Diesel Exhaust Exposure in the Duwamish Study (DEEDS)

Technical Report Appendix

September 13, 2013

TABLE OF CONTENTS

INDEX OF FIGURES

INDEX OF TABLES

TRAFFIC COUNTS

Introduction

To address South Park and Georgetown community members' interest in learning more about trucks as a source of diesel exhaust in the neighborhoods, a video-based traffic counting effort was conducted. UW DEEDS contracted with Quality Counts (Tigard, OR) to count vehicle traffic at selected locations in the two study neighborhoods. Direct measurement of traffic was considered an opportunity to examine whether this approach correlated with air pollution, when compared to other model variables such as land-use, road-density or assessment of traffic impact based on regional models.

Methods

Video cameras (JVC model 120 with wide angle lens) were mounted approximately 15 feet high and positioned to capture vehicle traffic at South Park and Georgetown locations within one block of fixed air pollution monitoring sites. Moving vehicles were counted in two directions (E and W or N and S) at all sites except one with only one direction of traffic (TC04). Vehicles were classified based on the US Federal Highway Administration categories (Figure A1). Vehicles were sorted into four categories (Table A1), to include motorcycles, cars and small trucks (Bin 1), buses such as school and metro buses (Bin 2), single unit 2-axle truck (Bin 3) and all trucks with 3 or more axles (Bin 4).

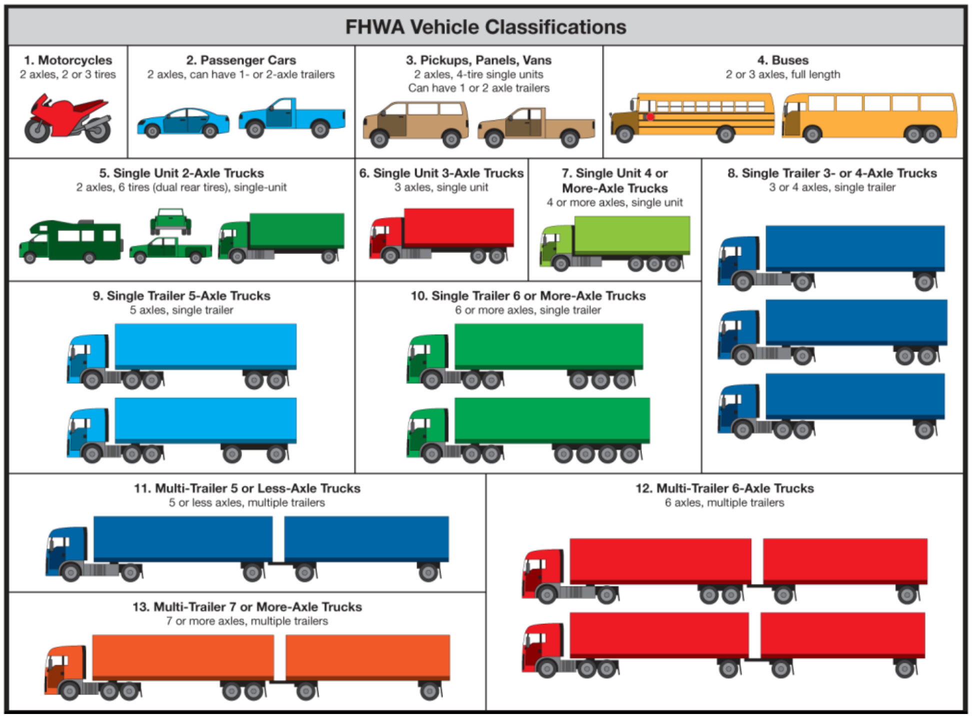


Figure A1. Federal Highway Administration Vehicle Classification[1]

Table A1. DEEDS designated vehicle classification

Bin Number	Vehicle Type
1	FHWA classes 1-3
2	FHWA classes 4
3	FHWA class 5
4	FHWA classes 6-13

To capture traffic variability by day of the week, traffic was counted on a high traffic weekday (Tuesday, Wednesday, or Thursday), a low traffic weekday (Monday or Friday), and a weekend day (Saturday or Sunday), for a total three days of counting at most locations. At the majority of weekday sites, traffic was counted from 6AM to 6PM, with counting at some sites starting at 5AM. Weekend traffic was counted from 8AM – 4PM. To verify traffic pattern assumptions, two sites were counted from midnight to midnight on all traffic count days. To maximize the data collected with limited

[1] From Texas Department ofTransportation (2012). Traffic Recorder Instruction Manual, Texas Department of Transportation. Retrieved 7/14/2013 from http://onlinemanuals.txdot.gov/txdotmanuals/tri/vehicle_classification_using_fhwa_13category_scheme.htm.

resources, traffic was counted in alternating 15 minute intervals, except at two locations where all 15-minute intervals were counted. Although the goal was to count traffic during the December 2012 fixed site monitoring campaign, utility pole permit issues necessitated the completion of traffic counting in February 2013. The locations for the traffic counting sites are shown in Table A2. The camera locations of businesses and homes have intentionally been omitted to protect the privacy of business and home owners who participated in the study.

Vehicles were manually counted at the Quality Counts Video Reduction Center, which was described as a comfortable, controlled setting. Quality Counts internal quality control measures included selection of qualified traffic counters who passed a counting test, and repeat counting of a subset of video footage to verify accuracy. A UW DEEDS researcher recounted three 15-minute intervals and the range of the difference between the QC count and the UW count for cars was 0-2% and for trucks was 8-35%. Missing traffic count data were due to equipment failures or equipment theft, which occurred at one site.

Statistical Analysis

The counts collected in Bins 1-4 were reduced to two categories: "cars" from Bin 1 and "trucks" from the sum of Bins 2-4. Gasoline-operated trucks such as personal pick-up trucks were considered "cars" for the purposes of this study to distinguish counts of diesel vehicles from gasoline vehicles. Representative hourly mean counts for cars and trucks were calculated for counts observed between 5 AM and 6 PM. Counts from weekdays were upweighted compared to the Sunday count (by a factor of 2 for cars and 6 for trucks), in order to match the relative proportion of weekday and weekend traffic in the overall traffic load.

Due to the existence of missing data, some sites had only 1 weekday of data while others had 2. To correct for missing data and the skewed distribution of hourly means, standardized traffic "scores" were calculated based on $\log_{10}$ counts. For this purpose, all counts from February were considered to be from a single date. As a quality measure, the February count patterns were compared to the December patterns and found to be in very high agreement. Log-transformed and normalized counts from the resulting 20 by 4 matrix were processed via singular value decomposition (SVD), while automatically imputing missing values with least-square estimates (Sampson et al., 2011). The first vector of the resulting "scores" (U) matrix can be seen as a first-order estimates of relative ($\log_{10}$) traffic intensity for each of the 20 sites.

To investigate the contribution of large trucks and buses, counts of the bins 2, 3 & 4 were compared, corresponding to buses, single unit 2-axle vehicles and ≥3-axle vehicles respectively. Mean hourly weekday counts collected between 5 AM and 6 PM were incorporated in these calculations.

Results

The weighted car and truck means and corresponding scores for various sites in Georgetown and South Park are presented in Table A2. Correlations between measured pollutants and traffic scores ranged from 0.53 – 0.84 for car scores and 0.51 – 0.83 for truck scores (Table A3). The comparison of the counts of the three truck means for various sites are presented in Figure A2. Despite being reasonably correlated with observed pollution levels, traffic counts were ultimately not included as candidate variables in the model selection process because these variables were not available for points across the 50m prediction grid. In sensitivity analyses on sites with available traffic counts, the addition of traffic-count data to all other available variables did not improve prediction quality.

Table A2. Weighted truck and car counts

Site Description	Weighted Truck Means (vehicles/ hour)	Truck Scores	Weighted Car Means (Vehicles/ hour)	Car Scores	Camera ID
SoDo Agency Site (Puget Sound Clean Air Agency)	184	0.29	2146	0.34	TC01
Industrial Area in NW Georgetown	81	0.19	808	0.21	TC02
Residential Area in NE Georgetown	1	-0.24	41	-0.12	TC03
Commercial Area in NE Georgetown[2]	100	0.23	983	0.25	TC04
Residential Area in NE Georgetown	59	0.14	296	0.09	TC05
Residential Area in SE Georgetown	7	-0.08	26	-0.18	TC06
Residential Area in SE Georgetown	0	-0.32	14	-0.25	TC07
South Seattle Community College (E Marginal Way S)	145	0.26	691	0.20	TC08
Industrial Area in NE South Park (Near Business with a Truck Fleet)	30	0.06	73	-0.07	TC09
Residential Area in NE South Park	1	-0.26	7	-0.34	TC10
South Park Community Center (WA-99)	431	0.39	1957	0.31	TC11
Residential Area in NE South Park	1	-0.26	8	-0.32	TC12
Residential Area in SW South Park	62	0.24	522	0.21	TC13
Commercial Area in SE South Park (14th and Cloverdale)	49	0.18	377	0.16	TC14
Residential Area in SE South Park	1	-0.26	19	-0.21	TC15
Concord Elementary (W and S side)	2	-0.25	23	-0.20	TC16/TC18
Residential Area in SW South Park	1	-0.22	11	-0.30	TC17
Residential Area in SW South Park	12	-0.05	98	-0.02	TC19
Beacon Hill Agency Site (Washington Department of Ecology)	28	0.08	660	0.21	TC20
King County International Airport (Airport Way S)	41	0.08	433	0.12	TC21

[2] Traffic was only counted in one direction at this site.

