

Application & Methodology of using High-Resolution GPS Transit Data

PORTAL USERS GROUP MEETING
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PRESENTED BY
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Presentation Overview

- Data Discussion
 - Sources & Types of Data
 - Merging Data Sets
 - Processing for Mistakes and Outliers
 - Assumptions and Reminders
- Case Study
 - Road Diets
 - Tilikum Crossing

Data – General Transit Feed Specification

- Provides key identifying information for trips
- Stop names and features
 - Bench, Shelter, Sidewalk, Lighting, etc.
- GIS Shapefiles
 - Distances Traveled
- Trip Information
 - Stop Order, number of stops, planned/unplanned trip

Data Sources

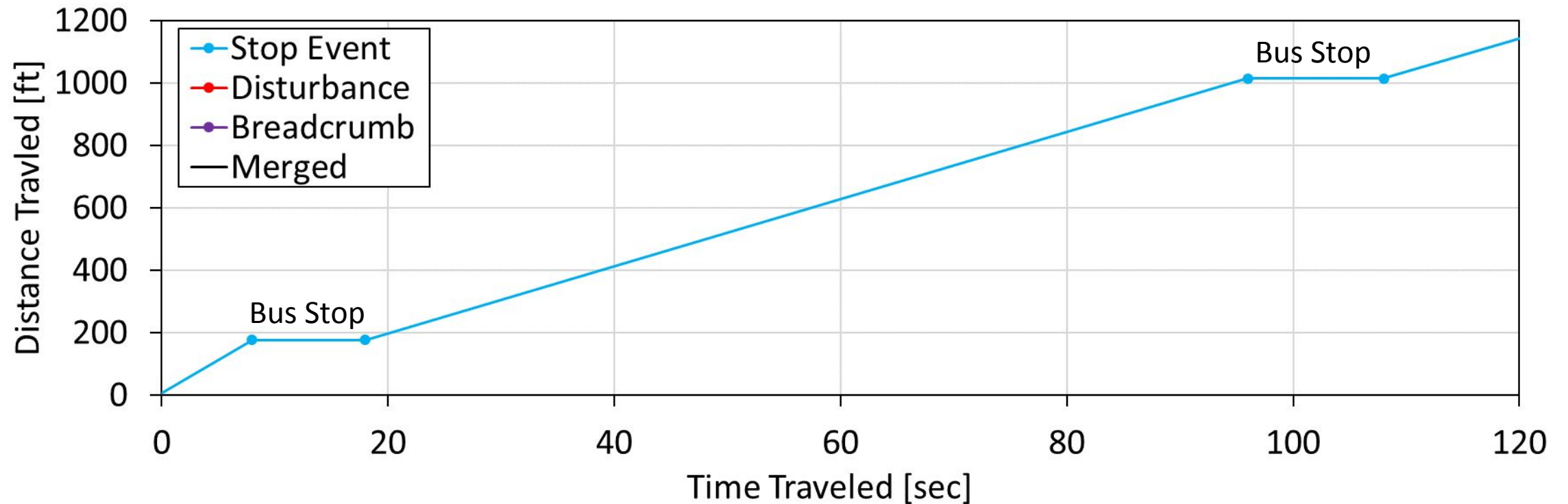
- TriMet Archived Transit Data (AVL/APC)
 - Stop Level
 - Disturbance
 - High-Resolution “Breadcrumb”
- General Transit Feed Specification (GTFS)
 - Online Archives
- Geographic Information Systems (GIS)
- The data files are HUGE (1 month = 15-20 Gb)
 - Per Weekday: 80 routes w/ 2 directions each; 6,618 bus stops; ~600 buses; ~5,280 trips; ~28,000 service stops

Data – Stop Level

- Data collected at the bus stops
 - Scheduled and Actual Time of: Arrival and Departure,
 - Boardings (Ons), Alightings (Offs), Lift Usage,
 - Estimated Load, Maximum Speed from Previous Stop
 - Door Open Times, Dwell,
 - Route, Direction, Bus Number, Date,
 - And Other Identifiers.

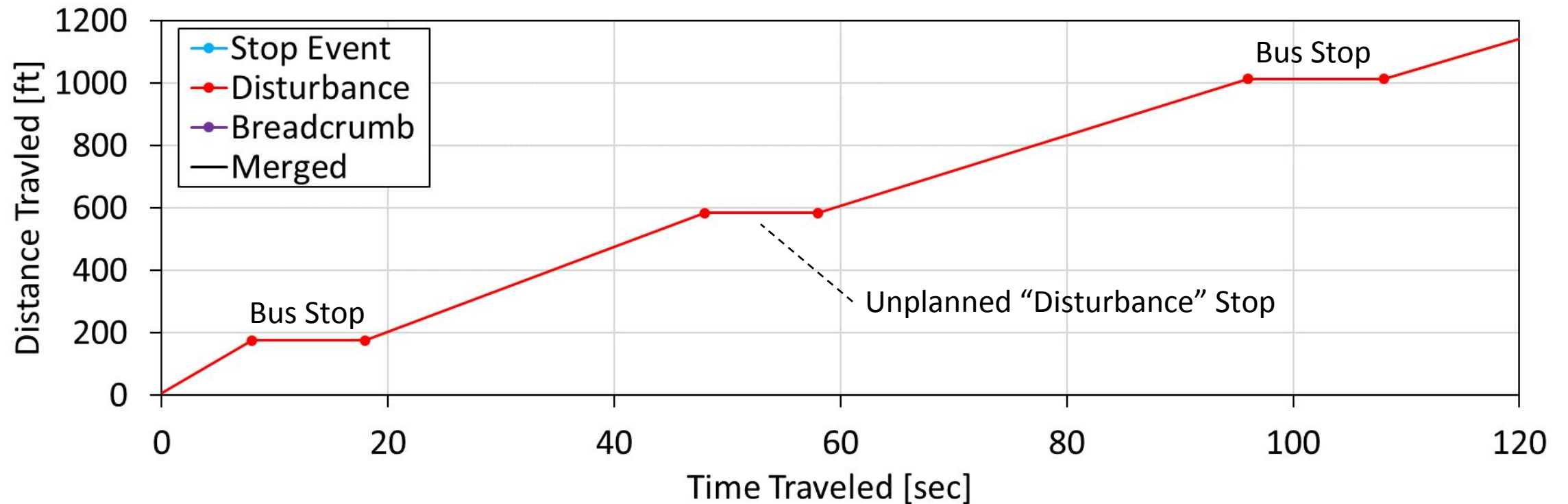
Data – Stop Level

- Data collected at the bus stops



Data – Disturbance

- Records every times the wheels stop

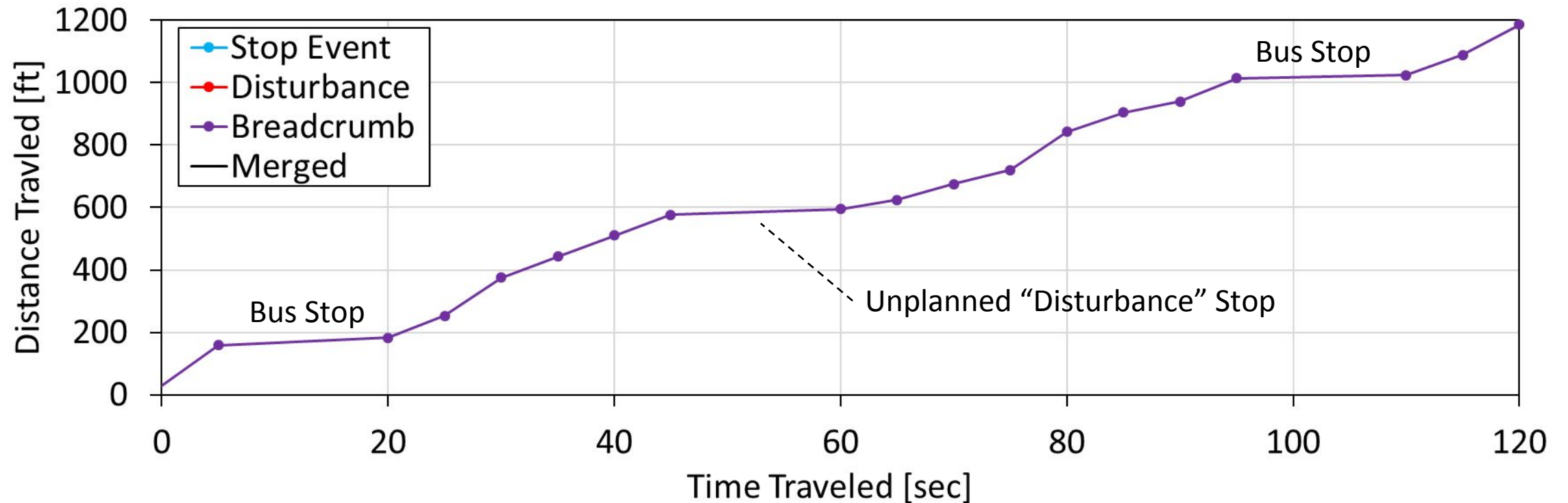


Data – High-Resolution GPS “Breadcrumb”

- 5-second resolution
 - Means “up-to 5 seconds”
- Includes GPS coordinate and Timestamp
- Doesn't record when wheels aren't moving
- Few identifiers in data
- Requires significant processing to use

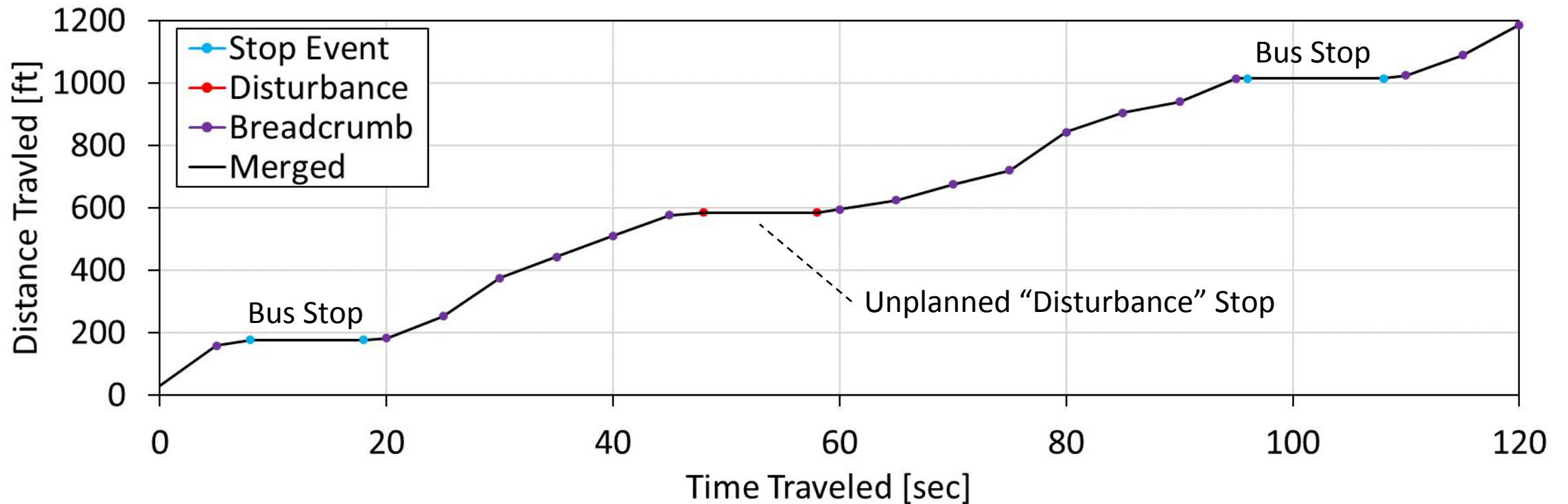
Data – High-Resolution GPS “Breadcrumb”

- Records when wheels are moving



Data – Merging Data Sets

- Each data set provides something different



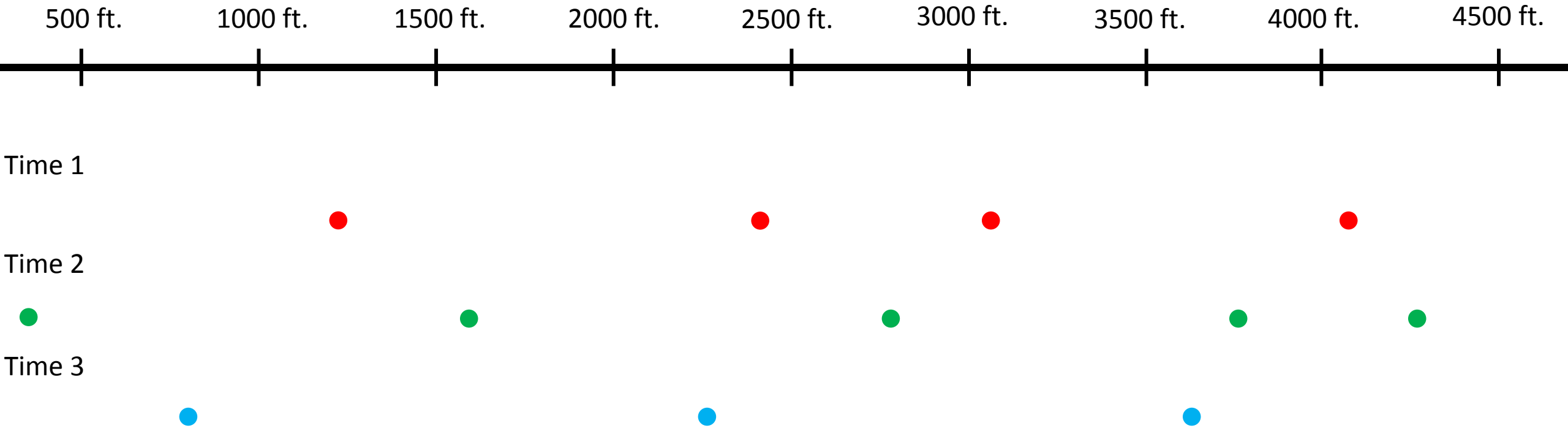
Processing Data – Headers

- Data Headers are NOT the same!!!
 - OPD_DATE = SERVICE_DATE
 - ROUTE = ROUTE_NUMBER
 - DIRECTION = DIR
- Data Headers are NOT consistent!!!
 - Headers change from month to month
 - Some may be missing or added
- To merge data sets, headers of identical data need to be identical
- Codes need to be customized

