FIRST AVENUE, RIVER ROAD TO GRANT ROAD- NEEDS ASSESSMENT STUDY

Contract Number: Contract No. 181820-07
Purchase Order: No. 40748

June 2021

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Prepared for:

City of Tucson

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EXECUTIVE SUMMARY

Project Description

In 2006, the City of Tucson and the Regional Transportation Authority (RTA) identified First Avenue as a key regional corridor for improvement. Widening First Avenue, from River Road to Grant Road to a six-lane divided roadway with bike lanes and sidewalks, was included in the voter-approved RTA Plan. The estimated total cost for the widening in 2006 was $74.4M. This is an RTA third period project, scheduled to begin between fiscal years 2017 and 2021.

As the City prepares to start the First Avenue, River Road to Grant Road improvements and the transportation system/context has changed in Tucson since the RTA plan was adopted in 2006, this assessment was conducted to update the mobility and complete streets needs within the corridor.

Challenges & Needs

Zoning and Land Use

Existing development density within the corridor, both residential and commercial is substantially less than the current zoning allows. The corridor has the potential for a significantly higher residential and commercial intensity that could be triggered with the First Avenue improvements.

Equity

Approximately 50% of First Avenue between Grant Road and River Road is adjacent to neighborhoods that may be at a disadvantage from a socio-economic and/or transportation mobility perspective. Provision of enhanced multi-modal facilities is needed to provide equitable transportation access and to improve mobility along the First Avenue corridor.

Study Objectives

The First Avenue, River Road to Grant Road Needs Assessment has been prepared by the City of Tucson Department of Transportation and Mobility (TDTM) to identify improvements that will address long-term multi-modal mobility and safety needs, as well as infrastructure upgrades. Study objectives include:

- Define roadway capacity, multimodal facilities, and connections, and infrastructure needs to provide for the mobility and safety needs of users of the corridor.
- Incorporate complete streets elements appropriate for the corridor context and functionality per the *Tucson Complete Streets Policy*.
- Review ITS solutions to maximize capacity and optimize operations and safety.
- Develop sound cost estimates of project alternatives.

Vehicular Traffic Operations

Currently, weekday traffic volume on First Avenue ranges from 25,000 to 31,000 vehicles per day. Traffic flow in the corridor is currently operating at Level of Service (LOS) C during the majority of the day, dipping to LOS D in the southbound direction in the PM peak hour. Average travel speeds during the weekday range from 20 to 30 mph. During the weekend, current vehicle operations are at LOS B/C throughout the day, with average travel speed ranging from 25 to 35 mph. All signalized intersections operate at LOS D or better during the AM and PM peak hours. However, at nearly all signalized intersections, one or more movements operate at LOS E during one of the peak periods.

Prior to the COVID-19 pandemic, traffic demand on First Avenue is projected to increase by up to 36% with six lanes on First Avenue, based on 2045 projections prepared by the Pima Association of Governments (PAG). Resulting average daily traffic volumes will range from 31,400 to 40,800 vpd. An increase of 16% is projected with a 4-lane roadway, resulting in average daily traffic volumes ranging from 26,800 to 34,800 vpd.

Not accounting for the potential impact of COVID-19 on future work options and travel demand, traffic operations will degrade substantially with the current roadway and intersection capacity based on the projected traffic growth. Corridor level of service will drop to LOS E/F with the high volume growth and LOS D with low volume growth. Several intersections will operate at LOS E/F for both volume growth projections. Additional intersection capacity will be required to provide LOS D or better.

Pedestrians

Pedestrian amenities on the corridor include sidewalks and signalized pedestrian crossings. However, only 64% of the corridor has sidewalks or paved surfaces. Pedestrian crossings include eight signalized intersections and one HAWK signal providing pedestrian crossings every ¼ to ½ mile apart. The highest pedestrian volumes were observed at the Fort Lowell Road intersection with 106 pedestrians crossing in the morning and 70 pedestrians crossing in the afternoon peak hours. First Avenue has a relatively high pedestrian crash frequency when compared with similar arterials in the City. Over a 5-year period (2013-2017), nearly five pedestrian crashes occurred per year. This includes two fatalities and 41 injury crashes. The City's Pedestrian Safety Action Plan includes First Avenue on the High Injury Network, which identifies priority roadway sections and intersections for pedestrian safety improvement.

Improvements and strategies to improve pedestrian access and safety include: continuous sidewalk along the corridor, mid-block signalized pedestrian crossings aligned with transit stops, raised medians to provide pedestrian refuge, street lighting, and landscape design that targets pedestrian and bicycle visibility, and reduction in vehicle operating speeds.

Transit

Transit service is provided by SunTran Route #6 which is part of the system's Frequent Transit Network, operating on 15-minute headways during weekday peak periods. Annual ridership on Route #6 ranks tenth on the regional transit system. Transit infrastructure on the corridor includes sheltered bus stops and pullouts. Approximately 65% of the transit stops/pullouts are located in close proximity of a signalized pedestrian crossing. The recently completed PAG Long-Range Regional Transit Plan maintains First Avenue as a frequent transit service route. Enhanced transit stop access and amenities, as well as redevelopment opportunities resulting from roadway improvements will likely result in increased ridership. Transit enhancements include locating stops within 100 feet of a signalized crossing, signalized pedestrian crossings at mid-block stops, pedestrian level lighting at transit stops to create a more secure environment, and the potential application of queue jump lanes and transit signal priority to minimize bus delays at signals and bus pull outs.

Bicycles

Bicycle lanes on First Avenue currently vary from four to five feet wide and operate with a Level of Traffic Stress (LTS) of 4, which corresponds to a high-stress bicycling environment. The highest bicycle volume was observed at the Glenn Street intersection with 23 bicyclists in the morning and 26 bicyclists in the afternoon. The development of a bike boulevard on Copper Street is currently programmed by the City of Tucson and will provide a HAWK crossing on First Avenue. Three future bike boulevards are planned on Pastime Road, Yavapai Road, and Blacklidge Drive. Increasing bicycle use on the corridor will require implementing bicycle facilities that create a lower stress environment. On an arterial carrying high traffic volume at higher speed, options to lower stress include a buffered bike lane, protected bike lane, and separated bike lane or multi-use path.

Infrastructure

Off-site storm runoff from the Navajo Wash and Cemetery Wash cross First Avenue at grade, inundating the roadway in larger events. Storm runoff from the Prince Road Wash is conveyed within First Avenue north to the Rillito Creek. Reducing or eliminating the impact of larger storm events will require significant off-site drainage improvements for the Navajo Wash and Cemetary Wash and substantially increasing the capacity of the roadway storm drain system to convey the runoff from Prince Road to the Rillito Creek.

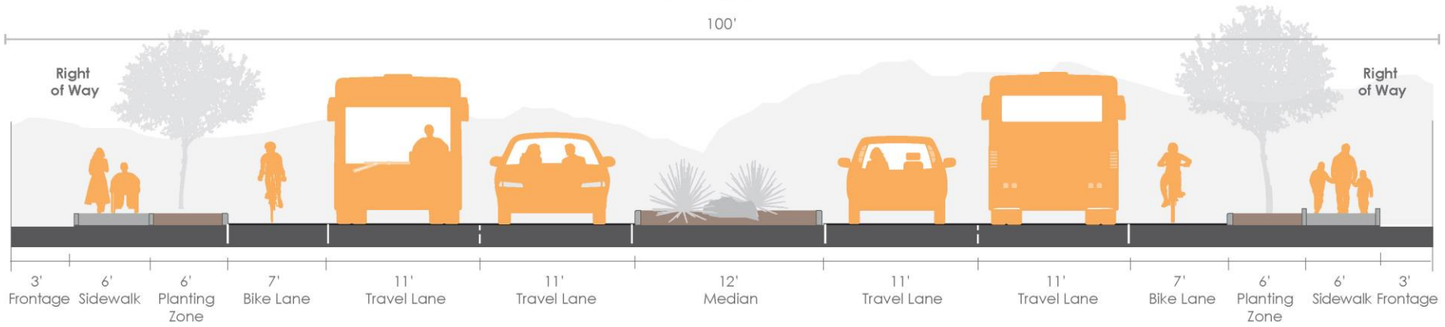
The 4-lane bridge over the Rillito Creek was constructed in 1961 and currently functions adequately with no structural distress or scour concerns. However, the bridge is 60 years old, which puts it at about 80% of its intended 75-year lifespan. Bicycle and pedestrian facilities on the bridge do not meet the current City of Tucson guidelines. The need to replace the bridge as part of the First Avenue widening will depend upon the roadway improvements that are implemented.

Improvement Alternatives

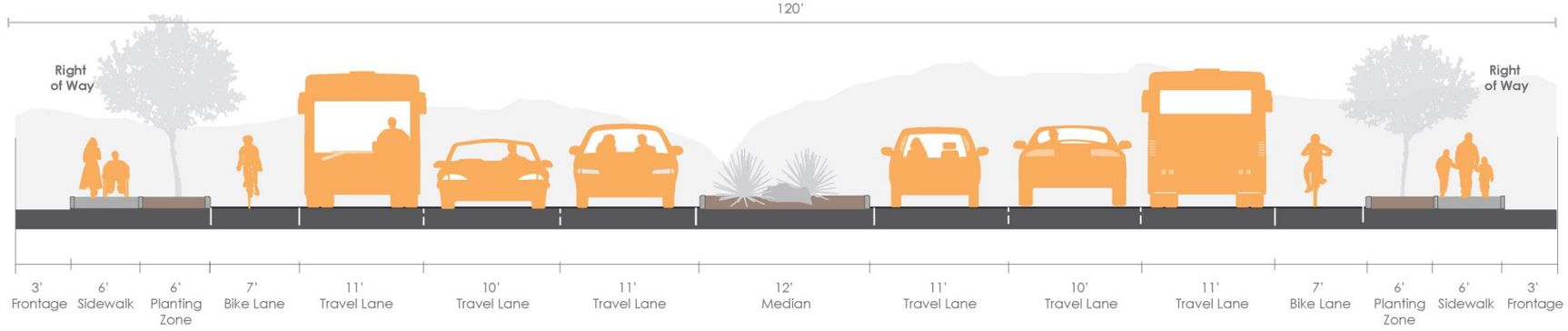
Four-lane and six-lane alternatives, as illustrated in the figure below, with intersection capacity improvements were evaluated. Layouts for each alternative, provided in Appendix A. were prepared in order to estimate project costs, including design, construction, and right-of-way. Each alternative includes mid-block signalized pedestrian crossings between traffic signals and continuous roadway lighting. The 4-lane alternative includes bus pull-throughs at each signalized intersection. First Avenue improvements will also include the application of Intelligent Transportation System (ITS) technologies, potentially including traffic adaptive signal control and transit system priority signal control. The following tables summarize the performance and cost of each alternative.

1ST AVENUE CROSS SECTION ALTERNATIVES

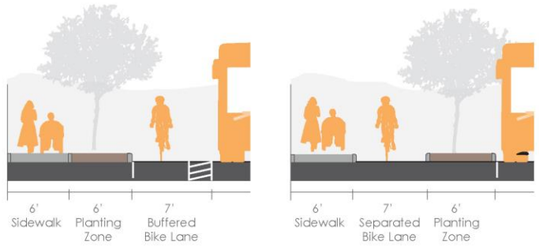
4-Lane Cross-Section



6-Lane Cross-Section



Bike Lane Configuration Alternatives



ALTERNATIVE SUMMARY

Performance Measure		Alternative	
		4-lane	6-lane
Mobility	Vehicular	Corridor operates at LOS D or better except during the afternoon peak hour (LOS E). Prince Road and Fort Lowell Road intersections operate at LOS E. Other intersections are at LOS D or better.	Corridor operates at LOS C or better. Intersections operate at LOS D or better.
		The application of Intelligent Transportation Systems (ITS) will optimize intersection performance.	
	Transit	Travel time is estimated to increase from 15 minutes to 19 minutes. Transit will experience additional delay at pull-throughs during peak hours. Potential solutions to reduce transit delay include queue jump lanes and transit signal priority. Enhanced transit facilities to promote transit ridership and improve frequent transit service levels (15-minute headways or less).	Travel time is estimated to increase from 15 minutes to 16 minutes. Enhanced transit facilities to promote transit ridership and improve frequent transit service levels (15-minute headways or less).
	Pedestrian	Continuous 6 ft ADA sidewalk with a 3 ft to 5 ft buffer. Midblock signalized pedestrian/bicycle crossings aligned with transit stops and planned bicycle boulevards at approximately ¼-mile spacing. Pedestrian LOS at signalized intersections LOS B/C. Pedestrian Level of Traffic Stress of 3 (moderate) at unsignalized crossings.	Continuous 6-ft ADA sidewalk with a 3 ft to 5 ft buffer. Midblock signalized pedestrian/bicycle crossings aligned with transit stops and planned bicycle boulevards at approximately ¼-mile spacing. Pedestrian LOS at signalized intersections LOS C. Pedestrian Level of Traffic Stress of 4 (high) at unsignalized crossings.
	Bicycle	Bike lane options include buffered/protected bike lane with Level of Traffic Stress (LTS) 3 and separated bike lane with LTS 2.	Bike lane options include buffered/protected bike lane with Level of Traffic Stress (LTS) 3 and separated bike lane with LTS 2.
Safety	Vehicular	Reduced crash potential from roadway enhancements such as street lighting, a raised median, and lowered operating speed.	Reduced crash potential from roadway enhancements such as street lighting, a raised median, and lowered operating speed.
	Pedestrian, Bicycle, and Transit	Street lighting and landscape that targets pedestrian and bicycle visibility. Midblock signalized pedestrian crossings aligned with transit stops. Raised medians provide a refuge area for pedestrians. Narrowed travel lanes reduce vehicle operating speeds.	Street lighting and landscape that targets pedestrian and bicycle visibility. Midblock signalized pedestrian crossings aligned with transit stops. Raised medians provide a refuge area for pedestrians. Narrowed travel lanes reduce vehicle operating speeds. More vehicle exposure to pedestrians in unmarked crossings
Access		Enhanced pedestrian, bicycle, and transit features provide more convenient and safe mobility for all residents within the corridor and support walking and bicycling to promote a healthier lifestyle.	
Right-of-Way		Full Takes – 13 Partial Takes – 122	Full Takes – 20 Partial Takes – 149

Cost Estimates

	Design and Construction Cost	Right-of-Way Cost	Total Project Cost
4-lane w/Existing Bridge	$43,400,000	$18,700,000	$62,100,000
4-lane w/New Bridge	$54,700,000	$18,700,000	$73,400,000
6-lane w/New Bridge	$59,900,000	$31,800,000	$91,700,000
Cross Drainage Improvements	$20,000,000 (1)	(2)	

1. Does not include the cost to construct upstream/downstream detention basins.
2. Right-of-way cost for detention basins unknown.

