A Critical Review of TOPR34 (HCM 2016 Update)

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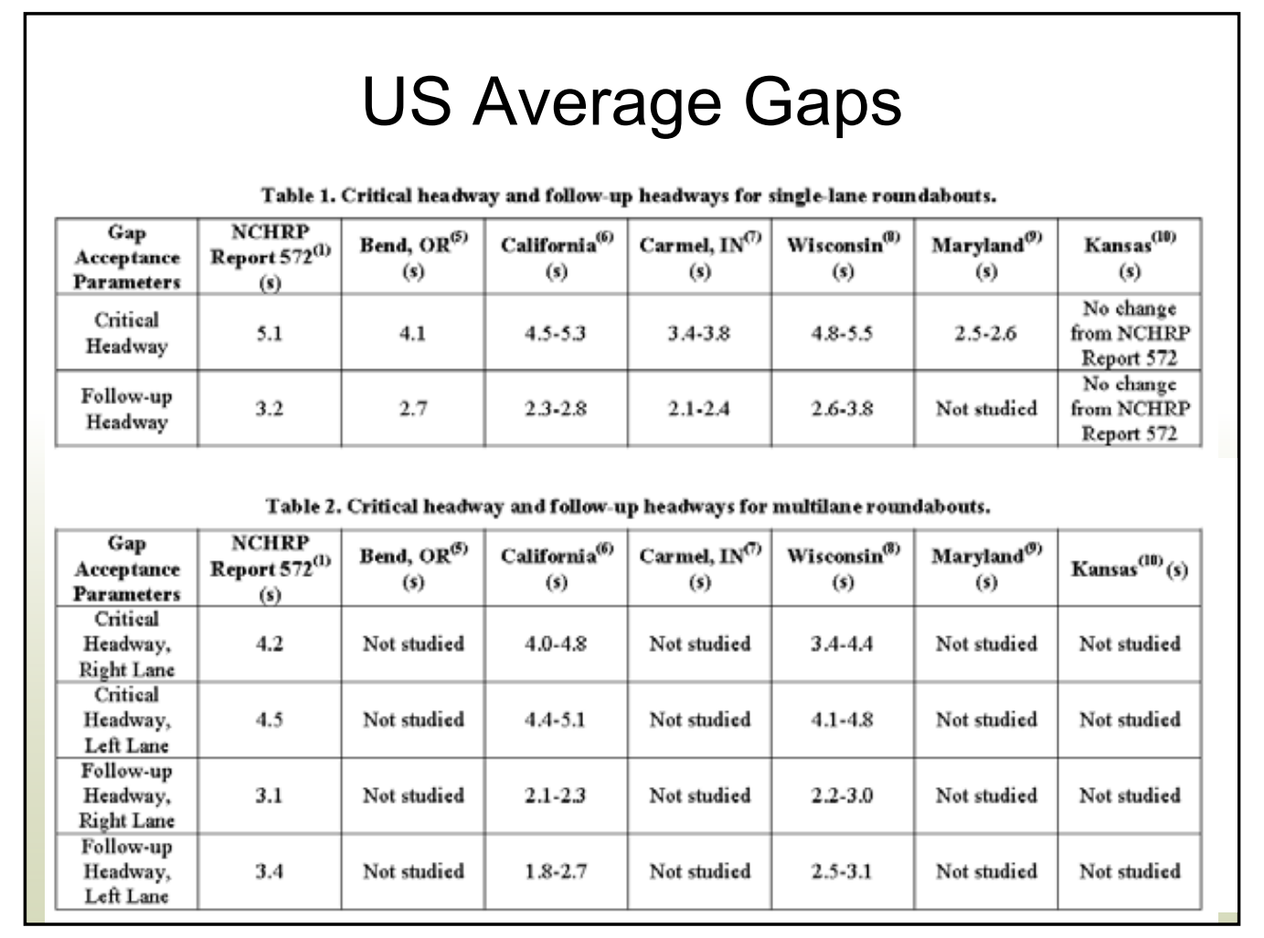
THEIR KEY FINDINGS: TOPR34 (HCM 2010 UPDATE - HCM 6)

TOPR34 provides an update to the HCM 2010 capacity model.

- Gap Based Model Form is essentially unchanged from the HCM 2010 model: Siegloch, W., 1973, "Capacity Calculations for series of T Unsignalized Intersections."
- Removes the "critical gap" parameter as a calibration input.
- Maintains the "follow-on time" gap parameter as the primary calibration input.
- Establishes a "global" y intercept value of 1,385 vph. The average follow-on gaps of the collected data = 2.6 sec/3,600 sec/hr=1,385vph.
- Jurisdictions with previously developed follow-on times and critical gap calibration can use these in the updated model.
- Capacity increase as compared to the HCM 2010 due to the 2.6 sec. average global follow-on time anchor to the y intercept: 1,385 (HCM '16) vs 1,135 (HCM '10).

Multi Lane (by lane data) Calibration

- Similar to the model development process for single-lane sites, it is desirable to determine whether a field-observable parameter, particularly follow-on time, can be used to anchor the multi-lane regression models and thus enable their calibration to local conditions.
- Follow-on time is especially desirable as a calibration parameter for multi-lane sites due to it being considerably easier to collect than critical headway. The collection and estimation of critical headway is particularly challenging at multi-lane roundabouts, and for consistency with most modeling practices for critical headway, it requires the assumption that the circulating flow is a single conflicting stream (i.e., without regard to lane use). Follow-on time, on the other hand, can be directly measured for each lane independently.



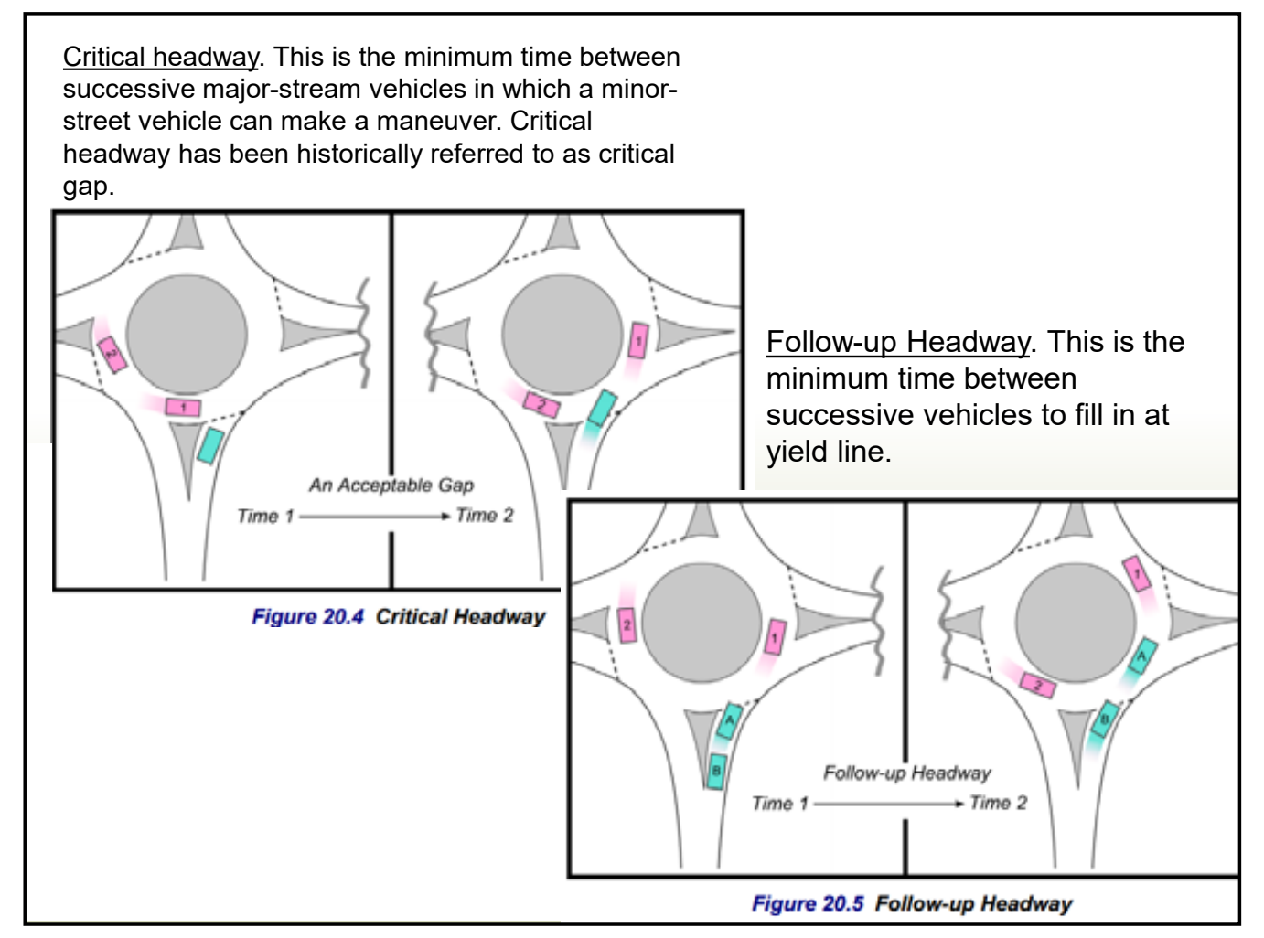
US Average Gaps

Table 1. Critical headway and follow-up headways for single-lane roundabouts.

Gap Acceptance Parameters	NCHRP Report 572[1] (s)	Bend, OR[5] (s)	California[6] (s)	Carmel, IN[7] (s)	Wisconsin[8] (s)	Maryland[9] (s)	Kansas[10] (s)
Critical Headway	5.1	4.1	4.5-5.3	3.4-3.8	4.8-5.5	2.5-2.6	No change from NCHRP Report 572
Follow-up Headway	3.2	2.7	2.3-2.8	2.1-2.4	2.6-3.8	Not studied	No change from NCHRP Report 572

Table 2. Critical headway and follow-up headways for multilane roundabouts.

Gap Acceptance Parameters	NCHRP Report 572[1] (s)	Bend, OR[5] (s)	California[6] (s)	Carmel, IN[7] (s)	Wisconsin[8] (s)	Maryland[9] (s)	Kansas[10] (s)
Critical Headway, Right Lane	4.2	Not studied	4.0-4.8	Not studied	3.4-4.4	Not studied	Not studied
Critical Headway, Left Lane	4.5	Not studied	4.4-5.1	Not studied	4.1-4.8	Not studied	Not studied
Follow-up Headway, Right Lane	3.1	Not studied	2.1-2.3	Not studied	2.2-3.0	Not studied	Not studied
Follow-up Headway, Left Lane	3.4	Not studied	1.8-2.7	Not studied	2.5-3.1	Not studied	Not studied



Critical headway. This is the minimum time between successive major-stream vehicles in which a minor-street vehicle can make a maneuver. Critical headway has been historically referred to as critical gap.

