for the most common lawn and garden equipment used at universities and colleges. Horsepower confidence

intervals ranged from 5 to 8 percent, while the confidence interval for annual hours was between 16 and 24 percent for the common types of equipment (Table 2-10).

Table 2-9: Universities and Colleges Lawn and Garden Equipment Ratio per 100 Acres

Equipment Type	SCC	n	Mean	Standard Deviation	Confidence Level
Commercial Lawn Mowers	2260004011	6	0.5	1.3	1.0
Rotary Tillers	2260004016	1	0.1	#	#
Chain Saws	2260004021	27	2.1	4.1	1.6
Trimmers/Edgers/Brush Cutters	2260004026	54	4.3	17.4	4.7
Blowers, Vacuums & Sweepers	2260004031	35	2.8	3.4	1.1
Other L&G Equipment	2260004076	2	0.2	#	#
Commercial Lawn Mowers	2265004011	15	1.2	4.5	2.3
Rotary Tillers	2265004016	5	0.4	1.0	0.8
Trimmers/Edgers/Brush Cutters	2265004026	1	0.1	#	#
Rear Engine Riding Mowers	2265004041	31	2.5	8.1	2.8
Front Engine Riding Mowers	2265004046	6	0.5	2.7	2.1
Shredders	2265004051	2	0.2	#	#
Lawn and Garden Tractors	2265004056	1	0.1	#	#
Commercial Turf Equipment	2265004071	4	0.3	1.6	1.6
Other L&G Equipment	2265004076	10	0.8	2.9	1.8
Blowers, Vacuums & Sweepers	2270004031	2	0.2	#	#
Riding Rear Engine Mowers	2270004041	7	0.6	0.5	0.4
Shredders	2270004051	1	0.1	#	#
Lawn and Garden Tractors	2270004056	8	0.6	4.6	3.2
Other L&G Equipment	2270004076	1	0.1	#	#

[#]Statistics only calculated for equipment with more than 4 survey responses

Table 2-10: Confidence Interval at 95% for University and Colleges Lawn and Garden Equipment

Equipment Type	SCC	Horsepower				Hours/Year			
		n	Mean	Confidence Interval	Percent of Mean	n	Mean	Confidence Interval	Percent of Mean
Push Lawn Mowers	2260004011	6	6.2	0.9	14%	6	322	237	74%
Tiller & Aerators	2260004016	1	3.0	-	-	1	131	-	-
Chainsaw	2260004021	27	1.8	0.1	5%	27	437	168	38%
Trimmer	2260004026	53	1.6	0.1	6%	53	823	128	16%
Blowers, Vacuums & Sweepers	2260004031	35	2.7	0.1	5%	35	391	93	24%
Push Lawn Mowers	2265004011	15	5.4	0.8	14%	15	513	178	35%
Tiller & Aerators	2265004016	5	8.1	5.0	62%	5	209	63	30%
Edger	2265004026	1	3.5	-	-	1	522	-	-
Riding Rear Engine Mowers	2265004041	31	20.4	1.7	8%	31	660	112	17%
Riding front Engine Mower	2265004046	6	18.3	5.4	29%	6	613	267	44%
Shredder	2265004051	2	13.0	-	-	2	117	-	-
Tractors	2265004056	1	16.0	-	-	1	1305	-	-
Tow Behind Cutters & Turf Mowers	2265004071	4	15.6	5.6	36%	4	331	338	102%
Blowers, Vacuums & Sweepers	2270004031	2	3.0	-	-	2	313	-	-
Riding Rear Engine Mowers	2270004041	7	31.4	1.8	6%	7	1342	283	21%
Shredder	2270004051	1	200.0	-	-	1	131	-	-
Tractors	2270004056	8	3.9	0.3	7%	8	1631	260	16%
Other Lawn and Garden Equipment	2260004076	2	18.5	-	-	2	522	-	-
Other Lawn and Garden Equipment	2265004076	10	13.9	0.1	0%	10	522	0	0%
Other Lawn and Garden Equipment	2270004076	1	62.0	-	-	1	261	-	-

[#]Statistics only calculated for equipment with more than 4 survey responses

2.6. Public School Districts

Of the 45 school districts in the San Antonio-New Braunfels MSA, 49 percent responded to the survey (Table 2-11). These responding districts account for 71 percent of the public schools in the region. Emissions were calculated for school districts instead of individual schools because school districts often have one central maintenance department for the whole district. As provided in Table 2-12, the majority of the schools in the MSA are located in Bexar County (75 percent), but Guadalupe County (6 percent), and Comal County (5 percent) also have a number of public schools.

Table 2-11: Public Schools Survey Response Ratios, 2012

Survey Results	Number of School Districts		Number of Public Schools	
	Total	Percent of Total School Districts	Total	Percent of Public Schools
Responded to First 2012 Survey	9	20%	260	42%
Responded to Second 2012 Survey	7	16%	43	7%
Responded to 2005 Survey	6	13%	141	23%
Total	45	100%	624	100%

Table 2-12: Allocation of Public Schools by County, 2012[18]

FIPS	County	Total Number of Schools*	Percentage
48013	Atascosa	25	4%
48019	Bandera	6	1%
48029	Bexar	493	75%
48091	Comal	35	5%
48187	Guadalupe	37	6%
48259	Kendall	14	2%
48325	Medina	20	3%
48493	Wilson	28	4%
Total (San Antonio – New Braunfels MSA)		658	100

*Military Base Schools are not included (lawn and garden equipment from these schools are included in the Airport/Military emission inventory)

The type of commercial lawn and garden equipment most commonly used at public schools was 2-stroke trimmers with 0.9 per school (Table 2-13). Other common equipment types were 2-stroke leaf blowers (0.6 per school), 4-stroke riding rear engine mowers (0.4 per school), and 2-stroke push lawn mowers (0.3 per school). The 2-stroke trimmers had an average horsepower of 1.1 and annual usage of 341 hours, while 2-stroke leaf blowers had an average horsepower of 2.9 and annual usage of 34 hours (Table 2-14).

[18] U.S. Department of Education. “Search for Public School Districts”. National Center for Education Statistics, Washington, DC. Available online: http://nces.ed.gov/ccd/districtsearch/. Accessed 10/03/11.

Table 2-13: Public Schools Lawn and Garden Equipment Ratio per Public School

Equipment Type	SCC	n (survey)	Mean	Standard Deviation[#]	Confidence Level[#]
Blowers, Vacuums & Sweepers	2260004031	267	0.6	0.9	0.1
Blowers, Vacuums & Sweepers	2265004031	1	0.0	-	-
Chainsaw	2260004021	85	0.2	0.9	0.2
Hedge Trimmer	2265004026	3	0.0	-	-
Other	2270004076	4	0.0	-	-
Other	2265004076	191	0.4	0.4	0.1
Push Lawn Mowers	2260004011	149	0.3	0.4	0.1
Push Lawn Mowers	2265004011	29	0.1	0.5	0.2
Riding front Engine Mower	2270004046	14	0.0	0.5	0.3
Riding front Engine Mower	2265004046	65	0.1	0.3	0.1
Riding Rear Engine Mowers	2270004041	21	0.0	0.5	0.2
Riding Rear Engine Mowers	2265004041	160	0.4	0.6	0.1
Shredders	2270004066	6	0.0	0.0	0.0
Shredders	2265004066	3	0.0	-	-
Tiller & Aerators	2260004016	9	0.0	0.2	0.1
Tiller & Aerators	2265004016	11	0.0	0.5	0.3
Tractors	2270004056	34	0.1	0.2	0.1
Tractors	2265004056	8	0.0	0.4	0.3
Trimmer	2260004026	397	0.9	1.0	0.1

Table 2-14: Confidence Interval at 95% for Public Schools Lawn and Garden Equipment

Equipment Type	SCC	Horsepower				Hours/Year			
		n	Mean	Confidence Interval[#]	Percent of Mean[#]	n	Mean	Confidence Interval[#]	Percent of Mean[#]
Blowers, Vacuums & Sweepers	2260004031	267	2.9	0.1	2%	267	221	34	15%
Blowers, Vacuums & Sweepers	2265004031	1	5.0	-	-	1	783	-	-
Chainsaw	2260004021	85	1.7	0.2	12%	85	134	24	18%
Hedge Trimmer	2265004026	3	6.5	-	-	3	522	-	-
Other	2270004076	4	45.5	-	-	4	653	-	-
Other	2265004076	191	15.1	0.4	3%	191	313	18	6%
Push Lawn Mowers	2260004011	149	5.9	0.1	2%	149	140	55	39%
Push Lawn Mowers	2265004011	29	5.9	0.3	6%	29	436	124	28%
Riding front Engine Mower	2270004046	14	22.0	1.8	8%	14	483	286	59%
Riding front Engine Mower	2265004046	65	19.1	0.2	1%	65	67	34	51%
Riding Rear Engine Mowers	2270004041	21	32.9	3.0	9%	21	1,129	159	14%
Riding Rear Engine Mowers	2265004041	160	23.5	0.4	2%	160	517	96	18%
Shredders	2270004066	6	59.7	19.2	32%	6	848	590	70%
Shredders	2265004066	3	42.0	-	-	3	1,175	-	-
Tiller & Aerators	2260004016	9	3.3	0.7	22%	9	115	87	76%
Tiller & Aerators	2265004016	11	6.9	2.9	42%	11	56	57	100%
Tractors	2270004056	34	48.6	6.1	12%	34	540	176	33%
Tractors	2265004056	8	31.0	15.4	50%	8	1,201	345	29%
Trimmer	2260004026	397	1.1	0.0	2%	397	341	44	13%

[#]Statistics only calculated for equipment with more than 4 survey responses

2.7. Commercial Lawn and Garden and Maintenance Companies

A list of registered lawn and garden companies was compiled and survey questionnaires were mailed to their addresses. In all, 374 addresses for companies were identified and contacted, of which 41 responded to the survey after two mailing efforts. These results, along with the 2005 survey results from 36 other companies are summarized in Table 2-15. The majority, 79 percent of the companies identified in this category are located in Bexar County, while 10 percent of the companies are in Comal County, and 6 percent of the companies are in Guadalupe County (Table 2-16).

Table 2-15: Lawn and Garden Maintenance Companies and Response Ratios, 2012

Survey Results	Number of Companies		Companies Employees	
	Total	Percent of Total Companies	Total	Percent of Total Employees
Responded to First 2012 Survey	21	6%	76	3%
Responded to Second 2012 Survey	20	5%	171	7%
Responded to 2005 Survey	36	10%	225	9%
Commercial Companies Operating in 2012	374	100%	2513	100%

Table 2-16: Commercial Lawn and Garden Companies in the San Antonio-New Braunfels MSA, 2010[19]

FIPS	County	Number of Commercial Companies	Percentage of Companies
48013	Atascosa	0	0%
48019	Bandera	0	0%
48029	Bexar	296	79%
48091	Comal	39	10%
48187	Guadalupe	22	6%
48259	Kendall	12	3%
48325	Medina	0	0%
48493	Wilson	5	1%
Total (San Antonio – New Braunfels MSA)		374	100%

From the survey results, 2-stroke trimmers were the most common type of equipment used at commercial companies with an average of 3.1 per company (Table 2-17). Other popular equipment types were 2-stroke leaf blowers (2.4 per company), 2-stroke chainsaws (2.2 per company) and 4-stroke lawn mowers (1.4 per company). Average horsepower and annual hours per equipment type are provided in Table 2-18.

[19] U.S. Census Bureau, April 2013. "County Business Patterns". Available online: http://www.census.gov/econ/cbp/index.html. Accessed 12/19/13.

