Attainment Demonstration for the 2015 8-hour Ozone Standard

Item #2

Scientific, Technical & Modeling Peer Review (STMPR)
Advisory Group Meeting

March 16, 2022

Outline

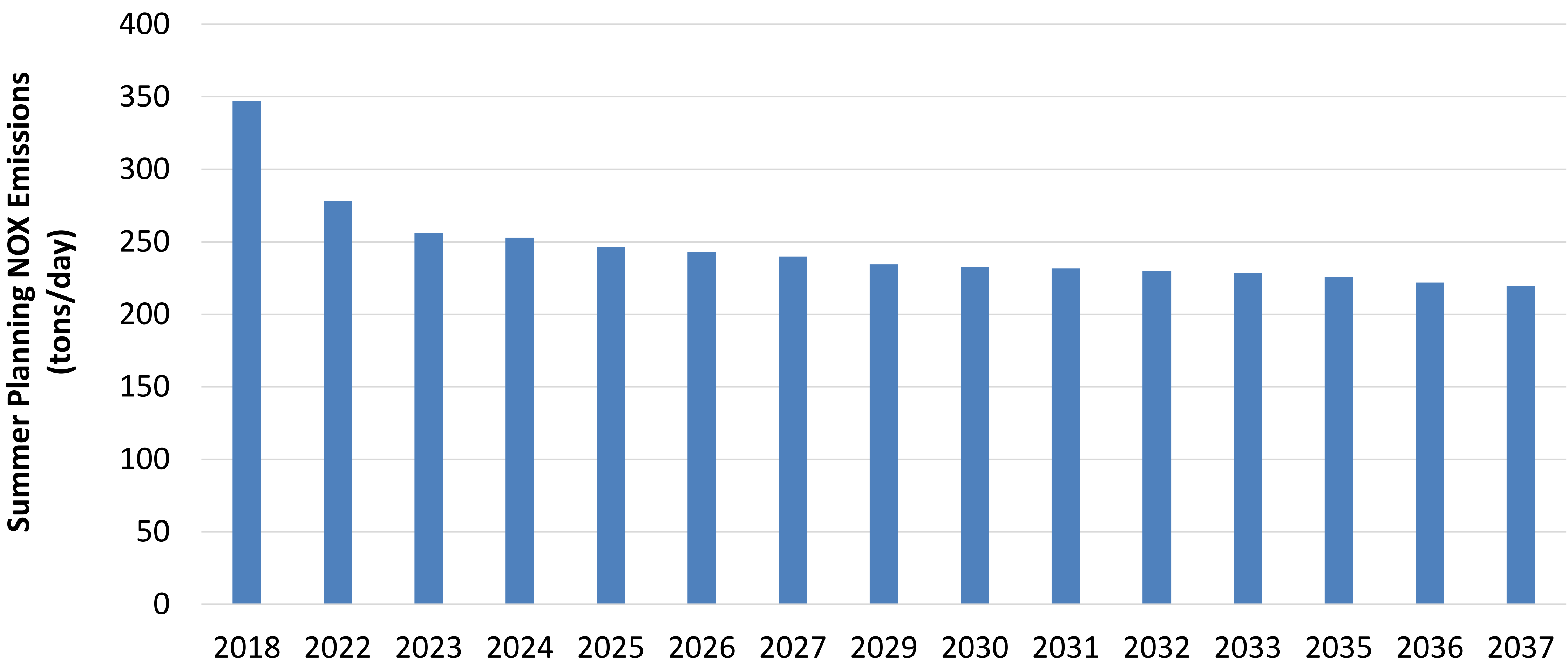
- South Coast Air Basin Attainment Demonstration
  – Ozone Design Values
  – Carrying capacity plots completed for 2022 AQMP
  – Preliminary attainment scenario
- Coachella Valley Attainment Demonstration

2022 Air Quality Management Plan

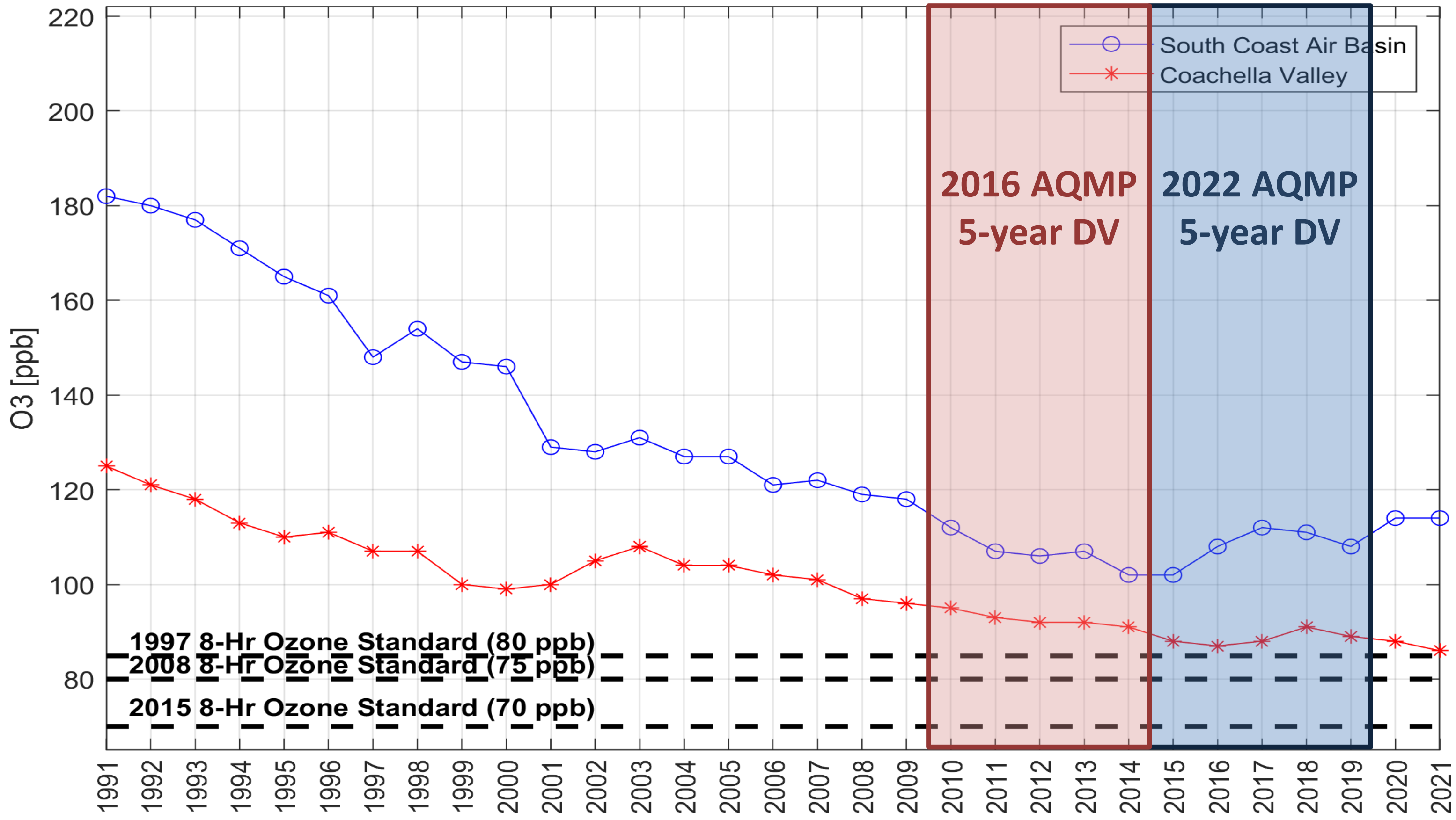
- 2022 AQMP focuses on attaining the 2015 federal 8-hour ozone National Ambient Air Quality Standard (NAAQS), 70 ppb
  - South Coast Air Basin’s (SCAB) attainment due – 2037
  - Coachella Valley’s attainment due – 2032
- Baseline NOx emissions in SCAB in 2037 are 220 tpd
- Preliminary NOx carrying capacity* is approximately 60 tpd to attain the 70ppb ozone standard

*Carrying capacity is the maximum allowable emissions to attain NAAQS

South Coast Air Basin Total Baseline NOx Emissions



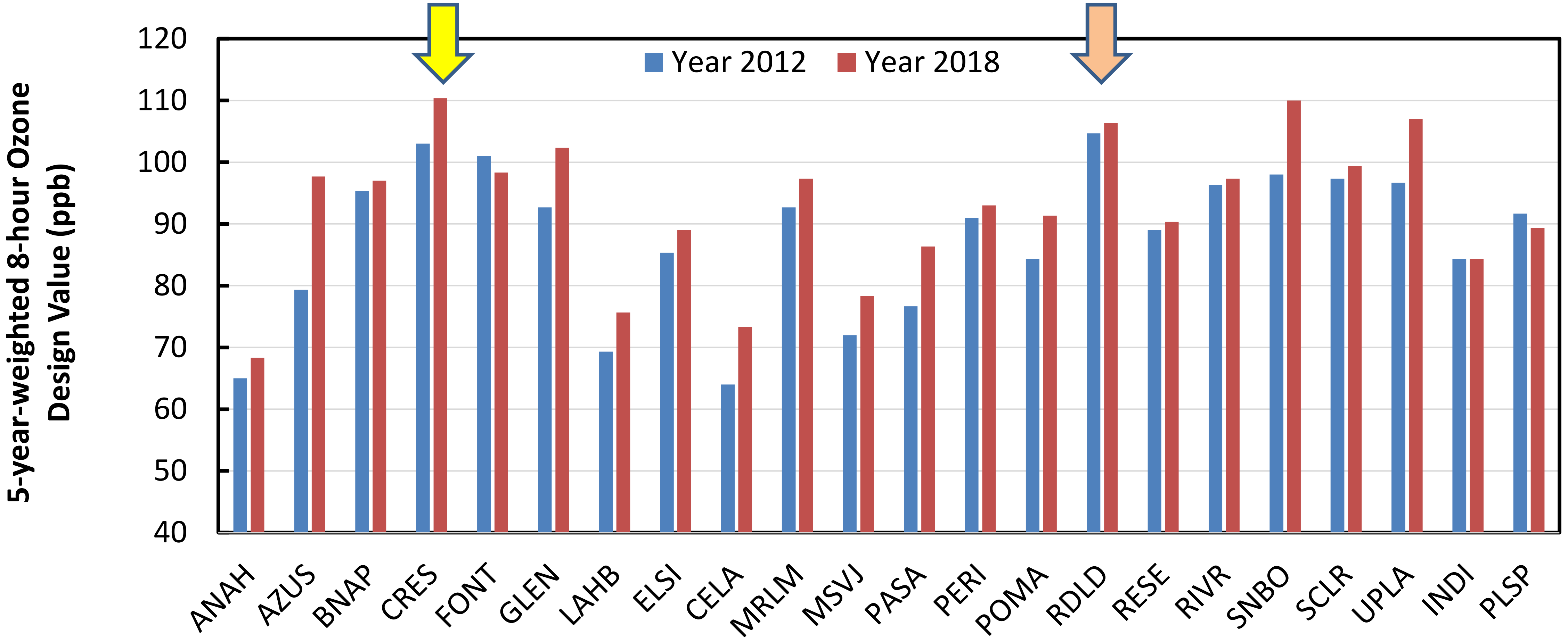
Ozone Trends in the South Coast Air Basin and Coachella Valley



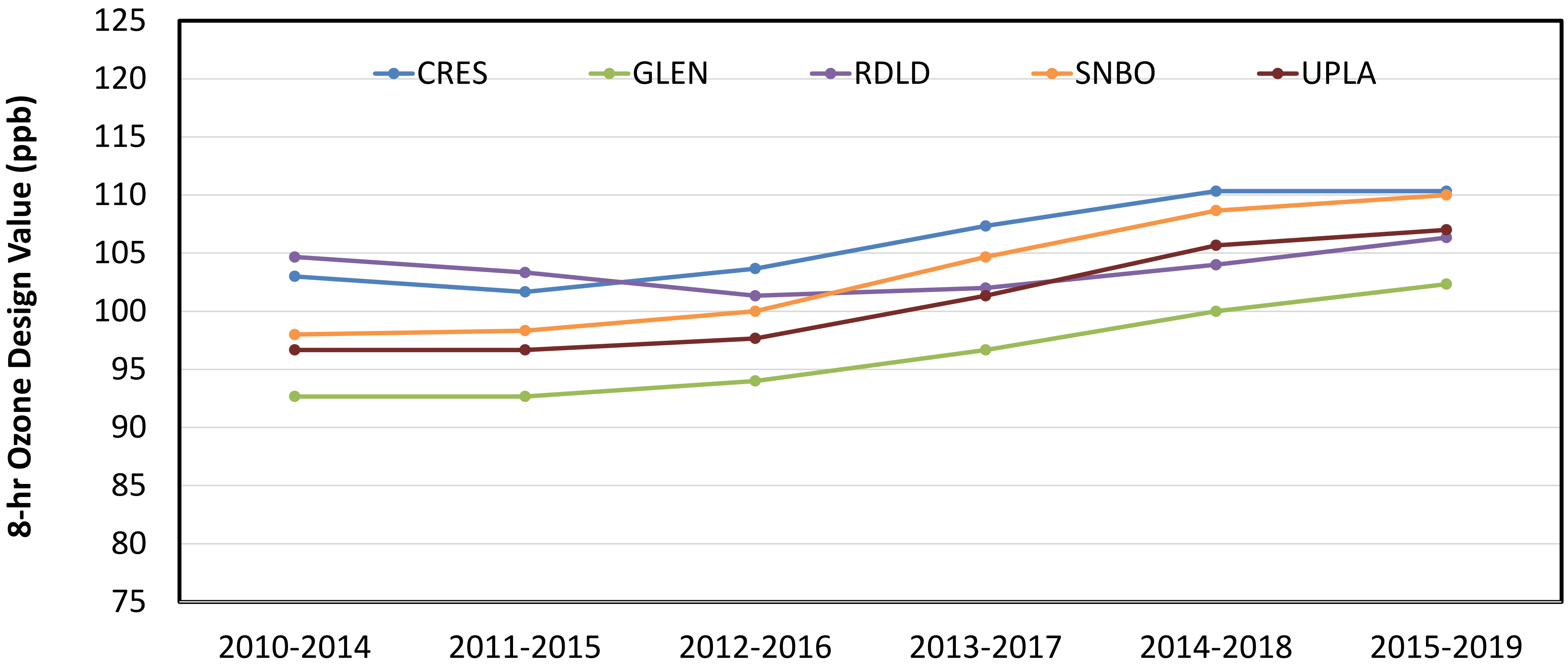
Poor meteorology and complex photochemistry have resulted in recent poor ozone air quality despite on-going emission reductions

**Preliminary data for 2021*

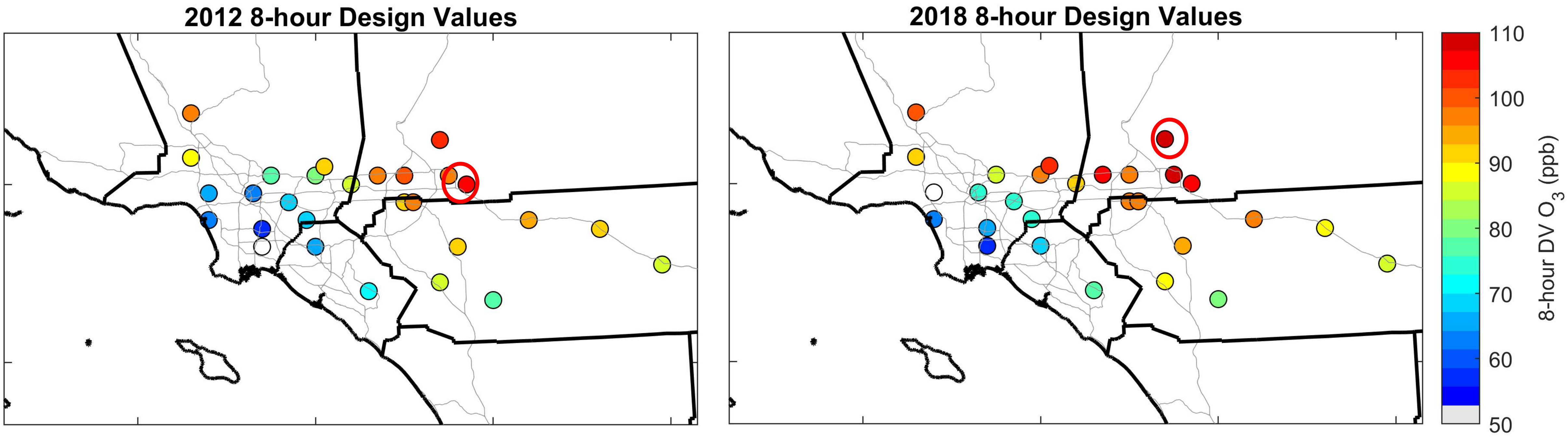
5-year weighted 8-hour Ozone – 2012 vs. 2018 Base Year