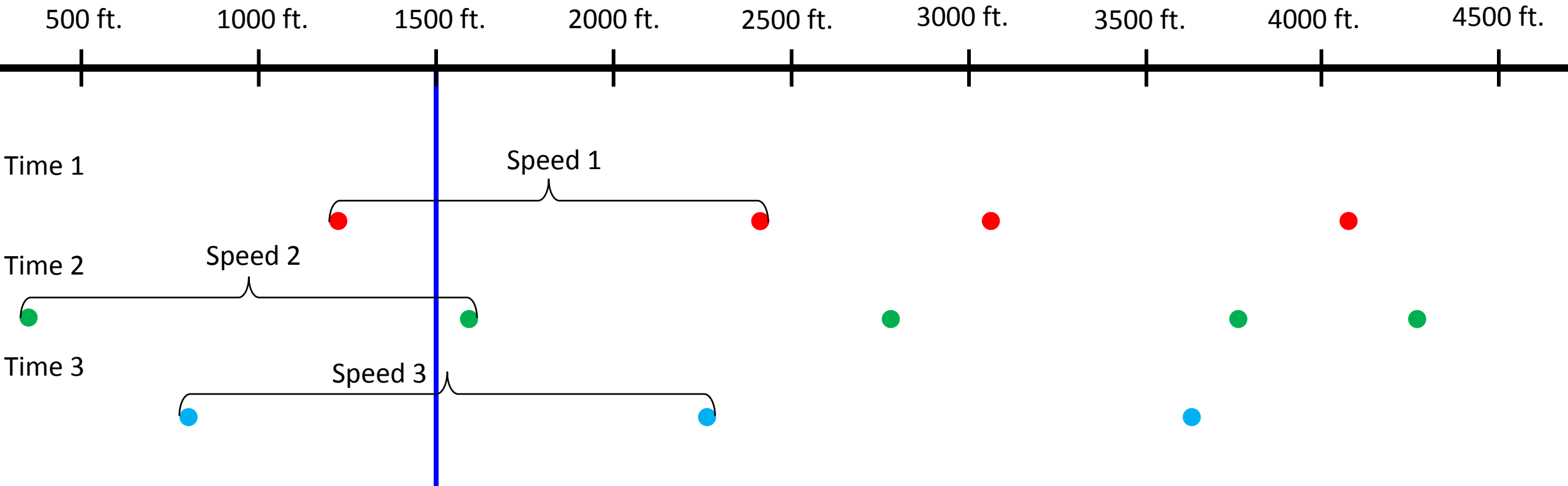
Processing Data – Mistakes and Outliers

- Deadhead trips must be excluded
- Data has a lot of mistakes
 - Broken Passenger Counters
 - ~ 9% of buses*
 - *Changes over time and by route, bus, etc.
 - Load greater than maximum capacity
 - Extreme values for Ons and Offs
- Bad GPS coordinates
- Broken buses
 - Long Dwells

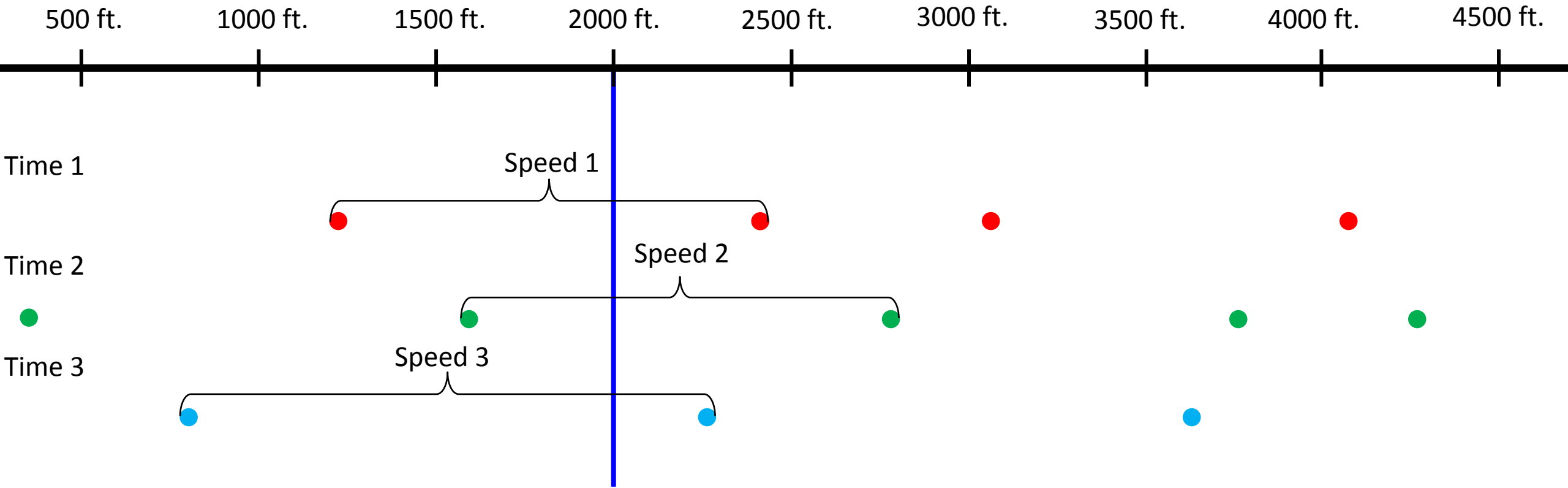
Processing Data – Speeds



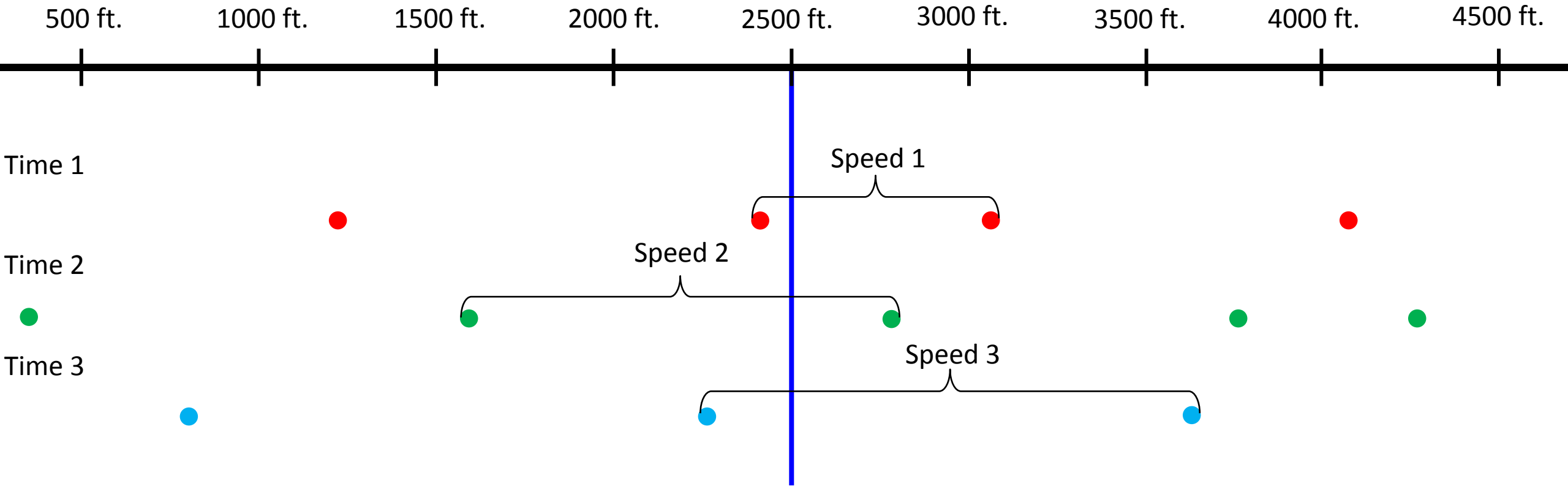
Processing Data – Speeds



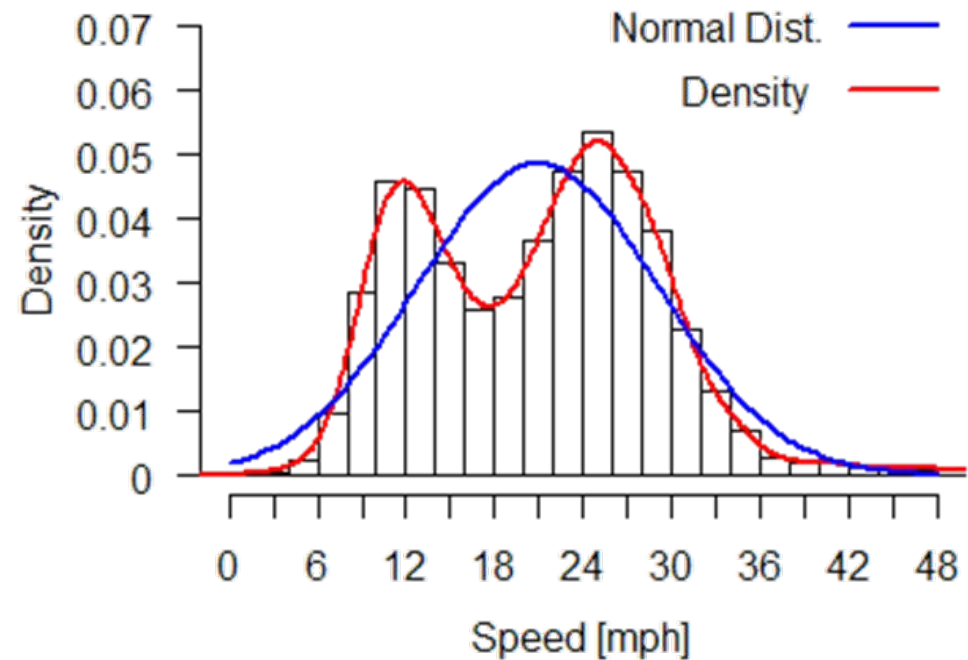
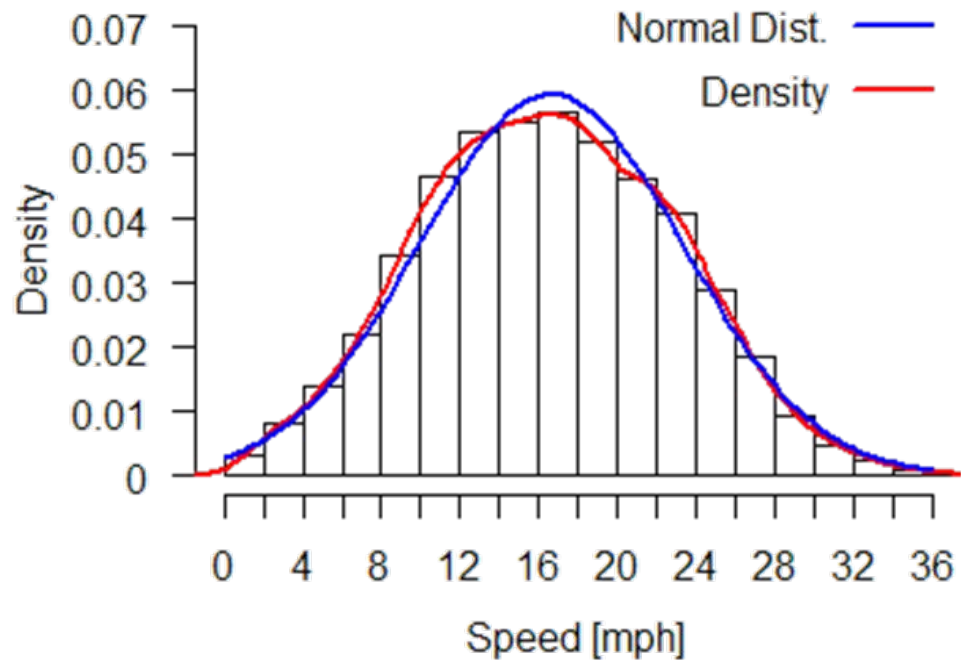
Processing Data – Speeds



