



# KNOX COURT

## BIKE BOULEVARD STUDY



October 2013

# Knox Court Bike Blvd Study



***Prepared for:***

**City and County of Denver**

***Prepared by:***

**Felsburg Holt & Ullevig**

6300 South Syracuse Way, Suite 600

Centennial, CO 80111

303/721-1440

FHU Reference No. 09-038-23

October 14, 2013

*The work that provided the basis for this publication was supported by funding under an award with the U.S. Department of Transportation Tiger II Planning Grant. The substance and findings of the work are dedicated to the public. The author and publisher are solely responsible for the accuracy of the statements and interpretations contained in this publication. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the Author(s) and do not necessarily reflect the views of the Federal Government.*



---

## TABLE OF CONTENTS

	<u>Page</u>
<b>I. Introduction .....</b>	<b>1</b>
Background.....	1
Purpose.....	1
Study Process.....	1
<b>II. Existing Conditions .....</b>	<b>5</b>
Land Uses and Demographics .....	5
Transportation Inventory .....	12
Summary of Needs .....	18
<b>III. Corridor Design Elements .....</b>	<b>19</b>
Process.....	19
Alameda Avenue Intersection .....	20
Knox Court Design Elements .....	23
<b>IV. Implementation.....</b>	<b>28</b>
Phasing .....	28
Cost Estimates .....	28
Next Steps.....	28

## LIST OF APPENDICES

Appendix A.	Public Input
Appendix B.	Conceptual Design
Appendix C.	Cost Estimates



---

## LIST OF FIGURES

	<u>Page</u>
Figure 1. Study Area .....	2
Figure 2. Existing and Proposed Bike Network.....	3
Figure 3. Building Land Uses.....	6
Figure 4. Corridor Land Uses .....	7
Figure 5. Population Density .....	8
Figure 6. Race and Ethnicity .....	9
Figure 7. Westwood Census Tracts .....	10
Figure 8. Commute to Work.....	11
Figure 9. Vehicle Availability.....	11
Figure 10. Existing Traffic Control.....	13
Figure 11. Traffic Volumes and Traffic Operations.....	14
Figure 12. Existing Bicycle and Pedestrian Volumes .....	16
Figure 13. Crash History .....	17
Figure 14. Knox Court Bike Boulevard Concept.....	24

## LIST OF TABLES

	<u>Page</u>
Table 1. Knox Court/Alameda Avenue/Morrison Road Traffic Operations .....	21



## I. Introduction

### Background

The Denver Livability Partnership (DLP) is a consortium of local and regional organizations with a common set of principles aimed at expanding affordable housing, improving access to jobs and creating better multimodal connectivity for Denver’s west side neighborhoods. The DLP received a sustainable communities grant through the U.S. Department of Transportation (DOT), the U.S. Department of Housing and Urban Development (HUD), and the U.S. Environmental Protection Agency (EPA) partnership. The grant covers six distinct programs/projects that address housing, jobs, and transportation to varying degrees. This Knox Court Bike Boulevard Study was one



of the projects funded through the grant. The study area map (**Figure 1**) shows both the Knox Court Bike Boulevard study corridor (Kentucky Avenue to Alameda Avenue) as well as the overall DLP West Side study area.

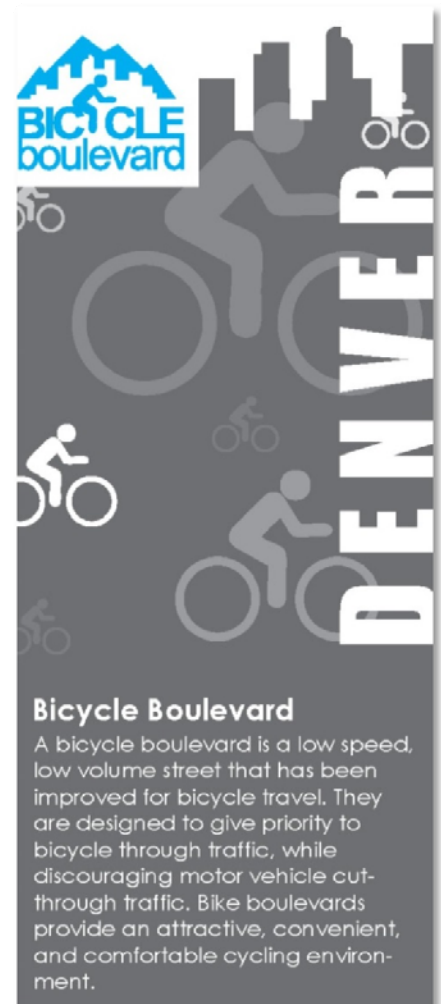
### Purpose

As shown in **Figure 2**, the section of Knox Court from Kentucky Avenue to Alameda Avenue was identified in *Denver Moves* (2011) as a proposed bike boulevard. A bike boulevard is a street designed to give priority to non-motorized users and discourage traffic by motorized vehicles (particularly non-local cut-through traffic). A separated space in the street is not necessary because the priority for non-motorized users is communicated through the roadway design, signage, and traffic calming measures. A bike boulevard is not a single treatment, but rather a combination of treatments used to convey the intended use of the street and provide a comfortable environment with minimal delays for bicyclists.

With the potential to become Denver’s first bike boulevard, the purpose of this study was to gather technical data, work directly with the adjacent property owners and surrounding community, assess the viability of Knox Court as a bike boulevard, and to identify appropriate bike boulevard treatments based on technical evaluation and public input. This report summarizes the study process, existing conditions assessment, alternative improvements and presents the recommended bike boulevard concept, shown on **Figure 14** (page 23).

### Study Process

The Knox Court Bike Boulevard Study was led the Denver Livability Partnership in coordination with Denver Public Works and Denver Community Planning and Development. Participation from several neighborhood groups was fundamental to the success of the study: LiveWell Westwood, Westwood Unidos, Westwood Registered Neighborhood Organization (RNO), Westwood LRC, BuCu West, and the City Council local district office.



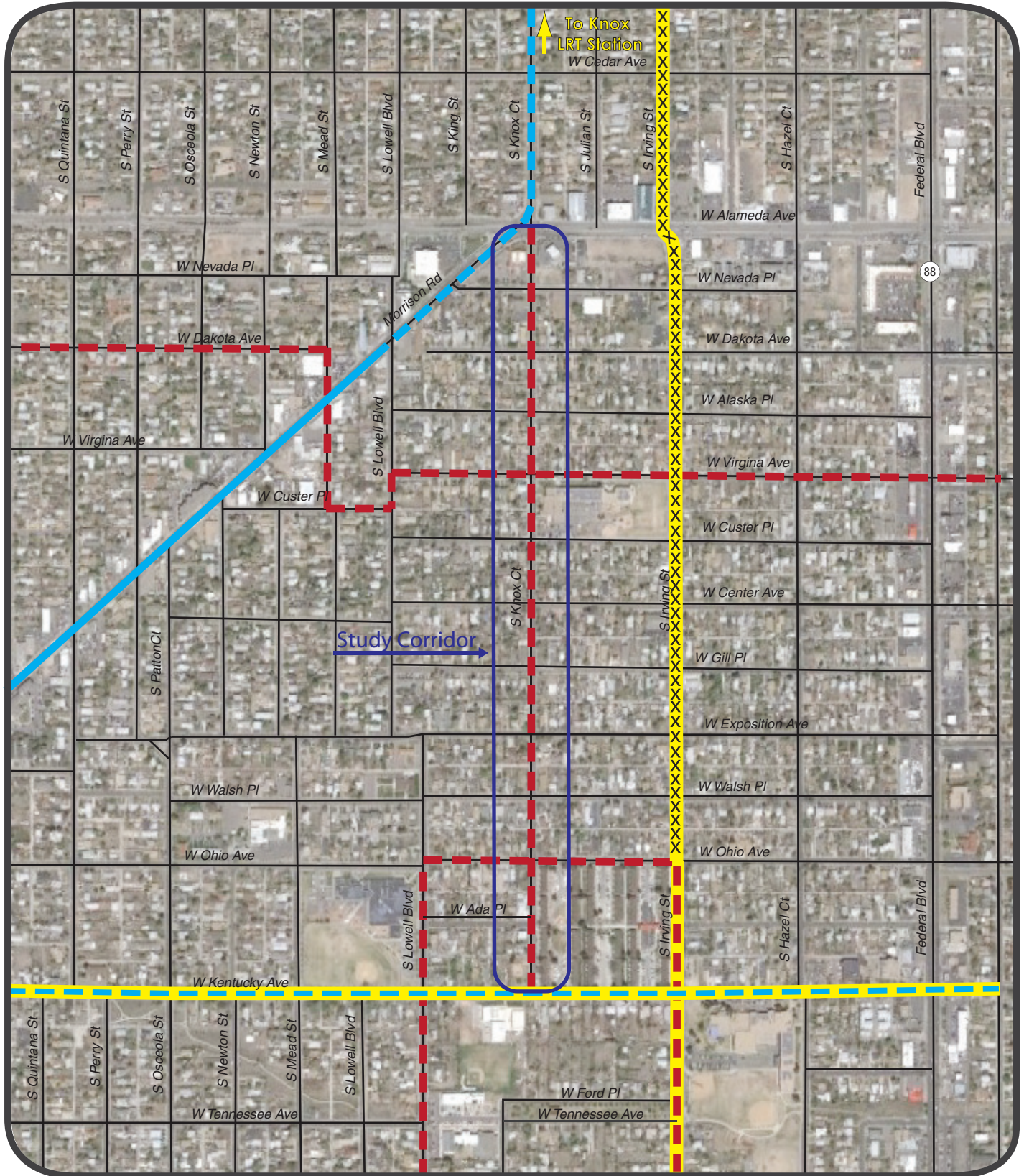


**LEGEND**

- = Existing Light Rail Stations
- = Planned Light Rail Stations
- = Statistical Neighborhood Boundaries
- = West Side Focus Area
- = Planned Bicycle Facility
- = Existing Bicycle Facility



*Figure 1*  
Study Area



Source: Denver Moves

## LEGEND

- = Existing Bike Lane
- - - - = Proposed Bike Lane
- - - - = Proposed Bike Boulevard

- = Existing Signed Bike Route
- XXXXXX = Signed Route to be Removed



**Figure 2**  
Existing and Proposed  
Bike Network



The transition of a street into a bike boulevard can dramatically change the appearance and function of the street. Public outreach was critical to the Knox Court study process, allowing property owners on the study corridor and adjacent corridors and the larger community to be involved in the decision making process. Public outreach occurred twice during the study:

- ▶ At the onset of the study to understand the needs and concerns of the community as well as to educate the public on the concept and benefits of a bike boulevard;
- ▶ During the alternatives evaluation process, at which time the public provided input on the alternative bike boulevard treatments being considered.