5-year weighted 8-hour Ozone Design Value Trends



5-year weighted 8-hour Ozone DV



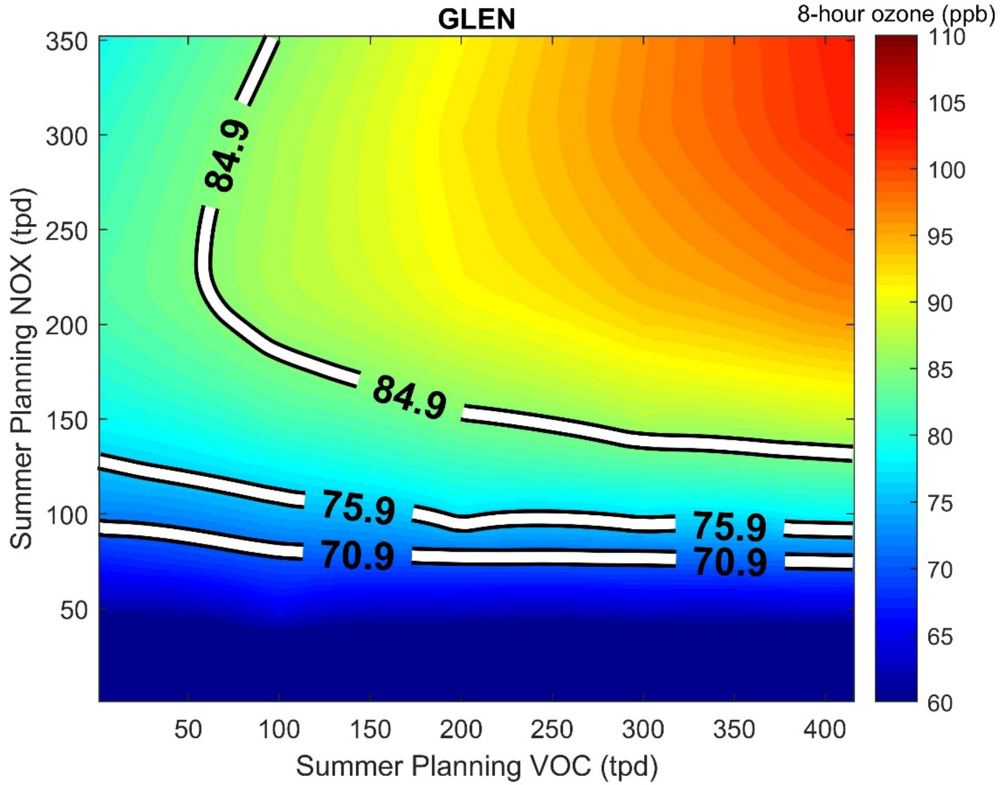
Development of Ozone Isopleths

- CMAQ nested domains
  - 12 km including the entire California and portions of neighboring states and northern Mexico
  - 4km is the AQMP analysis domain
- Basin total anthropogenic VOC and NOx emissions used as x and y axis, respectively
- Simulations were conducted with NOx and VOC emissions in 50 tons per day (tpd) increments with MatLab spatial interpolation function
  - Emission reductions were assumed to occur equally in the entire modeling domain
- Preliminary basin total summer planning emissions

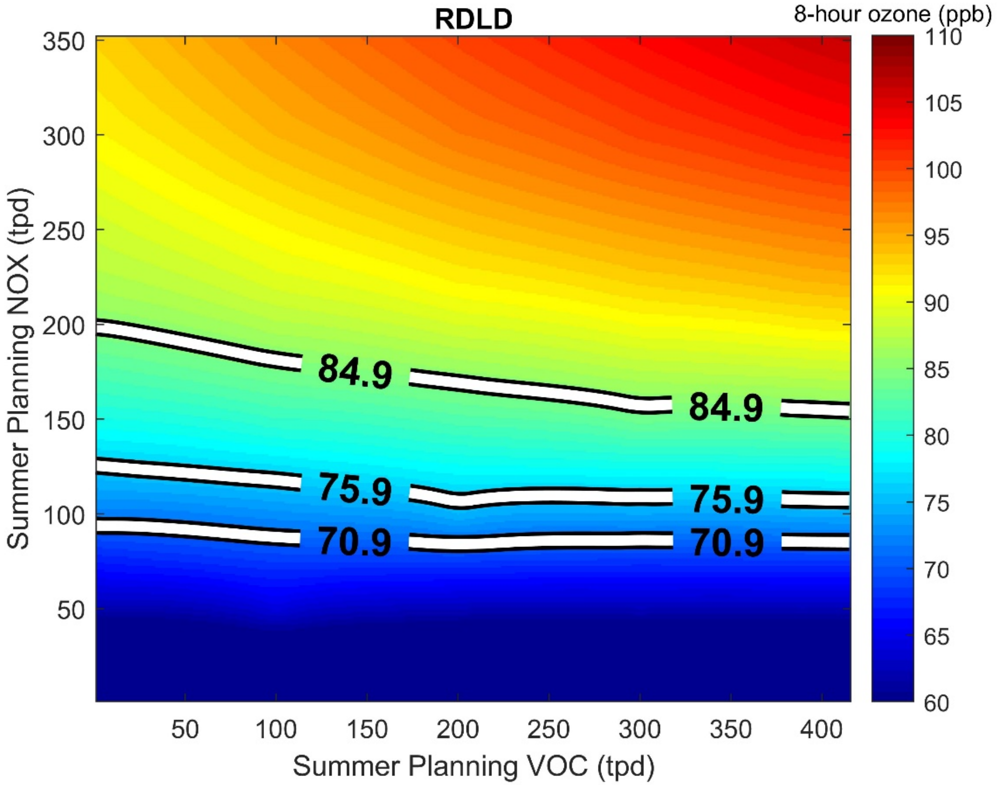
Year	VOC (tpd)	NOx (tpd)
2018	417	347
2037	389	220