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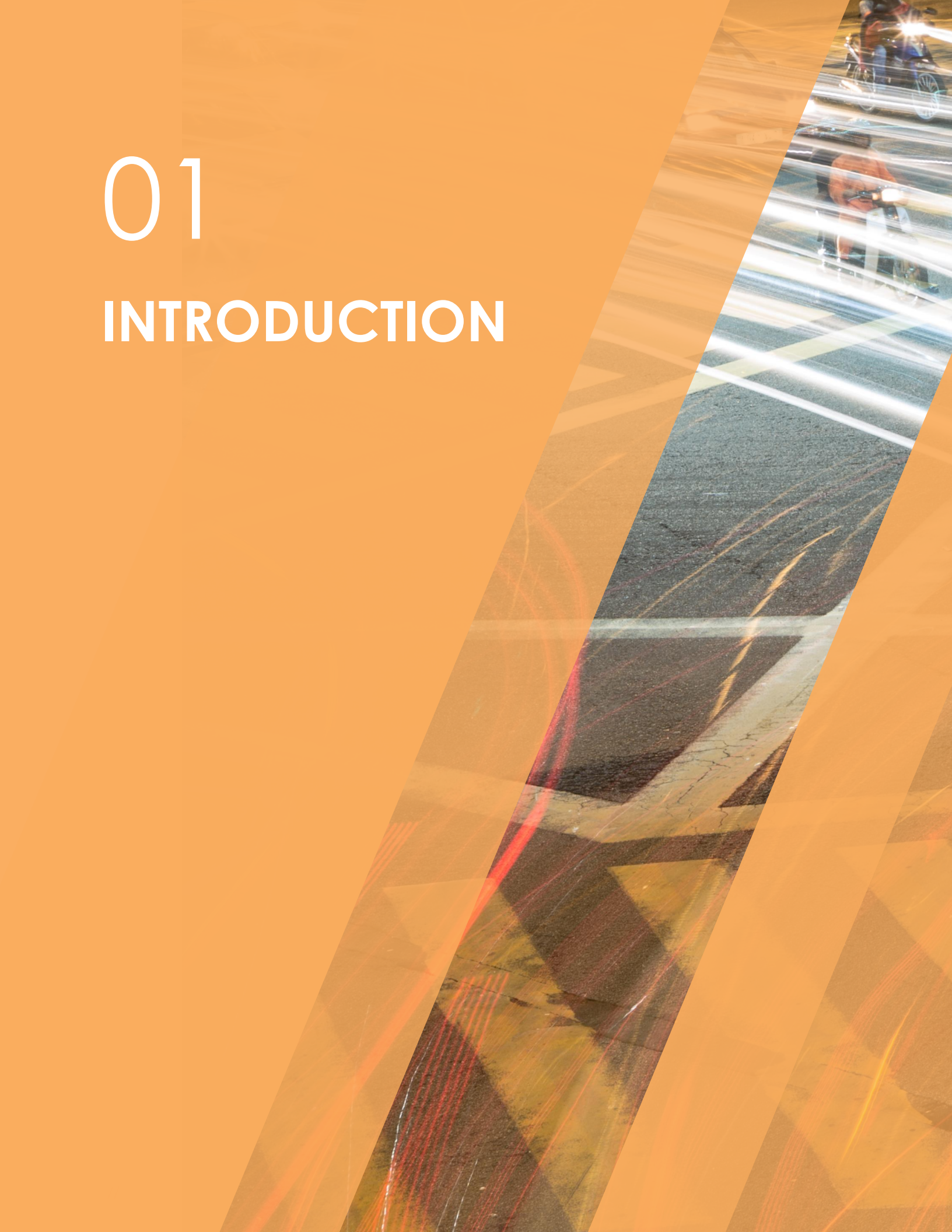
INTRODUCTION



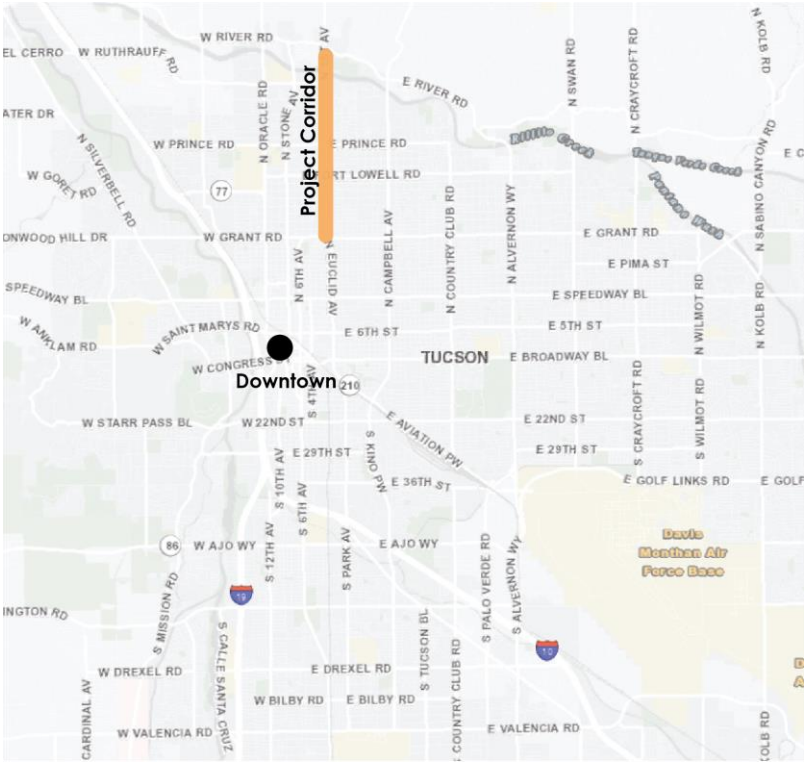
INTRODUCTION

Project Description

First Avenue is a north-south arterial extending from Ina Road south to Grant Road. In 2006, the City of Tucson and the Regional Transportation Authority (RTA) identified First Avenue as a key regional corridor for improvement. Widening First Avenue, from River Road to Grant Road to a six-lane divided roadway with bike lanes and sidewalks, was included in the RTA Plan as the first section of the corridor for improvement. The estimated total cost for the widening in 2006 was $74.4M. The First Avenue improvement project in the RTA plan is a third-period project, scheduled to begin between fiscal years 2017 and 2021.

As the City of Tucson Department of Transportation and Mobility (TDTM) prepares to start the planning phase of the First Avenue, River Road to Grant Road improvements and the transportation system and context has changed in Tucson since the RTA plan was adopted, this assessment was conducted to identify the mobility needs and complete streets improvements needed for this important corridor.

Figure 1. Project Location



Study Objectives

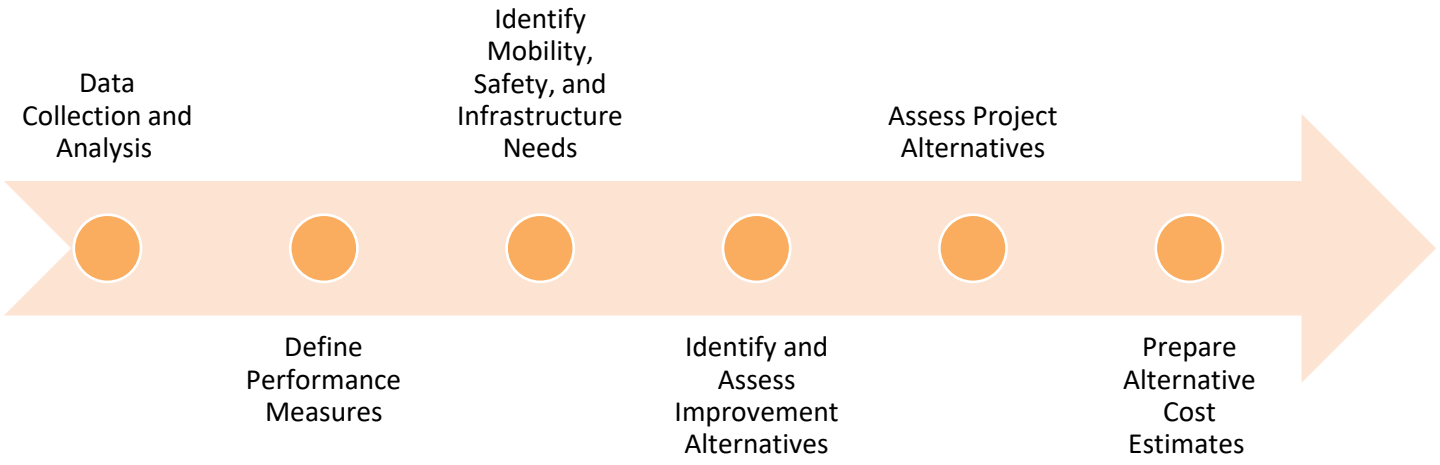
The First Avenue, River Road to Grant Road Needs Assessment will help the City of Tucson identify improvements to address long-term multi-modal mobility and safety needs, as well as infrastructure upgrades. Study objectives included:

- Defining multimodal facilities and connections, access, safety, mobility, and infrastructure needs for 2045
- Incorporating complete streets elements appropriate for the corridor context and functionality per the *Tucson Complete Streets Policy* adopted on February 5, 2019.
- Reviewing ITS solutions to maximize capacity and optimize operations and safety.
- Developing a sound cost estimate of project alternatives.

Study Participants

The assessment was developed through coordination between the City of Tucson, Pima Association of Governments (PAG), and the RTA. A study Working Group (WG) comprised of the Project Manager and Tucson Department of Transportation and Mobility staff was formed to provide an understanding to the existing conditions and needs within the corridor, assistance in defining performance measures and identifying and assessing improvement alternatives, and review of the options for project implementation. Additionally, a Technical Advisory Committee made up of additional Transportation and Mobility staff, PAG, and RTA members provided study oversight.

Study Process



Performance Measures

Needs assessment and improvement alternative evaluation were conducted based on five performance categories – Mobility, Safety, Access, Right-of-Way, and Cost. Specific performance measures that were evaluated are listed in Table 1.

Table 1. Performance Measures

Performance Measure	Mode	Criteria
 Mobility	Vehicular	Corridor travel time
		Corridor travel speed
		Corridor travel speed
		Level of service - corridor
		Level of service - signalized intersections
	Transit	Corridor travel time
	Pedestrian	Level of service – signalized intersections
		Level of service – corridor
		Pedestrian level of traffic stress – unsignalized crossings
		Percentage of the roadway with continuous ADA (5' min) sidewalk
		Frequency of signalized or enhanced crossings
		Percentage of mid-block transit stops within 500 feet of a signalized or enhanced crossing
	Bicycle	Level of traffic stress
		Level of service at intersections
		Signalized crossings connecting bike routes/boulevards
 Safety	Vehicular	Fatal and injury crash frequency[1]
		Total crash frequency[1]
	Pedestrian & Bicycle	Pedestrian/bicycle crash frequency[1]
		Frequency of signalized or enhanced crossings
		Percentage of transit stops within 500 feet of enhanced signalized crossings
		Proportion of the roadway with a raised median (min 10 feet wide)
		Proportion of roadway with street lighting
 Access		Proportion of properties with left-turn access (not requiring a U-turn)
 Right-of-Way		Partial property acquisition Full Property Acquisition
 Cost		Total Project Cost

1. Crash frequencies (crashes/yr) and rate based on 5 yrs of reported crash data

Data Summary

The following data was gathered and used for needs assessment and alternatives evaluation.

Travel time data was gathered over a 2-week period using Google Earth API.

Traffic counts gathered included 24-hour counts/vehicle classifications and peak period intersection counts (vehicles, pedestrians, and bicycles) at each signalized intersection, major unsignalized intersection/driveway, and HAWK crossing at Graybill Drive. These intersection counts also included pedestrians and bicycles.

Multi-modal counts were provided by the PAG Bicycle/Pedestrian Count Program

Crash data for the most current 5-year period was obtained from the City of Tucson.

Transit operations information, including boarding/alighting data from each transit stop within the corridor and transit travel time data, was provided by Sun Tran. Planned transit service and enhancements for First Avenue were identified from the PAG Draft Regional Transit Plan Update.

GIS shapefiles were provided by PAG Information included planned or approved development within the corridor and the surrounding area that could impact current and future traffic demand or patterns. TDTM conducted a land use assessment of the corridor to identify areas with the potential for mixed-use/higher density development.

Right-of-way information was obtained from Pima County Assessor's data available from Pima County MapGuide/PimaMaps.

COMPLETE STREETS

"Complete Streets" is an approach to transportation planning and design that guides the development of a safe, connected, and equitable transportation network for everyone - regardless of who they are, where they live, or how they get around. The City of Tucson adopted a Complete Streets policy on February 5, 2019, formalizing the City's intent to consistently fund, plan, design, construct and operate an interconnected street network for all anticipated users and transportation modes.

The complete streets approach is not a one-size-fits-all solution and recognizes that all modes cannot receive the same type of accommodation on every street. The overall goal is that everyone can safely and comfortably travel throughout the network.

COMPLETE STREETS MAY INCLUDE.

- Sidewalks, enhanced crosswalks, and bike routes along busy roads
- Shade trees and traffic calming features on quiet neighborhood streets
- Inviting public spaces for people to walk, bike, and interact
- Accessible, comfortable transit stops along high capacity transit corridors.

City of Tucson https://www.tucsonaz.gov/tdot/complete-streets-tucson

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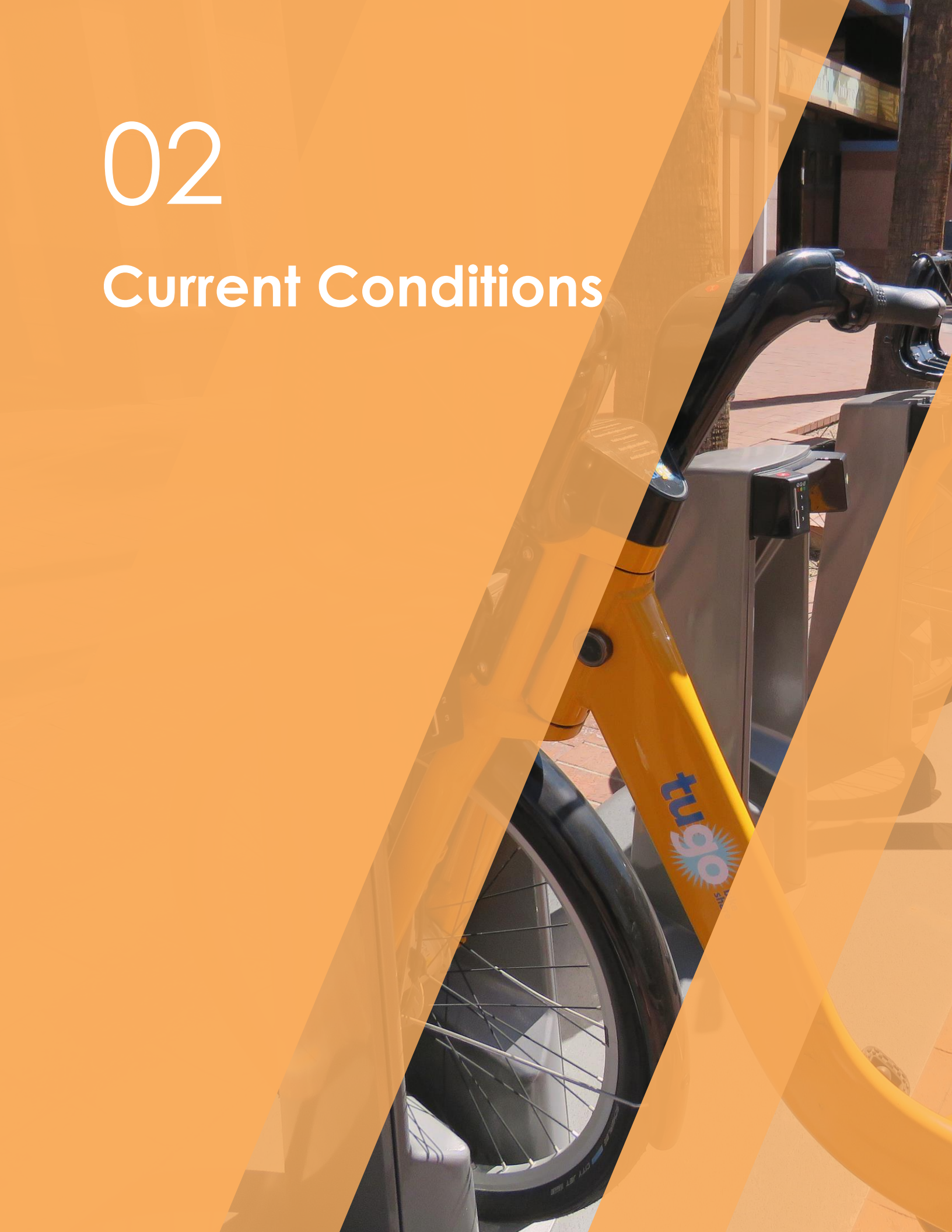
Current Conditions



CURRENT CONDITIONS

Zoning and Land Use

The property within the corridor is primarily zoned for residential and commercial/office land use. The majority of the properties immediately adjacent to First Avenue are commercially zoned with general commercial use, and low density uses. Residential zoning is provided behind commercial zoning. Residential zoning in the vicinity of the corridor is medium density (R-2) or high density (R3) residential zoning. North of Roger Road, several larger parcels are zoned for high-density multi-family residences. Commercial zoning includes low-intensity (C-1), general commercial (C-2), some mid-rise commercial (C-3), and office (O-3) for mid-rise office and medical.