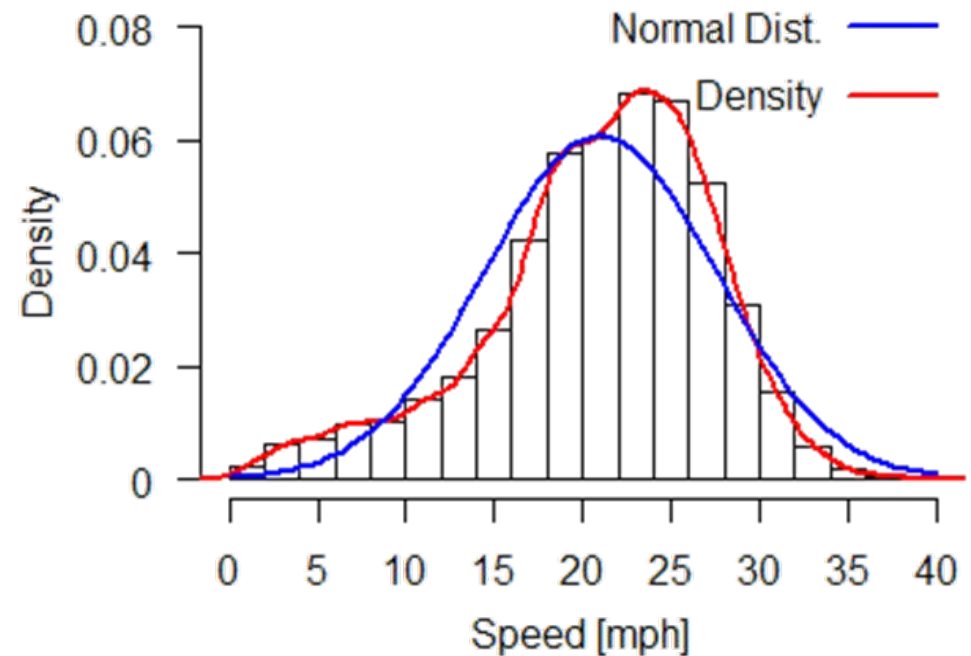
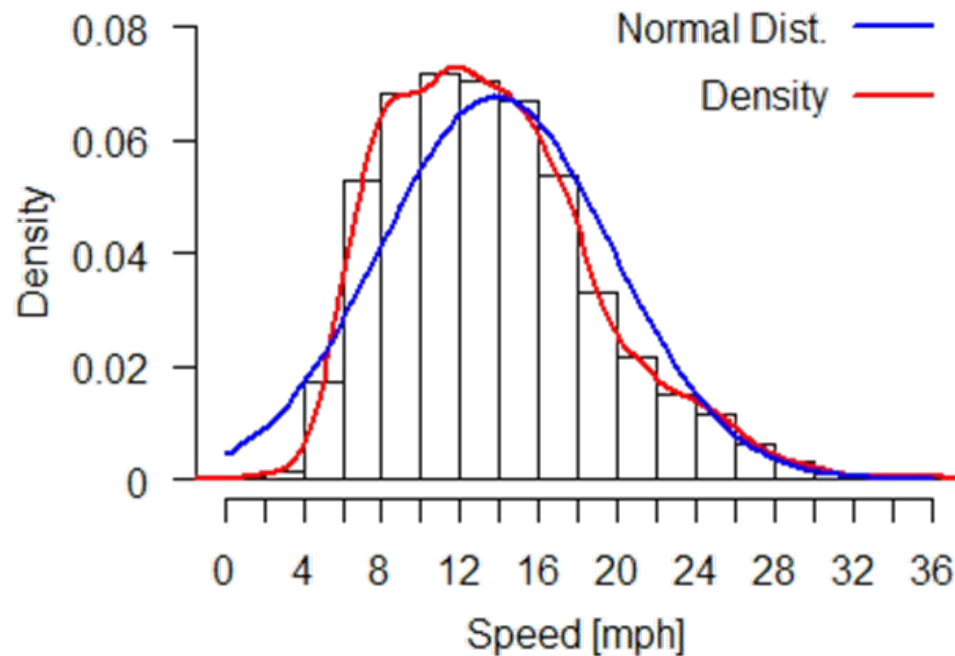
Processing Data – Speeds

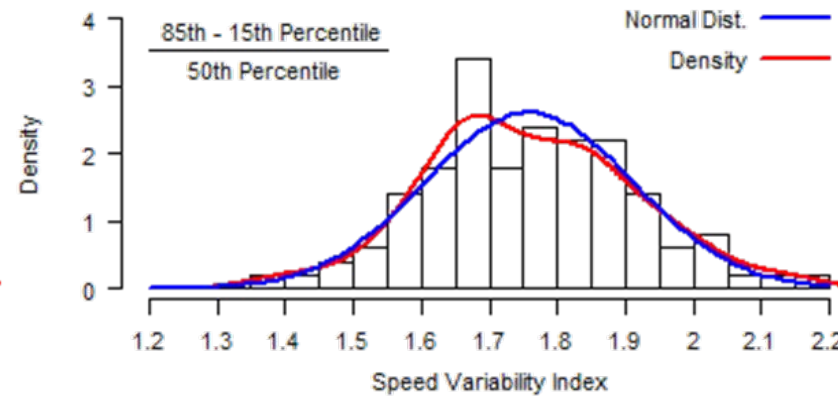
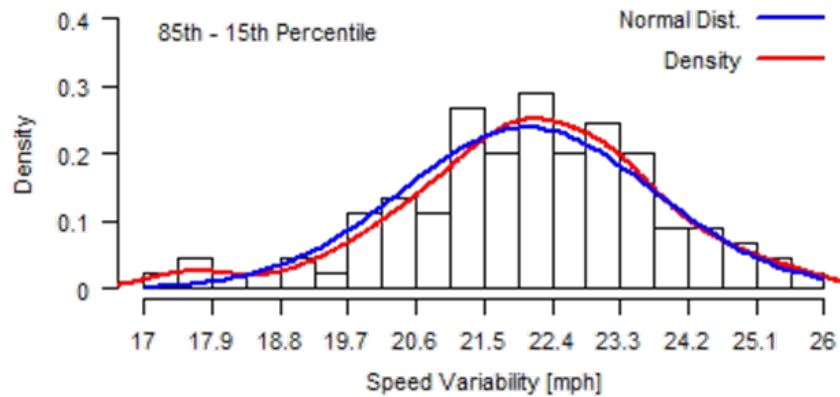
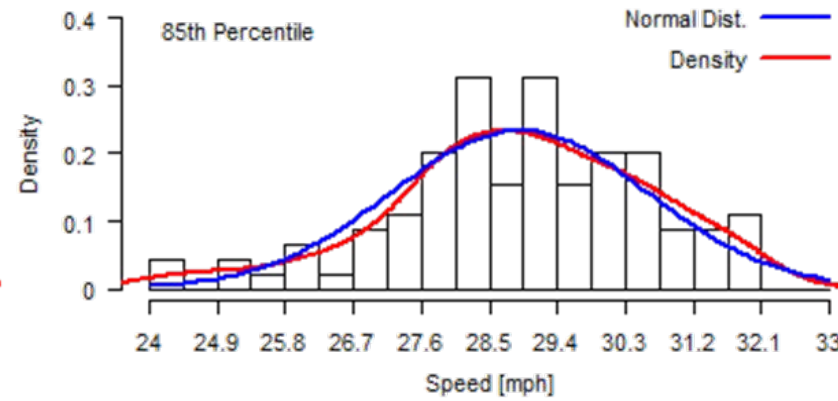
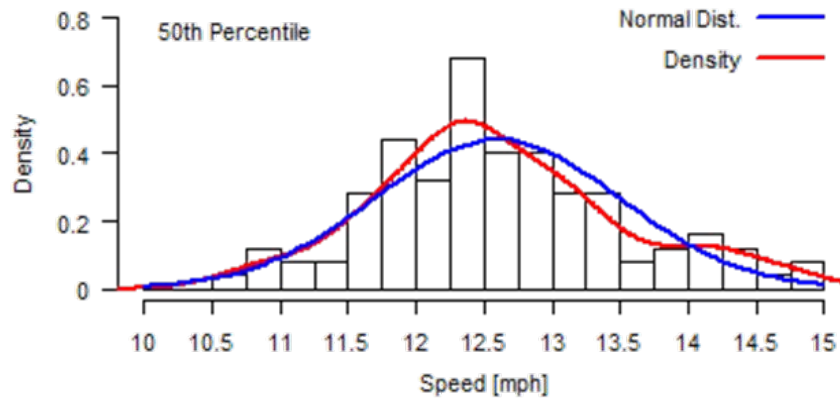
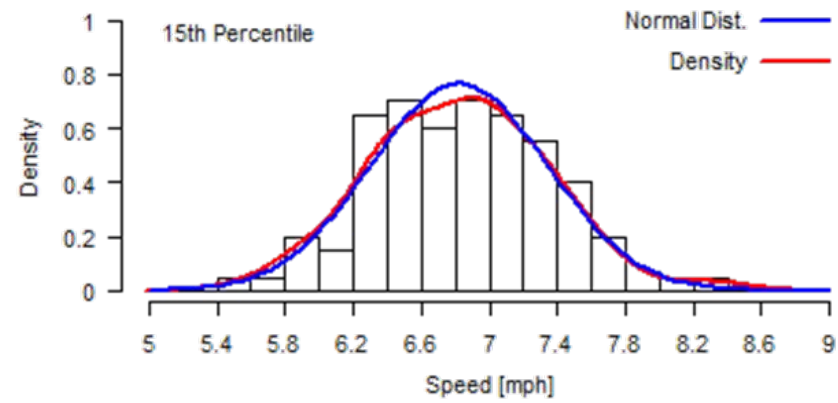
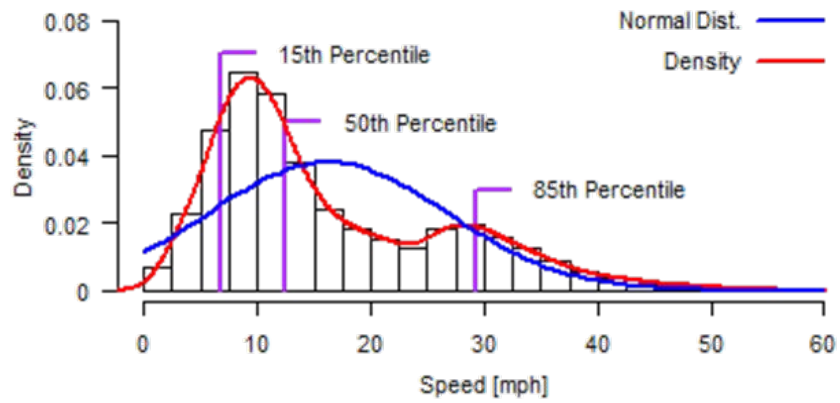


Processing Data – Normality Assumptions



Processing Data – Normality Assumptions





Processing Data – Propagation of Errors

- Statistics come with error
- Error (from source 1) + Error (from source 2) = more error
 - But not linearly

- Known formula for estimates when

- Adding or subtracting values

$$\sigma_q = \sqrt{\sigma_{x_1}^2 + \dots + \sigma_{x_N}^2}$$

- Multiplying or dividing values

$$\frac{\sigma_q}{|q|} = \sqrt{\left(\frac{\sigma_{x_1}}{x_1}\right)^2 + \dots + \left(\frac{\sigma_{x_N}}{x_N}\right)^2 + \left(\frac{\sigma_{y_1}}{y_1}\right)^2 + \dots + \left(\frac{\sigma_{y_M}}{y_M}\right)^2}$$

- These assume independence of data sources
 - (small problem) The data is not independent

Processing Data – Propagation of Errors

- In graphics, the thickness of lines is confidence interval
 - Determined by propagation of error estimates

- Correlation and Covariance

- $85^{\text{th}} - 15^{\text{th}}$
$$\sigma_{\Delta v_{ij}} = \sqrt{\sigma_{i,85}^2 + \sigma_{i,15}^2 - 2 \cdot \text{Cov}(v_{i,85}, v_{i,15})}$$

- 85^{th} (after) – 85^{th} (before)
$$\delta\sigma_{v_{i,85}} = \sqrt{\sigma_{v_{i,85},1}^2 + \sigma_{v_{i,85},0}^2 - 2 \cdot \text{Cov}((v_{i,85})_1, (v_{i,85})_0)}$$

- $(85^{\text{th}} - 15^{\text{th}}) / 50^{\text{th}}$
$$\frac{\sigma_{\mu_i}}{\mu_i} \sim \sqrt{\frac{\sigma_{i,85}^2 + \sigma_{i,15}^2 - 2 \cdot \text{Cov}(v_{i,85}, v_{i,15})}{(v_{i,85} - v_{i,15})^2} + \left(\frac{\sigma_{i,50}}{v_{i,50}}\right)^2 - 2 \cdot \frac{\text{Cov}(v_{i,85} - v_{i,15}, v_{i,50})}{(v_{i,85} - v_{i,15}) \cdot v_{i,50}}}$$