The first outreach effort began with a public meeting on November 15, 2012 at the Redeemer Lutheran Church. The public meeting attracted community leaders, but there was low representation from the corridor residents and business owners. To more effectively reach these groups, the public outreach approach was modified to include door to door surveys along the study corridor, which were conducted by LiveWell Westwood. The survey included a series of questions to understand the residents' travel patterns and habits as well as their preferences for different types of treatments associated with bike boulevards. Fifty-nine people completed the survey, which was offered in English and Spanish. The results are summarized in **Appendix A**.



Additionally, the project team presented information about the study at existing neighborhood meetings with Westwood RNO and Westwood Unidos, both on March 20, 2013. These meetings were each attended by approximately 20 people.

Input from this first round of public outreach was used to inform the development of corridor improvement alternatives, which were then presented to the public at a series of three previously established meetings with neighborhood groups, as follows:

- ▶ Westwood LRC Meeting – April 18, 2013 (attended by 25 people)
- ▶ Westwood Unidos Built Environment Meeting – Wednesday, July 17<sup>th</sup> - 9:00 am @ BuCu West – 4200 Morrison Rd. Unit 3 – Denver, CO (attended by 20 people)
- ▶ Westwood RNO Meeting – Wednesday, July 17<sup>th</sup> – 6:00 pm @ Mean Bean Coffee – 4300 W. Alameda Ave. – Denver, CO (attended by 15 people)

Overall, reviews of the Knox Court Bike Boulevard design were positive. Residents and business owners provided insightful feedback, asking questions about how the design would function once implemented and offering suggestions for further improvement. These issues were addressed in the public meetings, in the conceptual design, or within this report. For a detailed description of public comments, refer to **Appendix A**.

Spanish translation services were provided at all public meetings.





## II. Existing Conditions

The transportation inventory documented in this chapter serves as a baseline survey of the existing transportation facilities and operations along Knox Court and also as the basis for identifying future improvements. The land use and demographic inventory provides an understanding of the likely bicycle/pedestrian origins and destinations as well as some insight into the travel habits of the neighborhood residents.

### Land Uses and Demographics



*Single family residential is the predominant land use along Knox Ct.*

Alameda Avenue, including a gas station on the southeast corner of Alameda Avenue/Knox Court and a restaurant on the southwest corner. There is a multi-family residential area on the east side of Knox Court between Kentucky Avenue and Ohio Avenue which generates higher rates of on-street parking than the rest of the corridor.

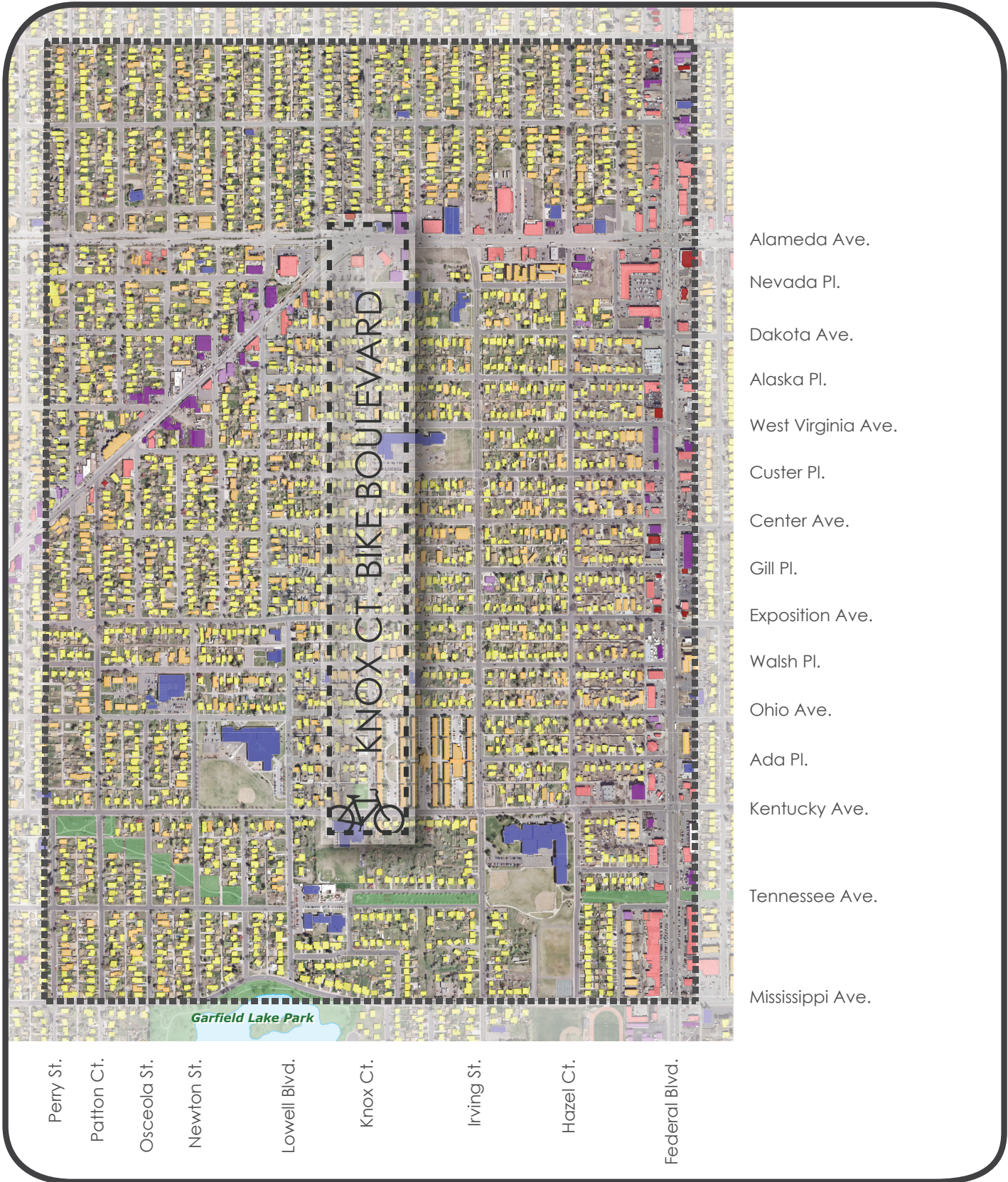
**Figure 3** provides an overview of the land uses in the larger context. The area is primary residential with major employment corridors along Federal Boulevard, Alameda Avenue, and Morrison Road. The land use along Knox Court is primarily single family residential, as shown on **Figure 4**. There are several schools in the corridor study area including two public elementary schools, a public middle school, and a Lutheran School. Monroe Elementary School is located immediately on Knox Court, between Custer Place and Virginia Avenue. There is some commercial activity near



*Restaurant on the southwest corner of Alameda Avenue and Knox Court*

**Figure 5** shows the housing density along the Knox Court corridor and in the surrounding area. Along the corridor, the density is generally in the range of 14-27 units per acre, except in the multi-family area on the south end of the corridor, which has a density in the range of 28-44 units per acre. As indicated by the race and ethnicity charts on **Figure 6**, all of the blocks along the corridor and the surrounding area have a predominant Hispanic population. There is also a notable Vietnamese population in the neighborhoods east of Knox Court.

Two census tracts make up the study area neighborhood, as shown on **Figure 7**. Tract 45.05 includes the area between Exposition Avenue and Alameda Avenue, while Tract 45.06 is the area south of Exposition Avenue to Mississippi Avenue. The Westwood neighborhood commuting travel modes generally follow those for all of the City and County of Denver. **Figure 8** does show a higher than City-wide average use of carpooling for the Westwood neighborhoods, and a higher than average use of public transportation for the Westwood 45.06 census tract (south of Exposition Avenue). As shown in **Figure 9**, auto ownership in Westwood 45.06 (south of Exposition Avenue) is considerably lower than the City-wide average, whereas the auto ownership in Westwood 45.05 (north of Exposition Avenue) is higher slightly higher than the City-wide average.



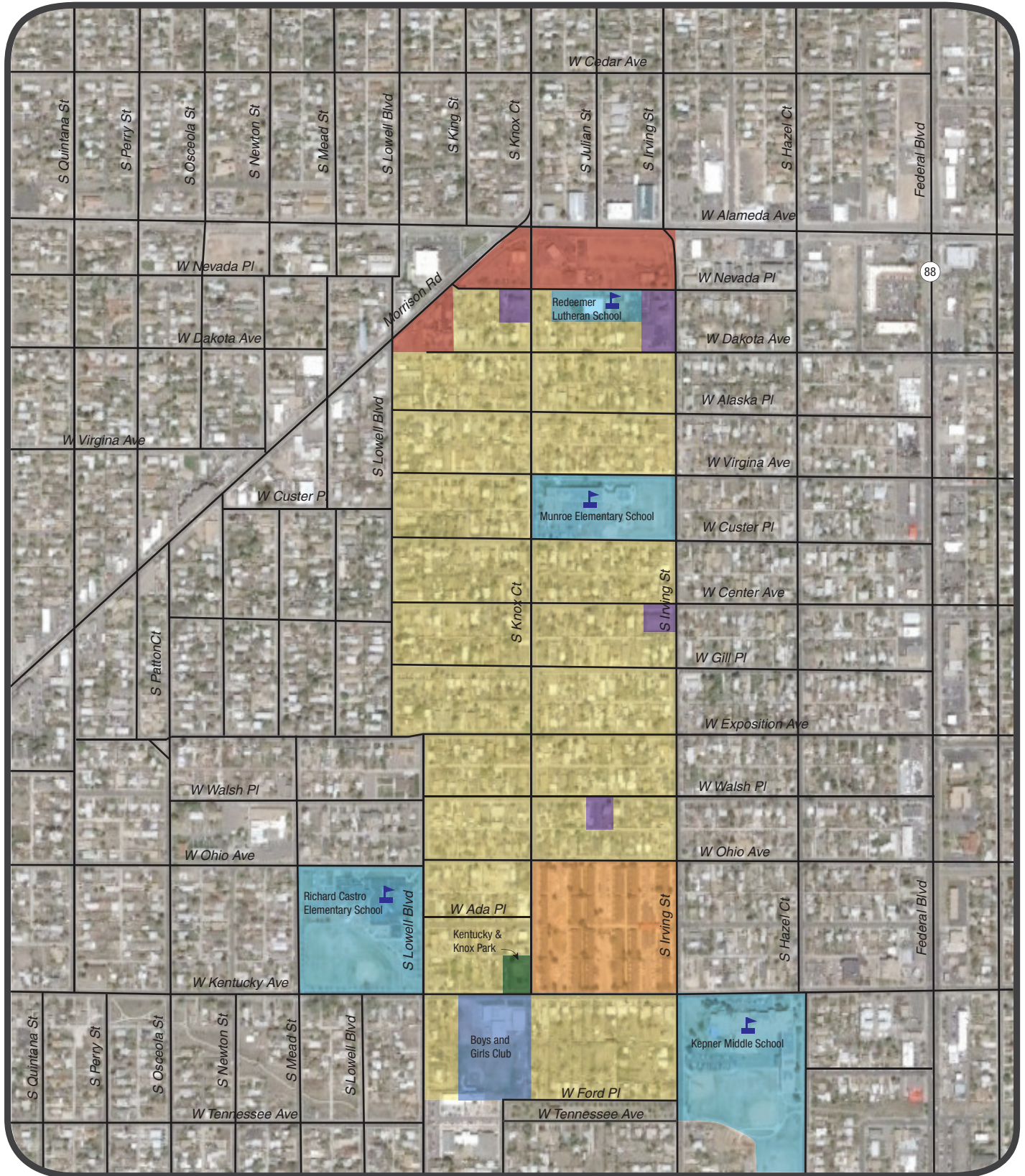
- Alameda Ave.
- Nevada Pl.
- Dakota Ave.
- Alaska Pl.
- West Virginia Ave.
- Custer Pl.
- Center Ave.
- Gill Pl.
- Exposition Ave.
- Walsh Pl.
- Ohio Ave.
- Ada Pl.
- Kentucky Ave.
- Tennessee Ave.
- Mississippi Ave.

