6.0 STATE AND CLASS I AREA SUMMARIES

As described in Section 2.0, each state is required to submit progress reports at interim points between submittals of Regional Haze Rule (RHR) State Implementation Plans (SIPs), which assess progress towards visibility improvement goals in each state's mandatory Federal Class I areas (CIAs). Data summaries for each CIA in each Western Regional Air Partnership (WRAP) state, which address Regional Haze Rule (RHR) requirements for visibility measurements and emissions inventories are provided in this section. These summaries are intended to provide individual states with the technical information they need to determine if current RHR implementation plan elements and strategies are sufficient to meet all established reasonable progress goals, as defined in their respective initial RHR implementation plans.

6.5 HAWAII

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. Hawaii has 2 mandatory Federal CIAs, which are depicted in Figure 6.5-1 and listed in Table 6.5-1, along with the associated IMPROVE monitor locations. Note that two sites are listed to represent the Haleakala CIA, but one site (HALE1) was discontinued in 2012, and the other site (HACR1) began operation in 2007. Data collected from both sites are summarized in this report, but future regional haze progress will be determined using only the HACR1 site.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- The 5-year average deciview metric decreased between the baseline and progress period at all 3 sites on best days, and increased on the worst days.
- The largest aerosol contributor to increases on the worst days was ammonium sulfate. The major source of ammonium sulfate for the State of Hawaii is SO_2 emissions from volcanic sources.
- Increases in ammonium sulfate were partially offset by decreases in ammonium nitrate, particulate organic mass and elemental carbon at all sites. Decreases in emissions inventories oxides of nitrogen (NO_X) were shown for mobile and point sources, but these were offset by increases in marine emissions.
- Slight increases for the worst days were observed in soil and coarse mass at the HAVO1 site, but these soil and coarse mass components combined comprised less than 2% of the total measured extinction.

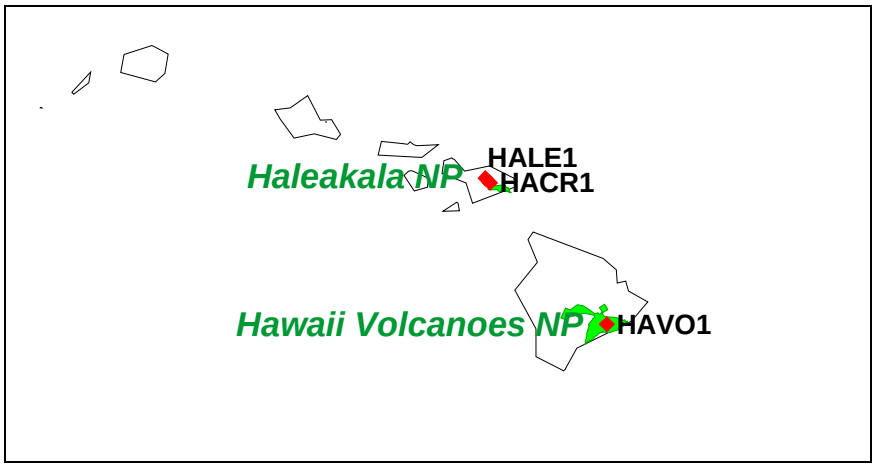

Figure 6.5-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in Hawaii.

Table 6.5-1
Hawaii CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Haleakala NP	HACR1*	20.76	-156.25	2158
	HALE1*	20.81	-156.28	1153
Hawaii Volcanoes NP	HAVO1	19.43	-155.26	1258

*Monitoring at the HACR1 site began in 2007 and monitoring at the HALE1 site was discontinued in 2012.

6.5.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in Hawaii, including estimates of baseline concentrations for the Haleakala HACR1 site. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix E.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.5.1.1 Haleakala Baseline Estimate

In Hawaii, the HALE1 IMPROVE monitor began operation in 2000 at a site approximately 3.5 miles outside of Haleakala National Park boundaries. In 2007 a second IMPROVE monitor, HACR1, was installed at a higher elevation within park boundaries. The intention of the HACR1 site was to replace the HALE1 site, as the new HACR1 site was determined to be more representative of conditions in the park. A map depicting both Haleakala sites is presented in Figure 6.5-2. Data from the HALE1 site were used to represent Haleakala in the Hawaii RHR Federal Implementation Plan (FIP), but progress for both the HALE1 and HACR1 sites will be presented in Hawaii's first RHR progress report. Future RHR SIPs and progress updates will use only HACR1 data, as monitoring at the HALE1 site was discontinued in 2012.

RHR guidelines require that progress be measured again the 2000-2004 baseline period[81], but baseline data were not measured at the HACR1 location. The RHR also states that approximations should be made for baseline conditions if these monitoring data are not available.[82] A methodology to estimate baseline conditions for the HACR1 site was developed in consultation with staff from the State of Hawaii Department of Health – Clean Air Branch, the National Park Service, and U.S. EPA Region 9. This methodology and baseline results are presented in this section.

[81] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (see page 4-2 in the Guidance document).

[82] Section 308(d)(2)(i) of the RHR states, "For mandatory Class I Federal areas without onsite monitoring data for 2000-2004, the State must establish baseline values using the most representative available monitoring data for 2000-2004, in consultation with the Administrator or his or her designee."