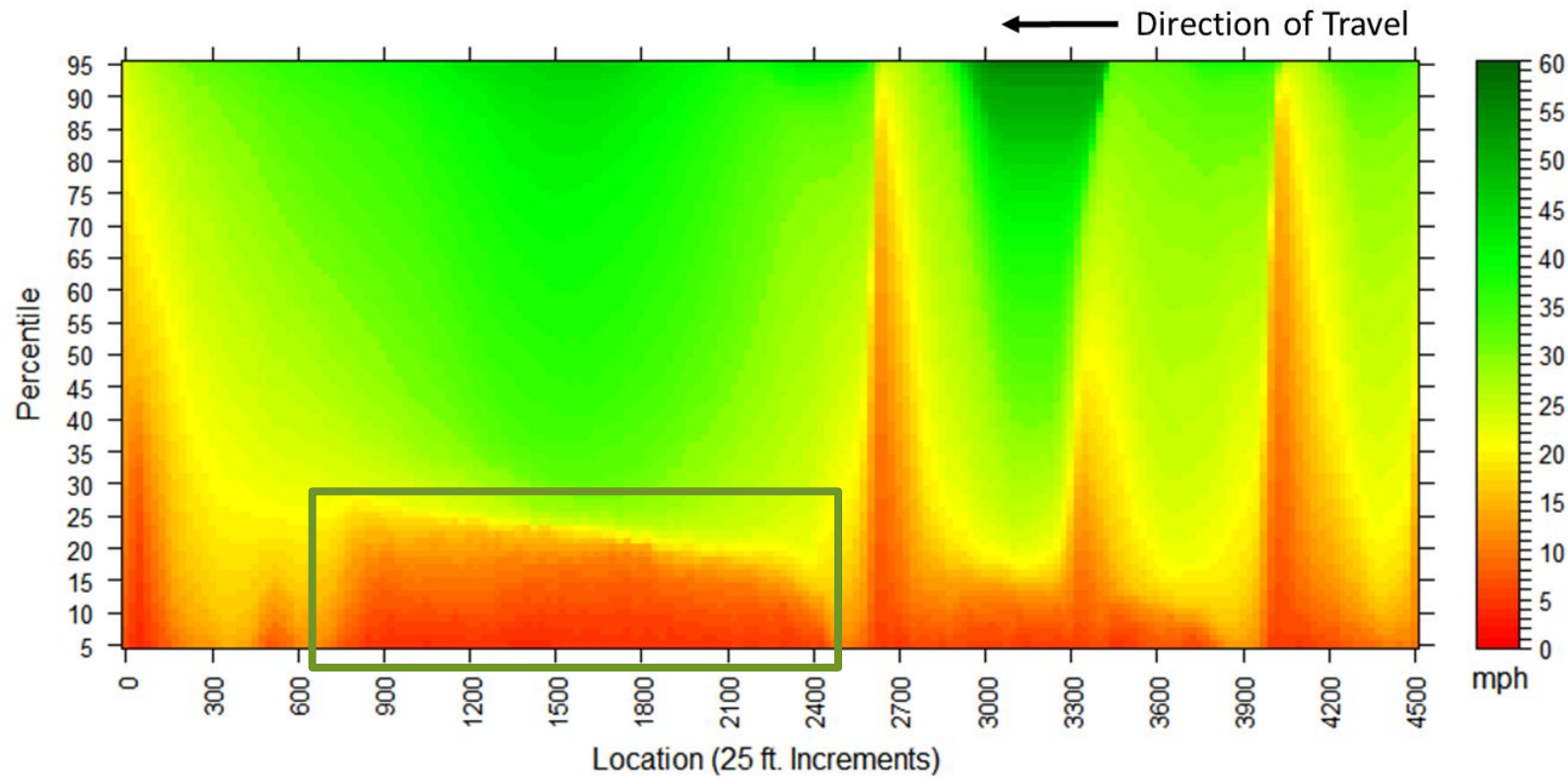
Processing Data – Recap

- Data files are HUGE
 - Need LOTS of external storage
 - As much computer memory as you can
- Each type of data has different identifying information
 - Multiple sources are needed to merge files
- Data files are inconsistent and have mistakes
- **Codes require regular upkeep to continue working**
- Keep an up-to-date Data Dictionary

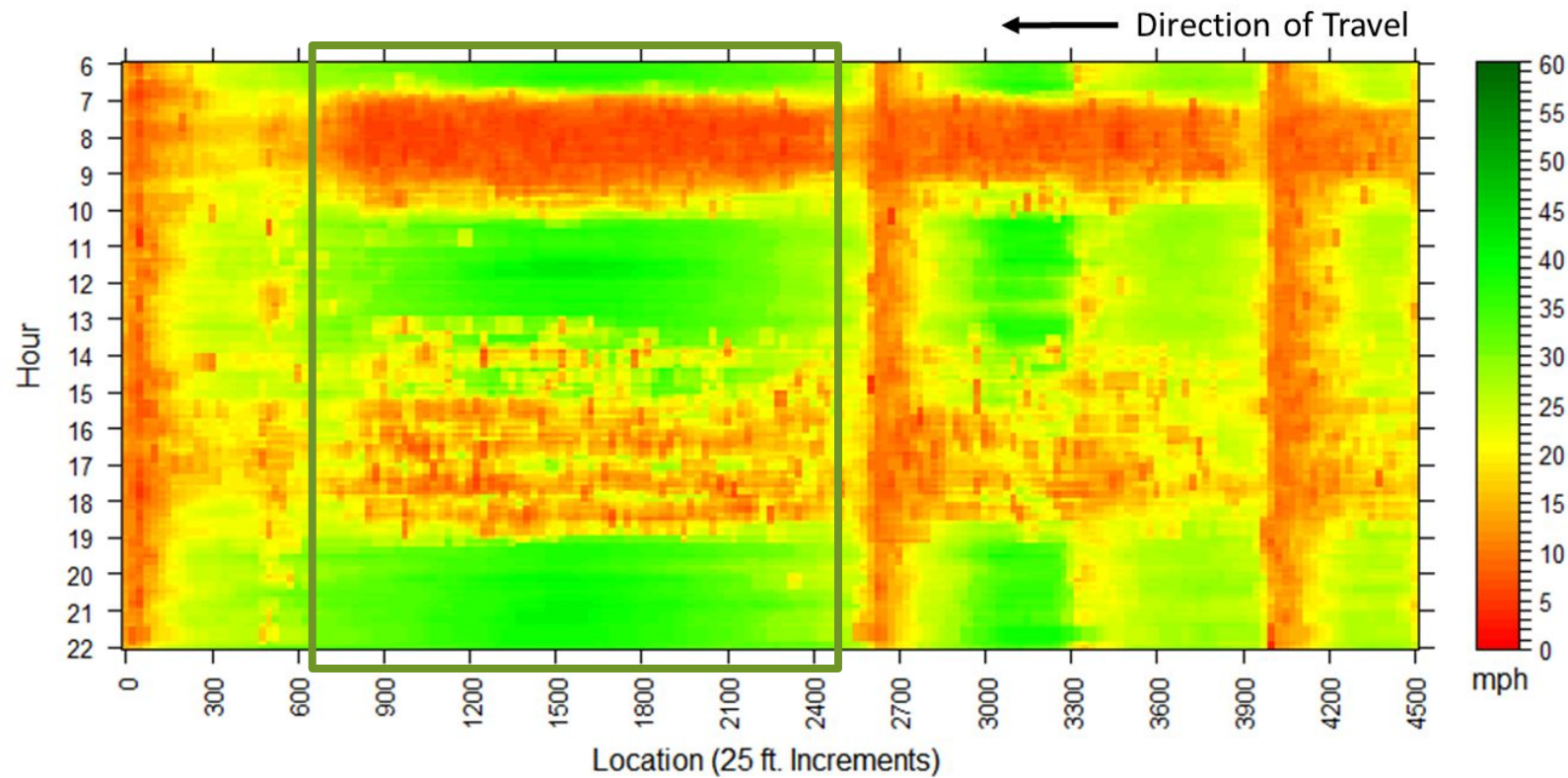
Previous Application

- Quantify changes to a roadway
 - Inform future decisions
- Determine the impact of road diets on transit
 - Traditionally excluded
 - Understudied
- Examine effect of new Transit only bridge
 - Evaluate performance of transit
- Another use for transit high-resolution data

