CITY OF BOULDER
TRANSPORTATION ADVISORY BOARD
AGENDA ITEM

MEETING DATE: May 11, 2015

AGENDA TITLE: Staff briefing and TAB input regarding the Complete Streets Phase II Living Laboratory program

PRESENTERS:
Michael Gardner-Sweeney, Acting Director of Public Works for Transportation
Kathleen Bracke, GO Boulder Manager
Dave (DK) Kemp, Senior Transportation Planner
Marni Ratzel, Senior Transportation Planner
Bill Cowern, Transportation Operations Engineer
Shannon Young, Transportation Engineer

EXECUTIVE SUMMARY

This item provides a status report, check in and opportunity for the Transportation Advisory Board (TAB) to provide input on the Complete Streets Living Laboratory Phase II program. Candidate corridors for the Phase II pilot projects include Iris, Folsom, 55th, and 63rd streets. The public engagement process launches in May to gather community feedback on the design options for street repurposing (rightsizing) pilot projects under consideration for each corridor. At the May 11 TAB meeting staff will brief the Board on design options and provide an update on the community engagement process and public feedback received to date. Public input along with the technical analysis and financial considerations will guide a staff recommendation regarding the installation of potential pilot projects along these corridors in summer 2015.

TAB ACTION REQUESTED

Review and provide feedback on the Complete Streets Living Laboratory or "Living Lab" Phase II design options, the technical analysis, and community engagement opportunities for pilot projects along candidate corridors.

BACKGROUND

The vision of the 2014 Transportation Master Plan (TMP) is to a create and maintain safe and efficient multimodal transportation system meeting the sustainability goals of the community TMP objectives include safety improvements for people using all modes of transportation working "Toward Vision Zero" for fatal and serious injury crashes. The 2014 TMP enhanced objectives include reducing single occupant vehicle travel to 20 percent of all trips for residents and to 60 percent of work trips for non-residents and reducing vehicle miles traveled for both

residents and non-resident employees. In addition, the TMP increases the goals for walking, biking, and transit mode share. Currently, Boulder residents ride the bus at twice the national average, walk three times as much and bicycle at 21 times the national average. The TMP sets ambitious yet realistic mode share goals of 30 percent bike, 25 percent walk, and 10 percent transit mode share for all trips taken within the city. To accomplish these goals, the TMP's Complete Streets focus area supports innovative approaches to enhance walking, biking and transit opportunities for people who live, work, and visit Boulder, with an emphasis to increase walk and bike trips by women, older adults and families.

Complete Streets Living Lab Program
The Complete Streets "Living Lab" pilot projects program began as part of the Transportation Master Plan (TMP) update to enhance the existing system for cyclists of all ages and riding abilities. The Living Lab program is being deployed in phases of pilot projects, with qualitative and quantitative analysis, including extensive community feedback, to evaluate the potential for long-term application in Boulder. The Living Lab program builds on prior city experience with "rightsizing" streets such as North Broadway and Baseline, as well as from similar work being done in peer cities and national/international examples.

Phase I - The first phase of Living Lab projects is providing an excellent forum for testing new, innovative facilities and contemporary treatments to improve Boulder's existing bicycle infrastructure. Phase I projects have been opportunistic and primarily bicycle-related, with a focused public engagement process prior to installations and a robust evaluation process after installation including community feedback, technical evaluation, and field "before and after" behavior observations.

Phase II – Complete Streets Corridors.
Responding to input from the community, boards, and City Council during the 2014 Transportation Master Plan update, staff is developing a set of 2015 Phase II Living Lab projects. Phase II projects include a 'street rightsizing' approach along four candidate corridors, including Iris, Folsom, 55th and 63rd. These projects are primarily comprised of restriping and signing the streets to increase comfort and safety of the corridor for people using all modes of transportation.

In Feb. 2015, the TAB provided input regarding the development of design options and community public engagement processes. At the Feb. 24, City Council study session discussion, staff received guidance from Council to continue the Living Lab approach of piloting innovations and use the "enhanced and focused" public process approach for the Phase II arterial candidate corridors right-sizing planning efforts. TAB input was considered as part of the discussion.

STAFF ANALYSIS
(New material: Sections highlighted in yellow)
Phase II Candidate Corridor Analysis and Conceptual Design Options

The Transportation Division has conducted a technical analysis of current conditions along each corridor and has developed conceptual design options based upon the TMP goals of enhancing

the bicycling, walking and transit experience, improving safety, and managing potential trade-offs such as vehicle travel time delays. The "rightsizing" process includes options to reallocate street space to better serve people using all modes of transportation. Rightsizing a street can encompass a broad array of design treatments and strategies. The in-depth technical analysis of the four proposed corridors is provided in Attachment A and more details of the corridor plans, renderings, and open house materials can be viewed on GO Boulder's Living Lab webpage: www.goboulder.net.

Highlights of Multimodal Analysis

The results of the technical analysis have provided an understanding of the operational and safety benefits and challenges associated with rightsizing the four candidate corridors. Staff anticipates the overall safety of the candidate corridors will be improved by reducing motor vehicle speeds while increasing the visibility of vulnerable users traveling along the corridors. Other benefits of rightsizing include improved safety and comfort for bicyclists by widening and buffering the bike lanes from vehicle travel lanes, fewer vehicle travel lanes for pedestrians to cross, and improved access to transit.

From an operational perspective, rightsizing each of the candidate corridors is feasible; however, the technical analysis projects significant increases in vehicle travel delays in specific segments in two of the corridors – Folsom Street and Iris Avenue. To address these operational challenges, staff has prepared multiple design options to be considered. These design options are intended to strike a balance between acceptable vehicle travel times and the installation of the enhanced multimodal transportation facilities (See Attachments B-J).

Proposed Corridor Design Options for Candidate Street Corridors

Based upon the technical analysis, staff has prepared the following brief descriptions to explain existing conditions vs. proposed conditions.

Iris Avenue
Existing conditions: Four lane arterial roadway with sub-standard vehicle and bike lanes in each direction. Proposed conditions: Two lane arterial roadway with continuous center two-way left turn lane and protected bike lanes in each direction.

Folsom Street
Existing conditions: Four/five lane arterial roadway with substandard vehicle and bike lanes in each direction. Proposed conditions: Two lane arterial roadway with continuous center two-way left turn lane and protected bike lanes in each direction along specific segments of the corridor. Design options provide multiple rightsizing extensions along corridor for consideration.

55th Street
Existing conditions: Five lane arterial roadway with standard bike lanes in each direction. Proposed conditions: Two lane arterial roadway with buffered bike lanes in each direction.

63rd Street
Existing Conditions: Five lane arterial roadway without bike lanes.
Proposed conditions: Two lane arterial roadway with buffered bike lanes in each direction.

The multimodal technical analysis and developed draft design options represent the work to date. Refinement of the design options will be conducted following TAB's input and the larger community engagement effort during the month of May. Staff will return to TAB in June with design and installation recommendations.

Public Engagement Process

Based on guidance from City Council provided during the Feb. 24 study session discussion, the Transportation Division developed an enhanced and focused public process to gather public input on design options for Phase II Complete Streets corridor rightsizing pilot projects.
A calendar with details of these public engagement forums is included in **Attachment J**.

On May 4, an *East Boulder Corridors* stakeholder meeting will be held to seek input on the design options for the 55th Street and 63rd Street corridors. The meeting will be held at the Valmont Presbyterian Church on 61st Street, which is near both candidate corridors.

On May 6, the Folsom Street and Iris Avenue corridors are the focus for a *West Boulder Corridors* stakeholder meeting. The meeting will be held from 4 to 6 p.m. at the Unity Spiritual Center of Boulder.

Community input from the May 4 and 6 public events will be shared at the TAB meeting on May 11.

The TAB hosted Open House meeting is scheduled for May 20 from 4 to 6 p.m. at BMoCA to coincide with a Wednesday Boulder County Farmer's Market event. Design options for all four candidate corridors and public input gathered to date will be presented.

There will also be an active, on-going community engagement process throughout the duration of the Living Laboratory Phase II program to seek on-going feedback from the community on their experiences using the new street configurations. This community feedback will be used along with the technical analysis of the Phase II projects to determine future phases for the Living Lab program.

Key Questions for TAB:

1. Does TAB have input regarding the technical analysis guiding the planning and development of design options for Phase II Complete Streets candidate corridor pilot projects?
2. Do the conceptual design options accomplish the TMP Complete Streets' goals?
3. Does the TAB have input on the proposed community engagement process proposed to advance the Phase II Living Lab Complete Street repurposing and right sizing experiments?

4. Is there additional information and/or analysis that TAB would like to see to help evaluate and select the 2015 Living Lab Phase II projects in advance of the June TAB meeting?

NEXT STEPS

Public input, technical analysis and financial considerations will guide the development of a staff recommendation on the proposed Phase II candidate corridors and design options. A public hearing and consideration of the Phase II Living Lab corridor pilot projects is scheduled for the June 8 TAB meeting. City Council will review the staff recommendations at their meeting on June 16. Based upon the TAB recommendation and Council direction, installation of selected pilot projects will be scheduled in summer 2015 and evaluation will be conducted throughout 2015-16.

Information is available regarding the Living Lab program at: www.goboulder.net

Attachments:

Attachment A:	FTH Technical Memo
Attachments B-J:	Conceptual Designs and Alternatives
Attachment K:	Calendar of Community Engagement Events

FOX TUTTLE HERNANDEZ
TRANSPORTATION GROUP

MEMORANDUM

To: David Kemp, City of Boulder

From: Bill Fox, PE
Steve Tuttle, PE, PTOE

Date: April 29, 2015

Project: Living Lab "Rightsizing" Corridor Evaluations

Subject: Technical Summary

As part of the ongoing Living Lab project, the Fox Tuttle Hernandez Transportation Group has been working with City of Boulder staff to evaluate potential changes to several roadway corridors to better optimize effective use of existing roadway widths for all modes of travel. These "rightsizing" evaluations have included several stages of evaluation and preliminary concept design to identify impacts and trade-offs between current and proposed operating conditions. The purpose of this memorandum is to summarize these efforts.

Candidate corridors being considered for the rightsizing pilot project design treatments include:

- Iris Avenue from Broadway to Folsom Street
- Folsom Street from Arapahoe Avenue to Valmont Road
- 55th Street from Arapahoe Avenue to Pearl Parkway
- 63rd Street from Lookout Road to Gunbarrel Avenue

All of these roadways, except 63rd Street, currently have on-street bicycle lanes with two through lanes in each direction and with varying left-turn lane accommodations. An initial assessment of

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daily traffic volumes by City Staff along these corridors suggests there is the potential for repurposing an existing through lane in each direction to enhance multi-modal travel. The more detailed assessments that have been performed by Fox Tuttle Hernandez are described in the following text.

Preliminary Level of Service Screening

Fox Tuttle Hernandez performed a comparison of vehicle Level of Service (LOS) modeling at signalized intersections using Synchro software between the existing and future roadway design. The existing laneage on each corridor was compared to the possible repurpose of one through lane per direction to provide an improved bicycle facility. This analysis was summarized in detail in a memo to staff dated December 31, 2014. The results of this LOS screening showed that the majority of the corridor intersections could operate with repurposed vehicular lanes without significant impacts to overall intersection or individual approach movement LOS. The screening also identified key intersections and traffic movements along the Iris Avenue, Folsom Street, and 55th Street corridors where removal of existing vehicular lanes would result in poor LOS (typically LOS E or F), particularly in the PM peak hours due to heavy traffic volumes. These key locations include:

Level of Service: *To measure and describe the operational status of an intersections a grading system referred to as "Level of Service" (LOS) is used that is defined by the Highway Capacity Manual. LOS characterizes the operation conditions of traffic flow, ranging from LOS A (very good, free flow) to LOS F (congested and sometimes oversaturated). These grades represent the perspective of drivers and are an indication of the comfort and convenience associated with traveling through the intersections. The intersection LOS is represented as a delay in seconds per vehicle for the intersection as a whole and for each turning movement.*

- Iris Avenue – Westbound Approach at Broadway (existing dual-left turn lane)
- Folsom Street – Southbound Approach at Arapahoe Avenue (existing dual-left turn lane)
- Folsom Street – Northbound and Southbound Approach at Canyon Boulevard
- Folsom Street – Northbound Approach at Pearl Street
- 55th Street – Southbound Approach at Arapahoe Avenue (existing dual-left turn lanes)

The capacity analysis of 63rd Street focused on the signalized intersections at Lookout Road and at Spine Road. The LOS results indicated that the rightsizing of 63rd Street will not impact the overall LOS of either intersection. Lookout Road will have LOS C overall in both scenarios and Spine Road will have LOS B overall in both scenarios. The movement LOS will remain the same as existing even

with the repurposing of one travel lane and there would be relatively low impacts to the vehicular operations along the corridor. Due to the acceptable LOS results with one travel lane repurposed on 63rd Street, it was determined that further evaluation in VISSIM was unnecessary.

Deciding to Rightsize between 4 to 3 Lanes OR 4 to 2 Lanes

Currently, Iris Avenue and the northern segment of Folsom Street have 4 travel lanes with no center turn lane between the larger signalized intersections. In these sections there is the potential to rightsize to either 2 or 3 lanes, where the 3 lane segments would maintain a two way center turn lane in the middle of the roadway. Maintaining a center turn lane allows left turning motorists to move out of the through lane when slowing and potentially waiting to turn left at a driveway or unsignalized intersection. Eliminating the center turn lane allows for wider buffers, but also results in the potential for an increase in traffic accidents, particularly rear-end collisions.

Based on a review of existing traffic counts and information in the National Cooperative Highway Research Program's (NCHRP) Report 279, *Intersection Channelization Design Guide* (see Appendix for reference materials), and the Federal Highway Administration's (FHWA) *Road Diet Informational Guide*, it is recommended to eliminate the rightsize opton from 4 to 2 lanes. The minor street volumes compared to the main street volumes indicated that Iris Avenue and Folsom Street (north section) needed to provide a center turn lane to reduce the potential congestion and conflict with left-turning vehicles. All of these areas still allowed for a significant buffer between the through lane and the bike lane in each direction.

The corridors of 55th Street and 63rd Street were not considered for a 4 to 2 lane conversion because there are physical medians and prohibit restriping to a 4 to 2 lane conversion. The medians provide left-turn lanes where necessary and divide the roadway along the entire length of the study areas. It is proposed that these corridors rightsize from a 4 to 3 lane roadway, with the center lane maintaining the existing median.

Travel Time and VISSIM Modeling

While the LOS analysis using Synchro modeling provided a high-level, macroscopic view of projected intersection delays, VISSIM software modeling was then used to provide a microscopic simulation of traffic flow for both vehicles and bicycles along the Iris Avenue, Folsom Street, and 55th Street corridors. VISSIM modeling provides a three dimensional depiction of the corridor and models all vehicles and traffic controls. The model can be viewed to observe traffic queues and vehicular interactions, while also providing quantitative results such as corridor and segment travel times. While individual intersection LOS results provided by the Synchro model are a

common metric used by transportation engineers, travel times are more easily understood by a greater audience and also tell more about potential impacts on a corridor-length basis.

The VISSIM models for Iris Avenue, Folsom Street, and 55th Street were created for existing AM and PM peak hour conditions, with existing laneage, vehicular volumes, bicycle volumes, pedestrian crossing volumes, existing signals and signal timing. To validate the accuracy of the VISSIM model and determine if any calibration was needed, the VISSIM travel time results were compared to travel time data collected in the field for these corridors.

Existing travel time was collected manually for Iris Avenue, Folsom Street, and 55th Street. On the week of November 18, travel time runs were completed for each corridor during the AM and PM peak hours. The data collection plan and methodology is consistent with the *Travel Time Data Collection Handbook (FHWA, March 1998)*.

Six travel time runs for each direction were performed for each corridor. The start and end times, control point times, and stopped times were recorded during each run. The start location was the upstream intersection from the beginning of first intersection of the rightsize corridor. The signalized intersections were identified as the control points where the time was taken when the stop bar was crossed. The amount of delay was recorded when the vehicle slowed or stopped (less than 5 mph). The end of the travel time was the downstream intersection from the last intersection of the study corridor. All of the recorded times provided the total trip time, running time, stopped time, travel speed, and running speed per travel time run and as an average per peak hour. The data is provided in the Appendix.

The field-collected travel time results were then compared to the VISSIM results for the existing AM and PM peak hour conditions. The results are summarized on charts depicting the elapsed travel time from the start of the study corridor (crossing the near-side stop bar), through to the end of the study corridor for each direction of travel (passing the near-side stop bar of the final intersection). Note that this differs slightly from the "raw" travel time data, which also included the time on the approach to the first intersection in the total travel time. These charts are provided in the Appendix. The charts illustrate that the VISSIM travel time results are very similar to existing field conditions for all scenarios, indicating that the VISSIM model was well calibrated and will provide a useful tool in predicting the effects of corridor rightsizing.

The existing-condition VISSIM models were then modified for several laneage scenarios, with the variations related to addressing the "key" locations noted on page 2 of this report. The travel time charts for each scenario evaluated, which compare each laneage scenario with the "existing"

VISSIM (calibrated) travel time, are provided in the Appendix. The travel time charts are summarized by direction of travel and time period, and include the following information:

- Existing travel time
- Modified laneage travel time. Note that for any corridor, "VISSIM-01" on the travel time chart refers to a repurposed lane in each direction and with reduction of a dual left-turn to a single-left turn for the following approaches (Iris Avenue westbound at Broadway, Folsom Avenue southbound at Arapahoe Avenue, and 55th Street southbound at Arapahoe). "VISSIM-02" refers to a scenario with a repurposed through lane in each direction but maintaining the dual left-turn lanes noted above.
- The "high" travel time for the worst 10-min period of the scenario which had the highest increase in travel time; this was used to evaluate potential variation between the average and worst travel times throughout the hour, particularly where the VISSIM model showed compounding queues and delay extending significant lengths of the corridors, which would continue to build throughout much of the peak hour.
- For the peak hours and directions determined to be most critical (highest potential increases in travel times), there are also charts that show the existing and modified travel times for the "shoulder" peak periods from 3pm-5pm and 6pm-8pm, for some context to what impacts there may be to travel times outside of the peak hour. The volumes used for these "shoulder" peak hours were based on City of Boulder hourly count data at nearby count stations.

The results are summarized and discussed, as follows, with travel time charts provided in the Appendix:

<u>Iris Avenue:</u>

Existing Conditions:

- In the AM peak hour, the VISSIM existing eastbound and westbound travel times averaged 2:33 and 2:42, respectively. In the PM peak hour, the existing eastbound and westbound travel times averaged 2:26 and 2:54, respectively.

Rightsizing Options:

1. Repurpose one through lane in each direction but with maintaining the westbound dual left-turn lanes at Broadway, average travel times increased as follows:
    - AM eastbound: from 2:33 to 2:38
    - AM westbound: from 2:42 to 2:58
    - PM eastbound: from 2:26 to 2:39
    - PM westbound: from 2:54 to 3:06
2. Repurpose one through lane in each direction and repurpose one of the westbound left-turn lanes at Broadway to widen the existing bicycle lanes, average travel times increased as follows:
    - AM eastbound: from 2:33 to 2:41
    - AM westbound: from 2:42 to 3:12, with majority of this added delay on the Broadway approach
    - PM eastbound: from 2:26 to 2:39
    - PM westbound: from 2:54 to 4:50, with majority of this added delay on the Broadway approach and queues spilling back from Broadway through 16th Street
    - Further analysis of the PM westbound data showed that during the worst 10-min period, travel times could be as high as 6.5 minutes with this lane configuration

<u>Folsom Street:</u>

Existing Conditions:

- In the AM peak hour, the VISSIM existing northbound and southbound travel times averaged 2:25 and 2:56, respectively. In the PM peak hour, the existing northbound and southbound travel times averaged 3:31 and 3:12, respectively.