Carrying Capacity Plots

Glendora

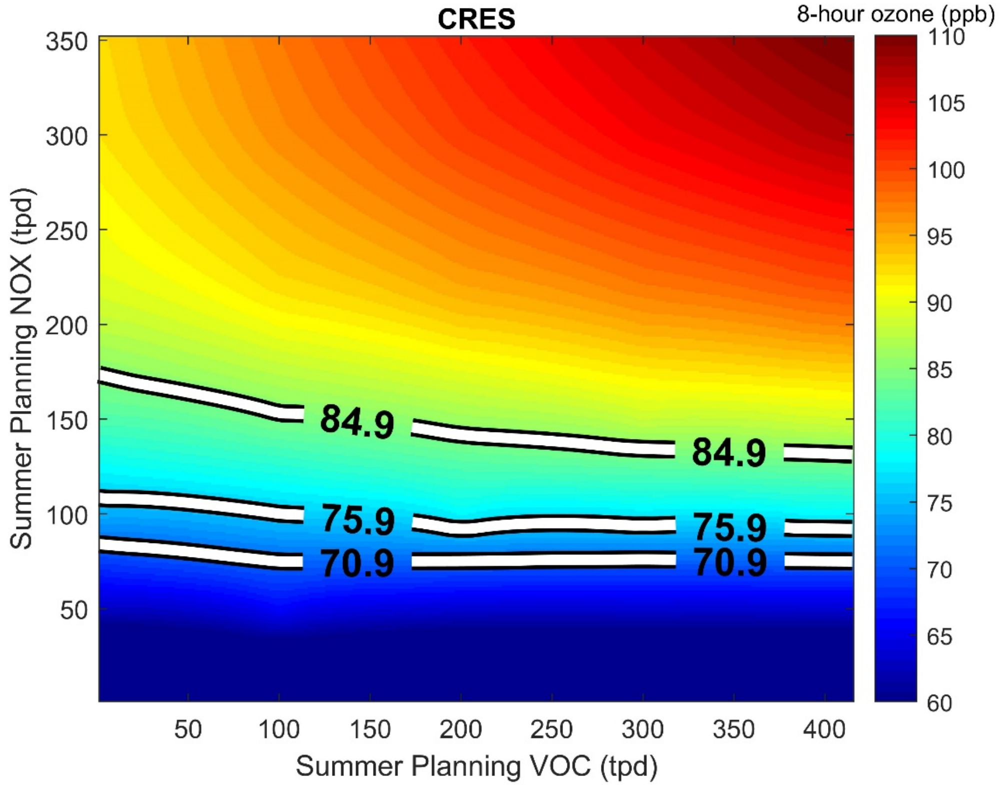


Redlands

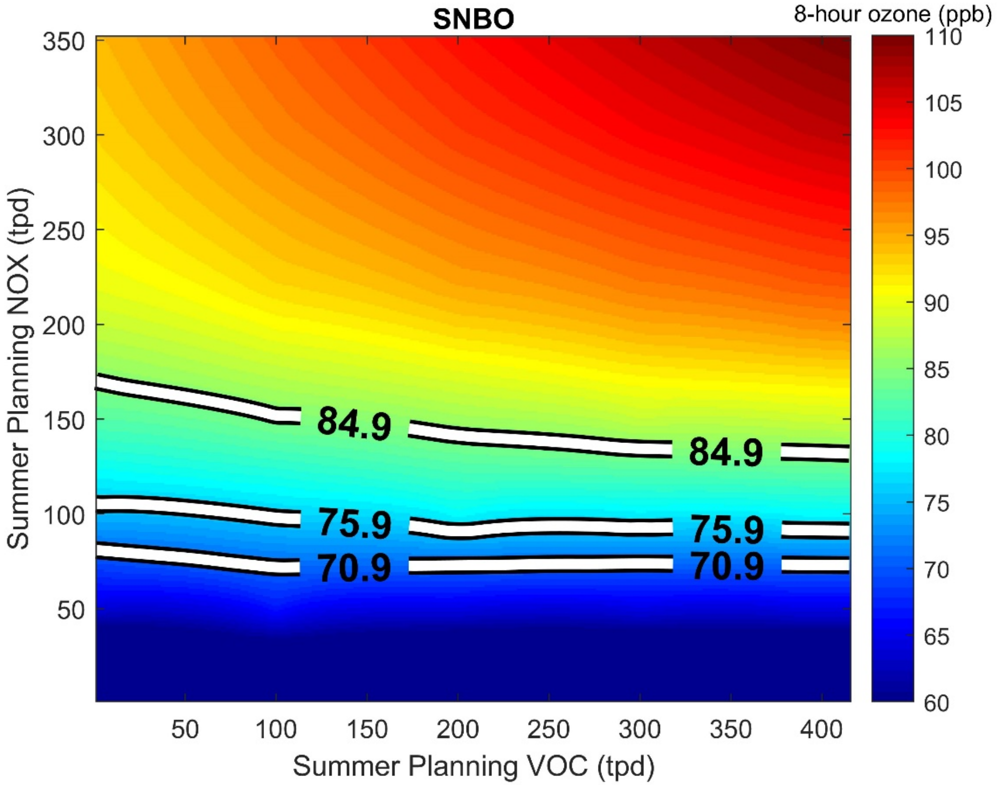


Carrying Capacity Plots – Inland San Bernardino Stations

Crestline

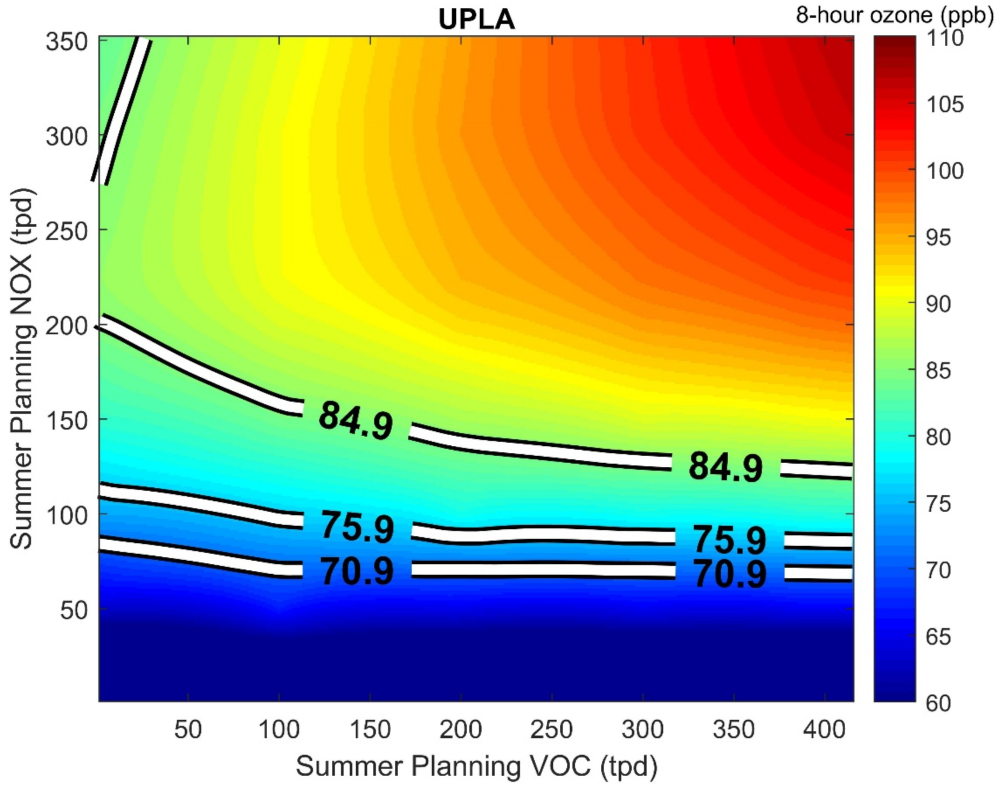


San Bernardino

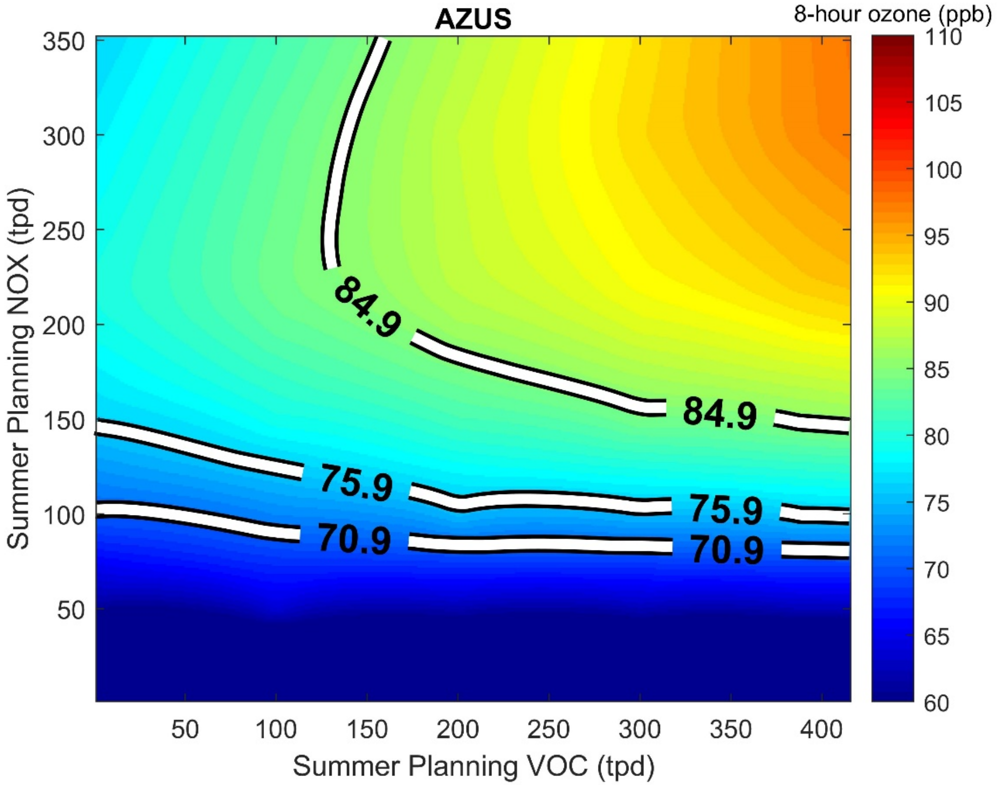


Carrying Capacity Plots – San Gabriel Foothill Stations

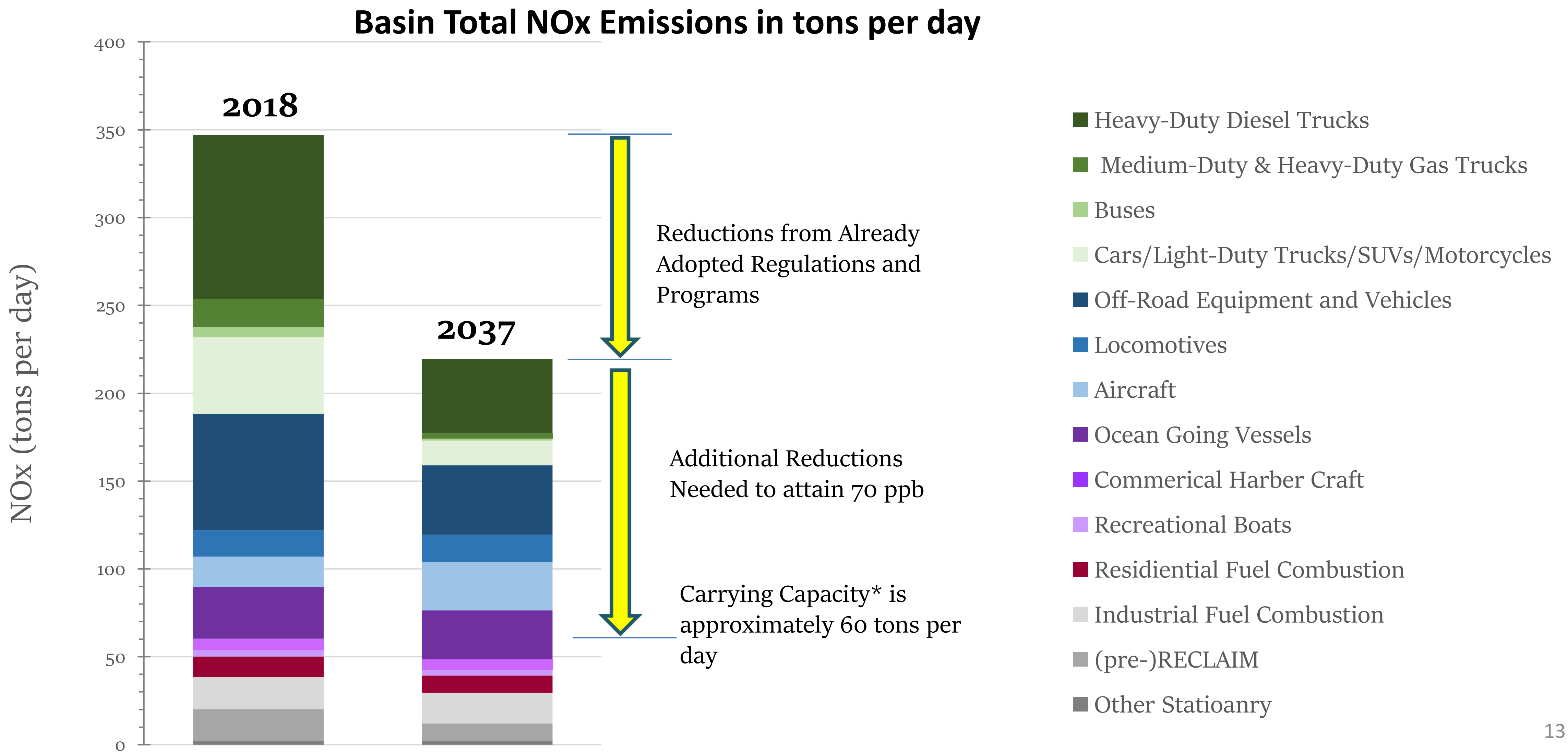
Upland



Azusa



NOx Reductions Needed for Attainment



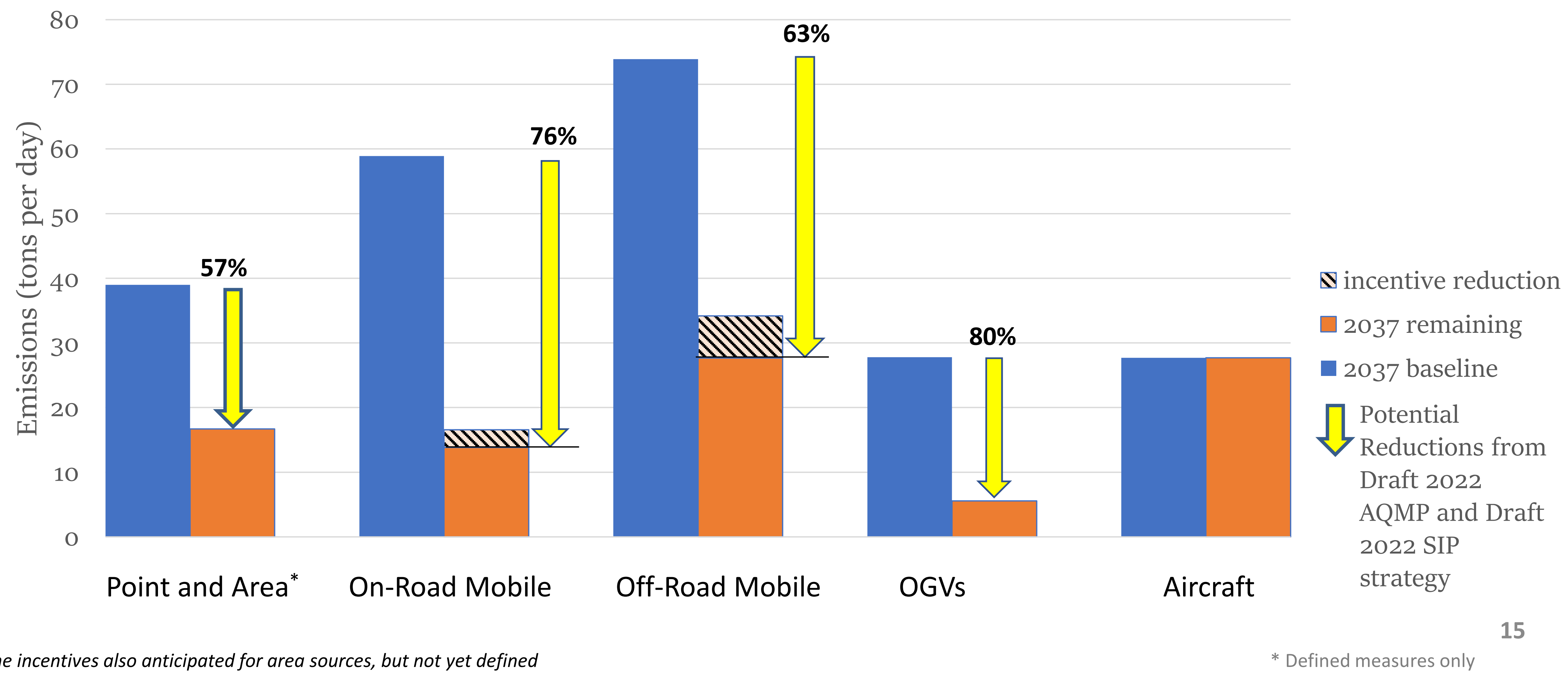
CARB DRAFT SIP Strategy

- CARB measures included in Draft 2022 SIP Strategy
- Draft 2022 AQMP will include CARB measures for the following categories
  - Area sources
  - On-Road Vehicles
  - Off-Road Vehicles and Equipment
  - CARB's measures for federally and internationally regulated sources
  - Federally and internationally regulated sources that required federal action

Table 8- South Coast Expected Emissions Reductions from the 2022 State SIP Strategy

Proposed Measure	2037	
	NOx	ROG
On-Road Heavy-Duty		
Advanced Clean Fleets Regulation	5.3	0.5
Zero-Emissions Trucks Measure	NYQ	NYQ
Total On-Road Heavy-Duty Reductions	5.3	0.5
On-Road Light-Duty		
On-Road Motorcycle New Emissions Standards	0.9	2.1
Clean Miles Standard	<0.1	<0.1
Total On-Road Light-Duty Reductions	0.9	2.1
Off-Road Equipment		
Tier 5 Off-Road Vehicles and Equipment	1.8	NYQ
Amendments to the In-Use Off-Road Diesel-Fueled Fleets Regulation	1.3	0.1
Transport Refrigeration Unit Regulation	4.6	NYQ
Commercial Harbor Craft Amendments	2.6	0.2
Cargo Handling Equipment Amendments	1.2	0.3
Off-Road Zero-Emission Targeted Manufacturer Rule	1.1	NYQ
Clean Off-Road Fleet Recognition Program	NYQ	NYQ
Spark-Ignition Marine Engine Standards	0.3	1.2
Total Off-Road Equipment Reductions	12.9	1.8
Other		
Consumer Products Standards	NYQ	8
Zero-Emission Standard for Space and Water Heaters	5.8	0.8
Enhanced Regional Emission Analysis in State Implementation Plans	NYQ	NYQ
Total Other Reductions	5.8	8.8
Primarily-Federally and Internationally Regulated Sources – CARB Measures		
In-Use Locomotive Regulation	12.7	0.3
Future Measures for Aviation Emission Reductions	NYQ	NYQ
Future Measures for Ocean-Going Vessel Emissions Reductions	NYQ	NYQ
Total Primarily-Federally and Internationally Regulated Sources – CARB Measures Reductions	12.7	0.3
Primarily-Federally and Internationally Regulated Sources – Federal Action Needed		
On-Road Heavy-Duty Vehicle Low-NOx Engine Standards	10.2	NYQ
On-Road Heavy-Duty Vehicle Zero-Emission Requirements	NYQ	NYQ
Off-Road Equipment Tier 5 Standard for Preempted Engines	2.0	NYQ
Off-Road Equipment Zero-Emission Standards Where Feasible	1.2	NYQ
More Stringent Aviation Engine Standards	NYQ	NYQ
Cleaner Fuel and Visit Requirements for Aviation	NYQ	NYQ
Zero-Emission On-Ground Operation Requirements at Airports	NYQ	NYQ
More Stringent National Locomotive Emission Standards	NYQ	NYQ
Zero-Emission Standards for Switch Locomotives	NYQ	NYQ
Address Locomotives Remanufacturing Loophole	NYQ	NYQ
More Stringent NOx and PM Standards for Ocean-Going Vessels	0.8	NYQ
Cleaner Fuel and Vessel Requirements for Ocean-Going Vessels	21.1	NYQ
Total Primarily-Federally and Internationally Regulated -Federal Action Needed Reductions	35.3	NYQ
Aggregate Emissions Reductions	72.9	13.5

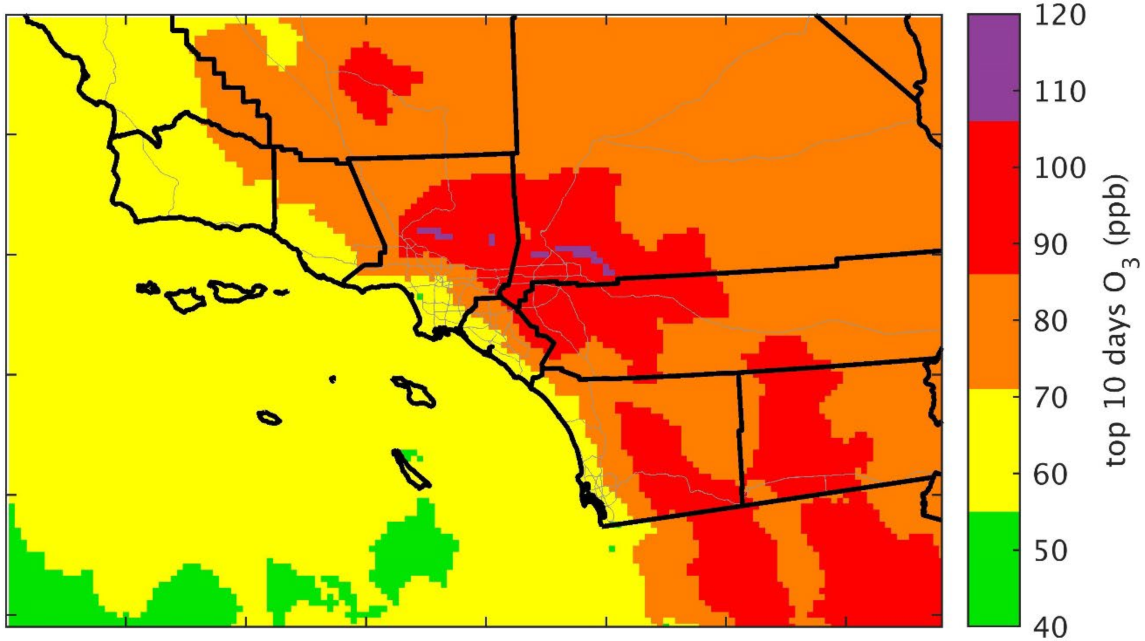
Summary of Potential Approach to Reducing NOx by Major Source Category



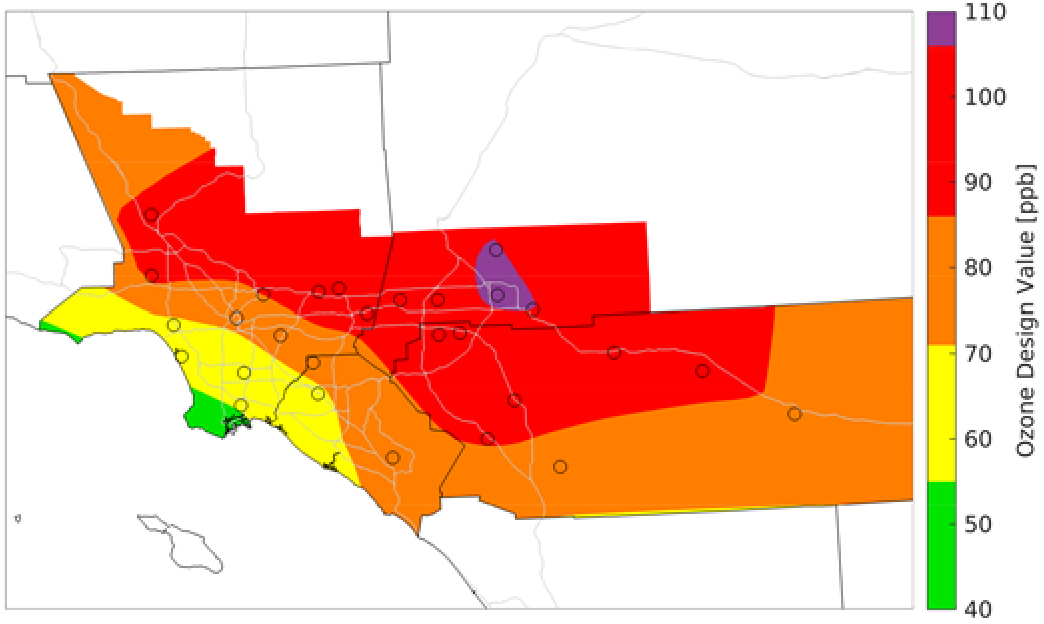
*Some incentives also anticipated for area sources, but not yet defined

Maximum Daily 8-hour Average (MDA8) Ozone – Base Year (2018)

