# Fifth Annual Report and Contingency Plan
## for
# Air Emissions Reduction
# in Central Florida

By:
C. David Cooper, PhD, PE, QEP
Jessica Ross, EIT, EPI

University of Central Florida
Department of Civil, Environmental,
and Construction Engineering

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# Table of Contents


List of Figures ........ 3
List of Tables ........ 4
Executive Summary ........ 5
Acknowledgments ........ 8
Introduction ........ 9
Background ........ 9
Current Air Quality Status – Ozone ........ 10
Effects of Meteorology ........ 13
Emissions Inventory ........ 15
On-road Mobile Sources ........ 15
Potential Action Steps ........ 17
On-road Mobile Summary ........ 24
Non-road Mobile Sources ........ 27
Potential Action Steps ........ 29
Non-road Mobile Summary ........ 32
Point and Area Sources ........ 34
Point Sources ........ 35
Area Sources ........ 38
Conclusions and Recommendations ........ 40
References ........ 43

# List of Figures


Figure EX-1 - Total VOC emissions for OSO by source category ........ 6
Figure EX-2 - Total NOx emissions for OSO by source category ........ 6

Figure 1 - Past and projected trends in VMT and vehicular emissions in OSO ........ 9
Figure 2 - Locations of Ambient Ozone Monitors in Central Florida ........ 11
Figure 3 - Year 2008 Maximum Monthly 8-hr Ozone Readings in Central Florida ........ 14
Figure 4 - Five-year History of Maximum Monthly 8-hr Ozone Readings at one OUA location ........ 14
Figure 5 - 2008 On-road VOC contributions by vehicle type for the OSO area ........ 16
Figure 6 - 2008 On-road NOx contributions by vehicle type for the OSO area ........ 16
Figure 7 - HDDV $NO_x$ emissions in OSO as a function of speed ........ 23
Figure 8 - Diagram of ORVR system ("My beloved Sable--help me save her", 2009) ........ 23
Figure 9 - 2008 Non-road VOC contributions by source for the OSO area* ........ 28
Figure 10 - 2008 Non-road $NO_x$ contributions by source for the OSO area* ........ 28
Figure 11 - Total VOC emissions for OSO by source category ........ 34
Figure 12 - Total $NO_x$ emissions for OSO by source category ........ 34
Figure 13 - 2008 Point source VOC contributions by source for the OSO area* ........ 37
Figure 14 - 2008 Point source $NO_x$ contributions by source for the OSO area* ........ 37
Figure 15 - 2008 Area source VOC contributions by source for the OSO area ........ 39
Figure 16 - 2008 Area source $NO_x$ contributions by source for the OSO area ........ 40

# List of Tables


Table EX-1 - 2002 and 2008 OSO emission totals for VOC and NOx ........ 5

Table 1 - Historical 4th-Highest 8-hr Ozone Readings in Central Florida ........ 10
Table 2 - Fourth highest 8-hr $O_3$ Readings in OSO, 2006-2010, by monitor ........ 12
Table 3 - Highest 8-hr O3 Readings in 2010 at each Monitor in OUA ........ 12
Table 4 - Monthly peak 8-hr Ozone Concentrations in Central Florida (all monitors) ........ 13
Table 5 - 2008 On-road vehicle emissions for OSO by vehicle type ........ 15
Table 6 - NOx emission factors for HDDV at common highway speeds ........ 22
Table 7 - Reduction steps for on-road mobile sources ........ 26
Table 8 - 2008 NONROAD Emission totals for OSO ........ 27
Table 9 - Reduction steps for non-road mobile sources ........ 33
Table 10 - 2008 Point source emission totals for OSO ........ 36
Table 11 - 2008 Annual $NO_x$ emissions of OSO power plants ........ 36
Table 12 - 2008 airport (aircraft) emission results ........ 36
Table 13 - List of categories included in area sources ........ 38
Table 14 - 2008 Area Source Emission Totals for OSO ........ 39
Table 15 - Major VOC contributors by source type ........ 41
Table 16 - Major $NO_x$ contributors by source type ........ 41

## Executive Summary

This report outlines steps for Orange, Seminole, and Osceola counties (OSO area) to reduce VOC and $NO_x$ emissions in order to reduce ozone concentrations. OSO is at risk of becoming ozone non-attainment and if this occurs, EPA will mandate a contingency plan for central Florida to reduce emissions of ozone precursors. An emissions inventory was submitted to MetroPlan in summer 2010 that presented the contributions from on-road and non-road mobile, area, and point sources, based on 2008 emissions estimates. Table EX-1 shows how emissions of VOCs and $NO_x$ have changed from the previous inventory to the current one.

Overall, despite population growth, emissions of both VOCs and $NO_x$ have decreased from 2002 to 2008. On-road emissions decreased substantially, contrary to what might be expected from having more vehicles on the roadways. The decrease was because of improved vehicle pollution control efficiencies on newer vehicles and normal turnover of the fleet. Non-road VOCs increased mainly because of large growth in emissions from pleasure craft (boats, jet skis, etc). Point source VOCs increased very slightly, but $NO_x$ decreased by about 15%. Area source VOCs decreased only slightly, while area source $NO_x$ increased slightly. Because of the big drop in on-road emissions, area sources now account for the largest percentage of VOC emissions in the region. Figure EX-1 and Figure EX-2 show the contributions of each source type to overall OSO emissions.

**Table EX-1 - 2002 and 2008 OSO emission totals for VOC and NOx**

| Source | 2002 | | 2008 | |
|---|---|---|---|---|
| | VOC, tons/yr | $NO_x$, tons/yr | VOC, tons/yr | $NO_x$, tons/yr |
| **On-road** | 37,511 | 49,872 | 23,582 | 37,726 |
| **Non-road** | 13,389 | 15,889 | 15,190 | 10,172 |
| **Point** | 1,711 | 12,596 | 1,901 | 10,987 |
| **Area** | 31,198 | 103 | 30,648 | 158 |
| **TOTALS** | **83,809** | **78,460** | **71,321** | **59,043** |

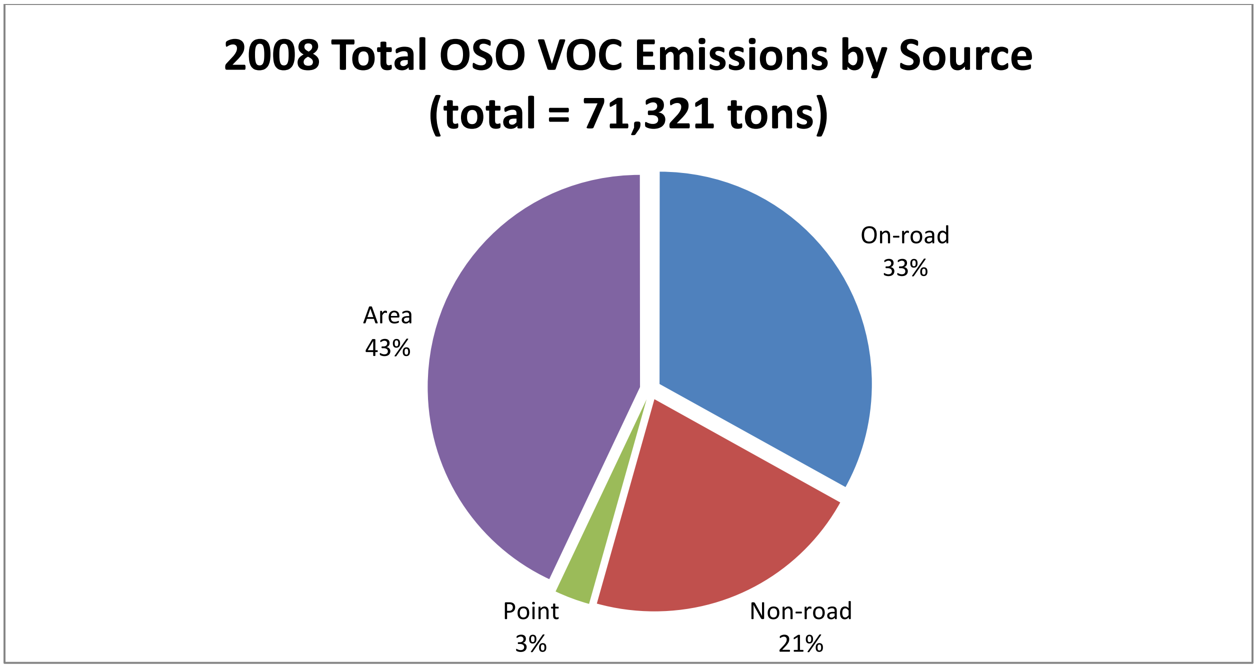


Figure EX-1 - Total VOC emissions for OSO by source category

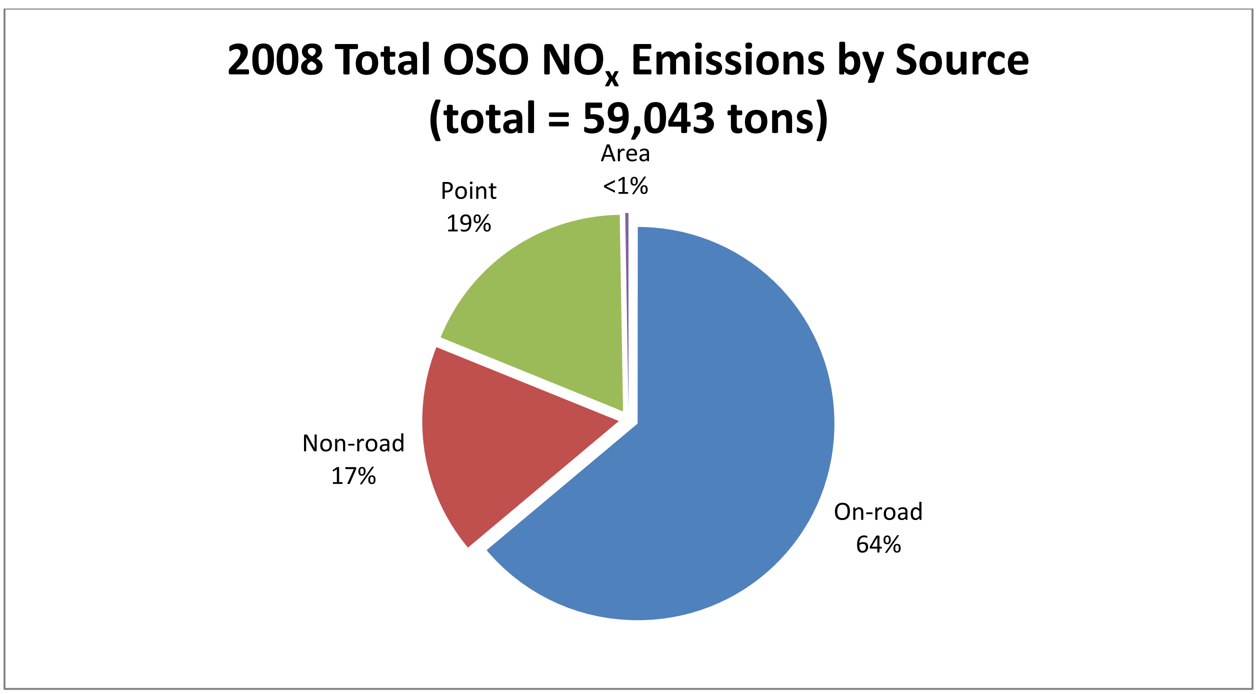


Figure EX-2 - Total NOx emissions for OSO by source category

It is believed that OSO is a $NO_x$-limited area regarding ozone production (Olson, 2010). This means that $NO_x$ emissions reduction should be more heavily targeted, but VOC reduction remains important as well. The main sources of $NO_x$ emissions are on-road vehicles (especially large trucks, aka HDDVs), point sources (mainly one large power plant), and non-road sources (mainly construction equipment). Steps that can significantly reduce $NO_x$ emissions include reducing VMT (vehicle miles traveled) by all vehicles (personal cars as well as trucks), reducing idling by construction equipment, slowing down HDDVs on I-4, and/or excluding HDDV access from the left-most lane on I-4. The largest contributors of VOCs are area sources (48%), followed by on-road mobile sources (30%), and then non-road sources (20%). On-road measures that can significantly reduce VOC emissions include reducing VMT (e.g., carpooling and increased transit use) and stage 2 vapor recovery (S2VR); non-road measures include reducing use of gasoline powered lawn care equipment and reducing pleasure craft use. Area source emissions reduction steps were not investigated in this report. As all of the steps were evaluated, some were determined to reduce emissions by substantial amounts and others by only small amounts. Additionally, some steps were determined to cost money (such as installing catalytic converters on lawnmowers) and others would actually save money (such as reducing vehicle idling).

To make substantial cuts in emissions in the future, steps which save money should be accomplished first, followed by steps that will incur costs, but which have a better cost-effectiveness (the cost per ton of pollutants averted). This strategy will produce good emission reductions, without requiring the expenditure of substantial funding. The U.S. EPA is continually mandating that industry reduce emissions from small engines as well as from motor vehicles. EPA efforts have resulted in major decreases in emission over the past thirty years, a trend that is projected to continue into the near future. As long as the region remains in attainment, we should wait to see the effects of these further emission reductions in the next few years. On a more pro-active note, the best way to deal with future emissions is to conduct comprehensive planning for minimizing emissions. Building homes and apartments near office space encourages people to live near where they work. Designing roads to allow for public transportation to be implemented promotes the use of such systems. Avoiding urban sprawl slows the growth of VMT thereby reducing commuter emissions. These are some planning options that can be done in advance which may help keep OSO in ozone attainment and may render some of the more drastic steps discussed in this report unnecessary.

## Acknowledgments

We would like to thank MetroPlan Orlando for their financial support of this project over the past five years. They have made it possible for several students to conduct detailed research and contribute to this report while getting their degrees. The efforts of these students (Mike Radford, Oscar Duarte, Jessica Ross, Wyatt Champion, Mark Ritner, Ali Bayat, and Megan Crum) are hereby acknowledged.

# Introduction

## Background

Metroplan Orlando is the metropolitan planning organization (MPO) for Orange, Osceola and Seminole Counties (OSO, which is also called the Orlando Urban Area – OUA). As the regional MPO, Metroplan Orlando provides the forum for local elected officials and transportation experts to work together to improve mobility for Central Florida residents, businesses, and visitors. It has the mission to provide leadership in planning and promoting a comprehensive intermodal surface transportation system that will provide for regional mobility, encourage a positive investment climate, and foster sustainable development sensitive to community and natural resources. An important part of fostering sustainable development is promoting clean air in the region through understanding and encouraging best practices for reducing mobile source emissions.