Rightsizing Options:

1. Repurpose one through lane in each direction and maintain the southbound dual left-turn lanes at Arapahoe Avenue, average travel times increased as follows:
    - AM northbound: from 2:25 to 2:45
    - AM southbound: from 2:56 to 3:01
    - PM northbound: from 3:31 to 4:47, with majority of this added delay on the Folsom approach to Pearl Street; further analysis indicated travel times as high as 6:00 during the worst 10-min period.
    - PM southbound: from 3:12 to 4:30, with majority of this added delay on the approach to Canyon Boulevard.
2. Repurpose one through lane in each direction and repurpose one of the southbound left-turn lanes at Arapahoe Avenue to widen the existing bicycle lanes, average travel times increased as follows:
    - AM northbound: from 2:25 to 2:45
    - AM southbound: from 2:56 to 3:02
    - PM northbound: from 3:31 to 4:48, with majority of this added delay on the Folsom approach to Pearl Street; further analysis indicated travel times as high as 6:00 during the worst 10-min period.
    - PM southbound: from 3:12 to 6:35, with majority of this added delay on the approaches to Arapahoe and Canyon; further analysis indicated travel times as high as 8.5 min during the worst 10-min period, with queues extending north of Pine towards Valmont

<u>55th Street:</u>

Existing Conditions:

- In the AM peak hour, the VISSIM existing northbound and southbound travel times averaged 2:15 and 2:10, respectively. In the PM peak hour, the existing northbound and southbound travel times averaged 2:49 and 2:16, respectively.

Rightsizing Options:

1. Repurpose one through lane in each direction, a single northbound left turn lane at Pearl Parkway, a single westbound left-turn lane on Pearl Parkway to southbound 55th Street, and maintain the southbound dual left-turn lanes at Arapahoe Avenue, average travel times increased as follows:
    - AM northbound: from 2:15 to 2:30
    - AM southbound: from 2:10 to 2:17
    - PM northbound: no increase (this is due to improved operation of the northbound left-turn at Pearl Parkway operating as a protected-permissive single left-turn lane vs. the existing dual protected-only operation, offsetting any delay created by the repurposed through lane along the corridor)
    - PM southbound: from 2:16 to 2:26
2. Repurpose one through lane in each direction and reduce to one southbound left turn lane at Arapahoe Avenue:
    - AM northbound: from 2:15 to 2:30
    - AM southbound: from 2:10 to 2:26
    - PM northbound: no increase (this is due to improved operation of the northbound left-turn at Pearl Parkway operating as a protected-permissive single left-turn lane vs. the existing dual protected-only operation, offsetting any delay created by the repurposed through lane along the corridor)
    - PM southbound: from 2:16 to 5:35, with delays and queues initially building up from Arapahoe but then extending the length of the corridor through each signal; further analysis indicated travel times as high as 10.5 min during the worst 10-min period.

- VISSIM modeling of the existing at-grade railroad crossing between Western Avenue and Central Avenue showed that northbound traffic queues during the AM peak hour (the heaviest northbound traffic period) could extend south to Arapahoe Avenue if the train

event lasted 6 minutes. With the repurposed scenario, the queue would back to Arapahoe Avenue with a 3 minute train event.

The following table summarizes the travel time for each roadway and scenario as described above:

Direction	Peak Hour	Existing	Alternative 1 Rightsize and maintain dual lefts at key Intersection	Alternative 2 Rightsize and reduce to single left at key Intersection
Iris Avenue				
Eastbound	AM	2:33	2:38 (+0:05)	2:41 (+0:08)
	PM	2:26	2:39 (+0:13)	2:39 (+0:13)
Westbound	AM	2:42	2:58 (+0:16)	3:12 (+0:30)
	PM	2:54	3:06 (+0:12)	4:50 (+1:56)
Folsom Street				
Northbound	AM	2:25	2:45 (+0:20)	2:45 (+0:20)
	PM	3:31	4:47 (+1:16)	4:48 (+1:17)
Southbound	AM	2:56	3:01 (+0:05)	3:02 (+0:06)
	PM	3:12	4:30 (+1:18)	6:35 (+3:23)
55th Street				
Northbound	AM	2:15	2:30 (+0:15)	2:30 (+0:15)
	PM	2:49	2:49 (no change)	2:49 (no change)
Southbound	AM	2:10	2:17 (+0:07)	2:26 (+0:16)
	PM	2:16	2:26 (+0:10)	5:35 (+3:19)

The results of the VISSIM modeling for the Iris Avenue, Folsom Avenue, and 55th Street corridors largely confirmed the LOS analysis and that 1) most of the corridor lengths could function with repurposed through lanes and 2) the key approaches and movements noted above could experience long vehicular delays and corresponding increases in corridor travel time if the laneage were reduced on these approaches. The VISSIM modeling and travel time estimates also illustrated the compounding nature of decreased capacity for heavy movements, where traffic queues could quickly extend for several intersections upstream from a bottleneck. The resulting effect on travel times due to multi-block queues spilling back from these heavy movements would be expected to result in some diversion onto other roadways.

Multimodal Enhancements

It should be noted that the decrease in roadway capacity and increase in travel time is a negative impact on vehicles traveling along the corridors, however, the bicyclists and pedestrians are expected to have an increased level of service, safety, and comfort.

Bicyclist experience will improve and they will benefit from:

- Wider bike lanes for comfort and to safely pass other bicyclists
- Buffer from vehicular traffic
- Protection from vehicular traffic encroaching on bike lane (where flexible delineators are provided)
- Slower automobile traffic due to narrower travel lanes
- Enhanced right-turn treatments at high volume intersections
- Increased driver awareness of the bike facility

Pedestrian experience will also improve and they will benefit from:

- Shorter crossing distances since the buffer can be used as a refuge
- Buffer from vehicular traffic that will minimize the "splash zone" and encourage use of the entire sidewalk width
- Slower automobile traffic due to narrower travel lanes creating a better walking environment

With any rightsizing project there are trade-offs between modes of travel and the goal is to balance the available space and level of service for all users.

Design Considerations

On Iris Avenue and Folsom Street the dual left-turns noted previously are locations where maintaining both left-turn lanes would preclude significant improvement to the existing on-street bicycle lanes. The buffered bikeway would have to end prior to the distance required to accommodate the dual left-turn lanes. The LOS analysis indicated the need to maintain the dual left-turn lanes. Further evaluation with VISSIM determined there will be significant queues, blocked turn lanes, and excessive delay if the rightsizing project changed the dual left-turns to a single left-turn (refer to the Travel Time and VISSIM section for more detail).

On 55th Street at Arapahoe Avenue, the roadway width is able to accommodate the buffered bike lanes in both directions while maintaining the dual left-turn lanes. The through lane alignment

across Arapahoe Avenue in both directions was slightly altered to provide the dual lefts and the buffered bikeway.

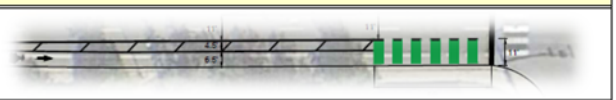
The repurposing of an existing through lane in each direction facilitates the addition of buffered bike lanes. Each corridor varies in width, number of accesses, type of center median, number of bus stops, and travel mode composition, which greatly informed the design of each rightsize corridor. The following design elements are being proposed on each of the studied corridors to fit within the existing roadway width:

Corridor		Bike Lane	Buffer	Travel Lane	Center Lane / Median	Flexible Delineators
Iris Avenue		6.5'	3'	11'	10.5'	Yes
Folsom Street						
North of Spruce St		7'	3.5'	10'	10.5'	Yes
South of Spruce St		7'	6' – 7.5'	10' – 11'	15' – 16'	Yes
55th Street		7'	10'	11'	2' – 14'	No
63rd Street		7'	6'	12'	14'	No

Note: Some variations in the widths occur at signalized intersections to accommodate turn lanes and right-turn treatments.

It should be noted that it is proposed to install a 10-foot multi-use path on the north side of Iris Avenue between Broadway and 16th Street to alleviate some of the conflict for westbound turning bicyclists and vehicles.

As part of this Living Lab project, three design options were created for right-turn treatments at the signalized intersections. These were developed based on information in the NCHRP Intersection Channelization Design Guide, from the National Association of City Transportation Official's (NACTO) Bikeway Design Guide design guidelines and right-turning volume. It is anticipated that the evaluation process will study the compliance and safety of each treatment for further use. The following table lists and illustrates the three right-turn treatments used throughout the four rightsizing corridors.

Right-Turn Treatment	Right-Turning Volume (vph)	Illustration
Skip with Green Dash	1-75	
Mixing Zone	76-125	
Buffered Transition	126+	

On April 7, 2015 staff from the City and Fox Tuttle Hernandez presented the conceptual design on Folsom Street to NACTO in a webinar that was broadcast nationally for a design critique. The purpose of the critique was to gather feedback on additional design options for the corridor and learn from the critics past experiences on similar projects. The project team has received the comments and suggestions which will be discussed further in a future meeting.

Additional designs were created to address the operational challenges as listed previously. The VISSIM analysis indicated that the rightsizing the entire length of the corridor and removing the existing dual left-turn lanes on some of the study corridors has significant impacts to the vehicular capacity and travel time. Therefore, alternative designs were created for Iris Avenue and Folsom Street. The following table lists some considerations with each scenario:

Alternative	Considerations
Iris Avenue	
1 Maintain dual WB dual lefts at Broadway	• Maintains vehicular capacity at Broadway for high-volume left-turn and mitigates most the potential corridor travel time increase with rightsizing • Significantly reduces potential WB queues when compared to full rightsize option. • Shortens the length of the potential EB buffered bikeway to 13th Street. • Narrows travel lanes in both directions for length of left-turn lane/taper
2 Full rightsize and reduce to single WB left at Broadway	• Provides buffered bikeway the entire length of the corridor in both directions. • Allows double buffered bikeway at Broadway WB. • Increases delay and queue of WB traffic at Broadway. The queue blocks vehicles from reaching appropriate turn lane and resulting compounding queues were modeled to extend east to 19th Street • Increases average WB travel time significantly (nearly double) in the PM peak hour.

Alternative	Considerations
Folsom Street	
1 Rightsize between Valmont Rd and Canyon Blvd and maintains dual left at Arapahoe Ave	• Maintains vehicular capacity SB at Arapahoe for high-volume left-turn • Reduces SB queues from impacting entire corridor when compared to full rightsize option. • Mitigates potential increases of the VISSIM-modeled average travel time to less than 78 seconds in each direction and during both peak hours. • Moves the beginning of the NB buffered bikeway to Canyon Blvd. • Ends the SB buffered bikeway at Canyon Blvd. • Provides a SB bike box at Arapahoe Ave. • Provides wider bike lane between Canyon Blvd and Arapahoe Ave.
2 Full rightsize and reduce to single SB left at Arapahoe Ave	• Provides buffered bikeway the entire length of the corridor in both directions. • Increases delay and queue of SB traffic between Canyon Blvd and Arapahoe Ave. The queues extents a large portion of corridor. • Increases average SB travel time significantly (nearly double) in the PM peak hour. • Increases NB travel time by one minute 17 seconds in the PM peak hour.
3 Rightsize between Valmont Rd and South St and maintains dual left at Arapahoe Ave	• Improves vehicular operations at Arapahoe Ave and Canyon Blvd. • Reduces SB queues from impacting entire corridor when compared to full rightsize option. • Results in less travel time increase compared to other alternatives. • Moves the beginning of the NB buffered bikeway to South St. • Ends the SB buffered bikeway at South St. • Provides a SB bike box at Arapahoe Ave. • Provides wider bike lane between Canyon Blvd and Arapahoe Ave. • Introduces a lane reduction with merge for NB vehicles.

As a part of this project, there is potential for the Folsom Street corridor to extend south of Arapahoe Avenue to Colorado Avenue. A conceptual design has been drafted and is currently under review. Further evaluation is needed along this portion of Folsom Street to determine the impacts to the existing intersections, left-turn lanes, and bicycle safety up/down the hill.

/BF/SGT

Appendix:

NCHRP Report 279, *Intersection Channelization Design Guide*
Field Travel Time Data
Travel Time Charts – Iris Avenue
Travel Time Charts – Folsom Street
Travel Time Charts – 55th Street

Appendix:

NCHRP Report 279, Intersection Channelization Design Guide

Field Travel Time Data

Travel Time Charts – Iris Avenue

Travel Time Charts – Folsom Street

Travel Time Charts – 55th Street

NCHRP Report 279, Intersection Channelization Design Guide

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM REPORT **279**

INTERSECTION CHANNELIZATION DESIGN GUIDE

TIMOTHY R. NEUMAN
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Evanston, Illinois

RESEARCH SPONSORED BY THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS IN COOPERATION WITH THE FEDERAL HIGHWAY ADMINISTRATION

AREAS OF INTEREST:

FACILITIES DESIGN
OPERATIONS AND TRAFFIC CONTROL
(HIGHWAY TRANSPORTATION)

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
WASHINGTON, D.C.

NOVEMBER 1985

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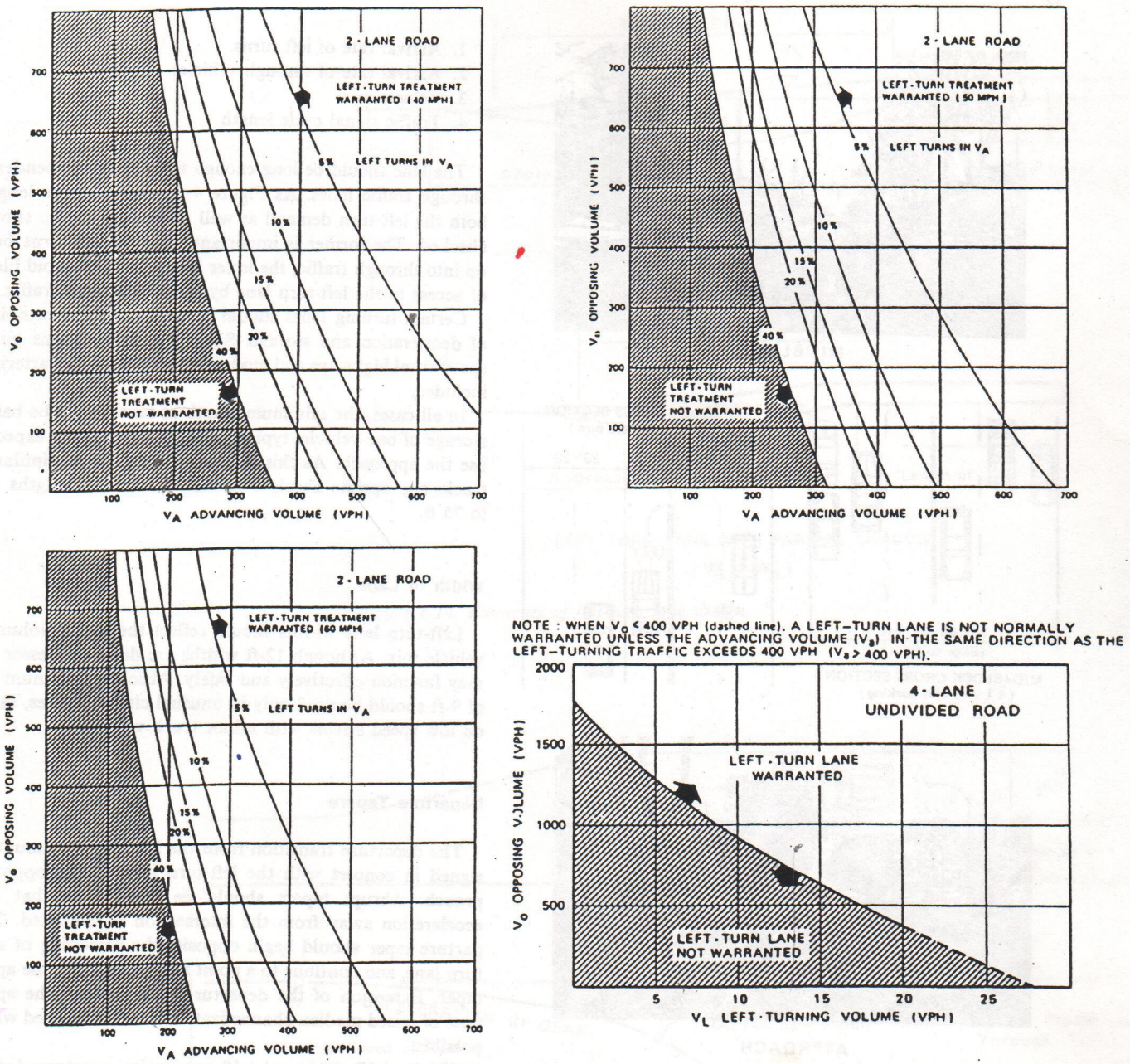


Figure 4-12. Volume warrants for left-turn lanes at unsignalized intersections. (Source: Ref. 4-7)

a partially shadowed left-turn lane, as illustrated in Figure 4-14. With partially shadowed left-turn lanes, the offset created by the approach taper does not entirely protect or "shadow" the turn lane.

Length of Lane

The left-turn lane length is among the most important design element of left-turn lanes. Its design is directly tied to the particular function of the lane, which is based on prevailing speeds, traffic volumes, and traffic control. The design basis for length can be deceleration, storage, or a combination of both.

Left-turn lanes on high-speed highways should be designed to accommodate vehicle deceleration and braking. The channelization principle of removing slow or decelerating vehicles from through traffic applies at such locations. Figure 4-15 illustrates the functional basis for design of deceleration-based left-turn lanes according to AASHTO. The assumed "reasonable" driver behavior includes deceleration in gear for 3 sec., followed by comfortable braking completely within the turning lane. Where constraints exist and speeds are moderate, an al-

L_d/b -- Length of Taper and Lane For Deceleration and Braking

Functional Basis: To provide sufficient length for a vehicle to decelerate and brake entirely outside the through traffic lanes

Desirable Design: Deceleration in gear for 3 seconds (occurs over bay taper) followed by comfortable braking to a stopped position

Design Values For L_d/b

S--Speed (mph)	Length (ft) Total	Lane	Bay Taper
30	235	90	(145)
40	315	125	(190)
50	435	195	(240)
60	530	240	(290)

Minimum Design: Braking begins at 2/3 full lane width, with minimum 50-foot storage. For low speeds only, the following values apply:

Design Values For L_d/b

S--Speed (mph)	Length (ft) Total	Lane	Bay Taper
30	230	50	(180)
35	250	70	(180)
40	280	100	(180)
45	320	140	(180)

Figure 4-18. Guidelines for design lengths of left-turn lanes.

