Development of County- and Airshed-specific Input Data for the NONROAD Model for Clark County, NV

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ABSTRACT

The purpose of the Clark County-Wide Inventory of Non-road Engines Project was to gather county-specific data on emissions from non-road vehicles within the various airsheds/hydrographic areas in Clark County, NV. This project consisted primarily of updating and revising activity and engine population data that relate to the calculation of emissions. Surveys were conducted to gather data regarding the types, numbers, and usage patterns of non-road engines within Clark County.

The sectors surveyed included:

- Construction equipment
- Light industrial and commercial equipment
- Lawn and garden equipment
- Recreational off-road vehicles
- Recreational marine vehicles
- Railroad locomotives

In conjunction with the survey, econometric surrogates and activity level estimates were developed for the various types of equipment. Survey data were examined to determine if there are seasonal variations for the various equipment sectors and data were presented by airshed/hydrographic area to the greatest extent possible.

This study was designed to determine how Clark County's unique features, such as high rate of population growth and construction, desert conditions which result in fewer lawns, and more golf courses present than most counties compared to the default input data used

for the latest version of the United States Environmental Protection Agency (EPA) NONROAD model.

We compared the data collected during the survey phase to the default data found in the NONROAD model. Our findings indicated that:

- Estimates for hours of use per year may be underestimated in the NONROAD model for most of the equipment types surveyed;
- Sector use pattern differences (e.g., us of lawn and garden equipment in construction) can be substantial; and
- Monthly and seasonal allocations are more evenly distributed in Clark County than the default regional averages (due to the temperate meteorological conditions found in the region).

Information developed for this project was integrated into Excel™ spreadsheets and, to the extent possible, into input files suitable for the EPA NONROAD model. Problems and issues associated with incorporating the data into the NONROAD model are also discussed.

INTRODUCTION

The purpose of the Clark County-Wide Inventory of Non-road Engines Project was to gather county-specific data on emissions from non-road vehicles within the various airsheds/hydrographic areas in Clark County. This project consisted primarily of updating and revising activity and engine population data that relate to the calculation of emissions.

The MACTEC Engineering and Consulting team (including E.H. Pechan and Sierra Research) utilized the latest version of the United States Environmental Protection Agency (EPA) NONROAD model as a starting point for the development of the Clark County-specific non-road population and activity data. The NONROAD model is based on a database of emission factors for different engines as characterized by combinations of power rating and fuel type and information on engine populations and activity factors. More specifically, inventory estimates from the NONROAD model are based on estimates of engine populations as a function of a large number of different equipment types, engine types (gasoline versus diesel and two- versus four-stroke), and average horsepower ratings within several defined power ranges (e.g., 0 to 50 horsepower, 50 to 100 horsepower, etc.). Usage rates in hours (including in some cases disaggregation into seasonal or weekend/weekday values), engine lifetimes in hours, and average load ratings for engines during use are also assumed for each equipment type, and engine power rating. These data were used to calculate emissions and to account for the attrition of equipment over time.

Emission factors were reviewed in light of knowledge of Clark County's unique features, such as high rate of population growth and construction, desert conditions which result in fewer lawns, and more golf courses present than most counties. New emission factors

were not created, but EPA standard emission factors were compared with Clark County specific data.

Surveys were conducted to gather data regarding the types, numbers, and usage patterns of non-road engines within Clark County.

The sectors surveyed included:

- Construction equipment
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- Lawn and garden equipment
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- Recreational marine vehicles
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In conjunction with the survey, econometric surrogates and activity level estimates were developed for the various types of equipment. Survey data were examined to determine if there are seasonal variations for the various equipment sectors and data were presented by airshed/hydrographic area to the greatest extent possible.

Information developed for this project was integrated into Excel™ spreadsheets and, to the extent possible, into input files suitable for the EPA NONROAD model. Data were also checked for consistency and quality to the greatest extent possible. It should be noted that some data checking is not possible without actually running the NONROAD model; because this task was excluded from the scope of this project, this QA/QC step was not included.

DEVELOPMENT OF COUNTY SPECIFIC DATA

A major objective of this project was to obtain valid, Clark County-specific estimates of many of the inputs to the NONROAD model, including engine populations (by size and fuel type), activity levels, and load factors; all by airshed. We did this through three types of investigation:

- Mail and telephone surveys of commercial, industrial, institutional and residential users of non-road equipment;
- Analyses of data on railroad operations in Clark County; and
- A review of the results of previous surveys of recreational watercraft use

The sections below discuss the methods used for the surveys and summary results for those surveys. The locomotive emissions analysis and recreational watercraft data are not discussed here but details can be found in the final report prepared for Clark County (MACTEC E&C, 2003).

SURVEY METHODS

Objectives

At the start of the project, we decided that the best way to obtain Clark County-specific information would be to conduct a survey of *users* of non-road equipment. The objectives of the survey were:

- To obtain data on engine populations, power ratings, age, annual hours of operation, temporal distribution of activity, and place of use for the categories of interest; and
- To minimize the width of a 90-percent confidence interval about the survey results.