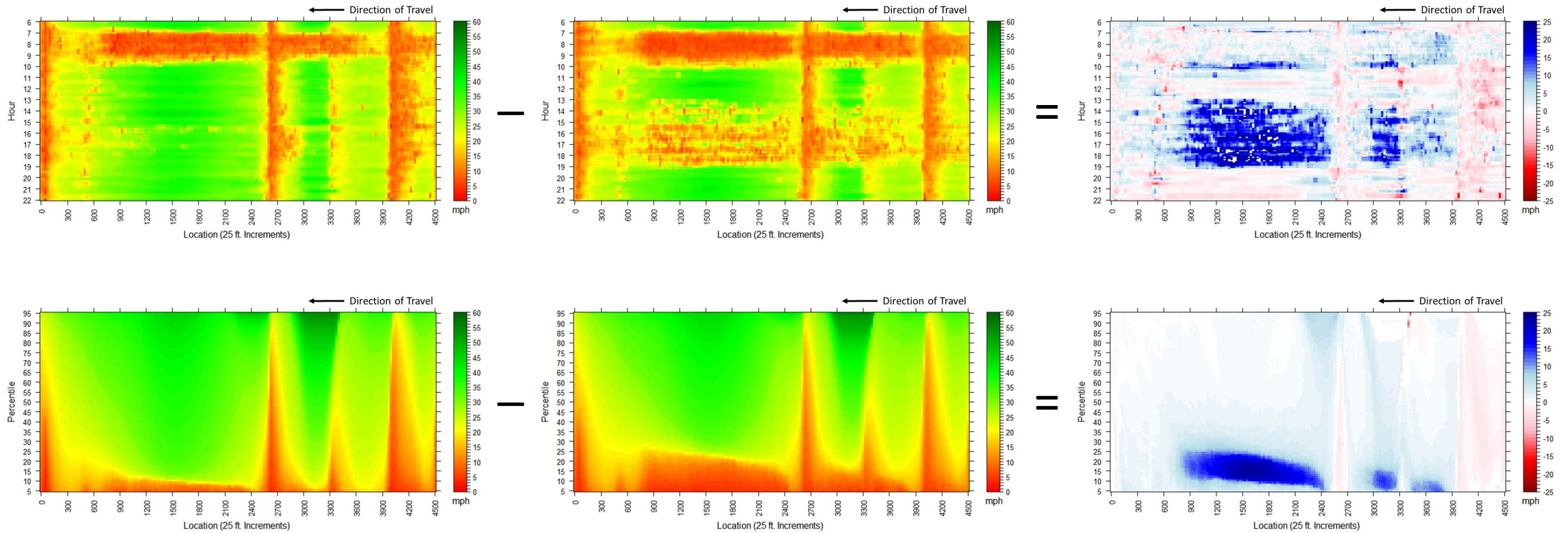
Percentiles



Time of Day



After minus Before equals Difference

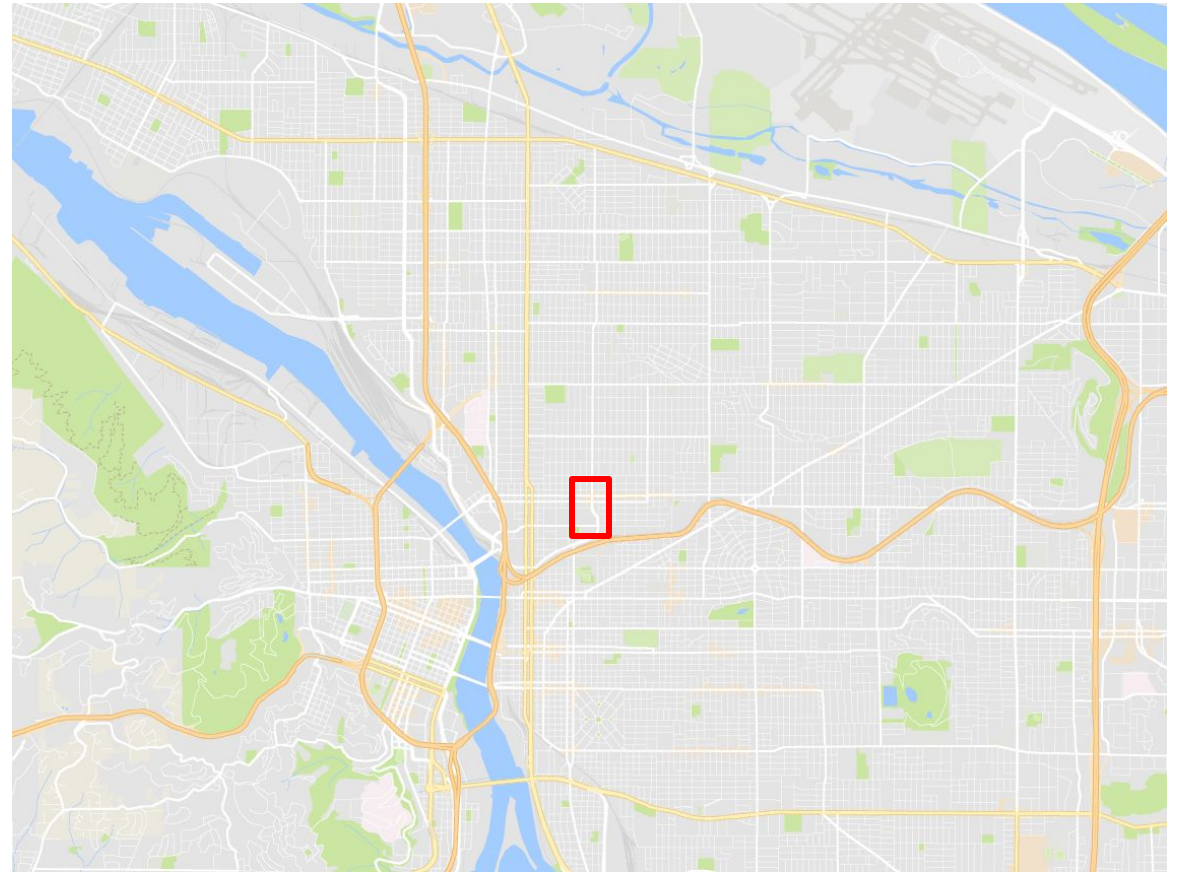


Road Diets

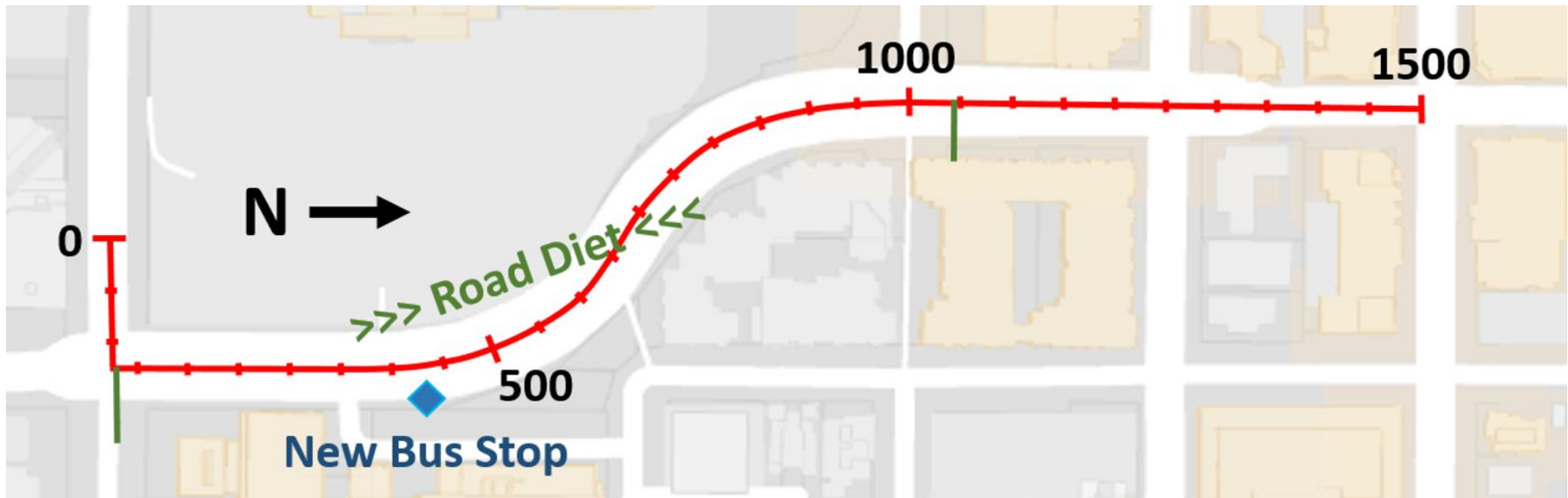
- Reduce the width or number of travel lanes to add:
 - Bike lanes
 - Bike buffers
 - Transit lanes
 - Center turn lanes
- Reduce travel speeds
- Increase safety

When and Where

- Portland, OR
- 16th Street (road diet)
 - Before: June and July 2015
 - After: July and August 2016
- Lane reduction project
 - Added Bike buffers
 - Low-moderate volumes



Study Area: 16th Street

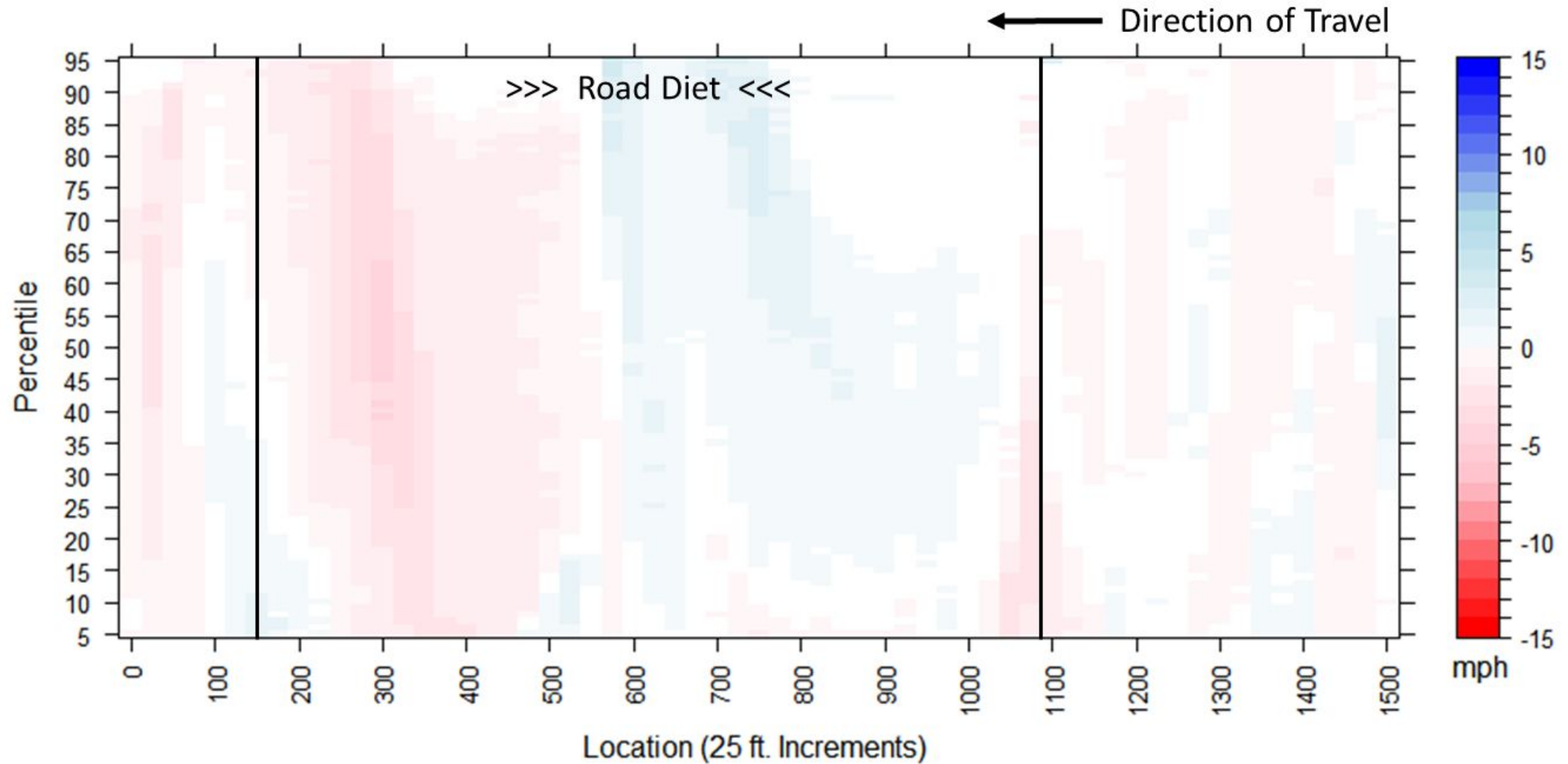




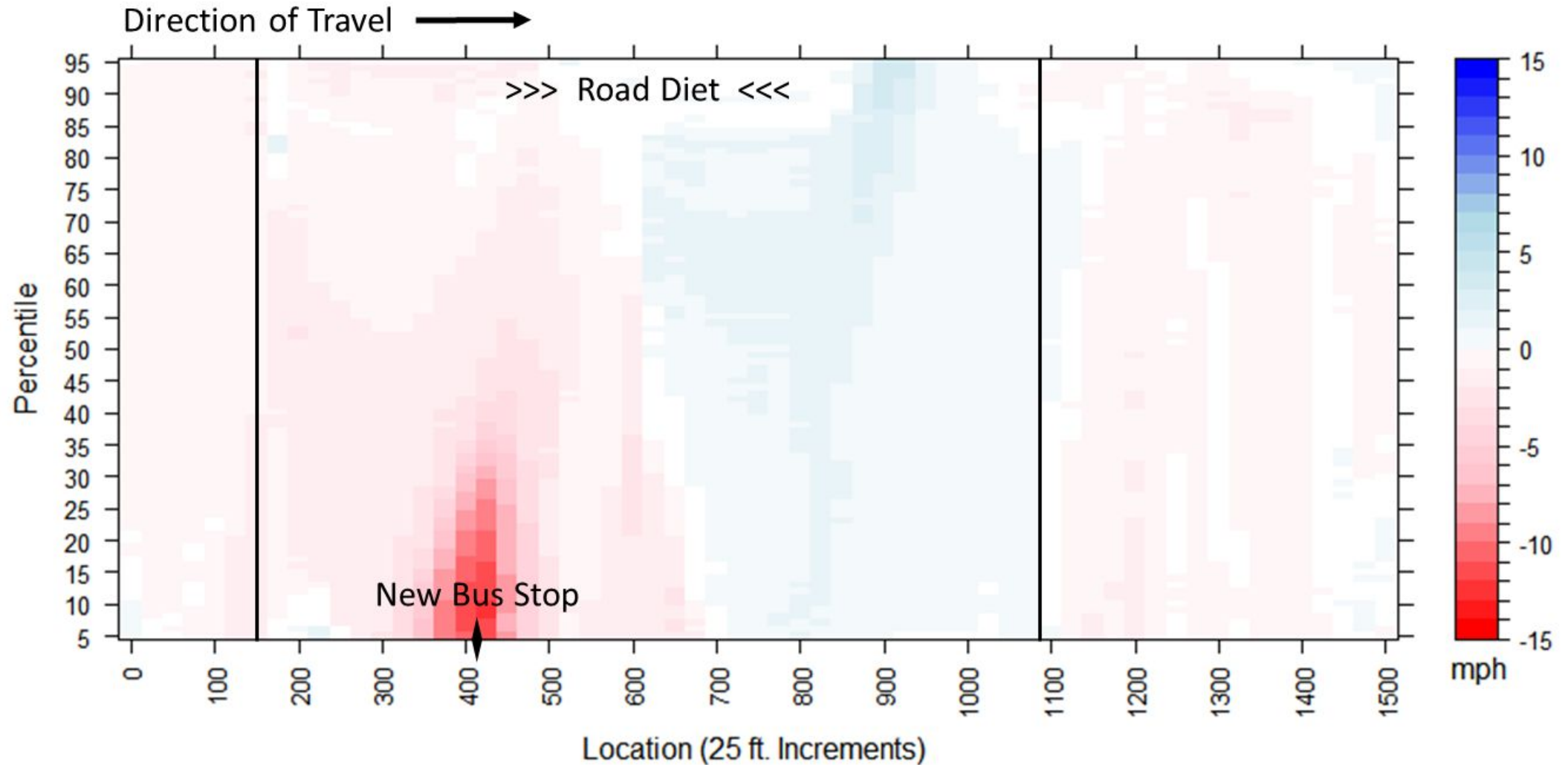
Before



Study Area: 16th Street



Study Area: 16th Street



Road Diets

- Do road diets increase congestion for buses?
 - No.
- Neither does it decrease congestion
- Added stops will slow down regular traffic