L_s -- Length of Lane For Storage (Full Width Lane)

Functional Basis: To provide sufficient length for a reasonable number of vehicles to queue within the lane without affecting other lanes

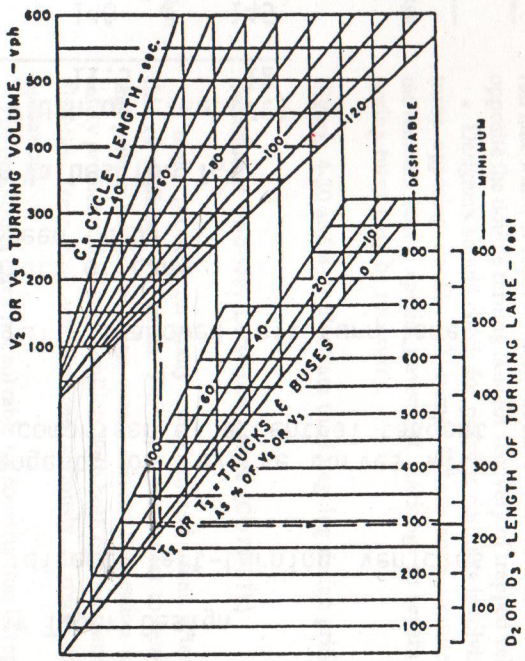
Desirable Design: Based on twice the mean arrival rate (per cycle for signals, per 2-minute period for stop control) during the peak hour of traffic

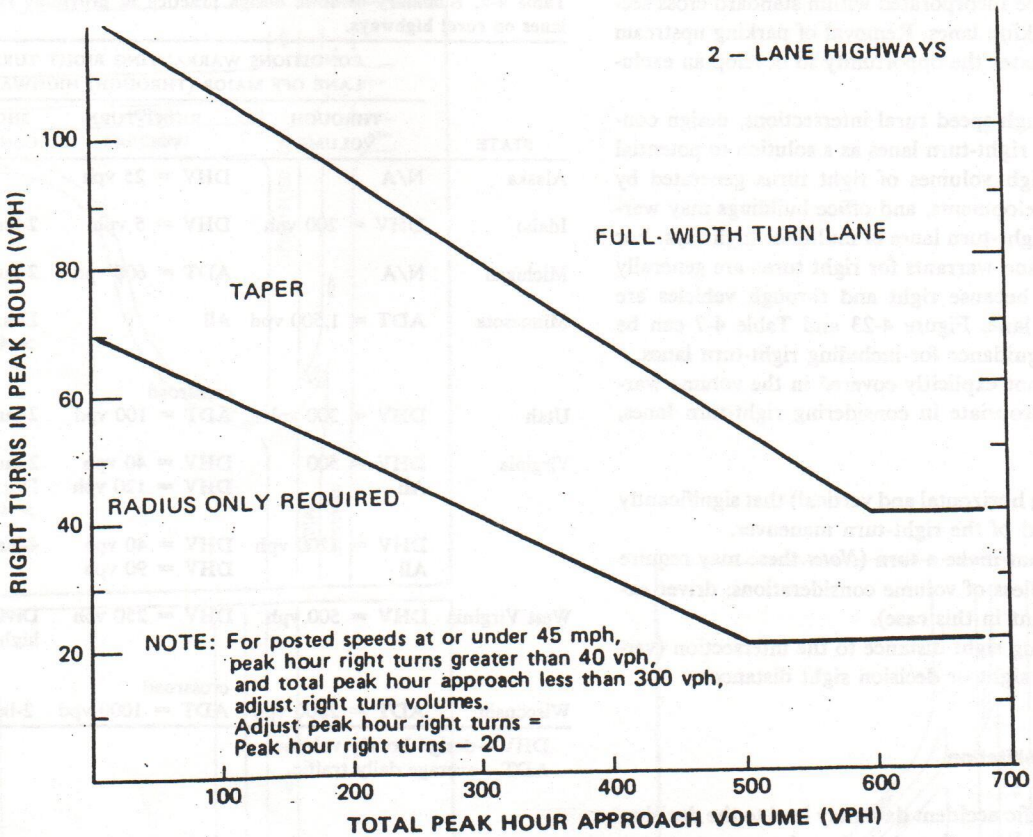
Minimum Design: Based on mean arrival rate, with minimum storage for one vehicle

L_s for Stop Control

DHV (vph)	L_s (ft)
≤60	50-75
61-120	100
121-180	150
>180	200 or more

L_s for Traffic Signal Control





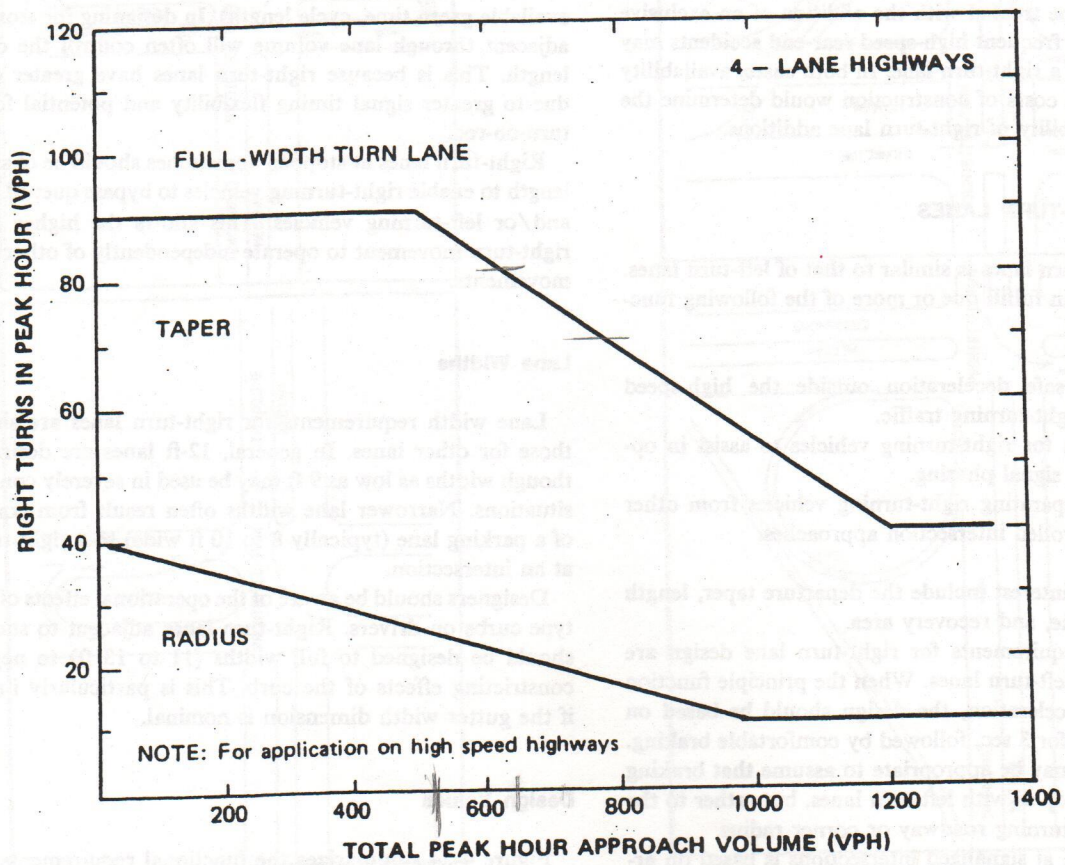


Figure 4-23. Traffic volume guidelines for design of right-turn lanes. (Source: Ref. *4-11*)

$L_d/_b$ -- Length of Taper and Lane For Deceleration and Braking

Functional Basis: To provide sufficient length for a vehicle to decelerate and brake entirely outside the through traffic lanes.

Desirable Design: Deceleration in gear for 3 seconds (occurs over bay taper) followed by comfortable braking to a stopped position or to the design speed of the corner radius.

Design Values For $L_d/_b$

For Design Speed of Corner Radius (mph)

Highway Design speed, V (mph)	Stop Condition*	15	20	25	30
30	235	185	160	140	-
40	315	295	265	235	185
50	435	405	385	355	315
60	530	500	490	460	430
65	570	540	530	490	480
70	615	590	570	550	510

*Appropriate for right turn lanes on approaches to stop signs and traffic signals.

L_s -- Length of Lane For Storage (Full Width Lane)

Functional Basis: To provide sufficient length for a reasonable number of vehicles to queue within the lane without affecting other lanes.

Desirable Design: Based on twice the mean arrival rate (per cycle for signals, per 2-minute period for stop control) during the peak hour of traffic.

Minimum Design: Based on mean arrival rate, with minimum storage for one vehicle.

L_s for Stop Control

DHV (vph)	L_s (ft)
≤60	50-75
61-120	100
121-180	150
>180	200 or more

L_s for Traffic Signal Control

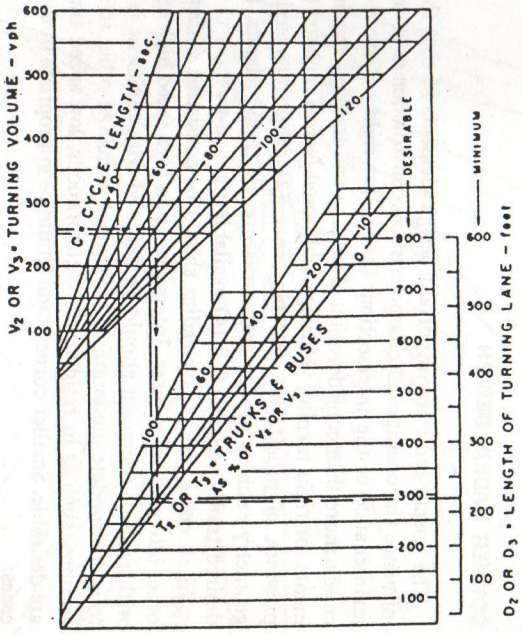


Figure 4-24. Guidelines for design lengths of right-turn lanes.

Field Travel Time Data

Iris Avenue
Travel Time Data
AM Peak 7:30 AM
Date: 11/18/2014
Weather:

From: Retail Access w/o 28th Ave
To: Hawthorne Ave (Westbound)
Juniper Ave (Eastbound)

Direction	Trip No.	Time at Control Points					Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Broadway	16th St	19th St	22nd St	Folsom St	Location	Time	Cause	Notes							
East	1	0:15	1:21	1:47	2:10	2:35	Broadway	0:36	Signal		1.24	2:58	2:22	0:36	25	31	
	2	0:26	0:57	1:38	2:07	2:45	Broadway Folsom St	0:18 0:09	Signal Signal		1.24	3:09	2:42	0:27	24	28	Posted speed limit is 35 mph. The school zone near 22nd is 20 mph. Occurred during morning travel time.
	3	0:36	1:09	1:34	2:02	2:35	Broadway	0:26	Signal		1.24	2:58	2:32	0:26	25	29	School zone flashing.
	4	0:54	1:28	2:37	3:10	3:48	Broadway 19th St	0:41 0:35	Signal Signal	Arrived on FYA, did not get a gap.	1.24	4:12	2:56	1:16	18	25	School zone flashing.
	5	0:45	1:15	1:57	2:32	3:01	Broadway 19th St	0:30 0:08	Signal Signal		1.24	3:26	2:48	0:38	22	27	
	6	0:38	1:08	2:15	2:39	3:29	Broadway 19th St Folsom St	0:26 0:36 0:11	Signal Signal Signal		1.24	3:56	2:43	1:13	19	27	
	Average	***0:35***	***1:13***	***1:58***	***2:26***	***3:02***					***Average***	***3:26***	***2:40***	***0:46***	***22***	***28***	

Direction	Trip No.	Time at Control Points					Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Folsom St	22nd St	19th St	16th St	Broadway	Location	Time	Cause	Notes							
West	1	0:36	1:11	1:38	2:08	2:44	Folsom St Broadway	0:09 0:31	Signal Signal		1.28	3:37	2:57	0:40	21	26	
	2	0:25	1:01	1:30	1:57	3:15	Broadway	0:46	Signal		1.28	3:35	2:49	0:46	21	27	The WB left at Folsom St had a queue of 14 vehicles that blocked through lane.
	3	0:21	0:59	2:23	2:56	3:50	19th St Broadway Hawthorne	0:42 0:16 0:06	Signal Signal Bus stop	Arrived at stop bar at 1:40.	1.28	4:28	3:24	1:04	17	23	School zone flashing.
	4	0:26	0:57	1:21	1:49	2:56	Broadway	0:25	Signal		1.28	3:13	2:48	0:25	24	27	The WB left at Folsom St had a queue blocking through lane. School zone on Iris off, but is flashing on Broadway.
	5	0:24	0:52	1:37	2:09	2:39	19th St	0:10	Signal		1.28	2:56	2:46	0:10	26	28	
	6	0:42	1:12	1:49	2:17	3:32	Folsom St 19th St Broadway	0:15 0:06 0:45	Signal Signal Signal	 Arrived at stop bar at 2:50.	1.28	3:48	2:42	1:06	20	28	
	Average	***0:29***	***1:02***	***1:43***	***2:12***	***3:09***					***Average***	***3:36***	***2:54***	***0:41***	***22***	***27***	

Note: "Time at Control Points" is the time the vehicle crossed the stop bar.

Iris Avenue
Travel Time Data
PM Peak 4:30 PM
Date: 11/18/2014
Weather:

From: Retail Access w/o 28th Ave
To: Hawthorne Ave (Westbound)
Juniper Ave (Eastbound)

Direction	Trip No.	Time at Control Points					Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Broadway	16th St	19th St	22nd St	Folsom St	Location	Time	Cause	Notes							
East	1	0:30	1:04	1:34	1:58	2:27	Broadway	0:18	Signal	Arrived at stop bar at 0:13.	1.24	2:55	2:37	0:18	26	28	
	2	0:43	1:14	2:15	2:41	3:26	Broadway 19th St Folsom St	0:32 0:30 0:10	Signal Signal Signal	Arrived on FYA, did not get a gap.	1.24	3:55	2:43	1:12	19	27	
	3	0:43	1:13	1:38	1:59	2:28	Broadway 28th St	0:28 0:45	Signal Signal	Arrived on FYA, did not get a gap. Queue from 28th extended to Iris Ct Walk (1000 ft)	1.24	3:45	2:32	1:13	20	29	
	4	1:51	2:23	2:47	3:09	3:34	Broadway	1:43	Signal	Arrived on green, did not make it through green or FYA. Queue extended past Juniper Ave.	1.24	3:57	2:14	1:43	19	33	
	5	1:12	1:44	2:40	3:05	3:45	Broadway 19th St Folsom St	0:54 0:20 0:05	Signal Signal Signal		1.24	4:12	2:53	1:19	18	26	
	6	1:40	2:10	2:35	2:55	3:22	Broadway	1:28	Signal	Arrived on yellow arrow.	1.24	3:45	2:17	1:28	20	33	
	Average	***1:06***	***1:38***	***2:14***	***2:37***	***3:10***					***Average***	***3:44***	***2:32***	***1:12***	***20***	***29***	

Direction	Trip No.	Time at Control Points					Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Folsom St	22nd St	19th St	16th St	Broadway	Location	Time	Cause	Notes							
West	1	0:30	1:05	1:39	2:13	2:43	Folsom St 19th St	0:01 0:03	Signal Signal		1.28	3:02	2:58	0:04	25	26	
	2	0:47	1:27	1:55	2:27	4:14	Folsom St 19th St Broadway	0:18 0:03 1:12	Signal Signal Signal	Arrived at stop bar at 0:34.	1.28	4:32	2:59	1:33	17	26	EB at Folsom queued 8+ vehicles in both lanes.
	3	0:25	0:55	1:17	1:45	2:50	Broadway	0:32	Signal		1.28	3:07	2:35	0:32	25	30	
	4	1:07	1:41	2:08	2:39	3:57	Folsom St Broadway	0:31 0:41	Signal Signal		1.28	4:13	3:01	1:12	18	25	
	5	0:38	1:11	1:44	2:13	4:01	Folsom St 19th St Broadway	0:09 0:03 1:04	Signal Signal Signal		1.28	4:17	3:01	1:16	18	25	
	6	1:06	1:57	2:24	2:53	4:10	Folsom St 22nd St Broadway	0:38 0:11 0:46	Signal Ped Signal Signal		1.28	4:27	2:52	1:35	17	27	
	Average	***0:45***	***1:22***	***1:51***	***2:21***	***3:39***					***Average***	***3:56***	***2:54***	***1:02***	***20***	***27***	

Note: "Time at Control Points" is the time the vehicle crossed the stop bar.

Folsom Street From: Harvest Manor Apartment Access To: Fremont Street

Travel Time Data

AM Peak 7:30 AM
Date: 11/19/2014
Weather: 37 degrees, partly cloudy

Direction	Trip No.	Time at Control Points: Arapahoe Ave	Canyon Blvd	Pearl St	Pine St	Valmont Rd/ Edgewood Dr	Stops: Location	Time	Cause	Notes	Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
North	1	0:18	0:42	1:28	1:49	2:42	Pearl St	0:08	Signal		1.28	3:02	2:51	0:11	25	27	
							Mapleton Ave	0:03	Left-Turn								
	2	0:42	1:07	1:54	2:14	2:57	Arapahoe Ave	0:21	Signal		1.28	3:14	2:41	0:33	24	29	
							Pearl St	0:12	Signal								
	3	1:00	1:29	2:12	2:42	3:28	Arapahoe Ave	0:40	Signal		1.28	3:49	2:59	0:50	20	26	There is a high volume of bicyclists on Folsom.
							Pearl St	0:05	Signal								
							Spruce St	0:05	Ped Signal								
	4	0:17	0:38	1:21	1:44	2:27	Walnut St	0:07	Ped Signal		1.28	2:46	2:39	0:07	28	29	
	5	0:36	1:04	1:52	2:15	2:56	Arapahoe Ave	0:13	Signal		1.28	3:14	2:51	0:23	24	27	
							Pearl St	0:10	Signal								
	6	1:36	2:01	2:49	3:09	4:00	Arapahoe Ave	1:15	Signal		1.28	4:22	3:07	1:15	18	25	
							Pearl St	0:10	Signal								
							Valmont Rd	0:02	Signal								
	7	0:14	0:34	1:16	1:34	2:23	Pearl St	0:03	Signal		1.28	2:42	2:39	0:03	28	29	
	Average	***0:40***	***1:05***	***1:50***	***2:12***	***2:59***					***Average***	***17:20***	***11:19***	***0:28***	***24***	***27***	

Direction	Trip No.	Time at Control Points: Valmont Rd/ Edgewood Dr	Pine St	Pearl St	Canyon Blvd	Arapahoe Ave	Stops: Location	Time	Cause	Notes	Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
South	1	0:14	1:01	1:20	2:00	3:19	Canyon Blvd	0:03	Signal		1.28	3:41	2:54	0:47	21	26	Posted Speed Limit 30 mph
							Arapahoe Ave	0:44	Signal								
	2	0:16	1:08	1:28	1:59	3:20	Pine St	0:03	Right-turn	RT vehicle was waiting for crossing bike.	1.28	3:04	2:06	0:58	25	37	
							Arapahoe Ave	0:55	RT & Signal	RT vehicle was waiting for crossing peds.							
	3	0:36	1:27	1:47	2:24	3:29	Valmont Rd	0:19	Signal		1.28	4:02	2:57	1:05	19	26	
							Arapahoe Ave	0:46	Signal								
	4	1:15	2:05	2:24	3:03	4:21	Valmont Rd	0:53	Signal		1.28	4:42	2:59	1:43	16	26	
							Arapahoe Ave	0:50	Signal								
	5	0:14	0:57	1:15	1:46	2:37	Arapahoe Ave	0:21	Signal		1.28	2:58	2:37	0:21	26	29	
	6	0:16	0:59	1:18	1:51	2:54	Arapahoe Ave	0:24	Signal		1.28	3:12	2:48	0:24	24	27	
	7	0:17	1:02	1:25	3:15	4:35	Canyon Blvd	0:12	Right-turn		1.28	4:56	4:44	0:12	16	16	
							Canyon Blvd	1:05	Signal								
							Arapahoe Ave	0:49	Signal								
	Average	***0:26***	***1:14***	***1:33***	***2:19***	***3:30***					***Average***	***3:47***	***3:00***	***0:47***	***21***	***27***	

Note: "Time at Control Points" is the time the vehicle crossed the stop bar.

Folsom Street From: Harvest Manor Apartment Access To: Fremont Street

Travel Time Data

PM Peak 4:30 PM
Date: 11/19/2014
Weather: 37 degrees, Clear Skies

Direction	Trip No.	Time at Control Points					Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Arapahoe Ave	Canyon Blvd	Pearl St	Pine St	Valmont Rd/ Edgewood Dr	Location	Time	Cause	Notes							
North	1	0:19	1:04	1:55	2:17	3:05	Goss St	0:12	Ped Signal		1.28	3:30	3:05	0:25	22	25	
							Pearl St	0:13	Signal								
	2	0:43	1:11	2:14	2:34	3:35	Arapahoe Ave	0:18	Signal		1.28	4:03	3:19	0:44	19	23	
							Pearl St	0:19	Signal								
							Valmont Rd	0:07	Signal								
	3	0:37	2:22	3:51	4:12	5:29	Arapahoe Ave	0:14	Signal		1.28	6:02	3:32	2:30	13	22	
							Goss St	0:09	Ped Signal								
							Canyon Blvd	1:04	Signal								
							Pearl St	0:47	Signal								
							Access across from Mobile Home Access	0:16	Left-Turn								
	4	0:15	2:01	3:25	3:49	4:41	Goss St	0:21	Ped Signal		1.28	5:10	3:22	1:48	15	23	
							Canyon Blvd	0:47	Signal								
							Pearl St	0:40	Signal								
	5	0:30	0:55	2:09	2:44	3:43	Arapahoe Ave	0:04	Signal		1.28	4:18	3:27	0:51	18	22	
							Pearl St	0:33	Signal								
							Spruce St	0:04	Ped Signal								
							Valmont Rd	0:10	Signal	Arrived on green but at back of queue.							
	6	1:36	2:02	3:17	3:44	4:40	Arapahoe Ave	1:16	Signal		1.28	5:03	3:47	1:16	15	20	
							Pearl St	0:35	Signal								
	Average	***0:40***	***1:35***	***2:48***	***3:13***	***4:12***					***Average***	***4:41***	***3:25***	***1:15***	***17***	***23***	

Direction	Trip No.	Time at Control Points					Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Valmont Rd/ Edgewood Dr	Pine St	Pearl St	Canyon Blvd	Arapahoe Ave	Location	Time	Cause	Notes							
South	1	0:40	1:31	1:51	2:24	2:53	Valmont Rd	0:16	Signal		1.28	3:20	3:04	0:16	23	25	
	2	0:24	1:13	1:32	2:22	4:08	Canyon Blvd	0:13	Signal	Queue extended 8 vehicles.	1.28	4:27	2:58	1:29	17	26	
							Arapahoe Ave	0:05	Signal	Arrived at the back of queue. Did not make it through green.							
							Arapahoe Ave	1:11	Signal								
	3	0:19	1:07	1:28	3:22	3:57	Walnut St	0:05	Ped Signal		1.28	4:18	3:11	1:07	18	24	
							Canyon Blvd	1:02	Signal								
	4	0:19	1:06	2:26	3:22	3:58	Pearl St	0:54	Signal		1.28	4:20	3:16	1:04	18	24	
							Canyon Blvd	0:10	Signal								
	5	0:37	1:29	1:48	3:39	4:15	Valmont Rd	0:16	Signal		1.28	4:38	3:09	1:29	17	24	
							Canyon Blvd	1:13	Signal								
	6	0:19	1:08	1:45	2:16	3:28	Pearl St	0:43	Signal		1.28	3:47	3:02	0:45	20	25	
							Canyon Blvd	0:02	Right-Turn								
	Average	***0:26***	***1:15***	***1:48***	***2:54***	***3:46***					***Average***	***4:08***	***3:06***	***1:01***	***19***	***25***	

Note: "Time at Control Points" is the time the vehicle crossed the stop bar.

