Draft Final

Traffic Engineering Study Silverbell Road, Ina Road to Grant Road

Tucson, Arizona

November 2009

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Traffic Engineering Study

Silverbell Road, Ina Road to Grant Road

Tucson, Arizona

Prepared For:
City of Tucson DOT
201 N. Stone Ave.
Tucson, AZ 85701

Prepared By:
Kittelson & Associates, Inc.
33 N. Stone Ave., Suite 800
Tucson, AZ 85701
(520) 544-4067

Project Manager: Khang M. Nguyen, P.E.
Project Principal: Jim Schoen, P.E.
Project Analysts: Ning Zou, E.I.T.

Project No. 9589.0

November 2009

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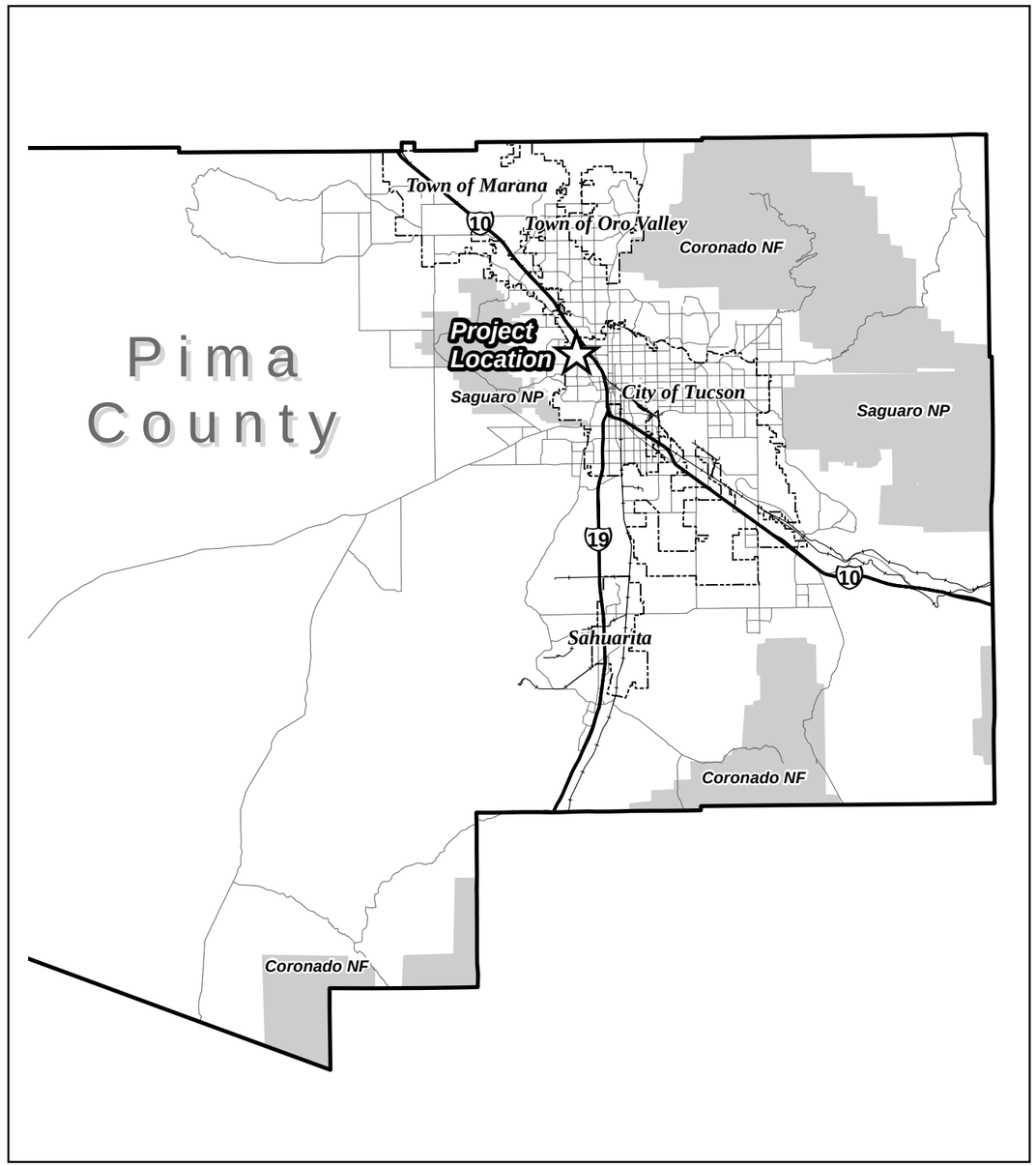
1. Introduction