Figure 20.4 Critical Headway

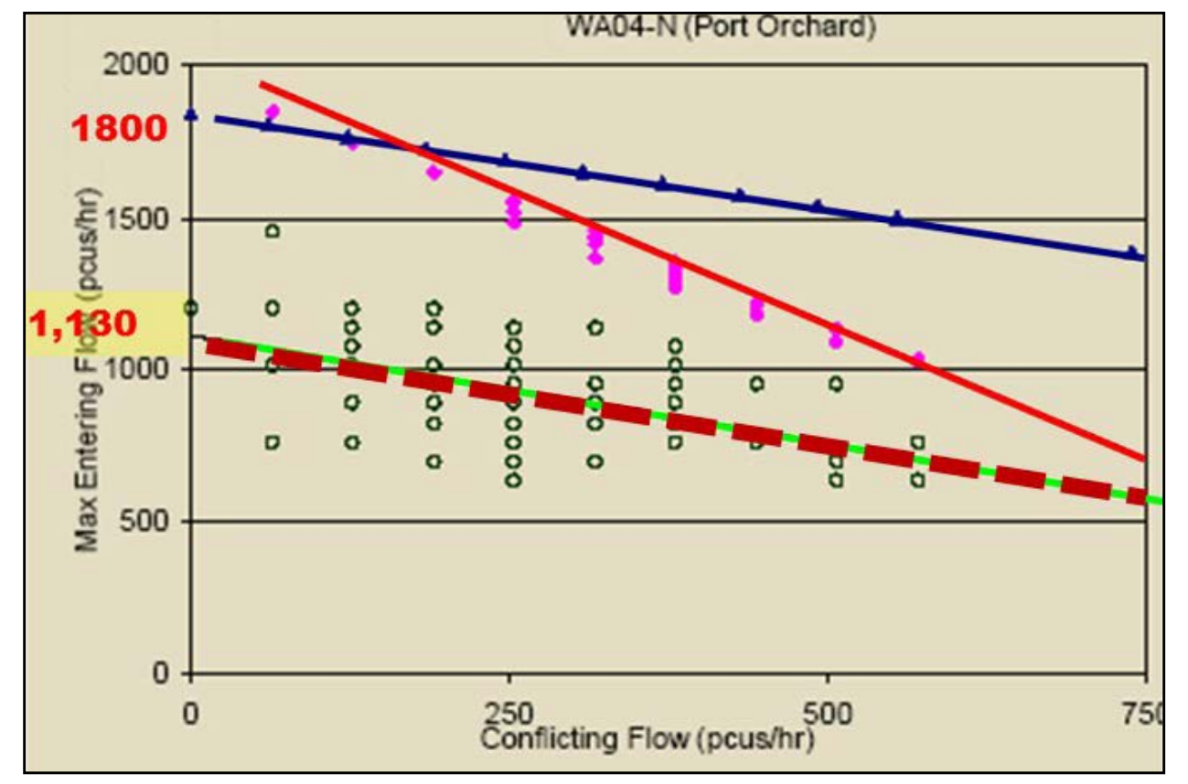
Follow-up Headway. This is the minimum time between successive vehicles to fill in at yield line.

Figure 20.5 Follow-up Headway

Establishes a global y intercept value of 1,385vph

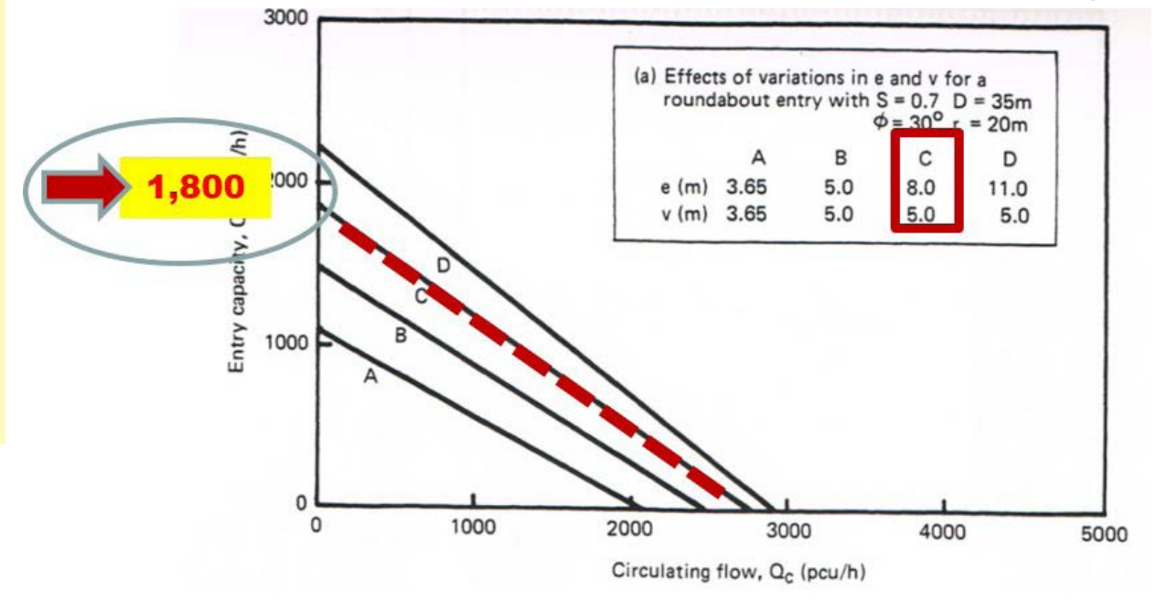
OUR REVIEW FINDINGS: THE UNCOVERING OF SIGNIFICANT DIFFERENCES

- The uncovering of "significant differences" were due to incorrect use of model used to estimate UK capacity and not actual differences in capacity.
- Our review of the original UK data from the source has found very good correlation between UK data and US data both the 2002 and also the new 2012 data.

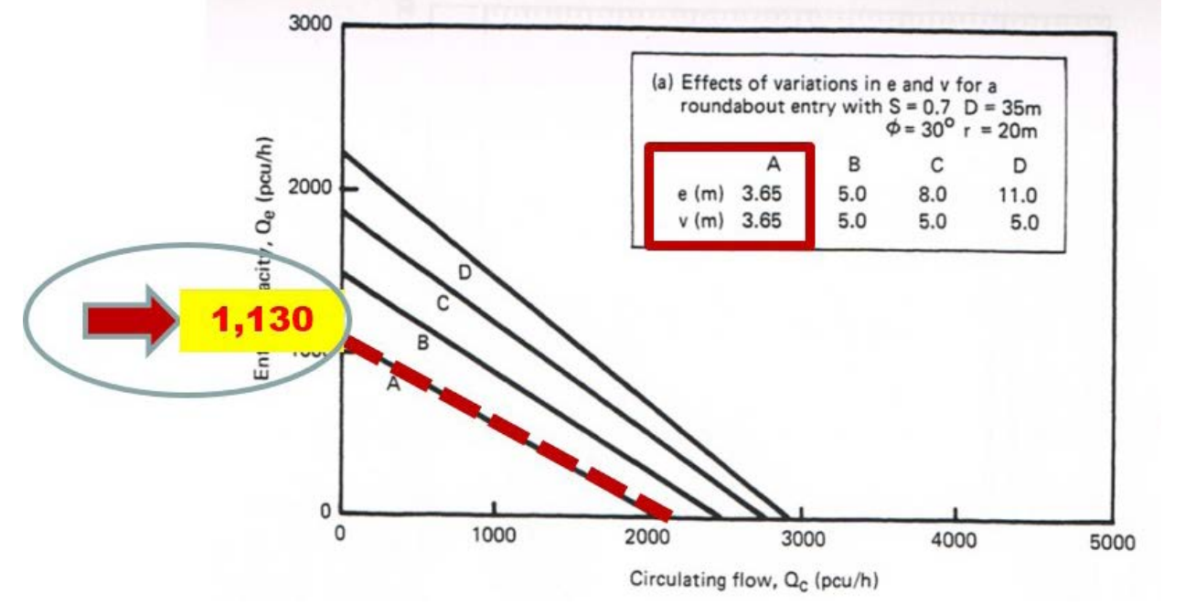


Source: NCHRP Report 572

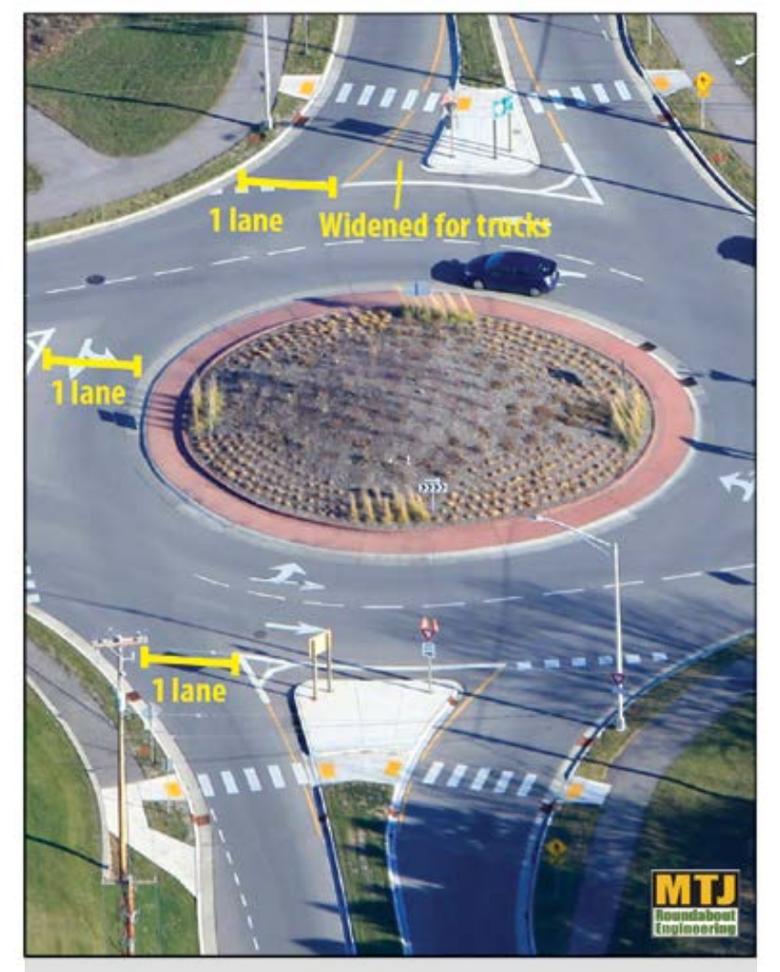
Kimber LR 942 - Flared Two-Lane Capacity



Kimber LR 942 - Single-Lane Capacity



Flared two-lane entry



Single lane entry widened for trucks, not capacity

HCM 6 East Bound Single Lane y Anchored at 1,385

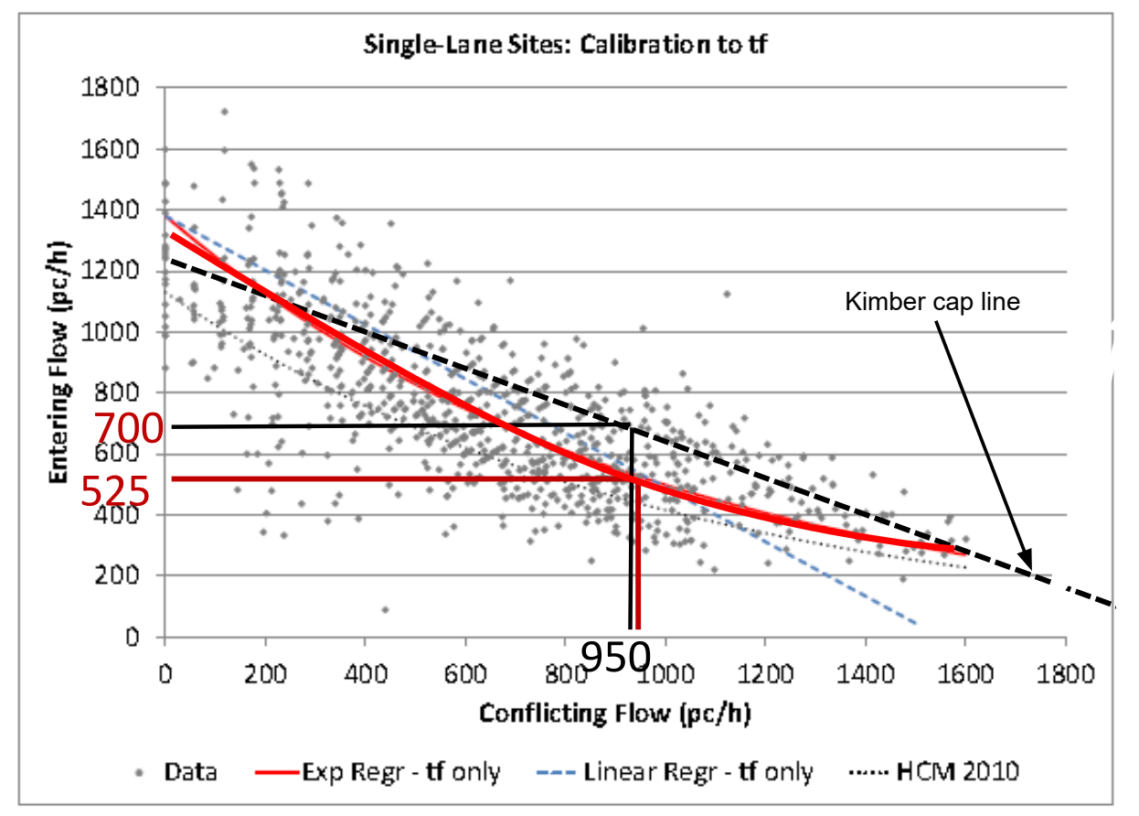
Artificial Anchor at 1380 skews Fit For Linear Reg Line

Expo can curve to fit.

