



2017

# Smog Check Performance Report

(An Analysis of Roadside Inspection Data)

DEPARTMENT OF CONSUMER AFFAIRS

**BAR**

Bureau of Automotive Repair

6/30/2017

# 2017 Smog Check Performance Report

## Introduction and Summary

Assembly Bill (AB) 2289 (Eng, Chapter 258, Statutes of 2010) marked the first major update to the Smog Check Program since the mid-1990s. The law was a comprehensive effort to modernize California's vehicle emissions inspection and maintenance program (Smog Check). The legislation required the Bureau of Automotive Repair (BAR) to implement both inspection-based performance standards<sup>1</sup> for stations inspecting directed vehicles<sup>2</sup> and improved On-Board Diagnostics (OBD II) inspections for newer vehicles.<sup>3</sup> It also enhanced BAR's ability to identify and discipline stations performing improper inspections.<sup>4</sup> Lastly, the law required BAR, in cooperation with the California Air Resources Board (CARB), to perform annual evaluations of the Smog Check Program using roadside inspection data.

This report presents an analysis of tailpipe emissions from roadside inspected vehicles and satisfies the statutory requirement for 2017. It is the first Smog Check Performance Report ("Report") with roadside follow-up pass rate data (2015-16) based on certifications issued entirely after BAR implementation of the STAR program. Finally, this report addresses the findings and recommendations of an independent review of BAR's 2016 Report which was conducted by Revecorp, Inc.<sup>5</sup>

BAR uses a voluntary roadside pullover and testing program and other data to help evaluate the Smog Check Program. Analysis of the 2015-16 roadside test data on model year 1976-99 vehicles subject to tailpipe inspection shows that these vehicles had a significantly lower rate of failing within a year than the vehicles sampled and tested at roadside by BAR in 2003-06 and reported by Sierra Research in its 2009 study.<sup>6</sup> The lower roadside fail rate is evident, especially just after Smog Check certification, when comparing the most recent roadside emission failure plot prepared by BAR with the earlier one prepared by Sierra (Figures 1A and 1B, respectively).

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<sup>1</sup> BAR implemented the STAR Program in January 2013. The Program requires stations interested in inspecting directed vehicles to apply for STAR certification. BAR grants certification upon finding that the station meets inspection-based performance standards based on each calendar quarter's performance. In addition to performance, stations must also be in compliance with the enforcement-related standards of the STAR Program.

<sup>2</sup> A directed vehicle must have its Smog Check performed at a STAR certified station. These vehicles are model year 1999 and older vehicles and newer vehicles with the greatest likelihood of failing their next inspection.

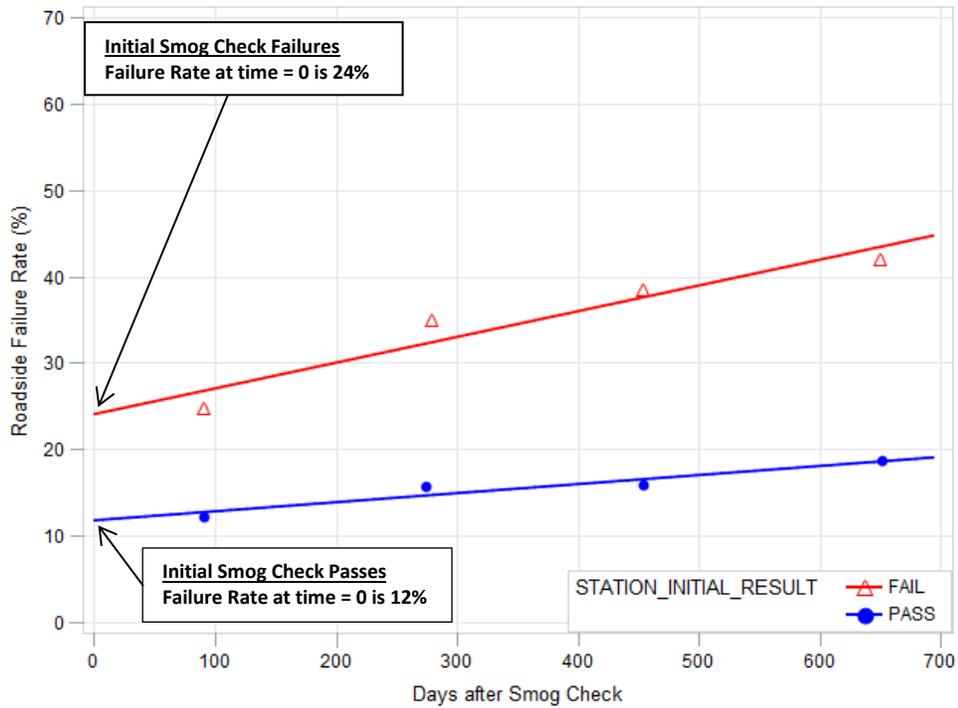
<sup>3</sup> BAR implemented statewide OBD II testing on March 9, 2015, for 2000 and newer gasoline-powered vehicles and for 1998 and newer diesel-powered vehicles. These vehicles do not require a tailpipe emissions inspection.

<sup>4</sup> As part of the OBD II implementation, BAR developed Smog Check database software to provide significantly better detection of improper inspections on newer model year vehicles.

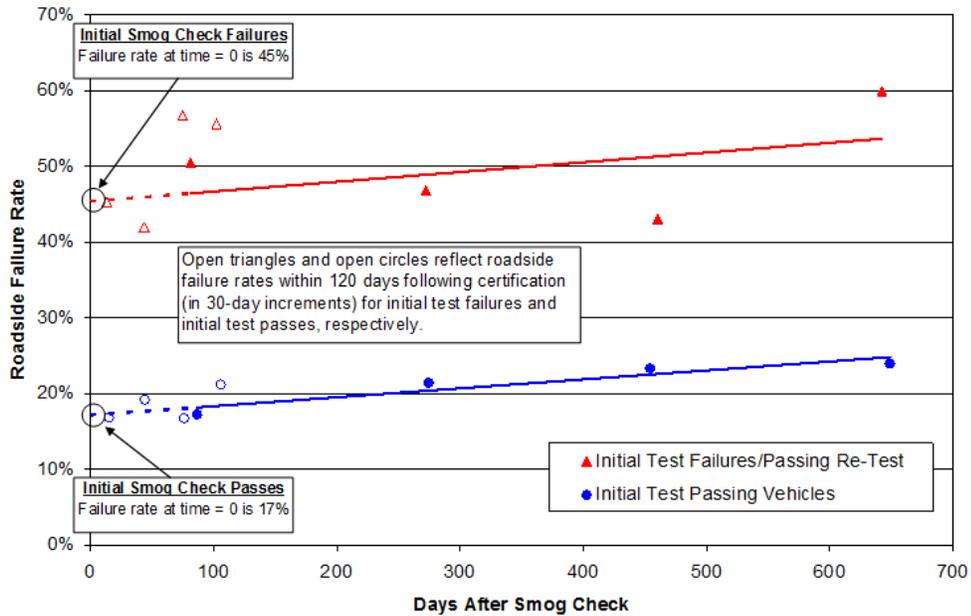
<sup>5</sup> In June 2016, BAR engaged Revecorp, Inc., to conduct "...an independent validation of the evaluation methods, findings, and conclusions presented in the report."

<sup>6</sup> CARB, in cooperation with BAR, engaged Sierra Research, Inc. ("Sierra") to conduct an independent analysis of the Smog Check Program using data collected from roadside inspections conducted in 2003-2006.

**Figure 1A - 2015-2016 Roadside ASM Failure Rates for 1976-99 Model Year Vehicles for Initial Smog Check Test Passing and Failing Vehicles Certified at Time = 0 (Source: BAR)**



**Figure 1B - 2003-2006 Roadside ASM Failure Rates for 1976-95 Model Year Vehicles for Initial Smog Check Test Passing and Failing Vehicles Certified at Time = 0 (Source: Sierra Research, 2009)**



One of the most troubling findings in the 2009 report by Sierra was that initially failing vehicles that were subsequently certified by a Smog Check station "...either were not actually repaired or were repaired only temporarily."<sup>7</sup> This can be seen in Figure 1B from the high roadside failure rate (45%) zero days after passing Smog Check. By comparison, 2015-16 roadside data show the zero day re-fail rate to be less than 25%. These data and analyses of BAR's 2015-16 random roadside emissions testing and of Smog Check station testing of 1976-99 model year vehicles lead us to conclude the following:

1. The analysis of 2015-2016 roadside data continues to show that the Smog Check Program has improved significantly since implementation of AB 2289 and the STAR Program.
2. Despite being more than ten years older, model year 1976-99 vehicles, which are subject to Smog Check tailpipe testing, have a significantly lower rate of failing a roadside tailpipe test within a year after passing Smog Check (16%) than the model year 1976-95 vehicles that were roadside tested in 2003-06 and reported by Sierra Research in its 2009 study (24%).
3. As measured by follow-up random roadside failure rates, STAR stations tend to outperform non-STAR stations. This is true whether the Smog Check certification occurs following an initial failing Smog Check (i.e., "re-fail," with presumed follow-up repairs and then a passing Smog Check) or is an initial passing Smog Check.
4. Compared to the results reported in 2016, low-performing stations have, on average, continued to deteriorate in performance as measured by the roadside fail rates of vehicles that they have certified.
5. The emission reduction benefit lost in 2016 due to Smog Check station performance is provisionally estimated, with limited data for older vehicles, to be 34 tons per day of smog-forming pollutants.<sup>8</sup>
6. As recommended by Revecorp in its independent review, BAR believes that the limited roadside sample of older vehicles, which became more acute in 2015 and 2016, needs to be increased to avoid jeopardizing the ability to estimate excess emissions from the older vehicles.
7. More work is needed to understand the durability of Smog Check repairs and their effect upon roadside fail rates and excess emissions.

After a brief background on BAR's roadside sampling, the remainder of this report provides a summary of the results from analysis of the 2015-16 roadside tailpipe sampling data in accordance with the requirements of AB 2289.

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<sup>7</sup> "Evaluation of the California Smog Check Program Using Random Roadside Data," Sierra Research Report No. SR09-03-01, March 12, 2009.

<sup>8</sup> The estimate of emission reduction benefit lost in calendar year 2016 may be unduly influenced by the small sample size for older model year groups.

## Background

The purpose of BAR's Roadside Inspection Program is to provide data that can be used to evaluate the effectiveness of the Smog Check Program and to help assess the performance of Smog Check stations. Roadside tailpipe testing, which is voluntary for drivers, entails randomly pulling over model year 1976-99 gasoline-powered light-duty vehicles and performing an Acceleration Simulation Mode (ASM) inspection of tailpipe emissions. For an ASM test, the vehicle is placed on a chassis dynamometer and emission-tested using a BAR-97 Emissions Inspection System (EIS). This is the same emission test that is performed by Smog Check stations in enhanced areas.<sup>9</sup> Most other parts of a normal Smog Check test, such as the visual inspection and functional testing, are not performed as part of a roadside inspection in order to minimize inconvenience to participants. As with regular Smog Check inspections, model year 1996-99 vehicles inspected at the roadside are also subjected to the On-Board Diagnostic (OBD) test, in which the EIS is connected to the under-dashboard connector of each OBDII (second generation of onboard diagnostics) vehicle to review the status of fault codes and readiness monitors (although this data is not included in the current analysis). Roadside inspection results do not affect the Smog Check status of any vehicle.

Roadside inspections are a stratified random sample that gives preference to the sampling of older vehicles, thus affording a large enough volume to accurately represent their respective model year groups. This also provides the most efficient means for accurately estimating the fail rate for the entire vehicle population. Absent this adjustment to the roadside sampling protocols, older vehicles would be sampled at too low a rate to accurately calculate their contribution to overall vehicle emissions. (As noted later, older vehicles, while relatively small in number and annual mileage accrual, tend to have a disproportionately large effect upon overall smog-forming emissions.)

Prior to roadside sampling, target vehicle counts by model year group are set by BAR based on zip code and vehicle registration numbers, and individual sites are selected based upon safety, space, traffic volumes and other factors. It is also important to note that the final selection of which vehicles to pull over is made by a California Highway Patrol officer who directs each target vehicle out of the traffic lane and into a temporary inspection lane. Vehicles with bald tires, liquid leaks, or other safety issues are excluded from roadside ASM testing.<sup>10</sup>

In March 2009, Sierra Research (Sierra) released a report entitled "Evaluation of the California Smog Check Program Using Random Roadside Data." The report analyzed the effectiveness of the California Smog Check Program. In that report, Sierra documented the basis for its

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<sup>9</sup> Enhanced areas are California Smog Check Program areas within any part of an urbanized area of the state that is classified by the U.S. Environmental Protection Agency as not meeting air quality standards. Pre-2000 model year gasoline-powered vehicles registered in enhanced areas require an ASM inspection.

<sup>10</sup> This exclusion is consistent with BAR's Smog Check Inspection Procedures Manual, which requires inspectors to "Ensure the vehicle is safe to test" as part of the Pre-Test Check List. Similarly, if a safety concern arises during either a roadside or Smog Check test, the technician aborts the inspection.

conclusion about lack of repairs or temporary repairs after studying the rate at which vehicles that were previously certified by a Smog Check station failed a subsequent roadside inspection. More specifically, Sierra found (as reflected in Figure 1B) that for model year 1976-95 vehicles that initially failed, then passed the ASM tailpipe test at a Smog Check station, 49% failed an ASM roadside inspection within one year of certification (i.e., Fail-Pass-Roadside Fail vehicles). The roadside inspections occurred, on average, about six months after the vehicle had been certified. For model year 1976-95 vehicles that passed their initial ASM test at a Smog Check station, 19% failed an ASM roadside inspection within one year of certification (i.e., Pass-Roadside Fail vehicles).

Assembly Bill (AB) 2289 (Eng, Chapter 258, Statutes of 2010), which was adopted subsequent to the Sierra report, was designed to modernize the Smog Check Program and authorized BAR to address specified known issues, including re-fail rates of vehicles. In response to the bill and following a series of public workshops, BAR implemented the STAR Program in 2013 and in 2014 implemented the On-Board Diagnostics Inspection System (OIS) as a substitute for tailpipe testing of newer vehicles. These and other measures are described in the annual Smog Check Performance Reports prepared and published from 2012 through 2016 by BAR in cooperation with the California Air Resources Board.<sup>11</sup>

In 2016, Revecorp, Inc. was issued a contract to conduct an independent review of BAR's 2016 Smog Check Performance Report. That review, which is required by statute,<sup>12</sup> was conducted in order to provide, "an independent validation of the evaluation methods, findings and conclusions presented in the report." Revecorp made the following findings and recommendations with respect to BAR's 2016 Report:

- *The STAR Program appears to be increasing the effectiveness of the Smog Check Program, although the report has only a limited evaluation of the differences between STAR and non-STAR stations, and the relative impact of low-performing STAR stations.*
- *The low performing stations appear to be where the majority of excess emissions occur. The Smog Check Performance Report should provide more focus on:*
  - a. *Evaluating STAR versus non-STAR stations*
  - b. *Evaluating the impacts of low performing stations participating in the STAR Program*
  - c. *Evaluating the impact of removing low-performing stations would have on the roadside fail rate, which is an indication of excess emissions*
- *The Smog Check Performance Report evaluation has been mostly limited to older vehicles comprising a small fraction of the fleet although approximately half of the fleet*

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<sup>11</sup> See "AB 2289 Annual Reports" at BAR's website: <https://BAR.ca.gov/FormsPubs/index.html>.

