Appendix

This section includes additional statistical analyses comparing Aclima's mobile monitoring data with nearby regulatory sites. These comparisons may be limited due to the relatively short 2 week time period of this pilot data collection. For a more comprehensive analysis of Aclima's mobile data compared to regulatory sites as well as a detailed description of the entirety of Aclima's QA system, please refer to Section 5.1 in the "Hyperlocal Ambient Concentration Estimate Validation and Quality Assurance System" document. Additionally, typical performance metrics for all of Aclima's sensors can be found in Table 5 of the "Mobile Ambient Air Pollution Measurement Quality Assurance System" document.

A.1 Mobile-stationary validation: Device Level Comparison

This analysis allows for a device level comparison of the mobile sensors to regulatory measurements and is primarily intended to determine whether any systematic bias is present between the mobile measurements and the existing regulatory network. This mobile to stationary comparison is different from traditional collocations as defined by the EPA (which requires measurements within 10 m horizontally and 3 meters vertically according to 40 CFR 58), and, therefore, the comparison metrics should not be interpreted directly as performance metrics of Aclima's mobile sensors. There are a number of factors that can influence these comparisons, including some factors that cannot be controlled and can vary from site to site and over time such as hyperlocal variability in concentrations around the sites and the range of concentrations observed over the full collection time period (in this case limited to 2 weeks). These factors typically impact precision based metrics such as RMSE, MAE, and R2; however, we have found that with a suitable number of comparison data points collected over enough distinct hourly time periods, these mobile to stationary comparisons can often be a good indicator of the presence of systematic bias or drift over time (estimated as mean bias error or MBE) in measurement between Aclima's mobile measurements and the local regulatory measurements.

This data set was compiled using all 1 Hz data points collected within a 250 m radius of any regulatory site and aggregating to an hourly time scale to align with the hourly measurements of each regulatory site. There is no minimum completion threshold applied to the mobile data, so there are a variable number of data points aggregated for the comparison, and in many cases as little as a few minutes may be used as a comparison point to an hourly average. The sites that were not within the three mapping neighborhoods were targeted for drive-by collocations while driving from one neighborhood to another. From these hourly measurement pairs, a series of comparison metrics and figures are generated to give the hourly results. Additionally, the hourly measurement pairs are aggregated to daily time scales, from which a second set of daily metrics and figures are generated. Tables A.1-3 below show the comparison

metrics for all regulatory sites and Aclima's mobile dataset within a 250m radius, combined by pollutant.

General Findings

- The R2 for NO_2 is quite low, related to 2 factors : 1) some apparent sensor drift in the mobile measurement is observed during the last 3 days of the pilot; 2) the range of hourly values observed during the 2 week period at the stationary sites is relatively small (5-10 ppb) compared to the sensor precision uncertainty (approximately 5 ppb, typically). There does not appear to be a strong overall systematic bias in the aggregated NO_2 data (MBE of +2.4 ppb). The MBE is lower at the Near Road site than the neighborhood and urban scale sites. Spatial variability in the segment medians should be relatively unimpacted by sensor drift due to consistent sampling in all 3 neighborhoods on each day of the 2 week pilot.
- There is a small systematic bias in the CO and BC measurements compared to the stationary monitors, which is consistent with what we typically see in comparing Aclima's mobile data to stationary and likely due to mobile sources impacting on-road measurements more directly than the stationary monitors for these pollutants (PM, NO_2, and O_3 tend to be more evenly spatially distributed)
- The bias between mobile and stationary O_3 measurements is noticeably higher for the River Terrace site than for the other two sites (McMillian and Aurora Hills), suggesting a possible instrument bias in the FEM monitor at that site or suggesting that the measurement there is not representative of the immediately surrounding surface roads.

Table A1. Hourly comparison metrics across all sites for each pollutant.

Pollutant	MBE	MAE	R^2	precision
$PM_{2.5}$	-0.3 µg/m3	2.4 µg/m3	0.90	2.4 µg/m3
NO_2	+2.4 ppb	6.8 ppb	0.04	7.0 ppb
O_3	+1.7 ppb	5.6 ppb	0.78	6.4 ppb
CO	+0.2 ppm	0.2 ppm	0.33	0.1 ppm
BC (1 site only)	+0.7 µg/m3	0.7 µg/m3	0.40	0.5 µg/m3

Table A2. Hourly comparison metrics for individual sites for each pollutant.

Pollutant	Regulatory site	MBE	MAE	R^2	Precision
$PM_{2.5}$	["DCNearRoad", "Washington-Arlington-Alexandria"]	+0.1 µg/m3	3.5 µg/m3	0.78	3.4 µg/m3

$PM_{2.5}$	["King Greenleaf Rec C", "Washington-Arlington-Alexandria"]	-0.5 µg/m3	2.8 µg/m3	0.87	2.7 µg/m3
$PM_{2.5}$	["RIVER_Terrace", "Washington-Arlington-Alexandria"]	+0.0 µg/m3	2.8 µg/m3	0.86	2.7 µg/m3
$PM_{2.5}$	["McMillan Reservoir", "Washington-Arlington-Alexandria"]	+0.6 µg/m3	2.7 µg/m3	0.84	2.7 µg/m3
O_3	["RIVER_Terrace", "Washington-Arlington-Alexandria"]	+8.5 ppb	9.5 ppb	0.74	6.9 ppb
O_3	["McMillan Reservoir", "Washington-Arlington-Alexandria"]	-2.3 ppb	6.7 ppb	0.77	6.4 ppb
O_3	["AURORA HILLS", "Washington-Arlington-Alexandria"]	-1.0 ppb	6.7 ppb	0.78	6.6 ppb
NO_2	["DCNearRoad", "Washington-Arlington-Alexandria"]	-0.2 ppb	8.3 ppb	0.04	8.1 ppb
NO_2	["McMillan Reservoir", "Washington-Arlington-Alexandria"]	+6.7 ppb	8.3 ppb	0.03	6.9 ppb
NO_2	["AURORA HILLS", "Washington-Arlington-Alexandria"]	+5.8 ppb	8.0 ppb	0.02	6.6 ppb
CO	["DCNearRoad", "Washington-Arlington-Alexandria"]	+0.2 ppm	0.2 ppm	0.15	0.1 ppm
CO	["AURORA HILLS", "Washington-Arlington-Alexandria"]	+0.3 ppm	0.3 ppm	0.36	0.1 ppm
BC	["McMillan Reservoir", "Washington-Arlington-Alexandria"]	+0.7 µg/m3	0.7 µg/m3	0.40	0.5 µg/m3

Table A3. Daily aggregated comparison metrics across all sites, for each pollutant

Daily	MBE	MAE	R^2	precision
$PM_{2.5}$	-0.4 µg/m3	1.5 µg/m3	0.97	1.8 µg/m3
NO_2	+2.1 ppb	4.1 ppb	0.01	4.9 ppb
O_3	+2.2 ppb	4.4 ppb	0.84	5.6 ppb
CO	+0.2 ppm	0.2 ppm	0.71	0.1 ppm
BC (1 site only)	+0.7 µg/m3	0.7 µg/m3	0.76	0.2 µg/m3

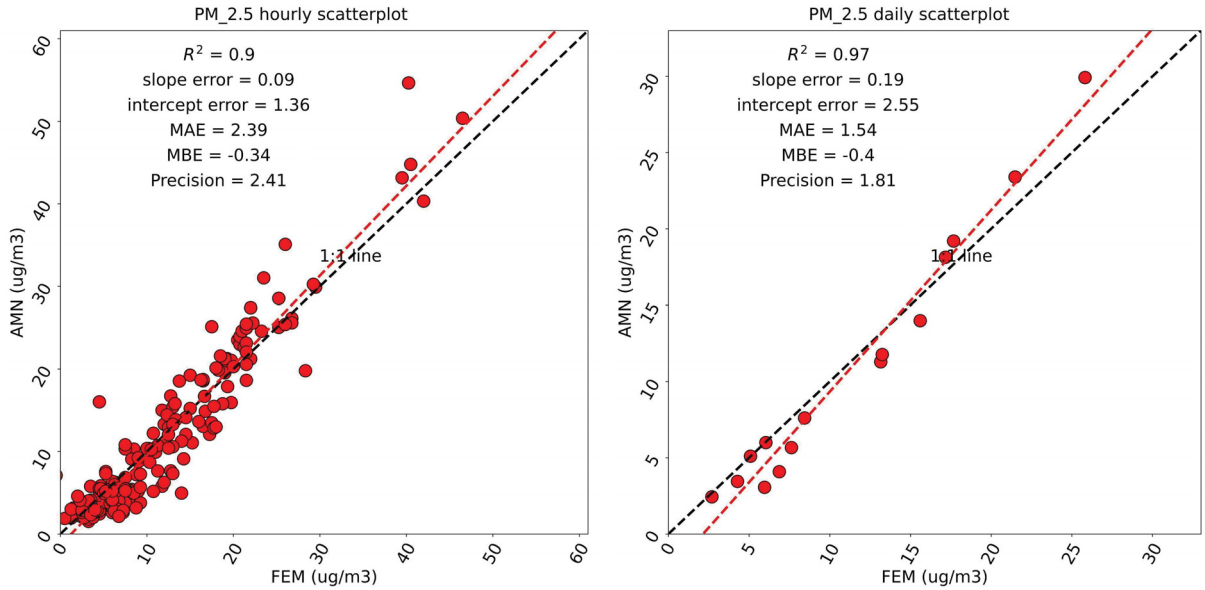

Figure A1: Comparison of hourly (left) and daily (right) mean Aclima mobile sensor measurements within a 250 m radius circle centered at all available stationary regulatory sites to the corresponding collocated data at those regulatory sites for $PM_{2.5}$ [µg/m3], including comparison metrics (including R2, slope error, intercept error, MAE, MBE, and precision) that represent Aclima AMN 1-hr or 24-hr device-level performance.

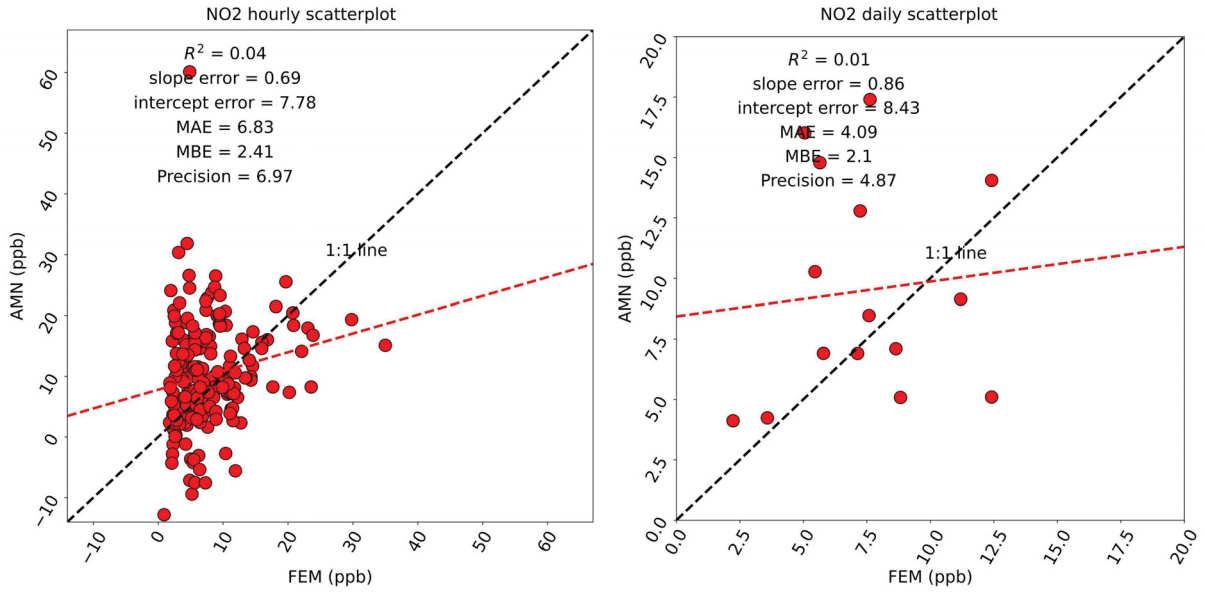

Figure A2: Comparison of hourly (left) and daily (right) mean Aclima mobile sensor measurements within a 250 m radius circle centered at all available stationary regulatory sites to the corresponding collocated data at those regulatory sites for NO_2 [ppb], including comparison metrics (including R2, slope error, intercept error, MAE, MBE, and precision) that represent Aclima AMN 1-hr or 24-hr device-level performance.