The OUA has been one of the fastest growing regions in the country for many years. It is known that cars have been getting cleaner – the per vehicle emission factors (EFs) have declined for the past thirty years. But, because of the steady high rate of growth in vehicle miles traveled (VMT) in the region, vehicular emissions continue to be significant (see Figure 1). Overall, regional emissions of VOCs and $NO_x$ (the two pollutants that cause ground-level ozone problems) generally have been declining for the past thirty years due to improvements in individual vehicles and all sorts of internal combustion engines. But if VMT continues to grow, total emissions of VOCs and $NO_x$ may begin to increase in the future, and central Florida could become classified as air quality non-attainment. Furthermore, the U.S. Environmental Protection Agency (EPA) has been contemplating stricter ozone standards for some time. EPA has announced that the new standard will likely be between 60 and 70 ppb (the current standard is 75 ppb), and it is expected that the new standard will result in OSO being declared non-attainment.

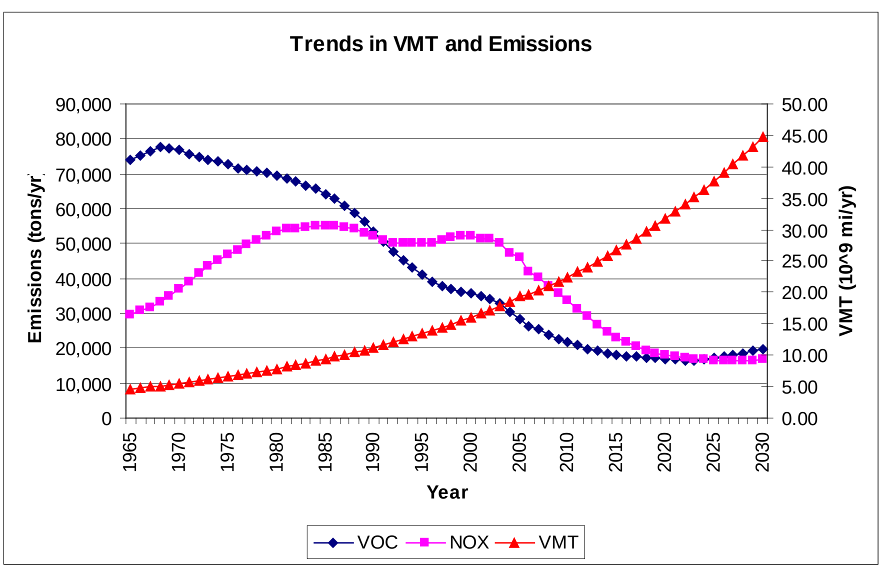


**Figure 1 - Past and projected trends in VMT and vehicular emissions in OSO**

Non-attainment is a designation by the EPA that the area has measured concentrations of one or more air pollutants that are in violation of federal and state standards. Getting approval for future road-building projects would be more difficult if OSO becomes a non-attainment area. Being declared non-attainment means that the three-county area would be subject to state and federal actions, sanctions, or mandates that would require the region to develop plans and action steps to reduce emissions to get back into attainment status. The action steps we might have to take include required installation of stage 2 vapor recovery systems on all gasoline stations in the three-county area, mandatory vehicle inspection and maintenance programs, enforceable carpool lanes, not allowing certain road building projects, and many other steps to cut emissions from a variety of other sources. Hopefully, some of these other steps would be much less onerous than the first few mentioned above. Central Florida governmental leaders need a contingency plan that lists various action steps along with their costs and emission reduction benefits so that they can take the right steps at the appropriate times.

## Current Air Quality Status – Ozone

The major air pollution problem in Central Florida at this time is ozone ($O_3$) – a pollutant of national concern that results from atmospheric reactions of VOCs and $NO_x$ catalyzed by sunshine. Both VOCs and $NO_x$ are emitted in large quantities from motor vehicles. In March 2008, EPA lowered the federal ozone standard to 0.075 ppm (75 ppb), over an 8-hour averaging time, considered over a three-year period. This standard is interpreted such that the three-year average of the fourth-highest concentration cannot exceed 75 ppb. In January 2010, EPA announced that it is considering further lowering the standard to between 0.06 ppm and 0.07 ppm. In recent years, the four ozone monitoring sites in Central Florida have experienced ozone concentrations that exceed these levels (see Table 1). Fortunately, since 2008 when the standard was lowered to .075 ppm, none of the monitors has experienced a three-year average above that level, so OSO remains in attainment. The locations of these monitors are shown in Figure 2.

**Table 1 - Historical 4th-Highest 8-hr Ozone Readings in Central Florida**

| Year | Monitor Location | 4$^{th}$-Highest 8-Hour Average Ozone Conc., ppb |
|---|---|---|
| 2010 | Winegard Elementary School | 71 |
| 2009 | Winegard Elementary School | 66 |
| 2008 | Osceola Fire Station – Four Corners | 71 |
| 2007 | Winegard Elementary School | 78 |
| 2006 | Lake Isle Estates | 80 |
| 2005 | Winegard Elementary School | 86 |
| 2004 | Lake Isle Estates | 76 |
| 2003 | Seminole State College | 76 |
| 2002 | Seminole State College | 78 |

A violation of national ambient air quality standards only occurs if, for any one monitor, its 3-year average of the fourth-highest annual concentrations exceeds 75 ppb. Thus, OSO is not now a non-attainment area. However, if ozone concentrations grow by even just a little in the future, or if the standard is reduced to say, 0.065 ppm, then OSO likely will become non-attainment. The U.S. EPA is scheduled to make non-attainment determinations based on the data from 2006-2008 (the fourth-highest readings for 2006-2010 are listed in Table 2). However, the process will continue into the future with each year's new data (and any new standards) being considered each year. At this point in time, with the current standard, OSO is within the limits, and still is attainment.

The data for 2009 showed lower-than-average ozone readings, perhaps due to lower emissions from traffic and construction activity in 2009, or perhaps due to the wetter spring season that central Florida experienced that year. Note that the month of May 2009, was very unusual in that 8-hour ozone readings were very low that year (perhaps due to the large amounts of rain received during May 2009). The month of April 2010 was similarly wetter than normal, and the 4$^{th}$-highest ozone readings have been lower than typical. Table 3 shows the highest ozone concentrations in 2010.

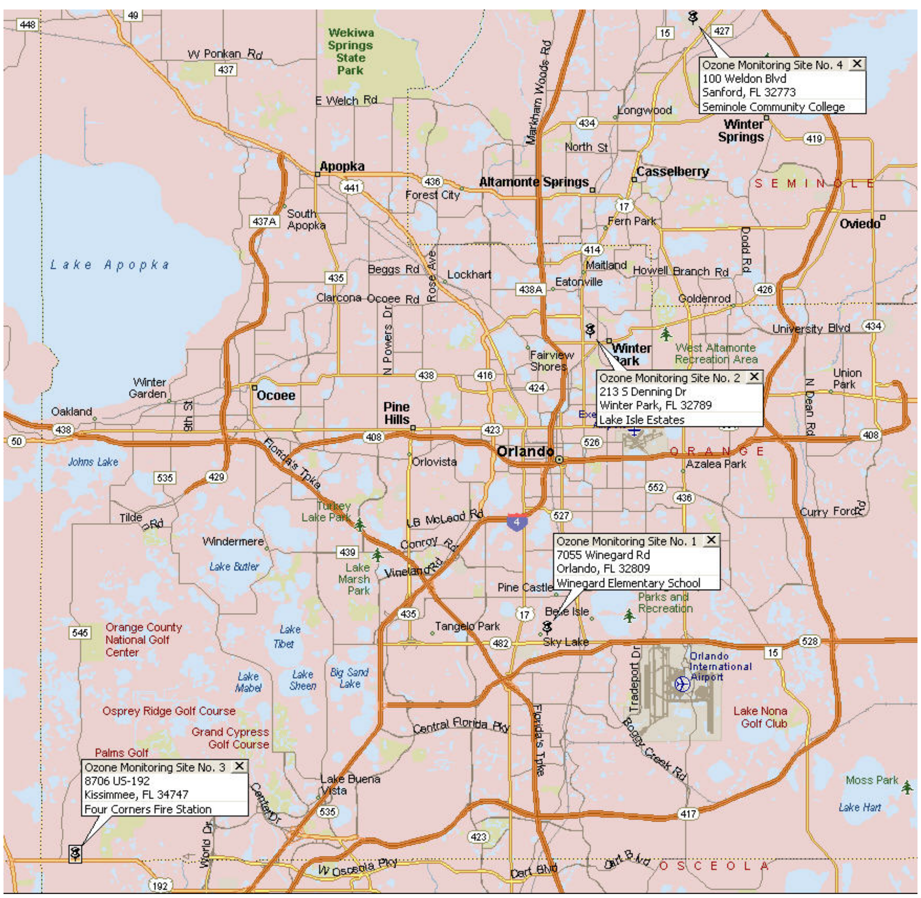


**Figure 2 - Locations of Ambient Ozone Monitors in Central Florida**

Table 2 - Fourth highest 8-hr $O_3$ Readings in OSO, 2006-2010, by monitor

| Monitor Location | Year | 8-Hour Average $O_3$, ppb |
|---|---|---|
| Seminole State College, Seminole County | 2010 | 67 |
| | 2009 | 62 |
| . | 2008 | 67 |
| | 2007 | 69 |
| | 2006 | 80 |
| **2008-2010 average** | | **65** |
| Lake Isle (Morse/Denning), WP, Orange County | 2010 | 70 |
| | 2009 | 65 |
| | 2008 | 70 |
| | 2007 | 76 |
| | 2006 | 80 |
| **2008-2010 average** | | **68** |
| Winegard Elem, Pinecastle, Orange County | 2010 | 71 |
| | 2009 | 66 |
| | 2008 | 70 |
| | 2007 | 78 |
| | 2006 | 79 |
| **2008-2010 average** | | **69** |
| Four Corners Fire Station, Osceola County | 2010 | 67 |
| | 2009 | 63 |
| | 2008 | 71 |
| | 2007 | 73 |
| | 2006 | 73 |
| **2008-2010 average** | | **67** |

Table 3 - Highest 8-hr O3 Readings in 2010 at each Monitor in OUA

| Monitor Location | Highest 8-Hour Average $O_3$, ppb (date) | $4^{th}$-Highest 8-Hour Average $O_3$, ppb (date) |
|---|---|---|
| Four Corners Fire Station | 80 (4/1) | 67 (4/29) |
| Winegard Elementary School | 80 (7/9) | 71 (10/10) |
| Lake Isle Estates | 79 (7/9) | 70 (4/22) |
| Seminole State College | 72 (2/2) | 67 (4/1) |

## Effects of Meteorology

The year-by-year declining trends in vehicle emissions shown previously in Figure 1 are welcome, but our ozone concentrations have not declined as significantly (see Table 1 presented previously). Ozone is a product of emissions plus meteorology plus complex atmospheric reactions involving both VOCs and $NO_x$, so it is not possible to make a one-for-one prediction of lower ozone for each increment of emissions reduction. Also, the reductions in mobile source emissions do not tell the whole story; non-road sources and point sources emit large amounts of both $NO_x$ and VOCs, and area sources emit large amounts of VOCs. Meteorology plays a very important role as well. Of course, we cannot control the weather, so we focus our efforts on controlling emissions. But it is important to be aware of the effects of weather on ozone concentrations. To explore that statement, let us next look at how ozone concentrations in central Florida have historically varied throughout the year.

Table 4 and Figure 3 and Figure 4 portray an important fact about ozone in OSO. As can be seen, ozone in the OUA peaks in the April-May time frame (and this holds true over many years). This early peak period is due in part to an increase in the non-roads emissions (more lawn and garden work) in those months, and in part to the hotter, drier weather. This suggests that some contingency steps could be taken specifically in those months.

**Table 4 - Monthly peak 8-hr Ozone Concentrations in Central Florida (all monitors)**

| Month | Peak 8-hour Ozone Concentration, ppb | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Four Corners | | | Winegard | | | Lake Isle | | | SCC | | |
| | '08 | '09 | '10 | '08 | '09 | '10 | '08 | '09 | '10 | '08 | '09 | '10 |
| January | 48 | 51 | 45 | 45 | 50 | 46 | 47 | 49 | 50 | 45 | 48 | 47 |
| February | 52 | 56 | 53 | 52 | 66 | 53 | 55 | 52 | 55 | 53 | 59 | 72 |
| March | 67 | 59 | 64 | 70 | 59 | 70 | 69 | 60 | 71 | 67 | 54 | 72 |
| April | 74 | 68 | 80 | 74 | 75 | 75 | 73 | 72 | 74 | 73 | 65 | 67 |
| May | 77 | 54 | 60 | 85 | 61 | 62 | 81 | 65 | 63 | 76 | 62 | 60 |
| June | 53 | 62 | 73 | 57 | 66 | 60 | 63 | 63 | 56 | 63 | 59 | 56 |
| July | 43 | 60 | 67 | 54 | 57 | 80 | 60 | 56 | 79 | 60 | 54 | 66 |
| August | 52 | 51 | 60 | 59 | 59 | 66 | 65 | 61 | 56 | 62 | 61 | 53 |
| September | 57 | 47 | 50 | 59 | 49 | 57 | 62 | 51 | 54 | 61 | 46 | 53 |
| October | 59 | 64 | 67 | 55 | 62 | 71 | 59 | 64 | 66 | 55 | 59 | 67 |
| November | 44 | 48 | 49 | 48 | 53 | 54 | 49 | 52 | 52 | 48 | 52 | 49 |
| December | 42 | 38 | 50 | 41 | 40 | 50 | 41 | 41 | 51 | 42 | 42 | 51 |