HCM '16 gives 525 capacity at 950 circulating with default follow on gap of 2.6s

y = 1,385, and curved line dipping down at this circulating flow

700 vs 525 = Difference of 175vph

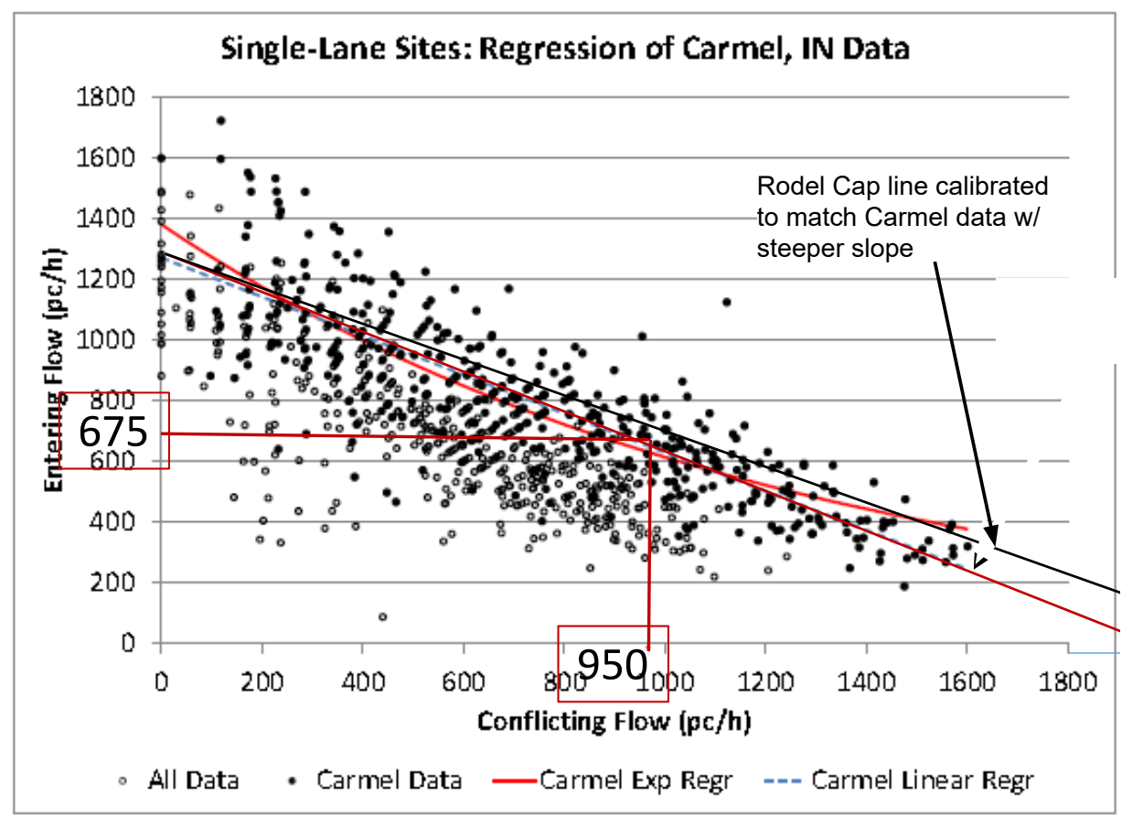


Scatter plot: Regression models for single-lane roundabout sites with calibration to follow-up time.

Calibrated to Carmel Data (not artificially anchored at y = 1,385)

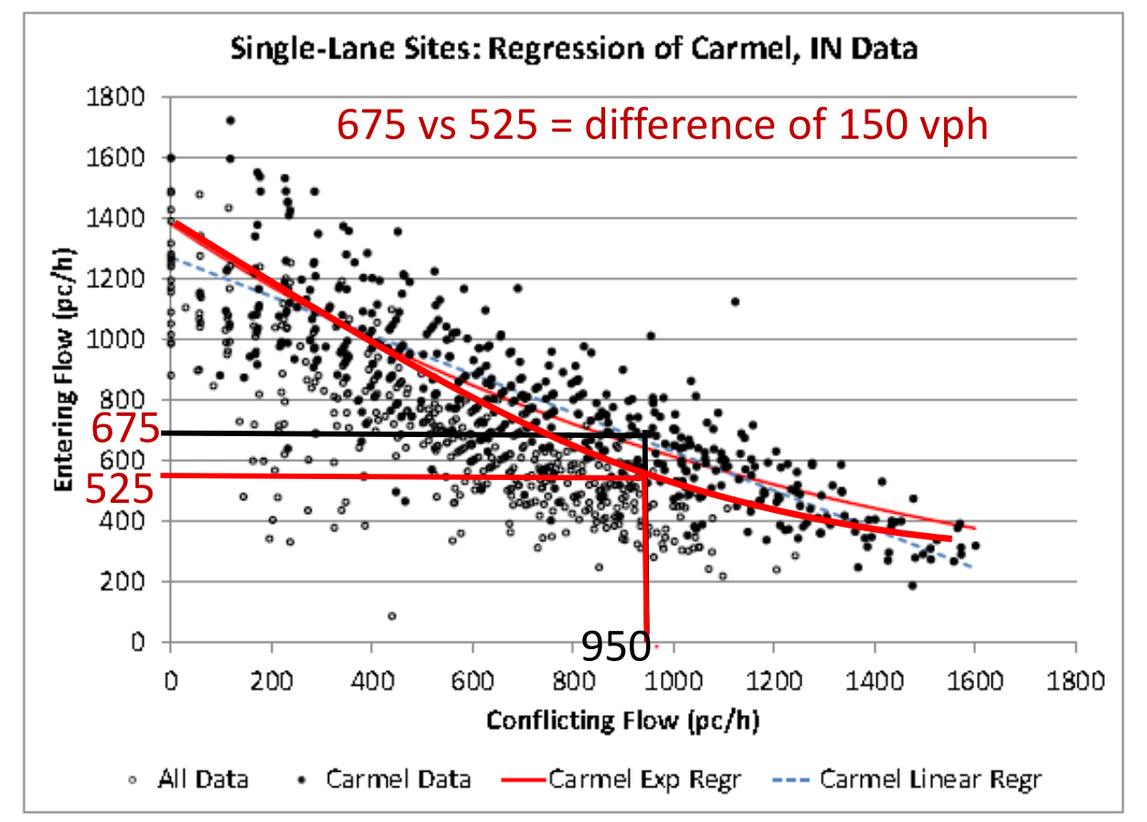
EB entry: Cap at 950 Circulating = 675

Carmel Cap data = 675 Matches Rodel Cap



Scatter plot: Regression models for Carmel, IN data.

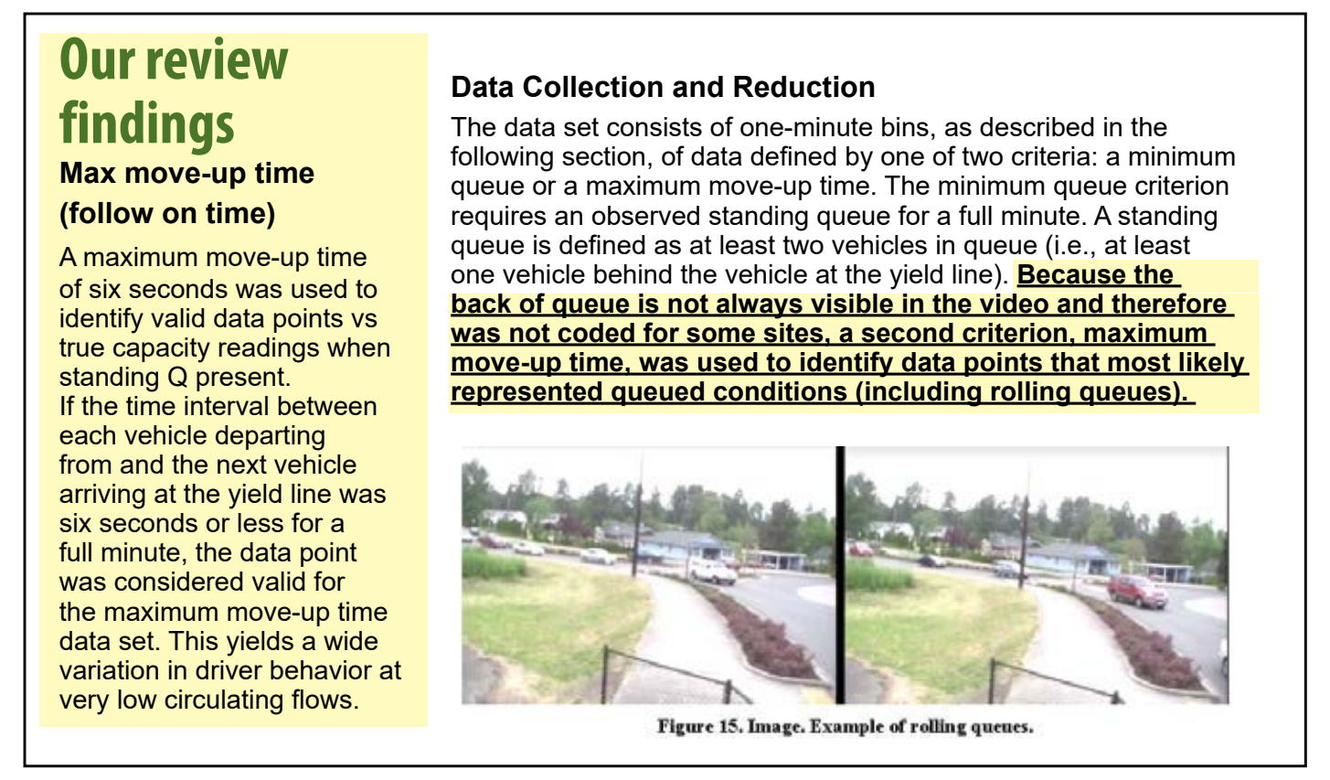
EB Entry Calibrated Carmel Data



Scatter plot: Regression models for Carmel, IN data.