Existing development density within the corridor, both residential and commercial is substantially less than the current zoning allows. While there currently are no specific City development incentives in place within the corridor, given the current zoning and land use, there is potential for a significantly higher residential and commercial intensity that could be triggered with the First Avenue improvements.

Figure 2. Existing Zoning

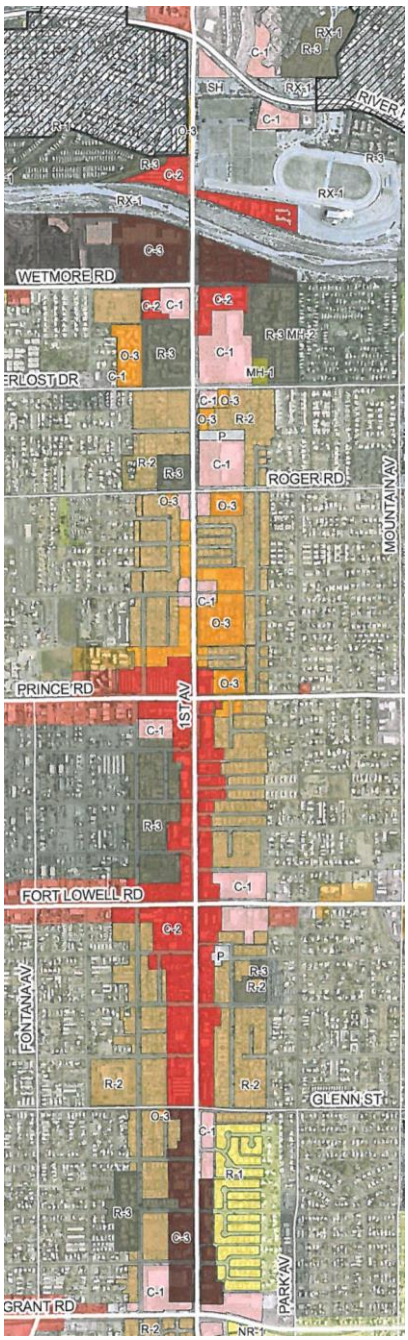
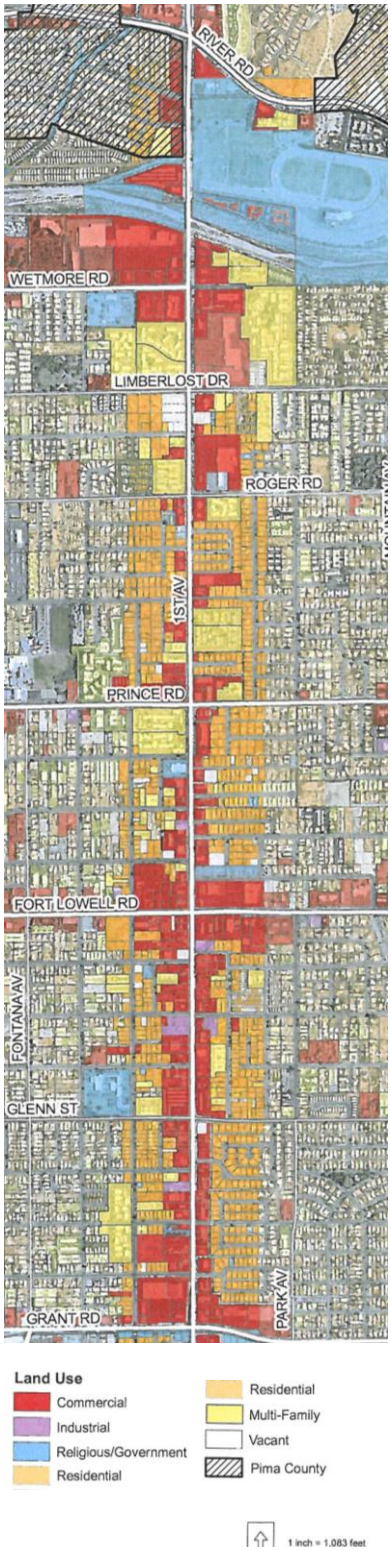


Figure 3. Existing Land Use



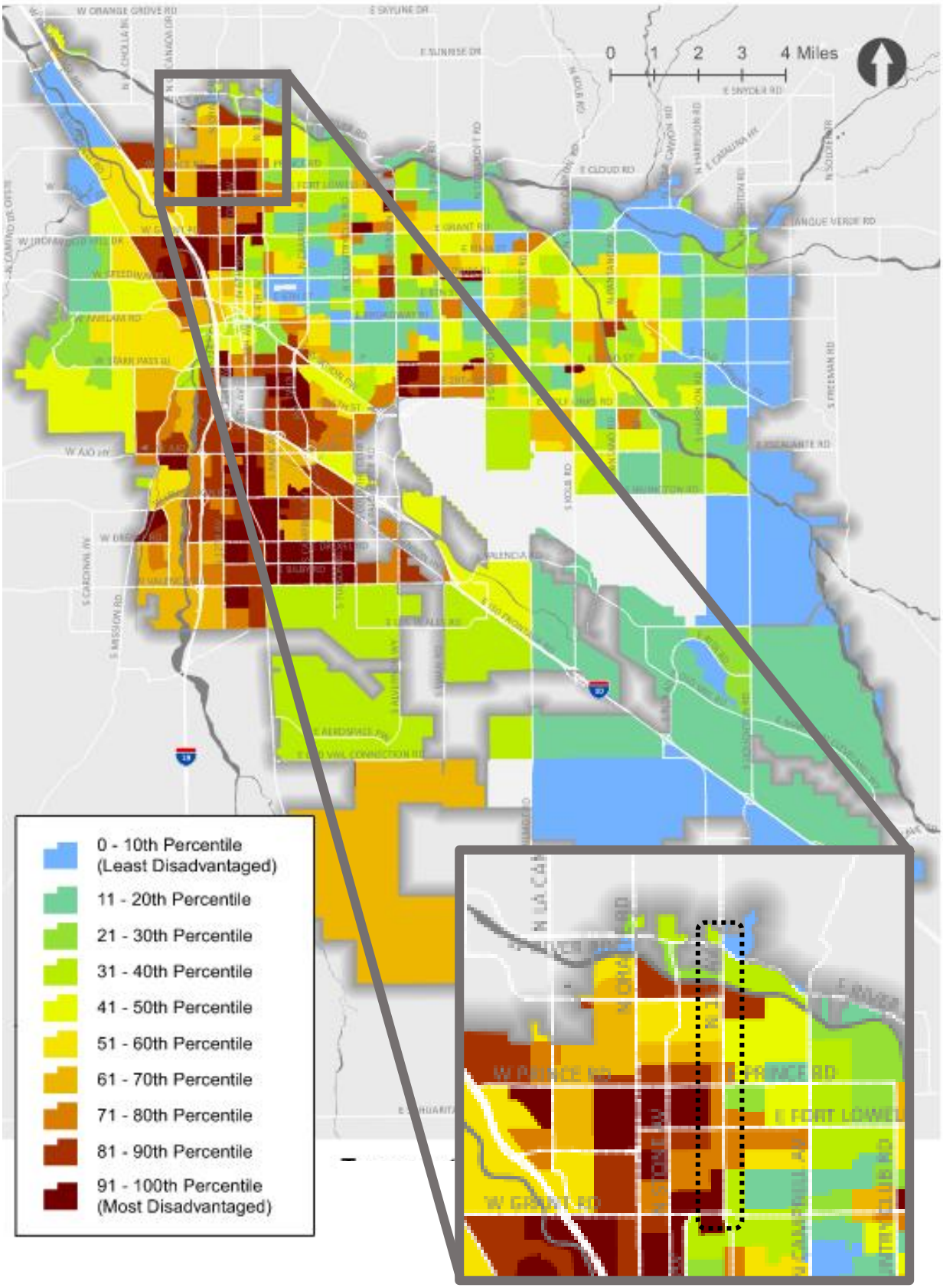
Equity

Using a Transportation Disadvantaged Population (TDP) index developed for the City of Tucson Pedestrian Safety Action Plan (PSAP) areas along the First Avenue corridor with a high percentage of residents who experience challenges achieving access to services, goods, employment, and/or education. The TDP index was developed using 2017 five-year American Community Survey (ACS) data available at the Census block group level and included the following attributes:

1. Communities of Color (All races other than white, non-Hispanic)
2. Low-Income Population (Less than 200% of the Federal Poverty line)
3. Limited English Proficiency Population (limited English-speaking households)
4. Zero-vehicle Households
5. Seniors Over Age 75
6. Youth Under Age 10
7. Persons with a Disability
8. Single-Parent Families
9. Overburdened Renters (Paying at least 40% of monthly income in rent)

The Census block groups are displayed by their relative transportation disadvantage index value (in percentile) in Figure 4. From this figure, approximately 50% of the study segment of 1st Avenue is next to neighborhoods with a population that may be at disadvantage from a socio-economic and/or transportation mobility perspective.

Figure 4. City of Tucson Transportation Disadvantage Score

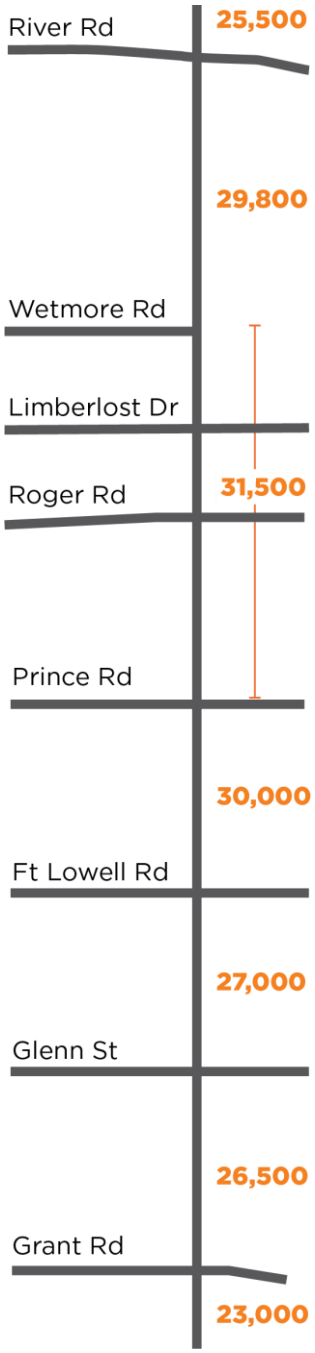


Mobility

TRAFFIC VOLUME

The current average daily traffic volumes range from 26,500 to 31,500 vehicles per day (vpd). 2018 average daily traffic volumes from PAG are provided in Figure 5.

Figure 5. Daily Traffic Volumes (2018)



CORRIDOR LEVEL OF SERVICE

Vehicle travel time data collected by Google API along the 3-mile corridor was used to assess current corridor level traffic operations during a weekday and weekend in November 2018. Directional travel speeds, calculated from the travel time data, were used to determine corridor Level of Service (LOS) throughout the day. Table 2 provides a description of the level of service provided by the Highway Capacity Manual for urban streets. Level of service is defined by the average travel speed of vehicles traveling along a section of roadway. Note that travel speed includes delays at signalized intersections and pedestrian crossings, as opposed to operating speed, which is the speed at which vehicles are moving between intersections.

Existing speed and level of service on the corridor are provided in Figures 6 and 7. The level of service during the weekday is at LOS C during the day, only dipping to LOS D in the southbound direction in the evening. Average travel speeds during the day range from 20 to 25 mph. During the weekend, current vehicle operations is at LOS B/C throughout the day, with travel speed ranging from 25 to 30 mph.

Table 2. Level of Service Description for Urban Streets

Level of Service	Definitions	Travel Speed, mph [1]
A	Free-flow operation; vehicles are completely unimpeded in the ability to maneuver; minimal delay at intersections	>32
B	Minor impedance to vehicle maneuverability; some delay at intersections	>27
C	Stable flow; some restriction to mid-block maneuverability; longer queues at intersections	>20
D	Less stable flow; vehicles entering the roadway from side streets and driveways can result in substantial increase in delay and lower travel speed; delay at intersections is substantial	>16
E	Unstable operations and significant delay; high delay and long queues at intersections; vehicles attempting to enter the roadway from a side street or driveway experience long delay	>12
F	Extremely low travel speed due to high congestion; stop and go conditions	≤12

1. Travel speed criteria is based on the free-flow speed of the roadway. This was assumed to be equal to the posted speed limit of 40 mph.

