Appendix J:
Recreational Watercraft
Emissions Inventory Methodology

November 2014

California Air Resources Board
Air Quality Planning and Science Division
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EXECUTIVE SUMMARY

Recreational watercraft (RW) is a broad category of marine vessels that includes gasoline-powered spark-ignition marine watercraft (SIMW) and diesel-powered marine watercraft. The focus of this report is to support the emissions inventory developed for the California Air Resources Board’s (ARB) proposed regulation to control evaporative emissions from SIMW. The regulation is needed in order to meet the 2007 State Implementation Plan (SIP) commitment to reduce reactive organic gas (ROG) emissions from SIMW.

To support the regulatory proposal, staff developed a revised emissions inventory model (PC2014) to estimate evaporative ROG emissions generated by SIMW in each region of the State. This emissions inventory revision focuses on evaporative emissions and builds on the previous ARB off-road model, OFFROAD2007. PC2014 contains updated inputs for population, hours of use (activity), growth rates, emissions factors, and the technology change from carbureted (CB) to fuel injected engines (FI), and changes in the population split between 2-stroke (G2) and 4-stroke (G4) gasoline engines. The updated inputs for emission factors, population, and activity are based upon in-house testing conducted at ARB, updated population and activity estimates from the California Department of Motor Vehicles (DMV), and a survey conducted by the California State University, Sacramento (CSUS). The inventory revision also accounts for the economic recession that began in December 2007.

The long useful life of RW coupled with the recent downturn in new boat sales due to the recession has led to an older average fleet age. As a result, it will take longer to realize the evaporative emissions benefits from the proposed regulation as the existing SIMW population operating in California is replaced by new compliant marine watercraft.

The table below summarizes the statewide summer RW ROG inventory for three critical air quality attainment deadlines in California: 2020, 2023, and 2035. There are no exhaust emissions benefits as the proposed regulation focuses solely on the control of evaporative emissions. By 2020, 2023, and 2035, the evaporative emissions benefits of the proposed regulation are estimated to be 0.15 tons per day (TPD), 0.34 TPD, and 1.06 TPD, respectively. Emissions reductions in 2020 and 2023 are presented for SIP comparison purposes. Emissions reductions in 2037 are presented based on the 20-year lifetime of a SIMW.

<table>
<thead>
<tr>
<th>Statewide Summer ROG Emissions and Post Regulation Benefits (tons/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>Baseline</td>
</tr>
<tr>
<td>Proposed Regulation</td>
</tr>
<tr>
<td>Benefits</td>
</tr>
</tbody>
</table>
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I. BACKGROUND

Evaporative emissions from SIMW are a significant source of ROG, which are an important precursor to the formation of ground level ozone. Reductions in ROG are necessary for the California to comply with ambient air quality standards for ozone.

The previous ARB off-road emissions inventory model (OFFROAD2007) was used to estimate emissions from off-road sources such as RW, lawn and garden equipment, construction equipment, and other types of off-road equipment. As part of the SIMW rulemaking, OFFROAD2007 was replaced with an updated stand-alone Microsoft Access-based model (PC2014) that was used to estimate RW exhaust and evaporative emissions. Because less than five percent of RW is diesel-powered, the majority of the evaporative emissions contribution from RW is SIMW. PC2014 has grouped RW into the six types listed in Table I-1.

Table I-1: Types of RW

<table>
<thead>
<tr>
<th>Boat Type</th>
<th>Gasoline</th>
<th>Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outboard</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Inboard</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sterndrive</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Personal Watercraft</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Jet Boat</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Auxiliary Sailboat</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

A. DATA, METHODOLOGIES, AND ASSUMPTIONS

This document describes the data, methodologies, and assumptions applied in PC2014. It also describes the steps taken to estimate the emissions benefits of the proposed regulation. The following descriptions provide a brief overview of the data, methodologies, and assumptions.

Base Year Population and Model Year (MY) Distribution (2006 to 2013)

The base calendar year (CY) for the RW emissions inventory is 2013. Updated California Department of Motor Vehicle (DMV) registration data provided detailed information on the total population and MY distribution for each CY from 2006 to 2013. An estimate of the population of active and inactive (stored at households but not used) RW is included in PC2014.

Forecasting RW Populations and Age Distributions (2014 to 2050)

Staff used DMV registration data to reevaluate the projected life span of each RW type and to estimate the expected total life, useful life (or median life), and year-to-year survival ratios.
Forecasting Annual RW Sales

Staff used economic data from a 2014 UCLA Economic Forecast to estimate the near-term annual sales of RW (2014 to 2019). To forecast long-term annual sales (2020 and later), staff used an estimate of California’s annual population growth as a surrogate.

Technology Shifts

Staff used ARB’s marine engine certification database as well as sales information from manufacturers to estimate the split of gasoline 2-stroke (G2) and 4-stroke (G4) engines. The updated base year and future year RW populations have a greater proportion of G4 engines, which significantly lowers the estimate of exhaust emissions.

Activity

In 2009, ARB funded a CSUS phone survey of over 1,123 respondents (CSUS, 2009). Staff used the results of the survey to estimate the annual activity as well as the spatial allocations for operation and storage for RW.

Emissions Factors

Staff updated exhaust emissions factors based on ARB marine engine certification data. Evaporative emissions factors were also updated based on ARB in-house SIMW testing. Finally, weathering correction was applied to active and inactive SIMW to account for the evaporative rates that decline over extended storage periods. Weathering occurs when a SIMW is stored for extended time periods. The gasoline evaporative emissions rate starts to decline and reaches a steady state after most light-end molecules escape from liquid gasoline over an extended storage period.

Spatial Allocation

Exhaust and evaporative emissions (running loss and hot soak) that occur during RW operation were allocated to areas of operation. Other evaporative processes (diurnal and resting loss) were allocated to areas of SIMW storage. Both allocations are based on the CSUS activity survey.

Correction Factors

Temperature/Reid Vapor Pressure (RVP) correction is used to scale down the diurnal and resting loss evaporative emissions from the test temperature range of 65°F to 105°F to local temperature conditions experienced by SIMW during storage. This correction factor is based on normalized calculations of vapor generation from the fuel tank and permeation from fuel hoses using the Reddy equation (Reddy, 1989).
II. EMISSIONS CALCULATION METHODOLOGY

In this section, the data sources, methodology, assumptions, and algorithms used in developing the emissions inventory are described. Topics that require more detailed explanation are included in Section VI of this document.

The top-down process of calculating RW emissions starts with multiplying the population by activity, relevant emissions factors, and load factors, where applicable, resulting in the statewide uncorrected emissions. The statewide uncorrected emissions are then allocated to the local geographic area of interest (GAI) and adjusted with different correction factors to reflect the local conditions (e.g., ambient temperature and humidity correction). Final outputs of the emissions inventory are based on counties, air districts, and the state for specific CYs.

A. METHODOLOGY

1. EXHAUST EMISSIONS

Exhaust emissions are not affected by the proposed regulation, which focuses only on evaporative ROG emissions. However, for completeness, exhaust emissions are investigated and evaluated for the category. Exhaust emissions are estimated using the equation and variables listed below for ROG, total organic gases (TOG), oxides of nitrogen (NOx), carbon monoxide (CO), carbon dioxide (CO2), and particulate matter (PM) by RW type, age, and CY.

\[
P_{iy} = \sum \text{Pop}_{iy} \times \text{EF}_{iy} \times \text{Hrs}_{iy} \times \text{Ave. Hp} \times \text{Load Factor}
\]

Where,
- \( P \) = pollutant (HC, CO, NOx, PM, CO2)
- \( \text{Pop} \) = engine population
- \( \text{EF} \) = emissions factor
- \( \text{Hrs} \) = annual average use hours
- \( \text{Ave. Hp} \) = average horsepower
- \( \text{Load factor} \) = load factor
- \( y \) = scenario year (1990-2050)
- \( i \) = equipment type
- \( v \) = vintage (age of equipment) for year \( y \)

2. EVAPORATIVE EMISSIONS

The proposed regulation controls evaporative emissions through more stringent diurnal and permeation standards for SIMW with engines greater than 30 kW and harmonizes evaporative standards for SIMW with engines less than 30 kW. The evaporative emissions inventory is separated into four distinct processes: diurnal, resting loss, hot soak, and running loss. These are defined as:
• Diurnal: Emissions from vapor expansion and venting during the heating part of the diurnal temperature cycle. Fuel also permeates as a function of rising temperature from fuel lines and gas tanks and evaporates on the outside surfaces of these components. Diurnal emissions occur in equipment that is not in operation.
• Resting loss: Emissions that occur as a result of fuel permeation through rubber or plastic fuel system components such as fuel hoses and fuel tanks. They occur during the cooling part of the diurnal temperature cycle. Resting loss emissions occur in equipment that is not in operation.
• Hot soak: Emissions that occur after an engine is shut off as the temperature of equipment and fuel delivery systems rises and then gradually returns to ambient temperature.
• Running loss: Emissions that occur while the equipment is operating; and the temperature of the equipment and fuel delivery systems are above ambient temperature.

Note that the definition of diurnal in a regulatory context represents the sum of the diurnal and resting loss processes.

The basic equations for estimating evaporative emissions are provided below:

\[
\text{Diurnal/Resting} = \text{Population} \times EF_{\text{Diurnal/Resting}} \times \text{Temp/RVP Correction}
\]

\[
\text{Hot Soak} = \text{Population} \times EF_{\text{Hot Soak}} \times \text{RVP Correction}
\]

\[
\text{Running Loss} = \text{Population} \times EF_{\text{Running Loss}} \times \text{Activity} \times \text{RVP Correction}
\]

Where,
- \( EF_{\text{Diurnal/Resting}} \) = gram per day for diurnal and resting losses
- \( EF_{\text{Hot Soak}} \) = gram per event of hot soak
- \( EF_{\text{Running Loss}} \) = grams per hour of running loss
- \( \text{Activity} \) = usage in hours per year
- \( \text{RVP Correction} \) = RVP correction factor (region specific)
- \( \text{Temp/RVP Correction} \) = temperature and RVP correction factor (region specific)

**B. EMISSIONS INVENTORY INPUTS**

1. **ACTIVE AND INACTIVE ENGINE POPULATION**

Staff used 2006 to 2013 CYDMV registration data to update the RW population. As shown in Table II-1, DMV has designated different codes to define vehicle usage. Based on the DMV definitions, staff divided the RW population into two groups: active and inactive. Active RW include the DMV registration code of “C”, “E”, or “S” whereas inactive RW include DMV registration code of “N”, “P”, or “R.”
Approximately 80 percent of the RW population is active and the rest is inactive. For this assessment, staff assumed inactive RW are not in use, therefore the only emissions associated with inactive RW are the evaporative emissions of ROG.

### Table II-1: Definition of Active and Inactive Status

<table>
<thead>
<tr>
<th>DMV code</th>
<th>Definition</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Currently registered</td>
<td>Active</td>
</tr>
<tr>
<td>E</td>
<td>Evidence of use</td>
<td>Active</td>
</tr>
<tr>
<td>S</td>
<td>Pending</td>
<td>Active</td>
</tr>
<tr>
<td>N</td>
<td>Not currently registered</td>
<td>Inactive</td>
</tr>
<tr>
<td>P</td>
<td>Planned non-operational</td>
<td>Inactive</td>
</tr>
<tr>
<td>R</td>
<td>Prior history</td>
<td>Inactive</td>
</tr>
</tbody>
</table>

DMV registration data is useful for identifying the population of RW in California, but does not account for RW with more than one engine. The CSUS survey information was used to supplement the DMV database and to estimate the average engine-to-RW ratio. Engine-to-RW ratios are applied to the population to determine the total active and inactive engine populations. Table II-2 shows the engine-to-RW ratios used for estimating engine population for outboard, inboard, and sterndrive. For PWC, jet drives, and sailboats with an auxiliary engine, staff assumed that there is only one engine per RW.

### Table II-2: Engine-to-RWRatio per RWType

<table>
<thead>
<tr>
<th>Boat Type</th>
<th>One engine</th>
<th>Two Engines</th>
<th>Three Engines+</th>
<th>Total Boats</th>
<th>Total Engines</th>
<th>Average Engine-to-RWRatio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inboard</td>
<td>117</td>
<td>35</td>
<td>0</td>
<td>152</td>
<td>187</td>
<td>1.23</td>
</tr>
<tr>
<td>Outboard</td>
<td>367</td>
<td>35</td>
<td>0</td>
<td>402</td>
<td>437</td>
<td>1.09</td>
</tr>
<tr>
<td>Sterndrive</td>
<td>295</td>
<td>16</td>
<td>1</td>
<td>312</td>
<td>330</td>
<td>1.06</td>
</tr>
</tbody>
</table>

2. LIFESPAN BY RW

We define the “total life” of a RW as the length of time when a population of RW is manufactured in a given year to the time when such population is removed. We define the “useful life” as the time a population of RW is manufactured to the time when half of the population is removed. This assessment is conducted on a RW-specific category basis. It is based on DMV registration data. We assume that the total life of the engine(s) in each RW is the same as the RW. In addition, we assume engine MY and RW MY is the same. Finally, we assume engines are not rebuilt or replaced during a RW’s life span.

Figure II-1 illustrates the age distribution of outboard based on DMV registration data. The figure plots age distributions for 2006, 2008, 2009, 2011, and 2013 CYs. The actual age distribution covers ages from -1 up to 110, with the bulk of the population at around 60 years. RW with an age of -1 represent early sales of a new MY. RW older than 60 years
makes up a negligible fraction of the entire population. Therefore, staff assumed 60 years to be the total life for outboard RW.

Similarly, for the rest of the other five RW categories, staff analyzed age distributions within DMV data and estimated their total life, as summarized in Table II-3. For outboards, inboards, sterndrives, and sailboats with auxiliary engine, the total life is 60 years. For PWC and jetdrives, the total life is 40 years and 50 years, respectively.

**Figure II-1: Age Distribution of Outboard from DMV Data**

![Age Distribution of Outboard from DMV Data](image)

**Table II-3: Total Life of RW**

<table>
<thead>
<tr>
<th>Boat Type</th>
<th>Total Life (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outboard</td>
<td>60</td>
</tr>
<tr>
<td>Inboard</td>
<td>60</td>
</tr>
<tr>
<td>Sterndrive</td>
<td>60</td>
</tr>
<tr>
<td>PWC</td>
<td>40</td>
</tr>
<tr>
<td>Jet Drive</td>
<td>50</td>
</tr>
<tr>
<td>Auxiliary Sail</td>
<td>60</td>
</tr>
</tbody>
</table>
3. FORECASTING RW POPULATION BY AGE

Population growth for RW is based on incoming population (estimated by new RW annual sales) and the outgoing population (estimated by the survival rate).

\[ \text{New Population} = \text{Old Population} + \text{New RW Sales} - \text{Scrapped Population (each age)} \]

a. Annual RW Sales

Estimating future annual sales of RW is a challenging task as no direct forecasts are available. However, based on historical housing start data contained in the 2014 UCLA Economic Forecast Report (UCLA, 2014), we found that RW annual sales correlate well with nationwide housing starts.

As seen in Figure II-2, there is a good correlation between past nationwide housing starts and historical annual sales of outboard with R² of 0.92. Since the UCLA Economic Forecast Report also projects the future nationwide housing starts, staff used it as a surrogate to project future annual sales of outboard. Below, we illustrate the method to estimate the growth of annual sales using outboard as an example.

**Figure II-2: Correlation of Annual Sales and Nationwide Housing Starts**

![Graph showing the correlation between outboard annual sales and housing starts.]
Example Calculation: Forecasted Outboard Annual Sales

The National Marine Manufacturer Association (NMMA) tracks nationwide RW sales. However, because no California specific sales data are available, staff used the NMMA nationwide sales data to confirm the accuracy of the annual sales projection in PC2014. Staff compared the “new” RW population in PC2014 (defined as age=0) with NMMA’s annual sales data from 1990 to 2013. As the NMMA data are nationwide and PC2014 is California-specific, all data was normalized to CY 2000 to facilitate a comparison. The general trend is in good agreement with the nationwide annual sales of outboard as shown in Figure II-3. An analysis of annual sales data suggests that the recent recession has had a greater impact on California sales than nationwide sales. The short-term annual sales forecast (2014 to 2019) is based on UCLA’s projected nationwide housing starts, whereas the long-term annual sales forecast (2020 and beyond) is based on the historical annual growth rate of California human population (1.2 percent per year).

Figure II-3: Normalized Annual Sales of Outboard (PC2014 vs. NMMA)

b. Survival Rate

The survival rate is used to estimate the year-to-year change of RW population. A fraction of the RW population is removed each year due to accidents, attrition, or being placed permanently out of service. Staff evaluated year-to-year changes of RW population using DMV registration data and estimated the survival rate for each RW category. Using the estimated survival rate, staff can determine the survival ratio between two populations of consecutive ages.
Ideally, the survival rate should decline starting from the first year the RW is sold. However, for discretionary items such as RW or recreational vehicles the trend is for the population to initially increase before it decreases due to attrition. In the case of RW, an initial increase in the survival rate is observed. This issue to newly manufactured RW being sold over the course of several years rather than in the same year in which it was manufactured. This trend is reflected in our survival rate estimates. More details on the estimate of survival rate for each RW type can be found in Attachment A and B of Section VI.