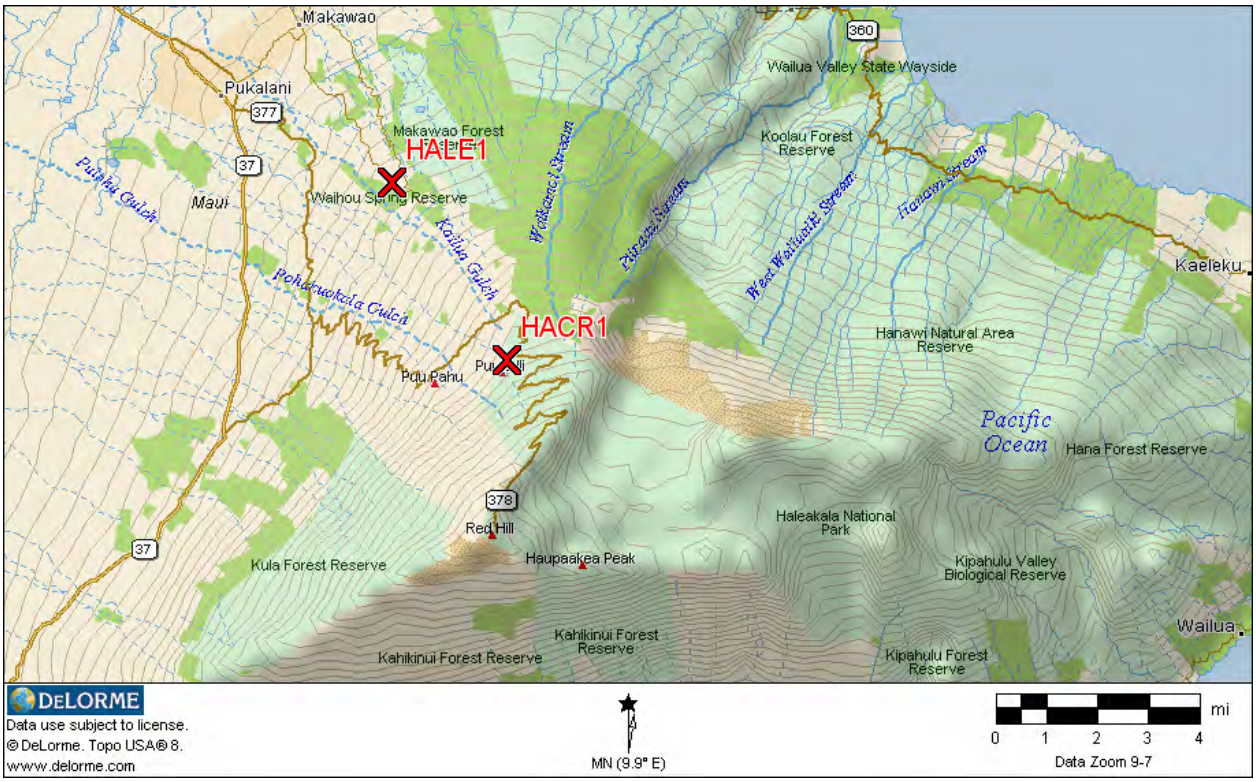

Figure 6.5-2. Map of HALE1 and HACR1 Sites Representing Haleakala National Park.

Both baseline (2000-2004) and first progress period (2004-2009) average data were available for the HALE1 site, but only the progress period average was available for the HACR1 site. To estimate baseline conditions at the HACR1 site, ratios between the 2005-2009 progress period and the 2000-2004 baseline period were determined for each aerosol species at the HALE1 site, for both the 20% most impaired and 20% least impaired days. These ratios were then applied to the HACR1 progress period to estimate a 5-year average baseline for each species. Table 6.5-2 lists the average progress to baseline period ratios for the HALE1 for the 20% most impaired days and least impaired days. These average ratios were applied to the 2005-2009 progress period for HACR1 site to obtain species and group specific estimates, such that, for each species:

$$\frac{\text{HACR1 Progress Period}}{\text{HALE } \frac{\text{Progress}}{\text{Baseline}} \text{ Average}} = \text{HACR1 Baseline Period Estimate}$$

Table 6.5-2
HALE1 Averages and Ratios

Species	Group	2000-2004 Baseline Period	2005-2009 Progress Period	HALE1 Progress/ Baseline Ratio
Ammonium Sulfate (Mm^{-1})	Best 20% Days	2.2	2.1	0.96
	Worst 20% Days	17.5	26.5	1.51
Ammonium Nitrate (Mm^{-1})	Best 20% Days	0.6	0.4	0.76
	Worst 20% Days	2.7	2.1	0.79
Particulate Organic Mass (Mm^{-1})	Best 20% Days	0.7	0.5	0.76
	Worst 20% Days	2.9	2.2	0.77
Elemental Carbon (Mm^{-1})	Best 20% Days	0.2	0.2	0.79
	Worst 20% Days	1.4	1.2	0.84
Soil (Mm^{-1})	Best 20% Days	0.1	0.1	0.89
	Worst 20% Days	0.4	0.4	1.08
Coarse Mass (Mm^{-1})	Best 20% Days	1.0	0.9	0.82
	Worst 20% Days	2.6	1.9	0.73
Sea Salt (Mm^{-1})	Best 20% Days	1.1	1.5	1.37
	Worst 20% Days	1.3	2.0	1.54

Because of the logarithmic nature of the deciview calculation (i.e., $dv = 10\ln(b_{ext}/10)$), average deciview ratios were not applied. Instead, in a manner consistent with RHR calculations, ratios were applied to individual species and individual days, and 5-year average deciview value was calculated from annual average deciviews, which was in turn calculated from daily average deciview values. Table 6.5-3 lists results for the HACR1 site, showing deciview values for the baseline period approximated as being slightly higher than the measured progress period for both the 20% most impaired and least impaired days. These estimated baseline averages are used to represent the HACR1 for all summaries presented in this report. Note that similar baseline estimates have also been applied to estimate baseline conditions for the ZICA1 site in Utah, as described in Section 6.13.1.1.

Table 6.5-3
HACR1 Baseline Estimates

Species	Group	HACR1 2005-2009 Progress Period	HALE1 Progress/ Baseline Ratio	HACR1 2000-2004 Baseline Estimate
Ammonium Sulfate (Mm^{-1})	Best 20% Days	1.0	1.0	1.07
	Worst 20% Days	16.5	1.5	10.93
Ammonium Nitrate (Mm^{-1})	Best 20% Days	0.1	0.8	0.18
	Worst 20% Days	1.1	0.8	1.39
Particulate Organic Mass (Mm^{-1})	Best 20% Days	0.1	0.8	0.09
	Worst 20% Days	1.8	0.8	2.39
Elemental Carbon (Mm^{-1})	Best 20% Days	0.0	0.8	0.05
	Worst 20% Days	0.6	0.8	0.76
Soil (Mm^{-1})	Best 20% Days	0.1	0.9	0.08
	Worst 20% Days	0.4	1.1	0.41
Coarse Mass (Mm^{-1})	Best 20% Days	0.3	0.8	0.38
	Worst 20% Days	1.7	0.7	2.32
Sea Salt (Mm^{-1})	Best 20% Days	0.3	1.4	0.22
	Worst 20% Days	0.7	1.5	0.48
Deciviews (dv)	Best 20% Days	0.9	N/A	**1.00***
	Worst 20% Days	10.8	N/A	**9.48***

*Calculated from daily average b_{ext} determined using species specific average ratios from HALE1 site

6.5.1.2 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.308 (g)(3)(i))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[83] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.5-2 and 6.5-3 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days for each of the Federal CIA IMPROVE monitors in Hawaii. Figure 6.5-2 presents 5-year average extinction for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the

[83] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

- The highest aerosol extinction (24.9 dv) was measured at the HAVO1 site, and the lowest aerosol extinction (10.8 dv) was measured at the HACR1 site.
- The largest contributors to aerosol extinction at Hawaii sites was ammonium sulfate (72-96% of aerosol extinction).

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air. Average extinction (including Rayleigh) ranged from 0.9 dv (HACR1) to 4.4 dv (HALE1).

