DOCUMENTATION OF INPUT FACTORS FOR THE NEW OFF-ROAD MOBILE SOURCE EMISSIONS INVENTORY MODEL

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EXECUTIVE SUMMARY

E.1 OVERVIEW

Off-road mobile source emissions have been difficult to estimate because of a lack of detailed knowledge of their population, use and emission characteristics. The Air Resources Board has historically relied on an in-house inventory model to estimate emissions from such sources, but recent improvements in the knowledge base have made the model outdated. Manyof the recent improvements in the understanding of off-road mobile source emissions have come as a result of new regulatory initiatives by ARB, to a lesser extent the Environmental Protection Agency, to control emissions from various categories of off-road mobile sources. The goal of this effort was to develop a new, more comprehensive model of off-road emissions, one that incorporates all of the knowledge that has become available in the 1990s.

The term "off-road mobile sources" covers a wide variety of equipment types, not all of which are represented in the existing ARB inventory model. For this study, the equipment types are grouped into 14 categories, where each category includes a range of equipment used by a particular industry or for a similar purpose. Four categories are not modeled, and their emissions are represented simply as numbers within the new model. These categories are: (1) Commercial and government vessels, (2) Locomotive and rail operations, (3) Commercial, military and general aviation aircraft, and, (4) Agricultural aircraft. In the other 10 categories, there are detailed representations of each equipment type (where a particular equipment type performs a specific operation, e.g. lawnmowers for cutting grass) for a total of 85 types of equipment.

In each case, the exhaust emissions inventories are calculated from the simple formula for pollutant type, P, and equipment type, i, and vintage, v.

$$P_i = \Sigma_v \ \text{Population}_v \ * \text{use hours} \ * \text{work output/hr} * (\text{emissions/unit of work})_v$$

Evaporative emissions are calculated from knowledge of fuel properties, equipment tank size, total annual fuel use, and the number of use cycles. Most of the effort in this contract was to develop detailed data at the equipment type level on all of the variables needed to calculate emissions. The documentation of the source code and use of the computer program of the Off-Road Mobile Source Inventory Model are provided in companion volumes to this report entitled "Source Code Documentation of the Motor Vehicle Off-Road Model" and "User's Guide to the Off-Road Model" by Systems Applications, Inc.

E.2 DATA

This report is a detailed documentation of the data utilized for the calculation of the emissions inventory by equipment type at the county level for California. A brief overview of the data sources and methods employed is provided below.

The approach used to estimate emissions in this model is to subdivide each equipment type into engine types, where a particular engine type is defined by its fuel use, engine horsepower (HP) rating (in ranges), operation type (2-stroke or 4-stroke) and, in some cases, technology type (e.g. side-valve or overhead valve). The same engine type can be found in several categories of equipment and in various equipment types within a category. Hence, emissions per unit of work are estimated at the engine type level, while the other variables of population, use hours and work output per hour (as represented by the load factor) are specific to equipment type and engine type. Engines are divided into three fuel types: diesel, gasoline, and CNG/LPG, while gasoline engines are further subdivided into 2-stroke and 4-stroke types. Each of these engine types is further subdivided into HP ranges: 9 for diesel, 3 for 2-stroke gasoline and 10 each for 4-stroke gasoline and CNG/LPG engines, for a total of 32 types. In addition, some of these 32 types also include additional technology classifications such as side valve/overhead valve for gasoline 4-stroke engines up to 50 HP, and direct injection/indirect injection for diesel engines.

As a result of the subcategorization of engines, and the large number of equipment types, the data needs for such a model are very high. The executive summary merely provides a broad outline of the methods used to obtain the data and provide a validation where possible. The major data sources are:

- Previous studies by the ARB on specific categories of equipment
- The EPA Non-road Engine and Vehicle Emissions Study (NEVES)
- Engine and equipment manufacturer submissions to the ARB and EPA, or directly to EEA
- Power Systems Research (PSR), an independent vendor of non-road equipment sales and population data
- Registration records for those equipment types (e.g. recreational vehicles) that are registered by the California Department of Motor Vehicles

Population estimates are derived from all of the above sources depending on equipment type. Typically, population data for California were available from two or more sources for most equipment types, allowing some validation of data quality. Populations for the state as a whole are the reference total, and these populations are allocated to California counties based on activity indices that vary by category, unless registration data by county are available. For example, Light Commercial Equipment are allocated by the number of wholesale and retail establishments within a county relative to the state total. The distribution of individual equipment types within an equipment category was held to the same percentages as for the state.

Using the examples of Light Commercial Equipment, the percent of generator sets was assumed constant as a fraction of total equipment population of Light Commercial Equipment, and set equal to the fraction of the state total.

Scrappage and sales of new equipment are based on knowledge of the scrappage curve shape developed by PSR. The curve normalizes scrappage to the mean engine life based on use hours, and a particular equipment types' engine and annual use hours determine how quickly it is scrapped from the fleet. This curve is not based on engine life for some equipment types (such as lawn and garden equipment) that are lightly used and scrapped because of equipment age related failures. Sales by year are forecast from the growth rates of the activity indices that allocate equipment populations to counties; these growth rates are an input to the model.

Annual hours of use and load factors are based largely on survey data for the former, and test data for the latter as submitted by manufacturers to EPA, or as provided by PSR. Few alternative independent sources of survey data or average use hours and load factor are available, so the data could not be validated. Seasonality and time-of-day usage is based largely on ARB data from its existing off-road emission inventory model, modified in some instances where seasonality of use was determined by industry association submissions.

Emission factors for exhaust and evaporative emissions are compiled from a range of available test data. Tests have been sponsored by ARB, EPA and by the manufacturers, but the sample of data available for many engine subcategories remains small, typically two to five engine tests. For larger engines over 50 HP, emissions are set to levels equivalent to uncontrolled (pre-1975) on-road engines due to the similarity in technology and engine design. Most test data available were for engines at or near the beginning of their useful life. Deterioration factors for emissions were largely derived from equivalent on-road engine data, although some data were available for small gasoline engines used in lawn and gasoline and in light commercial equipment.

<u>**Evaporative emission factors**</u> are largely unknown for off-road equipment, as few tests have been conducted. Data on diurnal emissions are based on a theoretical model of uncontrolled diurnal emissions. Limited data are available on hot soak, running and refueling loss emissions, and the available data quality is suspect. At this time, the revised inventory model contains place-holders for such emissions, and these should be updated when better and more data become available.

E.3 POTENTIAL FUTURE EFFORTS

There is uncertainty in all inputs for computing off-road emissions, and additional studies to improve data quality would be useful for practically every variable considered. The three areas with the greatest uncertainty are:

- Annual use hours per year, which can be established only by detailed survey of end-users of each equipment type
- Scrappage and replacement patterns, especially for equipment powered by engines under 50 HP
- Evaporative emissions testing, especially for a wide range of hand-held and other lawn and garden equipment types

These areas are the ones where the data needs are most pressing and the current data subject to the most uncertainty.

1. INTRODUCTION

1.1 OVERVIEW

This report documents the input factors utilized in the Off-Road Mobile Equipment Inventory Model, newly developed for the Air Resources Board, and which will replace the current ARB Off-Road Emissions Inventory Model. The new model provides more detailed and comprehensive coverage of most of the off-road equipment catagories. The existing ARB model has categorized off-road equipment into 12 groups, but the existing documentation did not specify all the equipment types covered under one group. In addition, some equipment types appeared to be completely absent from the existing model. The new model includes 14 categories of equipment and also provides detailed lists of all equipment types covered in each category.

Mobile equipment includes all self-propelled or transportable equipment.* Table 1-1 provides a detailed review of the 12 categories in the current ARB model. The largest source of uncertainty is in the category labeled as "light-duty equipment" which appears to be a "catch-all" with no specific or detailed equipment list. Equipment types that appear to be missing (unless they are somehow accounted for under "light-duty equipment") include:

- All terrain vehicles (ATVs)
- Golf cars and personnel carriers.
- Airport ground service equipment
- Railroad refrigeration units
- Small logging and agricultural equipment (engines under 25 HP)

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* Non-self propelled equipment with engines over 50 HP are considered as stationary sources, even if they may be transportable.

TABLE 1-1
INVENTORY CATEGORIES IN CURRENT ARB MODEL

Category	Equipment Covered	Not Covered
Off-Road Vehicles	Recreational motorcycles, snowmobiles, 4WD, boats-diesel, boats-gas, and ATV	Golf cars/Specialty Vehicles
Light-duty Industrial Equipment	25-175 HP gas and diesel nonfarm equipment; 25-500 HP LPG nonfarm equipment	<25 HP gas and diesel nonfarm equipment, <25 HP, >500 HP LPG nonfarm equipment
Heavy-Duty Non-Farm Equipment	175-500 HP gas and diesel nonfarm equipment	>500 HP gas and diesel nonfarm equipment and Airport Ground Service Equipment
Utility Equipment	All gas/diesel residential and commercial utility equipment under 25 HP	Any CNG/LPG equipment
Heavy-Duty Farm Equipment	25-500 HP gas and diesel farm equipment	<25 HP, >500 HP gas and diesel farm equipment; LPG farm equipment
Aircraft, Civil and Military	Aircraft landing and takeoff operations (LTO) under 3000 feet	Non-LTO operations under 3000 feet
Locomotive and Rail Operations	Locomotives used for line haul and yard operations	On train generator sets, refrigeration units
Agricultural aircraft	Crop dusting below 3000 ft not part of LTO	--
Transport Refrigeration Units	Truck and trailer mounted i.c. engine powered units	I.c. engine powered railcar units
Commercial Boats	Boats-diesel and boats-gas	Unregistered boats
Seagoing Vessels	US steam and motor, foreign steam and motor ships maneuvering, berthing and in-transit; tugboats maneuvering	Ships passing the coastline but not entering harbors

The first steps towards developing the new, more comprehensive Off-Road Equipment Inventory Model were to develop a more detailed categorization of equipment and a more comprehensive list of equipment types under each category. This resulted in the development of 14 categories of equipment, many of which closely parallel the categories defined in the existing model. However, the category labeled "Utility Equipment" in the existing model has been dissagregated into "Lawn and Garden Equipment" and "Light Commercial" in the new model. New categories have also been created for Logging Equipment and Airport Ground Service Equipment, and these equipment types may be included in the existing ARB model under "Light-Duty Equipment" or "Heavy-Duty Equipment".

A detailed list of all equipment types covered under each of the 14 equipment categories is provided in Table 1-2. Except for the Light Commercial Equipment category and for certain types of other equipment noted in Table 1-2, none of the equipment categories were restricted by engine horsepower rating. The objective of the model was to develop a detailed estimate of emissions inventory by county at the equipment type level. However, it should be noted that four categories of equipment, namely:

- Locomotive and Rail Operations
- Commercial and Government Vessels
- Aircraft Operations
- Agricultural Aircraft Operations

are not modeled, but a detailed baseline emissions inventory estimate is included for each county as a simple number. Piston engines, whether powered by gasoline, diesel fuel, or liquid petroleum gas (LPG), are the only engines modeled in all of the equipment categories where detailed population and use data were collected. However, emissions from all propulsion systems, including turbine engines and boilers, are included in the above four equipment categories.

TABLE 1-2
LIST OF EQUIPMENT BY CATEGORY*

1. Lawn and Garden Equipment

    1. Trimmers/Edgers/Brush Cutters
    2. Lawn Mowers
    3. Leaf Blowers/Vacuums
    4. Rear Engine Riding Mowers
    5. Front Mowers
    6. Chain Saws <5 HP
    7. Shredders <5 HP
    8. Tilers <5 HP
    9. Lawn and Garden Tractors
    10. Wood Splitters
    11. Snow Blowers
    12. Chippers/Stump Grinders
    13. Commercial Turf Equipment
    14. Other Lawn and Garden Equipment

2. Light Commercial Equipment (0-50 HP)

    1. Generator Sets
    2. Pumps
    3. Air Compressors
    4. Gas Compressors
    5. Welding Machines
    6. Pressure Washers

3. Recreational Equipment

    1. All Terrain Vehicles (ATVs) (3&4 wheel vehicles)
    2. Off-road Motorcycles
    3. Golf Carts
    4. Specialty Vehicles/Carts
    5. Snowmobiles
    6. Minibikes

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* Unless specified, all horsepower ranges and engine types are covered in each equipment category

TABLE 1-2
LIST OF EQUIPMENT BY CATEGORY (cont'd)

4. Industrial Equipment

    1. Aerial Lifts
    2. Forklifts
    3. Sweepers/Scrubbers
    4. Other General Industrial Equipment
        - Abrasive Blasting Equimpment
        - Industrial Blowers/Vacuums
        - Marine/Industrial Winches and Hoists
        - Multipurpose Tool Carriers
        - Other Misc. Industrial Equipment (Catch All)
    5. Other Material Handling Equipment
        - Conveyors
        - Other Misc. Material Handling (Catch All)
        - Industrial Tractors

5. Construction and Mining Equipment

    1. Asphalt Pavers
    2. Tampers/Rammers
    3. Plate Compactors
    4. Concrete Pavers
    5. Rollers
    6. Scrapers
    7. Paving Equipment
    8. Surfacing Equipment
    9. Signal Boards
    10. Trenchers
    11. Bore/Drill Rigs
    12. Excavators
    13. Concrete/Industrial Saws
    14. Cement and Mortar Mixers
    15. Cranes
    16. Graders
    17. Off-Road Trucks
    18. Crushers/Proc. Equipment

TABLE 1-2
LIST OF EQUIPMENT BY CATEGORY (cont'd)

5. Construction and Mining Equipment (cont'd)

    19. Rough Terrain Forklifts
    20. Rubber Tire Loaders
    21. Rubber Tire Dozers
    22. Tractor/Loaders/Backhoes
    23. Crawler Tractors
    24. Skid Steer Loaders
    25. Off-Road Tractors
    26. Dumpers/Tenders
    27. Other Construction Equipment

6. Farm Equipment

    1. 2-Wheel Tractors
    2. Agricultural Tractors
    3. Agricultural Mowers
    4. Combines
    5. Sprayers
    6. Balers
    7. Tillers >5 HP
    8. Swathers
    9. Hydro Power Units
    10. Other Agricultural/Farm Equipment

7. Logging Equipment

    1. Chain Saws >5 HP
    2. Shredders >5 HP
    3. Log Skidders
    4. Fellers/Bunchers

8. Airport Ground Support Equipment

    1. Airplane Tow Tractors
    2. Baggage/Cargo Tow Tractors
    3. Ground Power Units

TABLE 1-2
LIST OF EQUIPMENT BY CATEGORY (cont'd)

8. Airport Ground Support Equipment (cont'd)

    4. Start Units
    5. Deicing Units
    6. Load Lifting and Handling
    7. Service Utility Carts
    8. Pressure Washers

9. Pleasure Craft

    1. Inboard Powerboats <250 HP
    2. Outboard Powerboats
    3. Sterndrive Powerboats
    4. Inboard Sail-Auxiliary
    5. Outboard Sail-Auxiliary

10. Commercial and Government Vessels

    1. Commercial Inboard Boats >250 HP
    2. Commercial In/Outboard Boats
    3. Commercial Tug Boats
    4. U.S. Coast Guard Boats
    5. Seagoing Vessels
        a. Motorships
        b. Steamships

11. Transport Refrigeration Units

    1. Small Units <25 HP
    2. Large Units >25 HP

12. Locomotive and Rail Operations

    1. Line Haul Operations
    2. Yard Operations

TABLE 1-2
LIST OF EQUIPMENT BY CATEGORY (cont'd)

13. Aircraft: Commercial, Military, and General Aviation

    1. Landing and Takeoff Operations (LTO)

14. Agricultural Aircraft

    1. Aircraft Operations Below 3,000 ft.

1.2 METHODOLOGY

The calculation of the emission inventory in year y, from equipment type i for pollutant P is:

$$P_i = \sum_{v} \text{Population}_{i,v} * \text{Emission Factor}_{i,v} * \text{Use Hours}_{i,v}$$

where v is the vintage (or age) of equipment, and emission factors for pollutant P are specified per use hour by equipment vintage. In the new model, further subdivisions are made first by fuel type, and also by horsepower range. These subdivisions are required to create relatively homogenous subgroups within each equipment type in terms of emissions and use characteristics. Some emissions such as those due to fuel evaporation or due to refueling spillage are not directly linked to use hours, but can be accounted for on a seasonal or daily basis. Nevertheless, the basic elements of the calculation at each subcategory level utilizes the same form of equation, and calculation of the total inventory requires summations over horsepower ranges, fuel types, and vintages within equipment types, and across all equipment types.

The methodology also utilizes a "top down" approach in that populations are specified for the total state of California and use hours specified on an annual basis. These total California populations of equipment types are than allocated to counties by equipment category using "activity" indicators, while the use is allocated seasonally, by day of week and temporally, using exogenously determined allocation indices.

This report provides detailed documentation for all the data and the sources utilized to compile population, use, scrappage, allocation by county, temporal allocation, and emission factors at the equipment type or engine type level. The calculation methodology and details of the Off-Road Model's operation are found in companion volumes[1,2] to this report.

1.3 PRINCIPLE DATA SOURCES

Although the data presented in this report are derived from a large number of sources, including confidential manufacturer submissions to EEA, five sources were used to generate a large percentage of all of the data presented here.

EPA's Non-Road Equipment and Vehicle Emissions Study (NEVES) is a relatively comprehensive source of information for all variables of interest, since that study was intended to develop a nationwide inventory of emissions from off-road mobile sources for 1990. EEA supported the NEVES, and this report essentially uses the NEVES equipment categories and types.

Power Systems Research (PSR) is a major source of population and use data for most equipment types. Unlike the other sources of information, the PSR data base is proprietary and therefore not subject to the same degree of public scrutiny as other non-confidential sources. However, EEA has checked population estimates for a range of equipment types against other sources, including equipment manufacturer estimates, and found PSR data to be within ±5 percent of what could be considered as the most likely estimate for larger equipment (engines over 25 HP).

EEA also relied on three other studies conducted for the ARB in the 1988-1992 timeframe that address Lawn and Garden/Utility Equipment[3], Light Duty Equipment in the 25 to 50 HP range[4], and Heavy-Duty Construction Equipment[5]. The Light Duty and Heavy Duty reports have, in turn, relied on PSR estimates for populations of several equipment types. Data from these five sources have been supplemented with data from numerous other sources referenced in the following sections.

REFERENCE

1. User's Guide to the Offroad Model (OFFROAD), Systems Applications International for the California Air Resources Board, June 1995.

2. Source Code Documentation of the Offroad Model (OFFROAD) - Systems Applications International for the California Air Resources Board, June 1995.

3. Technical Support Document for California Exhaust Emissions Standards and Test Procedures for 1994 and Subsequent Model Year Utility and Lawn and Garden Equipment Engines, Booz-Allen and Hamilton, Inc. for the California Air Resources Board, 1990.

4. Regulatory Strategies for Off-Highway Equipment, Energy and Environmental Analysis, Inc. for the California Air Resources Board, January 1992.

5. Feasibility of Controlling Emissions from Offroad, Heavy Duty Construction Equipment - Final Report, Energy and Environmental Analysis, Inc. for the California Air Resources Board, December 1988.

2. CALIFORNIA EQUIPMENT POPULATION AND USE

2.1 INTRODUCTION

This section discusses the estimated equipment population and use data that comprise the 1990 baseline for the offroad equipment model. State population estimates for nine broad categories of equipment covering more than 75 equipment types were developed using several sources, and annual hours of use and operating load factor estimates associated with each type of equipment were also developed. The methodologies used to allocate the state equipment populations to the county level are also discussed in this section, and the county activity indicators for each equipment type are displayed in Appendix C.

2.2 POPULATION DATA SOURCES

Power Systems Research (PSR) is the source for much of the state population estimates that are used in the new offroad emissions model. PSR compiles engine population data through a process which has been developed over a period of several years. PSR attempts to maintain an engine sales record for every engine make and model installed in original equipment in North America, and they compile a record of each imported engine driven product delivered to North America. The combined records are an estimate of the total number of engines originally placed into service in North America.

The combined population is adjusted by the number of engine-driven products produced in North America or imported to North America that are subsequently exported. This includes both new and used equipment. The source of the export information is primarily the U.S. Department of Commerce export records. These records are used to annually adjust the units in operation by the number of exported engine-driven products within a specific SIC code. The PSR data base closely match the SIC codes, but the government data do not distinguish between gasoline and diesel power, and in many cases horsepower is not specified. PSR makes assumptions on these segmentations based upon their investigations of typical export shipments. After these adjustments are made, PSR has an estimate of the number of engine-driven products placed into service in North America.

The number of engine-driven products in service at any time is calculated through the use of attrition or scrappage curves, which are discussed in Section 3. The aggregation of the numbers of units in service through the year in question allows PSR to compile the expected units in service at that date. Units in service are initially compiled on a national basis, and geographic distribution is accomplished through use of employment and revenue data ("activity indicators") compiled by the U.S. Bureau of the Census. The state level populations published in this section are developed through this process.

Several other sources of offroad equipment population data were also used in developing the baseline population estimates. Many of these alternative data sources have been reviewed by EEA, ARB, and EPA under previous work efforts, and these sources have much narrower coverage of offroad equipment. However, alternatives to PSR data are preferred for certain equipment types, such as Booz-Allen and Hamilton's estimates of lawn and garden equipment population. These alternative population data sources and the reasons why they were or were not chosen for use in the model are discussed below.

Population data for all types of equipment within the broad equipment categories are presented in tables in the sections that follow. Although the tables show equipment totals, the population data used in the model are disaggregated by average engine horsepower into horsepower groups for each type of equipment. Except for airport ground service equipment, the percentages of equipment type by horsepower group (and average horsepower within the horsepower group) come from PSR, even for equipment where the overall populations are from sources other than PSR. PSR is the only known data source that is able to provide this information. Detailed population data by HP group is provided in Appendix B.

2.3 RECREATIONAL EQUIPMENT

The recreational equipment category includes motorcycles and minibikes, motorcycle-like all terrain vehicles (ATVs), golf cars, specialty vehicles and carts, and snowmobiles. This category excludes any type of vehicle that is used offroad but is also registered for onroad use, such as four wheel drive trucks and sport utility vehicles, and dual purpose motorcycles.

The California Department of Motor Vehicles (DMV) maintains registration data for many types of offroad recreational equipment. Registrations are done on a two year cycle, and recreational vehicles can be registered as active or inactive. Active vehicles are those that the owners have indicated are currently in use, while inactive vehicles are not supposed to be in use. Recreational vehicle registration data for 1990 were obtained from the Public Records Unit of the DMV and are used to represent the baseline population of certain offroad recreational vehicles, as explained below. Inactive registrations are used to represent unregistered recreational vehicles.

2.3.1 Motorcycles and ATVs

In previous versions of the offroad model, ARB estimated the population of motorcycles used off-road by applying percentages of motorcycle type and percentages of motorcycles used off-road to the registered motorcycle population. The percentages of motorcycles by type and the percentages of motorcycles used off-road were determined in a 1985 survey conducted for the Motorcycle Industry Council[1] (MIC), and registration data were provided by the Department of Motor Vehicles. Applying this methodology to data from the 1992 MIC statistical annual[2], the

MIC estimates there were 322,295 on-highway motorcycles, 55,104 dual-purpose motorcycles, and 65,997 off-road motorcycles in use in California in 1990. Further, MIC estimates that nine percent of on-highway motorcycles, 91 percent of dual purpose motorcycles, and 100 percent of off-road motorcycles were used off-road, for a total of 145,149 off-road motorcycles. The MIC estimates the 1990 ATV population, all of which were used off-road, at 197,349.

One problem with this methodology is that it omits unregistered motorcycles, which are thought to be significant. Tyler and Associates, for instance, estimated in 1990[3] that there are about five times as many off-road motorcycles in use as there are registered off-road motorcycles. The Tyler population estimates, which were developed from telephone surveys of randomly selected California residents, clearly do not agree with industry data.

Neither methodology is appropriate for use in the model, as both Tyler and the MIC methodology double count emissions from onroad motorcycles used offroad, which are accounted for by the EMFAC mobile source emissions factors model. Since active and inactive offroad motorcycle and ATV registration data from the DMV are thought to be reasonable estimates of registered and unregistered offroad motorcycles and all terrain vehicles, they used in the new model, as shown in Table 2-1. (Note: As of 7/31/90, California DMV reported that 46 percent of motorcycle and ATV registrations were inactive.) Load factor data are from PSR, and annual use data are from the MIC.

Allocating motorcycle usage to the county level has been done in the past by using the county registration data. This methodology accurately places offroad motorcycles and ATVs for purposes of calculating diurnal evaporative emissions, but it doesn't account for the fact that motorcycles and ATVs are often used outside of the county of registration. One alternative is to allocate usage according to the county share of the state total public land acreage, since public lands are where most off-road riding is done. However, that methodology would overpredict

TABLE 2-1
CALIFORNIA OFFROAD RECREATIONAL VEHICLE POPULATIONS

Equipment Type	Engine Type					
	Gasoline, 2-Stroke			Gasoline, 4-Stroke		
	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours
All Terrain Vehicles (ATV's)	15,604	0.72	20	138,457	0.72	20
Golf Carts	2,975	0.46	400	7,382	0.46	400
Minibikes	0	0.00	0	4,576	0.62	20
Off-Road Motorcycles	266,468	0.76	20	122,529	0.76	20
Snowmobiles	9,340	0.81	90	0	0.00	0
Specialty Vehicle Carts	24,406	0.58	1145	12,478	0.58	1145
Class Total	318,793			285,422		

usage in very rural counties far removed from where the motorcycles and ATVs are garaged. The Tyler report also includes survey results of total off-road fuel use by county, but the fuel use reported in that publication seems unreasonably high, and it includes highway vehicles. Finally, the Off-Road Motor Vehicle Recreation Division of the California Department of Parks and Recreation, is currently developing estimates of offroad recreational vehicle by county, but that information will not be available until 1995 or 1996. Therefore, until an accurate survey of motorcycle and ATV use by county can be obtained, offroad motorcycles and ATVs are allocated to the counties using DMV registration data.

2.3.2 Snowmobiles

ARB's current methodology for calculating in-use populations of snowmobiles consists of applying correction factors (from Tyler) to the registered population of snowmobiles to determine the actual populations in use. Tyler, however, estimates there are seven times as many snowmobiles in use as are registered, which undoubtedly overestimates the number of snowmobiles used in California. The International Snowmobile Industry Association, which represents the major manufacturers of snowmobiles, estimated that the 1990 population of California snowmobiles was between 9,000 and 10,000. The ISIA estimate is based on sales reports from its member companies and an assumed snowmobile life of nine years. The ISIA and DMV numbers are very similar, so the active and inactive registrations reported by the DMV (9,340 registered snowmobiles) are used for the baseline snowmobile population. Load factor (0.81) and annual use estimates (90 hours per year) were obtained from the ISIA[4].

Previously, ARB apportioned snowmobile use to the counties according to fuel usage data collected from snowmobile users by U.C. Davis[5], and that methodology is likely the best available. Diurnal evaporative emissions are most likely to occur in the county of registration, so DMV registration data are used to allocate snowmobiles to the counties for purposes of calculating diurnal evaporative emissions.

2.3.3 Golf Carts and Specialty Vehicles

PSR is the only known source of state population estimates for golf carts and specialty vehicles. Load factor and annual use estimates for California golf carts are from manufacturer submissions to ARB, and specialty vehicles are from the NEVES study. The methodology that was used in the NEVES study to allocate the state population to the county level is the number of motorcycle dealers (SIC 557) in the county. Motorcycle dealers traditionally sell golf carts and specialty vehicles, so the presence of such dealers indicates demand for their services. However, it is recognized that sales of golf carts and specialty vehicles to golf courses and resorts, for instance, may be handled other than through retail channels, so a methodology for allocating golf carts by end user was developed.

The methodology that the model uses to allocate golf cart and specialty vehicle populations to the counties uses data from the publication California Golf[6]. This publication lists addresses for all golf courses and resorts in the state, and identifies which use powered golf carts. It is assumed that the share of gasoline powered golf carts is constant throughout the state. The county allocations are then made according to the counties' share of the state total of golf courses and resorts.

2.4 CONSTRUCTION AND MINING EQUIPMENT

This equipment category is the most diverse in terms of the characteristics of each equipment type. Gasoline and diesel engines from under 15 horsepower to over 250 horsepower are used in the construction and mining industries. PSR is the source for the population estimates of construction equipment that ARB currently uses, and it is the best source for developing the 1990 baseline population estimate, given the diverse nature of the category. The construction and mining categories contain many types of equipment that PSR has tracked for years, and EEA believes that PSR's estimates of California equipment populations are more reasonable than estimates derived by the Construction Industry Manufacturers Association (CIMA). CIMA used construction equipment sales and shipment data for the U.S. for several types of construction equipment covering a period of several years, along with equipment life expectancies from equipment manufacturers and users, to estimate construction equipment populations. CIMA then applied estimated market share percentages for sales to California and subtracted out equipment believed to be used for purposes other than construction to arrive at an estimate of the California construction equipment population.

EEA studied the CIMA population estimates in 1988[7], and it was concluded that the CIMA estimates significantly understated the actual population of equipment in California. CIMA used short life expectancies and underestimated the percentage of California's share of the U.S. construction equipment market by about one-half. The PSR population estimates for this category are more consistent with the use and scrappage data developed by EEA from a survey[7] and also with California's share of U.S. construction activity. Therefore, PSR data are used in the new model. Load factors and use hours also come from PSR, as shown in Table 2-2.

ARB has previously used construction permit valuation and mining production valuation to allocate construction and mining equipment to the county level. For the NEVES study[8], EEA determined that the number of construction employees is the preferred indicator of the population of construction equipment at the state level. The results of the regression of construction employees versus construction equipment population for different states are shown in Table 2-3, and it is seen that the constant, at -4.566 with a standard error of 7.867, is not statistically different from zero at the 90 percent confidence level. The independent variable (total construction employees) has a coefficient of 0.501 and a standard error of 0.037, and is statistically significant at better than 99 percent confidence. The regression, with an adjusted R-squared value of 0.890 and an F-ratio of 178.8, explains almost all of the observed variations in construction equipment populations. Therefore, the percentage of the state total of construction employees within each county is used by itself to allocate construction equipment to the county level. Construction employment by county comes from the U.S. Census Bureau's County Business Patterns[9] publication.

All construction equipment over 500 horsepower are assigned to the county level on the basis of mining employment only, as the mining industry has a much greater use for these equipment than the construction industry.

2.5 INDUSTRIAL EQUIPMENT

Industrial equipment consists mainly of materials handling equipment such as aerial lifts and industrial lift trucks (i.e., forklifts). Many of these pieces of equipment are used indoors in warehouses and on factory floors, and consequently, LPG is used extensively. The engines in industrial equipment also cover a wide horsepower range - from under 25 horsepower to over 250 horsepower.

PSR and the Industrial Truck Association (ITA) are the best sources of industrial lift truck (i.e., fork lifts) population estimates, and their respective population estimates are very similar for gasoline and LPG lift trucks. However, the two organizations disagree on the number of diesel powered lift trucks, with PSR estimating there are about three times as many in California as ITA believes. The reasons for this discrepancy are two-fold: First, Power Systems believes that the ITA does not represent the majority of the diesel lift truck market, and therefore underestimates the annual sales of diesel powered lift trucks. (However, ITA claims to represent 95 percent of the total lift truck market, including both electric and internal combustion powered lift trucks.) Second, ITA predicts faster turnover than PSR, as ITA assumes an eight year life expectancy for diesel lift trucks, and PSR assumes a 12 year expected life. Under-predicting sales and equipment life necessarily results in an under-prediction of population. Therefore, as the ITA

TABLE 2-2
CALIFORNIA CONSTRUCTION EQUIPMENT POPULATIONS

Equipment Type	Engine Type								
	Diesel			Gasoline, 2-Stroke			Gasoline, 4-Stroke		
	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours
Asphalt Pavers	1,320	0.62	396	0	0.00	0	381	0.66	396
Bore/Drill Rigs	581	0.75	541	0	0.00	0	384	0.79	248
Cement and Mortar Mixers	532	0.56	300	0	0.00	0	27,626	0.59	92
Concrete Pavers	732	0.68	130	0	0.00	0	0	0.00	0
Concrete/Industrial Saws	17	0.73	592	0	0.00	0	4,323	0.78	622
Cranes	7,771	0.43	796	0	0.00	0	255	0.47	411
Crawler Tractors	28,172	0.58	1048	0	0.00	0	0	0.00	0
Crushing/Proc. Equipment	1,235	0.78	1146	0	0.00	0	98	0.85	289
Dumpers/Tenders	23	0.38	662	0	0.00	0	1,869	0.41	149
Excavators	6,168	0.57	893	0	0.00	0	2	0.53	393
Graders	7,832	0.61	821	0	0.00	0	0	0.00	0
Off-Road Tractors	3,574	0.65	975	0	0.00	0	0	0.00	0
Off-Road Trucks	914	0.57	1836	0	0.00	0	0	0.00	0
Other Construction Equipment	1,275	0.62	612	0	0.00	0	119	0.48	375
Paving Equipment	5,826	0.53	709	0	0.00	0	20,166	0.59	200
Plate Compactors	313	0.43	600	259	0.55	206	10,596	0.55	206
Rollers	11,621	0.56	745	0	0.00	0	2,449	0.62	621

TABLE 2-2
CALIFORNIA CONSTRUCTION EQUIPMENT POPULATIONS
(Continued)

Engine Type	Engine Type								
	Diesel			Gasoline, 2-Stroke			Gasoline, 4-Stroke		
	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours
Rough Terrain Forklifts	7,217	0.60	761	0	0.00	0	298	0.63	475
Rubber Tired Dozers	244	0.59	1016	0	0.00	0	0	0.00	0
Rubber Tired Loaders	27,154	0.54	875	0	0.00	0	445	0.54	569
Scrapers	3,947	0.72	1005	0	0.00	0	0	0.00	0
Signal Boards	2,688	0.50	750	0	0.00	0	132	0.50	284
Skid Steer Loaders	8,516	0.55	843	0	0.00	0	16,039	0.58	319
Surfacing Equipment	0	0.00	0	0	0.00	0	5,301	0.49	503
Tampers/Rammers	0	0.00	0	3,021	0.55	182	140	0.55	182
Tractors/Loaders/ Backhoes	38,837	0.55	1146	0	0.00	0	177	0.48	879
Trenchers	5,916	0.75	640	0	0.00	0	3,126	0.66	434
Class Total	172,425			3,280			93,926		

TABLE 2-3

RESULTS OF REGRESSING CONSTRUCTION EQUIPMENT POPULATION VS. TOTAL CONSTRUCTION EMPLOYMENT

MODEL PSRCLS7 = a + b(EMPCST)

PSRCLS7 = PSR STATE EQUIPMENT POPULATIONS FOR ALL CONSTRUCTION EQUIPMENT (x1000)

EMPCST = TOTAL CONSTRUCTION ACTIVITY (EMPLOYEES) (x1000)

DEP VAR: PSCRCLS7 N: 23 MULTIPLE R: 0.946 SQUARED MULTIPLE R: 0.895

ADJUSTED SQUARED MULTIPLE R: 0.890 STANDARD ERROR OF ESTIMATE: 23.878076

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	-4.5660209	7.866897	0.000000		-0.58043	0.56780
EMPCST	0.501182	0.037480	0.945991	1.00000	0.13e+02	0.00000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	.101949E+06	1	.10194E+06	178.807047	0.000000
RESIDUAL	.119734E+05	21	570.162510		

Source: Reference 8

and PSR estimates of gasoline and LPG lift trucks are similar to each other, and as PSR's diesel lift truck population estimate appears to be the more reasonable of the two estimates, PSR's data for industrial equipment population are used in the new model. Load factors and use hours are also from PSR. The 1990 California population of industrial equipment is shown in Table 2-4.

Industrial equipment are used in various manufacturing activities, and as shown in Table 2-5[9], the NEVES suggested that the number of employees in manufacturing was a good predictor of the industrial equipment population. Consequently, the number of employees engaged in manufacturing at the county level as a percent of the state manufacturing employment is used to allocate the state equipment populations to the counties.

2.6 LAWN AND GARDEN EQUIPMENT

Booz-Allen and Hamilton, Inc.[10] has performed the most comprehensive study of California lawn and garden equipment population and use patterns. The BAH study was based on information provided by lawn and garden equipment manufacturers, small engine manufacturers, and trade associations such as the Outdoor Power Equipment Institute (OPEI).

PSR data for lawn and garden equipment populations in California are not considered representative of the true population, as a recent review[11] of PSR's lawn and garden equipment populations indicated that the methodology PSR uses to apportion the national lawn and garden equipment population to the state level is not appropriate for states such as California, where lot sizes are smaller than the national average, and the climate for large parts of the state, including the major population centers in Southern California, is semi-arid.

The Booz-Allen estimates (Reference 1) of state-wide lawn and garden equipment populations, on the other hand, are in general agreement with information provided by the equipment manufacturers and other sources. BAH apportioned the state totals to the county and air basin levels based on the number of single family housing units (SFHU) in each county as a percentage of the state total of SFHU. This index does not seem appropriate when allocating the national population to state levels because of the variability in equipment population per household that is observed across different regions of the U.S. However, this index may be appropriate for allocating the state population of residential equipment to the county level, as the household population of lawn and garden equipment is approximately constant for single family housing units across the state.

Some households, however, may use landscaping services and, own little if any lawn and garden equipment. Apartment complexes and office buildings typically rely on landscaping services to meet their lawn and garden needs. Therefore, the number of employees in Landscape and Horticultural Services is also used to allocate state populations of lawn and garden equipment to the county level. The equation that relates single family houses and SIC 78 (employees) to lawn and garden equipment population, which was developed for NEVES, is used in the model. That equation is:

Lawn/Garden Equipment population = 1.205(SFHU) + 173.442(SIC 78 Employees)

ARB proposed modifying the county allocations of lawn and garden equipment through the application of county specific average household water use, the rationale being that deviations from the state average would indicate more or less gardening activity. However, the water usage data were not available in time to include them in the model.

The Booz-Allen study did not estimate the population of commercial front mowers, wood splitters, chippers/stump grinders, miscellaneous equipment, or diesel powered lawn and garden equipment by type. PSR data were used to estimate the California populations of these types of lawn and garden equipment. Load factor and use estimates come from the source of the population estimates (i.e., Booz-Allen for most equipment, PSR for diesel and selected gasoline equipment). The 1990 baseline lawn and garden equipment population is listed in Table 2-6.