Selection of Types of Equipment Users to Survey

The non-road equipment of interest is used by a variety of industrial, commercial, institutional and governmental entities, as well as by individuals. In order to maximize project resources, we chose to survey those users who accounted for a significant portion of non-road emissions (as determined from previous runs of the NONROAD model) and who were likely to be able to provide the data we needed. These include the following:

- Construction firms;
- Construction, industrial and commercial equipment rental firms;
- Manufacturing plants;
- Wholesale and retail stores, including grocery stores and department stores;
- Schools;
- Cemeteries;
- County and city agencies;
- Commercial lawn and gardening service providers;
- Golf courses; and
- Households

Sampling Frames and Sample Sizes

A *sampling frame* is the presumed universe of individuals or facilities that use a particular category of non-road equipment. Using information sources to be discussed below, we identified at least one sampling frame for each of the following non-road mobile equipment categories:

- Construction Equipment;
- Small Light Industrial and Commercial Engines; and
- Lawn and Garden Equipment

Table 1 shows the sampling frames for each equipment category, along with their estimated populations. From each sampling frame, we wished to obtain a *sample* of facilities or individuals. In some cases, we wished the sample to be equal to the sampling frame; i.e., we wished to obtain data from every facility or individual. In other cases, we wished to obtain a random sample that was smaller than the total for the sampling frame. The desired size of each sample depended upon several factors, which differed among the sampling frames, and are discussed below. Because response rates for voluntary surveys

are rarely 100 percent, we had in some cases to sample more facilities or individuals than we needed, to improve the chances of obtaining the desired sample size. The attempted sample is called the *potential sample.* Table 1 also shows the potential sample and desired sample for each sampling frame.

Table 1. Sampling Frames and Potential Samples

Category	Sampling Frame	Estimated Population	Sample Type		Sample Sizes			Expected Response %
			100%	Random	Desired Sample	Potential Sample	Potential Sample for Category	
Construction Equipment	Construction Firms-Large	14	♦		14	14	3,244	90 - 100
	Construction Firms-Other	3,773		♦	298	2,980		10
	Equipment Rental Firms	250	♦		250	250		30
Industrial/Commercial Equipment	SIC 20 - 89 (£ 100 per SIC)	771	♦		771	771	2,008	20
	SIC 20 - 89 (> 100 per SIC)	16,376		♦	243	1,215		20
	Department Store Chains	17	♦		17	17		80 - 100
	Grocery Store Chains	5	♦		5	5		80 - 100
Lawn & Garden Equipment	Golf Courses	59	♦		59	59	2,107	80
	Cemeteries	8	♦		8	8		80
	Public School Regional Districts	5	♦		5	5		100
	Private Schools	16	♦		16	16		80
	Colleges	7	♦		7	7		100
	City/County Recreation Departments	5	♦		5	5		100
	Single-Family Households	294,822		♦	384	1,536		25
	Landscaping and Gardening Firms	471	♦		471	471		15

Survey Instruments and Data Management

Survey Instruments

For the surveys, we developed six mail survey "packages" and one telephone script. Table 2 shows which forms were used for which sampling frame(s).

Although the content of the questionnaires varied with the intended respondents, all survey packages had the following:

- An introductory letter from the Clark County Board of Supervisors, explaining the purpose of the survey, highlighting its importance, and requesting a response;
- A questionnaire; and
- An addressed, stamped return envelope

Table 2. Assignment of Survey Instruments

Survey Package	Major Equipment Categories	Sampling Frame(s)	Survey Name	Mode
C	Construction	Construction Firms - Large	CL	M

		Construction Firms - Other	CO	
IC	Industrial/Commercial	SIC 20 - 89 (£ 100 per SIC)	IC	M
		SIC 20 - 89 (^{3} 100 per SIC)		
		Department Store Chains	DSC	
		Grocery Store Chains	GSC	
ER	All	Equipment Rental	ER	M
LGC	Lawn and Garden	Landscaping and Gardening Firms	LGC	M
LGI	Lawn and Garden	Cemeteries	LGI	M
		Clark County School District		
		Private Schools		
		Colleges		
		City/County Recreation Departments		
GC	Lawn and Garden	Golf Courses	GC	M
N/A	Lawn and Garden	Residences	HH	T

Form 1 of each survey requested facility information, including the number of employees. For some of the surveys, it also asked for other econometric surrogate values, such as the number of holes at golf courses. Form 1 gave the respondent the opportunity to opt out of the survey for specific reasons, such as that it did not use any of the equipment types of interest. The respondent could mail or fax back just form 1 if it wished to declare itself ineligible.

Form 2 of all the questionnaires requested equipment-specific information. Part "A" of each Form 2 listed the equipment categories of interest, and asked the respondent to state, for each category, the number of pieces of its equipment for each of five engine types.[1] Part "A" also asked, for each equipment category, how many hours per day, days per week and weeks per year the equipment was used. This information was used to calculate operating hours per year. Part "B" of each Form 2 asked for temporal pattern information, such as the percentage of annual use that occurred in each month.