<sup>12</sup> See California Health and Safety Code Section 44024.5.

*excess emissions. BAR plans to expand the model years of vehicles sampled in the future.*<sup>13</sup>

- *A larger sample of vehicles tested at roadside is necessary to trace progress by the Smog Check Program over time.*
- *The set of in-use data analyzed as part of the Evaluation should be expanded to use additional data sources.*

BAR's 2016 Smog Check Performance Report may be found at BAR's website.<sup>14</sup> The full independent review of it by Revecorp, which was completed in 2017, is provided as Attachment C to this year's Report. As a part of the findings and conclusions, made by Revecorp in its review pursuant to the requirements of the California Health and Safety Code,<sup>15</sup> Revecorp provided "specific comments for improving the (2016) report." These specific comments, annotated with BAR's responses to each comment, are included as Attachment A to this year's report. Additional details about BAR's Roadside Inspection Program and analysis of roadside data may be found there.

The next section of this report provides an update of the results from BAR's roadside tailpipe testing. Results from roadside OIS testing, which was greatly expanded in 2016, will be presented in a future report.

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<sup>13</sup> As described further in Attachment A (see pg. 20), BAR samples vehicles at roadside of all the model years that are subject to Smog Check. BAR's only plan to "expand the model years of vehicles sampled" is to include the most recent model year with each passing calendar year.

<sup>14</sup> BAR's "2016 Smog Check Performance Report" is available here:  
[https://BAR.ca.gov/pdf/2016\\_Smog\\_Check\\_Performance\\_Report.pdf](https://BAR.ca.gov/pdf/2016_Smog_Check_Performance_Report.pdf)

<sup>15</sup> California Health and Safety Code §44024.5(b)(1).

## Analysis for 1999 and Older Gasoline Vehicles Based on Tailpipe Testing

Statute requires that BAR perform an annual analysis of Smog Check inspection data in order to understand the trends in the roadside emissions fail rate and to gauge the effectiveness of the measures that were adopted to reduce on-road re-fail rates subsequent to Sierra’s 2009 report.

For the current analysis, BAR analyzed roadside data collected from January 2015 to December 2016 and Smog Check data from January 2013 to October 2016. BAR paired the roadside test results with the prior Smog Check records for each vehicle.<sup>16</sup> Table 1 (1<sup>st</sup> two columns) compares the ASM emission failure rates for model year 1976-99 vehicles tested at roadside in 2015-16 to the 2014-15 roadside testing results that were described in the 2016 Report. Results are shown in separate rows for the vehicles that initially failed Smog Check (and presumably were repaired, since they subsequently passed Smog Check), and those which initially passed Smog Check.

**Table 1 - ASM Emission Failure Rates for Model Year 1976-99 Vehicles Tested at Roadside within One Year after Passing a Smog Check**

| Initial Smog Check Result   | BAR Roadside (RS) Surveys*<br>Model Years 1976-99 |                                      |                         |                               |
|-----------------------------|---------------------------------------------------|--------------------------------------|-------------------------|-------------------------------|
|                             | All Station Types<br>2014-15 RS Data              | All Station Types<br>2015-16 RS Data | STAR<br>2015-16 RS Data | Non-STAR**<br>2015-16 RS Data |
| Fail***                     | 29%<br>(984)                                      | 30%<br>(813)                         | 30%<br>(802)            | 41%<br>(11)                   |
| Pass****                    | 13%<br>(4976)                                     | 14%<br>(4956)                        | 14%<br>(4797)           | 20%<br>(159)                  |
| <b>Overall Failure Rate</b> | <b>15%</b><br>(5960)                              | <b>16%</b><br>(5769)                 | <b>16%</b><br>(5599)    | <b>21%</b><br>(170)           |

\* Roadside sample sizes are shown in parentheses beneath the roadside failure rate percentages.

\*\* Alternative weighting was used, as recommended by Revecorp, due to limited sample size for Non-STAR data.

\*\*\* Vehicles failed initial Smog Check, were eventually certified as passing, but failed at roadside within 1 year.

\*\*\*\* Vehicles passed initial Smog Check, but failed at roadside within 1 year.

The 15-16% one-year failure rates shown in Table 1 are markedly lower than the 24% one-year failure rate (described earlier) reported by Sierra from BAR’s 2003-06 roadside survey.<sup>17</sup> This is remarkable because, on average, both of these fleets have aged more than ten years since the time of the 2003-06 roadside survey. As such, many of these vehicles would typically be more

<sup>16</sup> Vehicles sampled at roadside were matched by Vehicle Identification Numbers (“VINs”) to their prior Smog Check records contained in California’s Vehicle Information Database (VID).

<sup>17</sup> Note that Sierra’s 2009 report examined fail rates for the 1976-95 model year fleet, whereas the BAR study followed the 1976-99 model year fleet.

prone to fail a Smog Check inspection<sup>18</sup> than they were in the earlier survey. In addition, the 49% re-fail rate for Fail-Pass-Roadside Fail vehicles from the 2009 Sierra study dropped to 30% in the latest roadside survey.<sup>19</sup>

Table 1 also shows the difference in roadside fail rates between STAR and non-STAR stations (last two columns). This data indicates that STAR stations outperformed non-STAR stations in terms of roadside re-fail rates. The finding of lower roadside re-fail rates for vehicles certified at STAR stations, which also occurred in the 2014-15 roadside survey as documented in the 2016 Report, was true whether or not the previous certification occurred following: 1) an initial failing Smog Check, presumed repairs, and a follow-up passing Smog Check; or 2) an initial passing Smog Check.

The demonstrably better performance for STAR stations is important not only because STAR stations test the majority of the most failure-prone older vehicles,<sup>20</sup> but also because they tend to have higher inspection volumes than non-STAR stations. As shown in Table 2, STAR stations performed 87% of the tailpipe Smog Check tests in 2016, and identified more than 90% of the

**Table 2 – Summary of Initial Smog Check Tailpipe Tests Performed in 2016<sup>21</sup>**

| Station Type        | Initial Tests in 2016<br>(and % of all tailpipe tests) | Number of Failed Initial Tests<br>(and % by Station type) | % of Initial Tests Failed |
|---------------------|--------------------------------------------------------|-----------------------------------------------------------|---------------------------|
| STAR                | 2,205,523 (87.1%)                                      | 499,858 (90.6%)                                           | 22.7%                     |
| Non-STAR            | 305,811 (12.1%)                                        | 47,104 (8.5%)                                             | 15.4%                     |
| Other <sup>22</sup> | 21,290 (0.8%)                                          | 4,923 (0.89%)                                             | 23.1%                     |
| <b>Total</b>        | <b>2,532,624 (100.0%)</b>                              | <b>551,885 (100%)</b>                                     | <b>21.8%</b>              |

<sup>18</sup> The Smog Check initial failure rate for model year 1976-99 vehicles was 15.4% in 2005 vs. 22.1% in 2016.

<sup>19</sup> The need for and effect of including model year 1996-99 vehicles is addressed in BAR’s 2016 Report.

<sup>20</sup> Although model year 1976-99 vehicles are “directed vehicles” requiring inspection at STAR stations, a small fraction of these vehicles (<1%) are tested at the “Other” station types as listed in the last row of Table 2 which address captive fleets and referee testing .

<sup>21</sup>The numbers of tailpipe tests shown here are far fewer than the overall number of Smog Check tests (including OIS testing), which was more than 11.5 million tests in 2016; the overall percentage of initial tests that failed was 11.36% in 2016, and has not changed by more than a few percentage points over the last decade. Additional details may be found in BAR’s 2016 Executive Summary, which is available at:

[https://www.bar.ca.gov/pdf/ExecSumRepData/Executive\\_Summary\\_Report\\_2016.pdf](https://www.bar.ca.gov/pdf/ExecSumRepData/Executive_Summary_Report_2016.pdf).

<sup>22</sup> “Other” includes: dealers, business fleets, permanent fleets registered, referees, government fleets.

vehicles that failed their initial tests. As of December 31, 2016, there were 7,048 licensed, active Smog Check stations, of which 3,915 (56%) were STAR certified.<sup>23</sup>

Finally, Figures 1A and 1B depict the vehicle re-fail rates (upper lines) and fail rates (lower lines) at roadside for a period of up to two years following certification by a Smog Check station. The figures show that the projected “time-zero” re-fail rate of 45% for previously failing-then passing vehicles (Figure 1B) has declined to 24% (Figure 1A). Similarly, the corresponding time-zero fail rates for initial passes has declined from 17% to 12%<sup>24</sup>. In addition, the re-fail and fail rate lines are lower in Figure 1A than in Figure 1B for the full range of times shown in the figures (from 0 to 700 days). These results demonstrate that Smog Check performance, as measured by roadside failure rates, has improved significantly since the 2009 Sierra study and, notably, following the adoption of AB 2289 and BAR’s implementation of the STAR Program. However, Table 1 also shows a slightly higher one-year roadside fail rate in 2015-16 than in the prior (partially overlapping) 2014-15 roadside campaign (16% vs 15%, respectively).

It is noteworthy that the re-fail line in Figure 1A is no longer parallel with the re-fail line determined by Sierra (Figure 1B) or with the initial pass (lower) lines from either survey period. Instead, the slope of the re-fail line has become much steeper. If, alternatively, the slope had remained unchanged (i.e. the re-fail line was still parallel to the line for initially passing vehicles, as was the case in Figure B), then that would imply that the recertified vehicles were deteriorating at a similar rate to the initially passing vehicles (and the fleet in general). Instead, the steeper curve suggests a more rapid deterioration rate of the repaired fleet and a need to better understand the durability of Smog Check repairs.

The re-fail rate for STAR stations is negatively impacted by the fact that some low performing stations can at least temporarily achieve STAR station status under the current program. There are two primary ways in which this can occur. First, removing STAR privileges for existing STAR stations that fail to meet performance standards can be a lengthy process. Second, the quality of STAR stations can be diminished by new stations enrolling new inspectors. The existing STAR regulations allow stations entry into the program provided they have one calendar quarter’s worth of passing data for the STAR Program’s short-term performance measures. This means that they can enter the program without consideration of any long-term inspection data (i.e., they have no prior FPR score). Some of these new stations may perform low-quality inspections until their STAR privileges are invalidated.

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<sup>23</sup> Smog Check station participation in the STAR Program is voluntary but, as noted previously, it requires ongoing adherence to higher standards of performance and other requirements. In return, STAR stations receive the benefit of testing “directed vehicles,” i.e., those vehicles which tend to have higher expected fail rates are required to have their Smog Check tests at STAR stations.

<sup>24</sup> The reader should keep in mind that Figure 1A includes the additional model years 1996-99 which tends to lower average fail rates, but vehicles are more than ten years older than in Figure 1B, which typically increases fail rates.

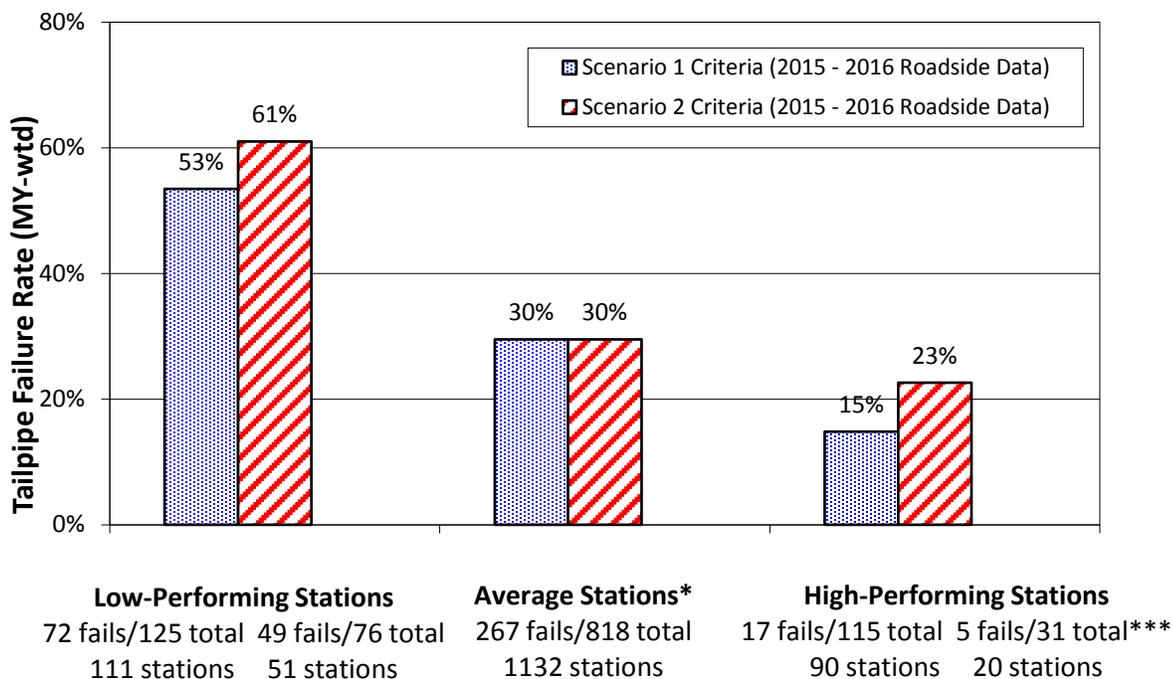
STAR regulatory changes are currently being pursued to address both of these issues. The proposal would provide stations that appeal a STAR suspension the ability to inspect directed vehicles only through the completion of the informal hearing process. In addition, certification of new STAR stations would no longer be permitted without at least meeting a minimum FPR standard. Program performance improvements from these changes will follow regulation adoption by at least one year.

### Station Performance Analysis

To better understand the performance of the Smog Check Program, Sierra's 2009 report grouped roadside results using a station performance algorithm. BAR enhanced this measure to evaluate station performance under the STAR Program. The performance measure, which is called the Follow-up Pass Rate (FPR), evaluates Smog Check stations and technicians based upon the rate at which the vehicles they certified in the previous inspection cycle are passing their Smog Check in the current cycle, regardless of where that next inspection occurs, and as compared to similar vehicles. FPR scores range from a low of zero (0.00) to a high of one (1.00).

The 2009 Sierra report grouped stations as high-, medium-, and low-performing. The report further analyzed the performance of these station groups under two scenarios. In Scenario 1, high-performing stations had a 0.90 or greater FPR, and low-performing stations had a 0.10 or lower FPR. In the more stringent Scenario 2, FPR thresholds were 0.975 or higher for high-performing stations and 0.025 or lower for low-performing stations. Figure 2 shows the corresponding results for the 2015-16 roadside data under both scenarios using the expanded range of model year 1976-99 vehicles. The main point of this chart is to illustrate how certification at low-performing stations sharply increases the likelihood of tailpipe failure at roadside. This is true when low-performing station failure rates (left side of Figure 2) are compared with either average stations (center) or high-performing stations (right side), and it is true for both Scenarios 1 and 2.

**Figure 2: Scenario 1 and Scenario 2 Criteria  
Roadside ASM Tailpipe Failure Rates for Vehicles  
Within One Year of Failing Initial Smog Inspection Prior to Certification  
(Model Year 1976-99 Vehicles)**



\* "Average Stations" includes High-, Medium-, and Low-Performing Stations.