TABLE 2-4
CALIFORNIA INDUSTRIAL EQUIPMENT POPULATIONS

Equipment Type	Engine Type											
	CNG/LPG			Diesel			Gasoline, 2-Stroke			Gasoline, 4-Stroke		
	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours
Aerial Lifts	1,712	0.46	375	1,505	0.46	399	0	0.00	0	1,712	0.46	750
Forklifts	13,125	0.30	1818	18,514	0.30	1717	0	0.00	0	6,534	0.30	1818
Industrial Tractors	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00	0
Other General Industrial Equipment	0	0.00	0	1,831	0.51	1071	87	0.54	375	1,801	0.54	870
Other Material Handling Equipment	0	0.00	0	649	0.59	455	0	0.00	0	252	0.53	417
Sweepers/Scrubbers	0	0.00	0	4,589	0.68	1293	0	0.00	0	3,069	0.71	547
Class Total	14,837			27,088			87			13,368		

TABLE 2-5

RESULTS OF REGRESSING INDUSTRIAL EQUIPMENT POPULATION VS. TOTAL MANUFACTURING EMPLOYMENT

MODEL: PSRCLS6 - a + b(EMPMFG)

PSRCLS6 - PSR STATE EQUIPMENT POPULATIONS FOR CLASS 6 (x1000)

EMPMFG - TOTAL MANUFACTURING ACTIVITY (EMPLOYEES) (x1000)

DEP VAR: PSRCLS6 N: 23 MULTIPLE R: .966 SQUARED MULTIPLE R: .934

ADJUSTED SQUARED MULTIPLE R: .930 STANDARD ERROR OF ESTIMATE: 2.734937

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	-0.379266	0.927407	0.000000	.	-0.40895	0.68671
EMPMFG	0.020828	0.001212	0.966237	1.00000	.17E+	0.00000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	2209.064094	1	2209.064094	295.334044	0.000000
RESIDUAL	157.077543	21	7.479883		

Source: Reference 8

TABLE 2-6
CALIFORNIA LAWN AND GARDEN EQUIPMENT POPULATIONS

Equipment Type	Engine Type								
	Diesel			Gasoline, 2-Stroke			Gasoline, 4-Stroke		
	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours
Chainsaws <=5 HP	0	0.00	0	518,048	0.50	83	0	0.00	0
Chippers/Stump Grinders	25	0.37	516	0	0.00	0	572	0.39	512
Commercial Turf Equipment	9,673	0.50	1239	1,187	0.50	800	10,682	0.50	800
Front Mowers	0	0.00	0	0	0.00	0	73,052	0.50	50
Lawn & Garden Tractors	35,701	0.50	317	0	0.00	0	39,202	0.50	60
Lawn Mowers	0	0.00	0	159,157	0.36	55	1,989,369	0.36	36
Leaf Blowers/Vacuums	0	0.00	0	345,564	0.50	46	3,639	0.36	87
Other Lawn & Garden Equipment	24	0.50	197	49,644	0.50	79	128,356	0.50	79
Rear Engine Riding Mowers	685	0.38	48	0	0.00	0	24,377	0.38	49
Shredders <= 5 HP	0	0.00	0	549	0.36	126	10,422	0.36	126
Snowblowers	0	0.00	0	2,110	0.35	17	40,092	0.35	17
Tillers <= 5 HP	0	0.00	0	3,637	0.40	25	787,110	0.40	25
Trimmers/Edgers/Brush Cutters	0	0.00	0	941,157	0.50	46	52,979	0.36	60
Wood Splitters	0	0.00	0	0	0.00	0	62,209	0.50	20
Class Total	46,108			2,021,053			3,222,061		

2.7 FARM EQUIPMENT

There are many different types of farm (agricultural) equipment in use, and some of these are designed for specific applications. However, the vast majority of farm equipment belong to the agricultural tractor and tiller categories. Other specialized equipment, such as nut harvesters and tomato harvesters, which are generally not used for any purpose other than their intended task, can be grouped under the "other" category. The farm equipment population category is dominated by diesel engines, with the exception of the light duty gasoline engines used in tillers.

Some farm equipment population data other than that from PSR are available, such as data from the Bureau of the Census and sales data from the Equipment Manufacturers Institute (EMI). EMI submitted some estimates of farm equipment sales and population for the Inventory B used in EPA's NEVES, and an example of the sales data provided by EMI is shown in Table 2-7. However, EMI's sales data do not exist prior to 1980, and their estimates of equipment populations cannot, therefore, rely on the use of equipment sales, scrappage, and engine rebuild/-replacement rates, but are instead based on other data sources. One of those sources is the 1987 Agricultural Census, which compiled national and local counts of certain types of farm equipment. However, the Agricultural Census apparently includes even those equipment that are out of commission, as the farm equipment totals in it exceed all other known estimates by significant amounts.

The PSR data base of farm equipment populations is more defensible and ARB's previous population inventories of California farm equipment have been based on PSR data. Given that the alternative data sources were unreliable, PSR data were also used to develop the farm equipment inventory used in the new offroad model. PSR also provided load factor and annual use estimates. Table 2-8 lists the 1990 baseline farm equipment population for California.

TABLE 2-7

FARM WHEEL TRACTOR RETAIL SALES BY STATE

State	1985 2-wheel Drive	1985 4-wheel Drive	1985 Total Tractors	1986 2-wheel Drive	1986 4-wheel Drive	1986 Total Tractors	1987 2-wheel Drive	1987 4-wheel Drive	1987 Total Tractors	1988 2-wheel Drive	1988 4-wheel Drive	1988 Total Tractors	1989 2-wheel Drive	1989 4-wheel Drive	1989 Total Tractors
Alabama	2,872	2	2,874	3,041	0	3,041	2,943	1	2,944	2,959	2	2,961	4	2,874	2,878
Alaska	39	0	39	22	0	22	20	0	20	12	0	12	0	18	18
Arizona	1,240	29	1,269	657	16	673	638	2	640	677	8	685	20	805	825
Arkansas	3,683	70	3,753	3,154	55	3,209	3,083	31	3,114	3,145	105	3,250	178	3,442	3,620
California	4,931	74	5,005	5,138	73	5,211	4,970	49	5,019	5,963	87	6,050	235	5,971	6,207
Colorado	983	89	1,072	711	50	761	682	59	741	750	98	848	109	795	904
Connecticut	715	1	716	937	0	937	1,091	1	1,092	1,005	0	1,005	0	874	874
Delaware	286	7	293	351	6	357	320	4	324	369	12	381	17	409	426
Florida	4,543	30	4,573	4,732	31	4,763	4,375	55	4,430	4,815	68	4,883	98	4,235	4,333
Georgia	5,242	5	5,247	5,077	6	5,083	5,173	3	5,176	4,644	5	4,649	11	4,491	4,502
Hawaii	126	9	135	142	4	146	149	4	153	194	2	196	4	206	210
Idaho	786	83	869	483	35	518	497	17	514	490	23	513	71	805	876
Illinois	3,327	252	3,579	3,182	155	3,337	3,204	116	3,320	3,070	173	3,243	322	3,364	3,686
Indiana	2,789	113	2,902	2,784	68	2,852	2,712	46	2,758	2,348	100	2,448	195	2,694	2,889
Iowa	1,894	68	1,962	2,022	69	2,091	2,433	64	2,497	2,516	111	2,627	161	2,489	2,650
Kansas	1,739	248	1,987	1,585	134	1,719	1,591	132	1,723	1,778	268	2,046	293	1,767	2,060
Kentucky	3,044	23	3,067	2,643	11	2,654	2,519	8	2,527	2,506	14	2,520	34	2,923	2,957
Louisiana	3,419	66	3,485	2,602	15	2,617	2,430	23	2,453	2,212	66	2,278	79	2,297	2,375
Maine	625	0	625	806	0	806	824	0	824	903	0	903	1	695	696
Maryland	2,139	3	2,142	2,081	1	2,082	2,279	2	2,281	2,022	3	2,025	8	1,869	1,877
Massachusetts	783	0	783	999	0	999	1,188	0	1,188	1,043	2	1,045	0	650	660
Michigan	2,975	74	3,049	3,051	51	3,102	2,624	34	2,658	2,782	56	2,838	104	2,713	2,817
Minnesota	1,714	202	1,916	1,651	183	1,834	1,816	153	1,969	1,777	227	2,004	311	1,965	2,276
Mississippi	3,172	20	3,192	2,516	7	2,523	2,317	16	2,333	2,351	21	2,372	31	2,471	2,502
Missouri	3,159	35	3,194	3,290	38	3,328	3,266	43	3,309	3,268	97	3,365	119	3,056	3,175
Montana	602	122	724	373	103	476	340	76	416	347	79	426	147	443	590
Nebraska	963	63	1,026	1,258	66	1,324	1,314	64	1,378	1,585	90	1,675	146	1,614	1,760
Nevada	113	4	117	102	2	104	99	1	100	87	1	88	3	111	114
New Hampshire	946	0	946	1,139	0	1,139	1,293	0	1,293	1,117	1	1,118	1	725	726
New Jersey	1,062	1	1,063	1,275	0	1,275	1,337	0	1,337	1,395	1	1,396	4	1,068	1,072
New Mexico	529	18	547	418	9	427	444	5	449	456	6	462	9	455	464
New York	3,717	21	3,738	4,065	24	4,089	4,074	6	4,080	3,937	16	3,953	37	3,410	3,447
North Carolina	4,478	9	4,487	4,511	7	4,518	5,334	3	5,337	5,218	4	5,222	27	4,955	4,982
North Dakota	917	351	1,268	892	292	1,184	1,092	223	1,315	623	285	908	397	805	1,202
Ohio	4,537	56	4,593	4,364	67	4,431	4,276	25	4,301	3,758	33	3,791	85	3,783	3,868
Oklahoma	2,203	167	2,370	1,899	82	1,981	1,857	81	1,938	1,729	164	1,893	208	1,682	1,890
Oregon	1,606	36	1,642	1,699	24	1,723	1,579	11	1,590	1,612	28	1,640	60	1,720	1,780
Pennsylvania	4,095	16	4,111	4,524	15	4,539	4,640	9	4,649	4,462	11	4,473	18	4,007	4,025
Rhode Island	97	0	97	117	0	117	119	0	119	115	0	115	0	83	83
South Carolina	2,171	5	2,176	2,033	1	2,034	2,127	2	2,129	2,646	5	2,651	8	2,465	2,473
South Dakota	809	158	967	934	149	1,083	1,130	118	1,248	837	179	1,016	223	1,023	1,246
Tennesee	4,522	16	4,538	4,207	13	4,220	4,472	6	4,478	4,015	15	4,030	34	3,814	3,848
Texas	13,252	192	13,444	9,849	77	9,926	8,183	95	8,278	6,839	150	6,989	146	6,718	6,864
Utah	625	6	631	480	4	484	308	1	309	283	5	288	8	342	350
Vermont	600	2	602	625	0	625	630	0	630	612	0	612	1	580	581
Virginia	3,253	5	3,258	3,309	6	3,315	3,704	1	3,705	3,722	2	3,724	3	3,579	3,582
Washington	1,652	83	1,735	1,450	39	1,489	1,433	30	1,463	1,325	53	1,378	87	1,627	1,714
West Virginia	685	0	685	925	1	926	850	0	850	685	0	685	1	631	632
Wisconsin	2,615	60	2,675	2,225	41	2,266	1,900	23	1,923	1,844	40	1,884	59	2,373	2,432
Wyoming	168	18	186	149	7	156	131	8	139	105	12	117	25	165	190
U.S. Government	13	0	13	29	0	29	183	2	185	368	1	369	1	54	55
Miscellaneous	306	0	306	250	0	250	529	0	529	835	0	835	6	509	515
TOTAL	112,761	2,912	115,673	106,758	2,037	108,795	106,531	1,653	108,184	104,017	2,729	106,746	4,151	102,419	106,570

TABLE 2-8
CALIFORNIA FARM EQUIPMENT POPULATIONS

Equipment Type	Engine Type								
	Diesel			Gasoline, 2-Stroke			Gasoline, 4-Stroke		
	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours
2-Wheel Tractors	0	0.00	0	0	0.00	0	2,092	0.62	332
Agricultural Mowers	0	0.00	0	0	0.00	0	1,800	0.48	180
Agricultural Tractors	443,377	0.70	532	0	0.00	0	1,038	0.62	616
Balers	359	0.58	139	0	0.00	0	5,534	0.55	99
Combines	37,054	0.70	183	0	0.00	0	326	0.74	153
Hydro Power Units	12,681	0.48	814	0	0.00	0	5,801	0.56	464
Other Agricultural Equipment	3,175	0.51	446	0	0.00	0	1,110	0.55	145
Sprayers	1,822	0.50	110	0	0.00	0	10,939	0.50	98
Swathers	8,807	0.55	136	0	0.00	0	5,783	0.52	118
Tillers >5 HP	7	0.78	263	0	0.00	0	127,845	0.71	71
Class Total	507,282			0	0.00	0	162,268		

EEA has tested many combinations of activity indicators to determine the appropriate methodology for apportioning the state population of farm equipment to the county levels. In developing the NEVES, the use of SIC 07, Agricultural Services (employees) for allocating farm equipment to the county level was investigated, but it was found that this methodology over-predicted farm equipment populations in those counties where Veterinary Service (SIC 074) and Other Animal Services (SIC 075) employment was high. This finding is logical as those sectors are associated with livestock production, which is not as equipment intensive as farming endeavors like crop production. The county populations of wheel tractors (indicative of total farming equipment populations) and grain and bean harvesters (indicative of heavy-duty farming equipment populations) were available from the 1987 Agriculture Census, and this is the most recent count of farm equipment available. Even though the Agriculture Census appears to count out-of-service equipment, its use as an indicator of county population of farming equipment relative to the state total is considered valid. This is the methodology that was ultimately developed for use in NEVES, and has been reviewed and approved by the EMI.

2.8 LIGHT COMMERCIAL EQUIPMENT

Under the current ARB off-road model, equipment from many categories are included in the Light Duty Equipment category, including light duty utility equipment. Several types of low horsepower equipment are also grouped with lawn and garden equipment under the "general utility" category. Under the new model, the light commercial category includes equipment that are generally used in light manufacturing, and various wholesaling and retailing activities - namely generator sets, pumps, air compressors, gas compressors, welding machines, and pressure washers.

Booz-Allen estimated the overall population of commercial equipment as part of its utility and lawn and garden equipment study, but it did not break out commercial equipment by type, and it did not estimate the population of diesel commercial equipment separately from other diesel equipment under 40 horsepower. PSR is the only source which breaks out the population data for light commercial equipment by equipment type and horsepower, and their estimates of gasoline powered commercial equipment are similar to Booz-Allen's estimates. Therefore, PSR population data are used as are their load factor and annual use data. The 1990 light commercial equipment population for California is shown in Table 2-9.

The NEVES methodology for allocating light commercial equipment to the county level relied on the number of wholesale establishments as an indicator of light commercial equipment population at the county level. This model barely met the NEVES acceptability criteria, and ARB had EEA modify the NEVES allocation methodology to use the county total of wholesale plus retail establishments (relative to the state total) as an indicator of the light commercial equipment population. This methodology allocates light commercial equipment used in retail operations such as automotive service stations as well as equipment used in wholesale operations. The number of wholesale and retail establishments by county were taken from County Business Patterns for California[9].

2.9 LOGGING

The logging category includes equipment with small gasoline engines (2-stroke chainsaws and 4-stroke shredders over 5 hp) and larger diesel powered equipment such as fellers/bunchers and skidders. PSR is the only known data source that provides population data for this equipment category, and they also provided load factor and annual use data. The 1990 California baseline population of logging equipment is shown in Table 2-10.

ARB has previously used reports of million board feet of lumber harvested to represent logging activity at the county level. This methodology has the disadvantage of not accounting for the type of logging being conducted in the county. Helicopter and cable logging have very different equipment requirements than traditional logging practices, and this difference is not reflected in

TABLE 2-9
CALIFORNIA LIGHT COMMERCIAL EQUIPMENT POPULATIONS

Equipment Type	Engine Type								
	Diesel			Gasoline, 2-Stroke			Gasoline, 4-Stroke		
	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours
Air Compressors <=50 HP	1,513	0.48	937	0	0.00	0	13,939	0.56	557
Gas Compressors <=50 HP	0	0.00	0	0	0.00	0	0	0.00	0
Generator Sets <=50 HP	16,827	0.74	375	2,491	0.68	128	214,579	0.68	128
Pressure Washers <=50 HP	513	0.30	168	0	0.00	0	34,703	0.85	133
Pumps <=50 HP	6,814	0.74	480	4,957	0.69	263	51,800	0.69	263
Welders <=50 HP	8,723	0.45	746	0	0.00	0	32,726	0.51	241
Class Total	34,420			7,418			347,747		

TABLE 2-10
CALIFORNIA LOGGING EQUIPMENT POPULATIONS

Equipment Type	Engine Type								
	Diesel			Gasoline, 2-Stroke			Gasoline, 4-Stroke		
	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours
Chainsaws > 5 HP	0	0.00	0	30,646	0.92	206	0	0.00	0
Fellers/Bunchers	814	0.71	1386	0	0.00	0	0	0.00	0
Shredders >5 HP	0	0.00	0	0	0.00	0	12,704	0.80	242
Skidders	1,522	0.74	1442	0	0.00	0	0	0.00	0
Class Total	2,336			30,646			12,704		

the reported lumber harvest. Therefore, logging equipment is allocated to the county level by the use of employees in SIC 24, Lumber and Wood Products, Except Furniture. This methodology was also used in NEVES.

2.10 AIRPORT GROUND SUPPORT EQUIPMENT

Ground support equipment (GSE) are found at all commercial airports, and over 20 different types of GSE have been identified. However, there are few population data available for the class as a whole, even from PSR, and practically none for the individual equipment types by horsepower rating. However, as part of a recent analysis for the EPA[12], EEA developed estimates of GSE populations for California based on data obtained from six commercial air carriers. The GSE population estimates are listed in Table 2-11.

Ground support equipment operations include a wide variety of equipment that services commercial aircraft while unloading and loading passengers and freight at an airport. As a group, GSE include primarily the following types of equipment.

- **Aircraft Tugs -** Tow aircraft in the terminal gate area. They also tow aircraft to and from hangers for maintenance. These were broken into two categories: tugs for narrow body aircraft and tugs for wide body aircraft.
- **Air Start Units -** Provide large volumes of compressed air to an aircraft's main engines for starting.
- **Air-Conditioning Units -** Provide conditioned air to ventilate and cool parked aircraft.
- **Baggage Tugs -** Haul baggage between the aircraft and the terminal.
- **Belt Loaders -** Mobile conveyor belts used to move baggage between the ground and the aircraft hold.
- **Bobtail Tractors** - truck bodies that have been specially modified to tow trailers and equipment.
- **Cargo Loaders -** Equipment employed to load large packages, containers, and other cargo into the aircraft.

TABLE 2-11
CALIFORNIA AIRCRAFT GROUND SERVICE EQUIPMENT POPULATIONS

Equipment Type	Engine Type								
	Diesel			Gasoline, 2-Stroke			Gasoline, 4-Stroke		
	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours
A/C Tug, Narrow Body	62	0.80	551	0	0.00	0	22	0.80	551
A/C Tug, Wide Body	9	0.80	515	0	0.00	0	0	0.00	0
Air Conditioner	13	0.75	22	0	0.00	0	10	0.75	22
Air Start Unit	36	0.90	135	0	0.00	0	3	0.90	135
Aircraft Support Equipment	1,236	0.51	842	0	0.00	0	292	0.56	842
Baggage Tug	252	0.55	876	0	0.00	0	325	0.55	876
Belt Loader	109	0.50	810	0	0.00	0	150	0.50	810
Bobtail	0	0.00	0	0	0.00	0	56	0.55	876
Cargo Loader	90	0.50	719	0	0.00	0	10	0.50	719
Cart	0	0.00	0	20	0.50	150	0	0.00	0
Deicer	1	0.95	22	0	0.00	0	17	0.95	22
Forklift	13	0.30	726	0	0.00	0	90	0.30	726
Fuel Truck	3	0.25	22	0	0.00	0	61	0.25	22
Ground Power Unit	108	0.75	796	0	0.00	0	10	0.75	796

TABLE 2-11
CALIFORNIA AIRCRAFT GROUND SERVICE EQUIPMENT POPULATIONS
(Continued)

Equipment Type	Engine Type								
	Diesel			Gasoline, 2-Stroke			Gasoline, 4-Stroke		
	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours
Other	4	0.50	183	0	0.00	0	116	0.50	183
Service Truck	27	0.20	1299	0	0.00	0	55	0.20	1299
Terminal Tractors	7,590	0.82	1408	0	0.00	0	750	0.78	1408
Water Truck	0	0.00	0	0	0.00	0	4	0.20	310
Class Total	9,557			33			2,209		

- **Carts -** Small vehicles used to shuttle personnel and small loads around the airport.
- **Deicers -** Vehicles used to transport, heat, and spray deicing fluid.
- **Forklifts -** Vehicles with a pronged platform used to lift and carry heavy loads.
- **Ground Power Unit (GPU) -** Mobile ground-based generator units that supply aircraft with electricity while they are parked at the airport.
- **Lav Carts -** Small vehicles used to service aircraft lavatories. Lav carts, which do not have engines that provide propulsion, include engines to operate the on-board pumps.
- **Lifts -** Equipment employed to lift baggage, containers, cargo, and other heavy loads onto and off of aircraft. This category includes aerial lifts.
- **Other -** This is a category that includes small miscellaneous types of equipment commonly found on airports such as compressors, scrubbers, sweepers, and specialized units.

EEA found very little information on turbine-powered air start units, such as engine size and operating practice, although some were reported by the airlines in their equipment inventory. The air start category noted above includes only gasoline, diesel, and electric equipment. For the few instances where turbine-powered units did appear it was assumed the service was provided by an APU. In addition, there are five truck types for which we have population estimates. These trucks are certified for on-road use, but may not be registered for on-road use at the owners' discretion. They include:

- **Fuel Trucks -** Vehicles used to provide fueling service to aircraft. At larger airports these are generally hydrant trucks, which include filters and hoses to hook up to the airport central fueling hydrant. At other airports, this category could include trucks with fuel tanks.
- **Lavatory Trucks -** Trucks with tanks used to service aircraft lavatories. The engine used for propulsion also is used to power other truck auxiliaries.
- **Maintenance Trucks -** Conventional pick up-style trucks modified to carry maintenance equipment and tools for servicing aircraft and other vehicles on the airport.

- **Service Trucks -** This is a category of larger equipment, generally specially modified trucks, used to service aircraft at airports. This category includes cabin service and food service vehicles.
- **Water Trucks -** These are trucks that transfer water onto the aircraft.

GSE emissions do not appear in the inventory for air taxi and smaller air carrier aircraft since these aircraft typically do not require GSE. For example, the Oxnard/Ventura County Airport inventory does not include any GSE emissions since all aircraft that operate at the airport are air taxi or small air carrier aircraft and are assumed not to need ground services from mobile equipment. It is assumed that any necessary services are supplied through fixed facilities or vehicles licensed for highway use.

To calculate an accurate estimate of GSE population and operating conditions, EEA relied to the maximum extent on data provided by the major airlines who operate in California. GSE operating and population data were provided by seven carriers: American Airlines, Delta Airlines, Federal Express, Northwest Airlines, Southwest Airlines, Trans World Airlines, and United Airlines. Since these carriers represent only a portion of the GSE operations in California, a technique was needed to estimate total population for the whole basin. Data provided by six carriers (the data from Federal Express was received too late to use for this step) were used to develop a population estimation method. Regression analysis of GSE populations and air carrier activity (expressed in landing-takeoff operations, or LTOs) provided the most reasonable correlation among the different combinations of variables tested. The best statistical representation used two separate equations to estimate the population of GSE at commercial airports. Both equations describe a linear relationship between GSE population and the level of activity represented by the total airport LTOs. Large air carriers were defined as airlines with greater than 1000 wide body aircrafts at Los Angeles International Airport (LAX) in 1990. For large air carriers at LAX the estimation equation is:

$$P_{LAX} = k + (RC \times LTO_{LAX})$$

Where:

P_{LAX} = GSE population at LAX for large air carriers

k = 135.5; constant for large air carriers at LAX

RC = 0.00575; regression coefficient for large air carriers at LAX

LTO_{LAX} = number of large air carrier aircraft LTOs at LAX

At all other airports, and smaller operations at LAX, the sampled airlines were found to utilize GSE at a different rate:

$$P_{OTHER} = k + (RC \times LTO_{OTHER})$$

Where:

P_{OTHER} = GSE population at all other airports and for small air carriers at LAX

k = 8.23; constant for other air carriers

RC = 0.0022; regression coefficient for other air carriers

LTO_{OTHER} = number of aircraft LTOs at all other airports and for small air carriers at LAX

Figures 2-1 and 2-2 plot each of these equations and the data provided by the carriers. The differences in GSE populations between carriers with more than 1000 wide body LTOs and other carriers may reflect the significance of California as a major transfer point for flights to Asia, which typically rely on wide body aircraft. The airlines operating wide body aircraft typically also have the highest level of activity and may find it necessary to equip their GSE operations to meet the daily peak demands, which require a higher concentration of GSE to service all of the aircraft without delay.

For carriers with more than 1,000 wide body operations and groups of smaller carriers the equations serve as good predictors of GSE population over the range of operations encountered in the California.

FIGURE 2-1

RELATIONSHIP BETWEEN LTOs AND GSE POPULATION SMALL CARRIER OPERATIONS

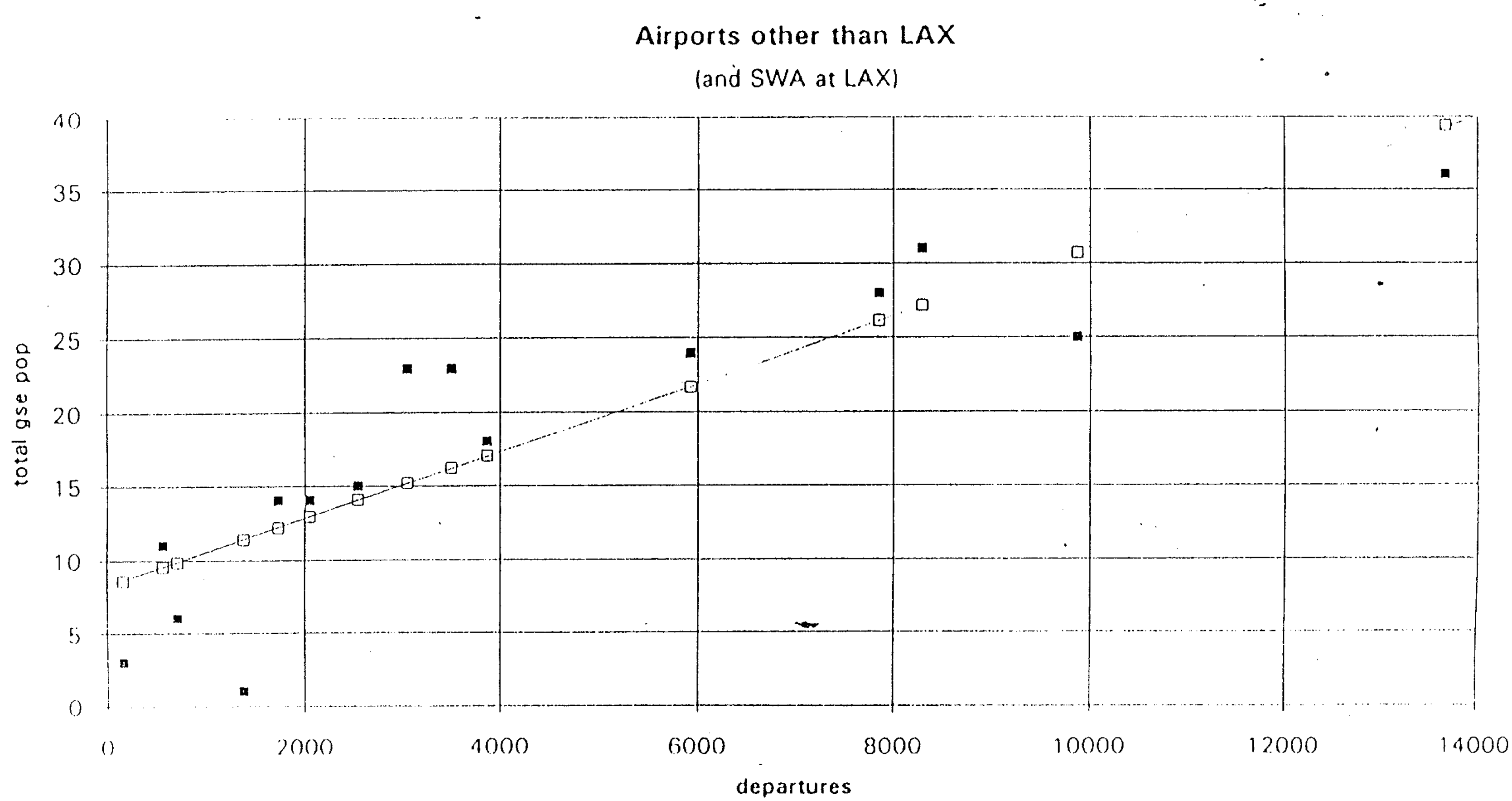
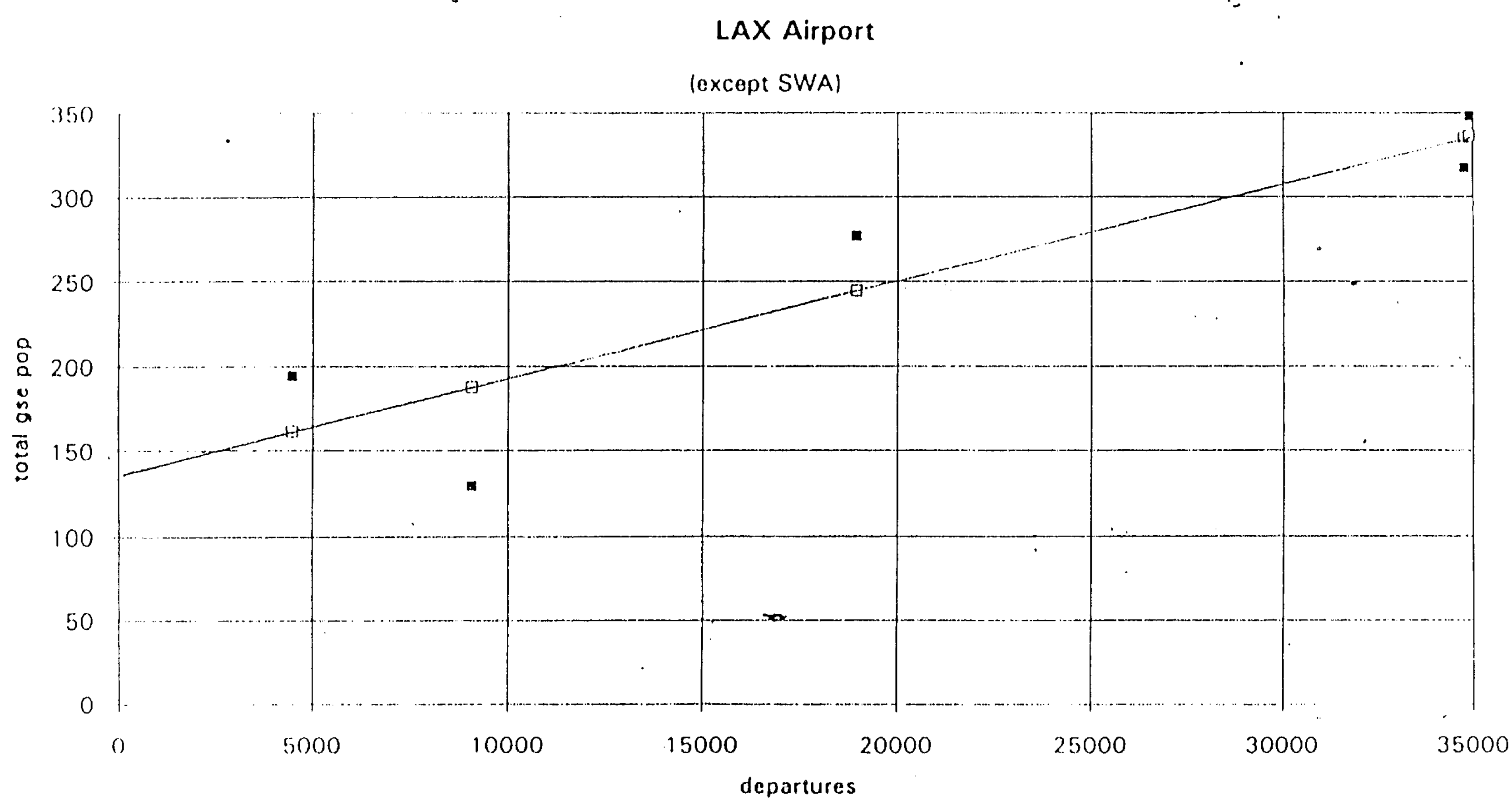


FIGURE 2-2

RELATIONSHIP BETWEEN LTOs AND GSE POPULATION LARGE CARRIER OPERATIONS



After estimating the total population of GSE at airports in the air basins, the equipment types (e.g., baggage tugs) were assumed to be represented in the total equipment populations in the same proportion as they were represented in the GSE operations as reported by the six air carriers. Since the prediction of GSE population reflects a measure of wide body aircraft operations, the aircraft tugs also were broken out by wide body and narrow body. Tugs designed for use with wide body aircraft do not appear in the GSE populations for airlines or airports that do not have wide body LTOs. Otherwise the equipment mix remained constant.

Most of the carriers provided only partial, if any, data on engine horsepower ratings. Data from United were most comprehensive and were used as the basis for this variable. Data from other carriers, *Jane's Airport and ATC Equipment*, and discussions with equipment vendors were used to supplement the United data as necessary. None of the carriers reported load factors explicitly, but fuel consumption data were used to the extent possible to estimate load factors. Fuel consumption data were supplemented with information from GSE and engine manufacturers and the ground service operations supervisors of two airlines.

Usage rate data were provided by United Airlines and included hours of annual usage for each equipment type/fuel type combination. This formed the basis of the usage rates used by EEA. As necessary they were supplemented with information provided by the ground service operations supervisors from United and Alaska Airlines and discussions with GSE manufacturers.

2.11 PLEASURE CRAFT

Pleasure craft or recreational marine vessels use 2-stroke and 4-stroke gasoline and diesel engines that cover a vast range of power output. Two sources were used to develop California pleasure craft population estimates by engine and fuel type, using a methodology[7] that was developed in support of EPA's NEVES. County level pleasure craft populations were estimated using data from ARB. These methodologies and the resulting pleasure craft populations are described below.

As part of a national program, states annually report to the U.S. Coast Guard the population of registered vessels. These reports are compiled in Report of Certificates of Number Issued to Boats, which profiles registered boats by length class (i.e., 1 to 16 feet, 16 to 26 feet, 26 to 40 feet, 40 to 65 feet, and over 65 feet) and propulsion type (i.e., inboard, outboard, sterndrive, and sail). The Coast Guard data indicate multi-engine crafts, so the number of engines can be determined given the number of boats. However, the Coast Guard data do not indicate the county of residence.

California is one of the few states that tabulates boat registrations by county. However, California counts boats and not engines. Therefore, the state registration data were disaggregated, using the methodology described below, to translate the state total pleasure craft population to a count of engines. (State registration data are reported by California Department of Motor Vehicles in the report "Currently Registered Vessels, as of 31 Dec 1990", shown in Table 2-12. According to DMV, personal watercraft are included in inboard engine powered vessels under 16 feet.)

Boat manufacturers were contacted to acquire information as to the expected number of engines by length of boat and propulsion system. Table 2-13 presents the weighting scheme that was developed from this information and used to estimate engine populations from boat counts. For example, the population of inboard engines in boats between 26 and 40 feet was calculated as $\{(\mathbf{P} * 0.32) + (2\mathbf{P} * 0.68)\}$, where **P** is defined as the state registration total of boats between 26 and 40 feet long with inboard engines. This process was performed for all boat lengths and propulsion types, except sailboats. It is assumed that each sailboat has one auxiliary engine, so that the total sailboat registrations represents the total count of sailboat auxiliary engines.

TABLE 2-12

CALIFORNIA PLEASURE CRAFT REGISTRATIONS BY TYPE AND LENGTH

TYPE	LENGTH	1990 REGISTRATIONS
INBOARDS	0-16 feet	74,002
	16-26 feet	57,682
	26-40 feet	14,974
	40-65 feet	2,940
	> 65 feet	176
OUTBOARDS	0-16 feet	248,990
	16-26 feet	114,285
	26-40 feet	3,551
	40-65 feet	818
	> 65 feet	296
STERNDRIVE	0-16 feet	2,445
	16-26 feet	142,047
	26-40 feet	6,976
	40-65 feet	1,261
	> 65 feet	90
SAIL W/ INBOARD	0-16 feet	0
	16-26 feet	0
	26-40 feet	13,695
	40-65 feet	1,202
	> 65 feet	26
SAIL W/ OUTBOARD	0-16 feet	1,645
	16-26 feet	7,488
	26-40 feet	0
	40-65 feet	0
	> 65 feet	0

TABLE 2-13

NUMBER OF ENGINES PER BOAT: LENGTH AND ENGINE TYPE

TYPE	LENGTH	PERCENT OF CATEGORY	NUMBER OF ENGINES
INBOARDS	0-16 feet	100	1
	16-26 feet	100	1
	26-40 feet	32 68	1 2
	40-65 feet	68	2
	> 65 feet	100	2
OUTBOARDS	0-16 feet	100	1
	16-26 feet	90 10	1 2
	26-40 feet	90 10	2 3
	40-65 feet	*	*
	> 65 feet	*	*
STERNDRIVE	0-16 feet	100	1
	16-26 feet	50 50	1 2
	26-40 feet	20 80	1 2
	40-65 feet	5 95	2 3
	> 65 feet	100	3
SAIL AUXILIARY - INBOARD	0-16 feet	100	1
	16-26 feet	100	1
	26-40 feet	100	1
	40-65 feet	99 1	1 2
	> 65 feet	98 2	1 2

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* These two classes were determined to be barge-type vessels or house-boats, vessels with limited usage levels. Consequently, they were excluded from this study.