For industrial, commercial and institutional entities, Form 3 asked about certain characteristics of the equipment identified in Form 2, including horsepower and age. For construction firms and commercial landscaping firms, Form 3 asked for the percentage of their activity that occurred in each of 21 specific Clark County communities, in unspecified Clark County communities, and in areas outside Clark County. For those survey groups, the questionnaire included a Form 4 to request equipment characteristics data.

For the household survey, we used a formal printed telephone script. Each question or statement in the script was numbered. At each point where more than one response was possible, the script directed the caller to the appropriate next line number. As will be

[1] 2- and 4-stroke gasoline, diesel, LPG and CNG.

discussed in the next section, the numbering was coordinated with the data entry forms on the computer, so that the caller could enter results while still conversing with the surveyed household.

The script had an introduction explaining the purpose of the survey and making it very clear that we were not selling anything or asking for personal data. It then asked various questions to determine whether the household qualified for the survey. The remainder of the script was devoted to data gathering.

Data Management

To manage the survey activities, store responses and perform some calculations, MACTEC designed two survey databases in Microsoft Access™. One was for the household survey and the other was for all the remaining surveys. The databases had two main functions: survey tracking and storage of response data. In addition, each database had "queries" for extracting information for export to Microsoft Excel™ for analysis.

Survey Tracking

The main tables for tracking survey responses were called "Facilities" and "Status." The Facilities Table included identifying information on each facility and household to be surveyed, including name, address, contact (where known), and telephone number. It also included one or more fields corresponding to information obtained by the surveys, such as number of employees. Each facility and household was assigned a unique identification (ID) number. The Facilities Table included a field that indicated the sampling frame to which each facility belonged.

The Status Table contained one row for each facility and household surveyed and was linked to the Facilities Table through the facility's or household's ID number. Its fields tracked the following events:

- Initial sending mode (letter, phone call, etc.) and date
- Need for re-sending and mode
- Re-sending mode and data
- Date and reason for eliminating from survey
- Date and mode of response
- Check for completeness and date
- Flag for follow-up needed
- Follow-up attempt number and date
- Flag and date for response entered into results tables
- Comments
- Date record last updated
- Initials of person who last updated the record

One of the most important fields was that for comments. Because more than one person used the database, it was important that everyone know certain things, especially about contacting facilities. For example, it was noted in some cases that the contact person was available only at certain specific times of day.

We designed on-screen forms for transferring raw data from survey forms to the database. The on-screen forms resembled the physical questionnaires, for ease in data entry. For the telephone surveys, where there were no intermediate paper forms, the on-screen forms followed the telephone script; callers entered the information into the computer as they conducted their interviews.

The survey tracking portion of the database also had many regularly used and *ad hoc* "queries" to search for information and perform simple statistical operations. For example, one query was used every few days to generate a list of names and telephone numbers of facilities that had not yet responded.

Survey Execution

The first several weeks of the survey were devoted to sending out questionnaires and trying to obtain responses from non-responding firms. Questionnaire packages were photocopied and mailed in batches between November 2002 and February 2003. Many mailings were returned by the U.S. Postal Service as having incorrect addresses. In each such case, MACTEC tried at least once to obtain the correct address and re-mail or fax the survey. As discussed above, we queried the survey database every few days to identify non-responding firms or institutions and printed out a calling list with organization and contact names and telephone numbers. For most of the survey, the names of places to call were selected randomly. Later, when it appeared that the response was too light in one area or another, we selected particular firms or organizations to call. On the follow-up calls, we asked if the survey forms had been received. If they had not been, then we offered to mail or fax another copy.

In addition to the bulk mailings and follow-up calls, we identified certain organizations that could provide responses for a large number of individual facilities. These included, for example, the Clark County School District and the regional offices of grocery store chains. We contacted these organizations individually and asked them to respond for multiple facilities.

As responses arrived, they were logged in with the survey tracking portion of the database. As time permitted, we called back respondents who had left important items blank or whose responses were indecipherable or otherwise deficient. Note that as long as any question on any portion of the questionnaire that was relevant to the emission inventory had been filled out, the response was included in the results portion of the database.

Data Analysis Methods

The purpose of the survey data analyses was to extract and prepare information for use in other parts of the project. The same procedures were used for all the survey groups. First, we used queries in Access to extract equipment counts, engine characteristics and

temporal data and export them to Microsoft Excel™ workbooks. For a given survey, the following workbooks were set up:

- Pieces
- Horsepower and Age
- Hours per Year
- Month and Season
- Place of Use (if applicable)
- Results Summary

One worksheet ("RawData") in each workbook (except the Results Summary) contained all the records for all EQUIPID numbers in the survey. Within the workbook, we then set up one worksheet for each equipment category and performed all the analyses in that worksheet. The Results Summary workbook contained one worksheet for each of the five workbooks listed above. The rows of each worksheet in the Results Summary workbook corresponded to equipment categories.

Equipment Pieces and Equipment Factors

For each survey group and each equipment category, the reported pieces of equipment were summed. To calculate the equipment factor, we then divided the reported population by the appropriate base (number of employees, number of firms, number of golf course holes, etc.). The bases were calculated as follows.