The outboard population is backcasted from 2005 to 1990, based on survival rate. Figure II-4 depicts actual DMV RW registrations from 2006 to 2013. It also depicts the forecast and backcast populations of outboard. Likewise, RW population is forecasted from 2014 to 2019 (short-term projection). For 2020 and beyond (long-term projection), the estimated RW population is based on the survival rate and forecast of annual sales. The outboard population declines proportionally, which is similar to the DMV registration data. The recent recession has contributed to a slow recovery of annual sales and caused a decline of the outboard population.

Figure II-4: Projection of Outboard Fleet Population

4. LOAD FACTORS

Engine load is the average operational level of an engine in a given application as a fraction of the engine manufacturer’s maximum rated horsepower (Hp). Since emissions are directly proportional to engine horsepower, load factors are used in the inventory
calculations to adjust the maximum rated horsepower to the horsepower levels typically observed during normal operation.

The load factors used in PC2014 are the same as those that were used in OFFROAD2007 as staff did not conduct any studies on the load factors for the current RW inventory update. For outboards, PWC, and sailboats with auxiliary engine, the load factors were based on data provided by Power System Research (PSR). For sterndrives and inboards, the load factors are based on the marine engine steady-state cycle (E-4) as shown in Table II-4.

Table II-4: Load Factors of RW

<table>
<thead>
<tr>
<th>Boat Type</th>
<th>Load Factor</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outboard</td>
<td>0.32</td>
<td>PSR</td>
</tr>
<tr>
<td>PWC</td>
<td>0.4</td>
<td>PSR</td>
</tr>
<tr>
<td>Sterndrive</td>
<td>0.21</td>
<td>Marine engine steady-state test cycle (E-4)</td>
</tr>
<tr>
<td>Inboard</td>
<td>0.21</td>
<td>Marine engine steady-state test cycle (E-4)</td>
</tr>
<tr>
<td>JetBoat</td>
<td>0.21</td>
<td>Marine engine steady-state test cycle (E-4)</td>
</tr>
<tr>
<td>Auxiliary</td>
<td>0.35</td>
<td>PSR</td>
</tr>
</tbody>
</table>

5. TECHNOLOGY AND HORSEPOWER SPLIT

Population estimates are split by technology type and horsepower group to match the emissions factors. Technology type refers to G2 or G4 engine types and whether the engine is carbureted (CB) or fuel injected (FI). Engine technology affects exhaust emissions. For example, a G2 engine produces more hydrocarbon (HC) exhaust emissions than a G4 engine. Likewise, horsepower affects the evaporative emissions rates; equipment with higher horsepower tends to have a larger fuel tank and, therefore, will have larger evaporative emissions rates.

Unlike automobiles, where the VIN number provides technology information, RW are assigned a Hull Identification Number (HIN), which does not provide similar information. The DMV database for RW was supplemented with engine technology data staff obtained from manufacturers and related websites to compile a database of equipment that manufacturers produce. Staff also reviewed the ARB marine engine certification database from 2001 to 2010. This database consists of data submitted by manufacturers for certification of equipment for sale in California. Information from the database includes model family, equipment type, fuel system, horsepower, engine certification level for pollutants, and projected sales in California.

Using the data gathered from websites and the marine engine certification database, staff compiled the technology and horsepower split by model year for each RW type in PC2014. It was observed that there was a technology shift from G2 to G4 engines around the early 1990s. In order to corroborate the information collected, staff requested data from marine engine manufacturers on the history of PWC and outboard engine production. Only one manufacturer provided limited proprietary data on PWC and outboard. Table II-5 compares
the technology split assumed in PC2014 with the manufacturer data. The comparison confirms a shift of technology in the marine engine industry from G2-CB to G4-FI, which is a cleaner technology for marine engines. Likewise, as shown in Table II-6, the horsepower split used in PC2014 is in good agreement with the manufacturer data.

**Table II-5: Comparison of Technology Split**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Model Year</th>
<th>PC2014</th>
<th>Manufacturer Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWC</td>
<td>1980</td>
<td>100%</td>
<td>0% 0% 0% 0%</td>
</tr>
<tr>
<td></td>
<td>1985</td>
<td>100%</td>
<td>0% 0% 0% 0%</td>
</tr>
<tr>
<td></td>
<td>1990</td>
<td>100%</td>
<td>0% 0% 0% 0%</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>100%</td>
<td>0% 0% 0% 0%</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>64%</td>
<td>36% 0% 0% 0%</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>0%</td>
<td>15% 0% 85% 8%</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>0%</td>
<td>0% 0% 100% 100%</td>
</tr>
<tr>
<td>Outboard</td>
<td>1980</td>
<td>100%</td>
<td>0% 0% 0% 0%</td>
</tr>
<tr>
<td></td>
<td>1985</td>
<td>100%</td>
<td>0% 0% 0% 0%</td>
</tr>
<tr>
<td></td>
<td>1990</td>
<td>96%</td>
<td>4% 0% 0% 0%</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>78%</td>
<td>9% 13% 0% 0%</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>25%</td>
<td>14% 61% 0% 0%</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>0%</td>
<td>19% 37% 44% 5%</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>0%</td>
<td>19% 29% 52% 5%</td>
</tr>
</tbody>
</table>

**Table II-6: Comparison of Horsepower Group**

<table>
<thead>
<tr>
<th>Source</th>
<th>Model Year</th>
<th>Horsepower (Hp) Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>25 50 120 175 250 500 750</td>
</tr>
<tr>
<td>PC2014 (PWC)</td>
<td>1990</td>
<td>0% 85% 15% 0% 0% 0% 0%</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>0% 40% 60% 0% 0% 0% 0%</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>0% 20% 55% 25% 0% 0% 0%</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>0% 0% 43% 44% 13% 0% 0%</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>0% 0% 24% 20% 54% 3% 0%</td>
</tr>
<tr>
<td>Manufacturer (PWC)</td>
<td>1990</td>
<td>85% 15%</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>40% 60%</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>60% 40%</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>60% 40%</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>70% 30%</td>
</tr>
</tbody>
</table>

6. EXHAUST EMISSIONS FACTORS

Exhaust emissions factors were primarily developed using the ARB marine certification database from 2001 to 2011 due to limited in-use exhaust emissions data on RW. Since
MY 2001, all marine manufacturers have been required to certify to show compliance with the exhaust emissions standards.

Staff categorized the exhaust emissions factors by RW type, technology group, and MY group. Technology groups are subdivided into four main categories: G2-CB, G2-FI, G4-CB, and G4-FI. MY groups are subdivided into single MY or multiple MY groups that can be supported by the certification data.

Uncontrolled exhaust emissions factors for pre-2001 MYs are based on test data from Systems Applications International (1995). These factors are based on a 5-mode recreational marine test cycle. For MYs 2001 to 2010, the exhaust emissions factors are based on the certification database. For 2011 and later MYs, exhaust emissions factors are assumed to be the same as in 2010.

Because of the size of the final emissions factor table, only a portion of the exhaust emissions factors for outboard of 50 to 120 horsepower, and technology groups G2-CB carburetor and G4-FI fuel injection is presented in Table II-7. As illustrated in the table, for the technology group of G2-CB, there is an order of magnitude change in HC emissions for the presented MYs. A decrease in exhaust emissions due to different control technology is also indicated between G2-CB and G4-FI, especially for the earlier MYs.

Table II-7: Summary of Exhaust Emissions Factors for Outboard

<table>
<thead>
<tr>
<th>Horsepower</th>
<th>Tech Group</th>
<th>MY</th>
<th>HC (g/bhp-hr)</th>
<th>CO (g/bhp-hr)</th>
<th>NOx (g/bhp-hr)</th>
<th>PM (g/bhp-hr)</th>
<th>CO2 (g/bhp-hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 to 120</td>
<td>G2-CB</td>
<td>2003 and before</td>
<td>116.4</td>
<td>170.4</td>
<td>4.4</td>
<td>7.1</td>
<td>636.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2004 - 2007</td>
<td>24.3</td>
<td>43.0</td>
<td>6.0</td>
<td>7.1</td>
<td>636.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2008 and after</td>
<td>10.6</td>
<td>18.8</td>
<td>2.6</td>
<td>7.1</td>
<td>636.1</td>
</tr>
<tr>
<td></td>
<td>G4-FI</td>
<td>2001 and before</td>
<td>13.3</td>
<td>180.3</td>
<td>3.8</td>
<td>0.1</td>
<td>708.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2002</td>
<td>9.2</td>
<td>180.3</td>
<td>3.8</td>
<td>0.1</td>
<td>708.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2003</td>
<td>8.5</td>
<td>166.3</td>
<td>4.5</td>
<td>0.1</td>
<td>708.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2004</td>
<td>8.5</td>
<td>180.3</td>
<td>4.1</td>
<td>0.1</td>
<td>708.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2005</td>
<td>8.3</td>
<td>180.3</td>
<td>3.8</td>
<td>0.1</td>
<td>708.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2006</td>
<td>8.3</td>
<td>195.0</td>
<td>4.6</td>
<td>0.1</td>
<td>708.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2007</td>
<td>8.5</td>
<td>195.0</td>
<td>4.7</td>
<td>0.1</td>
<td>708.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2008</td>
<td>8.6</td>
<td>175.0</td>
<td>4.7</td>
<td>0.1</td>
<td>708.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2009</td>
<td>8.8</td>
<td>140.8</td>
<td>4.2</td>
<td>0.1</td>
<td>708.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2010 and after</td>
<td>9.1</td>
<td>132.0</td>
<td>4.0</td>
<td>0.1</td>
<td>708.4</td>
</tr>
</tbody>
</table>
7. EVAPORATIVE EMISSIONS FACTORS

ARB has been active in collecting evaporative emissions data on different SIMW using a sealed housing for evaporative determination (SHED) at its Haagen-Smit Laboratory in El Monte, California. The purpose of such testing was to investigate the control efficiency of low permeable materials and to develop the in-use baseline evaporative emissions factors for SIMW. Hot soak, diurnal, and resting loss evaporative emissions were measured for each SIMW tested. Running loss tests were not performed due to design limitations of the SHED. The current design prevents the collection of data while a SIMW engine is running inside the SHED.

Diurnal and resting loss tests were conducted over a temperature range of 65°F to 105°F. The RVP for test gasoline was kept close to seven pounds per square inch (psi). This is important because evaporative emissions are proportional to the vapor pressure of gasoline. Some SIMW were tested using gasoline with different ethanol concentrations (gasoline without ethanol [E0], gasoline with six percent ethanol [E6], and gasoline with ten percent ethanol [E10]) to investigate the impact of ethanol content on evaporative emissions.

After combining the data measured by ARB with evaporative emissions test data previously conducted by Automotive Testing Laboratory (ATL), staff was able to develop uncontrolled baseline emissions factors for more than 37 different SIMW. The detailed calculation process is described in Attachment B of Section VI.

Table II-8 summarizes the uncontrolled baseline emissions factors used in PC2014. Because of limited data, emissions factors are grouped by fuel system and horsepower. Uncontrolled diurnal and resting emissions factors can be more than double the hot soak emissions factors and account for most of the evaporative emissions from SIMW. While there is no difference in emissions factors for E6 and E10 fuel, there is a slight difference when using E0 (applied to CY 2003 and earlier).
Table II-8: Uncontrolled Evaporative Emissions Factors for PC2014

<table>
<thead>
<tr>
<th>Type</th>
<th>Fuel System</th>
<th>HP Group</th>
<th>Hot Soak (g/event)</th>
<th>Diurnal &amp; Resting (g/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>E0</td>
<td>E6/E10</td>
</tr>
<tr>
<td>Outboard</td>
<td>CB/FI</td>
<td>25 and less</td>
<td>6.1</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26+</td>
<td>12.9</td>
<td>14.1</td>
</tr>
<tr>
<td></td>
<td>FI</td>
<td>All</td>
<td>7.6</td>
<td>8.3</td>
</tr>
<tr>
<td>Inboard/ Auxiliary</td>
<td>CB/FI</td>
<td>175 and less</td>
<td>9.5</td>
<td>10.4</td>
</tr>
<tr>
<td>sail</td>
<td></td>
<td>176+</td>
<td>25.0</td>
<td>27.3</td>
</tr>
<tr>
<td>Sterndrive</td>
<td>CB/FI</td>
<td>175 and less</td>
<td>6.9</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>176+ Hp</td>
<td>11.3</td>
<td>12.3</td>
</tr>
<tr>
<td>PWC/Jet Drive</td>
<td>CB</td>
<td>All</td>
<td>6.1</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>FI</td>
<td>All</td>
<td>2.8</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Note: E0 fuel applies to CY2003 and earlier whereas E6/E10 fuel applies to CY2004 and later.

8. ACTIVITY

RW usage (e.g., hours used per year) is a critical component in estimating the RW emissions inventory. In 2009, ARB funded a CSUS phone survey of 1,127 randomly selected California RW owners to update the activity estimate for the RW emissions inventory.

Based on the information on annual days of operation and typical hours of usage per day, staff estimated the annual hours of operation for each type of RW listed in Table II-9. Attachment C of Section VI provides a detailed analysis showing how the activity was estimated for each type of RW.

Table II-9: Annual Activity for RW

<table>
<thead>
<tr>
<th>RW Type</th>
<th>Average (hr/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outboard</td>
<td>62</td>
</tr>
<tr>
<td>Inboard</td>
<td>60</td>
</tr>
<tr>
<td>Sterndrive</td>
<td>47</td>
</tr>
<tr>
<td>Auxiliary &amp; Sail</td>
<td>78</td>
</tr>
<tr>
<td>PWC</td>
<td>42</td>
</tr>
<tr>
<td>Jet Drive</td>
<td>42</td>
</tr>
</tbody>
</table>

C. CORRECTION TO BASELINE EMISSIONS

1. CORRECTION FOR AMBIENT CONDITIONS AND FUEL RVP

Ambient temperature and humidity changes affect RW exhaust and evaporative emissions. Emissions can vary depending on where the RW is operated and stored. Baseline evaporative emissions factors are developed under controlled laboratory
conditions. Corrections are necessary to account for the differences between laboratory and real-world operation.

California is divided into 58 counties, 35 local air districts, and 15 air basins. The boundary of each air basin or air district does not necessarily coincide with each county's political boundaries. Emissions were estimated for each county, local air district, and air basin. A smaller unit of area, called a GAI, is used to represent the intersection of three political boundaries. The RW emissions inventory for 69 separate GAI was developed. The correction accounts for the respective ambient temperature and humidity characteristics and seasonal fuel RVP requirement. The following section discusses the correction factors for evaporative and exhaust emissions to reflect the effect of local conditions such as seasonal variation of fuel RVP, temperature, and humidity.

a. Temperature/RVP Correction (Diurnal and Resting Loss)

Based on previous recommendations by the Eastern Research Group (2013), Temperature/RVP corrections are estimated for two main processes: vapor generation (uncontrolled system), and permeation.

Vapor Generation

The work to model the amount of vapor generated from the evaporation of gasoline was first undertaken by Wade in the 1960s, who established equations relating vapor generation to fuel temperature rise and several fuel properties, including RVP, distillation properties, density and molecular weight (Wade, 1967). These equations were used by the United States Environmental Protection Agency (U.S. EPA) for earlier versions of their on-road emissions model (MOBILE), as well as their off-road emissions model (NONROAD). In the 1980s, Reddy developed a simplified model for vapor generation based only on fuel temperature rise and RVP, and published model coefficients reflecting variations in altitude (sea level, Denver) and ethanol level (E0, E10) (Reddy, 1989).

For this analysis we used the Reddy equation for estimating grams of gasoline vapor generated per gallon of fuel tank vapor space. Our estimate used coefficients for sea level and E10 gasoline, as these are most reflective of California conditions:

\[
Vapor\ Generated\ (g/gal\ vapor\ space) = A \times e^{B \times RVP} \times \left( e^{C \times T2} - e^{C \times T1} \right)
\]

Where,

- T1 = starting temperature
- T2 = ending temperature
- A = 0.00875
- B = 0.2056
- C = 0.0430

\[
Mass\ of\ Vapor\ Generated\ (grams) = Vapor\ Generated\ (g/gallon\ vapor\ space) \times Fuel\ Capacity\ (gal) \times (1-\ Fill\ %)
\]
Note that the gasoline vapor model was developed for vehicles without sealed tanks or pressure relief valves, but has been adapted for SIMW. The amount of gasoline vapor restricted from venting to the atmosphere depends on the setting of the pressure relief valve. For example, the U.S. EPA estimates that the range of pressure relief valves installed on PWC varies from 0.5 to 4.0 psi. Reddy and the U.S. EPA independently assessed the impact of a 1.0 psi pressure relief valve on vapor generation. Both concluded that the pressure relief valve would reduce vapor generation by about 0.7 grams per gallon vapor space. This would apply to different temperature and RVP conditions, as the relief valve is operating at the same threshold regardless of the conditions under which vapor was generated (although the relative reduction may be quite different). Using the Reddy equation, staff assumes a 1.0 psi “trigger” for pressure relief valves and corrects the existence of a pressure relief valve by subtracting 0.7 grams/gallon off of the uncontrolled vapor generation rate.

Based on the discussion above, Attachment D provides an illustrative example calculation of vapor generation under various RVP and temperature conditions.