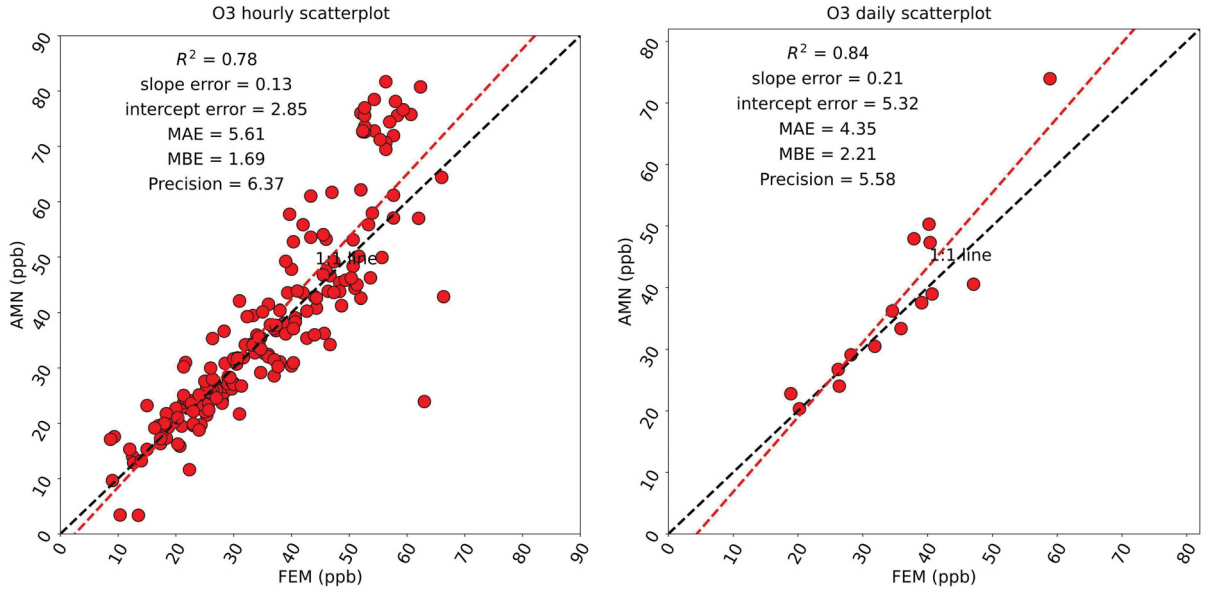

Figure A3: Comparison of hourly (left) and daily (right) mean Aclima mobile sensor measurements within a 250 m radius circle centered at all available stationary regulatory sites to the corresponding collocated data at those regulatory sites for O_3 [ppb], including comparison metrics (including R2, slope error, intercept error, MAE, MBE, and precision) that represent Aclima AMN 1-hr or 24-hr device-level performance.

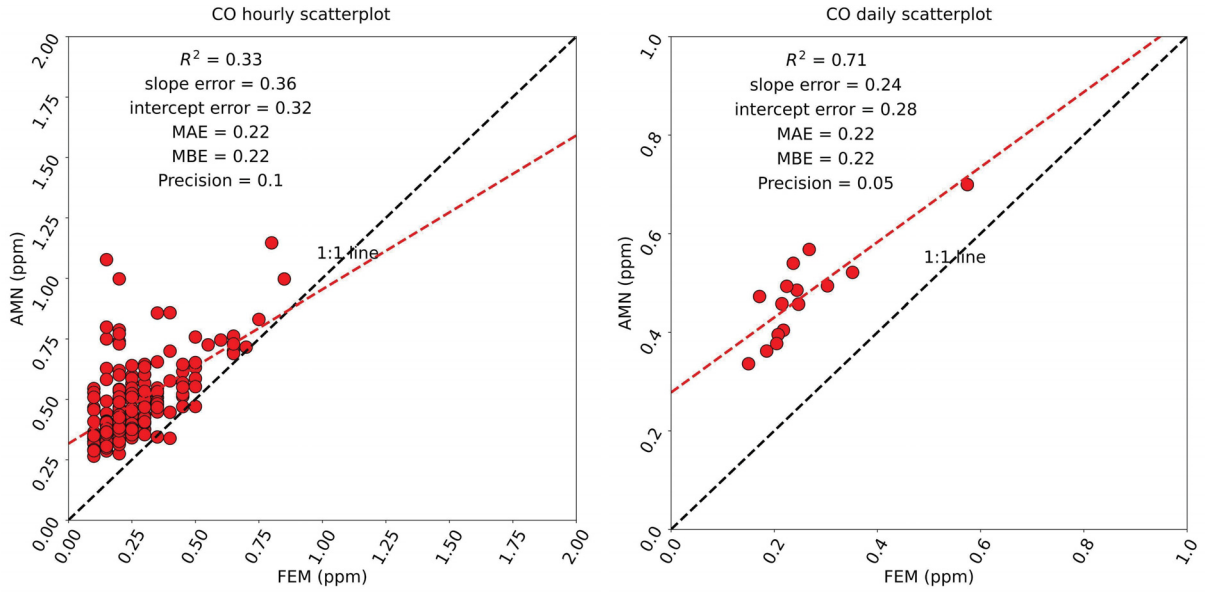

Figure A4: Comparison of hourly (left) and daily (right) mean Aclima mobile sensor measurements within a 250 m radius circle centered at all available stationary regulatory sites to the corresponding collocated data at those regulatory sites for CO [ppm], including comparison metrics (including R2, slope error, intercept error, MAE, MBE, and precision) that represent Aclima AMN 1-hr or 24-hr device-level performance.

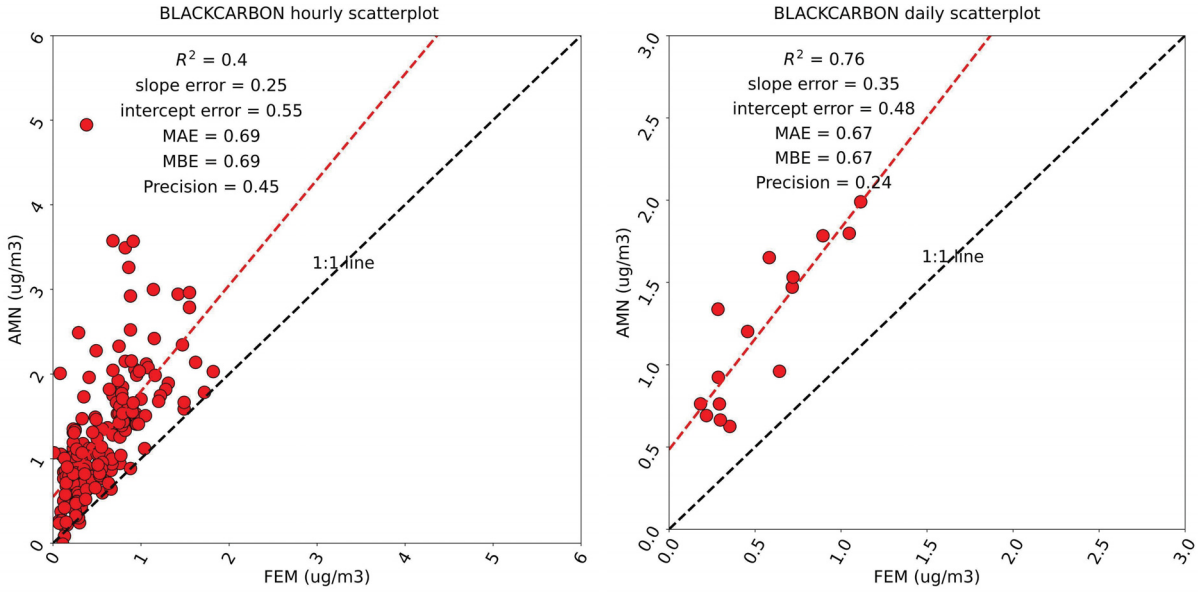

Figure A5: Comparison of hourly (left) and daily (right) mean Aclima mobile sensor measurements within a 250 m radius circle centered at all available stationary regulatory sites to the corresponding collocated data at those regulatory sites for Black Carbon [µg/m3], including comparison metrics (including R2, slope error, intercept error, MAE, MBE, and precision) that represent Aclima AMN 1-hr or 24-hr device-level performance.

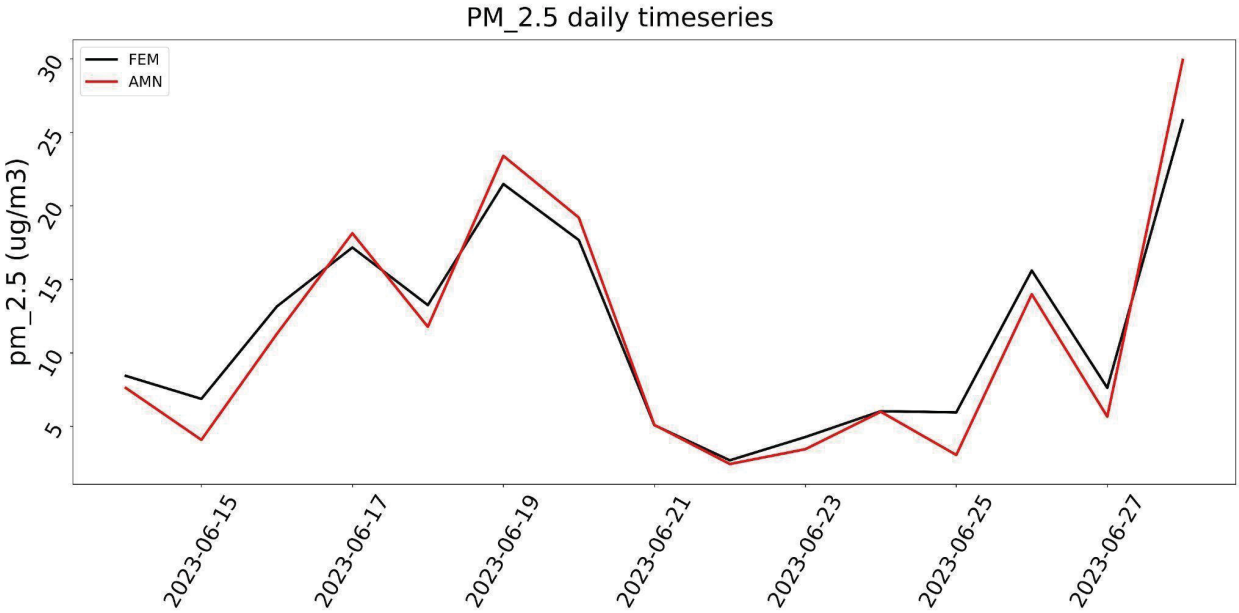

Figure A6: Daily time series showing the comparisons between daily mean Aclima mobile sensor measurements within a 250 m radius circle centered at all available stationary regulatory sites to the corresponding collocated data at those regulatory sites for $PM_{2.5}$ [µg/m3].

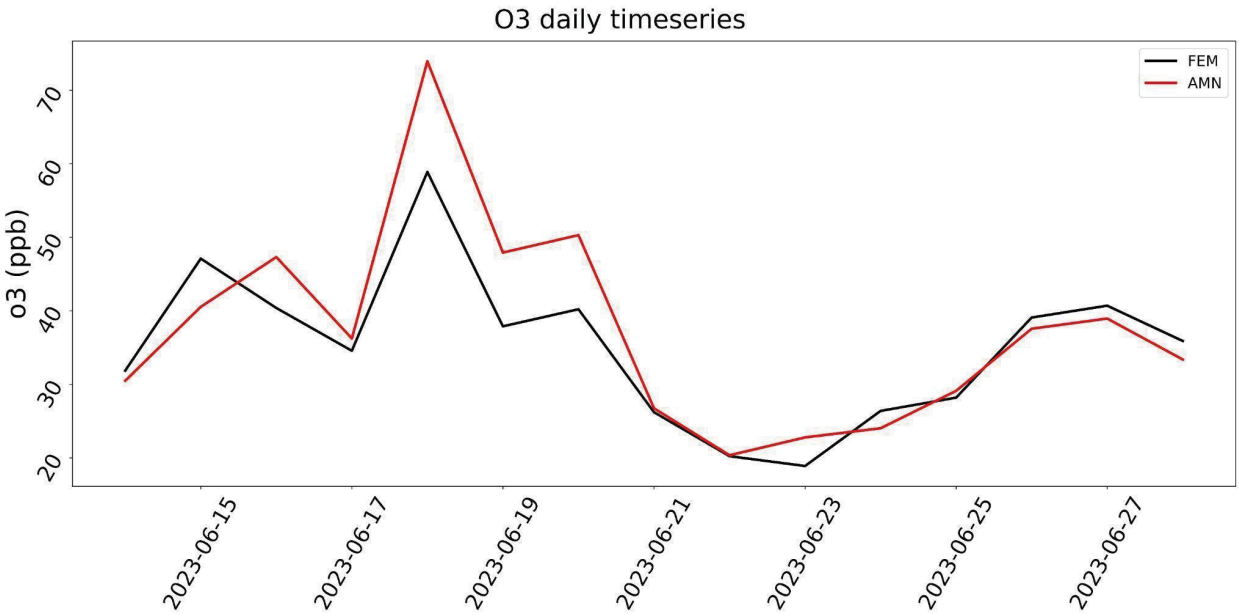

Figure A7: Daily time series showing the comparisons between daily mean Aclima mobile sensor measurements within a 250 m radius circle centered at all available stationary regulatory sites to the corresponding collocated data at those regulatory sites for O3 [ppb].

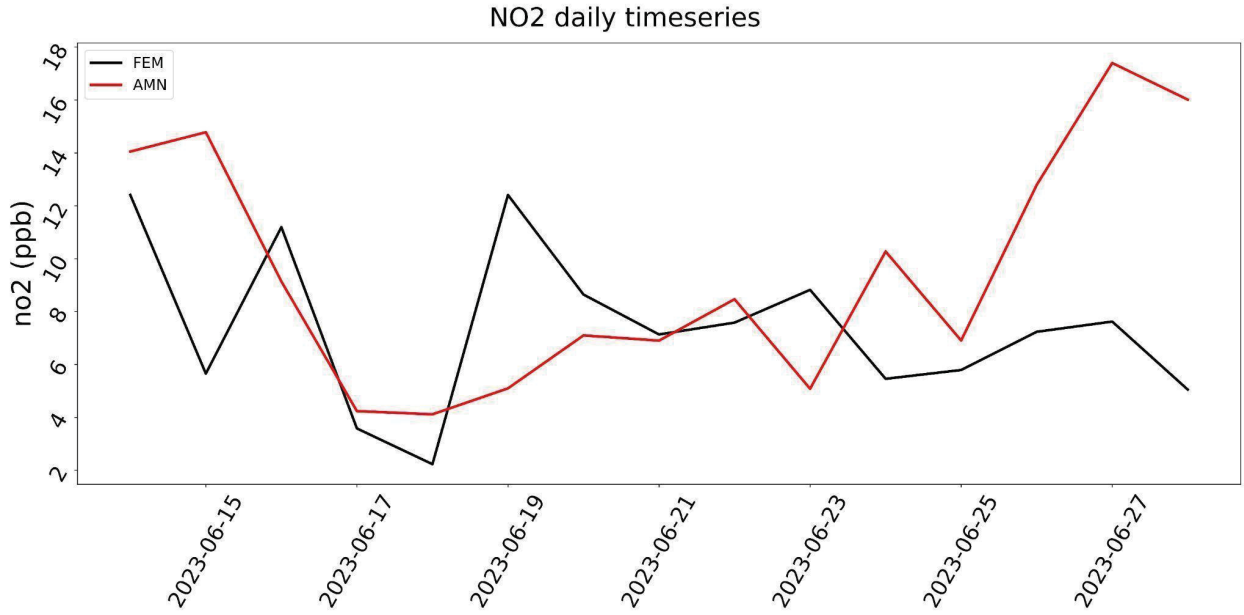

Figure A8: Daily time series showing the comparisons between daily mean Aclima mobile sensor measurements within a 250 m radius circle centered at all available stationary regulatory sites to the corresponding collocated data at those regulatory sites for NO_2 [ppb]. Note that the NO_2 sensor started developing drift during the latter part of the 2 week campaign.