Sailboat auxiliary engines can be either inboard or outboard, and state registration data were used to specify auxiliary propulsion type. Engine specifications (engine and fuel type, horsepower, and load factors) were determined using PSR data, resulting in the population of pleasure craft engines shown in Table 2-14.

Although county specific registrations are available from the state, they represent the county of registration and not the county of use. In NEVES, state engine populations were distributed to the county of use level by application of the water covered surface area of each county relative to the water covered surface area of the state. Water covered surface area includes both inland water (expressed in square miles) and miles of public beach (an approximation of coastline miles). It was assumed that most recreational boating takes place within one mile of the coastline, so the surface area of coastal waters equals the miles of public beach times one mile. State and county level data on miles of public beach were collected from the National Oceanic and Atmospheric Administration's National Estuarine Inventory: Data Atlas, 1988, and data on inland water covered surface area were derived from Census's Area Measurements Reports, GE-20 No. 1, 1970. The county level distributions derived from the water covered surface area were then multiplied by fuel use adjustment factors that EPA developed using fuel use data submitted by the National Marine Manufacturers Association.

For this analysis, however, county level fuel consumption data (gallons of gasoline and diesel fuel used by recreational marine vessels in 1987) developed by ARB[13] were used to distribute pleasure crafts to the county level. The fuel consumption data were then used to apportion diesel and gasoline pleasure craft engines to the county and air basin level. County level engine distributions by type (inboard, outboard, etc.), were made using Table 2-13, and engine type and horsepower distributions were made using the PSR data. Load factors were also from PSR and were held constant across the state.

TABLE 2-14
PLEASURE CRAFT (RECREATIONAL MARINE ENGINE) POPULATIONS

Equipment Type	Engine Type								
	Diesel			Gasoline, 2-Stroke			Gasoline, 4-Stroke		
	1990 Population	Avg. Load Factor	Avg. Annual Use (gallons)	1990 Population	Avg. Load Factor	Avg. Annual Use (gallons)	1990 Population	Avg. Load Factor	Avg. Annual Use (gallons)
Sailboat Auxiliary Inboard Engines	11,948	0.75	41	0	0.0	0	2,987	0.75	23
Sailboat Auxiliary Outboard Engines	0	0.00	0	9,133	0.75	13	0	0.00	0
Inboard Engines	23,654	0.75	810	0	0.00	0	139,482	0.75	442
Outboard Engines	0	0.00	0	373,642	0.75	206	0	0.00	0
Sterndrive Engines	0	0.00	0	0	0.00	0	164,200	0.75	486
Class Total	35,602			382,775			306,669		

2.12 TRANSPORT REFRIGERATION UNITS

Transport refrigeration units (TRUs) are gasoline and diesel powered cooling units that are used to preserve produce, meat, dairy products and other perishables during transport to market. TRUs are found on refrigerated trucks and trailers, and it is reasonable to expect that TRUs use the same fuel as the truck or truck tractor engine. The methodology for estimating the TRU population, which is described below, is based on a methodology developed by ARB, with modifications to more accurately estimate the population of diesel powered truck mounted TRUs.

The Public Records Unit of the DMV reported that in 1990, 0.14 percent of commercial truck registrations were refrigerated trucks, and 0.6 percent of commercial trailers were refrigerated. Commercial truck and trailer registrations at the county level for 1990 were obtained, and the number of refrigerated trucks and trailers is used as a surrogate for the number of truck and trailer mounted TRUs in use. However, the registration data are not fuel specific, so the fuel type share for TRUs is estimated. It is assumed that all trailer mounted TRUs are diesel powered, since tractor-trailer combinations are diesel powered, but straight trucks and TRUs mounted on them can be powered by gasoline or diesel. In earlier estimations of TRU populations, ARB assumed that all refrigerated trucks were gasoline powered, but a more accurate assumption is that the gasoline share of refrigerated trucks is the same as the gasoline share of all light-heavy (8500 to 14,000 pounds GVW) and medium-heavy duty trucks (14,000 to 33,000 pounds GVW). All heavy-heavy duty trucks are diesel powered, and the gas/diesel split of light- and medium-heavy trucks is estimated by the following method.

The Motor Fuel Consumption Model[14] is used by the U.S. Department of Energy to estimate national fuel consumption by all types of onroad vehicles. As such, it tracks national truck registrations by weight class and fuel type at a level of detail that is not available from emissions models such as EMFAC7 or MOBILE5. Therefore, the MFC's data are used to estimate the fuel

split of truck mounted TRUs. According to the MFC, the gasoline share of light-heavy duty trucks is 85 percent, and the gasoline share of medium-heavy duty trucks is 62 percent. Using the appropriate shares of light-duty and medium-heavy duty trucks, then the gasoline share of all truck mounted TRUs is calculated at 77 percent, and the diesel share of truck mounted TRUs is 23 percent. The DMV county specific commercial truck and trailer registration data and the MFC shares of light-heavy and medium-heavy trucks are used to allocate the TRUs to the county level. The California populations of truck and trailer mounted TRUs are shown in Table 2-15; the estimates of average load factor and annual hours of use are from ARB.
TRUs are also used extensively on railroad boxcars, but no population data for train mounted TRUs could be found. According to information received from PSR and industry, train mounted TRUs are significantly larger than truck or trailer mounted units, so it is assumed that only train mounted TRUs use engines over 50 horsepower. PSR reports that there are 4507 TRUs with diesel engines over 50 horsepower in use in California. In the absence of other data, this number is used to represent railroad TRUs. Allocating the railroad TRUs to the county level is done using each county's share of the total annual California locomotive emissions (see Section 6).

2.13 LOCOMOTIVES, MARINE VESSELS, AND AIRCRAFT EMISSIONS

The populations of four categories of equipment, namely locomotives, commercial and government marine vessels, commercial/general/military aircraft, and agricultural aircraft were not calculated. Instead, baseline emissions data in tons per day were collected from the most recently available sources, and the model calculates future emissions by application of growth rates to the baseline emissions. The exception to this is emissions from locomotives, for which emissions estimates were obtained for 1987, 2000, and 2010. Linear interpolation is used to determine locomotive emissions in future years other than 2000 and 2010.

Booz-Allen & Hamilton, Inc. investigated locomotive emissions in California under the direction of the Locomotive Emission Advisory Committee and produced a report[15] in 1991. Under that

TABLE 2-15
TRANSPORT REFRIGERATION UNIT POPULATIONS

Equipment Type	Engine Type					
	Diesel			Gasoline, 4-Stroke		
	1990 Population	Avg. Load Factor	Avg. Annual Use Hours	1990 Population	Avg. Load Factor	Avg. Annual Use Hours
Truck Mounted	1,305	0.50	2,500	4,367	0.50	750
Trailer Mounted	6,751	0.50	3,000	0	0	0
Rail Boxcar	4,507	0.40	3,000	0	0	0
Class Total	12,563			4,367		

effort, Booz-Allen estimated the state total air pollution emissions arising from the operation of railroad locomotives in the base year (1987) and, by applying likely strategies and technologies for the reduction of locomotive emissions, in 2000 and 2010. EEA distributed the state emissions to the county level by application of ARB's rail transport process rates, as published in "Methods for Assessing Area Source Emissions (1991)". The resulting locomotive emissions are shown in Table 2-16.

Booz-Allen also authored a report for ARB which estimates the amount of air pollution generated by non-recreational marine vessels[16]. Booz-Allen estimated populations of ocean-going, harbor, and fishing vessels, broken out by vessel type, size, mode of propulsion and horsepower. They derived statewide average values for vessel size and rated shaft horsepower, based on sample populations from the ports "receiving the largest and most diverse quantities of vessel traffic." The levels and types of activity associated with the vessels was defined in terms of fuel consumption, and using applicable emission factors, the total pounds of pollutants were calculated and presented by basin and mode (i.e., in port, at sea, harbor activities, and fishing).

The air basin emissions for harbor, fishing, and at sea operations were allocated to the counties within each air basin by EEA. Booz-Allen published in-port emissions by port, and EEA determined the county the ports were located in by use of maps and by contacting local officials if more information was needed. Harbor emissions were allocated to the counties using the in-port allocation scheme. Fishing emissions were allocated to the counties within each air basin using the ratios of county estuarine coastline in miles to air basin estuarine coastline as published in the National Oceanic and Atmospheric Administration's National Estuarine Inventory: Data Atlas, 1988. At sea emissions were allocated to the counties by the ratios of county coastline in miles to air basin coastline in miles. Commercial and government marine vessel emissions in tons per day are shown in Table 2-17.

TABLE 2-16

LOCOMOTIVE EMISSIONS (TPD)

		1987				2000				2010			
BASIN	COUNTY	HC	CO	NOx	PM	HC	CO	NOx	PM	HC	CO	NOx	PM
GREAT BASIN VALLEY	ALPINE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GREAT BASIN VALLEY	INYO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GREAT BASIN VALLEY	MONO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LAKE COUNTY	LAKE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LAKE TAHOE	EL DORADO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LAKE TAHOE	PLACER	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	AMADOR	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	CALAVERAS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	EL DORADO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	MARIPOSA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	NEVADA	0.042	0.133	1.033	0.022	0.038	0.120	0.937	0.020	0.035	0.114	0.914	0.019
MOUNTAIN COUNTIES	PLACER	0.077	0.243	1.893	0.041	0.069	0.221	1.717	0.037	0.065	0.209	1.675	0.035
MOUNTAIN COUNTIES	PLUMAS	0.071	0.268	1.926	0.041	0.064	0.244	1.747	0.037	0.060	0.231	1.705	0.035
MOUNTAIN COUNTIES	SIERRA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	TUOLUMNE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NORTH CENTRAL COAS	MONTEREY	0.102	0.325	2.780	0.058	0.091	0.295	2.522	0.053	0.086	0.279	2.461	0.050
NORTH CENTRAL COAS	SAN BENITO	0.014	0.045	0.321	0.007	0.013	0.041	0.292	0.006	0.012	0.039	0.284	0.006
NORTH CENTRAL COAS	SANTA CRUZ	0.008	0.027	0.209	0.004	0.008	0.025	0.189	0.004	0.007	0.023	0.185	0.004
NORTH COAST	DEL NORTE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NORTH COAST	HUMBOLDT	0.016	0.052	0.384	0.027	0.015	0.047	0.348	0.025	0.014	0.045	0.339	0.024
NORTH COAST	MENDOCINO	0.025	0.074	0.562	0.041	0.022	0.067	0.509	0.037	0.021	0.064	0.497	0.035
NORTH COAST	SONOMA	0.011	0.033	0.241	0.016	0.010	0.030	0.219	0.015	0.009	0.028	0.213	0.014
NORTH COAST	TRINITY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NORTHEAST PLATEAU	LASSEN	0.060	0.214	1.468	0.033	0.054	0.194	1.332	0.030	0.051	0.184	1.300	0.028
NORTHEAST PLATEAU	MODOC	0.063	0.225	1.622	0.036	0.057	0.204	1.471	0.032	0.053	0.193	1.435	0.031
NORTHEAST PLATEAU	SISKIYOU	0.151	0.501	4.849	0.101	0.136	0.455	4.399	0.092	0.128	0.431	4.292	0.087
SACRAMENTO VALLEY	BUTTE	0.119	0.404	3.402	0.071	0.107	0.367	3.086	0.064	0.101	0.347	3.011	0.061
SACRAMENTO VALLEY	COLUSA	0.006	0.019	0.170	0.004	0.005	0.017	0.155	0.003	0.005	0.016	0.151	0.003
SACRAMENTO VALLEY	GLENN	0.007	0.023	0.211	0.004	0.006	0.021	0.191	0.004	0.006	0.020	0.186	0.004
SACRAMENTO VALLEY	PLACER	0.123	0.403	3.371	0.071	0.111	0.366	3.057	0.064	0.104	0.346	2.983	0.061
SACRAMENTO VALLEY	SACRAMENTO	0.170	0.531	4.022	0.087	0.153	0.482	3.648	0.079	0.144	0.456	3.559	0.074
SACRAMENTO VALLEY	SHASTA	0.131	0.428	3.980	0.082	0.118	0.388	3.611	0.075	0.111	0.367	3.523	0.071
SACRAMENTO VALLEY	SOLANO	0.041	0.130	1.047	0.022	0.037	0.118	0.949	0.020	0.035	0.111	0.926	0.019
SACRAMENTO VALLEY	SUTTER	0.017	0.056	0.527	0.011	0.015	0.051	0.478	0.010	0.015	0.048	0.467	0.009
SACRAMENTO VALLEY	TEHAMA	0.076	0.250	2.340	0.048	0.069	0.227	2.123	0.044	0.065	0.215	2.071	0.042

TABLE 2-16
(continued)
LOCOMOTIVE EMISSIONS (TPD)

		1987				2000				2010			
BASIN	COUNTY	HC	CO	NOx	PM	HC	CO	NOx	PM	HC	CO	NOx	PM
SACRAMENTO VALLEY	YOLO	0.005	0.017	0.160	0.003	0.005	0.016	0.146	0.003	0.004	0.015	0.142	0.003
SACRAMENTO VALLEY	YUBA	0.073	0.243	1.955	0.041	0.066	0.220	1.774	0.038	0.062	0.208	1.730	0.036
SAN DIEGO COUNTY	SAN DIEGO	0.025	0.068	0.647	0.014	0.022	0.062	0.587	0.012	0.021	0.059	0.572	0.012
SAN FRANCISCO	ALAMEDA	0.106	0.363	2.659	0.058	0.095	0.329	2.412	0.052	0.090	0.312	2.353	0.049
SAN FRANCISCO	CONTRA COSTA	0.200	0.640	4.509	0.099	0.180	0.581	4.090	0.090	0.169	0.549	3.991	0.085
SAN FRANCISCO	MARIN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SAN FRANCISCO	NAPA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SAN FRANCISCO	SAN FRANCISCO	0.023	0.060	0.459	0.010	0.021	0.054	0.416	0.009	0.020	0.051	0.406	0.009
SAN FRANCISCO	SAN MATEO	0.111	0.287	2.203	0.049	0.100	0.260	1.998	0.044	0.094	0.246	1.949	0.042
SAN FRANCISCO	SANTA CLARA	0.089	0.233	1.818	0.040	0.080	0.212	1.649	0.036	0.075	0.200	1.609	0.035
SAN FRANCISCO	SOLANO	0.031	0.095	0.680	0.015	0.028	0.086	0.617	0.014	0.026	0.081	0.602	0.013
SAN FRANCISCO	SONOMA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SAN JOAQUIN VALLEY	FRESNO	0.099	0.296	2.429	0.052	0.089	0.268	2.204	0.047	0.084	0.254	2.150	0.044
SAN JOAQUIN VALLEY	KERN	0.421	1.292	9.044	0.203	0.379	1.172	8.204	0.184	0.357	1.109	8.004	0.174
SAN JOAQUIN VALLEY	KINGS	0.009	0.029	0.272	0.006	0.008	0.026	0.246	0.005	0.008	0.025	0.240	0.005
SAN JOAQUIN VALLEY	MADERA	0.062	0.200	1.728	0.036	0.056	0.182	1.568	0.033	0.053	0.172	1.530	0.031
SAN JOAQUIN VALLEY	MERCED	0.084	0.270	2.339	0.049	0.076	0.245	2.122	0.045	0.071	0.232	2.070	0.042
SAN JOAQUIN VALLEY	SAN JOAQUIN	0.178	0.558	4.052	0.088	0.160	0.506	3.675	0.080	0.151	0.479	3.586	0.075
SAN JOAQUIN VALLEY	STANISLAUS	0.060	0.181	1.536	0.033	0.054	0.165	1.393	0.029	0.051	0.156	1.360	0.028
SAN JOAQUIN VALLEY	TULARE	0.123	0.403	3.379	0.071	0.111	0.366	3.065	0.064	0.104	0.346	2.991	0.061
SOUTH CENTRAL COAST	SAN LUIS OBISPO	0.072	0.231	2.004	0.042	0.065	0.209	1.818	0.038	0.061	0.198	1.774	0.036
SOUTH CENTRAL COAST	SANTA BARBARA	0.077	0.245	2.169	0.045	0.069	0.222	1.967	0.041	0.065	0.210	1.919	0.039
SOUTH CENTRAL COAST	VENTURA	0.044	0.138	1.237	0.026	0.040	0.125	1.122	0.024	0.037	0.118	1.095	0.022
SOUTH COAST	LOS ANGELES	0.792	2.350	16.020	0.360	0.713	2.133	14.531	0.327	0.670	2.018	14.177	0.309
SOUTH COAST	ORANGE	0.108	0.336	2.354	0.052	0.097	0.305	2.135	0.048	0.091	0.288	2.083	0.045
SOUTH COAST	RIVERSIDE	0.174	0.541	3.558	0.080	0.157	0.491	3.227	0.073	0.147	0.465	3.149	0.069
SOUTH COAST	SAN BERNARDINO	0.475	1.449	9.173	0.213	0.428	1.315	8.321	0.193	0.402	1.244	8.119	0.183
SOUTHEAST DESERT	IMPERIAL	0.288	0.899	6.101	0.159	0.259	0.816	5.535	0.144	0.244	0.772	5.400	0.136
SOUTHEAST DESERT	KERN	0.151	0.493	3.014	0.071	0.136	0.448	2.734	0.065	0.128	0.423	2.667	0.061
SOUTHEAST DESERT	LOS ANGELES	0.110	0.375	2.225	0.052	0.099	0.341	2.018	0.047	0.093	0.322	1.969	0.045
SOUTHEAST DESERT	RIVERSIDE	0.263	0.847	5.564	0.134	0.237	0.768	5.047	0.122	0.223	0.727	4.924	0.115
SOUTHEAST DESERT	SAN BERNARDINO	1.644	5.205	29.937	0.704	1.480	4.725	27.156	0.638	1.392	4.470	26.494	0.605

Source: "Locomotive Emission Study", Booz-Allen & Hamilton for California ARB, August 1991

TABLE 2-17

COMMERCIAL AND GOVERNMENT MARINE VESSEL EMISSIONS (TPD)

		IN PORT			AT SEA			HARBOR			FISHING		
BASIN	COUNTY	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX
GREAT BASIN VALLEY	ALPINE												
GREAT BASIN VALLEY	MONO												
GREAT BASIN VALLEY	INYO												
LAKE COUNTY	LAKE												
LAKE TAHOE/MOUNTAIN COUNTIES	EL DORADO												
LT / MC / SACRAMENTO VALLEY	PLACER												
MOUNTAIN COUNTIES	MARIPOSA												
MOUNTAIN COUNTIES	SIERRA												
MOUNTAIN COUNTIES	TUOLUMNE												
MOUNTAIN COUNTIES	NEVADA												
MOUNTAIN COUNTIES	PLUMAS												
MOUNTAIN COUNTIES	AMADOR												
MOUNTAIN COUNTIES	CALAVERAS												
NORTH CENTRAL COAST	MONTEREY				1.856	4.737	42.700				0.576	1.340	6.546
NORTH CENTRAL COAST	SAN BENITO												
NORTH CENTRAL COAST	SANTA CRUZ				0.914	2.333	21.030				0.284	0.660	3.224
NORTH COAST	DEL NORTE										0.164	0.401	1.966
NORTH COAST	HUMBOLDT	0.183	0.125	0.827	2.580	6.600	61.070	0.030	0.080	0.370	1.092	2.676	13.104
NORTH COAST	TRINITY												
NORTH COAST	MENDOCINO										0.564	1.383	6.770
NORTHEAST PLATEAU	MODOC												
NORTHEAST PLATEAU	LASSEN												
NORTHEAST PLATEAU	SISKIYOU												
SACRAMENTO VALLEY	BUTTE												
SACRAMENTO VALLEY	SACRAMENTO	0.185	0.298	2.539				0.030	0.060	0.280	0.060	0.110	0.590
SACRAMENTO VALLEY	YOLO												
SACRAMENTO VALLEY	YUBA												
SACRAMENTO VALLEY	TEHAMA												
SACRAMENTO VALLEY	SHASTA												
SACRAMENTO VALLEY	SUTTER												
SACRAMENTO VALLEY	COLUSA												
SACRAMENTO VALLEY	GLENN												
SAN DIEGO	SAN DIEGO	0.164	0.138	1.005	0.740	1.880	16.950	0.040	0.170	0.840	1.560	4.560	22.320
SAN FRANCISCO	SAN FRANCISCO	0.246	0.238	1.780	1.020	2.640	23.810	0.013	0.040	0.176	0.013	0.031	0.154
SAN FRANCISCO	SAN MATEO	0.196	0.240	1.938				0.011	0.040	0.192	0.208	0.510	2.506
SAN FRANCISCO	SANTA CLARA										0.010	0.024	0.116
SAN FRANCISCO	ALAMEDA	0.535	0.519	3.952				0.029	0.087	0.392	0.288	0.706	3.470

TABLE 2-17
(continued)

COMMERCIAL AND GOVERNMENT MARINE VESSEL EMISSIONS (TPD)

		IN PORT			AT SEA			HARBOR			FISHING		
BASIN	COUNTY	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX
SAN FRANCISCO	MARIN										0.864	2.117	10.411
SAN FRANCISCO	NAPA												
SAN FRANCISCO	CONTRA COSTA	3.172	3.464	27.233				0.173	0.579	2.699	0.018	0.043	0.212
SAN FRANCISCO / NORTH COAST	SONOMA										0.192	0.470	2.314
SF / SACRAMENTO VALLEY	SOLANO										0.008	0.020	0.096
SAN JOAQUIN VALLEY	STANISLAUS												
SAN JOAQUIN VALLEY	SAN JOAQUIN	0.136	0.224	1.927				0.020	0.040	0.180	0.060	0.090	0.530
SAN JOAQUIN VALLEY	FRESNO												
SAN JOAQUIN VALLEY	TULARE												
SAN JOAQUIN VALLEY	KINGS												
SAN JOAQUIN VALLEY	MADERA												
SAN JOAQUIN VALLEY	MERCED												
SJV / SOUTHEAST DESERT	KERN												
SOUTH CENTRAL COAST	SANTA BARBARA										0.608	1.482	7.160
SOUTH CENTRAL COAST	VENTURA	0.284	0.177	1.123	2.030	5.210	46.910	0.030	0.100	0.470	0.078	0.190	0.918
SOUTH CENTRAL COAST	SAN LUIS OBISPO										0.094	0.228	1.102
SOUTH COAST	ORANGE				0.644	1.653	14.889				0.679	2.030	9.669
SOUTH COAST	SAN BERNARDINO												
SOUTH COAST	LOS ANGELES	4.856	3.367	22.547	0.466	1.197	10.781	0.190	0.760	3.490	0.491	1.470	7.001
SOUTH COAST	RIVERSIDE												
SOUTHEAST DESERT	IMPERIAL												
	Statewide Total	9.9566	8.789	64.871	10.25	26.25	238.14	0.566	1.956	9.089	7.91	20.54	100.18

Source: "Inventory of Air Pollutant Emissions from Marine Vessels", Booz-Allen & Hamilton, Inc. for California ARB, March 1991.

Booz-Allen has inventoried aircraft emissions (other than agricultural aircraft) for the ARB, and the air basin aircraft emissions used in the offroad model are taken from that study[17]. Booz-Allen based its estimates of emissions for commercial aircraft, general aviation aircraft, and military aircraft on landing/takeoff operations (LTO) and aircraft emission factors. Only the emissions of aircraft operations under 3000 feet are considered; therefore, emissions of aircraft in transit above 3000 feet are not included in the Booz-Allen inventory. Booz-Allen noted that LTO activity for commercial and general aviation aircraft are well documented by the Federal Aviation Administration, CALTRANS, and individual airport authorities. Operations data at military airports were very difficult to acquire, and largely were compiled through survey and personal contact with the major military airports in the State. They note that the weakest component of the estimation procedure is the emission factors, most of which were taken from AP-42 and were over ten years old at the time. However, Booz-Allen used the available data to estimate aircraft emissions by airport, county, and air basin. Where counties spanned more than one air basin, EEA allocated the emissions to the counties within the air basins by location of each airport or military base. Aircraft emissions for 1990 are shown in
Table 2-18.

The last category of offroad equipment for which emissions were estimated are agricultural aircraft (i.e., commercial aircraft used for crop dusting). ARB estimated emissions for seven types of agricultural aircraft representing piston engine powered fixed-wing aircraft and piston engine powered and turbine engine powered helicopters (Reference 13, Section 9-1, Revised May 1991). ARB used emission factors from AP-42, which are expressed in terms of mass of pollutant per mass of fuel consumed, and then calculated statewide agricultural aircraft emissions using available emission factors and statewide crop dusting fuel consumption data from the Department of Tax Administration. The total gallons of fuel consumed was apportioned to the counties according to the ratio of the number of acres sprayed by aerial applications in each county, which was taken from the Pesticide Use Report. Agricultural aircraft emissions for 1990 are shown in Table 2-19.

TABLE 2-18

1990 AIRCRAFT EMISSIONS (TPD)

		General Aviation				Commercial Carriers				Military Aircraft			
BASIN	COUNTY	HC	CO	NOx	PM	HC	CO	NOx	PM	HC	CO	NOx	PM
GREAT BASIN VALLEY	ALPINE	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GREAT BASIN VALLEY	MONO	0.018	0.297	0.006	0.001	0.011	0.017	0.003	0.001	0.001	0.001	0.000	0.000
GREAT BASIN VALLEY	INYO	0.040	0.739	0.013	0.003	0.003	0.005	0.001	0.000	0.052	0.088	0.019	0.019
LAKE COUNTY	LAKE	0.033	0.835	0.011	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LAKE TAHOE/MOUNTAIN COUNTIES	EL DORADO	0.116	2.149	0.039	0.008	0.009	0.156	0.097	0.016	0.019	0.032	0.007	0.007
LT / MC / SACRAMENTO VALLEY	PLACER	0.079	1.631	0.026	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	MARIPOSA	0.009	0.280	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	SIERRA	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	TUOLUMNE	0.081	2.046	0.030	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	NEVADA	0.109	1.739	0.033	0.007	0.056	0.105	0.052	0.003	0.002	0.003	0.001	0.001
MOUNTAIN COUNTIES	PLUMAS	0.040	0.654	0.015	0.003	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000
MOUNTAIN COUNTIES	AMADOR	0.006	0.210	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	CALAVERAS	0.026	0.510	0.009	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NORTH CENTRAL COAST	MONTEREY	0.178	2.814	0.061	0.013	0.160	0.482	0.214	0.017	0.606	1.890	0.217	0.084
NORTH CENTRAL COAST	SAN BENITO	0.046	0.931	0.013	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NORTH CENTRAL COAST	SANTA CRUZ	0.086	1.658	0.027	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NORTH COAST	DEL NORTE	0.009	0.179	0.003	0.001	0.006	0.011	0.004	0.000	0.004	0.007	0.002	0.002
NORTH COAST	HUMBOLDT	0.174	2.959	0.061	0.013	0.085	0.185	0.078	0.006	0.221	0.375	0.080	0.080
NORTH COAST	TRINITY	0.015	0.513	0.005	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NORTH COAST	MENDOCINO	0.060	1.158	0.022	0.005	0.004	0.007	0.001	0.000	0.000	0.000	0.000	0.000
NORTHEAST PLATEAU	MODOC	0.052	0.796	0.019	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NORTHEAST PLATEAU	LASSEN	0.013	0.302	0.004	0.001	0.000	0.000	0.000	0.000	0.017	0.030	0.009	0.018
NORTHEAST PLATEAU	SISKIYOU	0.057	1.169	0.019	0.004	0.021	0.040	0.020	0.001	0.010	0.017	0.004	0.004
SACRAMENTO VALLEY	BUTTE	0.104	2.000	0.034	0.007	0.040	0.072	0.029	0.003	0.014	0.024	0.005	0.005
SACRAMENTO VALLEY	SACRAMENTO	0.395	6.087	0.127	0.030	0.628	2.351	1.183	0.079	4.592	6.928	1.368	1.348
SACRAMENTO VALLEY	YOLO	0.114	1.839	0.035	0.008	0.000	0.000	0.000	0.000	0.002	0.003	0.001	0.001
SACRAMENTO VALLEY	YUBA	0.068	0.793	0.016	0.005	0.000	0.000	0.000	0.000	9.680	17.970	2.270	2.866
SACRAMENTO VALLEY	TEHAMA	0.054	0.771	0.018	0.004	0.000	0.000	0.000	0.000	0.006	0.010	0.002	0.002
SACRAMENTO VALLEY	SHASTA	0.153	2.708	0.051	0.013	0.160	0.348	0.147	0.012	0.049	0.084	0.018	0.018
SACRAMENTO VALLEY	SUTTER	0.040	0.669	0.013	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SACRAMENTO VALLEY	COLUSA	0.014	0.310	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SACRAMENTO VALLEY	GLENN	0.030	0.583	0.011	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SAN DIEGO	SAN DIEGO	1.459	16.702	0.424	0.111	1.414	5.364	3.260	0.257	3.400	9.283	2.113	2.720
SAN FRANCISCO	SAN MATEO	0.249	4.079	0.083	0.017	4.794	14.381	8.679	0.601	0.055	0.094	0.020	0.020
SAN FRANCISCO	SANTA CLARA	0.248	7.915	0.079	0.019	0.665	3.114	1.675	0.117	0.314	0.558	0.148	0.120
SAN FRANCISCO	ALAMEDA	0.749	10.220	0.205	0.057	0.927	3.943	2.007	0.149	0.200	0.644	0.192	0.154
SAN FRANCISCO	MARIN	0.093	2.118	0.021	0.007	0.000	0.000	0.000	0.000	0.002	0.006	0.001	0.000
SAN FRANCISCO	NAPA	0.330	2.829	0.067	0.024	0.000	0.000	0.000	0.000	0.052	0.088	0.019	0.019

TABLE 2-18
(continued)
1990 AIRCRAFT EMISSIONS (TPD)

		General Aviation				Commercial Carriers				Military Aircraft			
BASIN	COUNTY	HC	CO	NOx	PM	HC	CO	NOx	PM	HC	CO	NOx	PM
SAN FRANCISCO	CONTRA COSTA	0.090	2.591	0.032	0.007	0.008	0.064	0.027	0.002	0.014	0.025	0.005	0.005
SAN FRANCISCO / NORTH COAST	SONOMA	0.171	3.638	0.056	0.012	0.093	0.167	0.070	0.006	0.014	0.023	0.005	0.005
SF / SACRAMENTO VALLEY	SOLANO	0.139	2.558	0.040	0.010	0.000	0.000	0.000	0.000	2.045	2.488	0.564	0.671
SAN JOAQUIN VALLEY	STANISLAUS	0.122	2.144	0.038	0.009	0.171	0.310	0.132	0.010	0.424	0.746	0.191	0.149
SAN JOAQUIN VALLEY	SAN JOAQUIN	0.171	3.575	0.055	0.012	0.074	0.220	0.102	0.008	0.264	0.484	0.097	0.091
SAN JOAQUIN VALLEY	FRESNO	0.380	4.321	0.101	0.028	0.456	1.187	0.546	0.042	0.217	0.369	0.078	0.079
SAN JOAQUIN VALLEY	TULARE	0.201	4.178	0.052	0.014	0.030	0.048	0.009	0.002	0.004	0.007	0.001	0.001
SAN JOAQUIN VALLEY	KINGS	0.055	1.003	0.014	0.004	0.000	0.000	0.000	0.000	1.999	6.290	1.628	1.458
SAN JOAQUIN VALLEY	MADERA	0.039	0.887	0.013	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SAN JOAQUIN VALLEY	MERCED	0.084	1.878	0.026	0.007	0.034	0.061	0.025	0.002	18.994	20.326	2.244	5.089
SJV / SOUTHEAST DESERT	KERN	0.329	5.452	0.103	0.026	0.361	0.767	0.367	0.023	0.317	1.114	0.107	0.097
SOUTH CENTRAL COAST	SANTA BARBARA	0.335	4.965	0.101	0.027	0.682	1.922	0.926	0.072	1.055	1.435	0.182	0.311
SOUTH CENTRAL COAST	VENTURA	0.721	5.131	0.175	0.052	0.133	0.239	0.099	0.008	0.822	1.767	0.418	0.487
SOUTH CENTRAL COAST	SAN LUIS OBISPO	0.146	2.199	0.042	0.011	0.179	0.324	0.135	0.011	0.068	0.340	0.045	0.008
SOUTH COAST	ORANGE	0.414	8.960	0.113	0.031	0.273	1.749	0.956	0.104	1.362	4.579	1.317	0.677
SOUTH COAST/SED	SAN BERNARDINO	0.453	10.961	0.143	0.038	0.858	3.701	2.047	0.136	3.024	5.864	1.357	3.846
SOUTH COAST/SED	LOS ANGELES	2.272	33.001	0.747	0.171	8.228	24.149	14.124	0.980	8.562	14.188	3.005	2.899
SOUTH COAST/SED	RIVERSIDE	0.436	9.242	0.131	0.038	0.327	1.123	0.578	0.046	6.364	10.279	2.373	2.900
SOUTHEAST DESERT	IMPERIAL	0.126	2.365	0.039	0.010	0.152	0.284	0.139	0.008	0.547	2.523	0.455	1.284

Source: "Inventory of Air Pollutant Emissions from Aircraft Operations", Booz-Allen & Hamilton for California ARB, January 1991.

TABLE 2-19

1990 AGRICULTURAL AIRCRAFT EMISSIONS (TPD)

BASIN	COUNTY	TONS PER DAY HC	CO	NOx	PM
GREAT BASIN VALLEY	ALPINE	0.000	0.000	0.000	0.000
GREAT BASIN VALLEY	INYO	0.000	0.000	0.000	0.000
GREAT BASIN VALLEY	MONO	0.000	0.000	0.000	0.000
LAKE COUNTY	LAKE	0.000	0.000	0.000	0.000
LAKE TAHOE	EL DORADO	0.000	0.000	0.000	0.000
LAKE TAHOE	PLACER	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	AMADOR	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	CALAVERAS	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	EL DORADO	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	MARIPOSA	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	NEVADA	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	PLACER	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	PLUMAS	0.000	0.001	0.000	0.000
MOUNTAIN COUNTIES	SIERRA	0.000	0.000	0.000	0.000
MOUNTAIN COUNTIES	TUOLUMNE	0.000	0.000	0.000	0.000
NORTH CENTRAL COAST	MONTEREY	0.003	0.147	0.002	0.000
NORTH CENTRAL COAST	SAN BENITO	0.000	0.005	0.000	0.000
NORTH CENTRAL COAST	SANTA CRUZ	0.000	0.004	0.000	0.000
NORTH COAST	DEL NORTE	0.000	0.001	0.000	0.000
NORTH COAST	HUMBOLDT	0.000	0.001	0.000	0.000
NORTH COAST	MENDOCINO	0.000	0.001	0.000	0.000
NORTH COAST	SONOMA	0.000	0.000	0.000	0.000
NORTH COAST	TRINITY	0.000	0.000	0.000	0.000
NORTHEAST PLATEAU	LASSEN	0.000	0.001	0.000	0.000
NORTHEAST PLATEAU	MODOC	0.000	0.010	0.000	0.000
NORTHEAST PLATEAU	SISKIYOU	0.000	0.009	0.000	0.000
SACRAMENTO VALLEY	BUTTE	0.001	0.061	0.001	0.000
SACRAMENTO VALLEY	COLUSA	0.002	0.088	0.001	0.000
SACRAMENTO VALLEY	GLENN	0.001	0.058	0.001	0.000
SACRAMENTO VALLEY	PLACER	0.000	0.006	0.000	0.000
SACRAMENTO VALLEY	SACRAMENTO	0.001	0.023	0.000	0.000
SACRAMENTO VALLEY	SHASTA	0.000	0.001	0.000	0.000
SACRAMENTO VALLEY	SOLANO	0.000	0.005	0.000	0.000
SACRAMENTO VALLEY	SUTTER	0.002	0.074	0.001	0.000
SACRAMENTO VALLEY	TEHAMA	0.000	0.007	0.000	0.000
SACRAMENTO VALLEY	YOLO	0.001	0.073	0.001	0.000
SACRAMENTO VALLEY	YUBA	0.000	0.018	0.000	0.000
SAN DIEGO	SAN DIEGO	0.000	0.002	0.000	0.000
SAN FRANCISCO	ALAMEDA	0.000	0.020	0.000	0.000
SAN FRANCISCO	CONTRA COSTA	0.001	0.037	0.000	0.000
SAN FRANCISCO	MARIN	0.000	0.004	0.000	0.000
SAN FRANCISCO	NAPA	0.000	0.004	0.000	0.000
SAN FRANCISCO	SAN MATEO	0.000	0.009	0.000	0.000
SAN FRANCISCO	SANTA CLARA	0.000	0.032	0.000	0.000
SAN FRANCISCO	SOLANO	0.003	0.227	0.001	0.000
SAN FRANCISCO	SONOMA	0.001	0.052	0.000	0.000

TABLE 2-19
(continued)

1990 AGRICULTURAL AIRCRAFT EMISSIONS (TPD)

BASIN	COUNTY	TONS PER DAY HC	CO	NOx	PM
SAN JOAQUIN VALLEY	FRESNO	0.013	0.651	0.011	0.001
SAN JOAQUIN VALLEY	KERN	0.006	0.298	0.005	0.000
SAN JOAQUIN VALLEY	KINGS	0.007	0.347	0.006	0.000
SAN JOAQUIN VALLEY	MADERA	0.001	0.064	0.001	0.000
SAN JOAQUIN VALLEY	MERCED	0.002	0.119	0.002	0.000
SAN JOAQUIN VALLEY	SAN JOAQUIN	0.002	0.093	0.002	0.000
SAN JOAQUIN VALLEY	STANISLAUS	0.001	0.057	0.001	0.000
SAN JOAQUIN VALLEY	TULARE	0.002	0.124	0.002	0.000
SOUTH CENTRAL COAST	SAN LUIS OBISPO	0.000	0.017	0.000	0.000
SOUTH CENTRAL COAST	SANTA BARBARA	0.001	0.021	0.000	0.000
SOUTH CENTRAL COAST	VENTURA	0.001	0.023	0.000	0.000
SOUTH COAST	LOS ANGELES	0.000	0.001	0.000	0.000
SOUTH COAST	ORANGE	0.000	0.000	0.000	0.000
SOUTH COAST	RIVERSIDE	0.001	0.043	0.001	0.000
SOUTH COAST	SAN BERNARDINO	0.000	0.004	0.000	0.000
SOUTHEAST DESERT	IMPERIAL	0.009	0.460	0.008	0.001
SOUTHEAST DESERT	KERN	0.001	0.032	0.001	0.000
SOUTHEAST DESERT	LOS ANGELES	0.000	0.002	0.000	0.000
SOUTHEAST DESERT	RIVERSIDE	0.001	0.072	0.001	0.000
SOUTHEAST DESERT	SAN BERNARDINO	0.000	0.001	0.000	0.000

Source: "Methods for Assessing Area Source Emissions in California (Section 9-1)", California ARB, September 1991

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3. EQUIPMENT SCRAPPAGE AND MODEL YEAR DISTRIBUTION

3.1 INTRODUCTION

As discussed in the previous section, the offroad model estimates future year equipment populations as the sum of (sales - scrappage) for all years up to the calendar year of interest. Future year sales are derived from growth rates applied to the base year's equipment sales, and scrappage is a static function of equipment age and use. In the real world, however, both equipment sales and scrappage are functions of economic cycles, and the use of an econometric model for estimating sales and scrappage would be preferred. However, this model is not an econometric model, and must rely on a methodology for projecting future year equipment populations which does not consider fluctuations in the economy.