DATA COLLECTION

SINGLE-LANE



Our review findings

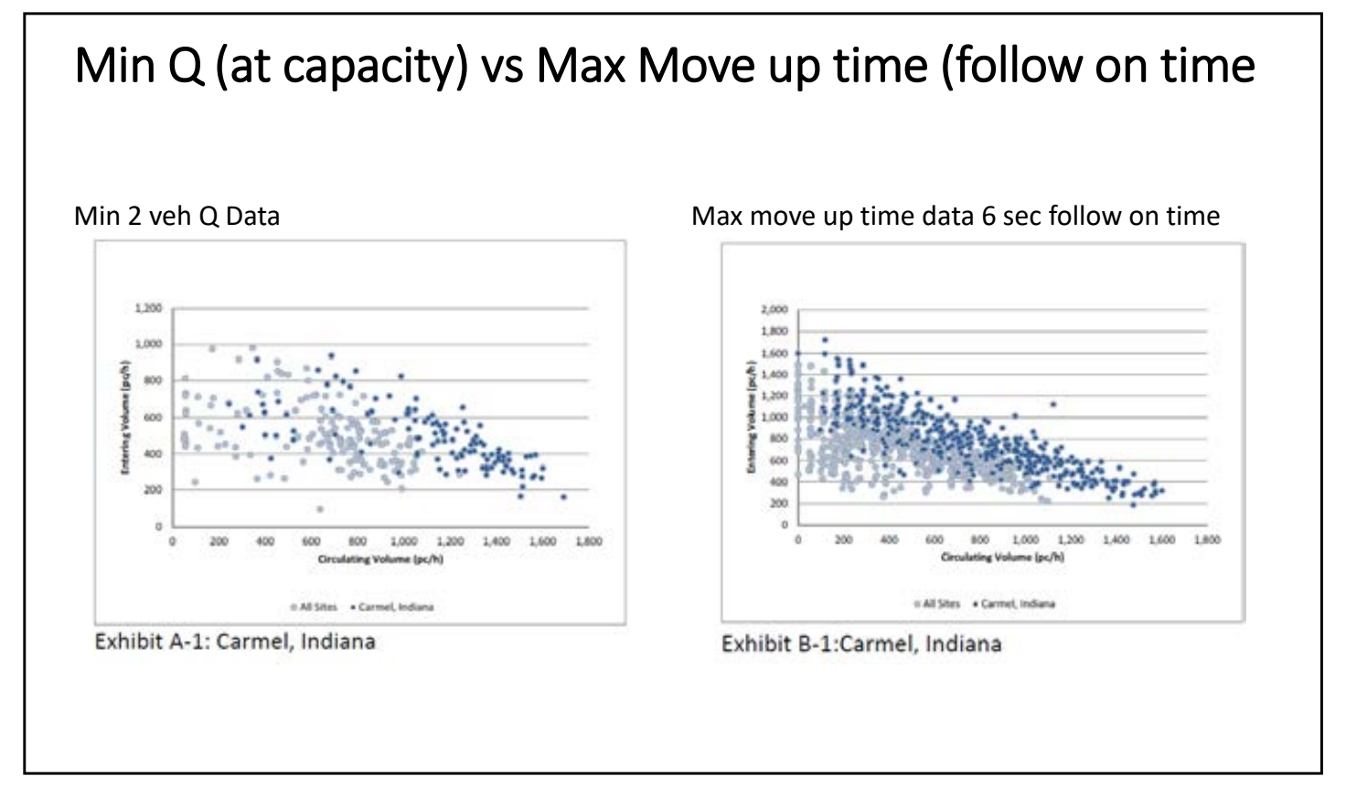
Max move-up time (follow on time)

A maximum move-up time of six seconds was used to identify valid data points vs true capacity readings when standing Q present.
If the time interval between each vehicle departing from and the next vehicle arriving at the yield line was six seconds or less for a full minute, the data point was considered valid for the maximum move-up time data set. This yields a wide variation in driver behavior at very low circulating flows.

Data Collection and Reduction

The data set consists of one-minute bins, as described in the following section, of data defined by one of two criteria: a minimum queue or a maximum move-up time. The minimum queue criterion requires an observed standing queue for a full minute. A standing queue is defined as at least two vehicles in queue (i.e., at least one vehicle behind the vehicle at the yield line). **Because the back of queue is not always visible in the video and therefore was not coded for some sites, a second criterion, maximum move-up time, was used to identify data points that most likely represented queued conditions (including rolling queues).**

Figure 15. Image. Example of rolling queues.



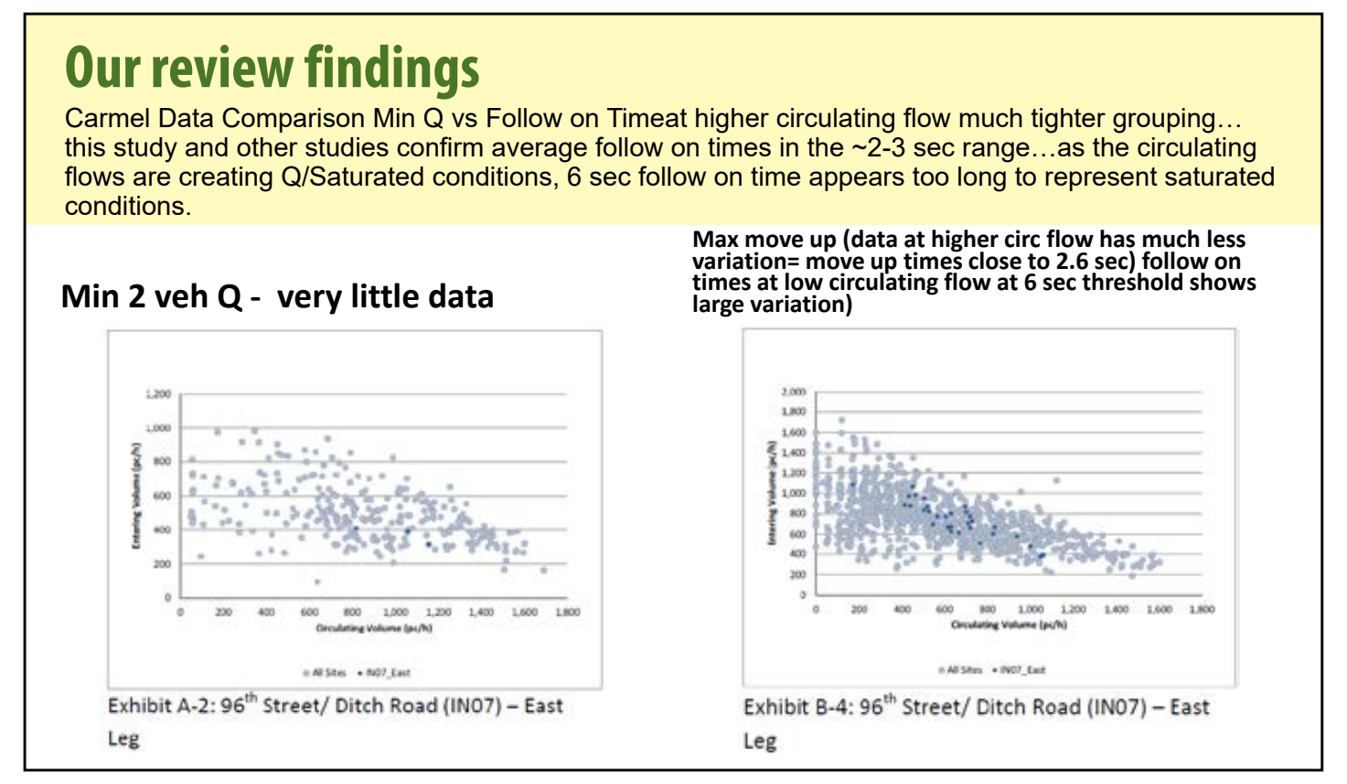
Min Q (at capacity) vs Max Move up time (follow on time

Min 2 veh Q Data

Max move up time data 6 sec follow on time

Exhibit A-1: Carmel, Indiana

Exhibit B-1:Carmel, Indiana



Our review findings

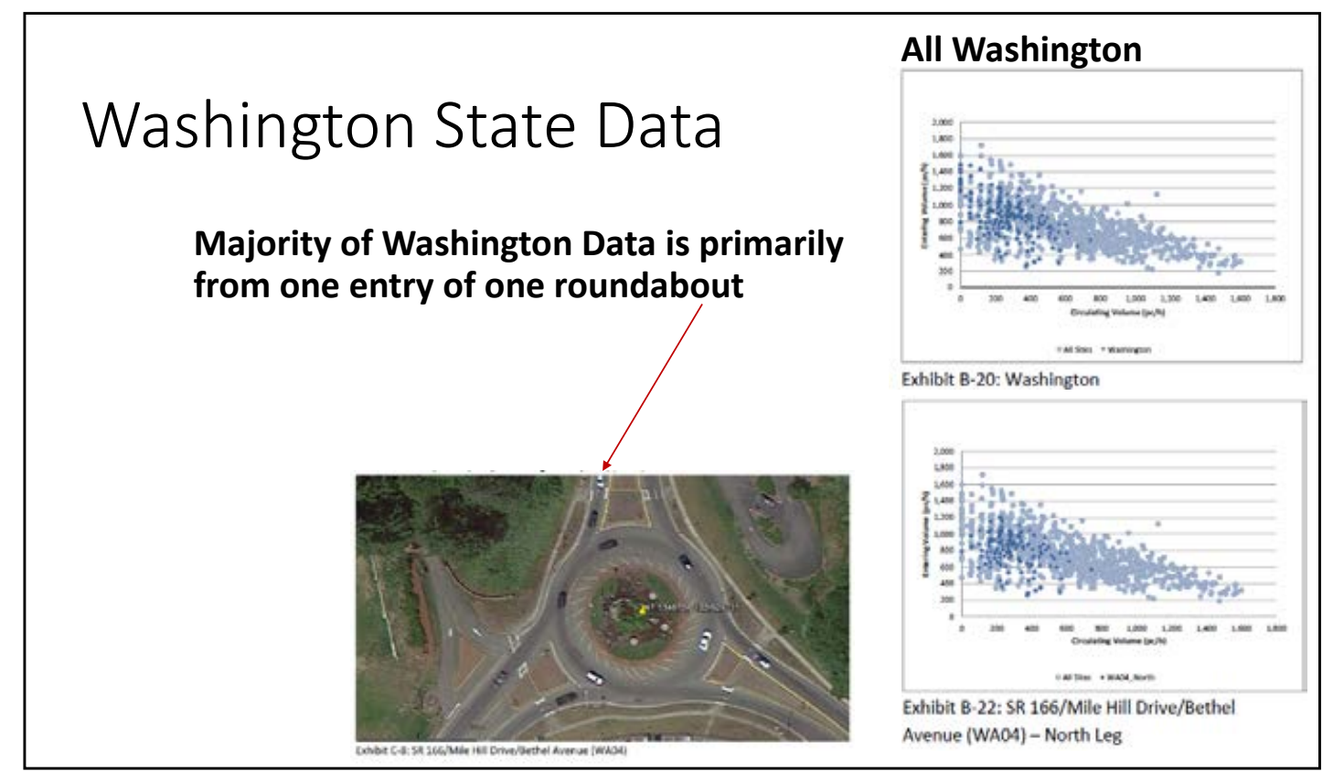
Carmel Data Comparison Min Q vs Follow on Timeat higher circulating flow much tighter grouping… this study and other studies confirm average follow on times in the ~2-3 sec range…as the circulating flows are creating Q/Saturated conditions, 6 sec follow on time appears too long to represent saturated conditions.

