

Appendix E – Model Performance Evaluation

In addition to the evaluations presented in the main report, below are supplemental tables and maps of an in-depth evaluation of four major toxic VOCs modeled by CMAQ.

Table E-1. (a) Comparison between modeled and monitored annual average concentrations in mg/m³ of total 1,3-butadiene simulated by CMAQ, (b) A map indicating the monitor locations.

(a)

Monitor Location	Latitude	Longitude	Observed	Modeled
Los Angeles-North Main Street	34.07	-118.23	0.13	0.12
Rubidoux	34.00	-117.42	0.09	0.04
San Jose - Jackson	37.35	-121.89	0.08	0.20
Livermore	37.69	-121.78	0.01	0.03
Oakland	37.74	-122.17	0.03	0.06
Oakland West	37.81	-122.28	0.05	0.06
Laney College	37.79	-122.26	0.03	0.06
Berkeley Aquatic Park	37.86	-122.30	0.02	0.05
Chico-East Avenue	39.76	-121.84	0.07	0.02
Concord	37.94	-122.03	0.01	0.03
Richmond - 7th St.	37.95	-122.36	0.01	0.03
Crockett - Kendall Ave	38.05	-122.23	0.01	0.01
Bethel Island	38.01	-121.64	0.01	0.01
San Pablo	37.96	-122.36	0.02	0.03
Martinez - Jones St.	38.01	-122.13	0.01	0.02
Fresno - Garland	36.79	-119.77	0.12	0.05
Calexico-Ethel Street	32.68	-115.48	0.17	0.07

Bakersfield-California	35.36	-119.06	0.08	0.07
Azusa	34.14	-117.92	0.07	0.12
San Rafael	37.97	-122.52	0.01	0.02
Ft. Cronkhite	37.83	-122.53	0.01	0.01
Napa	38.31	-122.30	0.08	0.02
Roseville-N Sunrise Ave	38.75	-121.26	0.08	0.03
Chula Vista	32.63	-117.06	0.09	0.10
El Cajon - Lexington Elementary School	32.79	-116.94	0.10	0.08
San Francisco	37.77	-122.40	0.05	0.07
Stockton-Hazelton	37.95	-121.27	0.10	0.03
Redwood City	37.48	-122.20	0.03	0.06
San Jose - Knox Avenue	37.34	-121.85	0.02	0.14
Vallejo	38.10	-122.24	0.04	0.02
Sebastopol	38.40	-122.82	0.02	0.02
Simi Valley-Cochran Street	34.28	-118.68	0.06	0.02

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(b)