Let n_r be the number of facilities that reported their employment and E_r be the reported employment. Finally let n_t be the total number of facilities in the sample. (Since not all facilities reported their employment, usually $n_r < n_t$). Then the projected total employment base for the sample was calculated as:

$$E_t = (n_t/n_r)\, E_r$$

Horsepower and Age Data

For a given combination of survey group and equipment type, let n_i be the number of pieces of equipment in the ith horsepower range. The fraction represented by that horsepower range is:

$$f_i = n_i/\Sigma n_i$$

Let H_j be the horsepower rating for a given EQUIPID number, and let n_j be the number of pieces of that type of equipment reported. The average horsepower within the range was calculated as:

$$H = (\Sigma n_j H_j)/\Sigma n_j$$

A similar method was used to calculate the mean age within each horsepower category.

Hours per Year

The values for hours per year per equipment category were calculated in two steps. First, if the reported values for hours per day, days per week and weeks per year were all greater than zero, we calculated hours per year as the product of the three values. If one or more was zero, then we used the facility's reported value for hours per year. The next step was to calculate the weighted average hours per year for the equipment category, the weights being the number of pieces of equipment for each EQUIPID number.

Month and Season

Let n_j be the number of pieces of equipment for the jth reported EQUIPID number. Let P_{ij} be the percentage of annual activity for that equipment in the ith month. Then the weighted average monthly activity fraction is calculated as follows:

$$F_i = [\sum_j n_j P_{ij}] / \sum_i (\sum_j n_j P_{ij})$$

Seasonal fractions were calculated by adding monthly fractions for the three months corresponding to each season.

Place of Use

A major objective of the survey was to allocate equipment use by airshed, within Clark County. For the surveys of facilities with fixed locations (golf courses, schools, manufacturers, department stores, etc.) and residences, all equipment use was assumed to occur at the respondents' physical addresses. For construction firms and commercial lawn and garden services, whose equipment may be used in many locations, respondents were asked to report the percentages of their activity in different communities in Clark County, and/or in areas outside the county. We did this through the following steps:

1. For each survey group (e.g. commercial lawn and garden firms), determine the airshed code for each respondent's home office.
2. Group respondents by the airshed of their home office.
3. For each home office airshed group, calculate the average fraction use in each place-of-use airshed.
4. Determine the distribution of airshed codes for likely existing[2] home offices.
5. Multiply the each airshed code's fraction of the total sampling frame by the total no. pieces of equipment projected from the survey data; that gives pieces per home office airshed.
6. Allocate each home office airshed's pieces to each place-of-use basin.
7. Add the totals per place-of-use basin.

[2] This distribution was calculated from the potential sample after eliminating firms that were determined to be out of business, in the wrong SIC code, etc.

Quality Assurance

Quality control (QC) measures were an integral part of survey design and implementation. The following QC considerations guided our design of questionnaires and telephone scripts:

- The forms and scripts minimized open-ended questions;
- Measurement units were shown unambiguously;
- Questions were worded in terms that the survey respondents immediately understood;
- The on-screen forms for data entry had the same layout as the paper questionnaire and the telephone script

The data entry software had several "error traps" built in. For example, it was not possible to enter a fuel code for a piece of equipment other than one of the four that were subject of the inventory. Similarly, the days per week of operation had to be between 1 and 7 (or blank if the data were not reported).

During the survey follow-up period, the Survey Manager reviewed the two main survey databases at least three times per week (often daily) and used various *ad hoc* queries to search for errors and discrepancies. For example, respondents were sometimes coded as having responded but not as having been received. In other cases, a respondent was given the elimination code for "other," while the comment field contained information supporting another elimination code, or even inclusion in the survey. Another QC measure was to check the horsepower rating of each piece of equipment against the horsepower rating (if applicable) in its equipment type description. For example, the item may have been coded as a 2-stroke chainsaw with less than 6 HP, while the horsepower entry was 10 HP.

Every results calculation was double checked by the Survey Manager or project staff under his direction. Among the tests given the results were the following:

- Average horsepower values had to be with the range of each horsepower class
- Horsepower range fractions had to sum to 1 for each equipment code;
- Monthly and seasonal activity fractions each had to sum to 1 for each equipment code

SURVEY RESULTS

Response Rates

Table 3 summarizes the responses to all the surveys except those of the households. For all these surveys, the potential sample was adjusted by subtracting firms that were out of business, improperly ascribed to the sampling frame of interest, or otherwise ineligible. A "useful response" was defined as a response that included detailed data on equipment and/or activity levels, or that confirmed that no equipment of interest was used. The

useful response rate, based on the adjusted potential sample, ranged from 20 percent for the institutional lawn and garden equipment users to 51 percent for the equipment rental firms.

Table 4 details the results of the household survey. We attempted to call 441 households with a working telephone number. After three tries without a response, we eliminated a household from the survey. As a result, we had 339 telephone interviews. Of these, 220 (65 percent) yielded information that was useful to the survey. At least some equipment data were obtained from 69 households.