Study Area: Tilikum Crossing

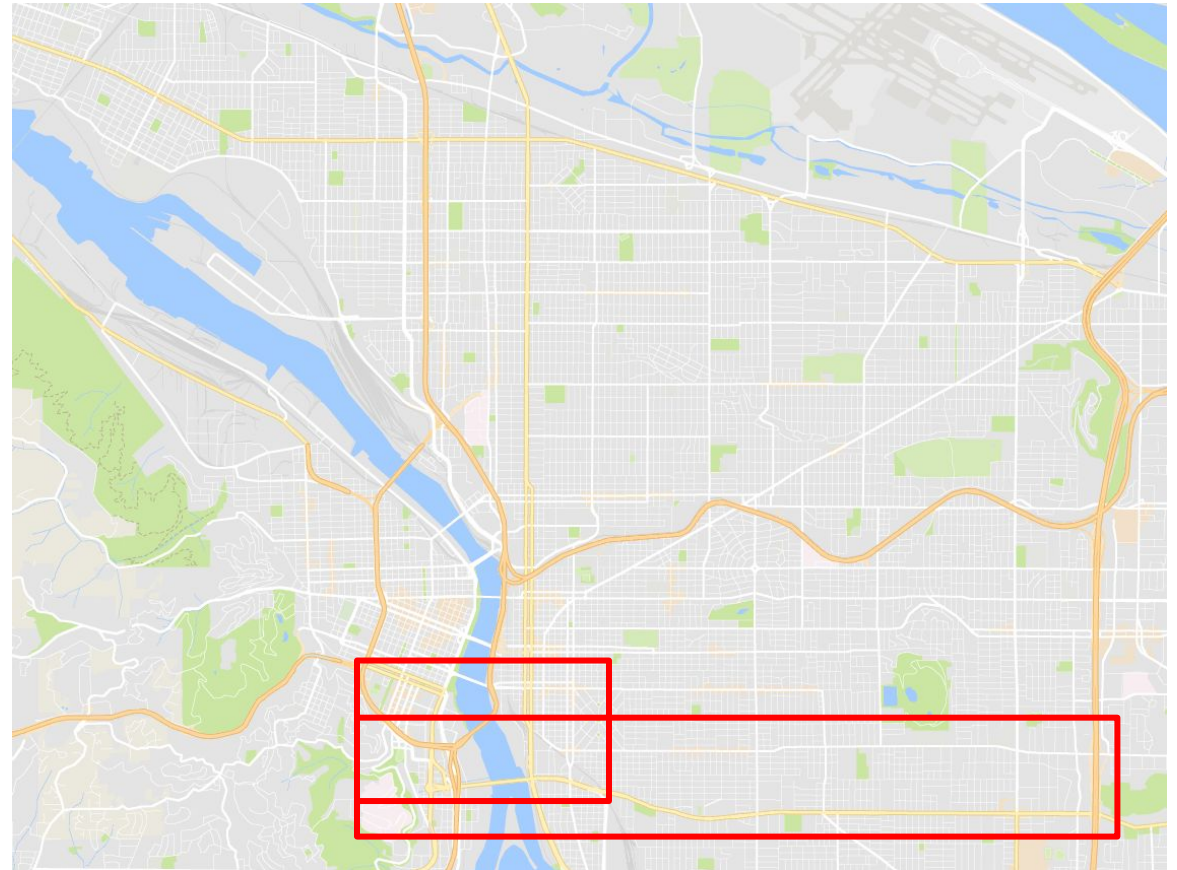
- Largest Vehicle Free bridge in the United States
- Carries:
 - Light Rail
 - Buses
 - Street Car
 - Bikes
 - Pedestrians



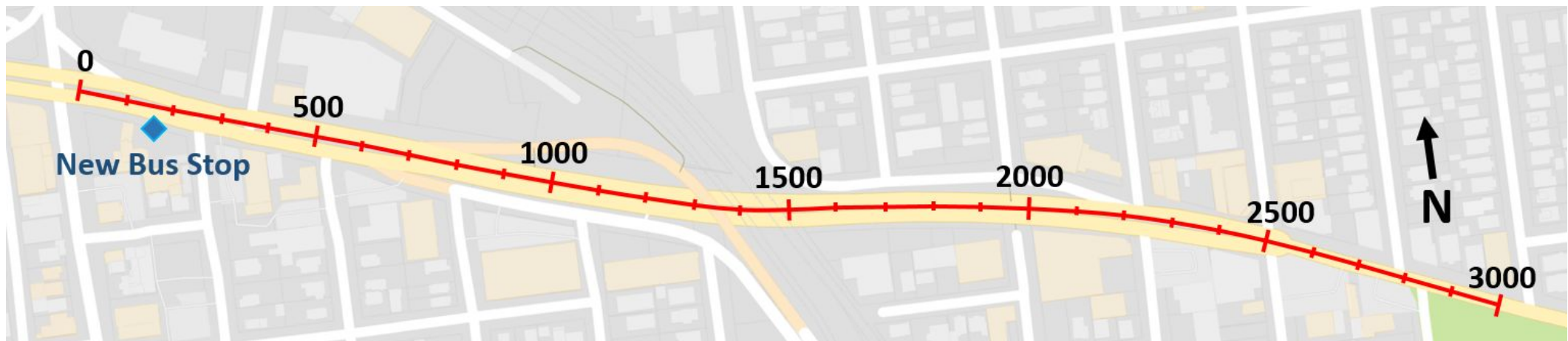
http://www.hntb.com/HNTB/media/HNTBMediaLibrary/Expertise/Tilikum_Crossing_042web_1.jpg?ext=.jpg

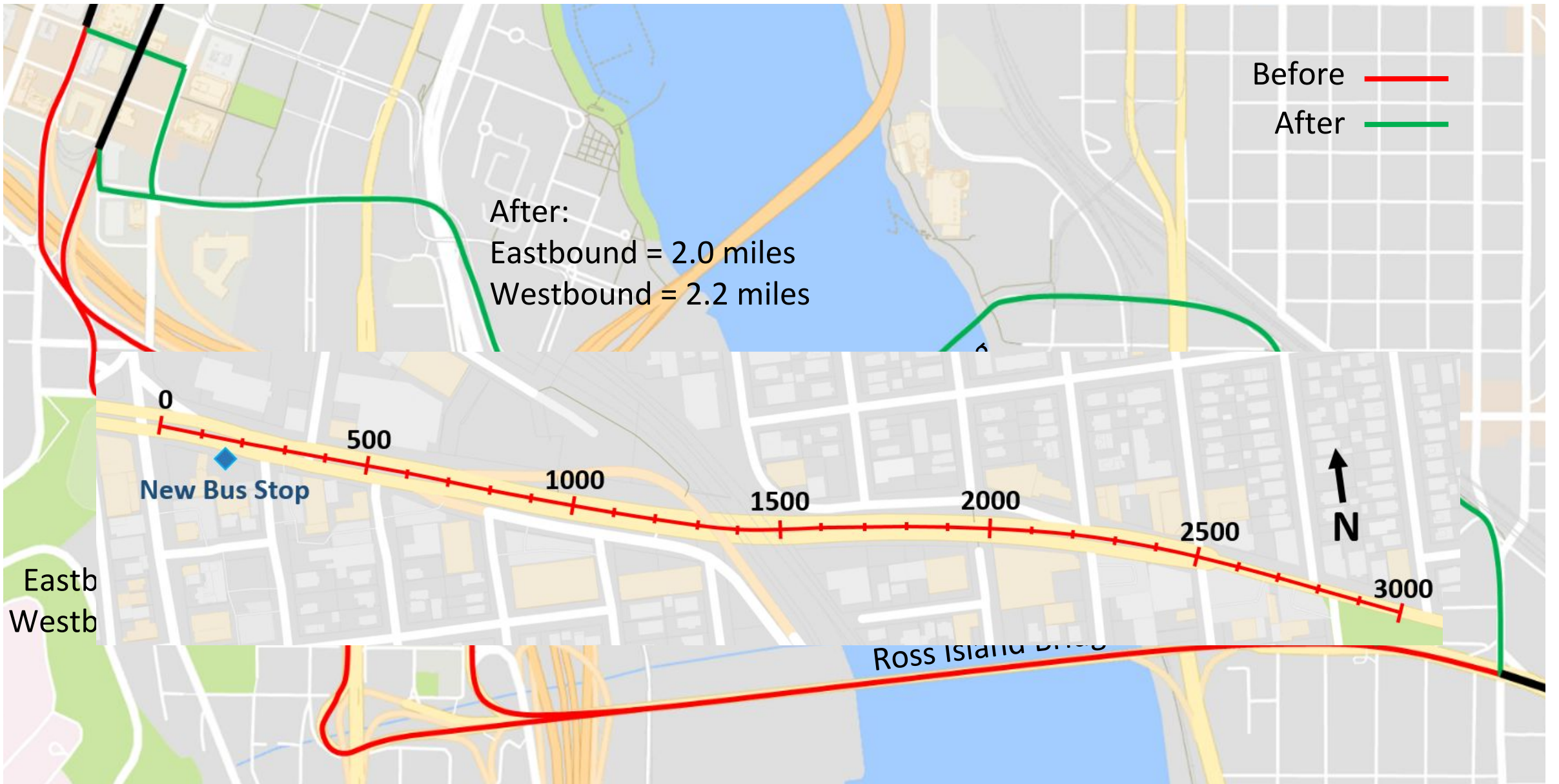
The When and Where

- Portland, OR
- Powell Blvd and Route 9
 - Before: September 2014
 - After: August 2016