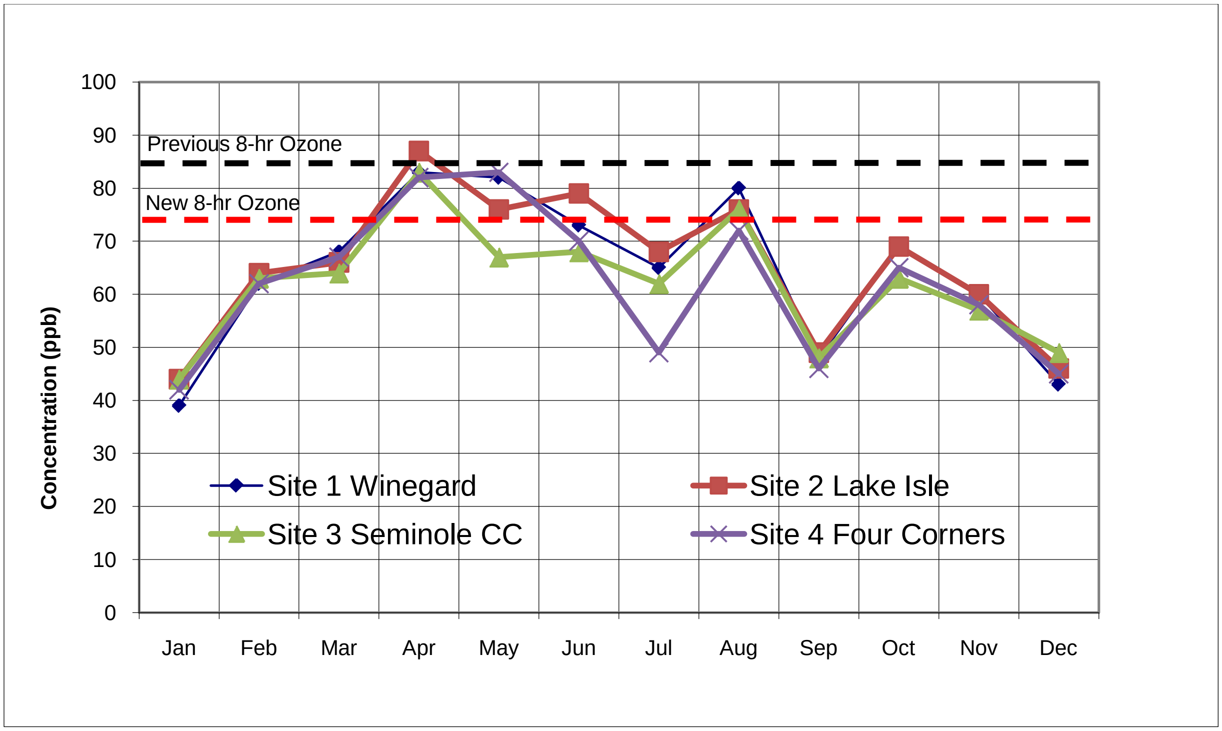


**Figure 3 - Year 2008 Maximum Monthly 8-hr Ozone Readings in Central Florida**

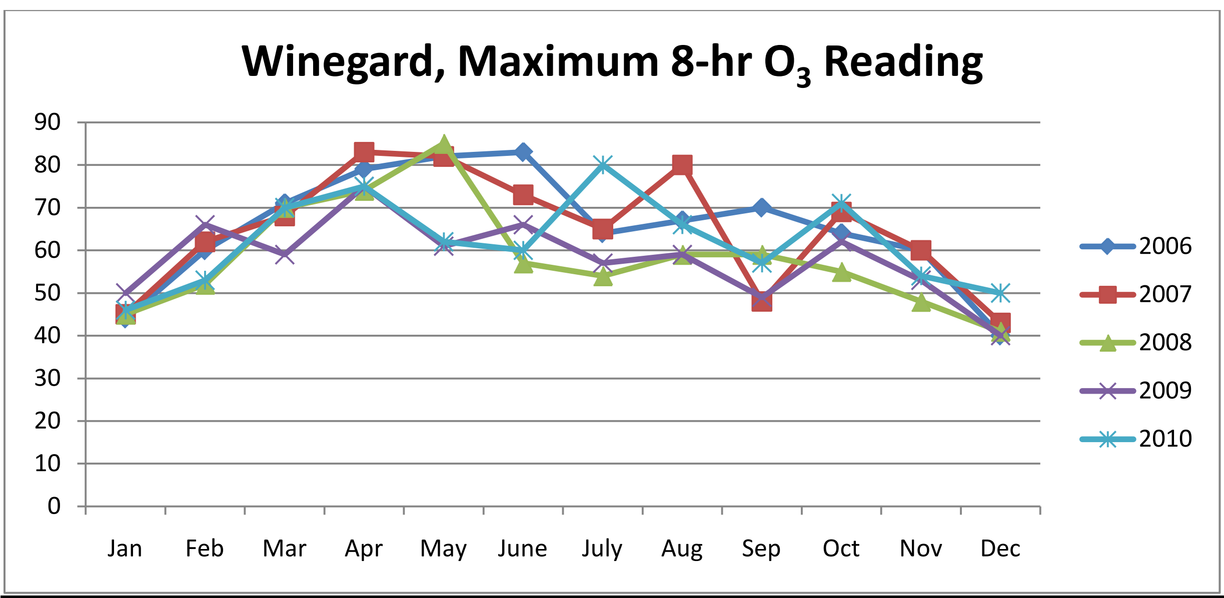


**Figure 4 - Five-year History of Maximum Monthly 8-hr Ozone Readings at one OUA location**

# Emissions Inventory

## On-road Mobile Sources

In 2008, on-road mobile source emissions accounted for 30% (23,582 tons) of the VOC and 62% (37,726 tons) of the $NO_x$ emissions in OSO. These numbers are lower than the 2002 levels by about 14,000 tons of VOCs and 12,000 tons of $NO_x$. The major reason for this substantial decrease is the big improvements in per-vehicle emissions. On-road vehicles include cars, vans, SUVs, pick-ups, delivery trucks, heavy trucks, buses, and motorcycles. Newer model vehicles are more fuel efficient and much less polluting than older models. However population is increasing in central Florida, thus increasing the vehicle miles traveled (VMT) each year. However, from 2002 to 2008, the improvements in the per-vehicle emissions outweighed the growth in VMT, resulting in a decline in total emissions from this sector. Even more surprising is that vehicle miles traveled (VMT) increased faster than population and the results still showed decreased emissions. Table 5 and Figure 5 and Figure 6 show the distribution of on-road VOC and $NO_x$ emissions (respectively) by vehicle type. There are a number of ways in which to reduce VOCs and $NO_x$ even further that are discussed in the following sections.

**Table 5 - 2008 On-road vehicle emissions for OSO by vehicle type**

| Vehicle Type | VOCs | | $NO_x$ | |
|---|---|---|---|---|
| | tons/year | percent | tons/year | percent |
| LDGV | 8,186 | 34.7% | 6,096 | 16.2% |
| LDGT12 | 8,228 | 34.9% | 7,310 | 19.4% |
| LDGT34 | 4,774 | 20.2% | 3,708 | 9.8% |
| HDGV | 1,144 | 4.9% | 2,613 | 6.9% |
| LDDV | 3 | 0.0% | 7 | 0.0% |
| LDDT | 25 | 0.1% | 43 | 0.1% |
| HDDV | 903 | 3.8% | 17,791 | 47.2% |
| MC | 319 | 1.4% | 158 | 0.4% |
| **TOTALS** | **23,582** | **100%** | **37,726** | **100%** |

Key: LDGV = light duty gasoline vehicles (0-6000 lbs), LDGT12 = light duty gasoline trucks (< 6000 lbs), LDGT34 = light duty gasoline trucks (6001-8500 lbs), HDGV = heavy duty gasoline vehicles (> 8500 lbs), LDDV = light duty diesel vehicles (0-6000 lbs), LDDT = light duty diesel trucks (< 8500 lbs), HDDV = heavy duty diesel vehicles (> 8500 lbs), MC = motorcycles

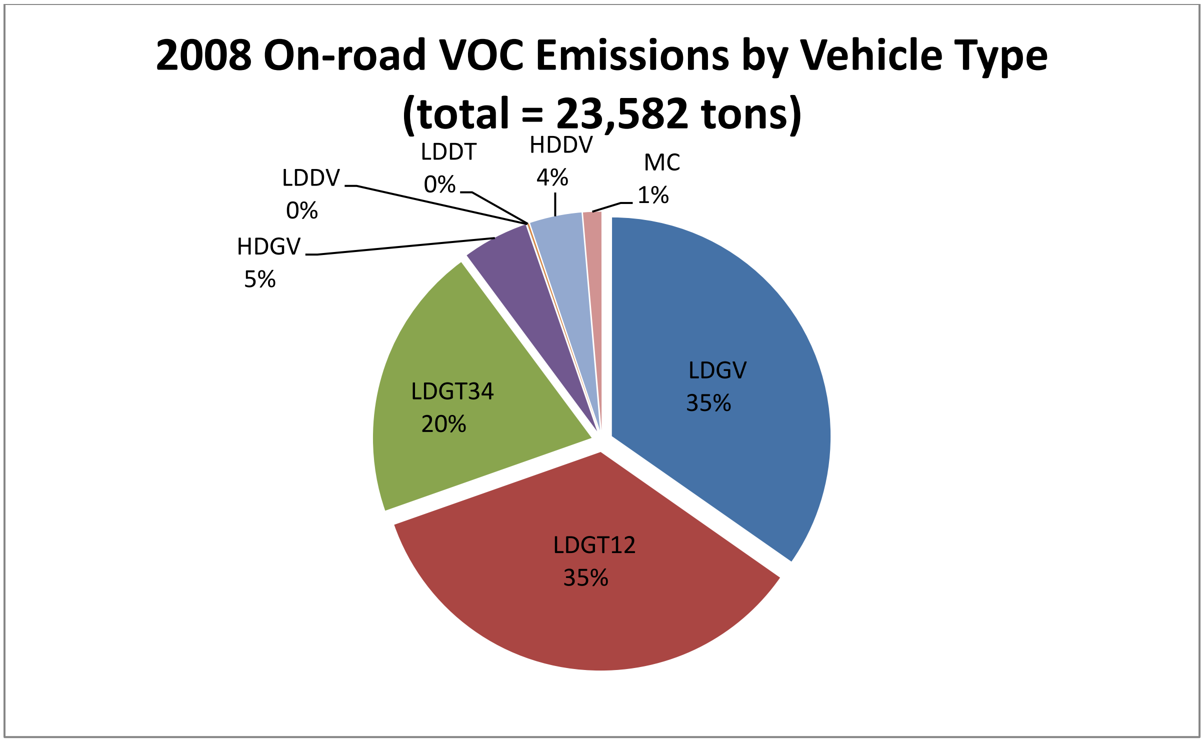


Figure 5 - 2008 On-road VOC contributions by vehicle type for the OSO area

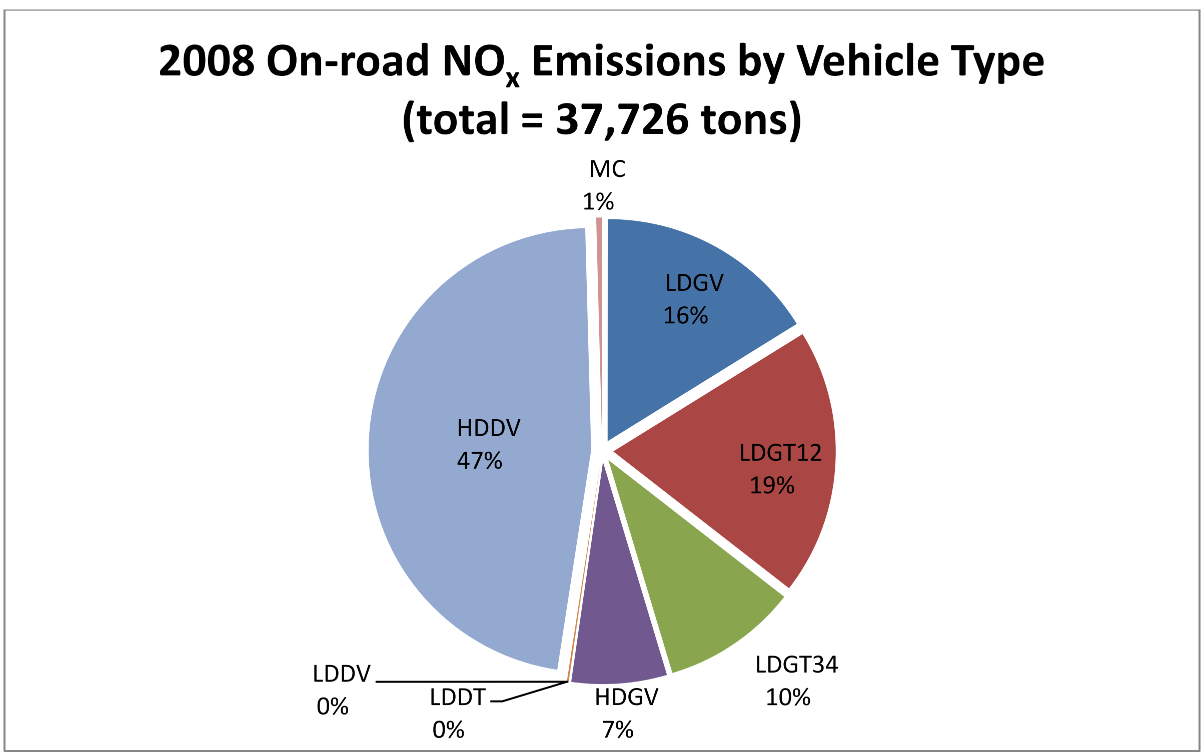


Figure 6 - 2008 On-road NOx contributions by vehicle type for the OSO area

## Potential Action Steps

### *Decrease School Bus Idling Time*

This action step has the potential to reduce VOC emissions by 1.1 tons/year and $NO_x$ emissions by 11 tons/year. Central Florida has a hot, humid climate which tends to make sitting in a vehicle without the air conditioner running uncomfortable. One reason buses are left running is to keep them cool to maximize passenger (and driver) comfort. Drivers also leave buses idling before they start their route in the mornings and as they wait in line during after-school pick-ups. This step is difficult to regulate because it relies on the word of the driver that they will turn off the bus while not in use. There is no actual penalty for not turning it off. The three counties already have a policy against idling. The savings calculated (based on fuel savings) amounted to $13,700 per ton of VOCs and $NO_x$ reduced and $166,000 annually. These savings are split between the three counties with Orange County seeing the largest return since its fleet is larger than the other two.

### *Switch School Bus Fleet from ULSD to B20*

The school bus fleet currently uses ultra low sulfur diesel (ULSD) and emits approximately 28 tons/year of VOCs and 380 tons/year of $NO_x$. These emissions can be cut by 3.4 tons/year of VOCs by substituting a biodiesel blend (B20). B20 may or may not cause an increase in $NO_x$, but the data are inconclusive. To be conservative, an increase was estimated at approximately 2.3 tons. Biodiesel costs approximately $0.15/gal more than petroleum diesel (U.S. Department of Energy, 2009). The cost of switching to B20 is approximately $2,280,000 per ton of emissions reduced but may vary depending on the price difference of B20 over ULSD. This expense would be distributed among the three counties.

### *Implement More Aggressive Carpooling Programs*

Orlando's major carpooling service is currently provided by LYNX. It is a computer-based voluntary program, and LYNX's involvement is solely to match the participants. They do not keep track of interested parties after they have been put in contact with one another, so the reductions estimated in this report are based on estimated ridership. There were 3,868 participants who contacted LYNX in the 2007/2008 fiscal year (Metroplan, 2009). Estimating that 20% of interested parties actually followed through and began carpooling, 440 automobiles were removed from the roads because of carpooling (based on 2 people per car). This resulted in a reduction of 2.79 tons of VOCs and 1.95 tons of $NO_x$ annually. The cost of the program is attributed to having one full time employee, a website, and web maintenance. This was estimated to be $81,000 annually and equates to $16,800/ton averted. However, from the participants' point of view, they saved on gasoline consumption as well as wear and tear on their vehicles. Thus, it is estimated that this action step saved them about $550,000/year (for a net savings of $470,000/year in OSO). A more aggressive program might well result in a substantial increase in carpoolers.

FDOT began a program to promote ride sharing in central Florida called "ReThink Your Commute." It utilizes Google Maps to verify that the origin and destination are correct, as well as provides the safest biking and walking routes. This program was started on July 12, 2010 and its success has not yet been measured. There are currently over 600 people registered with the program. Registered users were to be contacted in December, 2010, to determine the success of the program. A potential incentive is being considered which would be similar to that offered by the "Clear Air Campaign" in Georgia (currently $3 per day, up to $100 over a 90 day period) (Clear Air Campaign, 2010).