Table 3. Survey Response Characteristics

	Survey Group											
	CL & CO		IC & DSC & GSC		ER		LGC		LGI		GC	
TOTAL SURVEY PACKAGES MAILED		3,019		1,585		121		478		159		59
Presumed Out of Business		399		199		23		55		9		3
Returned by US Postal Service	354		193		20		53		9		3	
Telephone Disconnected	45		6		3		2					
AVAILABLE FOR SURVEY		2,620		1,386		98		423		150		56
Ineligible for the Survey		345		169		23		63		2		2
Claimed to be Out of Business	130		37		12		50				1	
Administrative/Sales Office Only[a]	184		101		2						1	
Duplicate of Other Facility							5					
Not in Presumed Sampling Frame	31		31		9		8		2			
ADJUSTED POTENTIAL SAMPLE		2,275		1,217		75		360		148		54
Eligible But Did Not Provide Data		1,525		906		37		228		119		38
Explicitly Refused to Respond	56		13		10		3				2	
Did Not Respond	1,469		893		27		225		119		36	
Useful Responses		750		311		38		132		29		16
Provided Detailed Information	172		71		15		110		13		16	
No Mobile Equipment	215		35		19		4		12		0	
No Fossil Fuel Equipment	363		205		4		18		4		0	
Percent Useful Responses[b]	33.0		25.6		50.7		36.7		19.6		29.6	

[a]Includes construction firms that subcontract out all their work.

[b]Useful responses as a percentage of the adjusted potential sample.

Summary Tables

For each survey group, the following types of information were tabulated and/or calculated for each equipment type:

- Pieces of equipment per some economic surrogate variable (e.g. per employee);
- Fraction of equipment population in each of 14 horsepower (HP) ranges;

- Mean HP rating in each HP range; and
- Mean equipment age (in years) in each HP range

These results are reported in the following sections. In addition, we calculated, for each survey group and equipment type:

- Operating hours per year;
- Fraction of operating hours occurring in each month and season; and
- Distribution of reported equipment by airshed

This information was provided to Sierra Research and to E.H. Pechan and Associates, and was provided to Clark County DAQM in Excel files.

Table 4. Summary of Responses to Household Survey

Total in Sampling Frame			1,600
Telephone Disconnected or Fax/Modem		57	
Adjusted Sampling Frame			1,543
Total Attempts to Call			441
Unsuccessful After 3 Tries			102
Successful Contacts			339
Ineligible for the Survey			70
	Not a Residence	14	
	No Vegetation	56	
Eligible for the Survey			269
	Have Gardener	81	
	Refused	93	
	Other Non-Responses	26	
	Provided Detailed Information	69	

Development of Economic Surrogates

Because it is not possible to conduct a comprehensive survey of every user of each type of nonroad equipment in Clark County, it was necessary to estimate these populations from sample data obtained from the nonroad surveys. The objectives for this portion of the project were:

(1) Identify econometric surrogate indicators for the equipment populations for each equipment category;
(2) Compile Clark County base year (2001) data for each econometric surrogate indicator identified from (1);

(3) Calculate year 2001 equipment populations by multiplying the Clark County econometric surrogate data by the equipment population factors described in Section 3;
(4) Compile county airshed proportions from econometric surrogate indicator data for each equipment category;
(5) Calculate airshed-level 2001 equipment populations by multiplying the county estimates from (3) by the appropriate proportions from (4);
(6) Compile growth factors from econometric surrogate indicator forecast data from the University of Nevada, Las Vegas (UNLV)'s Center for Business and Economics Research; and
(7) Calculate horizon year (2002, 2005, 2010, 2015, and 2025) equipment population estimates by multiplying the growth factors from (6) by the year 2001 equipment populations from (5).

Sector Specific Surrogate Selection

Nonroad equipment populations were estimated from factors relating equipment counts to econometric surrogate indicators of equipment use. Total Clark County nonroad equipment populations were estimated by multiplying the equipment population factors by Clark County values for the applicable surrogate indicators. An example equipment population factor is 5 forklifts per 1,000 industrial sector employees. In this case, industrial sector employment is the econometric surrogate indicator used with the equipment population factor derived from the industrial equipment survey responses.

The key to the equipment population factor approach is the identification of the econometric surrogate for the population of each equipment type. To assist in this step, MACTEC reviewed a number of reports that address this issue. These reports included:

- "Methodology to Estimate Nonroad Equipment Populations by Nonattainment Areas, Final Report," (EEA, 1991).
- "Methodology to Calculate Nonroad Emission Inventories at the County and Sub-County Level, Final Report," (EEA, 1992).
- "A Study to Develop Projected Activity for Non-Road Mobile Categories in California, 1970-2020," (Puri and Kleinhenz, 1994).
- "Literature Review and Brief Description of Proposed Methodology for Estimating Locality-Specific Lawn and Garden Activity," (Heiken and Pollack, 1996).
- "Documentation of Input Factors for the New Off-Road Mobile Source Emissions Inventory Model," (EEA, 1997a).
- "Methodologies for Estimating the Population of Nonroad Engines, Task 1B Report," (EEA, 1997b).
- "Evaluation of Power Systems Research (PSR) Nonroad Population Data Base," (Pechan, 1997).
- "Geographic Allocation of State-Level Nonroad Engine Population Data to the County Level," (EPA, 1998a).
- "Geographic Allocation of State-Level Nonroad Engine Population Data to the County Level," (EPA, 2000).