Table 2-17: Lawn and Garden Maintenance Companies Lawn and Garden Equipment Ratio per Company

Equipment Type	SCC	n (survey)	Mean	Standard Deviation[#]	Confidence Level[#]
Chainsaws	2260004021	170	2.2	3.0	0.4
Trimmers/Edgers/Brush Cutters	2260004026	236	3.1	3.0	0.4
Blowers, Vacuums & Sweepers	2260004031	185	2.4	2.8	0.4
Other L&G Equipment	2260004076	3	0.0	#	#
Commercial Lawn Mowers	2265004011	104	1.4	1.3	0.3
Rotary Tillers	2265004016	8	0.1	0.3	0.2
Chain Saws	2265004021	7	0.1	0.6	0.4
Trimmers/Edgers/Brush Cutters	2265004026	6	0.1	0.5	0.4
Blowers, Vacuums & Sweepers	2265004031	8	0.1	0.6	0.4
Rear Engine Riding Mowers	2265004041	64	0.8	1.8	0.4
Front Engine Riding Mowers	2265004046	51	0.7	1.8	0.5
Shredders	2265004051	13	0.2	1.2	0.6
Lawn and Garden Tractors	2265004056	3	0.0	#	#
Chippers/Stump Grinders	2265004066	37	0.5	2.0	0.6
Commercial Turf Equipment	2265004071	7	0.1	0.5	0.4
Other L&G Equipment	2265004076	8	0.1	0.5	0.3
Rear Engine Riding Mowers	2270004041	6	0.1	0.3	0.3
Front Engine Riding Mowers	2270004046	1	0.0	#	#
Lawn and Garden Tractors	2270004056	15	0.2	0.7	0.3
Chippers/Stump Grinders	2270004066	3	0.0	#	#
Shredders	2270004051	3	0.0	#	#

[#]Statistics only calculated for equipment with more than 4 survey responses

Table 2-18: Confidence Interval at 95% for Lawn and Garden Maintenance Companies

Equipment Type	SCC	Horsepower				Hours/Year			
		n	Mean	Confidence Interval[#]	Percent of Mean[#]	n	Mean	Confidence Interval[#]	Percent of Mean[#]
Commercial Lawn Mowers	2260004011	17	5.0	0.8	17%	17	1,711	500	29%
Rotary Tillers	2260004016	6	2.2	1.6	72%	6	444	153	35%
Chain Saws	2260004021	170	2.0	0.1	3%	170	1,103	117	11%
Trimmers/Edgers/Brush Cutters	2260004026	236	1.4	0.1	6%	236	1,359	107	8%
Blowers, Vacuums & Sweepers	2260004031	185	1.9	0.1	4%	185	1,046	122	12%
Other L&G Equipment	2260004076	2	1.1	-	-	2	938	-	-
Commercial Lawn Mowers	2265004011	104	8.1	0.7	8%	104	1,195	132	11%
Rotary Tillers	2265004016	8	5.9	0.9	16%	8	504	460	91%
Chain Saws	2265004021	7	2.5	0.2	9%	7	194	85	44%
Trimmers/Edgers/Brush Cutters	2265004026	6	3.2	1.0	31%	6	1,844	302	16%
Blowers, Vacuums & Sweepers	2265004031	8	2.6	0.6	23%	8	862	427	50%
Rear Engine Riding Mowers	2265004041	64	20.9	1.0	5%	64	1,196	217	18%
Front Engine Riding Mowers	2265004046	51	17.0	2.1	13%	51	1,312	301	23%
Shredders	2265004051	13	3.2	0.5	14%	13	1,365	210	15%
Lawn and Garden Tractors	2265004056	3	14.8	-	-	3	226	-	-
Chippers/Stump Grinders	2265004066	37	155.3	24.9	16%	37	1,105	119	11%
Commercial Turf Equipment	2265004071	7	10.5	5.2	50%	7	1,230	712	58%
Other L&G Equipment	2265004076	8	9.1	3.2	35%	8	946	421	44%
Rear Engine Riding Mowers	2270004041	6	22.2	1.8	8%	6	1,271	1133	89%
Front Engine Riding Mowers	2270004046	1	25.0	-	-	1	783	-	-
Lawn and Garden Tractors	2270004056	15	36.4	15.3	42%	15	1,686	388	23%
Chippers/Stump Grinders	2270004066	3	86.0	-	-	3	783	-	-
Shredders	2270004051	3	102.7	-	-	15	1,218	-	-

[#]Statistics only calculated for equipment with more than 4 survey responses

2.8. Cemeteries

A total of 14 cemeteries out of 18 in the San Antonio – New Braunfels MSA responded to the surveys (Table 2-19). Since these cemeteries represent 94 percent of the total acres of all cemeteries, the survey had an excellent response rate. As shown in Table 2-20, the majority of the cemeteries are in Bexar County with several small cemeteries in Comal, Medina, Guadalupe, and Wilson counties.

Table 2-19: Cemeteries Survey Response Ratios, 2012

Survey Results	Number of Cemeteries		Cemeteries Acres	
	Total	Percent of Total Cemeteries	Total	Percent of Total Acres
Responded to First Survey	8	44%	829	55%
Responded to Second Survey	4	22%	128	8%
Contract Work Lawn and Garden Maintenance Out	2	11%	478	32%
Cemeteries Operating in 2012	18	100%	1,514	100%

Table 2-20: Number and Acres of Operating Cemeteries in the San Antonio-New Braunfels MSA, 2012

County	FIPS	Number of Cemeteries	Number of Acres
Atascosa	48013	0	0
Bandera	48019	0	0
Bexar	48029	12	1,389
Comal	48091	2	51
Guadalupe	48187	1	20
Kendall	48259	0	0
Medina	48325	1	38
Wilson	48493	2	16
Total (San Antonio – New Braunfels MSA)		18	1,514

The majority of the commercial lawn and garden equipment operating at cemeteries are 2-stroke trimmers, edgers, & dethatchers with 1.4 per 100 acres. Other common types of equipment used at cemeteries include diesel tractors (0.9 per 100 acres), 4-stroke riding rear engine mowers (0.8 per 100 acres), and leaf blowers (0.5 per 100 acres). All the commercial lawn and garden equipment used at cemeteries, summarized from survey responses, are listed in Table 2-21, while the average horsepower and annual hours are located in Table 2-22. For 2-stroke trimmers, edgers, & dethatchers, the average horsepower was 1.3 with an annual use of 1,249 hours per year.

Table 2-21: Cemeteries Lawn and Garden Equipment Ratio per 100 Acres

Equipment Type	SCC	n (survey)	Mean	Standard Deviation	Confidence Level
Blowers, Vacuums & Sweepers	2260004031	7	0.5	1.8	1.3
Chainsaws	2260004021	5	0.3	1.7	1.5
Other	2270004076	1	0.1	#	#
Shredders	2270004076	2	0.1	#	#
Push Lawn Mowers	2265004010	1	0.1	#	#
Push Lawn Mowers	2265004011	1	0.1	#	#
Riding Front Engine Mowers	2265004046	1	0.1	#	#
Riding Rear Engine Mowers	2270004046	4	0.3	#	#
Riding Rear Engine Mowers	2265004041	11	0.8	4.1	2.4
Tractors	2270004056	13	0.9	2.9	1.6
Trimmers, Edgers, & Dethatchers	2260004026	20	1.4	4.7	2.0

#Statistics only calculated for equipment with more than 4 survey responses

Table 2-22: Confidence Interval at 95% for Cemeteries Lawn and Garden Equipment

Equipment Type	SCC	Horsepower				Hours/Year			
		n	Mean	Confidence Interval	Percent of Mean	n	Mean	Confidence Interval	Percent of Mean
Blowers, Vacuums & Sweepers	2260004031	7	1.3	0.5	34%	7	639	353	55%
Chainsaws	2260004021	5	2.1	0.5	23%	5	63	51	81%
Other	2270004076	1	55.0	-	-	1	1,827	-	-
Shredders	2270004076	2	45.0	-	-	2	68	-	-
Push Lawn Mowers	2265004010	1	3.0	-	-	1	65	-	-
Push Lawn Mowers	2265004011	1	4.5	-	-	1	26	-	-
Riding Front Engine Mowers	2265004046	1	16.0	-	-	1	783	-	-
Riding Rear Engine Mowers	2270004046	4	21.0	-	-	4	1,305	-	-
Riding Rear Engine Mowers	2265004041	11	18.8	2.5	13%	11	1,388	452	33%
Tractors	2270004056	13	30.9	1.9	6%	13	1,546	288	19%
Trimmers, Edgers, Dethatchers	2260004026	20	1.3	0.2	13%	20	1,249	282	23%

[#]Statistics only calculated for equipment with more than 4 survey responses

2.9. Commercial and Private Airports

The City of San Antonio's Aviation Department operates two municipal airports: San Antonio International Airport and Stinson Municipal Airport. San Antonio International Airport (SAIA) is located approximately seven miles north of the San Antonio central business district. Stinson Municipal Airport, the second oldest general aviation airport in continuous operation in the United States, is located south of the central business district. As the primary reliever for general aviation traffic in San Antonio, Stinson is extremely appealing to operators of light aircraft, individuals, and private aviation companies. There are also 14 other small municipal and private airports in the San Antonio-New Braunfels MSA that operate on a continuous basis.

A total of 11 airports responded to the commercial lawn and garden equipment survey which represents 70 percent of the airports in the MSA (Table 2-23). Six of these airports are within Bexar County and 4 airports are located in Medina County while Comal, Guadalupe, and Atascosa counties also have airports (Table 2-24).

Table 2-23: Airports Survey Response Ratios, 2012

Survey Results	Number of Airports	Percent of Total Airports
Responded to First 2012 Survey	3	19%
Responded to Second 2012 Survey	6	38%
Responded to 2008 Survey	2	13%
Small Airports Operating in 2012	16	100%

Table 2-24: Number of Airports in the San Antonio-New Braunfels MSA, 2012

County	FIPS	Number of Airports
Atascosa	48013	1
Bandera	48019	0
Bexar	48029	6
Comal	48091	3
Guadalupe	48187	2
Kendall	48259	0
Medina	48325	4
Wilson	48493	0
Total (San Antonio – New Braunfels MSA)		16

A ratio of commercial lawn and garden equipment per small airport was calculated to estimate equipment usage at small airports that did not respond to the survey. The survey responses from SAIA and Stinson were not included in this calculation. There were 1.0 4-stroke trimmers/edgers/brush cutters per small airport and 0.8 diesel tractors per small airport (Table 2-25). Small airports also reported 2-stroke chainsaws (0.4 per small airport), 2-stroke leaf blowers (0.4 per small airport), and 4-stroke push lawn mowers (0.4 per small airport). As listed in Table 2-26, diesel tractors on average had 74 horsepower and are used 1,019 hours per year, while 2-stroke trimmers averaged 1.8 horsepower and are used 247 hours per year.

Table 2-25: Small Airports Lawn and Garden Equipment Ratio per Airport

Equipment Type	SCC	n	Mean	Standard Deviation	Confidence Level
Chainsaws	2260004021	4	0.4	0.7	0.4
Trimmers/ Edgers/ Brush Cutters	2260004026	10	1.0	2.0	1.2
Blowers, Vacuums & Sweepers	2260004031	4	0.4	0.5	0.3
Push Lawn Mowers	2265004011	4	0.4	0.5	0.3
Riding Rear Engine Mowers	2265004041	3	0.4	0.5	0.3
Riding Front Engine Mowers	2265004046	3	0.2	#	#
Lawn and Garden Tractors	2265004056	2	0.1	#	#
Riding Rear Engine Mowers	2270004046	2	0.2	#	#
Tractors	2270004056	9	0.8	1.5	0.9
Shredders	2270007010	1	0.1	#	#

#Statistics only calculated for equipment with more than 3 survey responses

Table 2-26: Confidence Interval at 95% for Small Airports Lawn and Garden Equipment

Equipment Type	SCC	Horsepower				Hours/Year			
		n	Mean	Confidence Interval	Percent of Mean	n	Mean	Confidence Interval	Percent of Mean
Chainsaws	2260004021	4	2.0	0.0	0%	4	138	52	37%
Trimmers/Edgers/Brush Cutters	2260004026	11	1.8	0.3	19%	11	854	247	29%
Blowers, Vacuums & Sweepers	2260004031	4	2.0	0.0	0%	4	125	71	57%
Push Lawn Mowers	2265004011	4	5.9	1.6	27%	4	264	138	52%
Riding Rear Engine Mowers	2265004041	4	18.0	8.3	46%	4	306	382	125%
Riding Front Engine Mowers	2265004046	2	30.0	-	-	2	2,088	-	-
Lawn and Garden Tractors	2265004056	1	16.0	-	-	1	1,305	-	-
Riding Rear Engine Mowers	2270004046	2	30.0	-	-	2	1,774	-	-
Tractors	2270004056	9	73.7	14.7	20%	9	1,019	449	44%
Shredders	2270007010	1	42.0	-	-	1	653	-	-

2.10. Local Government Facilities

Commercial lawn and garden equipment surveys were also distributed to local government municipalities and agencies. The survey results represent 76 percent of the government agencies and 96 percent of the population in the San Antonio-New Braunfels MSA (Table 2-27). The only municipalities that did not respond to the survey were several small cities and towns in the region. If a government entity did not respond to the survey, commercial lawn and garden equipment emissions were not calculated for this entity.