\*\* Tailpipe Failure Rates are VID-weighted by MY group; # of fails and totals are unweighted vehicle counts.

\*\*\*The 23% weighted fail rate is very uncertain due to small sample size; see Attachment A, for more information.

Current Excess Emissions: Model Year 1976-95 Vehicles

The 2009 Sierra report included an analysis of emissions reductions lost due to poor Smog Check inspection performance. Using Scenario 2 criteria, the 2009 Sierra report indicated that an additional 70 tons per day (tpd) of reactive organic gases (ROG) and oxides of nitrogen (NOx) could have been eliminated from the air, provided all Smog Check stations performed on par with high-performing stations when testing 1976-1995 model year vehicles. This was based on CARB's EMFAC 2002 emissions model run for calendar year 2005. A recalculation for the 2016 Report using CARB's more recent EMFAC 2011 model for calendar year 2005 revised that lost emissions benefit from 70 tpd to 50 tpd. For this Report, the EMFAC 2011 model was used to estimate the lost benefit for calendar year 2016 based on 2015-2016 roadside data. It estimates the lost benefit to be 34 tpd. However, this estimate may be considered provisional as it may be unduly influenced by a small roadside sample size for these older model year groups.

## Conclusions

Data and analyses of BAR's 2015-16 roadside emissions testing and from Smog Check station testing of model year 1976-99 vehicles lead us to conclude the following:

1. The analysis of 2015-2016 roadside data continues to show that the Smog Check Program has improved significantly since implementation of AB 2289 and the STAR Program.
2. Despite being more than ten years older, model year 1976-99 vehicles, which are subject to Smog Check tailpipe testing, have a significantly lower rate of failing a roadside tailpipe test within a year after passing Smog Check (16%) than the model year 1976-95 vehicles that were roadside tested in 2003-06 and reported by Sierra Research in its 2009 study (24%).
3. As measured by follow-up random roadside failure rates, STAR stations tend to outperform non-STAR stations. This is true whether the Smog Check certification occurs following an initial failing Smog Check (i.e., "re-fail," with presumed follow-up repairs and then a passing Smog Check) or is an initial passing Smog Check.
4. Compared to the results reported in 2016, low-performing stations have, on average, continued to deteriorate in performance as measured by the roadside fail rates of vehicles that they have certified.
5. The emission reduction benefit lost in 2016 due to Smog Check station performance is provisionally estimated, with limited data for older vehicles, to be 34 tons per day of smog-forming pollutants.<sup>25</sup>
6. As recommended by Revecorp in its independent review, BAR believes that the limited roadside sample of older vehicles, which became more acute in 2015 and 2016, needs to be increased to avoid jeopardizing the ability to estimate excess emissions from the older vehicles.
7. More work is needed to understand the durability of Smog Check repairs and their effect upon roadside fail rates and excess emissions.

The remainder of this report consists of three attachments. Attachment A contains specific comments by Revecorp for improving the 2016 Report and/or later reports, which is annotated with responses from BAR. Attachment B provides highlights from a modeling analysis of roadside fail rates that attempts to provide further insights into the causes of excess emission test failures at roadside. Attachment C is Revecorp's independent review of the 2016 Report (without annotation).

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<sup>25</sup> The estimate of emission reduction benefit lost in calendar year 2016 is may be unduly influenced by the small sample size for older model year groups.

## Attachment A

This attachment to BAR's 2017 Smog Check Performance Report includes Chapter 3 (only) of the "Independent Review of 2016 Smog Check Performance Report," by Revecorp, Inc., with annotation (*in italics*) to show BAR's responses. Revecorp's bulleted comments refer to BAR's 2016 Smog Check Performance Report and to page numbers in that Report, while citations in BAR's responses refer to the current (2017) Smog Check Performance Report and the pages herein, reflecting BAR's consideration and/or adoption of many of the specific comments and recommendations. The entire Independent Review by Revecorp of the 2016 Report (without annotation) may be found in Attachment C.

### 3 SPECIFIC COMMENTS FOR IMPROVING THE REPORT

Listed below are specific comments and questions that should be used to clarify some of the discussion in the Report and/or should be considered for the 2017 report.

- Comment - Page 1, bottom of the last paragraph – The sample selection process should briefly be explained. Was the roadside inspected sample random or was it limited to specific model years and vehicles that received a Smog Check within the last 12 months? If data beyond the past 12 months were collected, it may be useful to evaluate these data as well.

*Data collection and analysis is not restricted to 12 months. See pp. 1-2 for discussion and presentation of roadside data collected more than 12 months after Smog Check and see Attachment B (pp. 21-23) for discussion of BAR's modeling analysis of the roadside data. The "Background" Section (pp. 4-6) provides additional information on BAR's roadside testing program.*

- Comment - Page 2, first paragraph – Were the same ASM standards used at roadside for the vehicles in the 2009 Sierra report and the roadside sample used in the current analysis?

*Yes (in most cases). Many changes to ASM standards occurred between 1998 and 2003, prior to the latest (2003-06) BAR roadside data on which Sierra's 2009 report relied. However, one significant change occurred after 2006, which was the implementation of vehicle-specific cutpoints in 2010. This had the effect of tightening NOx ASM cutpoints for a number of vehicles (and relaxing standards for a few).*

- Comment - Page 2, first paragraph – An analysis to evaluate if the vehicles failed for the same pollutants on-road versus what they were last failed for during their Smog Check may provide additional insight.

*When BAR examined this in the past, we found that certain pollutant failure combinations are more common than others. Consequently, a vehicle failing for the same combination of pollutants may not be a reliable indicator that the same problem is at fault. Nor do different failing pollutants necessarily indicate that the current problem is unrelated to the previous problem.*

- Comment - Page 2, first paragraph – Are the roadside failures only ASM emissions failures or are visual, functional and fuel cap failures included in the analyses? If data besides tailpipe results were used, these need to be described.

*To minimize inconvenience to participants, roadside testing does not include the full suite of tests that are performed as part of Smog Check. Only ASM test results are considered in the roadside analysis contained in the current Report (pg. 4).*

- Comment - Page 2, second paragraph – It would be useful to include the current Smog Check ASM failure rates in this discussion so the pass-fail rate could be compared to what is normally experienced.

*The Smog Check station initial fail rate for emissions is shown in Table 2 (pg. 8). Many additional tables and graphs showing the failure rates for emissions by model year (and other descriptive statistics) can be found in the annual Executive Summaries which are posted on BAR's website going back to 1998.<sup>26</sup>*

- Comment - Page 3 – The majority of vehicles tested at roadside were initially tested at STAR stations, however, only approximately 60% of the Smog Check stations are STAR stations. Is the high rate of capturing vehicles inspected at STAR stations due to a higher number of vehicles being inspected at STAR stations? The “All Station Types” column results should be normalized to the rates of inspections at STAR versus non-STAR stations.

*Compared to non-STAR stations, STAR stations tend to have higher testing volumes and higher rates of vehicle test failure. The higher failure rate is, in large part, because only STAR stations can certify “directed vehicles” (which, by design, are those vehicles most likely to fail). These include essentially all the 1976-99 vehicles and certain others. In 2016, STAR*

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<sup>26</sup> Additional details may be found in BAR's annual Executive Summary, which is available here: [https://www.bar.ca.gov/FormsPubs/Executive\\_Summary\\_Reports\\_and\\_Data.html](https://www.bar.ca.gov/FormsPubs/Executive_Summary_Reports_and_Data.html).

*stations performed 87% of initial tailpipe tests and identified more than 90% of initial tailpipe test failures (see discussion pp. 8-9 and breakdown by station type in Table 2).*

- Comment - Page 3, notes to Table 1 – Note \*\* and Note \*\*\* indicate that the tests were all conducted within one year of when the last station based Smog Check was performed. As noted in the comment on Page 1 above, were vehicles that were more than a year from when they received their Smog Check excluded from the roadside testing or just excluded from the analysis? If the data are available, they could be included to increase sample size if the time lapse between Smog Check and roadside inspection could be accounted for.

*As described in the Background section (pp. 4-6), no vehicles were excluded from roadside testing based on time from last Smog Check. Tabular summary data comparing failure rates one year after Smog Check certification was patterned after the reporting used by Sierra Research and by BAR in previous reports. Since STAR stations have been operating for as long as 3 years since January 1, 2013 (the inception of STAR), additional data and analysis have been included in the 2017 Report to show roadside fail rates over a full 2-year Smog Check cycle (see pp. 1-2, Figures 1A and 1B, and Attachment B, pp. 21-23).*

- Comment - Page 3, bottom – It is noted that the “...quality of the Smog Check Program has improved substantially since Sierra’s 2003-2006 study.” The term “substantially” is subjective and should be removed.

*BAR’s opinion is different from Revecorp’s on this point, and the current Report provides additional results from and clarification about BAR’s roadside testing which supports this view. Additional results include the re-fail plot and associated discussion (Figure 1A, pg. 2) which documents the improved re-fail performance (e.g., sharply reduced zero-day roadside re-fail rate in 2015-16 compared to 2003-06), and the logistic regression-based modeling of roadside fail rates (Attachment B, pp. 21-23) which further supports the findings from the re-fail analysis.*

- Comment - Page 3, bottom – An explanation as to why the overall re-fail rate is unchanged over time would be useful here, although it may be difficult to determine.

*BAR’s analysis (pg. 2, and Figures 1A and 1B) highlights what we believe to be an important trend over time in the roadside re-fail rate. In the years following the January 1, 2013, commencement of STAR, the “zero day” re-fail rate (i.e., the rate of roadside ASM test failures shortly after routine Smog Check certification) has been significantly reduced, which tends to confirm a significant improvement in the integrity of Smog Check testing. However, more work is needed to understand the nature and effects of Smog Check repairs.*

- Comment - Page 4, end of paragraph 2 – The description as to why the re-fail rate in the 2016 Report is poorer (higher) than in the 2015 Report is difficult to understand. Possibly, it could simply be stated that some vehicles in the 2016 Report were certified at a Smog Check station prior to the implementation of the STAR program, so not all vehicles in the roadside sample exhibited the effects of the STAR program.

*The suggestion may now be moot because, as pointed out in the current report (pg. 1), the 2017 Report is the first in which all of the pre-roadside Smog Check certifications have been completed after two full years of STAR implementation (2013-14). Furthermore, as noted by BAR in response to a later comment, the roadside samples from 2014-15 and 2015-16, both have limitations due to the small size of the samples in the older model year groups. However, as also noted later, BAR is working to improve the understanding of the effects of Smog Check repairs and is exploring options to increase the roadside sample size for older vehicles.*

- Comment - Page 4, paragraph 3 – It is noted that removing directed vehicle inspection privileges from a STAR station can be “... a long and drawn out process...” How long does this process take?

*That depends. If a station is cited and does not contest it, removal of STAR certification can occur quickly. But depending on the station’s actions, STAR decertification can take considerably longer.*

- Comment - Page 4, paragraph 3 – Although the population of vehicles sampled is small, data from stations which have been removed from the Smog Check program should be separated from the rest of the STAR stations to show the relative impact on the effectiveness of STAR stations.

*This is something BAR is considering for future analysis.*

- Comment - Page 4, paragraph 4 – It is noted that “Some of these new stations may perform low-quality inspections...” Similar to the analysis suggested above, the data from new STAR stations should be analyzed separately from the rest of the STAR stations to show the relative impact new stations have on the pass-fail rates of STAR stations.

*See the logistic regression modeling results (Appendix B, pp. 21-23). While the narrative there highlights the effects of FPR upon roadside failure rates, the model also includes a term (which has a statistically significant effect on roadside fail rate) for STAR vs. non-STAR stations, which goes beyond just the effect that is ‘captured’ by the poorer FPR (on average) or non-STAR stations.*

- Comment - Page 5, Table 2 – It would be useful to see the model year 1996 to 1999 vehicles separately from the other vehicles.

*For this model year subsample, which consists entirely of OBDII (second generation on-board diagnostic) vehicles, BAR has collected both tailpipe and OBD-based information, which is currently being analyzed. Interestingly, the initial Smog Check emission failure rates in 2016 for these model years range from about 5-10%, which is markedly lower than all previous model years dating back to 1976, which ranged from 16-21%. The mass introduction of OBDII with the 1996 model year also reduced overall failure rates.*

- Comment - Page 5, Station Performance Analysis – BAR should explain in more detail how specifically the Follow-up Pass Rate is calculated. The figures display the data for stations. Would evaluating performance based on technicians’ FPR provide additional insight?

*BAR provides general information on its web page<sup>27</sup> related to FPR; however, details of the calculations are not public information. FPR scores are calculated for both Smog Check stations and technicians and are made available as a kind of ‘report card’ to aid stations and technicians in monitoring and improving their performance.*

- Comment - Pages 6, 7 and 8 - Figures 1, 2 and 3 – Add error bars and sample sizes to the charts. Also, list the number of stations in each group and the number of inspections performed by these stations so their relative impact can be assessed.

*The numbers of stations, roadside tests and roadside fails in each group has been added to new Figure 2 (pg. 11). In addition, a new Table 2 (pg. 8) has been added which shows numbers of STAR, non-STAR and other stations, along with their respective total numbers of initial tests, failed initial tests, and failure rates. Error bars have not been added to the figure because of the complexity of mixing the weighted and unweighted vehicle counts. Instead, to provide insight into the associated uncertainties of roadside fail rates (and to provide insight into the contributing factors to roadside failures), BAR has provided (pp. 21-23, including Figures B-1 and B-2) initial logistic regression modeling results of roadside fail rates as a function of certifying station FPR scores and time between Smog Check certification and the follow-up roadside test. The vertical range of the shaded band shown in each figure represents the 95% confidence interval for the estimated probabilities of roadside average fail rate. These roadside failure probabilities account for vehicle model year, time between certifying Smog Check test and roadside test, prior initial test result, and FPR. The regression-based estimates of*

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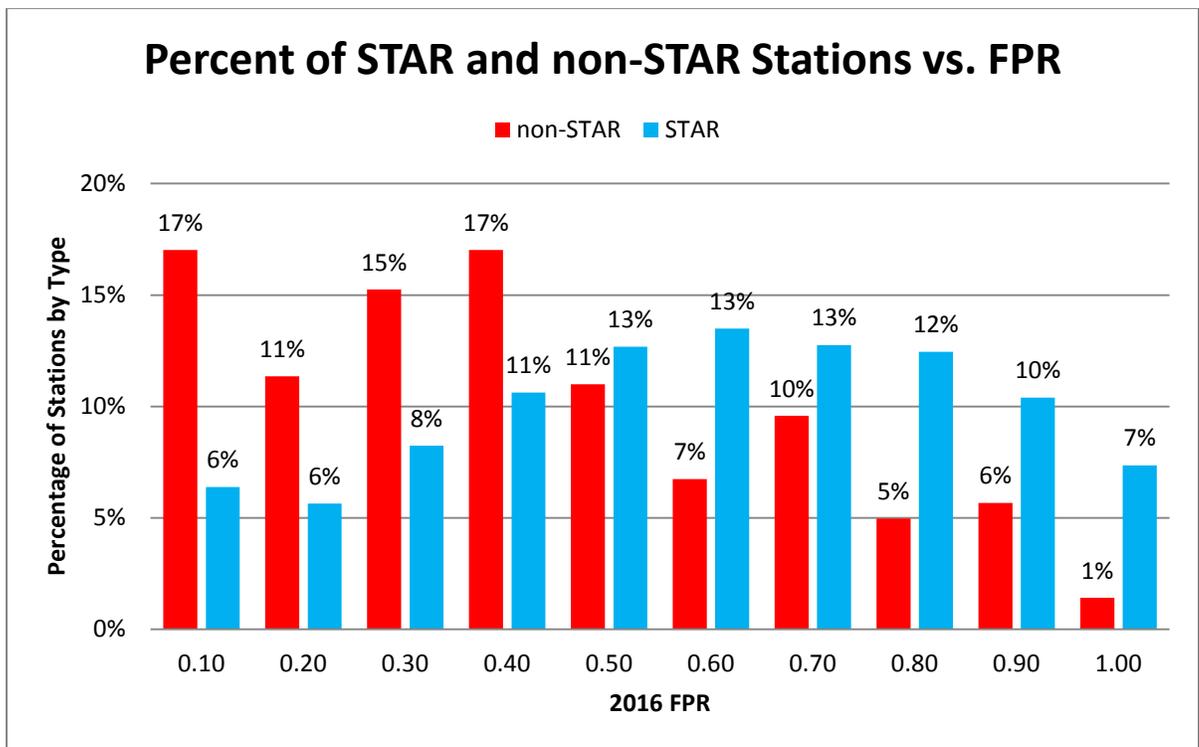
<sup>27</sup>See Sect. 6, (FPR) of BAR’s website: [https://BAR.ca.gov/Industry/Q&As\\_STAR\\_Program.html](https://BAR.ca.gov/Industry/Q&As_STAR_Program.html).

failure rate are weighted by numbers of vehicle initial test by model year, which is analogous to how the data were weighted by BAR and by Sierra (by model year group) in preparing Figure 1A and B. This weighting is done to provide an estimate that reflects the vehicle population stored in the VID rather than the raw sample collected at roadside which could over- or under-represent certain model years.