Table A3. Correlation coefficients of measured pollutants and traffic scores

Pollutant Measured	Truck Score	Car Score
Log_{10} August 1-NP	0.60	0.62
Log_{10} December 1-NP	0.51	0.53
Log_{10} August BC	0.65	0.68
Log_{10} December BC	0.58	0.59
Log_{10} August NO_x	0.83	0.84
Log_{10} December NO_x	0.80	0.79
August Pollution Score	0.77	0.79
December Pollution Score	0.70	0.71

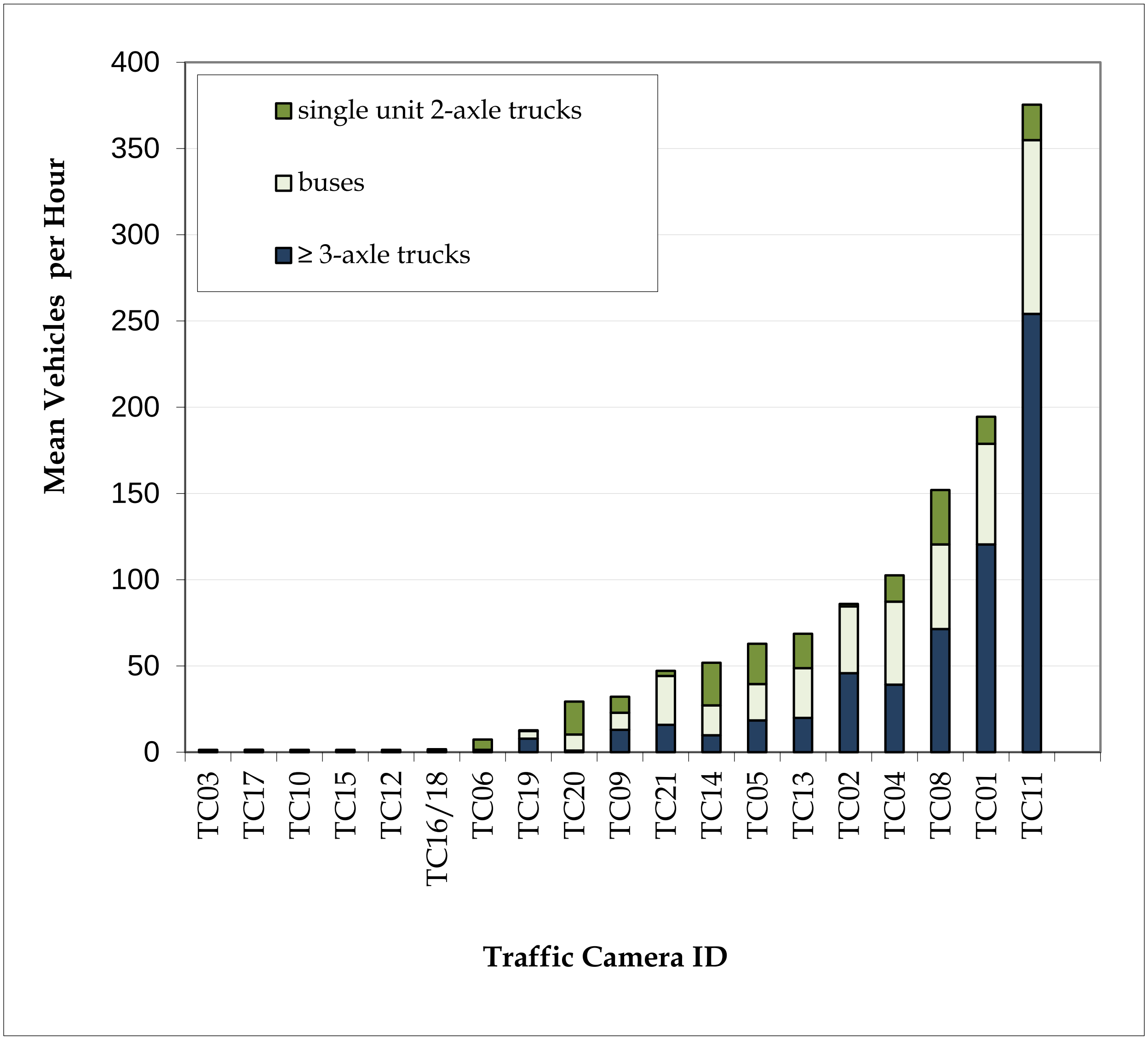
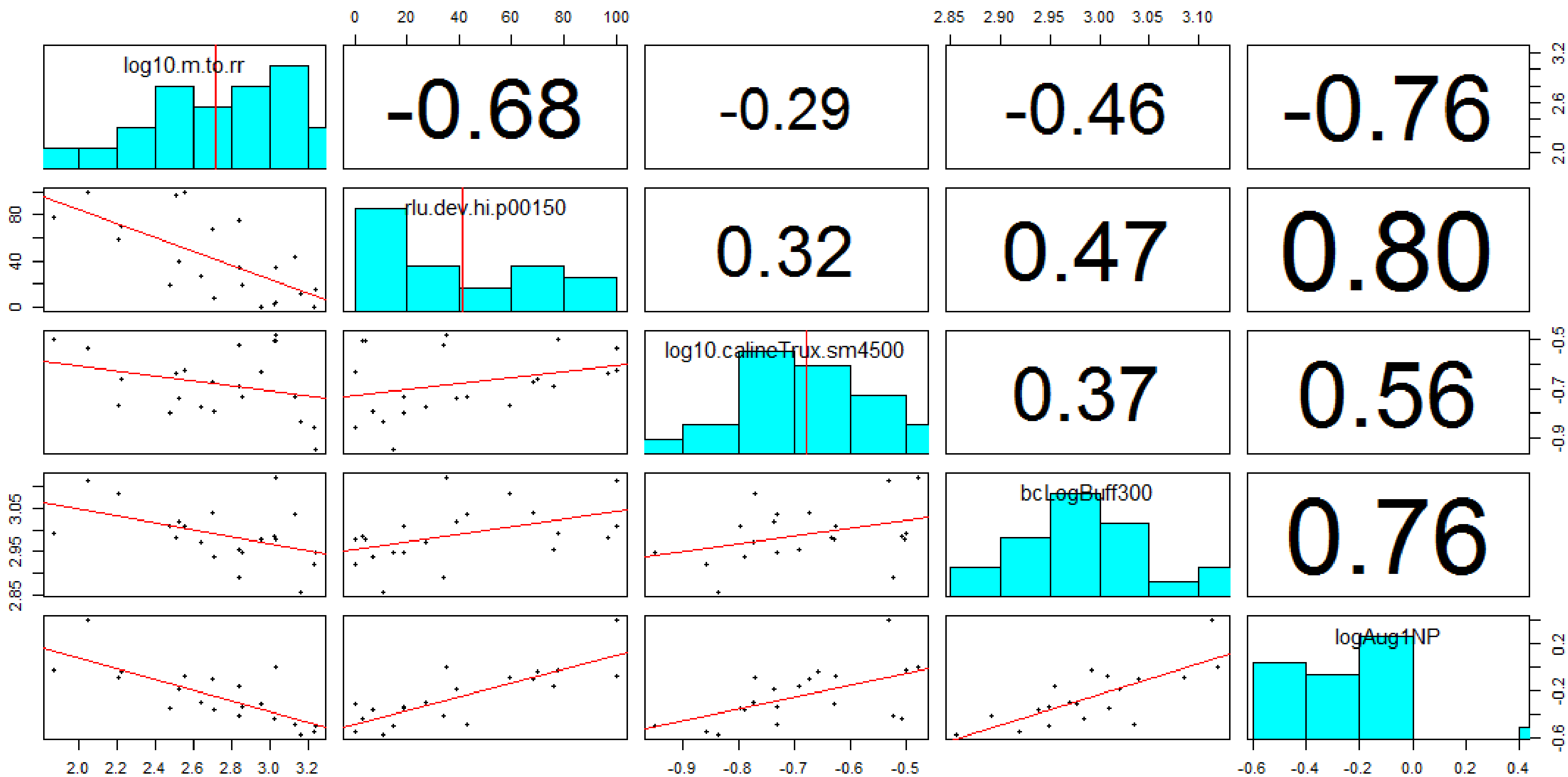


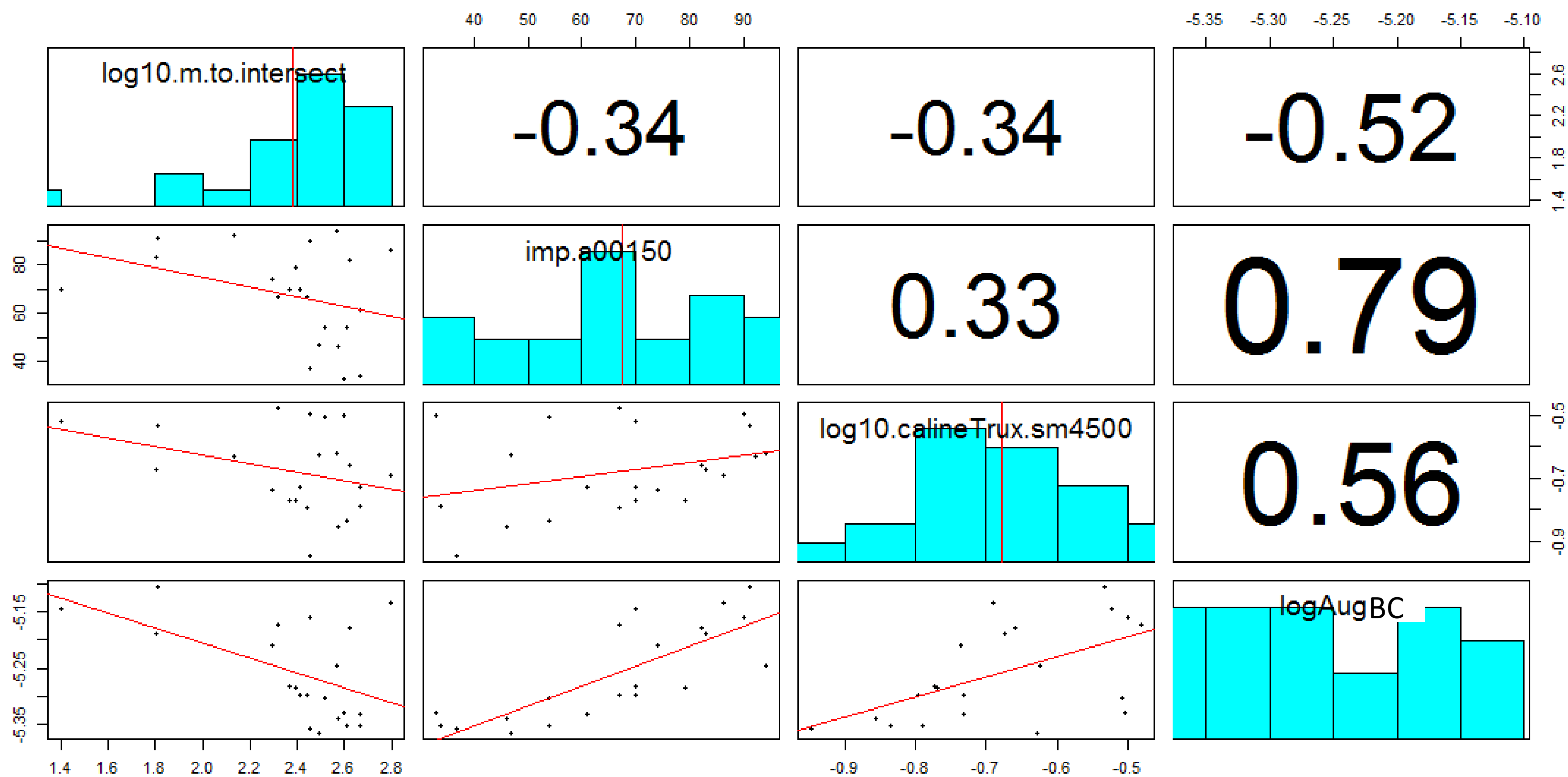
Figure A2. Weekday counts of large trucks and buses