**Permeation**

The permeation process is assumed to include both fuel tank permeation and fuel hose permeation. The base permeation emissions factors are 10.7 g/m²/day for tanks, and 222 g/m²/day for hoses based on the U.S. EPA NONROAD model (E10 fuel). Temperature corrections for permeation in NONROAD are based on the assumption that permeation emissions double with every increase of 18°F (10°C) from a reference temperature. As a result, a temperature adjustment is applied to the hose or tank reference temperature when estimating the permeation emissions factor at a different temperature.

Hose permeation doubles with each 18°F increase from the reference temperature of 73°F, and is estimated by the following equation:

\[ TCF = 0.06013899 \times e^{0.03850818 \times T} \]

Tank permeation doubles with each 18°F increase from the temperature of 85°F, and is estimated by the following equation:

\[ TCF = 0.03788519 \times e^{0.03850818 \times T} \]

Finally, the diurnal and resting loss emissions are estimated by the following:

\[ \text{Diurnal} = \text{Vapor Generation} + 0.5 \times (\text{Tank Permeation} + \text{Hose Permeation}) \]

\[ \text{Resting Loss} = 0.5 \times (\text{Tank Permeation} + \text{Hose Permeation}) \]

By calculating the absolute values of diurnal and resting loss at 65°F to 105°F, as well as at other local temperature and fuel RVP conditions, staff was able to normalize all calculated values. These normalized values are used as the Temperature/RVP correction to adjust
diurnal and resting loss emissions factors to the local temperature and fuel RVP conditions. The tank size and hose diameter that is assumed represents the typical fleet average and is not important in the final calculation as staff is only interested in the normalized values from different temperature and fuel RVP conditions. Attachment D provides a sample calculation of how the Temperature/RVP correction can be applied to diurnal and resting loss emissions conducted at different temperature profiles and fuel RVP.

b. RVP Correction (Hot Soak and Running Loss)

The RVP correction is applied to the hot soak and running loss evaporative emissions tests that are conducted with a fuel RVP of seven psi. When the winter fuel with an RVP of nine psi is used, the following formula is used:

\[ CF_{RVP} = 0.3 \times RVP - 1.1 \]

Applying RVP = nine psi, the above equation becomes 0.3 x 9-1.1 = 1.6 which is used for all GAI when winter fuel is used. For summer fuel (RVP is at seven psi), there is no correction for RVP, which indicates that CF\(_{RVP}\) is one.

c. Fuel Correction Factors (Exhaust Emissions)

The fuel correction factors (FCFs) are dimensionless multipliers applied to the basic exhaust emissions rates. The FCFs account for differences in the properties of certification fuels compared to those of commercially dispensed fuels. California went through three phases of reformulated gasoline in the past two decades: California Reformulated Phase 1 Fuel (1992 to 1995), California Reformulated Phase 2 Fuel (1996 to 2003), and California Reformulated Phase 3 Fuel (2004 and beyond). In those instances where engines or vehicles are not required to certify, FCFs are used to reflect the impact of changes in dispensed fuel over time as refiners respond to changes in fuel specific regulations compared to the fuel used to obtain the test data. E10 is the reference fuel assumed in PC2014, because it is the gasoline currently commercially sold in California. As a result, staff renormalized previous FCFs in OFFROAD2007 to E10 fuel (Sicat, 2007).

d. Temperature and Humidity Correction (Exhaust Emissions)

The temperature and humidity correction factors for exhaust emissions were developed as follows:

Temperature Correction

For hydrocarbons and NOx, the temperature correction factor is

\[ CF_{\text{Temp}} = 10^{(T-75)a} \]

Where,
- \( T \) = ambient temperature (°F)
- \( a \) = coefficient for temperature correction
The coefficient for temperature correction depends on engine type and whether the ambient temperature is above or below 75°F as shown in Table II-10.

Table II-10: Coefficients for Temperature Correction

<table>
<thead>
<tr>
<th>Pollutants</th>
<th>Low Temp (&lt;75°F)</th>
<th>High Temp (&gt;75°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G-2</td>
<td>G-4</td>
</tr>
<tr>
<td>CO</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HC</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>NOx</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

To simplify the calculation methods used in developing the RWemissions inventory, staff applied the temperature correction on a daily basis to the average daily temperature. This approach captures the general trend of the correction factor without requiring calculations on an hourly basis. Finally, the exhaust temperature correction for a typical month is based on the hourly average of ambient temperatures between 9 a.m. to 4 p.m. to reflect the typical temperatures experienced by RW during operation.

**Humidity Correction for NOx**

For humidity correction for NOx, the correction factor is:

\[
CF_{Humd} = 1 - 0.0038 \times (A - 75)
\]

Where,

\[A\] = absolute humidity

The absolute or scenario humidity is derived from the relative humidity and ambient temperature based on the following equation:

\[
ABH = RH \times (-0.09132 + 0.01594 \times T - 0.00029 \times T^2 + 0.00000437 \times T^3)
\]

Where,

\[ABH\] = scenario humidity (grains/pound)
\[T\] = scenario temperature (°F)
\[RH\] = relative humidity (%)

This equation is limited to use with ambient temperatures between 40°F and 120°F, and to predict absolute humidity values not greater than 200 grains/pound. If the ambient temperature is less than 40°F, then 40°F is used for the calculation. Similarly, if the ambient temperature is higher than 120°F, then 120°F is used for calculation. If the calculated absolute humidity is greater than 200 grains/pound, then only 200 grains/pound is used.

2. CONVERSION FACTORS FOR POLLUTANTS
As total hydrocarbons are measured from exhaust and evaporative emissions, it is necessary to apply a conversion to total hydrocarbon (THC) to estimate TOG, ROG, and methane (CH$_4$) emissions. Because gasoline content affects the composition of HC in evaporative and exhaust emissions, the conversion factors are different for California Reformulated Phase 1 Fuel (1992 to 1995), California Reformulated Phase 2 Fuel (1996 to 2003), and California Reformulated Phase 3 Fuel (2004 and beyond). In addition, the methodologies used for estimating fuel consumption and sulfur dioxide (SO$_2$) emissions are described.

**ROG and TOG Correction**

The conversion factor varies by CY (due to phase-in schedule of reformulated gasoline), engine type and emissions process (evaporative or exhaust). The conversion coefficients are listed in Table II-11.

**Table II-11: Coefficients Used for TOG/ROG Conversion from THC**

<table>
<thead>
<tr>
<th>CY</th>
<th>Engine</th>
<th>Process</th>
<th>TOG</th>
<th>ROG</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>Diesel</td>
<td>Exhaust</td>
<td>THC*1.44</td>
<td>THC*1.21</td>
</tr>
<tr>
<td></td>
<td>CNG/LPG</td>
<td>Exhaust</td>
<td>THC*0.99</td>
<td>THC*0.09</td>
</tr>
<tr>
<td>Pre-1996</td>
<td>Gasoline</td>
<td>Exhaust (G2)</td>
<td>THC*1.01</td>
<td>THC*0.92</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exhaust (G4)</td>
<td>THC*1.04</td>
<td>THC*0.89</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evaporative</td>
<td>THC*1.04</td>
<td>THC*1.04</td>
</tr>
<tr>
<td>1996-2003</td>
<td>Gasoline</td>
<td>Exhaust</td>
<td>THC*1.09</td>
<td>THC*1.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evaporative</td>
<td>THC*1.12</td>
<td>THC*1.12</td>
</tr>
<tr>
<td>2004+</td>
<td>Gasoline</td>
<td>Exhaust</td>
<td>THC*1.10</td>
<td>THC*1.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evaporative</td>
<td>THC*1.14</td>
<td>THC*1.14</td>
</tr>
</tbody>
</table>

**CH$_4$**

CH$_4$ is derived as a fraction of TOG. The formula is:

$$CH_4 = TOG \times Coefficients$$

The coefficients are shown in Table II-12.
Table II-12: Coefficients Used for CH₄ Conversion from TOG

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>CY</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>G2</td>
<td>Pre-1996</td>
<td>0.0774</td>
</tr>
<tr>
<td></td>
<td>1996-2003</td>
<td>0.0558</td>
</tr>
<tr>
<td></td>
<td>2004+</td>
<td>0.0572</td>
</tr>
<tr>
<td>G4</td>
<td>Pre-1996</td>
<td>0.1132</td>
</tr>
<tr>
<td></td>
<td>1996-2003</td>
<td>0.0558</td>
</tr>
<tr>
<td></td>
<td>2004+</td>
<td>0.0572</td>
</tr>
</tbody>
</table>

Fuel Consumption

The fuel consumption correction factor is derived from mass balance using CO, CO₂ and with TOG, with units in tons per year. The formula for fuel consumption is:

\[
Fuel\ Consumption = \left(\frac{12.011}{12.011 + \text{Alpha} \times 1.008}\right) \times TOG + 0.429 \times CO + 0.273 \times CO_2 ÷ (0.866 \times 2000 \times \text{Fuel Density})
\]

Where,
- \(\text{Alpha} = 1.85\)
- Density for gasoline = 6.17 lb/gal
- Density for diesel = 7.1 lb/gal

SO₂ Calculation

The SO₂ correction factor is calculated based on sulfur content in the fuel and will differ by fuel type. The formula is:

\[
SO_2\ (tpd) = FC \times (S\ ppmw / 10^5) \times Fuel\ Density \times 2\ lb\ SO_2\ per\ lb\ of\ S \times \text{ton}/2000\ lb
\]

Where,
- FC = fuel consumption (gal/day)

3. SPATIAL ALLOCATION

Allocating emissions spatially is an important part of an emissions inventory development. While operating a RW, the exhaust, hot soak and running loss evaporative emissions are allocated to the area of operation (typically lakes or coastal areas). However, when the SIMW is stored, the diurnal and resting loss evaporative emissions occur at the storage location (typically residential areas or marina slips).

The CSUS survey results provided information on the location of storage and operation. From this information, staff was able to develop allocation factors for storage and operation based on four distinct ranges (differentiated by shading) within California. The allocation factors are unitless scalar multipliers used in the emissions inventory analysis. Staff used
the allocation factors to spatially allocate storage and operation emissions as shown in Figure II-5 and Figure II-6.

**Figure II-5: Area of Storage for PC2014**
Figure II-6: Area of Operation for PC2014

Statewide Allocation

- 0.000052 - 0.007456
- 0.007457 - 0.022459
- 0.022460 - 0.042754
- 0.042755 - 0.085695
Operation Allocation Factor

The operation allocation factor was derived using the CSUS survey data as shown in the following formula which uses the actual activities reported on the survey to weigh the allocation of emissions into specific counties:

\[
AF_{OP,i} = \frac{\sum_j D_j \times H_j \times PT_{i,j}}{\sum_i \sum_j D_j \times H_j \times PT_{i,j}}
\]

Where,
- \(AF_{OP,i}\) = the operation allocation factor for county \(i\)
- \(D_j\) = days of RW operation for respondent \(j\) per year
- \(H_j\) = hours of operation per day for respondent \(j\)
- \(PT_{i,j}\) = percent of time respondent \(j\) operates the RW in county \(i\)

Storage Allocation

Storage allocation was also derived using the CSUS survey data. Unlike on-road vehicles which are stored primarily at the address of the owner, RW can be stored at a marina or lake, which is different from the owner’s or operator’s home address. The CSUS survey included specific questions on the location where respondents typically store their RW. Instead of using the owner’s address to develop the storage allocation, CSUS storage location data provides more realistic information on where the RW are actually stored. Based on storage location data, staff developed county-specific storage allocation factors for diurnal and resting loss emissions from SIMW.

4. SEASONALITY

To model seasonal variability in RW usage in California, staff analyzed the activity survey data collected by CSUS in 2009. Questionable survey responses were filtered out and not used for subsequent analysis based on the following criteria:

- Daily usage of RW greater than 10 hours.
- More than 365 days of usage reported in a year.

For each valid response, the total hours of use per year was calculated by multiplying the reported days of use per year by the reported hours of use per day.

The monthly usage frequency (MoUF) was developed for each of the four seasons: winter (December to February), spring (March to May), summer (June to August), and fall (September to November). The monthly usage was calculated using the following equation:

\[
MoUF_i = \frac{THU \times UF_i}{3}
\]
Where,
\[ MoUF_i = \text{the monthly usage frequency for season } i \]
\[ THU = \text{the total hours of usage per year} \]
\[ UF_i = \text{the usage frequency for season } i. \]

Since the seasonal definition in the PC2014 model is different from what was defined in the survey, the seasonal usage frequency (SUF) is calculated by summing the monthly usage frequency over the specified season. In the model, the summer season refers to the 6 months from May to October while the winter season refers to the remaining 6 months from November to April.

\[ SUF_i = \sum_j MoUF_{i,j} \]

Where,
\[ SUF_i = \text{the seasonal usage frequency for a given season } i \]
\[ MoUF_{i,j} = \text{the } j\text{ month usage frequency within a given season } i. \]

The PC2014 model assumes summer months to include May through October and winter months to include November through April. The seasonality adjustment is calculated using the following equation:

\[ SA_i = \frac{SUF_i}{\sum_i SUF_i} \]

Where,
\[ SA_i = \text{the seasonal adjustment factor for season } i. \]

Using the methodology described above, the seasonality adjustment factor for RW is 1.48 for summer months and 0.52 for winter months.

5. **LONG TERM STORAGE CORRECTION FOR ACTIVE AND INACTIVE SIMW**

In the previous SIMW emissions inventory based on OFFROAD2007, evaporative emissions rates (diurnal and resting loss) are assumed to remain constant throughout all days of the year for active and inactive SIMW. This incorrectly assumes the liquid-phase composition of the tank fuel is constant (no depletion of volatile components over time and no impact of refueling of active SIMW). We assume that there are no evaporative emissions for diesel-powered watercraft. However, active SIMW are refueled more frequently and stored for much shorter periods between uses. The reverse is true for inactive SIMW. To improve the characterization of evaporative emissions, staff has developed correction factors for active and inactive SIMW.

For active SIMW, multi-day SHED testing of three SIMW over the average Los Angeles temperature profile of 65°F to 82°F was conducted. Results were used to correct the current diurnal and resting loss emissions factors, which are based on a 3-day average of
diurnal and resting loss emissions. Based on the SHED tests, a correction factor of 0.72 was developed to correct the current diurnal and resting loss emissions factors. The details of the SHED test results are provided in Attachment E of Section VII.

For inactive SIMW, the majority of the diurnal emissions come from the venting of the fuel tank since there is very little fuel left in the fuel hoses. Instead of conducting diurnal and resting loss of a typical fuel tank for 12 months, staff decided to use vapor-liquid equilibrium (VLE) mass balance to estimate the loss of gasoline vapor over 12 months based on the typical Los Angeles monthly temperature. Staff simplified the mass balance by selecting 12 major components in the gasoline. In short, staff developed a correction factor of 0.53 to adjust the diurnal and resting loss emissions factor for inactive SIMW (i.e., stored long term). The details of such VLE estimate and the development of the correction factor can be found in Attachment F of Section VII.

III. PC2014 MODEL

The PC2014 emissions inventory model is based on the Microsoft Access platform. Input information such as population, activity, emissions factors, correction factors, and spatial allocation are stored as Microsoft Access tables. The computation is comprised of queries that combine variables from different tables and carry out the calculation process.

A. INVENTORY ESTIMATE FOR THE SIMWRULEMAKING

Reductions associated with the federal rule have been applied to the uncontrolled baseline emissions. Specifically, reductions associated with U.S. EPA evaporative control measures have already been implemented since 2012. Both ARB and U.S. EPA evaporative controls focus on reducing the permeation of HC emissions through fuel tanks and fuel hoses. The U.S. EPA evaporative control is based on the use of low permeable materials for fuel hoses and fuel tanks while ARB’s proposed evaporative control measure further tightens the permeation standard for fuel hoses and fuel tanks.

ARB has conducted an in-house study to estimate the reduction of HC and ROG associated with the adopted U.S. EPA rule and proposed ARB regulation. Based on the data gathered on a SIMW that was tested for uncontrolled baseline emissions, U.S. EPA controls, and ARB proposed controls, staff was able to estimate the emissions reductions associated with these proposed controls.

The following table summarizes the percent reduction from baseline used in estimating the benefits of the U.S. EPA rule as well as ARB’s proposed controls. As seen in Table III-1, for the control of hot soak from CB engines, U.S. EPA’s adopted control measures result in a 27 percent reduction (2012 MY and later) from baseline hot soak emissions while ARB’s proposed control measures result in an 83 percent reduction (2018 MY and later). Likewise, for the control of diurnal and resting loss emissions, U.S. EPA’s adopted controls result in a 49 percent reduction (2012 MY and later) from baseline diurnal and resting loss emissions while ARB’s proposed controls offer a 69 percent reduction (2018 MY and later).
Table III-1: Summary of Evaporative Reduction from Baseline

<table>
<thead>
<tr>
<th></th>
<th>Hot Soak</th>
<th>Diurnal and Resting Loss</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>2012 MY and later</td>
<td>2018 MY and later</td>
</tr>
<tr>
<td>CB</td>
<td>U.S. EPA Control</td>
<td>27%</td>
</tr>
<tr>
<td></td>
<td>Proposed ARB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>FI</td>
<td>U.S. EPA Control</td>
<td>57%</td>
</tr>
<tr>
<td></td>
<td>Proposed ARB</td>
<td>65%</td>
</tr>
</tbody>
</table>

B. CALCULATION PROCESS

The population input table includes six RW categories: outboard, inboard, sterndrive, PWC, auxiliary and sail, and jet drive. Each category includes active or inactive status, CY, MY, horsepower group, and technology. The technology group is subcategorized into diesel, G2-CB, G2-FI, G4-CB and G4-FI. The activity input table provides the annual activity with respect to age while the emissions factor input tables include exhaust and evaporative emissions factors grouped by CY or technology.