55th Street From: Lodge Ln (south) To: Valmont Rd corner (USPS)

Travel Time Data

AM Peak 7:30 AM
Date: 11/20/2014
Weather: 28 degrees, Clear skies

Direction	Trip No.	Time at Control Points				Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Arapahoe Ave	Central Ave	Flatirons Pkwy	Pearl St/ Valmont Rd	Location	Time	Cause	Notes							
North	1	1:44	2:23	2:49	3:24	Arapahoe Ave Pearl St	1:05 0:05	Signal Signal		1.27	3:42	2:32	1:10	21	30	
	2	1:42	2:20	2:47	3:33	Arapahoe Ave Pearl St	1:10 0:14	Signal Signal		1.27	3:51	2:27	1:24	20	31	Posted speed between Pearl St and Flatirons is 35 mph. Majority of 55th St is 40 mph.
	3	0:42	1:24	1:50	3:10	Arapahoe Ave Pearl St	0:05 0:51	Signal Signal		1.27	3:29	2:33	0:56	22	30	
	4	0:26	0:59	1:24	2:54	Pearl St	0:58	Signal		1.27	3:10	2:12	0:58	24	35	Buses stop at the railroad tracks for a few seconds before crossing.
	5	0:50	1:40	2:40	3:29	Arapahoe Ave Flatirons Pkwy Pearl St	0:20 0:25 0:13	Signal Signal Signal		1.27	3:44	2:46	0:58	20	28	
	6	1:38	2:56	3:26	3:51	Arapahoe Ave Central Pkey	1:09 0:32	Signal Signal	Arrived at stop bar at 0:29. Arrived at stop bar at 2:28.	1.27	4:05	2:24	1:41	19	32	
	Average	***1:10***	***1:57***	***2:29***	***3:23***					***Average***	***3:40***	***2:29***	***1:11***	***21***	***31***	

Direction	Trip No.	Time at Control Points				Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Pearl St/ Valmont Rd	Flatirons Pkwy	Central Ave	Arapahoe Ave	Location	Time	Cause	Notes							
South	1	0:13	0:41	1:08	2:30	Arapahoe Ave	0:44	Signal		1.27	3:06	2:22	0:44	25	32	
	2	0:16	0:44	1:13	2:30	Arapahoe Ave	0:31	Signal		1.27	3:10	2:39	0:31	24	29	Vehicles slow over railroad tracks.
	3	1:13	1:40	2:07	2:45	Pearl St	0:56	Signal		1.27	3:17	2:21	0:56	23	32	
	4	0:26	1:00	1:22	2:08	Pearl St Arapahoe Ave	0:07 0:03	Signal Signal	Queue extended 10 vehicles.	1.27	2:41	2:31	0:10	28	30	
	5	1:07	1:37	2:04	3:09	Pearl St Pearl St Arapahoe Ave	0:07 0:43 0:08	RT & Signal Signal Signal	 Queue extended 12 vehicles.	1.27	3:41	2:43	0:58	21	28	
	6	0:26	1:25	1:50	2:30	Pearl St Arapahoe Ave	0:09 0:25	Signal Signal	 Arrived at stop bar at 2:13.	1.27	3:02	2:28	0:34	25	31	SB Pearl St queued about 200 feet. SB left-turn at Flatirons Pkwy queued into through lane.
	Average	***0:36***	***1:11***	***1:37***	***2:35***					***Average***	***3:09***	***2:30***	***0:38***	***24***	***30***	

Note: "Time at Control Points" is the time the vehicle crossed the stop bar.

55th Street From: Lodge Ln (south) To: Valmont Rd corner (USPS)

Travel Time Data

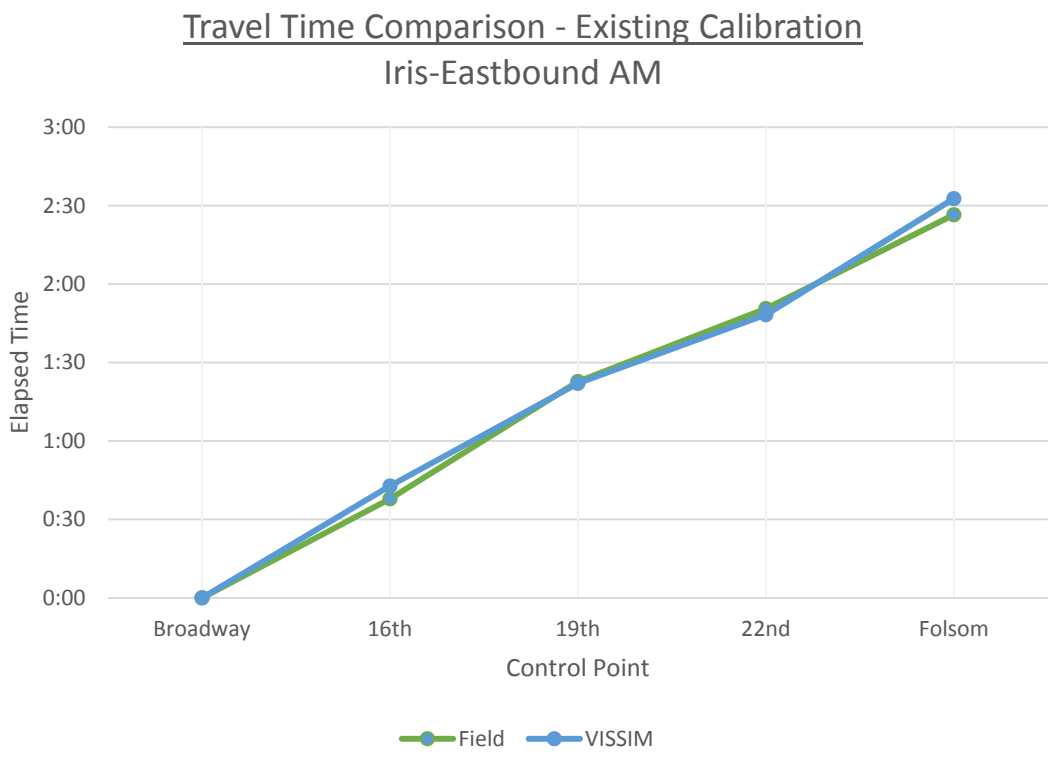
PM Peak 4:30 PM
Date: 11/20/2014
Weather: 45 degrees, Cloudy

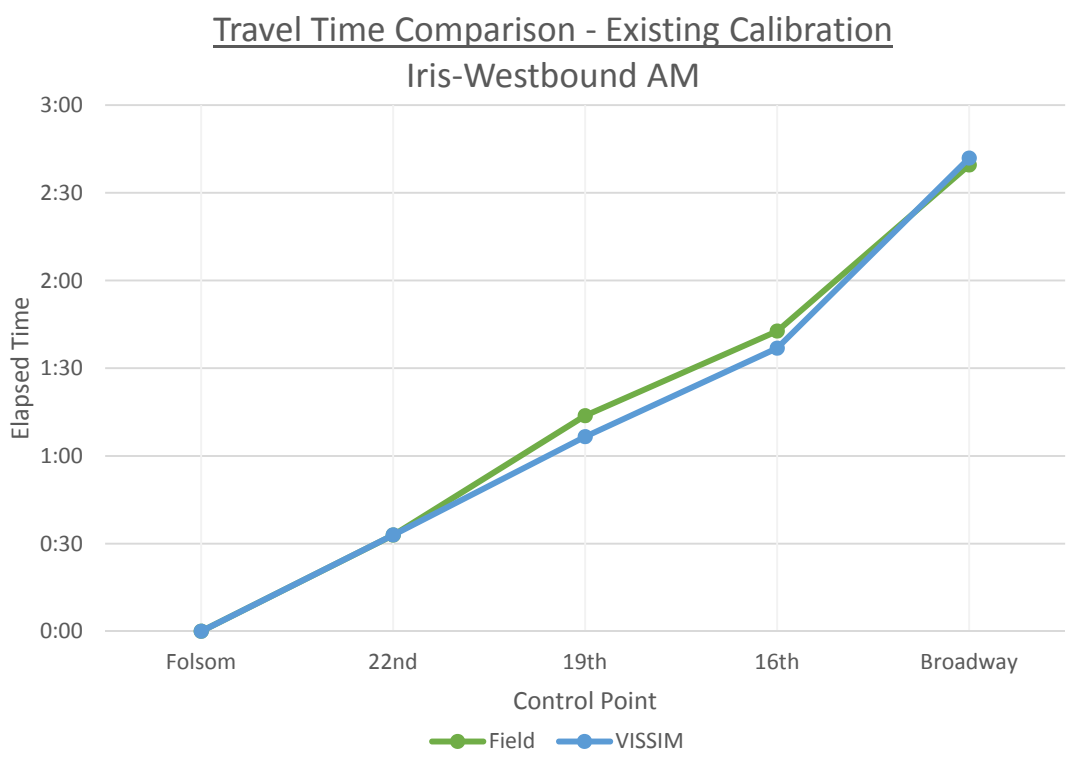
Direction	Trip No.	Time at Control Points				Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Arapahoe Ave	Central Ave	Flatirons Pkwy	Pearl St/ Valmont Rd	Location	Time	Cause	Notes							
North	1	0:34	1:11	1:43	2:57	Pearl St	0:39	Signal		1.27	3:14	2:35	0:39	24	29	The north/southbound left phases at Pearl are Protected.
	2	1:50	2:36	3:35	4:41	Arapahoe Ave Flatiron Pkwy Pearl St	1:17 0:25 0:30	Signal Signal Signal	Arrived at stop bar at 0:34. Arrived at stop bar at 3:10.	1.27	4:58	2:46	2:12	15	28	The north/southbound left phases at Arapahoe are Permitted. Slow for people crossing the railroad.
	3	0:25	1:28	2:03	3:47	Central Ave Pearl St Pearl St	0:19 0:04 0:53	Signal Signal Signal	Arrived at the back of queue (15 vehicles). Did not make it through green. Arrived at stop bar at 2:52.	1.27	4:09	2:53	1:16	18	26	
	4	0:28	2:08	2:41	4:40	Railroad Crossing Central Ave Pearl St Pearl St	0:38 0:10 0:27 0:49	Train Signal Signal Signal	As gates raised, it was slow to get to speed and through next intersection. Queue extended 18 vehicles in right lane. Majority of vehicles turning right	1.27	5:03	2:59	2:04	15	26	
	5	1:42	2:20	2:48	4:13	Arapahoe Ave Pearl St	1:05 0:43	Signal Signal		1.27	4:30	2:42	1:48	17	28	At Arapahoe: all left phases are permitted except the WBL, which is protected. The northbound right-turning vehicles create delay for the through vehicles and the queue can extend to the bridge.
	6	1:47	2:30	3:01	3:37	Arapahoe Ave	1:18	Signal	Arrived at stop bar at 0:28.	1.27	3:52	2:34	1:18	20	30	
	Average	***1:07***	***2:02***	***2:38***	***3:59***					***Average***	***4:17***	***2:44***	***1:32***	***18***	***28***	

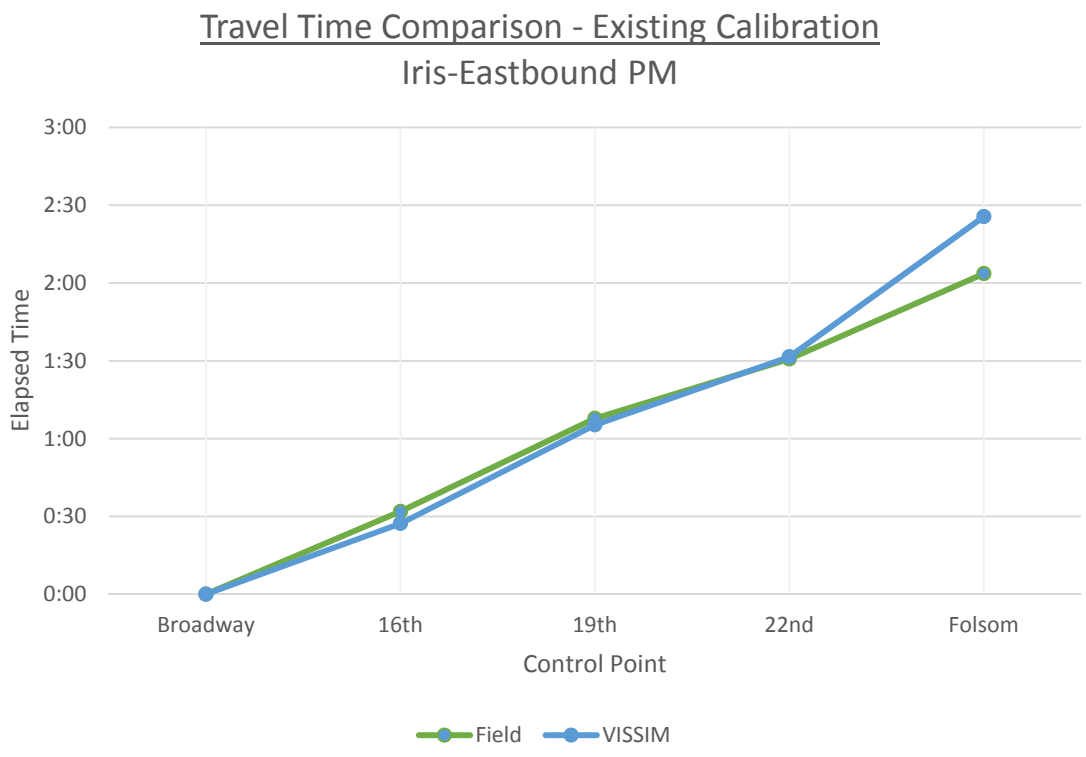
Direction	Trip No.	Time at Control Points				Stops				Trip Length (mile)	Trip Time (min)	Running Time (min)	Stopped Time (min)	Travel Speed (mph)	Running Speed	Notes
		Pearl St/ Valmont Rd	Flatirons Pkwy	Central Ave	Arapahoe Ave	Location	Time	Cause	Notes							
South	1	0:14	0:45	1:13	2:26	Railroad Crossing Pearl St	0:09 0:12	Bus stopped Signal	 Queue extended 200 ft	1.27	3:03	2:42	0:21	25	28	
	2	0:14	0:44	1:15	2:05	Arapahoe Ave	0:09	Signal	Arrived at back of queue when green started.	1.27	2:39	2:30	0:09	29	30	
	3	0:30	1:09	1:38	2:46	Pearl St Flatiron Pkwy Arapahoe Ave	0:09 0:02 0:17	Signal Signal Signal	Queue extended 10 vehicles. Queue extended 8 vehicles.	1.27	3:23	2:55	0:28	23	26	
	4	1:05	1:39	2:11	3:41	Pearl St Arapahoe Ave	0:45 0:39	Signal Signal	 Queue extended 500 ft.	1.27	4:28	3:04	1:24	17	25	
	5	1:06	1:40	2:11	3:32	Pearl St Railroad Crossing Arapahoe Ave Access s/o Arapahoe (gas station)	0:47 0:03 0:23 0:02	Signal Bus stop Signal Left-turn		1.27	4:16	3:01	1:15	18	25	
	6	0:13	0:41	1:08	3:01	Arapahoe Ave	1:15	Signal	Arrived at stop bar at 1:46.	1.27	3:34	2:19	1:15	21	33	
	Average	***0:33***	***1:06***	***1:36***	***2:55***					***Average***	***3:33***	***2:45***	***0:48***	***22***	***28***	

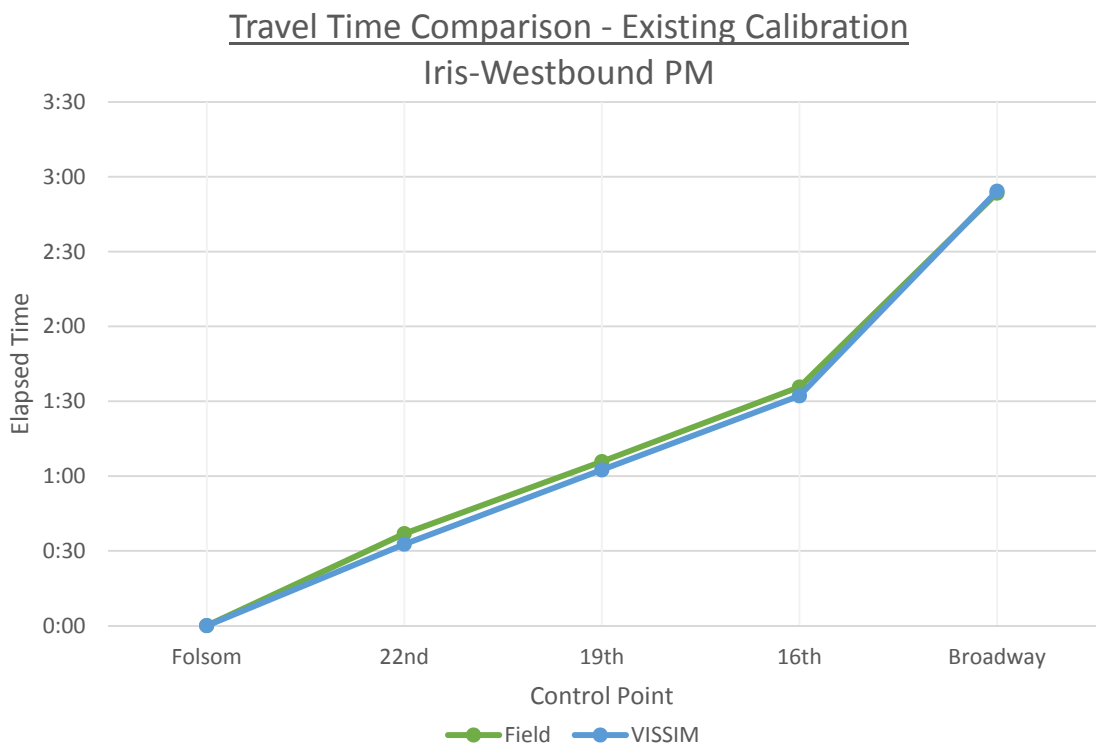
Note: "Time at Control Points" is the time the vehicle crossed the stop bar.