Power Systems Research applies a scrappage function to its engine sales and import/export data to arrive at base year equipment population estimates, and the offroad model applies a similar function to the base year equipment populations to determine the expected equipment populations in future years. This section describes how the offroad model calculates the annual scrappage of the base year equipment populations, and how the model calculates the model year distribution of the baseline equipment population.

3.2 THE SCRAPPAGE MODEL

For most types of equipment, the expected equipment life is dependent on the engine life. That is, the equipment is taken out of service when the engine becomes inoperable. Therefore, equipment scrappage is a function of the expected life of the engine used in it, the annual hours of operation, and the average load factor. The relationship between engine use and engine life is discussed below. Note that for those equipment types that are re-engined instead of replaced (e.g., marine vessels, pleasure craft), installation of the new engine is analogous to the equipment being removed from service and replaced with a new unit. Therefore, there is no net emissions difference between equipment replacement and engine replacement.

In the scrappage model, offroad equipment engines are assumed to be scrapped on the basis of the time over which they operate and the load to which they are subjected during operation. The load the engine carries is known as the load factor, and is simply the average operating level in a given application as a percent of the engine manufacturer's maximum horsepower rating (the average load factors by application were listed in the tables in Section 2). Each engine in a specific application is assumed to operate for the average annual number of hours at the average load factor. Average engine life expectancies at 100 percent load factor, which are dependent on the engine type and average horsepower, are shown in Table 3-1.

Dividing the annual engine use (in hours) by the expected engine life (also in hours) gives the fraction of engine life consumed in a year. This value is multiplied by the number of years in use to determine the fraction of total engine life consumed. A numerical representation of the scrappage curve shown in Figure 3-1 is then used to determine the percentage of engines in operation by comparing the fraction of engine life consumed to a tabular representation of the scrappage curve.

The scrappage curve was developed by PSR over years of research, and represents the engine fleet retirement rate based on data gathered through surveys of equipment users. Variations in maintenance, accidental failures, and variations around the norm in terms of engine quality and performance influence when a particular engine will wear out in actual use, and the smoothed curve estimates the effect of these factors on engine life expectancies. Note that the curve

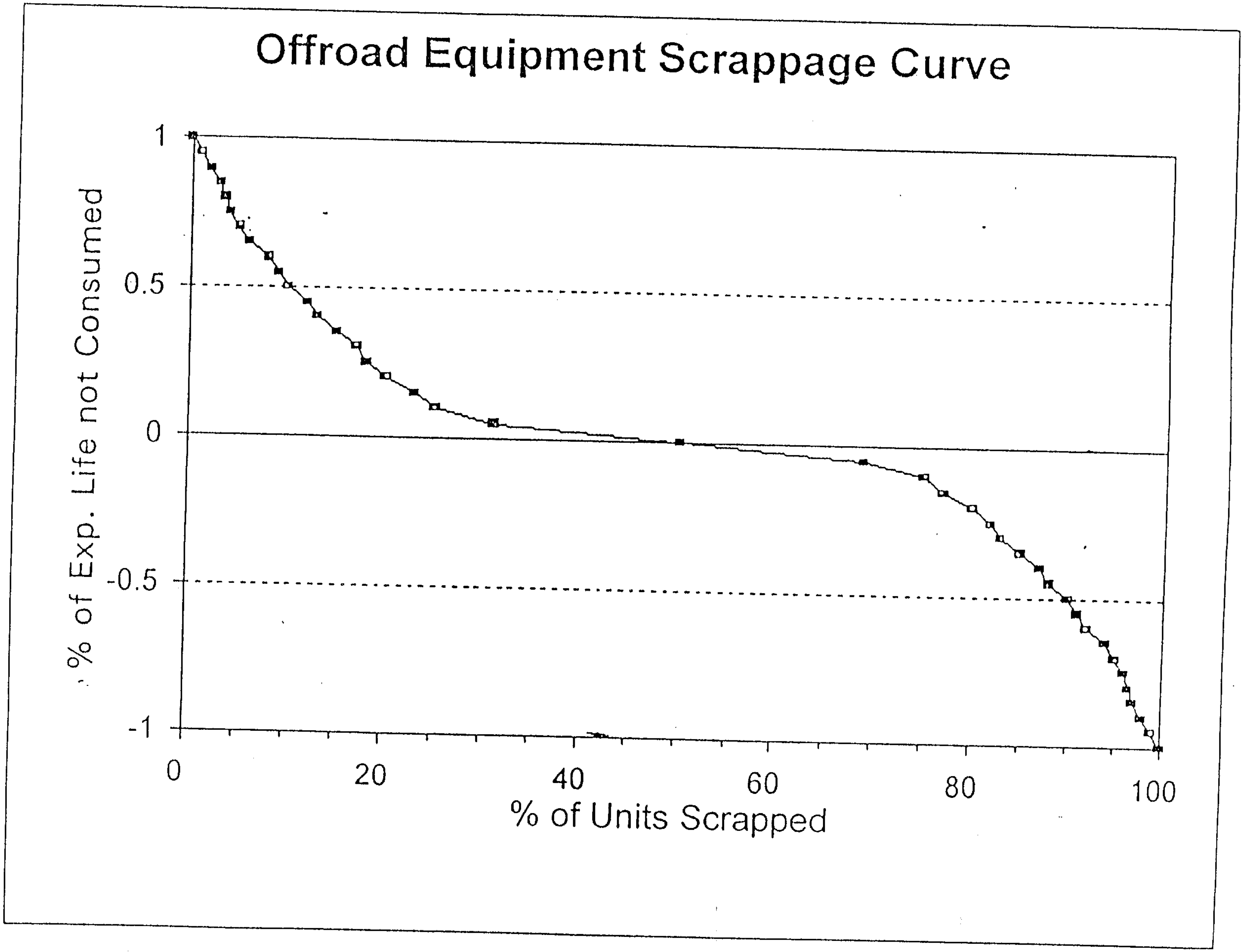
TABLE 3-1

EXPECTED ENGINE LIFE IN HOURS

Engine Type	HP 1	HP 2	HP 3	HP 4	HP 5	HP 6	HP 7	HP 8	HP 9	HP 10
Diesel	1250	2500	2500	4000	4000	4000	6000	6000	6000	--
Gasoline, 2-stroke	150	200	750	--	--	--	--	--	--	--
Gasoline, 4-stroke	200	400	750	1500	3000	3000	3000	3000	3000	3000
CNG/LPG, 4-stroke	200	400	750	1500	3000	3000	3000	3000	3000	3000

HP Rating	Diesel	2-stroke	4-stroke
HP1	£15	£2	£5
HP2	16-25	3-15	6-15
HP3	26-50	16-25	16-25
HP4	51-120	26-50	26-50
HP5	121-175	51-120	51-120
HP6	176-250	121-175	121-175
HP7	251-500	176-250	176-250
HP 8	501-750	251-500	251-500
HP9	751+	501-750	501-750
HP 10	--	751+	751+

FIGURE 3-1



Offroad Equipment Scrappage Curve
1
0.5
0
-0.5
-1
% of Exp. Life not Consumed
0
20
40
60
80
100
% of Units Scrapped

indicates that at the point at which 100 percent of engine life is presumed to have been consumed, 50 percent of engines will still be in operation. The end point of the curve, i.e., the point at which it is assumed no engines are any longer in service, was cut off at two times expected engine life. The following example illustrates how the scrappage model works.

Assume that 500 units of a specific type of equipment were placed into operation six years ago, that the annual hours of operation are 600, the load factor is 50 percent, and the engines have an expected lifetime of 4,000 hours at 100 percent load. To get the fraction remaining, the expected equipment life is calculated first, then the fraction remaining in any year of operation up to twice the expected life is obtained from a numerical representation of the scrappage curve, which is presented in Table 3.2. The expected equipment life is calculated as (engine life at 100% load) / (annual use) * (load factor), where engine life is in hours, and annual use is in hours/year. In this example, the expected equipment life is 4000 / [600 * 0.5] = 13.33. After rounding the expected life to 13 years, Table 3-2 is referenced to find that after six years of use, 91 percent (455) of the original engines with an expected equipment life of 13 years are still in service. This calculation is made for engines that were placed into service as many years back as twice the expected equipment life, so that a summation of these total units in operation by model year will provide a total population for this equipment and engine combination.

Only lawn and garden equipment and offroad recreational equipment are not scrapped on the basis of engine life expectancies. Lawn and garden equipment and recreational equipment are operated, stored, and maintained in such a way that their engines often are operable when the equipment becomes unusable and is scrapped. For example, an 18 horsepower, 4-stroke gasoline engine, typical of engines used in rear engine riding mowers, has an expected lifetime of 750 hours at 100 percent load, so such an engine in a rear engine riding mower that is used 49 hours per year at 38 percent average load factor is expected to last 40 years [750 / (49 * 0.38)].

TABLE 3-2

JULY 1 FRACTION OF EQUIPMENT IN USE BY VINTAGE

Vintage	Life expectancy (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	0.462	0.472	0.476	0.483	0.491	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
1	0.512	0.869	0.910	0.936	0.958	0.970	0.970	0.980	0.980	0.980	0.980	0.980	0.980	0.990	0.990	0.990
2	0.026	0.532	0.824	0.878	0.940	0.950	0.960	0.960	0.960	0.965	0.965	0.970	0.970	0.970	0.970	0.980
3	0.000	0.114	0.548	0.798	0.870	0.900	0.910	0.930	0.940	0.950	0.950	0.960	0.960	0.960	0.965	0.970
4		0.013	0.166	0.548	0.800	0.840	0.880	0.900	0.910	0.923	0.930	0.940	0.950	0.950	0.960	0.960
5		0.000	0.067	0.192	0.500	0.780	0.830	0.840	0.880	0.900	0.910	0.920	0.930	0.940	0.950	0.950
6			0.010	0.114	0.200	0.500	0.770	0.820	0.840	0.870	0.880	0.900	0.910	0.910	0.920	0.930
7			0.000	0.046	0.130	0.220	0.500	0.760	0.810	0.830	0.850	0.870	0.890	0.900	0.910	0.910
8				0.007	0.060	0.160	0.230	0.500	0.750	0.800	0.830	0.840	0.860	0.880	0.890	0.900
9				0.000	0.035	0.100	0.170	0.240	0.500	0.750	0.790	0.820	0.830	0.850	0.870	0.880
10					0.016	0.050	0.120	0.180	0.250	0.500	0.740	0.780	0.810	0.830	0.840	0.840
11					0.000	0.020	0.080	0.160	0.190	0.250	0.500	0.720	0.770	0.810	0.830	0.830
12						0.010	0.040	0.100	0.160	0.200	0.260	0.500	0.720	0.770	0.800	0.820
13						0.000	0.030	0.070	0.120	0.170	0.210	0.280	0.500	0.720	0.760	0.800
14							0.010	0.035	0.090	0.130	0.170	0.220	0.280	0.500	0.710	0.760
15							0.000	0.017	0.060	0.100	0.150	0.180	0.230	0.280	0.500	0.700
16								0.008	0.030	0.080	0.120	0.160	0.190	0.230	0.290	0.500
17								0.000	0.020	0.045	0.090	0.130	0.170	0.190	0.240	0.300
18									0.010	0.030	0.070	0.100	0.140	0.170	0.200	0.240
19									0.000	0.017	0.050	0.080	0.110	0.150	0.170	0.200
20										0.010	0.030	0.060	0.090	0.120	0.160	0.180
21										0.000	0.015	0.040	0.070	0.100	0.130	0.170
22											0.010	0.025	0.050	0.090	0.110	0.160
23											0.000	0.015	0.040	0.060	0.090	0.120
24												0.010	0.025	0.050	0.080	0.100
25												0.000	0.015	0.037	0.050	0.090
26													0.010	0.028	0.040	0.070
27													0.000	0.010	0.035	0.050
28														0.005	0.025	0.040
29														0.000	0.010	0.028
30															0.005	0.017
31															0.000	0.010
32																0.005
33																0.000

However, according to estimates developed by ARB in 1982 and the Outdoor Power Equipment Industry (OPEI) and reported by Booz-Allen and Hamilton[1], the average rear engine riding mower in California has a lifespan of 6 to 7 years, or less than one-fifth the expected engine life. Table 3-3 lists estimates of average lifespans of lawn and garden equipment from several sources.

Similarly, data presented by the Motorcycle Industry Council[2] indicates that offroad motorcycles and all-terrain vehicles are retired much sooner than is expected from calculations of the expected engine life. For example, a 40 horsepower, 2 stroke gasoline engine has an expected lifetime of 1500 hours at 100 percent load, so such an engine used in an offroad motorcycle at 76 percent load for 20 hours a year, would be expected to last 98 years [1500 / (20 * 0.76)]. However, the MIC data indicate that offroad motorcycles have an average life of a little over five years. Table 3-4 lists the MIC retirement rate estimates for offroad motorcycles and ATVs. These retirement rates are not similar to PSR's retirement scrappage data, which were developed for equipment unlike motorcycles and ATVs. Therefore, the MIC data are used. An average life of 9 years, which was recommended by the International Snowmobile Industry Association, is used for snowmobiles, and the PSR scrappage rates for vehicles with an average life of 9 years are used for calculating snowmobile scrappage, since no alternative scrappage function existed. All equipment of a given model year are still scrapped within twice the expected equipment lifetime, which translates to 11 years for off-road motorcycles, 13 years for ATVs, and 18 years for snowmobiles.

Lawn and garden equipment life expectancies are weighted by the percentages of commercial and residential equipment, using the data shown in Table 3-5, so that one life expectancy is used for the sum of commercial and residential equipment populations.

TABLE 3-3
ESTIMATES OF AVERAGE LIFESPAN OF LAWN & GARDEN EQUIPMENT
(YEARS)

Product Category	ARB		OPEI		Briggs & Stratton	
	Home	Commercial	Home	Commercial	Home	Commercial
Walk Behind Mowers	7.0	2.68	6.0	3.0	7.0	2.4
Riding Mowers	7.0	3.78	6.9*	3.0	7.0	2.4
Miscellaneous Lawn & Garden	7.0	2.68	10.0	--	7.0	2.4
Tillers	7.0	2.68	9.0	3.0	7.0	2.4
General Utility	5.21	2.85	--	--	7.0	2.4
Miscellaneous 2 Stroke	5.21	2.85	--	--	--	--
Chainsaws	5.21	2.85	--	--	--	--

Source: Booz-Allen and Hamilton[1]

* 6 years for riding mowers; 9 years for garden tractors.

TABLE 3-4
OPERABILITY RATES OF OFF-ROAD
MOTORCYCLES AND ATVs

Age of Vehicle	Percent Projected in Use	
Years	Motorcycles	ATVs
0	0.49	0.50
1	0.89	0.93
2	0.82	0.88
3	0.70	0.74
4	0.59	0.69
5	0.48	0.57
6	0.35	0.48
7	0.26	0.39
8	0.22	0.30
9	0.16	0.20
10	0.10	0.16
11	0.04	0.12
12	--	0.04
13	--	0.00

Source: Motorcycle Industry Council[2]

TABLE 3-5

COMMERCIAL AND RESIDENTIAL USE OF
LAWN AND GARDEN EQUIPMENT IN CALIFORNIA

PRODUCT CATEGORY	% HOME	% COMMERCIAL
WALK BEHIND MOWERS	95%	5%
RIDING MOWER (FRT ENG)	97%	3%
RIDING MOWER (REAR ENG)	97%	3%
GARDEN TRACTOR	97%	3%
TILLERS	68%	32%
SNOWTHROWERS	90%	10%
GENERAL UTILITY	44%	56%
SHREDDERS/GRINDERS	64%	36%
SPECIALIZED TURF CARE	0%	100%
4-CYC BLOWERS/VACUUMS	75%	25%
4-CYC EDGERS/TRIMMERS	79%	21%
2-CYC EDGERS/TRIMMERS	90%	10%
2-CYC BLOWERS/VACUUMS	90%	10%
CHAIN SAWS	92%	8%

Source: Reference 1

The above discussion reveals that the scrappage model must track equipment by model year in order to scrap the proper number of equipment each year, as the scrappage rate is not linear with time. That is, there is significantly greater per annum scrappage (on a percentage basis) in the year of operation that coincides with the actual equipment life expectancy than when the equipment is new or when it has been in operation for almost twice its life expectancy. Thus, within a given calendar year, different equipment model years are scrapped at different rates, and the model needs to keep track of the equipment inventory by model year. However, since model year equipment sales information is generally not available, especially in conjunction with engine information, the model year distribution for the baseline equipment population must be estimated, as explained below.

3.3 BASELINE MODEL YEAR DISTRIBUTION

The model year equipment distribution is calculated using the data shown in Table 3-2, which is the numerical representation of the scrappage curve for equipment with expected useful lives of one to sixteen years. (Since equipment can last as long as twice the expected life, thirty-two model years have to be accounted for.) First, the equipment fraction remaining in use are summed over the period covering two times the expected equipment life (e.g., if the expected life is two years, sum the expected fraction remaining in Column 2 in Table 3-2). This sum is a surrogate for the total number of pieces of equipment sold in the years leading up to the current year, and is referred to as the Sales Population Surrogate. The model year specific equipment population in the baseline year (1990) is then calculated as the product of the expected fraction remaining in $year_i$ * the Sales Population Surrogate. The following example illustrates the methodology for calculating the model year specific population of 4-stroke gasoline powered Lawn & Garden Tractors.

The 1990 population of 4-stroke gasoline powered Lawn & Garden Tractors is estimated to be 39,202. Since some of this equipment is modeled to be in use for twice its expected life, the model has to determine model year equipment populations for the last 14 model years (the expected life for Lawn and Garden Tractors is 6.9 years, which is rounded off to 7 years, and is then doubled). Table 3-6 lists the information needed to calculate the model year specific equipment population for 1990. First, Column C ("Expected Fraction Remaining") is summed across all model years to get the Sales Population Surrogate (i.e. an integer twice the expected life). Next, the value "Expected Fraction Remaining"/"Sales Population Surrogate" is calculated for each model year; this value expresses the equipment population of each model year in service as a fraction of the baseline population. Finally, the Model Year Specific Population (cells in Column D) is calculated by multiplying the 1990 baseline population (39,202) by the fractional representation of the model year specific equipment population.

This methodology has two acknowledged deficiencies. First, it assumes that equipment sales have been the same in each model year over the period of interest, even though this is known not to be the case for most types of equipment. However, since actual sales and scrappage tend to move together (i.e., when new equipment sales increase, scrappage of old equipment tends to increase as well) in response to economic conditions, the effect of using this model year distribution over the long term is expected to be small, since the scrappage curve is also kept invariant.

The second problem with this methodology is that it cannot be used to determine model year specific populations in years prior to 1990 in the absence of a complete set of equipment populations for the chosen baseline year. (The model does backcasts of equipment populations prior to 1990 for the purpose of comparing this model's output to that of previous models.) Therefore, the model year specific population distribution for 1990 is used for all years 1970 through 1990. This is accurate for mature markets such as those for construction and agricultural equipment, but it may not be the case for new, rapidly growing markets (such as the market for handheld lawn and garden equipment in the 1980s).

TABLE 3-6

EXAMPLE OF OFF-ROAD EQUIPMENT SCRAPPAGE
LAWN AND GARDEN TRACTORS

Model Year	Years in Use	Expected Fraction Remaining	Model Yr Specific Population Remaining
A	B	C	D = C/Total(C) * Actual Pop.
1990	0	0.5	2,800
1989	1	0.97	5,432
1988	2	0.96	5,376
1987	3	0.91	5,096
1986	4	0.88	4,928
1985	5	0.83	4,648
1984	6	0.77	4,312
1983	7	0.50	2,800
1982	8	0.23	1,288
1981	9	0.17	952
1980	10	0.12	672
1979	11	0.08	448
1978	12	0.04	224
1977	13	0.03	168
1976	14	0.01	56
Total		7.0	39,202

REFERENCES

1. Technical Support Document for California Exhaust Emission Standards and Test Procedures for 1994 and Subsequent Model Year Utility and Lawn and Garden Equipment Engines, Booz-Allen and Hamilton for the California Air Resources Board, October 1990

2. Motorcycle Statistical Annual 1992, Motorcycle Industry Council, Inc., 1992

4. SEASONALITY

4.1 INTRODUCTION

The term "seasonality" refers to the fact that offroad equipment use changes with the changing months or seasons. Equipment use is also dependent on the day of the week and on the hour of the day. For instance, it is well known that snowmobile use takes place entirely within about six months of the year (i.e., those months when snow is on the ground), and primarily during daylight hours on weekend days. This section discusses how offroad equipment use varies according to these temporal parameters.

Patterns of use by month, day, and hour that are used in the model were developed by ARB as part of previous offroad emission source inventories. These patterns of use are compared to use patterns obtained from other sources in the following sections.

4.2 MONTHLY USE PATTERNS

With the exception of snowmobiles and certain types of lawn and garden equipment, all equipment types within each of the broad equipment categories are assumed to share the same monthly use patterns. Although this assumption is not strictly true (e.g., agricultural combines and harvesters are used most heavily during the harvest season, while tractors are used throughout the year), it is not feasible, at this time, to develop use patterns for most individual equipment types. Most estimates of monthly equipment use are based on data provided by ARB[1], and are shown in Table 4-1.

TABLE 4-1

OFF-ROAD EQUIPMENT USE BY MONTH OF YEAR

Equipment Category	Fraction of Annual Use											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Recreational Vehicles	0.061	0.061	0.071	0.081	0.091	0.101	0.101	0.101	0.091	0.091	0.091	0.071
Construction Equipment	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
Industrial Equipment	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
Lawn and Garden Equipment	0.057	0.067	0.086	0.086	0.095	0.095	0.095	0.095	0.095	0.086	0.076	0.067
Farm Equipment	0.054	0.054	0.086	0.086	0.108	0.108	0.108	0.108	0.108	0.075	0.054	0.054
Light Commercial Equipment	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
Logging Equipment	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
Aircraft GSE	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
Transportation Refrigeration Units	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
Snowmobiles & Snowblowers	0.200	0.200	0.180	0.060	0.020	0.000	0.000	0.000	0.000	0.000	0.140	0.200
Chainsaws (£5 HP)	0.090	0.090	0.090	0.050	0.050	0.040	0.080	0.090	0.090	0.110	0.110	0.110
Tillers	0.030	0.030	0.040	0.150	0.150	0.150	0.110	0.110	0.110	0.040	0.040	0.040

The table shows that five categories of equipment - construction, industrial, logging, aircraft ground support, and transport refrigeration units - are assumed to be used uniformly throughout the year. Thus, each month accounts for 8.3 percent of the annual use for these types of equipment. Certainly there is some monthly variability in the use of equipment within these categories. For instance, construction activity such as asphalt paving slows down during the winter months, and logging activity generally occurs from August to November, but the use of helicopter and cable logging systems can extend logging operations up to eleven months. Finally, air travel, and hence aircraft ground support activity, has several peak periods within the year.

Lawn and garden equipment and light commercial equipment share the same monthly use patterns, and those patterns indicate that the highest use rates are in the summer months, and that the lowest use rates for these equipment types are in the winter months. This pattern of use is supported in the results of a 1983 survey[2] of California residents, which are shown below.

Annual Usage Rates of Lawn & Garden Equipment in California[2]

Equipment Type	Spring	Summer	Fall	Winter
Walk Behind Mowers	16%	67%	11%	6%
Tillers	45%	33%	12%	10%
Edgers/Trimmers	21%	63%	10%	6%
Chain Saws	14%	26%	33%	27%

The usage rates shown reflect the summer use peak for lawnmowers and trimmers/edgers, and they also show that tiller use peaks in the springtime, while chain saws are used most heavily in the fall and winter. Since there are over three million lawnmowers and trimmers/edgers/brushcutters in use in California, out of a lawn and garden equipment population of about five million, the choice of a monthly use pattern with a summer peak is reasonable.

However, HC and CO emissions from chain saws and tillers are significant, so they are assigned to the correct seasons. Of course, snowblowers are used only during the winter, which is not reflected in the overall lawn and garden equipment use pattern. Instead, snowblowers use the snowmobile pattern of use.

The ARB assumes that light commercial equipment follow the same use pattern as lawn and garden equipment. While some types of light commercial equipment are used more in the spring and summer (e.g., pressure washers), it is not intuitive that the entire category should be assigned the same use pattern as lawn and garden equipment. The EPA reported in its study of nonroad engines[3] that commercial equipment use is independent of any seasonal effects, so a uniform monthly activity distribution for light commercial equipment is used in this model.

Farm equipment use follows a pattern that is similar to lawn and garden equipment, but the summer use maximum and the winter use minimum are even more pronounced than they are in the lawn and garden category. As mentioned previously, some types of agricultural equipment (harvesters and combines) are used mainly in the fall, but in the absence of seasonal use profiles for all equipment types, the selected use pattern is reasonable.

Offroad recreational vehicles also have peak use in the summer months, but there is slightly more use (on a percentage basis) of these vehicles in the winter months than there is use of lawn and garden or farm equipment. As mentioned previously, snowmobile use occurs almost exclusively in the "winter" months of November through March. It is assumed there is no snowmobile use in June through October, and very little use occurs in April and May.

4.3 WEEKLY USE PATTERNS

All types of offroad equipment use one of the three weekly use patterns that ARB has developed, and they are shown in Table 4-2. Recreational vehicles, lawn and garden equipment, light commercial equipment, and snowmobiles share a pattern of twice as much use on either Saturday or Sunday as on any of the other days of the week. This is a reasonable assumption for non-commercial equipment, but it does not make sense for the light commercial equipment category. Welders and large generator sets, especially, are used almost exclusively in commercial applications and should be used more on weekdays than on weekend days. Therefore, the weekly use patterns for industrial equipment are utilized to describe weekly use patterns for light commercial equipment.

Based on ARB information, the construction, industrial, farm, and logging equipment categories are assumed to be used uniformly Monday through Saturday, with Sunday having less than one-half the use rate of the other days of the week. Finally, aircraft ground support equipment and transport refrigeration equipment are assumed to be used uniformly on all seven days of the week.

4.4 DAILY USE PATTERNS

ARB also developed the daily use patterns for offroad equipment. A day is divided into eight three-hour blocks, and each block is assigned a fraction of the total day's use. At present time, all equipment categories are assigned a single daily use pattern, as shown in Table 4-3. The daily use pattern shows equipment use building from zero in the early morning to a peak between 9:00 a.m. and 6:00 p.m., and then rapidly declining through the evening. This pattern is in line with many business and industry activity patterns.

The chosen daily use pattern is not a logical choice for the ground support equipment and transport refrigeration units categories. There is some use of equipment in these categories during all hours of the day, and the daily use patterns ARB has selected do not reflect this. For example, transport refrigeration units (TRU) are used at night when perishable products are shipped for morning delivery. Ground support equipment are used whenever the airports are open, not only for servicing passenger flights, but also for servicing cargo aircraft and for performing maintenance.

Traffic into and out of an airport is an indicator of aircraft flight activity, which in turn implies ground support equipment activity. Incoming and outgoing vehicle counts were obtained from Los Angeles International Airport[4] for use as a surrogate for ground support equipment activity by hour of day. The traffic counts are collected via automated vehicle counters embedded in the pavement in the airport's access roads. The data show that there is activity at all hours of the day, with the peak traffic in the 9:00 am to noon block, and the noon to 3:00 pm and 6:00 to 9:00 pm blocks being almost as busy. The data, which are listed in Appendix D, are used to describe ground support equipment activity by time of day, as shown in Table 4-3. TRU activity was allocated by assuming that activity during daytime (6 a.m. to 6 p.m.) was twice that as for nighttime, but was uniform within those two periods.

TABLE 4-2

OFF-ROAD EQUIPMENT USE BY DAY OF WEEK

Equipment Category	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Recreational Vehicles	0.222	0.111	0.111	0.111	0.111	0.111	0.222
Construction Equipment	0.064	0.164	0.164	0.164	0.164	0.164	0.115
Industrial Equipment	0.064	0.164	0.164	0.164	0.164	0.164	0.115
Lawn and Garden Equipment	0.222	0.111	0.111	0.111	0.111	0.111	0.222
Farm Equipment	0.064	0.164	0.164	0.164	0.164	0.164	0.115
Light Commercial Equipment	0.064	0.164	0.164	0.164	0.164	0.164	0.115
Logging Equipment	0.064	0.164	0.164	0.164	0.164	0.164	0.115
Aircraft GSE	0.143	0.143	0.143	0.143	0.143	0.143	0.143
Transportation Refrigeration Units	0.143	0.143	0.143	0.143	0.143	0.143	0.143
Snowmobiles	0.222	0.111	0.111	0.111	0.111	0.111	0.222

TABLE 4-3

OFF-ROAD EQUIPMENT USE BY TIME OF DAY

Equipment Category	Fraction of daily use in 3 hour periods ending at times indicated							
	03:00	06:00	09:00	12:00	15:00	18:00	21:00	24:00
Recreational Vehicles	0.000	0.008	0.152	0.255	0.255	0.246	0.084	0.000
Construction Equipment	0.000	0.008	0.152	0.255	0.255	0.246	0.084	0.000
Industrial Equipment	0.000	0.008	0.152	0.255	0.255	0.246	0.084	0.000
Lawn and Garden Equipment	0.000	0.008	0.152	0.255	0.255	0.246	0.084	0.000
Farm Equipment	0.000	0.008	0.152	0.255	0.255	0.246	0.084	0.000
Light Commercial Equipment	0.000	0.008	0.152	0.255	0.255	0.246	0.084	0.000
Logging Equipment	0.000	0.008	0.152	0.255	0.255	0.246	0.084	0.000
Aircraft GSE	0.021	0.067	0.135	0.180	0.172	0.142	0.171	0.112
Transportation Refrigeration Units	0.08	0.08	0.160	0.160	0.160	0.160	0.160	0.160
Snowmobiles	0.000	0.008	0.152	0.255	0.255	0.246	0.074	0.000

REFERENCES

1. Temporal Data for Area Source Categories, California Air Resources Board, 1992.

2. Report on Utility Equipment Emissions in California, CIC Research for the California ARB, 1983. (As reported by Booz-Allen & Hamilton)

3. Nonroad Engine and Vehicle Emission Study -- Report, U.S. Environmental Protection Agency, November 1991.

4. Hourly Traffic Report (102), 8/28/92 thru 8/29/92, Los Angeles International Airport, 1992.

5. EQUIPMENT POPULATION GROWTH

5.1 INTRODUCTION

The populations of offroad equipment in future years (i.e., all years after the 1990 baseline year) are calculated through the use of growth factors. The growth factors were developed by local air quality management district (AQMD) agencies and the ARB, and the ARB has compiled them into separate files for each air basin. For consistency, the offroad equipment model uses the growth factors supplied by the AQMDs. The growth factors are applied to the new equipment population (i.e., new equipment sales) to determine future year equipment populations. The growth factors and the methodology used to grow equipment populations are discussed below.

5.2 GROWTH FACTORS

Growth factors are derived from socio-economic indicators (e.g., housing units and manufacturing employment) that are assumed to have a close relationship with the offroad equipment categories. Forecasts of these indicators into the future are used as forecasts of future equipment sales, relative to baseline year sales. New equipment sales are the driver of future equipment populations, as discussed in Section 5.3.

Growth factors for each county were supplied to EEA by the ARB in sets of two files per air basin. The Growth Activity Correspondence (GAC) file[1] identifies which activity growth factor is associated with each offroad equipment category, and the County Activity Data (CAD) file[2] contains the activity growth factors. A third file contained the key to matching the growth factors to the ARB defined equipment categories. EEA combined the sets of paired GAC and CAD files, according to the ARB "keys", to create growth files for each air basin.

Table 5-1 lists the ARB equipment classes, their corresponding growth indicators, and the equipment classes that the model associates with the growth codes and indicators. The ARB equipment classes do not match all of the new models' equipment classes, necessitating some differences in growth indicators, as explained in Section 2, and EEA has made some changes so that equipment categories and growth indicators are more logically paired. Locomotive emissions are estimated in future years by interpolating between emissions estimates developed for 1987, 2000, and 2010.

Table 5-2 lists the indicators that are used to project growth of offroad equipment sales for two counties in the South Coast Air Basin. As the table shows, the South Coast Air Quality Management District, which provided the growth data to ARB, used 1990 as the base year for all of its growth projections. For all indicators except housing units and population, the base year value is 1.000 and future year growth factors are provided for 1996, 1997, 2000, and 2010. Actual numbers of housing units and population are provided for 1990, 2000, and 2010.

Table 5-2 indicates that almost all offroad equipment categories in the South Coast are forecast to grow significantly between 1990 and 2010. The SCAQMD forecasts for two categories, agricultural and construction, are compared below to alternative growth scenarios.

EEA has previously estimated the statewide growth of off-road mobile equipment activity for the California Air Resources Board[3,4]. EEA based the growth rate for light-duty (£50 hp) and heavy-duty (>50 hp) construction equipment on historical data for residential, non-residential and heavy construction from the Construction Industry Research Board, and on forecast data for residential and non-residential construction permit values from the UCLA Business Forecast for California. The residential building category includes new construction of and renovations to single and

TABLE 5-1

GROWTH CODES AND CORRESPONDING EQUIPMENT CLASSES

Growth Code	Growth Name	ARB Equipment Class	Model Equipment Class
110	Agriculture	HD Farm Equipment, Agricultural Aircraft	Farm, Agricultural Aircraft
120	Forestry	Not Active	Logging
130	Mining - Total	Not Active	Mining Construction >500 HP
200	Manufacturing	Not Active	Industrial
210	Food & Kindred Services	Transport Refrigeration Units	Transport Refrigeration Units
300	Services	Utility Equipment	Light Commercial
420	Rail Transport	Locomotives	Not Used
430	Ship Transport	Commercial Vessels	Commercial Marine
442	Jet Aircraft	Commercial Jets Civil Jets	Ground Service Equipment
510	Residential (Housing Units)	Residential Lawn & Garden	Lawn & Garden
521	Off-Road MV (recreation)	Offroad MC, Snowmobiles & 4-Wheel	Offroad Recreational
600	Miscellaneous Activities	Heavy Duty Non-Farm Equipment	Not Used
610	Construction	Not Active	Construction <=500

TABLE 5-2
OFF-ROAD EQUIPMENT POPULATION GROWTH RATES

County	Growth Code	1990	1996	1997	2000	2010	Indicator	Equipment Categories
Los Angeles	110	1.000	1.094	1.193	1.215	1.451	Agriculture, total	Farm
Los Angeles	120	1.000	1.094	1.193	1.215	1.451	Agriculture, total	Logging
Los Angeles	130	1.000	0.723	0.773	0.806	0.881	Mining, total	Mining & Construction > 500 HP
Los Angeles	200	1.000	1.107	1.216	1.280	1.531	Manufac., Total	Industrial
Los Angeles	210	1.000	0.898	0.972	1.028	1.261	Manufac., Food	Transport Refrig. Units
Los Angeles	300	1.000	1.049	1.123	1.223	1.651	Services	Light Commercial
Los Angeles	420	8619190	--	--	9555317	10662194	Population	Locomotives
Los Angeles	430	1.000	1.010	1.014	1.017	1.021	Commercial Vessels	Commercial Marine
Los Angeles	442	8619160	--	--	9555317	10662194	Population	Ground Service Equipment
Los Angeles	510	2909514	--	--	3146612	3498958	Housing Units	Lawn & Garden
Los Angeles	521	8619160	--	--	9555317	10662194	Population	Off-Road Rec.
Los Angeles	610	1.000	1.011	1.086	1.121	1.390	Construction	Construction <= 500
Orange	110	1.000	1.241	1.353	1.370	1.651	Agriculture, total	Farm
Orange	120	1.000	1.241	1.353	1.370	1.651	Agriculture, total	Logging
Orange	130	1.000	1.030	1.102	1.025	1.089	Mining, total	Mining & Construction > 500 HP
Orange	200	1.000	1.164	1.279	1.372	1.701	Manufac., total	Industrial
Orange	210	1.000	1.063	1.152	1.114	1.333	Manufac., Food	Transport Refrig. Units
Orange	300	1.000	1.094	1.171	1.364	2.041	Services, total	Light Commercial
Orange	420	2410672	--	--	2867900	3108000	Population	Locomotives
Orange	430	1.000	1.028	1.037	1.046	1.055	Commercial Vessels	Commercial Marine
Orange	442	2410672	--	--	2867900	3108000	Population	Ground Service Equipment
Orange	510	827063	--	--	946679	1027680	Housing Units	Lawn & Garden
Orange	521	2410672	--	--	2867900	3108000	Population	Off-Road Rec.
Orange	610	1.000	1.311	1.408	1.450	1.831	Construction	Construction

TABLE 5-2
OFF-ROAD EQUIPMENT POPULATION GROWTH RATES

County	Growth Code	1990	1996	1997	2000	2010	Indicator	Equipment Categories
Riverside		1.000	0.380	0.414	0.420	0.396	Agriculture, total	Farm
Riverside		1.000	0.380	0.414	0.420	0.396		Logging
Riverside		1.000	1.080	1.155	1.114	1.183	Mining, total	Construction > 500 HP
Riverside		1.000	1.387	1.503	1.484	1.744	Food & Kindred Svcs.	Transport Refrig. Units
Riverside		1.000	1.202	1.286	1.683	3.047	Services	Commercial Lawn & Garden, Light Commercial
Riverside		1.000	0.931	1.006	1.255	2.291	Transportation	Locomotives
Riverside		1.000	0.931	1.006	1.255	2.291		Ground Service Equipment
Riverside		288171	--	--	441501	619184	Population	Residential Lawn & Garden
Riverside		864192	--	--	1390320	1884864	Housing Units	Off-Road Rec., Industrial
Riverside		1.000	0.954	1.025	1.238	1.949	Construction	Construction
San Bernardino		1.000	0.549	0.598	0.607	0.572	Agriculture, total	Farm
San Bernardino		1.000	0.549	0.598	0.607	0.572		Logging
San Bernardino		1.000	0.944	1.009	0.974	1.034	Mining, total	Construction > 500 HP
San Bernardino		1.000	1.359	1.473	1.455	1.709	Food & Kindred Svcs.	Transport Refrig. Units
San Bernardino		1.000	1.190	1.274	1.667	3.018	Services	Commercial Lawn & Garden, Light Commercial
San Bernardino		1.000	1.138	1.229	1.534	2.799	Transportation	Locomotives
San Bernardino		1.000	1.138	1.229	1.534	2.799		Ground Service Equipment
San Bernardino		358949	--	--	442787	546049	Population	Residential Lawn & Garden
San Bernardino		1107582	--	--	1425262	1730680	Housing Units	Off-Road Rec., Industrial
San Bernardino		1.000	0.816	0.876	1.058	1.667	Construction	Construction

multifamily structures. Non-residential buildings are defined as commercial buildings such as offices, stores, hotels and hospitals. Heavy construction includes the building of streets and highways, bridges, sewerage and waste systems, and a host of other large public sector building projects. Light-duty construction equipment are used in all three construction categories, and heavy-duty equipment are used primarily in non-residential and heavy construction projects.