- Comment - Page 7, top paragraph – What fraction of the STAR stations is low-performing? How many low-performing Smog Check stations are longer-term, low-performing and how many are new to the STAR program?

The histogram in Figure A-1 (below) shows the percentages of STAR and non-STAR stations by FPR in calendar year 2016. The mean FPR score for STAR stations is significantly

**Figure A-1**



greater than that for non-STAR stations (even though the more failure-prone older vehicles are directed exclusively to STAR stations). The threshold FPR level at which STAR stations may lose certification is 0.10 and the threshold for non-STAR stations to be certified as STAR (provided that all other requirements are also met) is 0.40. These metrics were selected to provide incentive for testing volume to move from stations having FPRs that are below average, that is, stations which have an FPR of less than 0.50 (like most of the non-STAR

stations) to stations that have an FPR greater than 0.50 (like most of the STAR stations). Finally, it should be noted that only stations which have earned an FPR score are shown in the figure. Stations which have not performed any BAR-97 tests or have an insufficient number of tests to provide a reliable FPR score are excluded from the figure.

- Comment - Page 8, Figure 3 –Why do the Scenario 2 low-performing stations have higher tailpipe failure rates than the Scenario 1 stations?

*Scenario 2 stations are further out on the tails, so the lower-performing stations are worse than in Scenario 1, whereas the higher-performing stations are better than in Scenario 1. That is why the Scenario 2 low-performing stations have a higher tailpipe fail rate.*

- Comment - Page 8, second paragraph – BAR should update all modeling to EMFAC 2014, including re-performing the previous report modeling so going forward there is a common and current baseline for the modeling. We are aware that there are limitations using EMFAC 2014 to model the IM versus non-IM vehicles.

*BAR has used the calendar year 2016 results from EMFAC2011 as suggested by CARB staff, as this is the latest EMFAC version with I/M vs. Non-I/M results needed for this analysis.*

- Comment - Page 8, last two paragraphs – The explanation of why the lost benefit dropped so much in the 2016 Report (compared to the 2009 Sierra report) should include more data to describe the change. For example, the report could note that in calendar year 2005 (the last year of the roadside data relied upon by Sierra), 1976-1995 model year vehicles accounted for 25.5% of light-duty vehicle miles travelled (VMT), which dropped to 3.8% in calendar year 2015.

*BAR's computation of the lost excess emissions benefit, both for the 2016 and 2017 (current) Reports, accounts for all of the factors mentioned by Revecorp and more. BAR examined the changing roadside sample available each calendar year, vehicle population (VID-weighted by model year group) each year, miles travelled by each model year group, pollutant emissions from roadside ASM tailpipe measurements (adjusted to FTP conditions), with resulting tons per day emissions calibrated to EMFAC. The detailed methodology was reviewed by CARB staff. However, for the 2016 Report the number of older vehicles in the 2014-15 roadside sample was marginal, and for the 2017 Report the 2015-16 roadside sample of older vehicles declined further, resulting in too small a sample to ensure an unbiased estimate of emissions. Accordingly, BAR's efforts to improve this estimate will primarily be focused on improving sample size for the older model year vehicles (rather than trying to explain what appear to be random sampling variations due to small sample size.)*

- Comment - Page 9, last paragraph – Revecorp believes the expansion to collecting OBD data and increasing sample sizes should happen as soon as possible. This will retain the statistical validity of the sample. This will be one of the most critical things that will need to be done moving forward for evaluating overall Smog Check Program performance.

*Revecorp's report, which was prepared in late 2016 and early 2017, does not fully reflect BAR's roadside OBD testing of vehicles in 2016. Consistent with the transition of Smog Check to OIS that was authorized by AB 2289, BAR's roadside teams tested more vehicles by OIS (OBD data exclusively) than by BAR-97 (tailpipe testing) in 2016. In other words, the recommended "expansion to collecting OBD data" has already occurred, and Revecorp's reference (pg. 1 of their Independent Review) to BAR's plan "to expand the model years of vehicles sampled in the future," was well underway with BAR's OIS sampling in 2016. However, BAR agrees with Revecorp on the need to increase sample size "as soon as possible" in order to capture a sufficient number of 1976-95 model year vehicles to characterize their excess emissions reliably. This is particularly important for 1976-87 model year vehicles. Absent such an expansion, the limited extent of roadside sampling of older vehicles, which became more acute with the 2015-16 roadside data collection, jeopardizes BAR's ability to provide an unbiased estimate of excess emissions.*

## Attachment B

### Modeling Analysis of Roadside Fail Rates

In order to gain further insight into the causes of excessive emission test failures at roadside, BAR has begun investigating the relationships between roadside failures, Follow-up Pass Rate (FPR), days between the roadside test and Smog Check test (DATEDIFF), vehicle model year (which reflects both differences in emission control technology and vehicle age and condition), previous Smog Check initial test result, and other factors. The analyses, which rely on logistic regression, use the same type of roadside data that were used to construct the prior re-fail plots, but allow for separating the effects of the multiple continuous and categorical variables in order to better predict roadside tailpipe results and understand their causes and associated uncertainty, which is expressed here as a 95% confidence interval for the expected roadside average fail rate. Portions of the modeling results are shown in Figures B-1 and B-2 (below).

Figure B-1 shows estimated roadside average fail rates as a function of time between Smog check and follow-up roadside test for vehicles that initially failed Smog Check (red upper band) and those which initially passed (lower band), respectively. This figure presents a more detailed description of the fail rates shown earlier in Figure 1-A, except that the logistic regression results shown here, unlike the linear regressions used in Figure 1, do not require the aggregation of results from hundreds of tests into just four points, and they do not assume that the data are best described by a straight line fit to just four data points. In addition, the shaded area in each logistic regression plot shows the model's 95% confidence interval for the estimated average failure rates. The values plotted in both figures are for the average model year vehicle (1997) from the 2015-16 roadside dataset. These regression results, similar to the ones shown in Figure 1, are also VID-weighted to match numbers of initial tests by model year (although the regression models used in Figures 1A and 1B relied upon fail rates that were weighted by model year groups). Within each band, the solid line represents the expected roadside emissions test result for an "average" vehicle tested at the stated number of days after being certified at a Smog Check station. The vertical width of the band at each stated number of days indicates the 95% confidence interval for the estimated average value.<sup>28</sup>

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<sup>28</sup> Note that the logistic regression model is used to estimate the average failure rate at each point along the line, and the confidence band characterizes the uncertainty in how well the model represents the data. Like the linear regressions shown in Figures 1A and 1B, Figures B-1 and B-2 do not attempt to quantify the total uncertainty in the estimate (which may include errors and uncertainties in the measurements and/or other random variations that are unaccounted for).

Figure B-2 (below) is similar to the previous figure, except that the predicted roadside failure rates are shown as a function of the certifying station's Follow-up Pass Rate. This figure, rather than showing results as a function of DATEDIFF (the number of days between Smog Check certification and roadside test), shows results for an average DATEDIFF in the roadside dataset, which happens to be 353.9 days, or about one year. Therefore, the upper band in Figure B-2, which represents vehicles that initially failed, roughly corresponds to the one-year re-fail data shown earlier in the bar chart of Figure 2, where low-performing stations with FPRs near zero were seen to yield average one-year roadside failure rates of 53 and 61% (depending upon the scenario) and high-performing stations having FPRs close to 1 were seen to yield one-year roadside failures at a rates of 15 and 21%.<sup>29</sup> However, the logistic regression results describe the roadside fail rates in greater detail, filling in the gaps between the bars and providing consistent estimates of the confidence intervals for the failure probabilities. They also quantify and provide insights into the effects of vehicle age (from model year), date differences between tests, station FPR, type of station (STAR vs. non-STAR), and effects of the initial test result.

More work is planned to attempt incorporating the effects of repairs into the model as better repair data become available, which may lead to a better understanding of the durability of emissions-related repairs and how it affects subsequent failure rates.

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<sup>29</sup> The dataset used to develop Figures B-1 and B-2, like the dataset reflected in the bar chart of Figure 2, excludes stations having no FPR score or having an assigned (default) FPR score of 0.50. Note also, that Figure B-2, which provides the best overall modeled fit of the dataset to FPR, shows a lower weighted roadside fail rate at the FPR value of 0.975 (Sierra's High-Performing station in Scenario 2) than at 0.90 (Scenario 1), as expected. This contradicts the order shown in Figure 2 (pg. 11). While both the model and the bar graph rely on the same dataset, the model represents the optimal solution for all the data and appears, at this extreme of the distribution, to provide a more reliable estimate of fail rate than the limited 'slice' of data reflected in the final bar graph of Figure 2.

Figure B-1

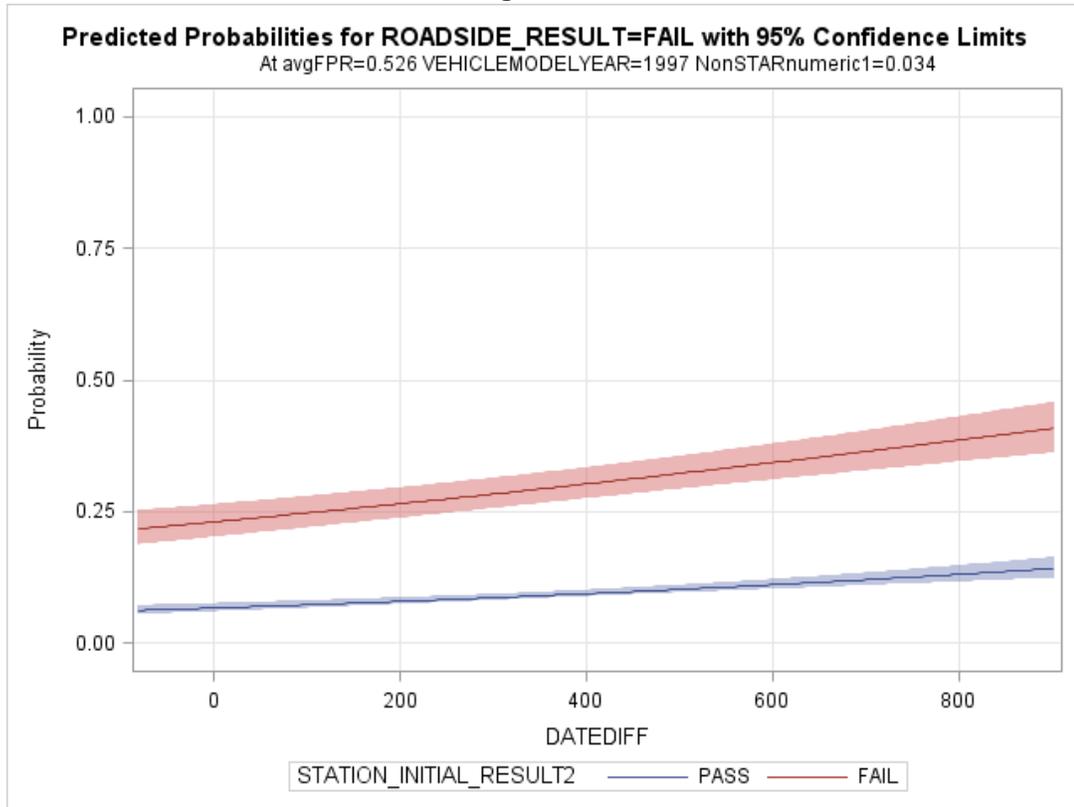
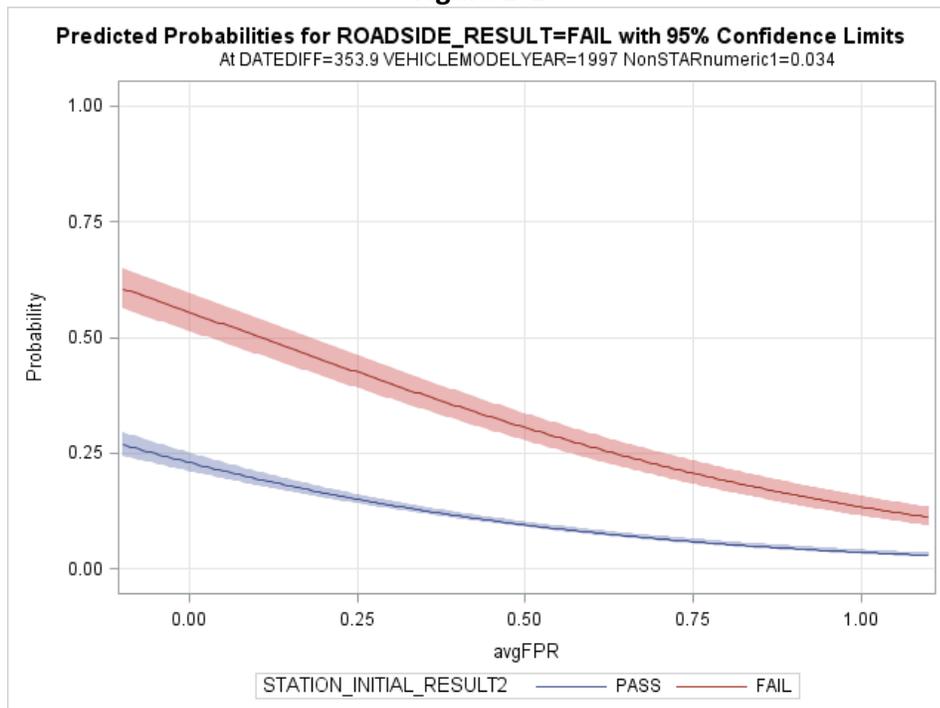


Figure B-2



## **Attachment C**

This attachment is a copy of the report entitled “Independent Review of 2016 Smog Check Performance Report,” by Revecorp, Inc., May 19, 2017.