UCF began a "Zimride" carpooling program in summer 2010. Zimride is a national service with universities and businesses as its subscribers (Zimride, 2010). There were 543 active rides posted on December 1, 2010 for the UCF program. There is not a method for ridership participation to allow us to determine Zimride's success, and thus to estimate the emissions reduction achieved. The goal is to connect UCF students, faculty, and staff with rides to and from campus as well as throughout the area.

### *LYNX VanPlan Program*

The LYNX VanPlan program is another service which LYNX provides to aid in the carpooling effort of the region. LYNX provides the commuter group with a van, insurance, and vehicle maintenance. Each van can accommodate between seven and fifteen passengers. The IRS offers up to $230/month in tax-free salary to assist in the cost of the vanpool. In the 2007/2008 fiscal year, the LYNX VanPlan program provided 180,065 rides using 71 vans (Champion, 2010). This effort averted 3.6 tons of VOCs and 2.5 tons of $NO_x$ in 2008. The program costs LYNX an estimated $300,000/year, which equates to $49,100/ton averted (Champion, 2010).

### *Parking Cash Out in Downtown Orlando*

Parking cash out programs offer employees an incentive to carpool by giving a cash subsidy to participants. This subsidy is generally representative of the cost of the parking space that is no longer needed and is paid by the employer. Estimates suggest that single passenger car use can be reduced by approximately 20% for any given company that implements this program (Champion, 2010). If this program were to be implemented in Orlando, emissions could be decreased by 3.7 tons of VOCs and 2.5 tons of $NO_x$ per year. The projected cost of this program is $22,600/year and $3,620/ton averted. The annual cost is the net difference between the cost to the employers of paying for the parking spaces less the cost for them to pay the employees not to use the parking spaces.

### *"Free" Transit for UCF Students*

This action step would allow UCF students to use public transportation (Lynx buses) throughout the metro area along with the UCF shuttles free of charge. This "free" charge is actually only free to the student. The university would pay a negotiated annual lump sum to the transit agency based on projected ridership estimates; that money most likely would come from increased student fees. This program has been successful in other university cities. Once implemented, none of the schools have discontinued the "Unlimited Access" program (Champion, 2010). Students are only required to show a valid student ID to board the bus. According to a survey of 35 universities who offer this type of program, ridership increased between 71 and 200 percent during the first year (Champion, 2010). Because of increased use, the public transit system service also improved. This would then benefit the LYNX service area because there would be a guaranteed amount of funding that could potentially be used to expand the service to lesser populated areas making it even more accessible. At an estimated $30 per student per year and approximately 56,000 students at UCF, LYNX could expect about $1,680,000 of additional funding per year. The survey of 35 universities showed that the average number of rides provided by the programs annually to students at universities of comparable size was 2,221,000 (Brown, 2001).

Assuming a round trip distance to UCF of approximately 5 miles, this program could decrease VOC emissions by 18.5 tons and $NO_x$ by 11.7 tons per year. This equates to $55,700 per ton averted. An estimated 4,830 cars would be removed from the road each day (approximately 8.5% student participation) and the savings passed on to the students who utilize this feature is $797,000 annually.

### *Increase Transit Use (Lynx) in the OUA*

Increasing transit use by all persons in the OUA on existing buses will reduce VMT and fuel consumption. This will result in decreases in $CO_2$, VOCs, and $NO_x$. Emissions reductions are evaluated for this situation in two ways:

1. Increasing passengers on existing buses
2. Adding new buses

LYNX currently operates 268 buses on 65 fixed routes (LYNX Fast Facts, 2010). Adding an average of three people to each of these buses would decrease OUA emissions of VOCs by 4.4 tons and $NO_x$ by 3.1 tons per year. This would generate additional revenues for LYNX and would also likely save money for the 804 new passengers. This estimate was based on the assumption that the new passengers would replace their car use by the bus for their work commute (but still use their cars for leisure driving).

Based on the MOBILE6 model's emission factors for urban buses and light duty gasoline vehicles, it was determined that the $NO_x$ emissions from one large diesel bus are equal to that of 18 cars. Additional buses are recommended if ridership is expected to be 18 or greater to yield both emissions and traffic reduction. Fewer passengers would result in an increase in $NO_x$ emissions, while any number greater than 18 results in emissions reductions. For VOCs, the "breakeven" passenger load is about 3.

Another option is to add smaller buses to the fleet. Smaller buses use less fuel, emit less pollution, and may be more attractive to operate on routes where ridership is light. As ridership increases on the routes using the smaller buses, larger buses may be substituted and the smaller buses can be used to expand LYNX service to other low ridership areas.

### *Replace Existing Buses with CNG or Diesel/Electric Hybrid Buses*

A report from the National Renewable Energy Laboratory (NREL) found that CNG buses can reduce $NO_x$ emissions by as much as 53% ("Evaluating the Emission Reduction Benefits of WMATA Natural Gas Buses", 2003). The diesel emission factor from the study is higher than that of the one used for data calculations in this report, so that percentage reduction would not be realized. However, using the numbers from the MOBILE6 model, $NO_x$ emissions would decrease by 38%. By replacing 20% of the LYNX fleet (approximately 54 buses) with CNG buses, $NO_x$ emissions could be reduced by 30.3 tons per year (or 7.6% of bus $NO_x$ emissions).

A study of the New York area's buses on emissions from diesel/electric hybrid buses found that $NO_x$ emissions decreased between 36% and 44% (Chandler, Walkowicz, and Eudy, 2002). There was not a clear pattern for VOC emissions as two of the routes saw decreases of 28% and 43%, while the third route saw an increase of 88%. Substituting 20% of the LYNX fleet with diesel/electric hybrid buses could decrease $NO_x$ by 32 tons per year (or 8% of bus $NO_x$ emissions).

CNG and diesel/electric hybrid buses result in approximately the same reduction in $NO_x$. The advantage of diesel/electric hybrid buses is that they have the potential to reduce VOCs depending on the speed at which they travel.

According to a report by the U.S. Department of Transportation, the capital cost of a CNG bus is $371,000 ("Transit Bus Life Cycle Cost and Year 2007 Emissions Estimation", 2007). The capital cost of a diesel/electric hybrid bus is $533,000[1]. These costs include emissions equipment, depot modification, a refueling station, and the vehicle cost. The operating cost of a CNG bus is $350,200 and a diesel/electric hybrid it is $375,200. Annualizing the capital cost of each bus over 10 years, the annual operating cost for a CNG bus is $387,300, while that of a diesel/electric hybrid bus is $428,500. These costs are no doubt higher than conventional diesel buses, but a detailed cost comparison should be made if the OUA should go into non-attainment.

### *Shuttle Service for UCF Students*

UCF offers a free shuttle service to students, visitors, faculty, and staff from off-campus student apartments and park-and-ride lots in Research Park. During the 2008-2009 academic year, the shuttle service provided an average of 8,255 one-way rides per day (Champion, 2010). This kept approximately 3,100 vehicles off campus each day. The car traffic (which uses gasoline) was replaced with bus traffic (which uses diesel). To promote the service, UCF provided extra buses, resulting in fewer than 18 riders per bus in many cases, and causing an increase in $NO_x$ emissions of 3.4 tons per year. VOC emissions decreased by 5.2 tons per year. The shuttle service cost UCF's Student Government Association $4.9 million during the 2009-2010 academic year (Keena, 2010). The cost per ton of pollutant averted is $2.72 million. However, there is also a savings that is distributed among the riders (gasoline costs, vehicle wear and tear, and parking permit savings). This was estimated to be $1,430,000 per year. The net cost is approximately $3.5 million, or $1.94 million per ton..

### *Inspection/Maintenance (I/M) Programs*

Inspection and maintenance (I/M) programs require people to drive their vehicles to an inspection station periodically for evaluation of their emissions control system. The programs range from basic tailpipe emissions tests to a more detailed "Enhanced I/M" program developed by the EPA, which includes visual inspection and evaluation of evaporative emissions. Visual inspection determines if the system has been tampered with. Evaporative emissions can occur even when the vehicle is not in operation.

[1] This includes the cost of a refueling station for the new buses (about $2,000 per bus). The cost may change depending on the cost of the station divided by the number of buses ordered.

Vehicles must pass these tests before their registration can be renewed. Costs for these tests are either paid at the time of inspection, or included in vehicle registration fees. The maximum cost for an inspection in the U.S. is $50 in Anchorage, Alaska (St. Denis and Lindner, 2005). The lowest cost (aside from free inspection) was $8 in Memphis, Tennessee. There is also a maximum cost to the owner for the mandatory repairs on the vehicles. This varies by program, but the literature showed that it was generally less than $1000. Assuming an average cost of the programs that test for VOCs and $NO_x$ to be $25, the cost of an I/M program to central Floridians would be approximately $38.7 million per year. This estimate does not include the cost of lost time.

I/M programs were effective in the 1980s and 1990s, when there was a substantial fraction of older vehicles in the fleet. EPA models still show a reduction in VOCs and $NO_x$ with a properly operated, high compliance program. However, other studies show that actual reductions are much less than those indicated by the models. This is especially true for a modern fleet, which typically has a very low percentage of vehicles out of compliance.

According to an EPA document ("Clean Cars for Clean Air: Inspection and Maintenance Programs", 1994), I/M programs can reduce VOC and $NO_x$ emissions substantially (5 to 15% for VOCs and 0-10% for $NO_x$). That EPA study was based on data from the late 1980s and early 1990s – a time when the vehicle fleet had a high percentage of older, higher emitting vehicles than exists today. Using conservative reduction estimates to reflect the 2010 fleet, it was estimated that OSO on-road VOC emissions could be reduced by 708 tons/year and $NO_x$ by 377 tons/year (3% and 1% reductions, respectively). This step would cost $34,839 per ton of VOCs and $NO_x$ averted. The use of such conservative reduction estimates was made due to the older timeframe of the data from the EPA article. The cars that make up the majority of today's fleet are running on engines that are regulated by computers, and have more modern exhaust emissions reduction technology.

An article evaluating vehicle I/M programs in Arizona and California found that the EPA overestimated the effectiveness of such programs (Harrington, 2000). The difficulty with I/M programs lies in the large fleet population being managed. It tries to regulate the behavior of millions of small sources rather than one large source. In addition to being less effective than anticipated, the programs also cost more. The article also attributes emissions reduction to improved vehicle technology more than to repairs on failed vehicles. It is the opinion of the author that I/M programs are not worth the expense, however, since the models show a reduction, one was included in our list of action steps.

### *Reduce HDDV Speeds on I-4*

Heavy duty diesel vehicles (HDDVs) are responsible for the majority of $NO_x$ emissions from on-road mobile sources in central Florida. They produce 47% of $NO_x$ from on-road mobile sources and 4% of VOCs. Interstate $NO_x$ emissions amount to 4,630 tons/year of which it was estimated that approximately 80% come from HDDVs (despite the fact that they make up only 8.5% of total VMT). Based on computer modeling runs using MOBILE6, the approximate highway speed at which they produce the least grams per mile of $NO_x$ is 45 miles per hour. At this speed, the emissions factor is 8.966 grams per mile. At an average speed of 65 miles per hour, the emissions factor is 15.165 grams per mile. By lowering this speed to 60 miles per hour, $NO_x$ emissions can be reduced from 1,195 tons per year to

993 tons per year – an improvement of 202 tons. Peak hours (morning and evening rush hours) for weekdays were not included in the emissions calculations because at those times traffic on the interstate is already travelling well below 65 miles per hour. This action step would have little effect on VOC emissions. Table 6 shows the $NO_x$ emissions factors for speeds between 45 and 65 mph.

**Table 6 - NOx emission factors for HDDV at common highway speeds**

| Speed (mph) | Emission Factor (g/mi) |
|---|---|
| 45 | 8.966 |
| 50 | 9.733 |
| 55 | 10.907 |
| 60 | 12.639 |
| 65 | 15.165 |

The costs associated with HDDV speed reduction involve additional signage and enforcement. These costs are highly variable depending on the required signage per mile, size of signs, and number and types of patrols. Therefore, the cost for this action step was not quantified.

### *Restrict HDDVs to the Right Lanes on I-4*

Big trucks (HDDVs) often drive slower than other vehicle types, causing slow downs on the road. This can frustrate drivers and may result in less efficient driving practices and increased emissions. By restricting HDDVs from using the left lane or lanes, other cars can move along faster and decrease the occurrence of traffic congestion due to slower moving semi-trucks. This also has the desirable effect of further slowing down the HDDVs. Through simplified traffic modeling, it was estimated that truck speeds on I-4 (in the non-rush hour times) would decrease from the current estimate of 69 mph to 65 mph by restricting semi-truck access to the left-most lane only. Also, 147 tons of $NO_x$ per year would be averted by this restriction. This step is also one of few that has the potential for reducing large quantities of $NO_x$. Figure 7 shows how speed affects $NO_x$ emissions from HDDVs in OSO. As with the HDDV speed reduction step on I-4, the costs for this step were too uncertain to be quantified.

### *Change Signal Timing on Major Arterials*

A methodology was developed to estimate the potential emissions reductions from changing signal timing on all major arterial roads in OSO. If the signal timing can be computerized to reduce the delay times for the vehicles on the major arterials, it will result in a reduction of idling time at the signals. Assuming that such a signal optimization program can accomplish a 10% reduction in idling emissions throughout the region (this assumption is by no means assured), VOCs would decrease by up to 111.6 tons and $NO_x$ by 9.9 tons per year. Calculating the monetary costs of changing the signal timing was outside the scope of this study.