Min 2 veh Q - very little data

Max move up (data at higher circ flow has much less variation= move up times close to 2.6 sec) follow on times at low circulating flow at 6 sec threshold shows large variation)

Exhibit A-2: 96th Street/ Ditch Road (IN07) – East Leg

Exhibit B-4: 96th Street/ Ditch Road (IN07) – East Leg



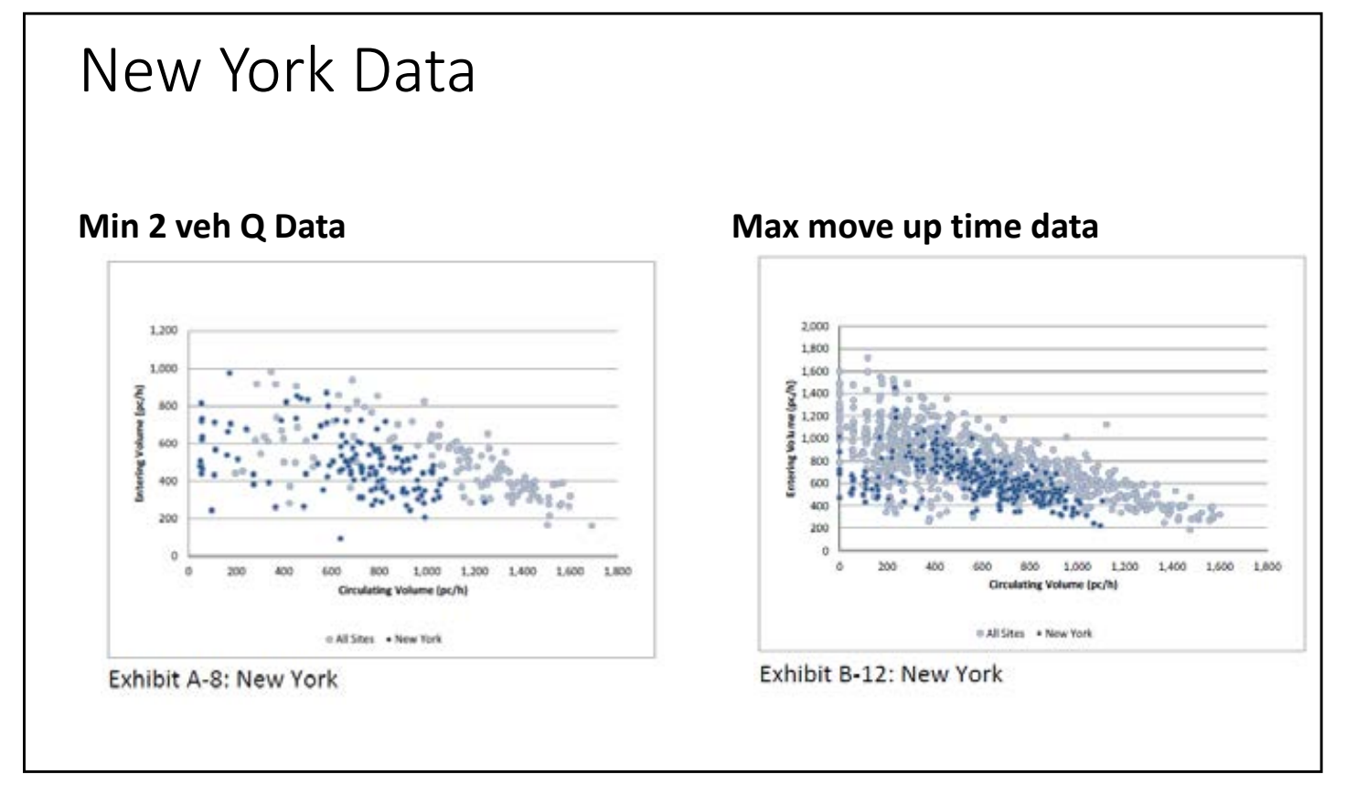
Washington State Data

Majority of Washington Data is primarily from one entry of one roundabout

All Washington

Exhibit B-20: Washington

Exhibit B-22: SR 166/Mile Hill Drive/Bethel Avenue (WA04) – North Leg



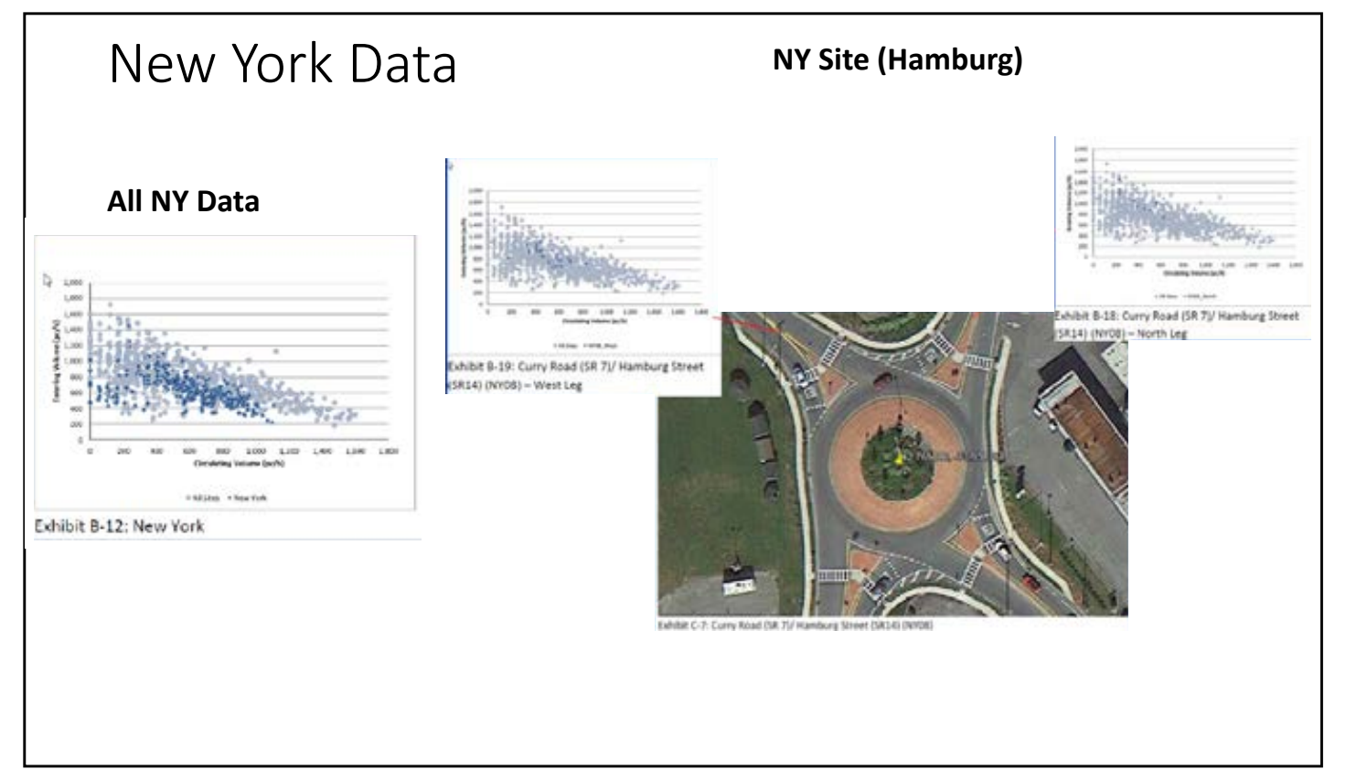
New York Data

Min 2 veh Q Data

Max move up time data

Exhibit A-8: New York

Exhibit B-12: New York

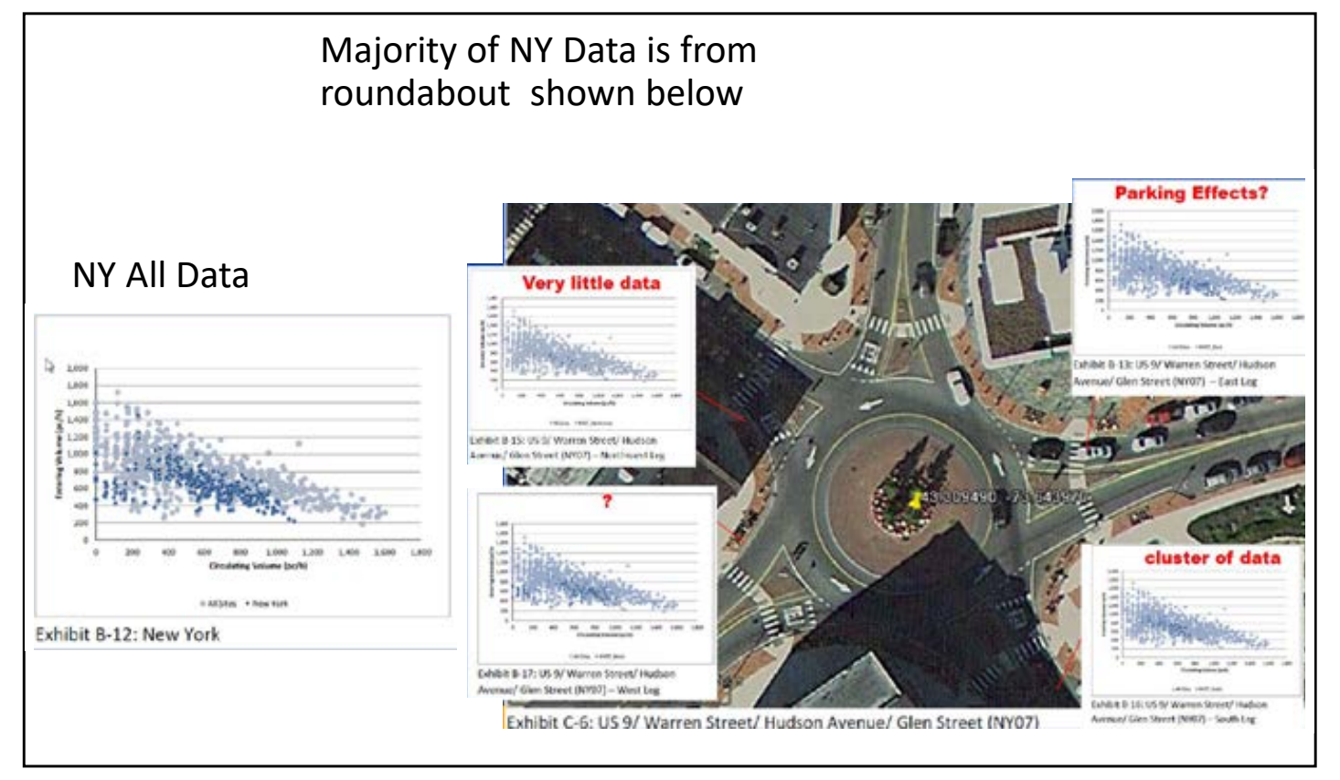


New York Data

NY Site (Hamburg)

All NY Data

Exhibit B-12: New York



Majority of NY Data is from roundabout shown below

NY All Data

Exhibit B-12: New York

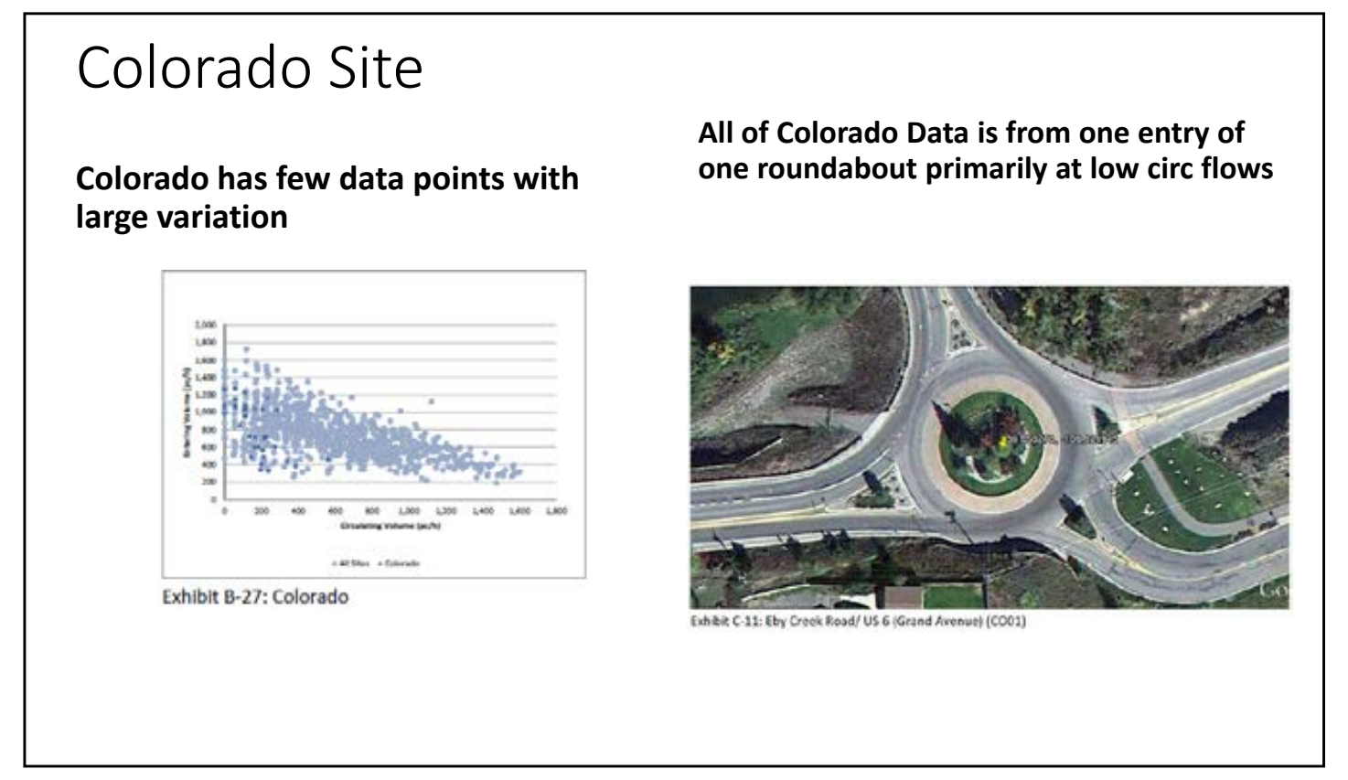
Very little data

Parking Effects?