**REVVECORP**

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ENGINEERING AND DATA SOLUTIONS

Independent Review  
of the  
2016 Smog Check Performance Report

PREPARED FOR:

**THE CALIFORNIA  
DEPARTMENT OF CONSUMER AFFAIRS  
BUREAU OF AUTOMOTIVE REPAIR**

Agreement 001546

June 6, 2017

**Independent Review  
of the  
2016 Smog Check Performance Report**

Prepared for:

Bureau of Automotive Repair  
10949 N. Mather Blvd.  
Sacramento, CA 95670

Agreement 001546

June 6, 2017

Prepared By:

[Revecorp Inc.](#)  
Dr. Michael J. St. Denis  
Robert Budd  
5732 Lonetree Blvd  
Rocklin, CA 95765  
(916) 786-1006

[www.Revecorp.com](http://www.Revecorp.com)

With

Eastern Research Group  
Sandeep Kishan  
Jim Lindner  
3508 Far West Blvd., Suite 210  
Austin, TX 78731  
(512) 407-1830  
[www.ERG.com](http://www.ERG.com)



**Disclaimer:**

The statements and conclusions in this report are those of the Contractor and not necessarily those of the Bureau of Automotive Repair (BAR) or the State of California. The mention of commercial products, their source, or their use in conjunction with material reported herein is not to be construed as actual or implied endorsement of such products.

**Table of Contents**

Independent Review  
of the  
2016 Smog Check Performance Report

**1 EXECUTIVE SUMMARY..... 1**

**2 2016 SMOG CHECK PERFORMANCE REPORT REVIEW REQUIREMENTS..... 2**

**3 SPECIFIC COMMENTS FOR IMPROVING THE REPORT..... 3**

**4 DISCUSSION ON WAYS TO IMPROVE THE REPORT..... 5**

4.1 Expand the Roadside Sample Size and Model Years .....5

4.2 Data Stratification in Future Reports .....5

4.3 Response to HSC Section 44024.5 (b)(6).....6

4.4 Trends.....7

**APPENDIX A – EMFAC 2014 MODELING RESULTS ..... 10**

**APPENDIX B – 2016 IM SOLUTIONS ANNUAL IM PROGRAM SUMMARY ..... 16**

## 1 EXECUTIVE SUMMARY

Revecorp was tasked with providing an independent review of the 2016 Smog Check Performance Report (the Report) developed by the Bureau of Automotive Repair (BAR). The Report is mandated by Assembly Bill (AB) 2289 (Eng, Chapter 258, Health and Safety Code 44024.5) which requires BAR, in cooperation with the California Air Resources Board (CARB) to perform an evaluation of the Smog Check Program using available data.

This independent review is an evaluation of the 2016 Smog Check Performance Report versus the specific requirements of AB 2289. In addition to addressing statutory requirements, this review offers suggestions to improve the clarity and to increase the usefulness of the Report in future years.

The major findings from the review of the Report that BAR could expand on are:

- The STAR Program appears to be increasing the effectiveness of the Smog Check program, although the Report has only a limited evaluation of the differences between STAR and non-STAR stations, and the relative impact of low-performing STAR stations.
- The low performing stations appear to be where the majority of excess emissions occur. The Smog Check Performance Report should provide more focus on:
  - a. Evaluating STAR versus non-STAR stations
  - b. Evaluating the impacts of low performing stations participating in the STAR program
  - c. Evaluating the impact removing low-performing stations would have on the roadside re-fail rate which is an indication of excess emissions
- The Smog Check Performance Report evaluation has been mostly limited to older (1976-1995) vehicles comprising a small fraction of the fleet although approximately half of the fleet excess emissions. BAR plans to expand the model years of vehicles sampled in the future.
- More vehicles need to be tested by BAR at roadside inspections to better trace performance of the Smog Check Program over time.
- The set of in-use data analyzed as part of the evaluation should be expanded to use additional data sources to identify the rates of unregistered and non-compliant vehicles operating on-road and their emissions rates.

## 2 2016 SMOG CHECK PERFORMANCE REPORT REVIEW REQUIREMENTS

BAR is required by Assembly Bill 2289 (2010), codified in Health and Safety Code (HSC) Section 44024.5, to perform an evaluation of the Smog Check program each year. HSC 44024.5 describes the specific goals to be met and methods to be used.

HSC Section 44024.5 (a) requires BAR to collect "emissions profiles" and "data from motor vehicles that are subject to the motor vehicle inspection program" using any source of data including Smog Check program data, roadside (in-use) testing data and remote sensing. The analysis of these data is "...to evaluate the program and to assess the performance of Smog Check stations".

HSC Section 44024.5 (b) describes seven specific tasks to be completed using the data collected in Section (a) to provide the evaluation of the program and Smog Check stations:

- (1) An independent validation of the evaluation methods, findings, and conclusions presented in the Report.
- (2) The percentage of vehicles that initially passed a Smog Check inspection and then failed a subsequent inspection as indicated by the data collected pursuant to subdivision (a).
- (3) The percentage of vehicles that initially failed a Smog Check inspection and then failed a subsequent inspection as indicated by the data collected pursuant to subdivision (a).
- (4) An estimate of excessive emissions resulting from vehicles identified in paragraphs (2) and (3).
- (5) A best-efforts explanation regarding the reasons vehicles identified in paragraphs (2) and (3) inappropriately failed or passed an inspection.
- (6) Recommended changes to the Smog Check program to reduce to a minimum the excess emissions identified in paragraph (4). In developing the recommended changes, the department and the state board shall undertake a thorough evaluation of the best practices of other state Smog Check inspection programs, and shall include in the recommendations how these other state best practices can be incorporated into California's program. Program recommendations pertaining to contracting with one or more entities to manage Smog Check stations shall not be implemented unless the Legislature, by statute, authorizes that contracting.
- (7) A comparison to the findings of the report "Evaluation of the California Smog Check Program Using Random Roadside Data" dated March 12, 2009.

Validation of the methods used for the evaluation (1) was performed in 2014 by UC Riverside. The methods used for the evaluation have not changed and therefore Revecorp was not asked to review this item. Items (2) through (7) were all addressed in the 2016 Smog Check Performance Report developed by BAR. Revecorp has reviewed these responses and from them developed questions related to the Report and ideas to increase the clarity and usefulness of the Report.

### 3 SPECIFIC COMMENTS FOR IMPROVING THE REPORT

Listed below are specific comments and questions that should be used to clarify some of the discussion in the Report and/or should be considered for the 2017 report.

- Comment - Page 1, bottom of the last paragraph – The sample selection process should briefly be explained in the Report. Was the roadside inspected sample random or was it limited to specific model years and vehicles that received a Smog Check within the last 12 months? If data beyond the past 12 months were collected, it may be useful to evaluate these data as well.
- Comment - Page 2, first paragraph – Were the same ASM standards used at roadside for the vehicles in the Sierra report and the roadside sample used in the current analysis?
- Comment - Page 2, first paragraph – An analysis to evaluate if the vehicles failed for the same pollutants on-road versus what they were last failed for during their Smog Check may provide additional insight.
- Comment - Page 2, first paragraph – Are the roadside failures only ASM emissions failures or are visual, functional and fuel cap failures included in the analyses? If data besides tailpipe results were used, these need to be described.
- Comment - Page 2, second paragraph – It would be useful to include the current Smog Check ASM failure rates in this discussion so the pass-fail rate could be compared to what is normally experienced.
- Comment - Page 3 – The majority of vehicles tested at roadside were initially tested at STAR stations, however, only approximately 60% of the Smog Check stations are STAR stations. Is the high rate of capturing vehicles inspected at STAR stations due to a higher number of vehicles being inspected at STAR stations? The “All Station Types” column results should be normalized to the rates of inspections at STAR versus non-STAR stations.
- Comment - Page 3, notes to Table 1 – Note \*\* and Note \*\*\* indicate that the tests were all conducted within one year of when the last station based Smog Check was performed. As noted in the comment on Page 1 above, were vehicles that were more than a year from when they received their Smog Check excluded from the roadside testing or just excluded from the analysis? If the data are available, they could be included to increase sample size if the time lapse between Smog Check and roadside inspection could be accounted for.
- Comment - Page 3, bottom – It is noted that the “...quality of the Smog Check Program has improved substantially since Sierra’s 2003-2006 study.” The term “substantially” is subjective and should be removed.
- Comment - Page 3, bottom – An explanation as to why the overall re-fail rate is unchanged over time would be useful here, although it may be difficult to determine.
- Comment - Page 4, end of paragraph 2 – The description as to why the re-fail rate in this report is poorer (higher) than in the last report is difficult to understand. Possibly it could simply be stated that some vehicles in last year’s report were inspected at a Smog Check station prior to the implementation of the STAR program, so not all vehicles in last year’s report exhibit the effects of the STAR program.

- Comment - Page 4, paragraph 3 – It is noted that removing directed vehicle inspection privileges from a STAR station can be “... a long and drawn out process,...” How long does this process take?
- Comment - Page 4, paragraph 3 – Although the population of vehicles sampled is small, data from stations which have been removed from the Smog Check program should be separated from the rest of the STAR stations to show the relative impact on the effectiveness of STAR stations.
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- Comment - Page 5, Table 2 – It would be useful to see the model year 1996 to 1999 vehicles separately from the other vehicles.
- Comment - Page 5, Station Performance Analysis – BAR should explain in more detail how specifically the Follow-up Pass Rate is calculated. The figures display the data for stations. Would evaluating performance based on technicians’ FPR scores provide additional insight?
- Comment - Pages 6, 7 and 8 - Figures 1, 2 and 3 – Add error bars and sample sizes to the charts. Also list the number of stations in each group and the number of inspections performed by these stations so their relative impact can be assessed.
- Comment - Page 7, top paragraph – What fraction of the STAR stations is low-performing? How many low-performing Smog Check stations are longer-term low-performing and how many are new to the STAR program?
- Comment - Page 8, Figure 3 –Why do the Scenario 2 low-performing stations have higher tailpipe failure rates than the Scenario 1 stations?
- Comment - Page 8, second paragraph – BAR should update all modeling to EMFAC 2014, including re-performing the previous report modeling so going forward there is a common and current baseline for the modeling. We are aware that there are limitations using EMFAC 2014 to model the IM versus non-IM vehicles.
- Comment - Page 8, last two paragraphs – The explanation of why the lost benefit dropped so much in the CY2015 analysis should include more data to describe the change. For example, the report could note that in CY2005, MY1976-1995 vehicles accounted for 25.5% of the light-duty vehicle VMT, which dropped to 3.8% in CY2015.
- Comment - Page 9, last paragraph – Revecorp believes the expansion to collecting OBD data and increasing sample sizes should happen as soon as possible. This will retain the statistical validity of the sample. This will be one of the most critical things that will need to be done moving forward for evaluating overall Smog Check Program performance.

## 4 DISCUSSION ON WAYS TO IMPROVE THE REPORT

### 4.1 Expand the Roadside Sample Size and Model Years

HSC Section 44024.5 (b) requires a comparison to the 2009 Sierra Research report. This was a reasonable and useful analysis in the 2015 Smog Check Performance Report to show the trends in program performance over time. The data for the Sierra Research report were from 2003 to 2006 roadside inspections of vehicles through model year 1995. Newer vehicles have significantly lower emission rates than older vehicles but tend to have higher vehicle miles traveled (VMT). This balance, at least in the short term will make the re-fail rates of older vehicles potentially important for some time into the future. Graphs showing the EMFAC 2014 estimated VMT and vehicle populations, as well as graphs indicating the emissions contributions of light duty vehicles by model year groups, for all of California in the summer of 2005 and in 2016, 2020, 2025 and 2030 are provided in Appendix A. Note that the emissions are in Tons per Day (TPD); however the scale on the left changes over time.

The 2016 Smog Check Performance report broadened the range of model years to 1976-1999, from the range of 1976-1995 model years that was analyzed in earlier SCPFs and in the Sierra report. In order to increase the usefulness of the Report "... to evaluate the program, and to assess the performance of Smog Check stations" (HSC 44024.5 (a)), the model years sampled on-road need to be further expanded. As noted on Page 9, BAR is collecting OBDII data and intends to include OBDII data in the 2017 report. This is necessary to keep up the validity and usefulness of the Report; however, sampling more newer vehicles, if the sample size remains the same, will lower the number of older vehicles sampled and lead to higher uncertainty in the analysis of all groups. Therefore, Revecorp recommends expansion of the roadside sampling to include more vehicles across more model years. The sampling should be stratified to represent the relative re-fail rates and contributions to excess emissions estimated for each model year group (as noted in the next section below). For example, the emissions of NO<sub>x</sub> in 2016 from pre OBDII vehicles are approximately 40 TPD (approximately a third of all NO<sub>x</sub> emissions) and drop to approximately 5 TPD in 2030. However, these vehicles will still represent approximately 13% of fleet wide NO<sub>x</sub> emissions, so they will still remain important and need to be sampled.

Because both ASM emissions rates and OBDII results are collected for 1996 and newer vehicles tested at roadside, the OBDII data can be correlated to tailpipe based emissions rates, providing data that may be used to evaluate station based OBDII data. BAR has noted that CARB has begun this work.

### 4.2 Data Stratification in Future Reports

As noted above, the data collected at roadside through year-end 2015 was mainly limited to model year 1999 or older vehicles. In the future, BAR plans to collect data on newer vehicles and there will be a need to evaluate these vehicles over time as well. Since vehicle technology changes with time, the most consistent approach would be to break out vehicles in model year groups that remain static. However, unless the total number of vehicles sampled is increased, over time the sample sizes by group will decrease leading to larger uncertainties on the impact of each group of vehicles.

For static groups, it is recommended that the data be grouped and reported by the following model year ranges (which were used in the graphs in Appendix A):

- 1976 to 1995 ("pre-OBDII" technology group)
- 1996 to 1999 (early OBDII technology group)
- 2000 to 2004 (mid OBDII technology group)

- 2005 to 2008 (early CAN OBDII technology group)
- 2009 to 2014 (all CAN technology group)
- 2015 to 2019
- Etc. at five year increments

The charts included in Appendix A show the suggested groups mostly evenly divide the emissions of vehicles in the middle portion of the graphs (1996 to 2014). Although using so many groups could reduce the size of the samples in each group if sampling cannot be expanded, the groups could always be aggregated together if necessary.

Selection of vehicles at the roadside study should be selectively stratified between these groups relative to their re-fail rates at roadside from the previous year's study combined with the EMFAC2014 estimated excess emissions impact. This should minimize the uncertainty potential error in the mean measurements so it is smallest for the groups that are causing the largest impacts. BAR should work to develop easy to use tools to screen vehicles at roadside locations to ensure the sampled vehicles fill the correct model year range needs. It is possible that a tool with automatic license plate reading or license plate input upstream of an officer combined with a properly tuned database could improve in vehicle selection for participation in the roadside monitoring program.