- Perry St.
- Patton Ct.
- Osceola St.
- Newton St.
- Lowell Blvd.
- Knox Ct.
- Irving St.
- Hazel Ct.
- Federal Blvd.

**LEGEND**

- = Office
- = Industrial
- = Single-Family
- = Commercial/Retail
- = Entertainment-Cultural
- = Multi-Family; Mobile Home/Trailer
- = Mixed-Use or Mixed-Use w/Residential
- = Parks/Recreation
- = Transportation, Communication, Utility
- = Public/Quasi-Public
- = Garage/Carport/Shed

**Figure 3**  
Building Land Uses

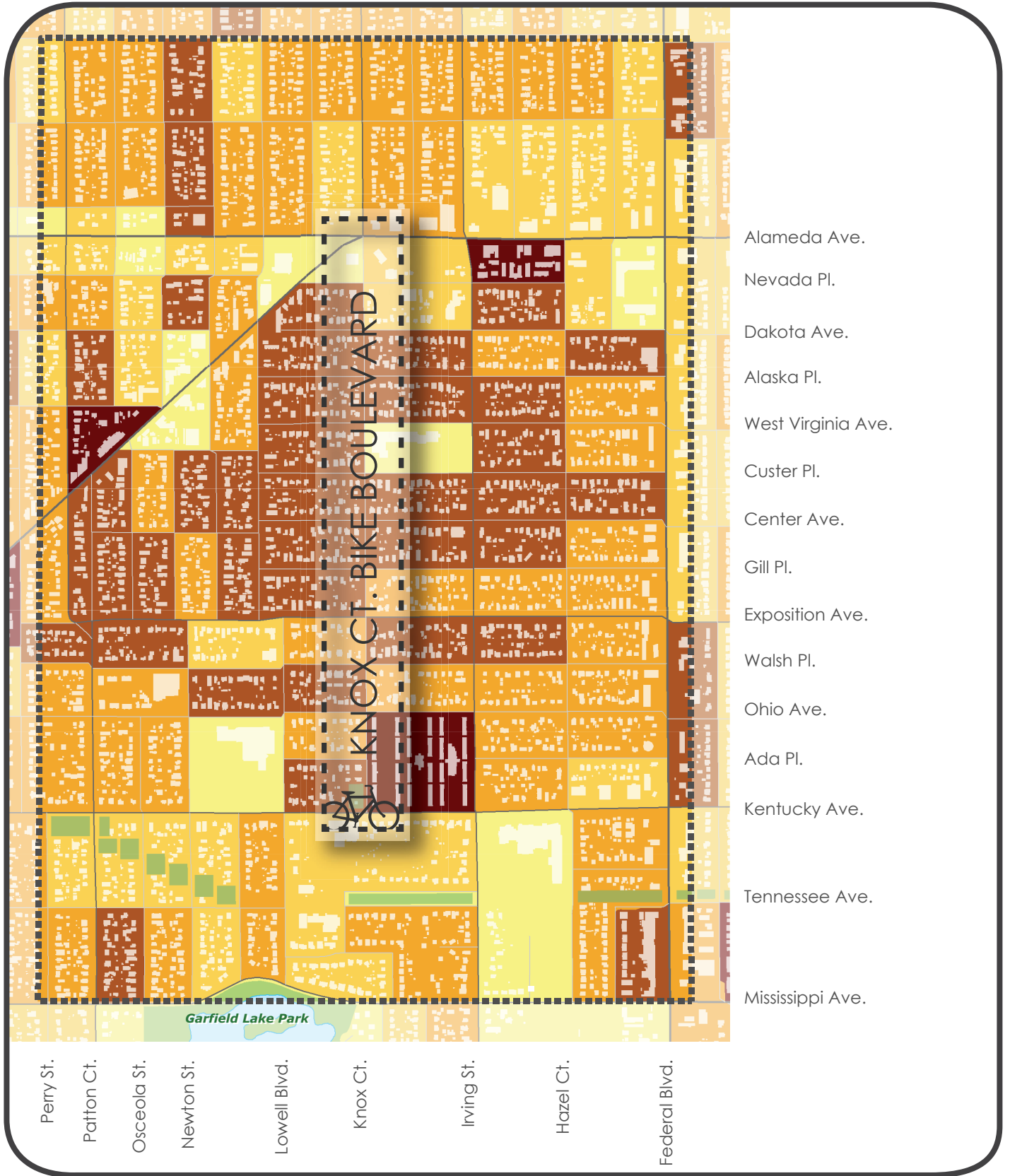


## LEGEND

- = Single Family Residential
- = Multi-Family Residential
- = School
- = Church
- = Park
- = Other



**Figure 4**  
Corridor Land Uses

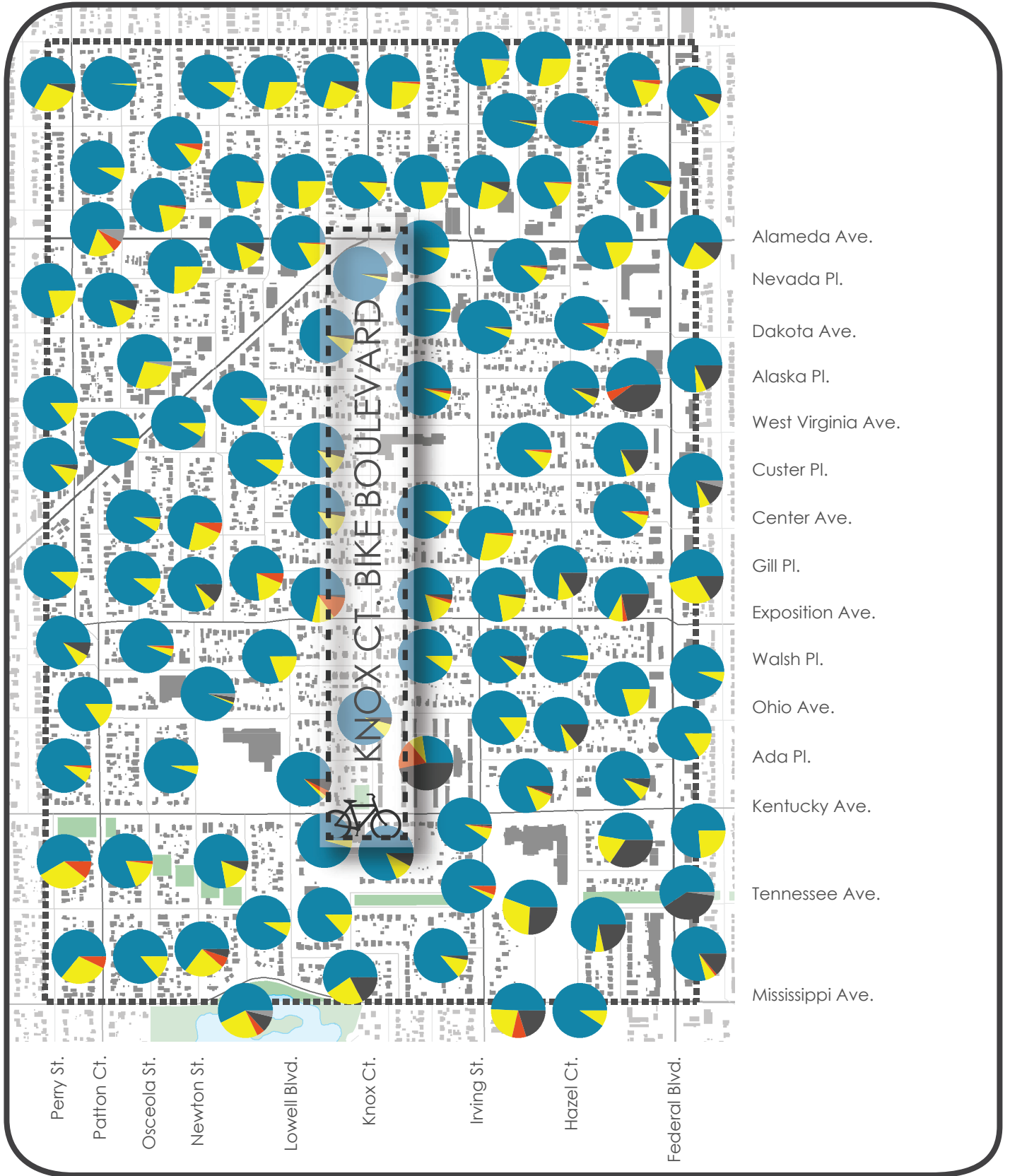


**LEGEND**

- = Open Space Units per Acre
- = 0-6 Units per Acre
- = 7-13 Units per Acre
- = 14-19 Units per Acre
- = 20-27 Units per Acre
- = 28-44 Units per Acre