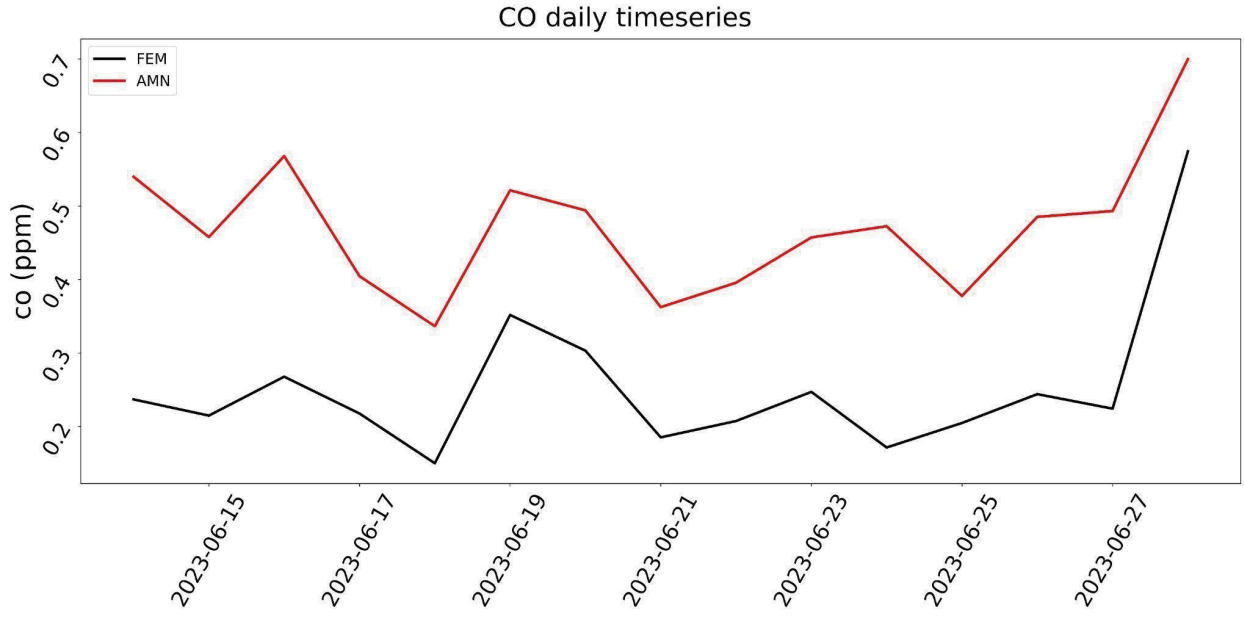

Figure A9: Daily time series showing the comparisons between daily mean Aclima mobile sensor measurements within a 250 m radius circle centered at all available stationary regulatory sites to the corresponding collocated data at those regulatory sites for CO [ppm].

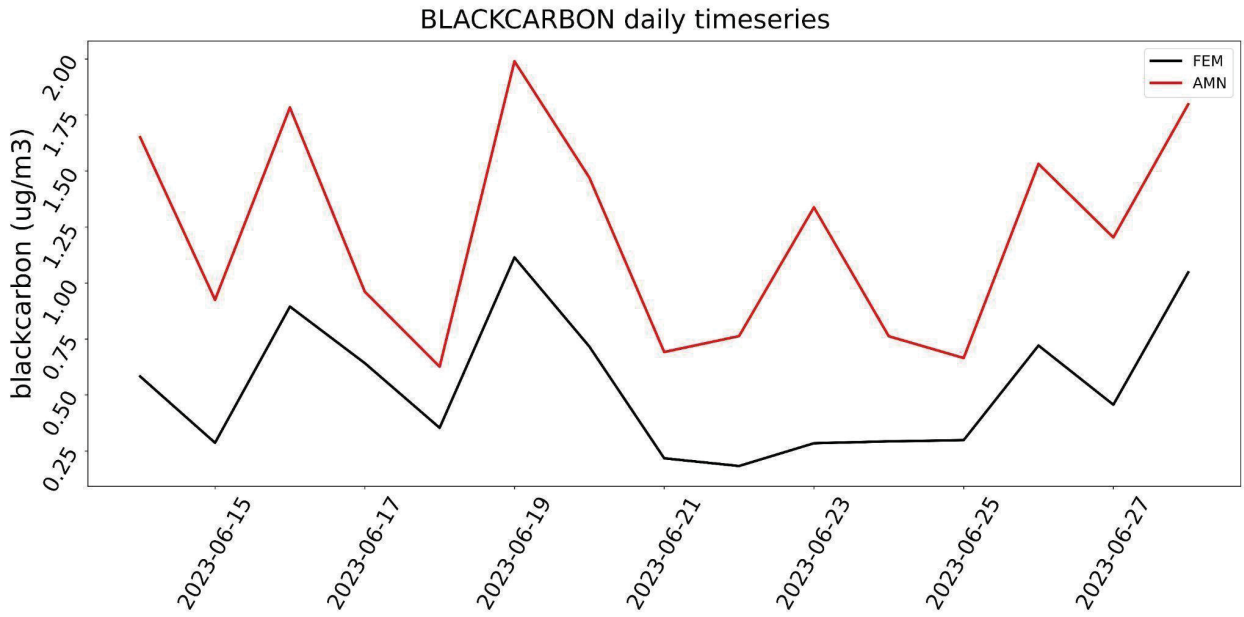

Figure A10: Daily time series showing the comparisons between daily mean Aclima mobile sensor measurements within a 250 m radius circle centered at all available stationary regulatory sites to the corresponding collocated data at those regulatory sites for Black Carbon [µg/m3].

A.2 Mobile-stationary validation: Platform Level Comparison

The analysis in this section differs from the device level comparison described in Section A.1, as it provides a comparison between the final segment median values over the two week time period to the median value of a nearby (within 250 m) regulatory monitor. This comparison can be impacted by device level uncertainty, but is also impacted by the sampling method, and therefore, can characterize any bias that results from the specific times that segments were sampled over the two week time period. Table A4 shows the 2-week segment median values for segments within 250 m of the regulatory sites within the contract area. The device level MBE and Precision (from Section A.1) is included in the table for context. Differences between the segment medians and the regulatory medians can arise due to device level systematic sensor bias (as evaluated in Section A1) as well as due to sampling bias (i.e. if there is unbalanced sampling over the 2 week period).

General Findings

- There appears to be a slight sampling bias for the $PM_{2.5}$ segment medians compared to the stationary monitor on the order of 1-2 ug/m3 (approx. 10-20%). The wildfire impact during the 2-week period is likely a contributing factor, with high temporal variability in $PM_{2.5}$ experienced during the time period.

- The difference between the segment medians for O_3 and the stationary median at River Terrace is explained by the device level bias that was described in Section A1 that appears to be specific to this site.
- CO and BC are biased high compared to stationary, consistent with the results of the device level analysis

Table A4. A comparison between the final segment median values over the two week time period to the median value of a nearby (within 250 m) regulatory monitor within the contract area. The device level MBE and Precision (from Table A1) are included in the table for context.

Pollutant	Regulatory site	Avg. Segment median (+/- std dev) (within 250 m)	Regulatory median (over 2 weeks)	MBE (Device Level)	Precision (Device Level)
$PM_{2.5}$	["DCNearRoad", "Washington-Arlington-Alexandria"]	8.7 ± 3.2 µg/m3	10.0 µg/m3	+0.1 µg/m3	3.4 µg/m3
$PM_{2.5}$	["King Greenleaf Rec C", "Washington-Arlington-Alexandria"]	7.8 ± 2.0 µg/m3	10.0 µg/m3	-0.5 µg/m3	2.7 µg/m3
$PM_{2.5}$	["RIVER_Terrace", "Washington-Arlington-Alexandria"]	6.7 ± 2.3 µg/m3	9.0 µg/m3	+0.0 µg/m3	2.7 µg/m3
O_3	["RIVER_Terrace", "Washington-Arlington-Alexandria"]	35.3 ± 3.9 ppb	27.0 ppb	+8.5 ppb	6.9 ppb
NO_2	["DCNearRoad", "Washington-Arlington-Alexandria"]	12.8 ± 6.9 ppb	11.1 ppb	-0.2 ppb	8.1 ppb
CO	["DCNearRoad", "Washington-Arlington-Alexandria"]	0.5 ± 0.2 ppm	0.3 ppm	+0.2 ppm	0.1 ppm

A.3 H3 Hex binning for determining unique days of observations

The following figure is an example of the use of H3 hex binning for determining the number of unique days of TVOC observations in an area for the TVOC analysis. The three colors indicate three TVOC classes (red = combustion, blue = evaporation, green = mixed).

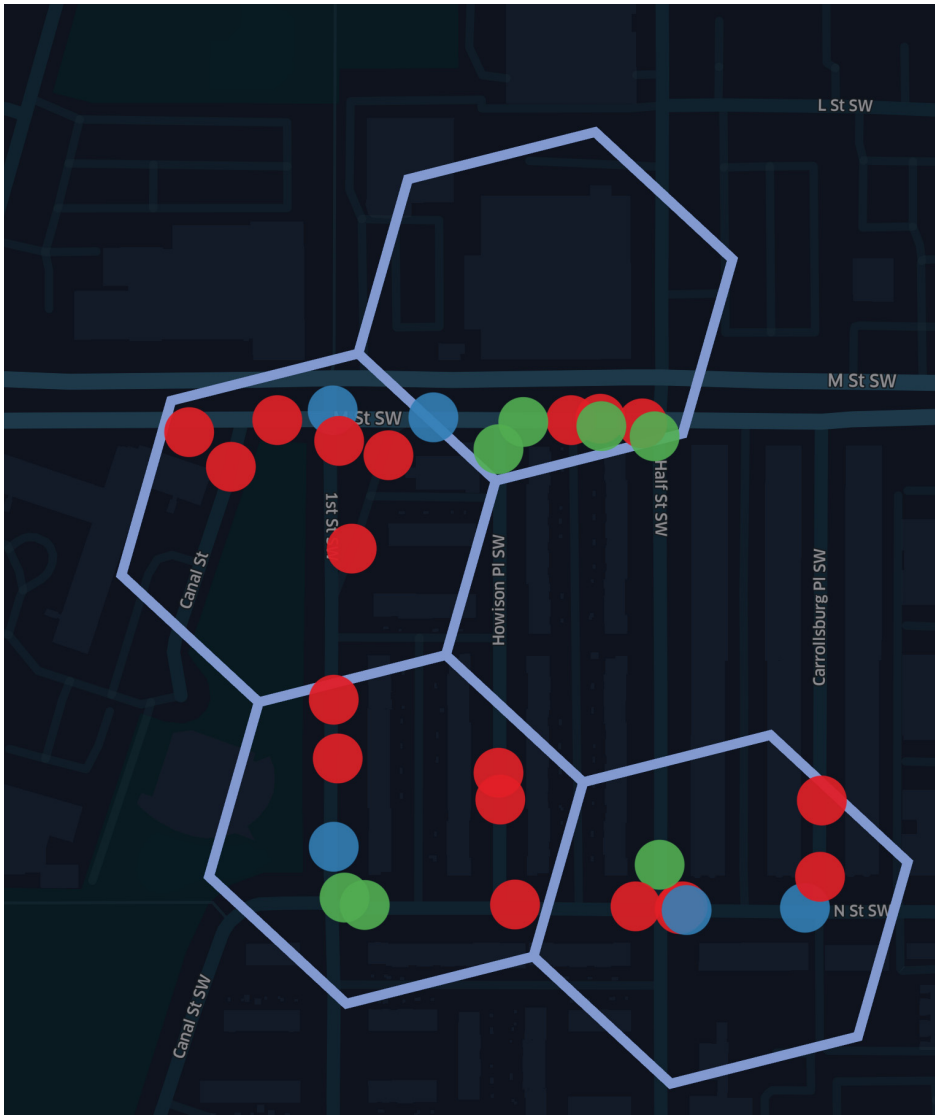

Figure A11. Example of the use of H3 hex binning for determining the number of unique days of TVOC observations. The three colors indicate three TVOC classes (red = combustion, blue = evaporation, green = mixed).

A.3 Additional pollutant maps

Segment median maps for each of the three neighborhoods.