Modeled Baseline Daily 8-Hour Max 2018

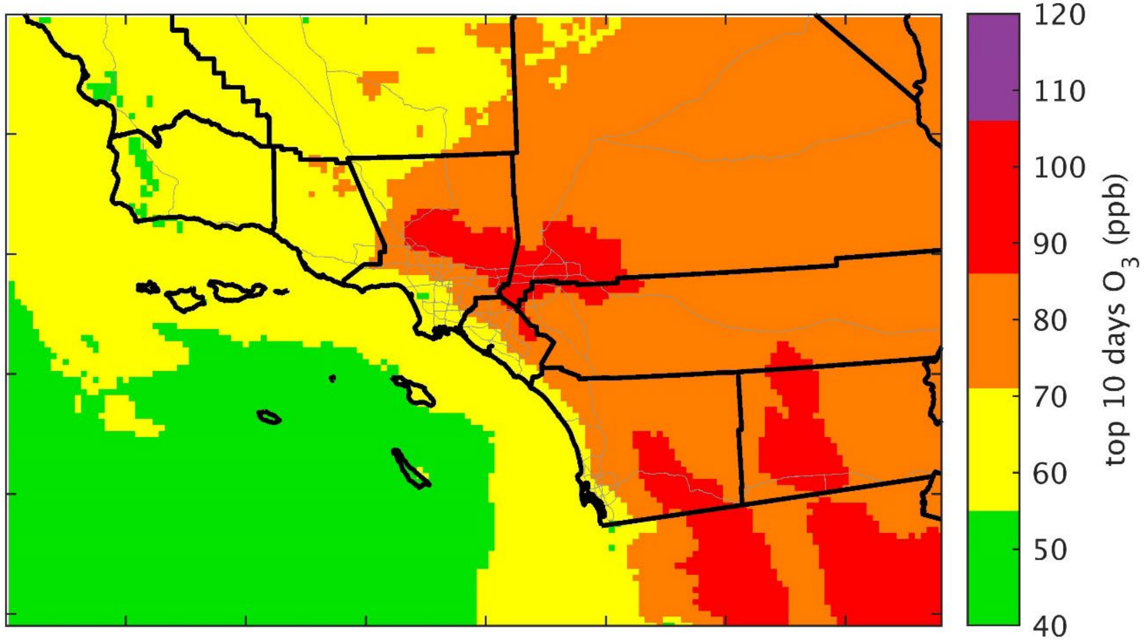


Monitoring Data DV Baseline 2018

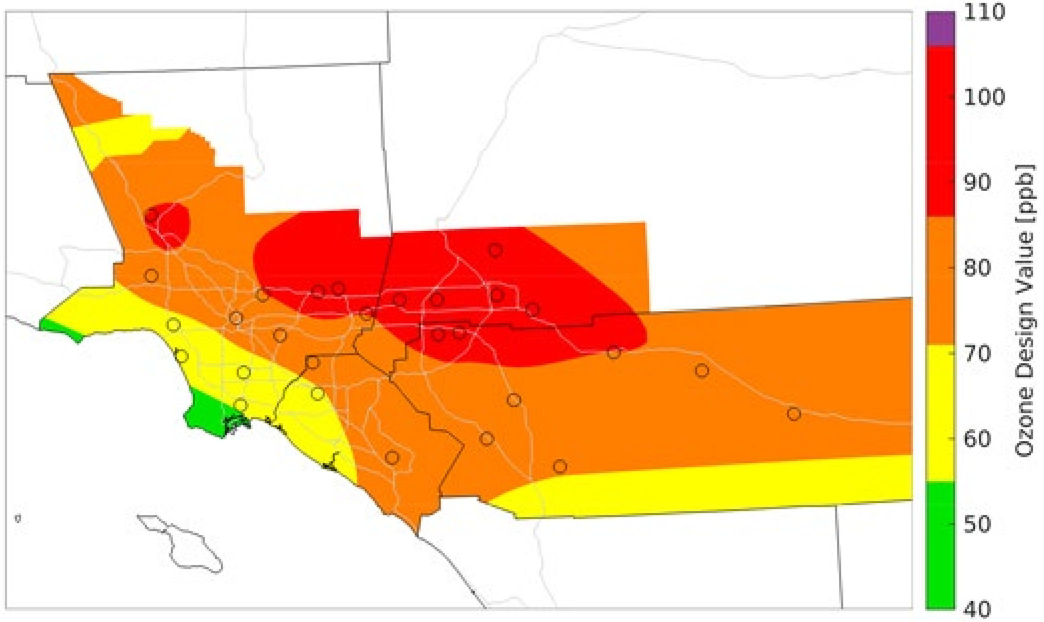


MDA8 for 2037 Baseline (Business-as-Usual)

Modeled Baseline Daily 8-Hour Max 2037



RRF-adjusted 2037 DV (Baseline)

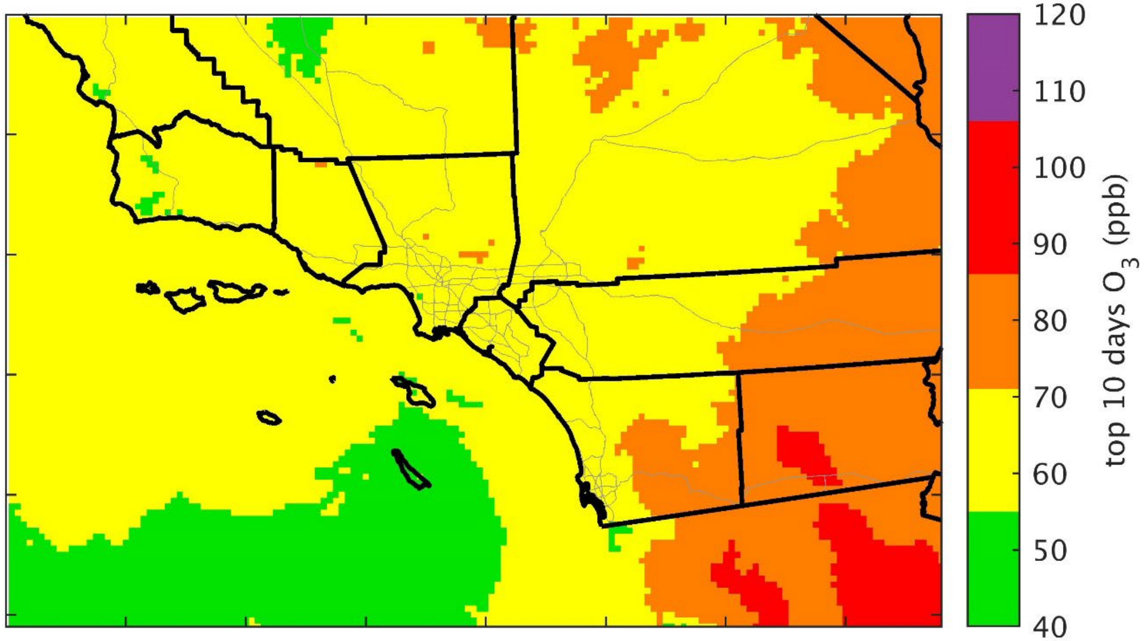


- Relative Response Factor (RRF) is calculated using the top 10 highest ozone days in the base year simulation: RRF = (average O3 in future)/(average O3 days base year)
- Future DV (DV_{FY}) is calculated by multiplying Base Year DV (DV_{BY}) times the RRF:

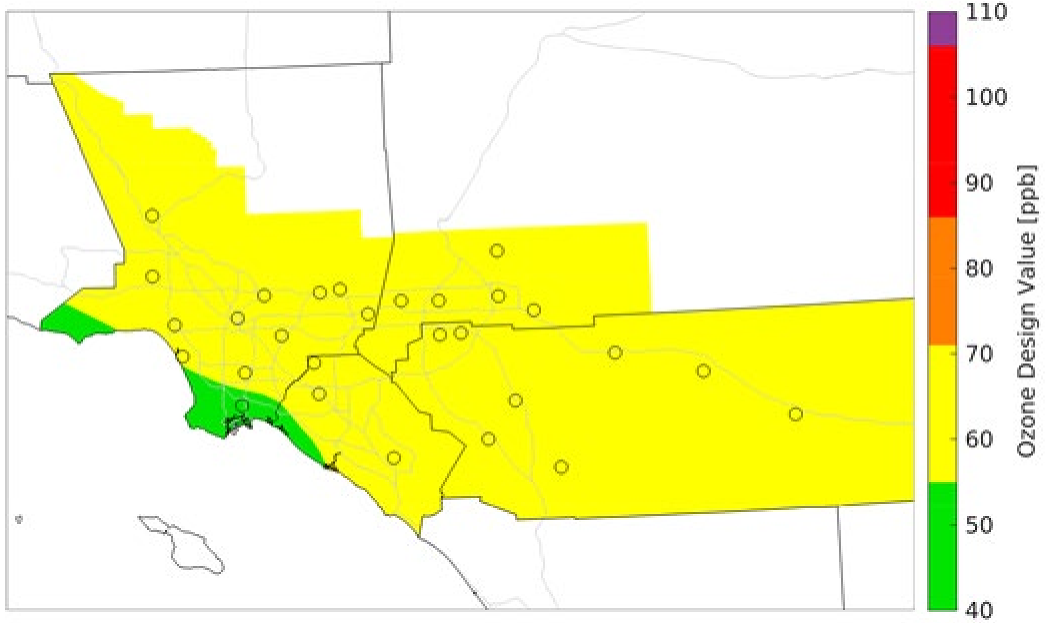
$$DV_{FY} = DV_{BY} \times RRF$$

MDA8 – 2037 Preliminary Attainment Scenario

Modeled Attainment 2037

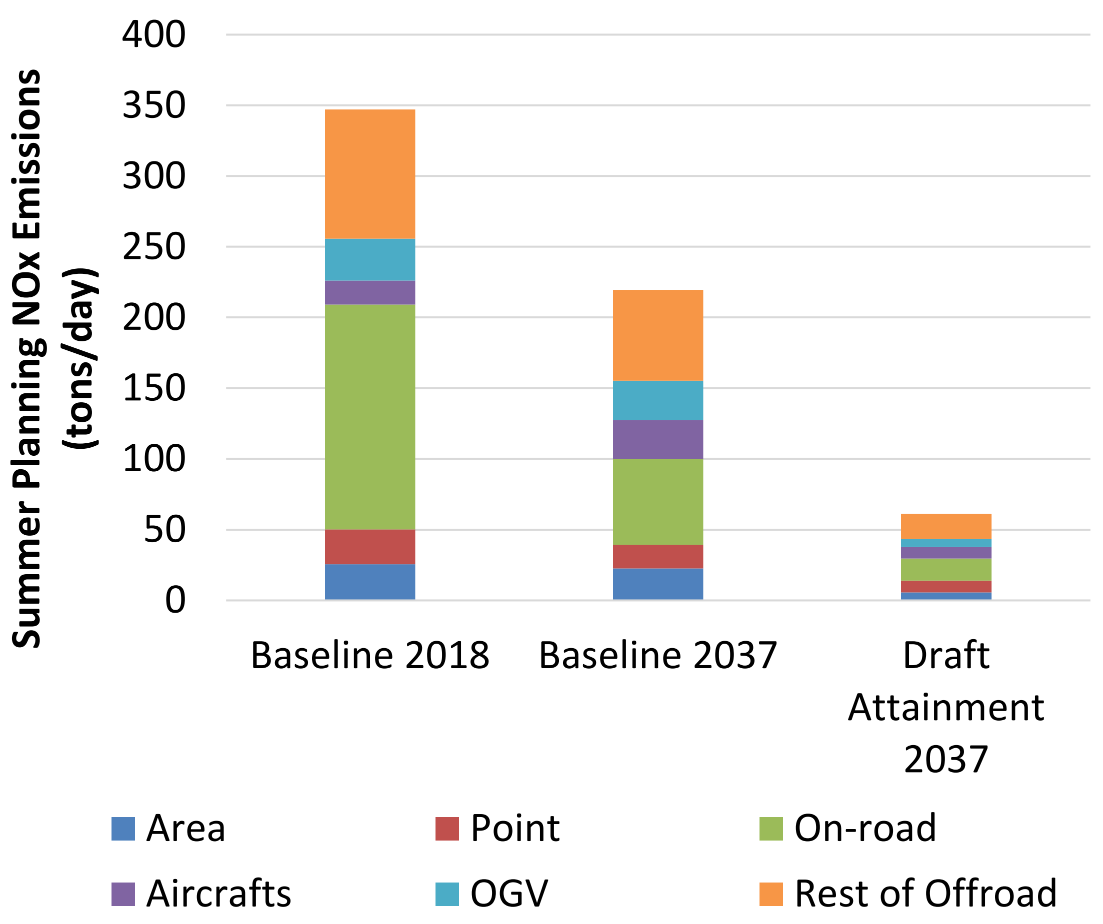


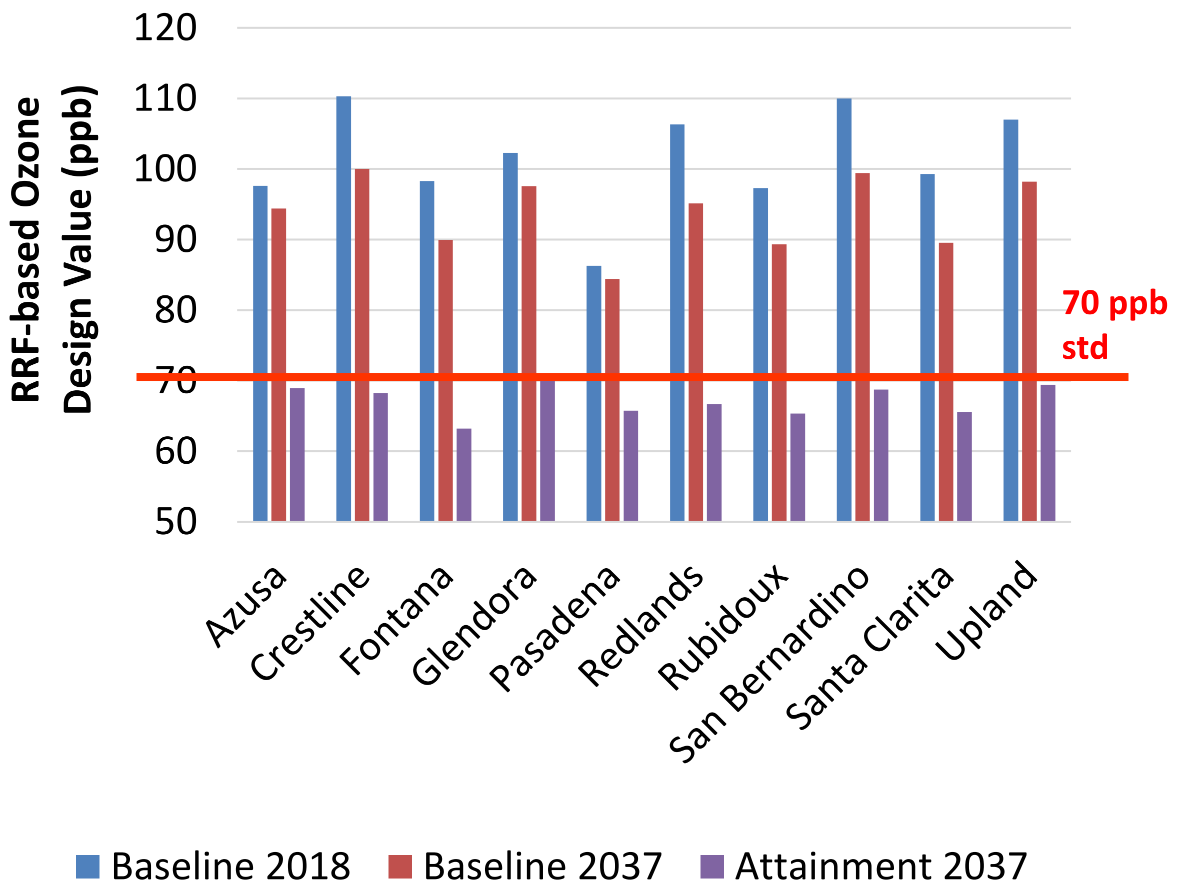
RRF-adjusted 2037 DV (Attainment)



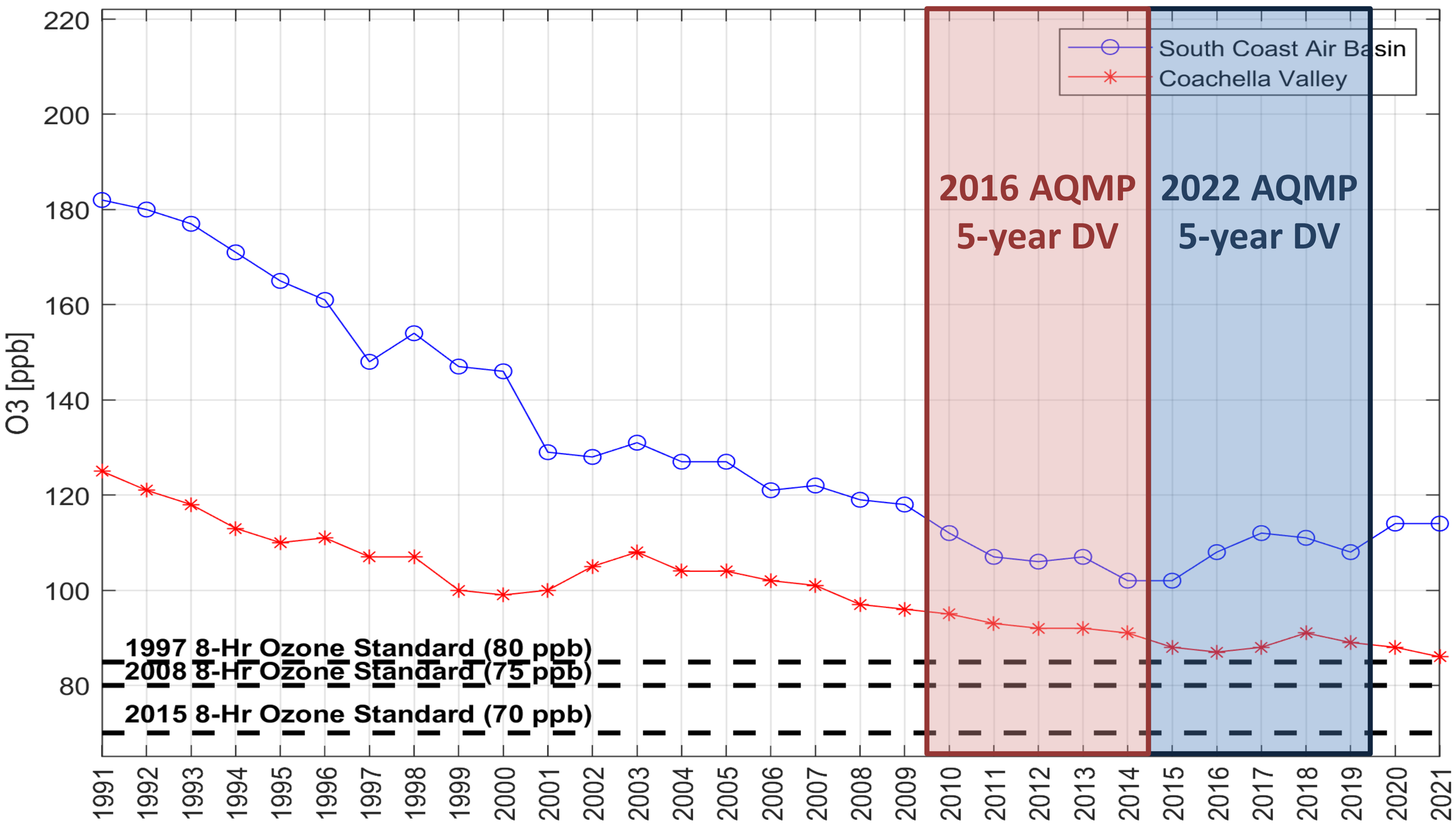
- Controls for mobile sources (except aircraft) are applied to entire modeling domain
- All emission controls over stationary sources and aircrafts are only applied SCAB and the Coachella Valley