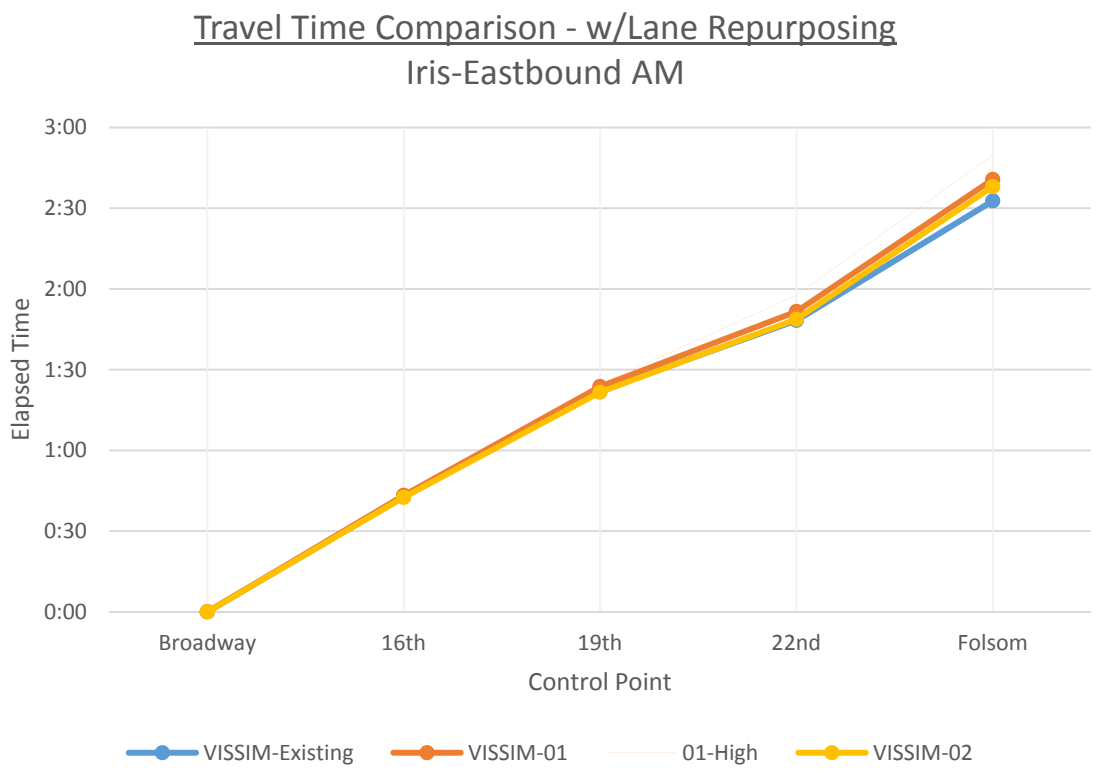
Travel Time Charts – Iris Avenue

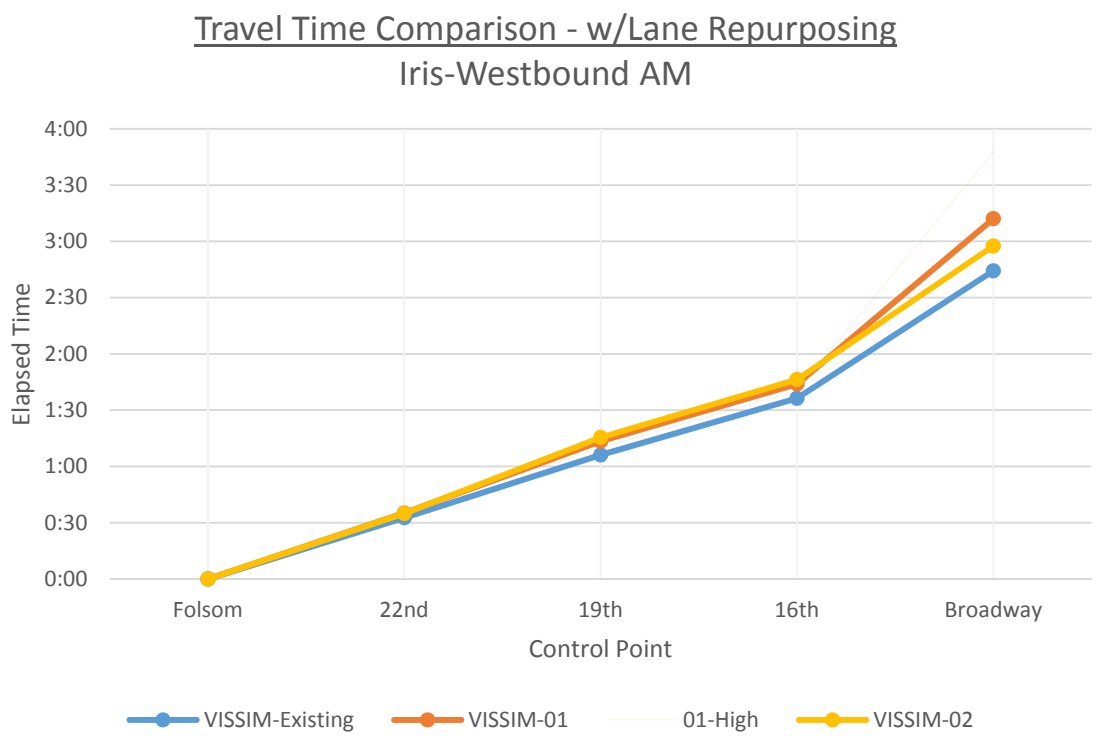

Travel Time Comparison - Existing Calibration
Iris-Eastbound AM
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Broadway
16th
19th
22nd
Folsom
Control Point
Field
VISSIM

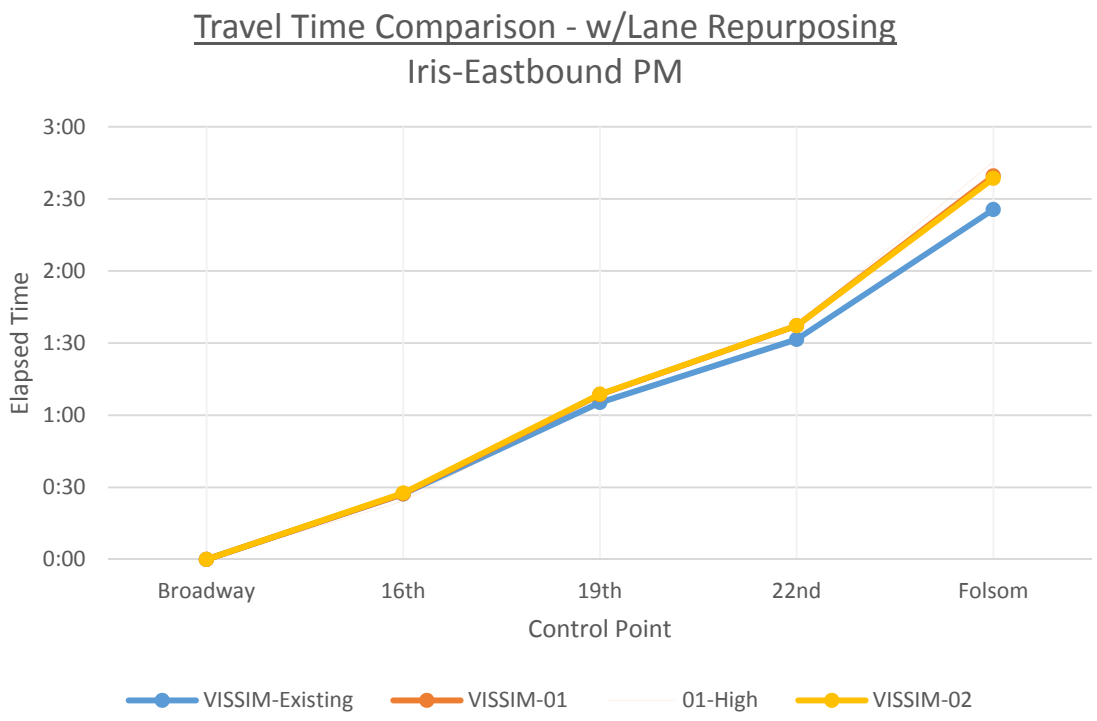

Travel Time Comparison - Existing Calibration
Iris-Westbound AM
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Folsom
22nd
19th
16th
Broadway
Control Point
Field
VISSIM

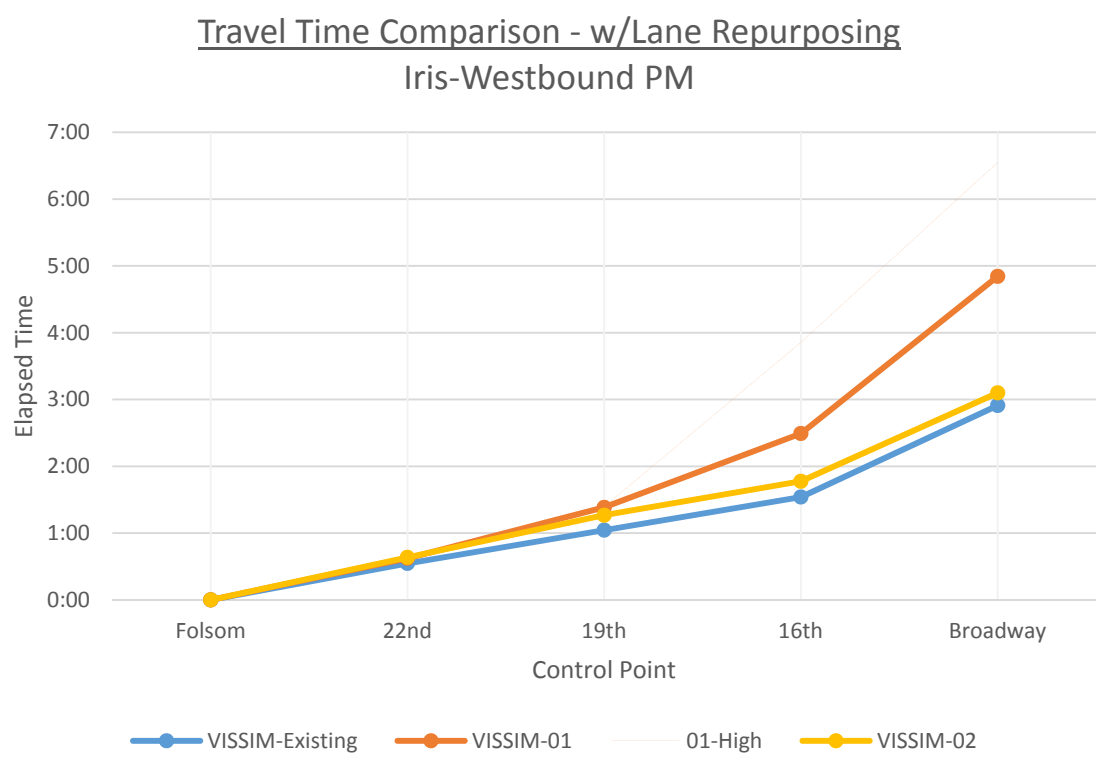

Travel Time Comparison - Existing Calibration
Iris-Eastbound PM
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Broadway
16th
19th
22nd
Folsom
Control Point
Field
VISSIM

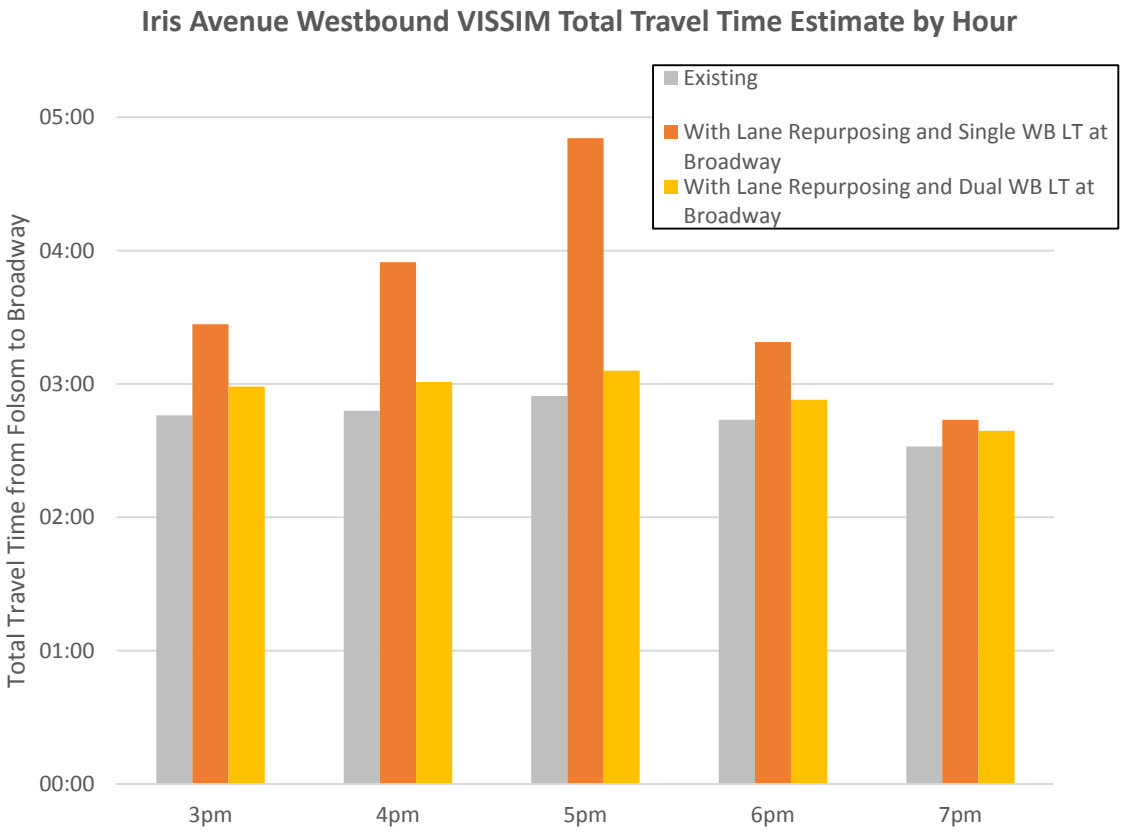

Travel Time Comparison - Existing Calibration
Iris-Westbound PM
3:30
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Folsom
22nd
19th
16th
Broadway
Control Point
Field
VISSIM


Travel Time Comparison - w/Lane Repurposing
Iris-Eastbound AM
Elapsed Time
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Broadway
16th
19th
22nd
Folsom
Control Point
VISSIM-Existing
VISSIM-01
01-High
VISSIM-02

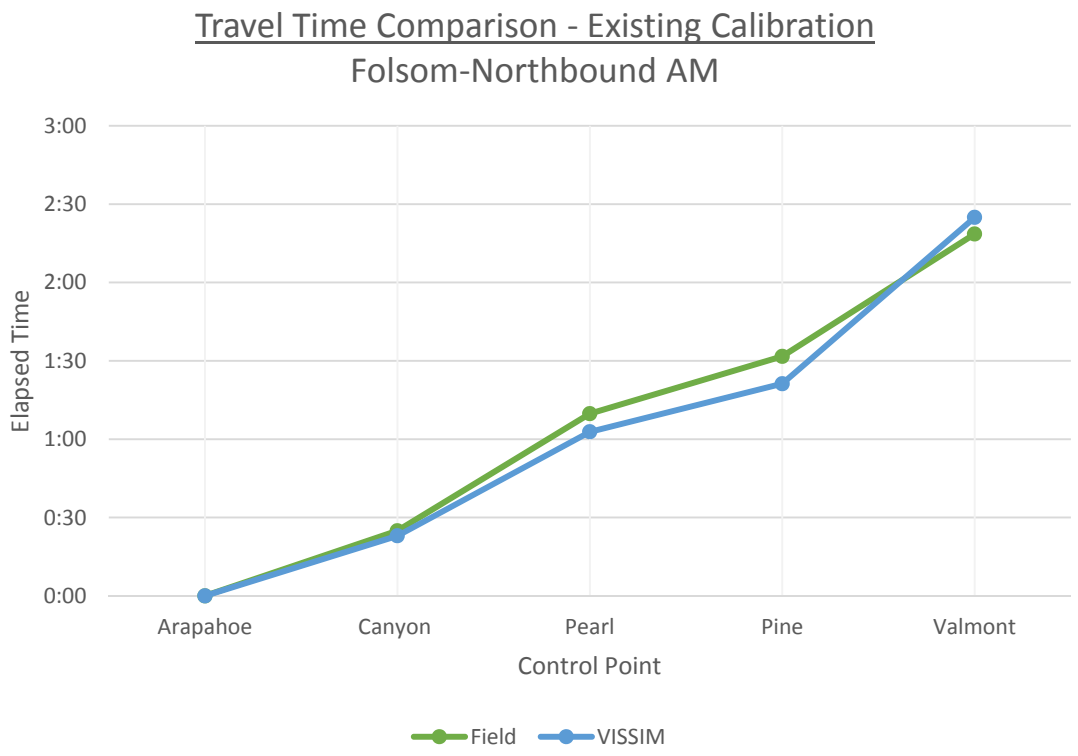

Travel Time Comparison - w/Lane Repurposing
Iris-Westbound AM
Elapsed Time
4:00
3:30
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Folsom
22nd
19th
16th
Broadway
Control Point
VISSIM-Existing
VISSIM-01
01-High
VISSIM-02

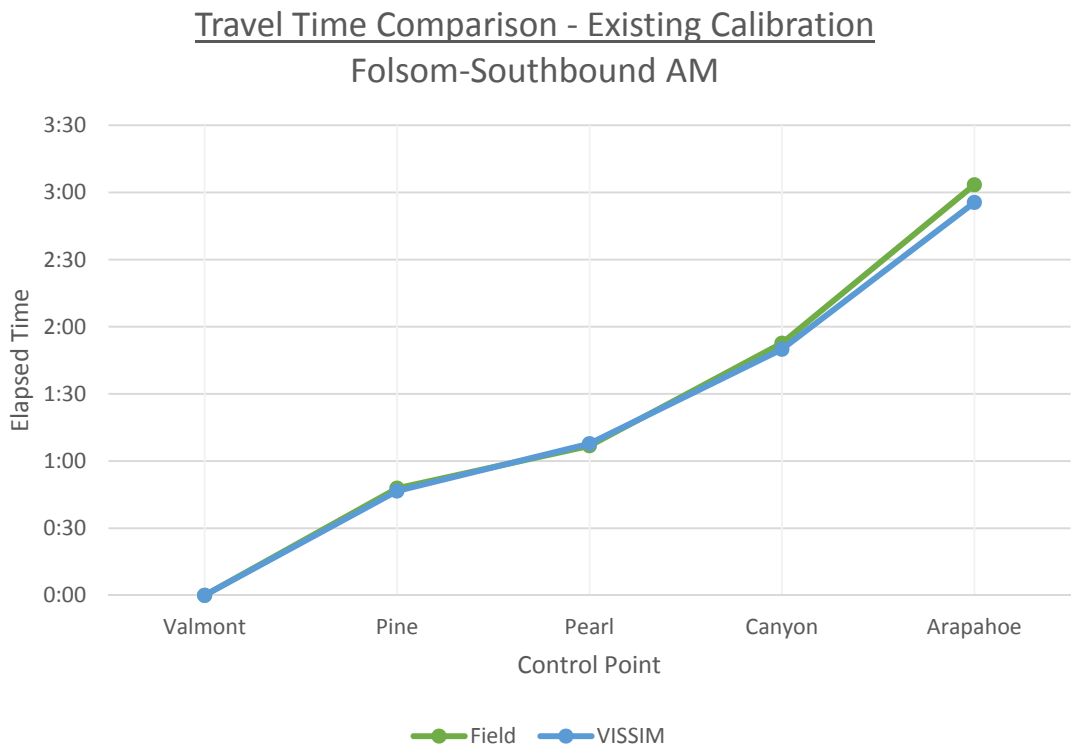

Travel Time Comparison - w/Lane Repurposing
Iris-Eastbound PM
Elapsed Time
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Broadway
16th
19th
22nd
Folsom
Control Point
VISSIM-Existing
VISSIM-01
01-High
VISSIM-02