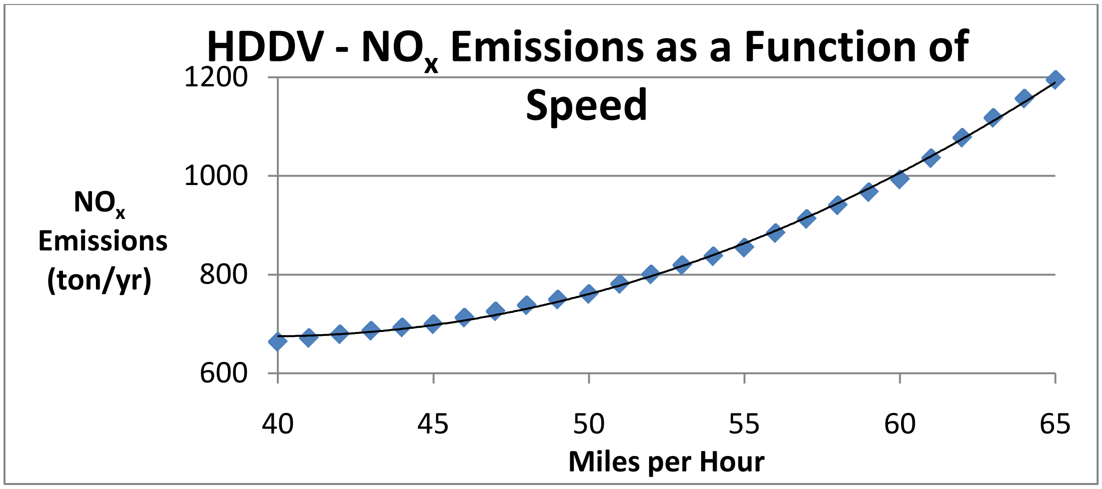


Figure 7 - HDDV $NO_x$ emissions in OSO as a function of speed

### *Stage II Vapor Recovery*

Stage II vapor recovery (S2VR) systems are used at gas stations to recover VOCs that usually escape vehicle gas tanks during refueling. A cup-like device is attached to the nozzle and fits over the tank opening. When gas is pumped into the tank, the vapors are pushed out through a hose, and back into the underground storage tank. These systems are useful at recovering a large portion of the VOCs, but in recent years, this system has become less effective thanks to onboard refueling vapor recovery (ORVR) technology in newer vehicles (see Figure 8). The cars now recover the gasoline vapors themselves and pass the vapors along to an activated carbon packed canister (which adsorbs the vapor). The vapors later are used as fuel when they are drawn into the engine intake manifold during operation. However, the carbon canisters have a life of approximately 10 years (Koch, 1997). Unless the canister is replaced, VOCs will fail to be recovered by the car, and will be released to the atmosphere.

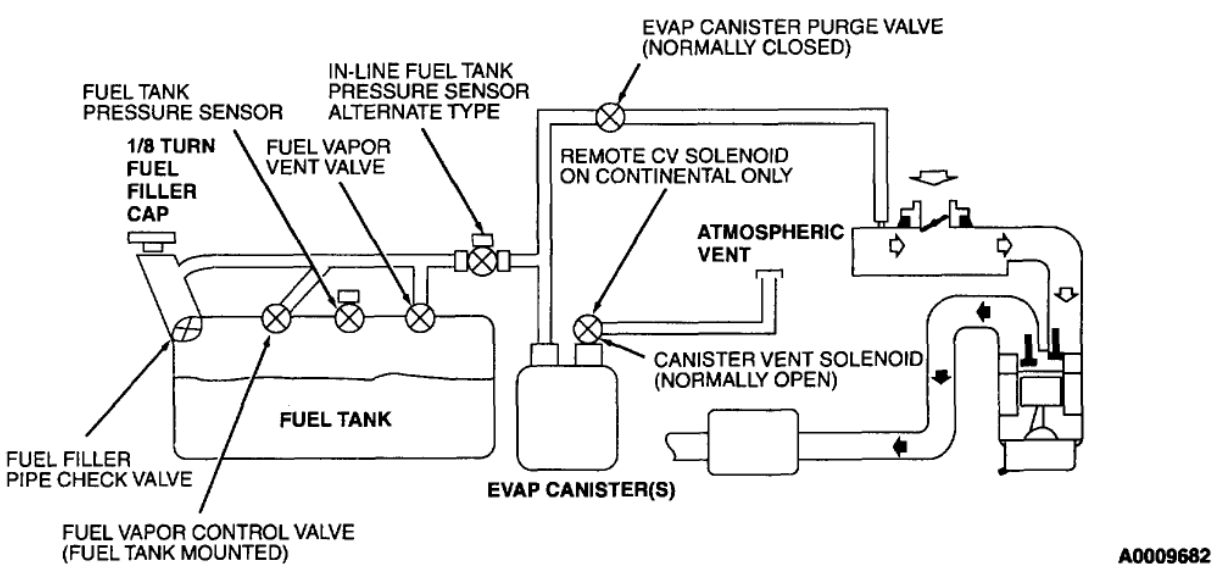


Figure 8 - Diagram of ORVR system ("My beloved Sable--help me save her", 2009)

Because of ORVR, there is a rate of diminishing returns occurring with S2VR. The systems were effective in the 1990s, and may still help today, but lose effectiveness each year as the older vehicles in the fleet continue to be replaced by newer vehicles. As the vehicle fleet is updated, more cars from 2000 and later will be on the road (catching their own vapors), and fewer vapors will be available to recover with S2VR. The equipment still costs the same to install but achieves decreasing emission reduction rates, making it cost more per ton reduced.

To estimate the cost for upgrading a conventional fueling station to S2VR capabilities, a "model" station was created on which to base the calculations. This station was estimated (based on the average number of pumps per station in Orange, Seminole, and Osceola counties) to have eight pumps. MOBILE6 predicted that with a 3-year phase-in period beginning in 2012, 2,608 tons of VOCs could be averted through 2015. Reductions for the first two years are approximately 260 and 460 tons of VOCs, then when fully implemented, reductions average around 630 tons per year. For equipment alone (no labor or demolition to upgrade a station), the estimated cost is $11,100. Labor and construction costs were estimated at $100,000 per station. For all stations in all three counties, this cost is approximately $73,659,000, or $283,000 per ton of VOC averted in the first year ($54,560[2] per ton of VOC averted after phased in).

### *Create High Occupancy Vehicle (HOV) Lanes*

Central Florida previously attempted to use HOV lanes (in the 1980s) without much success. Diamonds were painted and signs were posted, but the lanes wound up being used as just another lane on the highway. The biggest problem was enforcement because it was difficult and dangerous for police to pull into traffic and pull cars over across several lanes of traffic and onto the small shoulder of I-4. HOV lanes need to be designed and constructed rather than simply designated on existing roads. However, when done properly, HOV lanes work. In Dallas, Texas, and Los Angeles County, California, HOV lanes have been successful. A study in 1999 of the Dallas HOV lanes showed a 79% increase in carpools on eastbound I-635 and a 296% increase on I-35E North (Skowronek, P.E., Ranft, and Slack, 1999). This study also found that the lanes saved motorists an average of at least five minutes over the other non-HOV lanes on incident-free days. A similar study conducted in Los Angeles County, California, found that emissions (per person per mile) from carpool lanes are approximately half of those from other lanes (HOV Performance Program, 2002). Costs were not estimated for this step because HOV lanes are already in the plan for the I-4 expansion and funds for this have already been budgeted.

## On-road Mobile Summary

Table 7 shows the on-road mobile emissions reduction steps discussed previously. If all of these proposed steps were to be put into action, OSO could reduce on-road mobile emissions by 1,493 tons of VOCs and 1,199 tons of $NO_x$ annually. The steps which showed the biggest potential reductions for VOCs were changing the signal timing to reduce idling emissions, offering "free" transit to UCF students, and I/M programs. An effective I/M program can reduce emissions by about 700 tons of VOCs, but would cost residents about $38,000,000/year in inspection fees. Stage 2 vapor recovery would decrease VOC emissions by 260 tons in its first year of the phase-in period, ultimately saving 630 tons annually when

[2] $54,560 = total cost divided by the cumulative emissions reduced up to the time of full implementation.

fully phased in. The "free" UCF transit would save 18 tons of VOCs, but would cost $1,680,000, which would be paid for by UCF and not the counties. Stage 2 vapor recovery would save about 630 tons/year of VOCs, but would cost approximately $73.7 million. That cost would be spread to gas station owners and ultimately to consumers. The expense for stage 2 vapor recovery systems is for the estimated equipment, labor, and construction costs to update from conventional refueling to vapor recovery, but does not include operation and maintenance.

The steps which achieved the largest $NO_x$ reductions were I/M programs, reducing HDDV speeds on I-4 and restricting their access from the left lane (allowing them in the middle and right lanes). These latter two steps would reduce average speeds from 69 mph to 60 mph. They accounted for the majority of $NO_x$ reductions in OSO. However, if the I/M reductions are to be believed, I/M would save 380 tons of $NO_x$ at a cost of $38,000,000/year. The speed reduction steps were attractive, but the costs associated with them were not quantified due to the uncertainty of signage required and additional patrols to enforce them. These two $NO_x$ reduction steps would be a cost to the counties. And the trucking companies might claim some costs due to lost time. However, the increase time required for passage through the OSO area along I-4 at the 60 mph instead of 69 mph is only about 6 minutes. Furthermore, the fuel savings at the lower speeds might well result in a cost savings to the truckers. Thus, these latter two steps are highly recommended.

**Table 7 - Reduction steps for on-road mobile sources**

| Reduction Step | Pollutant reductions, tons/yr VOC | Pollutant reductions, tons/yr $NO_x$ | Cost, $/yr | Cost, $/(ton of VOC + $NO_x$ reduced) |
|---|---|---|---|---|
| Decrease school bus idling time 15 minutes/day | 1.1 | 11 | -$166,000 | -$13,720 |
| Switch from ULSD to B20 biodiesel) school bus fleet | 3.4 | -2.3 | $2,280,000 | $2,073,000 |
| Implement carpooling programs | 2.8 | 2 | $80,640 | $16,800 |
| Lynx VanPlan program | 3.6 | 2.5 | $300,000 | $49,100 |
| Parking cash out in downtown Orlando | 3.7 | 2.5 | $22,600 | $3,620 |
| "Free" transit for UCF students | 18.5 | 11.7 | $1,680,000 | $55,630 |
| Increase transit use (adding passengers to existing buses) | 4.4 | 3.1 | No additional cost | No additional cost |
| Replace existing buses with CNG or diesel/electric hybrid buses | not quantified | 31 | $21,600,000 | $696,770 |
| Shuttle service for UCF students or at large employment centers | 5.2 | -3.4 | $709,090 | $410,000 |
| Inspection/Maintenance Program | 708 | 377 | $37,800,000 | $34,840 |
| Reduce HDDV speeds on I-4 and other limited access highways in OSO | negligible | 607 | not quantified | not quantified |
| Restrict HDDVs on I-4 and other limited access highways to the right two lanes only | negligible | 147 | not quantified | not quantified |
| Changing the signal timing on major arterials | 112 | 10 | not quantified | not quantified |
| Stage 2 vapor recovery | 630 | 0 | $73,659,000[+] | $54,560 |
| Create HOV and HOT lanes | not quantified | not quantified | not quantified | not quantified |
| **TOTAL EMISSION REDUCTION POTENTIAL** | **1,493** | **1,199** | | |

[+] Cost to upgrade all stations; these are one-time costs, not annual operating costs.

## Non-road Mobile Sources

According to the EPA's NONROAD model, pleasure craft (motor boats and jet skis) are the largest source of non-road VOC emissions in OSO comprising 42% of the total, followed closely by lawn and garden equipment (mowers, edgers, trimmers, chain saws, blowers, etc) with 35% of the total. Construction and mining equipment is the largest source of $NO_x$ emissions, accounting for 67% of the total. Total OSO emissions of VOCs and $NO_x$ (as derived from the NONROAD model) are tabulated in Table 8 and displayed graphically in Figure 9 and Figure 10.

**Table 8 - 2008 NONROAD Emission totals for OSO**

| Classification | VOC, tons/yr | $NO_x$, tons/yr |
|---|---|---|
| **Agricultural Equipment** | 9 | 73 |
| **Airport Equipment** | 17 | 183 |
| **Commercial Equipment** | 1,195 | 771 |
| **Construction and Mining Equipment** | 1,013 | 6,796 |
| **Industrial Equipment** | 193 | 934 |
| **Lawn and Garden Equipment (Com)** | 3,575 | 762 |
| **Lawn and Garden Equipment (Res)** | 1,714 | 113 |
| **Logging Equipment** | 2 | 4 |
| **Pleasure Craft** | 6,339 | 500 |
| **Railroad Equipment** | 0 | 1 |
| **Recreational Equipment** | 1,133 | 35 |
| **TOTALS** | **15,190** | **10,172** |

In the years from 2005-2008, prior to the extreme slow-down in economic activity that occurred in the latter half of 2008, there had been very significant land development activity in the OSO area. This created a high usage of a large number of a wide variety of construction equipment (graders, pavers, dozers, excavators, off-highway trucks, scrapers, backhoes, etc). All this equipment is diesel engine driven (higher $NO_x$ emissions), and typically moves under high load for short distances or sits idling (waiting to be used) numerous times throughout the day. The stop-and-go movements are an inefficient use of fuel, and according to the modeling results, construction vehicles produce about two-thirds of all the non-road $NO_x$ emissions in this region. However, due to improvements by manufacturers of both small and large engines, even with the economic boom that occurred between the previous inventory (2002) and this one (2008), VOC emissions increased by only 1,801 tons (13.5%). The decreases in VOC emissions from lawn and garden equipment and construction and mining equipment from 2002 to 2008 mitigated the increases from pleasure craft and recreational equipment. Furthermore, $NO_x$ emissions actually decreased by 5,717 tons (36%), owing to improvements in lawn and garden and construction equipment per-engine emissions.

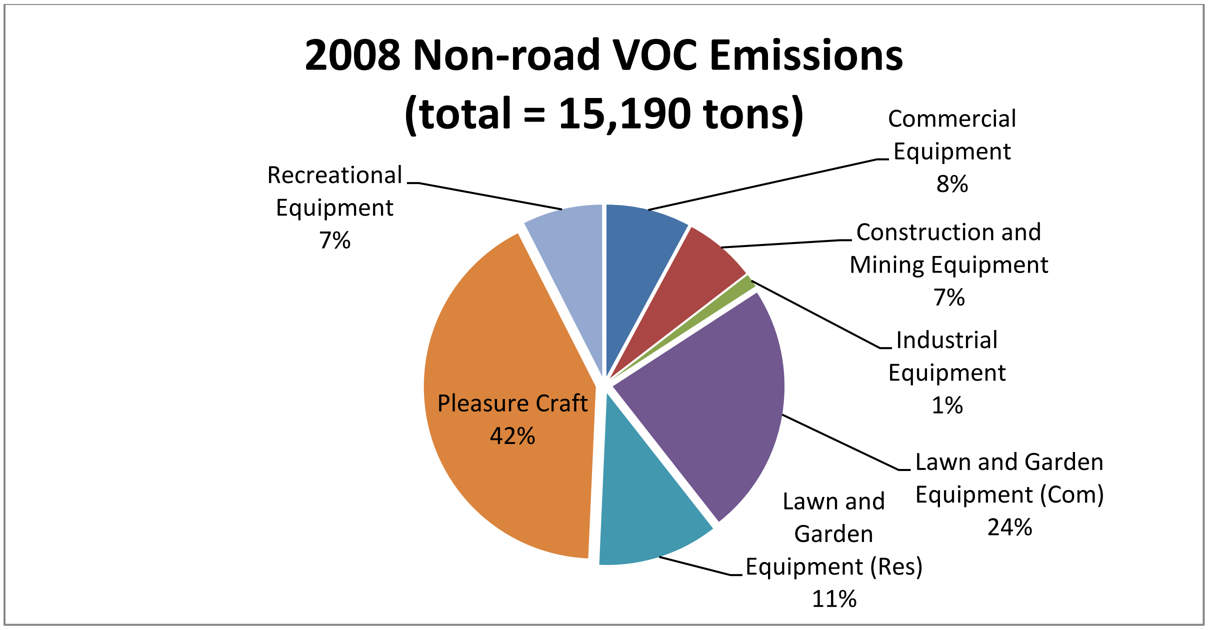


**Figure 9 - 2008 Non-road VOC contributions by source for the OSO area***

* Does not include agricultural equipment, airport equipment, logging equipment, and railroad equipment. The total from these sources combined was less than 0.25%.