Figure 6. Weekday Travel, Speed and LOS - Existing

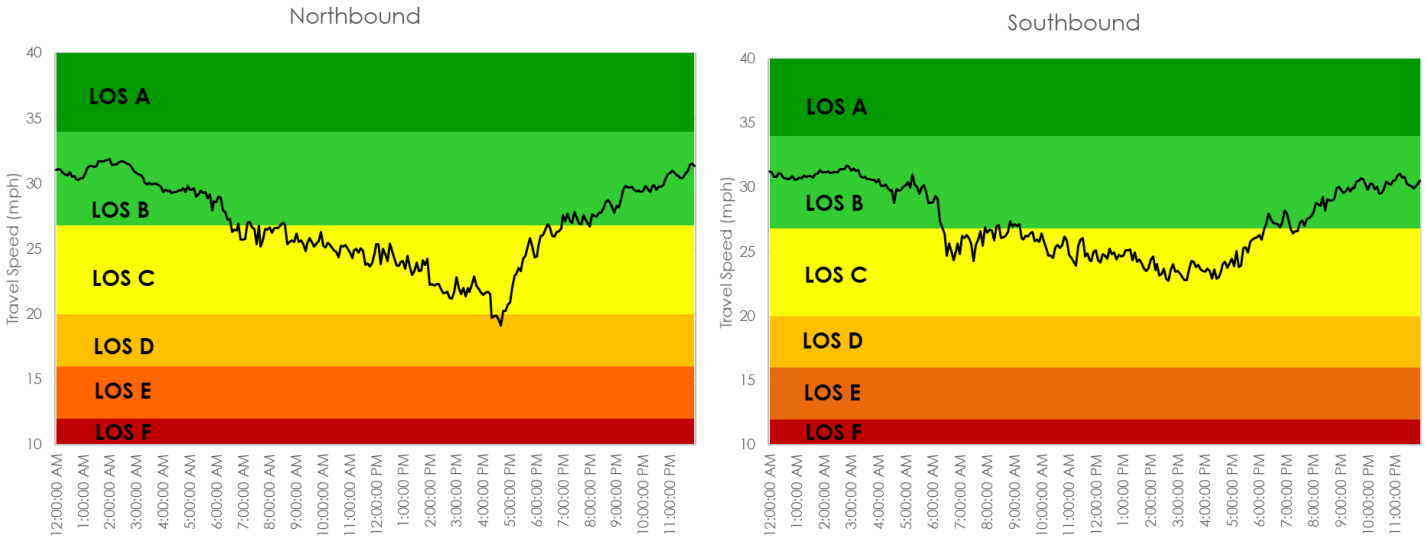
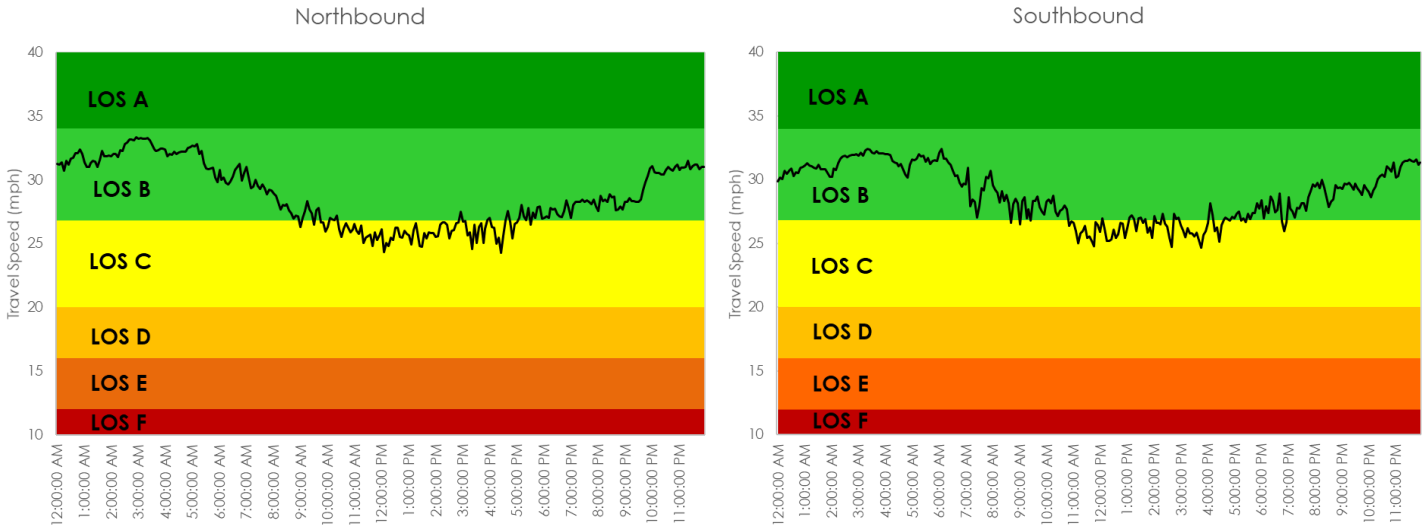


Figure 7. Weekend Travel, Speed and LOS - Existing



INTERSECTION LEVEL OF SERVICE

Intersection LOS is a standard measure of roadway performance. Table 3 provides a description of the level provided by the Highway Capacity Manual for signalized intersections. LOS reflects the average delay that motorists experience at a signalized intersection.

Figure 8 shows the existing Level of Service at the intersections within the corridor during the morning and evening peak periods. All intersections operate at LOS D or better during both peak hours. At Glenn Street, Prince Road, Roger Road, Limberlost Road, Wetmore Road, and River Road, one or more movements currently operate at LOS E or F during one of the peak periods.

Figure 8. Current Intersection LOS

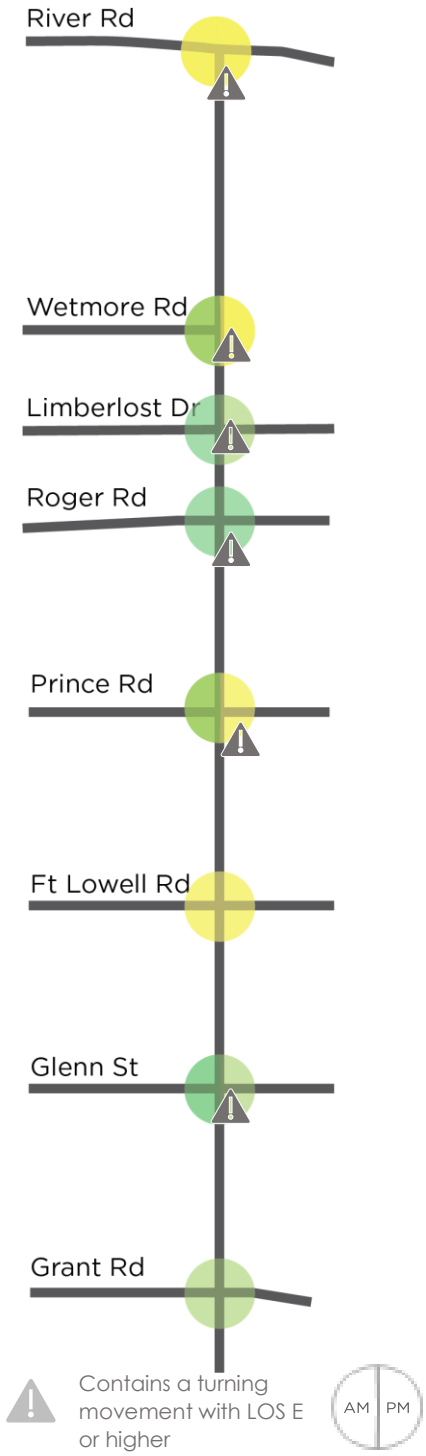


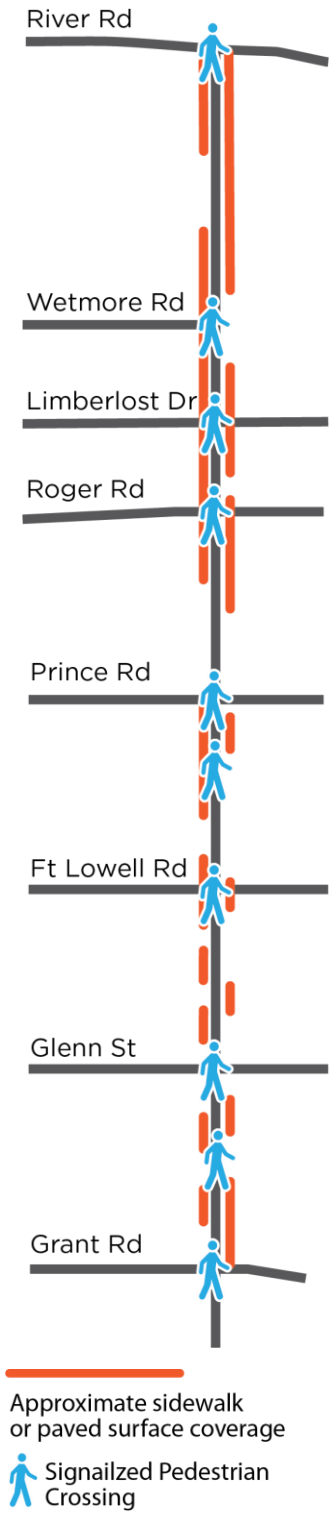
Table 3. Level of Service Description for Signalized Intersections

Level of Service	Definitions	Delay (sec/veh)
A	Very low delay and most vehicles do not stop.	≤ 10
B	Low delay and some vehicles stop.	≤ 20
C	Moderate delay and a significant number of vehicles stop although many do not stop	≤ 35
D	This is the limit of acceptable delay in an urban area; Many vehicles stop and some in the queue may not make it through one cycle.	≤ 55
E	High delay with poor progression; Most vehicles will not make it through in one cycle.	≤ 80
F	Delay at the intersection is unacceptable; Demand exceeds intersection capacity creating long queues; Many vehicles require two or more cycles to make it through.	>80

Pedestrian Operations

Pedestrian activity along the corridor includes residents walking to retail and commercial businesses and to transit stops. Figure 9 identifies the existing sidewalk and signalized pedestrian crossings along First Avenue. 56% of the west side and 72% of the east side of the corridor have sidewalks or paved surfaces. There are nine signalized pedestrian crossings (eight at signalized intersections, one HAWK), spaced from ¼ to ½ mile apart.

Figure 9. Existing Pedestrian Facilities



PEDESTRIAN VOLUMES

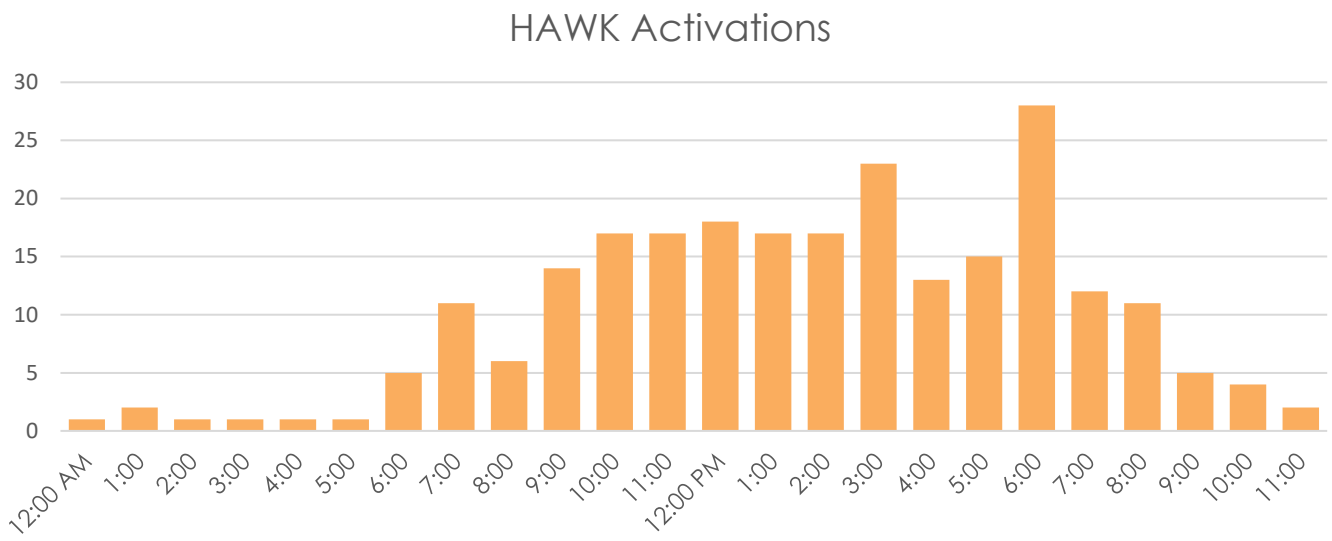
Table 4 summarizes peak hour intersection pedestrian counts collected in August 2018. The highest pedestrian volumes were observed at Fort Lowell Road.

Table 4. Pedestrian Peak Hour Volumes

No.	Intersection	Pedestrian Counts	
		AM	PM
1	River Rd	4	5
2	Wetmore Rd	35	24
3	Limberlost Dr	21	42
4	Roger Rd	23	56
5	Prince Rd	52	66
6	Fort Lowell Rd	106	70
7	Glenn St	13	9
8	Grant Rd	9	33

Data was provided by the City of Tucson for the existing HAWK crossing at Graybill Drive, providing access to Woods Memorial Library and adjacent bus stops. Weekday activations averaged 240 per day. Activations throughout the day are provided in Figure 10.

Figure 10. Weekday Activations at Graybill Drive HAWK



SIGNALIZED CROSSINGS

Pedestrian operations at signalized intersections can be assessed using the pedestrian Level of Service (LOS) methodology provided in the Highway Capacity Manual, 6th Edition. The methodology considers a range of factors that are indicators of comfort level and crash risk for pedestrians, including:

- The number of traffic lanes being crossed
- Number of right-turn channelizing islands
- Volume of vehicles
- Posted speed
- The vehicle movements and volume of those movements that conflict with the pedestrian "walk" phase (e.g., permitted left-turns, permitted right-turns)
- Pedestrian delay in waiting for the "walk" phase and quality of space at which to wait for the walk phase (e.g., presence of sidewalk and landing areas at the corners)

As shown in Table 5, current pedestrian LOS at signalized crossing during peak hours primarily ranges from LOS B to C. At River Road, the east-leg crossing operates at LOS D, primarily due to the larger corner radius and channelized right-turn lane which creates additional delay and a longer overall crossing distance.

Table 5. Pedestrian Level of Service at Signalized Intersections

No.	Intersection	AM Peak Hour				PM Peak Hour			
		North	East	South	West	North	East	South	West
1	River Rd	C	D	C	C	C	D	C	C
2	Wetmore Rd	C	B	C	C	C	B	C	C
3	Limberlost Dr	C	B	C	B	C	B	C	B
4	Roger Rd	C	B	C	B	C	B	C	B
5	Prince Rd	C	C	C	C	C	C	C	C
6	Fort Lowell Rd	C	C	C	C	C	C	C	C
7	Glenn Rd	C	B	C	B	C	B	C	B
8	Grant Rd	C	C	C	C	C	C	C	C

UNSIGNALIZED CROSSINGS

Pedestrian Level of Traffic Stress, PLTS, is a qualitative measure used to assess pedestrian safety and comfort at an unsignalized intersection. The PLTS measure, developed by the Mineta Transportation Institute, includes four stress levels, as described below.