Model Correlation Matrices



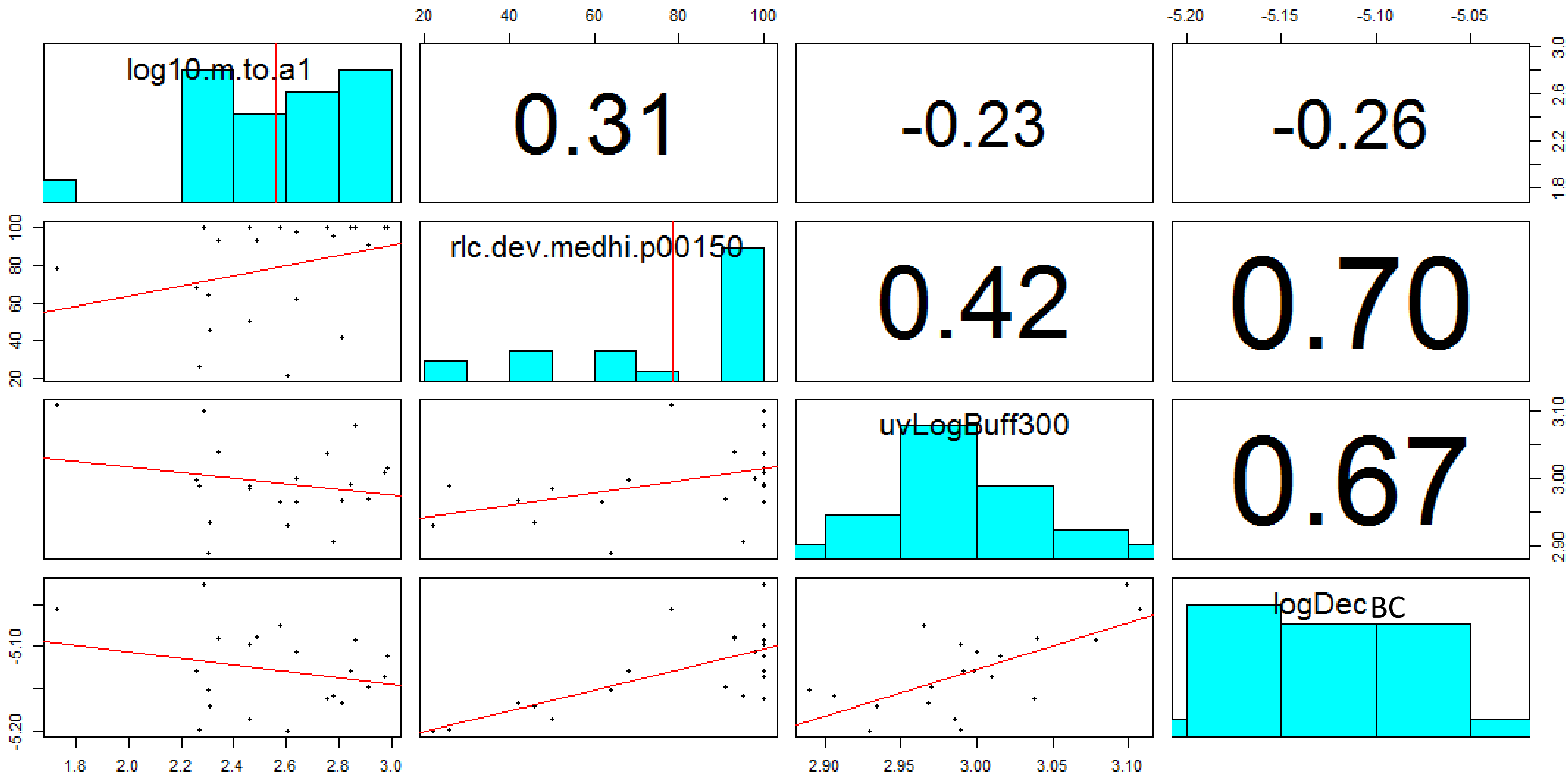
Where *log10.m.to.rr* = Log_{10} meters to railroad
rlu.dev.hi.p00150 = Developed high-intensity areas in 150 meters
log10.calineTrux.sm4500 = Log_{10} CAL3QHCR truck emission predictions in 4500m
bcLogBuff300 = Mean of log_{10} black carbon-channel Aethalometer® readings in 300m
logAug1NP = Log_{10} August 1NP measurements

Figure A3. Correlation matrix of log_{10} August 1-NP model terms



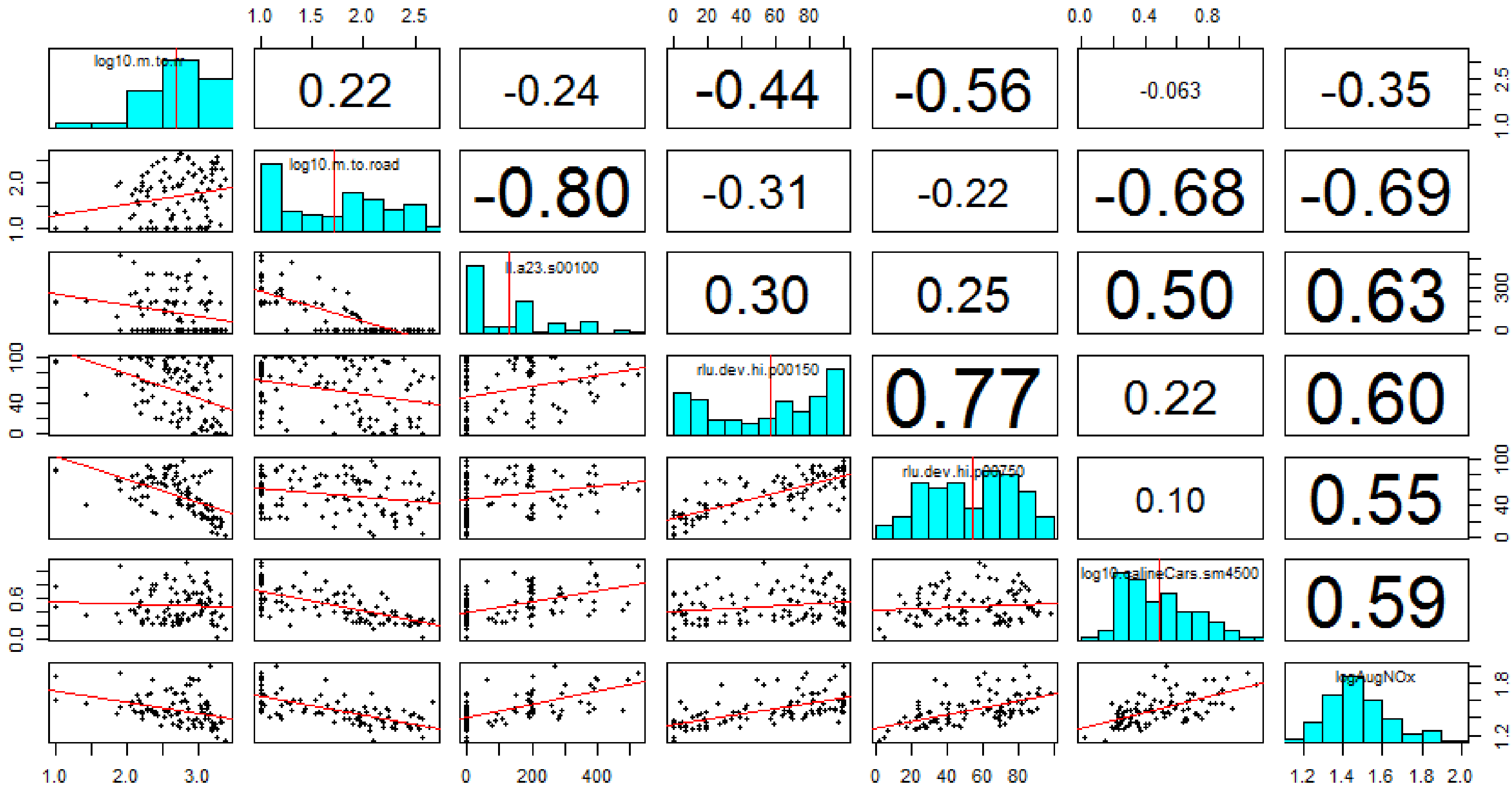
Where *log10.m.to.intersect* = Log_{10} meters to intersection
imp.a00150 = Area of impervious surface in 150m
log10.calineTrux.sm4500 = CAL3QHCR truck emission predictions in 4500m
logAugBC = Log_{10} August BC measurements