A.3.1 Brentwood/Ivy City

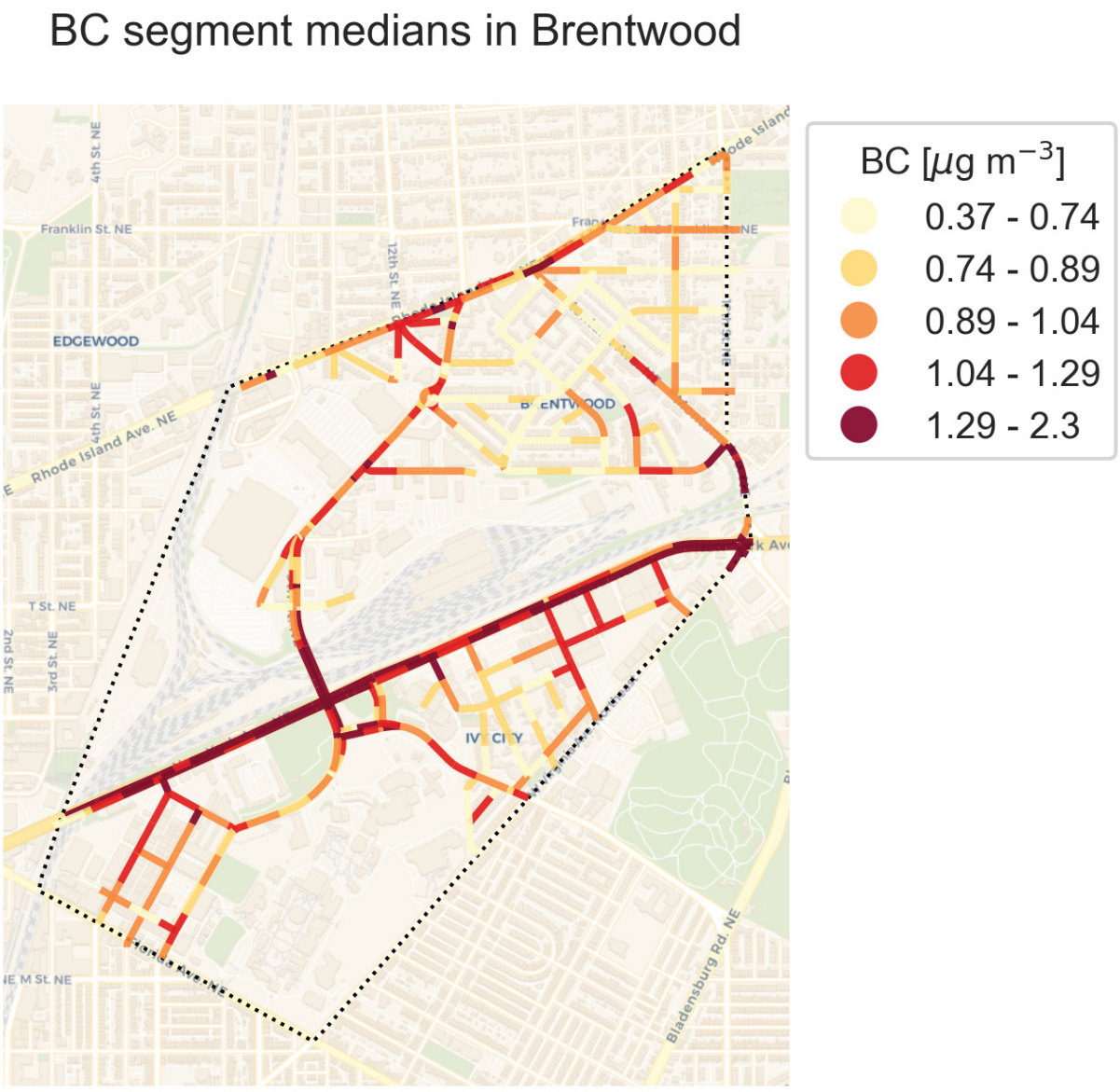

Figure A12. Black Carbon segment medians for Brentwood/Ivy City.

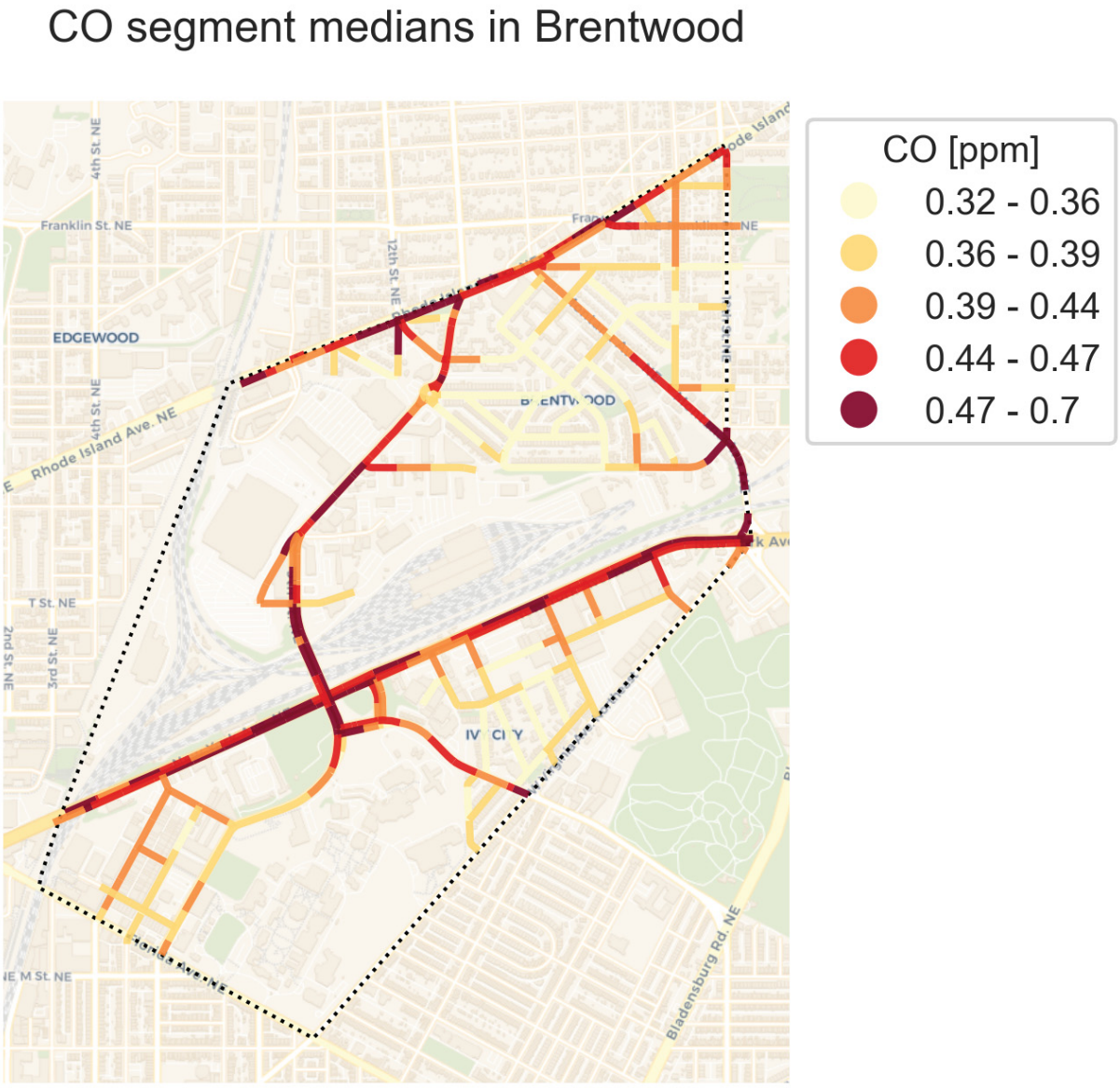

Figure A13. CO segment medians for Brentwood/Ivy City.

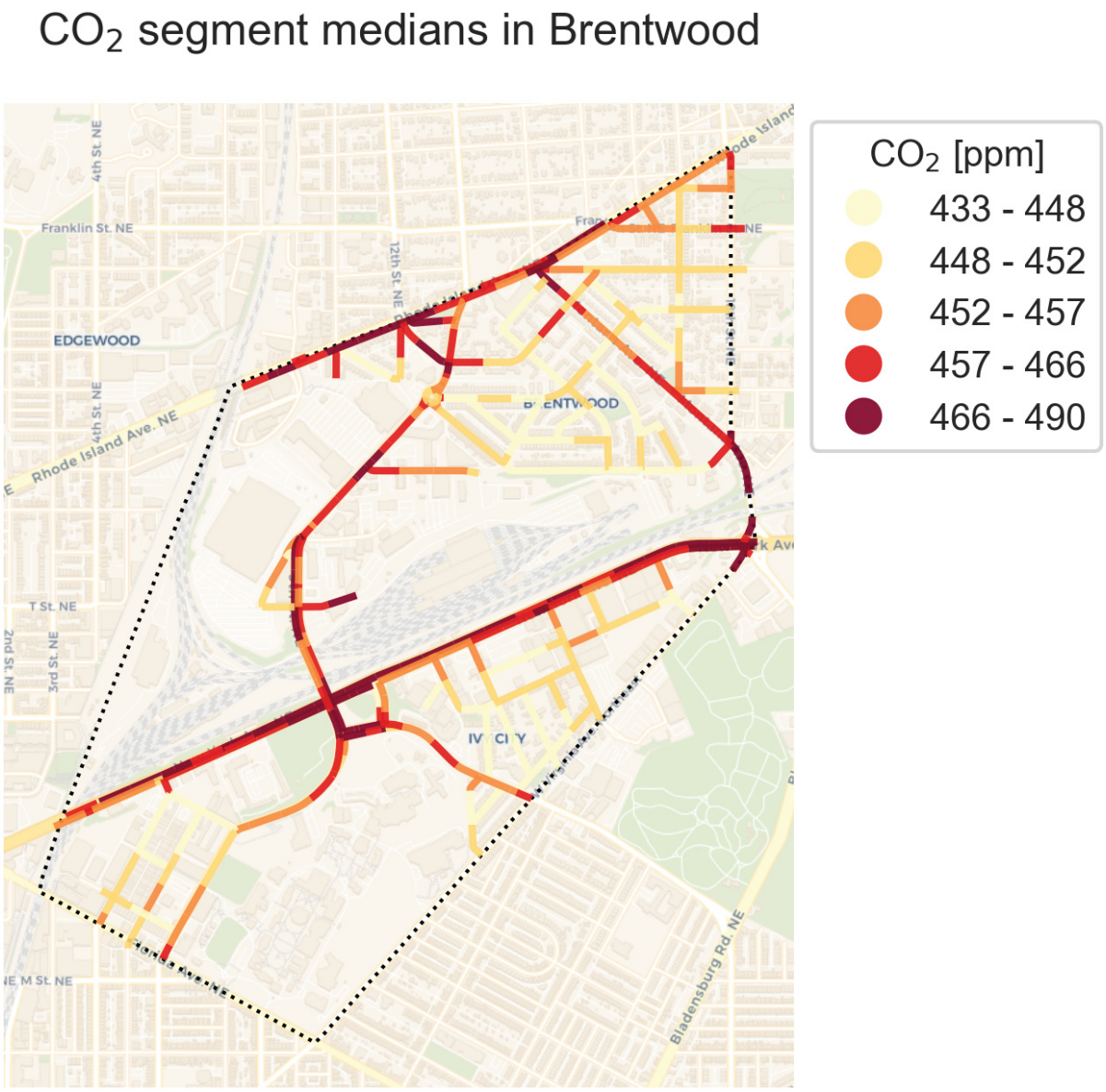

Figure A14. CO_2 segment medians for Brentwood/Ivy City.

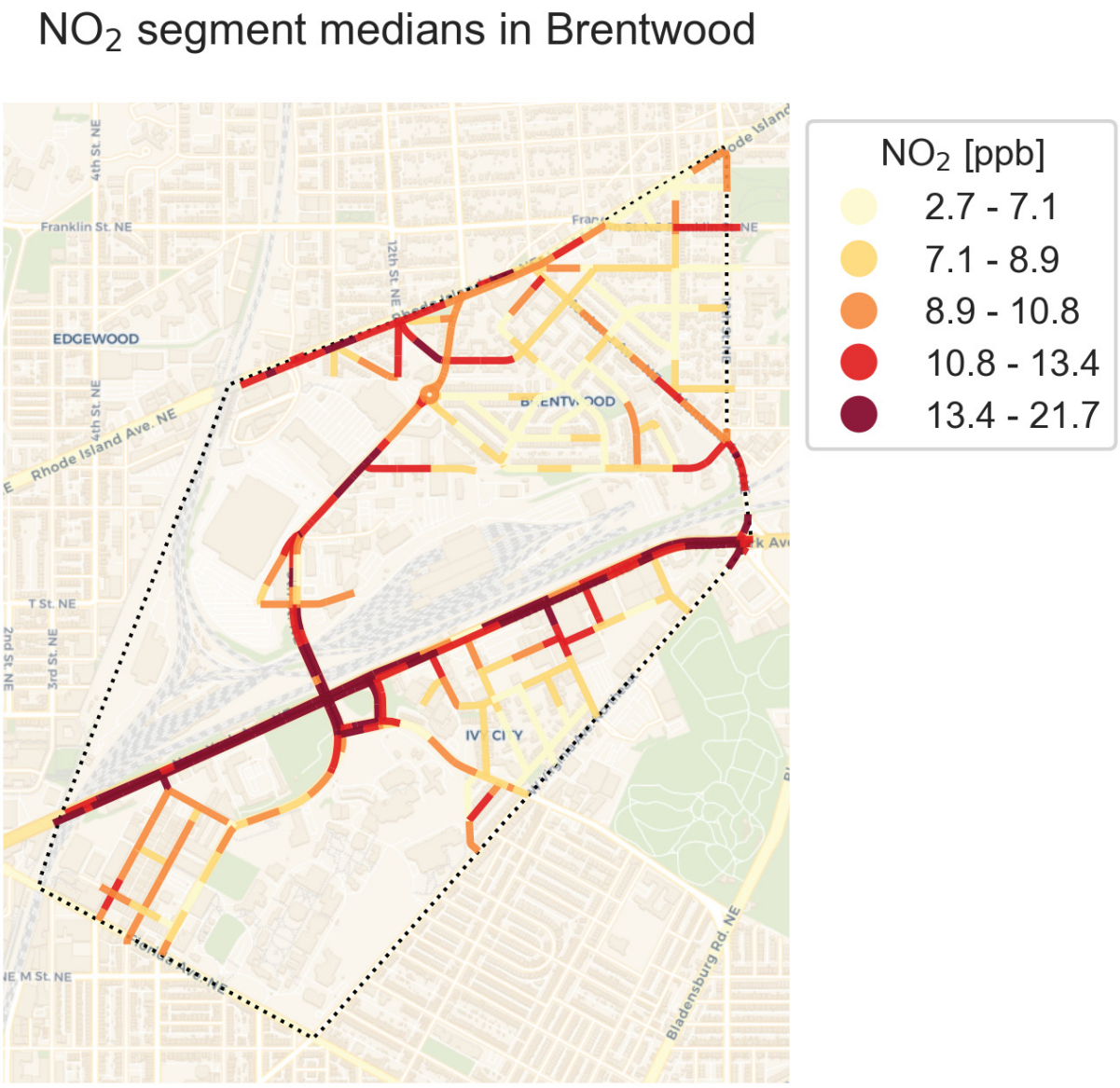

Figure A15. NO_2 segment medians for Brentwood/Ivy City.