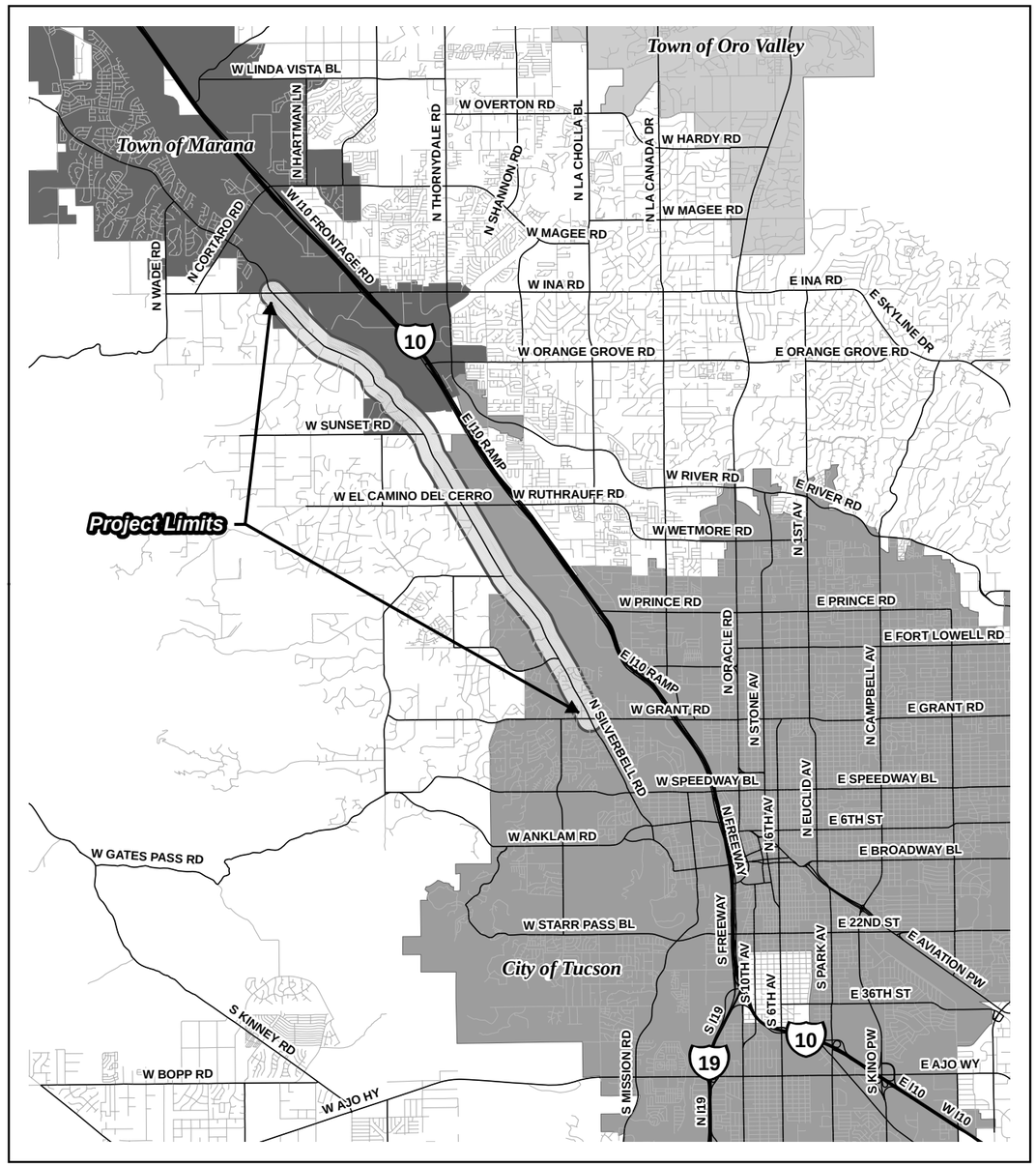
1.1 BACKGROUND AND SCOPE

The widening of Silverbell Road from Ina Road to Grant Road is a Regional Transportation Authority (RTA) funded roadway project. This traffic engineering report was prepared as part of the design process for the section of Silverbell Road from Ina Road to Grant Road. Study area maps are provided in Exhibit 1.

The purpose of this traffic report is to evaluate existing and future (2040) traffic conditions and provide specific recommendations to be used for the design of improvements on Silverbell Road. These recommendations include the lane configuration at signalized intersections, turn lane storage requirements, traffic control requirements, location and configuration of median openings, pedestrian, bicycle and transit features, and the need for roadway lighting.



VICINITY MAP



LOCATION MAP

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VICINITY AND LOCATION MAP
PIMA COUNTY, ARIZONA

EXHIBIT
1

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2. Existing Conditions

2.1 ROADWAY

Silverbell Road is classified as an urban principal arterial and considered a scenic route by both City of Tucson and Pima County. Its cross section generally consists of two lanes, the width of which varies from 11 to 12 feet. Sidewalks are provided near the Grant Road intersection. Six-foot paved shoulders exist between Goret Road and Grant Road. Paved shoulders vary in width from 4 to 6 feet from Goret Road to Sunset Road. North of Sunset Road and nearly to Ina Road, paved shoulders are one foot wide. A short frontage road runs along the east side of Silverbell Road from just north of Belmont Road to south of Silver Ridge Lane. Seventeen residences utilize this frontage