According to the UCLA Business Forecast, residential and non-residential construction activity is expected to grow slowly (0.63 %/year) between 1990 and 2000. Forecasts of heavy duty construction activity are unavailable, but since permit valuation of heavy construction projects has been very stable since about 1984, it is reasonable to assume that this sector will not experience much change in activity in the next decade. A growth index for construction equipment can be calculated then as the projected rate of annual growth for the combined California construction industries (residential + non-residential + heavy duty) for the period 1990 to 2000. The calculated rate of growth, 0.63 percent per year, is much less than the annual growth rates that are forecast by the SCAQMD for any of the counties in the South Coast.

Conversations with personnel in the Departments of Agricultural Economics and Agricultural Engineering at UC-Davis, and in the California Department of Food and Agriculture indicated that there are several reasons that the best estimate of agricultural equipment growth is one of no growth. These reasons are:

- Water resources are very questionable, and may require taking land out of production or changing crops.
- Acreage in production may be converted to dairy farming, or converted from dairy farming. For example, the last 5-10 year period has witnessed a boom/bust cycle in dairy farming in areas where crop production has historically been favored.
- Total horsepower/acre should remain constant for a given crop.

On the basis of the above discussion, it is reasonable to assume the inventory of agricultural equipment will remain essentially constant at current levels for the foreseeable future.

These alternative growth scenarios are based on state data, and there are bound to be local factors that could cause the local growth rates to be significantly different from the state growth. However, the state projections for agricultural equipment, in particular, disagree with those for the South Coast, as the SCAQMD has forecast that agricultural equipment activity in Los Angeles and Orange counties will grow by 21 and 37 percent, respectively, between 1990 and 2000, while other sources indicate there are few, if any, reasons to expect growth in the statewide agricultural equipment category. Further, the data for Los Angeles and Orange Counties often indicate relatively slow annual growth between 1990 and 1996, then raised growth between 1996 and 1997, and then much slower growth. Although the growth forecasts supplied were retained for the model, we caution the ARB that they do not appear realistic in instances such as agriculture. The scope of this effort did not extend to developing new growth factors, and it is recommended that ARB re-examine the basis for deriving the activity growth factors prior to the next update of the County Activity Data file.

5.3 EQUIPMENT GROWTH METHODOLOGY

In the model, growth factors are expressed as a fraction of the base year, which is always assigned the value of unity. For indicators that are provided as actual numbers by the local districts, or in cases where the base year used by the local district was not 1990, the 1990 and future year values are normalized to 1990 by dividing by the 1990 value. Future year population growth is indicated by growth factor values greater than one, and population decline is indicated by growth factors less than one.

The local air quality management districts have followed no consistent format for reporting the growth factors. For instance, some local districts provided data for all years between 1970 and 2020, while other agencies provided data for five or six years. This inconsistency in reporting format resulted in the need for considerable processing of the raw growth factor data, and it was determined that an external module for determining the growth factors was needed. The external growth factor module, which is run only when the input growth indicators are revised, performs the following functions:

- Converts any reported growth indicator values (such as housing units) into growth rates.
- Designates the correct year (1990) as the base year with a value of 1.00.
- Interpolates or extrapolates, as needed, to determine growth rates for all future years in all counties, based on the yearly data provided by the local agencies.
- Writes the processed growth data to a file that is read in when the offroad model is run.

The model year distribution for 1990, which is calculated as described in Section 3, determines the equipment population to which future growth is applied. Future growth applies only to sales of new equipment, so an annual population growth rate of two percent, for instance, means that the next year's new equipment population (i.e., sales) must increase over the previous year's sales by the amount which will increase the overall equipment population by two percent. Note that the percent increase in sales is not equivalent to the percent increase in overall population and must be much higher. An application of this methodology is demonstrated in the following example.

In the absence of any growth rate, sales/year is simply given by:

$$S = P/L$$

where P is the population and L the equipment mean life in years. If the activity and, hence, the population must grow at a rate, x_i, that can vary each year in the future, then sales in each future year can be calculated as follows.

(1) July 1 Population in year y+1 is

$$P_{y+1} = P_y (1 + x)$$

where P_y is population in year y, and x is the growth rate for the next year.

(2) Add the populations from vintage 2 to 2L in year y (using Table 3-2) to determine population of equipment older than 1 year and let this equal R.

(3) New equipment population added is

$$P_{new} = P_{y+1} - R - \frac{S'_{y-1} \cdot f_1}{2}$$

Where S'_{y-1} is the sales in the previous year between 7/1 and 6/30 and f_1 is the equipment fraction in use after 1 year, from Table 3-2.

(4) Sales between 7/1 and 6/30 is given by

$$S'_y = \frac{P_{new}}{(0.5\, f_1 + f_o)}$$

where f_o is year 0 population fraction in use from Table 3-2.

(5) Calendar year sales, $S_y = \frac{S'_y + S'_{y-1}}{2}$

For the initial calculation for year 0, sales are assumed to be flat historically so that $S'_0 = S_0 = S'_{-1}$

A simple numerical example illustrates the process for an equipment type where base year population is 100,000 and mean life is 10 years. To calculate sales in future years for a population growth rate of 2 percent, we have

$$P = 100{,}000,\ L = 10,\ x = 0.02$$

$$S_{Base} = 100{,}000/10 = 10{,}000$$

Step (1)

$$P_1 = P_o(1 + x) = 100{,}000\,(1 + 0.02) = 102{,}000$$

Step (2) R from Table 3-2 is given by

$$R = 10{,}000 * \sum_{v=2}^{20} \text{Fraction in use}$$

$$= 85{,}200$$

Note: Sales were considered constant to derive base year vintage distribution.

Step (3)

$$P_{new} = 102{,}000 - 85{,}200 - \frac{10{,}000 \times 0.980}{2}$$

$$= 11{,}900$$

Step (4)

$$S'_1 = \frac{11{,}900}{(0.5 \times 0.98 + 0.5)}$$

$$= 12{,}020$$

Step (5) S_1 $= \dfrac{10,000 + 12,020}{2}$

$= 11,010$

Vintage 0 Population in year 1

$= S'_1 \times f_o$

$= 12,020 \times 0.5$

$= 6010$

Vintage 1 Population in year 1

$= S_1 \times f_1$

$= 11,010 \times 0.98$

$= 10,790$

Repeat these steps for the next year. The example calculation is shown for year 1 and year 2 assuming a 2 percent growth rate in each year, in Table 5-3. All values are rounded to integers.

The table also shows the results for the year 4 calculation, so that the interested reader can check the numerical correctness of the above methodology, assuming continued 2 percent growth in population. Note that the year 4 population should total to 108,243, which is $100,000 \times (1.02)^4$.

TABLE 5-3

EXAMPLE CALCULATION FOR
A POPULATION GROWTH OF 2 PERCENT
(Base Population = 100,000, Life = 10 years)
July 1 Distribution

Vintage	Year 0	Year 1	Year 2	Year 4
0	5000	6010	6048	6129
1	9800	10790	11817	11970
2	9650	9650	10625	11708
3	9500	9500	9500	11454
4	9230	9230	9230	10162
5	9000	9000	9000	9000
.	.	.	.	
.	.	.	.	
.	.	.	.	
Step 1 P	100,000	102,000	104,040	108,243
Step 2 R	-	85,200	86,175	90,145
Step 3 P_{new}	-	11,900	11,975	12,135
Step 4 $\_{y}$	10,000	12,020	12,096	12,257
Step 5 S_y	10,000	11,010	12,058	12,214

REFERENCES

1. Growth Activity Correspondence, California Air Resources Board, 1994
2. County Activity Data, compiled by California Air Resources Board, 1994
3. Feasibility of Controlling Emissions from Off-Road, Heavy-Duty Construction Equipment, Final Report, Energy and Environmental Analysis, Inc. for the California Air Resources Board, December 1988
4. Regulatory Strategies for Off-Highway Equipment, Energy and Environmental Analysis, Inc. for the California Air Resources Board, January 1992

6. EMISSION FACTORS

6.1 OVERVIEW

Emission Factors for Off-Road Equipment can be broadly grouped into (1) exhaust emission factors (2) crankcase emissions, (3) refueling losses and (4) evaporative emission factors which include diurnal, hot soak, running and resting losses. Exhaust emission factors are based on the type of engine used and on the particular type of equipment through the duty cycle imposed on the engine. Since the same type of engine is used in different equipment types, it is possible to develop exhaust emission factors by engine type and apply them to all applicable equipment types after adjusting for duty cycle differences. Evaporative emissions are, however, dependent on the design of the fuel tank and fuel system in each equipment type and hence must be allocated by equipment type. Evaporative emissions are an issue for gasoline fueled equipment only since diesel fuel has very low volatility (RVP) and CNG/LPG systems are pressure sealed. However, refueling spillage loss and crankcase emissions are considered for all equipment.

The body of data from which emission factors have been developed is based on a relatively small number of emissions tests. Most of the testing has been sponsored by the ARB or by EPA. Additionally, engine manufacturers have submitted data on a confidential basis to ARB and EPA in support of recent rulemakings to control off-road emissions. They have also submitted data to EEA during the course of three previous studies on off-road engine emissions, two conducted for the ARB, and one for the EPA. Under this project, EEA has collected all of the data publicly available to date and combined it with our knowledge of anecdotal data and confidential data from the manufacturers. EPA had also completed a similar study in 1992, called the NEVES, and has published its own compilation of emission factors. The data provided here are contrasted with the data in NEVES, and reasons for any discrepancies explained.

6.2 ENGINE CLASSIFICATION AND EXHAUST EMISSIONS

Given the broad diversity of engines in the off-road mobile source categories, it is useful to group these engines into "like" types so that engines within one group are characterized by similar

- Technology level
- Fuel type
- Useful life
- Exhaust emissions

In addition, it was also required that the engine groups coincide with those specified in the regulatory framework that have been developed by ARB and EPA for the purposes of emission control. The parameters selected by EEA to categorize engines are as follows:

· Fuel Type	-Diesel, Gasoline, or CNG/LPG
· Technology Type	-2-Stroke/4-Stroke
	-Air cooled/water cooled
	-Side-valve/OHV
· Horsepower	-By range to include engines with similar useful life

It should be noted that not all distinctions are applicable or necessary, so that it is not necessary to distinguish between 2-stroke and 4-stroke diesel engines since their emissions are quite similar, and it is not necessary to distinguish between side-valve and overhead valve engines among diesel engines or among gasoline engines over 50 HP, as there are no side-valve versions in production.

Disaggregation by horsepower category is adequate for capturing most of the regulatory requirements except in the smallest engine sizes. ARB has defined emission regulations by engine displacement for these small engines, creating a distinction between small 2-stroke engines under and over 50 cubic centimeter (cc) displacement, and between small 4-stroke engines under and over 225 cc displacement. In other studies for EPA and the small engine industry, EEA has found that these distinctions can be translated into cutpoints of 2 HP and 5 HP respectively. It should be recognized that there are a few engines for which the displacement definition and HP based definition may not be identical, but such engines have very limited sales and the resulting inaccuracy has virtually no effect on modeled emissions.

Diesel engines are not used in recreational equipment except marine pleasure craft, and the population can be divided into nine horsepower categories, each with two technology subcategories. In the lower horsepower ranges up to 50 HP, engines are differentiated by the type of combustion system employed, labelled as "Direct Injection" and "Indirect Injection". Almost all of these diesels are naturally aspirated. In the higher horsepower categories (over 50 HP), engines are differentiated between turbocharged and naturally aspirated types; virtually all of these engines are direct injection. There are very few diesels above 500 HP in off-road equipment. Table 6-1 shows the different categories of diesel engines. Fuel consumption data are based on pre-control on-road engine fuel consumption tests for engines over 50 horsepower. Data submissions from engine manufacturers were used for smaller engines: Kubota provided data for 0-15 HP diesels, and Perkins provided data for 16-25 HP and 26-50 HP diesel engines.

Gasoline engines can be grouped by HP range and design type, but a third distinction is also required. This distinction is to separate out engines used in recreational equipment including:

- Off-road motorcycles
- All-terrain vehicles

- Snowmobiles
- Marine pleasure craft

The above four categories of equipment use engines typically rated at high RPM (higher than 5000 RPM), while all other categories of off-road equipment use engines rated at 3600 RPM or less.

Gasoline engines outside of the recreational vehicle category are generally rarely found in equipment with ratings over 120 HP, and the vast majority are rated at less than 25 HP. As noted in the overview, to differentiate between 2-stroke engines under 50 cc (for handheld equipment) and 4-stroke engines under 225 c.c, we have selected 0-2 HP and 0-5 HP as the appropriate ranges for 2-stroke and 4-stroke engines respectively. Technology categories are by 2-stroke and 4-stroke, and 4-stroke engines are further subdivided by type of valve system or by the type cooling (air/water). Table 6-2 shows the detailed classification of gasoline engines. An SwRI test program[1] provided fuel consumption for engines under 25 horsepower, and those data were extended to side valve units over 25 HP. Fuel consumption data for OHV engines over 25 HP were based on pre-control on-road engine bsfc (brake specific fuel consumption) test results.

6.3 EXHAUST EMISSIONS

A major part of the total emissions from off-road equipment is associated with exhaust emissions. At the present time, all existing and proposed emission regulations covering any of the equipment categories have focused primarily on exhaust emissions. In this model, exhaust emission data are associated with each engine type as defined by fuel type, horsepower range and technology subcategory. When a particular engine type is matched with an equipment category, exhaust emissions are adjusted to the duty cycle characteristics and actual engine size of the equipment, as explained in the following paragraphs.

TABLE 6-1
DIESEL ENGINE CATEGORIES

HP Range	Technology Types	Useful Life (hours)	Fuel Consumption (lb/hp-hr)
1) 0-15	1. Direct Injection 2. (Indirect Injection)*	1,250	0.49 0.61
2) 15-25	1. Direct Injection 2. Indirect Injection	1,250	0.49 0.55
3) 25-50	1. Direct Injection 2. Indirect Injection	2,500	0.49 0.55
4) 50-125	1. Turbocharged 2. Naturally Aspirated	4,000	0.46 0.50
5) 125-175	1. Turbocharged 2. Naturally Aspirated	4,000	0.44 0.49
6) 175-250	As above	4,000	0.44 0.49
7) 250-500	As above	6,000	0.38 0.44
8) 500-750	As above	6,000	0.38 0.44
9) 750+	As above	6,000	0.38 0.44

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* Very limited sales.

TABLE 6-2
GASOLINE ENGINE CLASSIFICATION
(Non-Recreational Equipment Only)

HP Range	Technology Type	Useful Life (hours)	Fuel Consumption (lb/BHP-hr)
Two Stroke			
0 - 2 HP	None	150	1.3
2 - 5 HP	None	200	1.3
5 - 15 HP	None	200	1.3
4-Stroke			
0 - 5 HP	(1) Side-valve (2) Overhead valve	200	1.1 1.0
5 - 15 HP	(1) Side-valve (2) Overhead valve	400	1.0 0.8
15 - 25 HP	(1) Side-valve (2) Overhead	750	1.0 0.7
25 - 50 HP	(1) Air cooled* (2) Water cooled	1500	1.0 0.6
50 - 125 HP	(1) Air cooled* (2) Water cooled	3000	1.0 0.55

* Includes side-valve units.

Exhaust emissions from all engines rated at 25 HP or less are measured on the SAE J1088 cycle, which tests the engine at idle, and at 85 percent of rated speed and 5 different load settings. All emissions are measured at steady state, and the emissions from the six modes are weighted together. The load factor, which is defined as the ratio of full load/rated speed output that is produced during operation, is 0.39 for the J1088 test. There is a simpler version of the J1088 for handheld two stroke engines where emissions are measured at idle, and at rated speed/full load. The load factor for this test is 0.9.

Engines over 25 HP are tested on the ISO/ARB 8-mode test for off-road engines. This test is also a steady-state test that is performed at two speeds (rated and intermediate) with a variety of loads, and at idle. The composite load factor is 56 percent for this test. Although both the J1088 and 8-mode tests are steady state tests, ARB studies have established that most off-road equipment do operate at quasi-steady state modes, in that there are no rapid speed transients and few rapid load transients. EPA, in its NEVES, "corrected" the steady state emissions for transient behavior associated with some equipment types, but the correction and its application to several equipment types were ad hoc, and not based on hard data or detailed studies.

The test derived emissions, measured in units of work, or gm/BHP-hr, are utilized to estimate emissions at the equipment level as follows:

Equipment Emissions/use hour = Engine Emissions/Bhp-hr * Engine BHP * Load Factor

The engine horsepower and load factor vary by equipment type and horsepower category, and this equation is applicable to equipment that operate at load factors in the range of 0.5 ± 0.2. If the load factor is significantly different from the test cycle load factor, then the engine emission factor itself may be inapplicable. At the extreme case of load factor = 0, emissions in gm/BHP-hr are infinite so that the above equation is inapplicable. However, most off-road equipment display load factors within the specified range, and no further load factor correction is necessary.

Emission factors for recreation vehicles are not specified in gm/BHP-hr; however they are specified in gm/mile for motorcycle/ATVs, and in gm/fuel gallon for pleasure craft. These units do not require the use of load factor, and emissions can be directly estimated from mileage or fuel use. A detailed discussion of the emission factors for all categories of engines is provided below.

6.3.1 Diesel Engines

0 to 15 HP - This category covers small single cylinder diesel engines used in generator sets, signal boards, pumps, etc. Virtually all models are air-cooled and feature direct injection fuel systems. Deutz/MWM and Yanmar are the major manufacturers in this segment. Emissions factors are derived from three tests, 2 from Yanmar and one from Deutz. Test data were submitted by Yanmar to ARB as part of the lawn and garden/utility rulemaking, and to EEA by Deutz as part of the ARB Off-Road Equipment study.

15 to 25 HP and 25 to 50 HP - These groups consist of 2, 3, or 4 cylinder air and water cooled models. These engines are used in a wide variety of agricultural, industrial and construction equipment. Yanmar, Kubota and Perkins dominate sales in this market and most of their sales are indirect injection diesels. Detailed emissions data were obtained from Deutz, Perkins and Yanmar as part of the ARB Off-Road Equipment Study, and the data were averaged to obtain the emission factors.

50 to 125 HP - Diesels over 50 HP are built for rugged use in agricultural, construction and industrial equipment. Engine sales in the 50 to 120 HP range are dominated by Deere, Kubota, Deutz and Perkins. These engines are split approximately evenly between naturally aspirated and turbocharged designs, and are not offered for sale in the on-highway segment. Detailed emissions data for this segment were provided by Deere, Kubota and Deutz as part of the ARB

Off-Road Heavy Duty Construction Equipment Study and the emissions factors are as reported in the Heavy Duty study.

125 to 175 and 175 to 250 HP - The range was originally defined as 125 to 250 HP but the additional 175 HP cutpoint was introduced to allow the ability to model emission regulations imposed by California on engines over 175 HP due to Federal pre-emption on emission control of smaller engines. Engines in this segment include those offered exclusively for use in off-road markets by Deere, Kubota, Deutz, and those offered in the medium duty truck market by Caterpillar, Cummins, DDC and Navistar. Eighty percent of the engines in this category are turbocharged. Emissions data for off-road engines were provided by all manufacturers listed above except Cummins and Navistar. Emission factors are as reported in the ARB Off-Road Heavy Duty Construction Equipment Study.

250 to 500 HP - This market is dominated by sales to the construction and mining industry, and Caterpillar, Cummins, DDC and Kubota are the major manufacturers. Virtually all engines are turbocharged. Emissions data for this segment were provided by Caterpillar, DDC and Kubota as part of the ARB Heavy Duty Construction Equipment Study. Emission factors are as reported in that study.

500 to 750 and 750+ HP - These engines are used in very large construction equipment or in mining equipment. Sales in this category are less than 1 percent of total off-road diesel engine sales; such engines are installed in equipment that are used in major earthmoving jobs, such as gravel pits, dam construction or new interstate highway construction. Engines in this segment are typically 8 or 12 cylinder versions of the six-cylinder engines in the 250 to 500 HP category. As a result, emissions for these engines (in g/Bhp-hr) are assumed to be identical to those in the 250 to 500 HP segment, as no test data are available.

All of the emissions data above refer to new engine (or zero hour) emission levels. Zero hour emissions by HP category are shown in Table 6-3. Emission factors for all engines over 125 HP are identical at the technology subcategory level, although the split between naturally aspirated and turbocharged engines varies.

As shown in Table 6-3, the ARB Heavy Duty Construction Equipment study allowed the derivation of historical emission factors that vary over time to capture the fact that some improvements to on-highway engines have found their way into the off-road market.

Differentiation between turbocharged and naturally aspirated diesels in the over 120 HP category is based on the limited data showing naturally aspirated diesels to have 50 percent higher HC and PM emissions relative to turbocharged diesels of the same vintage. No model year differentiation was possible for smaller diesels, and it is unlikely that their emissions have changed much over time, as these designs have little in common with on-highway diesels.

Data from EPA's NEVES study and ARB's existing non-road model are shown in Table 6-4 and Table 6-5, respectively. The data are not broken out by horsepower range or technology, but there is a fair amount of similarity between the EPA NEVES results and the emissions factors provided in Table 6-3 when average horsepower of the different equipment types are accounted for.

6.3.2 Gasoline Engines

Two-Stroke Engines - All 2-stroke engines are generally rated from 0 to 10 HP but most of the sales are concentrated in the 0 to 2 HP segment, used in handheld equipment. Outside of a few tests conducted by ARB and one by EPA, there are few actual emissions data on such engines. Zero hour emissions for the 0 to 2 HP are derived entirely from ARB data, and is as specified in the Technical Support Document for the 1994 Lawn and Garden/Utility Engine Emission

TABLE 6-3
ZERO HOUR EXHAUST EMISSION FACTORS
OFF-HIGHWAY DIESEL ENGINES
(g/BHP-hr)

		HC	CO	NO_x	PM	Reference
0 - 15 HP	DI	1.5	5.0	10.0	1.0	Manufacturer Submissions
	IDI	2.5	5.0	6.5	0.8	
15-25 HP	DI	1.3	5.0	11.0	0.9	1
	IDI	2.1	5.0	5.0	0.7	1
25-50 HP	DI	1.3	5.0	11.0	0.9	2
	IDI	2.1	5.0	5.0	0.7	2
50 - 125 HP						
Turbocharged	DI	1.2	4.0	13.0	0.70	3
Naturally Aspirated	DI	1.8	6.0	13.0	1.05	3
125 + HP						
Turbocharged	DI					
Pre - 1969		1.2	4.0	14.0	0.7	3
1969 - 1971		1.0	4.0	13.0	0.6	3
1972 - 1979		0.90	4.0	12.0	0.5	3
1980 - 1984		0.85	4.0	11.0	0.5	3
1985+		0.80	4.0	11.0	0.5	3
Naturally Aspirated	DI					
Pre - 1969		1.8	6.0	14.0	1.05	3
1969 - 1971		1.5	6.0	13.0	0.90	3
1972 - 1979		1.4	6.0	12.0	0.75	3
1980 - 1984		1.3	5.5	11.0	0.75	3
1985+		1.2	5.0	11.0	0.75	3

TABLE 6-4
EPA EMISSION FACTORS FOR HEAVY-DUTY ENGINES
(g/BHP-hr)

EQUIPMENT	GASOLINE			DIESEL		
	HC	NO_x	CO	HC	NO_x	CO
Agricultural						
Tractors	8.24	6.62	185.90	2.23	11.21	8.94
Combines	10.77	5.24	283.40	1.26	11.50	4.20
Sprayers	--	--	--	2.23	7.78	3.78
Balers	--	--	--	2.23	7.78	3.78
Swathers	10.77	5.24	283.40	2.23	7.78	3.78
Construction/Logging/Mining						
Log Skidders	--	--	--	0.84	11.30	5.20
Feller/Bunchers	--	--	--	0.84	11.30	5.20
Asphalt Pavers	--	--	--	0.60	10.30	3.20
Concrete Pavers	--	--	--	1.10	10.02	4.57
Rollers	--	--	--	0.80	9.30	3.10
Scrapers	--	--	--	0.70	8.70	5.00
Paving Equipment	--	--	--	1.01	11.01	4.60
Boring/Drilling	--	--	--	1.41	11.01	9.20
Excavators	9.74	4.79	257.40	0.70	10.75	5.20
Cranes	--	--	--	1.26	10.30	4.20
Graders	--	--	--	1.54	9.60	3.80
Off-Highway Trucks	--	--	--	0.84	9.60	2.80
Crushing Equipment	--	--	--	1.41	11.01	9.20
Rough Terrain Lifts	9.74	4.79	257.40	1.68	8.00	10.00
Wheel Loaders	8.34	5.42	211.90	0.84	10.30	4.80
Wheel Dozers	--	--	--	0.84	9.60	2.80
Backhoe Loaders	9.74	4.79	257.40	1.40	10.10	6.80
Crawler Tractors	--	--	--	1.26	10.30	4.80
Off-Highway Tractors	--	--	--	2.46	11.91	14.68
Other Equipment	9.74	4.79	257.40	1.41	11.01	9.20
Industrial						
Forklift	10.02	5.16	258.70	1.57	14.00	6.06
Sweepers	--	--	--	1.57	14.00	6.06
General Industrial	--	--	--	1.57	14.00	6.06
Material handling	--	--	--	1.57	14.00	6.06

Source: U.S. EPA, Nonroad Engine Vehicle Emission Study-Report, Draft, October 1991.

TABLE 6-5
ARB EMISSION FACTORS FOR HEAVY-DUTY ENGINES
(g/BHP-hr)

ENGINE TYPE	HP	HC	CO	NO_x
DIESEL	25-40	1.3	4.5	10
	41-100	1.2	4.0	11
	101-175	1.1	3.4	11
	176-300	1.0	2.8	12
	301-500	0.9	2.2	13
GASOLINE, 4-STROKE	25-40	8.5	255	2.5
	40-100	8.25	235	3.0
	101-175	7.5	215	4.5
	176-300	6.75	185	4.0
	301-500	6.0	175	4.0
GASOLINE, 2-STROKE	25-40	125	260	1.8
	40-100	125	260	1.8
NATURAL GAS AND LPG	25-40	5.0	140	3.0
	40-100	5.0	135	3.6
	101-175	4.7	125	5.4
	176-300	4.3	105	4.8
	301-500	3.8	95	4.8

Source: "Off-Road Mobile Equipment Emission Inventory Estimate" Booz-Allen & Hamilton Inc. Jan 1992, Exhibit 34 p.29

Standards. Emission test data for engines in the 2-15 HP range are based on recent manufacturers submissions for 26 engines, and are documented in Appendix A. Since there are virtually no 2-stroke engines with ratings over 15 HP sold outside of the recreational vehicle markets, there are no emission data for other HP categories, although placeholders are available. Zero hour emission factors for 2-stroke engines are shown in Table 6-6.

4-Stroke Engines

0 to 25 HP - Engines are of two technology types: side valve and overhead valve. This HP range is further subdivided into three horsepower categories: 0 to 5 HP, 5 to 15 HP, and 15 to 25 HP. Data for all these categories are based on recent manufacturers submissions to EPA and to Texas, and a detailed analysis of all engine emissions data submitted by manufacturers was performed by EEA. This analysis is documented in a letter to EPA, provided in Appendix A. The emissions factors are assumed to be identical for engines in the 5 to 15 HP category and engines in the 15 to 25 HP category, since no detailed breakout by HP exists for engines over 225 cc. Manufacturers have confirmed that this is a reasonable approximation. Zero hour emission factors are shown in Table 6-6.

25 to 50 HP and 50 to 125 HP - Most of the gasoline engines sold outside of the 0 to 25 HP category are in the 25 to 50 HP range, with very few engines in the 50 to 125 HP range. Emissions of engines in the 25 to 50 HP are separated into air-cooled and water cooled groups. This is because air cooled engines generally operate at significantly richer air-fuel ratios than water cooled engines to prevent detonation. Data on emissions for these engines are as derived from a small sample of manufacturer supplied data, and the averages are provided in the EEA's report to the ARB on Off-Road Light Duty Equipment.

Virtually all gasoline engines sold in the 50 to 125 HP market are off-road versions of on-highway light-truck engines. We are unaware of any test data on such engines, and their

TABLE 6-6
GASOLINE ENGINE EXHAUST EMISSION FACTORS
(Zero Hour Factors in g/BHP-hr)

	HC	CO	NO_x	PM*	Reference
2-stroke (Gasoline)					
0 to 2 HP	290	840	0.36	10.0	Ref 4
2 to 5 HP	209	311	0.90	6.5	Appendix A
5+ HP	209	311	0.90	6.5	As above
4-stroke (Gasoline)					
0 to 5 HP Side Valve	27.4	515	2.1	0.75	Appendix A
5 to 15 HP Side Valve	7.7	402	3.6	0.15	Appendix A
15 to 25 HP Side Valve	7.7	402	3.6	0.15	Appendix A
25 to 50 HP Air cooled*	7.0	400	3.5	0.10	Ref 2
0 to 5 HP OHV	8.1	300	2.4	0.57	Appendix A
5 to 15 HP OHV	5.3	313	2.4	0.03	Appendix A
15 to 25 HP OHV	5.3	313	2.4	0.03	Appendix A
25 to 50 HP Watercooled	4.0	240	4.0	0	Ref 2
50+ HP Watercooled	4.0	240	4.0	0	As Above
CNG/LPG (4-stroke)					
0 to 5 HP Side Valve	4.3	250	2.0	0.50	Manufacturer Submission
5 to 15 HP Side Valve	4.1	245	1.8	0.10	Manufacturer Submission
15 to 25 HP Side Valve	4.1	245	1.8	0.10	As above
0 to 5 HP OHV	3.2	218	1.8	0.30	Manufacturer Submission
5 to 15 HP OHV	2.7	195	1.5	0.02	SAE Paper 921696
15 to 25 HP OHV	2.7	195	1.5	0.02	As above
25 to 50 HP All	2.0	150	3.0	0	Ref 2

* PM emissions based on test reported in Reference 5 and Reference 8.

emission factors have been set to equal the emission factors of water cooled gasoline engines in the 25 to 50 HP category. Emission factors for all gasoline engines over 125 HP are simply placeholders, as very few equipment (other than recreational vehicles) are noted as having gasoline engines in higher HP ranges.

CNG/LPG Engines - CNG and LPG engines sold in the off-road market are conversions of gasoline engines. Zero-hour emission factors for these engines are based on data for one engine in each subcategory and should be taken as preliminary, subject to revisions when more data are available. These data were reported to EEA in its compilation of 0 to 25 HP emission factors for gasoline engines in this range, as described in Appendix A. It should be noted that ARB has also sponsored tests of LPG/CNG engines, one rated at 40 HP and the other at 60 HP. Both engines were set extremely lean for LPG/CNG operation, and the resulting NO_x emissions were approximately 20 g/BHP-hr. These results were not used, as the manufacturers confirmed that such lean settings were never used in practice, due to the large power loss (of 15 to 20 percent) encountered.

6.3.3 Recreational Vehicles

Emission factors for off-road motorcycles, ATVs, snowmobiles and pleasure craft were obtained from ARB and/or EPA studies. The emission factors for off-road motorcycles and ATVs are expressed in gram per hour based on the ARB calculated emission factors for 2-stroke and 4-stroke engines. These factors were expressed in gm/mile and converted to gm/hr using an average speed of 25 mph as representative (as per NEVES).

Snowmobile emission factors are as reported by the International Snowmobile Industry Association to EPA. These figures are for the entire industry, and differ only slightly from those reported by EEA to ARB based on a sample of eight engines test data. Emissions are in g/BHP-hr.

Marine pleasure vessels are subdivided into outboard and inboard, and further categorized as 2-stroke and 4-stroke for outboards and gasoline/diesel for inboards (all inboards are 4-stroke). Emission factors are based on the National Marine Manufacturers Association submission to EPA, which reported data on at least four engines in each subcategory. A separate subcategory was utilized for sailboat auxiliary diesel engines of very low horsepower. All factors are in gram/gallon.

Golf cars and specialty vehicles use lawn and garden engines and no separate factors are required in this case.

Recreational vehicle zero hour emission factors are shown in Table 6-7. The pleasure craft factors may change when ARB completes an ongoing study in this area.

6.3.4 Technology Mix Within Subcategory

Equipment populations are specified only by the HP range, and the mix of technology subcategories within each HP category is required to aggregate emissions to the equipment level. Technology mixes within subcategory were derived from the same sources as those for emission factors. The mix is assumed to be constant historically, which is approximately correct for the 1980-1994 period. The data are shown in Table 6-8.

6.4 EMISSION DETERIORATION RATES

Deterioration factors for off-road engines have not yet been assessed from actual durability tests, except for gasoline engines in the 0-25 HP range. As a result, deterioration factors (d.f.) for all other engine HP categories were based on the observed d.f. for on-highway engines with reasonably similar horsepower ranges.

TABLE 6-7
RECREATIONAL VEHICLE EMISSION FACTORS

	HC	CO	NO_x	PM	Reference
ATV/Motorcycles (g/hr)					
2-stroke 4-stroke	600 100	800 475	1.5 9.0	8.20 1.15	5 5
Snowmobiles (g/BHP-hr)					
2-stroke	109	169	1.7	4.80	NEVES
Pleasure Craft (grams/gallon)					
Outboard 2-stroke	728.1	1357	8.8	48.10	NEVES
Outboard 4-stroke	87.7	1422	66.6	0.74	NEVES
Inboard gasoline	72.5	1214	45.8	0.74	NEVES
Inboard diesel	24.4	37	172.5	10.90	NEVES
Sailboard Auxiliary Diesel	122.4	218	163.3	10.90	NEVES

TABLE 6-8
TECHNOLOGY FRACTIONS BY HP CATEGORY

	Tech 1	Tech 2	Note
Diesel			
0 to 15 HP	1.0	0.00	1 = DI, 2 = IDI
15 to 75 HP	0.32	0.68	1 = DI, 2 = IDI
25 to 50 HP	0.32	0.68	1 = DI, 2 = IDI
50 to 120 HP	0.60	0.40	1 = Turbo, 2 = NA
120 to 175 HP	0.80	0.20	1 = Turbo, 2 = NA
175 to 240 HP	0.80	0.20	1 = Turbo, 2 = NA
240 to HP	0.90	0.10	1 = Turbo, 2 = NA
Gasoline 4-stroke and CNG/LPG 4-stroke			
0 to 5 HP	0.95	0.05	1 = Side Valve 2 = OHV
5 to 15 HP	0.90	0.10	1 = Side Valve 2 = OHV
15 to 25 HP	0.90	0.10	1 = Side Valve 2 = OHV
25 to 50 HP	0.50	0.50	1 = Air Cooled 2 = Water Cooled
50 to 120 HP	0	1.00	1 = Air Cooled 2 = Water Cooled

The d.f. for each pollutant within a specific engine HP range and technology category is specified as a function of expected engine life, except in the case of recreational vehicles where it is specified in units common with the use specification (hours or gallons). Hence, emission d.f. are automatically scaled for each application, and are responsive to load factor. Engines operating at a higher load factor have a shorter useful life in hours and hence the deterioration per hour of use is higher.

In order to convert the on-highway d.f. from gm/mile/10,000 miles to an off-road d.f., an equation was developed to relate the percent change in emissions over the useful life for on-highway and off-road engines, i.e.

$$\frac{\text{Off-Road d.f. x Useful life}}{\text{Off-Road zero hour factor}} = \frac{\text{On-Highway d.f. x Useful life}}{\text{On-Highway zero mile factor}}$$

This equation implies that emissions increase by the same percentage over an engine's useful life, regardless of application.

In each horsepower category for the off-road fleet, "equivalent" on-highway categories were selected and the above equation applied. The categories that were compared are as follows:

- 50 - 120 HP gasoline engines were compared to pre-control light duty gasoline trucks.
- 120+ HP gasoline engines were compared to pre-control heavy duty gasoline vehicles
- 25 to 50 HP diesel engines were compared to pre-1980 light duty diesel engines (since they were close to uncontrolled IDI diesels)
- 120 to 175 HP and 175 to 240 HP diesel engines were compared to pre-1984 medium-heavy duty truck diesel engines
- 240+ HP diesel engines were compared to pre-1984 heavy-heavy duty truck engines

These comparisons were based on the physical similarities of engines sold in these markets. Since there are no engines in the on-highway markets equivalent to 25 to 50 HP gasoline engines and 50 to 125 HP diesel engines, EEA selected the d.f. of the next higher HP category (based on the similarity in useful life) for these engine categories.

Deterioration factors for off-road motorcycles and ATVs are based on pre-control on-road motorcycles. These on-road motorcycles included a mix of 2 and 4-stroke engines, and hence the same d.f. are used for 2-and 4-stroke off-road equipment. Snowmobiles, however, utilize unique engines and no comparable engines are employed in on-highway equipment; their emission d.f. could not be determined and are set to zero.