Preliminary Attainment Demonstration at Selected Stations





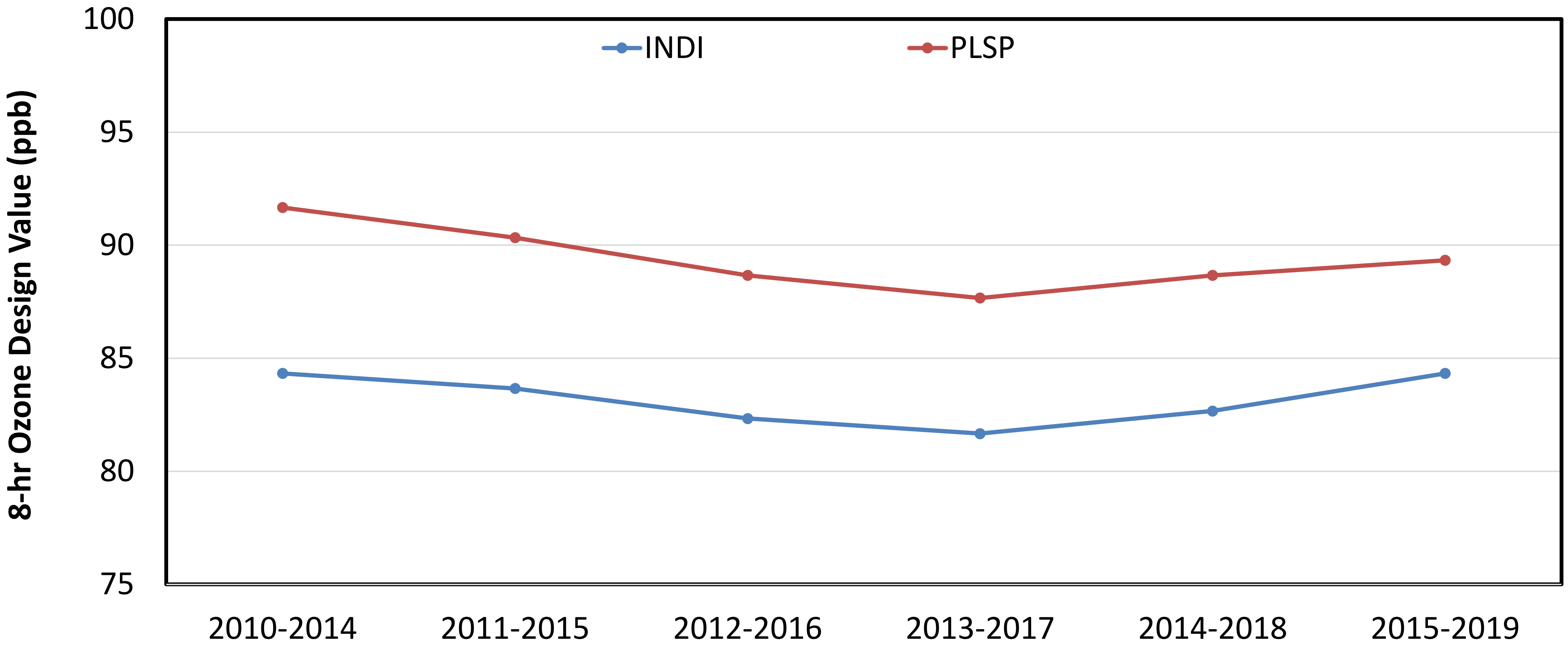
Ozone Trends in Coachella Valley



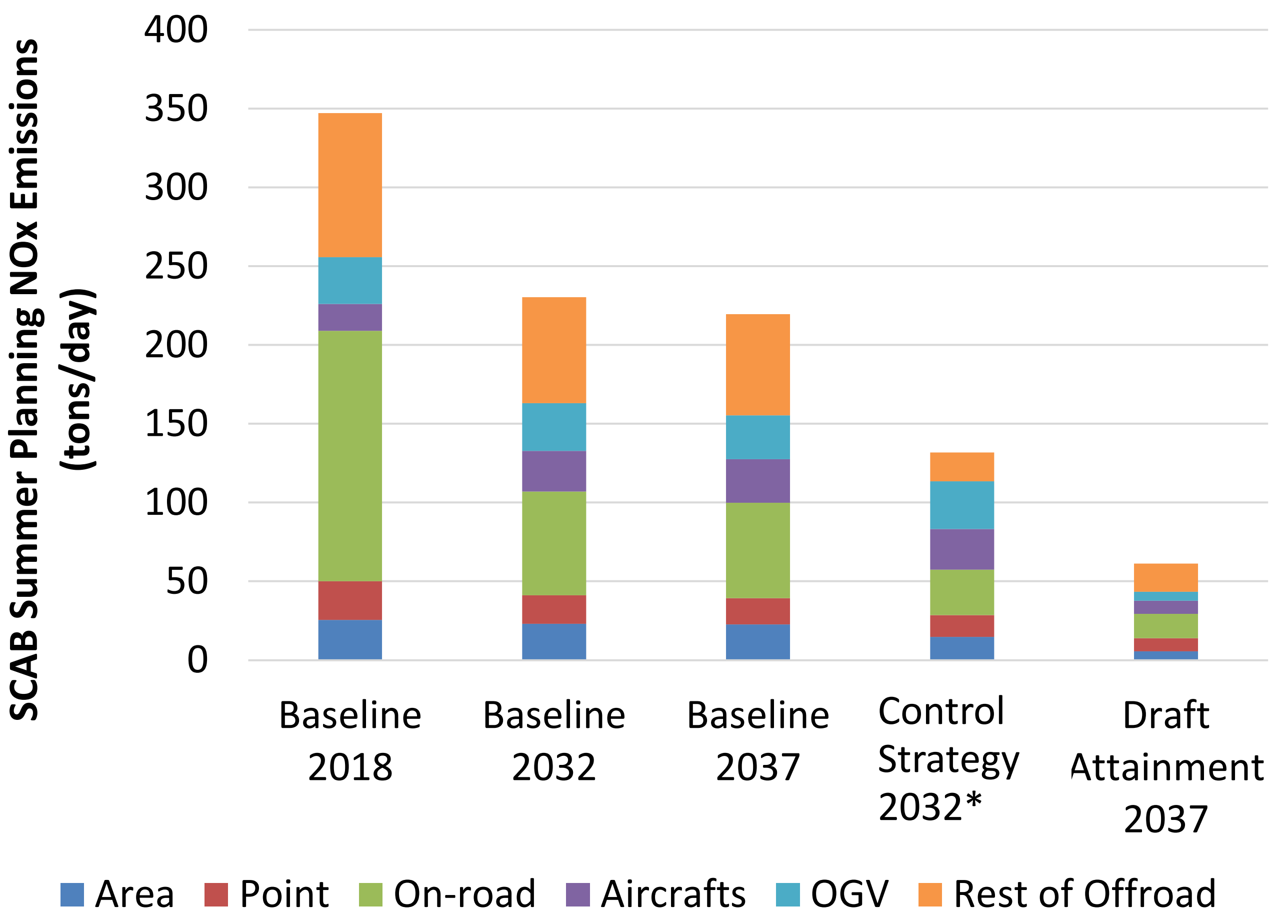
Unlike the SoCAB, ozone in Coachella Valley has continued to improve except for a spike in 2017-2018

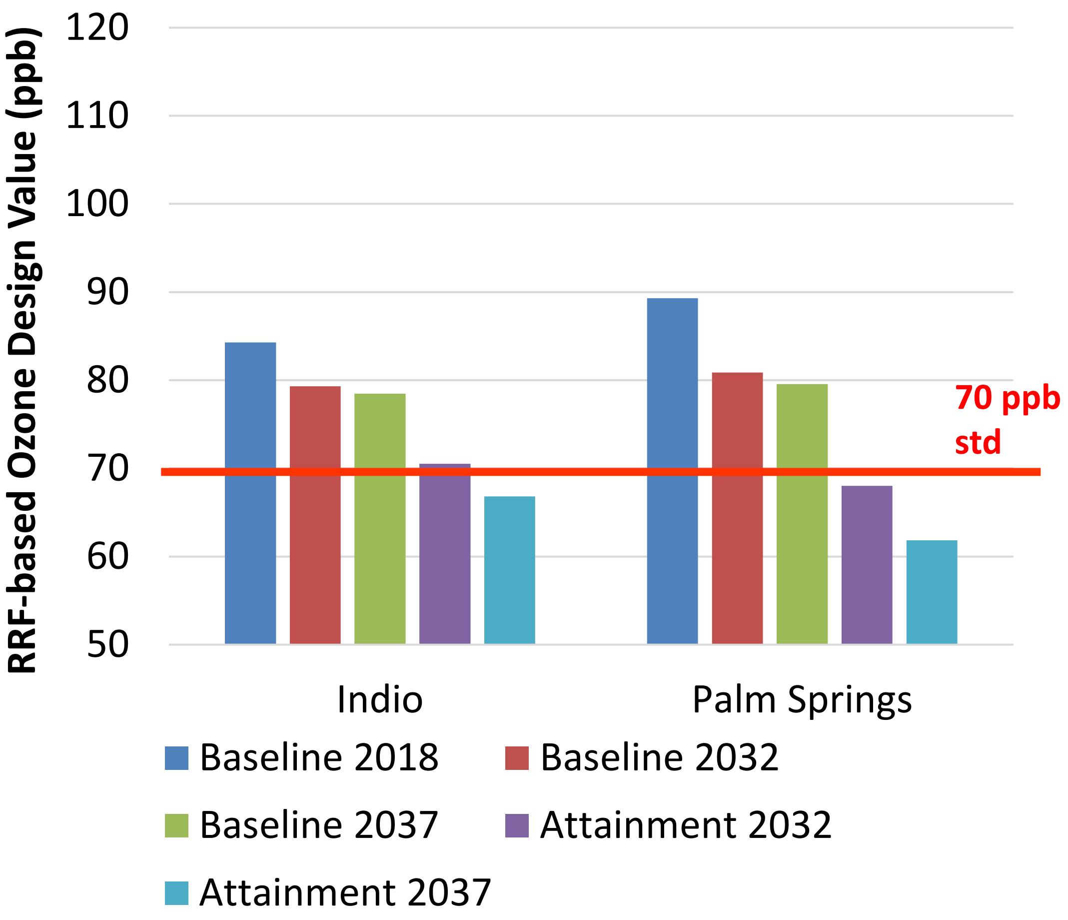
**Preliminary data for 2021*

5-year weighted 8-hour Ozone Design Value Trends – CV



Preliminary Attainment Scenario for Coachella Valley





* South Coast strategy – approximately 2/3 of the commitment for 2037
CARB strategy – year specific control factors based on the draft 2022 SIP Strategy
No reductions in aircraft emissions

Summary

- Carrying capacity plots based on draft inventory and air quality modeling are completed:
  - Carrying capacity estimated to be approximately 60 tons of NOx
  - Ozone responds to emission reductions differently, depending on the source of emissions
  - The preliminary attainment scenario relies on control profiles specified for individual source category
  - Preliminary attainment scenario suggests carrying capacity is approximately 60 tons per day of NOx emissions
  - Glendora is expected to be the design site in 2037
- Attainment for CV needs undefined control measures to attain ozone standard by 2032 using all the measures included in the South Coast Air Basin’s scenario

Sensitivity Analysis for the VOC emissions and its Impact on Attainment Scenario

Item #3

Scientific, Technical & Modeling Peer Review (STMPR)
Advisory Group Meeting

March 16, 2022

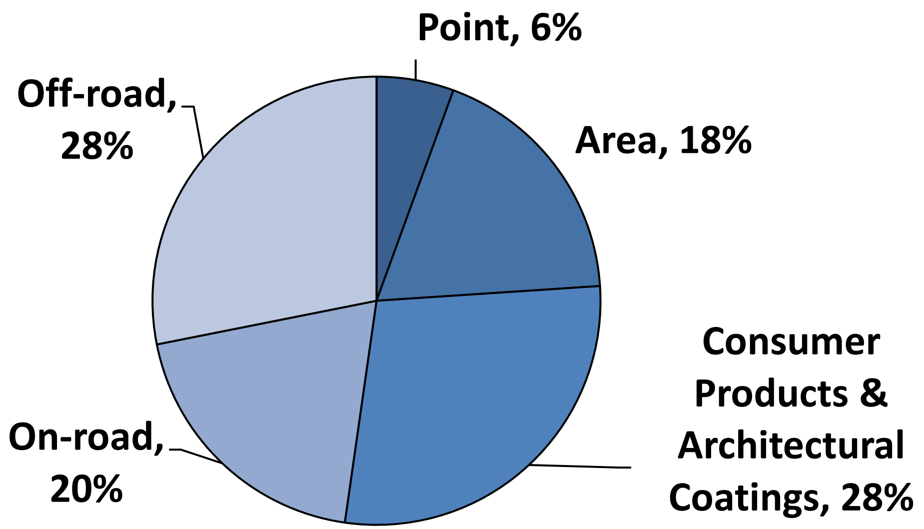
Outline

- Updates in VOC and Consumer Product emissions reflected in the 2022 AQMP
- Preliminary analyses looking into the effect of uncertainties in consumer product emissions
- Ozone responses to VOC emissions in base and future years

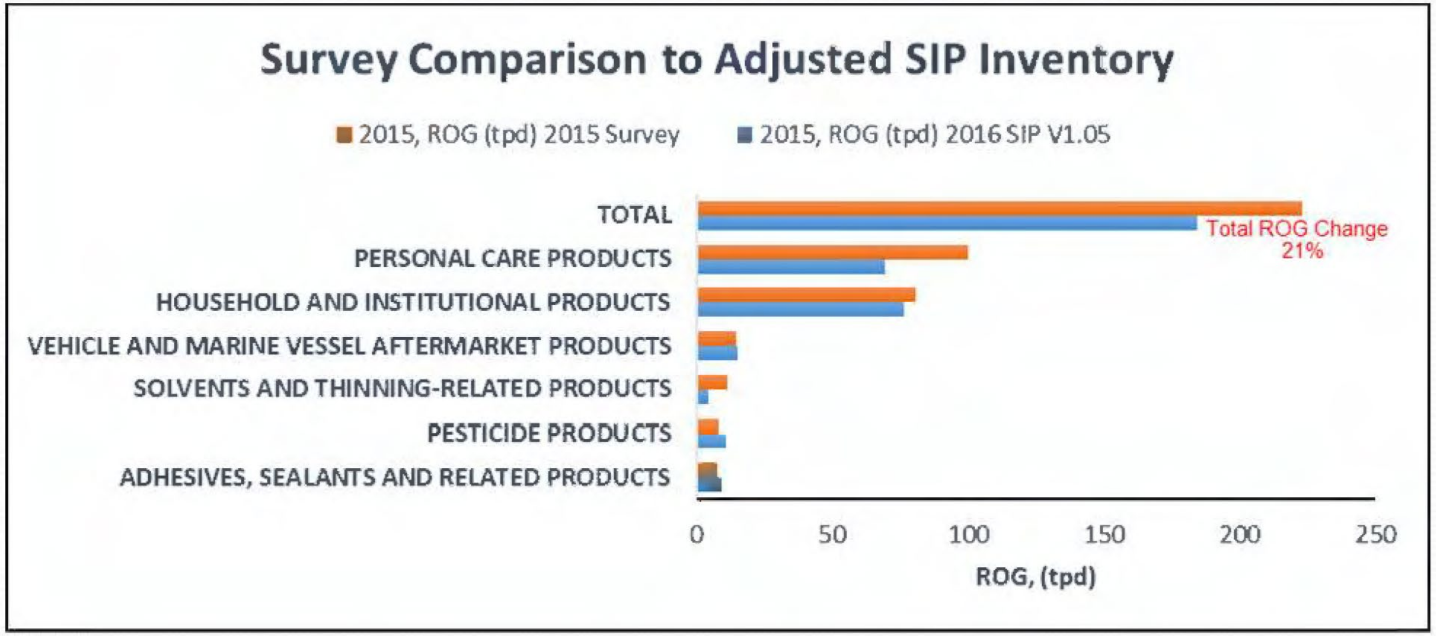
Updated Emissions Inventory for Consumer Products