Table 2-27: Local Government Facilities Response Rate, 2012

Survey Results	Number of Government Agencies	Percent of Total Government Agencies	Total Population in the Government Region[20]	Percent of Total Population
Responded to First 2012 Survey	29	51%	1,680,465	75%
Responded to Second 2012 Survey	9	16%	414,541	19%
Responded to Third 2012 Survey	3	5%	12,958	1%
Responded to 2005 Survey	3	5%	29,406	1%
Government Agencies in the San Antonio - New Braunfels MSA	58	100%	2,234,003	100%

As shown on Table 2-28, there was a wide variety of commercial lawn and garden equipment used at government facilities. The most common commercial lawn and garden equipment operated at government facilities was 2-stroke trimmers with an average horsepower of 1.8 and 718annual hours of use. Other common equipment was 2-stroke chainsaws, 2.8 horsepower and 626 hours of use per year, and 2-stroke leaf blowers, 2.3 horsepower and 471 hours of use per year.

[20] United States Census Bureau, June 27, 2013. "State & County QuickFacts". Available online: http://quickfacts.census.gov/qfd/states/48/4801600.html. Accessed 12/16/13. "CensusViewer". Available online: http://censusviewer.com/free-maps-and-data-links/. Accessed 12/16/13.

Table 2-28: Confidence Interval at 95% for Local Government Lawn and Garden Equipment

Equipment Type	SCC	Horsepower				Hours/Year			
		n	Mean	Confidence Interval	Percent of Mean	n	Mean	Confidence Interval	Percent of Mean
Push Lawn Mowers	2260004011	9	3.5	1.4	41%	9	569	299	53%
Tillers & Aerators	2260004016	15	3.7	0.8	22%	15	170	142	83%
Chain Saws	2260004021	283	2.8	0.1	4%	283	626	68	11%
Trimmer	2260004026	322	1.8	0.1	5%	322	718	75	10%
Blowers, Vacuums & Sweepers	2260004031	199	2.3	0.1	4%	199	471	79	17%
Other	2260004076	2	1.8	-	-	2	68	-	-
Lawn Mowers	2265004011	59	5.6	0.5	9%	59	614	156	25%
Tillers & Aerators	2265004016	7	5.3	1.1	21%	7	101	87	86%
Chainsaw	2265004021	5	2.0	0.0	0%	5	1044	0	0%
Trimmer	2265004026	18	2.0	0.7	33%	18	1508	371	25%
Rear Engine Riding Mowers	2265004041	64	22.7	1.4	6%	64	875	148	17%
Riding Front Engine Mowers	2265004046	12	16.8	0.6	4%	12	784	96	12%
Lawn and Garden Tractors	2265004056	24	38.3	12.4	32%	24	486	172	35%
Chippers/ Stump/ Grinders/ Mulchers	2265004066	5	50.1	44.1	88%	5	382	279	73%
Tow Behind Cutters & Turf Mowers	2265004071	4	33.0	-	-	4	388	-	-
Other	2265004076	28	6.4	2.3	36%	28	338	200	59%
Tillers & Aerators	2270004016	1	36.2	-	-	1	2387	-	-
Blowers, Vacuums & Sweepers	2270004031	3	55.3	-	-	3	1305	-	-
Riding Rear Engine Mowers	2270004041	48	23.6	1.4	6%	48	1022	212	21%
Front Mowers	2270004046	5	16.6	5.7	34%	5	626	376	60%
Lawn and Garden Tractors	2270004056	110	67.2	5.0	7%	110	1399	130	9%
Chippers/ Stump/ Grinders/ Mulchers	2270004066	4	77.8	-	-	4	783	-	-
Tow Behind Cutters & Turf Mowers	2270004071	4	25.0	-	-	4	2088	-	-
Other	2270004076	6	31.0	7.9	25%	6	1331	367	28%
Shredders	2270004051	24	63.0	11.1	18%	24	830	287	35%

[#]Statistics only calculated for equipment with more than 4 survey responses

2.11. Federal and State Parks

State Parks in the AACOG region include Hill Country - Louise Merrick Unit State Natural Area in Medina County, Government Canyon State Natural Area in Bexar County, and Guadalupe River State Park/Honey Creek State Natural Area in Kendall County. The National Historical Parks in the region are Mission Concepción, Mission San José, Mission San Juan, and Mission Espada. Of the 7 Federal and State Parks in the San Antonio-New Braunfels MSA, 4 responded to the survey (Table 2-29). If a federal or state park did not respond, the commercial lawn and garden equipment population was not calculated for the park.

Table 2-29: Federal and State Parks Survey Response Ratios, 2012

Survey Results	Number of Parks	Percent of Total Parks
Responded to First 2012 Survey	4	57%
Responded to Second 2012 Survey	0	0%
Small Airports Operating in 2012	7	100%

2.12. Other Companies Lawn and Garden Equipment

Large businesses or facilities not included in other categories were sent surveys to determine if they operate commercial lawn and garden equipment. To be included in the survey, the company had to have a large area of maintained land. Forty-four businesses met the qualifications and 16 responded to the survey (Table 2-30). If a business or facility did not respond, lawn and garden equipment populations were not calculated for this entity.

Table 2-30: Other Companies Response Rate, 2012

Survey Results	Number of Other Companies	Percent of Other Companies
Responded to First 2012 Survey	14	32%
Responded to Second 2012 Survey	2	5%
Total Number of Other Companies Surveyed	44	100%

These businesses reported a limited amount of equipment operated at their facilities (Table 2-31). The most commonly reported types of equipment were 2-stroke trimmers with an average horsepower of 0.9 and 436 annual hours of use. Leaf blowers with an average horsepower of 1.2 and 4-stroke lawn mowers with an average horsepower of 5.1 were also reported in the survey results.

Table 2-31: Confidence Interval at 95% for Other Companies Commercial Lawn and Garden Equipment

Equipment Type	SCC	Horsepower				Hours/Year			
		n	Mean	Confidence Interval	Percent of Mean	n	Mean	Confidence Interval	Percent of Mean
Blowers, Vacuums & Sweepers	2260004031	10	1.2	0.4	35%	10	233	191	82%
Chainsaw	2260004021	4	1.8	0.5	28%	4	86	142	166%
Edger	2260004016	1	1.0	-	-	1	783	-	-
Other Lawn and Garden	2265004076	1	11.0	-	-	1	3	-	-
Push Lawn Mowers	2260004011	2	3.0	-	-	2	31	-	-
Push Lawn Mowers	2265004011	10	5.1	1.0	20%	10	93	58	63%
Riding Front Engine Mowers	2265004046	8	11.3	2.2	20%	8	68	24	36%
Riding Rear Engine Mowers	2270004046	1	38.0	-	-	1	1044	-	-
Riding Rear Engine Mowers	2265004041	2	35.0	-	-	2	1044	-	-
Tractors	2270004056	3	63.3	-	-	3	522	-	-
Trimmer	2260004026	16	0.9	0.1	14%	16	436	230	53%
Trimmer	2265004026	2	6.8	-	-	2	44	-	-

2.13. Military Facilities

There were five military facilities surveyed in the San Antonio-New Braunfels MSA: Lackland, Randolph, Fort Sam Houston, Camp Bullis, and Canyon Lake Recreation Center. Randolph Air Force Base (RAFB) is located in Bexar County, Texas, northeast of the City of San Antonio. The base is home to the 12th Flying Training Wing and is one of the few bases that conduct instructor pilot training. Lackland Air Force Base is located in Bexar County, Texas, in the west southwestern part of the City of San Antonio. The base is home to the 37th Training Wing whose primary mission is to provide training to new recruits entering the Air Force. Lackland gained a flying mission when adjacent Kelly Air Force Base closed in 2001. The 2-mile-long runway is now a joint-use facility between Lackland AFB and the city of San Antonio. In addition, "with the closure of Kelly AFB Lackland gained the section of base known as Security Hill. Security Hill is home to numerous Air Combat Command units such as the 67th Network Warfare Wing and the Air Intelligence Agency."[21]

The US Army's Fort Sam Houston (Ft. Sam) is a 3,265-acre military reservation located in Bexar County, Texas 3 miles northeast of downtown San Antonio. "The primary mission at Ft. Sam Houston is medical training and a support post housing Headquarters U.S. 5th Army, U.S. 5th Army Recruiting Brigade, Brooke Army Medical Center (BAMC), Institute of Surgical Research (ISR), U.S. Army Medical Department Center and School, U.S. Army Center Brigade, and U.S. Army Medical Command."[22] Ft. Sam employs military, civilian and contractor personnel to perform functions in support of installation facilities and active, reserve and retired military personnel and their dependents. "Camp Bullis is located 18 miles northwest of downtown San Antonio and consists of 27,880 acres of training facilities, temporary barracks, firing ranges, and maneuvering areas. Camp Bullis provides field training, weapon firing, and assault landing strips for active US Army and US Air Force units, joint Army and Air Force exercises, Army, Navy and Marine Corps Reserve units, and the Texas National Guard units."[23] Canyon Lake Recreational Center (CLRC) is located in Comal County, Texas, southeast of Canyon Lake near the spillway. The center is approximately 30 miles northeast of downtown San Antonio and 10 miles northwest of New Braunfels. The center does not house any troops, but provides recreational facilities to local organizations and military personnel and their families.

There was a 100 percent response rate from the military facilities with Camp Bullis contracting out lawn and garden maintenance activities. Respondents reported operating 130 2-stroke trimmers with an average horsepower of 2.9 and 537 annual hours of use at the military bases. The 44 2-stroke leaf blowers had an average horsepower of 2.7 and 744 annual hours of use, while 18 2-stroke chainsaws had an average horsepower of 2.9 and 687 annual hours of use (Table 2-32).

[21] Wikipedia, 2013. Lackland Air Force Base. Available online: http://en.wikipedia.org/wiki/Lackland_Air_Force_Base Accessed 12/30/13.
[22] Fort Sam Houston, Texas, 2005. Air Emissions Inventory. TCEQ Account Number BG-0070-0, p. 1-1.
[23] Dickson Consulting Group, LLC., 2003. 2003 Emissions Inventory for U.S. Army – Camp Bullis, Texas. TCEQ Account Number BG-0771-O, p. 5.