All on-highway emission factor data are derived from EMFAC7E files for the "non I/M" case. For the model years examined, the two stage deterioration factor utilized in EMFAC7E was not an issue. The off-road d.f. for HC, CO and NO_x and particulates (for diesel) are shown in Table 6-9. The d.f. are non-dimensional, and are a percent increase in zero-hour emissions per percent of useful life consumed. As an example, diesel engines in the 25 to 50 HP will experience a 51 percent increase in HC relative to zero-hour levels at the end of their useful life (note that half of all engines survive beyond the average useful life). The d.f. also assume linear deterioration of emissions with use.

Data on emissions deterioration of gasoline engines in the 0 to 25 HP category were derived from data submitted by the engine manufacturers to EPA as part of the "Reg-Neg" for small non-road engines. EEA obtained the emissions data from EPA and then analyzed the data. The data were based on emissions from a sample of lawn and garden equipment tested at 50, 100, 150 and 200 hours of "normal" use. Within each engine and HP subcategory, data were available for approximately 5 to 10 pieces of equipment. Linear regression analysis was utilized to estimate the d.f., which are shown in Table 6-10. All equipment were below 15 HP, and d.f. for the 15 to

TABLE 6-9
OFF-HIGHWAY EXHAUST EMISSION
DETERIORATION FACTORS (d.f.)
(Percent increase per percent of useful life)

Category	Equivalent On-highway	On-highway MYR	On-highway Useful life	Off-highway HC d.f.	Off-highway CO d.f.	Off-highway NO_x d.f.	Off-highway PM d.f.
Gasoline							
25 to 50 HP	None	N/A	N/A	1.38	0.83	0.064	--
50 to 120 HP	LDGT	1969 NCAT	120,000	1.38	0.83	0.064	--
120+ HP	HDGV	1970 NCAT	120,000	0.37	0.56	0.140	--
Diesel							
25 to 50 HP	LDDT	1980	100,000	0.51	0.41	0.060	0.31
50 to 120 HP	None	N/A	N/A	0.28	0.16	0.14	0.44
120 to 175 HP	HDT	1975	180,000	0.28	0.16	0.14	0.44
175 to 240 HP	HDT	1975	180,000	0.28	0.16	0.14	0.44
240+ HP	HDT	1975	280,000	0.44	0.25	0.21	0.67
Motorcyles/ATV's							
All	MCY	1977	15,000	0.13	0.15	0.3	0

N/A = Not applicable.

TABLE 6-10
DETERIORATION FACTORS FOR 4-STROKE
ENGINES UNDER 25 HP

Category	HC	CO	NO_x	PM*
4-stroke				
0 to 5 HP Side Valve	1.12	0.32	0.035	1.12
0 to 5 HP OHV	0.59	0.30	0.036	0.59
5 to 15 HP Side Valve	1.67	0.085	0.37	1.67
5 to 15 HP OHV	0.85	0.085	0.48	0.85
15 to 25 HP Side Valve	1.67	0.085	0.37	1.67
15 to 25 HP OHV	0.85	0.085	0.48	0.85

D.F.s are in percent change in zero hour emission rates per percent of useful life consumed.

Source: EEA analysis of manufacturer submissions to EPA (except for PM)

* PM emission d.f. set equal to HC emission d.f.

25 HP category were set to those for the 5 to 15 HP category, consistent with the assumptions employed for the zero hour emission factor.

No data were available to estimate d.f. for particulate emissions, and these were set to equal the HC d.f. as an approximation.The higher d.f. for the larger engines may be surprising, but this partly is due to the fact that engines over 5 HP have a useful life that is twice as long as for those under 5 HP, and partly due to the fact that zero hour emissions for engines over 5 HP are much lower than zero hour emissions for engines under 5 HP. No data were available for 2-stroke engines and d.f. were set to equal the NEVES "in-use" adjustment factor at the category useful life.

6.5 CRANKCASE EMISSIONS

The methodology utilized to derive crankcase emission factors followed the EPA NEVES methodology. For gasoline engines the NEVES[7] estimated that crankcase HC emissions are 33 percent of untreated exhaust emissions for all gasoline engines with open crankcases. Four-stroke engines with closed crankcases and two-stroke engines are assumed to have no crankcase emissions. For diesel engines, crankcase emissions were developed by EPA for HC, CO and NO_x, and the emissions are also assumed to be related to exhaust emissions. The factors for diesel engines with open crankcases are:

HC = 2 percent

CO = 0.2 percent

NO_x = 0.05 percent

Seventy-nine percent of all 4-stroke gasoline engines under 25 HP are assumed to have closed crankcases, but all other four-stroke gasoline and diesel engines are assumed to have open crankcases, as per manufacturer submissions to EPA's NEVES.

6.6 EVAPORATIVE EMISSIONS

Evaporative emissions are of the following types:

- Refueling
- Hot soak
- Diurnal
- Resting
- Running

Refueling loss occurs due to fuel spillage. In its NEVES study, EPA concluded that refueling losses are much higher when equipment are refueled from a container than when they are refueled from a pump. Based on data submitted by the Outdoor Power Equipment Institute (OPEI), refueling from a container resulted in spillage of 17 gm of fuel per refueling, while filling from a pump resulted in spillage of 3.6 gm per refueling. Refueling losses per gallon of fuel used was estimated by EPA by dividing either 17 or 3.6 (depending on whether a particular equipment type was refueled from a container or a pump), by the tank volume, assuming all refuelings are fill ups. Vapor displacement during refueling was calculated using the model proposed by Rothman and Johnson[8] (as reported in the NEVES), and was calculated for summer and winter conditions, with separate calculations for container dispensed fuels and pump dispensed fuel. EPA's calculations yield the following results for refueling vapor loss:

Pump dispensed	-	Summer	5.08 g/gal
	-	Winter	6.09 g/gal
Container dispensed	-	Summer	6.70 g/gal
	-	Winter	6.0 g/gal

These factors were converted to gm/BHP-hr by multiplying by engine brake specific fuel consumption (bsfc). The NEVES emission factors for refueling were used without change in this model.

Hot Soak emission factors are not included in NEVES since no hot soak emissions data were available for off-road equipment at that time. More recently, South West Research and OPEI have provided hot soak emissions data on a small sample of lawn and garden equipment and on fuel containers. The data are reviewed in Table 6-11. Based on this data, the following preliminary emission factors, which are based on fuel tank volume, can be utilized:

All lawn and garden equipment (except riding mowers/tractors)	2.05 g/tank gallon
Riding mowers/lawn and garden tractors	1.12 g/tank gallon
Utility equipment	0.39 g/tank gallon

Since the data are so sparse, the above factors have not been included in the new Off-Road model, but can be inserted into the placeholders provided in the model.

Diurnal Emission losses were set at 3 g/gallon/day by NEVES based on tank gallons. However, the available test data presented in Table 6-11 on diurnal emissions makes a convincing case for using 1 g/gallon/day, at least for all equipment with gasoline engines under 25 HP. EEA has utilized 1 g/gallon/day for all such equipment, but has retained the EPA estimate of 3 g/gallon/day for all equipment with engines over 25 HP in the absence of any actual test data.

Resting Losses have not yet been measured for off-road equipment and no data are available for inclusion in the model. Placeholders have been provided in the model.

Running Losses are also not provided in the model, but the three available measurements are shown in Table 6-12. Because of the large variance in the data, the averages were not expected

TABLE 6-11
AVAILABLE EVAPORATIVE EMISSIONS DATA

Equipment Type	Engine	Tank Size	Diurnal		Hot Soak	
		gal	grams	g/gal	grams	g/gallon
Generator Set	8 HP/OHV	4.5	4.4	0.978	2.25	0.500
Garden Tractor	18 HP/SV	2.9	2.8	0.969	2.48	0.855
Lawn Mower	4 HP/SV	0.31	0.34	1.088	0.82	2.624
Garden Tractor	18 HP/SV	2.9	2.32	0.800	1.00	0.345
Generator Set	8 HP/OHV	4.5	4.69	1.042	1.26	0.280
Lawn Mower	4 HP/SV	0.31	0.25	0.800	0.60	1.920
Tractor	22 HP/NA	1.4	1.14	0.818	3.01	2.151
Lawn Mower	5 HP/SV	0.23	0.22	0.942	0.37	1.594
Engine Tank (Plastic)	--	1.1	1.14	1.096	NA	NA
Engine Tank (Metal)	--	0.9	0.88	0.978	NA	NA
Average (grams/gallon)				0.96		1.28

Source: OPEI data, SWRI data.

TABLE 6-12
AVAILABLE RUNNING LOSS EMISSIONS DATA
(g/hr)

Equipment	HC	CO	NO_x
8HP/OHV Generator Set	11.90	2.46	0.14
18HP/SV Garden Tractor	8.67	85.80	0.19
4HP/SV Lawn Mower	30.10	35.10	0.23

Source: SWRI

to be reasonable estimates for the total population for even lawn and garden equipment, and hence not worthy of inclusion in the model. However, the large magnitude of those emissions suggests that this data should be expanded as soon as possible to obtain a more significant estimate.

6.7 CORRECTIONS TO BASE EMISSION FACTORS

Exhaust and evaporative factors must be corrected for a range of conditions to account for:

- Fuel formulation
- Fuel volatility
- Ambient temperature
- Humidity

The corrections incorporated into the model are described below.

6.7.1 Exhaust Emission Factor Corrections for Fuel Formulation

Oxygenated and reformulated gasoline used in current technology 25 HP and larger gasoline off-road engines should affect HC and CO exhaust emissions as it affects exhaust emissions from mechanically similar non-catalyst equipped gasoline passenger vehicles. The effect of oxygenated and reformulated gasoline on exhaust emissions from small 4-stroke and 2-stroke gasoline engines used in many offroad applications has not been thoroughly researched, however. One study by South West Research reported HC and CO emissions from one small 4-stroke engine and one 2-stroke engine were reduced by the use of oxygenated fuel, but the results varied excessively depending on whether TOG, THC, NMOG, or NMHC were measured. EPA concludes, however, that these small engines can be assigned the large 4-stroke engine exhaust benefit for reformulated gasoline.

EPA recommends the following oxygenate fuel exhaust correction factor equations for non-catalyst vehicles be used in the offroad model for years where oxygenated (not reformulated) gasoline is used. The equations are:

1) $HCCF = 1.0 - [\ 0.0157 * (O_2\ wt\%)\ ]$

2) $COCF = 1.0 - [\ 0.0700 * (O_2\ wt\%)\ ]$

According to the EPA, Phase 1 reformulated gasoline reduces HC emissions from non-catalyst engines by an additional 10 percent over non-reformulated gasoline with 2.0 weight percent oxygen, but does not affect CO emissions. During modeling years which coincide with Phase I RFG years, therefore, equation (2) is used to calculate the CO correction factor, and the term in brackets in equation (1) is multiplied by 1.1 to derive the Phase 1 RFG HC correction factor. Phase 1 RFG with 2 percent oxygen, for example, would produce an HC exhaust correction factor of:

$$HCCF = 1.0 - [\ 0.0157 * 2 * 1.1\ ] = 0.965,$$

which implies a reduction of 3.5 percent.

Phase 2 reformulated gasoline will further reduce HC emissions, and CARB estimates the exhaust effect of 1996 California Phase 2 RFG on offroad gasoline engines to be a reduction of 9.5% from the baseline gasoline. During Phase II modeling years, therefore, equation (2) is used to calculate the CO correction factors as a function of fuel oxygen content, while the HC correction factor is constant at 1.0 - 0.095 = 0.905.

Available test data indicates that oxygenated gasoline and Phase 1 RFG should not affect NO_x emissions. Phase 2 RFG is expected to reduce NO_x emissions from modern technology vehicles by 5 to 6% relative to the baseline fuel, primarily due to reduction of fuel sulfur content, which tends to degrade catalyst NO_x control efficiency. While documentation of the Phase 2 RFG effect on NO_x emissions from non-catalyst engines is not available, it should not influence NO_x emissions from non-catalyst equipped engines if its effects are primarily related to increasing catalyst efficiency.

The above correction factors are incorporated into the model. It should be noted that:

- The correction factors are multiplicative correction factors.
- Fuel oxygen weight percent, as used in equations 1 and 2, has an upper bound of 2.7% for the HC correction factor equation and 3.5% for the CO correction factor equation.
- These oxygenated fuel correction factors are not for use with diesel engines.
- Future gasoline engines may use catalysts to control exhaust emissions, and the above equations will have to be supplemented with equations specific to the type of control system used (i.e., oxidation catalyst or 3-way catalyst systems).

6.7.2 Exhaust Emission Factor Corrections for Temperature and Volatility

Multiplicative correction factors for non-FTP temperature (75 degrees) and fuel volatility (RVP = 9.0 psi) are used in MOBILE5a and EMFAC7E to adjust the base exhaust emissions rates to in-use conditions. Twenty-five horsepower and larger four-stroke engines (both gasoline and gaseous fuel) used in offroad equipment are similar to uncontrolled on-highway engines. Since the exhaust emission rates for off-road equipment have also been developed under standard FTP ambients, those emission rates should be corrected for non-FTP temperatures. For reasons discussed below, offroad equipment exhaust emissions are not corrected for fuel RVP. No temperature or RVP corrections are made to emissions from diesel engines.

Temperature

The MOBILE and EMFAC temperature correction factors are calculated for each bag of the FTP. Offroad equipment, however, operate almost exclusively in a stabilized mode, so temperature correction factors for those equipment reflect the corrections that are applied to Bag 2 emissions for highway vehicles. The EMFAC7E temperature correction factor is of the form:

$$TCF = \exp[a(T-75)]$$

Where a is a constant (listed in Table 6-13) and T is the ambient temperature.

Separate temperature correction factor coefficients were developed by EPA (and used by ARB[10]) for low and high temperatures, although the same equation is used for both temperature ranges. The low temperature coefficients are used between 0° and 75°, and the high temperature coefficients are used between 75° and 100°F. The temperature correction factors are multiplied by the basic exhaust emission rates to obtain the exhaust emission rates adjusted for ambient temperature.

Fuel Volatility (RVP)

High volatility fuel (i.e., RVP > 9.0 psi) and high temperatures increase exhaust emissions from highway vehicles as a result of combustion of fuel vapors purged from evaporative canisters. EPA has developed correction factors that are dependent on the fuel RVP and the ambient temperature, but those correction factors are applicable only to vehicles with evaporative canisters. Since in-use RVP of California gasoline should always be less than 9.0 psi (EMFAC7E doesn't correct exhaust emissions for fuel volatility for that reason) and offroad equipment engines are not equipped with evaporative canisters at this time, no fuel volatility correction factors for exhaust emissions are provided for the offroad model.

TABLE 6-13
TEMPERATURE CORRECTION FACTOR
Co-efficients ($°F^{-1}$)

HC	Low Temperature	-0.0113
	High Temperature	+0.00484
CO	Low Temperature	-0.0146
	High Temperature	+0.01494
NO_x	Low Temperature	-0.0059
	High Temperature	0

Source: Technical Support Document, Derivation of the EMFAC7E Emission and Correction Factors for On-Road Motor Vehicles, California ARB, July 1990.

Start Offsets

The effect of hot or cold starts are modeled as an additive "offset" to the emission factor. As far as EEA is aware, there are no data available on start emission offsets as a function of ambient temperature, nor are there data on starts per day and soak periods for different types of off-road equipment. Start offsets are generally small for most uncontrolled or non-catalytically controlled engines, especially if the typical duty cycle per start is over 20 minutes. Most off-road equipment except for recreational vehicles are uncontrolled and have long duty cycles per start; hence, start emissions are not expected to be large. Nevertheless, placeholders are provided in the model and data can be inserted when actual start offset emissions are quantified for off-road equipment.

6.7.3 Evaporative Emissions Corrections

Evaporative emissions are affected by fuel volatility and ambient temperature. Baseline evaporative emissions for offroad equipment, as reported in the input data file, are for diurnal emissions only since current data on hotsoak and running losses are too limited for off-road equipment. Hence, only diurnal emissions correction factors for non-standard volatility and temperatures as required.

ARB developed a diurnal emissions correction equation for EMFAC7E that simultaneously corrects for non-standard temperature and fuel volatility. However, EPA has recently issued guidance for correcting offroad equipment emissions for fuel volatility and that guidance is used in the offroad model. The diurnal emission rate is first corrected for volatility less than 9.0 using EPA's RVP correction factors, and is then corrected for temperature over $75^{\circ}F$ using the EMFAC7E correction equation.

RVP

EPA has issued guidance for correcting evaporative emissions from offroad equipment for in-use fuel RVP, and this guidance is incorporated into the offroad model. The guidance states that in Class B volatility areas where gasoline RVP is about 7.8 psi, the evaporative emission rates for gasoline powered equipment should be reduced by 8.9 percent. In practice, the evaporative emission rates should be corrected for temperature and then multiplied by 0.911 to reflect the difference in evaporative emissions that result from using 7.8 psi fuel instead of the 9.0 psi fuel that was assumed when the baseline (input) diurnal emission factors were calculated.

A further reduction of the correct diurnal emission factors is introduced when Phase 1 RFG enters the market (1992 in California). According to EPA, and RVP of 7.1 psi for RFG results in a reduction of 3.2 percent (relative to 7.8 psi baseline fuel), or a multiplicative correction factor of 0.968.

Temperature

ARB developed a volatility and temperature correction factor equation for temperatures over 75°F using EPA test data and analysis. EPA's analysis does not differentiate between fuel-injected and carbureted vehicles, but in the absence of more complete test results, ARB has accepted this model for diurnal temperature corrections.

The diurnal temperature correction factor DICF is calculated from the equation:

$$DICF = a*EXP[b*R + c*R^2 + d*(ST-15)^2 + f*DT + g*R*(ST-15) + h*(ST-15)*DT + i*R*DT] / j$$

Where

R = Fuel RVP in psi

ST = Ambient in temperature in °F

DT = Diurnal Temperature change in °F

EXP = Exponential function

j = results of the diurnal equation at standard temperature conditions and actual RVP, and

a	=	8.2742000,	b	=	2.7710000,
c	=	-0.2198200,	d	=	-0.5646200,
e	=	0.0021525,	f	=	-0.3706000,
g	=	0.0271290,	h	=	0.0043684,
i	=	0.0223170			

At a fuel RVP of 7.8 psi, for example, the temperature correction factor equations is:

$$DICF = [a*exp(b*7.8 + c*7.8*7.8 + d*(ST-15) + e*(ST-15)^2 + f*DT + g*7.8*(ST-15) + h*(ST-15)*DT + i*7.8*DT)] / [a*EXP(b*7.8 + c*7.8*7.8 + d*60 + e*(60)^2 + f*24 + g*7.8*60 + h*60*24 + i*7.8*24)]$$

The uncorrected (i.e., input) diurnal emissions rate is multiplied by the DICF to get the diurnal emissions rate corrected for temperatures over 75 °F.

ARB has developed a methodology for determining emissions associated with vehicles experiencing two-day or three or more consecutive diurnals. Also, ARB has updated EPA's methodology for calculating partial diurnals, which account for time periods during the day which experience differing temperature excursions. EMFAC7E calculates partial diurnals and multiple-day diurnals, but these calculations are not relevant for the offroad model, as explained below.

In EMFAC7E, multiple-day diurnal emissions are calculated with the equation:

$$MDI = (26.08 * 0.5 * 0.078) + (26.08 * 0.083)$$

where

26.08 = uncontrolled emissions from pre-1971 vehicles

0.5 = emissions at one-half the uncontrolled rate

0.078 = fraction of the fleet which experience second day diurnals

0.083 = fraction of the fleet which experience three + diurnals

This equation can be modified for use with offroad equipment by replacing 26.08 with the equipment specific diurnal emissions rate, and dropping the 0.5 factor, as all offroad equipment diurnal emissions are uncontrolled. This results in all fractions of the fleet emitting at uncontrolled diurnal emission rates, and therefore no correction is necessary.

Partial Diurnals

Partial diurnals are calculated in EMFAC7E from one of three equations which account for time periods during the day which experience differing temperature excursions. Each of the three partial diurnal equations are weighted by the fraction of the fleet which is assumed to experience that particular partial diurnal. The partial diurnal emissions equations are subject to corrections for temperatures over 75 ^{o}F using the diurnal emissions temperature correction factor equation.

The methodology for calculating the partial diurnal emissions is explained in ARB's technical report "Correction Factors for PC Evaporative Emissions." The technical report assumes that 25.7% of the on road vehicle fleet experiences partial diurnal type 1 (PD1), 17.8% of the fleet experiences PD2, and 5.6% of the fleet experience PD3. There are no available data on off-road emission equipment starts by time of day, so partial diurnals are not calculated at this point for off-road equipment in the model.

6.8 EXHAUST EMISSIONS UNDER FUTURE STANDARDS

Exhaust emissions regulations affecting off-road equipment have already been promulgated for several types of engines and equipment.

Lawn and Garden and Utility Equipment powered by engines of up to 25 HP output are required to meet standards for 1995 and later years. The standards differentiate between lawn and garden equipment with engines of up to 225 cc displacement and those with engines over 225 cc displacement. Separate standards also apply to 2-stroke engines used in handheld equipment, and distinguish between engines up to 20 cc displacement, 20-50 cc displacement and above 50 cc displacement. EEA has developed emission factors for engines meeting these standards. The factors are based on zero hour emissions equalling standards, unless the uncontrolled emission rate is below the standard. In addition, engines meeting standards specified for a combination of pollutants HC + NO_x are provided individual HC and NO_x emission factors based on the average HC to NO_x emissions ratio of current engines meeting standards.

Diesel engine and recreational vehicle standards have also been promulgated, and the methodology to estimate emission factors for engines meeting the standard are identical to those used for engines in the 0 to 25 HP range.

The 2-stroke engine emission regulations apply only to handheld equipment. Starting in 1995, EEA anticipates the 2-stroke engines cannot meet the emission standards for non-handheld equipment and the technology sales fraction is set to zero for two stroke engines in these equipment types. Hence, the non-handheld standards will apply only to 4-stroke engines. As noted, the 5 HP cutpoint is used to distinguish engines above and below 225 c.c displacement, and the 2 HP cutpoint used to distinguish 2-stroke engines above and below 50 cc No distinction is made in the model to distinguish between 2-stroke engines above and below 20 cc, and the applicable standards are simply averaged to provide a standard for engines up to 50 cc.

Crankcase emissions are set to zero for naturally aspirated engines over 175 HP starting in 1996. Exhaust emission factors under future regulations are detailed in Table 6-14. Note that the data in Table 6-14 combine both future emission standards and current emission factors as defined for the offroad model. For example, ARB has promulgated lawn and garden equipment emission standards by engine size, not by engine horsepower rating. However, ARB's engine size classes correspond closely to the offroad model's HP ranges. Further, ARB has set HC + NO_x emission standards for two sizes of lawn and garden engines, and EEA has used the standards to develop future HC and NO_x emission factors. Finally, future emission factors do not increase from current factors even if future standards are greater than current emission factors.

TABLE 6-14
FUTURE OFF-HIGHWAY ENGINE EMISSIONS FACTORS
UNDER STANDARDS PROMULGATED AS OF 6/94

Equipment Type	HP Range	Year	HC	CO	NO_x	PM
Lawn and Garden/Utility (g/BHP-hr)	0-5 HP 4-stroke	1995-1999	9.2	300	2.8	0.75
	5-25 HP 4-stroke	1995-1999	7.0	300	3.0	0.15
	0-25 HP 4-stroke	2000+	0.5	100	2.7	0.25
	0-2 HP 2-stroke	1995-1999	200.0	600	4.0	10.00
	2-15 HP 2-stroke	1995-1999	120.0	300	4.0	6.50
	0-15 HP 2-stroke	2000+	50.0	130	4.0	0.25
All Diesel (g/BHP-hr)	175-750 HP	1996-2000	0.60	4.0	6.9	0.40
	175-750 HP	2001+	0.60	4.0	5.8	0.16
	750+ HP	2001+	0.60	4.0	6.9	0.40
Motorcycle/ATV (g/km)	All	1997+	1.2	15.0	1.2	0
Golf Cars	All	1997+	0	0	0	0
Specialty Vehicles (g/BHP-hr)	0-5 HP	1995-1998	9.2	300	2.8	0.75
	5-25 HP	1995-1998	7.0	300	3.0	0.15
	0-25 HP	1999+	0.5	100	2.7	0.25
	25+ HP	1997+	0.5	100	2.7	0.25

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3. Regulatory Strategies for Off-Road Equipment, EEA, Inc. Report to the ARB, February 1992.

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5. Technical Support Document for California Exhaust Emission Standards and Test Procedures for 1994 and Subsequent Utility and Lawn and Garden Equipment Engines, California ARB, August 1990.

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9. Refueling Emissions from Uncontrolled Vehicles, Rothman and Johnson, EPA-AA-SDSB-85-6.

10. Technical Support Document, Derivation of the EMFAC7E Emission and Correction Factors for On-Road Motor Vehicles, California ARB, July 1990.

APPENDIX A
SUMMARY OF BASELINE
EMISSIONS DATA FOR 0 TO 25 HP ENGINES

ENERGY AND ENVIRONMENTAL ANALYSIS, INC.

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October 6, 1994

William M. Guerry, Jr.
Collier, Shannon, Rill & Scott
Suite 400
3050 K Street, N.W.
Washington, D.C. 20007

Dear Mr. Guerry,

In response to your request for information related to the U. S. Environmental Protection Agency's (EPA's) June 1, 1994 memorandum to Pat Cupp of EPA Region VI, EEA has analyzed the 1994 0-25 horsepower (hp) engine database assembled under our contract with the Engine Manufacturers Association (EMA) and the Outdoor Power Equipment Institute (OPEI). While I have included aggregate statistics from the 1994 database in this letter, I am unable to provide data on specific engines due to contractual restrictions.

As you know, EEA is under contract with EMA/OPEI to provide technical support relating to the EPA's 0-25 hp engine emissions control rulemaking (as applicable to non-handheld applications). In that capacity, EEA's activities are directed by OPEI's Clean Air Act Committee (CAAC), a group comprised of representatives of eleven small engine manufacturers.

Much of our work related to the 0-25 hp rulemaking has involved the procurement and analysis of proprietary and confidential small engine data from members of CAAC. However, while the aggregated results of EEA analyses are presented to CAAC for review and comment, the raw data provided by an individual manufacturer is known only to that manufacturer and EEA. The terms of our contract with EMA/OPEI prohibit us from revealing manufacturer-specific data, or data which can be translated to individual manufacturer applicability (i.e., specific displacement references, etc.), to any party. This limitation is intended to avoid a breach in of inter-manufacturer confidentiality and is a necessary restriction, allowing EEA access to data which would otherwise be withheld.

CAAC consists of representatives of the following eleven 0-25 hp engine manufacturers:

Briggs & Stratton,
Honda,
Kawasaki,
Kohler,
Kubota,
Onan,
Robin America,
Suzuki,
Tecumseh,
Toro, and
WisCon.

EEA's 1994 database consists of data for 1994 engine production and associated U.S. sales volumes for 1993 (the last year for which full year data is available). It is our understanding that CAAC member manufacturers are responsible for virtually all of U.S. 0-25 hp four stroke engine sales, but a substantially smaller portion of corresponding two stroke sales. Therefore, to avoid potential misinterpretations would could result from the analysis of a limited fraction of total two stroke engine data, we have presented statistics for four stroke engine data only. Individual engine family/model data for nine of the eleven CAAC-member manufacturers was utilized to generate the aggregate statistics. One manufacturer, while continuing engine development for potential entry in the 0-25 hp market, reported zero sales for 1993 and therefore is not included in the database. A second manufacturer's 1994 production consisted solely of two stroke engines.

Some discussion of the issue of emission testing is warranted given EPA's specific request (see June 1, 1994 memorandum) related to this issue. EEA's database does include records for engines with no specific HC, CO or NO_x data. These records are indicative of engine families/models for which the manufacturer did not have sufficient test data to support a family/model-specific emission rate. It has been EEA's experience that some engine manufacturers are far more discriminating in their application of emission test results than perhaps we are accustomed, insisting that repeated test results be obtained prior to commitment to a family/model-specific emissions rate. At the same time, other manufacturers have relied on their experience, including detailed knowledge of engine configuration similarities, to develop best estimates of emission rates for families/models for which specific test results are not available. While we believe that the latter approach is more appropriate given each manufacturers level of knowledge with their own product, each manufacturer has retained the provide data in the format they deem appropriate. As a result, families/models for which no emission rate data is reported are treated as having emission rates equal to the average emission rate for the size/configuration group to which they belong (see analysis results below).

While ideally, specific emission rate testing for each model/family would be desirable, we should keep this analysis in perspective. The baseline, to which we are comparing the 1994 data, is that utilized for the 1990 Nonroad Engine and Vehicle Emissions Study (NEVES). Since the NEVES work constitutes the source of the 1990 0-25 hp engine emission inventories that states are using for SIP development work, it is the NEVES work which sets the "standard" to which the validity of the data included in our 1994 database should be compared. To the best of our knowledge, the entire database for 0-25 hp non-handheld engines used for the NEVES study consisted of about ten emission tests performed by Southwest Research Institute for the California Air Resources Board and some additional data submitted by manufacturers to EPA. By comparison, the 1994 database enclosed herein is based on actual emission testing results from over 500 individual emissions tests directly applicable to 74 specific four stroke engine families/models and indirectly applicable (due to manufacturer-developed estimates based on family/model similarities) to over 96% of the engines families/models included in the 1994 database. Clearly, the enclosed database is at least as rigorous than that utilized for NEVES.

The May 24, 1994 letter from EEA to Mr. Beecher Cameron of the Texas Natural Resource Conservation Commission (TNRCC) outlined aggregate statistics from EEA's 1994 database as it existed at that time. At the time the May 24 letter was developed, the 1994 database was still under development and several manufacturers whose data was not included in the May 24, 1994 version of the database have subsequently provided data. As a result, EEA has updated our analysis of the 1994 database (which now includes data from all manufacturers participating in CAAC). For comparison, the May 24 version of the database was based on 119 engine families/models, six manufacturers, and 9.3 million units in annual sales while the current database includes 156 engine families/models, nine manufacturers, and 10.8 million units in annual sales. Table 1 summarizes the key results from our analysis of the 1994 database.

Engine Type	HC (g/bhp-hr)	CO (g/bhp-hr)	NO_x (g/bhp-hr)	Sales Fraction
<225cc L-Head	27.4	515.4	2.1	0.706
≥225cc L-Head	7.7	403.0	3.6	0.197
<225cc OHV	8.1	300.3	2.4	0.035
≥225cc OHV	5.4	314.2	2.4	0.063
All <225cc	26.5	505.2	2.1	0.741
All ≥225cc	7.1	381.5	3.3	0.260
All Four Stroke	21.5	473.1	2.4	1.001

Table 1. 1994 0-25 hp Non-Handheld Four Stroke Emission Rate Data

The HC, CO, and NO_x emission rates indicated in the upper portion of Table 1 are based on the sales weighted emission data for each of the engine families/models for which emission rates are included in the database. Engine families/models for which no emission rate data is provided by the applicable manufacturer are excluded from the emissions calculation. Sales of these "no emissions data" engine families/models are however included in the sales fraction column. Under this methodology, the "no emissions data" families/models are treated as though they have emission rates equal to the sales weighted average of the "emissions data" families/models for the size/configuration group to which they belong. Using the emission rate and sales fraction data from the upper portion of Table 1, the aggregate four stroke emission rates have been calculated and are presented in the lower half of the table.

It is our understanding, through conversations with staff at TNRCC, that Texas utilized HC emission factors of 37.70 g/bhp-hr for engines of less than 225 cc's and 9.40 g/bhp-hr for engines of 225 cc's or greater as the 1990 baseline emission factors for their reduction demonstration. Based on the 1990 HC emission levels used for the Texas analysis and the sales fractions presented in Table 1, we calculate a sales weighted aggregate 1990 four stroke engine emission factor 30.3 g/bhp-hr:

$$\frac{(37.70 \times (0.706 + 0.035)) + (9.40 \times (0.197 + 0.063))}{1.001}$$

Furthermore, given the corresponding 1994 sales weighted emission factor estimate of 21.5 g/bhp-hr, as presented in Table 1, we calculate that, in the aggregate, 1994 non-handheld four stroke 0-25 hp engines are just over 29% cleaner than their 1990 counterparts.

Since the determination of the 1990 baseline emission factors utilized by Texas appeared to be rather simplistic, EEA also performed a more in depth analysis of the 1990 NEVES data to determine the sensitivity of HC reduction associated with 1994 engines. EEA's analysis of NEVES calculated the overall population weighted average HC emission rate based on all individual equipment types in which 0-25 hp non-handheld four stroke engines are utilized.

EEA began its analysis with the NEVES inventory B four stroke gasoline equipment populations for all 79 NEVES equipment types. Using horsepower splits from Power Systems Research (PSR), EEA determined the fraction of the population of each of the non-handheld equipment types which was powered by four stroke engines sized less than or equal to 25 horsepower. We eliminated from consideration, equipment types which are handheld or which do not utilize general "utility-type" engines (i.e., recreational vehicles other than golf and specialty vehicles and carts, and marine engines). Using the total four stroke populations and the associated 0-25 hp fractions, EEA determined the 0-25 hp non-handheld four stroke engine population for each applicable NEVES equipment type.

Using the relationship between individual equipment type 0-25 hp four stroke engine population and total 0-25 hp four stroke engine population, EEA determined the fraction of total 0-25 hp population found in each individual NEVES equipment type. The applicable population fractions are presented in Table 2. Finally, using the four stroke 0-25 hp non-handheld engine distributions presented in Table 2, EEA calculated a population weighted HC emission rate for NEVES of 30.3 g/bhp-hr. As indicated, the predicted value is virtually identical to the emission rate utilized by Texas for their emissions reduction analysis and, therefore, confirms the 29% emissions differential associated with 1994 engines relative to their 1990 counterparts.

NEVES Equipment Category	NEVES Equipment Type	Percentage of Total 0-25 hp Four Stroke Non-Handheld "Utility" Engines
1	Lawnmowers	58.33
1	Rear Engine Riding Mowers	3.47
1	Front Mowers	0.57
1	<5hp Shredders	0.18
1	<5hp tillers	5.52
1	Lawn and Garden Tractors	10.43
1	Wood Splitters	1.02
1	Snowblowers	7.17
1	Chippers/Stump Grinders	0.03
1	Commercial Turf Equipment	1.15
1	Other Lawn & Garden Equipment	0.58
3	Golf Carts	0.19
3	Specialty Vehicles/Carts	0.18
5	Generator Sets	5.55
5	Pumps	1.11
5	Air Compressors	0.34
5	Welders	0.64
5	Pressure Washers	0.59
6	Aerial Lifts	0.02
6	Sweepers/Scrubbers	0.01
6	Other General Industrial Equipment	0.03
7	Plate Compactors	0.24
7	Paving Equipment	0.43
7	Surfacing Equipment	0.06
7	Trenchers	0.03
7	Bore/Drill Rigs	0.01
7	Concrete/Industrial Saws	0.07
7	Cement & Mortar Mixers	0.47
7	Dumpers/Tenders	0.05
8	Two-Wheel Tractors	0.03
8	Agricultural Mowers	0.03
8	Sprayers	0.11
8	≥5hp Tillers	1.14
9	≥5hp Shredders	0.20
		99.98

Table 2. NEVES Four Stroke Non-Handheld "Utility" Engine Fractions

The observed differentials between 1990 and 1994 HC emission rates result from technology improvements and market share shifts which have occurred over the 1990 to 1994 timeframe. Manufacturers have reported to EEA, technology changes including: the wider use of graphite head gaskets, reduced exhaust valve sizing, and the wider use of mechanical compression release at startup. As a result, 1994 engines emit HC, in the aggregate, at a rate which is considerably less than the HC emission rate of their 1990 counterparts. In addition to technology improvements, a portion of the estimated emissions differential results from a shift in market share from side valve to overhead valve technology. While this shift has already contributed to the observed differential between 1990 and 1994 emissions, the long term impact of a continuation of this sales shift trend will bring about additional future emission rate reductions as well. In actuality, the impact of the sales shift trend will be greater than we have estimated under the population weighting basis used for this analysis. Since the larger displacement, higher horsepower engines which are gaining in market share are inherently lower emitting than their lower displacement, lower horsepower counterparts, an emissions differential based on aggregate brake horsepower hours will be larger than the 29% population based differential calculated herein.

In conclusion, it is apparent that 1994 emission rates from 0-25 hp non-handheld four stroke engines are significantly different from those used in Texas (and elsewhere) in 1990. As a result, it seems reasonable to allow states to account for these emissions differentials in their emission inventory calculations. If I can be of any additional assistance, please call me at (703) 528-1900.

Respectfully,

Daniel J. Meszler, P.E.