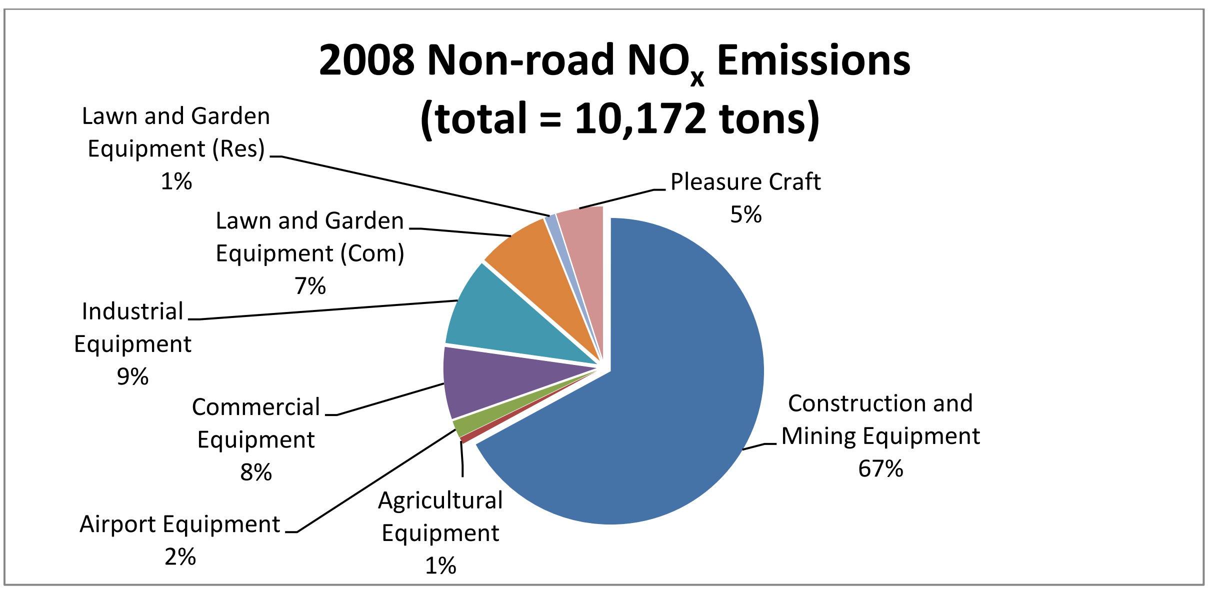


**Figure 10 - 2008 Non-road $NO_x$ contributions by source for the OSO area***

* Does not include logging equipment, railroad equipment, and recreational equipment. The total from these sources combined was less than 0.50%.

## Potential Action Steps

### *Use Biodiesel in Diesel Powered Lawn and Garden Equipment*

Results from a survey conducted for determining emissions from lawn and garden equipment showed that over half of commercial lawn care companies use gasoline-powered equipment (for at least 90% of their equipment). Ethanol is a potential replacement for gasoline, but changing to ethanol in gasoline-powered equipment may require changes to their fuel and engine systems. Because VOC emissions are approximately the same from ethanol as they are from gasoline, biodiesel is the only other option suggested for use in lawn and garden equipment.

Switching from diesel to biodiesel in all applicable lawn and garden equipment could save 5 tons of VOC emissions per year. These savings would be realized by consumption of an estimated 2.8 million gallons annually of B20. There is some debate over whether $NO_x$ emissions from B20 are greater than or less than petroleum diesel $NO_x$ emissions. Assuming $NO_x$ emissions would increase by no more than 1% after switching to B20, $NO_x$ emissions would increase by less than 0.5 tons per year. The net reduction of VOCs and $NO_x$ would be 4.5 tons per year. The monetary cost for this reduction is $445,000/year and $98,900/ton. Based on the literature, it was assumed that B20 costs approximately $0.15 more per gallon than regular diesel (U.S. Department of Energy, 2009).

### *Use PuriNOx in 20% of Diesel Construction Equipment*

"PuriNOx" is a water emulsified fuel (i.e. watered down diesel) that consists of approximately 15% water. $NO_x$ emissions can be reduced by about 14.5% while VOC emissions increase by 75%. Non-road diesel equipment emissions totaled 884 tons of VOCs and 8,439 tons of $NO_x$ in 2008. Converting 20% of the nonroad diesel construction equipment fleet to PuriNOx would yield a 245 ton reduction in $NO_x$, but an increase of 133 tons of VOCs. The cost per gallon of PuriNOx is about the same as that of petroleum diesel, however due to the lower energy content, 15-20% more fuel is required. The total estimated cost in OSO for this step would be $7.2 million/year and $64,200/ton averted.

### *Catalytic Converters on all Gasoline Lawn and Garden Engines*

Newly manufactured lawn and garden equipment will require catalytic converters by 2012 (EPA: "Lawn and Garden (Small Gasoline) Equipment", 2010). These changes will be phased in between 2010-2012 depending on the equipment type. In 2011, Class II engines (those above 225 cc) will require catalytic converters, and in 2012, Class I engines (those less than 225 cc). For now, they freely pollute (although, improvements in engine design have significantly reduced emissions from previous years). The catalytic converters will reduce VOC and $NO_x$ emissions further by approximately 35%. This is about 1850 tons of VOCs and 306 tons of $NO_x$ per year. However, since regulations have already been passed, a monetary cost for adding retrofit catalytic converters to lawn and garden engines was not calculated. It is recommended to wait for the EPA regulations to take effect.

### *Require Oxygen Catalysts or Diesel Selective Catalytic Reduction Units for Construction Equipment*

Oxidation catalytic converters are not required for construction equipment exhaust systems at this time. They have the potential to reduce 50-90% of VOCs, but do not reduce $NO_x$. The way this technology works is by oxidizing hydrocarbons (which include VOCs) to water and carbon dioxide, and carbon monoxide to carbon dioxide. By installing catalytic converters on 20% of the diesel construction vehicle fleet in OSO, and assuming 50% reduction, 70 tons of VOCs could be averted. The cost for updating 20% of the fleet is $5,700,000 capital cost. If the life of the oxygen catalyst is assumed to be 5 years, this is approximately $1,100,000 per year, or $16,000 per ton of VOCs averted.

Diesel selective catalytic reducers (SCRs) are highly effective at reducing $NO_x$ emissions. They have the potential to reduce 90% of $NO_x$ in exhaust gases. If 20% of the fleet were also fitted with SCRs, this would avert approximately 1,223 tons of $NO_x$ per year. Assuming the cost of an SCR to be $4,000 per unit, applied to 20% of the construction/mining equipment fleet population of 22,733 pieces of diesel equipment, the cost associated with this step is $242 million. This equates to $198,000 per ton of $NO_x$ averted. This cost is a lump sum which assumes that the equipment would be installed and emissions savings would begin to occur at once. These costs are borne by equipment owners, but ultimately will be passed on to their clients. Also incorporated into the cost estimate are the prices of diesel fuel and urea (a chemical needed to make the SCR units work).

### *Reduce Lawn Care Equipment Use by 25%*

An easy, inexpensive way to reduce non-road emissions is to cut down on the frequency with which central Floridians manicure their lawns. By stretching the time between mowing, trimming, and edging, a reduction of 1,322 tons of VOCs and 219 tons of $NO_x$ was calculated. This would not really affect lawn care companies as most are paid per month rather than per mow. They would actually save money because they would spend less on fuel, as would those citizens who do their own yard work. The savings cannot be quantified because there is no data estimating the amount of fuel used in all commercial and residential lawn care equipment. The only cost would be for a campaign to make the public aware of the effect frequent lawn maintenance has on the environment, particularly on high-level ozone days. This step is very amenable to partial implementation. That is, in those months when ozone formation potential is highest (March – June), reducing the use of lawn care equipment, may have the best “bang for the buck.” If only implemented for that time period, the total reduction would be much less, but the effect might be the most significant.

### *Reduce Idling in 20% of Diesel Tractors*

There are perhaps several hours of the workday when construction tractors are left idling. This may be due to lunch breaks, waiting for deliveries, or waiting for another piece of machinery to move or clear things away. The NONROAD model estimated 14,339 tractors in OSO in 2008. Emissions reduction calculations were based on the assumption that equipment idling could be reduced by 1 hour per day, 5 days per week, for 49 work weeks during the year for about 20% of all equipment. If this idling reduction can be achieved, it would prevent 599 tons of $NO_x$ (a 5.9% reduction in nonroad $NO_x$ emissions) from being released to the atmosphere. It was assumed that this step would be applied to newer equipment that can be shut down and re-started frequently. Many pieces of construction equipment use about 1 gallon of fuel per hour of idling. This step would actually save construction companies $2,200,000/year, and thus there would be a net savings of $3,700/ton averted.

### *Scrap Programs*

A scrap program would encourage citizens in OSO to get rid of their older, less efficient lawn care equipment. This has the benefit of speeding up the rate for new, cleaner machines to become part of the equipment population. A scrap program in California was used as the basis for our estimates, and their results were adjusted for the size of the OSO area. A similar program here was estimated to produce a 2 to 4 ton reduction in VOCs and $NO_x$, at a cost of approximately $18,000 per ton averted. The costs were due to subsidies and advertising to convince people to scrap their older equipment. However, equipment engines are emitting less than in the past, and new, even stricter EPA regulations are currently being phased in. The benefits depend on when the scrap program is implemented, and because lawn care equipment typically has a short life, it may be better to simply wait until after the new EPA regulations are in full effect.

### *Public Education Campaigns*

Public education campaigns have large variability in how to get across their messages. These methods can include television commercials, print mailings, radio spots, and encouraging public awareness by holding events/having a booth at an event. The basis for our estimates for public education costs was the "ReThink Your Commute" program set up by FDOT. The original contract is for five years and costs $1.9 million. Included in that cost are website maintenance, marketing, staffing, and rideshare incentives. Annualized, this is $380,000 per year. Since the program began about six months ago and still has much growth potential to be realized, emissions reduction from participants cannot yet be estimated, and the costs/ton averted are not available.

Another campaign by the Bay Area Air Quality Management District (BAAQMD) in California urged residents to abstain from certain activities on high-risk ozone days. A survey showed that about 8% of residents reduced their use of gasoline powered lawn equipment on those days ("Report to the Board on the Potential Electrification Programs for Small Off-Road Engines", 2004). This campaign was estimated to have averted 2 tons of VOCs and $NO_x$ and cost between $20,000 and $36,000 per ton.

### *Commercial and Residential Ban on Leafblowers/Vacuums*

Leafblowers and street vacuums serve the purpose of "clean up." The intention is to blow the grass clippings and leaves back into the lawn so that they can decompose naturally. Often blowers are used improperly, and they just blow the dirt and grass clippings off the sidewalks and into the street so that they end up in the gutters, and eventually into our lakes and streams. Blowers are also noisy and polluting. Leafblowers and vacuums accounted for 599 tons of VOCs (3.9% of total nonroad VOC emissions) and 59 tons of $NO_x$ (0.6% of total nonroad $NO_x$ emissions) in 2008. A ban would be one method for the counties to reduce emissions. However, lawn care businesses would lose money (hiring an extra person to do sweeping) and many citizens likely would oppose a ban. In some communities where bans have been passed, people were highly in favor and in others they were highly opposed (Crum, 2007). Central Floridians who subscribe to lawn care services expect a pristine yard. To achieve the same effect, lawn care companies would have to hire more employees to sweep the debris or use electric leafblowers. Both of these measures cost the companies more money. It was estimated that such a ban would cost OSO approximately $2,607,000 or $3,960/ton VOC and $NO_x$ averted.

### *Voluntary Electric-for-Gasoline Mower Exchange*

The mower exchange program would be targeted at residential users. It would work by offering the participant a rebate on an electric mower in exchange for turning in their old gasoline one. Adjusting a California program's success to the OSO area's size, it was estimated that 5 to 10 tons of VOCs and $NO_x$ could be averted. The cost associated with such a program is about $20,300 per ton. The costs include administration of the program, advertising, and rebates.

### *Voluntary Electric-for-Gasoline Handheld Exchange*

This program would also be targeted at residential users. The participant would be offered a rebate to buy hand-held electric equipment (leaf blowers, chain saws, trimmers, etc) if they turned in their old gasoline powered piece. Participation is expected to be higher for a handheld exchange than a mower exchange because electric powered equipment is more amenable to smaller devices. Because of this, a higher savings was estimated – 10 to 15 tons of VOCs and $NO_x$ per year – at a lower cost – $15,200 per ton of VOCs and $NO_x$ averted.

### *Reduction of Boating Emissions*

The year 2010 was the first model year where boat manufacturers were required to produce engines which will eventually reduce pleasure craft (personal boats and jet skis) emissions substantially. It is estimated that nationally, emissions will be reduced by 70% by 2030, or about 600,000 tons of VOC emissions and 130,000 tons of $NO_x$ emissions nationwide (U.S. Environmental Protection Agency, 2008). Using these EPA estimates, and the OSO portion of US population, we calculated that over the next 20 years this step could eventually reduce OSO's portion of these emissions by 2,516 tons of VOCs and 545 tons of $NO_x$. For this estimate, it was assumed that the annual reduction was linear. VOCs would be reduced by 126 tons per year and $NO_x$ by 27 tons/yr. EPA estimates the net cost for this boat engine standard is $236 million. Purchasers of watercraft in OSO will bear about $990,000 of this cost through 2030. That is $49,500 per year or $326 per ton averted.

## Non-road Mobile Summary

Table 9 shows the non-road mobile emissions reduction steps discussed above. If all of these proposed steps were to be put into action, OSO could reduce non-road mobile emissions by 3,737 tons of VOCs and 2,651 tons of $NO_x$ annually. The largest contributors are lawn and garden equipment, personal watercraft, and construction/mining equipment. Some of the most effective reduction measures involved using the equipment less, and resulted in a cost savings.

The largest reduction of VOCs comes from adding catalytic converters to gasoline powered lawn and garden equipment. Since the EPA has already passed legislation which requires the addition of catalytic converters by 2012, OSO should take no action and wait for the regulations to take effect. The second largest VOC reducing step is reducing overall use of lawn and garden equipment by 25%. This is an effective measure, however it would be extremely difficult to accomplish because it would require cooperation of almost all the residents in OSO. Also, the EPA requirement of catalytic converters on new equipment will accomplish significant reductions, so the reduced emissions achieved by reducing lawn care frequency would likely be less than what we have calculated. The costs for these steps were not quantified because the associated costs for catalytic converters will be applied to equipment manufacturers and the amount of gasoline used in this equipment in 2008 was not quantified. A complete ban on the use of leafblowers and vacuum trucks would also result in large savings of VOCs, but is considered unrealistic in central Florida at this time.