?

cluster of data

Exhibit C-6: US 9/ Warren Street/ Hudson Avenue/ Glen Street (NY07)



Colorado Site

Colorado has few data points with large variation

All of Colorado Data is from one entry of one roundabout primarily at low circ flows

Exhibit B-27: Colorado

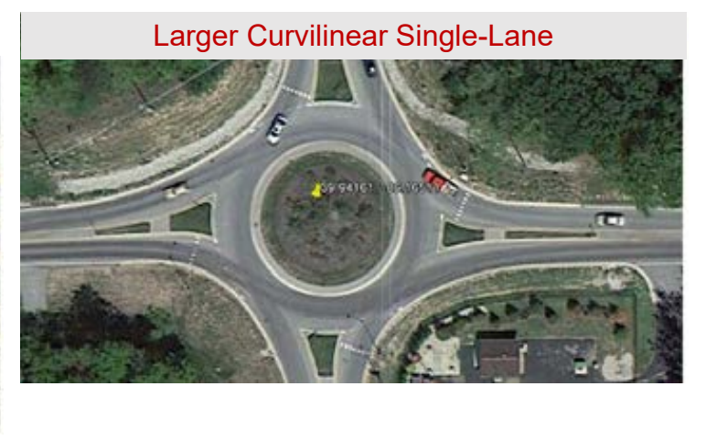
Exhibit C-11: Eby Creek Road/ US 6 (Grand Avenue) (CO01)

Our review findings of single-lane entry

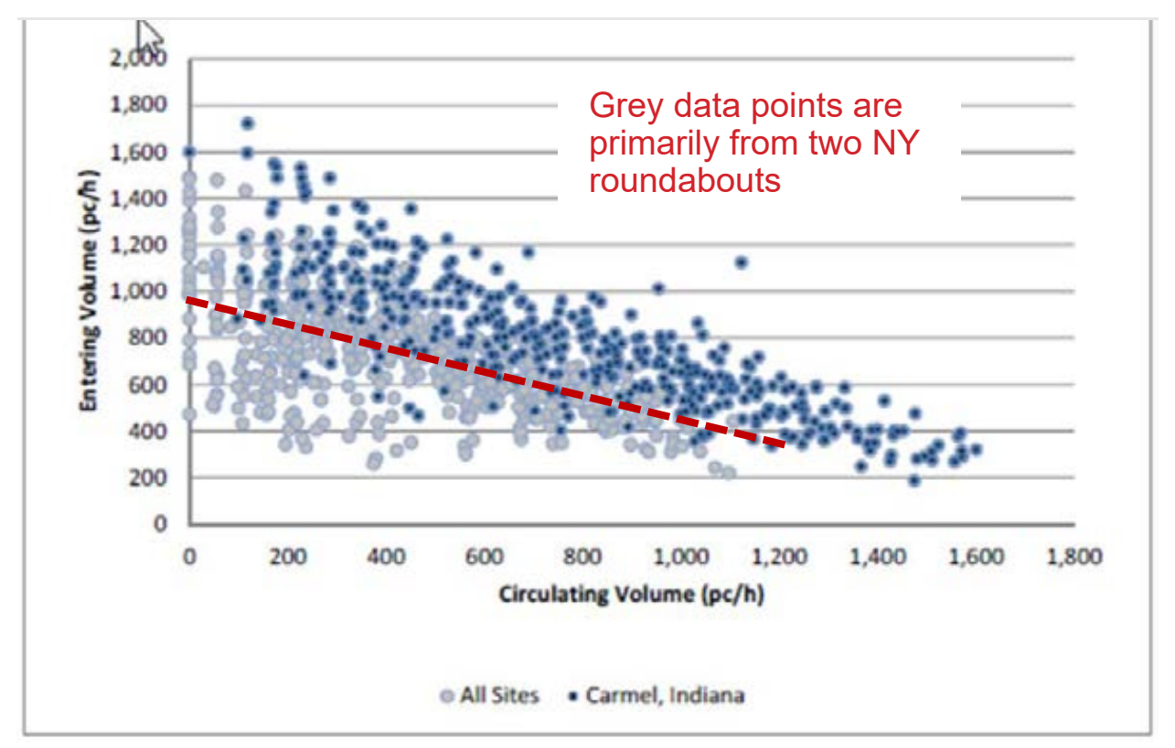
- Majority data influencers are from these two types of roundabouts: smaller geometry and larger geometry.
- In the case of the Carmel site(s) these are larger ICD more curvilinear style designs resulting in higher capacity; whereas, in NY and WA, the data is from smaller ICD with tighter geometric design elements and lower capacity.

Urban Single-Lane

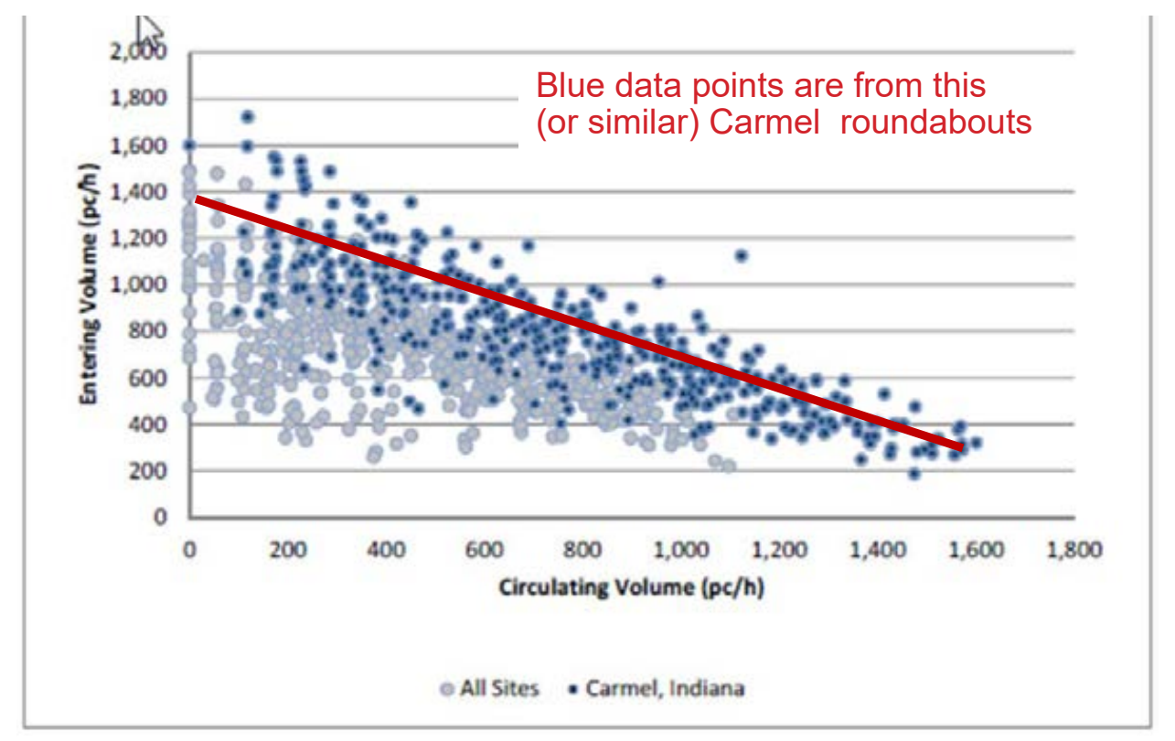
Larger Curvilinear Single-Lane



Kimber's Prediction vs N.Y. Data



Kimber's Prediction vs Original Data



MULTI-LANE

2x1 Left Lane

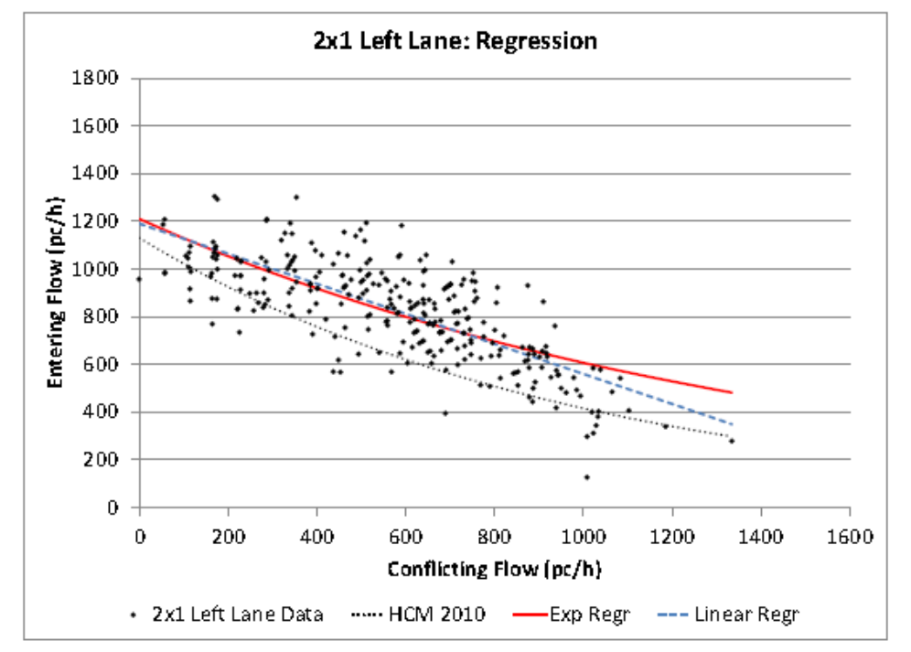


Figure 41. Scatter Plot. Regression models for multilane, 2x1 roundabout sites, left entry lane.

2x1 Right Lane

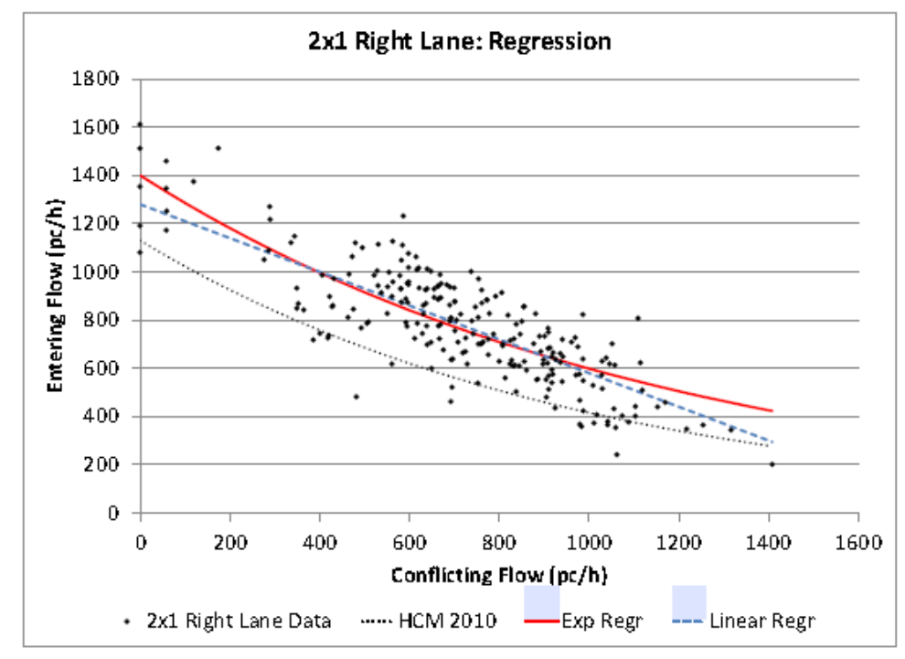


Figure 40. Scatter Plot. Regression models for multilane, 2x1 roundabout sites, right entry lane.