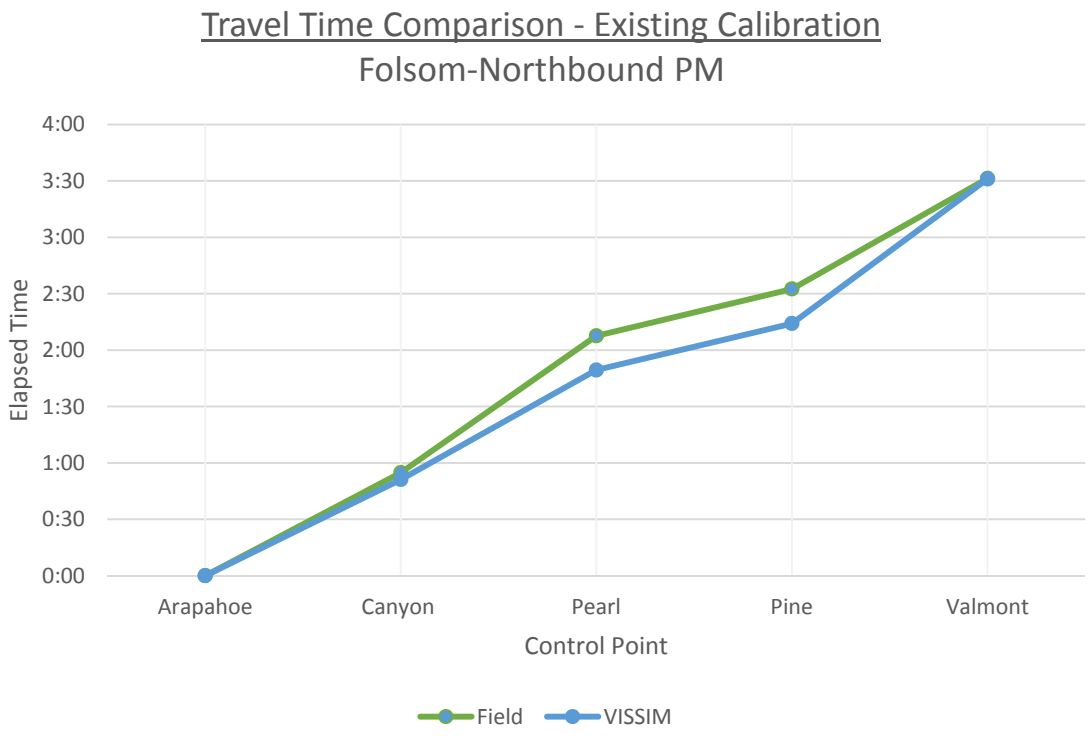

Travel Time Comparison - w/Lane Repurposing
Iris-Westbound PM
Elapsed Time
7:00
6:00
5:00
4:00
3:00
2:00
1:00
0:00
Folsom
22nd
19th
16th
Broadway
Control Point
VISSIM-Existing
VISSIM-01
01-High
VISSIM-02

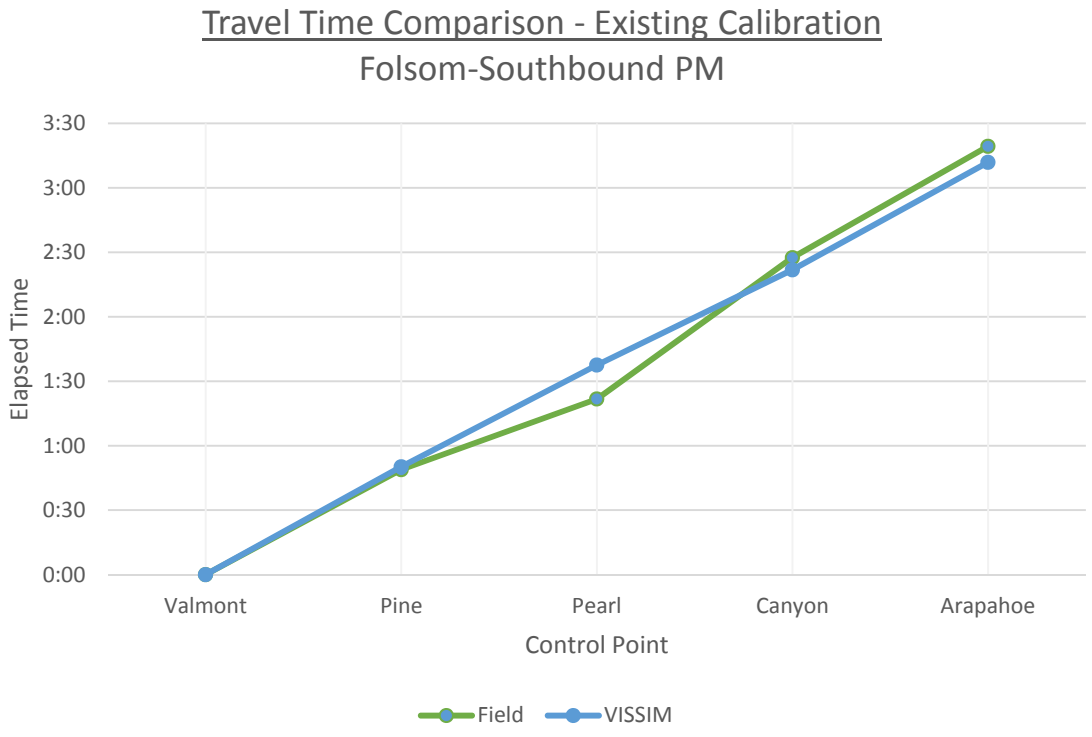

Iris Avenue Westbound VISSIM Total Travel Time Estimate by Hour
Existing
With Lane Repurposing and Single WB LT at Broadway
With Lane Repurposing and Dual WB LT at Broadway
Total Travel Time from Folsom to Broadway
05:00
04:00
03:00
02:00
01:00
00:00
3pm
4pm
5pm
6pm
7pm

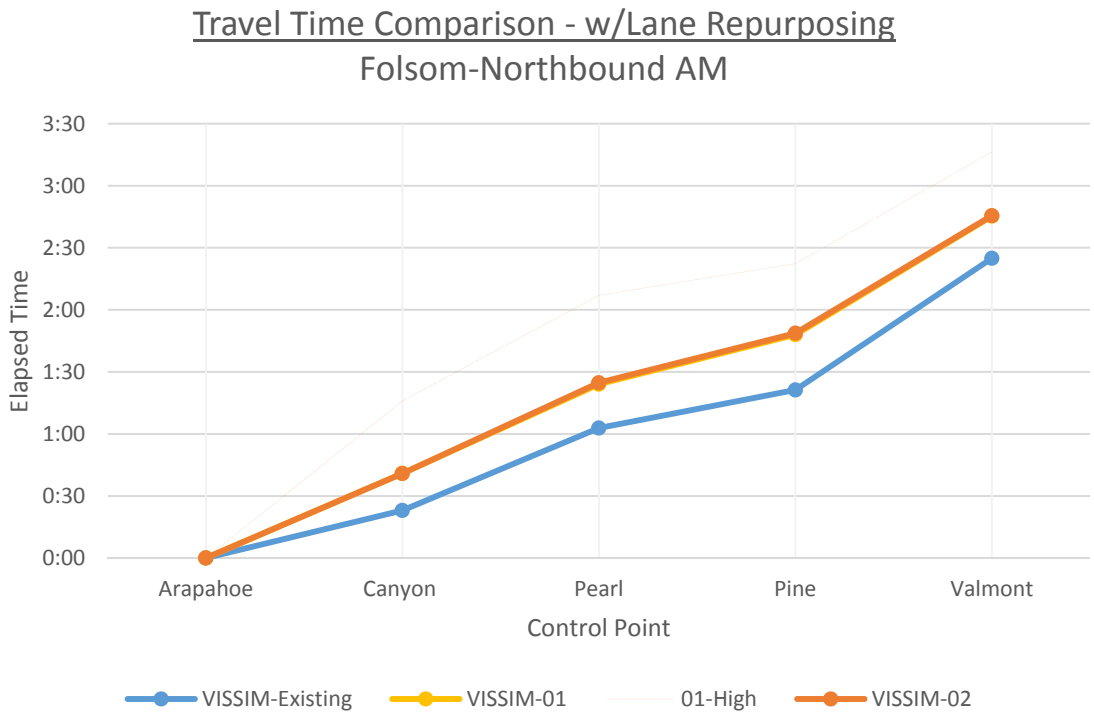
Travel Time Charts – Folsom Street

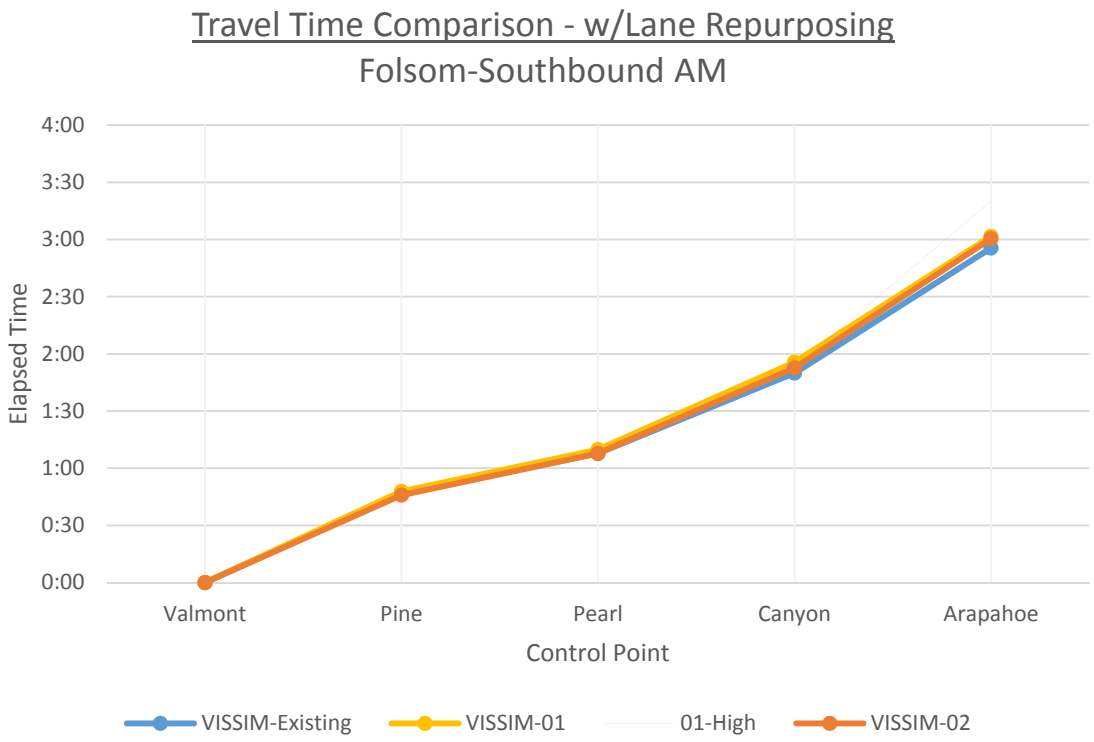

Travel Time Comparison - Existing Calibration
Folsom-Northbound AM
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Arapahoe
Canyon
Pearl
Pine
Valmont
Control Point
Field
VISSIM

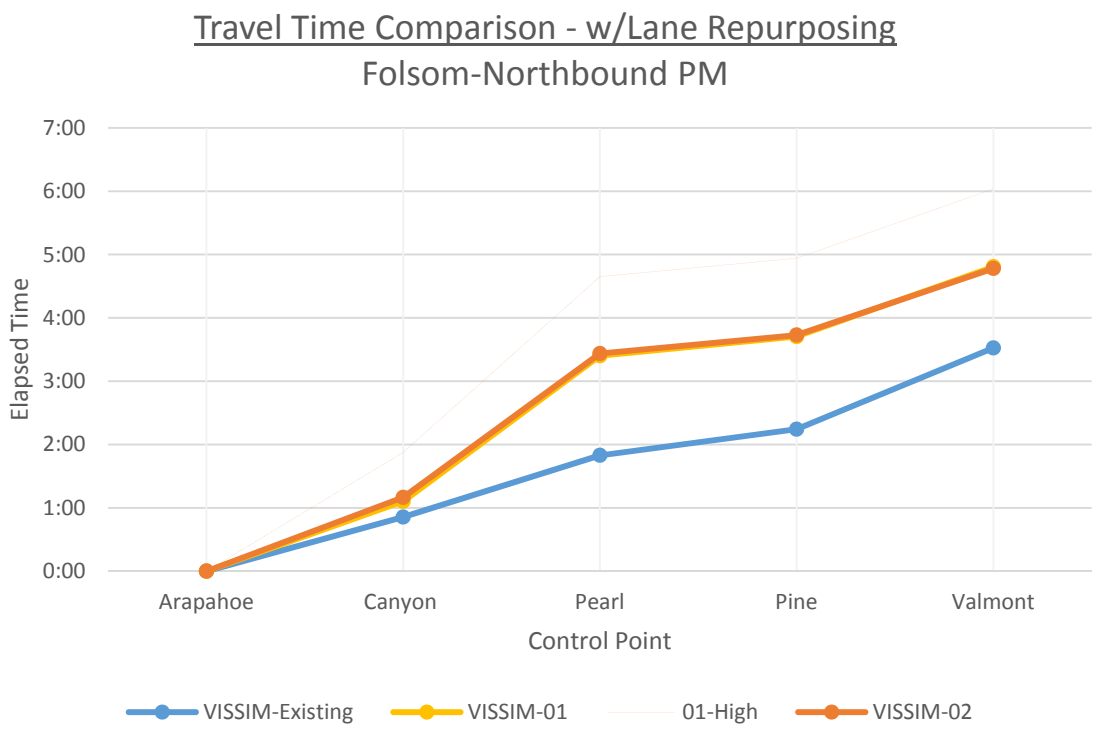

Travel Time Comparison - Existing Calibration
Folsom-Southbound AM
3:30
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Valmont
Pine
Pearl
Canyon
Arapahoe
Control Point
Field
VISSIM

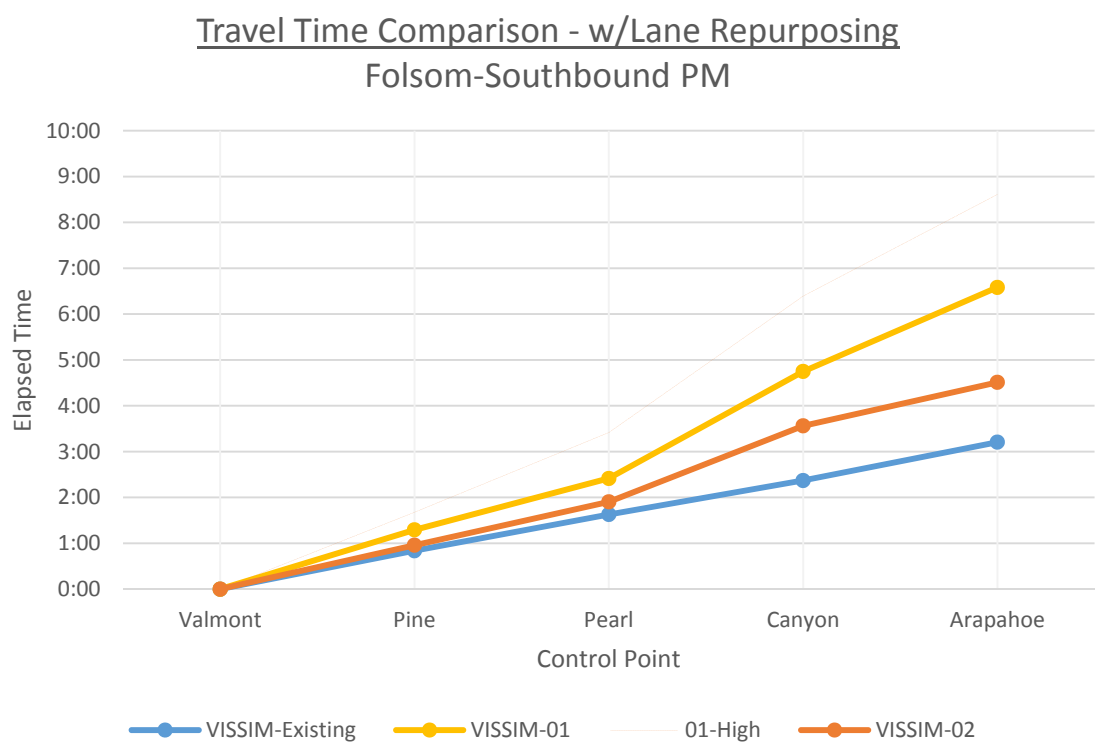

Travel Time Comparison - Existing Calibration
Folsom-Northbound PM
Elapsed Time
4:00
3:30
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Arapahoe
Canyon
Pearl
Pine
Valmont
Control Point
Field
VISSIM

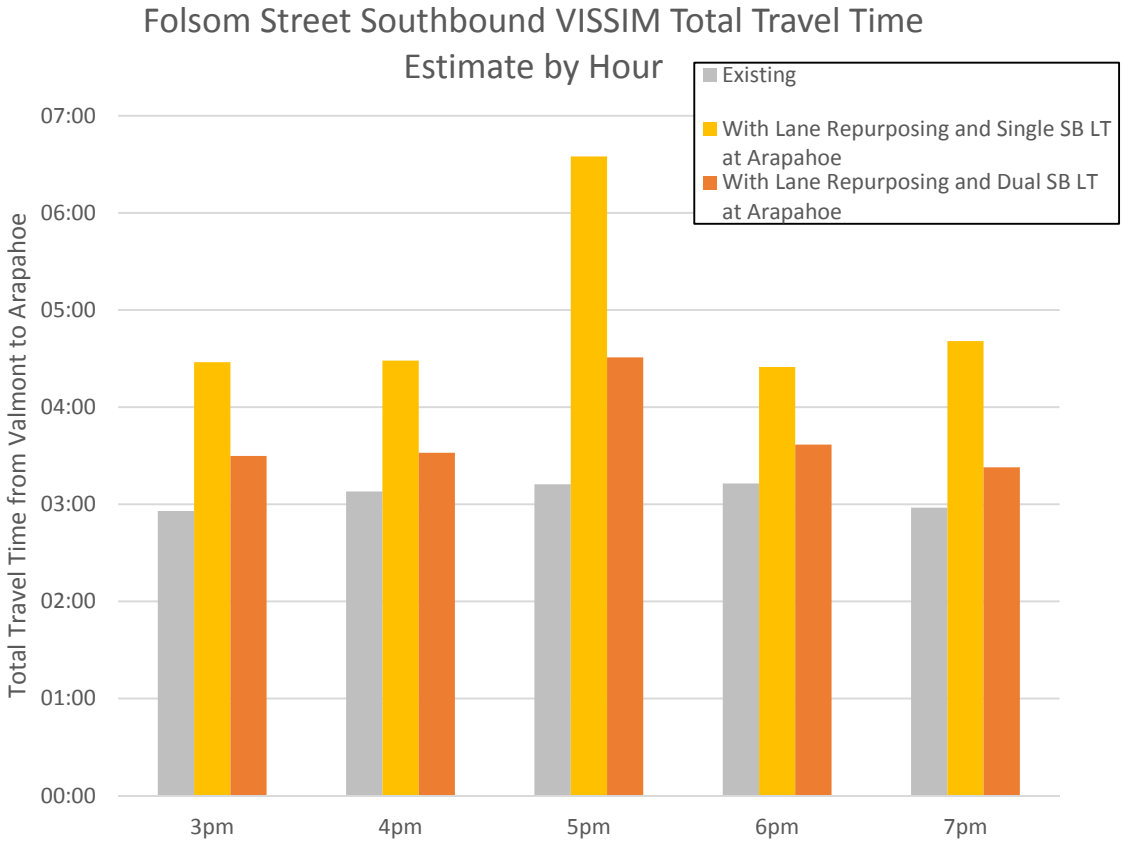

Travel Time Comparison - Existing Calibration
Folsom-Southbound PM
Elapsed Time
3:30
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Valmont
Pine
Pearl
Canyon
Arapahoe
Control Point
Field
VISSIM


Travel Time Comparison - w/Lane Repurposing
Folsom-Northbound AM
Elapsed Time
3:30
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Arapahoe
Canyon
Pearl
Pine
Valmont
Control Point
VISSIM-Existing
VISSIM-01
01-High
VISSIM-02