Table 6.5-2
Hawaii Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
HACR1	10.8	**72% (1)**	5% (4)	8% (2)	3% (6)	2% (7)	7% (3)	3% (5)
HALE1	14.8	**73% (1)**	6% (3)	6% (2)	3% (6)	1% (7)	5% (5)	5% (4)
HAVO1	24.9	**96% (1)**	0% (6)	1% (2)	1% (5)	0% (7)	1% (4)	1% (3)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.5-3
Hawaii Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
HACR1	0.9	**52% (1)**	7% (4)	4% (6)	2% (7)	4% (5)	16% (2)	15% (3)
HALE1	4.4	**37% (1)**	8% (5)	9% (4)	3% (6)	2% (7)	15% (3)	27% (2)
HAVO1	3.8	**47% (1)**	6% (4)	3% (5)	1% (6)	1% (7)	8% (3)	34% (2)

*Highest aerosol species contribution per site is highlighted in bold.

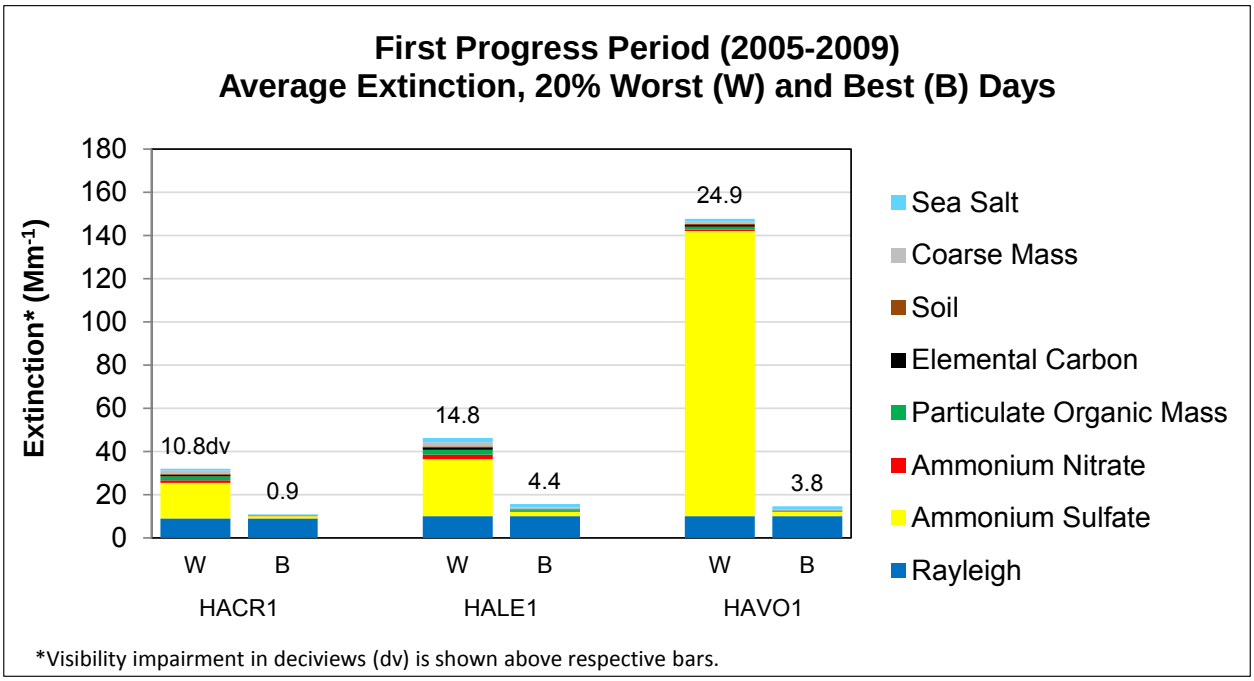

Figure 6.5-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at Hawaii Class I Area IMPROVE Sites.

6.5.1.3 Differences between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.308 (g)(3)(ii))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Table 6.5-4 presents the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in Hawaii for the 20% most impaired days, and Table 6.5-5 presents similar data for the least impaired days. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.5-3 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.5-4 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.5-5 and 6.5-6 present similar plots for the best days.

For the 20% most impaired days, the 5-year average RHR deciview metric increased between the 2000-2004 and 2005-2009 periods at all three Hawaii sites. Notable differences for individual species averages were as follows:

- At all three sites, increases in deciview were mostly due to increases in ammonium sulfate. These increases were partially offset by decreases in particulate organic mass, ammonium nitrate and elemental carbon.

- The HAVO1 site showed slight increases in soil and coarse mass.

For the 20% least impaired days, the 5-year average deciview metric decreased at all three Hawaii sites. Notable differences for individual species averages on the 20% least impaired days were as follows:

- The largest increases were measured in sea salt, but these increases were offset by decreases in most other species.

Table 6.5-4
Hawaii Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-2004 Baseline Period	2005-2009 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
HACR1	9.5	10.8	+1.3	+5.6	-0.3	-0.6	-0.1	0.0	-0.6	+0.3
HALE1	13.3	14.8	+1.5	+8.9	-0.6	-0.7	-0.2	0.0	-0.7	+0.7
HAVO1	18.9	24.9	+6.0	+72.2	-0.3	-1.2	-0.2	+0.2	+0.3	+0.1

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.5-5
Hawaii Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-2004 Baseline Period	2005-2009 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
HACR1	1.0	0.9	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	+0.1
HALE1	4.5	4.4	-0.1	-0.1	-0.1	-0.2	0.0	0.0	-0.2	+0.4
HAVO1	4.1	3.8	-0.3	0.0	0.0	-1.0	-0.1	0.0	0.0	+0.7