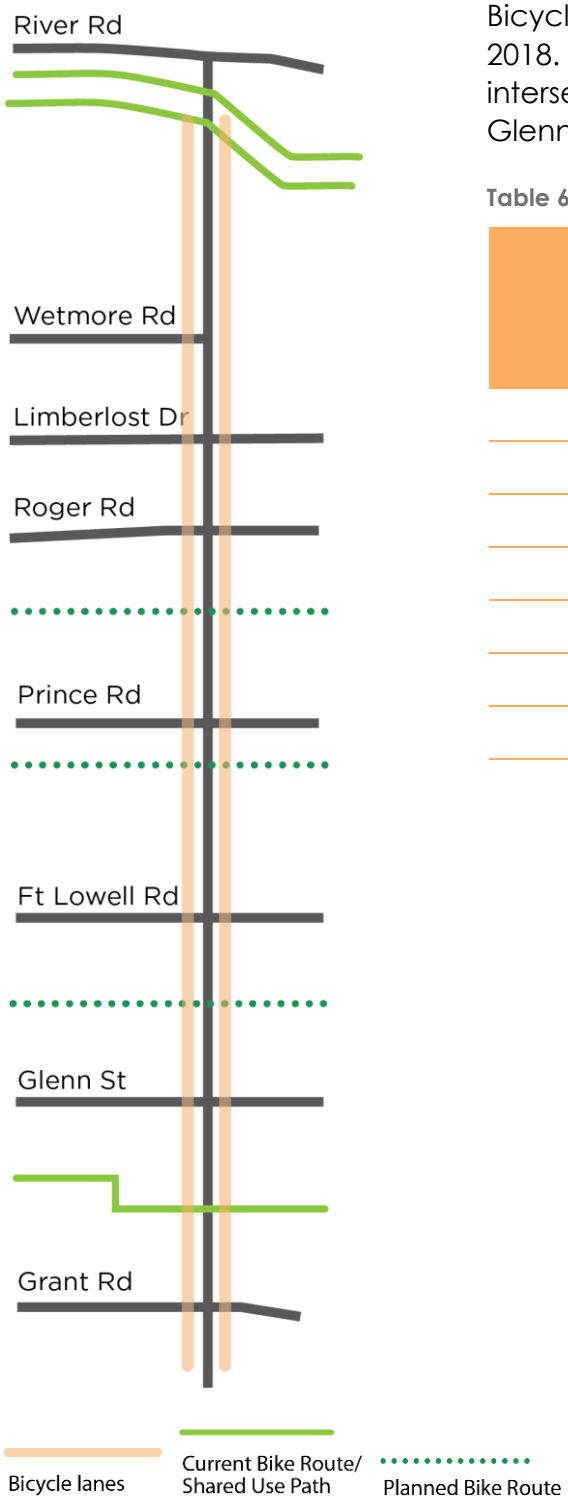
- PLTS 1: Low speed (25 mph or less), low volume (<5,500 vpd). Simple crossings suitable for children.
- PLTS 2: Low to moderate speed (25-30 mph), daily volume <12,000 vpd. A level of traffic stress that most adults can tolerate.
- PLTS 3: Moderate speed (35 mph), daily volume < 12,000 vpd. Typically 4-6 lane roadways, with traffic stress acceptable to confident pedestrians.
- PLTS 4: High speed (40 mph or higher) with high daily volumes (>12,000 vpd). High stress environment for even confident pedestrians.

Given the current corridor conditions, including a 40 mph speed limit, daily volume ranging from 26,500 to 31,500, and lack of a raised median to provide refuge, pedestrians crossing at unsignalized intersections is highly stressful, PLTS 4.

Bicycle Operations

Figure 11 shows the current bicycle facilities on First Avenue and the location of bike boulevards and other bicycle system connections. Bicycle lanes range from 4 to 5 feet wide. The development of a bike boulevard on Copper Street is currently programmed by the City and will provide signalized crossing on First Avenue. Three future bike boulevards are planned on Pastime Road, Yavapai Road, and Blacklidge Drive.

Figure 11. Existing Pedestrian Facilities



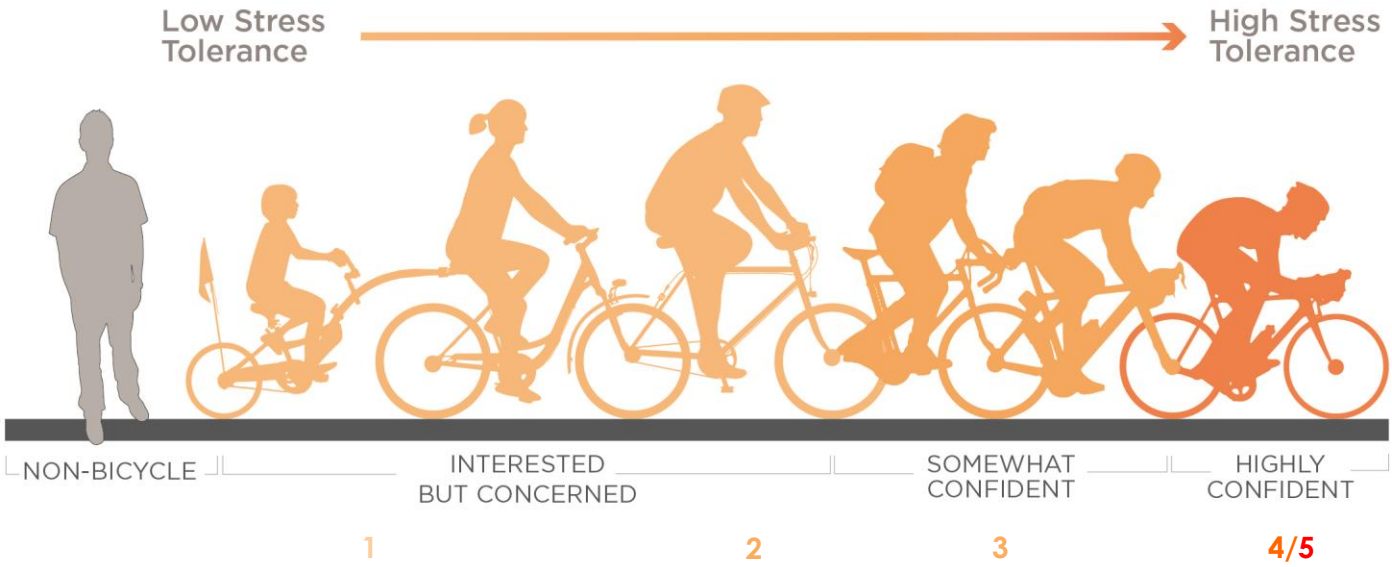
BIKE VOLUMES

Bicycle counts at signalized intersections were collected in August 2018. Table 6 summarizes peak hour bicycle volumes at each intersection. The highest bicycle volume was observed at the Glenn Street intersection.

Table 6. Bicycle Peak Hour Volumes

No.	Intersection	Bicycle Counts First Ave/Side Street AM	PM
1	River Rd	10/1	3/0
2	Wetmore Rd	1/0	0/1
3	Limberlost Dr	2/0	5/1
4	Roger Rd	0/0	0/0
5	Prince Rd	3/1	9/1
6	Fort Lowell Rd	0/6	3/2
7	Glenn St	2/9	4/12
8	Grant Rd	0/0	0/0

LEVEL OF TRAFFIC STRESS



Level of traffic stress qualitatively describes the bicycling environment relative to the type of rider that would use the facility. A low-stress environment would be comfortable for riders with limited experience, while a high-stress environment would be used only by very experienced and confident riders. Table 7 provides a general description of traffic stress levels.

Table 7. Level of Traffic Stress Description

Level of Stress	Description
1	Presents little traffic stress and demands little attention from cyclists. Suitable for almost all cyclists, including children. On links, cyclists are either physically separated from traffic, are in an exclusive bicycling zone next to a slow traffic stream with no more than one lane per direction, or are on a shared road where they interact with only occasional motor vehicles (as opposed to a stream of traffic) with a low-speed differential. Where cyclists ride alongside a parking lane, they have ample operating space outside the zone into which car doors are opened.
2	Presents little traffic stress and, therefore, is suitable to most adults who might want to ride a bike but demanding more attention than might be expected from children. Crossings are not difficult for most adults.
3	A roadway that provides an exclusive bike lane (six feet or wider) next to moderate-speed traffic (less than 40 mph) or shared lanes on streets that are not multilane and have low speed (less than 30 mph)
4	A multilane roadway that provides a paved bicycle lane or shoulder (four feet or wider) adjacent to high speed (>40 mph) traffic.
5	A multilane roadway with no paved bicycle lane or shoulder adjacent to moderate to high speed (>35 mph) traffic.

With the current conditions of the roadway, the bicycle level of traffic stress along First Avenue is Level 4, a high-stress bicycling environment.

INTERSECTION LEVEL OF SERVICE

Bicycle LOS at a roadway crossing, as defined by the Highway Capacity Manual, reflects delay and the presence of an exclusive bicycle lane or paved shoulder. As shown in Table 8, current bicycle LOS at signalized intersections during peak hours primarily ranges from LOS B to C. At River Road, the southbound bicycle LOS is D/E, due to the lack of a bicycle lane on the approach.

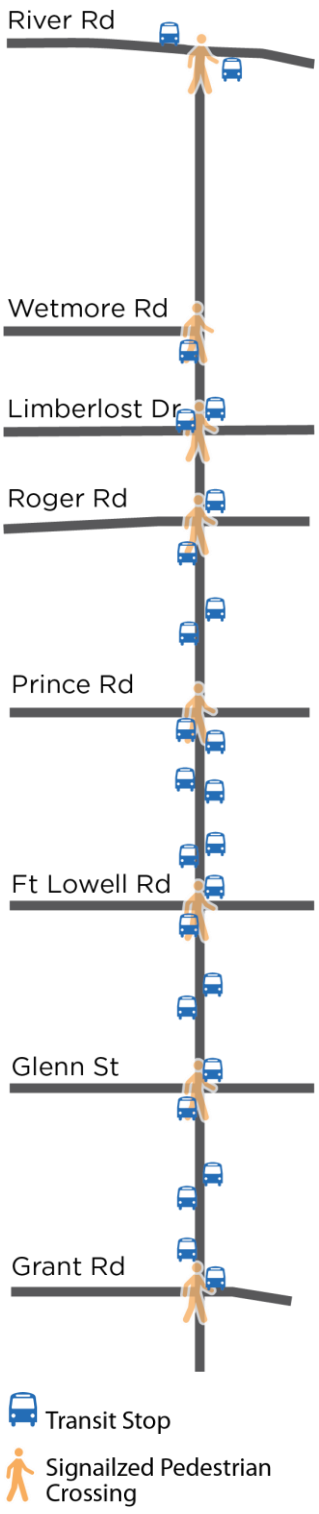
Table 8. Signalized Intersection Level of Service for Bicycles

		AM Peak Hour				PM Peak Hour			
No.	Intersection	NB	EB	SB	WB	NB	EB	SB	WB
1	River Rd	C	C	E	C	C	C	D	C
2	Wetmore Rd	B	C	C	B	C	C	C	B
3	Limberlost Dr	B	C	B	B	C	C	B	C
4	Roger Rd	B	B	B	B	B	B	B	B
5	Prince Rd	C	B	C	B	C	B	C	B
6	Fort Lowell Rd	C	C	C	C	C	C	C	C
7	Glenn Rd	B	C	C	B	C	B	B	B
8	Grant Rd	B	C	C	B	C	B	C	B

Transit

Figure 12 identifies the transit stops along First Avenue. The majority of transit stops (65%) are located in close proximity (within 200 feet) of a signalized intersection or signalized pedestrian crossing. SunTran Route #6 is part of the system's Frequent Transit Network, operating on 15-minute headways during weekday peak periods. Average ridership in 2018 was 21 passengers per hour during weekday peak periods. Annual ridership on Route #6 ranks tenth on the regional transit system. Current bus travel time between Grant Road and River Road is 12-14 minutes during the peak hour.

Figure 12. Current Transit Stops



Safety

CRASH DATA ANALYSIS

Crash data for the 5-year period from 2013 to 2017 was provided by the City of Tucson. Table 9 and summarize the types and severity of crashes that occurred along the corridor. Note that the number of property damage only, or no injury, reported are likely higher than those reported. Often, minor crashes are not reported by the parties involved, and the City of Tucson Police may not fill out a report if the vehicles involved are not disabled.

Intersection and segment crash data is provided in Table 10 and 11. Seventy-six percent of the crashes occurred at the signalized intersections, with the highest number of crashes occurring at the Grant Road, Fort Lowell Road, and River Road intersections. Only nine segment or mid-block crashes were reported between River Road and Roger Road, while 156 mid-block crashes occurred from Roger Road to Grant Road. The Fort Lowell Road intersection has the highest total of pedestrian injuries from crashes with 12.

Table 9. First Ave Corridor Crash Summary (2013-2017)

Fatal Crash	**4**	**2**	**2**
Injury Crash	**364**	**47**	**23**
No Injury Crash*	**340**	**4**	**5**
	708	53	30

**No injury (property damage only) crashes are often not reported or a crash report is not prepared.*

Table 10. Intersection Historical Crash Data

INTERSECTION	TOTAL CRASHES	VEHICLE		PEDESTRIAN		BIKE	
		FATAL	INJURY	FATAL	INJURY	FATAL	INJURY
River Road	101	2	47	0	0	0	2
Wetmore Road	64	0	28	0	6	0	1
Limberlost Drive	57	0	30	0	3	0	0
Roger Road	71	0	33	0	5	0	1
Price Road	75	0	28	0	2	1	5
Fort Lowell Road	99	0	37	0	12	0	1
Glenn Street	41	0	17	0	1	0	0
Grant Road	102	0	49	1	6	0	5

Table 11. Segment Historical Crash Data

SEGMENT	TOTAL CRASHES	VEHICLE		PEDESTRIAN		BIKE	
		FATAL	INJURY	FATAL	INJURY	FATAL	INJURY
River Road to Wetmore Road	8	1	4	0	0	0	0
Wetmore Road to Limberlost Drive	0	0	0	0	0	0	0
Limberlost Drive to Roger Road	1	0	0	0	0	0	0
Roger Road to Prince Road	31	0	26	0	3	0	3
Price Road to Fort Lowell Road	49	0	26	1	3	1	1
Fort Lowell Road to Glenn Street	36	1	18	0	2	0	2
Glenn Street to Grant Road	39	0	19	0	4	0	2

Data available from the PAG Safety Explorer database was used to provide a comparison of crash history for several roadway corridors: First Avenue, Oracle Road, Stone Avenue, and Campbell Avenue.

Table 11 provides a comparison of accidents by type and severity. The total crashes on First Avenue are comparable to total crashes on Oracle Road, although Oracle Road has substantially higher traffic volumes. Bicycle crashes along three of the corridors are comparable. However, First Avenue had a substantially higher number of pedestrian crashes than the other corridors. Over a 5-year period (2013-2017), nearly five pedestrian crashes occurred per year. This includes two fatalities and 41 injury crashes.

The Pedestrian Safety Action Plan (PSAP) recently completed by the City of Tucson has defined a pedestrian high-injury network, which includes the top 10% of roadway sections based on the severity of pedestrian crashes that have occurred. First Avenue is included in the high-injury network.

Table 12. Comparative Corridor Crash History by Type (2013-2017)

	First Avenue	Oracle Road	Stone Avenue	Campbell Avenue
Fatal Crash	4	3	2	0
Injury Crash	368	360	195	202
No Injury Crash*	287	373	167	192
	613	736	364	397

	First Avenue	Oracle Road	Stone Avenue	Campbell Avenue
Fatal Crash	2	2	0	3
Injury Crash	47	20	16	22
No Injury Crash*	4	2	0	5
	53	24	16	30

	First Avenue	Oracle Road	Stone Avenue	Campbell Avenue
Fatal Crash	2	1	0	0
Injury Crash	23	25	31	16
No Injury Crash*	5	7	2	1
	30	33	33	17

**No injury crashes are often not reported because police are not called*

Infrastructure

Figure 13. Current Drainage Crossings

LIGHTING

There is continuous street lighting only from Grant Road to Prince Road. Street lighting is only provided at signalized intersections from Prince Road to River Road.