In selecting an appropriate surrogate from those identified in the above studies, MACTEC considered the following:

1. the surrogate must represent information that survey respondents would be willing to provide (i.e., reject surrogates with confidentiality concerns);
2. the surrogate must be an indicator whose value would be known by, or readily available to, survey respondents; and
3. Clark County data must be available for the surrogate.

Table 5 presents a summary of potential nonroad sector econometric surrogates based on a review of the above documents. The first column in the table displays the surrogate that EPA plans to use in its final NONROAD model (EPA, 2000). The second column describes alternative surrogates identified from the literature review. The final column identifies the econometric surrogates used in this study. The following sections provide a discussion of why each surrogate was used in this study.

Table 5. Summary of Nonroad Source Category Econometric Surrogates

Source Category	Proposed Final NONROAD Model	Literature Review Alternatives	Used in This Study
Construction	Value of Housing Construction, value of Commercial Construction, and value of Public Works Construction	Number of Construction employees	Equipment owner-users – Number of Construction sector (SIC codes 15-17) employees[1] Equipment rental firms – Number of construction equipment rental firms[1]
Lawn and Garden – Commercial	Number of Landscape and Horticultural Services sector employees (note that Institutional and Golf course equipment use is included within this category)	License records for landscaping businesses	Commercial landscaping firms - Number of Landscape and Horticultural Services sector (SIC codes 0782 and 0783) employees[1] Institutions – Number of institutions Golf courses – Number of golf course holes
Lawn and Garden – Residential	Number of single and double-family housing units adjusted by 1997 human population estimates	Number of single family homes and number of households	Number of occupied single family housing units
Commercial	Number of Wholesale establishments	Number of Wholesale and Retail establishments	Number of Commercial sector establishments (see Table 4-2 for list of SIC codes)
Industrial – All except AC/Refrigeration	Number of Industrial employees		Number of Industrial sector (SIC codes 20-39) employees
Recreational Marine	Water surface area with different operating limits from shore for personal watercraft, outboards, and inboards (State allocation uses fuel consumption estimates)	Registration data, marina and boat ramp use, and boating accidents/violations	Lake Mead National Recreation Area Recreational Use study percentages representing proportion of boats by boat type and lake management zone (also assumptions about proportion of use in Nevada versus Arizona waters by lake management zone)
Recreational Vehicles – Golf Carts	Number of public golf courses	Number of public golf course employees	Total number of golf course holes

[1] Identified surrogate was only used to estimate the total county equipment population, airshed-level equipment population was calculated using proportional use of equipment in each airshed as computed from surveys.

Horizon Year

To estimate horizon year equipment populations, MACTEC compiled year 2001, 2002, 2005, 2010, 2015, and 2025 surrogate indicator data from UNLV's Center for Business and Economic Research (UNLV, 2003). Table 6 identifies the forecast year econometric surrogate data compiled in this study.

Table 6. Forecast Year Econometric Surrogate Data Sources

Equipment Category	Forecast Year Surrogate	Forecast Data Source(s)	Comment
Construction	Construction sector	Employment in SIC codes 15-17	

Equipment Category	Forecast Year Surrogate	Forecast Data Source(s)	Comment
	employment	(UNLV, 2003)	
Lawn and Garden – Commercial Landscaping Firms	Landscape and Horticultural Services sector employment	Employment in SIC codes 07-09 (UNLV, 2003)	
Lawn and Garden – Institutions	Population	UNLV, 2003	
Lawn and Garden – Residential	Population	UNLV, 2003	
Lawn and Garden – Golf Courses	Population	UNLV, 2003	
Commercial	Commercial sector employment	Employment in SIC codes 50-89 (UNLV, 2003)	
Industrial	Industrial sector employment	Employment in SIC codes 20-39 (UNLV, 2003)	
Recreational Marine	Population	UNLV, 2003	
Recreational Vehicles-Golf Carts	Population	UNLV, 2003	
Locomotives	Transportation expenditures adjusted for forecasted change in railroad energy intensity	Transportation expenditures (UNLV, 2003); Rail energy intensity forecast (DOE, 2003)	Federal locomotive standards modeled from information in EPA, 1998b.

Because forecast data were not available for the change in railroad locomotive fuel consumption in Clark County, MACTEC developed estimates from a combination of Clark County transportation expenditures data and national data representing the change in railroad energy intensity (i.e., fuel consumption per ton-mile) (UNLV, 2003; DOE, 2003).

RESULTS
Activity Data

Limitations of NONROAD Model Activity Estimates

The first concern is related to the NONROAD model's application of national average equipment usage rates to all areas of the country. National average activity rates are typically poor predictors of regional activity levels and even worse predictors of community-specific activity levels. For example, in a city like Las Vegas, where more than 30 percent of the total Clark County population resides, construction companies may operate their equipment more than the national average due to the rapid growth in the area and the milder weather. Because Nevada is defined as a Central Western state within the model and no distinctions are made for the different counties within the state, Clark County may be modeled in NONROAD to have more severe monthly and seasonal variations in activity than actually occur. A survey of equipment use in Clark County provides the opportunity to identify inconsistencies between default national average values and local activity rates.