road to access Silverbell Road. The vertical roadway alignment generally follows the existing rolling terrain with many at-grade drainage crossings. Based on a review of the AASHTO controlling design criteria for Silverbell Road, there appear to be four horizontal curves and 20 vertical curves that do not meet sight distance requirements. The AASHTO review is provided in Appendix A. Existing access points along Silverbell Road are summarized in Exhibit 2.

Exhibit 2 Summary of Existing Access

Section	Minor Cross Street	Residential Driveway	Commercial Driveway
Ina Rd. - Sunset Rd.	10	23	2
Sunset Rd. - El Camino Del Cerro	0	9	0
El Camino Del Cerro - Sweetwater Dr.	2	10	1
Sweetwater Dr. - Goret Rd.	3	5	3
Goret Rd. - Grant Rd.	10	6	8
Total	25	53	14

2.2 LAND USE

The Silverbell Road corridor, from Ina Road to Grant Road lies in three jurisdictions; the Town of Marana, Pima County, and the City of Tucson. Currently, a large portion of the property within each jurisdiction is undeveloped. Since existing and future land use will influence both the functional requirements of the roadway as well as the character of the corridor, it is important to establish a clear understanding of how properties along this section of Silverbell Road will develop. This was accomplished by preparing a detailed land use and zoning analysis for the corridor. The analysis report, which is included in Appendix B, describes a likely corridor development scenario based on a review of existing zoning, existing land uses, and planned developments, review of the current comprehensive plans for each jurisdiction, as well as discussions with planning staff from the Town, County, and City. A general summary of this corridor development scenario is provided below.