DRAINAGE

A preliminary assessment of drainage conditions and needs within the corridor was conducted.

There are four significant at-grade drainage crossings between Grant Road and Rillito Creek. There are two culvert crossings between the Rillito Creek and River Road. The existing drainage crossing locations are provided in Figure 13 and their characteristics are summarized in Table 13.

Table 13. Drainage Crossing Inventory

Crossing ID	Watercourse Name	Crossing Type	Q_{100} (cfs)	Designated FEMA Floodplain
CD1	Un-named	RCBC; 2-8' x 4' cells	< 500	No
CD2	Racetrack Wash	RCBC; 4-10' x 5.5' cells	1,883	No
CD3	Rillito Creek	Bridge	32,000	Yes
CD4	Prince Road Wash/ Navajo Wash Tributary	At-grade	241	No
CD5	Navajo Wash	At-grade	2,112	Yes
CD6	Cemetery Wash	At-grade	537	No
CD7	Storm drain by-pass	At-grade	169	No

Based on a planning level assessment, the First Avenue Bridge over the Rillito Creek is hydraulically sufficient. However, the available freeboard (1.26 feet) does not meet current Pima County standards.

Current City of Tucson drainage standards requires all-weather crossings for the 100-year storm event. Eliminating the at-grade crossings will be a challenge, given that the First Avenue corridor is very developed with all surface drainage, and no drainage outfalls exist for daylighting drainage structures.

There are approximately 12,500 feet of pavement storm-drain pipe in the First Avenue corridor. Most of it is corrugated metal pipe, which typically has a design life of 50-years. The existing storm-drain systems within the corridor are sufficient to handle pavement drainage. However, First Avenue, similar

to other older parts of town, is lacking drainage infrastructure to collect and convey offsite runoff. The offsite runoff flows into the roadway right-of-way and overburdens the storm-drain systems in place. During large storm events, First Avenue functions as a drainage channel, conveying flow from Navajo Wash north to the Rillito Creek. Over 300 cubic feet per second (cfs) is flowing on the surface of First Avenue towards Wetmore Road. Newer development within the corridor has included on-site detention to reduce flows into the roadway.

Most of the storm-drain pipes were installed in the 1960s and have served their useful life, especially the corrugated metal pipes. In addition to replacing the aged storm drain system along First Avenue, the system will need to be upgraded to reduce flooding caused by offsite runoff.

RILLITO BRIDGE

The bridge was constructed in 1961 and is a six-span, 363-foot long by 64-foot wide pre-cast concrete channel girder structure that supports a 4-lane undivided curbed roadway. The bridge provides four 12-foot travel lanes, a striped 4-foot bicycle lane in each direction, and a 4-foot raised sidewalk on the east side.

A limited structural assessment of the existing First Avenue bridge over the Rillito Creek was conducted. Based on a visual inspection of the bridge substructure and superstructure, no critical issues were observed. No cracking or spalling indicative of structural issues was observed at abutments, pier caps, or girder bearing locations. Girders and substructure elements were observed to be water stained, but signs of concrete damage due to water infiltration is not apparent. Several sidewalk girder displacements of up to 2-inches were observed. Based on a review of the most recent load rating analysis conducted by the ADOT Bridge Group, the bridge operates at a deficient level. However, ADOT is not requiring the bridge to be load posted. The drainage assessment conducted for the corridor noted that the bridge is hydraulically efficient and not scour critical; however, the available freeboard does not meet current requirements.

Overall, the bridge currently functions adequately with no structural distress or scour concerns. The bridge is 60 years old, which puts it at about 80% of its intended 75-year lifespan.

First Avenue Bridge over Rillito Creek

Right-of-way

Existing right-of-way along the corridor is provided on the concept layouts included in Appendix B and is as follows:

- Grant Road to Glenn Street – 75 to 100 feet
- Glenn Street to Fort Lowell Road – 75 to 90 feet
- Fort Lowell Road to Prince Road – 75 to 130 feet
- Prince Road to Roger Road – 85 to 100 feet
- Roger Road to Limberlost Drive – 100 to 120 feet
- Limberlost Drive to Wetmore Road – 100 to 120 feet
- Wetmore Road to River Road – 95 to 145 feet

The City of Tucson Major Streets and Routes Plan identifies First Avenue as an arterial with a right-of-way requirement of 120 feet.

Utilities

Public and private utilities are located within the First Avenue right-of-way. An initial utility list is provided in Table 14. Overhead power and communication lines run along one or both sides of the roadway for the majority of the corridor.

Table 14. Existing Utilities within the First Avenue Right-of-Way

Utility	Facility Types
First Digital	Communication - Fiber Optic
Pima County Wastewater Management	Sanitary Sewer
Southwest Gas	Gas
Tucson Electric Power	Electric
Tucson Water	Water – Potable, Reclaimed
Comcast Communications	CATV - Coaxial
Conterra Ultra Broadband LLC	Communication – Fiber Optic
Cox Communications	CATV – Fiber Optic
Crown Castle Solutions Corporation	Communication - Fiber Optic
Centurylink	Communication - Coaxial, Fiber
First Digital	Communication - Fiber Optic
MCI - Verizon Business	Communication – Fiber Optic
City of Tucson Department of Transportation and Mobility - Traffic Engineering	Streetlights, Traffic Signals, Irrigation
City of Tucson Facility Design & Maintenance	Electric, Gas, Sewer, Water
City of Tucson Communications	Communication - Fiber Optic
City of Tucson Parks and Recreation	Electric

03

FUTURE CONDITIONS

FUTURE CONDITIONS

2045 Traffic Projections

2045 traffic projections for the corridor were developed using forecasts generated by the PAG travel demand model. The projected growth in traffic was estimated by comparing the volumes produced by the PAG 2015 model, which represents existing conditions and the 2045 model, which includes projected population and employment growth in the region. The population in the region is currently projected to increase from the current 1 million residents to 1.2 million residents by 2045, or 20 percent. This projected population growth is substantially lower than previous projections of 90 percent and 50 percent in 2005 and 2010, respectively. Along the First Avenue corridor, the population is projected to increase by six percent, and employment is projected to increase by 17 percent.

Based on 4-lanes and 6-lanes on First Avenue, low and high traffic growth projections were generated. The projected traffic growth on First Avenue produced by the PAG regional model are provided in Table 15. Traffic demand on First Avenue is projected to grow between 16 and 36 percent.

Projected average daily volumes based on the low and high growth rates are provided in Table 16.

Table 15. Projected 2045 Average Traffic Growth on First Ave

	Existing	2045 Low Traffic Growth Projection (% Change)	2045 High Traffic Growth Projection (% Change)
First Ave, Grant Rd to River Rd	28,237	32,652 (+16%)	38,382 (+36%)

Table 16. Projected 2045 Average Daily Traffic Volumes Along First Ave

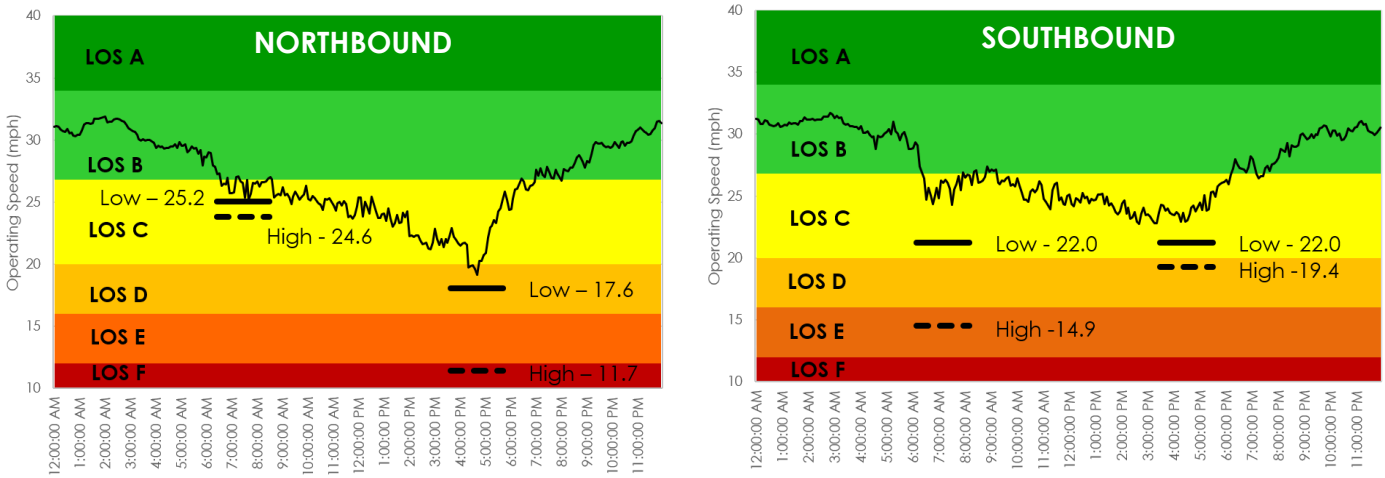
	Existing	2045 Low Traffic Volume	2045 High Traffic Volume
Speedway Blvd to Grant Rd	23,100	26,800	31,400
Grant Rd to Glenn St	26,500	30,700	36,000
Glenn St to Ft Lowell Rd	27,000	31,300	36,700
Ft Lowell Rd to Prince Rd	29,800	34,600	40,500
Prince Rd to Wetmore Rd	30,000	34,800	40,800
Wetmore Rd to River Rd	28,500	33,100	38,800
River Rd to Rudasill Rd	25,500	29,600	34,700

Mobility

CORRIDOR LEVEL OF SERVICE

Mobility of all users will be impacted by the projected growth in vehicular traffic demand. Traffic operations on First Avenue with increased traffic demand was estimated using Synchro/SimTraffic assuming the existing lane configuration and geometry of the corridor. Estimated peak hour average travel speeds across the corridor under low and high traffic growth scenarios are provided in Figure 14. Under both scenarios, average travel speeds are projected to decrease significantly. Peak hour corridor level of service will drop to LOS D in the low volume scenario and LOS E/F in the high traffic growth scenario. Note that travel times and level of service within a given segment may be better or worse than the overall corridor.

Figure 14. Weekday Corridor Travel Speed and LOS – Existing Roadway with Projected Traffic Growth



INTERSECTION LEVEL OF SERVICE

The projected higher traffic demand would result in increased delay and congestion at intersections, several failing at LOS F. Intersection level of service estimates during peak hours with existing, and 2045 low and high projections are provided in Table 17. Note that these results assumed the current intersection configuration and lane geometry.

Table 17. Existing and Projected Intersection Level of Service

No.	Intersection	AM Peak Hour			PM Peak Hour		
		Existing	Low Projection	High Projection	Existing	Low Projection	High Projection
1	River Rd	D*	D*	E*	D*	D*	D*
2	Wetmore Rd	C*	D*	E*	D*	E*	F*
3	Limberlost Dr	B	B	B	C*	C	D*
4	Roger Rd	B	B	D*	B	C	D*
5	Prince Rd	C	D*	F*	D*	E*	F*
6	Fort Lowell Rd	D	D	D*	D*	D*	E*
7	Glenn Rd	B	B	B	C	C	D*
8	Grant Rd	C	C	C	C	C	C

* At least one movement fails – LOS F

Pedestrians and Bicycles

Pedestrian and bicycle activity within the corridor is expected to increase with the improved connectivity and safety for these modes that will be implemented with roadway enhancements, as well as the anticipated redevelopment of commercial properties along the corridor in response to the roadway improvements. Given the current zoning, there is also the potential for longer-term redevelopment that would increase both residential and commercial density within the corridor, resulting in greater pedestrian and bicycle activity.

Transit

The recently completed PAG Long-Range Regional Transit Plan maintains First Avenue as a frequent transit service (15-minutes or less headways) route. The current PAG travel demand model estimates an 8 percent increase in ridership by 2045. Although current transit demand projections on First Avenue do not indicate a need for a service upgrade, improved transit stop access and amenities, as well as redevelopment opportunities resulting from enhancing or improving the roadway , will likely result in increased ridership.

04

Mobility, Safety, Infrastructure Needs and Alternatives

MOBILITY, SAFETY, INFRASTRUCTURE NEEDS AND ALTERNATIVES

Roadway and Intersection Capacity

Additional roadway capacity will be needed to serve the projected 2045 traffic demand at an acceptable level of service. Two alternatives were considered: 4-lane and 6-lane divided sections with added turn lane capacity at signalized intersections.

The traffic operations of each alternative were evaluated for both the low and high traffic growth projections. Using SimTraffic, traffic flow along the corridor was modeled to include the effect of HAWK crossings and side friction created by driveways. Existing travel speeds generated from the travel time data collected for the corridor were used to calibrate the traffic models.

The traffic models included HAWK crossings spaced at approximately ¼-mile from adjacent signalized intersections. The operation of the HAWK crossings were coordinated with traffic signals to provide optimal traffic progression in the corridor. Crossing demand at the HAWKs was assumed to be six activations per hour based on data collected at the existing crossing at Graybill Drive.

The effect of traffic activity at commercial and residential driveways along the corridor was incorporated into the traffic model using adjustment factors provided in the *Highway Capacity Manual*. These factors estimate delay to through-traffic created by right-turning vehicles into and out of driveways.

LOS D is the appropriate target for the design of most multimodal corridors, in most contexts. Short periods of LOS E are considered acceptable during peak periods if this results in better conditions for all users at other times of the day.

CORRIDOR LEVEL OF SERVICE

Estimated peak-hour corridor travel speed and LOS for the low and high traffic growth scenarios for each alternative are provided in Table 18. The results indicate that both alternatives will provide acceptable LOS (D or better) with the low traffic growth projections. At the high traffic growth projections, overall corridor operations will be at LOS E for the 4-lane alternative during the evening peak-hour; however, it is acceptable at all other times.

Detailed segment LOS information for each alternative is provided in Figure 15 for the low and Figure 16 for the high traffic growth projections.