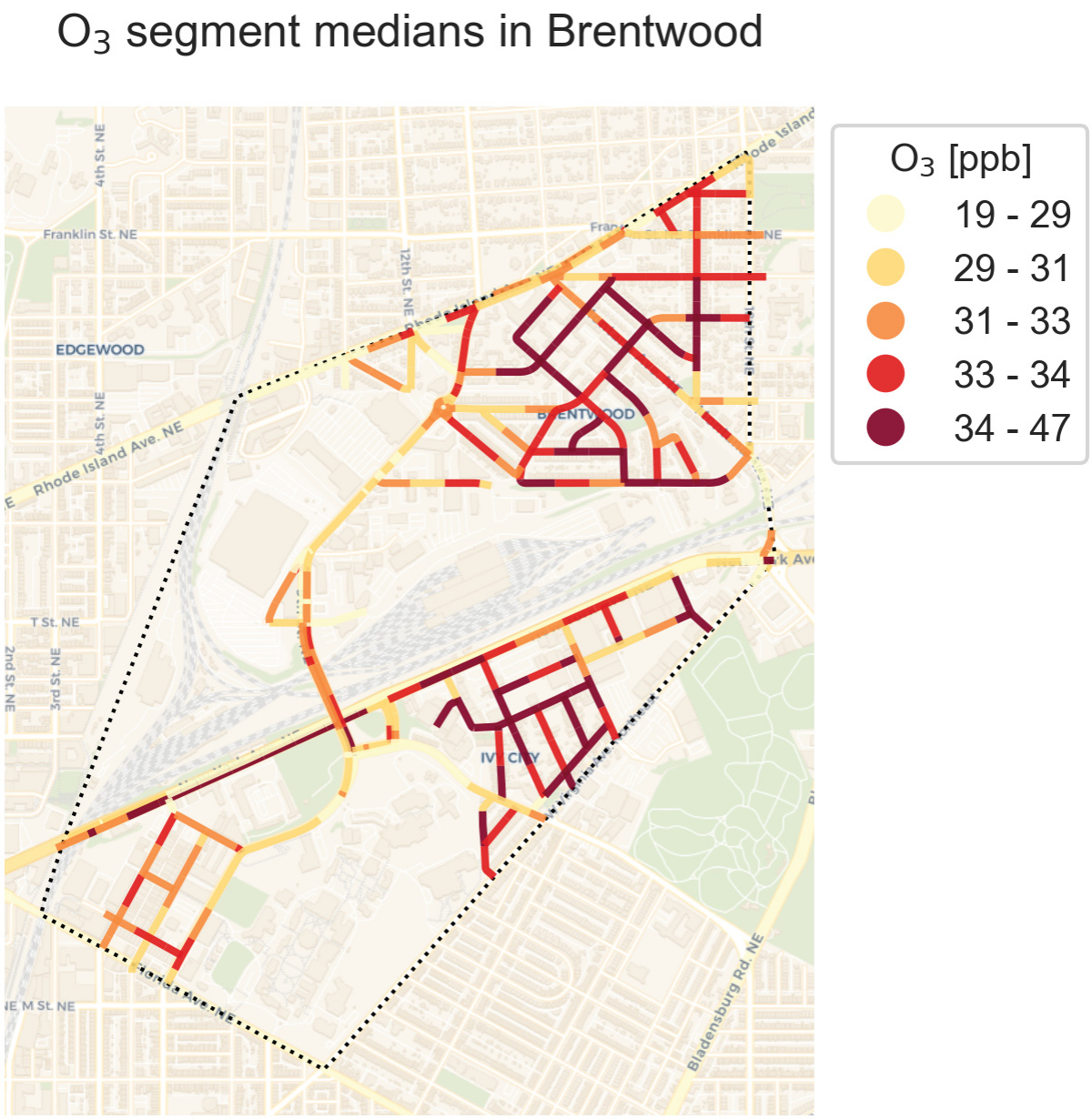

Figure A16. O_3 segment medians for Brentwood/Ivy City.

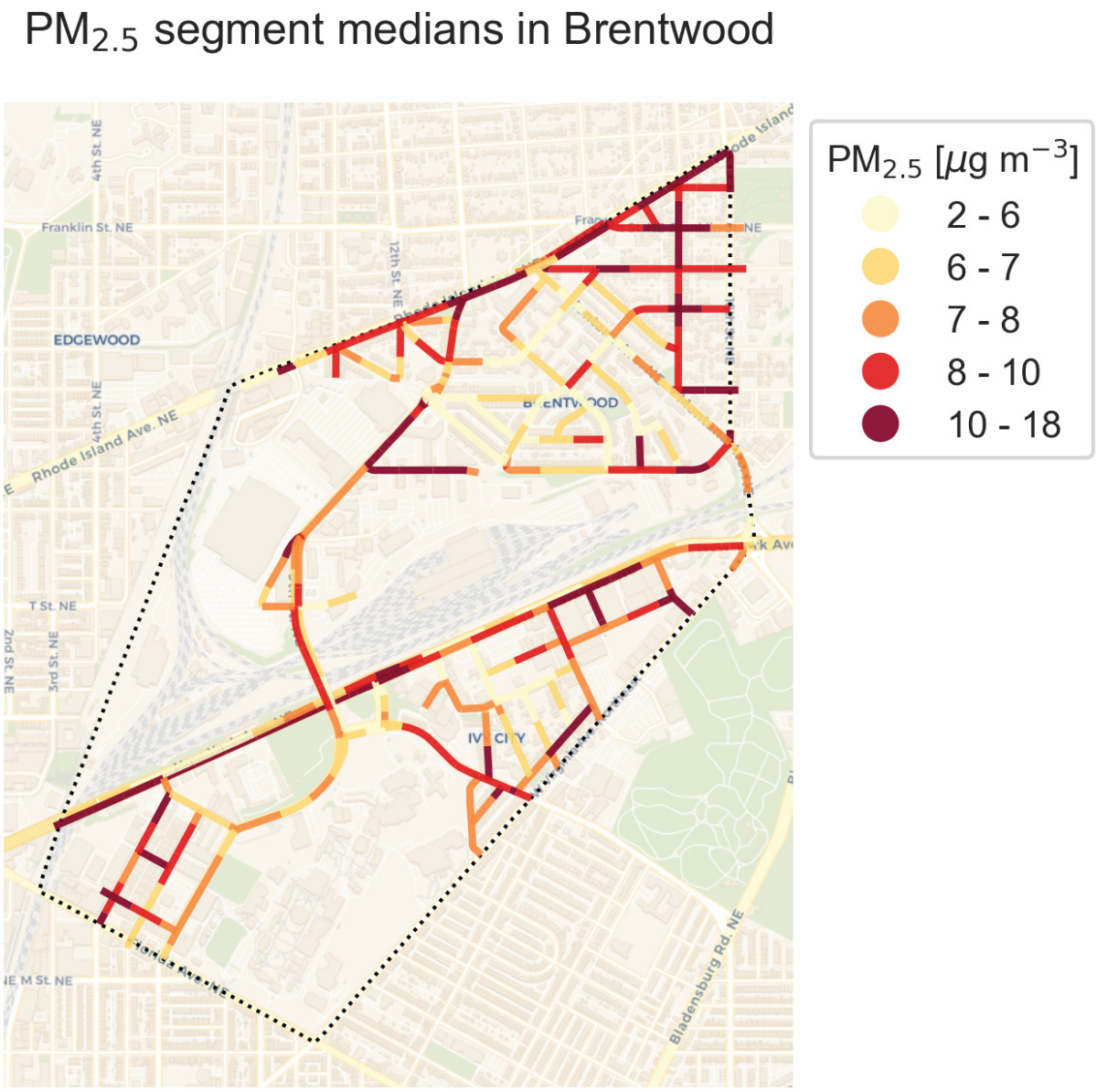

Figure A17. $PM_{2.5}$ segment medians for Brentwood/Ivy City.

A.3.2 Buzzard Point

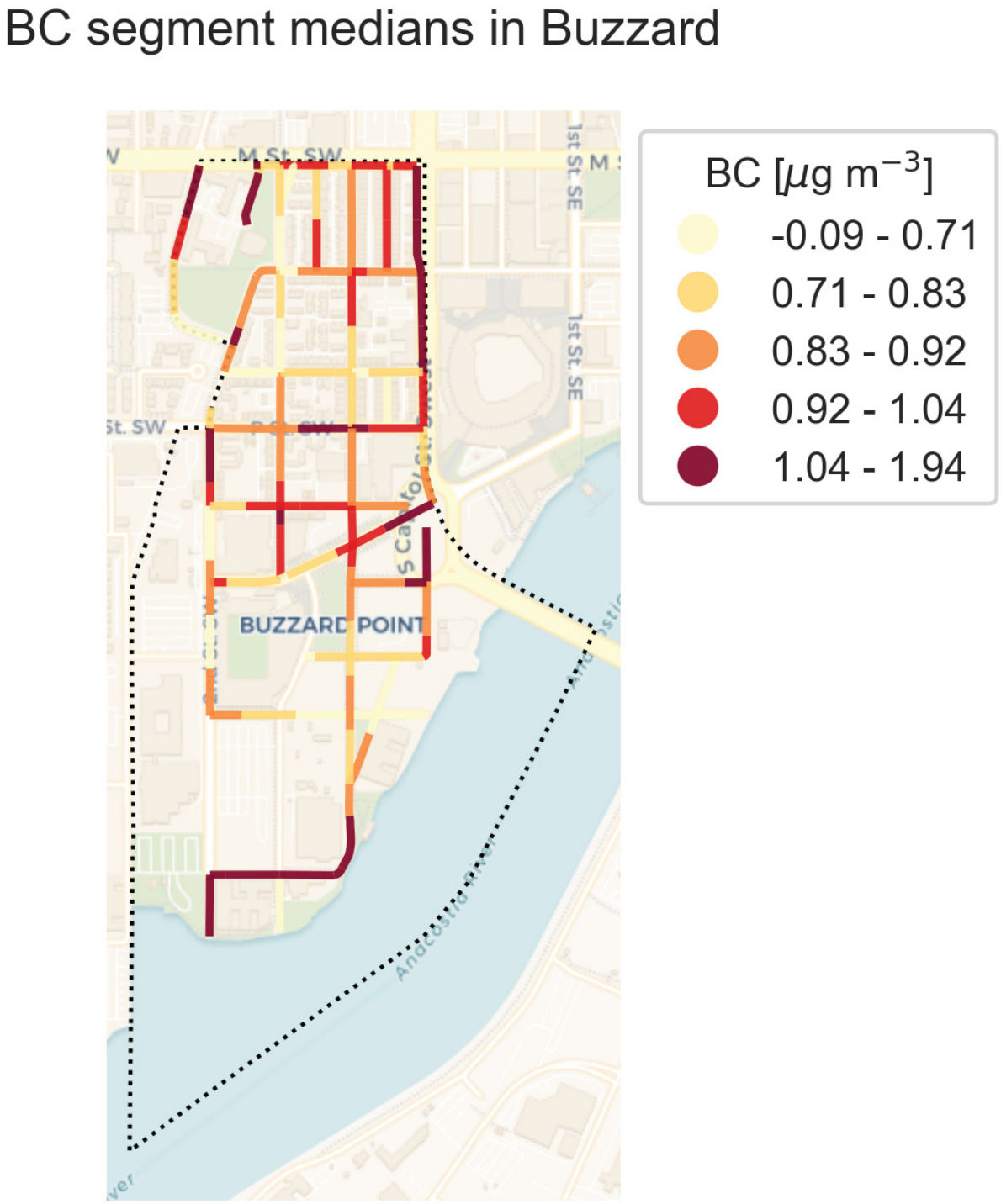

Figure A18. Black Carbon segment medians for Buzzard Point.