- Consumer products account for 28% of the total anthropogenic emissions in the Basin
- CARB's survey on consumer products quantified uncertainty in the 2016 SIP inventory
- Some studies postulate that VOC emissions from consumer products could be ~2X higher than SIP inventory

Draft 2022 AQMP VOC Emissions (2018)



VOC Emissions: 417 tons/day

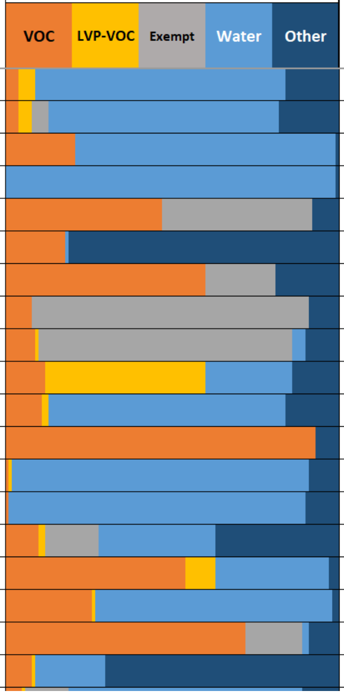


CARB Public Workshop for Consumer Products rule making (Apr12, 2019)

CARB’s 2015 Survey for Consumer Products

2015 CARB Consumer and Commercial Product Survey - December 12, 2019

Category Code	Category Name	Product Data					Emissions Data *(Fate and Transport Adjusted)*				
		Reporting Companies	Reported Products	Sales (tpd)	Sales Weighted Average VOC Content (undiluted)	Speciation (VOC, LVP-VOC, Exempt, Water, Other)	VOC (tpd)	ROG (tpd)	TOG (tpd)	PWMIR (gO_3/g)	Ozone Forming Potential (tpd)
70199	Other vehicle and marine vessel detailing products	32	171	1.43	4.23%		0.06	0.13	0.14	0.12	0.17
	Detailing Products	122	2635	53.30	4.24%		2.26	4.01	7.01	0.09	4.71
70203	Automotive Windshield Washer Fluid (Type "A" Areas)	7	35	3.73	21.73%		0.81	0.81	0.81	0.15	0.54
70204	Automotive Windshield Washer Fluid (Non Type "A" Areas)	12	42	65.32	0.07%		0.05	0.05	0.05	0.00	0.05
70205	Belt Dressing	22	28	0.16	47.52%		0.08	0.08	0.15	0.82	0.13
70206	Body Repair Products (other than coatings)	17	438	6.17	18.82%		1.16	1.17	1.17	0.33	2.06
70207	Brake Anti-Squeal Compound*	13	68	0.04	60.18%		0.02	0.02	0.03	0.73	0.03
70208	Brake Cleaner	41	120	10.14	8.73%		0.89	0.89	9.29	0.40	4.06
70209	Carburetor or Fuel-Injection Air Intake Cleaner	41	99	2.31	9.98%		0.23	0.25	1.99	0.58	1.35
70210	Engine Degreaser (aerosol)	20	32	1.15	12.57%		0.15	0.70	0.70	0.92	1.06
70211	Engine Degreaser (nonaerosol)*	15	53	0.32	11.28%		0.04	0.04	0.04	0.54	0.17
70212	Engine Starting Fluid	17	31	0.49	93.78%		0.05	0.05	0.05	0.17	0.08
70213	Home-Use Metal Parts Immersion Wash*	4	5	0.02	1.98%		0.00	0.00	0.00	0.10	0.00
70214	Mold and Mildew Retardant*	4	4	0.00	1.16%		0.00	0.00	0.00	0.02	0.00
70216	Tire Sealants and Inflator	16	103	2.95	10.21%		0.30	0.38	0.83	0.37	1.09
70217	Windshield De-Icer*	19	30	0.17	54.08%		0.09	0.10	0.10	0.65	0.11
70218	Windshield Washer Fluid Additive	20	53	4.22	26.99%		1.14	1.14	1.14	0.19	0.81
70219	Windshield Water Repellent	9	17	0.25	72.68%		0.18	0.18	0.22	1.03	0.26
70299	Other vehicle and marine vessel maintenance and repair products	53	401	2.14	8.99%		0.19	0.20	0.21	0.14	0.30



Aerosol Coating Products	**Reporting for 2015 Not Requested**					
All Categories		134.86	202.03	252.27	0.05	391.32

2016 AQMP vs 2022 AQMP

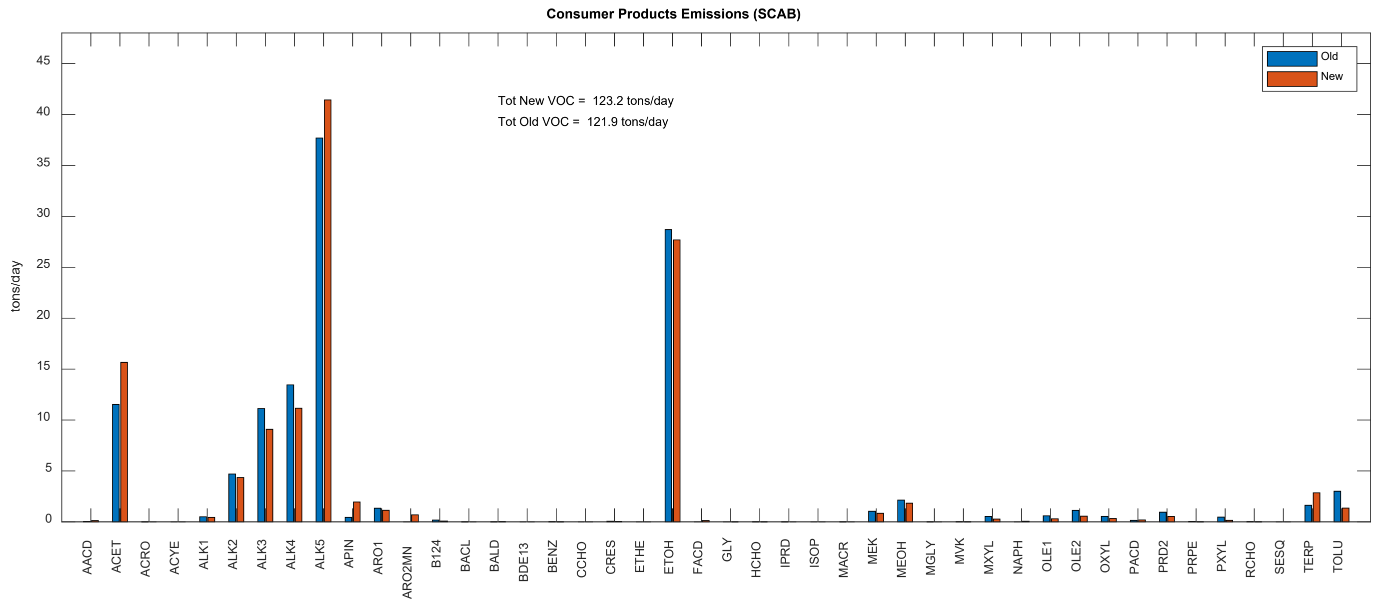
- TOG and VOC emissions from consumer products have been revised in the new AQMP inventory

- Annual average emissions from consumer products (tons per day):

	AQMP2016		AQMP2022	
Year	**TOG**	**ROG**	**TOG**	**ROG**
2018	105.3	87.6	135.8	107.4
2023	108.3	90.1	141.2	111.8
2031	113.1	94.1	154.9	123.0
2037	-	-	165.6	131.9

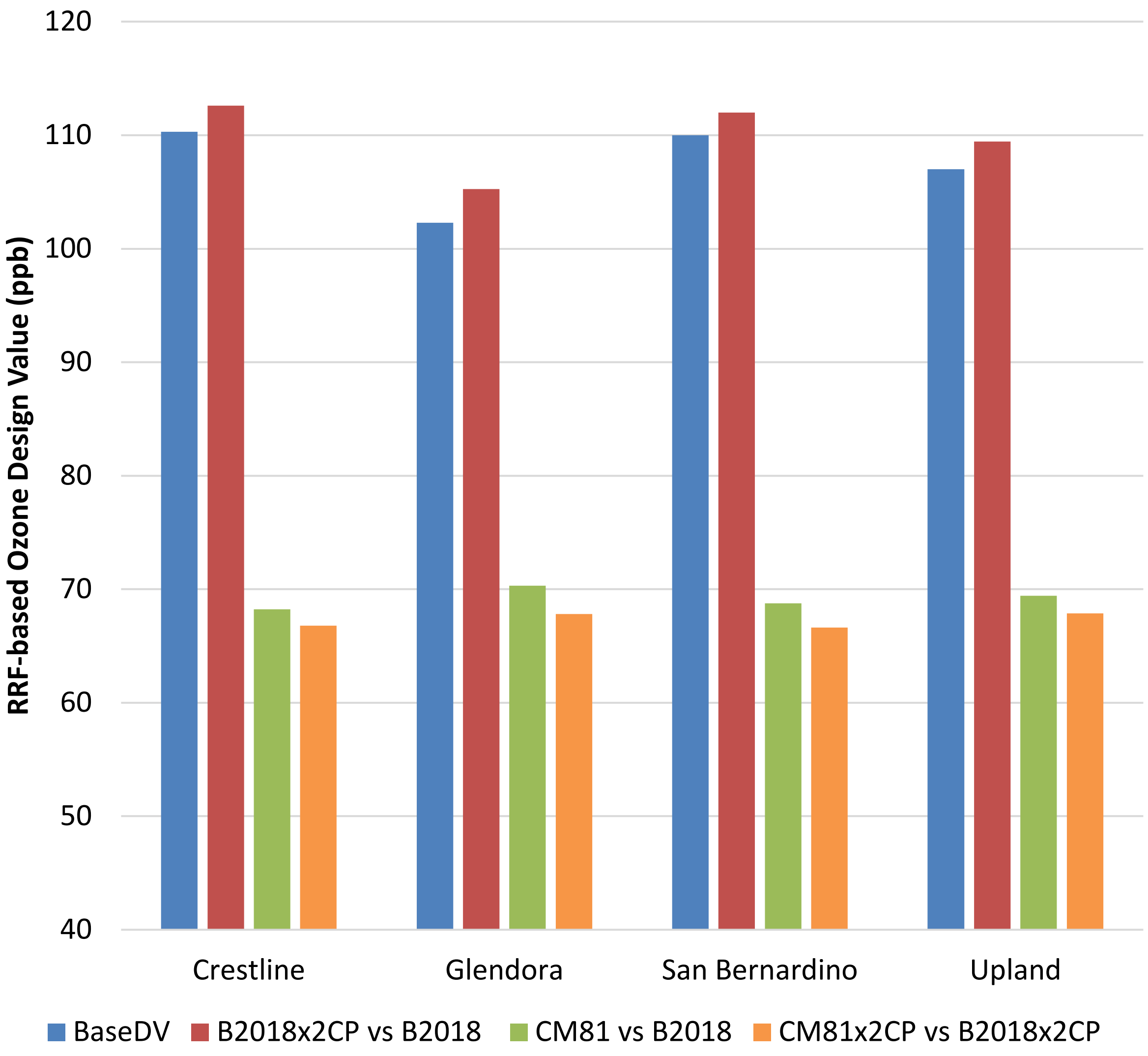
Preliminary Analysis of VOC Emissions Uncertainties

- Analyzed the potential contribution to increased intermediate-volatility VOC (IVOC) from diesel evaporative emissions (AQMP2016)
  - Simplified analysis suggested potential increase in O3 DV by up to 1.5 ppb
- Analyzed the effect of sensitivity to chemical speciation profiles
  - Updated VOC speciation profiles shift VOC speciation towards slightly more reactive species
  - Update profiles could increase O3 DV by 0.3 ppb

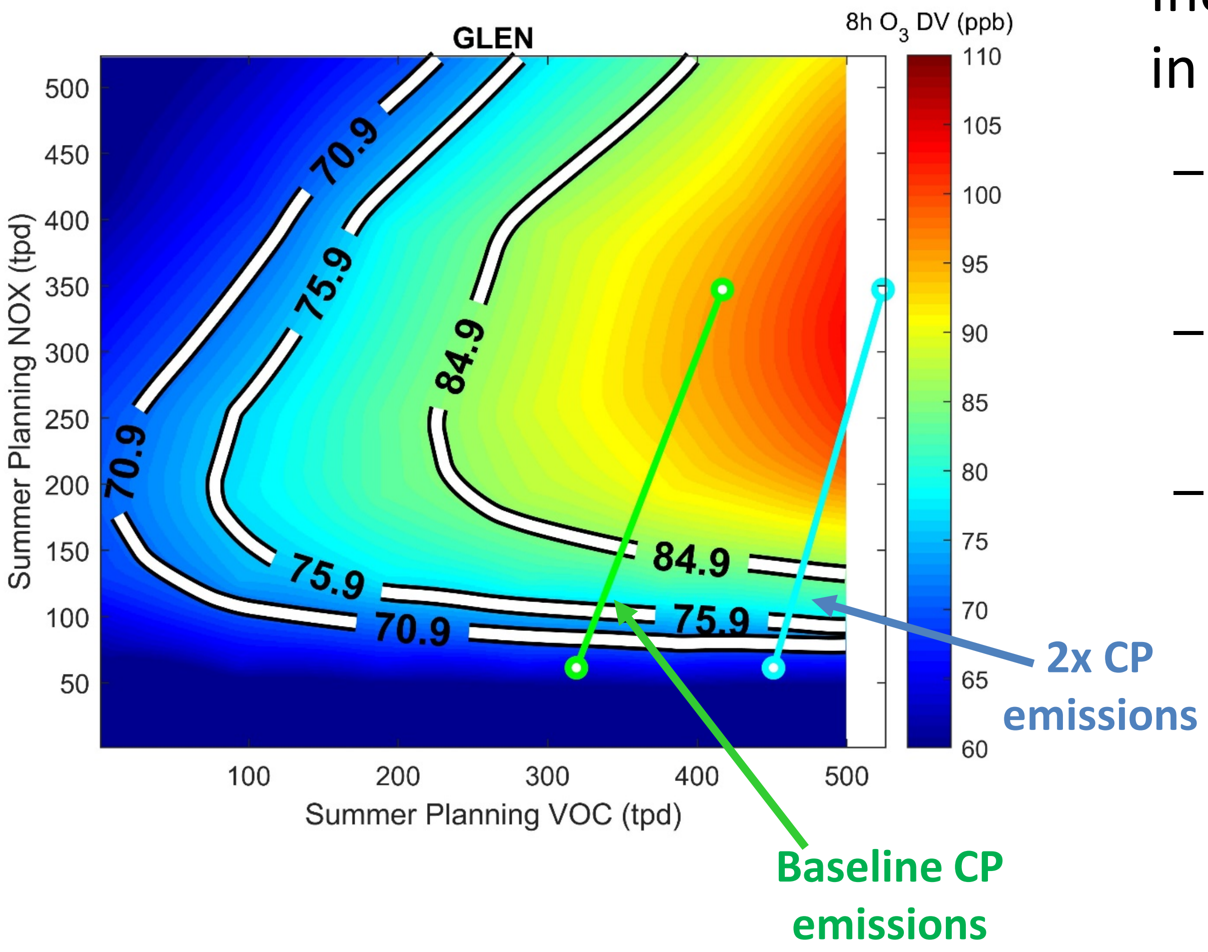


Preliminary Analysis of VOC emissions uncertainties

- Analyzed the implication of increasing consumer products (CP) VOC emissions
  - Doubling emissions of CP increases baseline 2018 O3 DV by up to 3 ppb (~3% increase in ozone DV)
  - Increasing CP in baseline and future scenarios makes NOx reductions more effective
    - Attainment scenario DV decreases by 2.5 ppb