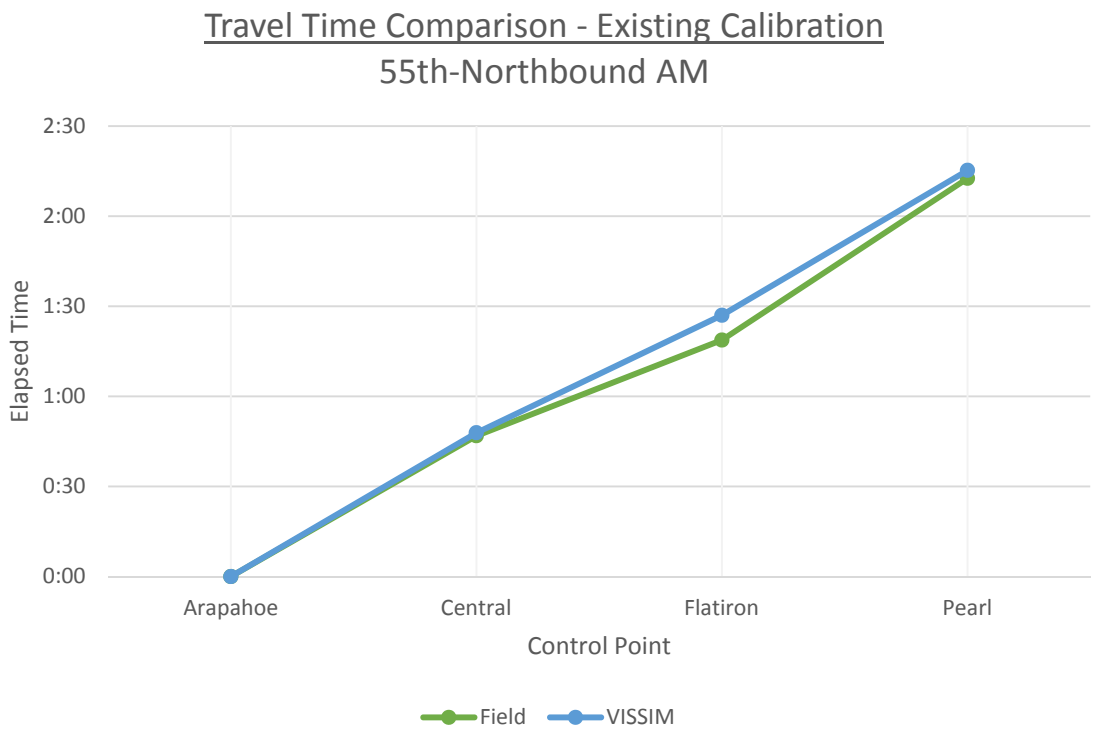

Travel Time Comparison - w/Lane Repurposing
Folsom-Southbound AM
Elapsed Time
4:00
3:30
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Valmont
Pine
Pearl
Canyon
Arapahoe
Control Point
VISSIM-Existing
VISSIM-01
01-High
VISSIM-02

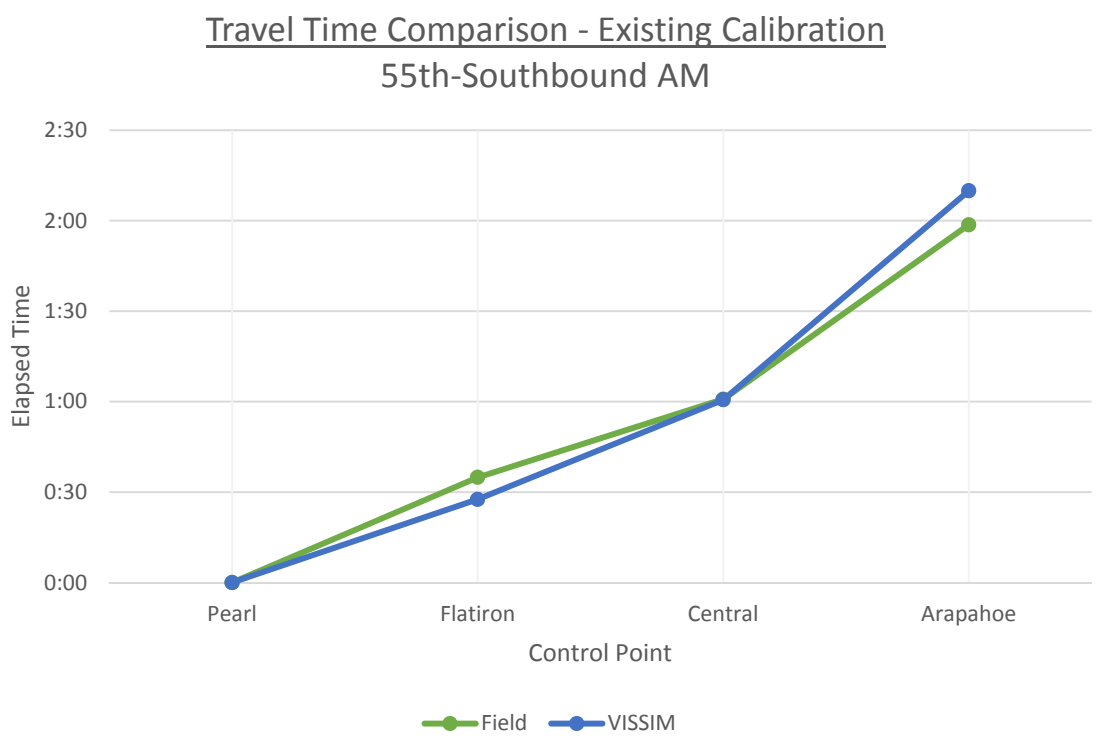

Travel Time Comparison - w/Lane Repurposing
Folsom-Northbound PM
Elapsed Time
7:00
6:00
5:00
4:00
3:00
2:00
1:00
0:00
Arapahoe
Canyon
Pearl
Pine
Valmont
Control Point
VISSIM-Existing
VISSIM-01
01-High
VISSIM-02

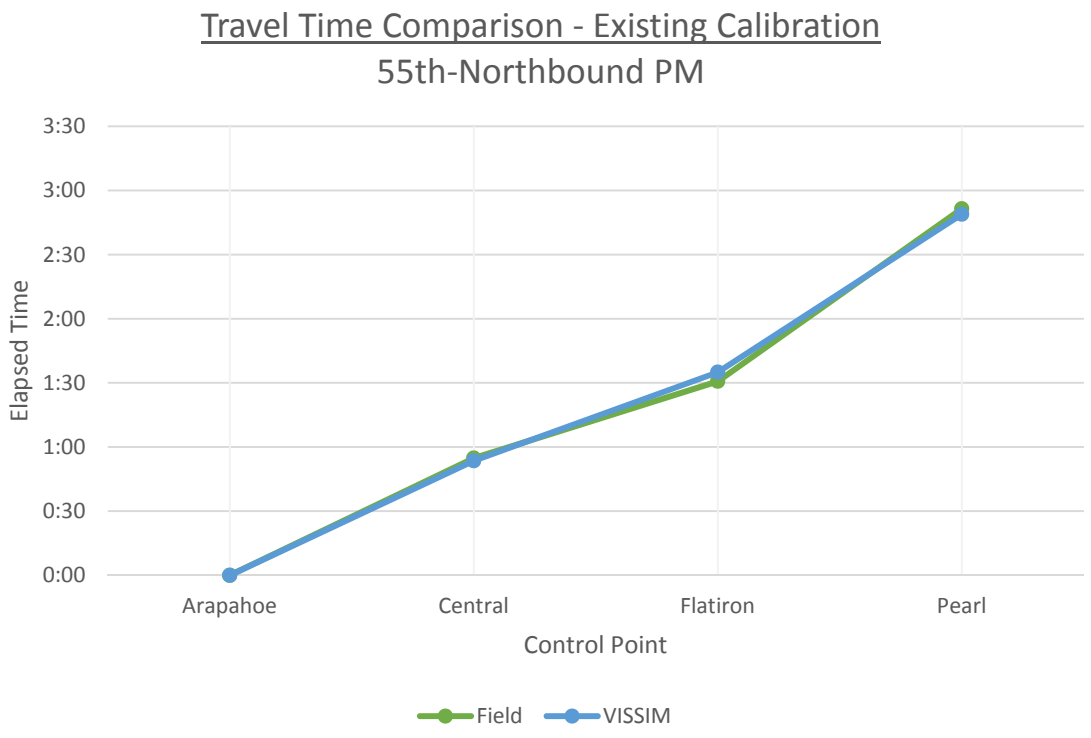

Travel Time Comparison - w/Lane Repurposing
Folsom-Southbound PM
Elapsed Time
10:00
9:00
8:00
7:00
6:00
5:00
4:00
3:00
2:00
1:00
0:00
Valmont
Pine
Pearl
Canyon
Arapahoe
Control Point
VISSIM-Existing
VISSIM-01
01-High
VISSIM-02

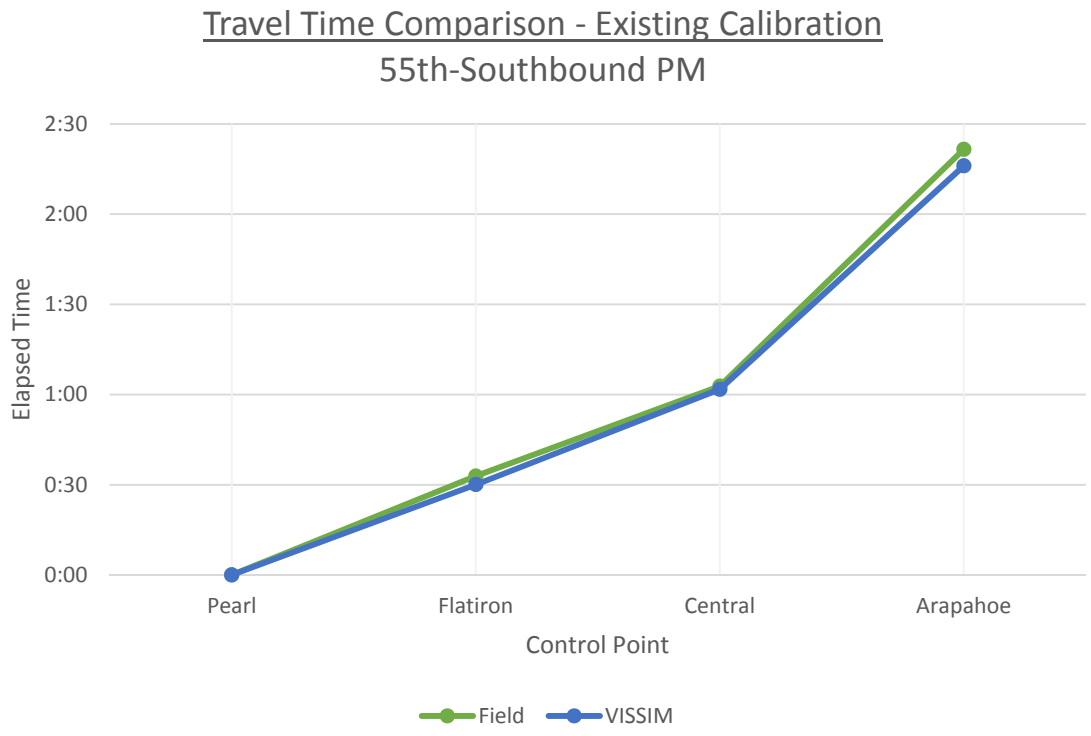

Folsom Street Southbound VISSIM Total Travel Time Estimate by Hour
Existing
With Lane Repurposing and Single SB LT at Arapahoe
With Lane Repurposing and Dual SB LT at Arapahoe
Total Travel Time from Valmont to Arapahoe
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
3pm
4pm
5pm
6pm
7pm

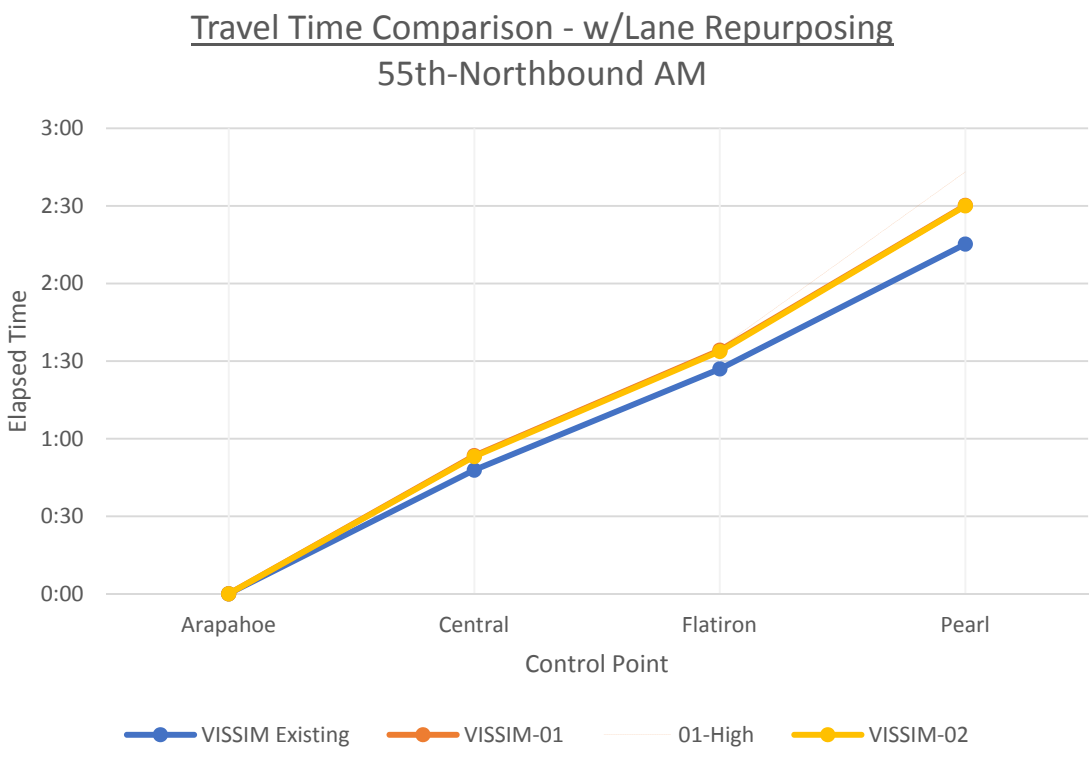
Travel Time Charts – 55th Street

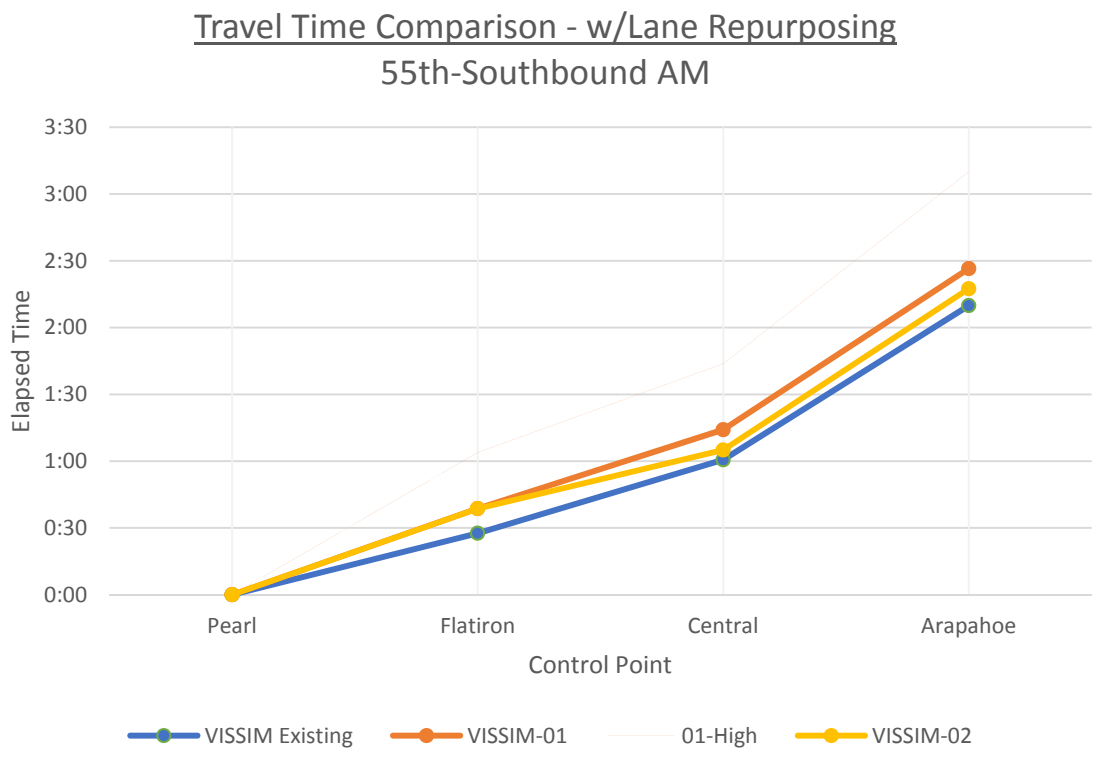

Travel Time Comparison - Existing Calibration
55th-Northbound AM
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Arapahoe
Central
Flatiron
Pearl
Control Point
Field
VISSIM

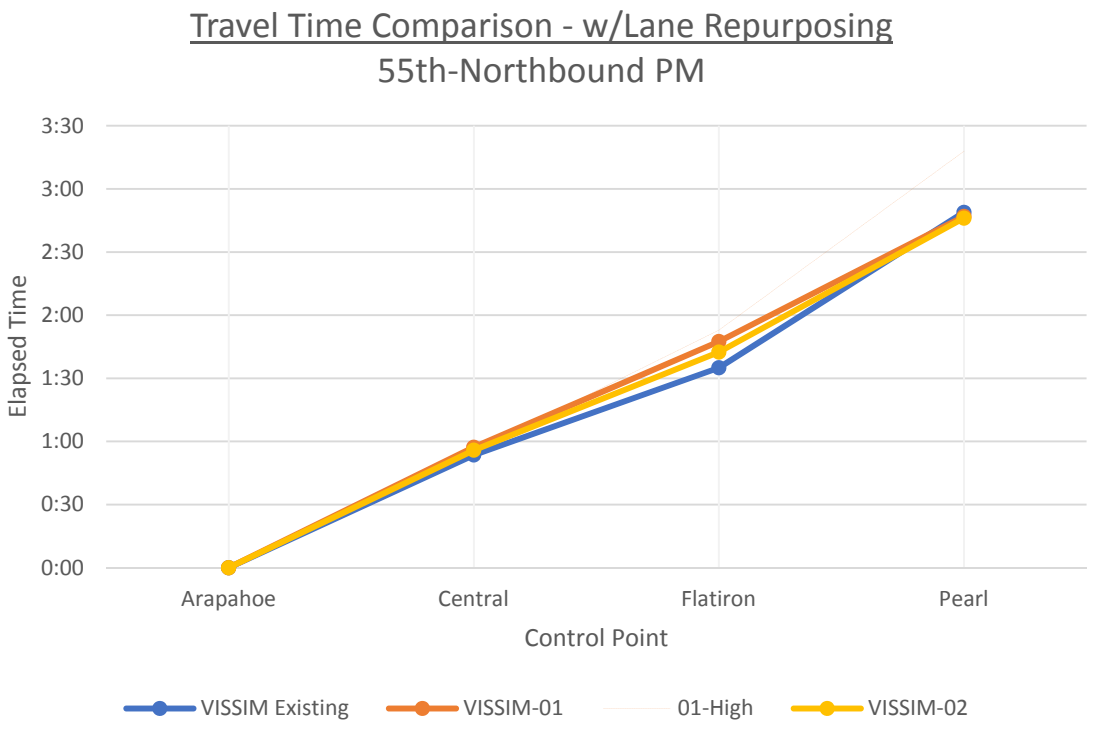

Travel Time Comparison - Existing Calibration
55th-Southbound AM
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Pearl
Flatiron
Central
Arapahoe
Control Point
Field
VISSIM