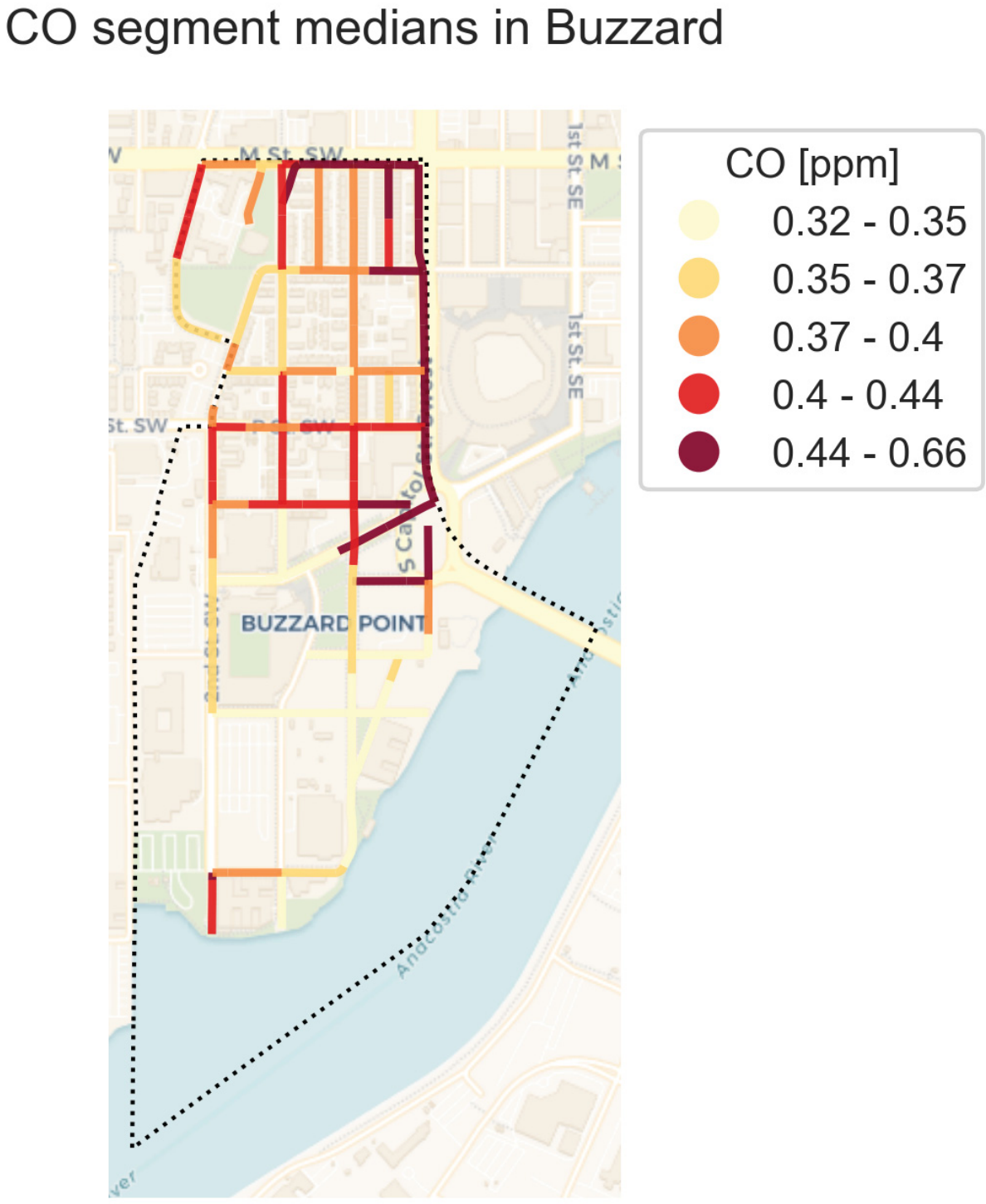

Figure A19. CO segment medians for Buzzard Point.

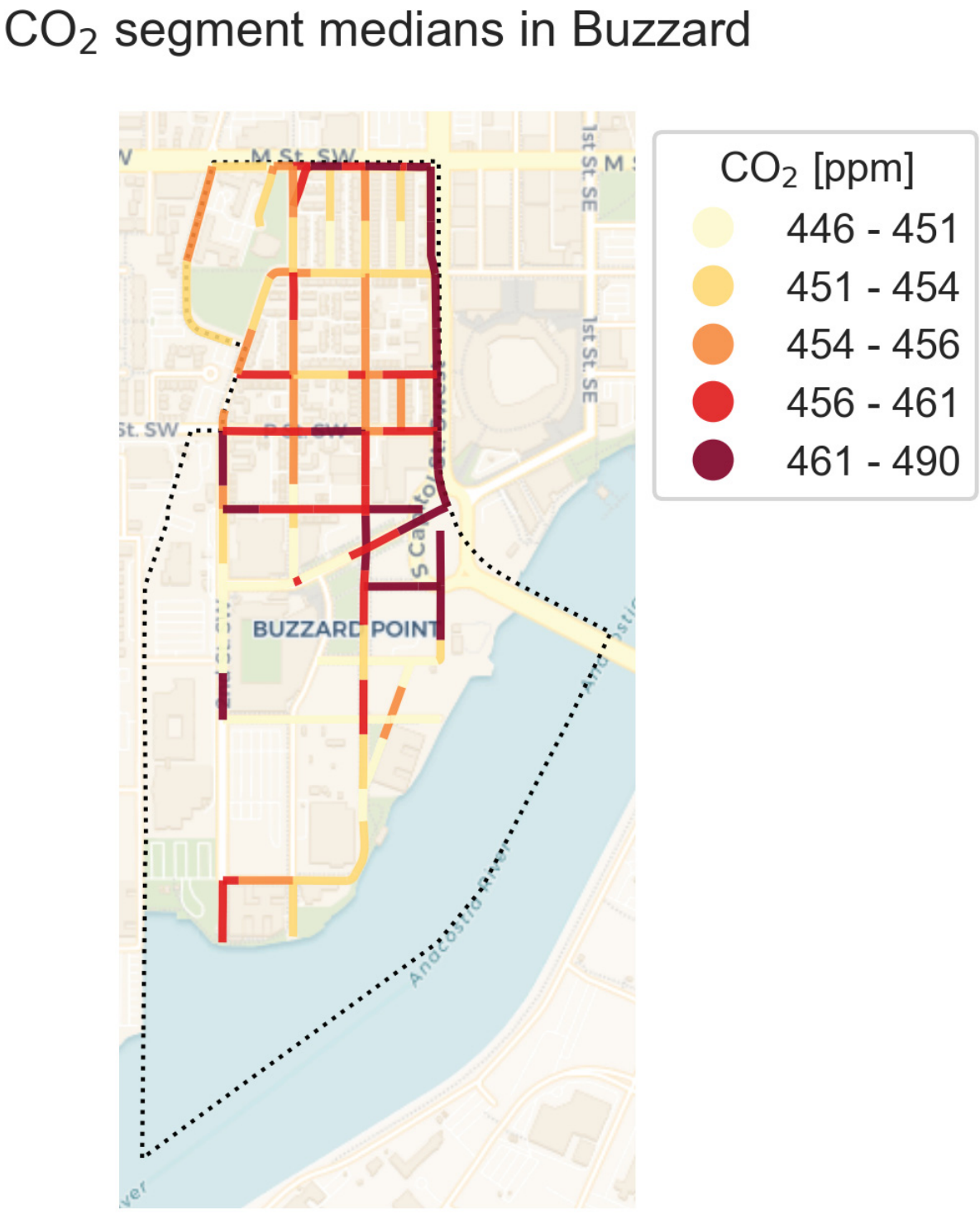

Figure A20. CO_2 segment medians for Buzzard Point.

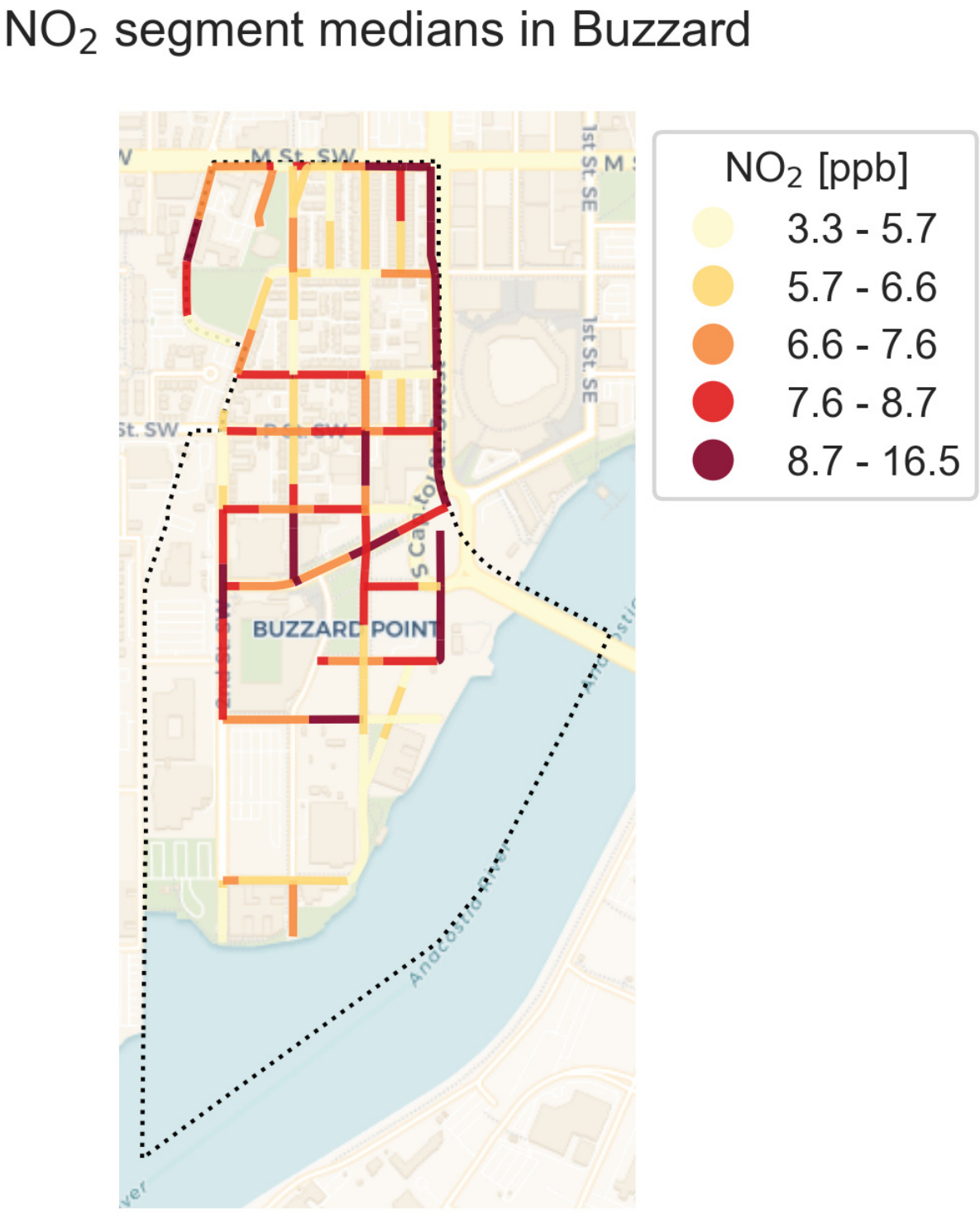

Figure A21. NO_2 segment medians for Buzzard Point.

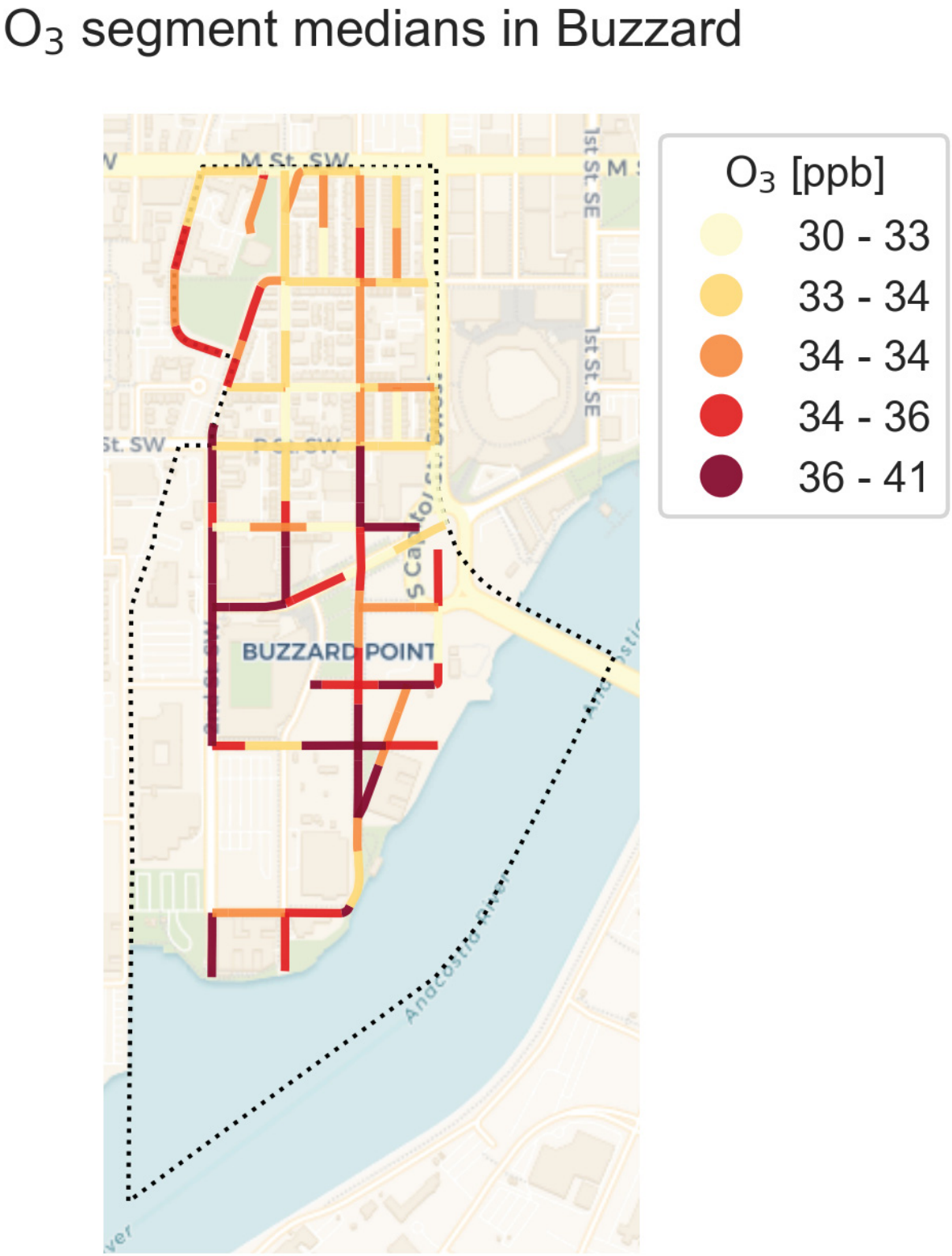

Figure A22. O_3 segment medians for Buzzard Point.