**Figure 5**  
Population Density

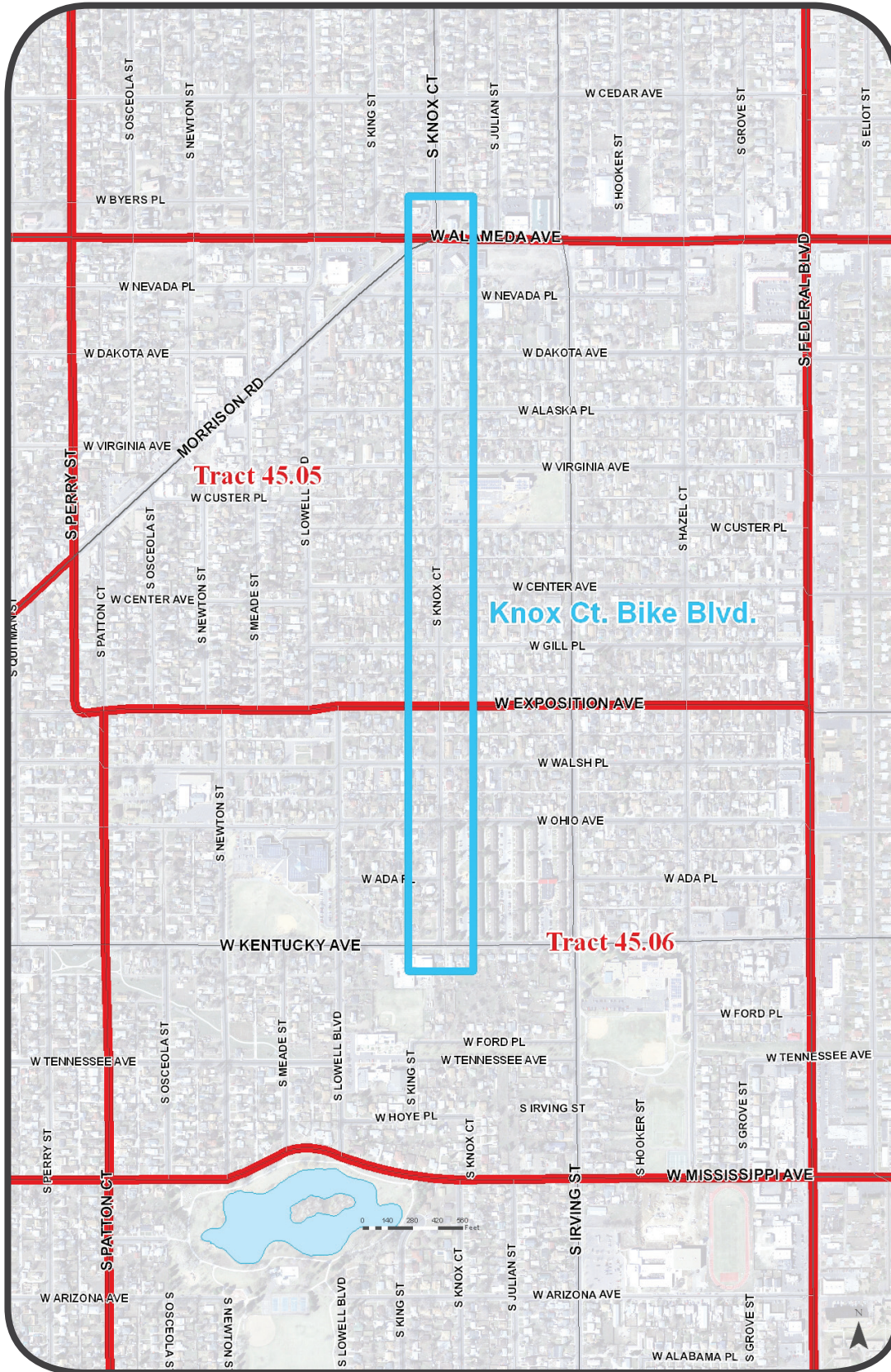


LEGEND

- = Hispanic
- = White
- = Black
- = Asian
- = Other
- = Open Sapce



**Figure 6**  
Race and Ethnicity

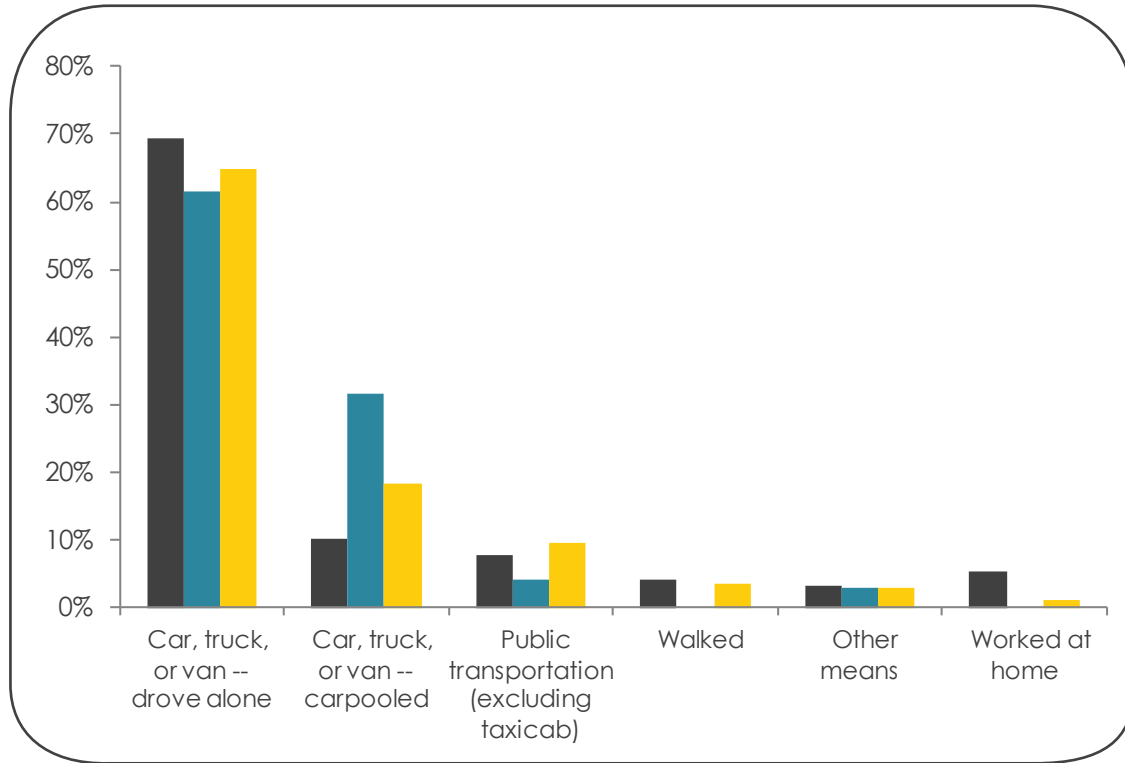


**LEGEND**

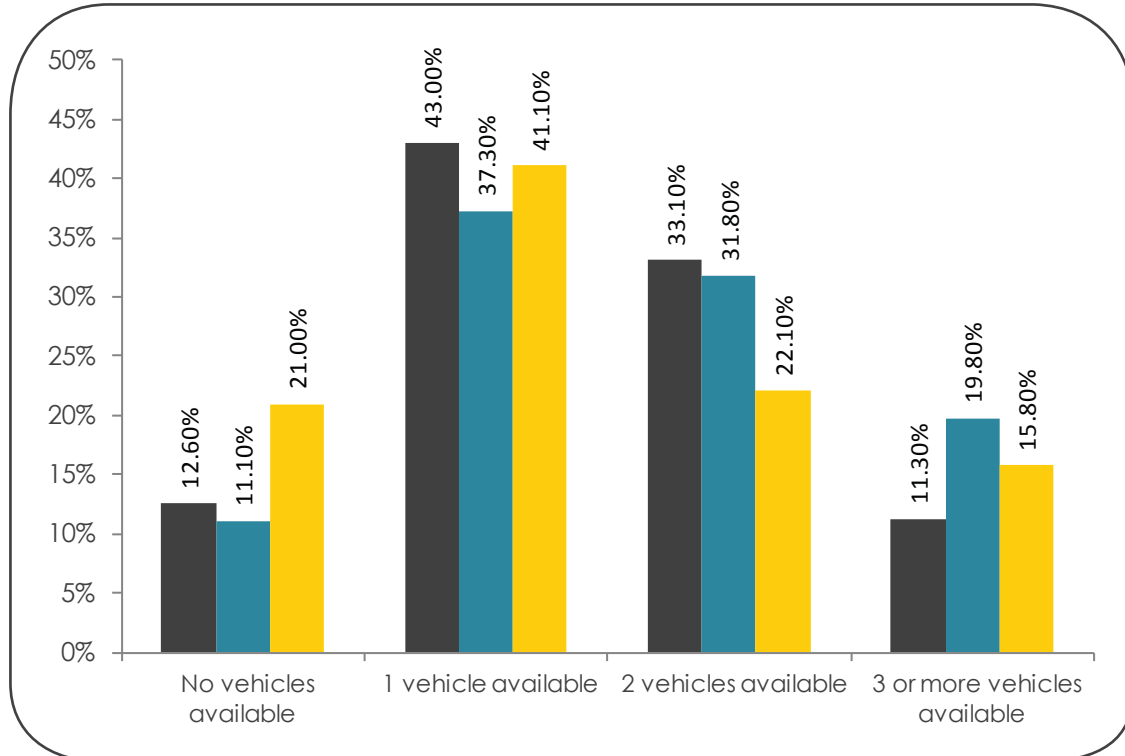
- █ = Knox Ct. Bike Blvd.
- █ = Tracts



*Figure 7*  
Westwood Census Tracts



**Figure 8**  
Commute to Work



**Figure 9**  
Vehicle Availability

**LEGEND**

- = Denver
- = Westwood (45.05)
- = Westwood (45.06)

Source: ACS(06-10)



## Transportation Inventory

### Infrastructure and Signing



*Knox Court currently has one travel lane in each direction, on-street parking and narrow sidewalks.*

Knox Court’s current cross section (as shown on **Figure 10**) includes 32 feet for one travel lane in each direction and on-street parking, plus a two foot gutter pan and curb on either side, and narrow 2 ½ foot sidewalks. The street has a posted speed limit of 25 mph, except in school zones near Monroe Elementary School and the Redeemer Lutheran School where the posted speed is 20 mph between 7:00 AM and 4:00 PM.

The only signalized intersection on the corridor is at Alameda Avenue, where Knox Court, Alameda Avenue, and Morrison Road intersect at a five-legged intersection and Knox Court to the south is limited to right-in/right-out movements. The remaining intersections along Knox Court have 2-way or 4-way stop sign control. Of the twelve stop controlled intersections; Knox Court has the right of way at

six of the intersections, while Knox Court traffic is stopped at the remaining six intersections. Painted crosswalks across at least one leg exist at five intersections along Knox Court.

### Traffic Volumes and Operations

Daily traffic volumes were recorded at two locations along Knox Court in September 2012. As shown on **Figure 11**, there are approximately 1,600 vehicles per day (vpd) on the south end of the corridor and over 2,000 vpd on the north end of the corridor. Bike boulevards have low traffic volumes, and the current volumes on Knox Court are in line with the acceptable range of up to 4,000 vpd for bike boulevards.