Table 18. Corridor Operations and Level of Service for 4-lane and 6-lane Alternatives

	Low Projection		High Projection	
	Travel Speed, mph	LOS	Travel Speed, mph	LOS
4-Lane				
AM NB	23	C	21	C
AM SB	22	C	18	D
PM NB	19	D	15	E
PM SB	21	C	19	D
6-Lane				
AM NB	24	C	23	C
AM SB	26	C	24	C
PM NB	22	C	22	C
PM SB	22	C	23	C

INTERSECTION LEVEL OF SERVICE

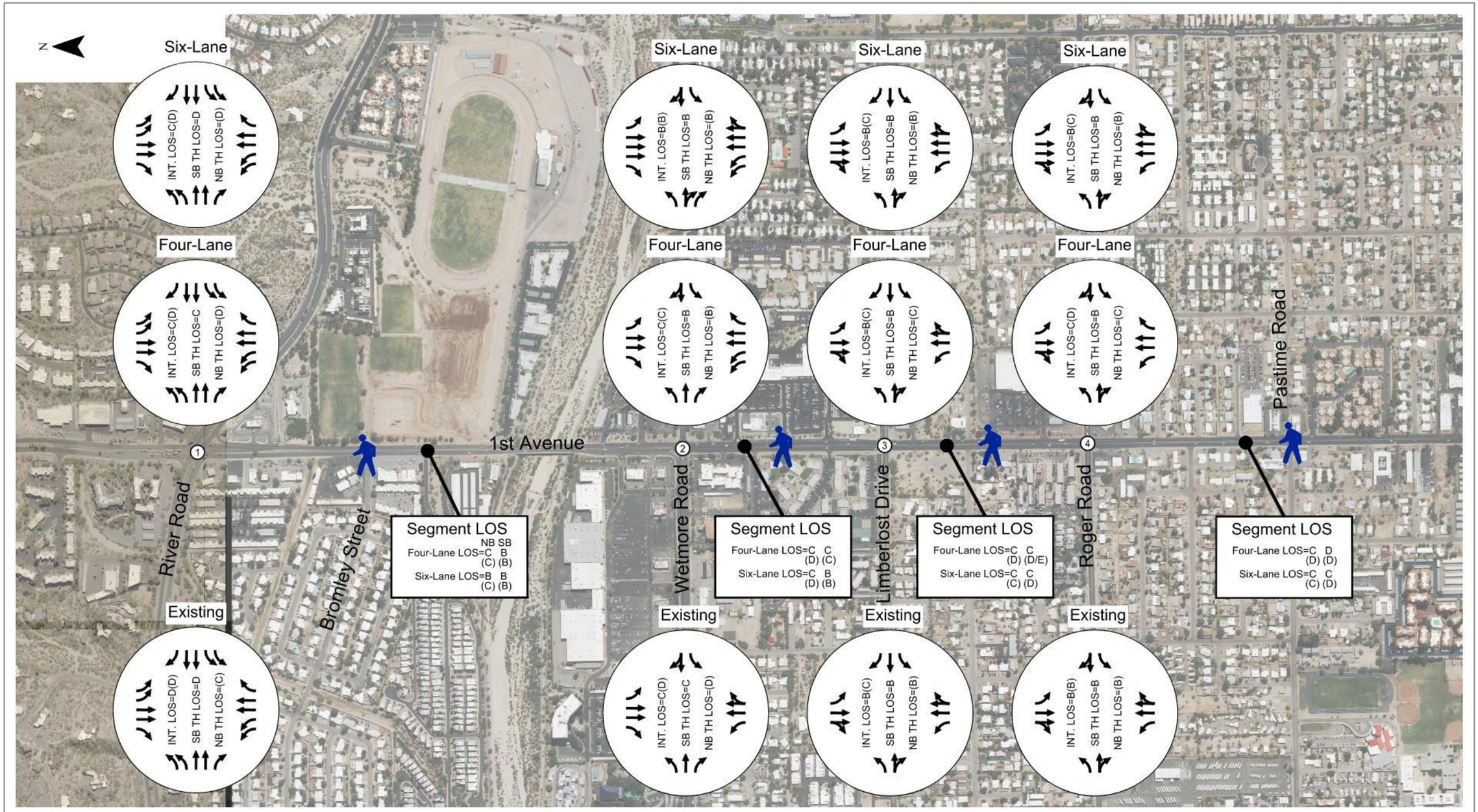
Estimated intersection LOS for each alternative and traffic growth projection are provided in Table 19. These LOS results reflect the intersection lane configurations provided in Figure 15 and 16. Operations at the River Road intersection are projected to fail under the high volume scenario primarily as a result of the increased demand on eastbound and westbound River Road, and not as a result of conditions on First Avenue. Considering the other intersections, the 4-lane alternative provides LOS D or better under the low traffic growth scenario, however several intersections (Prince Road and Fort Lowell Road) operate at LOS E during a peak hour under the high traffic projections.

The 6-lane alternative will provide excess capacity at several intersections under both traffic growth scenarios.

Table 19. Intersection Level of Service for 4 and 6-lane Alternatives

No.	Intersection	4-lane				6-lane			
		AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
		Low Projection	High Projection	Low Projection	High Projection	Low Projection	High Projection	Low Projection	High Projection
1	River Road	D	D	D	E	D	F	D	E
2	Wetmore Road	C	C	C	C	B	C	B	B
3	Limberlost Drive	B	C	C	D	B	B	C	C
4	Roger Road	C	C	C	D	B	B	C	C
5	Prince Road	C	E	D	D	C	D	C	C
6	Fort Lowell Road	C	C	C	E	C	C	C	C
7	Glenn Road	C	C	C	C	B	C	C	C
8	Grant Road	C	C	C	C	C	C	D	D

Figure 15. Roadway and Intersection Level of Service – Low Traffic Growth Projections



⊗ - Study Intersections
XX - AM Peak
(XX) - PM Peak

- Proposed HAWK Locations

Roadway and Intersection Level of Service
Low Traffic Growth Projections
River Road to Prince Road

Figure
15 A

⊗ - Study Intersections
XX - AM Peak
(XX) - PM Peak

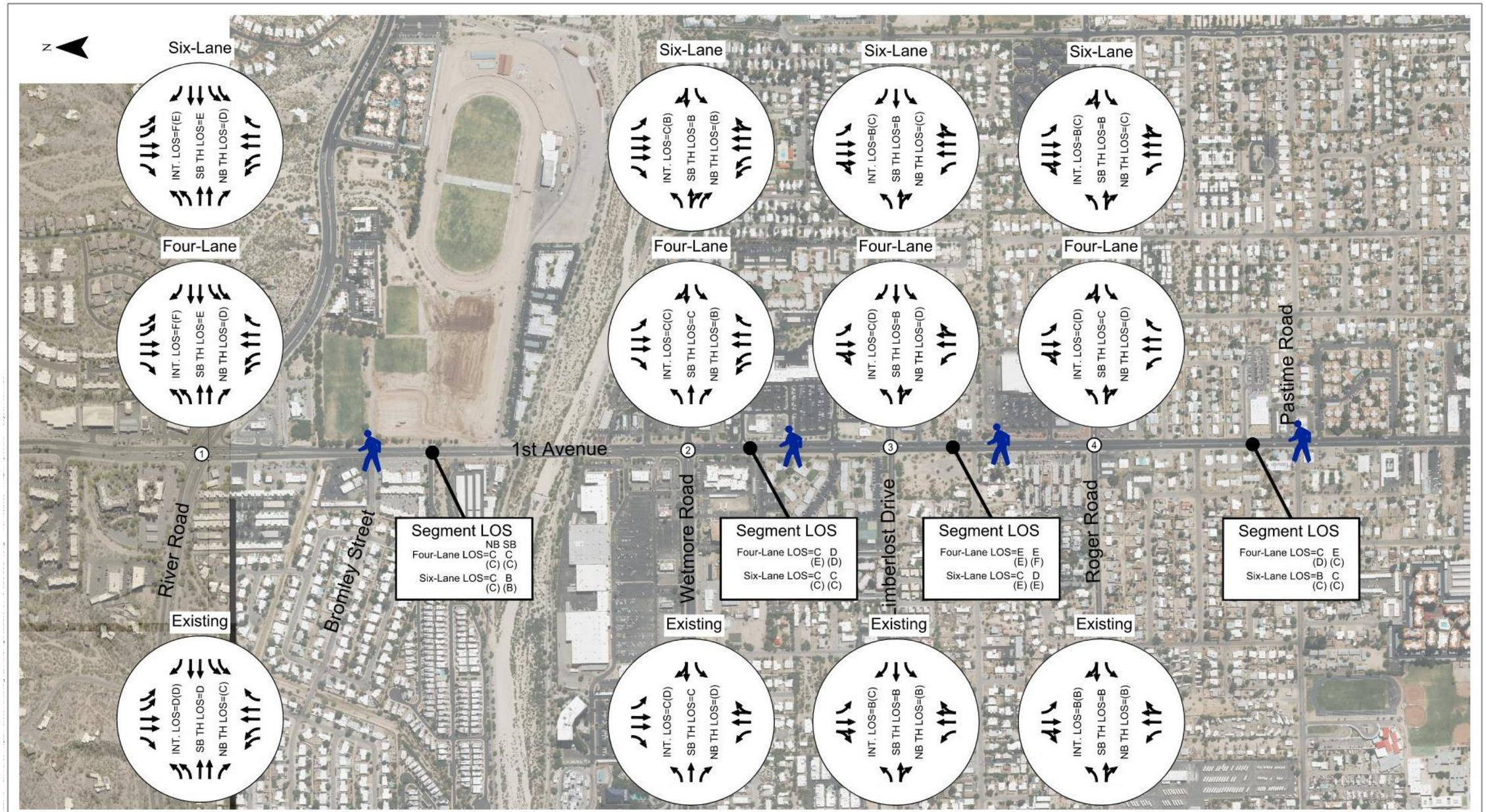
- Proposed HAWK Locations

Roadway and Intersection Level of Service
Low Traffic Growth Projections
River Road to Prince Road

Figure
15 B

KITTELSON & ASSOCIATES

Figure 16. Roadway and Intersection Level of Service – High Traffic Growth Projections



⊗ - Study Intersections
XX - AM Peak
(XX) - PM Peak
- Proposed HAWK Locations

Roadway and Intersection Level of Service
High Traffic Growth Projections
River Road to Prince Road

Figure
16 A

XX - Study Intersections
XX - AM Peak
(XX) - PM Peak

- Proposed HAWK Locations

Roadway and Intersection Level of Service
High Traffic Growth Projections
River Road to Prince Road

Figure
16 B

KITTELSON & ASSOCIATES

Complete Streets

Given the high proportion of residents that may be disadvantaged from a socio-economic and/or transportation mobility perspective, the provision of enhanced multi-modal facilities are needed to provide equitable transportation access and to improve the livability along the First Avenue corridor.

PEDESTRIANS

In addition to providing convenient pedestrian access and connectivity, the review of crash data points to a need to focus on improving pedestrian safety along First Avenue. The Pedestrian Safety Action Plan describes key strategies, focused on Engineering, Enforcement, Policy, and Education & Engagement, to improve pedestrian safety. The plan includes the following recommended engineering actions:

- Reduce vehicle speeds
- Enhance pedestrian visibility/conspicuity
- Improve motorist's yielding behavior
- Provide frequent and appropriately designed crossing opportunities for pedestrians
- Reduce or limit pedestrian exposure to vehicular traffic

The following roadway features are intended to provide a safe and convenient walking environment on First Avenue.

- **Continuous sidewalk**. Given the current and anticipated future level of pedestrian activity within the corridor, 6 ft sidewalks along both sides of the roadway are appropriate. The provision of a 3-foot to 5-foot buffer from the back of curb to the sidewalk is desirable. In areas where pedestrian activity may be higher, such as at transit stops, an 8-foot wide sidewalk can be considered. On a new bridge over the Rillito Creek, a 6-foot sidewalk with a concrete barrier is desirable.
- **Midblock signalized pedestrian/bicycle crossings** aligned with transit stops and planned bicycle boulevards (Copper Street(existing), Pastime Road, Yavapai Road, and Blacklidge Drive). Including signalized intersections, signalized pedestrian crossings would be provided at approximately ¼-mile spacing. It is assumed that mid-block crossings would have HAWK beacons; however, Pelican or Toucan pedestrian signals may be more appropriate. During peak morning and evening traffic periods, the mid-block signalized pedestrian/bicycle crossings should be operated as part of traffic signal coordination to provide efficient progression through the corridor.
- **Raised medians** on a multi-lane arterial provide a refuge area for pedestrians at both signalized and unsignalized crossings. A minimum width of 6 feet is required to provide a safe median pedestrian refuge.
- **Street lighting** should be designed to provide illumination that targets pedestrian and bicycle visibility. This includes providing positive illuminance of pedestrians in crosswalks and appropriate illumination of sidewalks and medians.
- **Landscape vegetation in the median and the planting strip between curb and sidewalk** should be designed and maintained so that it does not impact the visibility of pedestrians.

The pedestrian LOS estimates provided in Table 20 indicate a moderate level of stress is expected for pedestrians crossing either a 4 or 6 lane roadway under both low and high traffic growth projections. These estimates assume that a pedestrian refuge is provided on multi-lane approaches and the speed limit is 35 mph or less.

Table 20. Pedestrian Level of Service at Signalized Intersections with 4-lane and 6-lane Options

No.	Intersection	Low Traffic Growth Projection		High Traffic Growth Projection	
		4-lane	6-lane	4-lane	6-lane
1	River Rd	B	C	B	C
2	Wetmore Rd	C	C	C	C
3	Limberlost Dr	C	C	C	C
4	Roger Rd	C	C	C	C
5	Prince Rd	C	C	C	C
6	Fort Lowell Rd	C	C	C	C
7	Glenn Rd	C	C	C	C
8	Grant Rd	C	C	C	C

At unsignalized crossings, a 4-lane cross section with a minimum of a 10-ft wide raised median to provide pedestrian refuge will provide moderate level of traffic stress or PLTS of 3. The PLTS on a 6-lane cross section with similar pedestrian refute will level 4, or high stress.

BICYCLES

The selection of the type of bicycle facilities to provide along First Avenue will depend on the target population of cyclists the facilities are intended to accommodate and the prevailing traffic volume and speed. The latest national guidance on facility selection can be found in the FHWA *Bikeway Selection Guide* (2019). Based on the high traffic volume and operating speeds of 35-40 mph, Table 20 summarizes the available facility types on First Avenue that will accommodate the stress tolerance of each user type.

Table 201. Bicycle Facility Alternatives for First Avenue

User Type (Stress Tolerance)	Bicycle Facility Type			
	Bike Lane	Buffered Bike Lane	Protected Bike Lane/ Cycle Track	Separated Bike Lane/Multi-use Path
Interested but Concerned (Low, LTS 2)				✓
Somewhat Confident (Moderate, LTS 3)		✓	✓	✓
Highly Confident (High, LTS 4/5)	✓	✓	✓	✓

Bicycle facility selection is also influenced by other roadway features and constraints, including right-of-way, driveway frequency, drainage requirements, and maintenance requirements.

The City of Tucson Bicycle Boulevard Master Plan defines a low-stress bicycle network intended to serve the "Interested but Concerned" rider. This network includes collector roadways and local streets. Definitions of the bicycle user types for arterial roadways, including First Avenue, is being developed as part of the City's Mobility Master Plan.

Three bike lane options are considered appropriate given the frequency of driveways and side streets along First Avenue: striped bike lane, buffered bike lane, and separated bike lane. The three options have the same seven-foot width.

TRANSIT

Enhanced transit facilities will help to maintain a frequent transit service level (15-minute headways or less), better serve current transit users, and promote transit ridership within the corridor. The location and design of stops should minimize delay to both general traffic flow and buses pulling back into traffic, as well as provide safe and convenient access by users.

Transit Operations

The number of through lanes will impact transit operations primarily during weekday peak traffic periods. A 6-lane roadway would minimize delay to buses given that excess capacity is provided relative to overall traffic demand. Unlike a 4-lane section, bus pullouts at mid-block stops and pull-throughs at signalized intersections would not be needed to mitigate impacts to general traffic flow. Queue jump lanes with transit signal priority at signalized intersections would be required to reduce transit delay during peak traffic periods with a 4-lane section. Queue jump lane options include a shared right-turn/queue jump lane with a protected right-turn signal or a separate bus-only lane located between the through-lane and right-turn lane. Each option will require ITS equipment with a priority signal phase.