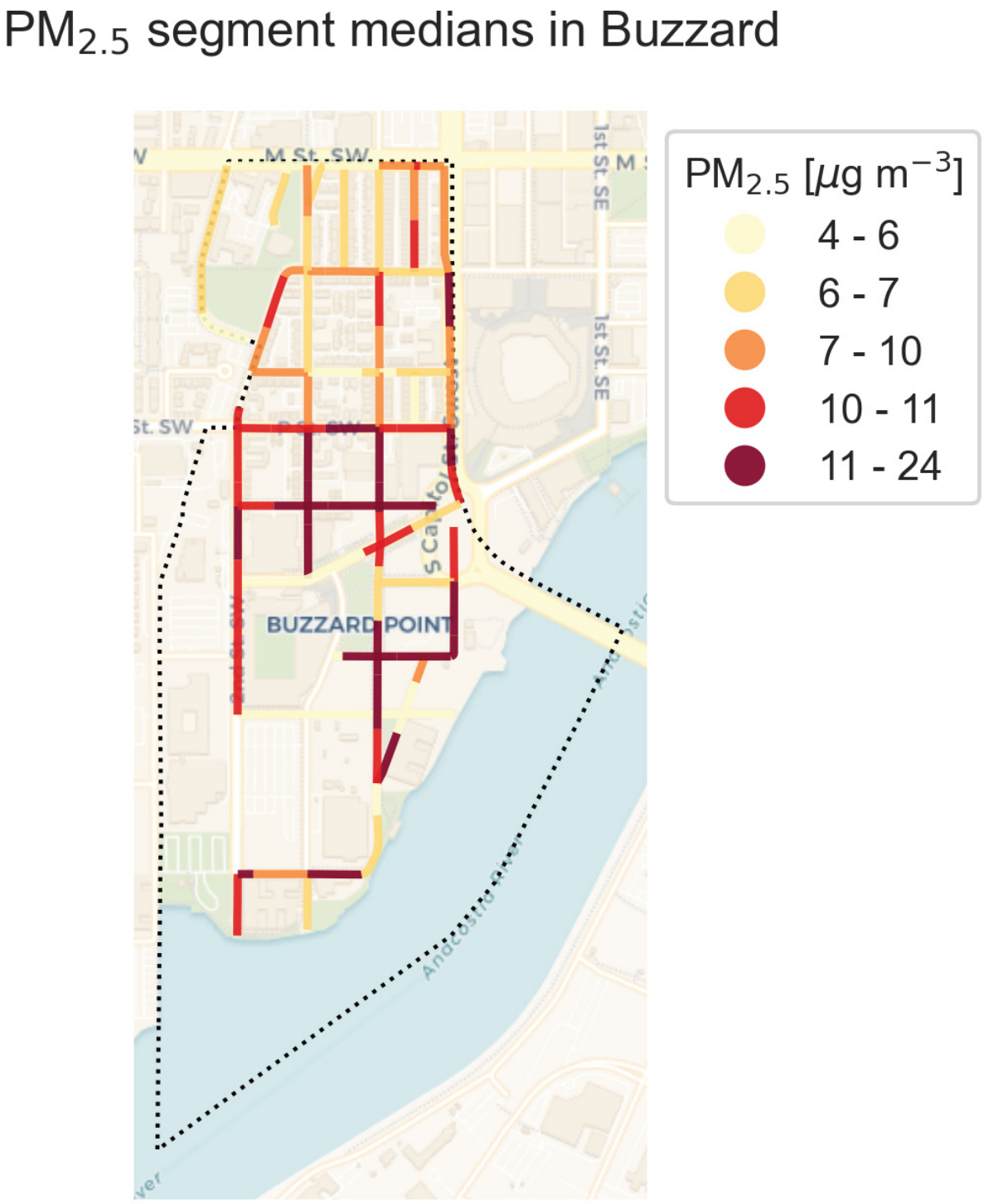

Figure A23. $PM_{2.5}$ segment medians for Buzzard Point.

A.3.3 Mayfair

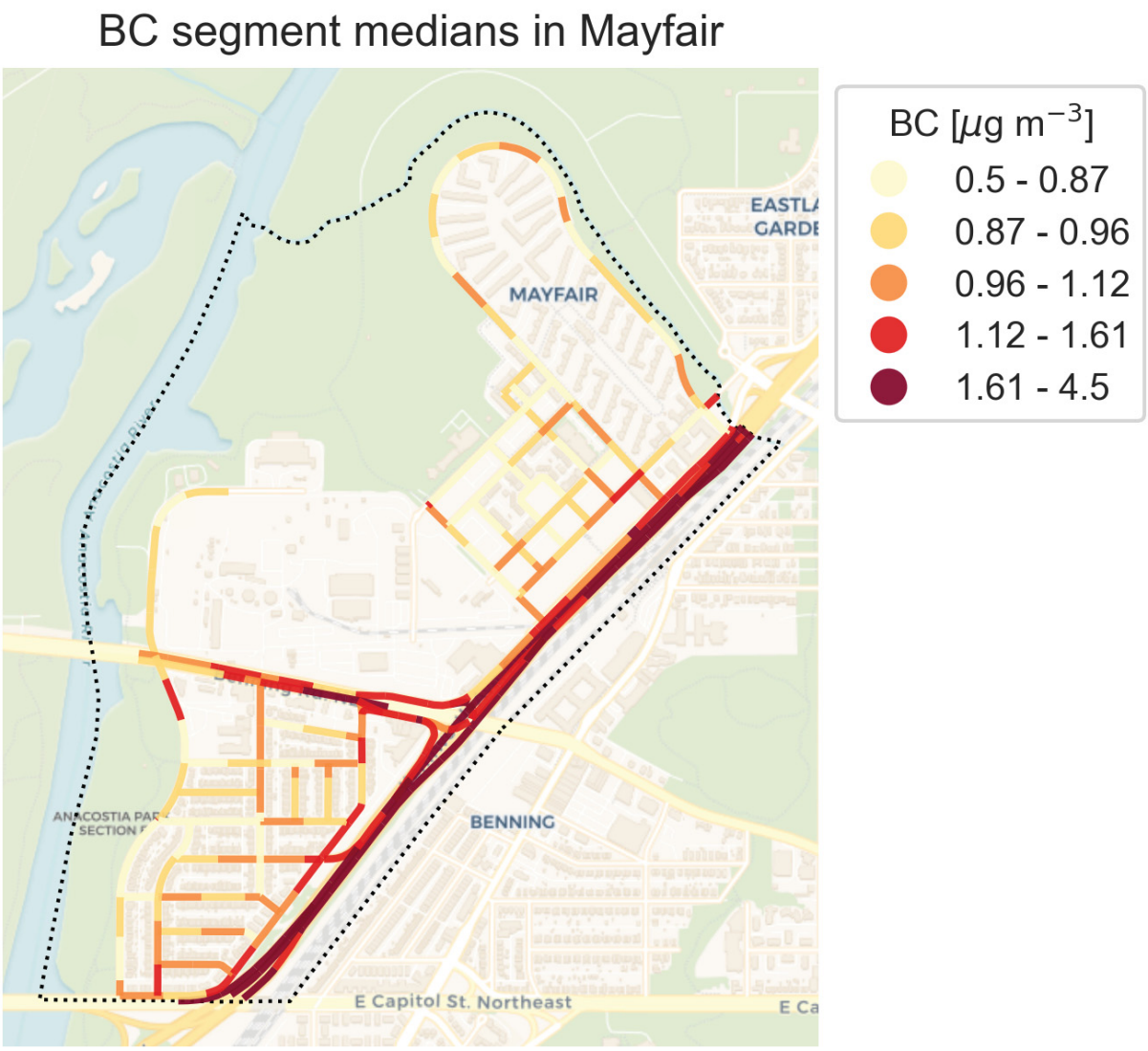

Figure A24. Black Carbon segment medians for Mayfair.

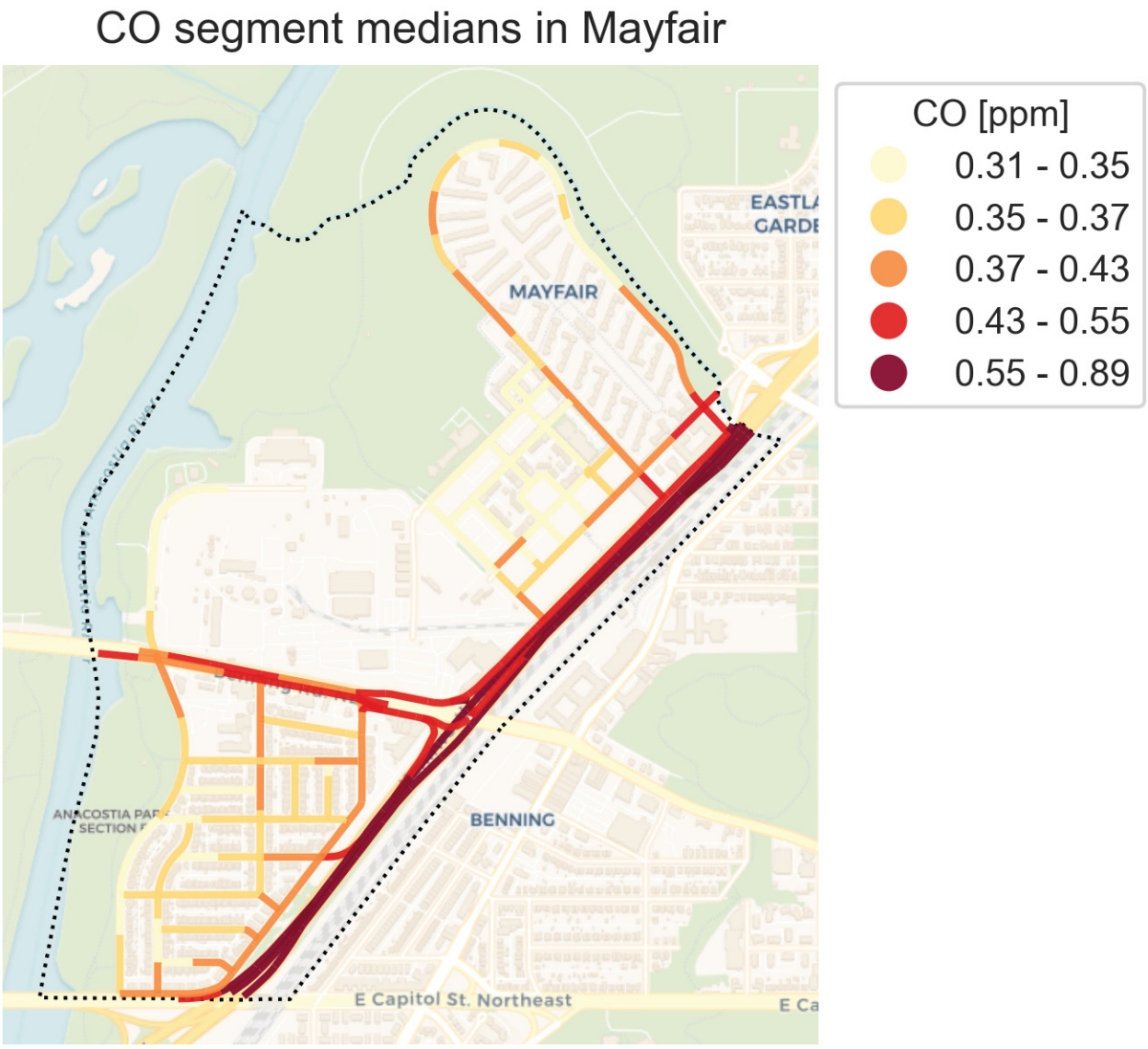

Figure A25. CO segment medians for Mayfair.