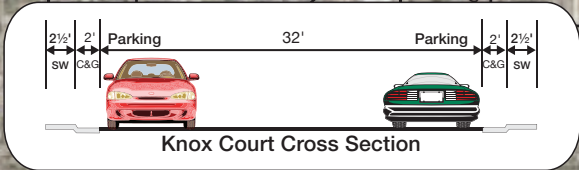
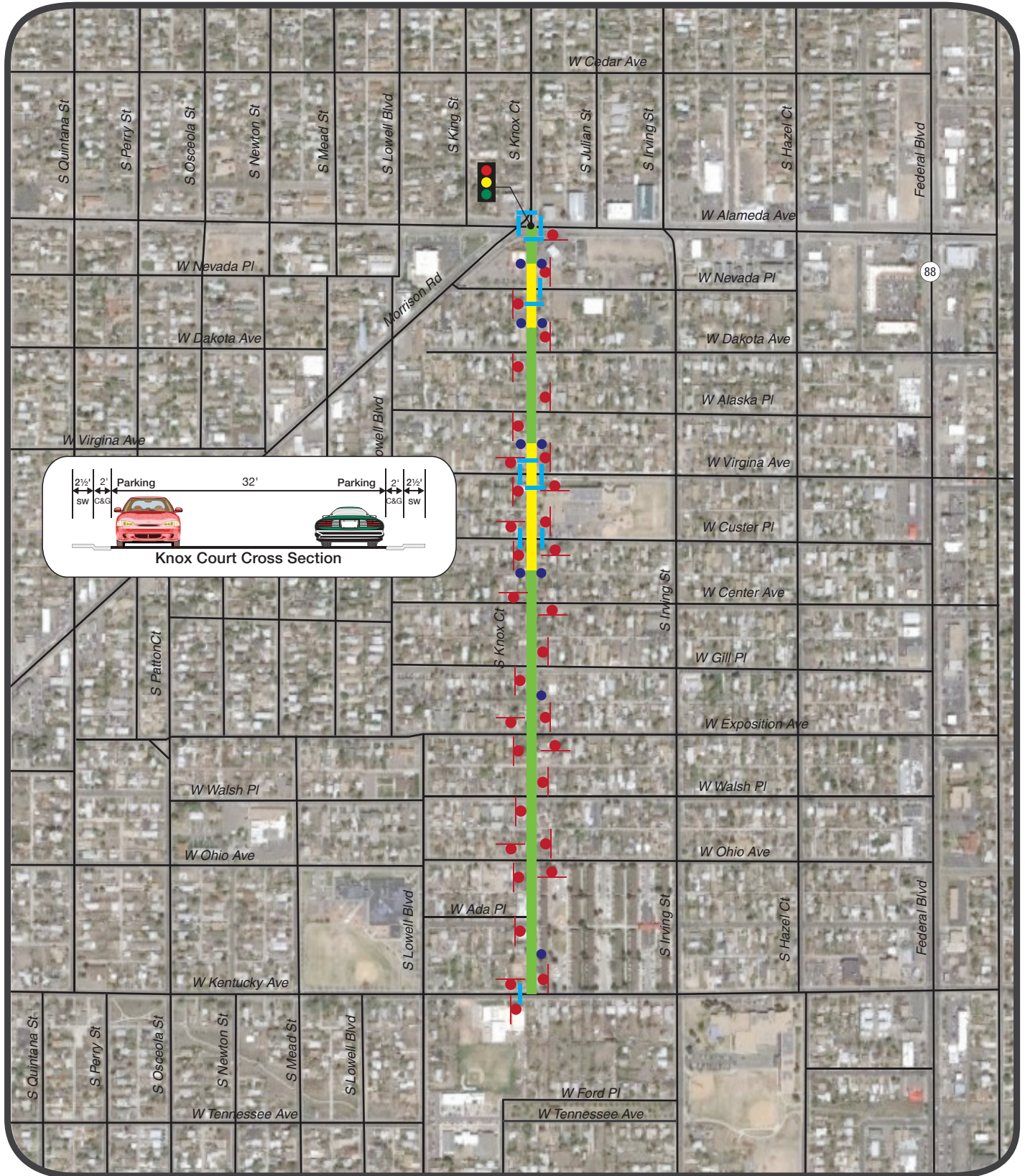
Morning and afternoon peak hour turning movement volumes were recorded at the intersection of Alameda Avenue/Knox Court/Morrison Road in order to evaluate the existing intersection operations and to understand how potential changes to the intersection might affect traffic operations.

Level of service (LOS) is a qualitative assessment of the traffic flow based on the average stopped delay per vehicle at an intersection. Levels of service are described by a letter designation ranging from “A” to “F,” with LOS A representing essentially uninterrupted flow, and LOS F representing a breakdown of traffic flow with excessive congestion and delay. The five-legged signalized intersection operates with a split phase for northbound Morrison Road and southbound Knox Court, with Knox Court to the south accommodating only right turn movements to and from Alameda Avenue and the southbound through movement from Knox Court. The intersection currently operates at LOS D during the AM and PM peak hours, which is considered acceptable during peak hours on busy arterial streets such as Alameda Avenue.



*The Alameda Avenue/Knox Court/Morrison Road intersection is 5-legged, resulting in long, exposed crossing distances for bicyclists and pedestrians.*



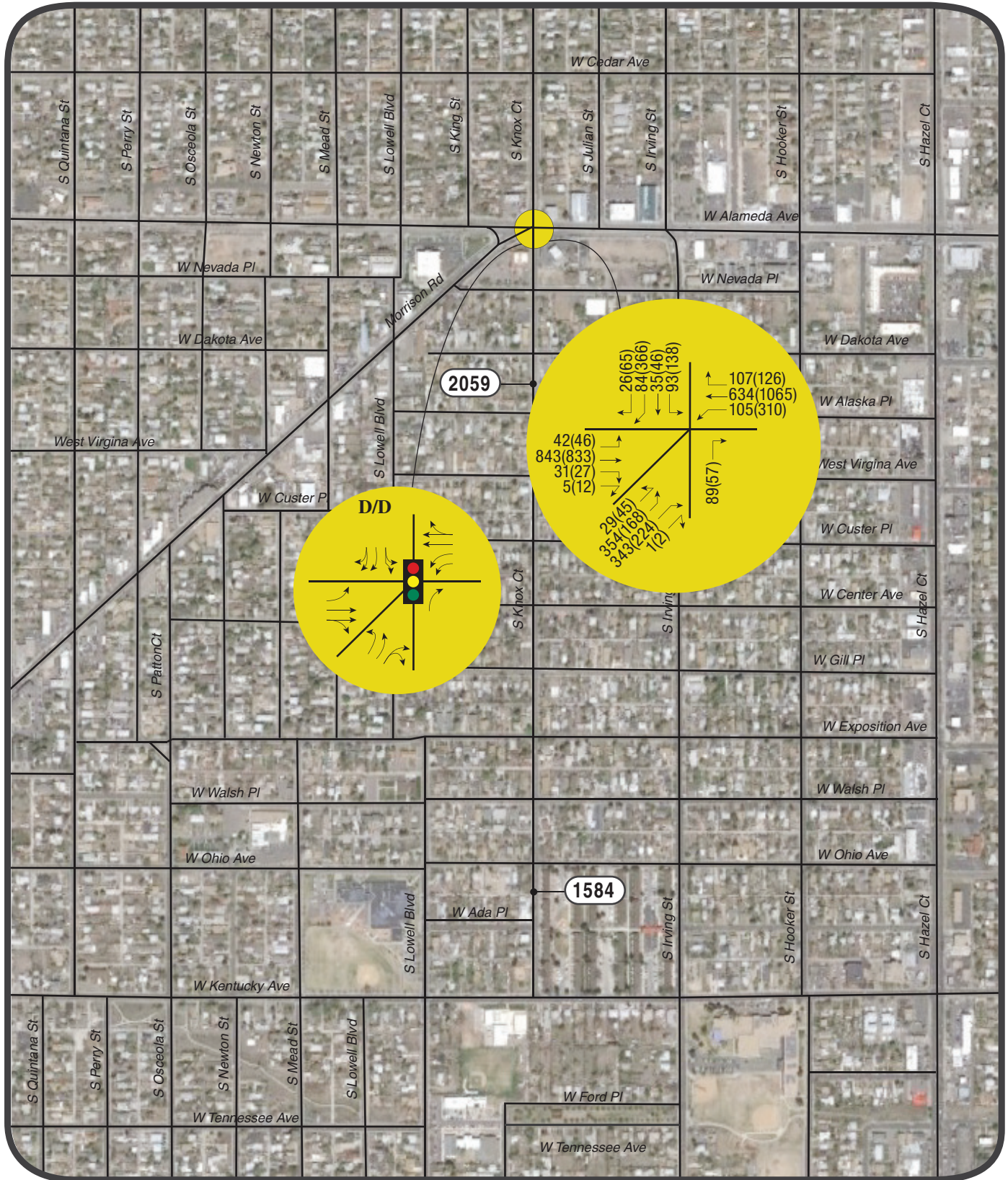


**LEGEND**

- = Stop Sign
- = Posted speed 25mph
- = Traffic Signal
- = School Zone, Posted Speed 20mph (7AM-4PM)
- = Crosswalk
- = Speed Limit Sign



**Figure 10**  
Existing Traffic Control



## LEGEND

- (XXXX)** = Daily Traffic Volumes
- XXX(XXX)** = AM(PM) Peak Hour Traffic Volumes
- X/X** = AM/PM Peak Hour Signalized Intersection Level of Service



**Figure 11**  
Traffic Volumes and  
Traffic Operations



## *Bicycle and Pedestrian Activity*

Bicyclists and pedestrians were counted at two locations on Knox Court: at the Alameda Avenue intersection and the Center Avenue intersection. Because Irving Street (one block east of Knox Court) is currently a signed bike route (and Knox Court is not), bicyclists and pedestrians were also counted at the intersection of Irving Street and Center Avenue. The counts were recorded from 7:00 – 9:00 AM and from 4:00 – 6:00 PM.

As shown on **Figure 12**, pedestrian activity at the two intersections with Center Avenue is highest in the morning when children are walking to Monroe Elementary School. Over 50 pedestrian movements were recorded at each intersection over the two hour morning period. In the afternoon, pedestrian activity was notably lower. At the Alameda Avenue/Knox Court intersection, over 44 pedestrian movements were recorded in the morning period, and 107 pedestrian movements in the afternoon period. The highest pedestrian movement was across Alameda Avenue on the east side of the intersection.