The model output provides current baseline emissions (which include the U.S. EPA adopted control measures) and the ARB proposed regulation at the statewide, air district, and air basin levels, as well as by season and CY. End-users may also specify the RW type, RW status (active or inactive), technology, and horsepower prior to getting the emissions summary. Finally, the model is capable of providing outputs by MY for a given CY.

C. MODEL INSTALLATION AND USER GUIDE

The PC2014 model can be downloaded from ARB’s website as follows:

http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles

The PC2014 model runs as an Microsoft Access database file. The model was developed in Microsoft Access 2010. Previous versions of Microsoft Access may not support all of the model’s functionality. Unzipped, the files are about 1.2GB. When running the model, the file size can grow to approximately 2GB. Model runtime varies depending on the processing power of the computer on which the model is installed. Output is provided through the user interface. Details on the model installation and user guide can be found in Attachment H. Finally, the source code of PC2014 is provided in Attachment I.
IV. EMISSIONS RESULTS

The emissions benefits from ARB’s proposed regulation are summarized in Table IV-I. To compare the emissions reductions to the SIP commitment, staff evaluated reductions associated with years in the 2007 SIP. The proposed regulation is expected to be implemented in MY 2018, and will require increasing control levels for SIMW manufactured starting in MY 2018 for SIMW with engines greater than 30 kW. A statewide benefit of 0.15TPD is observed starting in 2020. In 2023, the benefit increases to 0.34TPD, as more SIMW will be subject to the proposed regulation. By 2035, the statewide summer ROG benefit increases to 1.06TPD.

For the Bay Area Air Quality Management District, the ROG benefits are 0.03, 0.07, and 0.20TPD for 2020, 2023, and 2035, respectively. For the San Joaquin Valley Unified Air Pollution Control District, the ROG benefits are 0.02, 0.05, and 0.15TPD for 2020, 2023, and 2035, respectively. Finally, for the South Coast Air Quality Management District, ROG benefits are 0.03, 0.07, and 0.22TPD for 2020, 2023, and 2035, respectively.
Table IV-1: Benefit of the Proposed Regulation for Summer Emissions (tons/day)

<table>
<thead>
<tr>
<th></th>
<th>2020</th>
<th></th>
<th>2023</th>
<th></th>
<th>2035</th>
<th></th>
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<tr>
<td></td>
<td>Baseline</td>
<td>Proposed Regulation</td>
<td>Benefits</td>
<td></td>
<td>Baseline</td>
<td>Proposed Regulation</td>
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<tr>
<td></td>
<td>ROG</td>
<td>NOx</td>
<td>ROG</td>
<td>NOx</td>
<td>ROG</td>
<td>NOx</td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Statewide</td>
<td>129.48</td>
<td>24.74</td>
<td>129.33</td>
<td>24.74</td>
<td>0.15</td>
<td>0.00</td>
</tr>
<tr>
<td>Bay Area AQMD</td>
<td>23.57</td>
<td>4.49</td>
<td>23.54</td>
<td>4.49</td>
<td>0.03</td>
<td>0.00</td>
</tr>
<tr>
<td>SJV Unified APCD</td>
<td>17.74</td>
<td>3.32</td>
<td>17.72</td>
<td>3.32</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>South Coast AQMD</td>
<td>21.33</td>
<td>3.96</td>
<td>21.30</td>
<td>3.96</td>
<td>0.03</td>
<td>0.00</td>
</tr>
<tr>
<td>2023</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statewide</td>
<td>113.87</td>
<td>23.90</td>
<td>113.53</td>
<td>23.90</td>
<td>0.34</td>
<td>0.00</td>
</tr>
<tr>
<td>Bay Area AQMD</td>
<td>20.76</td>
<td>4.34</td>
<td>20.69</td>
<td>4.34</td>
<td>0.07</td>
<td>0.00</td>
</tr>
<tr>
<td>SJV Unified APCD</td>
<td>15.57</td>
<td>3.21</td>
<td>15.52</td>
<td>3.21</td>
<td>0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>South Coast AQMD</td>
<td>18.82</td>
<td>3.82</td>
<td>18.75</td>
<td>3.82</td>
<td>0.07</td>
<td>0.00</td>
</tr>
<tr>
<td>2035</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statewide</td>
<td>72.93</td>
<td>22.06</td>
<td>71.87</td>
<td>22.06</td>
<td>1.06</td>
<td>0.00</td>
</tr>
<tr>
<td>Bay Area AQMD</td>
<td>13.37</td>
<td>4.01</td>
<td>13.16</td>
<td>4.01</td>
<td>0.20</td>
<td>0.00</td>
</tr>
<tr>
<td>SJV Unified APCD</td>
<td>9.85</td>
<td>2.96</td>
<td>9.70</td>
<td>2.96</td>
<td>0.15</td>
<td>0.00</td>
</tr>
<tr>
<td>South Coast AQMD</td>
<td>12.22</td>
<td>3.53</td>
<td>12.00</td>
<td>3.53</td>
<td>0.22</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Attachment G provides a detailed breakdown of the evaporative emissions. For 2020 and 2023, the emissions benefits are small because the majority of the SIMW population is not covered by this regulation. By 2035, as more of the population is subjected to the proposed regulation, and the gradual turnover of older SIMW increases, more emissions benefits are expected.
V. REFERENCES


VI. ATTACHMENTS

A. ESTIMATE OF SURVIVAL RATE

**Survival rates** are a commonly used variable in emission inventory development. The survival rate is the fraction of vehicles that remain in the fleet (i.e. survive) as they age from year zero (defined as when the model year matches the calendar year) and beyond. The survival rate fraction for a specific year can be applied against the number of vehicles sold in year zero to estimate the number of vehicles remaining in that specific year. For example, if the survival rate at year 10 is 0.85, that means that on average 85% of vehicles sold in year zero are still in the fleet ten years later.

Survival rates are estimated using multiple years of registration data from the California Department of Motor Vehicles (DMV; more detail on how DMV data are analyzed is contained in the section below). Unlike with on-road automobiles, RW registration must be renewed with DMV every two years. The age distribution make-up of year-specific RW population is affected by a number of ownership circumstances that might transpire between two consecutive registrations (current versus prior registration two years earlier), including:

- Decline for re-registration of RW in the current year that was already registered in the prior years,
- Migration of a RW into California (positive migration) or out of California (negative migration),
- Whether a RW was unintentionally destroyed, and
- Scrappage (when a RW is intentionally destroyed and then disposed of, usually due to age).

In PC2014, the calculation of an age-specific RW population is based on the assumption that the survival rate for marine watercraft of a specific age represents all of the above factors that lead to a year-to-year change in population.

Figure VI-1, below, presents a plot of survival rates for Outboard RW. In this plot, the year zero base population is assumed to be ‘100’ as a reference. Typically, the survival rate near the end of life span is close to 0. One peculiar issue with recreational vehicles, like RW, is that new model year inventories can take several years to sell out. As a result, survival rates for the first few years can actually be higher than the year zero rate. For example, it would not be too uncommon for a new 2011 model year boat to be sold in calendar year 2014. This is reflected in survival rates greater than 100 for ages less than 10.
Figure VI-1: Final Survival Rate for Outboard
B. ESTIMATE OF SURVIVAL RATIO FROM SURVIVAL RATE

The model is designed to use a variable called survival ratio, not the survival rate, to estimate age distribution of the population.

The survival ratio, which is not the same as survival rate, refers to the ratio of population between two ages from two CYs. For example, the population of age 10 in CY 2012 is 50 and the population of age 11 in CY 2013 is 45, and the survival ratio at age 11 is 0.95. Typically, the survival ratio for off-road equipment ranges from 0.9 to 1.2.

To estimate the final survival rate and final survival ratio used in PC2014, staff first analyzed the DMV data and calculated the average survival ratios for two scenarios: with recession CYs and without CYs. Based on the average survival ratio for non-recession CYs, staff then constructed the final survival rate. Consequently, the final survival ratio was re-calculated based the final survival rate.

Calculation Process

As DMV includes the age distribution of RW for each calendar year, staff was able to track the change of population for multiple CYs. By following the change of populations of two specific ages at two CYs (e.g., age 10 in CY 2012 to age 11 in CY 2013), staff was able to estimate the average survival ratio between 2 specific ages of the entire life span for multiple pairs of consecutive CYs (e.g., CY 2007/CY2006, CY 2008/ CY2007, etc.).

Consequently, by multiplying the average survival ratio (between age 0 and age 1) to the reference population of 100 at age 0, staff could estimate the survived population at age 1. Likewise, by multiplying the average survival ratio (between age 1 and age 2) to the surviving population at age 1, staff could estimate the survived population at age 2. Finally, the survival rate is estimated by calculating the survived population for all ages based on the reference population at age 0.

Since RW owners are required to renew their RW registration every 2 years, the survival ratio is first calculated as the difference in the number of RW of a specific age registered with DMV between 2 consecutive registration years. Specifically, the number at age X in CY versus the number at age X+2 in CY+2 (e.g., age 2 in CY 2006 and age 4 in CY 2008). In other words, the survival ratios are developed for age 0, age 2, age 4, age 6 and so forth for the specified CYs.

Table VI-1 presents the DMV data that are used to develop the average survival ratio. By tracking the change of population every 2 years, staff developed the survival ratio for every 2 years. For instance, the population of age 12 in CY 2007 is 9,267 whereas the population of age 14 in CY2009 is 8,776, and the survival ratio between these 2 populations is 0.947. It should be noted that while the survival ratios between age 1 and age 3, and so forth, can also be calculated, such data are not used as the base population at age 1 is not known, whereas the reference population at age 0 is 100.
Ideally, the survival rate should decline with age. The increase of the RW population from age 2 to age 6 indicates that most marine watercraft are not sold in the same year that they are manufactured. They typically remain as part of the dealer inventory for 2 to 6 years before being sold.

The survival rate is also likely to be influenced by the economic conditions. RW owners may retain their RW for a longer period of time and delay a new purchase during poor economic conditions. The recent economic recession has definitely affected the survival rate. To estimate the survival rate with and without the impact of the recession, staff assumed the survival ratios developed from 2008/2006 and 2013/2011 would have minimal recession impact whereas the survival ratios developed from 2006 to 2013 would include the impact of recession. As expected, the average survival ratio developed with the recession years has a higher value in age 2 when compared to data without recession years.

The final survival rate (without recession impact) is based on the average survival ratio without impact from recession. Since the survival rates are developed only for age 0, age 2, age 4, and so forth, staff needed to interpolate those survival rates to estimate the final survival rate (see Table VI-2 and Figure VI-1). Based on the final survival rate, the final survival ratio at different ages were then re-calculated for the outboard as shown in Table VI-2.
### Table VI-1: Development of Outboard Average Survival Ratios

<table>
<thead>
<tr>
<th>Year</th>
<th>Ave Survival Ratio w/o Recession</th>
<th>Ave Survival Ratio w/o Other Recession</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>1</td>
<td>1.000</td>
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<tr>
<td>2</td>
<td>1.000</td>
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<td>3</td>
<td>1.000</td>
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<td>4</td>
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<tr>
<td>59</td>
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</tr>
</tbody>
</table>

Figure VI-2 illustrates the final survival ratio for the outboard. As indicated earlier in Table VI-1, the "spike" around age 2 to 6 is the delay of sales as most RW are not sold in the same year they are manufactured. Figure VI-2 also provides an example of survival ratio as seen from the shift of peaks and of age distributions of DMV data from CY2011 to CY2013.
Table VI-2: Final Survival Rate and Survival Ratio for Outboard

<table>
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<tr>
<th>Age</th>
<th>Survival Rate</th>
<th>Survival Ratio</th>
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<td>1</td>
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<tr>
<td>1</td>
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<tr>
<td>60</td>
<td>10</td>
<td>0.937</td>
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</tbody>
</table>
Figure VI-2: Final Survival Ratio for Outboard

Outboard Population

Survival Ratio

Age
C. EVAPORATIVE EMISSIONS FACTORS CALCULATION PROCESS

Evaporative emissions testing was conducted to estimate hot soak emissions (emissions after the engine is shut off) as well as diurnal and resting loss emissions (emissions from engine, fuel tank, and hoses due to the change of ambient temperature) from SIMW. Since the testing was not designed to measure running loss emissions from SIMW, the running loss basic emissions rates remain unchanged. Running loss emissions rates for SIMWare based on running loss emissions tests conducted by ATL (2003) on large spark-ignition engines.

Evaporative emissions tests were conducted in a SHED. Environmental conditions in the SHED were controlled to facilitate measuring the concentration of HCs emitted for each evaporative emissions process under simulated real-world conditions. Details of ARB’s SHED test procedure are contained in the following document:

http://www.arb.ca.gov/msprog/offroad/recmarine/draft_tp1501.pdf

For development of the uncontrolled baseline emissions factors, staff combined test data from two sources: ATL testing conducted in 2003 and ARB conducted in-house testing from 2008 to 2012. The number of tests by SIMW type is summarized in Table VI-3.

Table VI-3: Sample Size of ATL and ARBEvaporative Emissions Test Data

<table>
<thead>
<tr>
<th>Boat Type</th>
<th>ATL</th>
<th>ARB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outboard</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>PWC</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Sterndrive</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Inboard</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>30</td>
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</table>

Previously, the evaporative emissions factors for SIMW were based on nine boats tested by ATL. For PC2014, staff used both the ARB in-house evaporative test data and ATL test data to develop updated basic emissions rates for diurnal and resting loss as well as hot soak.

Since emissions testing under the two studies used different fuels, the test results had to be corrected for differences in fuel characteristics. First, staff made adjustments for variable RVP and ethanol content of tested fuels. Second, staff grouped the results according to engine technologies and horsepower group, where applicable. The following sections describe the process to standardize the test results so that results can be appropriately compared and analyzed.
RVP Adjustment

Evaporative emissions are influenced by the vapor pressure of the fuel. As a result, it is necessary to adjust teststo a reference level to facilitate comparisons among the results. Because ATL tests were conducted with a fuel RVP of 6.95 psi, this was used as the reference level.

ARB emissions tests were based on 3fuels: E0 with an RVP of 6.95 psi, E6 with 6.8 psi, and E10 with 6.53 psi. In order to adjust all fuels to the reference 6.95 psi basis, staff applied adjustment factors to ARB’s E6 and E10 results using the Reddy Equation through an empirical model developed by Dr. Sam Reddy named ReddyEvap:

http://evapconsulting.com/index.html

The ReddyEvap model was developed based on the testing of multiple on-road vehicles using different fuel blends and RVP combinations. Using this model, staff developed correction factors to correct ARB’s E6 and E10 test results to a reference of 6.95 psi, as shown in Table VI-4.

<table>
<thead>
<tr>
<th>RVP</th>
<th>Adjustment to 6.95 RVP</th>
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</thead>
<tbody>
<tr>
<td>E6 (6.8 psi)</td>
<td>1.06</td>
</tr>
<tr>
<td>E10 (6.53 psi)</td>
<td>1.18</td>
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</tbody>
</table>

Table VI-4: RVP Adjustment Based on ReddyEvap Model

Effect of Ethanol Content on Evaporative Emissions

Evaporative emissions factors are influenced by the ethanol content in the fuel. In California, ethanol-blended gasoline with ethanol content of 6 percent (E6) and ethanol content of 10 percent (E10) were introduced in 2004 and 2010, respectively. To evaluate the impact of ethanol content on evaporative emissions rates, staff conducted a statistical analysis after converting test results to 6.95 psi. After being standardized, results showed no significant difference between E6 and E10, but did show a difference between E0 and either E6 or E10. As a result, test results for E6 and E10 were combined and averaged together. Table VI-5 compares the ratio of evaporative emissions from E0 against E6 and E10 (combined E6 and E10 data are denoted as E6 in the table). While the range of ratio differences can span between -8 to 28 percent for hot soak and 12 to 40 percent for diurnal and resting losses, the average evaporative emissions for E6/E10 is about 9 percent higher for hot soak and 21 percent higher for diurnal and resting loss when compared to E0 fuel.
### Table VI-5: Effect of Ethanol on Hot Soak and Diurnal Emissions

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Fuel System</th>
<th>Hot Soak (g/event)</th>
<th>Diurnal/Resting (g/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>E0</td>
<td>E6</td>
</tr>
<tr>
<td>1995 Sea Doo XP PWC</td>
<td>CB</td>
<td>2.59</td>
<td>3.33</td>
</tr>
<tr>
<td>2000 Bayliner Capri 1750 Sterndrive</td>
<td>CB</td>
<td>7.82</td>
<td>8.31</td>
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<tr>
<td>2004 Polaris MSX150 Turbo PWC</td>
<td>FI</td>
<td>2.39</td>
<td>2.2</td>
</tr>
<tr>
<td>2005 Kawasaki STX-12F PWC</td>
<td>FI</td>
<td>0.57</td>
<td>0.62</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>1.09</td>
<td>1.21</td>
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</table>

#### Effect on Engine Technology

After the test data were adjusted for vapor pressure and fuel ethanol content, staff evaluated different types of engine technologies. The data show that CB engines have higher evaporative emissions than FI engines, due to CB engines having residual fuel remaining in the carburetor after use. As a result, test data were separated into CB and FI for each type of RW. In the case where there were not enough data to distinguish CB or FI, they are assumed to have the same emissions factor until more test data become available.