Figure A4. Correlation matrix of August BC model terms



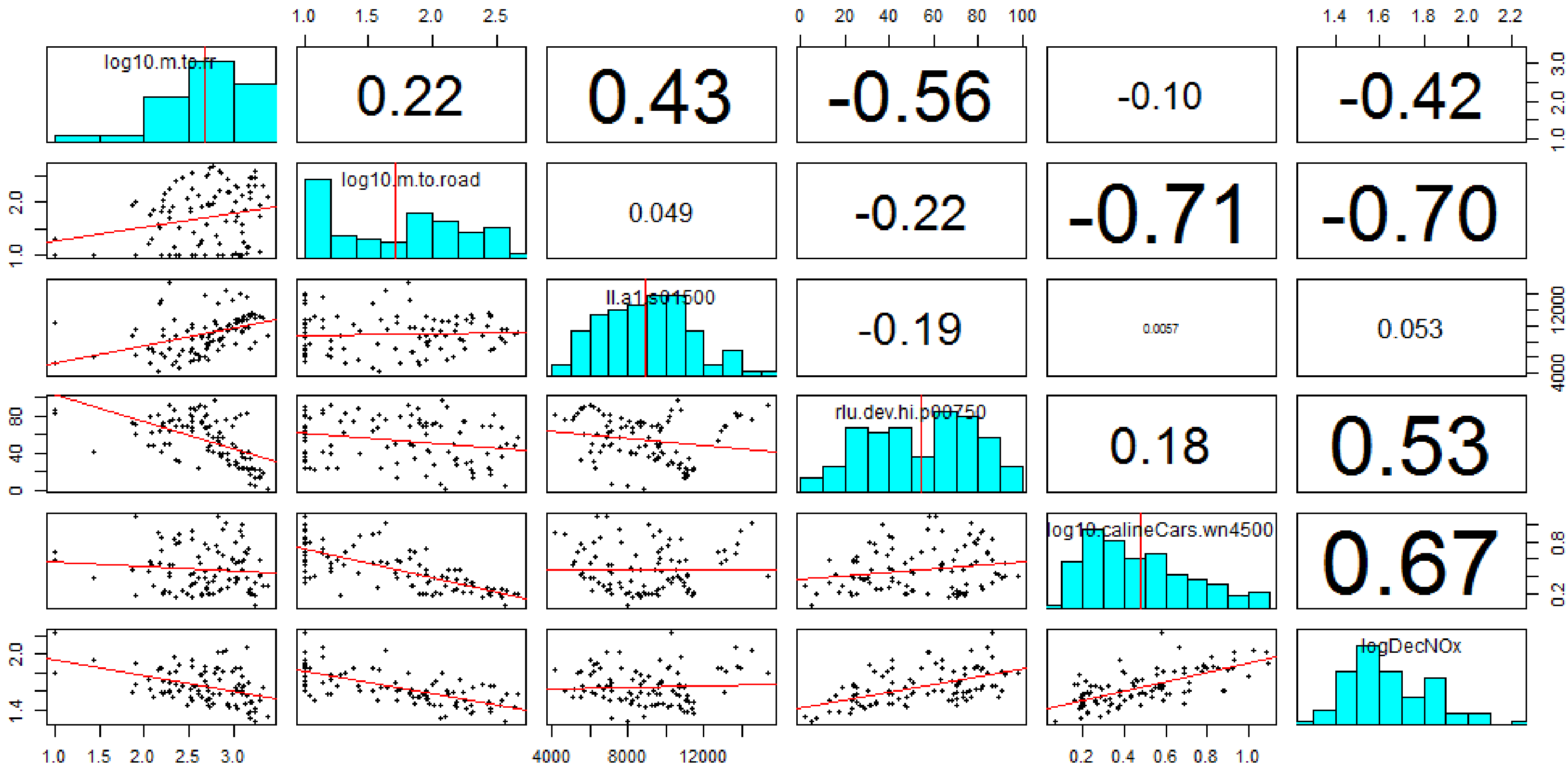
Where *log10.m.to.a1* = Log_{10} meters to A1 road
rlc.dev.medhi.p00150 = Developed medium and high intensity areas in 150m
uvLogBuff300 = Mean log_{10} ultraviolet-channel Aethalometer® readings in 300m
logDecBC = Log_{10} December BC measurements

Figure A5. Correlation matrix of log_{10} December BC model terms



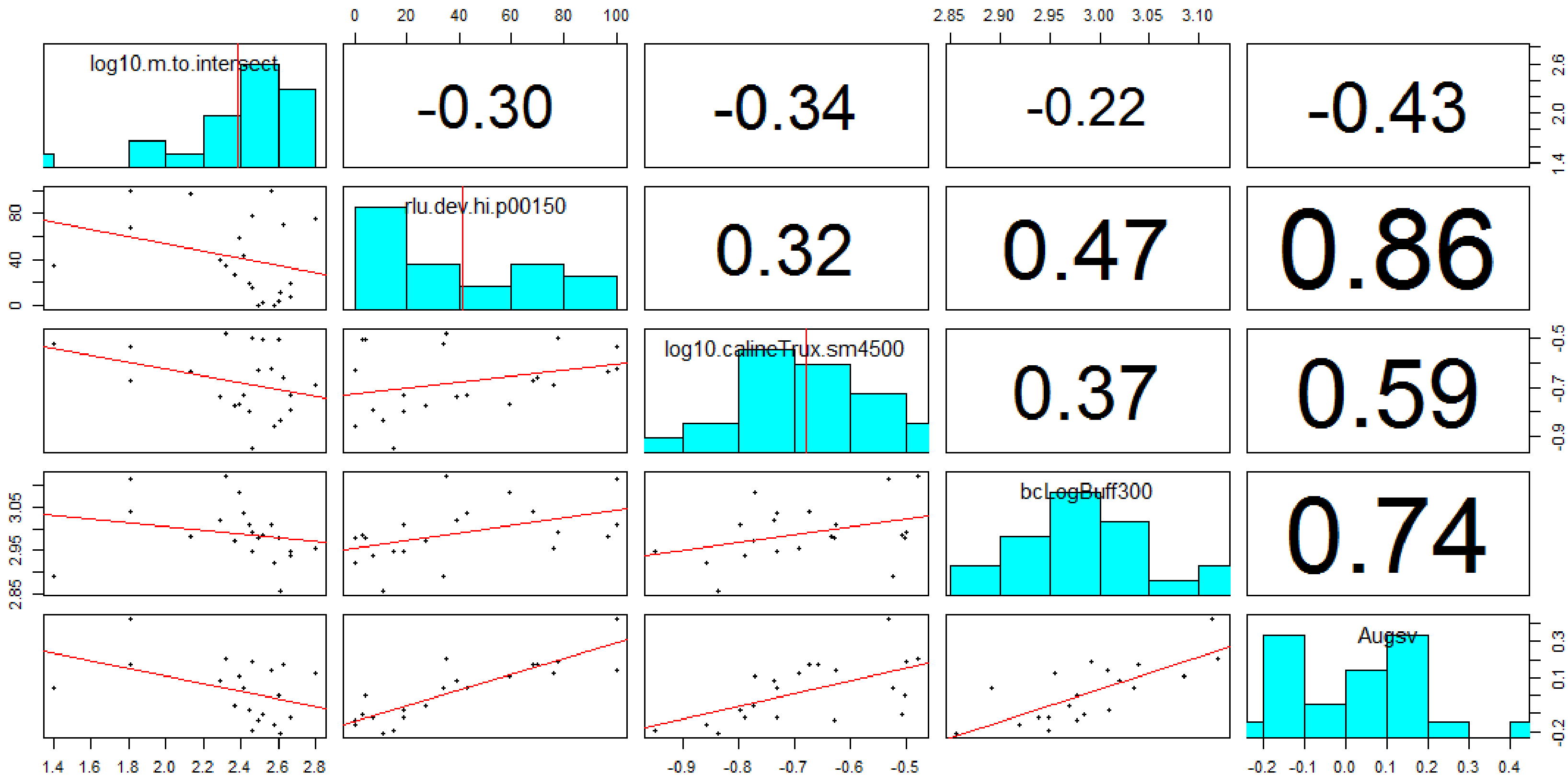
Where: *log10.m.to.l.port* = Log_{10} meters to Port of Seattle
log10.m.to.road = Log_{10} meters to road
ll.a23.s00100 = Length of A2 and A3 roads in 100m
rlu.dev.hi.p00150 = Developed high-intensity areas in 150m
rlu.dev.hi.p00750 = Developed high-intensity areas in 750m
log10.calineCars.sm4500 = CAL3QHCR car emission predictions in 4500m
logAugNOx = Log_{10} August NO_x measurements