Grant Road to Goret Road

This section is nearly fully developed with a mix of existing retail, commercial and residential land uses. Retail and commercial uses, including an auto shop, car wash, restaurants, a supermarket, fueling stations, banks, and retail stores are centered at the Grant Road intersection. North of the Grant Road intersection, the majority existing development on both sides of the roadway includes low to moderate density residential subdivisions. Blended in with the residences are an architecture office and a charter school (Luz Academy) on the west side and a nursery and trailer park on the east side. Sunset Ranch, which includes the nursery and the trailer park, was recently rezoned to C-1 and redevelopment plans for this property include an office park and a storage facility. The architecture office resides on a large parcel that is zoned C-1 (Commercial); however full development of this property will require significant floodplain mitigation.

Goret Road to El Camino del Cerro

Much of the land along the west side of Silverbell Road between Goret Road and Sweetwater Drive was purchased and rezoned as Open Space by the City of Tucson. Most of the land on the east side within this segment is also owned by the City of Tucson and includes the Silverbell Municipal Golf Course and Christopher Columbus Park. The City of Tucson plans to expand the Christopher Columbus Park further north and add athletic fields in the northeast and southeast corners of the Silverbell/El Camino Del Cerro intersection. Two residential developments are anticipated on the east side. Silverbell Crossings is a proposed 143-unit residential subdivision, located just across from Neosha Street. Silverbell Residential is an affordable housing 147-unit subdivision across from Goret Road and the first phase of construction is already underway. Further development on the east side is limited by the Santa Cruz River and its floodplain.

El Camino del Cerro to Sunset Road

Most of the land on the west side has been subdivided into large residential lots; therefore, growth in this area will be minimal. Land on the east side is mostly vacant and divided into three large parcels which are zoned as O-3 Office (mid-rise office development) and RX-1 Residence (suburban low density residential development). Similar to the southern section, development will be limited without significant mitigation to the Santa Cruz River floodplain.

Sunset Road to Ina Road

Two segments of Silverbell Road between Kiley Road and Ina Road are located in Pima County, while the rest is in the Town of Marana. The first segment extends from Kiley Court to just north of Sunset Road and the second segment from just south of Benjamen Road to Abington Road. In general, the west side of Silverbell Road has been almost completely built out with low density residential. A 41-unit low density residential subdivision, named Ina & Silverbell, has been approved for development just south of the Ina Road intersection. Except for a few small residential lots near Abington Road, the east side of Silverbell Road has not been developed and is mostly zoned as R-36 which is the low density residential zoning with a minimum lot size of ¾ acre. The majority of the land here is owned by either Pima County or the California Portland Cement Company. Other than the commercial development potential at the corners of the Silverbell/Ina intersection, the Town of Marana envisions some industrial development on the east side which

again may be somewhat limited due to its close proximity to the Santa Cruz River and the flood plain restrictions.

2.3 SPEED LIMIT

The existing posted speed limits on the roadways within the study area are as follows:

- Silverbell Road - 45 mph north of Ina Rd; 45 mph between Ina Rd and El Camino Del Cerro; 45 mph daytime, 40 mph nighttime between El Camino Del Cerro and Grant Road; 40 mph south of Grant Road;
- Ironwood Hills Drive - 40 mph daytime, 35 mph nighttime;
- Grant Road - 40 mph;
- Goret Road - 35 mph west of Silverbell Road, 25 mph east of Silverbell Road;
- Sweetwater - 45 mph west of Silverbell Road, dead end east of Silverbell Road;
- El Camino Del Cerro - 45 mph west of Silverbell Road, 45mph daytime, 40 mph nighttime east of Silverbell Road;
- Sunset Road - 35 mph;
- Ina Road - 45 mph;
- All other side streets - 25 mph.