2x2 Left Lane

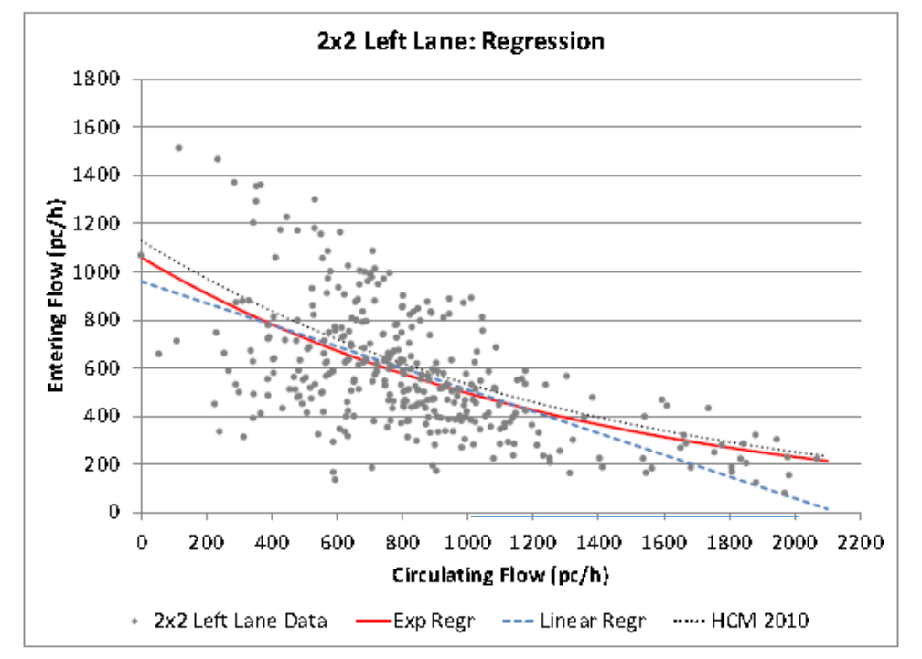


Figure 39. Scatter Plot. Regression models for multilane, 2x2 roundabout sites, left entry lane.

2x2 Right Lane

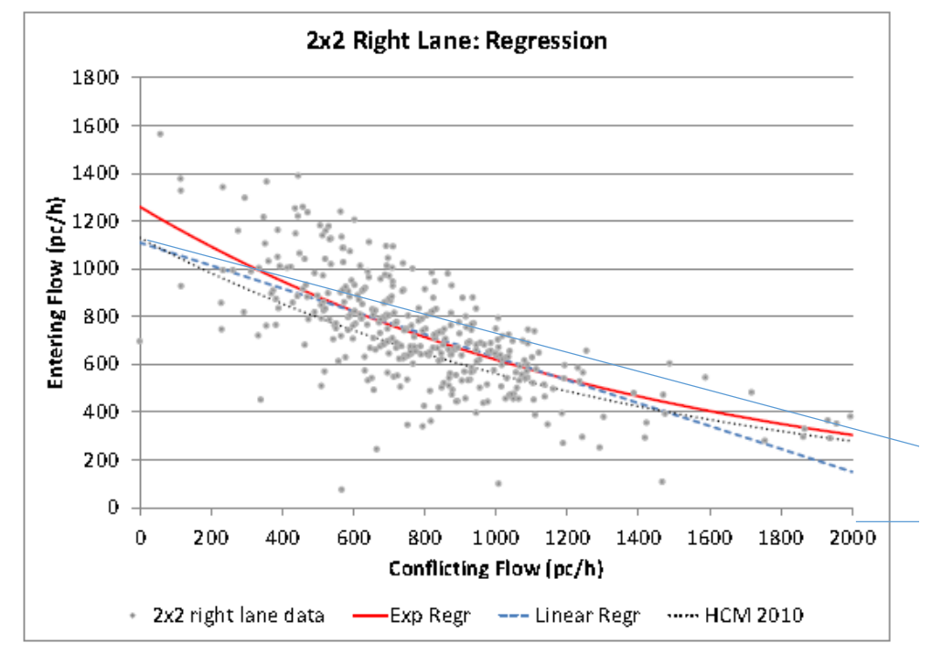


Figure 38. Scatter Plot. Regression models for multilane, 2x2 roundabout sites, right entry lane.

Authors State:

The 2x1 model reflected some inconsistencies and proved more challenging to calibrate. **The pure regression models fit much better than the ones anchored to a global follow-on time.** The observed follow-up times would result in an intercept that is much higher than the observed capacities at low circulating flows. The use of the intercept from the 2x2 right-lane model produces a much better fit to the data than the use of the directly measured follow-up times.

Multi-Lane

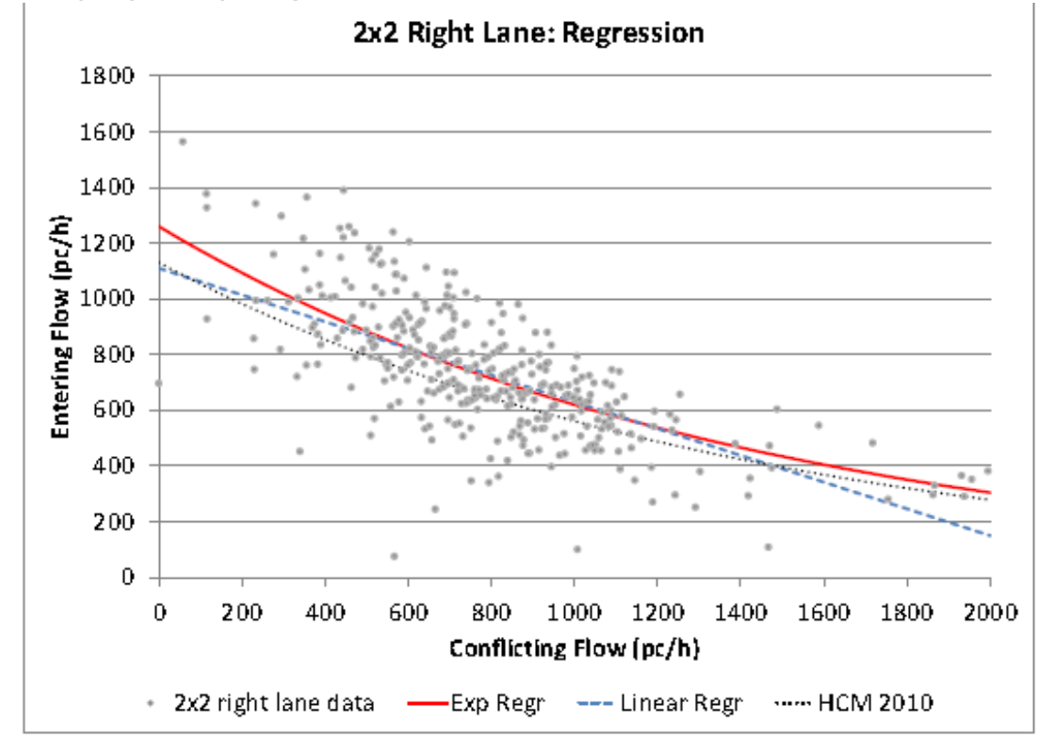


Figure 38. Scatter Plot. Regression models for multilane, 2x2 roundabout sites, right entry lane.

OUR REVIEW FINDINGS: MODEL FORM - LINEAR VS EXPONENTIAL

RMSE = How well model form predicts (lower number better) Rsq = Best fit to data (higher number better)

Our review findings of anchoring y intercepts

Anchoring y Intercept

Statistician's Response

Fixing the y intercept at the average follow on time of 2.6 seconds/3600 sec/hr = 1,385 vph is arbitrary from a true statistical analysis approach.

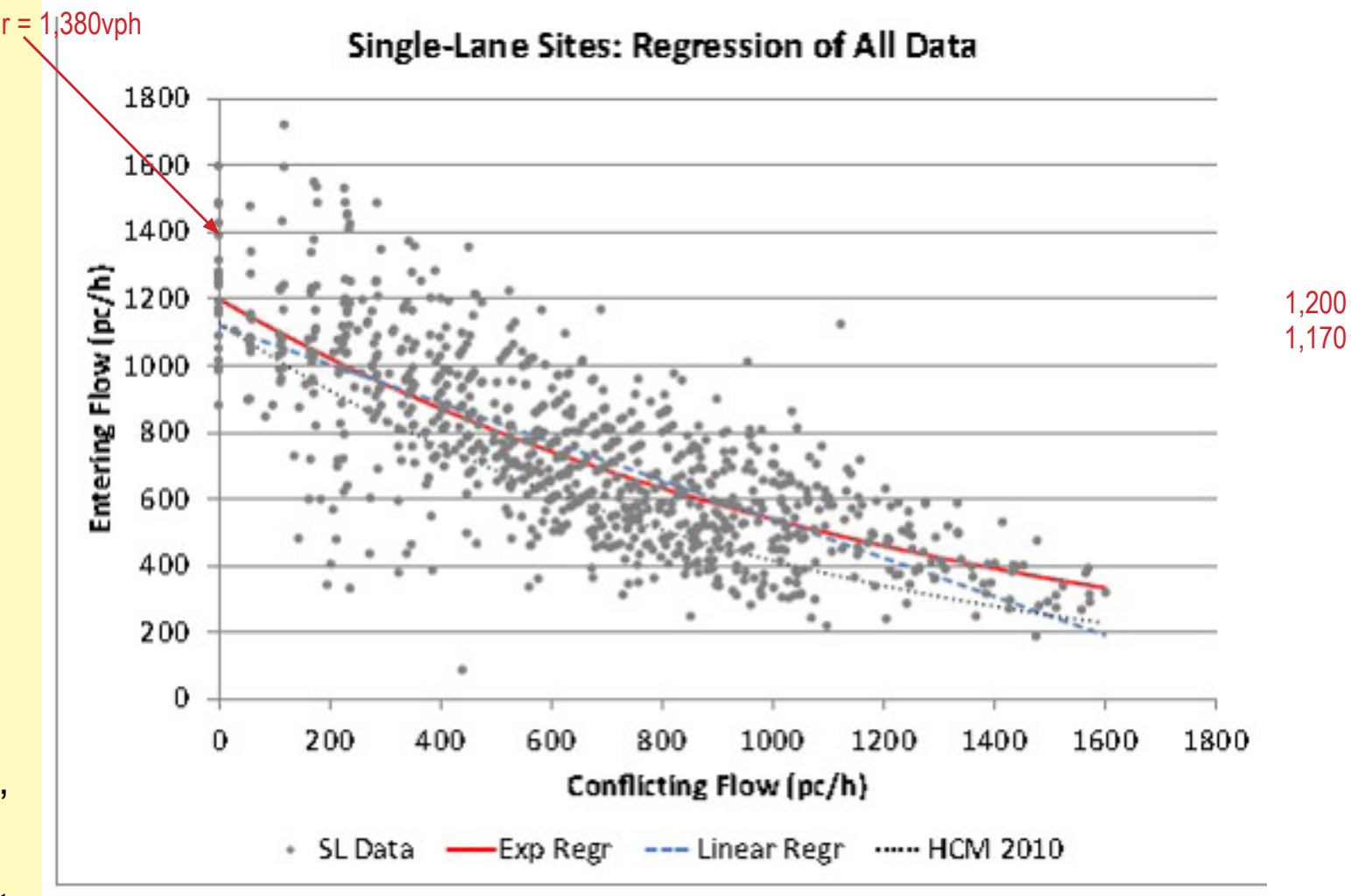
It put an unnecessary constraint on the model and made the model fit worse (higher RSME).