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

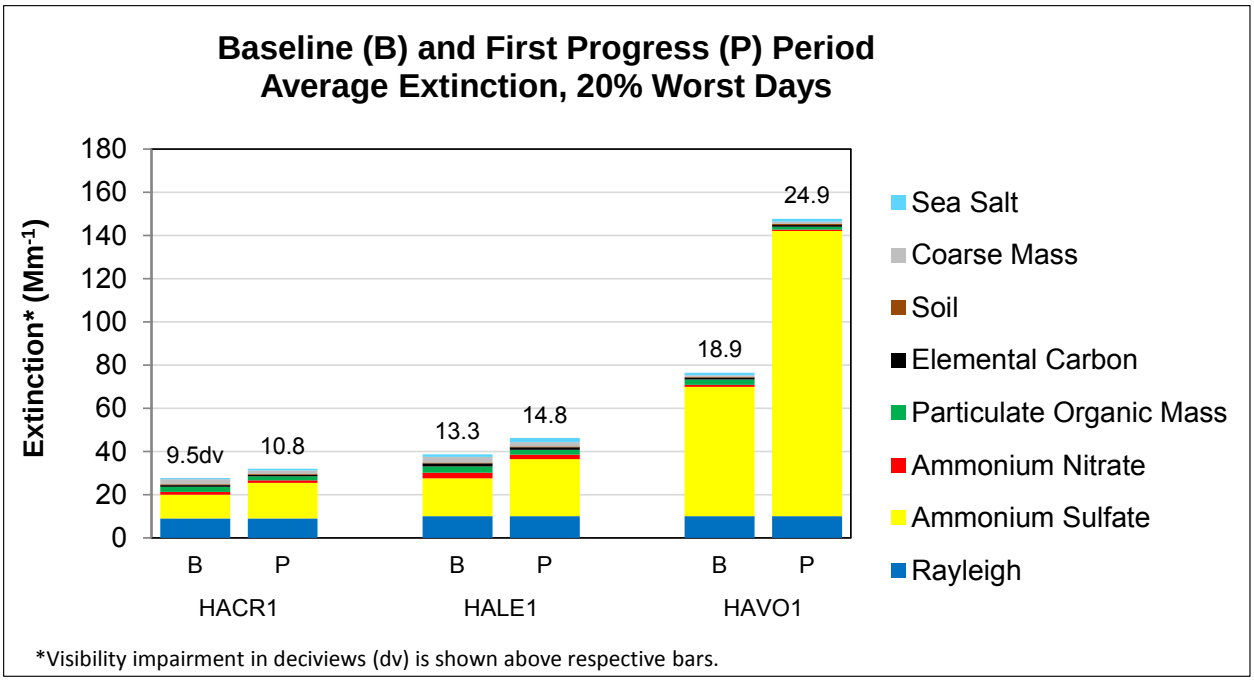

Figure 6.5-3. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at Hawaii Class I Area IMPROVE Sites.

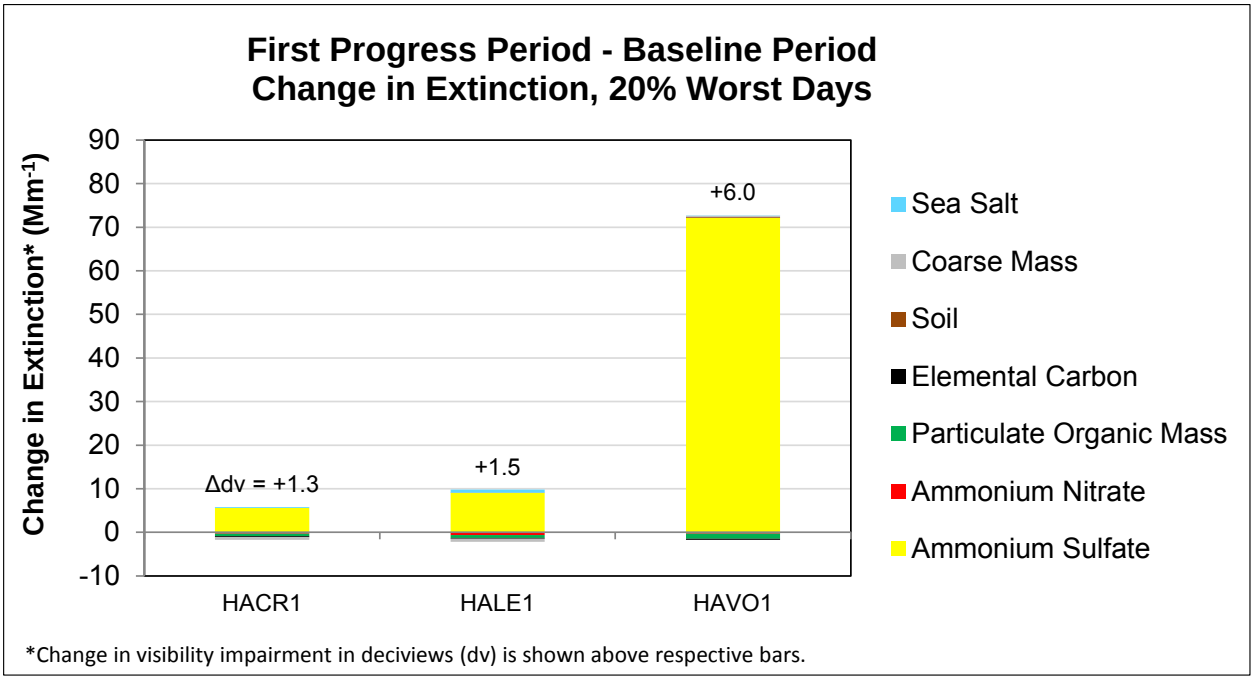

Figure 6.5-4. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at Hawaii Class I Area IMPROVE Sites.

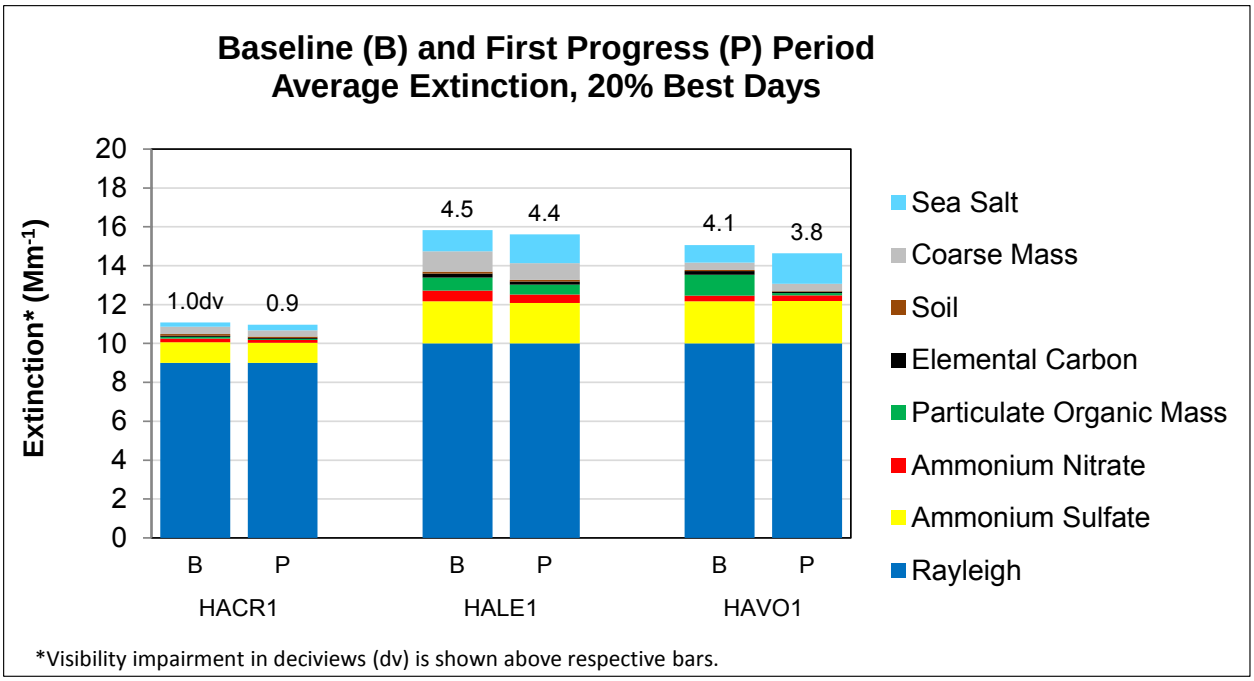

Figure 6.5-5. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at Hawaii Class I Area IMPROVE Sites.