#### 4.3 Response to HSC Section 44024.5 (b)(6)

In the Report, BAR does not address part of requirement of HSC 44024.5 (b)(6) which requests that best practices of other state emissions inspection programs be evaluated for incorporation into the Smog Check Program to reduce excess emissions. The following summary, requested by BAR fulfills this requirement.

For the analysis of other programs in the US and Canada, Revecorp relied upon data from the 2016 IM Solutions annual report (<http://www.obdclearinghouse.com/IMSolutions/#>, under "I/M Jurisdiction Report") and its own knowledge and experience in working with state vehicle inspection programs across the US.

The IM Solutions report includes data from 39 programs in 33 states (some programs are managed at the county level), summarized in Appendix B. Eleven programs inspect vehicles statewide with the remaining programs only inspecting vehicles for emissions in high population areas. In total, there were a reported 78,841,830 vehicle emissions inspections in 2016. California had the greatest number of inspections (11,500,000) with New York second (10,500,000) and Texas third (8,500,000). However, the New York vehicle inspection program has more decentralized inspection stations than California (10,000). The number of inspections per year per program ranges from 12,000,000 to 45,000 with the average number of inspections per year of 2,000,000 with 19 programs (half) having less than 1,000,000 tests per year. Additional program statistics are provided below, with the California values provided in parenthesis if available:

- Average exemption is 3.6 years (6 years)
- Overall average inspection cost is \$24.70 (\$57.33)
- Program Types and fees:
  - Centralized programs – 8. Average inspection cost is \$19.35
  - Decentralized programs – 25. Average inspection cost is \$27.70 (\$57.33)
  - Hybrid programs – 4. Average inspection cost is \$16.81
- Remote sensing is used in five programs (not used for enforcement by CA)
  - One uses remote sensing for clean screen
  - Three programs use remote sensing for dirty screen

- One program uses remote sensing for both clean and dirty screen
- Self-service OBDII kiosks are operational in three programs (not used in CA)
- Remote OBDII is available in two programs (in CA, applies to government fleets)
- Inspection frequencies:
  - Annual inspection programs – 12
  - Biennial inspection programs – 20 (CA)
  - Mixed depending on the vehicle type – 6
  - Approximately one-third of the programs require tests at change of ownership (CA)
- Program enforcement method:
  - Registration denial – 28 (CA)
  - Registration revocation or suspension - 3
  - Sticker based enforcement - 6

A notable aspect of the California program compared to the other programs is that California has one of the longest new model year exemption (6 years) with only certain areas within Washington State and Colorado being longer at 7-8 years. Another notable aspect of the California program is it has the highest reported average inspection cost of any program in the US or Canada, almost 2.5 times the overall average and slightly more than two times the average for other decentralized vehicle emissions inspection programs.

#### 4.4 Trends

Many programs, including CA, are moving to OBDII only inspections and the trend is to low cost, off-the-shelf OBDII scan tools combined with tablet based inspections. For example, the Vermont program recently began and is using off-the-shelf OBDII scan tools that cost under \$100, industrial tablets and wireless printers for a total package cost under \$2,000. Remote sensing for clean or dirty screen has not been popular in many programs after being evaluated by many jurisdictions, including the State of CA, over many years. This seems to be due to cost of clean screening being nearly the same as a Smog Check and dirty screening receiving poor public acceptance. Self-service OBDII kiosks have not caught on with the public and are used in three states. Remote OBDII, which in this day of connected vehicles and ubiquitous internet connectivity, is still not being implemented in many vehicle emissions inspection programs. Some vehicle inspection programs still require safety inspections, limiting the value of remote OBDII inspections and preventing the use of self-service kiosks.

Due to increasingly better air quality due to lower emissions vehicles in the fleet and the majority of vehicles being OBDII equipped, the trend is toward OBDII only vehicle emissions inspection programs, California included, for newer vehicles. In addition, centralized inspection programs are being phased out either completely or are slowly converting to decentralized inspection programs. The conversion to decentralized OBDII only inspection programs, less expensive technology and a limited but highly competitive number of vendors (only six vendors are assisting with the 39 programs), has been lowering the cost of inspections each year.

The major limitation of decentralized inspection has historically been the incentive to conduct fraudulent testing due to combining testing and repair at the same facility. In centralized testing programs, effective oversight is more readily accomplished. Furthermore, electronic data supplied by the OBDII systems in 1996 and newer vehicles allows decentralized inspection programs to identify potential fraudulent testing more easily and cost effectively. California has adopted the OBDII-based approach for model year 2000 and newer gasoline vehicles and for 1998 and newer diesels (gasoline vehicles from model years 1996-99 include simple OBDII monitoring along with their required tailpipe testing.) Some programs have identified electronic vehicle "simulators" to circumvent the electronic OBD monitoring systems. To date, no

comprehensive study of the frequency of use of these devices has been performed, therefore the impact on program effectiveness is also unknown.

Another significant issue with increasing program performance is when fraud is identified, significant time and resources are required to remove stations and inspectors performing inappropriate inspections. In centralized programs, the inspectors work directly for the program or a contractor and can simply be terminated if there is an issue with the quality of their inspections. In decentralized inspection programs, removing stations or inspectors is a more complex and time consuming process. Some of the tools other programs are using include having inspection stations sign agreements as part of their license which allows automatic performance triggers to suspend their license if they fall below particular metrics and incentives for stations which only perform testing (Massachusetts). Ontario Canada (a decentralized program) uses real-time test interruption with video conferencing when an item in the inspection meets certain trigger criteria (such as when the entered VIN and the VIN reported by the vehicles computer do not match). States share their "trigger" ideas through private "state-only" groups such as IM Solutions, as they desire to keep the "triggers" to state I/M administrators.

Although the California Smog Check Program is sometimes thought of mostly as an inspection program, the inspections only identify vehicles with excess emissions. This Smog Check Performance Report should also focus on the associated emissions control system repairs that take place after a vehicle fails. This could lead to an understanding of the durability of repairs and if there is more need for repair education to improve the cost effectiveness of repairs. Some states send auditors to repair shops and review the appropriateness of repairs to protect consumers and to ensure the program is maximizing emissions reductions through repairs. Information on repairs in these programs is also used to direct motorists to shops that have better repair performance (pass after repair and longer durability repairs). BAR conducted some repair studies in the mid 90's evaluating catalytic converter replacement programs, waiver repair programs, and vehicle scrap programs that led to some of the current tools being used today to improve Smog Check Program performance. The state of Colorado has recently conducted several repair studies that have generated useful information on the effectiveness and usefulness of repair technician training and the durability of repairs.

The Report states that BAR is pursuing regulatory changes to decrease the time it takes to remove a low-performing station's privileged STAR status. Such a change is clearly needed to offset the significant financial incentive that cheating stations now enjoy by continuing to conduct flawed emissions tests at elevated directed-vehicle volumes while their STAR status is being invalidated for poor performance. For example, if it took 2 months to remove a station, and the station performed 48 inspections per day (one every 15 minutes, 12 hours a day), the station could perform 2880 inspections prior to removing their STAR certification (48 inspections per day x 60 days). According to the BAR Executive Summary of November 2014 (the latest executive summary with repair data), the average vehicle repair cost at a STAR station is \$278 and in the Consumer Assistance Program (CAP) is \$414. If it is assumed that the average repair were the approximate average of these two (\$350) costs, and that a falsely passing Smog Check (to avoid the cost of repair) were worth at least half this amount (\$175), then the total revenue a Smog Check station could make in two months of falsely passing vehicles would be \$175 per inspection x 2,880 inspections = \$504,000. For many stations, the vast majority of this illicit business and profit could be the result of testing directed vehicles. Removing the STAR certification (which ends the directed vehicle privilege) while the process is underway, allows stations to remain in business, which due process requires, while the STAR status is being formally reviewed, but limits their ability to continue to reap profits from the improper inspections of directed vehicles during this period.

One potential solution would be to implement triggers using the inspection data that limit environmental damage from under-performing stations if their poor behavior increases. For instance, there could be a feedback mechanism that limits the number of inspections a station can conduct as their performance decreases.

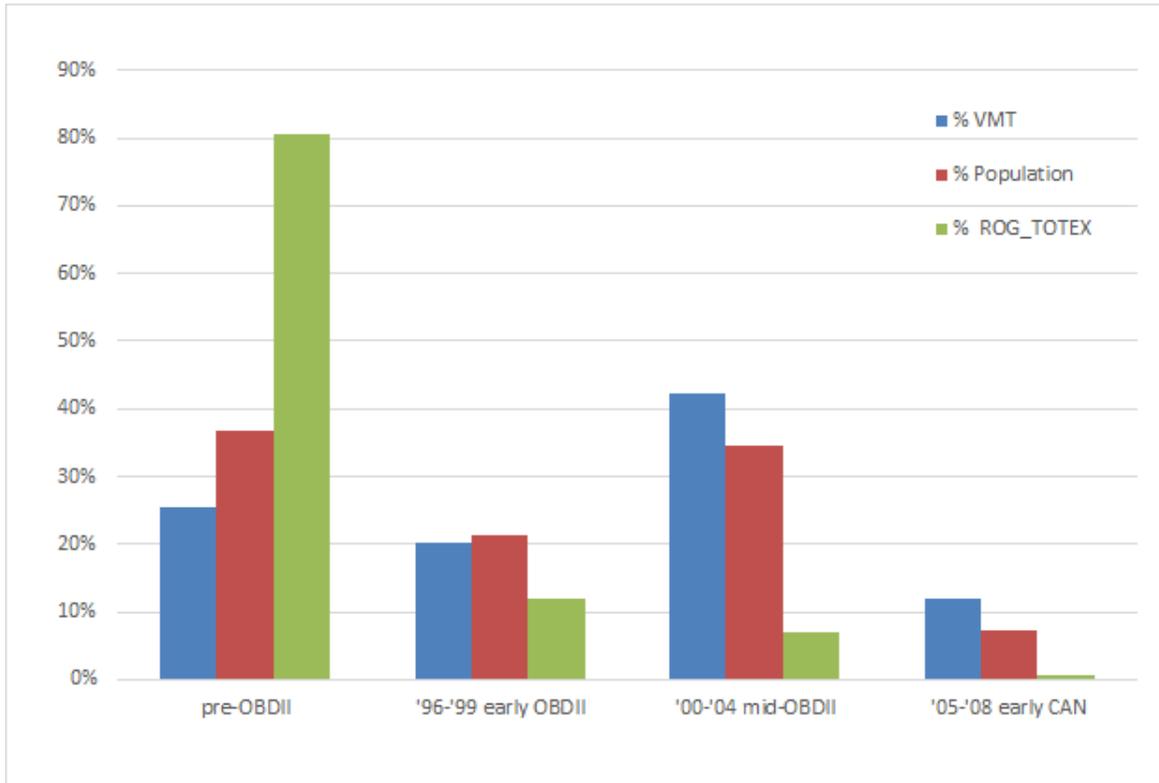
A metric that should be used year over year to evaluate the impact of station suspensions would be a comparison of the number of stations or inspectors with STAR certification invalidated per year. The performance of the stations or inspectors with STAR certification invalidated from the past year could be compared to the remaining stations to determine the relative impact these stations or inspector had on the re-fail rates on-road, and the environmental impact the excess emissions from these stations generated.

## **APPENDIX A – EMFAC 2014 MODELING RESULTS**

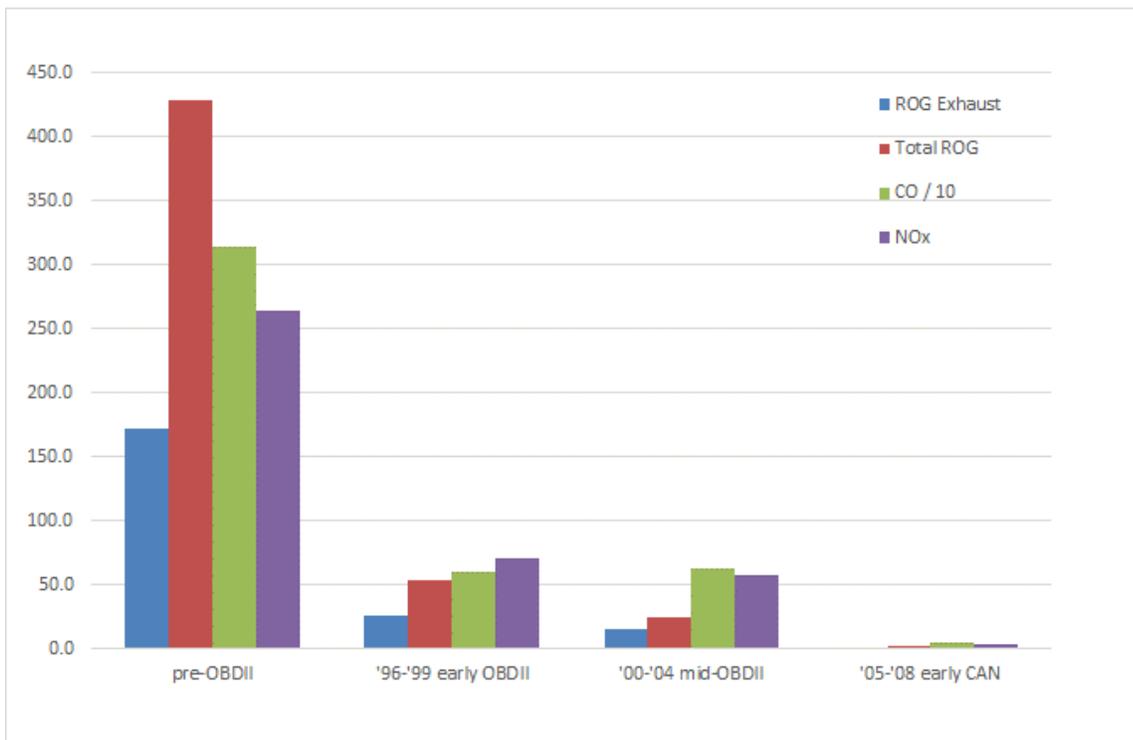
Estimated vehicle miles traveled, vehicle populations and emissions of light duty motor vehicles during summertime in California in the years 2005, 2016, 2020, 2025 and 2030 based on running ARB's Emission Factor model (EMFAC 2014).

The first figure on each page shows the persistent importance of the pre-OBDII fleet as a contributor to California smog. The second figure shows how emissions tend to remain roughly constant across model year groups, i.e. even as groups age and their numbers and VMT decline, emissions per vehicle tend to increase. This demonstrates the continuing need to maintain their emission control systems' integrity and it supports the suggested model year groupings.