#### Effect on Fuel Tank Size

Staff also evaluated the relationship between evaporative emissions and fuel tank size. Using survey data from CSUS, staff calculated the average fuel tank size for each horsepower group based on survey responses from RW owners (second column, Table VI-6). As shown in the table, there is a reasonable correlation between average tank size and horsepower group. Therefore, engine horsepower could be used as a surrogate for the size of the fuel tank. While staff attempted to segregate the test data into different horsepower groups, the RW tested did not cover all ranges of horsepower groups. As a result, staff assumed emissions factors for horsepower less or equal to 175 are all the same, whereas the emissions factors for horsepower greater than 175 will be higher, where applicable.
### Table VI-6: Correlation of Fuel Tank Size and Horsepower

<table>
<thead>
<tr>
<th>Horsepower Group (Hp)</th>
<th>Fuel Tank Size (gal)</th>
<th>Sample Size</th>
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</thead>
<tbody>
<tr>
<td>0-2 Hp</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>2-5 Hp</td>
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</tr>
<tr>
<td>5-15 Hp</td>
<td>16.3</td>
<td>23</td>
</tr>
<tr>
<td>15-25 Hp</td>
<td>18.4</td>
<td>74</td>
</tr>
<tr>
<td>25-50 Hp</td>
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<td>50-120 Hp</td>
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<td>96</td>
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<tr>
<td>120-175 Hp</td>
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<td>175-250 Hp</td>
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<td>103</td>
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<td>250-500 Hp</td>
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<td>3</td>
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<tr>
<td>500+ Hp</td>
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</table>

**Evaporative Emissions Factors**

After adjusting raw test data to 6.95 psi, and separating data by ethanol content, fuel tank size, and engine technology, staff developed two sets of proposed evaporative emissions factors. Evaporative emissions factors were developed for E0 fuels which are applicable to CYs before 2004 (before the introduction of E6 fuel). For CY 2004 and beyond, evaporative emissions factors based on E6/E10 were developed. The emissions rates developed in our new analysis vary by SIMW type, horsepower group, and technology (see Tables VI-7 and VI-8). The new analysis also compared the baseline uncontrolled emissions factors, baseline with adopted U.S. EPA control in 2012, and ARB proposed control starting in 2018.
Table VI-7: Comparison of Diurnal and Resting Loss Emissions Factors

<table>
<thead>
<tr>
<th>Type</th>
<th>HP Group</th>
<th>Diurnal and Resting Loss (g/day)*</th>
<th>Baseline (Uncontrolled) Emission Factors</th>
<th>Baseline (w/U.S. EPA Control) Emission Factors</th>
<th>ARB Proposed Control*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CB</td>
<td>FI</td>
<td>CB</td>
<td>FI</td>
</tr>
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<td>17.1</td>
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<td>51 to 120</td>
<td>33.6</td>
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<td>17.1</td>
<td>11.6</td>
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<td>17.1</td>
<td>11.6</td>
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<td>26.4</td>
<td>17.1</td>
<td>11.6</td>
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<td>21.7</td>
<td>11.1</td>
<td>9.5</td>
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<td>17.9</td>
<td>15.4</td>
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<td>34.0</td>
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<td>14.9</td>
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<tr>
<td>Jet Drive/ PWC</td>
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<td>17.8</td>
<td>9.9</td>
<td>9.1</td>
<td>4.4</td>
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<td>9.9</td>
<td>9.1</td>
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<td>9.9</td>
<td>9.1</td>
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</table>

*For CY2018 and later
Table VI-8: Comparison of Hot Soak Emissions Factors

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<tr>
<th>Type</th>
<th>HP Group</th>
<th>Hot Soak (g/event)*</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline Uncontrolled Emission Factors</td>
<td>Baseline (w/ U.S. EPA Control) Emission Factors</td>
<td>ARB Proposed Control* Emission Factors</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CB</td>
<td>FL</td>
<td>CB</td>
<td>FL</td>
</tr>
<tr>
<td>Outboard</td>
<td>0 to 25</td>
<td>6.7</td>
<td>8.3</td>
<td>4.9</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>26 to 50</td>
<td>14.1</td>
<td>8.3</td>
<td>10.3</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>51 to 120</td>
<td>14.1</td>
<td>8.3</td>
<td>10.3</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>121 to 175</td>
<td>14.1</td>
<td>8.3</td>
<td>10.3</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>176 and higher</td>
<td>14.1</td>
<td>8.3</td>
<td>10.3</td>
<td>3.6</td>
</tr>
<tr>
<td>Inboard/ Auxiliary Sail</td>
<td>0 to 25</td>
<td>10.4</td>
<td>10.4</td>
<td>7.6</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>26 to 50</td>
<td>10.4</td>
<td>10.4</td>
<td>7.6</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>51 to 120</td>
<td>10.4</td>
<td>10.4</td>
<td>7.6</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>121 to 175</td>
<td>10.4</td>
<td>10.4</td>
<td>7.6</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>176 and higher</td>
<td>27.3</td>
<td>27.3</td>
<td>19.3</td>
<td>11.7</td>
</tr>
<tr>
<td>Sterndrive</td>
<td>0 to 25</td>
<td>7.5</td>
<td>7.5</td>
<td>5.5</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>26 to 50</td>
<td>7.5</td>
<td>7.5</td>
<td>5.5</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>51 to 120</td>
<td>7.5</td>
<td>7.5</td>
<td>5.5</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>121 to 175</td>
<td>7.5</td>
<td>7.5</td>
<td>5.5</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>176 and higher</td>
<td>12.3</td>
<td>12.3</td>
<td>9.0</td>
<td>5.3</td>
</tr>
<tr>
<td>Jet Drive/ PWC</td>
<td>0 to 25</td>
<td>6.6</td>
<td>3.0</td>
<td>4.8</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>26 to 50</td>
<td>6.6</td>
<td>3.0</td>
<td>4.8</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>51 to 120</td>
<td>6.6</td>
<td>3.0</td>
<td>4.8</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>121 to 175</td>
<td>6.6</td>
<td>3.0</td>
<td>4.8</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>176 and higher</td>
<td>6.6</td>
<td>3.0</td>
<td>4.8</td>
<td>1.3</td>
</tr>
</tbody>
</table>

*Note for CY2018 and later
D. ACTIVITY ANALYSIS

Developing an updated estimate of RW activity was a critical portion of this emissions inventory update. In 2009, CSUS conducted a survey of RW usage and related information under ARB contract. Only registered RW were selected for sampling. The survey collected 1,126 respondents by telephone. The main information used in calculating the annual activity estimates were: (1) the age of equipment at the time of the interview, (2) the number of operating days used in the last year, (3) the typical months per year when used, and (4) the hours per day during which the RW are typically used. The equation used to estimate the annual activity is:

\[
\text{Annual Activity} = \text{Number of Operating Days (per year)} \times \text{Typical Hours (per day)}
\]

The survey data was divided into six RW types and annual activity was calculated by age for each RW type. Since the sample sizes for PWC and jetdrive were small, staff combined both data for analysis.

Figures VI-2 to VI-6 illustrate the CSUS survey-based activity distribution by RW age. The figures show a high level of variability in the annual activity data ranging from high usage to no usage (some RW owners indicated that they had no activity over the past year). Because of the high spread in the data, it is difficult to establish a best fit curve with an acceptable fit. Staff attempted to use a regression fit, but the associated $R^2$ values were far too small. As a result, annual activity is estimated based on the average activity per each type of RW (dark black line in each plot).

As the 2009 survey was conducted in the beginning of the recent recession (around 2008), the annual activity is likely to be influenced by the economic conditions. The survey data may not reflect the annual activity for non-recession years. To reflect the change of activity with respect to economic conditions, additional surveys on a periodic basis will be needed to estimate a more representative annual activity.
Figure VI-3: Annual Activity of Outboard by Age

Figure VI-4: Annual Activity of Inboard by Age
Figure VI-5: Annual Activity of Sterndrive by Age

\[ y = -1.3827x + 67.617 \]
\[ R^2 = 0.0412 \]

Figure VI-6: Annual Activity of Sailboats with Auxiliary Engine by Age

\[ y = -1.0913x + 98.468 \]
\[ R^2 = 0.0174 \]
Figure VI-7: Annual Activity of PWC/Jet DriveSIMW by Age

$y = -0.3551x + 48.044$

$R^2 = 0.0018$
E. TEMPERATURE/REID VAPOR PRESSURE CORRECTION

The following is an illustrative example of correcting the test data to different local temperature and fuel RVP conditions.

As indicated in the main report text, note that the vapor model was developed for vehicles without sealed tanks or pressure relief valves, but can be adapted for SIMW. The amount of vapor restricted from venting to the atmosphere will depend on the setting of the pressure relief valve.

Specifically, U.S. EPA estimates that the range of pressure relief valve installed on PWC varies from 0.5 to 4.0 psi. Reddy and U.S. EPA both assessed the impact of a 1.0psi pressure relief valve on vapor generation, with both concluding that a 1.0psi valve would reduce vapor generation by about 0.7 grams per gallon vapor space. This would apply to different temperature and RVP conditions, as the pressure relief valve operates at the same threshold regardless of the conditions under which vapor was generated (although the relative reduction may be quite different). Using the Reddy equation, staff assumes a 1.0psi “trigger” for pressure relief valves and corrects the existence of a pressure relief valve by subtracting 0.7 grams/gallon off of the uncontrolled vapor generation rate.

Figure VI-7 provides the sample calculation used in developing the RVP/Temp correction applied to diurnal test data which were conducted over 24 hours from 65°F to 105°F and back to 65°F. As shown in the spreadsheet, vapor generation, hose permeation, and tank permeation were estimated by Reddy’s equations based on a typical fuel tank of 25 gallons. The diurnal emissions are the sum of vapor generation and half of the total permeation whereas the resting emissions are half of the total permeation.

Different local temperatures and RVPs were then used to calculate the diurnal and resting loss emissions. Finally, RVP/Temperature corrections were developed based on diurnal and resting loss emissions normalized using 65°F to 105°F data as a reference.
Figure VI-2: Sample Calculation of Temperature/RVP Correction

**Typical Outboard fuel tank and hose**

### Vapor Generation

<table>
<thead>
<tr>
<th>Input</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tmin</td>
<td>65 F</td>
</tr>
<tr>
<td>Tmax</td>
<td>105 F</td>
</tr>
<tr>
<td>RVP</td>
<td>7 psi</td>
</tr>
<tr>
<td>Tank Size</td>
<td>25 gallons</td>
</tr>
<tr>
<td>Fill (%)</td>
<td>0.50</td>
</tr>
<tr>
<td>Vapor generation</td>
<td>2.07 g/gal</td>
</tr>
<tr>
<td>Vapor per day</td>
<td>25.85 g/day</td>
</tr>
</tbody>
</table>

### Reddy Coefficients

\[
\begin{align*}
A = 0.00875 \\
B = 0.2056 \\
C = 0.043 \\
\end{align*}
\]

(10% ethanol, sea level)

Assume tank has pressure relief valve of 1 psi and need to subtract 0.7 g/gal

\[
\text{Vapor generated (g/gal) = A} \times \exp(B \times \text{RVP}) \times (\exp(C \times \text{Tmax}) - \exp(C \times \text{Tmin})) - 0.7
\]

\[
\text{Vapor generated (grams) = Vapor (g/gallon vapor space) \times Fuel Capacity (gal) \times (1 - Fill \%)}
\]

\[
\text{Temp Correction} = 0.03788519 \times \exp(0.03850818 \times \text{T}) \text{ relative to 85 F}
\]

\[
S.A. = \sqrt{\frac{(\text{TANK SIZE} + 2T) \text{T}}{4}} - 1
\]

**Tank Permeation**

<table>
<thead>
<tr>
<th>Base EF</th>
<th>10.70 g/m2/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp Correction at Tmin</td>
<td>0.46 F</td>
</tr>
<tr>
<td>Temp Correction at Tmax</td>
<td>2.16 F</td>
</tr>
<tr>
<td>Ave Temp Correction</td>
<td>1.31 F</td>
</tr>
<tr>
<td>Adjusted EF</td>
<td>14.0 g/m2/day</td>
</tr>
<tr>
<td>Tank Surface Area (S.A.)</td>
<td>2.02 m2</td>
</tr>
<tr>
<td>Final Emissions</td>
<td>28.34 g/day</td>
</tr>
</tbody>
</table>

**Hose Permeation**

<table>
<thead>
<tr>
<th>Base EF</th>
<th>222.00 g/m2/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp Correction at Tmin</td>
<td>0.73 F</td>
</tr>
<tr>
<td>Temp Correction at Tmax</td>
<td>3.43 F</td>
</tr>
<tr>
<td>Ave Temp Correction</td>
<td>2.08 F</td>
</tr>
<tr>
<td>Adjusted EF</td>
<td>462.19 g/m2/day</td>
</tr>
<tr>
<td>Hose Surface Area</td>
<td>0.32 m2</td>
</tr>
<tr>
<td>Final Emissions</td>
<td>147.90 g/day</td>
</tr>
</tbody>
</table>

**Total Emission**

\[
\begin{align*}
\text{Total Emission} = & \text{Tank Permeation} + \text{Hose Permeation} \\
\text{Diurnal} = & \text{Vapor generation} + 0.5(\text{Total Permeation}) \\
\text{Resting} = & 0.5(\text{Total Permeation})
\end{align*}
\]

**Total Permeation**

\[
\text{Total Permeation} = \text{Tank Permeation} + \text{Hose Permeation}
\]

**Diurnal**

\[
\begin{align*}
\text{Diurnal} = & \text{Vapor generation} + 0.5(\text{Total Permeation})
\end{align*}
\]

**Resting**

\[
\begin{align*}
\text{Resting} = & 0.5(\text{Total Permeation})
\end{align*}
\]

### Local Temp and Fuel RVP

<table>
<thead>
<tr>
<th>RVP</th>
<th>Tmin</th>
<th>Tmax</th>
<th>Vapor Generation</th>
<th>Tank Permeation</th>
<th>Hose Permeation</th>
<th>Total</th>
<th>Diurnal</th>
<th>Resting Loss</th>
<th>Temp/RVP Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>65</td>
<td>105</td>
<td>25.85</td>
<td>28.34</td>
<td>147.90</td>
<td>202.09</td>
<td>113.97</td>
<td>88.12</td>
<td>1.00</td>
</tr>
<tr>
<td>7.8</td>
<td>73.7</td>
<td>86.7</td>
<td>0.94</td>
<td>18.53</td>
<td>96.69</td>
<td>116.16</td>
<td>58.55</td>
<td>57.61</td>
<td>0.51</td>
</tr>
<tr>
<td>7.8</td>
<td>53.8</td>
<td>70.2</td>
<td>0.00</td>
<td>9.36</td>
<td>48.85</td>
<td>58.21</td>
<td>29.11</td>
<td>29.11</td>
<td>0.26</td>
</tr>
<tr>
<td>7.8</td>
<td>72.1</td>
<td>90.7</td>
<td>6.04</td>
<td>20.03</td>
<td>104.53</td>
<td>130.60</td>
<td>68.32</td>
<td>62.28</td>
<td>0.60</td>
</tr>
<tr>
<td>7.8</td>
<td>71.4</td>
<td>89.7</td>
<td>5.27</td>
<td>19.35</td>
<td>100.97</td>
<td>125.59</td>
<td>65.43</td>
<td>60.16</td>
<td>0.57</td>
</tr>
<tr>
<td>7.8</td>
<td>75.7</td>
<td>93.4</td>
<td>7.33</td>
<td>22.48</td>
<td>117.33</td>
<td>147.14</td>
<td>77.24</td>
<td>69.91</td>
<td>0.68</td>
</tr>
</tbody>
</table>
F. STORAGE EFFECT FOR ACTIVE SIMW

As described in earlier sections, diurnal and resting loss emissions are measured from a gasoline-powered SIMW stored inside a SHED over a specific 24-hour temperature profile. Processes such as fuel tank vapor displacement during diurnal heating, tank or hose permeation, and transient CB fuel bowl drying are all associated with emissions measured during diurnal and resting loss.

Historically, diurnal and resting loss emissions factors for SIMW were based on a 3-day average of diurnal and resting loss tests. However, from the diurnal and resting loss emissions results from 30 SIMW, staff noticed that the emissions rate followed a consistent trend where day 1 was higher than day 2, while day 2 was higher than day 3. The survey data from CSUS also indicated that the average time between SIMW usages is about 3 to 4 weeks. Generally speaking, SIMW are used much less frequently than commuter cars or commercial equipment and there are long periods between uses. Thus, the 3-day average emissions factors for diurnal and resting loss may overestimate the diurnal and resting loss emissions as the time between each usage is over 3 weeks (24 days) instead of 3 days.