$NO_x$ reduction was best achieved by the addition of selective catalytic reducers to 20% of all diesel construction equipment. However, the cost for this step is prohibitively high. The next largest reduction step is to reduce tractor idling in 20% of all diesel and construction equipment by one hour each day. There is no net cost associated with this – only a savings to the construction companies.

**Table 9 - Reduction steps for non-road mobile sources**

<table>
<tr><th rowspan="2">Reduction Step</th><th colspan="2">Pollutant reductions, tons/yr</th><th rowspan="2">Cost, $/yr</th><th rowspan="2">Cost, $/(ton of VOC + NO<sub>x</sub> reduced)</th></tr>
<tr><th>VOC</th><th>NO<sub>x</sub></th></tr>
<tr><td>Use biodiesel in diesel-powered lawn and garden equipment</td><td>5</td><td>-0.5</td><td>$444,750</td><td>$98,833</td></tr>
<tr><td>"PuriNOx" water emulsion fuel for 20% of construction equipment</td><td>-133</td><td>245</td><td>$9,744,000</td><td>$87,000</td></tr>
<tr><td>Catalytic converters on all gasoline lawn & garden engines</td><td>1850</td><td>306</td><td>Not quantified</td><td>Not quantified</td></tr>
<tr><td>"Oxygen catalysts" installed on 20% of all diesel construction equip.</td><td>70</td><td>negligible</td><td>$1,100,000</td><td>$15,700</td></tr>
<tr><td>Diesel selective catalytic reducers installed on 20% of all tractors</td><td>negligible</td><td>1223</td><td>$242,120,000*</td><td>$197,972</td></tr>
<tr><td>Cut lawn care equipment use 25%</td><td>1322</td><td>219</td><td>Not quantified</td><td>Not quantified</td></tr>
<tr><td>Reduce idling by 60 min/day for 20% of construction equipment</td><td>negligible</td><td>599</td><td>-$2,200,000</td><td>-$3,673</td></tr>
<tr><td>Scrap programs</td><td colspan="2">3</td><td>Not quantified</td><td>$18,000</td></tr>
<tr><td>Public education campaigns</td><td colspan="2">2</td><td>Not quantified</td><td>$25,000</td></tr>
<tr><td>Leafblower/Vacuum ban</td><td>599</td><td>59</td><td>$2,607,000</td><td>$3,962</td></tr>
<tr><td>Electric-for-gas mower exchange</td><td colspan="2">7</td><td>Not quantified</td><td>$20,300</td></tr>
<tr><td>Electric-for-gas handheld exchange</td><td colspan="2">12</td><td>Not quantified</td><td>$15,200</td></tr>
<tr><td>Boating emissions mandated reductions</td><td>126</td><td>27</td><td>$49,500</td><td>$324</td></tr>
<tr><td>TOTAL EMISSION REDUCTION POTENTIAL</td><td>3,737</td><td>2,651</td><td></td><td></td></tr>
</table>

* Cost to purchase SCRs; these are one-time costs, not annual operating costs.

## Point and Area Sources

Point and area source emissions reductions were not the focus of this report.  However, the emissions inventory for 2008 submitted to MetroPlan in June 2010 found that area and point sources contributed significantly to emissions in OSO.  Figure 11 and Figure 12 show these categories and their VOC and $NO_x$ contributions as compared to the other categories for which action steps were created.

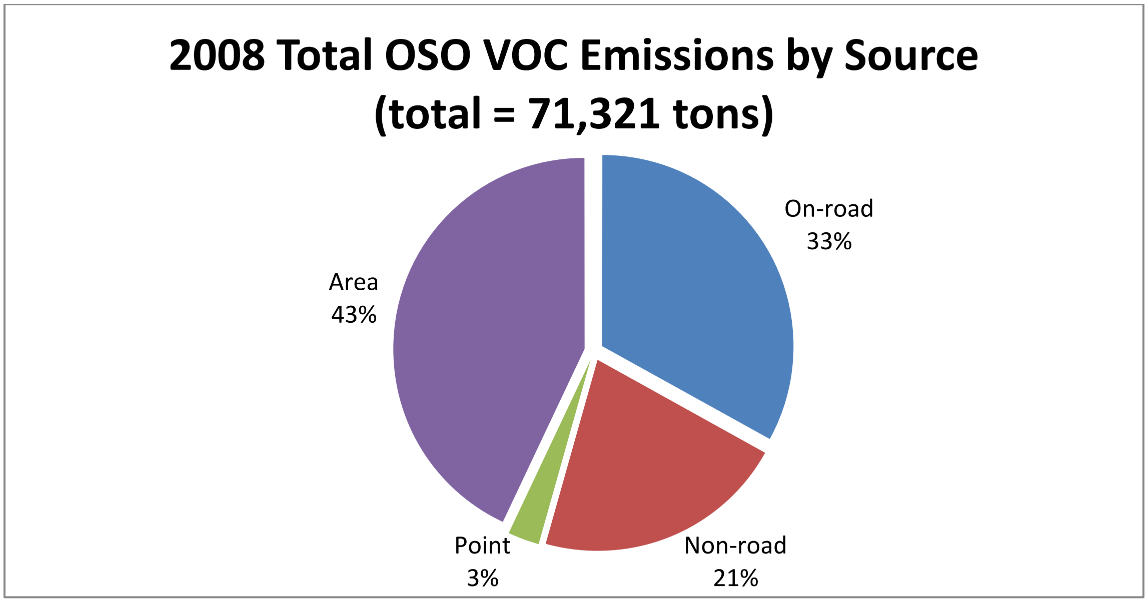


**Figure 11 - Total VOC emissions for OSO by source category**

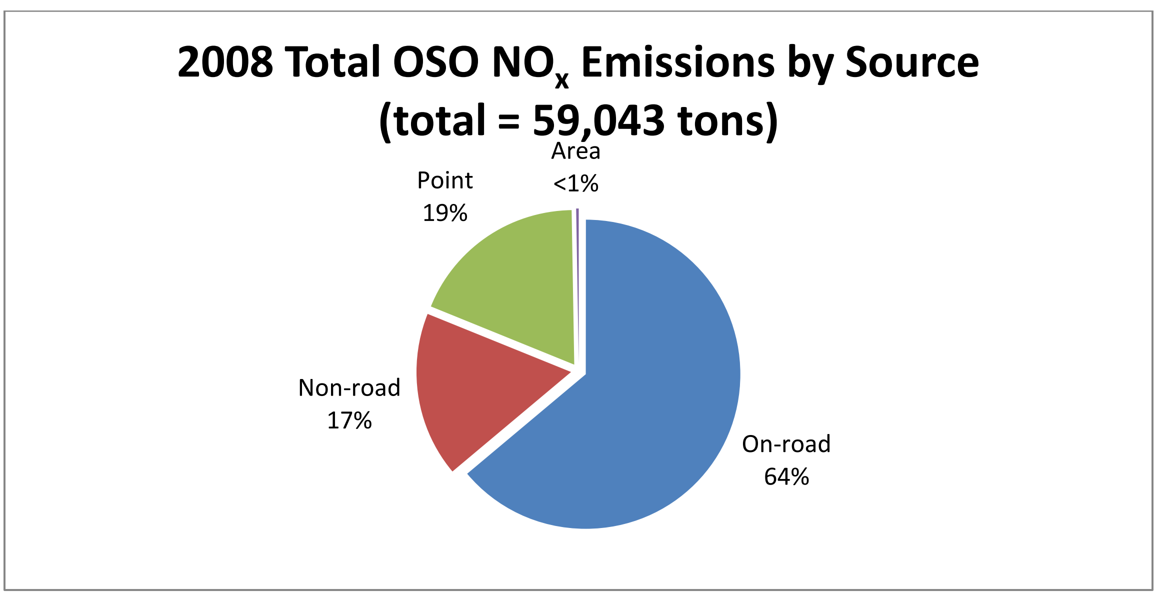


**Figure 12 - Total $NO_x$ emissions for OSO by source category**

## Point Sources

Point sources were identified from the US EPA Facility Emissions List and the central Florida office of the FDEP (U.S. Environmental Protection Agency, Clean Air Markets Division, 2010 and Ross, 2009). Point source facilities include large power plants (such as the OUC Stanton Plant), large facilities (such as Disney World, Lockheed Martin, large graphic arts shops, and large asphalt plants), and major airports (such as Orlando International). Each individual facility must submit annual emission records to the FDEP to show they are operating within their permitted limits.

Table 10 shows the categories in which facilities may be classified. Point sources of VOCs are relatively small in the OSO area. Within this category, "Airports" and "Other" sub-categories had the highest level of VOC emissions. The "Airport" category includes aircraft emissions, but does not include ground service equipment (GSE) emissions. GSE emissions were included in the non-road source section. There were many small companies included in the "Other" category; some of the larger ones were Cellofoam North America Inc., Sonoco Products Company, Walt Disney World Co., and Lockheed Martin Missiles & Fire Control. The airports in OSO are Orlando International Airport (OIA), Orlando Sanford International Airport, Orlando Executive Airport, and Kissimmee Gateway. OIA handled approximately 360,000 flights during the 2008 calendar year. The OIA emissions were estimated based on a detailed model of flight activity (data gathered directly from OIA) and using the Emissions and Dispersion Modeling Systems (EDMS) model. EDMS is the FAA's required model for airport emissions. The other three airports in OSO have drastically less air traffic, so the emissions from those were calculated as a simple factor (percentage) of OIA emissions. Airport aircraft emissions can be seen in Table 12.

Power plants emitted significant amounts of $NO_x$ in OSO, accounting for three-fourths of all the point source $NO_x$ emissions, and about 14% of the total regional emissions of $NO_x$ from all sources. Most of that came from the two (2) coal fired units at the Orlando Utilities Commission (OUC) Stanton Energy Center. The $NO_x$ emissions from each power plant are tabulated in Table 11. Figure 13 and Figure 14 graphically show the VOC and $NO_x$ emissions from point sources in OSO.

Table 10 - 2008 Point source emission totals for OSO

| Category | Total | |
|---|---|---|
| | VOC, tons/yr | $NO_x$, tons/yr |
| **Airports*** | 473 | 1,469 |
| **Asphalt Plant** | 31 | 66 |
| **Chemical Plant** | 2 | 0 |
| **Electric Production** | 0 | 36 |
| **Fiberglass Products Mfg.** | 103 | 0 |
| **Food Production** | 297 | 31 |
| **Graphic Arts/Printing** | 146 | 1 |
| **Hospitals/Health Care** | 5 | 77 |
| **Misc Wood Products Mfg.** | 2 | 0 |
| **MSW Landfill** | 37 | 24 |
| **Incineration** | 1 | 32 |
| **Petroleum Storage/Transfer** | 80 | 9 |
| **Power Plants** | 111 | 8,525 |
| **Secondary Metal Production** | 0 | 1 |
| **Surface Coating Operations** | 249 | 8 |
| **All Other** | 364 | 708 |
| **TOTALS** | **1,901** | **10,987** |

*Airports in this table represent aircraft emissions (landings and take-offs and taxiing) but do not include ground service equipment (GSE). This is included in the non-road inventory.

Table 11 - 2008 Annual $NO_x$ emissions of OSO power plants

| Facility Name | $NO_x$, tons/yr |
|---|---|
| **Curtis H. Stanton Energy Center** | 8,137 |
| **Orlando CoGen** | 144 |
| **RRI Energy Osceola** | 35 |
| **Reedy Creek** | 1 |
| **Stanton A** | 126 |
| **Cane Island** | 82 |
| **TOTALS** | **8,525** |

Table 12 - 2008 airport (aircraft) emission results

| Airport | VOC, tons/yr | $NO_x$, tons/yr |
|---|---|---|
| **Orlando International** | 322 | 1,353 |
| **Orlando Executive** | 40 | 3 |
| **Orlando-Sanford International** | 66 | 110 |
| **Kissimmee Gateway** | 45 | 3 |
| **TOTALS** | **473** | **1,469** |

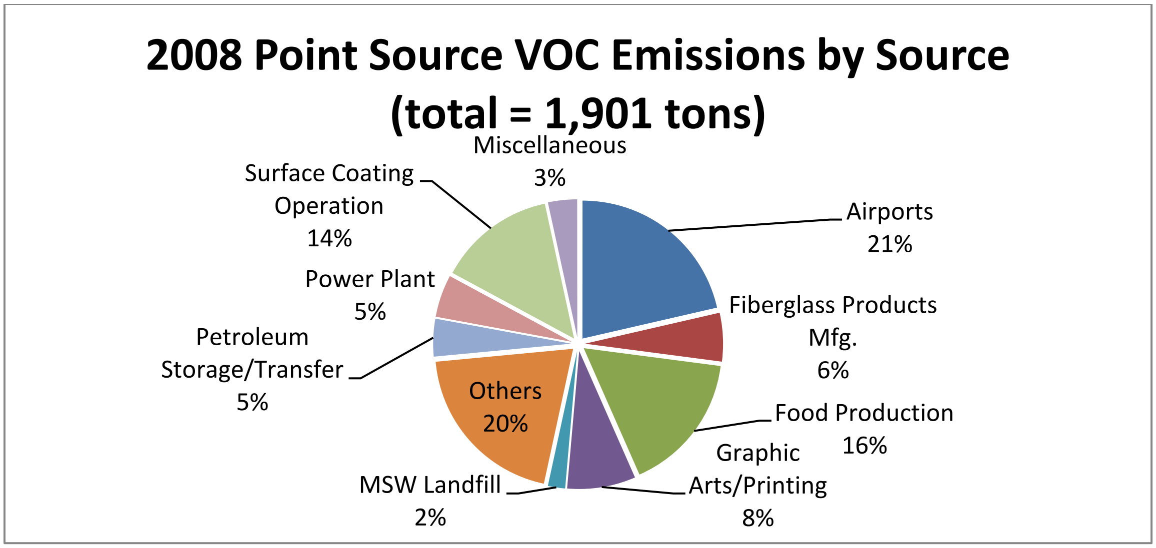


**Figure 13 - 2008 Point source VOC contributions by source for the OSO area***

* The “Miscellaneous” source category includes chemical plants, hospitals/healthcare facilities, miscellaneous wood products manufacturing, incineration, and asphalt plants

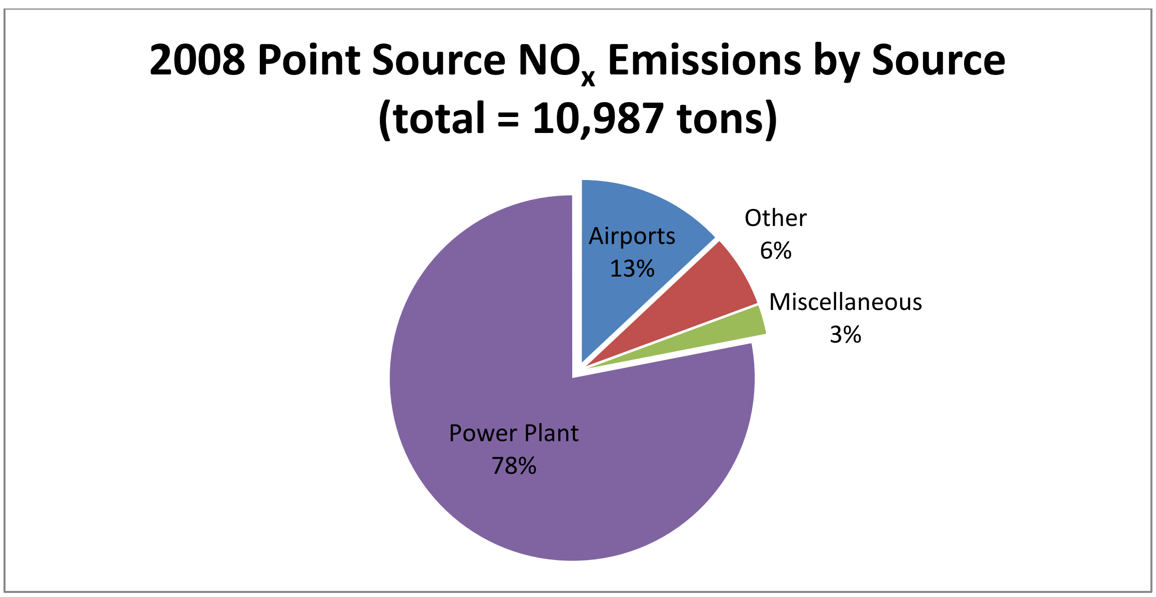


**Figure 14 - 2008 Point source $NO_x$ contributions by source for the OSO area***

* The "Miscellaneous" source category includes graphic arts/printing, petroleum storage/transfer, secondary metal production, surface coating operation, MSW landfill, asphalt plant, electric production, food production, hospitals/healthcare facilities, and other incineration

## Area Sources

Area source emissions data came from the US EPA 2008 National Emissions Inventory ("2008 National emissions inventory data & documentation," 2010). The EPA has developed county-level data for the major area-source sub-categories for every county in the United States; these are listed in Table 13. The totals for the area source emissions in the OSO region can be seen in Table 14. As can be seen area-source emissions of VOCs in the OSO area are substantial.