A second limitation with the NONROAD model involves the way equipment and equipment use are grouped and classified. The U.S. EPA has attempted to account for the variation in end-user equipment operation in the NONROAD model by defining separate

equipment categories. For example, separate SCC codes and activity estimates are used in the model for residential vs. commercial lawn and garden equipment. In addition, equipment types are defined as part of general use categories that include the following:

- Commercial Equipment,
- Construction and Mining Equipment,
- Industrial Equipment,
- Lawn and Garden Equipment (with Distinction Between Residential and Commercial),
- Logging Equipment, and
- Pleasure Craft.

Usage estimates are available only for the equipment types specified in the NONROAD model within the use categories given. This approach works well when the specified nonroad equipment is truly used only in the category to which it is assigned within the model. Unfortunately, this is not always the case. For example, commercial lawn and garden tractors, which are classified as lawn and garden equipment, are used by construction companies as well as landscaping companies and golf courses. Likewise, high-powered chain saws classified as logging equipment are used in commercial lawn and garden applications as well as at logging sites. Consequently, patterns of use may differ depending on the industry sector involved, and, unfortunately, the means to distinguish between sectors (e.g., sector-specific SCC codes) is currently outside of the NONROAD model's capabilities. In order to look at the extent to which use of the same equipment can vary, this study involved surveying separate residential and industrial sectors.

Sector-Specific Survey Results

Average annual use rates, defined as hours of operation per year, were estimated for each equipment type from the survey responses. Due to the volume of incomplete responses, usage or activity estimates are not available for some equipment types for which population estimates may be available. Quality assurance checks were performed to ensure that annual hours of operation reported fall within weekly and monthly use parameters. In addition to the average annual use, some data for estimating monthly and seasonal use allocations were received for a subset of the equipment. Weekend and weekday usage data were obtained only for residential lawn and garden equipment. Details of all the use estimates and quality assurance checks by SCC code are included in Appendix A.

Estimates for nonroad equipment patterns of use were developed for each equipment type and for each sector by averaging available responses. For some equipment types, representation in the responses was limited (fewer than 10 pieces surveyed). Of the 126 types of equipment surveyed, 53 (or 42 percent) had 10 or fewer responses. Many of those responses only provided estimates of annual activity use rates (i.e., no insight into seasonal activity was provided). The resulting Clark County equipment activity estimates are summarized and discussed in the following sections.

Nonroad Equipment Annual Activity

A summary of the hours of use per year estimated for each equipment type and sector is presented in Table 5-3 in the following pages, along with the number of pieces of equipment represented in each estimate. In addition to the survey results, the default annual usage data from the NONROAD model are included in the table for comparison. Because the equipment population fractions in the different use sectors are unknown, an average was computed for each equipment type over all the surveyed sectors.

As shown in Table 5-3, estimates developed using the Clark County survey data resulted, on the most part, in greater annual equipment usage than the national defaults available in the NONROAD model. Some differences are remarkable, but can be explained by the very small sample sizes available from the survey results. However, there are noteworthy discrepancies that cannot be explained as easily. Table 5-4 shows instances where the survey results are markedly different than the NONROAD (NR) model estimates (ratio of NR/survey is less than 0.5 or greater than 1.5), but for which more than 100 pieces of equipment were surveyed.

Use patterns of the different sectors can also differ substantially depending on the equipment type. For instance, 4-stroke commercial lawn mowers, which were well represented (more than 20 pieces surveyed) for institutional lawn and garden, golf course, and commercial lawn and garden sectors, varied in use from 95 to 328 to 1,185 hours per year for each sector, respectively. For some of the other equipment types, however, the small sample sizes within the separate sectors may account for the large discrepancies.

Monthly and Seasonal Equipment Use Allocations

The monthly activity allocation estimates obtained from the survey responses are summarized by sector in Table 5-5. Also included in Table 5-5 are the NONROAD model default monthly allocations for the corresponding equipment categories. Note that no monthly allocation data were obtained from the residential lawn and garden sector. Because the default allocations in the NONROAD model separate chain saws from the rest of the lawn and garden equipment, estimates for commercial and institutional lawn and garden were prepared similarly for the survey data. The monthly and seasonal equipment use allocations by equipment type are detailed in Appendix A.

A comparison between the NONROAD and survey results shows more variation in the former. The seasonal variation can be more clearly seen in Table 5-6 where the months were grouped into the four seasons using the definitions in Table 5-2. In addition, use data from residential lawn and garden equipment were obtained for the four seasons. Results of the Clark County survey data suggest that nonroad equipment use in the County may be more evenly distributed throughout the year than the NONROAD model default. This finding is hardly surprising when the temperature conditions of the region are contrasted with more severe seasonal fluctuations in activity that occur in other areas of the country (and make up the default national average values employed in the NONROAD model).