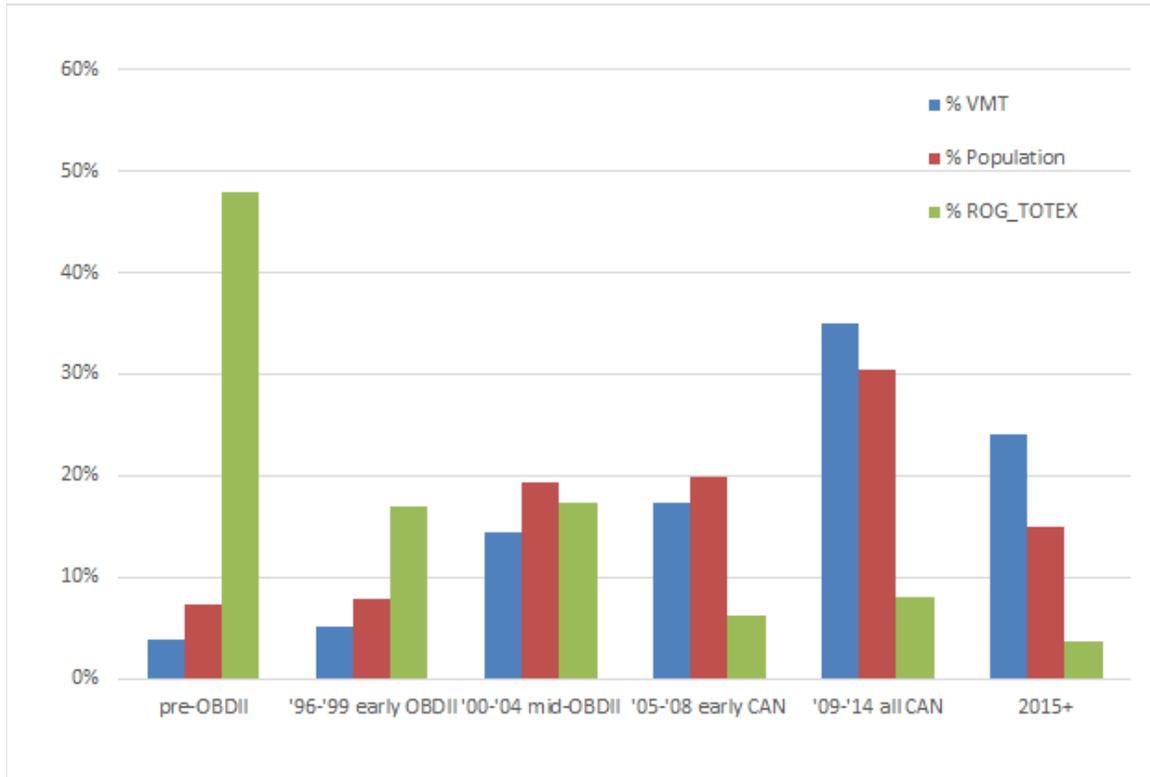
Fraction of Light Duty Vehicle Miles Traveled (VMT), Population and Total ROG in CA in 2005



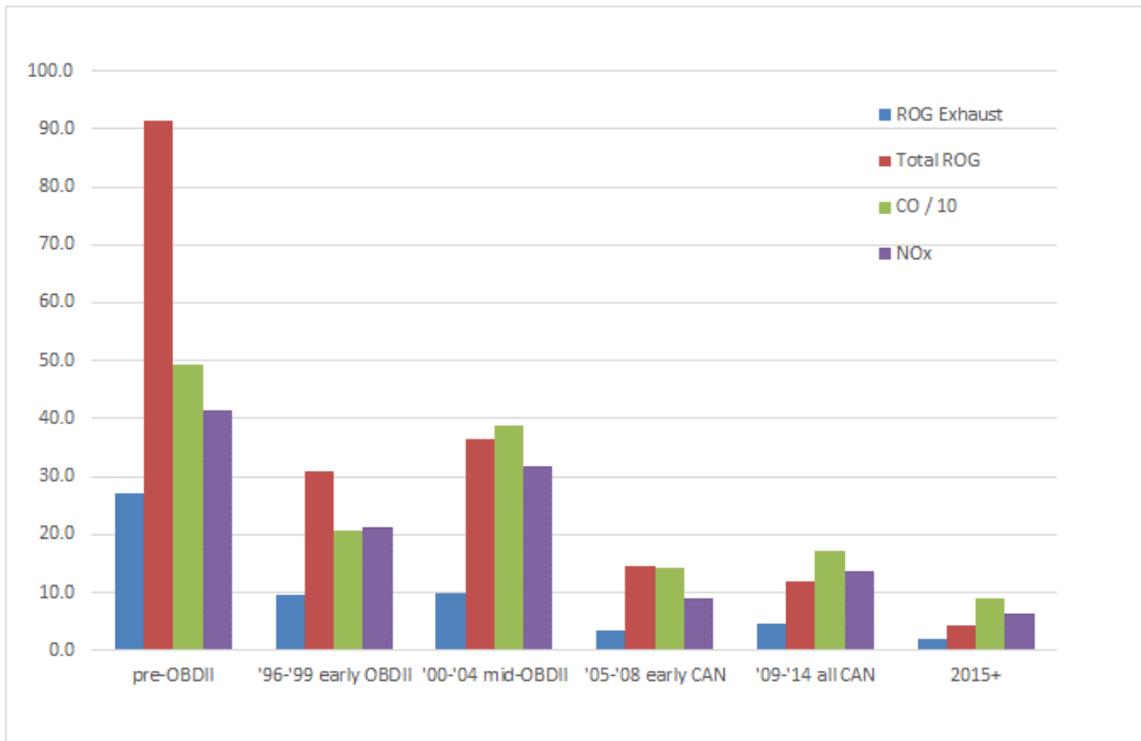
Emissions by Pollutant (TPD) Statewide in CA, Summer, 2005



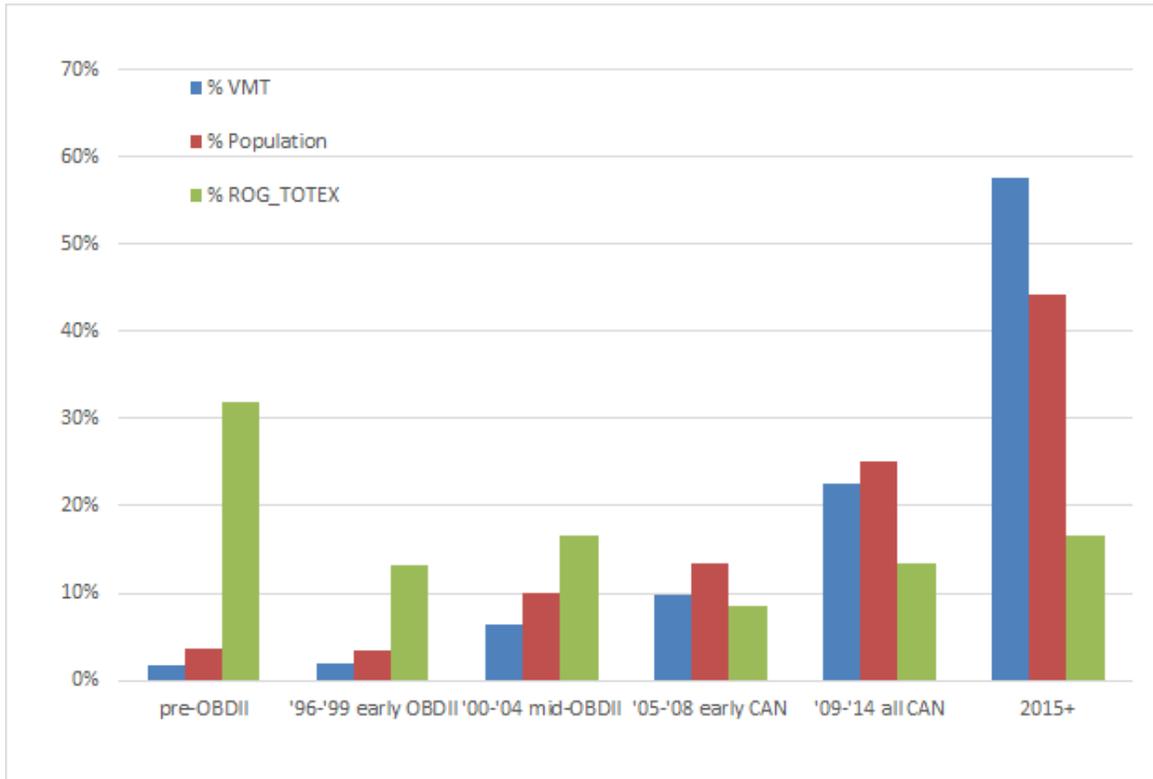
Fraction of Light Duty Vehicle Miles Traveled (VMT), Population and Total ROG in CA in 2016



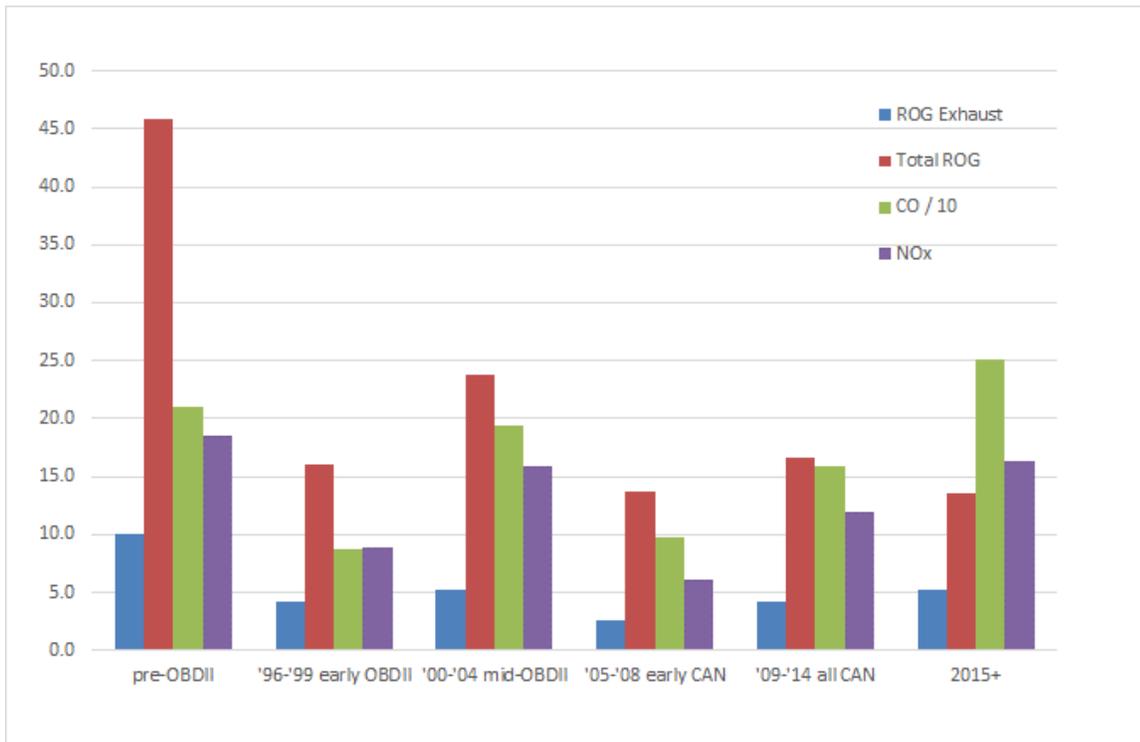
Emissions by Pollutant (TPD) Statewide in CA, Summer, 2016



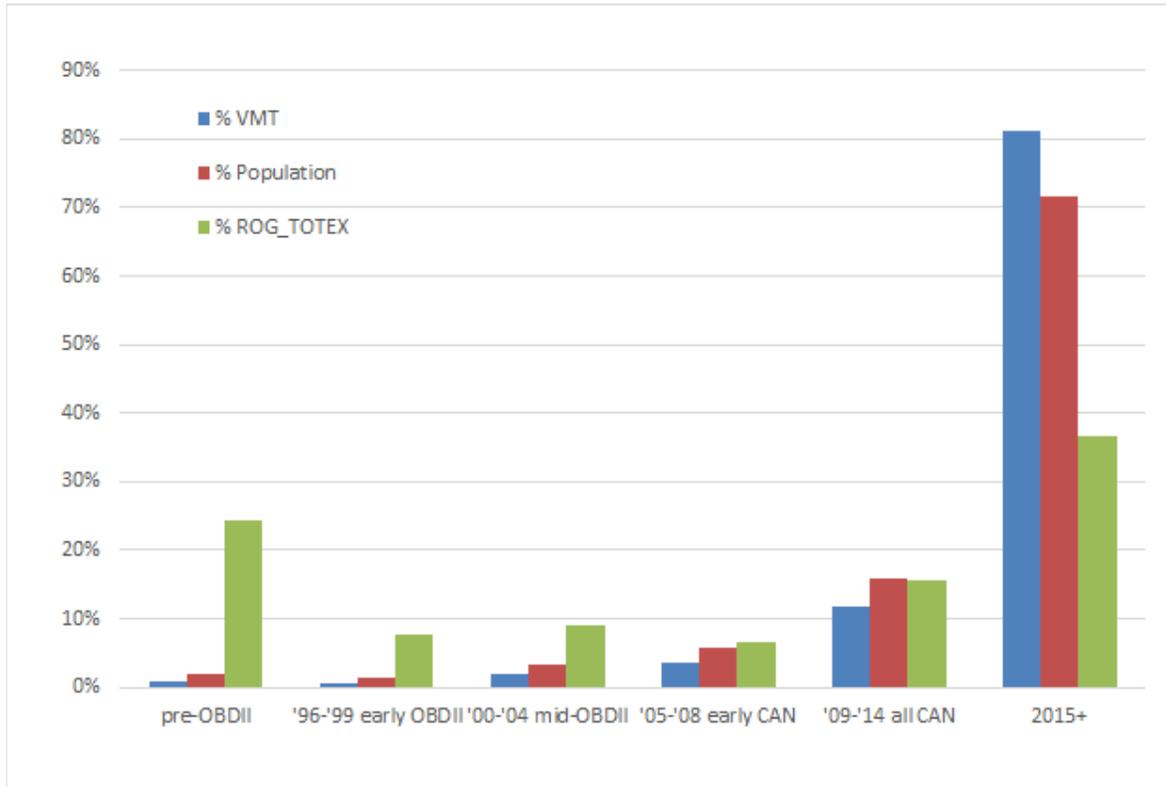
Fraction of Light Duty Vehicle Miles Traveled (VMT), Population and Total ROG in CA in 2020