The largest contributor of VOCs amongst the area sources was the chemicals and paint category, which comprised 47% of the area source total. The chemical solvent sub-category accounted for approximately half of that source with VOC emissions of 7,365 tons per year. The majority of area-source $NO_x$ emissions came from residential heating. There are about 53,000 homes in central Florida that use fossil fuels (mostly natural gas, propane, and No. 2 oil) for home heating. Open burning (yard waste and construction land clearing biomass) can produce both VOCs and $NO_x$ but in 2008 both Orange and Seminole counties had open burning bans, so emissions of both pollutants were low in 2008. Emission totals for area sources (by category) can be seen graphically in Figure 15 and Figure 16.

**Table 13 - List of categories included in area sources**

| Area Source Category | Sub-categories |
|---|---|
| **Coatings** | Architectural coatings<br>Industrial maintenance coatings<br>Other special purpose coatings<br>Surface coatings |
| **Chemicals and Paints** | Consumer solvents<br>Degreasing<br>Dry cleaning<br>Graphic arts (smaller print shops)<br>Pesticide application<br>Traffic paints |
| **Gasoline and Fuels** | Aviation gasoline distribution stages 1 and 2<br>Gasoline distribution – stage 1<br>Portable fuel containers<br>Residential heating<br>Stage 2 gasoline refueling |
| **Cooking** | Commercial cooking |
| **Asphalt** | Cutback asphalt (small operations)<br>Emulsified asphalt (small operations) |
| **Land Clearing*** | Land clearing |
| **Burning*** | Household waste burning<br>Open burning – yard waste |

*"Land clearing" includes emissions from open burning of land clearing debris (brush, stumps, trees) that remains after clearing land for construction of new homes, or other facilities. "Burning" means specifically homeowner burning of brush, branches, stumps, and other yard or household waste.

Table 14 - 2008 Area Source Emission Totals for OSO

| Sub-category | VOC, tons/yr | $NO_x$, tons/yr |
|---|---|---|
| **Asphalt** | 67 | 0 |
| **Burning** | 51 | 33 |
| **Chemicals and Paints** | 14,519 | 0 |
| **Coatings** | 5,229 | 0 |
| **Cooking** | 63 | 0 |
| **Gasoline and Fuels** | 10,719 | 125 |
| **Land Clearing** | 1 | 1 |
| **TOTALS** | **30,648** | **158** |

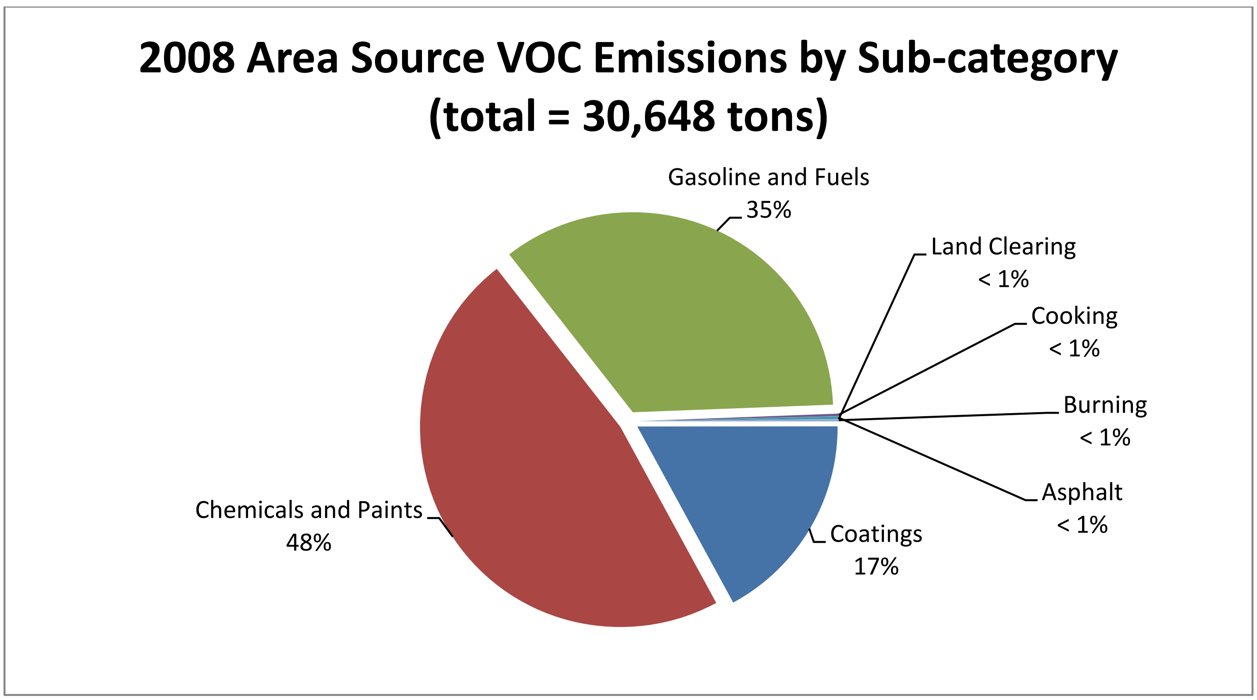


Figure 15 - 2008 Area source VOC contributions by source for the OSO area

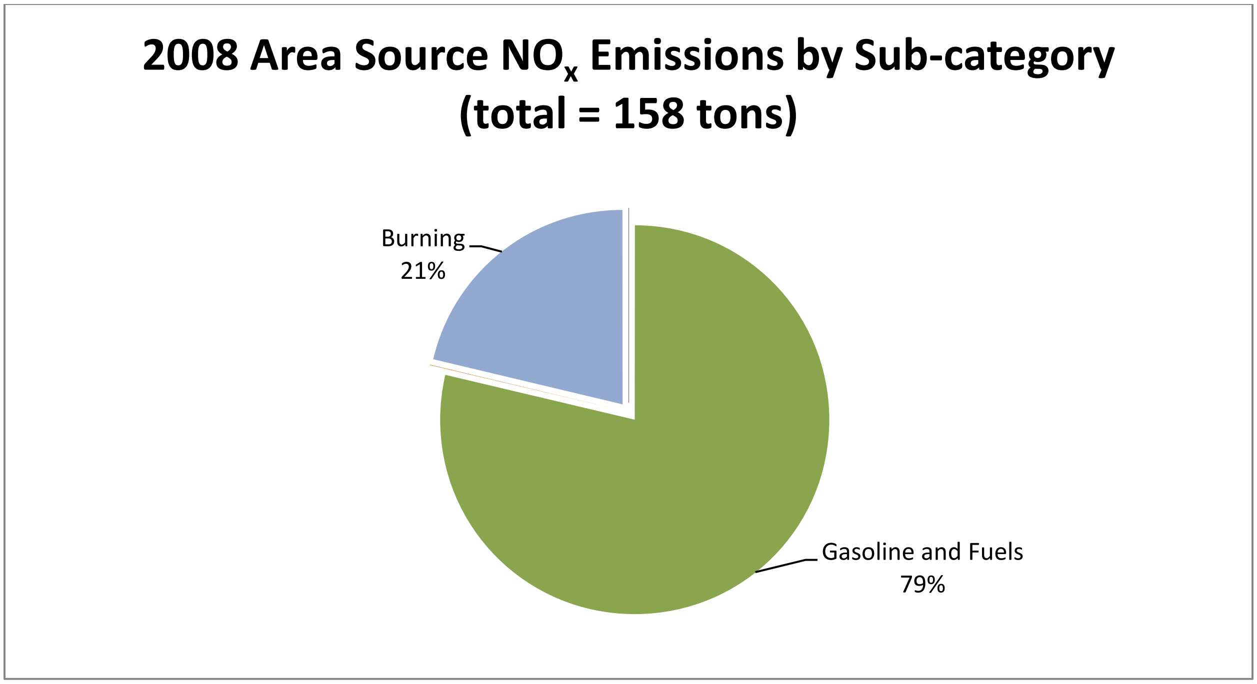


Figure 16 - 2008 Area source $NO_x$ contributions by source for the OSO area

## Conclusions and Recommendations

Central Florida is at risk of becoming ozone non-attainment. The current standard set by the EPA is 75 ppb and Orange County is close to that at 71 ppb. Since the new ozone regulations would be based on recent data, if the EPA sets the new standard between 60 and 70 ppb, as is expected, then OSO will become non-attainment. Orange, Seminole, and Osceola Counties are treated as one airshed (along with Lake County). If one county goes into non-attainment, the other counties also become non-attainment. The action steps outlined in this report provide options for local leaders for steps that can be taken to reduce emissions. The steps have varying costs and levels of effectiveness. This report has provided central Florida decision makers with a variety of action steps that can be taken prior to or shortly after OSO becomes non-attainment for ozone. Implementing some of these proposed steps will help OSO to achieve its goal of maintaining attainment status, and possibly preventing going into non-attainment in the future. Based on a recent emissions inventory (Ross and Cooper, 2010), the major sources of VOCs and $NO_x$ 0in OSO are as shown in Table 15 and Table 16, respectively.

**Table 15 - Major VOC contributors by source type**

| Source Type | Source | VOCs (tons/year) |
|---|---|---|
| **On-road** | Small pickups and SUVs (LDGT12) | 8,228 |
| | Passenger cars (LDGV) | 8,186 |
| | Big pickups and SUVs (LDGT34) | 4,774 |
| **Non-road** | Pleasure Craft | 6,339 |
| | Lawn and Garden Equipment (comm) | 3,575 |
| | Lawn and Garden Equipment (resid) | 1,714 |
| **Point** | Airports | 473 |
| | Food Production | 297 |
| | Surface Coating Operations | 249 |
| **Area** | Chemicals and Paints | 14,519 |
| | Gasoline and Fuels | 10,719 |

**Table 16 - Major $NO_x$ contributors by source type**

| Source Type | Source | $NO_x$ (tons/year) |
|---|---|---|
| **On-road** | Big diesel trucks & buses (HDDV) | 17,791 |
| | Small pickups and SUVs (LDGT12) | 7,310 |
| | Passenger cars (LDGV) | 6,096 |
| **Non-road** | Construction and Mining Equipment | 6,796 |
| | Industrial Equipment | 934 |
| | Commercial Equipment | 771 |
| **Point** | Power Plants | 8,525 |
| | Airports | 1,469 |
| **Area** | Gasoline and Fuels | 125 |
| | Burning | 33 |

It is the opinion of persons in FDEP that OSO is a $NO_x$-limited area, which means that $NO_x$ emissions reduction strategies should be more heavily targeted than VOC reductions. The main sources of $NO_x$ emissions are on-road vehicles (especially heavy diesel trucks), construction equipment, point sources, and lawn and garden equipment. The majority of steps for $NO_x$ reduction are aimed at these areas and those with a reasonable balance between tonnage reduced and cost should be utilized. The companies who manufacture this equipment are the ones who have the greatest potential to reduce emissions, and many are now being mandated by the EPA to redesign their engines. The most effective steps for $NO_x$ reduction in the OSO area are reducing construction equipment idling by an hour each day, slowing down HDDVs on I-4 and/or restricting their access to the right lanes on I-4, reducing lawn care equipment use by 25%, and possibly implementing an I/M program. Other effective steps require patience rather than action since the EPA has already enacted regulations to greatly reduce non-road mobile source emissions.

However, just because OSO is $NO_x$ limited does not mean that VOC emissions reduction steps can be ignored. The largest contributors of VOCs are area sources, with 48%, followed by on-road mobile sources, with 30%. Personal watercraft and lawn and garden equipment also emit large amounts of VOCs. Reduction measures determined to be most effective include carpooling, S2VR (if it can be implemented quickly), reducing lawn care equipment use by 25%, considering an I/M program, and banning the use of gasoline-powered leafblowers and vacuum trucks. Area source emissions reduction steps were not included in this report, however their major contribution to overall emissions warrants further investigation of reduction methods. Since area sources are comprised of many relatively small operations, direct regulation is difficult and thus, creative strategies may be required in order to make progress at reducing emissions from this sector.

In order to maximize the efficient use of funds spent on emissions reduction, the action steps should be evaluated with two objectives in mind. First, what are the steps that can be used to achieve large reductions? Second, what are the steps that have the best “bang for the buck” in terms of cost per ton averted? The best way to deal with emissions is to plan ahead and design for minimal emissions. Building homes and apartments near office space encourages people to live near where they work, and will reduce commute trip distances and emissions. Designing roads to allow for public transportation to be implemented promotes the use of such systems. Avoiding urban sprawl slows the growth of VMT thereby reducing commuter emissions. These are just examples of things that can be done in advance which will help keep OSO in ozone attainment and ideally render the steps discussed in this report unnecessary.

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**MetroPlan Orlando**
**315 East Robinson Street, Suite 355**
**Orlando, Florida 32801**
**(407) 481-5672**
**www.metroplanorlando.com**