Table 2-32: Confidence Interval at 95% for Military Facilities Commercial Lawn and Garden Equipment

Equipment Type	SCC	Horsepower				Hours/Year			
		n	Mean	Confidence Interval	Percent of Mean	n	Mean	Confidence Interval	Percent of Mean
Blowers, Vacuums & Sweepers	2260004031	44	2.7	0.2	8%	44	744	165	22%
Blowers, Vacuums & Sweepers	2265004031	1	1.0	-	-	1	1668	-	-
Chainsaw	2260004021	18	2.9	0.4	15%	18	687	309	45%
Edger	2260004026	3	3.5	-	-	3	1305	-	-
Power Pruner	2260004026	3	3.8	-	-	3	313	-	-
Power Pruner	2265004026	2	3.5	-	-	2	365	-	-
Push Lawn Mowers	2265004011	10	2.5	0.7	26%	10	511	414	81%
Riding Rear Engine Mowers	2270004041	5	1.9	0.9	45%	5	1356	1252	92%
Riding Rear Engine Mowers	2265004041	13	5.5	2.6	46%	13	2255	474	21%
Shredders	2270004066	2	3.1	-	-	2	1122	-	-
Shredders	2265004066	1	3.0	-	-	1	261	-	-
Tillers & Aerators	2260004016	2	3.5	-	-	2	2088	-	-
Tractors	2270004056	24	2.5	0.7	26%	24	683	340	50%
Trimmer	2260004026	130	2.9	0.1	4%	130	537	108	20%
Trimmer	2265004026	8	1.0	0.0	0%	8	1878	0	0%
Other Lawn and Garden Eq.	2265004076	20	3.6	0.7	19%	20	334	84	25%
Other Lawn and Garden Eq.	2270004076	37	2.2	0.5	23%	37	524	100	19%

2.14. Lawn and Garden Equipment Totals

Once the lawn and garden equipment was tallied for all categories, a comparison was done between TexN Model data and the results from the survey. Since most of the commercial lawn and garden equipment in the San Antonio-New Braunfels MSA is used more often than the existing usage rates in the TexN model, Equation 2-4 was used to compare total equipment populations between the survey responses and the TexN model.

Equation 2-4, Equipment Population by Commercial Lawn and Garden Category

$POP_{A.B}$ = $POP_{A.B.Actual}$ x $HRS_{A.B.Survey}$ / $HRS_{A.B.TexN}$

$POP_{A.B}$ = Daily ozone season emissions for equipment type A for Commercial Lawn and Garden category B

$POP_{A.B.Actual}$ = Calculated population of equipment type A for Commercial Lawn and Garden category B

$HRS_{A.B.Survey}$ = Survey results for annual hours for equipment type A for Commercial Lawn and Garden category B

$HRS_{A.B.TexN}$ = TexN Model annual hours for equipment type A for Commercial Lawn and Garden category B

Sample Equation: Equipment population for 4-stroke rear engine riding mowers (SCC code 2265004041) used at cemeteries

$POP_{A.B}$ = 12 mowers x 1,388 average hours from survey responses / 569 hours from TexN Model

= 28 4-stroke rear engine riding mowers used at cemeteries

There were significantly more trimmers, front mowers, shedders and rear engine mowers in the AACOG survey than listed in the TexN Model (Figure 2-1). Leaf blowers, turf equipment, lawn and garden tractors, and chainsaws are also under-predicted in the TexN Model. Conversely, the TexN Model over-predicted the number of tillers and lawn mowers. Most of the equipment in the "other" category are golf carts used for lawn and garden maintenance activities. As show in table 2-34, most of these golf carts are used at golf courses and public schools. This equipment can also be classified as specialty vehicles/carts with SCC codes of 2260001060, 2265001060, and 2270001060.

The greatest difference in commercial lawn and garden equipment populations by county was Bexar County with 35,719 pieces of equipment compared to 12,089 in the TexN Model (Table 2-33). Likewise, the survey results for Guadalupe County indicate a significantly higher lawn and garden equipment population (3,059) than the TexN Model (911). Comal County's surveyed equipment population increased from 1,716 to 3,959, while Kendall County's increased from 563 to 1,830 pieces of equipment, when compared to the TexN model counts.

Table 2-34 shows the breakdown by category for AACOG's 2005 survey results, 2012 survey results and ERG's 2002 survey.[24] AACOG's results match closely with ERG's findings for most categories. Overall, the TexN Model under-predicts the number of lawn and garden equipment in the San Antonio-New Braunfels MSA compared to the results from previous studies. AACOG's 2012 survey results were 280 percent higher than existing data in the TexN Model, while ERG's 2002 survey of equipment is 310 percent higher (ERG results indicate that the

[24] Rick Baker, Eastern Research Group and Sam Wells, Starcrest Consulting Group, November 24, 2003. "Development of Commercial Lawn and Garden Emissions Estimates for the State of Texas and Selected Metropolitan Areas". Austin, Texas. Available online: http://www.docstoc.com/docs/68161995/q-lawn-and-garden-equipmentdoc---DEVELOPMENT-OF-LAWN-AND-GARDEN. Accessed 12/26/13.

number was 223 percent, but they did not survey all categories). AACOG found more chainsaws, turf equipment, front mowers, and trimmers compared to ERG's results. There were fewer tillers, lawn mowers, and leaf blowers in the survey returns compared to ERG findings.

Figure 2-1: Comparison of Surveys Equipment Population Estimations and TexN Model Existing Estimates by Category, San Antonio-New Braunfels MSA

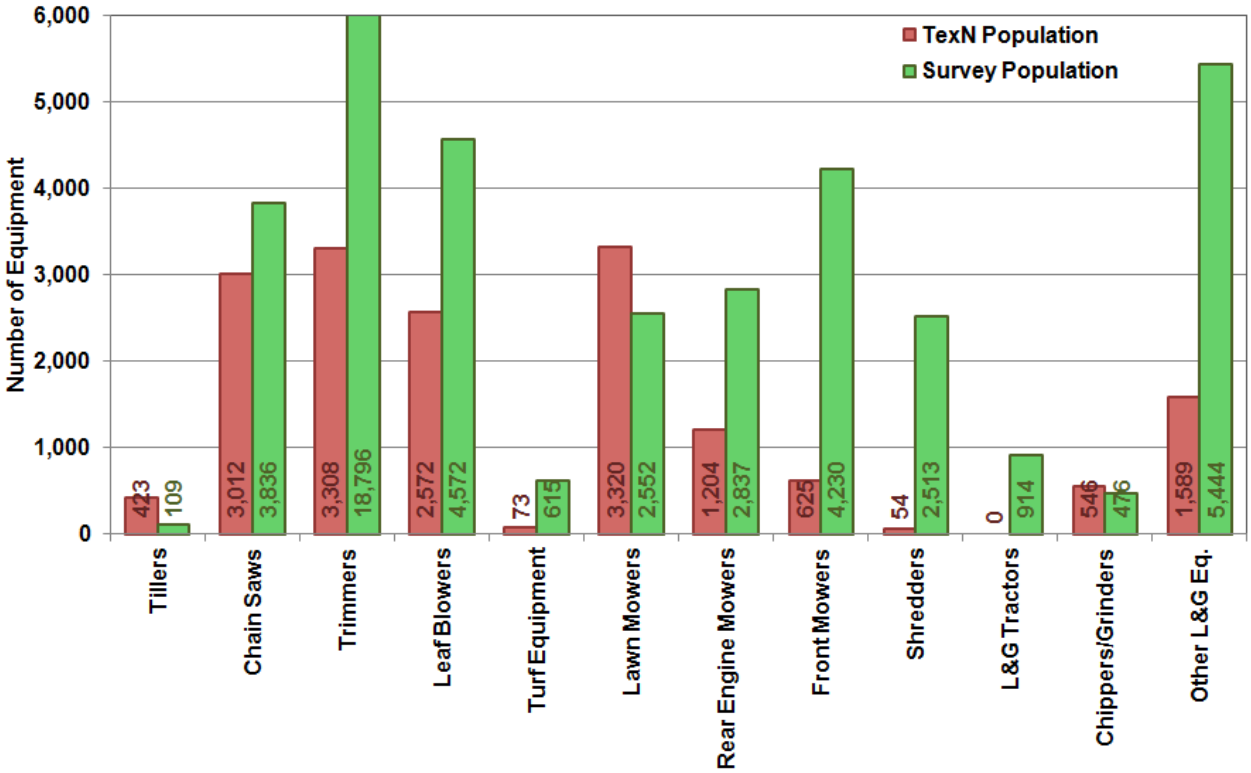


Table 2-33: Comparison of Surveys Equipment Population Estimations and TexN Model Existing Estimates by County, San Antonio-New Braunfels MSA, 2012

Equipment Type	SCC Code	Atascosa		Bandera		Bexar		Comal		Guadalupe		Kendall		Medina		Wilson		Total	
		TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.
Tillers	2260004016	8	0	6	0	204	42	29	3	15	2	9	1	8	0	3	1	282	49
	2265004016	4	0	3	0	102	43	14	5	8	3	5	2	4	0	2	1	141	55
	2270004016	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	5
Chain Saws	2260004021	82	38	63	1	2,177	2,953	309	347	164	250	101	110	82	40	34	56	3,012	3,795
	2265004021	-	0	-	0	-	35	-	2	-	1	-	1	-	0	-	0	-	41
Trimmers	2260004026	90	184	69	26	2,377	14,378	337	1,396	179	1,065	111	493	90	165	37	299	3,289	18,007
	2265004026	1	23	0	0	14	630	2	46	1	69	1	13	1	1	0	6	19	789
Leaf Blowers	2260004031	67	20	51	9	1,781	3,440	253	401	134	264	83	146	67	18	28	72	2,464	4,370
	2265004031	2	1	2	1	60	120	8	15	5	10	3	8	2	1	1	3	83	159
	2270004031	1	0	1	-	18	31	3	-	1	12	1	-	1	-	0	-	25	43
Turf Equipment	2260004071	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2265004071	1	9	1	24	36	341	5	53	3	45	2	68	1	18	1	21	50	580
	2270004071	1	0	0	1	17	30	2	1	1	1	1	2	1	0	0	1	24	36
Lawn Mowers	2260004011	-	5	-	2	-	358	-	48	-	27	-	16	-	5	-	10	-	470
	2265004011	90	18	69	16	2,400	1,560	341	196	181	133	112	97	90	23	37	39	3,320	2,081
Rear Engine Riding Mowers	2265004041	33	29	25	32	870	1,253	123	153	66	138	41	116	33	36	14	59	1,204	1,816
	2267004041	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2270004041	-	15	-	36	-	618	-	96	-	83	-	109	-	28	-	37	-	1,021
Front Mowers	2265004046	4	28	3	1	107	3,222	15	438	8	254	5	123	4	36	2	63	147	4,165
	2270004046	13	1	10	0	345	45	49	4	26	7	16	3	13	3	5	1	477	65
Shredders	2265004051	1	0	1	-	39	1,373	6	180	3	102	2	55	1	-	1	23	54	1,734
	2270004051	-	34	-	-	-	477	-	40	-	141	-	11	-	54	-	21	-	779
Lawn and Garden Tractors	2265004056	8	0	6	0	204	42	29	3	15	2	9	1	8	0	3	1	282	49
	2270004056	4	0	3	0	102	43	14	5	8	3	5	2	4	0	2	1	141	55

Equipment Type	SCC Code	Atascosa		Bandera		Bexar		Comal		Guadalupe		Kendall		Medina		Wilson		Total	
		TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.	TexN Pop.	Survey Pop.
Lawn and Garden Tractors	2265004056	-	1	-	1	-	37	-	4	-	10	-	4	-	5	-	3	-	65
	2270004056	-	24	-	6	-	630	-	59	-	59	-	32	-	25	-	13	-	849
Chippers/ Stump Grinders	2260004066	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2265004066	7	0	5	0	190	332	27	43	14	25	9	14	7	2	3	6	262	422
	2270004066	8	1	6	0	205	39	29	4	15	2	10	1	8	6	3	1	284	54
Other Lawn and Garden Equipment	2260004076	-	0	-	-	-	212	-	23	-	16	-	7	-	-	-	3	-	262
	2265004076	43	98	33	130	1,145	3,331	162	393	86	339	53	393	43	132	18	169	1,584	4,985
	2270004076	0	1	0	1	3	183	0	5	0	2	0	5	0	1	-	1	4	197
		456	530	348	289	12,089	35,719	1,716	3,959	911	3,059	563	1,830	456	600	187	909	16,726	46,895

Table 2-34: Comparison of Surveys Equipment Population Estimations and TexN Model Existing Estimates by SCC Code, San Antonio-New Braunfels MSA