2.4 EXISTING TRAFFIC CONDITIONS

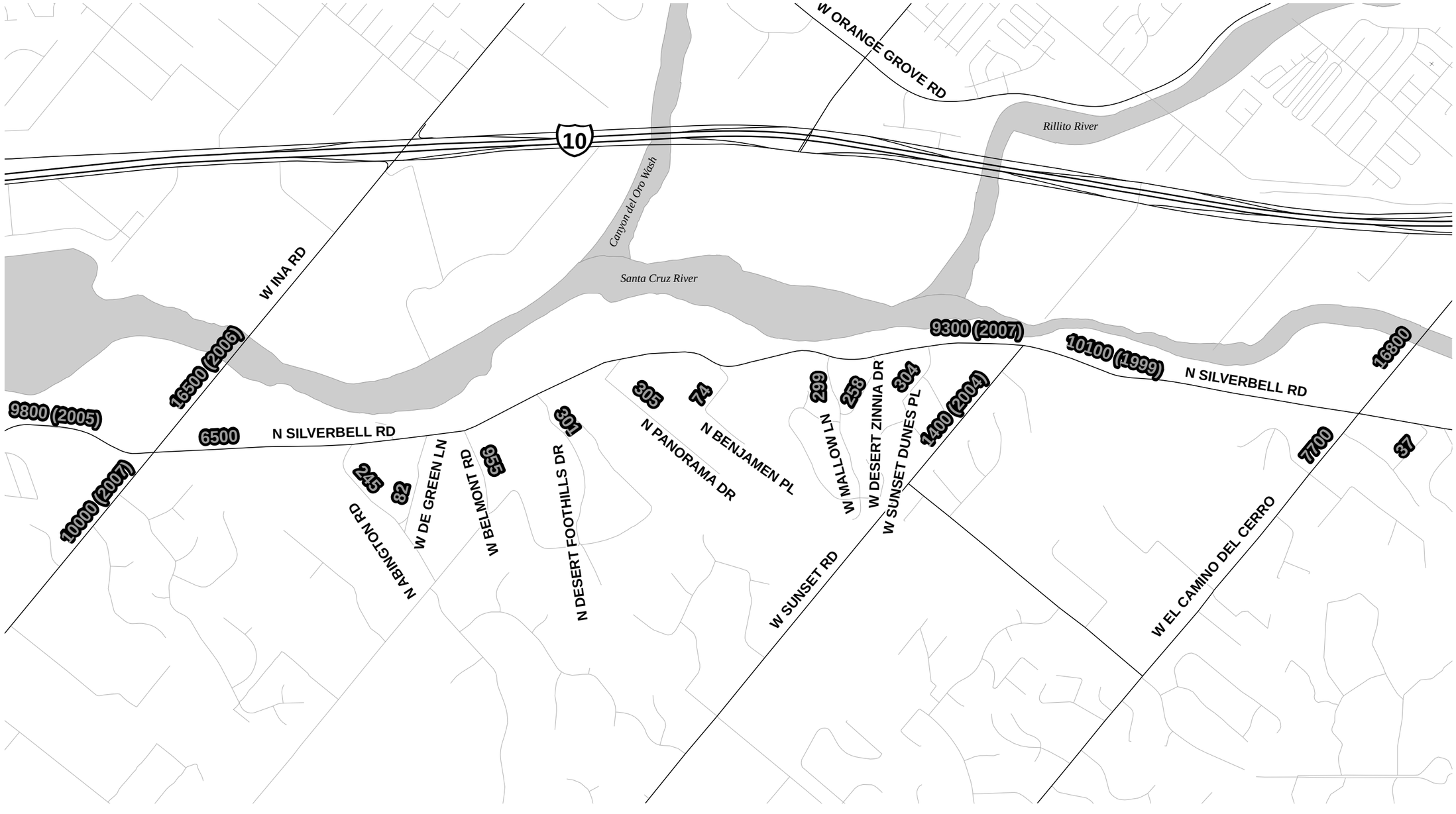
Traffic counts collected from May 19 to May 21, 2009 include morning and evening peak period turning movement counts at the six major intersections - Ina Road, Sunset Road, El Camino Del Cerro, Sweetwater Drive, Goret Road and Grant Road. 24-hour traffic counts were collected at several locations on Silverbell Road and on 25 side streets. The detailed count data are included in Appendix C. Additional daily traffic count data for the major cross streets were obtained from the Pima Association of Governments (PAG). PAG's daily traffic counts were collected between 1998 and 2007. These data were extended to 2009 using estimated growth rates. The 2009 daily traffic volumes are summarized in Exhibits 4A and 4B.