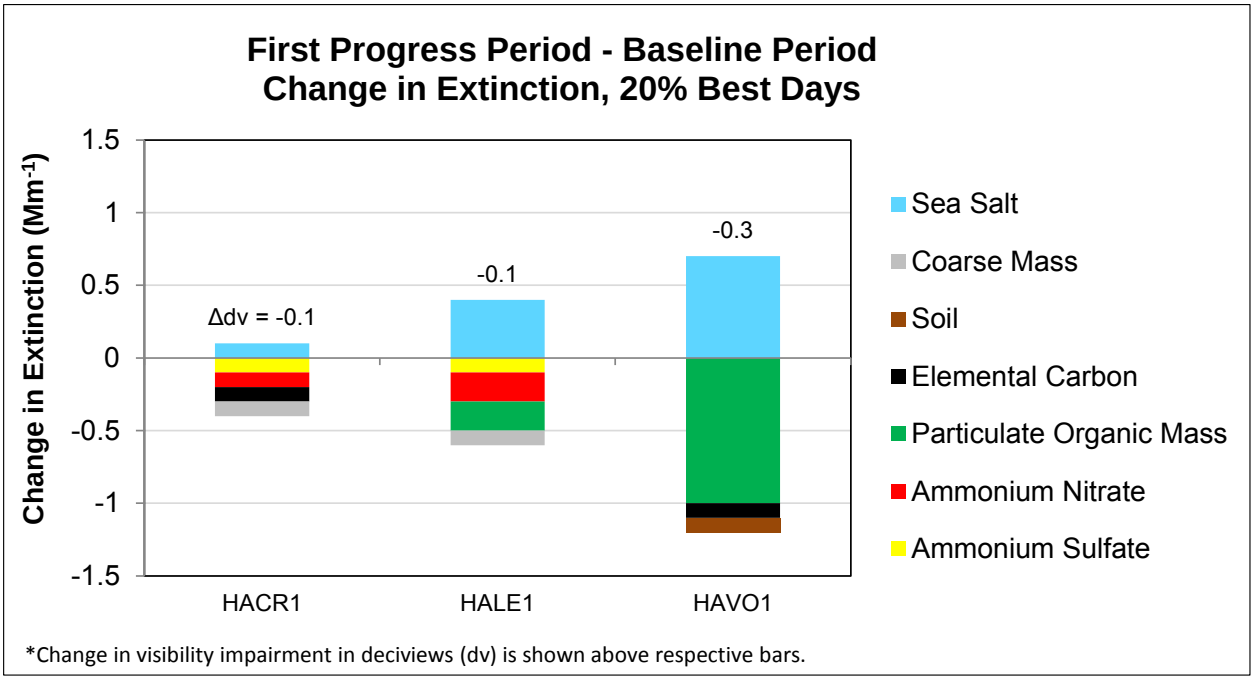

Figure 6.5-6. Difference Between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at Hawaii Class I Area IMPROVE Sites.

6.5.1.4 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.308 (g)(3)(iii))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in Hawaii are summarized in Table 6.5-6, and regional trends were presented earlier in Section 4.1.1.[84] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[85] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix E. Additionally, this appendix includes plots depicting 5-year, annual, monthly, and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in Hawaii are as follows:

- Ammonium sulfate, which is associated with volcanic activity in Hawaii, dominated aerosol extinction. The 5-year averages were higher during the progress period, and trend statistics showed increasing annual averages. Ammonium sulfate extinction at the HAVO1 site began climbing in 2007, with highs in 2008 and 2009. Ammonium sulfate extinction at the HACR1 and HALE1 site measured highest in 2008, with the largest events generally occurring in the spring.

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[84] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

[85] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

- Daily plots in Appendix E indicate an anomalously high particulate organic event on the first sampling day in 2007 at the HACR1 site. This sample day corresponded to a 2291 acre forest fire south-west of the HACR1 and HALE1 sites.[86]
- In general, particulate organic mass concentrations were lower at the HACR1 site than the HALE1 site. Proximity of the HALE1 site to sugar cane burning was part of the justification for a new location to represent the Haleakala NP.
- Note that the State of Hawaii is investigating potential anomalies in particulate organic mass and select metal measurements for source apportionment calculations.[87] For purposes of progress determination, particulate organic mass decreases at all of the Hawaii sites, but soil and coarse mass increased slightly at the HAVO1 site. Because of the large ammonium sulfate contribution to visibility impairment, the combined contribution of coarse mass and soil was less than 1% of the overall increase in extinction between the baseline and progress periods.

[86] This event, and other events at the HALE1 and HACR1 sites in 2007 and 2008, have been characterized in a report by the State of Hawaii, Clean Air Branch (HIDOHCAB) which is available at http://www.regulations.gov/#!documentDetail;D=EPA-R09-OAR-2012-0345-0005.

[87] Details of HIDOHCABs efforts to characterize potential sources of error in source apportionment calculations are available at http://www.regulations.gov/#!documentDetail;D=EPA-R09-OAR-2012-0345-0005.

Table 6.5-6
Hawaii Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
HACR1	20% Best	**	**	**	**	**	**	**
	20% Worst	**	**	**	**	**	**	**
	All Days	**	**	**	**	**	**	**
HALE1	20% Best	--	0.0	--	0.0	--	0.0	**0.1**
	20% Worst	**1.2**	**-0.1**	--	--	0.0	**-0.2**	**0.1**
	All Days	**0.4**	**-0.1**	0.0	0.0	--	**-0.1**	**0.1**
HAVO1	20% Best	**0.1**	--	**-0.1**	0.0	--	--	**0.1**
	20% Worst	**18.9**	**-0.1**	**-0.1**	0.0	**0.1**	--	--
	All Days	**3.9**	0.0	**-0.1**	0.0	--	--	--

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix E.
**Less than 5 years of monitoring were available for the HACR1 site, so trend statistics for this site were not calculated.

6.5.2 Emissions Data

Included here are summaries depicting differences between emission inventories representing the baseline period (2005) and the current progress period (2008). The year 2005 was selected, with EPA approval, as the baseline inventory for Hawaii's initial RHR implementation plan because it was the most complete inventory available at the time technical work commenced[88]. The same technical work also included the development of a 2008 inventory, which is summarized here. These inventories are described in more detail in Section 3.2.1. For reference, Table 6.5-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories are presented in this section.

[88] See the *Technical Support Document for the Proposed Action on the Federal Implementation Plan for the Regional Haze Program in the State of Hawaii*, developed by EPA Region 9

Table 6.5-7
Hawaii
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	Related Aerosol	Major Sources	Notes
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- And Off-Road Mobile Sources; Volcanic Emissions	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines. Also, in Hawaii, volcanic activity contributes significantly to natural emissions of SO_2, and it is possible that some of these emissions are transported to the contiguous states.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Fine soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.5.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.308 (g)(4))?*** For these summaries, emissions during the baseline and progress years are represented using 2005 and 2008 inventories, which were both available from technical support work used in the original RHR SIP strategy development, as referenced in Section 3.2.1. The differences between inventories are presented here for all major visibility impairing pollutants, and categorized by source for both anthropogenic and natural emissions.