Equipment Type	SCC Code	TexN Model Existing Population (2012)	AACOG 2012 Survey*											Percent of TexN Model Population	AACOG 2005 Results	ERG Results for San Antonio (2002)
			Commercial Lawn and Garden Companies	Universities / Colleges	Public Schools	Golf Courses	Cemeteries	Government Facilities	Federal and State Parks	Other Companies	Commercial/ Private Airports	Military Facilities	Total from AACOG's Survey			
Tillers	2260004016	282	27	1	3	-	-	5	1	2	1	9	49	17%	35%	292%
	2265004016	141	41	4	2	5	-	1	-	-	1	-	55	39%		
	2270004016	-	-	-	-	-	-	5	-	-	-	-	5	-		
Chain Saws	2260004021	3,012	3,010	78	57	16	1	585	1	1	5	41	3,795	126%	230%	107%
	2265004021	-	22	-	-	2	-	17	-	-	-	-	41	-		
Trimmers	2260004026	3,289	11,348	652	1,494	269	192	1,687	10	51	164	2,139	18,007	547%	444%	232%
	2265004026	19	392	8	26	-	-	198	-	1	1	164	789	4,155%		
Leaf Blowers	2260004031	2,464	3,330	98	316	135	17	332	1	8	19	116	4,370	177%	248%	347%
	2265004031	83	119	-	4	30	-	-	-	-	-	6	159	191%		
	2270004031	25	-	10	-	-	-	33	-	-	-	-	43	172%		
Turf Equipment	2260004071	-	-	-	-	-	-	-	-	-	-	-	0	-	737%	359%
	2265004071	50	61	4	-	512	-	2	-	-	-	-	580	1,159%		
	2270004071	24	-	-	-	14	-	8	-	-	14	-	36	149%		
Lawn Mowers	2260004011	-	348	10	78	22	-	13	-	-	-	-	470	-	131%	231%
	2265004011	3,320	1,550	38	47	332	-	89	-	2	10	13	2,081	63%		
Rear Engine Riding Mowers	2265004041	1,204	708	72	220	631	28	98	-	4	3	52	1,816	151%	163%	205%
	2267004041	-	-	-	-	-	-	-	-	-	-	-	0	-		
	2270004041	-	82	33	63	742	-	86	-	-	3	12	1,021	-		
Front Mowers	2265004046	147	3,778	86	76	-	10	109	-	6	99	-	4,165	2,833%	1,388%	186%
	2270004046	477	8	-	21	-	11	7	-	2	16	-	65	14%		
Shredders	2265004051	54	1,724	9	-	-	-	-	-	-	-	-	1,734	3,210%	5,514%	0%
	2270004051	-	355	5	-	-	3	399	1	-	18	-	779	-		

Equipment Type	SCC Code	TexN Model Existing Population (2012)	AACOG 2012 Survey*											Percent of TexN Model Population	AACOG 2005 Results	ERG Results for San Antonio (2002)
			Commercial Lawn and Garden Companies	Universities / Colleges	Public Schools	Golf Courses	Cemeteries	Government Facilities	Federal and State Parks	Other Companies	Commercial/ Private Airports	Military Facilities	Total from AACOG's Survey			
Lawn and Garden Tractors	2265004056	-	5	4	7	29	-	16	-	-	5	-	65	-	-	0%
	2270004056	-	226	48	69	119	39	283	-	3	32	30	849	-		
Chippers/ Stump Grinders	2265004066	-	407	-	11	-	-	4	-	-	-	1	422	-	122%	201%
	2267004066	262	-	-	-	-	-	-	-	-	-	-	0	0%		
	2270004066	284	25	-	17	1	-	7	-	-	-	5	54	19%		
Other Lawn and Garden Equipment	2260004076	-	224	34	-	-	-	2	1	-	-	-	262	-	283%	227%
	2265004076	1,584	610	172	1,440	2,490	-	161	-	-	5	108	4,985	315%		
	2270004076	4	-	1	9	13	4	18	-	-	3	149	197	4,930%		
Total		16,726	28,400	1,367	3,959	5,360	306	4,166	15	80	398	2,843	46,895	280%	310%	223%

*Survey results are weighted by the average hours from the TexN Model

[#]Based on the 2010 8-county MSA: Atascosa, Bandera, Bexar, Comal, Guadalupe, Kendall, Medina, and Wilson Counties

3. Commercial Lawn and Garden Equipment Emissions

3.1. Estimate Ozone Precursors Emissions

The methodology used to estimate commercial lawn and garden equipment emissions incorporated information on equipment type, equipment population, horsepower, and activity data extracted from returned survey questionnaires. When specific data such as load or emission factors were not provided in the survey returns, existing data in the TexN Model was used (Appendix A). The TexN Model run specifications were:

- Analysis Year = 2012
- Max Tech. Year = 2012
- Met Year = Typical Year
- Period = Ozone Season Day
- Summation Type = Typical Day (Weekday)
- Post Processing Adjustments = All
- Rules Enabled = All
- Regions = Bexar County
- Sources = Commercial Lawn and Garden Equipment

Ozone season daily VOC and NO_X emissions were calculated by horsepower bin using the formula provided below. Bexar County 2012 VOC and NO_X emission factors by horsepower bin are provided in Appendix A. If the emission factor was not available from the TexN Model for a specific hp bin, the emission factor from the closest horsepower bin was used.

Equation 3-1, Ozone season daily emissions for commercial lawn and garden equipment

$DE_{A.B} = POP_{A.B} \times HRS_{A.B} \times HP_{A.B} \times LF_A \times EF_{A.B}$ / 907,184.74 grams/ton / 365 days per year

Where,

$DE_{A.B}$ = Daily ozone season emissions for equipment type A for hp bin B (tons/day)
$POP_{A.B}$ = Population of equipment type A for hp bin B (from survey)
$HRS_{A.B}$ = Annual activity rate for equipment type A for hp bin B, hrs (from survey)
$HP_{A.B}$ = Average rated horsepower for equipment type A for hp bin B, hp (from survey)
LF_A = Load factor for equipment type A (from TexN Model)
$EF_{A.B}$ = Average emissions factor for equipment type A for hp bin B, g/hp-hr (from TexN Model)

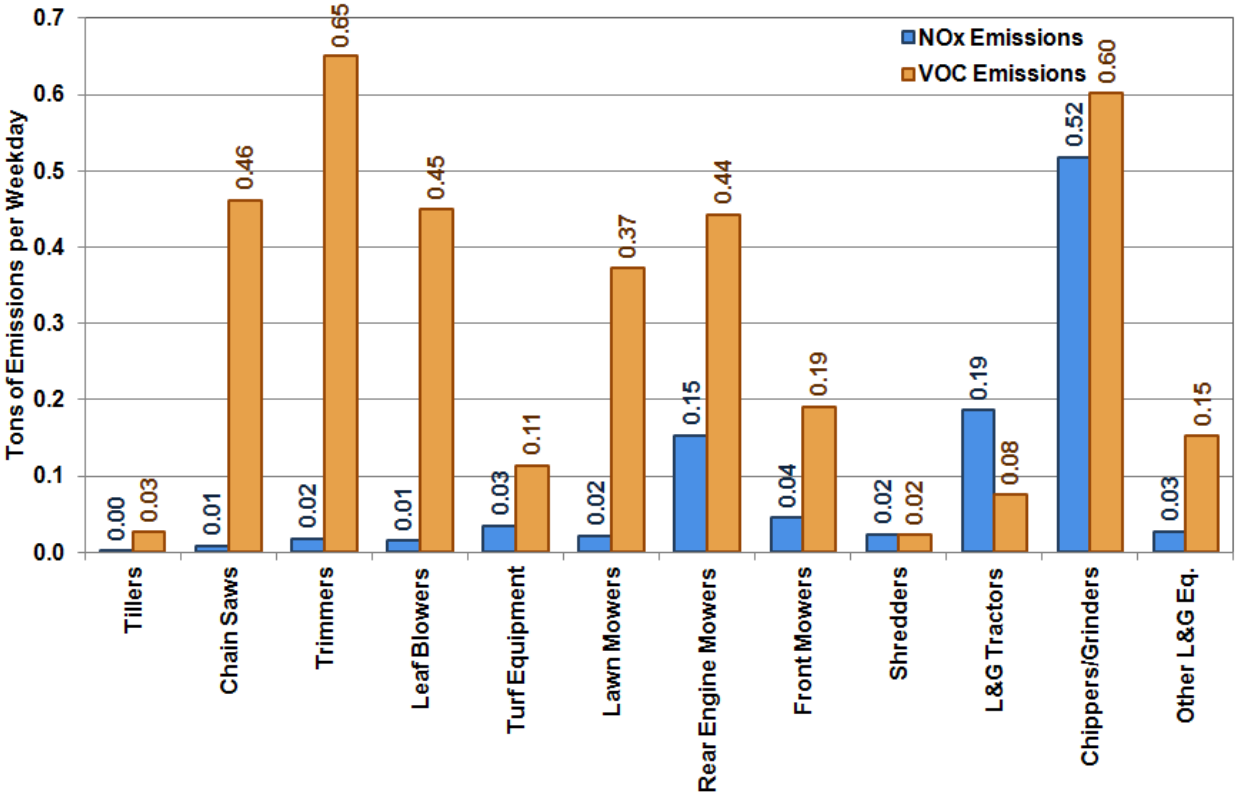
Sample Equation: Ozone season daily NO_X emissions from diesel tractors (SCC 2270004056) in hp bin 75-100 for Small Airports in the San Antonio-New Braunfels MSA

$DE_{A.B}$ = 8.18 tractors x 1,310 hours x 86.3 hp x 0.43 x 4.03 g of NO_X/hp-hr / 907,184.74 grams/ton / 365 days per year
= 0.0048 tons of NO_X per ozone season day

Based on data collected from the survey, commercial lawn and garden equipment was estimated to emit 3.6 tons of VOCs and 1.1 tons of NO_X per ozone season weekday. Trimmers were the largest source of VOC emissions, 0.65 tons per weekday, because of the large number and high activity rates of trimmers in the San Antonio New Braunfels MSA (Figure 3-1). The second largest source of VOC emissions was chippers/grinders (0.60 tons of VOC per weekday), followed by chainsaws (0.46 tons), leaf blowers (0.45 tons), and rear engine mowers (0.44 tons). The largest source of NO_X emissions was chippers and grinders with 0.52 tons per

weekday. Other sources of NO_X emissions included lawn and garden tractors, 0.19 tons per weekday and rear engine lawn mowers, 0.15 tons per weekday.

Figure 3-1: Commercial Lawn and Garden Equipment Emissions by Equipment Type, Tons per Ozone Season Weekday, 2012



Most lawn and garden equipment operated in the San Antonio-New Braunfels MSA is located in Bexar County; therefore, emissions estimates are highest for Bexar with, 2.73 tons of VOCs and 0.80 tons of NO_X per weekday (Figure 3-2). Comal County was second with 0.33 tons of VOCs and 0.09 tons of NO_X and Guadalupe County was third with 0.23 tons of NO_X and 0.07 tons of VOCs per weekday. As shown in Figure 3-3, NO_X emissions based on survey results were significantly higher than those based on the TexN model. The largest difference between survey-based and model-based NO_X emissions for individual equipment categories was chippers/grinders, lawn and garden tractors, and rear engine mowers. NO_X emissions were slightly lower for front mowers and tillers when using the results from the survey. Detailed emissions results for weekday and weekend NO_X and VOC emissions are provided in Table 3-1 to Table 3-4, while Table 3-5 provides a comparison between the results of the survey and existing data in the TexN model.