Correction factors were developed to adjust 3-day data to the 24-day period representative of average SIMW usage. More specifically, a CB sterndrive, a FI outboard SIMW, and a CB PWC were tested over a prolonged period ranging from 11 days to 20 days (the duration was dependent upon the number of days the test SIMW was available). To estimate the diurnal resting loss effects with respect to time and temperature, staff tested the SIMW based on an average Los Angeles temperature profile that starts at 65°F, peaks at 82°F, then returns to 65°F. Figures VI-8 to VI-10 show that over multi-day to multi-week periods daily diurnal and resting loss emissions all decline with respect to time and eventually reach a steady state after 2 or 3 weeks. To create a profile dataset that matches the average 24 day period of inactivity indicated from the CSUS survey, staff extrapolated the measured evaporative emissions data as needed to create 24 day profiles.
Figure VI-9: Multi-Day Evaporative Emissions for Sterndrive

Figure VI-10: Multi-Day Evaporative Emissions for Outboard
From the measured and extrapolated results from these 3SIMW, staff determined the average emissions rate over 3 days and over 24 days. Staff then divided the 24-day average over the 3-day average to come up with the correction factor. The correction factor was then applied to the baseline emissions factor for diurnal and resting loss. As shown in Table VI-9, the average correction factors for sterndrive, outboard, and PWCs are 0.76, 0.67, and 0.74, respectively. Instead of applying the correction factor individually to each SIMW type, staff decided to take the average which is 0.72.

### Table VI-9: Between-Use Storage Correction Factors for Active SIMW

<table>
<thead>
<tr>
<th>Boat Type</th>
<th>Fuel System</th>
<th>Size of Fuel Tank (gal)</th>
<th>3-day Avg (g/day)</th>
<th>24-day Avg (g/day)</th>
<th>Correction Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sterndrive</td>
<td>Carb</td>
<td>32</td>
<td>8.4</td>
<td>6.3</td>
<td>0.76</td>
</tr>
<tr>
<td>PWC</td>
<td>Carb</td>
<td>8</td>
<td>6.4</td>
<td>4.3</td>
<td>0.67</td>
</tr>
<tr>
<td>Outboard</td>
<td>FI</td>
<td>20</td>
<td>7.4</td>
<td>5.5</td>
<td>0.74</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.72</td>
</tr>
</tbody>
</table>
G. WEATHERING EFFECT FOR INACTIVE SIMW

In OFFROAD2007, evaporative emissions (diurnal and resting loss) were based on the assumption that the emissions rate remains constant throughout all 365 days of the year for inactive SIMW. This is tantamount to assuming that the ambient temperature extremes remain constant, and that the liquid-phase composition is constant (no depletion of volatile components or weathering). While such an assumption may be reasonable for active SIMW, which are refueled more frequently throughout the year, it may not be applicable for inactive SIMW, since they are more likely to be stored for many months without activity or refueling. Consequently, a different approach is needed to estimate the evaporative emissions (diurnal and resting loss) from inactive SIMW. Below, a simplified model which estimates evaporative emissions of hydrocarbons based on a 50 percent filled 5-gallon fuel tank is described. Results from this analysis are used to create a weathering “adjustment factor” for inactive SIMW.

Mass Balance Calculation of Fuel Tank Based on Vapor Liquid Equilibrium (VLE)

Based on the principle of vapor-liquid equilibrium (VLE), staff estimated the daily loss of emissions in an uncontrolled fuel tank (i.e., where gasoline vapor is not restricted from leaving the fuel tank).

Instead of including all gasoline species in the vapor-liquid mass balance, staff simplified the mass balance calculation by selecting 12 major components in the gasoline. With this method, the vapors expelled from the tank are assumed to be saturated (in equilibrium with the liquid). The volatilized components are deducted from the liquid phase and a new vapor-liquid equilibrium is established the next day.

Two scenarios were used: 50 percent full with MTBE gasoline; or 50 percent full with 0 percent ethanol (E0) fuel. In both cases, the density of the gasoline is assumed to be 6.2 lbs/gallon with 7 psi RVP. Staff also used the minimum and maximum of average monthly temperature to reflect the change of average daily conditions in Los Angeles County (see Table VI-10).
Table VI-10: Average Temperature Range in Los Angeles County

<table>
<thead>
<tr>
<th>Month</th>
<th>Min. Temp (F)</th>
<th>Max. Temp (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>49.1</td>
<td>65</td>
</tr>
<tr>
<td>Feb</td>
<td>49.6</td>
<td>65.1</td>
</tr>
<tr>
<td>Mar</td>
<td>51.2</td>
<td>66.9</td>
</tr>
<tr>
<td>Apr</td>
<td>52.4</td>
<td>67.7</td>
</tr>
<tr>
<td>May</td>
<td>57.1</td>
<td>72.8</td>
</tr>
<tr>
<td>Jun</td>
<td>60.7</td>
<td>76.6</td>
</tr>
<tr>
<td>Jul</td>
<td>64.8</td>
<td>82</td>
</tr>
<tr>
<td>Aug</td>
<td>64.6</td>
<td>82.9</td>
</tr>
<tr>
<td>Sep</td>
<td>63.2</td>
<td>80.8</td>
</tr>
<tr>
<td>Oct</td>
<td>58.6</td>
<td>74.8</td>
</tr>
<tr>
<td>Nov</td>
<td>53.6</td>
<td>69.8</td>
</tr>
<tr>
<td>Dec</td>
<td>48.8</td>
<td>64.6</td>
</tr>
</tbody>
</table>

To model the depletion of volatile species, staff applied the VLE mass balance on the 12 major component species of gasoline. As a result of daily rise of temperature, the light ends of the gasoline species (largely butane) that have lower boiling points are predicted to evaporate first. It was assumed that the vapor volume calculated beyond the tank capacity was emitted.

A constant temperature range is assumed for each month. It is also assumed that the decline in emissions during the month is due to evaporative “weathering” of the volatile species. The variation from month to month is due to the range of temperatures at different seasons. The VLE method estimated the average emissions per month starting from July and lasted for 12 months. As seen in Table VI-10, the average emissions rate is higher during summer, lower during winter, and it rises again during spring. The VLE method estimated the sequential day-by-day emissions and composition change for each month’s average temperature “swing” or range. As seen in Figure VI-11 the emissions rates versus time have a “U” shape which follows the seasonal temperatures. But each step of the “U” is slightly slanted downward. This is the slowing of the evaporative rate due to preferential vaporization of light components (weathering).
To calculate a weathered versus unweathered adjustment factor, results were estimated based on 2 temperature profiles: LA County (also presented in Table VI-11), and the previous profile of 65°F to 105°F. The “weathered” (including VLE) and “unweathered” (not including VLE) results are provided below in Table VI-11. Based on the Los Angeles County temperature profile, the annual “weathered” emissions over 12 months are 385 g/year, which is 2.7 percent of the liquid gasoline in the fuel tank. The annual emissions from “unweathered” rate are 737 g/year (assuming 2.03 g/day x 365 day/year). Thus, the annual emissions calculated from VLE mass balance is about 53 percent of the “unweathered” calculation. The adjustment factor for this weathering and temperature profile is 0.53. Based on the VLE (weathered) mass balance over 365 days of temperature profile at 65°F to 105°F, the annual emissions are 1,870 g/year. However, the annual emissions from “unweathered” rate are 2,900 g/year (assuming 7.94 g/day x 365 days/year). The adjustment factor for this weathering and temperature profile is 0.64 (Table VI-11).

Table VI-11: Emissions Estimated from Weathered and Unweathered Conditions

<table>
<thead>
<tr>
<th>Temp Profile</th>
<th>Method</th>
<th>g/yr</th>
<th>gal/yr</th>
<th>% of 5 gal tank</th>
<th>Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA County</td>
<td>Weathered (VLE mass balance)</td>
<td>385</td>
<td>0.14</td>
<td>2.7%</td>
<td>0.53</td>
</tr>
<tr>
<td>(12 months)</td>
<td>Unweathered</td>
<td>737</td>
<td>0.26</td>
<td>5.2%</td>
<td></td>
</tr>
<tr>
<td>65 to 105°F</td>
<td>Weathered (VLE mass balance)</td>
<td>1,870</td>
<td>0.66</td>
<td>13.0%</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>Unweathered</td>
<td>2,900</td>
<td>1.03</td>
<td>20.6%</td>
<td></td>
</tr>
</tbody>
</table>
In conclusion, while not all fuel tanks for inactive SIMW are “open” systems, it is likely that a majority of such inactive SIMW contain fuel tanks that are not fully sealed due to deterioration. Thus, it is assumed the approach described in this attachment can be used to estimate the weathering effect on emissions rates for inactive SIMW. Staff recommends that an adjustment factor of 0.53 to be applied to correct statewide annual emissions, since it is based on month-to-month changes of ambient temperature in LA County over 12 months.
H. DETAILED BREAKDOWN OF EVAPORATIVE EMISSIONS BENEFITS

Table VI-12 presents the emissions benefits for state and local districts for 2020, 2023, and 2035. These specific years were chosen for SIP comparison purposes.

Table VI-12: ROG and NOx Emissions Benefits for State and Local Districts (TPD)

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bay Area AQMD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot Soak</td>
<td>1.90</td>
<td>1.88</td>
<td>0.02</td>
<td>1.75</td>
<td>1.71</td>
<td>0.04</td>
<td>1.36</td>
<td>1.23</td>
<td>0.13</td>
</tr>
<tr>
<td>Diurnal &amp; Resting</td>
<td>15.03</td>
<td>14.90</td>
<td>0.13</td>
<td>13.96</td>
<td>13.66</td>
<td>0.30</td>
<td>10.86</td>
<td>9.95</td>
<td>0.93</td>
</tr>
<tr>
<td>Running Loss</td>
<td>6.02</td>
<td>6.02</td>
<td>0.00</td>
<td>5.75</td>
<td>5.75</td>
<td>0.00</td>
<td>4.79</td>
<td>4.79</td>
<td>0.00</td>
</tr>
<tr>
<td>Exhaust</td>
<td>106.54</td>
<td>106.54</td>
<td>0.00</td>
<td>92.42</td>
<td>92.42</td>
<td>0.00</td>
<td>55.90</td>
<td>55.90</td>
<td>0.00</td>
</tr>
<tr>
<td>ROG (total)</td>
<td>129.48</td>
<td>129.33</td>
<td>0.00</td>
<td>113.87</td>
<td>113.53</td>
<td>0.34</td>
<td>72.93</td>
<td>71.87</td>
<td>1.06</td>
</tr>
<tr>
<td>NOx</td>
<td>24.74</td>
<td>24.74</td>
<td>0.00</td>
<td>23.90</td>
<td>23.90</td>
<td>0.00</td>
<td>22.06</td>
<td>22.06</td>
<td>0.00</td>
</tr>
</tbody>
</table>

| SJV APCD          |               |                     |         |               |                     |         |
| Hot Soak          | 0.34          | 0.34                | 0.00    | 0.32          | 0.31                | 0.01    | 0.25          | 0.22                | 0.02    |
| Diurnal & Resting | 2.92          | 2.90                | 0.03    | 2.71          | 2.66                | 0.06    | 2.12          | 1.93                | 0.18    |
| Running Loss      | 1.09          | 1.09                | 0.00    | 1.04          | 1.04                | 0.00    | 0.87          | 0.87                | 0.00    |
| Exhaust           | 19.22         | 19.22               | 0.00    | 16.69         | 16.69               | 0.00    | 10.14         | 10.14               | 0.00    |
| ROG (total)       | 23.57         | 23.54               | 0.03    | 20.76         | 20.69               | 0.07    | 13.37         | 13.16               | 0.20    |
| NOx               | 4.49          | 4.49                | 0.00    | 4.34          | 4.34                | 0.00    | 4.01          | 4.01                | 0.00    |

| SCAQMD            |               |                     |         |               |                     |         |
| Hot Soak          | 0.30          | 0.30                | 0.00    | 0.28          | 0.27                | 0.01    | 0.22          | 0.20                | 0.02    |
| Diurnal & Resting | 3.15          | 3.12                | 0.03    | 2.92          | 2.86                | 0.06    | 2.28          | 2.08                | 0.20    |
| Running Loss      | 0.96          | 0.96                | 0.00    | 0.91          | 0.91                | 0.00    | 0.76          | 0.76                | 0.00    |
| Exhaust           | 16.92         | 16.92               | 0.00    | 14.70         | 14.70               | 0.00    | 8.96          | 8.96                | 0.00    |
| ROG (total)       | 21.33         | 21.30               | 0.03    | 18.82         | 18.75               | 0.07    | 12.22         | 12.00               | 0.22    |
| NOx               | 3.96          | 3.96                | 0.00    | 3.82          | 3.82                | 0.00    | 3.53          | 3.53                | 0.00    |
I. INSTALLATION AND USER GUIDE

- Download Instructions and Computer Specifications:
  - Zip: Use any zipping utility to unzip the file. Most operating systems like Windows come with a utility like ‘WinZip’. Others can be downloaded off the internet along with their user guides.
  - Computer Requirements: Your computer needs to have sufficient memory to store and run the model (these requirements are fairly small). Unzipped, the file will be about 1.2GB. When running the model it can grow up to 2.0GB. Model runtimes can vary depending on the processing power of the computer. Estimates are provided in the user interface.
  - Microsoft Access: The RWemissions inventory model runs as an Microsoft Access database file. The model was developed in Microsoft Access 2010. Previous versions of Access may not support all the model functionality.
  - Download Warnings: When the database is first loaded onto the computer, Microsoft Access will warn the user of possible unsafe code in the program. It is important to allow the program to open without any restrictions. **This means selecting options when Microsoft Access opens that ENABLE the program content** (if prompted with a warning such as ‘Do you want to allow Access to open with these unsafe expressions’ CLICK YES, OPEN, or ENABLE).
    - Microsoft Access allows a user to define security restrictions that will apply to every file on a user’s computer. If security restrictions have been set too restrictively, Access will not allow the Emissions Inventory model to open or run properly. The user might need to change the settings in the “Trust Center.” Information about having the proper settings for Microsoft Access are available on Microsoft’s website (1common setting is having the macro setting that does not inform the user when content has been blocked, in this case the question above will not come up).
  - *Note: allow a couple minutes for the model to compact itself when closing Access, this is an important step in managing space. If the model becomes unstable (errors or warnings), close the form then close Access and reopen. If problems persist, the model might be corrupt and a new version can be downloaded from the ARBwebsite.
Model Functionality (instructions also available within the model):

User Interface

When the model is opened, the main user interface opens (below). From here the user can choose to use 2 parts of the model: “Emissions Summary” or “Run Model.”
Emissions Summary

Clicking this button navigates to the “Emissions Summary” page (below) and estimates California RW emissions for any combination of equipment type, fuel type, status, horsepower, MY, CY, season, and/or region for baseline or regulation emissions.

Running the Emissions Summary by MY dramatically increases the runtime and restricts the user to selecting 1 region at a time. Equipment and fuel types must be selected with MY requests.

Run Model

The "Run Model" window is only used to run a simulation of the model (below). READ ALL THE INSTRUCTIONS ON THIS PAGE BEFORE USING THE RUN MODEL PROGRAM. This portion of the model is not for viewing the emissions inventory. Running the model recreates emissions from scratch. This is not necessary as the model comes with emissions already loaded and available through the Emissions Summary window.
Run Model

Emissions Information

Do not run this model to retrieve Pleasure Craft emissions.
Clicking 'Run Model' below will RECREATE the emissions inventory from scratch.
Go to 'Emissions Summary' from the main menu for Pleasure Craft emissions.

Instructions

Running the Pleasure Craft model will increase the size of the database dramatically. It is necessary to manually delete some tables and then close Access to compact the size before running the model. If you want to keep these tables, make a copy of this Access file and proceed deleting the tables in one of the versions conserving the original tables in the other. Uncheck 'Delete Intermediate Tables' to save all intermediate tables the model generates. These tables are intermediate steps and are usually irrelevant.

Delete Tables

Delete the following tables under 'Unassigned Objects' to the left:

1005 TPD allocated _T
1007 emission percentage _T

If Intermediate tables exist from a previous model run, delete:

1002 POP2 with Anl Act _T

If you have ran an Emissions Summary that is very large, you may need to delete the table 'Emissions Results'. When 'Run Model' is clicked, the model will check size requirements for you.

Now close Access to compact the size

<- Back  Run Model  Delete Intermediate Tables?
Model Code

The code of the model can be viewed at the following location:
Under main menu, click tab “Database Tools”, then click on the second selection
“Visual Basic”, depends on viewer’s needs, double click on “Form_FormMain” or
“Form_FormRunModel” or “Form_Portal” on the left side of the screen to see the
code of the model.