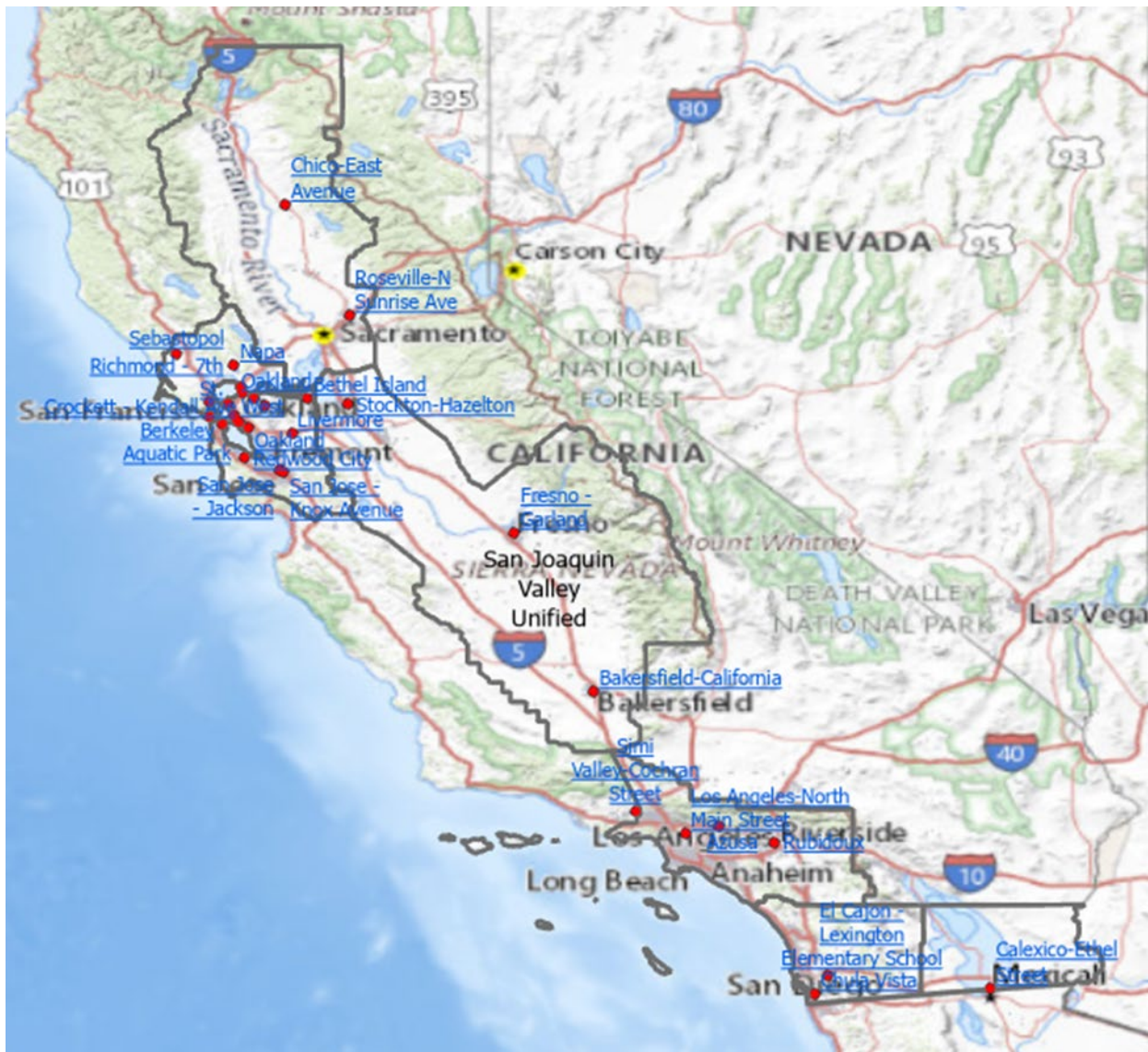


Table E-2. Comparison between modeled and monitored annual average concentrations in mg/m³ of total benzene (CMAQ). (b) A map indicating monitor locations.

(a)

Monitor Location	Latitude	Longitude	Observed	Modeled
Los Angeles-North Main Street	34.07	-118.23	0.98	1.09
Rubidoux	34.00	-117.42	0.74	0.53
San Jose - Jackson	37.35	-121.89	1.00	0.77
Livermore	37.69	-121.78	0.54	0.38
Oakland	37.74	-122.17	0.82	0.57
Oakland West	37.81	-122.28	0.90	0.66
Laney College	37.79	-122.26	1.02	0.65
Berkeley Aquatic Park	37.86	-122.30	0.69	0.55
Chico-East Avenue	39.76	-121.84	0.53	0.30
Concord	37.94	-122.03	0.45	0.49
Richmond - 7th St.	37.95	-122.36	0.57	0.56
Crockett - Kendall Ave	38.05	-122.23	0.38	0.35
Bethel Island	38.01	-121.64	0.41	0.33
San Pablo	37.96	-122.36	0.92	0.56
Martinez - Jones St.	38.01	-122.13	0.45	0.39
Fresno - Garland	36.79	-119.77	0.93	0.42
Calexico-Ethel Street	32.68	-115.48	1.12	0.58
Bakersfield-California	35.36	-119.06	0.84	0.37

Azusa	34.14	-117.92	0.78	1.29
LAX Hastings	33.96	-118.43	0.58	0.89
Santa Clarita	34.38	-118.53	0.69	0.36
San Rafael	37.97	-122.52	0.53	0.38
Ft. Cronkhite	37.83	-122.53	0.32	0.23
Napa	38.31	-122.30	1.06	0.37
Roseville-N Sunrise Ave	38.75	-121.26	0.56	0.44
Chula Vista	32.63	-117.06	0.62	0.64
El Cajon - Lexington Elementary School	32.79	-116.94	0.83	0.55
San Francisco	37.77	-122.40	0.63	0.80
Stockton-Hazelton	37.95	-121.27	0.84	0.46
Redwood City	37.48	-122.20	0.70	0.53
San Jose - Knox Avenue	37.34	-121.85	1.22	0.72
Vallejo	38.10	-122.24	0.73	0.44
Sebastopol	38.40	-122.82	0.45	0.27
Simi Valley-Cochran Street	34.28	-118.68	0.49	0.33
Pico Rivera #2	34.01	-118.07	0.98	0.87
Parlier	36.60	-119.50	0.24	0.24
Clovis-Villa	36.82	-119.72	0.27	0.34
Bakersfield-Muni	35.33	-119.00	0.40	0.35
Shafter	35.50	-119.27	0.31	0.24
Madera-Pump Yard	36.87	-120.01	0.21	0.24