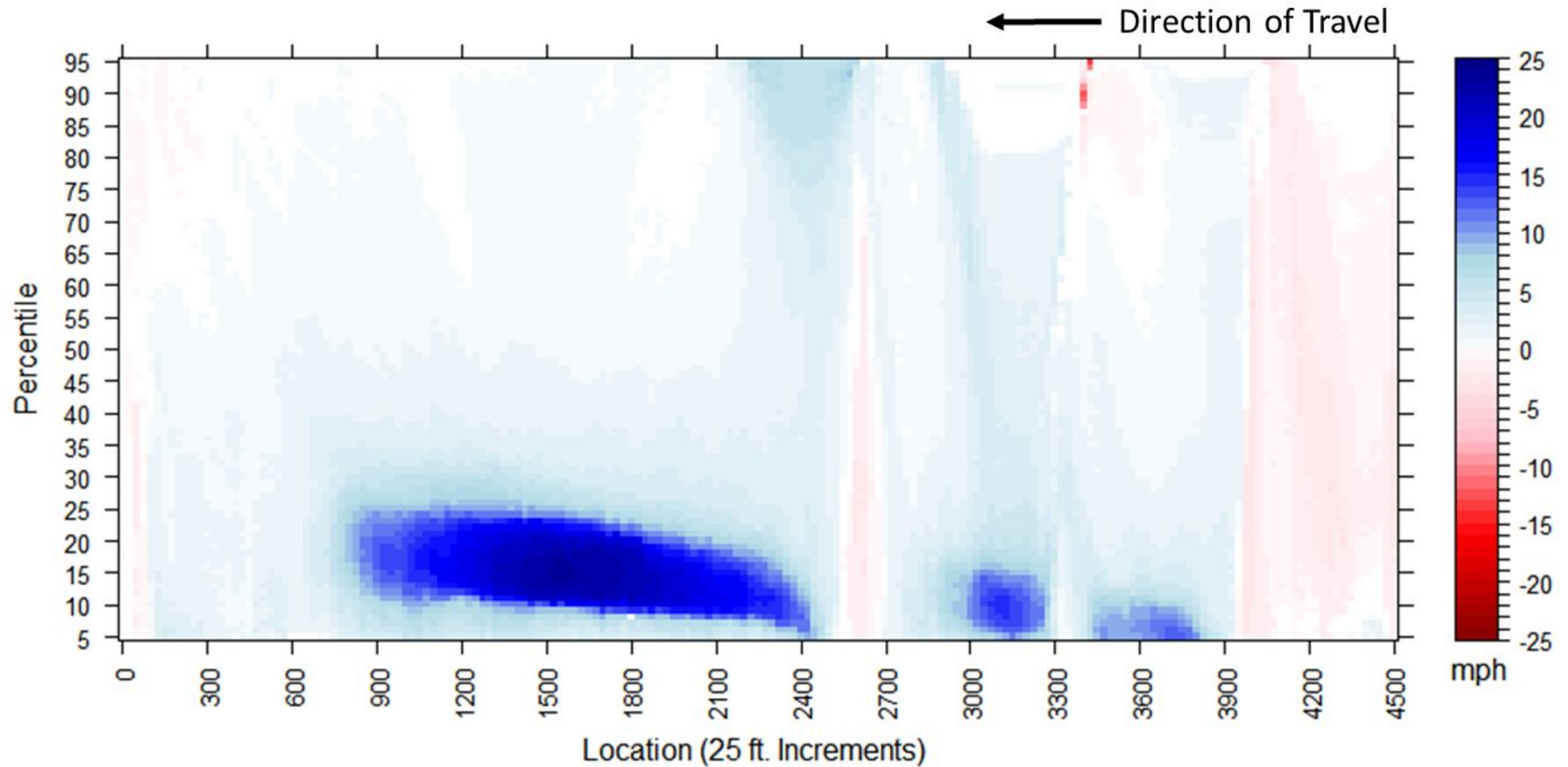


Study Area: Tilikum Crossing

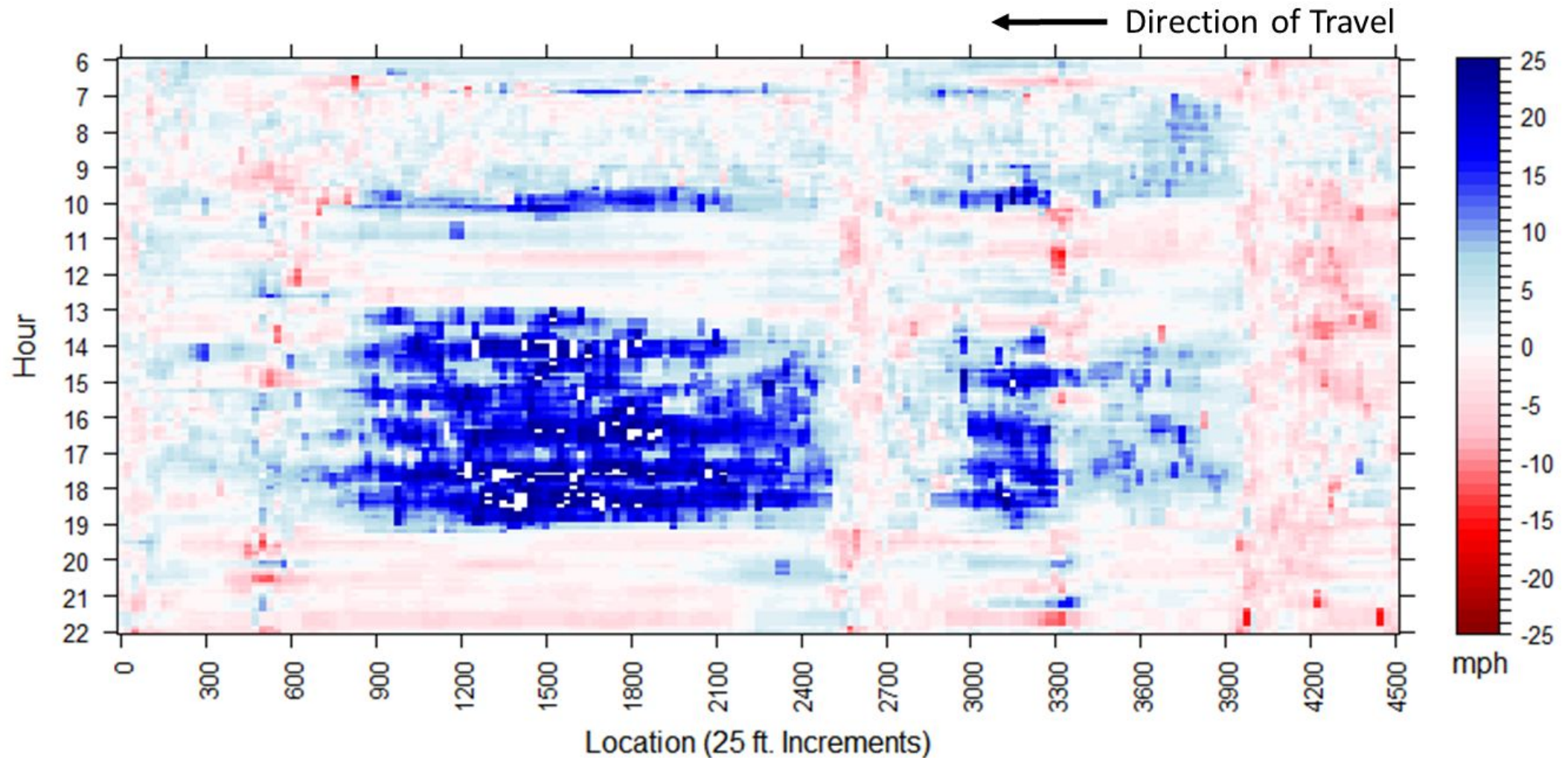




Study Area: Eastside of Bridge

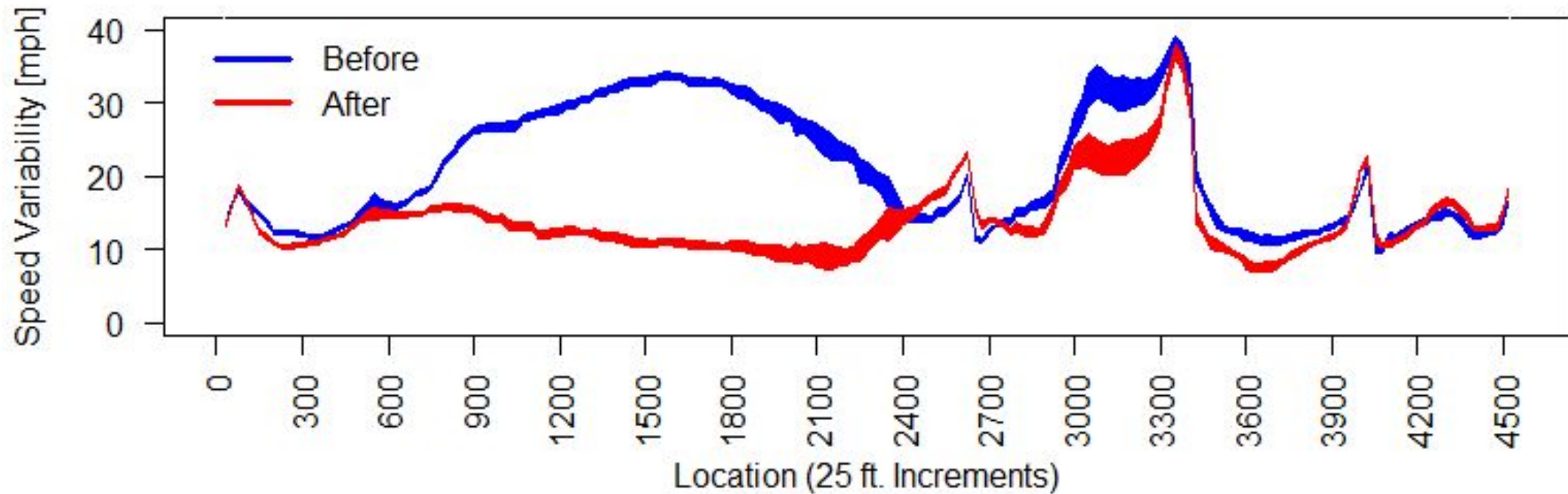


Study Area: Eastside of Bridge



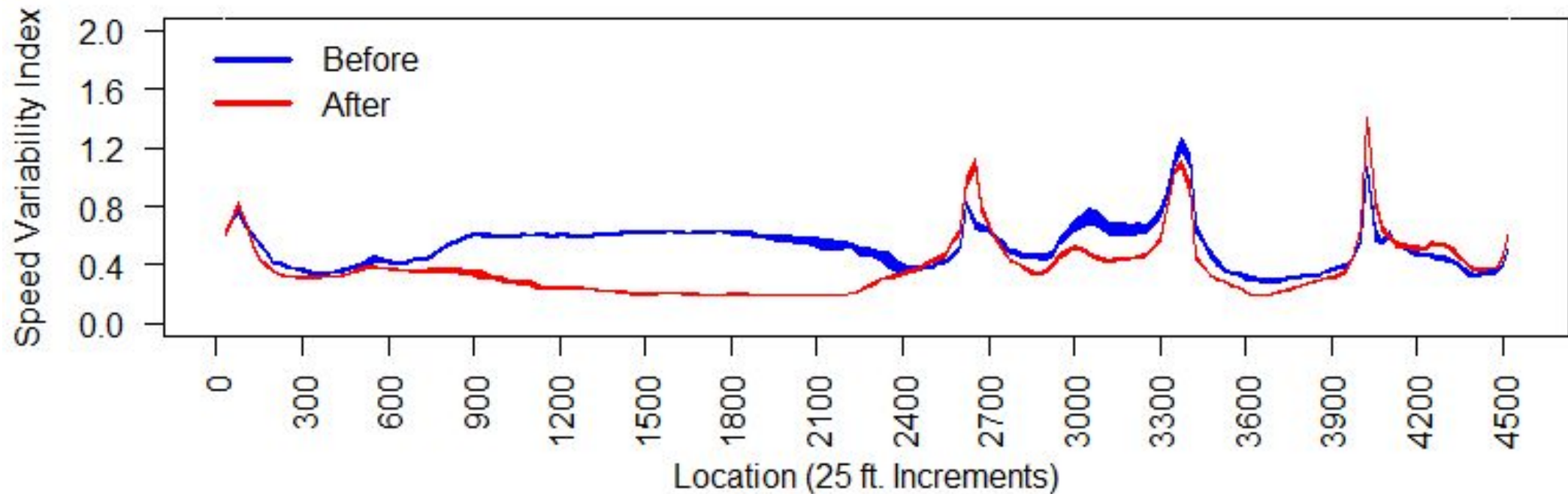
Speed Variability

- Difference in 85th and 15th percentiles

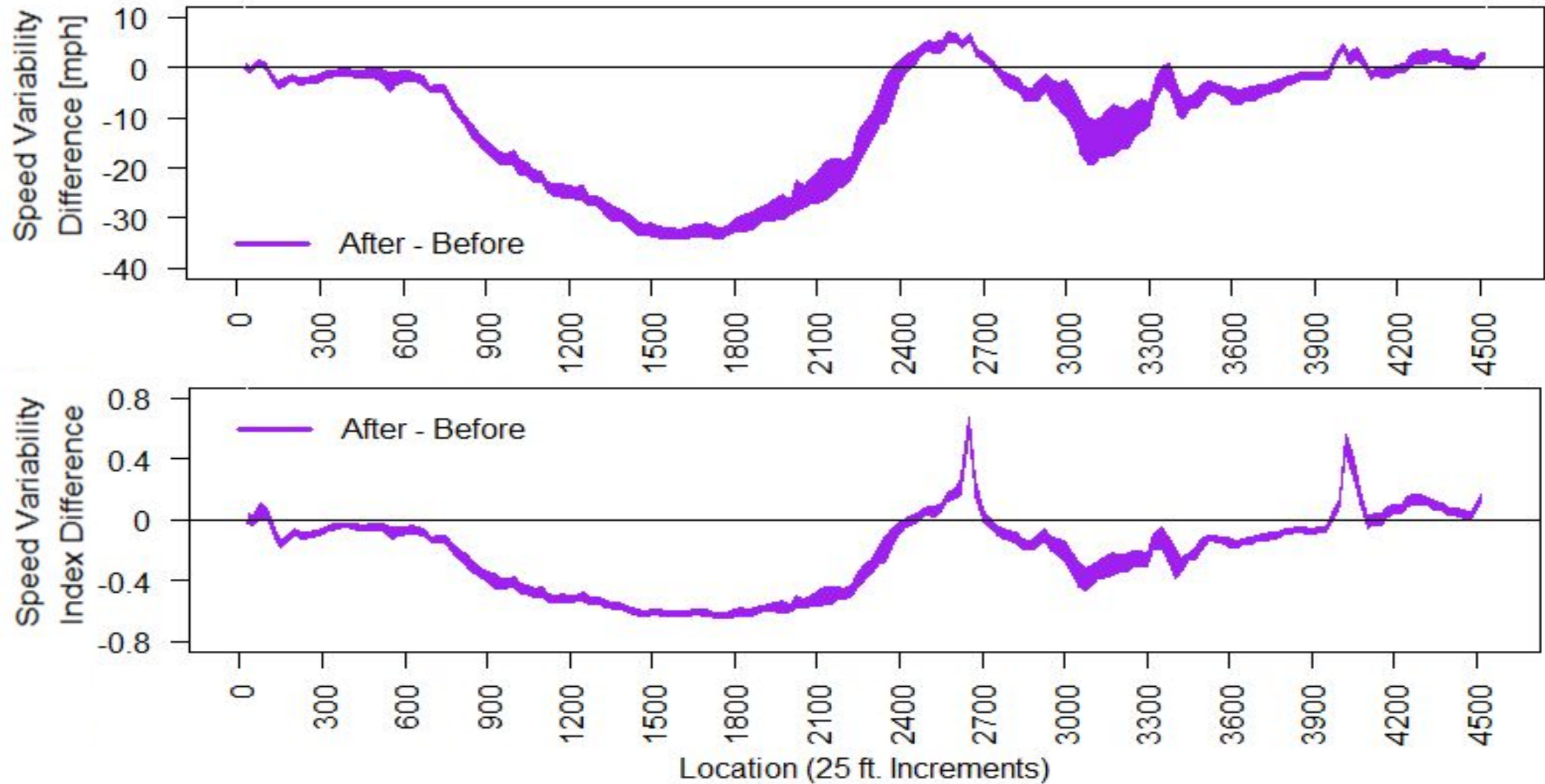


Speed Variability Index

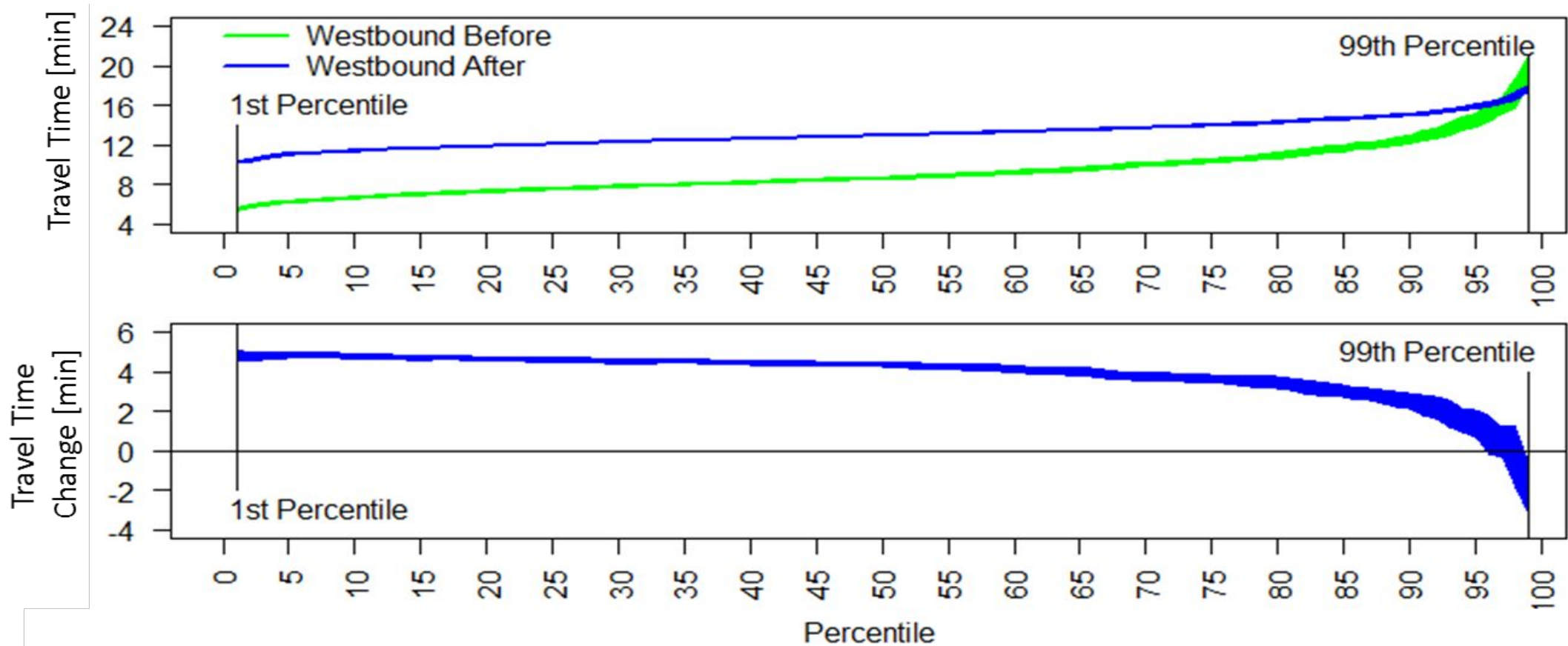
- Speed Variability Divided by 50th Percentile



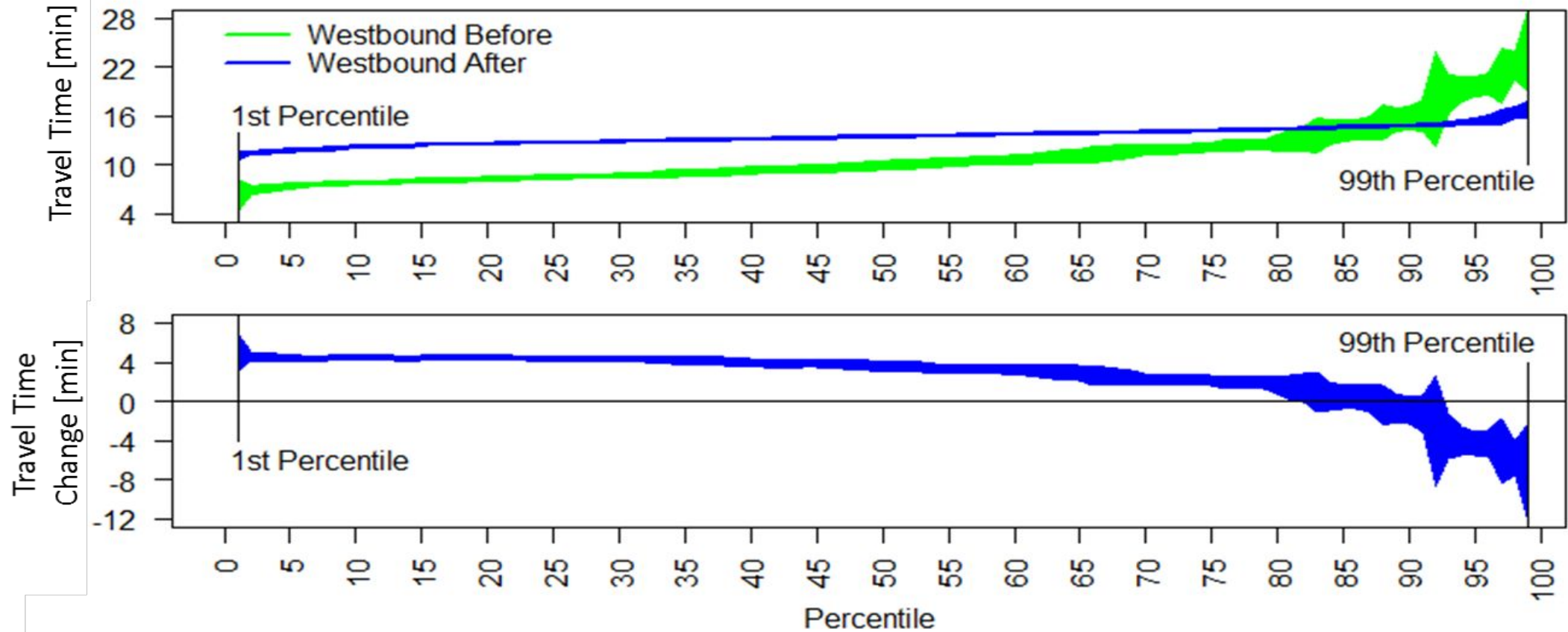
Study Area: Eastside of Bridge



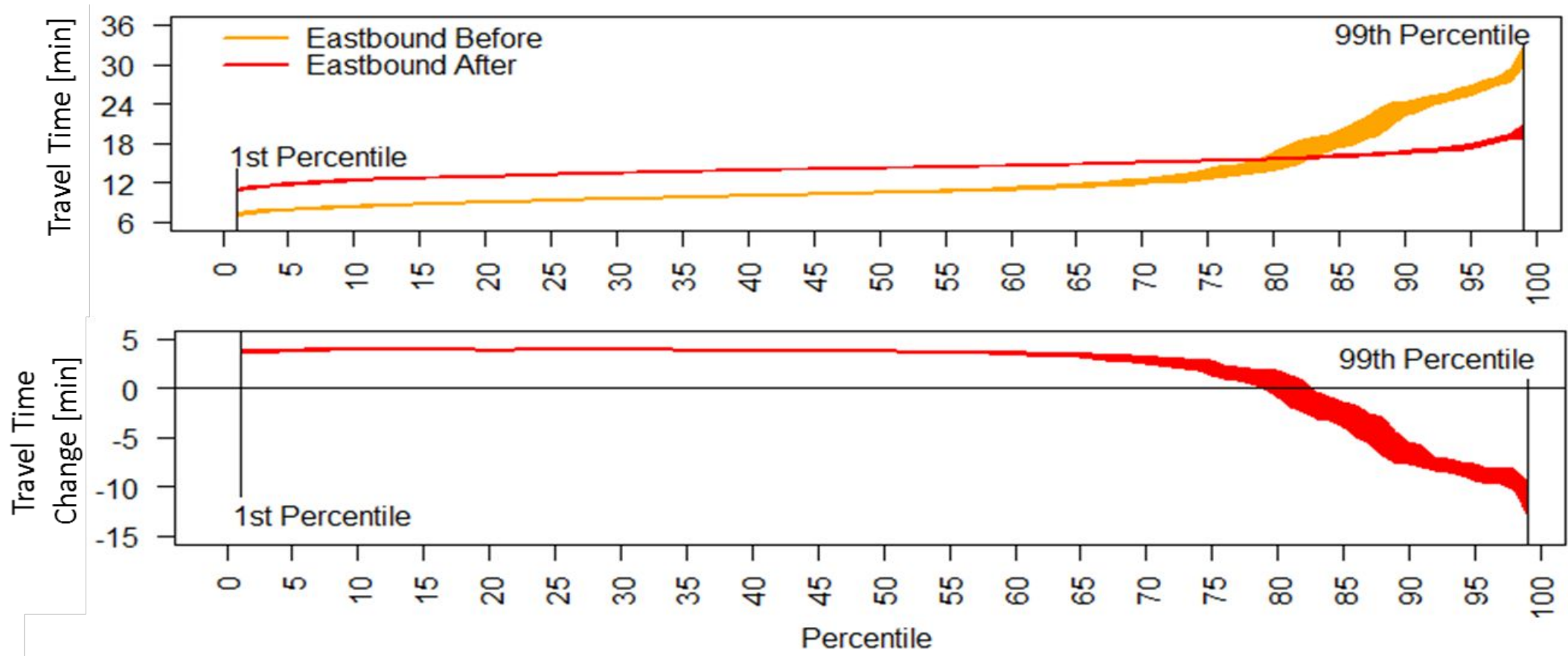
Travel Time Percentiles: Westbound – All Day



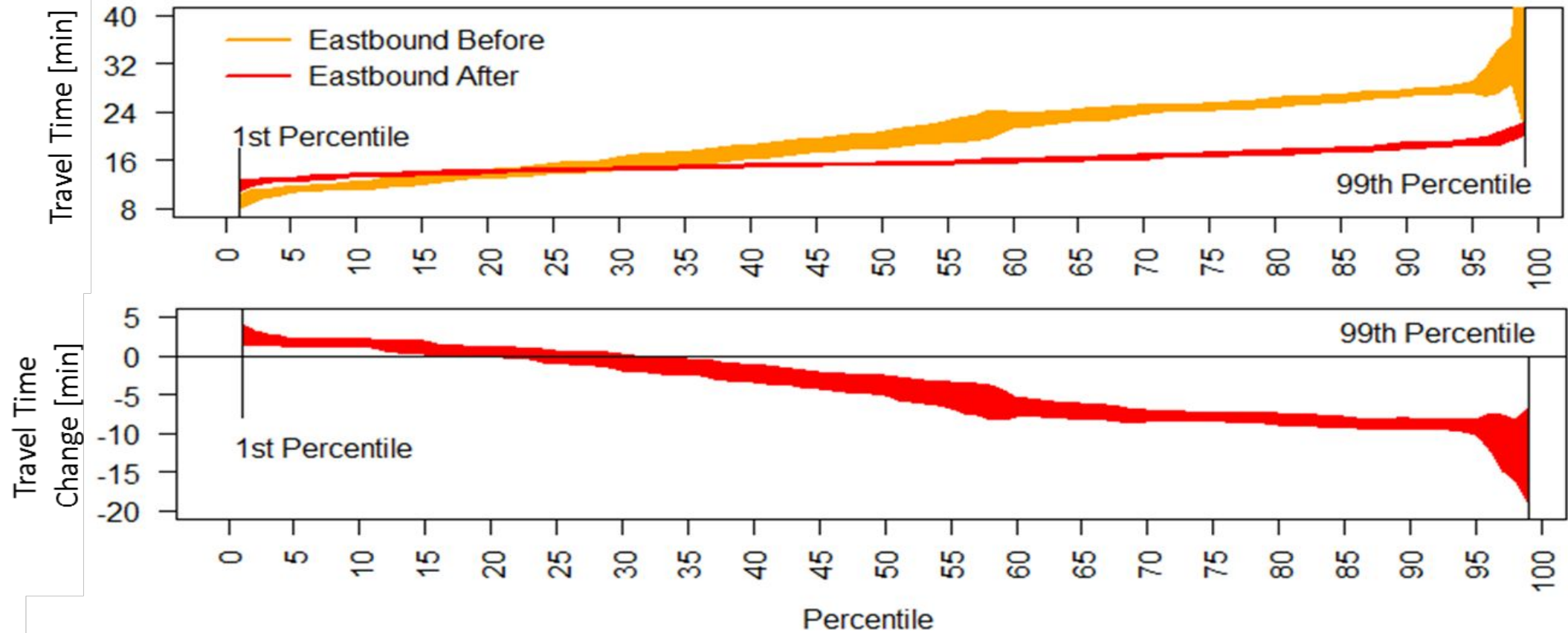
Travel Time Percentiles: Westbound – PM Peak



Travel Time Percentiles: Eastbound – All Day



Travel Time Percentiles: Eastbound – PM Peak



Study Area: Tilikum Crossing

- Travel Time Increased
- Range of travel times in peak period was reduced
- Increase on-time performance
- Assist with operational planning
- This can save TriMet money

Conclusions

- The methodologies can quantify roadway changes
- Apply methodologies in new ways
- Provide insights into how a change impacted transit and vehicles
- Show how travel time reliability changes
- Road diets are unlikely to increase congestion

Important References

- Glick, T. B.; Figliozzi, M. A.; “Evaluation of Route Changes Utilizing High-Resolution GPS Bus Transit Data.” *Transportation Research Record: Journal of the Transportation Research Board*. Forthcoming 2018.
- Glick, T. B.; Figliozzi, M. A.; “Novel Methodology to Estimate Traffic and Transit Travel Time Reliability Indices and Confidence Intervals at a Corridor and Segment Level” TRR: Journal of the TRB. Forthcoming 2017.
- Glick, T. B.; “Before and After Studies of Transit Corridors Using High-Resolution Archived Transit Data.” (2017) *PDX Scholar*. Graduate Thesis.
- Glick, T. B.; “Utilizing High-Resolution Archived Transit Data to Study Before-and-After Travel-Speed and Travel-Time Conditions.” (2017) Seminar Lecture; Friday Transportation Seminar — Portland State University (PSU). Portland, OR.

Thank you to the
following:



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