Please read all instructions provided in the model including this user guide. If
there is still any confusion, feel free to contact the Mobile Source Analysis
Branch at mseii@arb.ca.gov.
J. SOURCE CODE OF PC2014

Option Compare Database

'initialized global table names, column names, form names, etc.
'initialize for variable names (fuel comun name = "asdkjfhak")
'Put brackets around EVERYTHING
'Form Objects
Public glb_ChooseBoxName, glb_ListBoxName, glb_otherList1, glb_otherList2, glb_LookupTable, glb_ColumnName As String
Public glb_OptionName As String
'Form Lookup Tables
Public glb_FrmTblEquipType, glb_FrmTblFuel, glb_FrmTblCalYr, glb_FrmTblMdYr, glb_FrmTblSeason As String
Public glb_FrmTblAirBasin, glb_FrmDist, glb_FrmCounty, glb_FrmStatus, glb_FrmHHP As String
'Access Tables
Public glb_EmissionsTable, glb_EmissionsResults As String
Public glb_FldEquipType, glb_FldFuel, glb_FldCalYr, glb_FldMdYr, glb_FldSeason As String
Public glb_FldAirBasin, glb_FldDist, glb_FldCounty, glb_FldStatus, glb_FldHHP As String
Public glb_Validation As Boolean
'Region limit
Public glb_regionLimit As Integer
'SQL statement
Public SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
Private SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
Private Sub Form_Open(Cancel As Integer)
End Sub
Private Sub Form_Open(Cancel As Integer)
End Sub
Public SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
Private SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
Public SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
Private SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
Public SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
Private SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
Public SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
Private SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
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Private SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
Public SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
Private SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
Public SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
Private SQLS, SelectS, SumS, IntoFromS, GroupByS, HavingS, InnerJoinS As String
Public SQLS, SelectS, SumS, IntoFromS, GroupByG
Dim rstSumFields As dao.Recordset
Dim dbs As dao.Database
Dim strSumField, strMYField, strFNameField As String
Dim glb_ListBoxName As String
Dim glb_CheckBoxName As String
Dim glb_Validation As Boolean
Dim SelectS As String
Dim Me As Object

If glb_Validation = True Then
    Exit Function
End If

If glb_Validation = False Then
    Exit Function
End If

If Me.CheckBaseline = True Then
    Set rstSumFields = dbs.OpenRecordset("Summation1")
    ' Summation 1
    While Not rstSumFields.EOF
        strSumField = rstSumFields.Fields("[Fields to Sum]").Value
        If Me.CheckModelYear = False Then
            SelectS = SelectS & " Sum([" & glb_EmissionsTable & "].[" & strSumField & "] AS [SumOf_ & strFNameField & "]], ";
        ElseIf Me.CheckModelYear = True Then
            SelectS = SelectS & " Sum([" & glb_EmissionsTable & "].[" & strSumField & "]*" & glb_ModelYearTable & "].[" & strMYField & "] AS [SumOf_ & strFNameField & "]], ";
        End If
        rstSumFields.MoveNext
    Wend
    rstSumFields.Close
    Set rstSumFields = Nothing
End If

If Me.CheckRule = True Then
    Set rstSumFields = dbs.OpenRecordset("Summation2")
    ' Summation 2
    While Not rstSumFields.EOF
        strSumField = rstSumFields.Fields("[Additional Pollutants]").Value
        If Me.CheckModelYear = False Then
            SelectS = SelectS & " Sum([" & glb_EmissionsTable & "].[" & strSumField & "] AS [SumOf_ & strFNameField & "]], ";
        ElseIf Me.CheckModelYear = True Then
            SelectS = SelectS & " Sum([" & glb_EmissionsTable & "].[" & strSumField & "]*" & glb_ModelYearTable & "].[" & strMYField & "] AS [SumOf_ & strFNameField & "]], ";
        End If
        rstSumFields.MoveNext
    Wend
    rstSumFields.Close
    Set rstSumFields = Nothing
End If

If Me.CheckBaseline = False Then
    Exit Function
End If

If Me.CheckRule = False Then
    Exit Function
End If

SelectS = "SELECT "
SelectS = SelectS & " [" & glb_SumField & "] & & " & glb_FldCalYr & "] AS [SumOf_ & strFNameField & "]], ";
Just precautious, these shouldn't be anything
SelectS = SelectS & ";"
Set rstSumFields = Nothing
Set dbs = Nothing
Set dbs = CurrentDb()
If Me.CheckBaseline = True Then
    ' Summation 1
    Set rstSumFields = dbs.OpenRecordset("Summation1")
    rstSumFields.MoveFirst
    While Not rstSumFields.EOF
        strSumField = rstSumFields.Fields("[Fields to Sum]").Value
        strMYField = rstSumFields.Fields("[ModelYearField]").Value
        strFNameField = rstSumFields.Fields("[FinalName]").Value
        If Me.CheckModelYear = False Then
            SumS = SumS & " Sum([" & glb_EmissionsTable & "].[" & strSumField & "] AS [SumOf_ & strFNameField & "]], ";
        ElseIf Me.CheckModelYear = True Then
            SumS = SumS & " Sum([" & glb_EmissionsTable & "].[" & strSumField & "]*" & glb_ModelYearTable & "].[" & strMYField & "] AS [SumOf_ & strFNameField & "]], ";
        End If
        rstSumFields.MoveNext
    Wend
    rstSumFields.Close
    Set rstSumFields = Nothing
End If

If Me.CheckRule = True Then
    ' Summation 2
    Set rstSumFields = dbs.OpenRecordset("Summation2")
    rstSumFields.MoveFirst
    While Not rstSumFields.EOF
        strSumField = rstSumFields.Fields("[Additional Pollutants]").Value
        If Me.CheckModelYear = False Then
            SumS = SumS & " Sum([" & glb_EmissionsTable & "].[" & strSumField & "] AS [SumOf_ & strFNameField & "]], ";
        ElseIf Me.CheckModelYear = True Then
            SumS = SumS & " Sum([" & glb_EmissionsTable & "].[" & strSumField & "]*" & glb_ModelYearTable & "].[" & strMYField & "] AS [SumOf_ & strFNameField & "]], ";
        End If
        rstSumFields.MoveNext
    Wend
    rstSumFields.Close
    Set rstSumFields = Nothing
End If

If Me.CheckRule = False Then
    Exit Function
End If
'CheckCounty
  gb_OptionName = "OptionCounty"
gb_ListBoxName = "ListCounty"
gb_LookupTable = gb_FrmTblCounty
gb_ColumnName = gb_FldCounty
gb_EmissionsTable = gb_FrmTblCounty
VariableSelection
gb_EmissionsTable = DLookup("[Master Table (Yours)]", "References", "ID = 1")
'End county
  Just easier to hardcore checkboxes at this point
RegionCheckBoxes
  'Equipment Type
    gb_CheckBoxName = "CheckEquipmentType"
gb_ListBoxName = "ListEquipmentType"
gb_LookupTable = gb_FrmTblEquipType
    gb_ColumnName = gb_FldEquipType
gb_EmissionsTable = gb_FrmTblEquipType
VariableSelection
gb_EmissionsTable = DLookup("[Master Table (Yours)]", "References", "ID = 1")
''''end equipment type
  'Fuel Type
    gb_CheckBoxName = "CheckFuelType"
gb_ListBoxName = "ListFuel"
gb_LookupTable = gb_FrmTblFuel
    gb_ColumnName = gb_FldFuel
gb_EmissionsTable = gb_FrmTblFuel
VariableSelection
gb_EmissionsTable = DLookup("[Master Table (Yours)]", "References", "ID = 1")
''''end fuel
  'Status
    gb_CheckBoxName = "CheckStatus"
gb_ListBoxName = "ListStatus"
gb_LookupTable = gb_FrmTblStatus
    gb_ColumnName = gb_FldStatus
gb_EmissionsTable = gb_FrmTblStatus
VariableSelection
gb_EmissionsTable = DLookup("[Master Table (Yours)]", "References", "ID = 1")
'End status
  'HP
    gb_CheckBoxName = "CheckHP"
gb_ListBoxName = "ListHP"
gb_LookupTable = gb_FrmTblHP
    gb_ColumnName = gb_FldHP
VariableSelection
  'ModelYear
    gb_CheckBoxName = "CheckModelYear"
gb_ListBoxName = "ListModelYear"
gb_LookupTable = gb_FrmTblMdlYr
    gb_ColumnName = gb_FldMdlYr
gb_EmissionsTable = gb_ModelYearTable
VariableSelection
gb_EmissionsTable = DLookup("[Master Table (Yours)]", "References", "ID = 1")
'End MY
'Additional_Pollutants
  'Need placeholder in groupby statement-only for model year runs
If Me.CheckModelYear = True Then
  If Me.CheckBaseline = True Then
    Set rstSumFields = dbs.OpenRecordset("Summation3")
    rstSumFields.MoveFirst
    While Not rstSumFields.EOF
      GroupByS = GroupByS & " CDbl(0), "
      rstSumFields.MoveNext
    Wend
    rstSumFields.Close
    Set rstSumFields = Nothing
  End If
  If Me.CheckRule = True Then
    Set rstSumFields = dbs.OpenRecordset("Summation3")
    rstSumFields.MoveFirst
    While Not rstSumFields.EOF
      GroupByS = GroupByS & " CDbl(0), "
      rstSumFields.MoveNext
    Wend
    rstSumFields.Close
  End If
End If
Set dbs = Nothing
'Finalize SQL statement
  SumS = Left(SumS, Len(SumS) - 2) & " "
  GroupByS = Left(GroupByS, Len(GroupByS) - 2) & " "
  HavingS = HavingS & ");"
  SQLS = SelectS & SumS & IntoFromS & InnerJoinS & GroupByS & HavingS & ";"
If glb_Validation = True Then
  DoCmd.SetWarnings False
  DoCmd.RunSQL SQLS
  SQLS = ""
  SelectS = ""
  SumS = ""
  IntoFromS = ""
  GroupByS = ""
  HavingS = ""
Having s = "" 
InnerJoin s = "" 
If Me.CheckModel.Year.Value = True Then 
AdditionalPollutants = False 
End If 
DoCmd.SetWarnings True 
DoCmd.OpenTable "gb_EmissionsResults" 
ElseIf gb_Validation = False Then 
SQLS = "" 
SelectReCt = "" 
SumS = "" 
IntoFromS = "" 
GroupByS = "" 
HavingS = "" 
InnerJoinS = ""
End If 
End Function 
Public Sub AddPollutants() 
If Me.CheckBaseline.Value = True And Me.CheckRule.Value = True Then 
DoCmd.RunSQL "UPDATE EmissionsResults INNER JOIN FRACTIONSx11 ON (EmissionsResults.CY = FRACTIONSx11.CY) AND (EmissionsResults.CATEGORY = FRACTIONSx11.CATEGORY) SET EmissionsResults.[SUMOF THC_Total-Baseline] = [EmissionsResults].[SUMOF ROG_Total-Baseline] + [EmissionsResults].[SUMOF TOG_Total-Baseline] + [EmissionsResults].[SUMOF PM_Total-Baseline] + [EmissionsResults].[SUMOF HC_Total-Baseline]
ElseIf Me.CheckBaseline = True And Me.CheckRule.Value = False Then 
(12.011/(12.011+0.54*1.008)*[EmissionsResults].[SUMOF TOG_Exhaust-Baseline] - [EmissionsResults].[SUMOF TOG_Evap-Baseline]) *
ElseIf glb_Validation = False Then 
HavingS = ""
SQLS = ""
SelectReCt = ""
SumS = ""
IntoFromS = ""
GroupByS = ""
HavingS = ""
InnerJoinS = ""
End If 
End Function
Dim VarItem As Variant
Dim lstGUI As ListBox
Dim optGUI As OptionButton
Dim chkGUI As CheckBox

' Variables might be passed implicitly which makes these alterations ineffective
Tech=5.7,0.625(10000000000)), EmissionsResults.[SUMOF_NH3_BASELINE] = (EmissionsResults[[SumOf_Fuel_Consumption_Exhaust-Baseline]]\EmissionsResults[[SumOf_Fuel_Consumption_Exhaust-Baseline]])/EmissionsResults[[SumOf_Fuel_Consumption_Exhaust-Baseline]]

' Updates the SQL language for the final query
DoCmd.RunSQL UPDATE EmissionsResults INNER JOIN FRACTIONSx11 ON (FRACTIONSx11.[STRK_FUEL_TECH_Name] = EmissionsResults.[STRK_FUEL_TECH_Name]) AND (FRACTIONSx11.[CATEGORY_Name] = EmissionsResults.[CATEGORY]) AND (EmissionsResults.[CY] = FRACTIONSx11.[CY]) SET EmissionsResults.[SUMOF_TOG_exhaust-Rule] = ([EmissionsResults[[SumOf_HC-Exhaust-Rule]]\FRACTIONSx11.[FR-TOG]] EmissionsResults.[SUMOF_ROG_exhaust-Rule]) + ([EmissionsResults[[SumOf_HC-Exhaust-Rule]]\FRACTIONSx11.[FR-ROG]] EmissionsResults.[SUMOF_PM0.5-Rule]) + ([EmissionsResults[[SUMOF_PM0.5-Rule]]\FRACTIONSx11.[FR-PM10]] EmissionsResults.[SUMOF_THC-Total-Rule]) = ([EmissionsResults[[SumOf_HC-Exhaust-Rule]]\EmissionsResults[[SumOf_HC-HotSoak-Rule]]] EmissionsResults[[SumOf_HC-Diurnal-Rule]]) + EmissionsResults[[SumOf_HC-Rest-Rule]] + EmissionsResults[[SumOf_HC-Running-Loss-Rule]]

Dim optGUI As OptionButton
Dim chkGUI As CheckBox

ElseIf Me.CheckBaseline = False And Me.CheckRule.Value = True Then
MsgBox "You need to select Baseline or Rule emissions.
glb_Validation = False
End If
If glb_Validation = True Then
Set lstGUI = Me(glb_ListBoxName)
If lstGUI.ItemsSelected.Count = 0 Then
MsgBox "You need to select one or more " & Right(glb_ListBoxName, Len(glb_ListBoxName) - 4) & " & selection box.
End If
End Sub
Private Sub FormValidation()
Dim lstGUI As ListBox
Dim chkJUI As OptionButton
Dim optGUI As OptionButton
If Me.CheckBaseline = False And Me.CheckRule.Value = False Then
MsgBox "You need to select Baseline or Rule emissions.
End If
If glb_Validation = True Then
Set lstGUI = Me(glb_ListBoxName)
If glb_CheckBoxName = "NoOptionNoCheck" Then
If lstGUI.ItemsSelected.Count = 0 Then
MsgBox "You need to select one or more " & Right(glb_ListBoxName, Len(glb_ListBoxName) - 4) & " & selection box.
End If
End If
ElseIf glb_CheckBoxName = "OptionBox" Then
Set optGUI = Me(glb_OptionName)
Else
Set chkJUI = Me(glb_CheckBoxName)
If chkJUI.Value = True And lstGUI.ItemsSelected.Count = 0 Then
MsgBox "You need to select one or more " & Right(glb_ListBoxName, Len(glb_ListBoxName) - 4) & " & selection box.
End If
End If
End Sub
Public Sub VariableSelection()
' Updates the SQL language for the final query
' Variables might be passed implicitly which makes these alterations ineffective
FormValidation
Dim chkJUI As OptionButton
Dim optGUI As OptionButton
Dim lstGUI As ListBox
Dim VarItem As Variant
If glb_Validation = True Then
If glb_CheckBoxName = "OptionBox" Then
Set optGUI = Me(glb_OptionName)
Set lstGUI = Me(glb_ListBoxName)
If Me.FrameRegions.Value <> 1 And Me.FrameRegions.Value = optGUI.OptionValue And lstGUI.ItemsSelected.Count = 0 Then
MsgBox "You need to select one or more " & Right(glb_ListBoxName, Len(glb_ListBoxName) - 4) & " & selection box.
End If
End If
HavingS = HavingS & " AND ("

For Each VarItem In lstGUI.ItemsSelected
    If IsNumeric(lstGUI.ItemData(VarItem)) = True Then
        HavingS = HavingS & "[" & glb_ColumnName & "] = " & lstGUI.ItemData(VarItem) & " OR "
    Else
        HavingS = HavingS & "[" & glb_ColumnName & "] = '" & lstGUI.ItemData(VarItem) & "' OR "
    End If
Next VarItem

'Not sure if these should go inside the 'If' statement above
HavingS = Left(HavingS, Len(HavingS) - 3) & ""
HavingS = HavingS & ")"
'End If
End If

ElseIf glb_CheckedName = "NoOptionNoCheck" Then

    Set lstGUI = Me(glb_ListBoxName)
    SelectS = SelectS & "[" & glb_EmissionsTable & "] & "
    GroupByS = GroupByS & "[" & glb_EmissionsTable & "] & "

    HavingS = HavingS & " AND ("
        For Each VarItem In lstGUI.ItemsSelected
            If IsNumeric(lstGUI.ItemData(VarItem)) = True Then
                HavingS = HavingS & "[" & glb_ColumnName & "] = " & lstGUI.ItemData(VarItem) & " OR "
            Else
                HavingS = HavingS & "[" & glb_ColumnName & "] = '" & lstGUI.ItemData(VarItem) & "' OR "
            End If
        Next VarItem

        'Not sure if these should go inside the 'If' statement above
        HavingS = Left(HavingS, Len(HavingS) - 3) & ""
        HavingS = HavingS & ")"
        Set lstGUI = Nothing
    Else
        Set chkGUI = Me(glb_CheckBoxName)
        Set lstGUI = Me(glb_ListBoxName)
        'test if checkbox is selected
        If chkGUI.Value = True Then
            SelectS = SelectS & "[" & glb_EmissionsTable & "] & "
            GroupByS = GroupByS & "[" & glb_EmissionsTable & "] & "