APPENDIX B

POPULATION, USE HOURS AND LIFE BY EQUIPMENT TYPE AND HORSEPOWER

Record#	NAME	TYPE	HP_GRP	AVG_HP	POP	LF	USE	LIFE
2	Off-Road Motorcycles	G2	15	10.0	21813	0.76	20	5.2
3	Off-Road Motorcycles	G2	25	21.0	18769	0.76	20	5.2
4	Off-Road Motorcycles	G2	50	38.0	152796	0.76	20	5.2
5	Off-Road Motorcycles	G2	120	56.0	73090	0.76	20	5.2
12	Snowmobiles	G2	25	20.0	654	0.81	90	9.0
13	Snowmobiles	G2	50	38.0	3082	0.81	90	9.0
14	Snowmobiles	G2	120	65.0	5604	0.81	90	9.0
20	All Terrain Vehicles (ATVs)	G2	15	13.0	6222	0.72	20	6.5
21	All Terrain Vehicles (ATVs)	G2	25	20.0	4051	0.72	20	6.5
22	All Terrain Vehicles (ATVs)	G2	50	30.0	5331	0.72	20	6.5
38	Golf Carts	G2	15	9.0	2975	0.46	400	7.0
47	Specialty Vehicles Carts	G2	15	7.0	24406	0.58	1145	2.4
65	Tampers/Rammers	G2	15	4.0	3021	0.55	182	4.0
74	Plate Compactors	G2	15	4.0	259	0.55	206	3.5
326	Other General Industrial Equipment	G2	15	8.0	87	0.54	375	2.0
353	Lawn Mowers	G2	15	3.5	159157	0.36	55	6.8
362	Tillers <=5 HP	G2	15	4.0	3637	0.40	25	5.6
370	Chainsaws <=5 HP	G2	2	1.7	518048	0.50	83	5.0
379	Trimmers/Edgers/Brush Cutters	G2	2	0.9	941157	0.50	46	5.0
388	Leaf Blowers/Vacuums	G2	2	1.0	345564	0.50	46	5.0
398	Snowblowers	G2	15	5.0	2107	0.35	17	5.4
399	Snowblowers	G2	25	16.0	3	0.35	17	5.4
425	Shredders <=5 HP	G2	15	4.0	549	0.36	126	5.5
461	Commercial Turf Equipment	G2	15	10.0	795	0.50	800	3.8
462	Commercial Turf Equipment	G2	25	18.0	392	0.50	800	3.8
470	Other Lawn & Garden Equipment	G2	15	5.0	49644	0.50	79	6.6
568	Generator Sets <=50 HP	G2	2	2.0	1952	0.68	110	2.0
569	Generator Sets <=50 HP	G2	15	8.0	34	0.68	128	4.6
570	Generator Sets <=50 HP	G2	25	19.0	505	0.68	128	8.6
577	Pumps <=50 HP	G2	2	1.0	4786	0.69	110	2.0
578	Pumps <=50 HP	G2	15	6.0	73	0.69	263	2.2
579	Pumps <=50 HP	G2	25	17.0	68	0.69	263	4.1
623	Chainsaws >5 HP	G2	15	8.0	30646	0.92	206	2.0
749	Cart	G2	15	12.0	20	0.50	150	5.3
794	Lav Cart	G2	15	12.0	13	0.50	183	4.4
866	Vessels w/Outboard Engines	G2	15	7.0	124795	0.75	206	4.9
867	Vessels w/Outboard Engines	G2	25	20.0	67085	0.75	206	4.9
868	Vessels w/Outboard Engines	G2	50	43.0	62245	0.75	206	9.7
869	Vessels w/Outboard Engines	G2	120	90.0	80475	0.75	206	9.7
870	Vessels w/Outboard Engines	G2	175	154.0	25997	0.75	206	9.7
871	Vessels w/Outboard Engines	G2	250	221.0	11638	0.75	206	9.7
872	Vessels w/Outboard Engines	G2	500	291.0	1407	0.75	206	9.7
893	Sailboat Auxiliary Outboard Engines	G2	15	7.0	4485	0.75	13	16.0
894	Sailboat Auxiliary Outboard Engines	G2	25	20.0	2411	0.75	13	16.0
895	Sailboat Auxiliary Outboard Engines	G2	50	43.0	2237	0.75	13	16.0
911	Off-Road Motorcycles	G4	15	10.0	28534	0.76	20	5.2
912	Off-Road Motorcycles	G4	25	21.0	46036	0.76	20	5.2
913	Off-Road Motorcycles	G4	50	38.0	47959	0.76	20	5.2
929	All Terrain Vehicles (ATVs)	G4	15	13.0	8909	0.72	20	6.5
930	All Terrain Vehicles (ATVs)	G4	25	20.0	123953	0.72	20	6.5
931	All Terrain Vehicles (ATVs)	G4	50	30.0	5595	0.72	20	6.5
937	Minibikes	G4	5	4.0	4576	0.62	20	5.5
947	Golf Carts	G4	15	9.0	7343	0.46	400	7.0
948	Golf Carts	G4	25	17.0	39	0.46	400	7.0
955	Specialty Vehicles Carts	G4	5	5.0	5014	0.58	1145	2.4
956	Specialty Vehicles Carts	G4	15	7.0	2360	0.58	1145	2.4
957	Specialty Vehicles Carts	G4	25	19.0	5057	0.58	1145	2.4
958	Specialty Vehicles Carts	G4	50	31.0	47	0.58	1145	2.4
965	Asphalt Pavers	G4	15	9.0	66	0.66	300	2.0
966	Asphalt Pavers	G4	25	22.0	113	0.66	396	2.9
967	Asphalt Pavers	G4	50	32.0	130	0.66	396	5.7
968	Asphalt Pavers	G4	120	61.0	72	0.66	396	11.5
974	Tampers/Rammers	G4	15	9.0	140	0.55	182	4.0
982	Plate Compactors	G4	5	4.0	5142	0.55	180	2.0
983	Plate Compactors	G4	15	8.0	5454	0.55	206	3.5
1000	Rollers	G4	5	5.0	573	0.62	83	3.9
1001	Rollers	G4	15	9.0	927	0.62	310	2.1
1002	Rollers	G4	25	19.0	626	0.62	310	3.9
1003	Rollers	G4	50	37.0	107	0.62	621	3.9
1004	Rollers	G4	120	76.0	216	0.62	621	7.8
1018	Paving Equipment	G4	5	4.0	7196	0.59	170	2.0
1019	Paving Equipment	G4	15	10.0	12174	0.59	200	3.4
1020	Paving Equipment	G4	25	22.0	271	0.59	200	6.4
1021	Paving Equipment	G4	50	37.0	418	0.59	200	12.7
1022	Paving Equipment	G4	120	66.0	107	0.59	200	16.0
1027	Surfacing Equipment	G4	5	5.0	1321	0.49	200	2.0
1028	Surfacing Equipment	G4	15	8.0	3926	0.49	400	2.0
1029	Surfacing Equipment	G4	25	19.0	54	0.49	503	3.0

1036	Signal Boards	G4	5	5.0	16	0.76	130	2.0
1037	Signal Boards	G4	15	8.0	116	0.76	260	2.0
1046	Trenchers	G4	15	10.0	1074	0.66	300	2.0
1047	Trenchers	G4	25	21.0	832	0.66	434	2.6
1048	Trenchers	G4	50	31.0	703	0.66	434	5.2
1049	Trenchers	G4	120	67.0	504	0.66	434	10.5
1050	Trenchers	G4	175	124.0	13	0.66	434	10.5
1055	Bore/Drill Rigs	G4	15	10.0	31	0.79	124	4.1
1056	Bore/Drill Rigs	G4	25	18.0	153	0.79	124	7.7
1057	Bore/Drill Rigs	G4	50	36.0	6	0.79	248	7.7
1058	Bore/Drill Rigs	G4	120	65.0	105	0.79	248	15.3
1059	Bore/Drill Rigs	G4	175	125.0	89	0.79	248	15.3
1067	Excavators	G4	120	80.0	2	0.53	393	14.4
1072	Concrete/Industrial Saws	G4	5	4.0	563	0.78	130	2.0
1073	Concrete/Industrial Saws	G4	15	9.0	2533	0.78	260	2.0
1074	Concrete/Industrial Saws	G4	25	17.0	792	0.78	310	3.1
1075	Concrete/Industrial Saws	G4	50	34.0	278	0.78	622	3.1
1076	Concrete/Industrial Saws	G4	120	66.0	157	0.78	622	6.2
1081	Cement and Mortar Mixers	G4	5	5.0	10226	0.59	92	3.7
1082	Cement and Mortar Mixers	G4	15	8.0	17327	0.59	92	7.4
1083	Cement and Mortar Mixers	G4	25	25.0	73	0.59	92	13.8
1093	Cranes	G4	50	37.0	58	0.47	411	7.8
1094	Cranes	G4	120	63.0	69	0.47	411	15.5
1095	Cranes	G4	175	30.0	128	0.47	411	15.5
1118	Crushing/Proc. Equipment	G4	15	9.0	28	0.85	235	2.0
1119	Crushing/Proc. Equipment	G4	25	16.0	18	0.85	289	3.1
1121	Crushing/Proc. Equipment	G4	120	86.0	19	0.85	289	12.2
1122	Crushing/Proc. Equipment	G4	175	124.0	33	0.85	289	12.2
1129	Rough Terrain Forklifts	G4	50	47.0	22	0.63	475	5.0
1130	Rough Terrain Forklifts	G4	120	65.0	158	0.63	475	10.0
1131	Rough Terrain Forklifts	G4	175	126.0	118	0.63	475	10.0
1138	Rubber Tired Loaders	G4	50	41.0	102	0.54	569	4.9
1139	Rubber Tired Loaders	G4	120	70.0	318	0.54	569	9.8
1140	Rubber Tired Loaders	G4	175	127.0	25	0.54	569	9.8
1157	Tractors/Loaders/Backhoes	G4	120	63.0	177	0.48	879	7.1
1172	Skid Steer Loaders	G4	15	14.0	55	0.58	319	2.2
1173	Skid Steer Loaders	G4	25	19.0	3656	0.58	319	4.1
1174	Skid Steer Loaders	G4	50	37.0	11590	0.58	319	8.1
1175	Skid Steer Loaders	G4	120	66.0	738	0.58	319	16.0
1189	Dumpers/Tenders	G4	5	4.0	522	0.41	149	3.3
1190	Dumpers/Tenders	G4	15	9.0	1113	0.41	149	6.5
1191	Dumpers/Tenders	G4	25	19.0	206	0.41	149	12.3
1193	Dumpers/Tenders	G4	120	66.0	28	0.41	149	16.0
1203	Other Construction Equipment	G4	175	150.0	119	0.48	375	16.0
1208	Aerial Lifts	G4	15	13.0	17	0.46	375	2.3
1209	Aerial Lifts	G4	25	19.0	715	0.46	375	4.3
1210	Aerial Lifts	G4	50	33.0	616	0.46	375	8.7
1211	Aerial Lifts	G4	120	78.0	364	0.46	750	8.7
1218	Forklifts	G4	25	23.0	17	0.30	900	2.8
1219	Forklifts	G4	50	43.0	1190	0.30	1818	2.8
1220	Forklifts	G4	120	67.0	5181	0.30	1818	5.5
1221	Forklifts	G4	175	133.0	146	0.30	1818	5.5
1226	Sweepers/Scrubbers	G4	15	8.0	486	0.71	270	2.1
1227	Sweepers/Scrubbers	G4	25	18.0	475	0.71	270	3.9
1228	Sweepers/Scrubbers	G4	50	36.0	1123	0.71	547	3.9
1229	Sweepers/Scrubbers	G4	120	64.0	869	0.71	547	7.7
1230	Sweepers/Scrubbers	G4	175	126.0	116	0.71	547	7.7
1235	Other General Industrial Equipment	G4	15	8.0	964	0.54	375	2.0
1236	Other General Industrial Equipment	G4	25	18.0	316	0.54	430	3.2
1237	Other General Industrial Equipment	G4	50	30.0	308	0.54	870	3.2
1238	Other General Industrial Equipment	G4	120	73.0	200	0.54	870	6.4
1239	Other General Industrial Equipment	G4	175	132.0	13	0.54	870	6.4
1246	Other Material Handling Equipment	G4	50	45.0	64	0.53	417	6.8
1247	Other Material Handling Equipment	G4	120	53.0	188	0.53	417	13.6
1261	Lawn Mowers	G4	5	4.0	1989369	0.36	36	6.8
1270	Tillers <=5 HP	G4	5	4.0	787110	0.40	25	5.6
1288	Trimmers/Edgers/Brush Cutters	G4	5	1.0	52979	0.36	60	4.7
1297	Leaf Blowers/Vacuums	G4	5	2.0	3639	0.36	87	4.6
1306	Snowblowers	G4	5	4.0	22795	0.35	17	5.4
1307	Snowblowers	G4	15	9.0	17247	0.35	17	5.4
1308	Snowblowers	G4	25	16.0	50	0.35	17	5.4
1316	Rear Engine Riding Mowers	G4	15	10.0	24268	0.38	49	6.9
1317	Rear Engine Riding Mowers	G4	25	18.0	109	0.38	49	6.9
1325	Front Mowers	G4	15	14.0	40967	0.50	50	3.8
1326	Front Mowers	G4	25	17.0	32085	0.50	50	3.8
1333	Shredders <=5 HP	G4	5	4.0	10422	0.36	126	5.5
1343	Lawn & Garden Tractors	G4	15	11.0	28114	0.50	60	6.9
1344	Lawn & Garden Tractors	G4	25	17.0	11088	0.50	60	6.9
1351	Wood Splitters	G4	5	5.0	62209	0.50	20	6.1
1361	Chippers/Stump Grinders	G4	15	9.0	107	0.39	542	5.5

1362	Chippers/Stump Grinders		G4	25	21.0	465	0.39	542	5.5
1370	Commercial Turf Equipment		G4	15	10.0	7157	0.50	800	3.8
1371	Commercial Turf Equipment		G4	25	18.0	3525	0.50	800	3.8
1378	Other Lawn & Garden Equipment		G4	5	5.0	128356	0.50	79	6.6
1387	2-Wheel Tractors		G4	5	4.0	953	0.62	160	2.0
1388	2-Wheel Tractors		G4	15	8.0	1109	0.62	325	2.0
1389	2-Wheel Tractors		G4	25	16.0	30	0.62	332	3.6
1400	Agricultural Tractors		G4	120	82.0	924	0.62	616	7.9
1401	Agricultural Tractors		G4	175	125.0	114	0.62	616	7.9
1409	Combines		G4	120	102.0	181	0.74	153	16.0
1410	Combines		G4	175	151.0	92	0.74	153	16.0
1411	Combines		G4	250	194.0	53	0.74	153	16.0
1417	Balers		G4	50	35.0	4356	0.55	99	16.0
1418	Balers		G4	120	64.0	878	0.55	99	16.0
1419	Balers		G4	175	124.0	300	0.55	99	16.0
1424	Agricultural Mowers		G4	15	8.0	990	0.48	180	4.6
1425	Agricultural Mowers		G4	25	18.0	810	0.48	180	8.7
1432	Sprayers		G4	5	4.0	3756	0.50	98	4.1
1433	Sprayers		G4	15	7.0	1169	0.50	98	8.2
1434	Sprayers		G4	25	17.0	3024	0.50	98	15.3
1435	Sprayers		G4	50	34.0	500	0.50	98	16.0
1436	Sprayers		G4	120	66.0	2158	0.50	98	16.0
1437	Sprayers		G4	175	135.0	332	0.50	98	16.0
1442	Tillers >5 HP		G4	15	7.0	127845	0.71	71	7.9
1454	Swathers		G4	120	87.0	3248	0.52	118	16.0
1455	Swathers		G4	175	129.0	2535	0.52	118	16.0
1459	Hydro Power Units		G4	5	5.0	226	0.56	175	2.0
1460	Hydro Power Units		G4	15	8.0	452	0.56	350	2.0
1461	Hydro Power Units		G4	25	17.0	172	0.56	464	2.9
1462	Hydro Power Units		G4	50	34.0	248	0.56	464	5.8
1463	Hydro Power Units		G4	120	91.0	2596	0.56	464	11.5
1464	Hydro Power Units		G4	175	136.0	1008	0.56	464	11.5
1465	Hydro Power Units		G4	250	211.0	1099	0.56	464	11.5
1468	Other Agricultural Equipment		G4	5	4.0	158	0.55	145	2.5
1469	Other Agricultural Equipment		G4	15	10.0	138	0.55	145	5.0
1470	Other Agricultural Equipment		G4	25	25.0	35	0.55	145	9.4
1471	Other Agricultural Equipment		G4	50	32.0	81	0.55	145	16.0
1472	Other Agricultural Equipment		G4	120	67.0	587	0.55	145	16.0
1473	Other Agricultural Equipment		G4	175	135.0	88	0.55	145	16.0
1474	Other Agricultural Equipment		G4	250	246.0	23	0.55	145	16.0
1477	Generator Sets	<=50 HP	G4	5	4.0	42087	0.68	128	2.3
1478	Generator Sets	<=50 HP	G4	15	10.0	92167	0.68	128	4.6
1479	Generator Sets	<=50 HP	G4	25	19.0	66853	0.68	128	8.6
1480	Generator Sets	<=50 HP	G4	50	32.0	13472	0.68	128	16.0
1486	Pumps	<=50 HP	G4	5	4.0	24277	0.69	145	2.0
1487	Pumps	<=50 HP	G4	15	9.0	21198	0.69	263	2.2
1488	Pumps	<=50 HP	G4	25	17.0	5175	0.69	263	4.1
1489	Pumps	<=50 HP	G4	50	32.0	1150	0.69	263	8.3
1495	Air Compressors	<=50 HP	G4	5	5.0	4758	0.56	175	2.0
1496	Air Compressors	<=50 HP	G4	15	10.0	6389	0.56	350	2.0
1497	Air Compressors	<=50 HP	G4	25	17.0	2084	0.56	557	2.4
1498	Air Compressors	<=50 HP	G4	50	40.0	708	0.56	557	4.8
1514	Welders	<=50 HP	G4	15	12.0	5722	0.51	241	3.3
1515	Welders	<=50 HP	G4	25	17.0	23586	0.51	241	6.1
1516	Welders	<=50 HP	G4	50	46.0	3418	0.51	241	12.2
1522	Pressure Washers	<=50 HP	G4	5	5.0	17427	0.85	120	2.0
1523	Pressure Washers	<=50 HP	G4	15	9.0	14390	0.85	133	3.5
1524	Pressure Washers	<=50 HP	G4	25	18.0	2723	0.85	133	6.6
1525	Pressure Washers	<=50 HP	G4	50	37.0	163	0.85	133	13.3
1541	Shredders >5 HP		G4	15	8.0	12704	0.80	242	2.1
1570	Aircraft Support Equipment		G4	50	48.0	292	0.56	842	3.2
1580	Terminal Tractors		G4	120	82.0	750	0.78	1408	2.7
1590	A/C Tug, Narrow Body		G4	175	130.0	22	0.80	551	6.8
1608	Air Conditioner		G4	175	130.0	10	0.75	22	16.0
1617	Air Start Unit		G4	175	130.0	3	0.90	135	16.0
1625	Baggage Tug		G4	120	100.0	325	0.55	876	6.2
1634	Belt Loader		G4	120	60.0	150	0.50	810	7.4
1643	Bobtail		G4	120	100.0	56	0.55	876	6.2
1652	Cargo Loader		G4	120	70.0	10	0.50	719	8.3
1670	Deicer		G4	120	93.0	17	0.95	22	16.0
1678	Forklift		G4	50	50.0	90	0.30	726	6.9
1689	Fuel Truck		G4	175	130.0	61	0.25	22	16.0
1698	Ground Power Unit		G4	175	150.0	10	0.75	796	5.0
1716	Lav Truck		G4	175	130.0	42	0.25	1212	9.9
1724	Lift		G4	120	100.0	39	0.50	376	16.0
1734	Maint. Truck		G4	175	130.0	157	0.50	449	13.4
1741	Other		G4	50	50.0	116	0.50	183	16.0
1753	Service Truck		G4	250	180.0	55	0.20	1299	11.5
1761	Water Truck		G4	175	150.0	4	0.20	310	16.0
1768	Vessels w/Inboard Engines		G4	50	40.0	1438	0.75	442	4.5

1769	Vessels w/Inboard Engines	G4	120	111.0	12567	0.75	442	9.0
1770	Vessels w/Inboard Engines	G4	175	151.0	66166	0.75	442	9.0
1771	Vessels w/Inboard Engines	G4	250	206.0	58659	0.75	442	9.0
1772	Vessels w/Inboard Engines	G4	500	290.0	652	0.75	442	9.0
1786	Vessels w/Sterndrive Engines	G4	50	40.0	1046	0.75	486	8.2
1787	Vessels w/Sterndrive Engines	G4	120	111.0	9138	0.75	486	8.2
1788	Vessels w/Sterndrive Engines	G4	175	151.0	48110	0.75	486	8.2
1789	Vessels w/Sterndrive Engines	G4	250	206.0	42652	0.75	486	8.2
1790	Vessels w/Sterndrive Engines	G4	500	290.0	474	0.75	486	8.2
1791	Vessels w/Sterndrive Engines	G4	750	630.0	1	0.75	486	8.2
1793	Sailboat Auxiliary Inboard Engines	G4	15	7.0	2508	0.75	23	16.0
1795	Sailboat Auxiliary Inboard Engines	G4	50	30.0	424	0.75	23	16.0
1796	Sailboat Auxiliary Inboard Engines	G4	120	73.0	55	0.75	23	16.0
1811	Transport Refrigeration Units	G4	15	12.0	4367	0.50	750	2.0
2117	Aerial Lifts	C4	15	13.0	17	0.46	375	2.3
2118	Aerial Lifts	C4	25	19.0	715	0.46	375	4.3
2119	Aerial Lifts	C4	50	33.0	616	0.46	375	8.7
2120	Aerial Lifts	C4	120	78.0	364	0.46	375	16.0
2127	Forklifts	C4	25	23.0	7	0.30	1250	2.0
2128	Forklifts	C4	50	43.0	2777	0.30	1818	2.8
2129	Forklifts	C4	120	67.0	10058	0.30	1818	5.5
2130	Forklifts	C4	175	133.0	283	0.30	1818	5.5
2783	Asphalt Pavers	D	25	24.0	14	0.62	396	10.2
2784	Asphalt Pavers	D	50	36.0	674	0.62	396	10.2
2785	Asphalt Pavers	D	120	87.0	88	0.62	396	16.0
2786	Asphalt Pavers	D	175	164.0	510	0.62	396	16.0
2787	Asphalt Pavers	D	250	190.0	34	0.62	396	16.0
2800	Plate Compactors	D	15	8.0	313	0.43	600	4.8
2811	Concrete Pavers	D	50	37.0	250	0.68	130	16.0
2812	Concrete Pavers	D	120	94.0	175	0.68	130	16.0
2813	Concrete Pavers	D	175	175.0	156	0.68	130	16.0
2814	Concrete Pavers	D	250	250.0	69	0.68	130	16.0
2815	Concrete Pavers	D	500	300.0	82	0.68	130	16.0
2818	Rollers	D	15	9.0	578	0.56	745	3.0
2819	Rollers	D	25	19.0	242	0.56	745	6.0
2820	Rollers	D	50	37.0	1132	0.56	745	6.0
2821	Rollers	D	120	85.0	6636	0.56	745	9.6
2822	Rollers	D	175	156.0	2396	0.56	745	9.6
2823	Rollers	D	250	218.0	392	0.56	745	9.6
2824	Rollers	D	500	309.0	245	0.56	745	14.4
2830	Scrapers	D	120	105.0	78	0.72	1005	5.5
2831	Scrapers	D	175	164.0	739	0.72	1005	5.5
2832	Scrapers	D	250	234.0	742	0.72	1005	5.5
2833	Scrapers	D	500	354.0	2088	0.72	1005	8.3
2834	Scrapers	D	750	617.0	298	0.72	1005	8.3
2835	Scrapers	D	9999	825.0	2	0.72	1005	8.3
2837	Paving Equipment	D	25	19.0	174	0.53	709	6.7
2838	Paving Equipment	D	50	37.0	217	0.53	709	6.7
2839	Paving Equipment	D	120	79.0	3746	0.53	709	10.6
2840	Paving Equipment	D	175	153.0	1318	0.53	709	10.6
2841	Paving Equipment	D	250	184.0	371	0.53	709	10.6
2854	Signal Boards	D	15	6.0	2688	0.82	750	2.0
2863	Trenchers	D	15	9.0	67	0.75	640	2.6
2864	Trenchers	D	25	35.0	70	0.75	640	5.2
2865	Trenchers	D	50	35.0	2429	0.75	640	5.2
2866	Trenchers	D	120	69.0	2996	0.75	640	8.3
2867	Trenchers	D	175	152.0	308	0.75	640	8.3
2868	Trenchers	D	250	237.0	28	0.75	640	8.3
2869	Trenchers	D	500	316.0	18	0.75	640	12.5
2872	Bore/Drill Rigs	D	15	11.0	9	0.75	541	3.1
2873	Bore/Drill Rigs	D	25	17.0	28	0.75	541	6.2
2874	Bore/Drill Rigs	D	50	34.0	75	0.75	541	6.2
2875	Bore/Drill Rigs	D	120	79.0	228	0.75	541	9.9
2876	Bore/Drill Rigs	D	175	174.0	23	0.75	541	9.9
2877	Bore/Drill Rigs	D	250	228.0	35	0.75	541	9.9
2878	Bore/Drill Rigs	D	500	329.0	120	0.75	541	14.8
2879	Bore/Drill Rigs	D	750	605.0	13	0.75	541	14.8
2880	Bore/Drill Rigs	D	9999	810.0	50	0.75	541	14.8
2882	Excavators	D	25	23.0	27	0.57	893	4.9
2883	Excavators	D	50	47.0	5	0.57	893	4.9
2884	Excavators	D	120	112.0	1710	0.57	893	7.9
2885	Excavators	D	175	158.0	2451	0.57	893	7.9
2886	Excavators	D	250	220.0	1207	0.57	893	7.9
2887	Excavators	D	500	362.0	741	0.57	893	11.8
2888	Excavators	D	750	519.0	27	0.57	893	11.8
2891	Concrete/Industrial Saws	D	25	18.0	4	0.73	592	5.8
2892	Concrete/Industrial Saws	D	50	35.0	6	0.73	592	5.8
2893	Concrete/Industrial Saws	D	120	77.0	6	0.73	592	9.3
2894	Concrete/Industrial Saws	D	175	175.0	1	0.73	592	9.3
2899	Cement and Mortar Mixers	D	15	9.0	488	0.56	300	7.4

2900	Cement and Mortar Mixers	D	25	25.0	44	0.56	300	14.9
2910	Cranes	D	50	43.0	76	0.43	796	7.3
2911	Cranes	D	120	96.0	1312	0.43	796	11.7
2912	Cranes	D	175	148.0	2700	0.43	796	11.7
2913	Cranes	D	250	215.0	2512	0.43	796	11.7
2914	Cranes	D	500	329.0	938	0.43	796	16.0
2915	Cranes	D	750	555.0	233	0.43	796	16.0
2919	Graders	D	50	35.0	12	0.61	821	5.0
2920	Graders	D	120	97.0	1166	0.61	821	8.0
2921	Graders	D	175	162.0	4214	0.61	821	8.0
2922	Graders	D	250	224.0	2365	0.61	821	8.0
2923	Graders	D	500	300.0	70	0.61	821	12.0
2924	Graders	D	750	635.0	5	0.61	821	12.0
2930	Off-Highway Trucks	D	175	175.0	33	0.57	1836	3.8
2931	Off-Highway Trucks	D	250	231.0	215	0.57	1836	3.8
2932	Off-Highway Trucks	D	500	396.0	254	0.57	1836	5.7
2933	Off-Highway Trucks	D	750	612.0	275	0.57	1836	5.7
2934	Off-Highway Trucks	D	9999	890.0	137	0.57	1836	5.7
2937	Crushing/Proc. Equipment	D	50	45.0	112	0.78	1146	2.8
2938	Crushing/Proc. Equipment	D	120	86.0	325	0.78	1146	4.5
2939	Crushing/Proc. Equipment	D	175	171.0	134	0.78	1146	4.5
2940	Crushing/Proc. Equipment	D	250	250.0	13	0.78	1146	4.5
2941	Crushing/Proc. Equipment	D	500	470.0	1	0.78	1146	6.7
2942	Crushing/Proc. Equipment	D	750	740.0	650	0.78	1146	6.7
2946	Rough Terrain Forklifts	D	50	45.0	187	0.60	761	5.5
2947	Rough Terrain Forklifts	D	120	83.0	6163	0.60	761	8.8
2948	Rough Terrain Forklifts	D	175	165.0	796	0.60	761	8.8
2949	Rough Terrain Forklifts	D	250	227.0	43	0.60	761	8.8
2950	Rough Terrain Forklifts	D	500	361.0	28	0.60	761	13.1
2954	Rubber Tired Loaders	D	25	25.0	13	0.54	875	5.3
2955	Rubber Tired Loaders	D	50	47.0	485	0.54	875	5.3
2956	Rubber Tired Loaders	D	120	25.0	13160	0.54	875	8.5
2957	Rubber Tired Loaders	D	175	160.0	5245	0.54	875	8.5
2958	Rubber Tired Loaders	D	250	219.0	5196	0.54	875	8.5
2959	Rubber Tired Loaders	D	500	354.0	2886	0.54	875	12.7
2960	Rubber Tired Loaders	D	750	710.0	157	0.54	875	12.7
2961	Rubber Tired Loaders	D	9999	872.0	12	0.54	875	12.7
2966	Rubber Tired Dozers	D	175	175.0	2	0.59	1016	6.7
2967	Rubber Tired Dozers	D	250	248.0	78	0.59	1016	6.7
2968	Rubber Tired Dozers	D	500	361.0	122	0.59	1016	10.0
2969	Rubber Tired Dozers	D	750	538.0	40	0.59	1016	10.0
2970	Rubber Tired Dozers	D	9999	800.0	2	0.59	1016	10.0
2972	Tractors/Loaders/Backhoes	D	25	23.0	177	0.55	570	8.0
2973	Tractors/Loaders/Backhoes	D	50	45.0	2131	0.55	1146	4.0
2974	Tractors/Loaders/Backhoes	D	120	75.0	34376	0.55	1146	6.3
2975	Tractors/Loaders/Backhoes	D	175	147.0	2147	0.55	1146	6.3
2976	Tractors/Loaders/Backhoes	D	250	249.0	6	0.55	1146	6.3
2983	Crawler Tractors	D	120	82.0	14990	0.58	1048	6.6
2984	Crawler Tractors	D	175	152.0	4707	0.58	1048	6.6
2985	Crawler Tractors	D	250	205.0	4970	0.58	1048	6.6
2986	Crawler Tractors	D	500	330.0	2489	0.58	1048	9.9
2987	Crawler Tractors	D	750	566.0	825	0.58	1048	9.9
2988	Crawler Tractors	D	9999	886.0	191	0.58	1048	9.9
2990	Skid Steer Loaders	D	25	20.0	1676	0.55	843	5.4
2991	Skid Steer Loaders	D	50	37.0	1052	0.55	843	5.4
2992	Skid Steer Loaders	D	120	66.0	5788	0.55	843	8.6
3002	Off-Highway Tractors	D	175	165.0	1668	0.65	975	6.3
3003	Off-Highway Tractors	D	250	231.0	1808	0.65	975	6.3
3005	Off-Highway Tractors	D	750	624.0	70	0.65	975	9.5
3006	Off-Highway Tractors	D	9999	999.0	28	0.65	975	9.5
3008	Dumpers/Tenders	D	25	16.0	23	0.38	662	9.9
3016	Other Construction Equipment	D	15	13.0	316	0.62	612	3.3
3017	Other Construction Equipment	D	25	17.0	53	0.62	612	6.6
3018	Other Construction Equipment	D	50	36.0	84	0.62	612	6.6
3019	Other Construction Equipment	D	120	104.0	142	0.62	612	10.5
3020	Other Construction Equipment	D	175	137.0	193	0.62	612	10.5
3022	Other Construction Equipment	D	500	322.0	487	0.62	612	15.8
3025	Aerial Lifts	D	15	15.0	93	0.46	399	6.8
3026	Aerial Lifts	D	25	19.0	152	0.46	399	13.6
3027	Aerial Lifts	D	50	33.0	673	0.46	399	13.6
3028	Aerial Lifts	D	120	66.0	587	0.46	399	16.0
3036	Forklifts	D	50	38.0	2607	0.30	1717	4.9
3037	Forklifts	D	120	80.0	14235	0.30	1717	7.8
3038	Forklifts	D	175	149.0	1061	0.30	1717	7.8
3039	Forklifts	D	250	206.0	552	0.30	1717	7.8
3040	Forklifts	D	500	323.0	59	0.30	1717	11.6
3043	Sweepers/Scrubbers	D	15	14.0	55	0.68	650	2.8
3044	Sweepers/Scrubbers	D	25	14.0	55	0.68	650	5.7
3045	Sweepers/Scrubbers	D	50	37.0	1155	0.68	1293	2.8
3046	Sweepers/Scrubbers	D	120	90.0	1980	0.68	1293	4.5

3047	Sweepers/Scrubbers	D	175	160.0	1294	0.68	1293	4.5
3048	Sweepers/Scrubbers	D	250	216.0	50	0.68	1293	4.5
3052	Other General Industrial Equipment	D	15	10.0	86	0.51	1071	2.3
3053	Other General Industrial Equipment	D	25	10.0	86	0.51	1071	4.6
3054	Other General Industrial Equipment	D	50	32.0	83	0.51	1071	4.6
3055	Other General Industrial Equipment	D	120	98.0	976	0.51	1071	7.3
3056	Other General Industrial Equipment	D	175	149.0	561	0.51	1071	7.3
3057	Other General Industrial Equipment	D	250	245.0	38	0.51	1071	7.3
3058	Other General Industrial Equipment	D	500	490.0	1	0.51	1071	11.0
3063	Other Material Handling Equipment	D	50	44.0	20	0.59	455	9.3
3064	Other Material Handling Equipment	D	120	80.0	423	0.59	455	14.9
3065	Other Material Handling Equipment	D	175	166.0	144	0.59	455	14.9
3066	Other Material Handling Equipment	D	250	195.0	42	0.59	455	14.9
3067	Other Material Handling Equipment	D	500	259.0	20	0.59	455	16.0
3134	Rear Engine Riding Mowers	D	25	17.0	685	0.38	48	6.9
3160	Lawn & Garden Tractors	D	15	13.0	19558	0.50	317	6.9
3161	Lawn & Garden Tractors	D	25	20.0	16143	0.50	317	6.9
3179	Chippers/Stump Grinders	D	25	23.0	25	0.37	516	5.5
3187	Commercial Turf Equipment	D	15	11.0	167	0.50	1239	3.8
3188	Commercial Turf Equipment	D	25	20.0	9506	0.50	1239	3.8
3197	Other Lawn & Garden Equipment	D	25	18.0	24	0.50	197	6.6
3214	Agricultural Tractors	D	15	12.0	14764	0.70	532	3.4
3215	Agricultural Tractors	D	25	23.0	18206	0.70	532	6.7
3216	Agricultural Tractors	D	50	40.0	115522	0.70	532	6.7
3217	Agricultural Tractors	D	120	83.0	152907	0.70	532	10.7
3218	Agricultural Tractors	D	175	143.0	82284	0.70	532	10.7
3219	Agricultural Tractors	D	250	203.0	49906	0.70	532	10.7
3220	Agricultural Tractors	D	500	351.0	9538	0.70	532	16.0
3221	Agricultural Tractors	D	750	540.0	250	0.70	532	16.0
3226	Combines	D	120	102.0	151	0.70	183	16.0
3227	Combines	D	175	140.0	18957	0.70	183	16.0
3228	Combines	D	250	201.0	17544	0.70	183	16.0
3229	Combines	D	500	277.0	402	0.70	183	16.0
3234	Balers	D	50	50.0	29	0.58	139	16.0
3235	Balers	D	120	76.0	330	0.58	139	16.0
3251	Sprayers	D	25	19.0	304	0.50	110	16.0
3252	Sprayers	D	50	35.0	62	0.50	110	16.0
3253	Sprayers	D	120	89.0	804	0.50	110	16.0
3254	Sprayers	D	175	150.0	371	0.50	110	16.0
3255	Sprayers	D	250	250.0	11	0.50	110	16.0
3256	Sprayers	D	500	32.0	270	0.50	110	16.0
3259	Tillers >5 HP	D	15	7.0	7	0.78	263	6.1
3271	Swathers	D	120	78.0	8736	0.55	136	16.0
3272	Swathers	D	175	150.0	71	0.55	136	16.0
3277	Hydro Power Units	D	15	10.0	57	0.48	814	3.2
3278	Hydro Power Units	D	25	19.0	172	0.48	814	6.4
3279	Hydro Power Units	D	50	84.0	963	0.48	814	6.4
3280	Hydro Power Units	D	120	136.0	6548	0.48	814	10.2
3281	Hydro Power Units	D	175	150.0	3829	0.48	814	10.2
3282	Hydro Power Units	D	250	201.0	1030	0.48	814	10.2
3283	Hydro Power Units	D	500	332.0	82	0.48	814	15.4
3286	Other Agricultural Equipment	D	15	12.0	208	0.51	446	5.5
3287	Other Agricultural Equipment	D	25	22.0	578	0.51	446	11.0
3288	Other Agricultural Equipment	D	50	41.0	671	0.51	446	11.0
3289	Other Agricultural Equipment	D	120	79.0	1677	0.51	446	16.0
3290	Other Agricultural Equipment	D	175	122.0	30	0.51	446	16.0
3291	Other Agricultural Equipment	D	250	177.0	11	0.51	446	16.0
3295	Generator Sets <=50 HP	D	15	10.0	5905	0.74	375	4.5
3296	Generator Sets <=50 HP	D	25	19.0	4312	0.74	375	9.0
3297	Generator Sets <=50 HP	D	50	34.0	6610	0.74	375	9.0
3304	Pumps <=50 HP	D	15	9.0	2817	0.74	480	3.5
3305	Pumps <=50 HP	D	25	20.0	1131	0.74	480	7.0
3306	Pumps <=50 HP	D	50	37.0	2866	0.74	480	7.0
3314	Air Compressors <=50 HP	D	25	24.0	24	0.48	937	5.6
3315	Air Compressors <=50 HP	D	50	37.0	1519	0.48	937	5.6
3331	Welders <=50 HP	D	15	11.0	1859	0.45	746	3.7
3332	Welders <=50 HP	D	25	22.0	1474	0.45	746	7.4
3333	Welders <=50 HP	D	50	46.0	5390	0.45	746	7.4
3340	Pressure Washers <=50 HP	D	15	13.0	293	0.30	168	16.0
3341	Pressure Washers <=50 HP	D	25	19.0	71	0.30	168	16.0
3342	Pressure Washers <=50 HP	D	50	39.0	149	0.30	168	16.0
3370	Skidders	D	120	102.0	473	0.74	1442	3.7
3371	Skidders	D	175	151.0	756	0.74	1442	3.7
3372	Skidders	D	250	227.0	278	0.74	1442	3.7
3373	Skidders	D	500	270.0	15	0.74	1442	5.6
3379	Fellers/Bunchers	D	120	89.0	354	0.71	1386	4.1
3380	Fellers/Bunchers	D	175	165.0	124	0.71	1386	4.1
3381	Fellers/Bunchers	D	250	229.0	158	0.71	1386	4.1
3382	Fellers/Bunchers	D	500	342.0	178	0.71	1386	6.1
3389	Aircraft Support Equipment	D	175	137.0	1236	0.51	842	9.3