Table 6.5-8 and Figure 6.5-7 present differences between the 2005 and 2008 Sulfur dioxide (SO_2) inventories by source category. Tables 6.5-9 and Figure 6.5-8 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.5-10 through 6.5-12 and Figures 6.5-9 through 6.5-11 present data for ammonia (NH_3), volatile organic carbon (VOC), and total particulate matter (PM). General observations regarding emissions inventory comparisons are listed below.

- Natural emissions are significant for SO_2, VOC, and PM due to natural volcanic (SO_2) and sea spray (PM) emissions.
- Volcanic emissions account for the majority of SO_2 emissions for the state. The State of Hawaii, Clean Air Branch (HIDOHCAB) has analyzed the time variability of volcano impacts by applying the EPA Positive Matrix Factorization (PMF) model for the years 2003 through 2008 at both the HALE1 and HAVO1 sites, and estimated that on average, approximately 55% of the total extinction at the HALE1 site, and 94% of the extinction at the HAVO1 site was due to emissions from the Kilauea volcano.[89]
- Inventory comparisons show decreases in mobile NO_X emissions, which are likely due to tighter EPA regulations for on-road vehicles.
- Inventory comparisons show decreases in SO_2 emissions from marine sources, which may be partially attributable to decreased marine activity during the economic recession, especially cruise ship activity. EPA mandates requiring the use of lower sulfur fuels in ships operating within 200 miles of the United States, effective August 2012, are expected to further decrease SO_2 marine emissions.

[89] PMF results are detailed in the Hawaii Department of Health, Clean Air Branch *Heleakala National Park Visibility Assessment: Regional Haze Program Visibility Assessment* report dated 4/20/2012, available at http://www.regulations.gov/#!documentDetail;D=EPA-R09-OAR-2012-2012-0345-0005.

Table 6.5-8
Hawaii
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2005 (State Inventory)	2008 (State Inventory)	Difference (Percent Change)
Anthropogenic Sources			
Point	27,072	25,849	-1,223
Area	3,716	3,512	-204
On-Road Mobile	321	97	-224
Off-Road Mobile[1]	669	338	-331
Marine[2]	3,619	2,920	-699
Anthropogenic Fire	178	178	0
Total Anthropogenic	**35,575**	**32,894**	**-2,681 (-8%)**
Natural Sources			
Natural Fire	591	591	0
Biogenic	0	0	0
Volcano	961,366	1,195,314	233,948
Sea Spray	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**961,957**	**1,195,905**	**233,948 (24%)**
All Sources			
Total Emissions	**997,532**	**1,228,799**	**231,267 (23%)**

[1] Off-Road Mobile totals include aircraft and locomotive emissions
[2] Marine totals include in/near/underway emissions

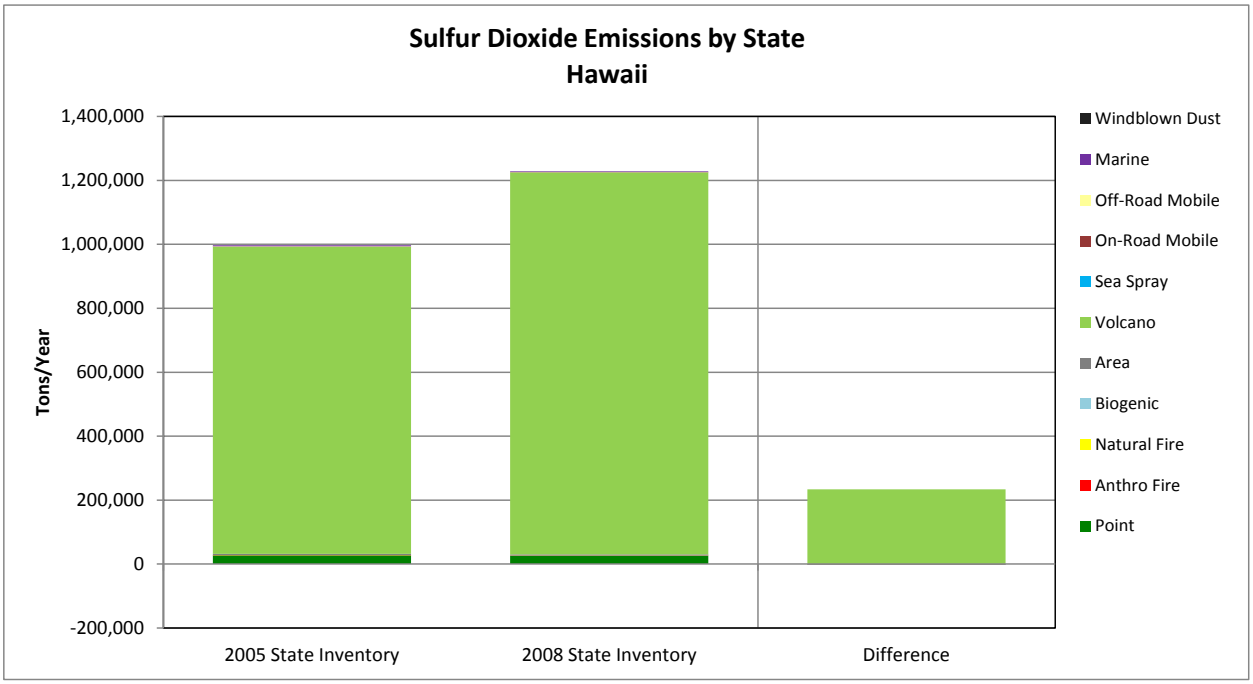

Figure 6.5-7. 2005 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for Hawaii.