Figure A6. Correlation matrix of August NO_x model terms



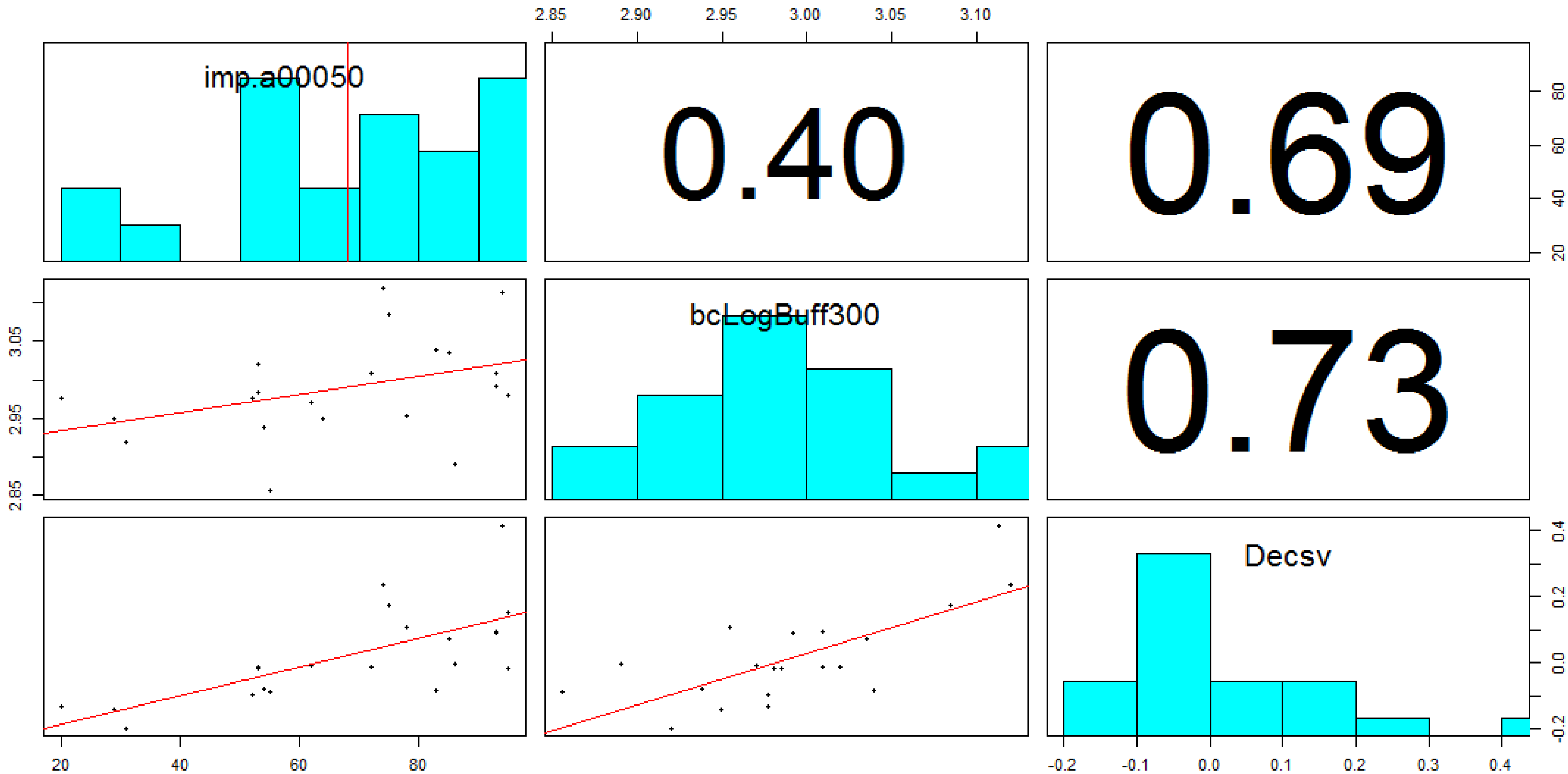
Where: *log10.m.to.rr* = Log_{10} meters to railroad
log10.m.to.road = Log_{10} meters to road
ll.a1.s01500 = Length of A1 roads in 1500m
rlu.dev.hi.p00750 = Developed high-intensity areas in 750m
log10.calineCars.wn4500 = CAL3QHCR car emission predictions in 4500m

Figure A7. Correlation matrix of log_{10} December NO_x model terms



Where: *log10.m.to.intersect* = Log_{10} meters to intersection
rlu.dev.hi.p00150 = Developed high-intensity areas in 150m
log10.calineCars.sm4500 = CAL3QHCR car emission predictions in 4500m
bcLogBuff300 = Mean of log_{10} black carbon-channel Aethalometer® readings in 300m
Augsv = August pollution score

Figure A8. Correlation matrix of August pollution score model terms



Where: *imp.a00050* = Area of impervious surface in 50m
bcLogBuff300 = Mean of $\log_{10}$ black carbon-channel Aethalometer® readings in 300m
Decsv = December pollution score

Figure A9. Correlation matrix of December pollution score model terms

MAPS OF MODEL RESIDUALS

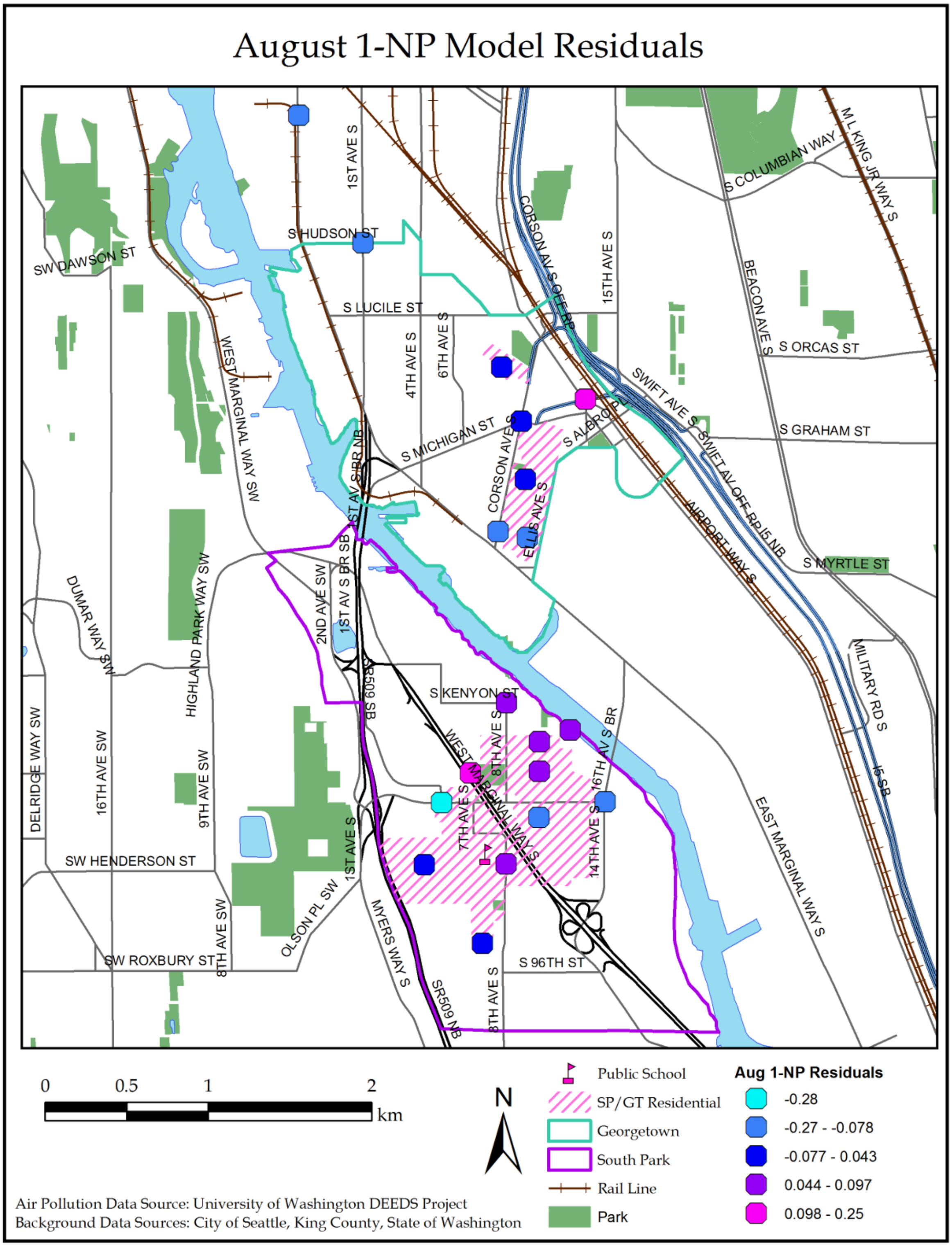


Figure A10. Map of $\log_{10}$ August 1-NP model residuals. Home/business sites were generalized to the nearest intersection.

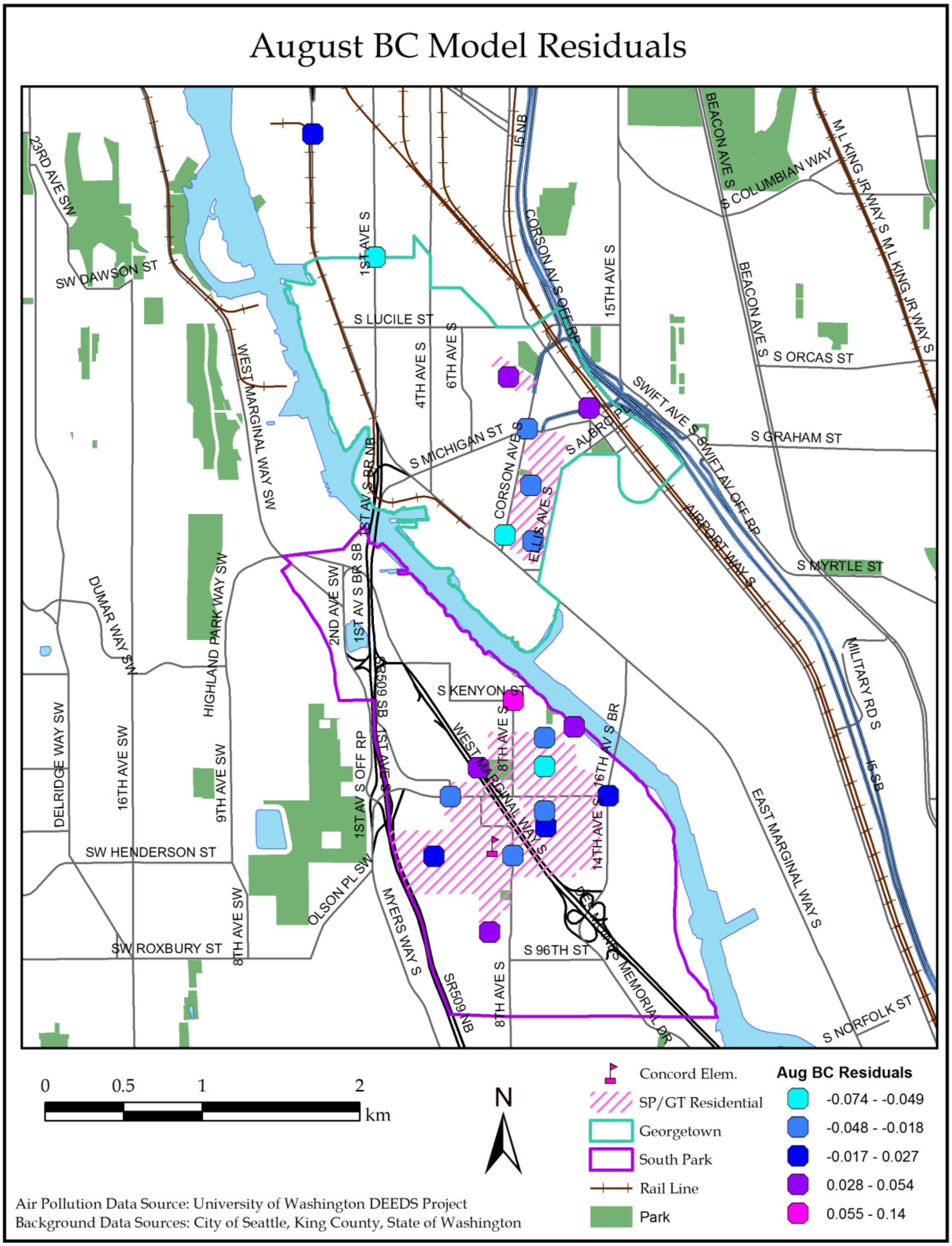


Figure A11. Map of $\log_{10}$ August BC model residuals. Home/business sites were generalized to the nearest intersection.