3397	Terminal Tractors	D	120	96.0	7590	0.82	1408	3.5
3407	A/C Tug, Narrow Body	D	175	175.0	62	0.80	551	9.1
3418	A/C Tug, Wide Body	D	500	500.0	9	0.80	515	14.6
3427	Air Conditioner	D	500	300.0	13	0.75	22	16.0
3437	Air Start Unit	D	750	600.0	36	0.90	135	16.0
3442	Baggage Tug	D	120	78.0	252	0.55	876	8.3
3450	Belt Loader	D	50	45.0	109	0.50	810	6.2
3469	Cargo Loader	D	120	76.0	90	0.50	719	11.1
3487	Deicer	D	120	93.0	1	0.95	22	16.0
3496	Forklift	D	120	52.0	13	0.30	726	16.0
3507	Fuel Truck	D	250	180.0	3	0.25	22	16.0
3515	Ground Power Unit	D	175	145.0	108	0.75	796	6.7
3551	Maint. Truck	D	175	130.0	4	0.50	449	16.0
3558	Other	D	50	50.0	4	0.50	183	16.0
3569	Service Truck	D	175	170.0	27	0.20	1299	15.4
3585	Vessels w/Inboard Engines	D	50	36.0	327	0.75	810	4.5
3586	Vessels w/Inboard Engines	D	120	103.0	3455	0.75	810	4.5
3587	Vessels w/Inboard Engines	D	175	154.0	8009	0.75	810	9.0
3588	Vessels w/Inboard Engines	D	250	216.0	3764	0.75	810	9.0
3589	Vessels w/Inboard Engines	D	500	337.0	7002	0.75	810	9.0
3590	Vessels w/Inboard Engines	D	750	722.0	1097	0.75	810	9.0
3610	Sailboat Auxiliary Inboard Engines	D	15	11.0	3550	0.75	41	16.0
3611	Sailboat Auxiliary Inboard Engines	D	25	20.0	2934	0.75	41	16.0
3612	Sailboat Auxiliary Inboard Engines	D	50	39.0	4062	0.75	41	16.0
3613	Sailboat Auxiliary Inboard Engines	D	120	71.0	1402	0.75	41	16.0
3629	Transport Refrigeration Units	D	25	17.0	1305	0.50	750	6.7
3630	Transport Refrigeration Units	D	50	34.0	6751	0.50	1500	3.3
3631	Transport Refrigeration Units	D	120	76.0	4507	0.40	3000	3.3

APPENDIX C

COUNTY ACTIVITY INDICATORS AND ALLOCATION OF ACTIVITY INDICATORS TO AIR BASINS

COUNTY ACTIVITY INDICATORS

BASIN	COUNTY	AIRS Code: Agricultural Employees SIC 07	Landscape/Hort. Employees SIC 078	Wheel Tractors	Grain & Bean Combines	Single Family Homes (Total)	Mining Employees (Total)	Construction Employees (Total)	Manufacturing Employees (Total)
SAN FRANCISCO	ALAMEDA	3221	2385	802	27	500820	496	33798	86152
GREAT BASIN VALLEY	ALPINE	-	-	12	0	1221	-	10	-
MOUNTAIN COUNTIES	AMADOR	-	-	509	8	12300	60	489	1082
SACRAMENTO VALLEY	BUTTE	750	276	3347	468	75726	60	3548	6010
MOUNTAIN COUNTIES	CALAVERAS	-	-	442	8	19827	212	763	373
SACRAMENTO VALLEY	COLUSA	60	-	1694	643	6123	10	60	359
SAN FRANCISCO	CONTRA COSTA	2699	1869	1026	9	306458	3750	23796	28170
NORTH COAST	DEL NORTE	-	-	153	0	3892	10	260	539
MOUNTAIN COUNTIES / LAKE TAHOE	EL DORADO	331	182	709	0	59842	78	3308	2148
SAN JOAQUIN VALLEY	FRESNO	3750	842	18738	158	236405	505	16659	24555
SACRAMENTO VALLEY	GLENN	74	-	2560	484	9755	-	175	1230
NORTH COAST	HUMBOLT	496	345	1292	0	50022	60	1802	6930
SOUTHEAST DESERT	IMPERIAL	1750	57	2605	89	39500	375	1365	1712
GREAT BASIN VALLEY	INYO	-	-	117	0	9359	189	175	210
SOUTHEAST DESERT / SJV	KERN	2443	455	7123	103	197819	8539	10478	10326
SAN JOAQUIN VALLEY	KINGS	321	62	3465	181	31582	60	713	3581
LAKE COUNTY	LAKE	72	-	1044	10	29706	375	587	414
NORTHEAST PLATEAU	LASSEN	-	-	881	81	10644	10	228	676
SOUTH COAST / SED	LOS ANGELES	17391	11844	2416	42	3131076	6222	166208	875837
SAN JOAQUIN VALLEY	MADERA	175	-	4467	89	31340	63	1421	3982
SAN FRANCISCO	MARIN	1750	864	398	3	100098	62	6251	5738
MOUNTAIN COUNTIES	MARIPOSA	-	-	291	1	7974	60	375	135
NORTH COAST	MENDOCINO	229	-	1268	16	34132	60	1255	4643
SAN JOAQUIN VALLEY	MERCED	750	95	7204	132	58998	60	2297	6480
NORTHEAST PLATEAU	MODOC	-	-	1166	157	4590	-	60	164
GREAT BASIN VALLEY	MONO	-	-	142	14	10318	10	683	60
NORTH CENTRAL COAST	MONTEREY	2661	281	3977	103	119609	64	4739	9630
SAN FRANCISCO	NAPA	375	249	1712	25	44825	60	2940	5584
MOUNTAIN COUNTIES	NEVADA	131	-	359	0	35163	78	2030	2915
SOUTH COAST	ORANGE	17500	10892	1170	30	951518	1906	84345	249977
LT / MC / SACRAMENTO VALLEY	PLACER	703	484	1297	64	73233	112	5909	7265
MOUNTAIN COUNTIES	PLUMAS	-	-	198	2	11627	10	192	932
SOUTH COAST / SED	RIVERSIDE	6150	2859	5543	69	439620	727	39719	40664
SACRAMENTO VALLEY	SACRAMENTO	3750	1886	3014	312	406845	319	29610	31313
NORTH CENTRAL COAST	SAN BENITO	874	-	1256	55	12068	50	855	1834

COUNTY ACTIVITY INDICATORS

BASIN	COUNTY	AIRS Code: Agricultural Employees SIC 07	Landscape/Hort. Employees SIC 078	Wheel Tractors	Grain & Bean Combines	Single Family Homes (Total)	Mining Employees (Total)	Construction Employees (Total)	Manufacturing Employees (Total)
SOUTH COAST / SED	SAN BERNARDINO	3750	2087	2642	12	527866	1248	38740	59709
SAN DIEGO	SAN DIEGO	8787	6598	5195	55	821940	716	66411	135153
SAN FRANCISCO	SAN FRANCISCO	960	529	6	0	327274	1932	25304	44673
SAN JOAQUIN VALLEY	SAN JOAQUIN	1750	611	8995	270	165014	154	10304	25156
SOUTH CENTRAL COAST	SAN LUIS OBISPO	1120	726	3237	149	87077	174	5297	6292
SAN FRANCISCO	SAN MATEO	1750	1053	482	12	250530	62	16507	36885
SOUTH CENTRAL COAST	SANTA BARBARA	1750	648	3279	225	132818	1058	8371	21028
SAN FRANCISCO	SANTA CLARA	3794	2789	1899	12	531534	179	35159	282433
NORTH CENTRAL COAST	SANTA CRUZ	817	369	1461	0	91439	165	5327	11437
SACRAMENTO VALLEY	SHASTA	271	116	1097	37	60248	229	4612	5520
MOUNTAIN COUNTIES	SIERRA	-	-	78	1	2097	10	10	173
NORTHEAST PLATEAU	SISKIYOU	73	-	1328	130	20993	60	386	1818
SACRAMENTO VALLEY / SF	SOLANO	375	276	1899	164	112223	337	8597	7800
NORTH COAST / SF	SONOMA	1589	751	4062	20	154948	230	13189	21299
SAN JOAQUIN VALLEY	STANISLAUS	750	300	8538	199	129956	96	10484	24007
SACRAMENTO VALLEY	SUTTER	375	64	3649	581	23779	10	1415	1818
SACRAMENTO VALLEY	TEHAMA	60	-	2134	77	20582	10	505	2595
NORTH COAST	TRINITY	-	-	140	0	7355	10	60	445
SAN JOAQUIN VALLEY	TULARE	2529	191	12335	165	104581	60	4959	12703
MOUNTAIN COUNTIES	TUOLUMNE	60	-	225	0	24596	375	1345	1147
SOUTH CENTRAL COAST	VENTURA	3616	1890	3671	36	222302	1212	16921	36075
SACRAMENTO VALLEY	YOLO	603	146	3260	415	52750	65	2770	6033
SACRAMENTO VALLEY	YUBA	60	-	1262	144	22087	50	785	1324

COUNTY ACTIVITY INDICATORS

BASIN	COUNTY	AIRS Code: Logging Employees SIC 241	Wholesale Establishments (Total)	Retail Establishments (Total)	Motorcycle Dlr Establishments SIC 557	Golf courses with power golf cars	Snowmobile gasoline use (% of state)	Off Highway Rec. Vehicle Registrations
SAN FRANCISCO	ALAMEDA	-	2960	7207	20	13	0.00%	14360
GREAT BASIN VALLEY	ALPINE	-	-	7	-	0	2.60%	61
MOUNTAIN COUNTIES	AMADOR	-	31	226	-	1	3.10%	988
SACRAMENTO VALLEY	BUTTE	175	234	1155	-	7	4.70%	5505
MOUNTAIN COUNTIES	CALAVERAS	89	26	205	-	5	1.00%	1053
SACRAMENTO VALLEY	COLUSA	-	35	99	-	2	0.00%	868
SAN FRANCISCO	CONTRA COSTA	-	1225	4212	-	22	0.00%	10923
NORTH COAST	DEL NORTE	175	22	177	-	2	0.00%	501
MOUNTAIN COUNTIES / LAKE TAHOE	EL DORADO	116	134	810	-	3	7.80%	3875
SAN JOAQUIN VALLEY	FRESNO	79	1120	3568	11	13	4.20%	12509
SACRAMENTO VALLEY	GLENN	-	42	133	-	1	0.50%	1362
NORTH COAST	HUMBOLT	827	160	987	-	4	0.00%	4565
SOUTHEAST DESERT	IMPERIAL	-	238	664	-	2	0.00%	4360
GREAT BASIN VALLEY	INYO	-	35	200	-	4	0.50%	757
SOUTHEAST DESERT / SJV	KERN	-	777	2800	9	20	1.60%	17214
SAN JOAQUIN VALLEY	KINGS	-	74	411	-	2	0.00%	2789
LAKE COUNTY	LAKE	-	38	326	-	4	0.00%	1320
NORTHEAST PLATEAU	LASSEN	167	23	154	-	1	11.40%	1409
SOUTH COAST / SED	LOS ANGELES	-	20149	44568	90	72	0.00%	132490
SAN JOAQUIN VALLEY	MADERA	-	91	420	-	4	2.10%	2284
SAN FRANCISCO	MARIN	-	579	1952	-	6	0.00%	1935
MOUNTAIN COUNTIES	MARIPOSA	-	10	102	-	2	0.50%	366
NORTH COAST	MENDOCINO	651	131	690	-	2	0.00%	2787
SAN JOAQUIN VALLEY	MERCED	-	160	778	-	4	0.00%	3167
NORTHEAST PLATEAU	MODOC	-	10	76	-	1	0.00%	222
GREAT BASIN VALLEY	MONO	-	6	146	-	2	6.70%	500
NORTH CENTRAL COAST	MONTEREY	-	477	2256	-	19	0.00%	4802
SAN FRANCISCO	NAPA	-	156	713	-	7	0.00%	2469
MOUNTAIN COUNTIES	NEVADA	93	82	546	-	6	5.20%	2485
SOUTH COAST	ORANGE	-	6487	14386	39	37	0.00%	58991
LT / MC / SACRAMENTO VALLEY	PLACER	69	264	1217	-	10	5.70%	5275
MOUNTAIN COUNTIES	PLUMAS	175	13	185	-	7	16.60%	1193
SOUTH COAST / SED	RIVERSIDE	-	1118	5473	16	84	0.00%	35612
SACRAMENTO VALLEY	SACRAMENTO	-	1527	5690	23	16	0.00%	14675
NORTH CENTRAL COAST	SAN BENITO	-	43	171	-	2	0.00%	1072

COUNTY ACTIVITY INDICATORS

BASIN	COUNTY	AIRS Code: Logging Employees SIC 241	Wholesale Establishments (Total)	Retail Establishments (Total)	Motorcycle Dlr Establishments SIC 557	Golf courses with power golf cars	Snowmobile gasoline use (% of state)	Off Highway Rec. Vehicle Registrations
SOUTH COAST / SED	SAN BERNARDINO	-	1554	6254	26	23	1.60%	49219
SAN DIEGO	SAN DIEGO	-	3802	13705	49	58	0.00%	70868
SAN FRANCISCO	SAN FRANCISCO	-	2154	6901	6	6	0.00%	1465
SAN JOAQUIN VALLEY	SAN JOAQUIN	60	655	2318	-	12	0.00%	8523
SOUTH CENTRAL COAST	SAN LUIS OBISPO	-	241	1622	-	7	0.00%	5387
SAN FRANCISCO	SAN MATEO	-	1795	3778	-	14	0.00%	6386
SOUTH CENTRAL COAST	SANTA BARBARA	-	531	2503	-	14	0.00%	5569
SAN FRANCISCO	SANTA CLARA	-	3114	8281	23	26	0.00%	20835
NORTH CENTRAL COAST	SANTA CRUZ	-	350	1599	-	6	0.00%	3562
SACRAMENTO VALLEY	SHASTA	680	252	1068	-	8	0.00%	5948
MOUNTAIN COUNTIES	SIERRA	-	-	22	-	0	3.10%	156
NORTHEAST PLATEAU	SISKIYOU	245	47	368	-	3	2.60%	1051
SACRAMENTO VALLEY / SF	SOLANO	-	271	1638	-	6	9.30%	4750
NORTH COAST / SF	SONOMA	-	641	2574	12	17	0.00%	6897
SAN JOAQUIN VALLEY	STANISLAUS	-	473	1921	-	6	0.00%	8708
SACRAMENTO VALLEY	SUTTER	-	106	375	-	2	0.00%	2272
SACRAMENTO VALLEY	TEHAMA	175	37	260	-	2	0.00%	1896
NORTH COAST	TRINITY	60	7	104	-	1	0.50%	510
SAN JOAQUIN VALLEY	TULARE	101	417	1599	-	9	0.50%	8526
MOUNTAIN COUNTIES	TUOLUMNE	175	53	383	-	6	2.10%	1320
SOUTH CENTRAL COAST	VENTURA	-	1012	3492	14	20	5.70%	16046
SACRAMENTO VALLEY	YOLO	-	290	755	-	5	0.00%	2208
SACRAMENTO VALLEY	YUBA	-	51	253	-	3	0.40%	1630

COUNTY ACTIVITY INDICATORS

BASIN	COUNTY	AIRS Code: Airport GSE Population	Commercial Truck Registrations	Trailer Registrations	Active Registrations: Off-Road Motorcycles	Active Registrations: ATCs & ATVs	Active Registrations: Snowmobiles	Active Registrations: All Others	Inactive Reg: Off-Road Motorcycles
SAN FRANCISCO	ALAMEDA	112	163648	52223	6698	1091	304	360	4210
GREAT BASIN VALLEY	ALPINE	0	287	73	11	4	26	1	8
MOUNTAIN COUNTIES	AMADOR	0	8555	2581	325	97	124	111	200
SACRAMENTO VALLEY	BUTTE	0	38292	14760	1733	839	308	353	1161
MOUNTAIN COUNTIES	CALAVERAS	0	9378	3344	399	126	75	82	198
SACRAMENTO VALLEY	COLUSA	0	5435	1625	187	181	88	90	119
SAN FRANCISCO	CONTRA-COSTA	0	102397	36512	5257	827	235	308	3330
NORTH COAST	DEL NORTE	0	4601	1655	143	54	3	71	166
MOUNTAIN COUNTIES / LAKE TAHOE	EL DORADO	0	28866	9960	1400	356	329	262	914
SAN JOAQUIN VALLEY	FRESNO	0	112093	34861	3939	2425	221	376	2325
SACRAMENTO VALLEY	GLENN	0	7650	3013	445	205	120	135	225
NORTH COAST	HUMBOLT	0	28724	8854	1747	434	22	114	1411
SOUTHEAST DESERT	IMPERIAL	0	23696	6074	1066	904	1	290	646
GREAT BASIN VALLEY	INYO	0	6111	2032	313	73	24	28	210
SOUTHEAST DESERT / SJV	KERN	0	105108	31957	5082	2511	179	803	4482
SAN JOAQUIN VALLEY	KINGS	0	17120	5277	649	708	36	-102	392
LAKE COUNTY	LAKE	0	13316	5605	523	175	7	70	333
NORTHEAST PLATEAU	LASSEN	0	7284	2849	409	98	172	142	279
SOUTH COAST / SED	LOS ANGELES	1310	930994	198178	58654	16498	318	4564	34587
SAN JOAQUIN VALLEY	MADERA	0	19268	6525	683	469	35	48	420
SAN FRANCISCO	MARIN	0	29374	7690	900	131	17	51	643
MOUNTAIN COUNTIES	MARIPOSA	0	4503	1384	180	41	8	18	73
NORTH COAST	MENDOCINO	0	21210	5484	1057	289	7	188	793
SAN JOAQUIN VALLEY	MERCED	0	32109	9878	1167	502	32	139	741
NORTHEAST PLATEAU	MODOC	0	3399	1165	64	33	15	34	45
GREAT BASIN VALLEY	MONO	0	2866	1019	130	31	144	9	95
NORTH CENTRAL COAST	MONTEREY	16	49249	12817	2185	313	30	146	1568
SAN FRANCISCO	NAPA	0	21062	7665	1233	270	16	54	664
MOUNTAIN COUNTIES	NEVADA	0	20016	7154	767	384	182	100	555
SOUTH COAST	ORANGE	126	289123	71699	27228	6672	81	2228	15576
LT / MC / SACRAMENTO VALLEY	PLACER	0	37817	14400	2067	580	247	340	1321
MOUNTAIN COUNTIES	PLUMAS	0	6512	2436	308	80	394	51	152
SOUTH COAST / SED	RIVERSIDE	121	158642	44796	14829	4591	16	1577	8907
SACRAMENTO VALLEY	SACRAMENTO	94	162915	53960	6015	1469	459	854	3967
NORTH CENTRAL COAST	SAN BENITO	0	7123	2072	521	122	4	45	252

COUNTY ACTIVITY INDICATORS

	AIRS Code:	Airport	Commercial		Active Registrations					Inactive Reg
		GSE	Truck	Trailer	Off-Road	ATCs &		All	Off-Road	
BASIN	COUNTY	Population	Registrations	Registrations	Motorcycles	ATVs	Snowmobiles	Others	Motorcycles	
SOUTH COAST / SED	SAN BERNARDINO	0	204329	57454	20316	6860	81	1881	12052	
SAN DIEGO	SAN DIEGO	166	313968	70485	25409	12861	16	3475	14441	
SAN FRANCISCO	SAN FRANCISCO	395	69069	22681	653	70	28	20	542	
SAN JOAQUIN VALLEY	SAN JOAQUIN	0	80902	28075	3132	1337	213	356	1910	
SOUTH CENTRAL COAST	SAN LUIS OBISPO	0	42424	13976	2043	519	12	310	1474	
SAN FRANCISCO	SAN MATEO	0	82468	18950	3301	461	122	120	1932	
SOUTH CENTRAL COAST	SANTA BARBARA	27	58610	15656	2381	636	12	180	1464	
SAN FRANCISCO	SANTA CLARA	119	186580	51215	10463	1581	305	690	6151	
NORTH CENTRAL COAST	SANTA CRUZ	0	39763	8922	1826	210	32	55	1168	
SACRAMENTO VALLEY	SHASTA	0	37256	16667	2359	739	171	410	1399	
MOUNTAIN COUNTIES	SIERRA	0	1183	379	33	10	44	8	20	
NORTHEAST PLATEAU	SISKIYOU	0	14202	4680	178	66	288	65	167	
SACRAMENTO VALLEY / SF	SOLANO	0	44197	14136	2206	421	103	132	1379	
NORTH COAST / SF	SONOMA	0	70955	21880	3263	480	55	285	2108	
SAN JOAQUIN VALLEY	STANISLAUS	0	67321	24522	3736	1231	196	383	1912	
SACRAMENTO VALLEY	SUTTER	0	14346	5310	630	404	238	116	398	
SACRAMENTO VALLEY	TEHAMA	0	12866	4997	573	280	106	267	298	
NORTH COAST	TRINITY	0	4286	1678	207	45	25	29	143	
SAN JOAQUIN VALLEY	TULARE	0	60319	18406	2373	1903	148	281	1518	
MOUNTAIN COUNTIES	TUOLUMNE	0	12900	4552	452	98	168	123	322	
SOUTH CENTRAL COAST	VENTURA	0	99586	26126	6981	1789	27	527	4227	
SACRAMENTO VALLEY	YOLO	0	25100	8590	788	274	83	225	513	
SACRAMENTO VALLEY	YUBA	0	12109	4147	500	268	68	84	375	

COUNTY ACTIVITY INDICATORS

		AIRS Code: nactive Registrations			Active & Inactive Registrations				Rec Marine 1000 Gals burned	
BASIN	COUNTY	ATCs & ATVs	Snowmobiles	All Others	Off-Road Motorcycles	ATCs & ATVs	Snowmobiles	All Others	Diesel	Gasoline
SAN FRANCISCO	ALAMEDA	1390	111	194	10908	2481	415	554	292	4034
GREAT BASIN VALLEY	ALPINE	2	9	0	19	6	35	1	0	86
MOUNTAIN COUNTIES	AMADOR	73	26	32	525	170	150	143	0	748
SACRAMENTO VALLEY	BUTTE	843	121	147	2894	1682	429	500	0	1965
MOUNTAIN COUNTIES	CALAVERAS	97	28	48	597	223	103	130	0	720
SACRAMENTO VALLEY	COLUSA	152	33	18	306	333	121	108	0	446
SAN FRANCISCO	CONTRA COSTA	749	59	157	8587	1576	294	465	334	4618
NORTH COAST	DEL NORTE	46	1	20	309	100	4	91	50	1929
MOUNTAIN COUNTIES / LAKE TAHOE	EL DORADO	365	144	105	2314	721	473	367	0	1914
SAN JOAQUIN VALLEY	FRESNO	2825	78	320	6264	5250	299	696	0	3757
SACRAMENTO VALLEY	GLENN	147	30	55	670	352	150	190	0	346
NORTH COAST	HUMBOLT	724	6	107	3158	1158	28	221	122	715
SOUTHEAST DESERT	IMPERIAL	1318	1	133	1712	2222	2	423	0	1613
GREAT BASIN VALLEY	INYO	76	19	14	523	149	43	42	0	172
SOUTHEAST DESERT / SJV	KERN	3653	68	436	9564	6164	247	1239	0	1381
SAN JOAQUIN VALLEY	KINGS	816	14	72	1041	1524	50	174	0	0
LAKE COUNTY	LAKE	168	7	36	856	343	14	106	0	6476
NORTHEAST PLATEAU	LASSEN	170	89	50	688	268	261	192	0	187
SOUTH COAST / SED	LOS ANGELES	15271	87	2504	93241	31769	405	7068	1439	14391
SAN JOAQUIN VALLEY	MADERA	575	19	35	1103	1044	54	83	0	346
SAN FRANCISCO	MARIN	156	8	29	1543	287	25	80	97	1338
MOUNTAIN COUNTIES	MARIPOSA	32	8	6	253	73	16	24	0	1015
NORTH COAST	MENDOCINO	349	1	102	1850	638	8	290	43	987
SAN JOAQUIN VALLEY	MERCED	484	13	89	1908	986	45	228	0	389
NORTHEAST PLATEAU	MODOC	21	4	6	109	54	19	40	0	116
GREAT BASIN VALLEY	MONO	19	67	5	225	50	211	14	0	906
NORTH CENTRAL COAST	MONTEREY	446	15	99	3753	759	45	245	0	1237
SAN FRANCISCO	NAPA	191	9	32	1897	461	25	86	55	759
MOUNTAIN COUNTIES	NEVADA	373	72	50	1322	757	254	150	0	1022
SOUTH COAST	ORANGE	6267	41	896	42804	12939	122	3124	993	5814
LT / MC / SACRAMENTO VALLEY	PLACER	538	50	132	3388	1118	297	472	0	2303
MOUNTAIN COUNTIES	PLUMAS	60	140	8	460	140	534	59	86	1669
SOUTH COAST / SED	RIVERSIDE	4885	11	792	23736	9476	27	2369	0	6807
SACRAMENTO VALLEY	SACRAMENTO	1382	173	356	9982	2851	632	1210	306	6175
NORTH CENTRAL COAST	SAN BENITO	108		20	773	230	4	65	0	0

COUNTY ACTIVITY INDICATORS

		AIRS Code: nactive Registrations			Active & Inactive Registrations				Rec Marine 1000 Gals burned	
BASIN	COUNTY	ATCs & ATVs	Snowmobiles	All Others	Off-Road Motorcycles	ATCs & ATVs	Snowmobiles	All Others	Diesel	Gasoline
SOUTH COAST / SED	SAN BERNARDINO	7025	64	940	32368	13885	145	2821	0	7110
SAN DIEGO	SAN DIEGO	13260	14	1388	39850	26121	30	4863	784	5842
SAN FRANCISCO	SAN FRANCISCO	133	7	12	1195	203	35	32	41	562
SAN JOAQUIN VALLEY	SAN JOAQUIN	1274	61	240	5042	2611	274	596	408	7130
SOUTH CENTRAL COAST	SAN LUIS OBISPO	807	3	218	3517	1326	15	528	124	1785
SAN FRANCISCO	SAN MATEO	366	24	59	5233	827	146	179	145	2008
SOUTH CENTRAL COAST	SANTA BARBARA	768	5	122	3845	1404	17	302	172	2201
SAN FRANCISCO	SANTA CLARA	1268	75	302	16614	2849	380	992	328	4534
NORTH CENTRAL COAST	SANTA CRUZ	212	11	48	2994	422	43	103	0	58
SACRAMENTO VALLEY	SHASTA	625	113	132	3758	1364	284	542	0	3770
MOUNTAIN COUNTIES	SIERRA	14	22	5	53	24	66	13	0	108
NORTHEAST PLATEAU	SISKIYOU	99	157	31	345	165	445	96	0	316
SACRAMENTO VALLEY / SF	SOLANO	405	28	76	3585	826	131	208	150	2017
NORTH COAST / SF	SONOMA	534	25	147	5371	1014	80	432	17	723
SAN JOAQUIN VALLEY	STANISLAUS	986	75	189	5648	2217	271	572	0	446
SACRAMENTO VALLEY	SUTTER	368	55	63	1028	772	293	179	0	460
SACRAMENTO VALLEY	TEHAMA	238	34	100	871	518	140	367	0	633
NORTH COAST	TRINITY	45	8	8	350	90	33	37	0	1050
SAN JOAQUIN VALLEY	TULARE	2001	60	242	3891	3904	208	523	0	917
MOUNTAIN COUNTIES	TUOLUMNE	80	47	30	774	178	215	153	0	763
SOUTH CENTRAL COAST	VENTURA	2167	9	319	11208	3956	36	846	159	2951
SACRAMENTO VALLEY	YOLO	227	31	67	1301	501	114	292	86	1280
SACRAMENTO VALLEY	YUBA	261	33	41	875	529	101	125	0	460

ALLOCATION OF COUNTY ACTIVITY INDICATORS BY AIR BASIN

	AIRS Code:	002	002	003	004		005	006
		<= 500 HP	> 500 HP		LAWN &	Snow-		LIGHT
BASIN	COUNTY	CONSTRUCTION	CONST.	INDUSTRIAL	GARDEN	blowers	FARM	COMMERCIAL
LAKE TAHOE	EL DORADO	67.80%	32.20%	60.00%	27.53%	28.46%	0.00%	27.52%
MOUNTAIN COUNTIES	EL DORADO	32.20%	67.80%	40.00%	72.47%	71.54%	100.00%	72.48%
SOUTH COAST	LOS ANGELES	98.00%	2.00%	99.12%	98.29%	0.00%	97.99%	98.29%
SOUTH EAST DESERT	LOS ANGELES	2.00%	98.00%	0.88%	1.71%	0.00%	2.01%	1.71%
SOUTHEAST DESERT	KERN	14.00%	86.00%	14.29%	13.72%	11.54%	14.00%	13.69%
SAN JOAQUIN VALLEY	KERN	86.00%	14.00%	85.71%	86.28%	88.46%	86.00%	86.31%
LAKE TAHOE	PLACER	0.77%	49.62%	25.00%	7.15%	7.37%	0.00%	7.17%
MOUNTAIN COUNTIES	PLACER	1.19%	49.40%	0.00%	10.70%	10.53%	12.00%	10.81%
SACRAMENTO VALLEY	PLACER	98.04%	0.98%	75.00%	82.14%	82.11%	88.00%	82.02%
SOUTH COAST	RIVERSIDE	74.00%	26.00%	86.78%	73.20%	0.00%	74.00%	73.21%
SOUTHEAST DESERT	RIVERSIDE	26.00%	74.00%	13.22%	26.80%	0.00%	26.00%	26.79%
SOUTH COAST	SAN BERNARDINO	81.00%	19.00%	94.69%	80.55%	100.00%	81.00%	80.55%
SOUTHEAST DESERT	SAN BERNARDINO	19.00%	81.00%	5.31%	19.45%	0.00%	19.00%	19.45%
SACRAMENTO VALLEY	SOLANO	26.89%	73.11%	11.30%	28.19%	0.00%	100.00%	28.18%
SAN FRANCISCO	SOLANO	73.11%	26.89%	88.70%	71.81%	0.00%	0.00%	71.82%
NORTH COAST	SONOMA	16.00%	84.00%	1.18%	16.19%	0.00%	16.00%	16.16%
SAN FRANCISCO	SONOMA	84.00%	16.00%	98.82%	83.81%	0.00%	84.00%	83.84%

ALLOCATION OF COUNTY ACTIVITY INDICATORS BY AIR BASIN

	AIRS Code:	007	008	009	001010	001020	001020	001030	001040
			AIRCRAFT	TRANSPORT	Off-Road	-- Snowmobiles --			
BASIN	COUNTY	LOGGING	GSE	REFRIG. UNITS	Motorcycles	Diurnal	Exhaust	ATVs	Minibikes
LAKE TAHOE	EL DORADO	79.18%	0.00%	27.59%	30.51%	30.51%	28.46%	30.51%	30.51%
MOUNTAIN COUNTIES	EL DORADO	20.82%	0.00%	72.41%	69.49%	69.49%	71.54%	69.49%	69.49%
SOUTH COAST	LOS ANGELES	0.00%	100.00%	98.30%	98.29%	98.29%	0.00%	98.29%	98.29%
SOUTH EAST DESERT	LOS ANGELES	0.00%	0.00%	1.70%	1.71%	1.71%	0.00%	1.71%	1.71%
SOUTHEAST DESERT	KERN	13.82%	0.00%	13.80%	13.78%	13.78%	11.54%	13.78%	13.78%
SAN JOAQUIN VALLEY	KERN	86.18%	0.00%	86.20%	86.22%	86.22%	88.46%	86.22%	86.22%
LAKE TAHOE	PLACER	7.30%	0.00%	7.29%	7.66%	7.66%	7.37%	7.66%	7.66%
MOUNTAIN COUNTIES	PLACER	10.70%	0.00%	10.69%	10.81%	10.81%	10.53%	10.81%	10.81%
SACRAMENTO VALLEY	PLACER	82.00%	0.00%	82.02%	81.53%	81.53%	82.11%	81.53%	81.53%
SOUTH COAST	RIVERSIDE	73.13%	78.07%	73.30%	73.19%	73.19%	0.00%	73.19%	73.19%
SOUTHEAST DESERT	RIVERSIDE	26.87%	21.93%	26.70%	26.81%	26.81%	0.00%	26.81%	26.81%
SOUTH COAST	SAN BERNARDINO	80.67%	0.00%	80.60%	78.79%	78.79%	100.00%	78.79%	78.79%
SOUTHEAST DESERT	SAN BERNARDINO	19.33%	0.00%	19.40%	21.21%	21.21%	0.00%	21.21%	21.21%
SACRAMENTO VALLEY	SOLANO	0.00%	0.00%	28.46%	33.00%	33.00%	0.00%	33.00%	33.00%
SAN FRANCISCO	SOLANO	0.00%	0.00%	71.54%	67.00%	67.00%	0.00%	67.00%	67.00%
NORTH COAST	SONOMA	16.30%	0.00%	16.28%	44.44%	44.44%	0.00%	44.44%	44.44%
SAN FRANCISCO	SONOMA	83.70%	0.00%	83.72%	55.56%	55.56%	0.00%	55.56%	55.56%

ALLOCATION OF COUNTY ACTIVITY INDICATORS BY AIR BASIN

	AIRS Code:	001050	001060	2282	
			Specialty	Rec Marine	
BASIN	COUNTY	Golf Cars	Vehicles	Diesel	Gasoline
LAKE TAHOE	EL DORADO	27.53%	27.53%	0.00%	27.59%
MOUNTAIN COUNTIES	EL DORADO	72.47%	72.47%	0.00%	72.41%
SOUTH COAST	LOS ANGELES	98.29%	98.29%	100.00%	99.34%
SOUTH EAST DESERT	LOS ANGELES	1.71%	1.71%	0.00%	0.66%
SOUTHEAST DESERT	KERN	13.72%	13.72%	0.00%	0.00%
SAN JOAQUIN VALLEY	KERN	86.28%	86.28%	0.00%	100.00%
LAKE TAHOE	PLACER	7.15%	7.15%	0.00%	7.29%
MOUNTAIN COUNTIES	PLACER	10.70%	10.70%	0.00%	10.68%
SACRAMENTO VALLEY	PLACER	82.14%	82.14%	0.00%	82.02%
SOUTH COAST	RIVERSIDE	73.20%	73.20%	0.00%	56.18%
SOUTHEAST DESERT	RIVERSIDE	26.80%	26.80%	0.00%	43.82%
SOUTH COAST	SAN BERNARDINO	80.55%	80.55%	0.00%	60.35%
SOUTHEAST DESERT	SAN BERNARDINO	19.45%	19.45%	0.00%	39.65%
SACRAMENTO VALLEY	SOLANO	28.19%	28.19%	58.00%	57.06%
SAN FRANCISCO	SOLANO	71.81%	71.81%	42.00%	42.94%
NORTH COAST	SONOMA	16.19%	16.19%	17.17%	49.93%
SAN FRANCISCO	SONOMA	83.81%	83.81%	82.83%	50.07%

APPENDIX D

HOURLY TRAFFIC ACTIVITY, LAX AIRPORT

Hourly Traffic Report (102)

08/28/92 thru 08/29/92

Location	0 / 12	1 / 13	2 / 14	3 / 15	4 / 16	5 / 17	6 / 18	7 / 19	8 / 20	9 / 21	10 / 22	11 / 23
Incoming												
CENTURY												
Lower	250	400	152	75	139	409	582	695	399	1481	2017	1841
	1794	2161	1922	1494	1909	1799	1941	2588	2721	2517	1943	1255
Upper	651	263	60	42	237	1397	3039	2719	2064	2153	2338	2504
	2163	2027	1802	1430	1516	1379	1360	1530	1999	2487	1891	1162
PARK ONE												
Other	24	11	6	7	43	146	157	125	85	180	62	35
	90	87	154	101	92	72	75	65	50	62	72	23
SEPULVEDA NORTHBOUND												
Lower	139	51	21	9	21	103	171	199	207	256	378	406
	367	452	450	375	411	365	394	451	492	347	261	177
Upper	133	39	13	13	54	405	839	860	664	597	769	875
	690	651	665	544	528	455	446	412	421	303	331	189
SEPULVEDA SOUTHBOUND												
Lower	57	34	33	32	42	122	185	127	115	133	300	175
	173	231	203	152	153	117	124	131	167	142	177	92
SKYWAY												
Lower	433	325	91	45	43	189	356	424	575	867	1425	1513
	1300	1476	1554	1395	1309	1651	1297	1643	1731	1475	1024	752
Upper	340	166	49	38	159	599	2174	2176	1609	1592	1852	1876
	1670	1459	1513	1223	1135	1111	948	1007	1201	1232	941	573
Total Incoming												
Lower	1539	822	300	151	246	822	1294	1446	1736	2877	4004	3540
	3634	4320	4052	3407	3732	3772	3756	4919	5111	4579	3405	2276
Upper	1124	468	122	93	450	2701	6042	5755	4337	4353	5095	5256
	4523	4177	3960	3254	3230	2945	2754	2949	3621	4232	3064	1929
Lower and Upper	2663	1290	422	254	696	3523	7336	7201	6133	7230	9012	9155
	8157	8497	8219	6761	7011	6717	6512	7765	8732	8901	6469	4205

[illegible]	0 / 12	1 / 13	2 / 14	3 / 15	4 / 16	5 / 17	6 / 18	7 / 19	8 / 20	9 / 21	10 / 22	11 / 23
Outgoing												
CENTER WAY												
Lower	2997	1855	595	240	154	416	1212	2147	2422	2553	3440	4721
	4670	4095	4781	5101	3139	4115	3690	3801	4633	5748	5134	3941
CENTURY												
Upper	489	252	64	25	134	827	1979	1987	1499	1316	1444	1537
	1431	1294	1307	1037	907	840	685	788	872	1146	1173	746
PARK ONE												
Other	50	11	11	2	6	19	37	40	25	36	32	47
	51	73	74	77	58	62	60	59	58	51	55	71
SEPULVEDA SOUTHBOUND												
Lower	373	239	99	44	27	53	211	308	328	407	562	773
	833	728	1005	1058	668	934	741	706	855	889	729	526
Upper	116	46	14	15	27	224	583	560	422	330	377	452
	414	431	376	489	341	353	287	243	220	297	245	163
SKYWAY												
Lower	370	198	75	48	39	270	901	1064	892	773	963	1224
	1136	1113	1143	1075	971	1064	922	751	847	1005	793	463
Upper	96	55	22	22	62	155	216	233	241	227	219	277
	114	134	270	219	234	114	169	137	159	163	125	93
Total Outgoing												
Lower	3630	2292	769	332	219	739	2324	3519	3642	3733	4973	5718
	6639	5937	6929	7265	4678	6104	5252	5258	6235	7643	6646	4930
Upper	701	357	100	62	233	1220	2778	2780	2162	1873	2043	2266
	3059	1949	1953	1665	1492	1407	1141	1168	1251	1606	1543	954
Lower and Upper	4331	2649	869	394	452	1959	5102	6299	5804	5606	7016	7984
	9698	7886	8882	8930	6150	7511	6394	6426	7586	9249	8189	5884