            HavingS = HavingS & " AND ("
                For Each VarItem In lstGUI.ItemsSelected
                    If IsNumeric(lstGUI.ItemData(VarItem)) = True Then
                        HavingS = HavingS & "[" & glb_ColumnName & "] = " & lstGUI.ItemData(VarItem) & " OR "
                    Else
                        HavingS = HavingS & "[" & glb_ColumnName & "] = '" & lstGUI.ItemData(VarItem) & "' OR "
                    End If
                Next VarItem

                'Not sure if these should go inside the 'If' statement above
                HavingS = Left(HavingS, Len(HavingS) - 3) & ""
                HavingS = HavingS & ")"
            End If

            'End If
        End If
        Set chkGUI = Nothing
        Set lstGUI = Nothing
    End If
End If

End Sub

Public Sub RegionCheckBoxes()

    If Me.CheckABDIS.Value = True Or Me.CheckCODIS.Value = True Then
        SelectS = SelectS & "[" & glb_FrmTblDist & "] & "
        GroupByS = GroupByS & "[" & glb_FrmTblDist & "] & "
    End If
    If Me.CheckABCO.Value = True Or Me.CheckDISCO.Value = True Then
        SelectS = SelectS & "[" & glb_FrmTblCounty & "] & "
        GroupByS = GroupByS & "[" & glb_FrmTblCounty & "] & "
    End If
    If Me.CheckDISAB.Value = True Or Me.CheckCOAB.Value = True Then

End Sub
Sub CheckUpdate()
' Updates the list box after you check the checkbox
Dim chkGUI As CheckBox
Dim lstGUI As ListBox
Set chkGUI = Me(glb_CheckBoxName)
Set lstGUI = Me(glb_ListBoxName)
If chkGUI.Value = True Then
    lstGUI.Visible = True
    lstGUI.Enabled = True
    lstGUI.FontWeight = 400
    lstGUI.Height = 930
    lstGUI.RowSource = "SELECT [" & glb_LookupTable & "].[" & glb_ColumnName & "] FROM [" & glb_LookupTable & "] ORDER BY [" & glb_ColumnName & "];
Else
    lstGUI.Visible = False
    lstGUI.Enabled = False
    lstGUI.FontWeight = 100
    lstGUI.Height = 330
    lstGUI.RowSource = "SELECT [" & glb_LookupTable & "].[" & glb_ColumnName & "] FROM [" & glb_LookupTable & "] WHERE [" & glb_LookupTable & "].[" & glb_ColumnName & "] = 'Combined' ORDER BY [" & glb_ColumnName & "];
End If
Set chkGUI = Nothing
Set lstGUI = Nothing
End Sub

Sub OptionUpdate()
' Updates the list box after you check the option
' Very similar to CheckUpdate, some names are still from 'checkbox' code
Dim chkGUI As OptionButton
Dim lstGUI, otherList1, otherList2 As ListBox
Set chkGUI = Me(glb_CheckBoxName)
Set lstGUI = Me(glb_ListBoxName)
Set otherList1 = Me(glb_otherList1)
Set otherList2 = Me(glb_otherList2)
If glb_CheckBoxName = "OptionStatewide" Then
    lstGUI.Visible = False
    lstGUI.Enabled = False
    lstGUI.FontWeight = 100
    lstGUI.Height = 330
    lstGUI.RowSource = "SELECT [" & glb_LookupTable & "].[" & glb_ColumnName & "] FROM [" & glb_LookupTable & "] WHERE [" & glb_LookupTable & "].[" & glb_ColumnName & "] = 'Combined' ORDER BY [" & glb_ColumnName & "];
Else
    lstGUI.Visible = True
    lstGUI.Enabled = True
    lstGUI.FontWeight = 400
    lstGUI.Height = 1450
    lstGUI.RowSource = "SELECT [" & glb_LookupTable & "].[" & glb_ColumnName & "] FROM [" & glb_LookupTable & "] ORDER BY [" & glb_ColumnName & "];
End If
Set otherList1 = Nothing
Set otherList2 = Nothing
End Sub

Sub ListAllCombined()
' Validates the listbox selection
Dim lstGUI As ListBox
Dim chkGUI As CheckBox
Dim VarItem As Variant
If glb_Validation = True Then
    Set lstGUI = Me(glb_ListBoxName)
    If lstGUI.ItemsSelected.Count > 0 Then
        If lstGUI.ItemsSelected.Item(0) = 1 Then
            For Each VarItem In lstGUI.ItemsSelected
                lstGUI.Selected(VarItem) = False
            Next VarItem
            lstGUI.Selected(1) = True
        End If
    End If
End Sub

Public Sub ListAll() ' Validates the listbox selection
Dim lstGUI As ListBox
Dim chkGUI As CheckBox
Dim VarItem As Variant
If glb_Validation = True Then
    Set lstGUI = Me(glb_ListBoxName)
    If lstGUI.ItemsSelected.Count > 0 Then
        For Each VarItem In lstGUI.ItemsSelected
            lstGUI.Selected(VarItem) = False
        Next VarItem
        lstGUI.Selected(1) = True
    End If
End Sub
Public Sub ListSelectLimit()
'Validates the listbox selection
Dim chkGUI As CheckBox
Dim lstGUI As ListBox

Set lstGUI = Me(glb_ListBoxName)
If lstGUI.ItemsSelected.Count > 0 Then
    If Me.CheckModelYear.Value = True Then
        Set chkGUI = Me(glb_CheckBoxName)
        If lstGUI.ItemsSelected.Count > glb_RegionLimit Or lstGUI.ItemsSelected.Item(0) = 0 Then
            MsgBox "You have selected Model Year output. You can only view " & glb_RegionLimit & " region(s) at a time. Choose a specific County, District, Air Basin, or Statewide (no regional selection)."
            lstGUI.Selected(lstGUI.ListIndex) = False
            glb_Validation = False
        End If
    End If
End If
Set lstGUI = Nothing
End Sub

Private Sub OptionStatewide_GotFocus()

    Me.CheckABDIS.Visible = False
    Me.CheckABCO.Visible = False
    Me.CheckDISAB.Visible = False
    Me.CheckDISCO.Visible = False
    Me.CheckCOAB.Visible = False
    Me.CheckCODIS.Visible = False
    Me.CheckABDIS.Value = False
    Me.CheckABCO.Value = False
    Me.CheckDISAB.Value = False
    Me.CheckDISCO.Value = False
    Me.CheckCOAB.Value = False
    Me.CheckCODIS.Value = False
    Me.LabelABDIS.Visible = False
    Me.LabelABCO.Visible = False
    Me.LabelDISAB.Visible = False
    Me.LabelDISCO.Visible = False
    Me.LabelCOAB.Visible = False
    Me.LabelCODIS.Visible = False
    Me.LabelABDIS.Value = False
    Me.LabelABCO.Value = False
    Me.LabelDISAB.Visible = False
    Me.LabelDISCO.Visible = False
    Me.LabelCOAB.Visible = False
    Me.LabelCODIS.Visible = False
    glb_CheckedListBoxName = "OptionStatewide"
    glb_ListBoxName = "ListAirBasin"
    glb_otherList1 = "ListAirDistrict"
    glb_otherList2 = "ListCounty"
    glb_LookupTable = glb_FrmTblAirBasin
    glb_ColumnName = glb_FldAirBasin
Private Sub OptionAirBasin_GotFocus()
If Me.CheckModelYear.Value = False Then
  Me.CheckABDIS.Visible = True
  Me.CheckABCO.Visible = True
  Me.CheckDISAB.Visible = False
  Me.CheckDISCO.Visible = False
  Me.CheckCODIS.Visible = False
  Me.CheckDISAB.Value = False
  Me.CheckDISCO.Value = False
  Me.CheckCODIS.Value = False
  Me.LabelABDIS.Visible = True
  Me.LabelABCO.Visible = True
  Me.LabelDISAB.Visible = False
  Me.LabelDISCO.Visible = False
  Me.LabelCODIS.Visible = False
End If

OptionUpdate
End Sub

Private Sub OptionAirDistrict_GotFocus()
If Me.CheckModelYear.Value = False Then
  Me.CheckABDIS.Visible = False
  Me.CheckABCO.Visible = False
  Me.CheckDISAB.Visible = True
  Me.CheckDISCO.Visible = True
  Me.CheckCODIS.Visible = False
  Me.CheckABDIS.Value = False
  Me.CheckABCO.Value = False
  Me.CheckCOAB.Value = True
  Me.CheckCODIS.Value = True
  Me.LabelABDIS.Visible = False
  Me.LabelABCO.Visible = False
  Me.LabelDISAB.Visible = False
  Me.LabelDISCO.Visible = False
  Me.LabelCODIS.Visible = False
End If

OptionUpdate
End Sub

Private Sub OptionCounty_GotFocus()
If Me.CheckModelYear.Value = False Then
  Me.CheckABDIS.Visible = False
  Me.CheckABCO.Visible = False
  Me.CheckDISAB.Visible = False
  Me.CheckDISCO.Visible = False
  Me.CheckCOAB.Visible = True
  Me.CheckCODIS.Visible = True
  Me.CheckABDIS.Value = False
  Me.CheckABCO.Value = False
  Me.CheckDISAB.Value = False
  Me.CheckDISCO.Value = False
  Me.LabelABDIS.Visible = False
  Me.LabelABCO.Visible = False
  Me.LabelDISAB.Visible = False
  Me.LabelDISCO.Visible = False
  Me.LabelCODIS.Visible = False
End If

OptionUpdate
End Sub
Me.LabelCODIS.Visible = True
glb_CheckBoxName = "OptionCounty"
glb_ListBoxName = "ListCounty"
glb_otherList1 = "ListAirDistrict"
glb_otherList2 = "ListAirBasin"
glb_LookupTable = glb_FrmTblCounty
glb_ColumnName = glb_FldCounty
OptionUpdate
End Sub

Private Sub CheckHP_Click()
  glb_CheckBoxName = "CheckHP"
glb_ListBoxName = "ListHP"
glb_LookupTable = glb_FrmTblHP
glb_ColumnName = glb_FldHP
  CheckUpdate
End Sub

Private Sub CheckModelYear_Click()
  glb_CheckBoxName = "CheckModelYear"
glb_ListBoxName = "ListModelYear"
glb_LookupTable = glb_FrmTblMdlYr
glb_ColumnName = glb_FldMdlYr
  CheckUpdate
End Sub

If Me.CheckModelYear.Value = True Then
  MsgBox "You have selected Model Year output. You can only view " & glb_RegionLimit & " region(s) at a time. Choose an individual County, District, Air Basin, or Statewide (no regional selection)."
  'Region deselction on form
  Me.ListAirDistrict.Enabled = False
  Me.ListAirDistrict.FontWeight = 100
  Me.ListAirDistrict.Height = 330
  Me.ListAirDistrict.RowSource = "SELECT [" & glb_LookupTable & "].[" & glb_ColumnName & "] FROM [" & glb_LookupTable & "] WHERE [" & glb_LookupTable & "].[" & glb_ColumnName & "] = 'Combined' ORDER BY [" & glb_ColumnName & "];"

  Me.ListAirBasin.Enabled = False
  Me.ListAirBasin.FontWeight = 100
  Me.ListAirBasin.Height = 330
  Me.ListAirBasin.RowSource = "SELECT [" & glb_LookupTable & "].[" & glb_ColumnName & "] FROM [" & glb_LookupTable & "] WHERE [" & glb_LookupTable & "].[" & glb_ColumnName & "] = 'Combined' ORDER BY [" & glb_ColumnName & "];"

  Me.ListCounty.Enabled = False
  Me.ListCounty.FontWeight = 100
  Me.ListCounty.Height = 330
  Me.ListCounty.RowSource = "SELECT [" & glb_LookupTable & "].[" & glb_ColumnName & "] FROM [" & glb_LookupTable & "] WHERE [" & glb_LookupTable & "].[" & glb_ColumnName & "] = 'Combined' ORDER BY [" & glb_ColumnName & "];"

  Me.FrameRegions.Value = 1
  Me.CheckABDIS.Visible = False
  Me.CheckABCO.Visible = False
  Me.CheckDISAB.Visible = False
  Me.CheckDISCO.Visible = False
  Me.CheckCOAB.Visible = False
  Me.CheckCODIS.Visible = False

  Me.CheckABDIS.Value = False
  Me.CheckABCO.Value = False
  Me.CheckDISAB.Value = False
  Me.CheckDISCO.Value = False
  Me.CheckCOAB.Value = False
  Me.CheckCODIS.Value = False

  Me.LabelABDIS.Visible = False
  Me.LabelABCO.Visible = False
  Me.LabelDISAB.Visible = False
  Me.LabelDISCO.Visible = False
  Me.LabelCOAB.Visible = False
  Me.LabelCODIS.Visible = False

  'equipment type and fuel type requirement
  Me.CheckEquipmentType.Value = True
  Me.CheckEquipmentType.Visible = False
  Me.ListEquipmentType.Enabled = True
  Me.ListEquipmentType.FontWeight = 400
  Me.ListEquipmentType.Height = 930
  Me.ListEquipmentType.RowSource = "SELECT [FormEquipmentTypes].[CATEGORY] FROM FormEquipmentTypes ORDER BY [CATEGORY];"

  Me.CheckFuelType.Value = True
  Me.CheckFuelType.Visible = False
  Me.ListFuelType.Enabled = True
  Me.ListFuelType.FontWeight = 400
  Me.ListFuelType.Height = 930
  Me.ListFuelType.RowSource = "SELECT [FormFuelTypes].[STRK-FUEL-TECH] FROM FormFuelTypes ORDER BY [STRK-FUEL-TECH];"
ElseIf Me.CheckModelYear = False Then
    Me.CheckEquipmentType.Visible = True
    Me.CheckFuelType.Visible = True
End If
End Sub

Private Sub CheckStatus_Click()
    glb_CheckBoxName = "CheckStatus"
    glb_ListBoxName = "ListStatus"
    glb_LookupTable = glb_FrmTblStatus
    glb_ColumnName = glb_FldIdStatus
    CheckUpdate
End Sub

Private Sub CheckEquipmentType_Click()
    glb_CheckBoxName = "CheckEquipmentType"
    glb_ListBoxName = "ListEquipmentType"
    glb_LookupTable = glb_FrmTblEquipType
    glb_ColumnName = glb_FldIdEquipType
    CheckUpdate
End Sub

Private Sub CheckFuelType_Click()
    glb_CheckBoxName = "CheckFuelType"
    glb_ListBoxName = "ListFuelType"
    glb_LookupTable = glb_FrmTblFuel
    glb_ColumnName = glb_FldIdFuel
    CheckUpdate
End Sub

Private Sub ListAirBasin_BeforeUpdate(Cancel As Integer)
    glb_CheckBoxName = "CheckAirBasin"
    glb_ListBoxName = "ListAirBasin"
    glb_LookupTable = glb_FrmTblAirBasin
    glb_ColumnName = glb_FldIdAirBasin
    ListSelectLimit
    ListAllCombined
End Sub

Private Sub ListAirDistrict_BeforeUpdate(Cancel As Integer)
    glb_CheckBoxName = "CheckAirDistrict"
    glb_ListBoxName = "ListAirDistrict"
    glb_LookupTable = glb_FrmTblDist
    glb_ColumnName = glb_FldIdDist
    ListSelectLimit
    ListAllCombined
End Sub

Private Sub ListCounty_BeforeUpdate(Cancel As Integer)
    glb_CheckBoxName = "CheckCounty"
    glb_ListBoxName = "ListCounty"
    glb_LookupTable = glb_FrmTblCounty
    glb_ColumnName = glb_FldIdCounty
    ListSelectLimit
    ListAllCombined
End Sub

Private Sub ListEquipmentType_BeforeUpdate(Cancel As Integer)
    glb_CheckBoxName = "CheckEquipmentType"
    glb_ListBoxName = "ListEquipmentType"
    glb_LookupTable = glb_FrmTblEquipType
    glb_ColumnName = glb_FldIdEquipType
    ListAllCombined
End Sub

Private Sub ListFuelType_BeforeUpdate(Cancel As Integer)
    glb_CheckBoxName = "CheckFuelType"
    glb_ListBoxName = "ListFuelType"
    glb_LookupTable = glb_FrmTblFuel
    glb_ColumnName = glb_FldIdFuel
    ListAllCombined
End Sub

Private Sub ListHP_BeforeUpdate(Cancel As Integer)
    glb_CheckBoxName = "CheckHP"
    glb_ListBoxName = "ListHP"
    glb_LookupTable = glb_FrmTblHP
    glb_ColumnName = glb_FldIdHP
    ListAllCombined
End Sub

Private Sub ListModelYear_BeforeUpdate(Cancel As Integer)
    glb_CheckBoxName = "CheckModelYear"
    glb_ListBoxName = "ListModelYear"
    glb_LookupTable = glb_FrmTblMdlYr
    glb_ColumnName = glb_FldIdMdlYr
    ListAllCombined
End Sub
Private Sub ListStatus_BeforeUpdate(Cancel As Integer)
    glb_CheckBoxName = "CheckStatus"
    glb_ListBoxName = "ListStatus"
    glb_LookupTable = glb_FrmTblStatus
    glb_ColumnName = glb_FldStatus
    ListAllCombined
End Sub