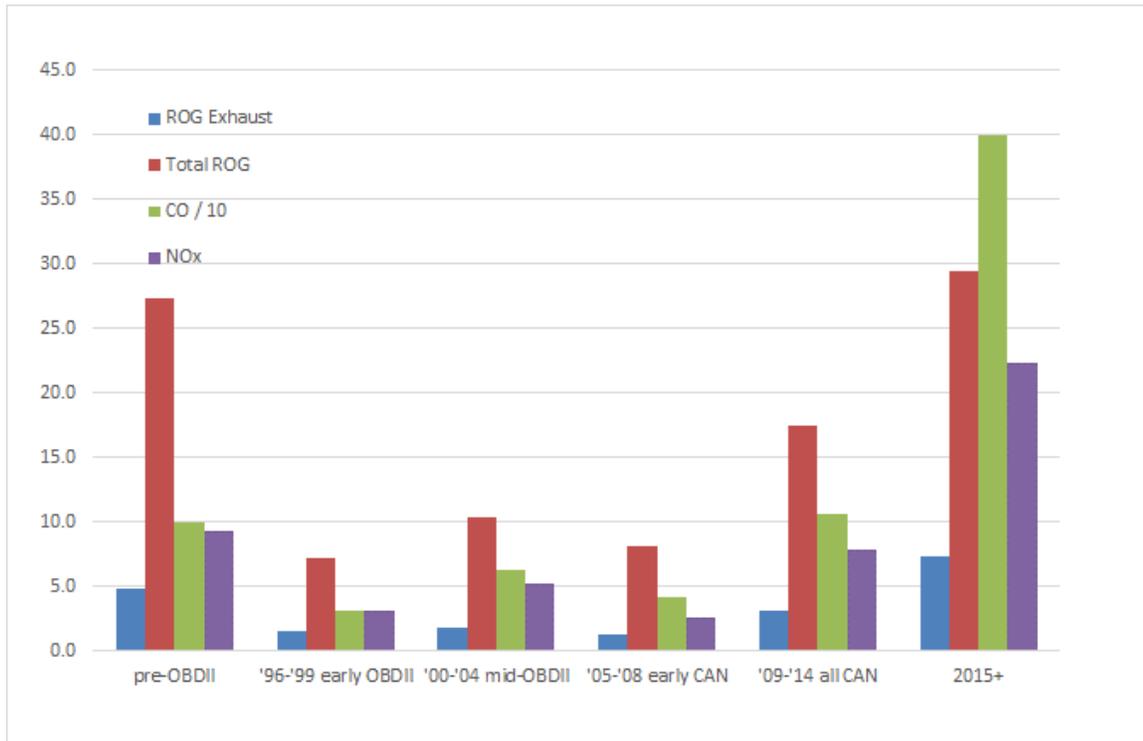
Emissions by Pollutant (TPD) Statewide in CA, Summer, 2020



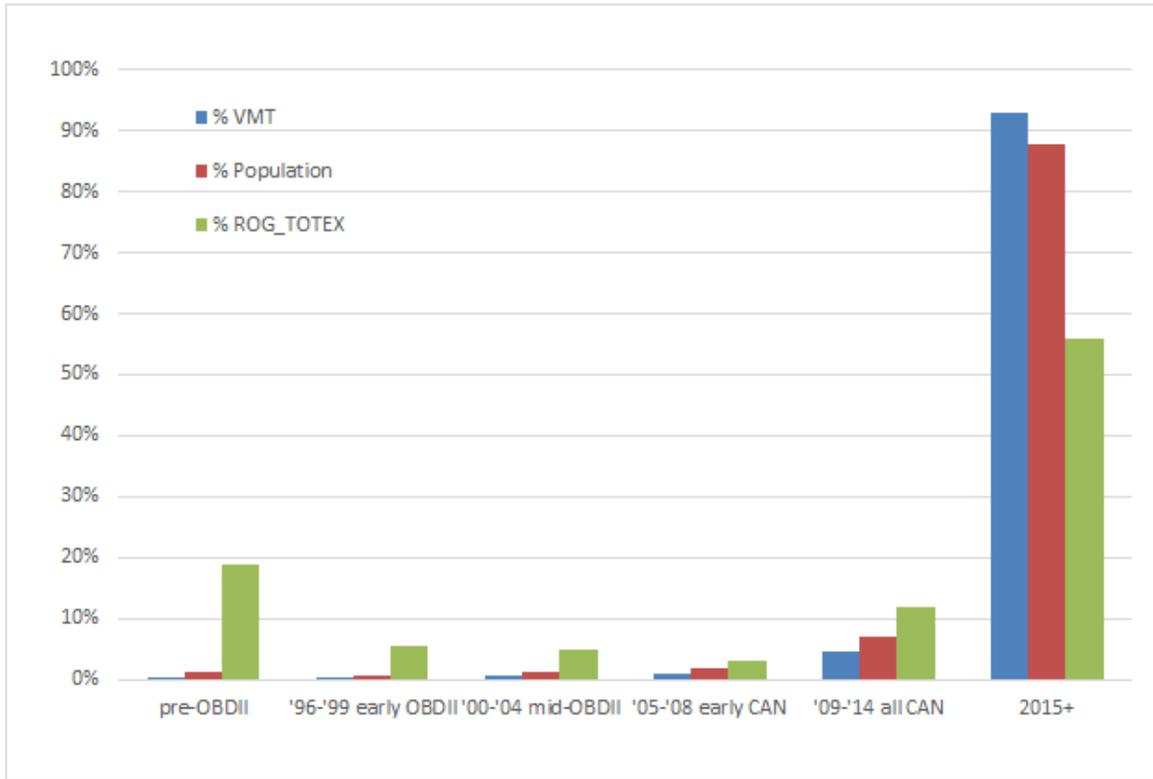
Fraction of Light Duty Vehicle Miles Traveled (VMT), Population and Total ROG in CA in 2025



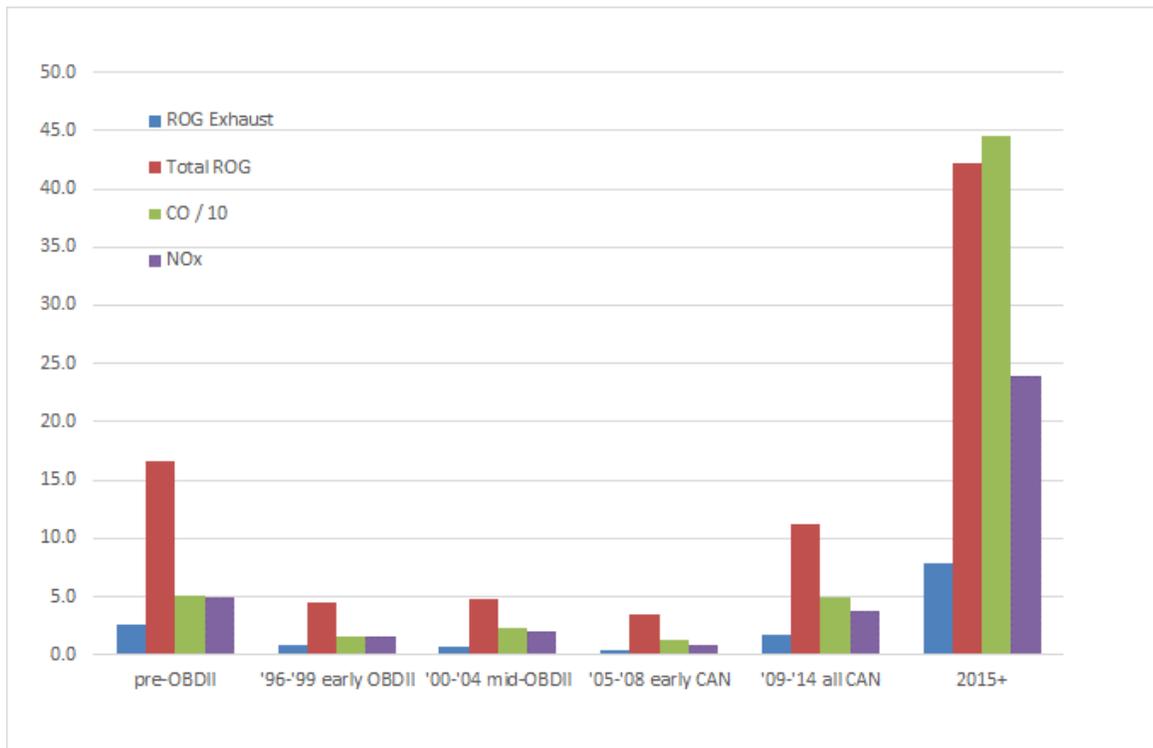
Emissions by Pollutant (TPD) Statewide in CA, Summer, 2025



Fraction of Light Duty Vehicle Miles Traveled (VMT), Population and Total ROG in CA in 2030



Emissions by Pollutant (TPD) Statewide in CA, Summer, 2030



## APPENDIX B – 2016 IM SOLUTIONS ANNUAL IM PROGRAM SUMMARY

| Summary of US and Canadian Vehicle Emissions Inspection Programs - From 2016 IM Solutions Annual Report |                                    |                             |      |          |          |                        |        |            |                 |           |                |              |
|---------------------------------------------------------------------------------------------------------|------------------------------------|-----------------------------|------|----------|----------|------------------------|--------|------------|-----------------|-----------|----------------|--------------|
| State                                                                                                   | Location                           | Contractor                  | Type | Stations | Fee      | RSD                    | Kiosks | Remote OBD | Exemption years | Frequency | Enforcement    | Annual Tests |
| AZ                                                                                                      | Pheonix                            | Gordon-Darby                | C    | 15       | \$ 20.35 |                        |        |            | 4               | Mixed     | Reg denial     | 1,200,000    |
| AZ                                                                                                      | Tucson                             | Gordon-Darby                | C    | 15       | \$ 12.25 |                        |        |            | 4               | Mixed     | Reg denial     | 800,000      |
| CA                                                                                                      | Mixed, Statewide                   | SGS                         | D    | 7,300    | \$ 57.33 |                        |        | Yes        | 6               | Biennial  | Reg denial     | 11,500,000   |
| CO                                                                                                      | Denver, Boulder, NFR               | Opus                        | H    | 18       | \$ 25.00 | Clean Screen           |        |            | 8               | Mixed     | Reg denial     | 1,200,000    |
| CT                                                                                                      | Statewide                          | Applus                      | D    | 213      | \$ 20.00 | Dirty Screen           |        |            | 4               | Biennial  | Reg denial     | 1,089,630    |
| DE                                                                                                      | Statewide                          | Opus                        | C    | 4        | Free     |                        |        |            | 6               | Biennial  | Reg denial     | 460,000      |
| DC                                                                                                      | Statewide                          | Opus                        | C    | 1        | \$ 35.00 |                        |        |            | 4               | Biennial  | Reg denial     | 180,000      |
| GA                                                                                                      | 13 counties                        | Applus                      | D    | 900      | \$ 25.00 |                        |        |            | 4               | Annual    | Reg denial     | 2,900,000    |
| ID                                                                                                      | Ada                                | Worldwide                   | D    | 45       | \$ 20.00 |                        |        |            | 4               | Biennial  | Reg revocation | 125,000      |
| ID                                                                                                      | Canyon                             | Applus                      | D    | 24       | \$ 11.00 |                        |        |            | 6               | Biennial  | Reg revocation | 45,000       |
| IL                                                                                                      | Chicago, E St. Louis               | Applus                      | H    | 55       | \$ 6.95  |                        |        |            | 4               | Biennial  | Reg denial     | 2,000,000    |
| IN                                                                                                      | Lake, Porter                       | Opus                        | C    | 7        | \$ 23.83 |                        |        |            | 4               | Biennial  | Reg denial     | 195,000      |
| LA                                                                                                      | Baton Rouge                        | Parsons, Opus               | D    | 161      | \$ 8.00  |                        |        |            | 2               | Annual    | Sticker        | 425,000      |
| ME                                                                                                      | Statewide                          | NONE - Paper based program  | D    | 700      | \$ 18.50 |                        |        |            | 1               | Annual    | Sticker        | 275,000      |
| MD                                                                                                      | DC, Balt, Hagerstown, Philly       | Opus                        | C    | 18       | \$ 14.00 |                        | Yes    |            | 2               | Biennial  | Reg suspension | 1,558,022    |
| MA                                                                                                      | Statewide                          | Parsons, changing to Applus | D    | 1,600    | \$ 35.00 |                        |        |            | 1               | Annual    |                | 4,600,000    |
| MO                                                                                                      | St. Louis                          | Opus, changing to Worldwide | D    | 853      | \$ 24.00 |                        |        |            | 2               | Biennial  | Reg denial     | 792,700      |
| NV                                                                                                      | Clark, Washoe                      | Worldwide                   | D    | 454      | \$ 43.75 |                        |        |            | 2               | Annual    | Reg denial     | 1,415,967    |
| NH                                                                                                      | Statewide                          | Gordon-Darby                | D    | 1,926    | \$ 35.00 |                        |        |            | 0               | Annual    | Sticker        | 1,103,576    |
| NJ                                                                                                      | Statewide                          | Parsons, SGS protested      | H    | 1,126    | \$ 20.29 |                        |        |            | 6               | Biennial  | Sticker        | 2,500,000    |
| NM                                                                                                      | Albuquerque                        | Worldwide                   | D    | 137      | \$ 20.00 |                        |        |            | 4               | Biennial  | Reg denial     | 250,000      |
| NY                                                                                                      | Statewide                          | Opus                        | D    | 10,000   | \$ 19.00 |                        |        |            | 2               | Annual    | Reg denial     | 10,500,000   |
| NC                                                                                                      | 48 Counties                        | Opus                        | D    | 4,500    | \$ 30.00 |                        |        |            | 3               | Annual    | Reg denial     | 5,000,000    |
| OH                                                                                                      | 7 cities                           | Opus                        | D    | 76       | Free     |                        | Yes    |            | 4               | Biennial  | Reg denial     | 850,000      |
| ON                                                                                                      | Southern Ontario                   | Parsons                     | D    | 1,800    | \$ 30.00 |                        |        |            | 7               | Biennial  | Reg denial     | 3,000,000    |
| OR                                                                                                      | Portland, Medford                  | Opus                        | C    | 7        | \$ 21.00 |                        | Yes    | Yes        | 5               | Biennial  | Reg denial     | 1,300,000    |
| PA                                                                                                      | 25 Counties                        | Parsons                     | D    | 8,000    | \$ 30.00 |                        |        |            | 1               | Annual    | Sticker        | 5,800,000    |
| RI                                                                                                      | Statewide                          | Opus                        | D    | 291      | \$ 55.00 | Dirty Screen           |        |            | 2               | Biennial  | Reg denial     | 342,101      |
| TN                                                                                                      | Nashville Mid-Tennessee            | Opus                        | C    | 16       | \$ 9.00  |                        |        |            | 1               | Annual    | Reg denial     | 1,400,000    |
| TX                                                                                                      | Austin, Dallas, El Paso, Houston   | Gordon-Darby                | D    | 4,800    | \$ 24.50 | Dirty Screen           |        |            | 2               | Annual    | Reg denial     | 8,500,000    |
| UT                                                                                                      | Cache County                       | Worldwide                   | D    | 49       | \$ 15.00 |                        |        |            | 7               | Biennial  | Reg denial     | 3,500,000    |
| UT                                                                                                      | Davis County                       | Worldwide                   | D    | 137      | No data  |                        |        |            | 2               | Mixed     | Reg denial     | 203,046      |
| UT                                                                                                      | Salt Lake County                   | Applus                      | D    | 433      | \$ 29.50 |                        |        |            | 2               | Mixed     | Reg denial     | 641,000      |
| UT                                                                                                      | Utah County                        | Opus                        | D    | 216      | \$ 26.00 |                        |        |            | 3               | Mixed     | Reg denial     | 263,738      |
| VT                                                                                                      | Statewide                          | Parsons                     | D    | 1,600    | \$ 32.50 |                        |        |            | 1               | Annual    | Sticker        | 650,000      |
| VA                                                                                                      | 10 cities and counties             | Opus                        | D    | 530      | \$ 28.00 | Clean and Dirty Screen |        |            | 4               | Biennial  | Reg denial     | 826,350      |
| WA                                                                                                      | Seattle-Tacome, Spokane, Vancouver | Applus                      | H    | 32       | \$ 15.00 |                        |        |            | 7               | Biennial  | Reg denial     | 800,000      |
| WI                                                                                                      | 7 counties                         | Opus                        | D    | 200      | No data  |                        |        |            | 4               | Biennial  | Reg denial     | 650,000      |