Ozone sensitivity to VOC emissions



- Increasing emissions of consumer products in base year and future years decreases RRF:
  - Base year ozone ($O_{3,b}$) increases with increasing VOC: $(O_{3,b})_{2x\ CP} > (O_{3,b})_{base\ CP}$
  - Future year ozone ($O_{3,f}$) is not sensitive to VOC emissions: $(O_{3,f})_{2x\ CP} \approx (O_{3,f})_{base\ CP}$
  - $RRF_{2xCP} = (O_{3,f}/O_{3,b})_{2x\ CP}$ is lower than $RRF_{base\ CP} = (O_{3,f}/O_{3,b})_{base\ CP}$

Ozone Impacts from Consumer Products

- Recent studies suggest VOC emissions from consumer products are currently underestimated in a regulatory inventory
  - Research suggests that adding these emissions results in increased O3 formation in SCAB
- Staff will explore a future modeling framework that incorporates:
  - Increased consumer product emissions
  - Improved speciation profiles
  - A revised chemical mechanism with improved treatment of consumer product species
- New modeling framework could be used to assess impacts to the attainment scenario in collaboration with EPA scientists

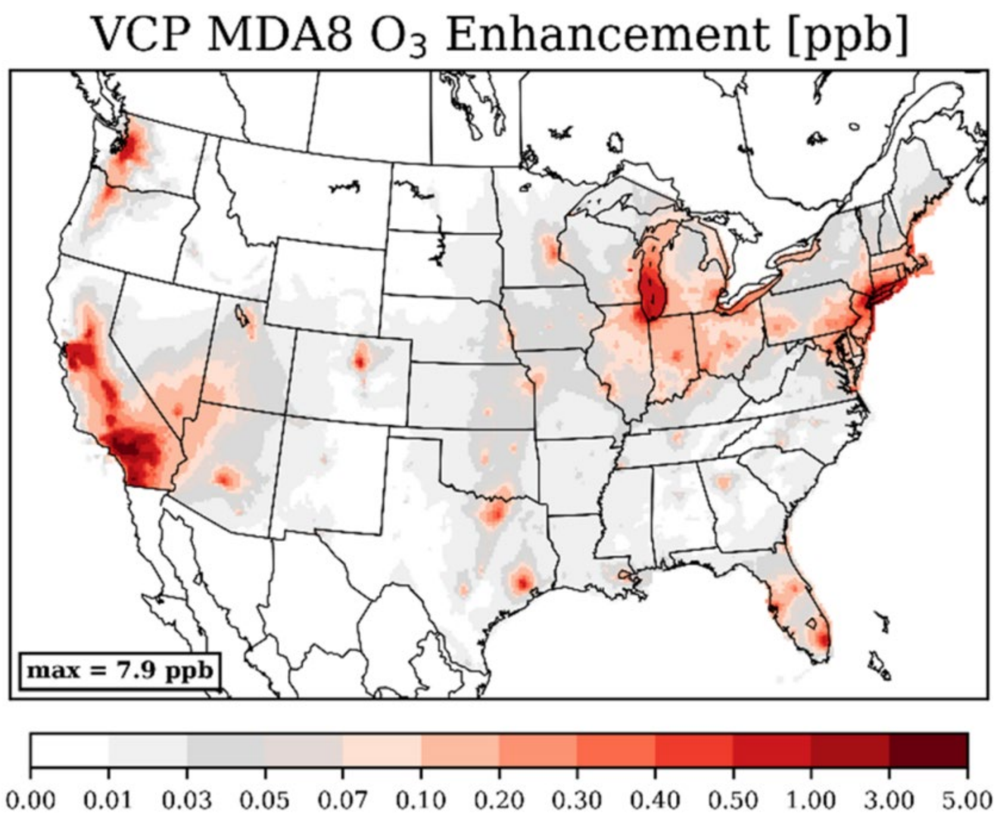


Figure reproduced from Seltzer et al., ES&T 2021. https://doi.org/10.1021/acs.est.1c04298

Summary

- Ozone sensitivity to VOC emissions from consumer products was evaluated using the AQMP modeling system
- While there may be likely uncertainties in VOC emissions from consumer products and/or fugitive emissions, NOx control strategy is the only viable attainment path for the ozone NAAQS
- Further analysis will be conducted using emerging data from fenceline monitoring (South Coast AQMD Rule 1180), field measurements data and collaboration with experts in U.S. EPA, academic institutes and other agencies

CALIFORNIA
AIR RESOURCES BOARD

EMFAC Heavy-Duty Vehicle Emission Rates

Mobile Source Analysis Branch
Air Quality Planning and Science Division
California Air Resources Board

March 16, 2022

Today's Presentation

- Overview of EMFAC Heavy-Duty NOx Emission Rates
  - Heavy-Duty Diesel
  - Heavy-Duty Natural Gas
- Port Congestion Assessment

EMFAC Heavy-Duty Emission Rates

Modeling Heavy-Duty (HD) Emission Rates in EMFAC

$$Emission\ Rate\ (\frac{g}{mile}) = (ZMR + DR \times Odometer) \times SCF$$

- Zero-mile emission rate (**ZMR**) – Fleet average UDDS emission rates while trucks are new
- In-Use Emission Deterioration (**DR**) – Increase of emissions over time within the in-use fleet caused by tampering, malfunction and mal-maintenance (TM&M) of engine components, and emission control systems
- Speed Correction Factors (**SCF**) – A method to correct emission rates at different driving speeds

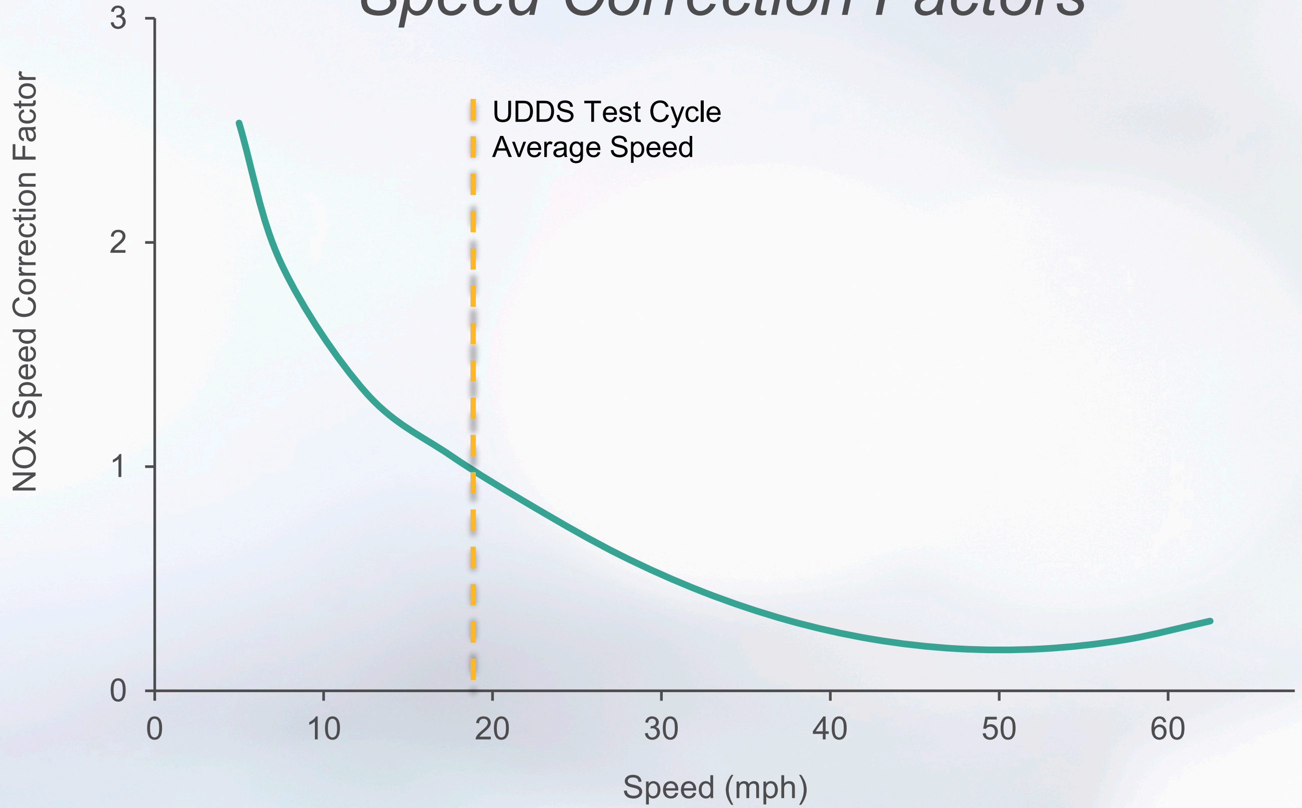
CARB

Emission Rate Modelling

Deterioration Rate

Increasing percentage of high-emitting (up to 12X ZMR) vehicles w/ emissions after-treatment malfunction as the fleet ages → larger fleet-average emission rate

Speed Correction Factors



Speed correction factors account for variation of emissions for SCR-equipped vehicles under different operating conditions (e.g. low load)

HD Emission Rates Updates Overview

EMFAC 2017

Heavy Heavy-Duty Diesel

- Revised running exhaust emission rates of 2013+ MY using dyno data from CARB and other sources
- Revised start and idle emission rates of 2010+ MY using PEMS data from CARB and other sources

Medium Heavy-Duty Diesel

- Estimated MHD diesel truck emission rates by scaling HHD truck emission rates

CNG

- Revised emission rates of 0.2g CNG transit buses using limited dyno data from several sources

EMFAC 2021

Heavy Heavy-Duty Diesel

- Revised running exhaust emission rates of 2013+ MY using additional dyno data from CARB
- Start emission rates of 2013+ MY diesel HD trucks based on PEMS data of CARB TBSP

Medium Heavy-Duty Diesel

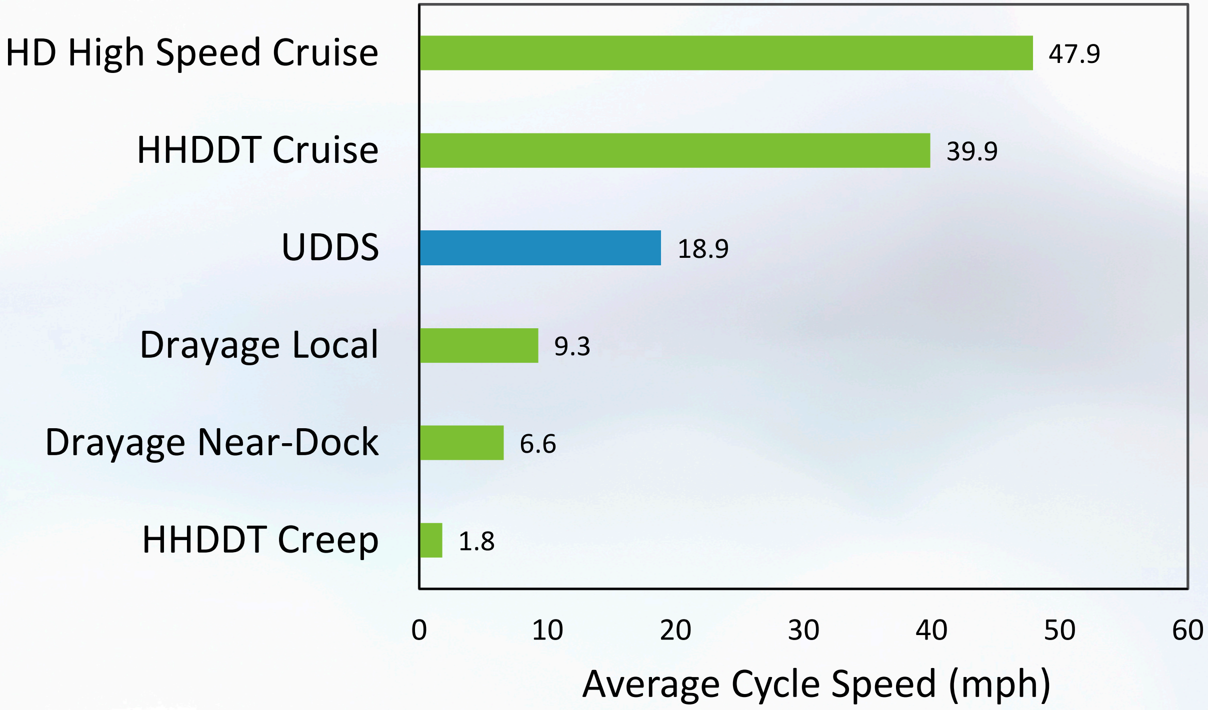
- Running exhaust emission rates of 2013+ MY MHD based on dyno test data from CARB TBSP

CNG

- Running exhaust emission rates of natural gas HD vehicles based on PEMS data from a multi-agency **200-vehicle testing project**

CARB Truck & Bus Surveillance Program (TBSP)

- In EMFAC2021, **38** MY2013+ trucks tested on dyno over 6 test cycles
- Testing data were used to update EMFAC2021 HHD diesel truck emission rates



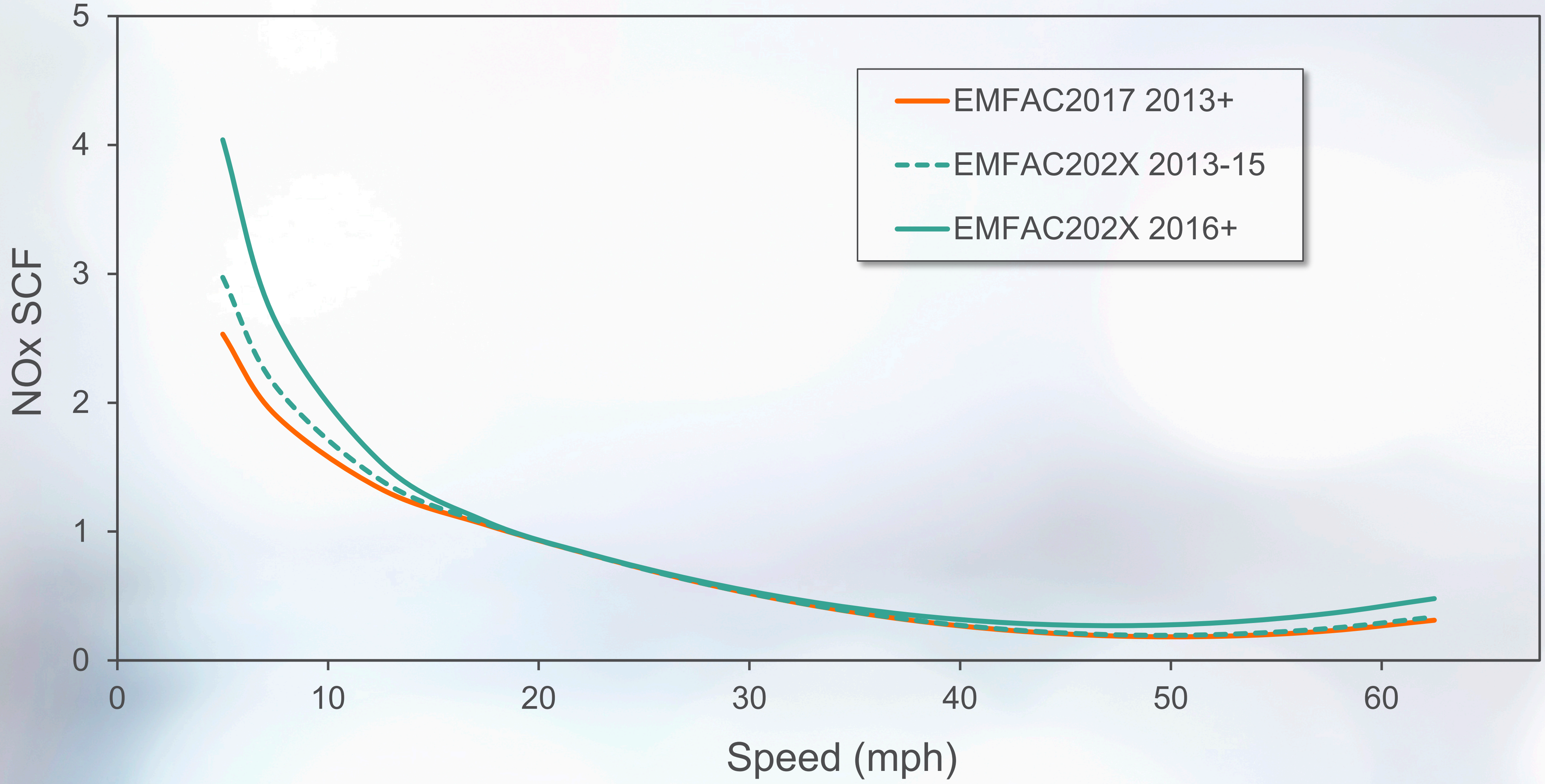
HHD Diesel Speed Correction Factors Derivation