Sacramento-Del Paso Manor	38.61	-121.37	0.36	0.48
Folsom-Natoma St.	38.68	-121.16	0.29	0.33
El Rio-Rio Mesa School #2	34.25	-119.14	0.38	0.32
San Ramon	37.74	-121.93	0.51	0.43
Elk Grove-Bruceville	38.30	-121.42	0.51	0.32

(b)

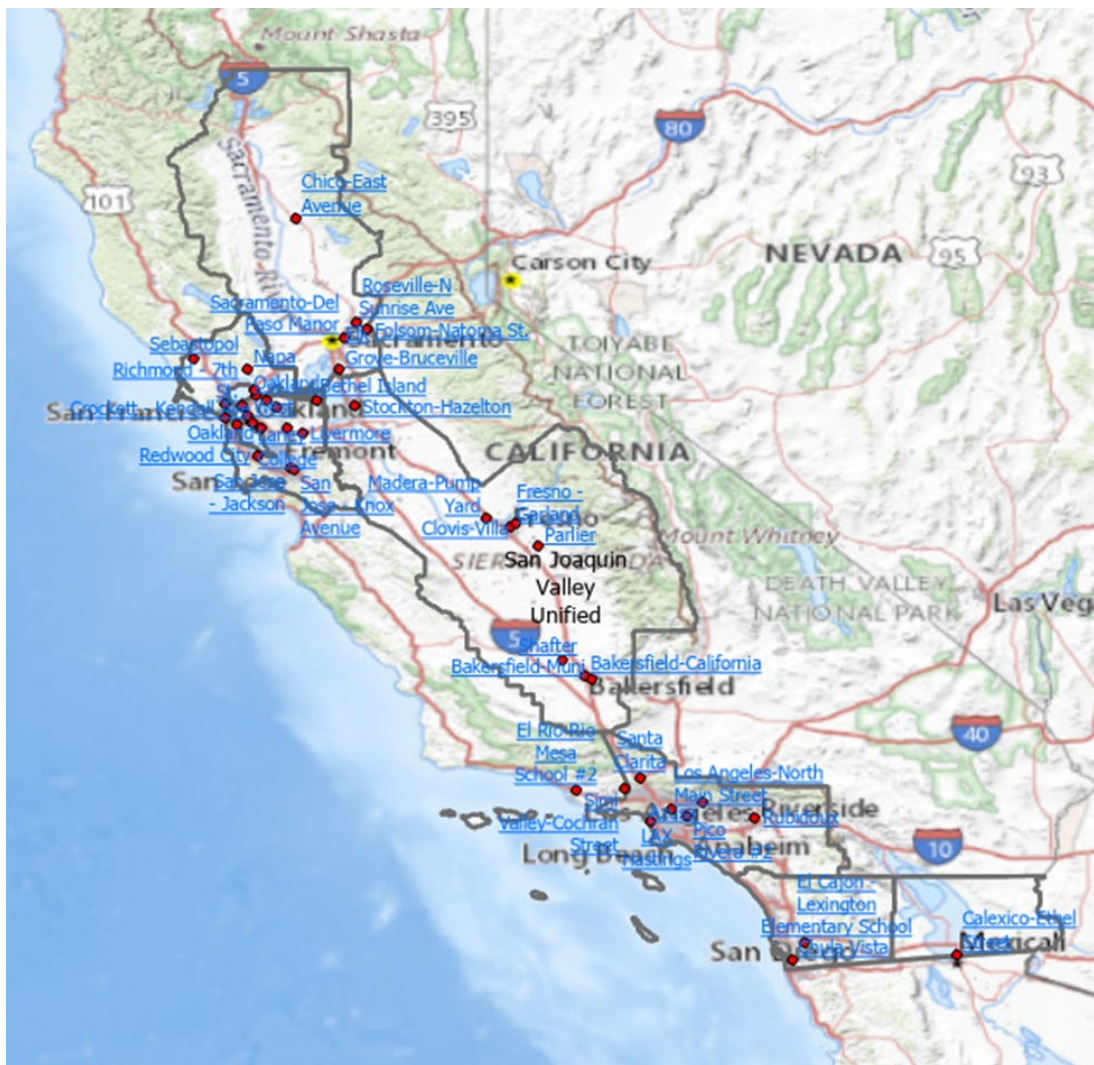


Table E-3. Comparison between modeled and monitored annual average concentrations in mg/m³ of total formaldehyde (CMAQ). (b) A map indicating monitor locations.