Intersection capacity analysis was performed using the Synchro 6 traffic analysis software which utilizes the current Highway Capacity Manual procedures. The Synchro model for this section of Silverbell Road was provided by the City of Tucson. The existing lane configurations and the capacity analysis results for the six major intersections (Ina Road, Sunset Road, El Camino Del Cerro, Sweetwater Drive, Goret Road and Grant Road) are summarized in Exhibit 5. The capacity analysis worksheets are provided in Appendix D. The results show that current overall intersection traffic operations are LOS D or better during the morning and evening peak periods. However, four movements operate at LOS E or F during one of the peak periods; they are the southbound left-turn (LOS E) at the Ina intersection during the PM peak, the westbound left-turn (LOS E) at the El Camino Del Cerro intersection during the AM peak, the eastbound left-turn and northbound left-turn (LOS F) at the Grant Road intersection during the PM peak.

Traffic factors listed in Exhibit 3 were calculated from the 24-hour roadway counts. The K-factor (K), which represents the percentage of daily traffic that occurs during the peak hour and directional split (D) are based on traffic flow during both morning and evening peak hours. The K-factors indicate that the peak traffic periods last one hour or so. The morning and evening peak hours occur from 7 to 8 a.m. and from 5 to 6 p.m. The morning peak direction is southbound while the evening peak direction is northbound. The directional split during both peak periods is relatively high.

Exhibit 3 Traffic Factors

Silverbell Road Section	K		D		Peak Direction	
	AM	PM	AM	PM	AM	PM
North of Sunset Road	0.10	0.09	0.75	0.72	South	North
South of El Camino Del Cerro	0.08	0.09	0.58	0.56	South	North
South of Goret Road	0.07	0.09	0.68	0.62	South	North



LEGEND

10000 Existing Average Daily Traffic Volume

(XXXX) Year of Traffic Volume (if not 2009)