Table 6.5-9
Hawaii
Oxides of Nitrogen Emissions by Category

Source Category	Oxides of Nitrogen Emissions (tons/year)		
	2005 (State Inventory)	2008 (State Inventory)	Difference (Percent Change)
Anthropogenic Sources			
Point	22,745	20,246	-2,499
Area	1,509	1,166	-343
On-Road Mobile	20,642	14,239	-6,403
Off-Road Mobile[1]	6,296	7,146	850
Marine[2]	5,624	12,994	7,370
Anthropogenic Fire	407	407	0
Total Anthropogenic	**57,223**	**56,198**	**-1,025 (-2%)**
Natural Sources			
Natural Fire	2,156	2,156	0
Biogenic	4,617	4,617	0
Volcano	0	0	0
Sea Spray	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**6,773**	**6,773**	**0 (0%)**
All Sources			
Total Emissions	**63,996**	**62,971**	**-1,025 (-2%)**

[1] Off-Road Mobile totals include aircraft and locomotive emissions
[2] Marine totals include in/near/underway emissions

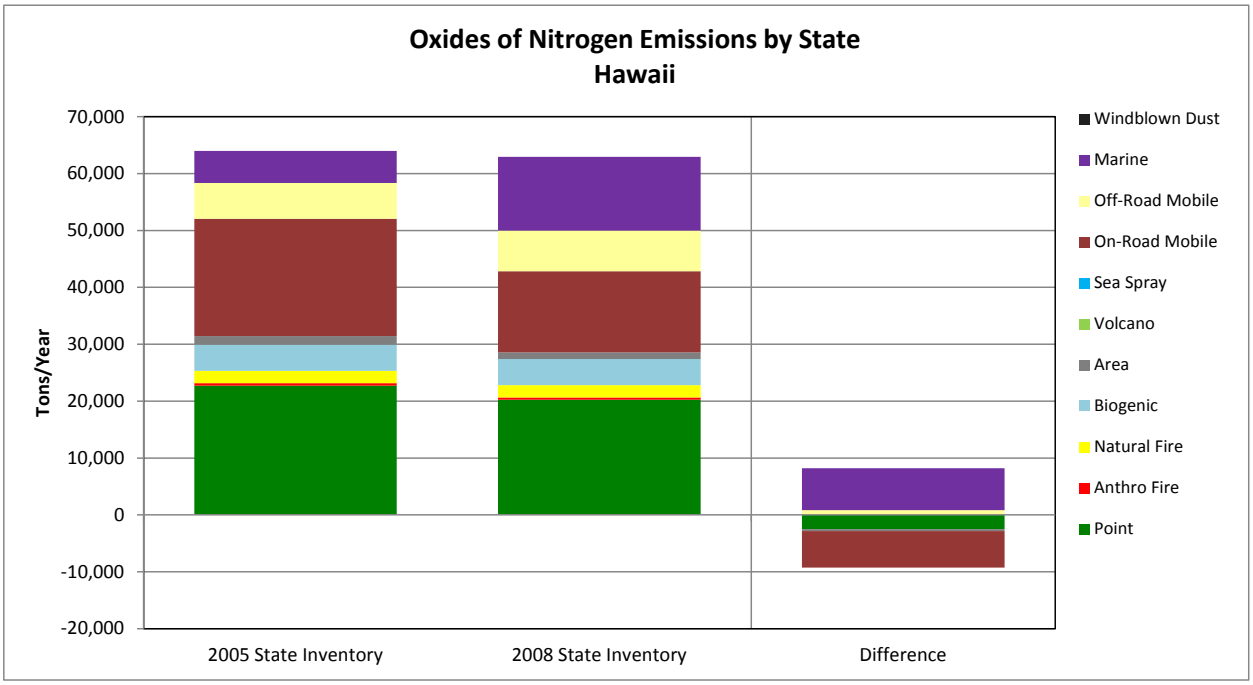

Figure 6.5-8. 2005 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Oxides of Nitrogen by Source Category for Hawaii.

Table 6.5-10
Hawaii
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2005 (State Inventory)	2008 (State Inventory)	Difference (Percent Change)
Anthropogenic Sources			
Point	12	12	0
Area	11,136	11,275	139
On-Road Mobile	1,085	1,124	39
Off-Road Mobile[1]	5	5	0
Marine[2]	0	0	0
Anthropogenic Fire	60	60	0
Total Anthropogenic	**12,298**	**12,476**	**178 (1%)**
Natural Sources			
Natural Fire	540	540	0
Biogenic	0	0	0
Volcano	0	0	0
Sea Spray	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**540**	**540**	**0 (0%)**
All Sources			
Total Emissions	**12,838**	**13,016**	**178 (1%)**

[1] Off-Road Mobile totals include aircraft and locomotive emissions
[2] Marine totals include in/near/underway emissions

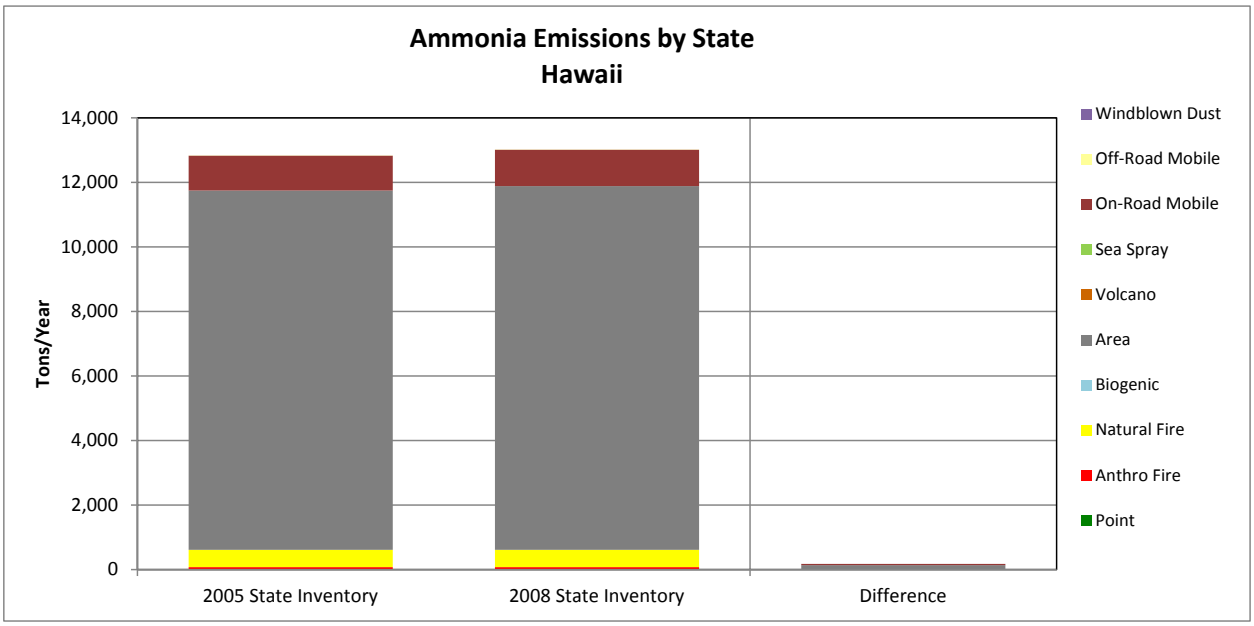

Figure 6.5-9. 2005 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Ammonia by Source Category for Hawaii.