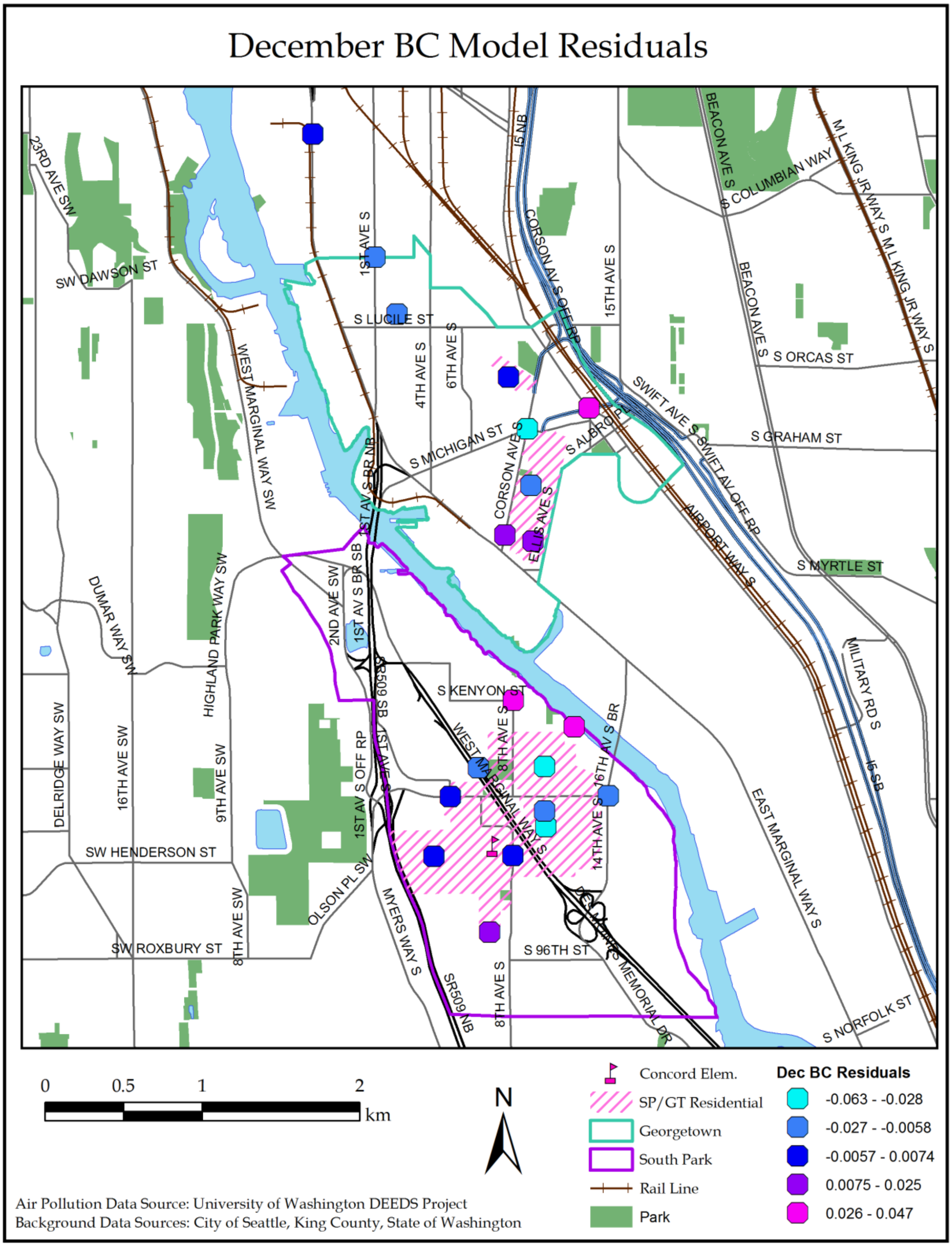


Figure A12. Map of $\log_{10}$ December BC model residuals. Home/business sites were generalized to the nearest intersection.

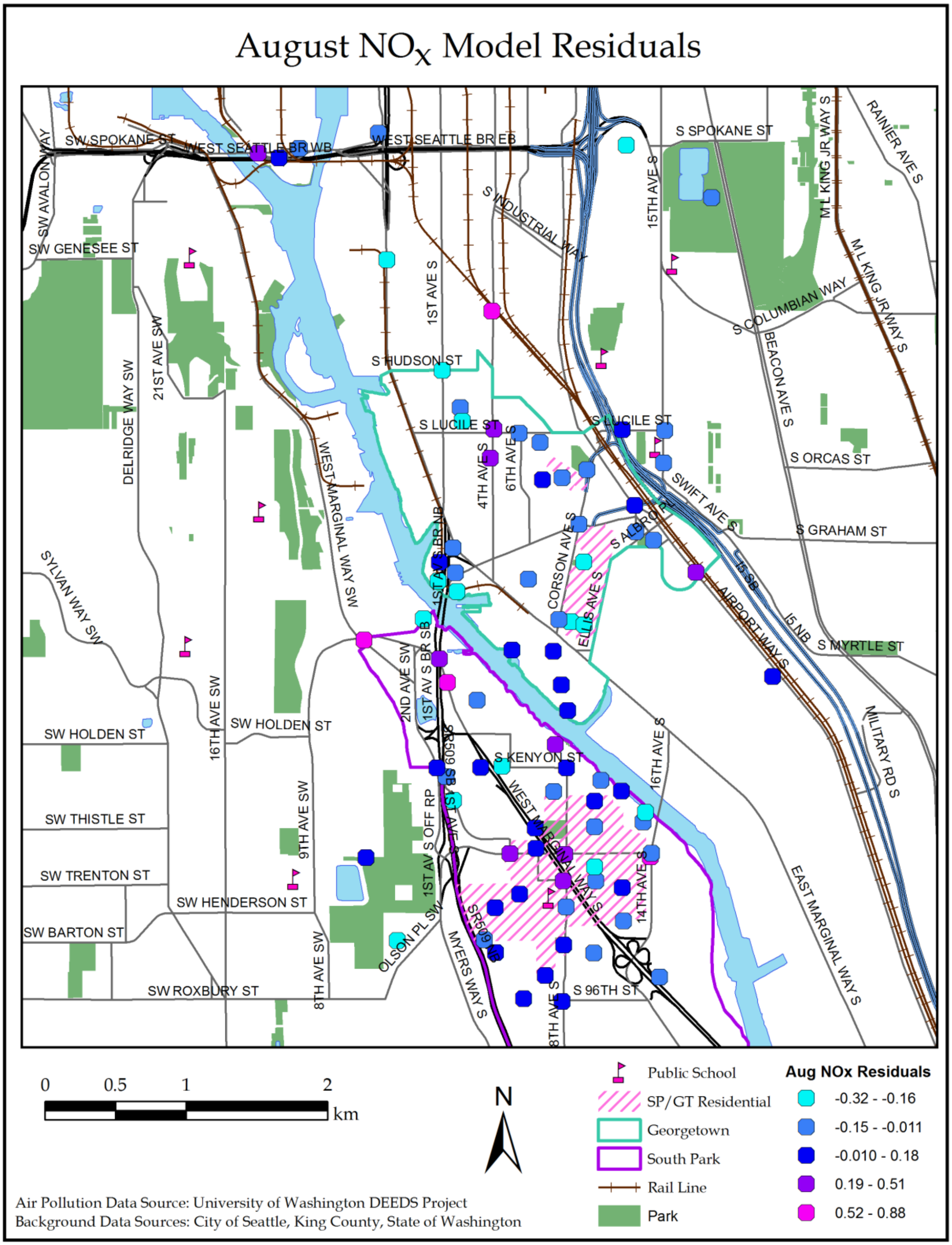


Figure A13. Map of $\log_{10}$ August NO_x model residuals. Home/business sites were generalized to the nearest intersection.