Figure 3-2: Commercial Lawn and Garden Equipment Emissions by County, Tons per Ozone Season Weekday, 2012

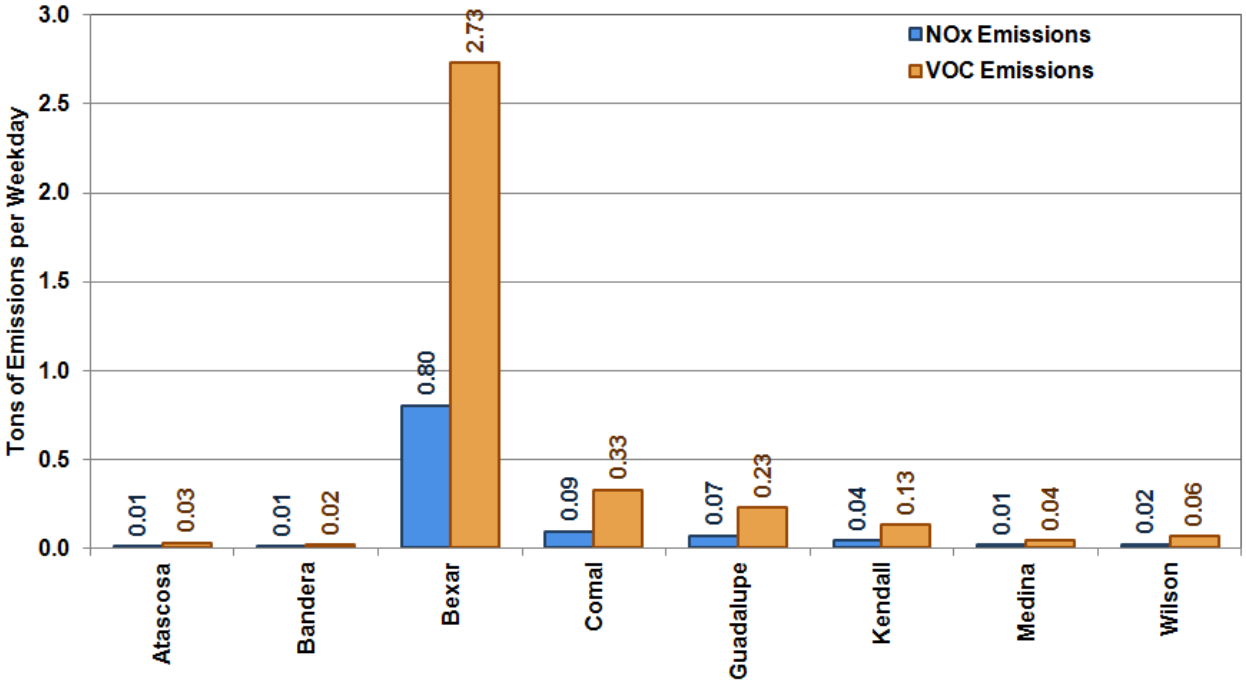


Figure 3-3: Ozone Season Daily Commercial Lawn and Garden Equipment NO_X Emissions by Equipment Type, San Antonio New Braunfels MSA, 2012

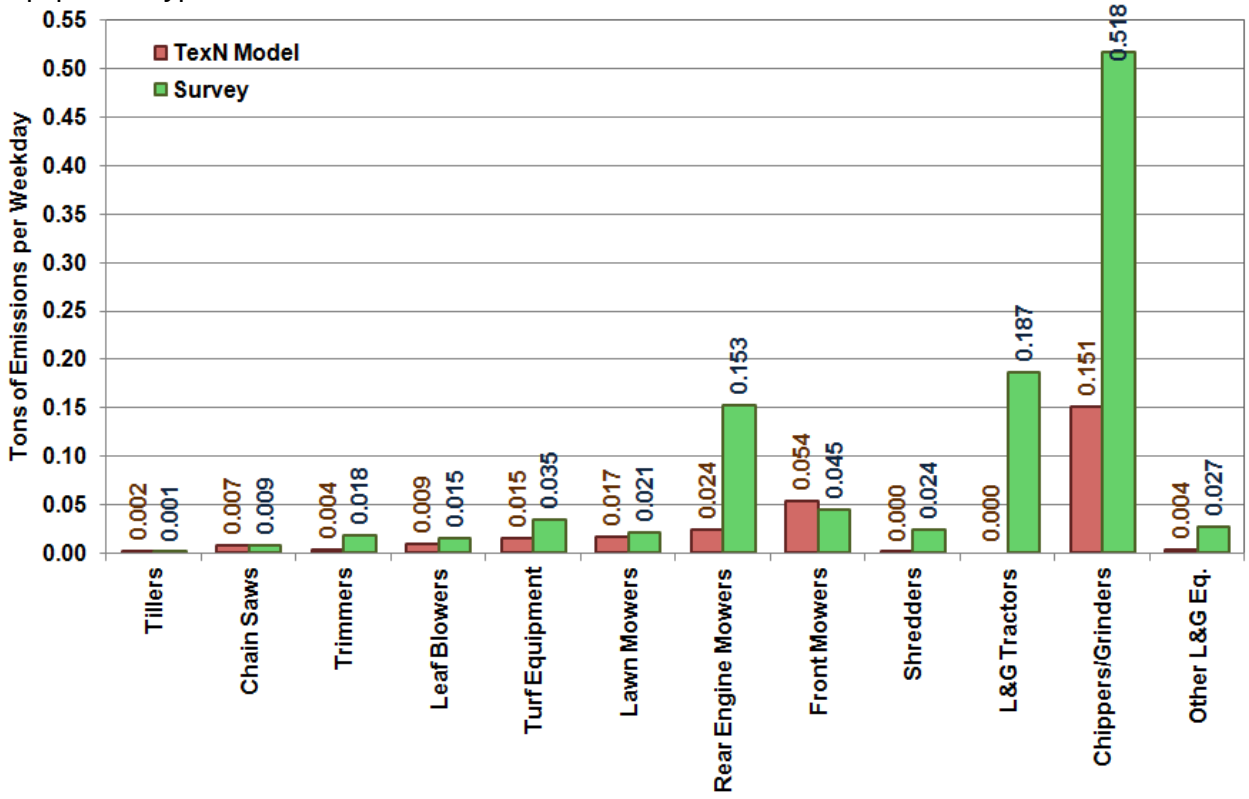


Table 3-1: Ozone Season Weekday Commercial Lawn and Garden Equipment NO_X Emissions by County, 2012

Equipment Type	SCC	Atascosa (48013)	Bandera (48019)	Bexar (48029)	Comal (48091)	Guadalupe (48187)	Kendall (48259)	Kerr (48265)	Medina (48325)	Total
Tillers	2260004016	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
	2265004016	0.0000	0.0000	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000	0.0007
	2270004016	-	-	0.0000	-	-	-	-	-	0.0000
Chain Saws	2260004021	0.0000	0.0000	0.0067	0.0007	0.0004	0.0002	0.0001	0.0001	0.0084
	2265004021	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
Trimmers	2260004026	0.0002	0.0000	0.0124	0.0013	0.0010	0.0004	0.0002	0.0002	0.0158
	2265004026	0.0001	0.0000	0.0014	0.0001	0.0001	0.0000	0.0000	0.0000	0.0018
Leaf Blowers	2260004031	0.0001	0.0000	0.0086	0.0011	0.0007	0.0004	0.0001	0.0002	0.0111
	2265004031	0.0000	0.0001	0.0013	0.0002	0.0001	0.0002	0.0000	0.0001	0.0020
	2270004031	0.0000	-	0.0011	-	0.0009	-	-	-	0.0019
Turf Equipment	2265004071	0.0003	0.0008	0.0130	0.0018	0.0015	0.0023	0.0006	0.0007	0.0210
	2270004071	0.0000	0.0001	0.0127	0.0002	0.0002	0.0003	0.0001	0.0001	0.0136
Lawn Mowers	2260004011	0.0000	0.0000	0.0017	0.0002	0.0001	0.0001	0.0000	0.0000	0.0022
	2265004011	0.0001	0.0000	0.0151	0.0019	0.0011	0.0006	0.0001	0.0003	0.0192
Rear Engine Riding Mowers	2265004041	0.0012	0.0008	0.0520	0.0057	0.0049	0.0033	0.0010	0.0023	0.0712
	2270004041	0.0012	0.0024	0.0499	0.0095	0.0063	0.0074	0.0020	0.0029	0.0816
Front Mowers	2265004046	0.0001	0.0000	0.0301	0.0041	0.0023	0.0012	0.0004	0.0005	0.0387
	2270004046	0.0001	0.0000	0.0045	0.0004	0.0005	0.0003	0.0003	0.0001	0.0063
Shredders	2265004051	0.0000	-	0.0013	0.0002	0.0001	0.0001	-	0.0000	0.0016
	2270004051	0.0001	-	0.0151	0.0013	0.0024	0.0004	0.0018	0.0009	0.0220
Lawn and Garden Tractors	2265004056	0.0001	0.0001	0.0016	0.0003	0.0021	0.0002	0.0003	0.0001	0.0047
	2270004056	0.0032	0.0010	0.1460	0.0089	0.0117	0.0041	0.0039	0.0030	0.1818
Chippers/ Stump Grinders	2265004066	0.0001	0.0000	0.3983	0.0523	0.0296	0.0163	0.0013	0.0068	0.5047
	2267004066	-	-	0.0003	-	-	-	-	-	0.0003
	2270004066	0.0001	0.0000	0.0090	0.0009	0.0006	0.0003	0.0019	0.0002	0.0130
Other Lawn and Garden Equipment	2260004076	0.0000	-	0.0003	0.0000	0.0000	0.0000	-	0.0000	0.0003
	2265004076	0.0004	0.0005	0.0128	0.0018	0.0013	0.0016	0.0005	0.0007	0.0196
	2270004076	0.0001	0.0000	0.0062	0.0002	0.0001	0.0001	0.0001	0.0001	0.0069
Total		0.0077	0.0059	0.8021	0.0931	0.0682	0.0397	0.0146	0.0194	1.0507

Table 3-2: Ozone Season Weekend Commercial Lawn and Garden Equipment NO_X Emissions by County, 2012

Equipment Type	SCC	Atascosa (48013)	Bandera (48019)	Bexar (48029)	Comal (48091)	Guadalupe (48187)	Kendall (48259)	Kerr (48265)	Medina (48325)	Total
Tillers	2260004016	-	-	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2265004016	0.0000	0.0001	0.0010	0.0002	0.0001	0.0002	0.0001	0.0001	0.0017
	2270004016	-	-	0.0000	-	-	-	-	-	0.0000
Chain Saws	2260004021	0.0000	0.0001	0.0020	0.0003	0.0002	0.0003	0.0001	0.0001	0.0032
	2265004021	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
Trimmers	2260004026	0.0002	0.0005	0.0075	0.0012	0.0010	0.0015	0.0005	0.0005	0.0128
	2265004026	0.0000	-	0.0002	0.0000	0.0000	0.0000	-	0.0000	0.0002
Leaf Blowers	2260004031	0.0002	0.0006	0.0080	0.0013	0.0011	0.0017	0.0005	0.0005	0.0139
	2265004031	0.0001	0.0001	0.0018	0.0003	0.0003	0.0004	0.0001	0.0001	0.0032
	2270004031	-	-	0.0000	-	0.0000	-	-	-	0.0000
Turf Equipment	2265004071	0.0016	0.0045	0.0533	0.0087	0.0076	0.0122	0.0034	0.0038	0.0950
	2270004071	0.0000	0.0000	0.0019	0.0000	0.0000	0.0001	0.0000	0.0000	0.0021
Lawn Mowers	2260004011	0.0001	0.0002	0.0022	0.0004	0.0003	0.0005	0.0001	0.0002	0.0039
	2265004011	0.0001	0.0004	0.0056	0.0009	0.0007	0.0010	0.0003	0.0003	0.0093
Rear Engine Riding Mowers	2265004041	0.0014	0.0039	0.0504	0.0080	0.0068	0.0108	0.0030	0.0034	0.0878
	2270004041	0.0001	0.0004	0.0063	0.0010	0.0008	0.0012	0.0003	0.0004	0.0104
Front Mowers	2265004046	0.0000	-	0.0029	0.0004	0.0003	0.0001	0.0001	0.0000	0.0039
	2270004046	0.0000	-	0.0004	0.0001	0.0001	0.0000	0.0001	0.0000	0.0008
Shredders	2265004051	-	-	0.0001	0.0000	0.0000	0.0000	-	0.0000	0.0002
	2270004051	0.0000	-	0.0011	0.0002	0.0001	0.0000	0.0001	0.0000	0.0015
Lawn and Garden Tractors	2265004056	0.0002	0.0004	0.0047	0.0008	0.0007	0.0010	0.0004	0.0003	0.0085
	2270004056	0.0003	0.0002	0.0120	0.0015	0.0011	0.0006	0.0011	0.0002	0.0169
Chippers/ Stump Grinders	2265004066	-	-	0.0383	0.0050	0.0028	0.0016	0.0000	0.0006	0.0484
	2267004066	-	-	-	-	-	-	-	-	-
	2270004066	0.0000	0.0000	0.0010	0.0001	0.0000	0.0000	0.0000	0.0000	0.0012
Other Lawn and Garden Equipment	2260004076	-	-	0.0000	0.0000	0.0000	0.0000	-	0.0000	0.0000
	2265004076	0.0008	0.0023	0.0282	0.0046	0.0040	0.0064	0.0018	0.0020	0.0501
	2270004076	0.0000	0.0000	0.0013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0014
Total		0.0053	0.0137	0.2302	0.0349	0.0281	0.0397	0.0118	0.0126	0.3765