Bus Stops

Bus stops should be located in close proximity to signalized intersections and pedestrian crossings to provide a convenient and safe roadway crossing opportunity. Provision of pedestrian level lighting at shelters will improve security for users.

Drainage

Providing all-weather crossings along First Avenue will have distinct challenges given the development, access, and drainage characteristics within the corridor. Based on discussions with TDTM – Engineering Division staff, the following potential solutions to meet the required drainage design criteria were identified as part of this need's assessment. These solutions are preliminary and will require more detailed evaluation as the First Avenue improvement project moves forward to determine their feasibility and cost. Each solution assumes that adjustments to the First Avenue profile will be minimal to avoid impacts to adjacent properties. A detailed drainage evaluation may also identify other feasible and cost-effective solutions to improve cross drainage conditions within the corridor.

- At Copper Street and Blacklidge Drive (Cemetery Wash), install large grate inlets on the east side of First Avenue and box culverts to convey the 100-yr event flow under First Avenue to a downstream basin. This will require the acquisition of property to create the basin.

- Navajo Wash has a listed regulatory discharge at First Avenue of 2,122 cfs. Navajo Wash crosses in an at-grade (dip) condition in existing conditions. Navajo Rd serves as the drainage channel. A 2007 Study prepared by the City of Tucson shows that undergrounding the Navajo Wash is cost-prohibitive. The Pima County Regional Flood Control District is planning to study the Navajo Wash on a regional scale and assess potential solutions. It is apparent that this will include the need for detention basins. Depending on the timing of the study, the results may inform the drainage improvements to be installed with the First Avenue widening. An alternative to consider includes installing a temporary conveyance, such as a drainage siphon, that would be replaced with future Navajo Wash drainage improvements.

Due to the age of the existing storm drain system, it is assumed that all of the existing pipe and catch basins will be replaced. A new storm drain system should provide sufficient capacity to accommodate the off-site flow that inundates the roadway during larger events. During the 100-yr event, over 300 cfs is flowing north in First Avenue to the Rillito Creek. A potential improvement would include providing trench drains at several locations with a box trunk line extending from Prince Road to Wetmore Road and connecting to an existing 16'x8' box drain that outfalls to the Rillito Creek. The new box trunk line would range in size from 8'x8' to 12'x8'. The impact of a large trunk line on existing utilities will need to be evaluated to determine required mitigation and cost.

Rillito Bridge

Based on the limited structural assessment conducted for the existing bridge there does not appear to be an immediate need to replace the structure. A detailed structural analysis of the bridge is required to confirm the potential remaining longevity of the structure based on current and future traffic loading. However, the initial assessment conducted for this study suggests approximately 12 years before replacement should be considered due to structural fatigue.

Replacement of the bridge as part of the First Avenue widening will depend upon the roadway cross section. With a 4-lane divided roadway, the existing bridge could remain; however, the 4-foot bike lanes and single 4-foot sidewalk would be deficient from the desired facility widths. The bike lanes and/or sidewalk could be widened by narrowing the existing through lanes from 12 feet to 11 feet. Full replacement of the structure could occur later as a separate project.

With a 6-lane roadway, the bridge will need to be widened, either by full replacement or expansion of the existing structure. Expansion of the existing bridge would be extremely challenging in coordinating grade elevations and roadway profiles and would not remedy the current freeboard limitations. Preliminary costs for these two options are $6.5 million for a new bridge (excluding the removal of the existing structure) and $6.9 million to expand the existing structure. Given the existing bridge's remaining lifespan, anticipated future traffic volume, and relative cost, a complete replacement is the preferred option.

Utilities

Overhead power lines and communication facilities will need to be accommodated within the right-of-way. Power poles will need to be placed along one or both sides of the roadway. Placement of poles a minimum of 10 feet behind the face of curb is desired. Per City of Tucson requirements, conduit will be provided to accommodate the placement of fiber optic cable to support the application of Intelligent Transportation System (ITS) technologies.

05

PROJECT ALTERNATIVES

PROJECT ALTERNATIVES

Project Alternatives

Concept layouts were prepared for the 4-lane and 6-lane alternatives presented in Figure 14. The layouts are included in Appendix A. The alternatives are consistent with the guidelines for an urban thoroughfare provided in the City of Tucson Complete Streets Manual. The alternatives include the following features:

- Three bike lane options are considered appropriate given the frequency of driveways and side streets along First Avenue: striped bike lane, buffered bike lane, and separated bike lane. The three options have the same 7 ft width.
- The 4-lane alternative includes bus pull-throughs at each signalized intersection. Considering the 6-lane alternative provides excess roadway capacity for future traffic demand, bus pull-throughs are not included with this alternative.
- Mid-block signalized bicycle/pedestrian crossings are provided between signalized intersections. This includes existing HAWK crossings at Graybill Drive at the Wood Memorial Library and at Copper Street, a bike boulevard crossings at planned bicycle boulevards, and crossings at locations where there is higher density residential and commercial land use where higher pedestrian demand would be expected.
- Median openings are spaced to generally coincide with the City of Tucson Access Management Guidelines.
- The 6-lane alternative requires the widening of the north leg of the Grant Road intersection, while the 4-lane alternative will tie in approximately 400 feet north of the intersection.
- The application of Intelligent Transportation System (ITS) technologies will be included with both roadway cross section alternatives. These technologies could include adaptive signal control, transit signal pre-emption, and advanced detection technologies. Fiber optic cable in conduit will provide communications for these systems.
    - Adaptive signal control technology (ASCT) can extend the effectiveness and reliability of optimized signal timing plans by adjusting the traffic signal settings along roadway corridors in response to real-time traffic patterns and congestion. ASCT benefits include reducing travel times and stops along the corridor with minimal impacts to crossing streets and the traffic signal systems' ability to recover from unexpected congestion events. ASCT does not require additional right-of-way, and there is no utility relocation cost associated with this technology.
    - Currently, a methodology is not available to quantify the potential traffic flow and capacity benefit of ASCT. However, before-and-after traffic flow studies conducted in Maricopa County indicated appreciable reductions in intersection delay and corridor travel time. Preliminary studies of the effectiveness of ASCT on a 16-mile section of Bell Road in Maricopa County show that average corridor travel time during peak hours decreased by 10 percent. Further applications of ASCT, including planned pilot tests to be conducted by the City of Tucson, will provide a broader understanding of potential capacity and operational benefits for both agencies and motorists. More study is required to determine how ASCT will perform in more urban contexts where there are higher number of bicyclists and pedestrians.

Performance

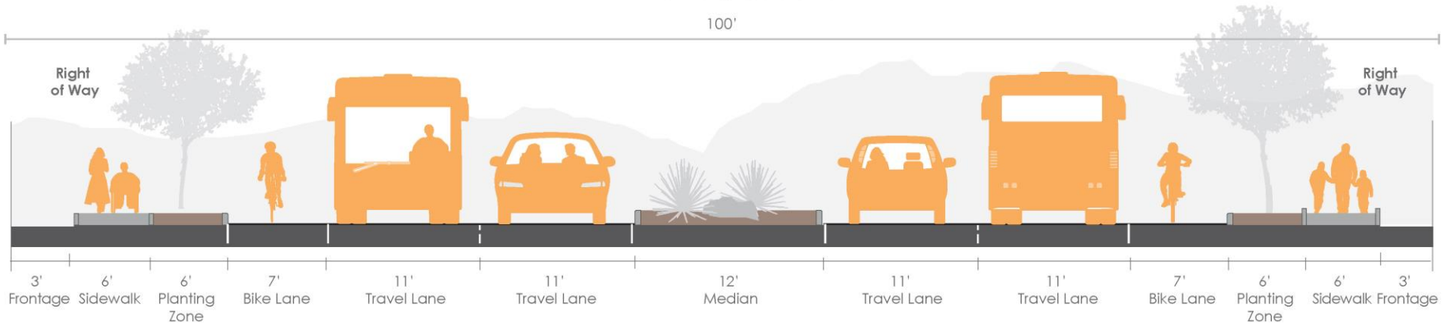
Table 21 summarizes the performance of each alternative relative to mobility, safety, equity, and right-of-way impacts.

Table 21 Alternatives Summary Measures

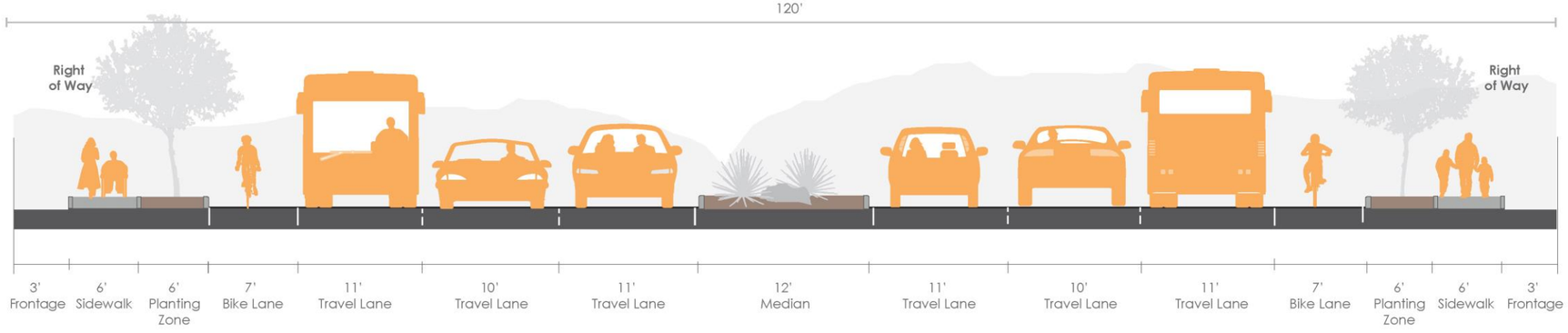
Performance Measure		Alternative	
		4-lane	6-lane
Mobility	Vehicular	Corridor operates at LOS D or better except during the afternoon peak hour (LOS E). Prince Road and Fort Lowell Road intersections operate at LOS E. Other intersections are at LOS D or better.	Corridor operates at LOS C or better. Intersections operate at LOS D or better.
		The application of Intelligent Transportation Systems (ITS) will optimize intersection performance.	
	Transit	Travel time is estimated to increase from 15 minutes to 19 minutes. Transit will experience additional delay at pull-throughs during peak hours. Potential solutions to reduce transit delay include queue jump lanes and transit signal priority. Enhanced transit facilities to promote transit ridership and improve frequent transit service levels (15-minute headways or less).	Travel time is estimated to increase from 15 minutes to 16 minutes. Enhanced transit facilities to promote transit ridership and improve frequent transit service levels (15-minute headways or less).
	Pedestrian	Continuous 6 ft ADA sidewalk with a 3 ft to 5 ft buffer. Midblock signalized pedestrian/bicycle crossings aligned with transit stops and planned bicycle boulevards at approximately ¼-mile spacing. Pedestrian LOS at signalized intersections LOS B/C Pedestrian Level of Traffic Stress of 3 (moderate) at unsignalized crossings	Continuous 6-ft ADA sidewalk with a 3 ft to 5 ft buffer. Midblock signalized pedestrian/bicycle crossings aligned with transit stops and planned bicycle boulevards at approximately ¼-mile spacing. Pedestrian LOS at signalized intersections LOS C Pedestrian Level of Traffic Stress of 4 (high) at unsignalized crossings
	Bicycle	Bike lane options include buffered/protected bike lane with Level of Traffic Stress (LTS) 3 and separated bike lane with LTS 2.	Bike lane options include buffered/protected bike lane with Level of Traffic Stress (LTS) 3 and separated bike lane with LTS 2.
Safety	Vehicular	Reduced crash potential from roadway enhancements such as street lighting, a raised median, and lowered operating speed.	Reduced crash potential from roadway enhancements such as street lighting, a raised median, and lowered operating speed.
	Pedestrian, Bicycle, and Transit	Street lighting and landscape that targets pedestrian and bicycle visibility. Midblock signalized pedestrian crossings aligned with transit stops. Raised medians provide a refuge area for pedestrians. Narrowed travel lanes reduce vehicle operating speeds.	Street lighting and landscape that targets pedestrian and bicycle visibility. Midblock signalized pedestrian crossings aligned with transit stops. Raised medians provide a refuge area for pedestrians. Narrowed travel lanes reduce vehicle operating speeds. More vehicle exposure to pedestrians in unmarked crossings
Access		Enhanced pedestrian, bicycle, and transit features provide more convenient and safe mobility for all residents within the corridor and support walking and bicycling to promote a healthier lifestyle.	
Right-of-Way		Full Takes – 13 Partial Takes – 122	Full Takes – 20 Partial Takes – 149

First Avenue Cross Section Alternatives

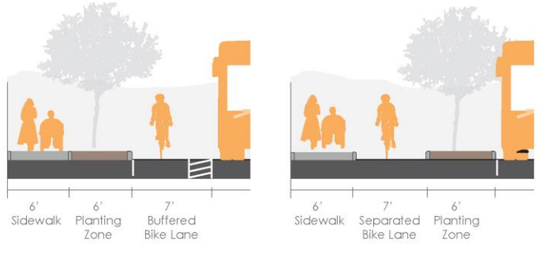
4-Lane Cross-Section



6-Lane Cross-Section



Bike Lane Configuration Alternatives



Cost

Alternative improvement cost estimates are summarized in Table 22. Detailed cost information is provided in Appendix B. The cost estimates are based on bid price information for City of Tucson arterial roadway widening projects between 2016 and 2019. Right-of-way costs were prepared by the City of Tucson and include the cost for property, acquisition costs, and relocation costs. The cost estimates are based on the following assumptions.

- Pavement thickness – 7 inches of asphaltic concrete on 8 inches of asphaltic base; the pavement section used for Broadway Boulevard, Euclid Avenue to Country Club Road.
- HAWK crossings are provided at each mid-block pedestrian/bicycle crossing, as opposed to other signal options.
- Drainage improvements include providing storm drain to essentially accommodate the 10-year event and does not include cross drainage improvements or improvements to address large storm event off-site runoff into First Avenue. Planning level estimates of potential improvements identified in the initial drainage assessment conducted with this assessment to address the 100-year drainage runoff within the corridor are provided separately. Note that these estimates do not include the cost to acquire property or construct upstream/downstream detention basins.
- ITS technologies include adaptive signal control and transit signal priority.

Table 22. Alternative Cost Estimates

	Design and Construction Cost	Right-of-Way Cost	Total Project Cost
4-lane w/Existing Bridge	$43,400,000	$18,700,000	$62,100,000
4-lane w/New Bridge	$54,700,000	$18,700,000	$73,400,000
6-lane w/New Bridge	$59,900,000	$31,800,000	$91,700,000
Cross Drainage Improvements	$20,000,000 (1)	(2)	

1. Does not include the cost to construct upstream/downstream detention basins.
2. Right-of-way cost for detention basins unknown.

REFERENCES

1. City of Tucson Pedestrian Safety Action Plan, Draft, March 2020
2. Pima Association of Governments Long-Range Regional Transit Plan, Draft, January 2020
3. Highway Capacity Manual, 6th Edition