Table 6.5-11
Hawaii
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compound Emissions (tons/year)		
	2005 (State Inventory)	2008 (State Inventory)	Difference (Percent Change)
Anthropogenic Sources			
Point	2,695	2,544	-151
Area	16,920	18,025	1,105
On-Road Mobile	12,066	8,526	-3,540
Off-Road Mobile[1]	6,383	5,540	-843
Marine[2]	209	326	117
Anthropogenic Fire	542	542	0
Total Anthropogenic	**38,815**	**35,503**	**-3,312 (-9%)**
Natural Sources			
Natural Fire	4,729	4,729	0
Biogenic	130,153	130,153	0
Volcano	0	0	0
Sea Spray	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**134,882**	**134,882**	**0 (0%)**
All Sources			
Total Emissions	**173,697**	**170,385**	**-3,312 (-2%)**

[1] Off-Road Mobile totals include aircraft and locomotive emissions
[2] Marine totals include in/near/underway emissions

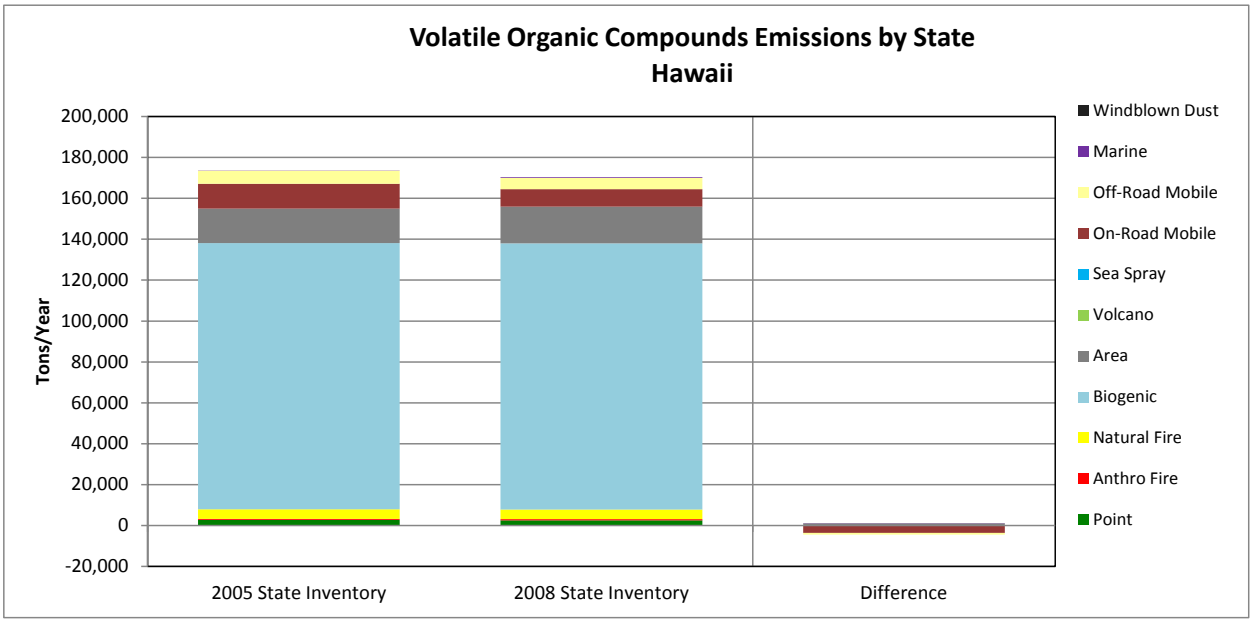

Figure 6.5-10. 2005 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for Hawaii.

Table 6.5-12
Hawaii
Particulate Matter Emissions by Category

Source Category	Particulate Matter Emissions (tons/year)		
	2005 (State Inventory)	2008 (State Inventory)	Difference (Percent Change)
Anthropogenic Sources			
Point	3,536	3,389	-147
Area	33,408	34,917	1,509
On-Road Mobile	638	547	-91
Off-Road Mobile[1]	649	545	-104
Marine[2]	398	647	249
Anthropogenic Fire*	1,574	1,574	0
Total Anthropogenic	**40,203**	**41,619**	**1,416 (4%)**
Natural Sources			
Natural Fire*	9,771	9,771	0
Biogenic	0	0	0
Volcano	0	0	0
Sea Spray	382,637	382,637	0
Wind Blown Dust	46,808	46,808	0
Total Natural	**439,216**	**439,216**	**0 (0%)**
All Sources			
Total Emissions	**479,419**	**480,835**	**1,416 (0%)**

[1] Off-Road Mobile totals include aircraft and locomotive emissions
[2] Marine totals include in/near/underway emissions

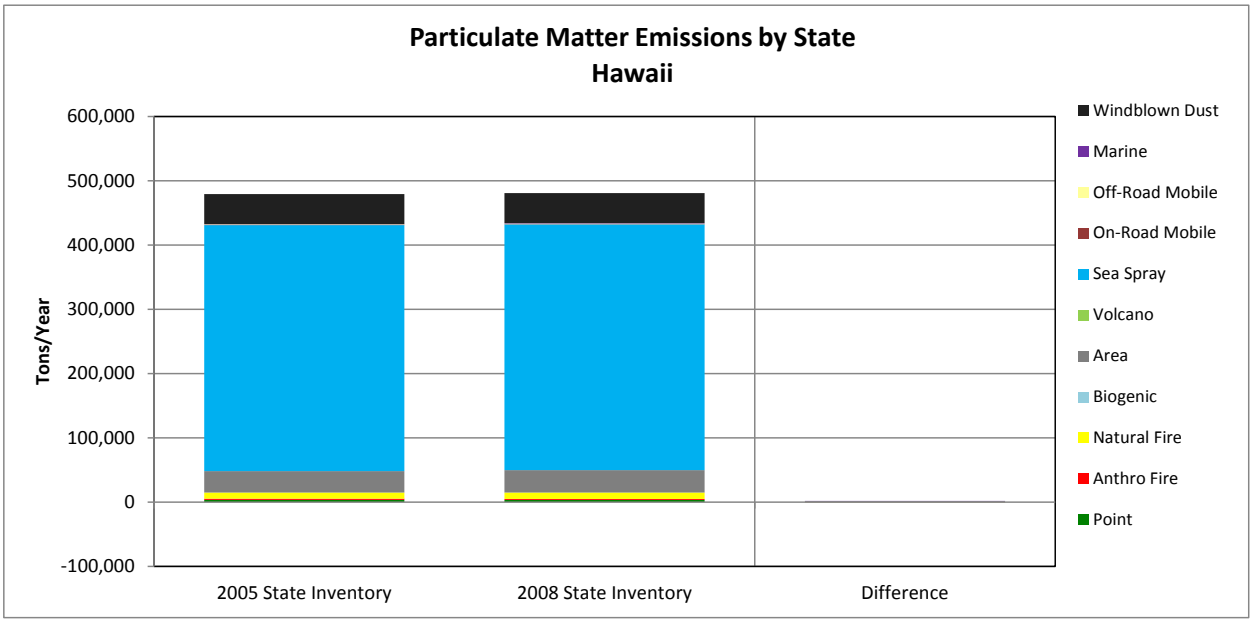

Figure 6.5-11. 2005 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Particulate Matter by Source Category for Hawaii.