Table 7 summarizes the weekday and weekend allocation estimates for residential lawn and garden equipment for the equipment types represented in the survey data. The default weekday and weekend allocations in the NONROAD model are given for each equipment category, and all equipment types within a category share the same allocation. Results of the survey effort for residential lawn and garden were expressed in percentages of use in weekdays, weekends, and in both. In order to compare the survey results with the NONROAD defaults, use under the "both" category was evenly distributed between weekdays and weekends.

Table 7. Residential Lawn and Garden Weekly Activity Allocations

SCC	Description	Survey Estimates		NONROAD Default	
		Weekday	Weekend	Weekday	Weekend
2265004010	4-Stroke Lawn Mowers Residential)	0.40	0.60	0.56	0.44
2265004040	4-Stroke Rear Engine Riding Mower (Res.)	0.50	0.50	0.56	0.44
2260004030	2-Stroke Leafblowers/Vacuums (Residential)	0.40	0.60	0.56	0.44
2260004025	2-Stroke Trimmers/Edgers/Brush Cutters	0.50	0.50	0.56	0.44
2265004055	2-Stroke Lawn & Garden Tractors (Residential)	0.50	0.50	0.56	0.44

The weekday and weekend allocation estimates from the surveys and the NONROAD model are similar, but the surveys indicate heavier use in the weekends. Because of the low sampling volumes, however, additional surveys are needed for more definitive findings (only the 4-stroke lawn mowers were represented with more than 15 pieces of equipment, 62 in all).

Issues Associated with Preparation of NONROAD Model Input Files

Since we wanted to develop estimates at the airshed level, MACTEC worked to develop NONROAD data files using the "subcounty" level capability of the model. This created a number of issues that were discovered when MACTEC initiated the model using the developed input files. Although the contract between MACTEC and Clark County DAQM was not set up for MACTEC to perform model runs, MACTEC used the model to QA the input files by running the model with the "subcounty" input files.

The first issue encountered was that the "subcounty" option cannot be run from the Windows interface. Subcounty runs must be performed using the command line method.

The second issue encountered was limits on the number of data values that could be entered for several parameters. For example we prepared growth factors using the actual engine populations forecast for each year by SCC. Since we ended up with 128 SCCs that we had forecasts for from the survey data and we had six projection years we ended up with several thousand growth records in the growth file (because the horsepower range must be specified for each SCC/growth record). However the NONROAD model has an upper limit of 2000 allocation cross references. Similar input limit issues were found for allocation indicators, allocation codes, and population records. These limits were not documented anywhere in the NONROAD model user's manual. We contacted U.S. EPA and found out about these limits. Craig Harvey of OTAQ was instrumental in resolving these issues, going so far as to compile a specific version of the draft NONROAD model that lifted these limits.

Once we resolved all of the input limitations, we discovered that several SCCs did not have matching spillage data for a particular horsepower level that we found in the survey data. MACTEC modified the existing spillage data to incorporate the upper horsepower limitations.

At this point Clark County is currently evaluating how best to use the revised data on populations, seasonal information and growth factors with the NONROAD model.

CONCLUSIONS

The results of the survey indicate that default NONROAD activity estimates poorly represent activity levels in Clark County. Results of this study indicate that:

- Estimates for hours of use per year may be underestimated in the NONROAD model for most of the equipment types;
- Sector use pattern differences (e.g., use of lawn and garden equipment in construction) can be substantial; and
- Monthly and seasonal allocations are more evenly distributed in Clark County than the default regional averages.

The total hours of use for the majority of equipment types surveyed is estimated to be higher than the default national NONROAD model estimate. To a certain degree, this can be explained by the high sector activity levels in Clark County (high development and growth rates) and the fact that the County has a temperate meteorology that enables year-round activity. Clearly, however, a large number of equipment types did not obtain enough survey responses to result in a statistically significant estimate of their use. The next step in the process would be to conduct a statistical analysis of the survey responses in order to identify the relevant activity levels that can be used in place of the NONROAD defaults to better estimate actual equipment use in Clark County.

In order to estimate the actual average use for equipment in an area, the differences in sector use need to be considered. Some sectors may share use patterns and others may vary wildly. A statistically valid sample of equipment activity from each sector can be used to determine if significant variations exist. When significant differences exist, a weighted average equipment activity level can be developed using the equipment population fraction within each sector.

It is not surprising that monthly and seasonal allocations are observed to be more evenly distributed in Clark County as compared to the national average allocations. As mentioned earlier, Clark County has a temperate meteorology and year-round outdoor activity is possible. Although the state of Nevada as a whole falls within the EPA's definition for a Medium/Central climate and in the Central Western region as described in the NONROAD model files, Clark County in particular does not. The warmer climate in Clark County and its location (latitude) can be better described as Warm/Southern, and the County may be better modeled as Southwestern when using NONROAD.

Significant undocumented limits on input file variables hampered attempts to verify the input files in test model runs. In addition, the current version of the NONROAD model is difficult to use when selecting the "subcounty" option. U.S. EPA was instrumental in helping to correct these deficiencies by recompiling a special version of the NONROAD draft model code.

REFERENCES

MACTEC E&C, 2003, "Draft Final Report for Inventory of Clark County-wide Non-road Engines," Oct., 2003.