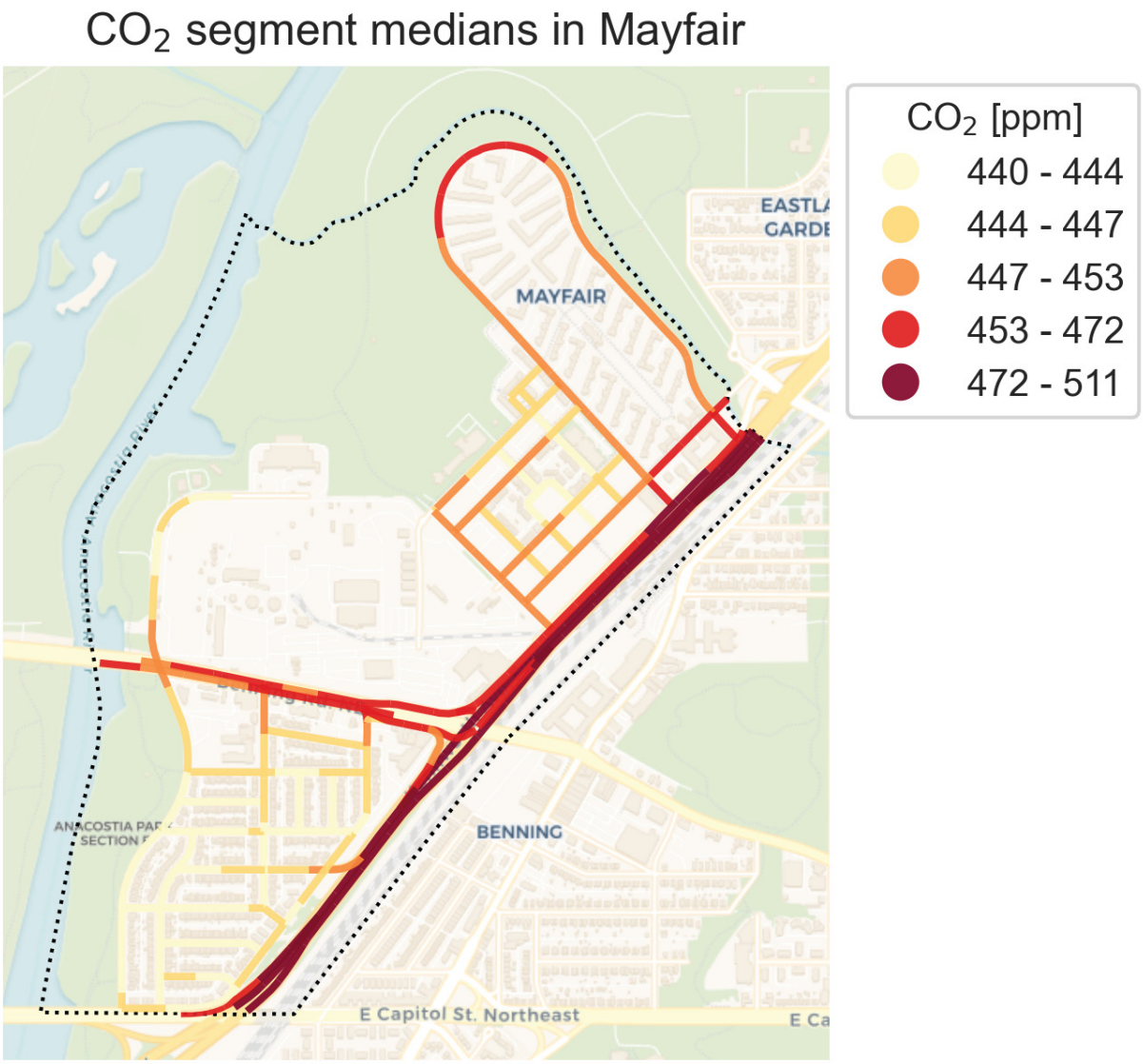

Figure A26. CO_2 segment medians for Mayfair.

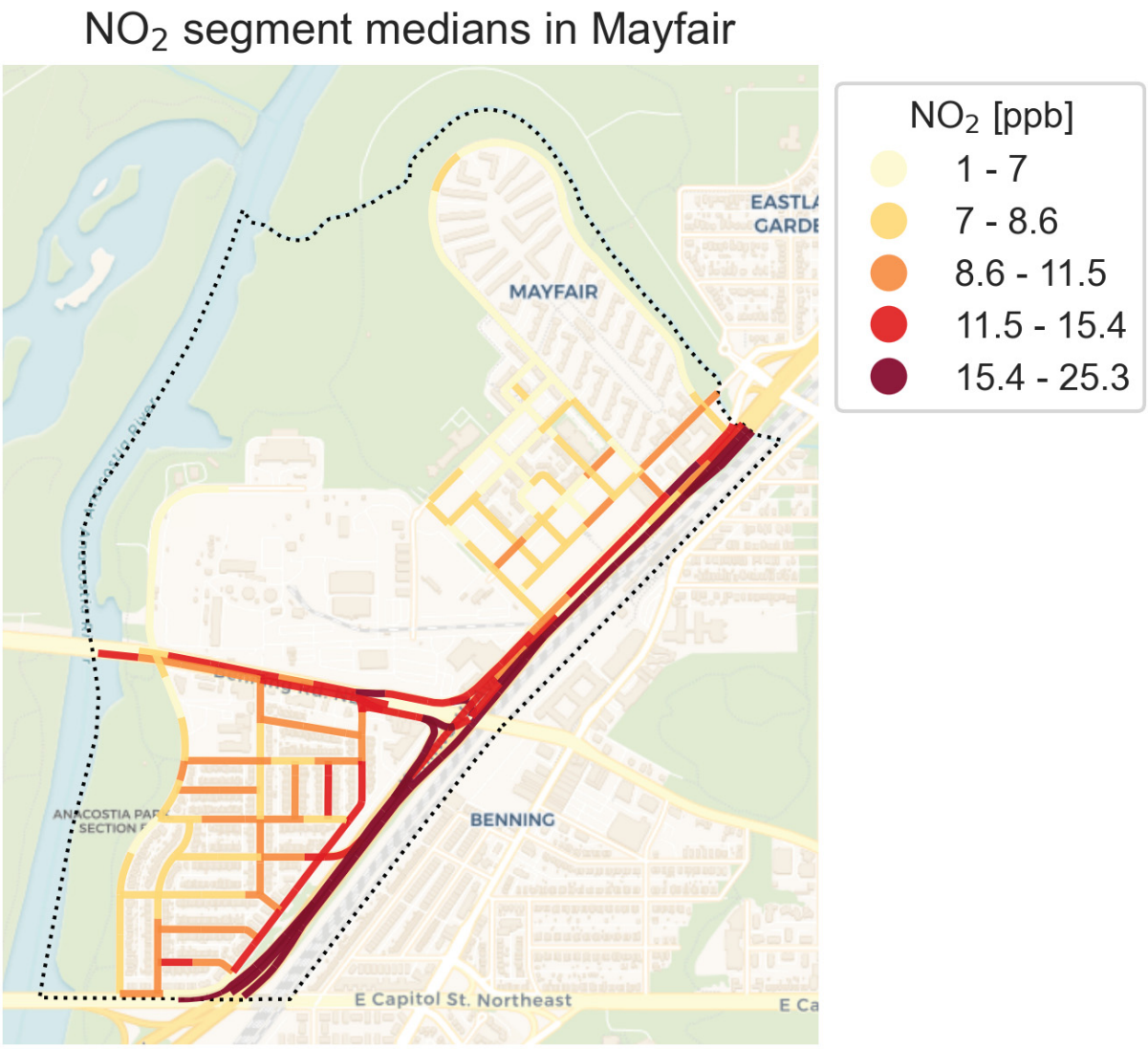

Figure A27. NO_2 segment medians for Mayfair.

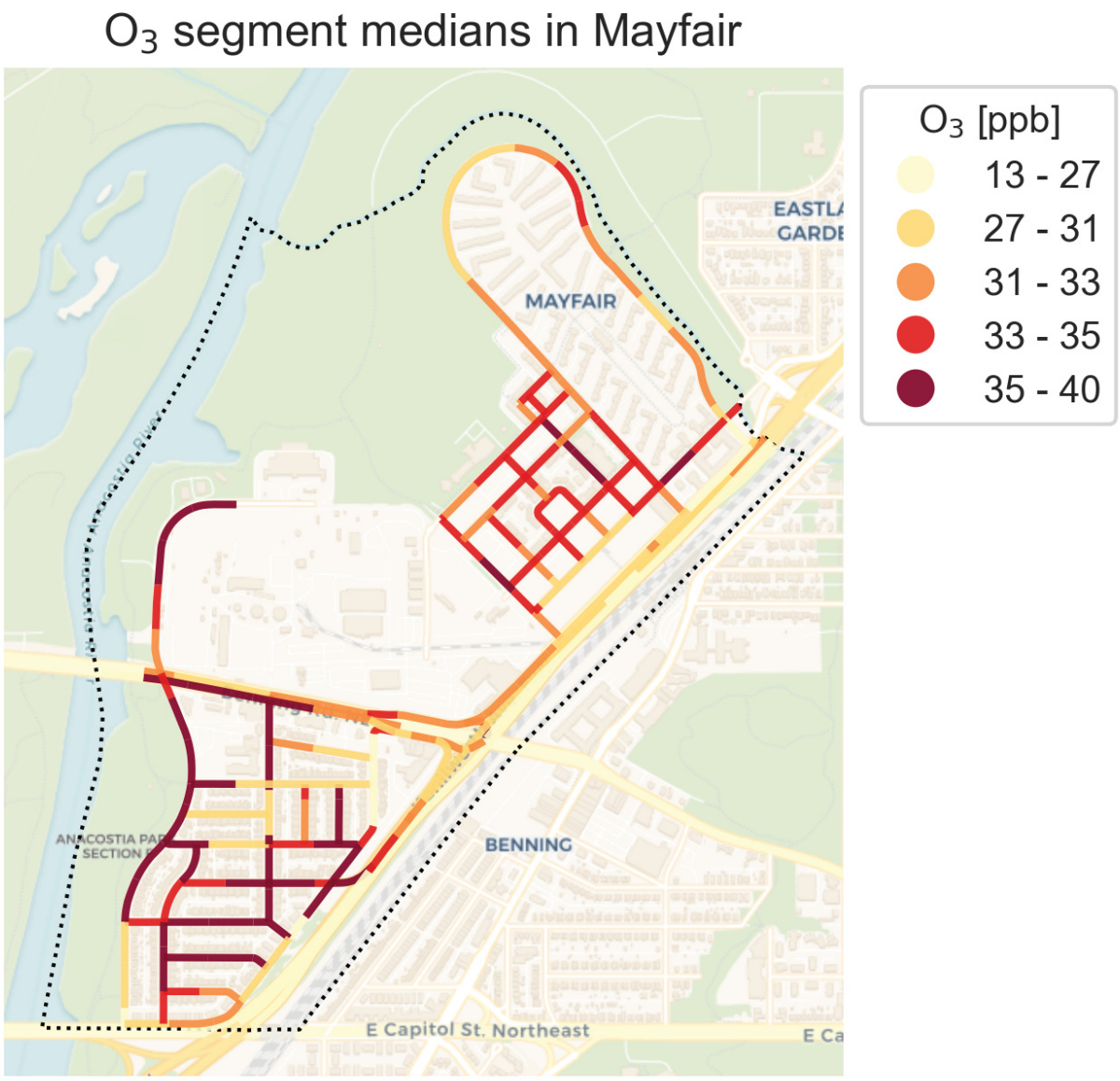

Figure A28. O_3 segment medians for Mayfair.

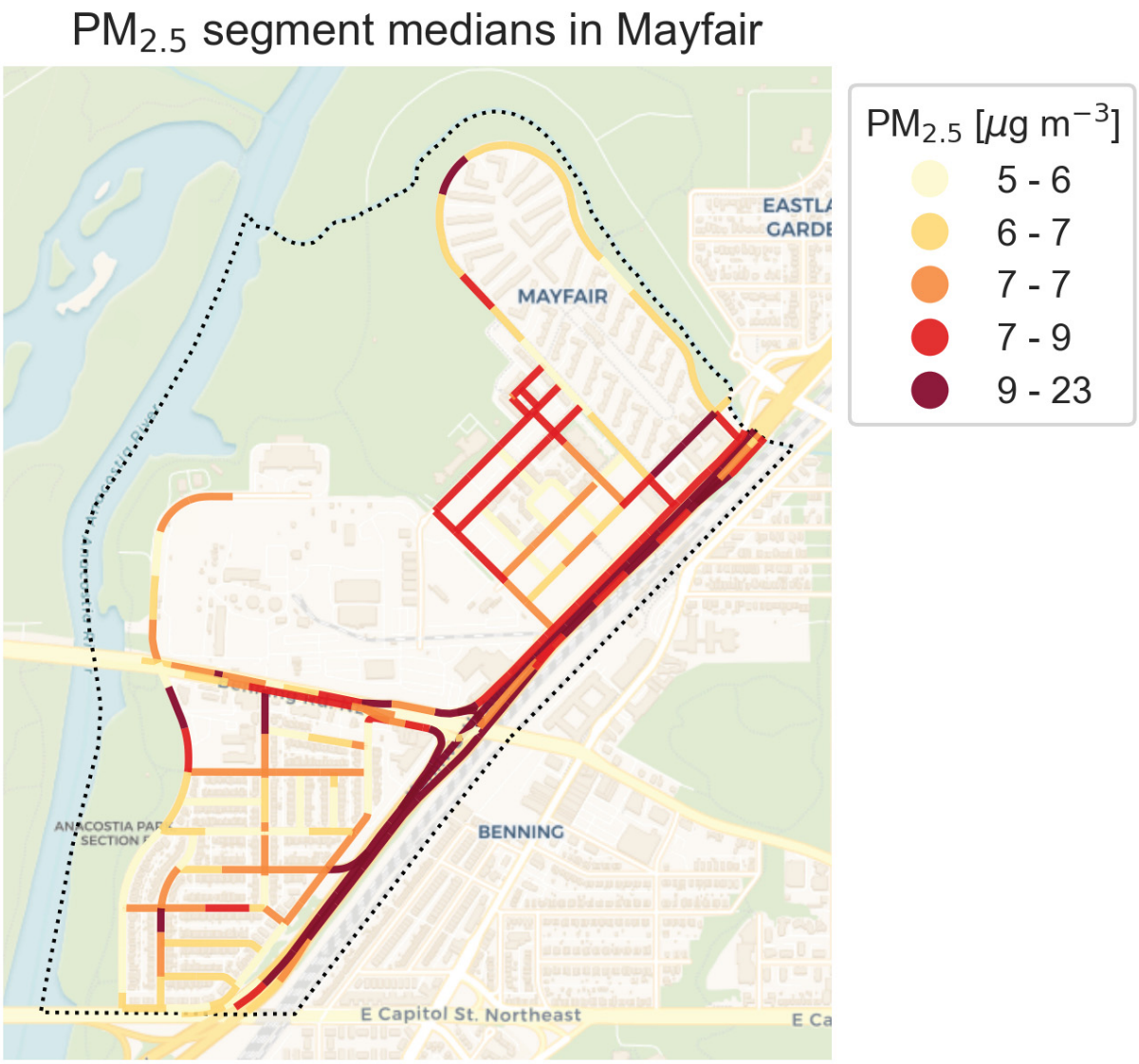

Figure A29. $PM_{2.5}$ segment medians for Mayfair.