(a)

Monitor Location	Latitude	Longitude	Observed	Modeled
Los Angeles-North Main Street	34.07	-118.23	4.30	2.33
Rubidoux	34.00	-117.42	3.27	1.76
San Jose - Jackson	37.35	-121.89	2.87	1.69
Calexico-Ethel Street	32.68	-115.48	3.94	1.80
Bakersfield-California	35.36	-119.06	4.74	1.75
Chula Vista	32.63	-117.06	2.73	1.67
El Cajon - Lexington Elementary School	32.79	-116.94	4.01	1.77
Simi Valley-Cochran Street	34.28	-118.68	3.12	1.42
Azusa	34.14	-117.92	4.80	2.15
Stockton-Hazelton	37.95	-121.27	3.44	1.42
Fresno - Garland	36.79	-119.77	4.70	1.72
Santa Clarita	34.38	-118.53	3.53	1.54
Roseville-N Sunrise Ave	38.75	-121.26	3.98	1.80
Chico-East Avenue	39.76	-121.84	3.33	2.01
San Francisco	37.77	-122.40	1.97	1.30
Clovis-Villa	36.82	-119.72	4.97	1.58
Bakersfield-Muni	35.33	-119.00	4.85	1.71
Sacramento-Del Paso Manor	38.61	-121.37	6.90	1.76

(b)



Table E-4. Comparison between modeled and monitored annual average concentrations in mg/m^3 of total acetaldehyde. (b) A map indicating monitor locations.

(a)

Monitor Location	Latitude	Longitude	Observed	Modeled
Los Angeles-North Main Street	34.07	-118.23	2.45	1.57
Rubidoux	34.00	-117.42	2.19	1.08
San Jose - Jackson	37.35	-121.89	1.90	1.02
Calexico-Ethel Street	32.68	-115.48	1.65	0.76
Bakersfield-California	35.36	-119.06	2.49	1.14
Chula Vista	32.63	-117.06	1.15	1.05
El Cajon - Lexington Elementary School	32.79	-116.94	1.65	1.14
Simi Valley-Cochran Street	34.28	-118.68	1.31	0.71
Azusa	34.14	-117.92	2.02	1.49
Stockton-Hazelton	37.95	-121.27	1.92	0.85
Fresno - Garland	36.79	-119.77	2.56	1.09
Santa Clarita	34.38	-118.53	2.92	0.78
Roseville-N Sunrise Ave	38.75	-121.26	1.52	1.17
Chico-East Avenue	39.76	-121.84	1.48	1.16
San Francisco	37.77	-122.40	1.15	0.70
Clovis-Villa	36.82	-119.72	3.15	0.97
Bakersfield-Muni	35.33	-119.00	6.78	1.23
Sacramento-Del Paso Manor	38.61	-121.37	2.63	1.21

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Table E-5. This table presents a statistical evaluation of CMAQ's performance at modeling the four major toxic VOCs, using the RMSE, BIAS, and the Index of Agreement as metrics.

	RMSE	BIAS	Index of Agreement
1, 3-Butadiene	0.04	~0	0.62
Benzene	0.26	-0.14	0.71
Formaldehyde	2.45	-2.23	0.40
Acetaldehyde	1.70	-1.20	0.41

Below are the equations used to calculate root-mean-square error (RMSE), absolute bias (bias), correlation coefficient (CC), and the Index of Agreement, used to evaluate the performance of the model.

$$RMSE = \sqrt{\frac{\sum_{i=1}^N ||x(i)-y(i)||^2}{N}} \quad (1)$$

$$BIAS = \frac{1}{N} \sum_{i=1}^N x(i) - y(i) \quad (2)$$

$$CC = \frac{\sum_{i=1}^N (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^N (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^N (y_i - \bar{y})^2}} \quad (3)$$

where N is the number of data points, $x(i)$ is the i -th measurement, and $y(i)$ is its corresponding modeled value, $\bar{x}$ is the mean of the values of x , and $\bar{y}$ is the mean of the values of y .

$$IA = 1 - \left[\frac{\sum_{i=1}^N (|x_i - y_i|)}{\sum_{i=1}^N (|x_i - \bar{x}|)} \right] \quad (4)$$

where N is the number of data points, $x(i)$ is the i -th measurement, $y(i)$ is its corresponding modeled value, and $\bar{x}$ is the mean of the values of x . IA ranges from 0 to 1, with 1 indicating perfect agreement between the observed and modeled values, while values closer to 0 indicate poorer agreement.