Table 3-3: Ozone Season Weekday Commercial Lawn and Garden Equipment VOC Emissions by County, 2012

Equipment Type	SCC	Atascosa (48013)	Bandera (48019)	Bexar (48029)	Comal (48091)	Guadalupe (48187)	Kendall (48259)	Kerr (48265)	Medina (48325)	Total
Tillers	2260004016	0.0001	0.0000	0.0094	0.0007	0.0004	0.0002	0.0004	0.0001	0.0114
	2265004016	0.0000	0.0001	0.0117	0.0013	0.0009	0.0006	0.0001	0.0004	0.0150
	2270004016	-	-	0.0000	-	-	-	-	-	0.0000
Chain Saws	2260004021	0.0026	0.0002	0.3693	0.0406	0.0232	0.0118	0.0066	0.0057	0.4600
	2265004021	0.0000	0.0000	0.0014	0.0001	0.0001	0.0000	0.0000	0.0000	0.0017
Trimmers	2260004026	0.0061	0.0009	0.4899	0.0495	0.0394	0.0175	0.0099	0.0087	0.6217
	2265004026	0.0012	0.0000	0.0230	0.0019	0.0013	0.0005	0.0000	0.0003	0.0283
Leaf Blowers	2260004031	0.0022	0.0011	0.3400	0.0434	0.0264	0.0138	0.0024	0.0076	0.4369
	2265004031	0.0001	0.0002	0.0089	0.0011	0.0007	0.0007	0.0001	0.0003	0.0121
	2270004031	0.0000	-	0.0001	-	0.0001	-	-	-	0.0003
Turf Equipment	2265004071	0.0016	0.0045	0.0675	0.0099	0.0085	0.0126	0.0034	0.0040	0.1119
	2270004071	0.0000	0.0000	0.0017	0.0000	0.0000	0.0001	0.0000	0.0000	0.0019
Lawn Mowers	2260004011	0.0004	0.0003	0.0669	0.0093	0.0051	0.0029	0.0005	0.0027	0.0881
	2265004011	0.0016	0.0004	0.2236	0.0275	0.0165	0.0093	0.0010	0.0040	0.2840
Rear Engine Riding Mowers	2265004041	0.0076	0.0046	0.3118	0.0343	0.0294	0.0198	0.0063	0.0137	0.4276
	2270004041	0.0002	0.0004	0.0094	0.0018	0.0012	0.0014	0.0004	0.0005	0.0153
Front Mowers	2265004046	0.0006	0.0000	0.1444	0.0198	0.0110	0.0056	0.0022	0.0026	0.1863
	2270004046	0.0000	0.0000	0.0041	0.0001	0.0001	0.0001	0.0001	0.0000	0.0046
Shredders	2265004051	0.0000	-	0.0154	0.0020	0.0011	0.0006	-	0.0003	0.0194
	2270004051	0.0000	-	0.0026	0.0002	0.0004	0.0000	0.0002	0.0002	0.0036
Lawn and Garden Tractors	2265004056	0.0004	0.0004	0.0104	0.0016	0.0129	0.0011	0.0016	0.0009	0.0293
	2270004056	0.0006	0.0002	0.0363	0.0044	0.0020	0.0007	0.0012	0.0006	0.0460
Chippers/ Stump Grinders	2265004066	0.0002	0.0000	0.4730	0.0621	0.0351	0.0194	0.0014	0.0081	0.5993
	2267004066	-	-	0.0001	-	-	-	-	-	0.0001
	2270004066	0.0000	0.0000	0.0013	0.0001	0.0001	0.0000	0.0003	0.0000	0.0018
Other Lawn and Garden Equipment	2260004076	0.0000	-	0.0375	0.0041	0.0028	0.0013	-	0.0005	0.0463
	2265004076	0.0021	0.0026	0.0674	0.0097	0.0070	0.0084	0.0028	0.0036	0.1037
	2270004076	0.0000	0.0000	0.0020	0.0001	0.0000	0.0001	0.0000	0.0000	0.0022
Total		0.0277	0.0159	2.7291	0.3257	0.2259	0.1285	0.0409	0.0646	3.5584

Table 3-4: Ozone Season Weekend Commercial Lawn and Garden Equipment VOC Emissions by County, 2012

Equipment Type	SCC	Atascosa (48013)	Bandera (48019)	Bexar (48029)	Comal (48091)	Guadalupe (48187)	Kendall (48259)	Kerr (48265)	Medina (48325)	Total
Tillers	2260004016	-	-	0.0010	0.0001	0.0000	0.0000	0.0000	0.0000	0.0012
	2265004016	0.0000	0.0000	0.0012	0.0002	0.0001	0.0001	0.0000	0.0000	0.0017
	2270004016	-	-	0.0000	-	-	-	-	-	0.0000
Chain Saws	2260004021	0.0001	0.0000	0.0302	0.0037	0.0020	0.0012	0.0002	0.0005	0.0378
	2265004021	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
Trimmers	2260004026	0.0008	0.0002	0.0489	0.0066	0.0040	0.0018	0.0027	0.0007	0.0656
	2265004026	0.0000	-	0.0045	0.0002	0.0001	0.0001	-	0.0000	0.0049
Leaf Blowers	2260004031	0.0001	0.0002	0.0314	0.0038	0.0022	0.0015	0.0002	0.0006	0.0399
	2265004031	0.0000	0.0000	0.0015	0.0002	0.0001	0.0002	0.0000	0.0001	0.0021
	2270004031	-	-	0.0000	-	0.0000	-	-	-	0.0000
Turf Equipment	2265004071	0.0005	0.0015	0.0187	0.0030	0.0026	0.0041	0.0011	0.0013	0.0329
	2270004071	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
Lawn Mowers	2260004011	0.0000	0.0001	0.0061	0.0008	0.0005	0.0004	0.0000	0.0002	0.0081
	2265004011	0.0001	0.0001	0.0218	0.0028	0.0017	0.0011	0.0001	0.0004	0.0282
Rear Engine Riding Mowers	2265004041	0.0005	0.0013	0.0382	0.0047	0.0034	0.0042	0.0010	0.0014	0.0549
	2270004041	0.0000	0.0001	0.0019	0.0003	0.0002	0.0004	0.0001	0.0001	0.0033
Front Mowers	2265004046	0.0001	-	0.0140	0.0022	0.0013	0.0005	0.0006	0.0002	0.0190
	2270004046	0.0000	-	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002
Shredders	2265004051	-	-	0.0015	0.0002	0.0001	0.0001	-	0.0000	0.0018
	2270004051	0.0000	-	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002
Lawn and Garden Tractors	2265004056	0.0002	0.0001	0.0024	0.0006	0.0007	0.0004	0.0006	0.0001	0.0051
	2270004056	0.0001	0.0001	0.0022	0.0003	0.0002	0.0002	0.0002	0.0001	0.0032
Chippers/ Stump Grinders	2265004066	-	-	0.0456	0.0060	0.0034	0.0018	0.0000	0.0008	0.0576
	2267004066	-	-	-	-	-	-	-	-	-
	2270004066	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002
Other Lawn and Garden Equipment	2260004076	-	-	0.0030	0.0004	0.0002	0.0001	-	0.0001	0.0038
	2265004076	0.0003	0.0008	0.0112	0.0017	0.0014	0.0022	0.0006	0.0007	0.0188
	2270004076	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005
Total		0.0028	0.0046	0.2865	0.0378	0.0244	0.0204	0.0076	0.0073	0.3914

Table 3-5: Ozone Season Daily Commercial Lawn and Garden Equipment Emissions by SCC Code, San Antonio New Braunfels MSA, 2012

Equipment Type	SCC Code	NO_X				VOC			
		Weekday		Weekend		Weekday		Weekend	
		TexN Model	Updated Emission Inventory	TexN Model	Updated Emission Inventory	TexN Model	Updated Emission Inventory	TexN Model	Updated Emission Inventory
Tillers	2260004016	0.0008	0.0001	0.0005	0.0000	0.0300	0.0114	0.0180	0.0012
	2265004016	0.0013	0.0007	0.0008	0.0017	0.0155	0.0150	0.0093	0.0017
	2270004016	-	0.0000	-	0.0000	-	0.0000	-	0.0000
Chain Saws	2260004021	0.0074	0.0084	0.0044	0.0032	0.5681	0.4600	0.3409	0.0378
	2265004021	-	0.0001	-	0.0001	-	0.0017	-	0.0001
Trimmers	2260004026	0.0038	0.0158	0.0023	0.0128	0.1724	0.6217	0.1034	0.0656
	2265004026	0.0001	0.0018	0.0001	0.0002	0.0010	0.0283	0.0006	0.0049
Leaf Blowers	2260004031	0.0069	0.0111	0.0041	0.0139	0.3284	0.4369	0.1971	0.0399
	2265004031	0.0023	0.0020	0.0014	0.0032	0.0097	0.0121	0.0058	0.0021
	2270004031	0.0002	0.0019	0.0001	0.0000	0.0000	0.0003	0.0000	0.0000
Turf Equipment	2265004071	0.0020	0.0210	0.0012	0.0950	0.0098	0.1119	0.0059	0.0329
	2270004071	0.0131	0.0136	0.0078	0.0021	0.0013	0.0019	0.0008	0.0003
Lawn Mowers	2260004011	-	0.0022	-	0.0039	-	0.0881	-	0.0081
	2265004011	0.0165	0.0192	0.0099	0.0093	0.1875	0.2840	0.1125	0.0282
Rear Engine Riding Mowers	2265004041	0.0238	0.0712	0.0143	0.0878	0.1088	0.4276	0.0653	0.0549
	2270004041	-	0.0816	-	0.0104	-	0.0153	-	0.0033
Front Mowers	2265004046	0.0013	0.0387	0.0008	0.0039	0.0059	0.1863	0.0035	0.0190
	2270004046	0.0527	0.0063	0.0316	0.0008	0.0071	0.0046	0.0043	0.0002
Shredders	2265004051	0.0001	0.0016	0.0001	0.0002	0.0012	0.0194	0.0007	0.0018
	2270004051	-	0.0220	-	0.0015	-	0.0036	-	0.0002
Lawn and Garden Tractors	2265004056	-	0.0047	-	0.0085	-	0.0293	-	0.0051
	2270004056	-	0.1818	-	0.0169	-	0.0460	-	0.0032
Chippers/ Stump Grinders	2265004066	0.0208	0.5047	0.0125	0.0484	0.0570	0.5993	0.0342	0.0576
	2267004066	-	0.0003	-	-	-	0.0001	-	-
	2270004066	0.1303	0.0130	0.0782	0.0012	0.0133	0.0018	0.0080	0.0002
Other Lawn and Garden Equipment	2260004076	-	0.0003	-	0.0000	-	0.0463	-	0.0038
	2265004076	0.0034	0.0196	0.0020	0.0501	0.0325	0.1037	0.0195	0.0188
	2270004076	0.0007	0.0069	0.0004	0.0014	0.0001	0.0022	0.0001	0.0005
Total		0.2873	1.0507	0.1724	0.3765	1.5498	3.5584	0.9299	0.3914

3.2. Temporal Allocation

A weekday versus weekend adjustment factor was calculated based on the total hours of commercial lawn and garden equipment usage for each time period as determined from the surveys for each facility type.