- For a given MY group, a pollutant's emission rates of all test cycles were first plotted versus the cycles' speeds.
- Curves were then fitted to find the equations best representing the data.
- a two-segment empirical curve was found best-fit and used in order to reasonably fit all the data points:

$$SCF = A \cdot speed^{B}$$

$$SCF = C \cdot speed^{2} + D \cdot speed + E$$

HHD Diesel Speed Correction Factors for NOx



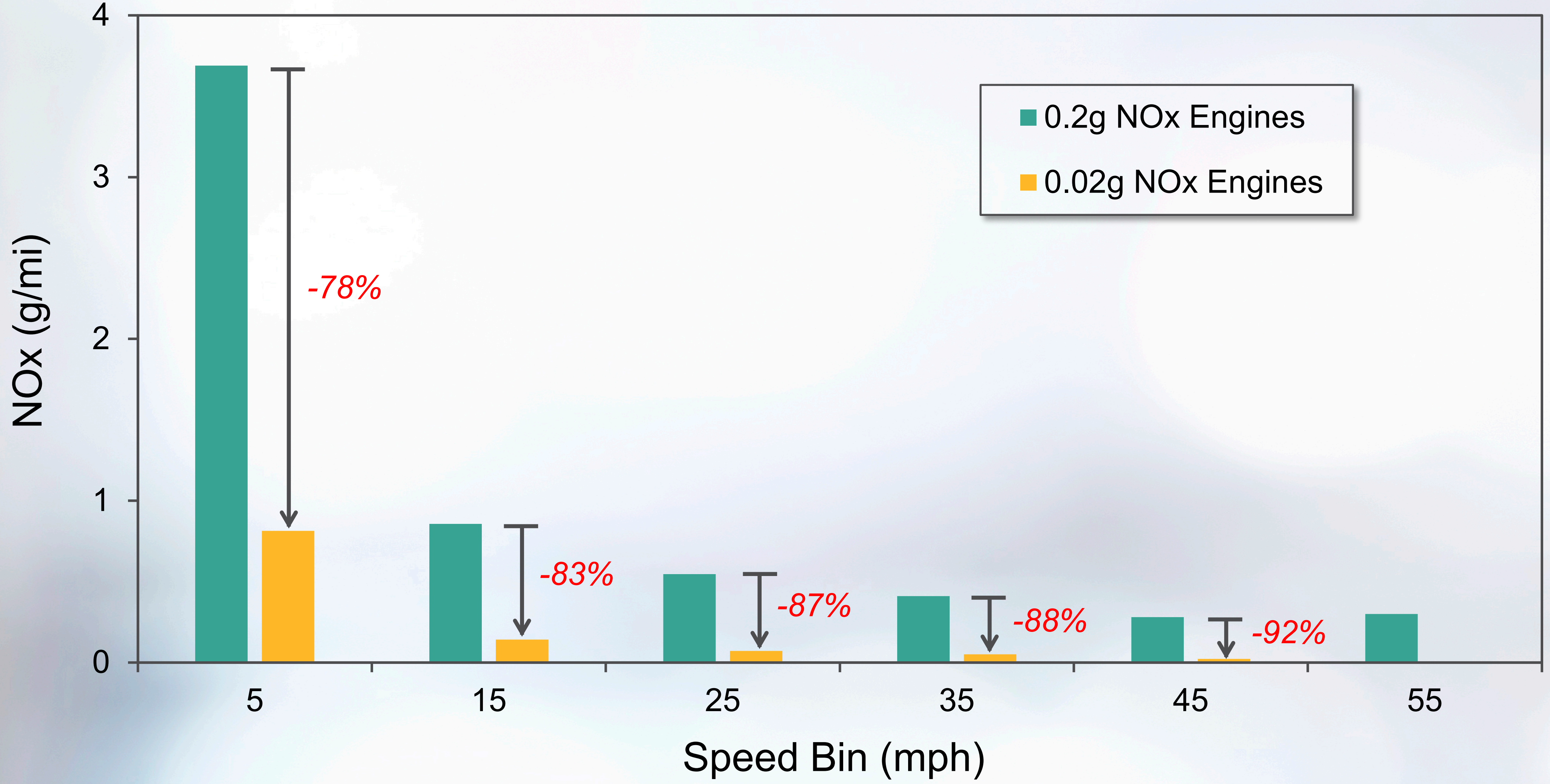
Emission Factors for Natural Gas Vehicles

- Test data from the multi-agency 200-vehicle testing project
  - PEMS testing of ~100 vehicles
- PEMS data from 47 NG HD vehicles were used in EMFAC2021

Technology	Transit Bus	School Bus	Refuse Truck	Goods Movement Truck	Delivery Trucks
TWC (0.2 g/bhp-hr)	5	5	11	8	3
TWC (0.02 g/bhp-hr)	5	--	1	9	--

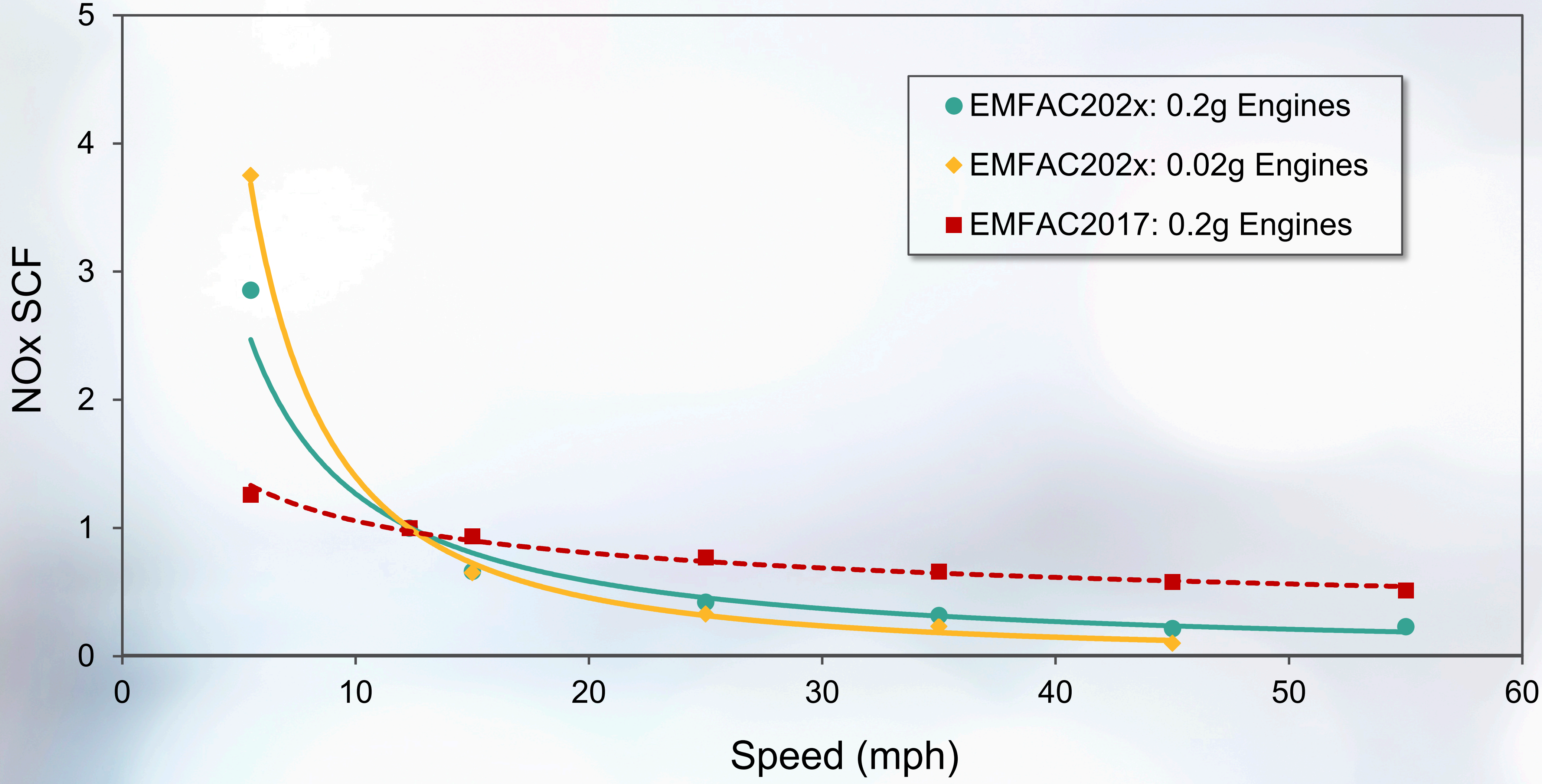
Preliminary Results

CNG Bus NOx Rates by Speed Bin



Preliminary Results

CNG Bus NOx Speed Correction Curves



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Actions to Control Low Load Emissions

California Heavy-Duty Omnibus (adopted)

- Suite of requirements that reduce NOx emissions from new CA-certified heavy-duty vehicles starting in 2024
- Includes low load cycle (LLC) certification standards to control NOx emissions under low load conditions

Federal Clean Trucks Plan (under development)

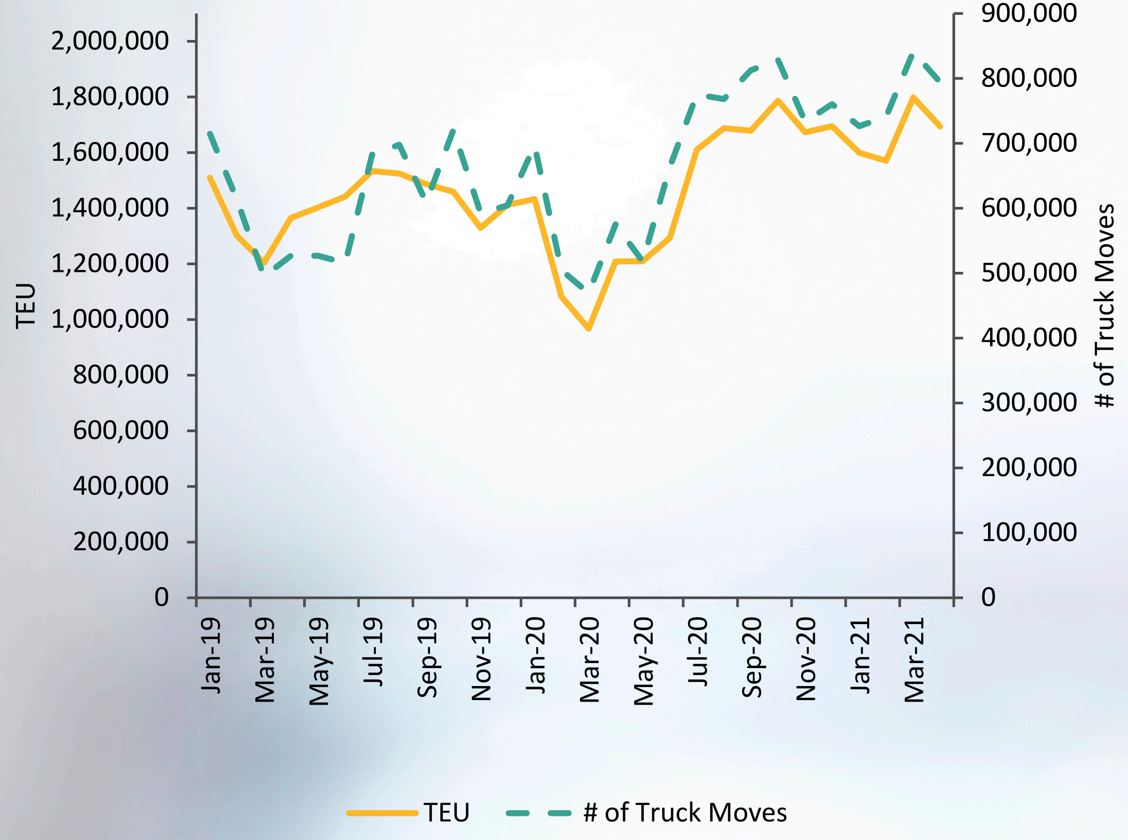
- Reduces NOx emissions from Federal-certified heavy-duty vehicles starting in 2027
- NPRM released in March 2022 includes proposed LLC standards

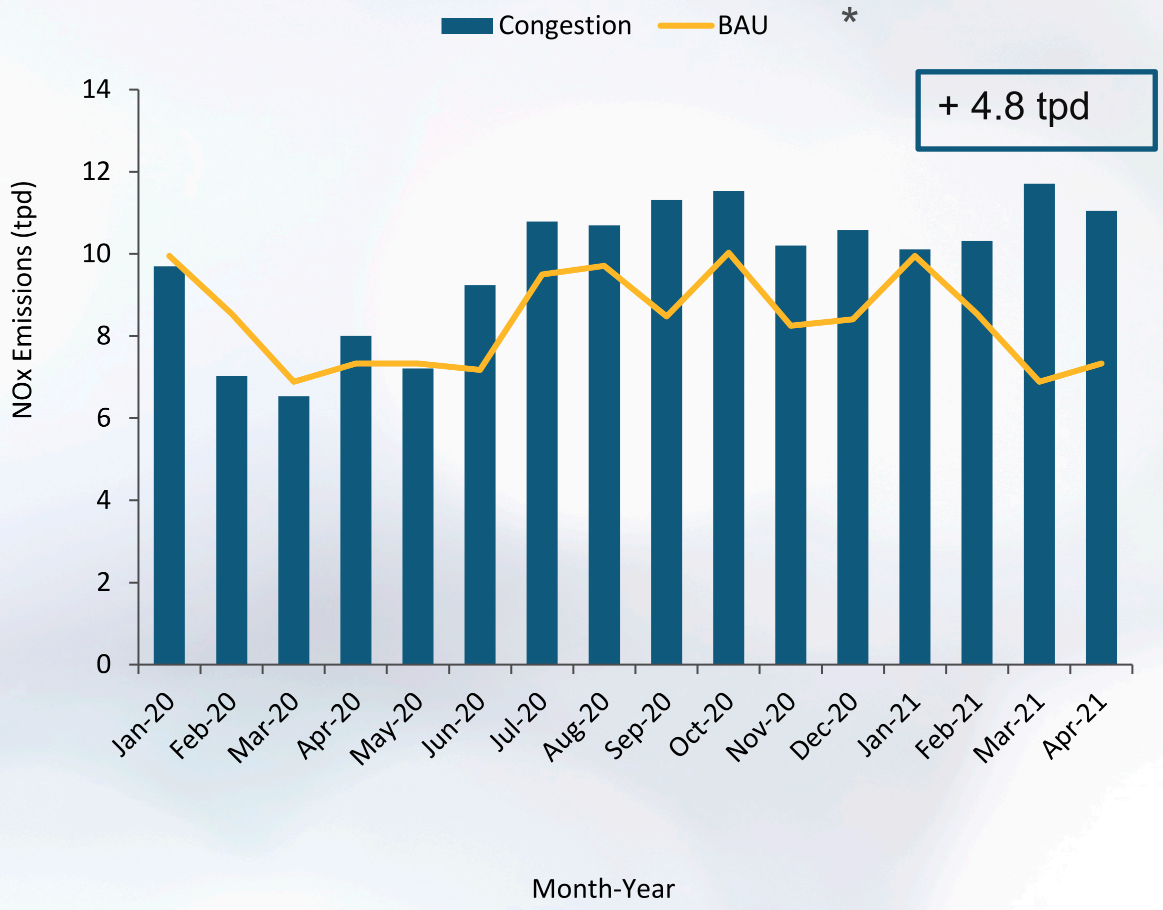
Advanced Clean Fleets (under development)

- Phase-in zero-emission trucks and buses starting in 2023
- Includes state and local government fleets, high priority private fleets, and drayage trucks serving ports and railyards

Technical Analysis of Port Truck Emissions Based on EMFAC2021

Emissions Impact of Recent Congestion at Port of Los Angeles and Long Beach





* BAU based on EMFAC2021

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Summary and future directions

- The 200-vehicle in-use emissions project data have been used in EMFAC2021 and will continue to inform inventory building in next EMFAC version
- Analyze more PEMS data from multiple sources (including TBSP, HDIUT, HDIUC) as they become available, and keep improving our understanding of HD emission rates and SCFs
- Continue to track the impact of increased port congestion on truck activity and emissions