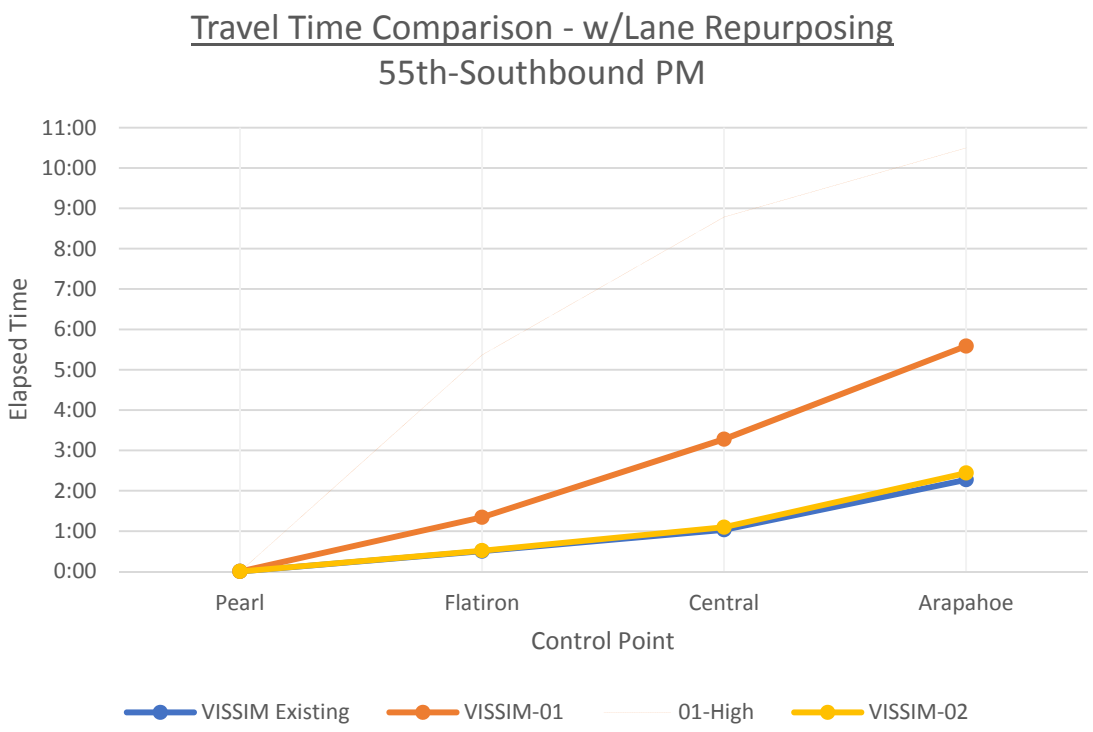

Travel Time Comparison - Existing Calibration
55th-Northbound PM
3:30
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Arapahoe
Central
Flatiron
Pearl
Control Point
Field
VISSIM

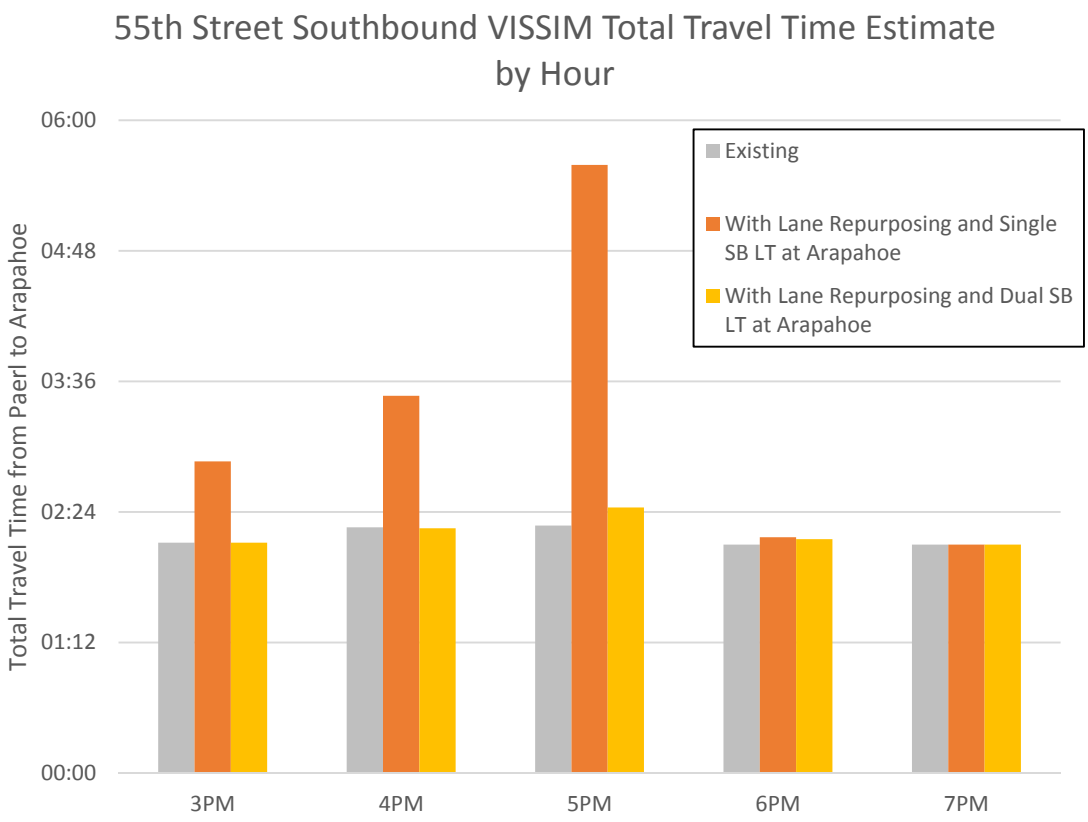

Travel Time Comparison - Existing Calibration
55th-Southbound PM
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Pearl
Flatiron
Central
Arapahoe
Control Point
Field
VISSIM


Travel Time Comparison - w/Lane Repurposing
55th-Northbound AM
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Arapahoe
Central
Flatiron
Pearl
Control Point
VISSIM Existing
VISSIM-01
01-High
VISSIM-02


Travel Time Comparison - w/Lane Repurposing
55th-Southbound AM
3:30
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Elapsed Time
Pearl
Flatiron
Central
Arapahoe
Control Point
VISSIM Existing
VISSIM-01
01-High
VISSIM-02


Travel Time Comparison - w/Lane Repurposing
55th-Northbound PM
Elapsed Time
3:30
3:00
2:30
2:00
1:30
1:00
0:30
0:00
Arapahoe
Central
Flatiron
Pearl
Control Point
VISSIM Existing
VISSIM-01
01-High
VISSIM-02


Travel Time Comparison - w/Lane Repurposing
55th-Southbound PM
Elapsed Time
11:00
10:00
9:00
8:00
7:00
6:00
5:00
4:00
3:00
2:00
1:00
0:00
Pearl
Flatiron
Central
Arapahoe
Control Point
VISSIM Existing
VISSIM-01
01-High
VISSIM-02


55th Street Southbound VISSIM Total Travel Time Estimate by Hour
Total Travel Time from Paerl to Arapahoe
06:00
04:48
03:36
02:24
01:12
00:00
3PM
4PM
5PM
6PM
7PM
Existing
With Lane Repurposing and Single SB LT at Arapahoe
With Lane Repurposing and Dual SB LT at Arapahoe

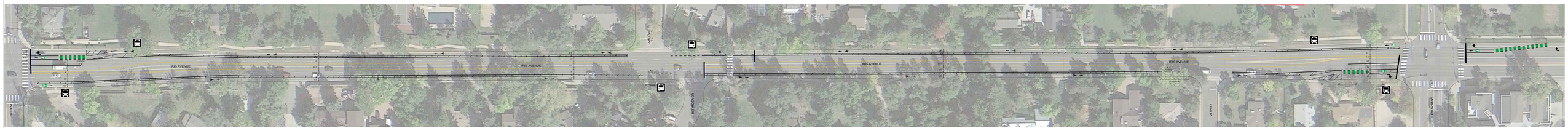
BOULDER, COLORADO

LIVING LABS RIGHT-SIZING -
IRIS AVENUE

N

4/29/2015

REDUCE TO ONE WESTBOUND LEFT AT BROADWAY



FOX TUTTLE HERNANDEZ TRANSPORTATION GROUP

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PRELIMINARY CONCEPTUAL DESIGN

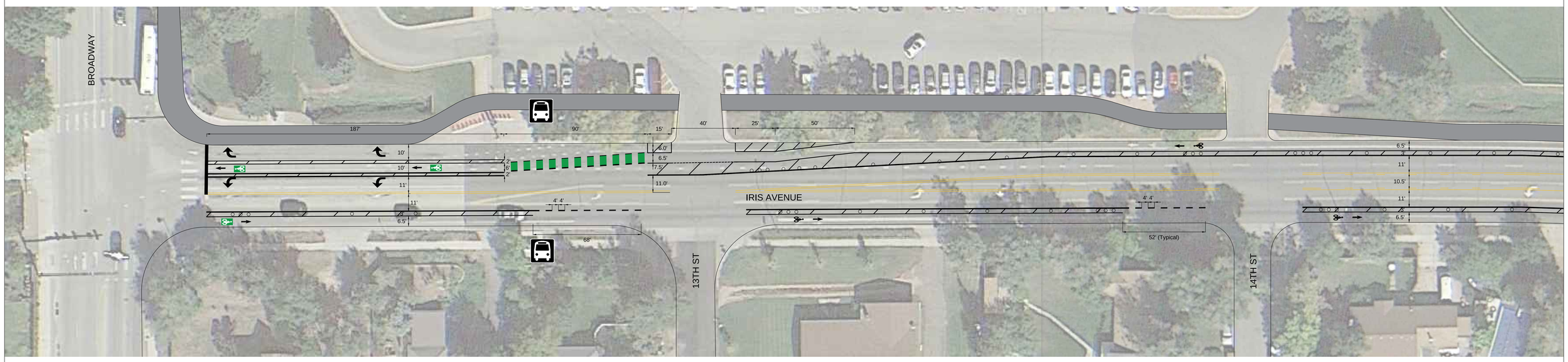
N

4/25/2015

BOULDER, COLORADO

LIVING LABS RIGHT-SIZING -

IRIS AVENUE



REDUCE TO ONE WESTBOUND LEFT AT BROADWAY

CITY OF BOULDER

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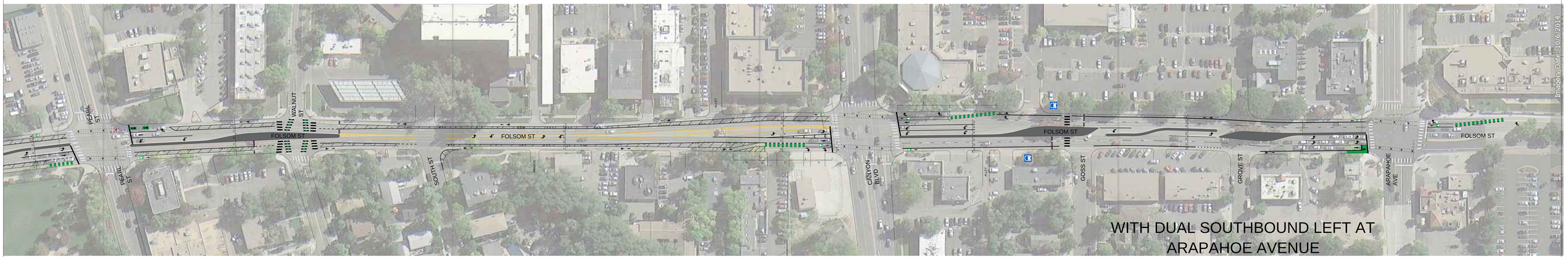
BOULDER, COLORADO

LIVING LABS RIGHT-SIZING -
FOLSOM STREET

4/25/2015



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BOULDER, COLORADO

LIVING LABS RIGHT-SIZING -
FOLSOM STREET

4/25/2015

WITH SINGLE SOUTHBOUND LEFT AT
ARAPAHOE AVENUE

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BOULDER, COLORADO

LIVING LABS RIGHT-SIZING -
FOLSOM STREET

4/25/2015

RIGHTSIZING BETWEEN VALMONT ROAD AND SOUTH STREET

CITY OF BOULDER

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BOULDER, COLORADO

LIVING LABS RIGHT-SIZING -
FOLSOM STREET

4/25/2015

WITH DUAL SOUTHBOUND LEFT AT
CANYON BOULEVARD

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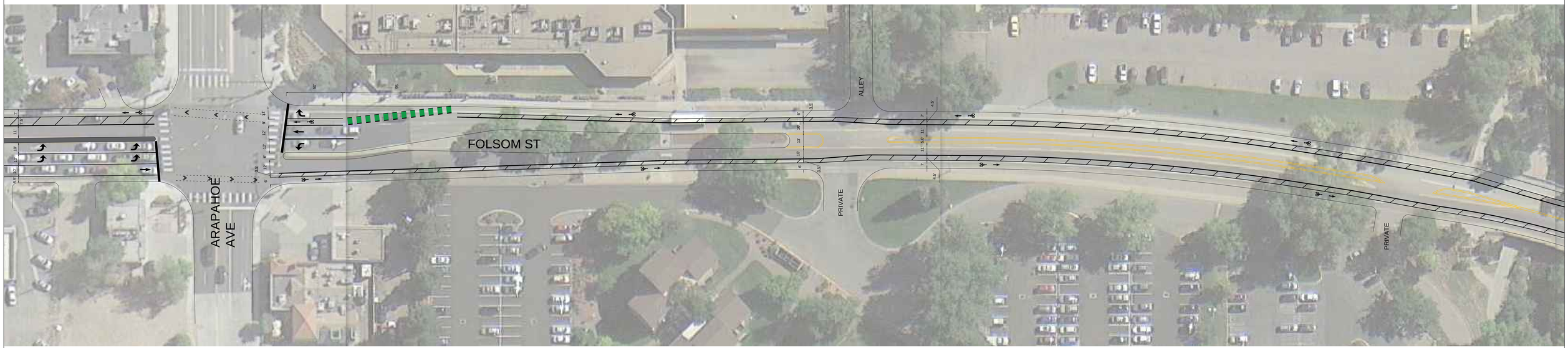
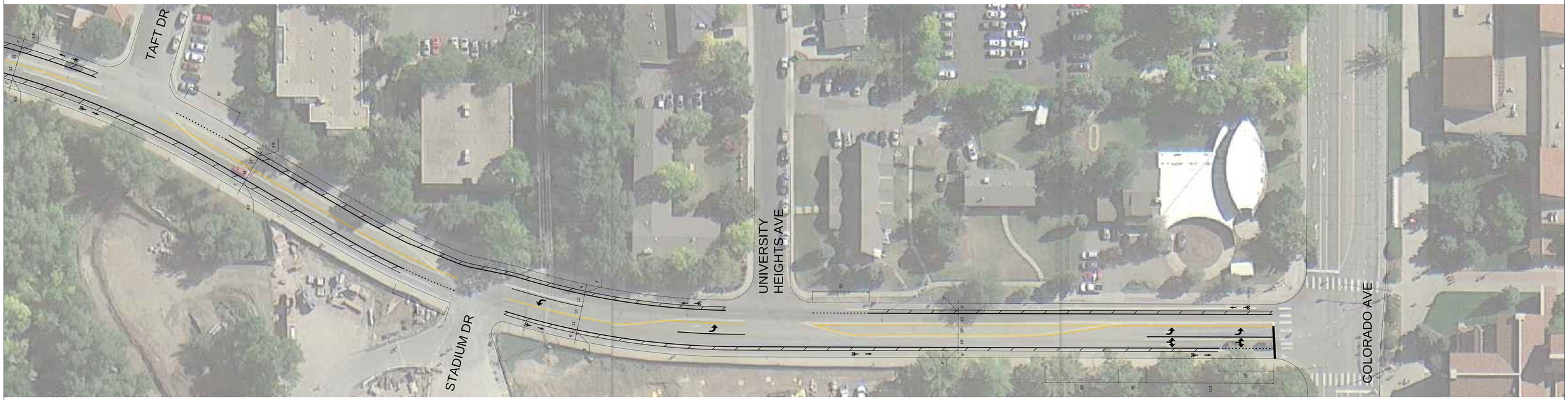
BOULDER, COLORADO

LIVING LABS RIGHT-SIZING -

FOLSOM STREET (SOUTH)

4/23/2015





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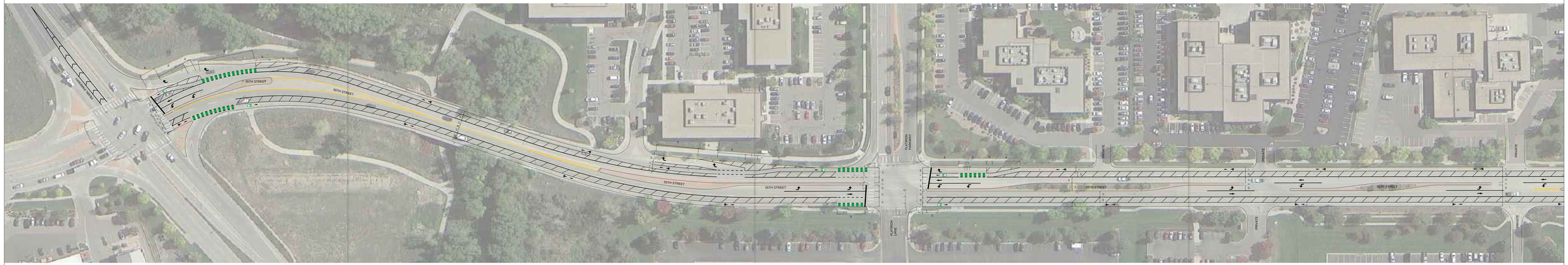
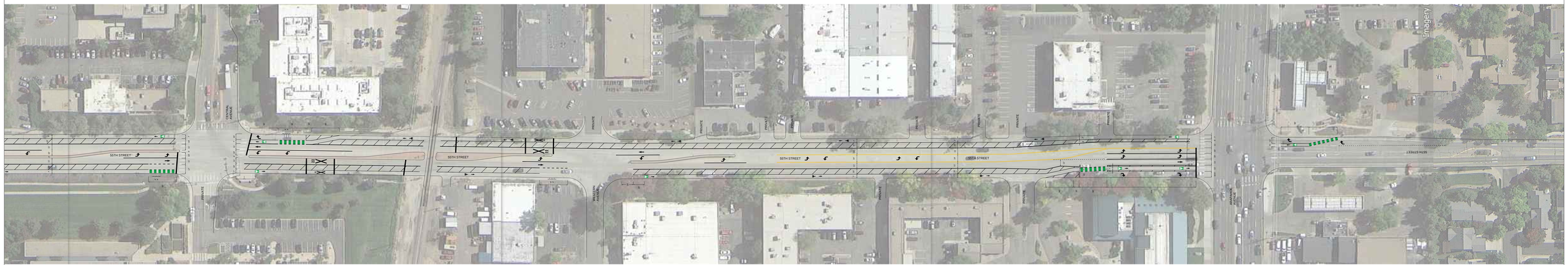
BOULDER, COLORADO

LIVING LABS RIGHT-SIZING -
55TH STREET

4/25/2015





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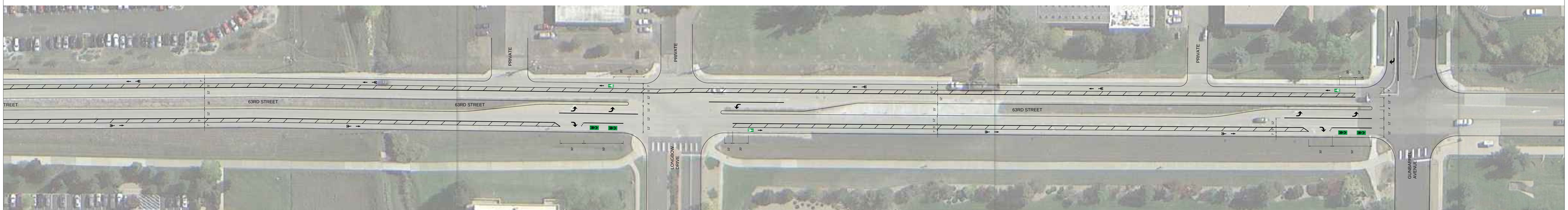
BOULDER, COLORADO

LIVING LABS RIGHT-SIZING -
63RD STREET

N

4/25/2015



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Workshops	Buisness	Status	Time	Contact	Notes
Iris May 5th	**Foothill Elementary School**	Talking to the principal	7:45-8:15am	(720) 561-2600	Same day as book fair
	Boulder County Health	Marni has a contact			
	Safeway (28th and Iris)	left a messge at corperate		(303) 938-1271	manager referd me to pr office, left message
	North Boulder Little Leauge	Waiting for a response			
Folsom May 7th	**McGuckins Hardware**	Confirmed	11:00am-2:00pm	**Louise Garrels**, *(720) 406-2062*	Tent Sale
55th May 12th	**Laughing Goat**	Working on Date/Time		John Jenkins - 720-427-8487	
	Ozo	Waiting for a response		(303) 440-0233	
	Upslope	Confirmed	4:00-6:00pm	tiffany@upslopebrewing.com	
63rd May 26th	Page Two	No Response to email			Talked on phone and seemed interested
	Avery Brewing	Waiting for a response			

Walk and Bike Audits	Meeting Locations	4-6pm
Iris and Folsom May 7th	NE Corner of Iris and Broadway (Boulder County Parking Lot)	
55th May 21th	55th and Boulder Creek Path (west side of BCP underpass)	
63rd May 28th	NW Corner of Nautilus and 63rd	