*A pedestrian waiting to cross Alameda Avenue from Knox Court.*

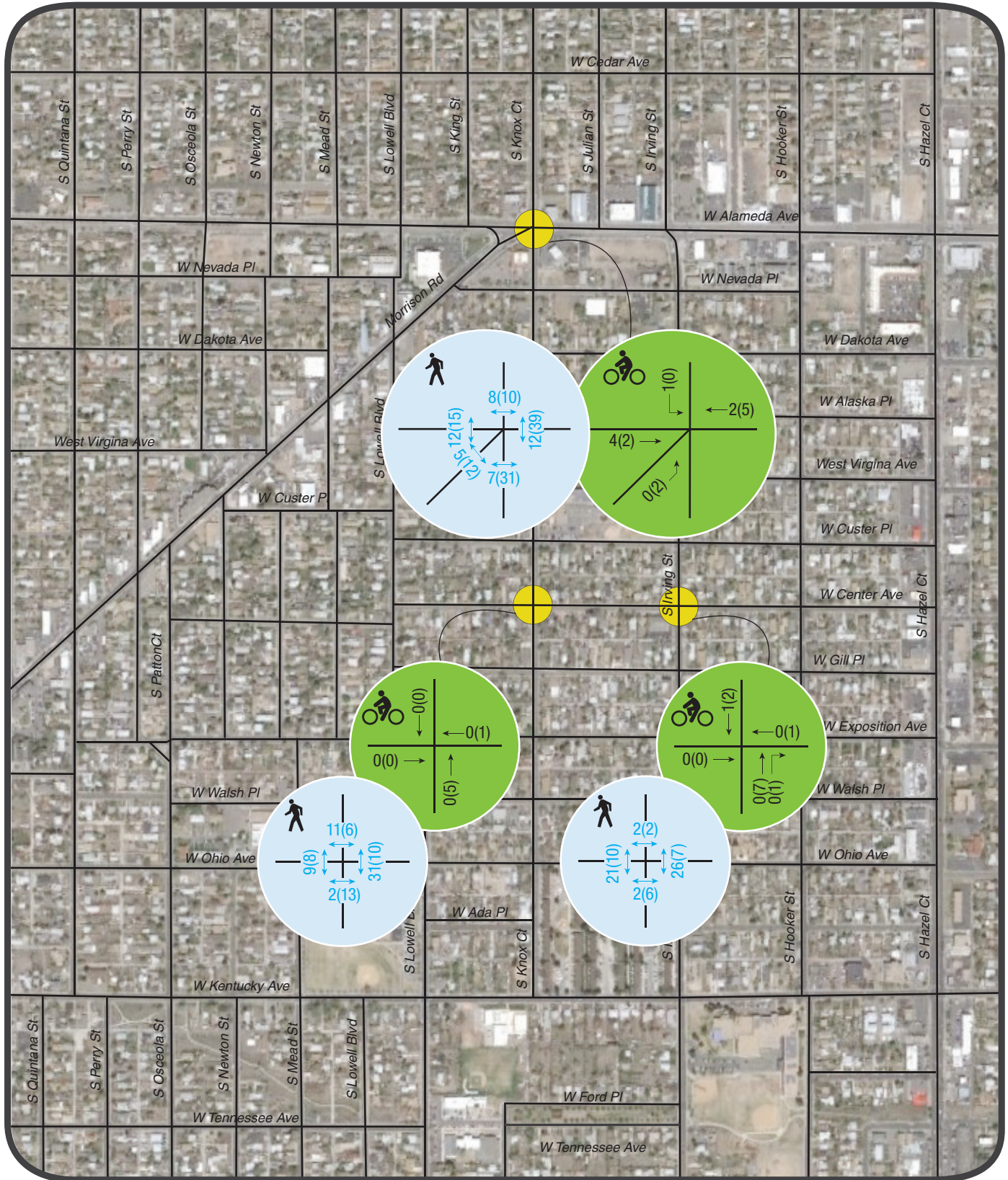
Bicycle activity on Knox Court today is low, with only five bicyclists traveling the corridor during the afternoon 2-hour period. On Irving Street (which is currently a signed bike route) the bicycle volumes are slightly higher with ten bicyclists traveling the corridor during the afternoon 2-hour period.

## *Crash History*

Crash data were collected for the three year period from January 1, 2009 through December 31, 2011 along Knox Court and Irving Street between Kentucky Avenue and Alameda Avenue (summarized on **Figure 13**). During that time period, there were 70 crashes on Knox Court. The majority (45) of the crashes were at the intersection of Alameda Avenue/Knox Court/Morrison Road, which is to be expected since this intersection has the highest level of traffic volumes on the corridor. Three of the crashes along Knox Court involved pedestrians; two of which involved injuries (one at Dakota Avenue and one at Kentucky Avenue) and one of which involved a fatality (at Alameda Avenue).

Along Irving Street, there were 72 crashes in the three year period, three of which involved bicyclists and one of which involved a pedestrian. The crashes involving a bicyclist/pedestrian are clustered in the northern stretch of the corridor. The intersection of Alameda Avenue/Irving Street had the highest number of crashes (26), followed by the intersection of Kentucky Avenue/Irving Street (10).

The Colorado Department of Transportation (CDOT) uses Safety Performance Functions (SPF) to evaluate the overall safety at intersections. The SPFs, which are essentially accident predication models, can be used to assess the magnitude of a safety problem based on the expected number of crashes at intersections with common characteristics (e.g., traffic volumes, traffic control, travel lanes, and area type). The results of applying CDOT's methodology at the two study intersections along Alameda Avenue (State Highway 26) indicate that both intersections have a slightly lower crash rate than expected; that is, the safety performance is better than expected.



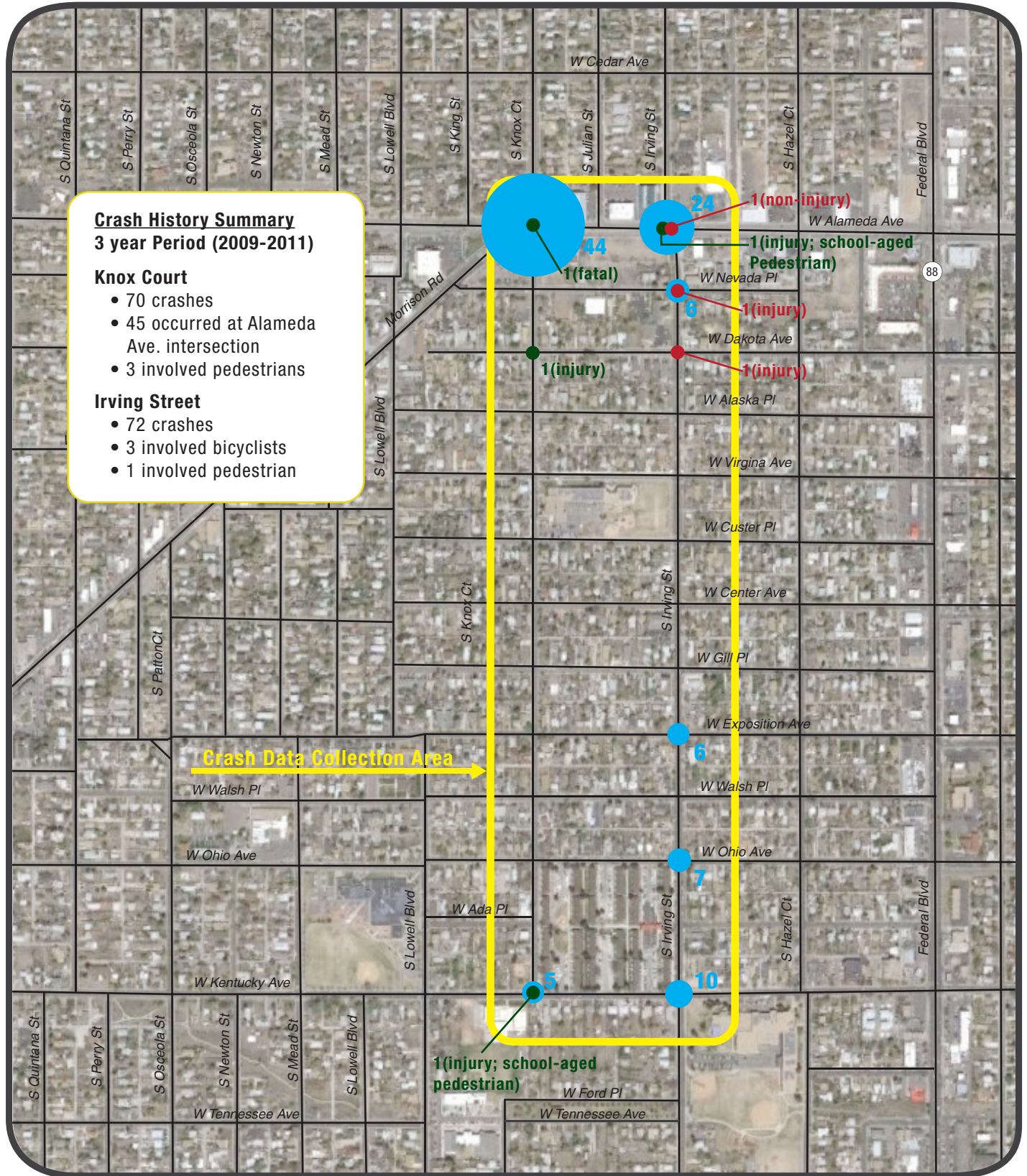
**LEGEND**

XX(X) = AM(PM) Peak 2-Hour\* Pedestrian Crossings  
 XX(X) = AM(PM) Peak 2-Hour\* Bicycle Counts

\*September 2012 - 7:00-9:00 AM; 4:00-6:00 PM



**Figure 12**  
Existing Bicycle and Pedestrian Volumes



**LEGEND**

- = Pedestrian/Vehicle Crash
- = Other Vehicle Crashes\*
- = Bike/Vehicle Crash
- X** = Number of Crashes by Travel Mode

\*Note: Other vehicular crashes are only shown at intersection where more than 5 occurred



**Figure 13**  
Crash History (2009-2011)



## Summary of Needs

The inventory of existing conditions along Knox Court and input from the adjacent residents illuminate several needs to effectively transition Knox Court into a bike boulevard:

- ▶ The intersection of Alameda Avenue/Knox Court/Morrison Road is complex and will require substantial bicycle and pedestrian improvements to encourage the use of the Knox Court bike boulevard.
- ▶ There is a perception that vehicles travel too fast on Knox Court; the bike boulevard design needs to encourage slower traffic that is more compatible with bicycling speeds.
- ▶ Stop signs for traffic on Knox Court are frequent and could discourage bicyclists from using the corridor.
- ▶ In addition to improving bicycling conditions on Knox Court, there is a strong desire from the community to make it pedestrian friendly by improving crossings and calming traffic.
- ▶ With relatively low bicycle volumes on Knox Court and Irving Street, a marketing/encouragement campaign, along with clear way-finding and corridor identity signing will be important to the success and level of use of the Knox Court as a bike boulevard.



### III. Corridor Design Elements

#### Process

Denver's *Bike Boulevard Guidebook* includes a toolbox of bike boulevard design elements to provide increased convenience for non-motorized users. The tools are organized in five categories:

- ▶ Prioritize Bicycle Travel
- ▶ Signage
- ▶ Intersection Treatments
- ▶ Crossing Treatments
- ▶ Traffic Calming and Diversion

Design elements from each of these categories were combined to identify improvements that could effectively respond to the needs along Knox Court and create an enhanced environment for bicyclists and pedestrians. In the next sections, the intersection of Knox Court with Alameda Avenue is addressed first, followed by the corridor as a whole.

#### Design

All bicycle boulevards are designed differently based on the characteristics of the specific street and surrounding community. There are a variety of design elements used to create bike boulevards. These elements fall into 5 categories - signage and pavement markings, prioritization for cyclists, traffic calming, traffic reduction strategies, and intersection treatments. A bike boulevard may use all of these elements or a select few depending on the existing conditions.