Equation 3-2, Weekday Allocation of Emissions

$DE_{B.Weekday} = (HRS_{B.Weekday} \times 5) / [(HRS_{B.Weekday} \times 5) + (HRS_{B.Weekend} \times 2)]$

Where,

$DE_{B.Weekday}$ = Percent of Emissions on Weekdays for Commercial Lawn and Garden category B

$HRS_{B.Weekday}$ = Total Survey Weekday Hours for Commercial Lawn and Garden category B

$HRS_{B.Weekend}$ = Total Survey Weekday Hours for Commercial Lawn and Garden category B

Sample Equation: Percentage of commercial lawn and garden equipment operated on weekdays at cemeteries

$DE_{B.Weekday}$ = (275.2 hours x 5) / [(275.2 hours x 5) + (1.2 hours x 2)]

= 99.8% of emissions from commerical lawn and garden emissions from cemeteries occur on weekdays.

The percentage of ozone season day emissions that occurs on weekdays and weekend days is provided in Table 3-6. Universities/colleges, public schools, federal and state parks, other companies, and Stinson airport reported no equipment usage on the weekends. The only categories with significant equipment usage on the weekends were small airports, military facilities, and golf courses. The survey results show that commercial lawn and garden equipment usage was higher on weekdays compared to data in the TexN Model. Table 3-7 documents EPS3 temporal allocation file factors by commercial lawn and garden category.

Table 3-6: Weekday and Weekend Allocation of Emissions by Category

Category	Weekday Allocation	Weekend Allocation
Commercial Lawn and Garden Companies	96.3%	3.7%
Universities / Colleges	100.0%	0.0%
Public Schools	100.0%	0.0%
Golf Courses	88.2%	11.8%
Government Facilities	99.3%	0.7%
Federal and State Parks	100.0%	0.0%
Other Companies	100.0%	0.0%
Cemeteries	99.8%	0.2%
Commercial/ Private Airports	80.9%	19.1%
Stinson Airport	100.0%	0.0%
San Antonio International Airport	93.8%	6.2%
Military Facilities	84.3%	15.7%
Weighted Average*	95.7%	4.3%
Existing Data in TexN Model[#]	81.0%	19.0%

*Weighted by total NO_X Emissions

[#]Based on Weekend Emissions per day being 60% compared to a Weekend day

Table 3-7: EPS3 Temporal Allocation File Factors by Commercial Lawn and Garden Category

Category	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
	1	2	3	4	5	6	7	
Commercial Lawn and Garden Companies	21	21	21	21	21	2	2	147
Universities / Colleges	1	1	1	1	1	0	0	7
Public Schools	1	1	1	1	1	0	0	7
Golf Courses	3	3	3	3	3	1	1	21
Government Facilities	54	54	54	54	54	1	1	378
Federal and State Parks	1	1	1	1	1	0	0	7
Other Companies	1	1	1	1	1	0	0	7
Cemeteries	142	142	142	142	142	1	1	994
Commercial/ Private Airports	5	5	5	5	5	3	3	35
Stinson Airport	1	1	1	1	1	0	0	7
San Antonio International Airport	6	6	6	6	6	1	1	42
Military Facilities	13	13	13	13	13	6	6	91
Weighted Average*	9	9	9	9	9	1	1	63
Existing Data in TexN Model	16	16	16	16	16	10	10	112
Existing Data in TCEQ Modeling Files	16	16	16	16	16	10	10	112

*Weighted by total NO_X Emissions

Appendix A: TexN Load and Emission Factors for Commercial Lawn and Garden Equipment: Bexar County, 2012

Equipment Type	SCC	Minimum HP	Maximum HP	LF	NO_X	VOC
Tillers	2260004016	0	1	0.4	1.12	175.55
	2260004016	1	3	0.4	1.15	182.63
Chain Saws	2260004021	1	3	0.7	1.23	64.41
	2260004021	3	6	0.7	0.85	66.42
Trimmers	2260004026	0	1	0.91	1.68	63.57
	2260004026	3	6	0.91	1.18	47.75
LeafBlowers	2260004031	0	1	0.94	1.59	62.25
	2260004031	3	6	0.94	1.11	43.68
Turf Equipment	2260004071	1	3	0.6	0.99	124.83
Shedders	2260007005	6	11	0.7	0.85	62.19
Lawn Mowers	2265004011	1	3	0.33	2.74	40.67
	2265004011	3	6	0.33	2.27	32.32
	2265004011	6	11	0.33	2.36	35.35
Tillers	2265004016	3	6	0.4	2.45	54.78
Trimmers	2265004026	3	6	0.91	1.74	23.76
	2265004026	6	11	0.91	1.82	10.73
	2265004026	11	16	0.91	1.79	8.70
	2265004026	16	25	0.91	1.79	8.67
LeafBlowers	2265004031	3	6	0.94	1.95	23.72
	2265004031	6	11	0.94	1.99	9.85
	2265004031	11	16	0.94	2.04	9.94
	2265004031	16	25	0.94	2.06	9.93
	2265004031	25	40	0.94	3.80	5.54
	2265004031	50	75	0.94	4.79	6.36
	2265004031	100	175	0.94	4.81	6.36
Rear Engine Riding Mowers	2265004041	3	6	0.38	2.04	24.16
	2265004041	6	11	0.38	2.46	13.83
	2265004041	11	16	0.38	2.58	14.66
	2265004041	16	25	0.38	2.43	14.51
Front Mowers	2265004046	6	11	0.65	2.05	9.66
	2265004046	11	16	0.65	1.97	8.96
	2265004046	16	25	0.65	2.36	10.95
	2265004046	25	40	0.65	4.49	5.04
Shredders	2265004051	1	3	0.8	1.87	22.04
	2265004051	3	6	0.8	1.92	22.06
Lawn and Garden Tractors	2265004056	3	6	0.44	2.01	22.86
	2265004056	6	11	0.44	2.50	15.01
	2265004056	11	16	0.44	2.50	15.34
	2265004056	16	25	0.44	2.38	14.51

Equipment Type	SCC	Minimum HP	Maximum HP	LF	NO_X	VOC
Chippers/Stump Grinders	2265004066	3	6	0.78	2.13	20.29
	2265004066	6	11	0.78	2.02	9.46
	2265004066	11	16	0.78	1.93	8.54
	2265004066	16	25	0.78	2.26	10.73
	2265004066	25	40	0.78	4.28	5.24
	2265004066	50	75	0.78	4.81	5.56
	2265004066	75	100	0.78	4.79	5.27
	2265004066	100	175	0.78	4.79	5.50
Turf Equipment	2265004071	3	6	0.6	2.31	32.25
	2265004071	6	11	0.6	2.56	13.52
	2265004071	11	16	0.6	2.49	12.56
	2265004071	16	25	0.6	2.45	12.97
	2265004071	25	40	0.6	4.78	5.75
	2265004071	50	75	0.6	4.81	4.92
Other Lawn and Garden Equipment	2265004076	0	1	0.58	2.11	37.64
	2265004076	1	3	0.58	1.65	21.47
	2265004076	3	6	0.58	1.98	20.08
	2265004076	6	11	0.58	2.03	11.15
	2265004076	11	16	0.58	2.15	10.01
	2265004076	16	25	0.58	2.42	12.84
	2265004076	25	40	0.58	3.69	4.43
	2265004076	50	75	0.58	3.70	4.09
	2265004076	75	100	0.58	3.70	3.99
	2265004076	100	175	0.58	3.70	3.91
Shredders	2265007010	6	11	0.8	1.92	9.52
	2265007010	11	16	0.8	2.01	8.22
	2265007010	16	25	0.8	2.28	9.14
Chippers/Stump Grinders	2267004066	25	40	0.78	6.45	1.78
	2267004066	50	75	0.78	7.26	1.90
	2267004066	75	100	0.78	7.23	1.90
	2267004066	100	175	0.78	7.23	1.90
Leaf Blowers	2270004031	3	6	0.43	5.67	1.03
	2270004031	25	40	0.43	4.35	0.85
	2270004031	40	50	0.43	4.35	0.85
	2270004031	50	75	0.43	4.09	0.56
	2270004031	75	100	0.43	4.03	0.56
	2270004031	100	175	0.43	3.97	0.40
Front Mowers	2270004046	3	6	0.43	5.36	0.97
	2270004046	6	11	0.43	5.10	0.92
	2270004046	11	16	0.43	4.76	0.95
	2270004046	16	25	0.43	4.83	0.96
	2270004046	25	40	0.43	4.31	0.84
	2270004046	40	50	0.43	4.38	0.85
	2270004046	50	75	0.43	4.09	0.56
	2270004046	75	100	0.43	4.05	0.56

Equipment Type	SCC	Minimum HP	Maximum HP	LF	NO_X	VOC
Lawn and Garden Tractors	2270004056	6	11	0.43	5.10	0.92
	2270004056	11	16	0.43	4.93	0.98
	2270004056	16	25	0.43	4.79	0.95
	2270004056	25	40	0.43	4.29	0.84
	2270004056	40	50	0.43	4.30	0.84
	2270004056	75	100	0.43	4.03	0.56
Chippers/Stump Grinders	2270004066	16	25	0.43	4.80	0.95
	2270004066	25	40	0.43	4.32	0.84
	2270004066	40	50	0.43	4.33	0.85
	2270004066	50	75	0.43	4.09	0.56
	2270004066	75	100	0.43	4.01	0.55
	2270004066	100	175	0.43	3.97	0.41
	2270004066	175	300	0.43	3.79	0.37
	2270004066	300	600	0.43	3.78	0.32
	2270004066	600	750	0.43	3.78	0.31
	2270004066	750	1000	0.43	4.75	0.43
	2270004066	1000	1200	0.43	4.75	0.43
Turf Equipment	2270004071	6	11	0.43	5.53	1.00
	2270004071	11	16	0.43	4.96	0.98
	2270004071	16	25	0.43	4.77	0.95
	2270004071	25	40	0.43	4.40	0.86
	2270004071	40	50	0.43	4.30	0.84
	2270004071	50	75	0.43	4.10	0.56
	2270004071	75	100	0.43	4.04	0.56
	2270004071	100	175	0.43	3.98	0.41
Other Lawn and Garden Equipment	2270004076	11	16	0.43	4.80	0.95
	2270004076	16	25	0.43	4.82	0.96
	2270004076	25	40	0.43	4.35	0.85
	2270004076	40	50	0.43	4.35	0.85
	2270004076	50	75	0.43	4.09	0.56
	2270004076	75	100	0.43	4.03	0.56
	2270004076	100	175	0.43	3.98	0.41
Specialty Vehicles/Carts	2260001060	6	11	0.58	1.94	12.67
	2260001060	25	40	0.58	0.70	142.78
	2260001060	50	75	0.58	0.70	142.63
Specialty Vehicles/Carts	2265001060	1	3	0.58	1.93	30.40
	2265001060	3	6	0.58	1.93	26.72
	2265001060	11	16	0.58	2.10	10.88
	2265001060	16	25	0.58	2.45	12.99
	2265001060	25	40	0.58	4.05	4.98
	2265001060	40	50	0.58	4.05	4.62
	2265001060	50	75	0.58	4.05	4.44
	2265001060	75	100	0.58	4.05	4.28
	2265001060	100	175	0.58	4.05	4.18

Equipment Type	SCC	Minimum HP	Maximum HP	LF	NO_X	VOC
Specialty Vehicles/Carts	2267001060	25	40	0.58	6.09	1.70
	2267001060	40	50	0.58	6.09	1.70
	2267001060	50	75	0.58	6.09	1.70
	2267001060	75	100	0.58	6.09	1.70
	2267001060	100	175	0.58	6.09	1.70
Specialty Vehicles/Carts	2270001060	11	16	0.21	5.35	2.16
	2270001060	16	25	0.21	5.35	2.16
	2270001060	25	40	0.21	4.77	2.00
	2270001060	40	50	0.21	4.77	2.00
	2270001060	50	75	0.21	4.60	1.31
	2270001060	75	100	0.21	4.63	1.35
	2270001060	100	175	0.21	4.63	1.00
	2270001060	175	300	0.21	4.41	0.92
	2270001060	300	600	0.21	4.41	0.80
	2270001060	1000	1200	0.21	5.37	1.03