The true intercept of the linear model is 1,116. The intercept of the exponential model is 1,170. Both intercepts are significantly different from 1,385.

Also "anchoring" (arbitrarily fixing) of y intercept then using this to compare "fit" of the exponential vs linear line has no 'statistical basis' to support such an approach.

In the case of the anchoring at 1,385 which is not the true y intercept, it renders the comparison of fit of expo vs linear statistically questionable.

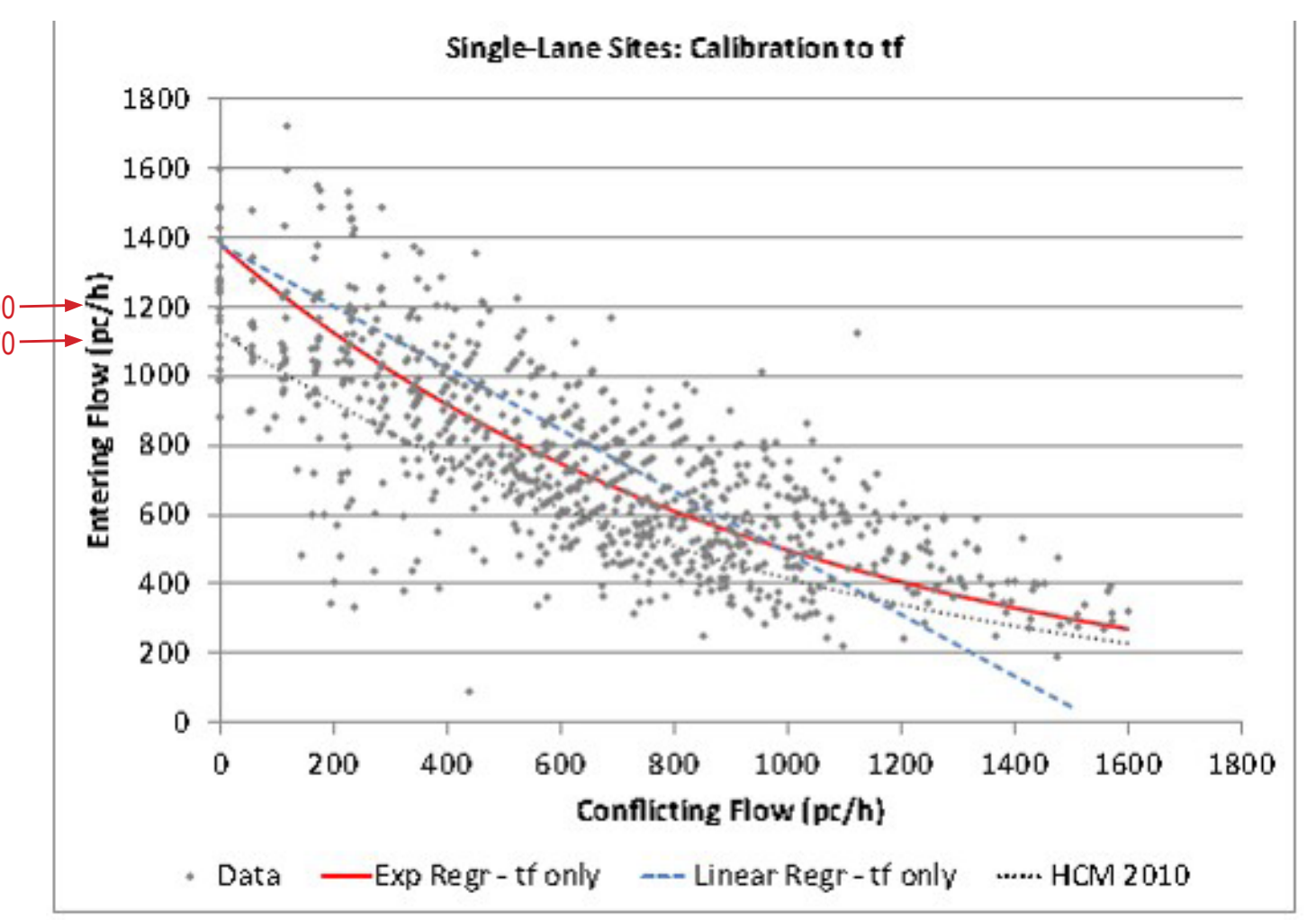
2.6 seconds/3600 sec/ hr = 1,380vph



Scatter plot: Regression models for single-lane roundabout sites.

Intercept Based on Actual Fit to Data

1,200
1,170



Scatter plot: Regression models for single=lane roundabout sites with calibration to follow-up time.

Intercept Anchored at 1385

Our review of the use of low and high circulating flows

Use of low and high circulating flows

Statistician's Response
Picking two sets of data at low then high circulating flows that show different slopes for linear vs expo line **is not a valid statistical approach.** This ignores the centralizing tendency of the mid-range data.

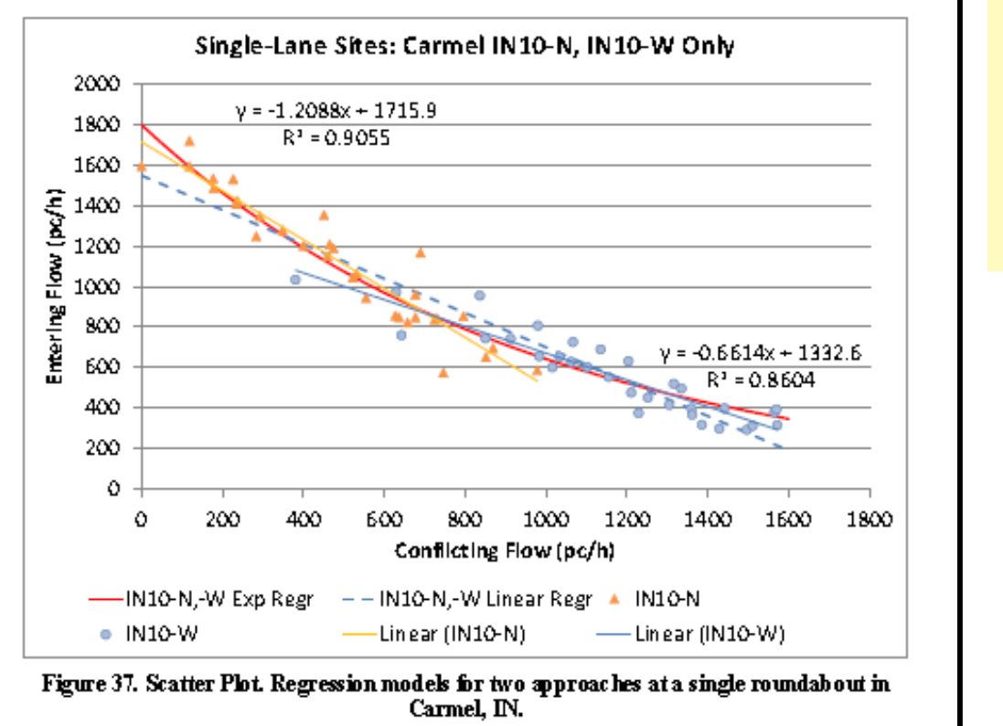


Figure 37. Scatter Plot. Regression models for two approaches at a single roundabout in Carmel, IN.

This analysis demonstrates two other important features. First, local calibration is important. The intercept that best fits the IN10 sites is higher than the best fitting intercept for the Carmel sites in general, and the intercept for the IN10 sites is much higher than experienced across the US. Second, both linear and exponential models appear to fit small data sets reasonably well. For analysis of existing roundabouts where one can calibrate to local conditions, either a linear or exponential model appears to work equivalently. However, when looking at larger data sets for prediction purposes, such as is necessary for proposed sites where local calibration is not possible, the exponential models appear to fit better than the linear models.

Our review of group means analysis

RMSE = how well model form predicts (lower = better)
R*R = best fit to data (higher = better)
Summary curved line is nearly flat, and statically there is very little to no difference.

A slightly different set of observations emerge when one separates the single-lane sites into two groups—Carmel and non-Carmel, as shown in figure 35 and figure 36, respectively. For the Carmel sites, the exponential group mean model has a RMSE of 78 and an R^2 of 0.88; the linear group mean model has a RMSE of 67 and a R^2 of 0.91. For the non-Carmel sites, the exponential group mean model has a RMSE of 57 and an R^2 of 0.93; the linear group mean model has a RMSE of 61 and a R^2 of 0.92. Based on these observations, a linear regression model appears to fit the Carmel group mean data better than the exponential model, particularly at high conflicting flows. The exponential model performs slightly better for the non-Carmel group mean data.

Carmel Data	RMSE (lower)	R*R	Best Fit (RMSE / R*R)
Linear	67	0.91	o/o
Exponential	78	0.88	x/x

Non Carmel Data	RMSE	R*R	Best Fit (RMSE / R*R)
Linear	61	0.92	
Exponential	57	0.93	

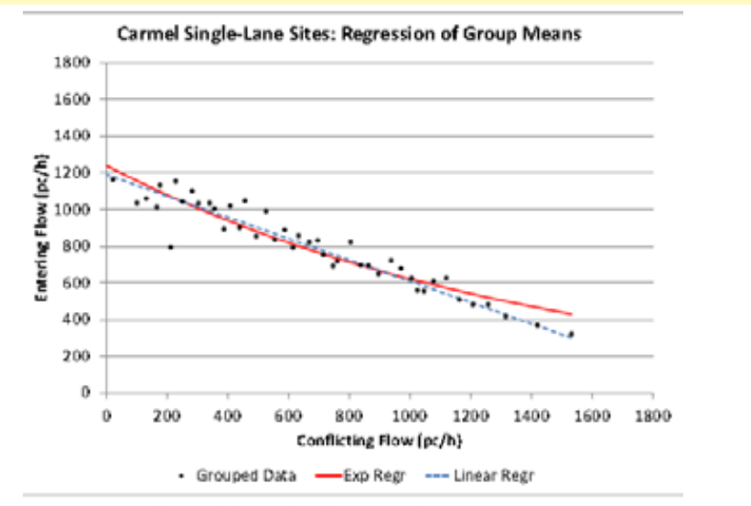


Figure 35. Scatter Plot. Regression of group means for Carmel-only single-lane roundabout sites.

RMS
R*R = best fit to data (higher = better) 0.03 diff

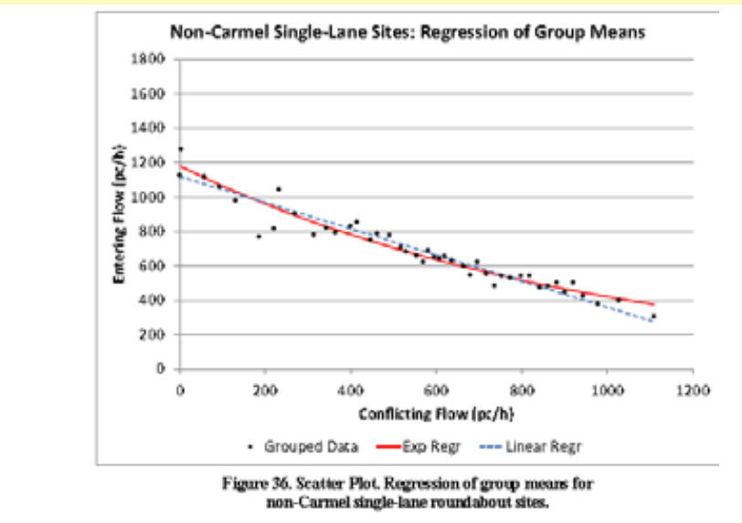


Figure 36. Scatter Plot. Regression of group means for non-Carmel single-lane roundabout sites.

RMSE = how well model form predicts (lower = better) dif = 4
R*R = best fit to data (higher = better) 0.01 diff

Linear line proves better fit for both RMSE and RR with no anchor to follow on time.