**Traffic Calming**

**Signage**

**Prioritize Travel On Bicycle Boulevard**

**Traffic Reduction**

**Intersection Treatment**

**Traffic circles serve as traffic calming devices.**

**Bicycle boulevard signs and pavement markings serve as wayfinding devices and reinforce that bicyclists are on a preferred route.**

**Raised medians and diverters allow bicyclists to cross arterial while preventing motorists from cutting through.**



## Alameda Avenue Intersection

The intersection of Knox Court/Alameda Avenue/Morrison Road is five-legged, resulting in long crossing distances, complex vehicular movements and many conflict points for crossing bicyclists and pedestrians. Because this intersection, in its current configuration, is difficult for bicyclists and pedestrians cross, the identification of bike boulevard design elements for Knox Court began with addressing this complex intersection. Without a safe and convenient crossing of Alameda Avenue, this intersection could function as a barrier, limiting Knox Court's usefulness for non-motorized travel.

With bike lanes planned on Knox Court north of Alameda Avenue (connecting to the West Line Station at 13<sup>th</sup> Avenue), there is a need to connect the future bike lanes to the Knox Court Bike Boulevard south of Alameda Avenue as well as to the existing bike lanes on Morrison Road which start one block south of Alameda Avenue. To make these connections, improved bicycle (and pedestrian) crossing treatments are needed at the Knox Court/Alameda Avenue/Morrison Road intersection. Several potential intersection modifications were identified that could affect traffic operations at the intersection:

- ▶ Colored concrete crossbikes (a designated intersection crossing area for bicyclists) across the north and east legs of the intersection to encourage this as the primarily connection between Knox Court to the north of Alameda Avenue and the bike boulevard south of Alameda Avenue
- ▶ An advance bicycle and pedestrian signal phase (allowing bicyclists and pedestrians a "head start" which can improve their visibility for drivers)
- ▶ An exclusive bicycle and pedestrian signal phase (in which all automobile traffic would be stopped until the bicyclists and pedestrians clear the intersection)
- ▶ Elimination of a southbound travel lane on Knox Court (approaching Alameda Avenue) to provide space for a bike lane and an improved pedestrian landing area in the northwest corner of the intersection
- ▶ A bike box on the north leg of the intersection (a marked waiting area for use by southbound bicyclists wishing to travel from Knox Court to southbound Morrison Road)
- ▶ Elimination of the northbound right turn movement from Knox Court onto Alameda Avenue (which would allow the eastern half of Knox Court between Nevada Place and Alameda Avenue to be repurposed as a sidepath)
- ▶ Restriction of the westbound right turn movement from Alameda Avenue onto Morrison Road to eliminate the large turn radius and shorten the pedestrian crossing distance.

### Traffic Operations

As shown on **Figure 11**, the signalized intersection currently operates at LOS D during the AM and PM peak hours. The signal operates with a split phase for northbound Morrison Road and southbound Knox Court, with Knox Court to the south accommodating only right turn movements to and from Alameda Avenue and the southbound through movement from Knox Court. The AM and PM peak hour traffic operations at Knox Court/Alameda Avenue/Morrison Road intersection (intersection LOS and average delay per vehicle) are shown in **Table 1** for some of the possible intersection modifications. The results and recommendations are detailed in the subsequent sections, and the recommended intersection configuration is shown on **Figure B-6** in **Appendix B**.





**Table 1. Knox Court/Alameda Avenue/Morrison Road Traffic Operations**

	Level of Service and Average Delay	
	AM Peak Hour	PM Peak Hour
Existing	LOS D (50 sec)	LOS D (47 sec)
A) Bicycle/Pedestrian Advance Phase (12 seconds)	LOS D (50 sec)	LOS D (48 sec)
B) Exclusive Bicycle/Pedestrian Phase	LOS F (>100 sec)	LOS F (>100 sec)
C) Eliminate a Southbound Lane	LOS D (53 sec)	LOS E (59 sec)
A) + C)	LOS E (58 sec)	LOS E (65 sec)

### Advance or Exclusive Bike/Pedestrian Phase

Provision of either an advance or exclusive bicycle and pedestrian phase would require bicycle signal heads. The advance or exclusive phase would operate only when activated by a bicyclist or pedestrian (through the use of video detection and/or push button). As shown in **Table 1**, an advance bike/pedestrian phase (approximately 12 seconds) for bicyclists and pedestrians crossing Alameda Avenue would result in a slight increase in average automobile delay at the intersection, but the intersection would remain at LOS D during the peak hours. An exclusive bike/pedestrian phase would result in LOS F with long delays. An advance bike/pedestrian phase is recommended because it provides a better balance between travel modes.

### Removal of Southbound Lane

The southbound approach to the Knox Court/Alameda Avenue/Morrison Road intersection is currently three lanes, and the approach to Alameda is on a steep uphill incline. The elimination of a southbound travel lane on Knox Court (approaching Alameda Avenue) would provide space for a bike lane and an improved pedestrian landing area in the northwest corner of the intersection. As shown in **Table 1**, elimination of a southbound lane would result in LOS D during the AM peak hour and LOS E during the PM peak hour. In combination with the advance bike/pedestrian phase, the intersection would operate at LOS E during both peak hours. Although this reconfiguration would result in some degradation to traffic operations, it would allow for improved bicycle and pedestrian crossing; the recommended configuration for the intersection is shown in **Figure B-6**.

### Bike Box

A bike box, which is a designated area at the head of a traffic lane at a signalized intersection that provides bicyclists a safe and visible area ahead of queuing traffic during the red signal phase, was considered for the southbound Knox Court approach to the Knox Court/Alameda Avenue/Morrison Road intersection. Although it would provide some benefits for crossing bicyclists, it is not recommended at this location because it would require southbound traffic to be positioned on the steep hill at the intersection approach. Drivers would be positioned with poor visibility of the intersection, which would likely cause vehicles to encroach on the bike box resulting in reduced effectiveness.





### *Closure of Northbound Knox Court*

Closure of the northbound Knox Court from Nevada Place to Alameda Avenue to vehicular traffic would allow the eastern half of Knox Court to be repurposed as a two-way sidepath for bicyclists. This configuration, as shown in **Figure A-6**, would facilitate the crossing of Alameda Avenue by positioning bicyclists on the east side of the intersection where the crossing distance is the shortest. It would also allow for a larger bicycle and pedestrian staging area on the southeast corner of the intersection.

Some traffic rerouting would be required as a result of the one-block closure of northbound Knox Court; however, access to the businesses would be maintained. Traffic that currently travels north on Knox Court turning right at Alameda Avenue would be required to turn right at Nevada Place and left on Irving Street to access eastbound Alameda Avenue via the signalized intersection. Access to the gas station on the southeast quadrant of the intersection would be retained for southbound traffic. Although this modification would result in some rerouting for vehicles, it is expected to facilitate the crossing for bicyclists at Alameda and provide an enhanced entrance into the Knox Court Bike Boulevard. The sidepath and related closure of northbound Knox Court are recommended.

### *Restriction of Eastbound Right onto Morrison Road*

Because of the tight angle between the west leg of Alameda Avenue and Morrison Road, a large turning radius is required to accommodate traffic turning right from eastbound Alameda Avenue onto Morrison Road (a low volume movement, as shown on **Figure 11**). There is a small “pork chop” island on which the signal/light pole is located. Pedestrians must cross right turning traffic to get to the island prior to crossing either Morrison Road or Alameda Avenue.

Two options to improve the pedestrian crossings to/from this corner of the intersection have been investigated:

- ▶ Restrict trucks from making eastbound to southbound right turns from Alameda Avenue onto Morrison Road, allowing for a tighter radius (for passenger cars only), elimination of the “pork chop” island, and shortening of the pedestrian crossing distances.
- ▶ Restrict all right turn movements to further tighten the radius and shorten the pedestrian crossing distance.

Either option would provide a significant reduction in the pedestrian crossing distances (across Alameda Avenue and across Morrison Road) and the creation of a pedestrian plaza area. Using 20 foot radius to accommodate passenger cars only would result in a 30 to 40 foot reduction in pedestrian crossing distances. By eliminating all right turn movements, a 10 foot radius could be used, resulting in an additional 15 foot reduction in the pedestrian crossing distances.

Based on low turning movement counts and the opportunity to enhance pedestrian movements through the intersection, restriction of the right turns onto Morrison Road is recommended. The conceptual design (**Figure B-6 in Appendix B**) shows both options (restricting trucks and restricting all right turns); selection of the preferred configuration should occur during final design in coordination with CDOT.





## Knox Court Design Elements

The recommended elements for Knox Court Bike Boulevard are depicted on **Figure 14**. This concept incorporates the input received through the public outreach process, the technical evaluation described in the previous section, and feedback from Traffic Engineering Services (TES). **Appendix B** includes the conceptual design and additional detail for the recommended concept. The recommended elements are described in the following sections.

### *Prioritize Bicycle Travel*

Design elements that prioritize bicycle travel help to remind roadway users that the street is intended as a bicycle thoroughway and create conditions that minimize delays for cyclists. Two such elements are recommended for Knox Court: pavement markings and stop control reconfiguration.

#### **Pavement Markings**

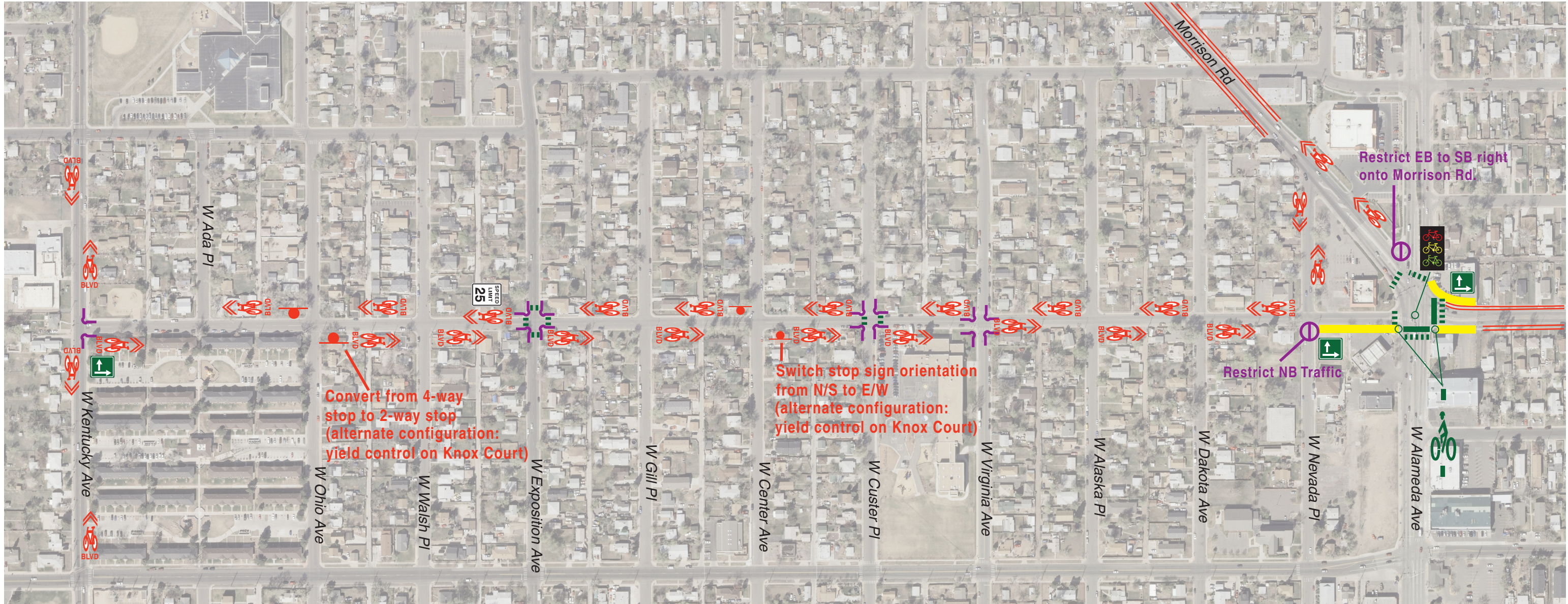
Shared Lane Markings (sharrows) placed immediately after each cross-street (22 total) to indicate the shared nature of the street for motorized vehicles and bicyclists, with the BLVD symbol below the sharrow to reinforce the corridor as a bike boulevard.