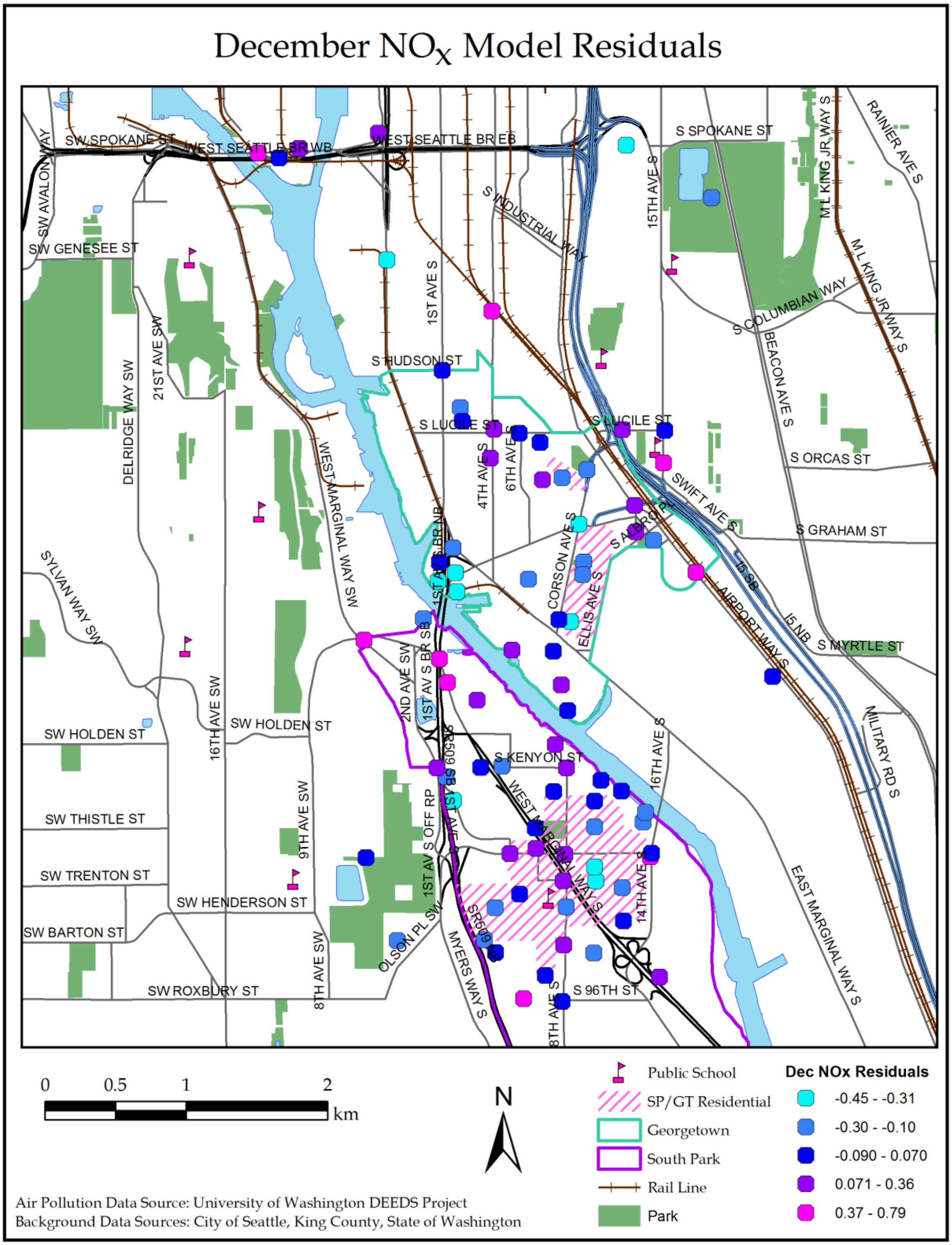


Figure A14. Map of $\log_{10}$ December NO_x model residuals. Home/business sites were generalized to the nearest intersection.

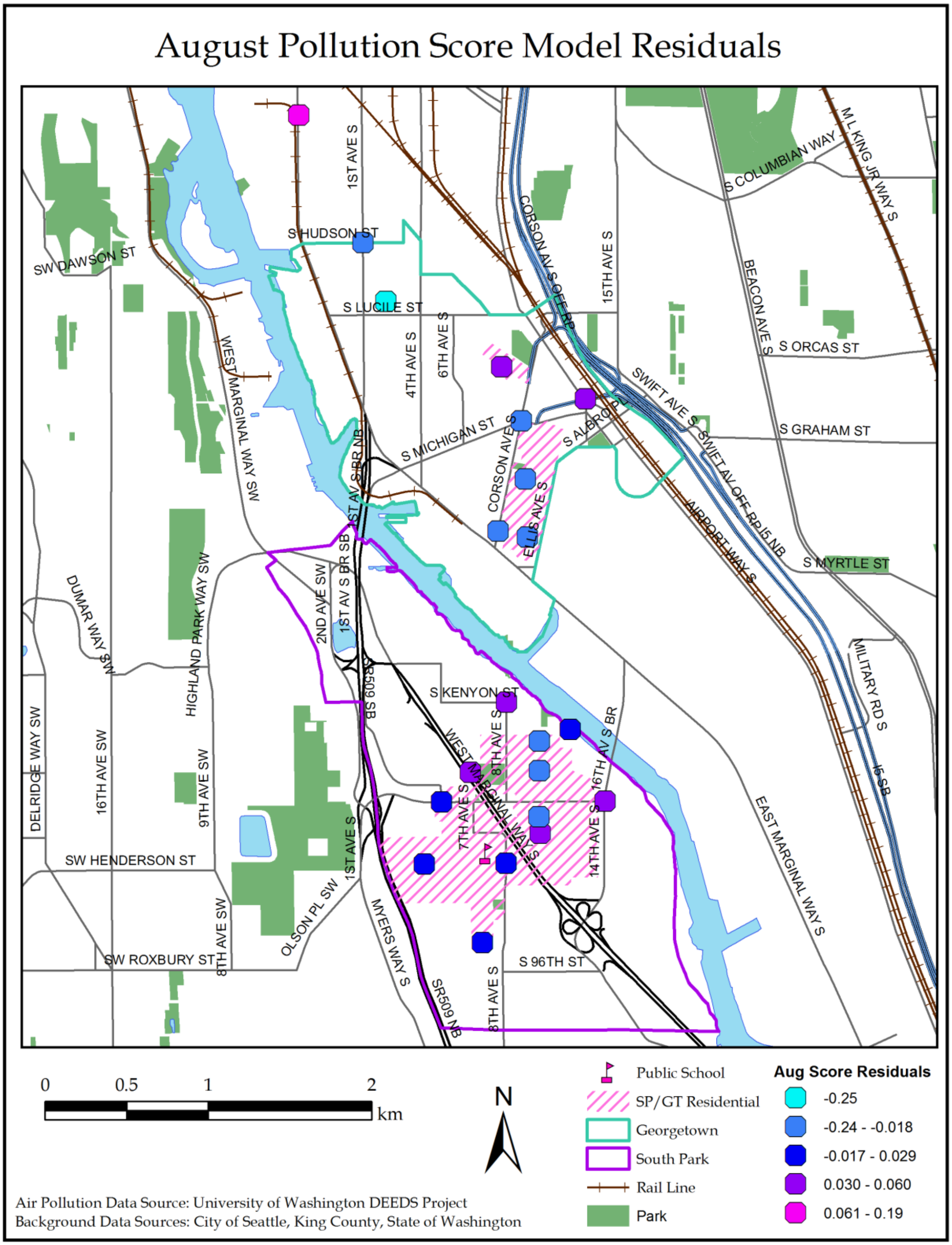


Figure A15. Map of August pollution score model residuals. Home/business sites were generalized to the nearest intersection.

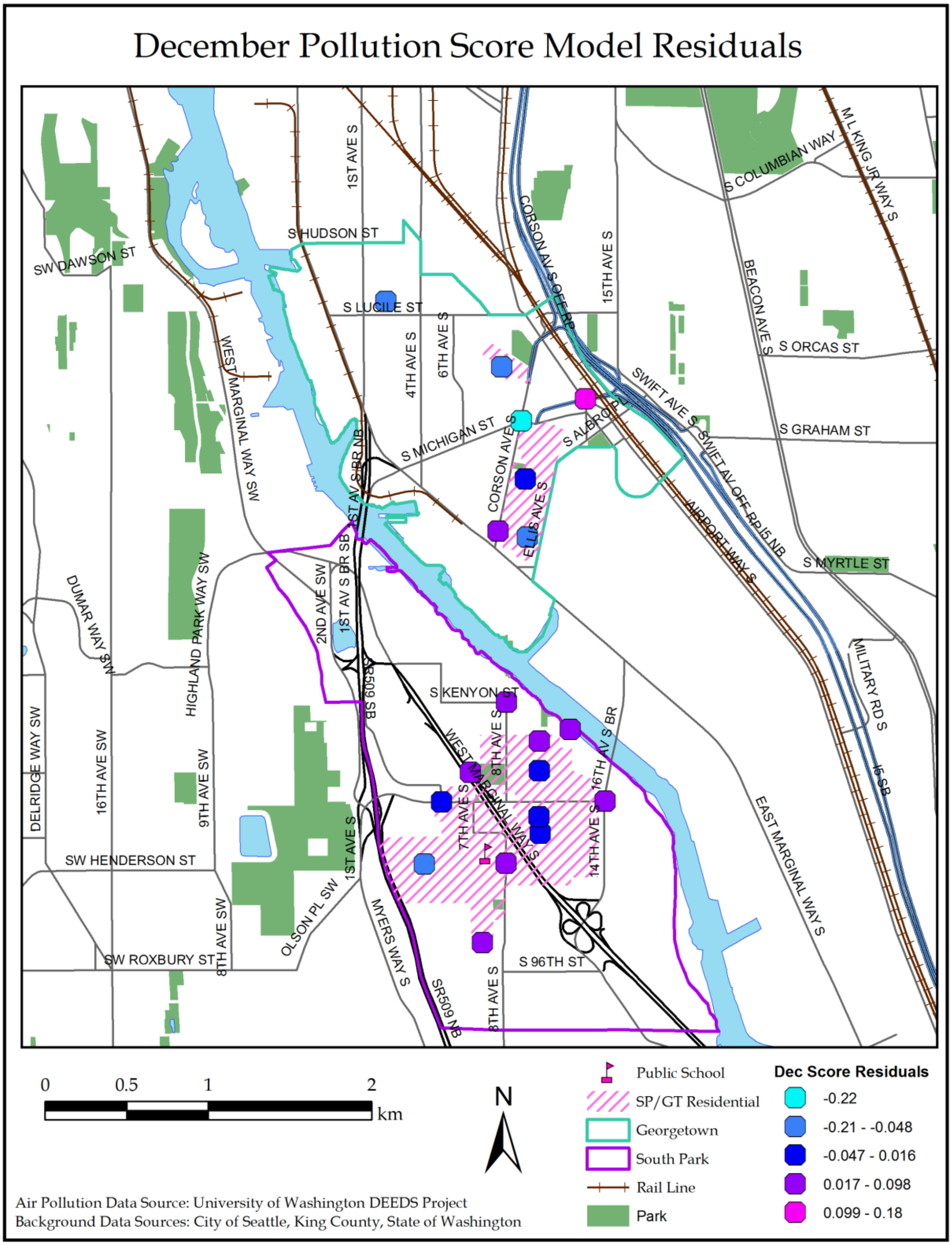


Figure A16. Map of December pollution score model residuals. Home/business sites were generalized to the nearest intersection.