#### **Stop Control**

There are currently five stop-controlled intersections for travel on Knox Court between Alameda and Kentucky (excluding the two ends). Stop control at two of these intersections should be modified so that there are only three stop-controlled intersections for bicyclists. The Bike Boulevard Concept includes the following modifications:

- ▶ Retain 4-way stop control at Virginia Avenue, Custer Avenue, and Exposition Avenue intersections; and there is a need to maintain and encourage a slow speed zone for motorists and bicyclists, giving crossing pedestrians the priority at these intersections (two of which – Virginia and Custer – are immediately adjacent to Monroe Elementary School).
- ▶ Switch orientation of stop signs at Knox Court/Center Avenue so that stop signs are on the Center Avenue (east/west) approaches. An alternate configuration could be to retain the sign orientation, but convert the stop signs to yield signs so that bicyclists traveling along Knox Court would not be required to come to a complete stop.
- ▶ Convert Knox Court/Ohio Avenue from 4-way stop control to 2-way stop control with stop signs on the Ohio Avenue (east/west) approaches. An alternate configuration could be to replace the 4-way stop control to yield control on Knox Court.



Prioritize Bicycle Travel

- Shared Lane Pavement Markings (Kentucky to Nevada Pl.)
- Stop sign re-orientation
- Bike Lane
- Sidepath

Signage

- Speed Limit sign (additional)
- Identification Signs (Alameda to Kentucky; add to street name signs)
- Wayfinding signs
- Warning Signs (as detailed in Conceptual Design - Appendix A)

Intersection Treatments

- Bicycle Detection
- Bicycle Leading Intervals

Crossing Treatments

- Colored Concrete Cross-bike
- Enhanced Crosswalk

Traffic Calming and Diversion

- Restrict Movements
- Curb Extensions



NOTE: Graphical depiction only; design elements are not to scale.

Figure 14  
Knox Court  
Bike Boulevard Concept



## Bike Lanes

Bike lanes, for the exclusive use of bicyclists, are currently provided on Morrison Road just south of Alameda Avenue (beginning approximately at Nevada Place). Bike lanes are also planned on Knox Court north of Alameda Avenue, although the design will be completed through a separate process. The Knox Court bike boulevard concept identifies appropriate connections to the existing and planned bike lanes just outside the study corridor.



## Sidepaths

A sidepath is a shared use path located immediately adjacent and parallel to a roadway. A two-way sidepath is recommended along the east half of Knox Court between Nevada Place and Alameda Avenue. One-way sidepaths are recommended along either side of Knox Court north of Alameda Avenue for approximately 175 feet as a transition to the planned bike lanes north of Alameda Avenue.

## Signage

Distinctive signage can be used to inform all roadway users that the street is a bike boulevard, to create a unique identity for the bike boulevard, and to convey to users how the street is expected to be used. Several types of enhanced signing are recommended as part of the bike boulevard concept for Knox Court.

## Residential Speed Limit

Speed limit signs (25 mph; 20 mph in schools zones) are generally posted every two to three blocks along Knox Court, however there is a six block stretch in the southbound direction with no speed limit sign. An additional speed limit sign (25 mph) for southbound travel between Exposition Avenue and Walsh Avenue is recommended to reinforce the residential speed.

## Identification Signs

Identification signs can be used to passively market the bike boulevard network. They may be an enhancement to help brand the corridor. “Bike Boulevard” signs should be added to all street name signs (between the east/west and north/south street name plaques) along the corridor (13 intersections; 26 signs).

## Wayfinding Signs

Wayfinding signs provide cyclists with direction and distance to major destinations on the citywide bike system, including transit stations, parks and trails. The signing is intended to reinforce local and neighborhood destinations as well as to promote connections between communities. Wayfinding signs should be placed at likely corridor entrance points for bicyclists: Alameda Avenue, Nevada Place, Virginia Avenue and Kentucky Avenue (existing and future bike routes).





## Warning Signs

Alert motorists and cyclists of road condition changes including end of bike boulevard, upcoming traffic calming features, and traffic control devices. Type and location are detailed in the conceptual design (**Appendix B**).

## Intersection Treatments

Improvements along bike boulevards should include intersection treatments at crossings with major roadways to enhance cyclist safety by raising awareness of potential areas of conflict between motorists and cyclists, and to reduce delay for cyclists. The bike boulevard concept for Knox Court includes several modifications to the intersection with Alameda Avenue to improve crossing for bicyclists and pedestrians.

### Activated Signals – Bicycle Detection

Bicycle activated signals allow a cyclist to trigger a green signal phase through the use of loop detection or push-button. Bicycle detection may reduce cyclist delay and discourage red-light running by cyclists. Bicycle detection (likely video) is recommended at the Knox Court/Alameda Avenue intersection.

### Activated Signals – Leading Interval

A leading interval stops all vehicle movement and allows cyclists and pedestrians to cross. A leading interval can be an exclusive phase for bicyclists and pedestrians or it can be an advance phase that provides bicyclists and pedestrians a head start in their path of travel across the intersection. As described in the traffic operations section, an advance bicycle and pedestrian phase is recommended at the Knox Court/Alameda Avenue intersection.

## Crossing Treatments

Enhanced crossing treatments can be used to improve motorists' awareness of potential for bicyclists and pedestrians. They can also improve safety by provide a refuge for cyclists and/or by increasing motorists and cyclists' awareness of potential conflicts.

### Crosswalk/Crossbike

Motor vehicle speeds can be reduced by creating a visibly prominent crossing location for bicyclists and pedestrians. Colored concrete crossbikes are recommended for crossing the north and east legs of the Knox Court/ Alameda Avenue intersection.

New crosswalk markings are recommended at several locations along the corridor to enhance pedestrian crossings:

- ▶ All legs of the Knox Court/Alameda Avenue intersection with enhanced colored concrete crosswalks (crosswalk markings exist but are worn)
- ▶ Crossing the north and south legs of the Knox Court/Custer Place intersection (crosswalks currently exist across the east and west legs of the intersection)
- ▶ All legs of the Knox Court/Exposition Avenue intersection





## Traffic Calming and Diversion

### Curb Extensions

Curb extensions (also referred to as “bulb outs”) extend the sidewalk or curb face into the parking lane at an intersection. This visually narrows the roadway and reduces the width of the crosswalk, shortening bicyclist and pedestrian crossing distance. This treatment is recommended along Knox Court to address the community’s concerns about speeding and desire to improve pedestrian crossings and amenities. Installation of curb extensions is recommended on all four corners at the intersections of:

- ▶ Knox Court/Virginia Avenue
- ▶ Knox Court/Custer Place
- ▶ Knox Court/Exposition Avenue

### Partial Non-Motorized Only Crossing

Partial non-motorized crossings through the use of diverters (bollards or raised barrier with curb and gutter) eliminate some motor vehicle movements at intersections, forcing motorists to turn off of and/or restricting turns onto the minor road. By restricting northbound traffic at the Knox Court/Nevada Place intersection, the Knox Court/Alameda Avenue intersection can be reconfigured to provide an improved bicycle and pedestrian crossing of Alameda Avenue and a larger staging area for bicyclists and pedestrians waiting to cross Alameda Avenue in the southeast corner of the intersection.





## IV. Implementation

### Phasing

Implementation of the Knox Court Bike Boulevard could be done in two phases to minimize initial costs and provide an opportunity to test the effectiveness of the recommended treatments prior to investment in capital improvements. Phase 1 (shown on **Figures B1-3** in **Appendix B**) includes the signing and striping elements only. Phase 2 (shown on **Figures B4-6** in **Appendix B**) represents the ultimate bike boulevard configuration for Knox Court. In addition to the Phase 1 elements, it includes:

- ▶ Curb extensions the Exposition Avenue, Custer Place, and Virginia Avenue intersections
- ▶ Sidewalk/Sidepath, median, and curb modifications in the vicinity of the Knox Court/Alameda Avenue/Morrison Road intersection
- ▶ Conversion of the crosswalks at the Knox Court/Alameda Avenue/Morrison Road intersection to patterned or colored concrete for enhanced visibility and longevity

### Cost Estimates

The cost estimate for Phase 1 includes signing and striping, which total approximately \$70,000. Phase 2 includes the additional capital items described above, which are estimated to cost an additional \$510,000. Cost estimation sheets are included in **Appendix C**.

### Next Steps

The next steps for Phase 1 and Phase 2 will follow different paths. The next steps for Phase 1 will entail conducting a field assessment to:

- confirm the sight distances for the proposed signs
- determine visibility and usability of the proposed signs for bicyclists
- identify right-of-way constraints
- determine sign placement constraints such as potential utility conflicts and sidewalk limitations

After the field assessment is complete, design plans can be developed and a contractor can install the proposed signing and striping.

The next steps for Phase 2 will require additional steps for the design process in order to clearly identify and accommodate the proposed curb and gutter and sidewalk modifications. In order to verify that the existing drainage patterns will not be altered and to avoid ponding within the curb and gutter, a detailed field survey will be required within the vicinity of the proposed curb and gutter and sidewalk areas. After the survey is completed, a detailed design including horizontal and vertical layouts for the proposed curb and gutter will be completed as part of the design plans. The limits for removals and resets required to implement the proposed improvements will be defined within the design plans as well. If any drainage improvements are required to accommodate the proposed improvements, the drainage improvements will be defined within the design plans including the modification of any inlets, the implementation of sidewalk chases or any new storm sewer pipe required. After the design plans have been reviewed and approved, a contractor can construct the proposed improvements in accordance to the plans.





**KNOX COURT**