SCATTERPLOTS OF PREDICTED VERSUS MEASURED VALUES

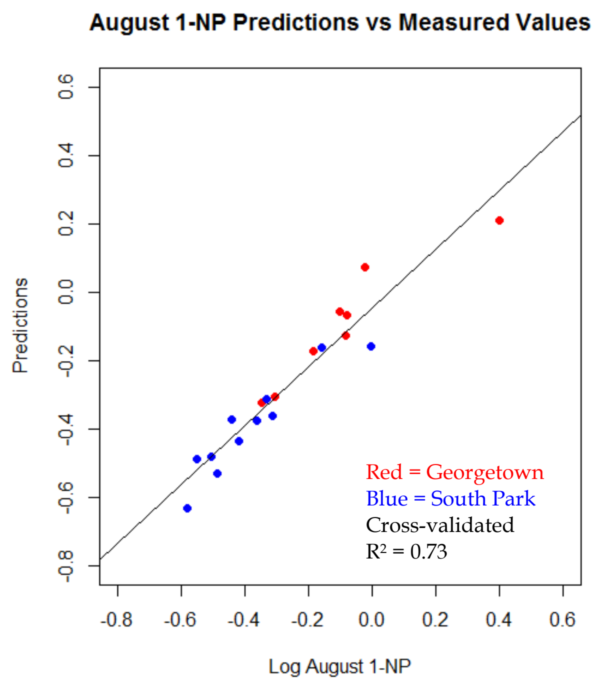


Figure A17. Scatterplot of predicted versus measured August 1-NP values

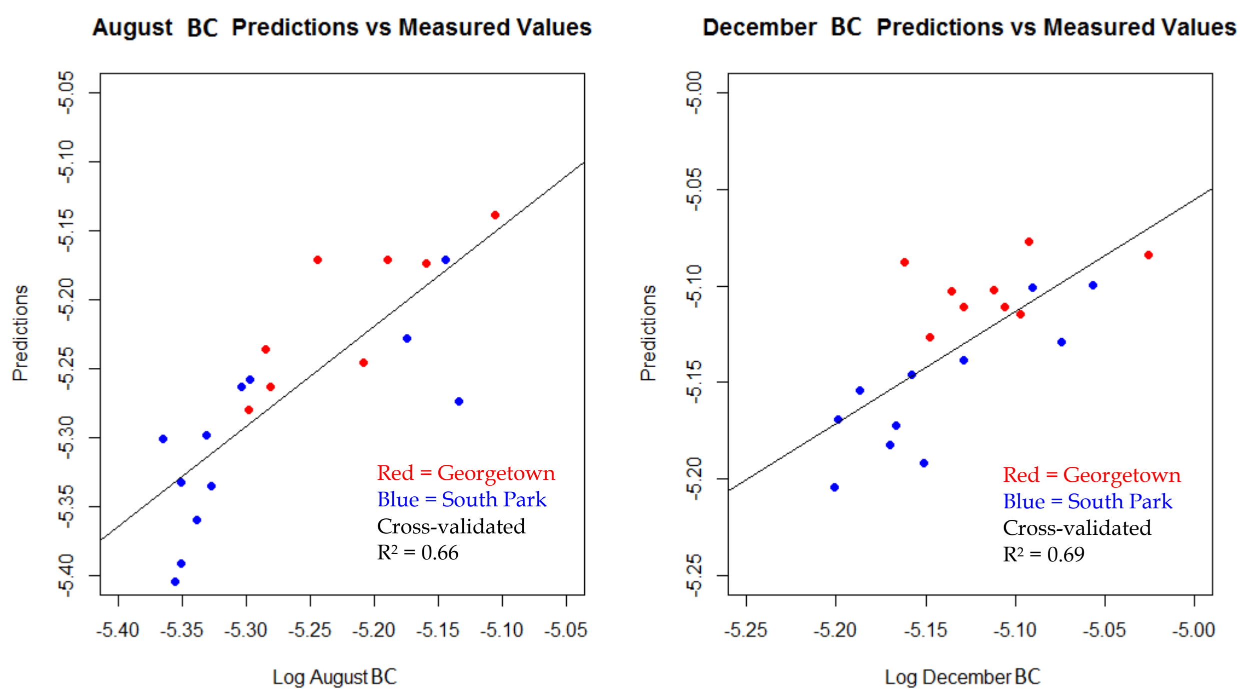


Figure A18. Scatterplots of predicted versus measured BC values

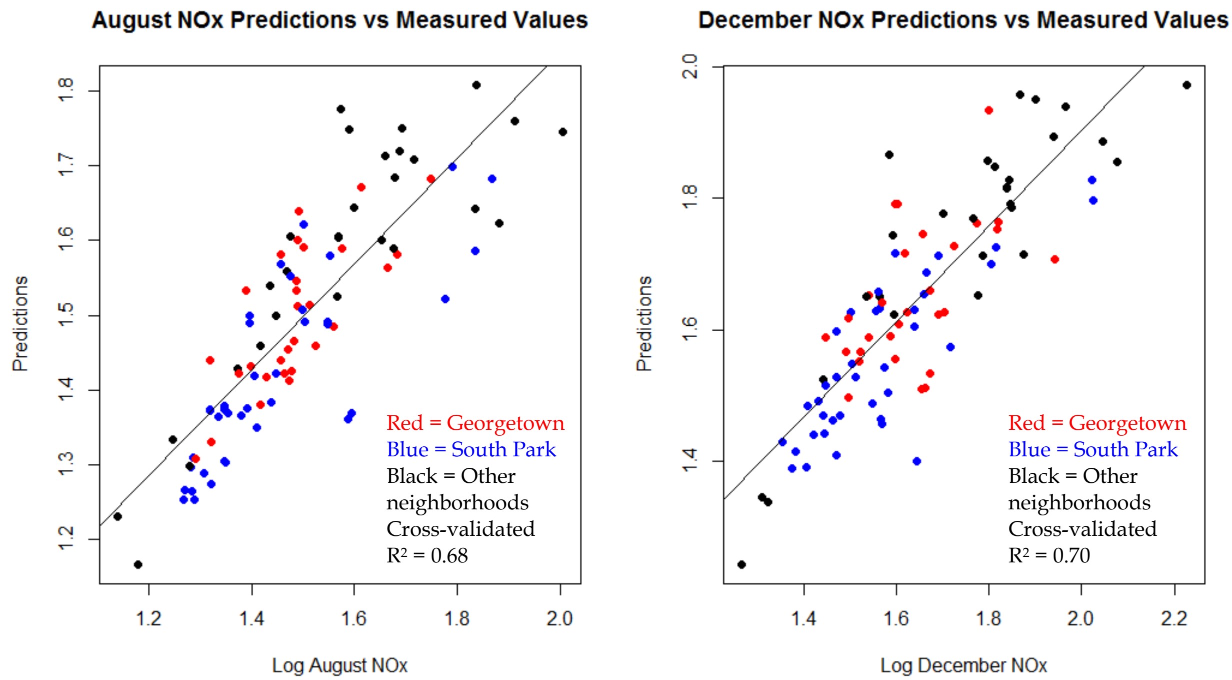


Figure A19. Scatterplots of predicted versus measured NO_x values

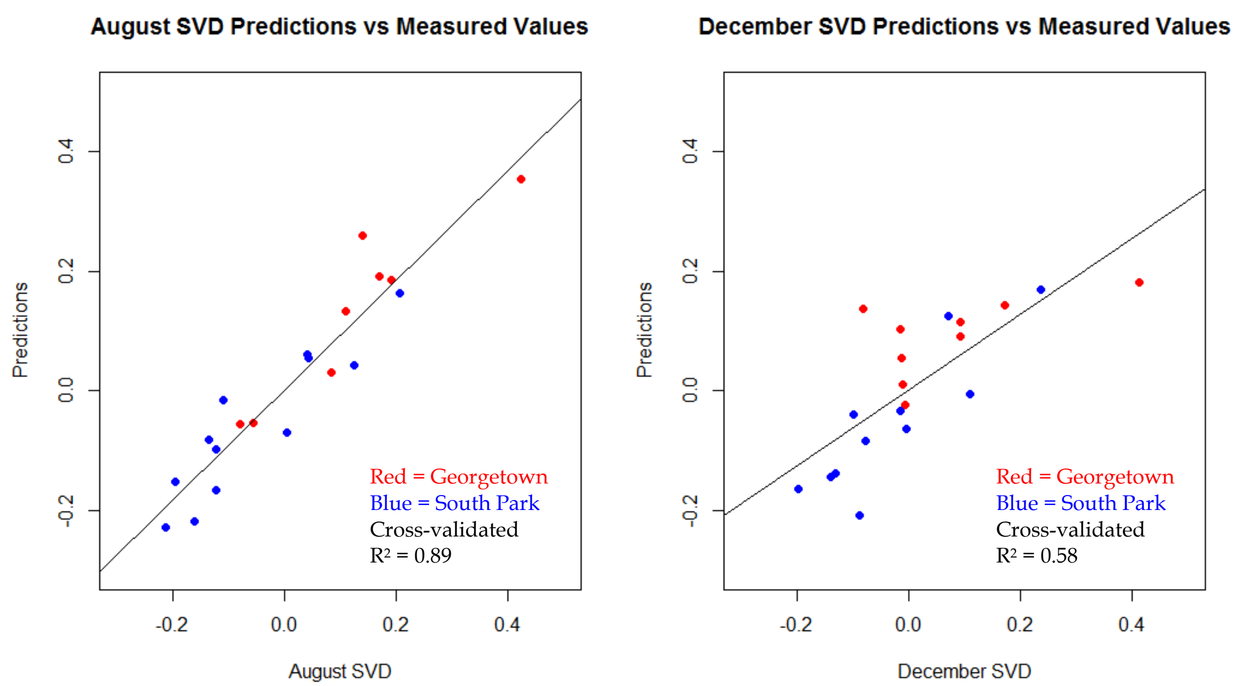


Figure A20. Scatterplots of predicted versus measured pollution score values