EXISTING AVERAGE DAILY TRAFFIC
PIMA COUNTY, ARIZONA

EXHIBIT **4A**

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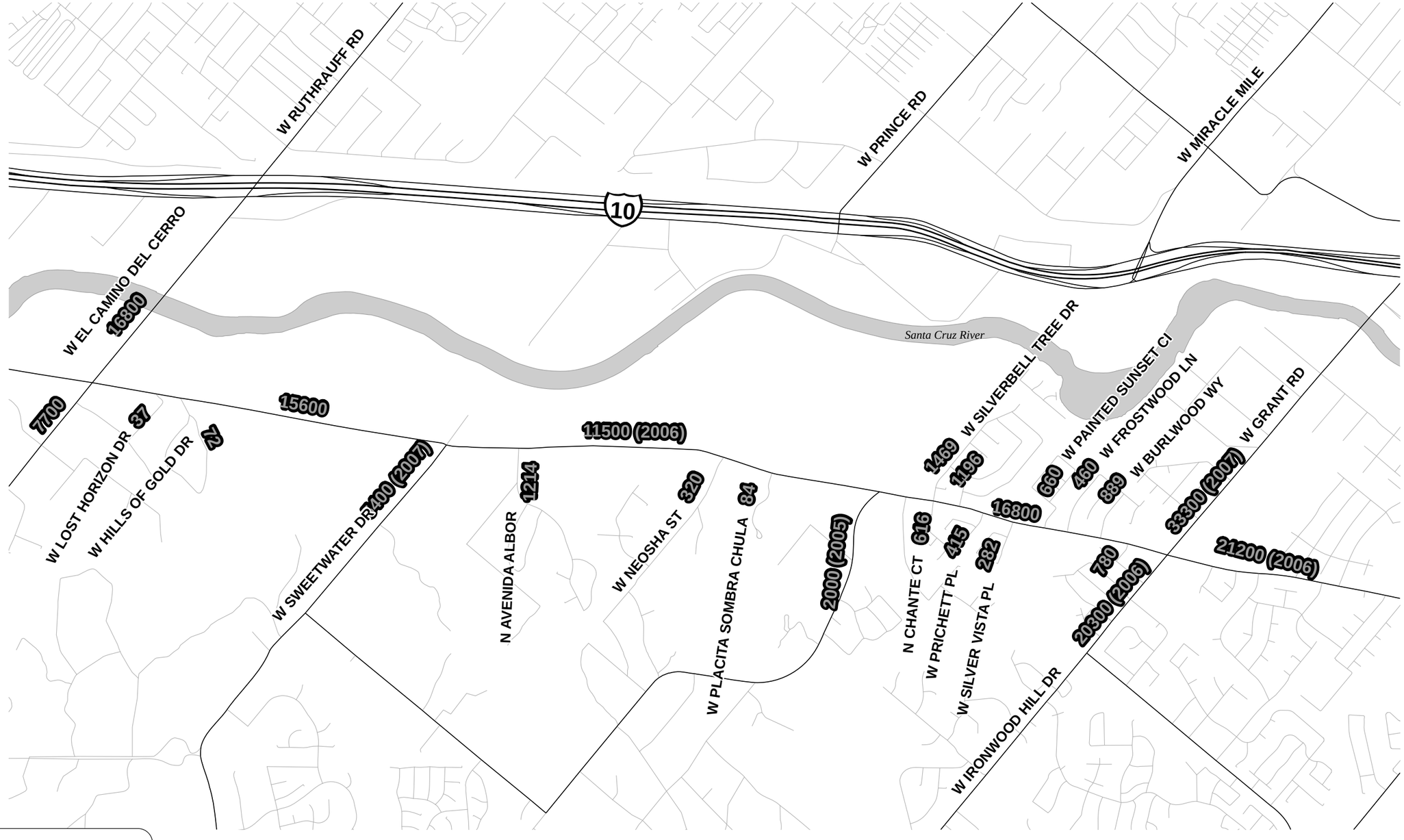

LEGEND

- 10000 — Existing Average Daily Traffic Volume
- (XXXX) — Year of Traffic Volume (if not 2009)

EXISTING AVERAGE DAILY TRAFFIC (CONTINUED)
PIMA COUNTY, ARIZONA

EXHIBIT **4B**

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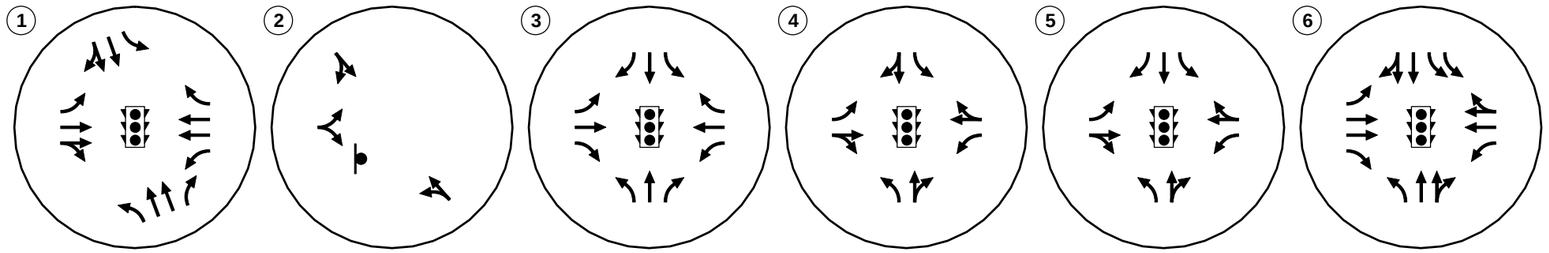
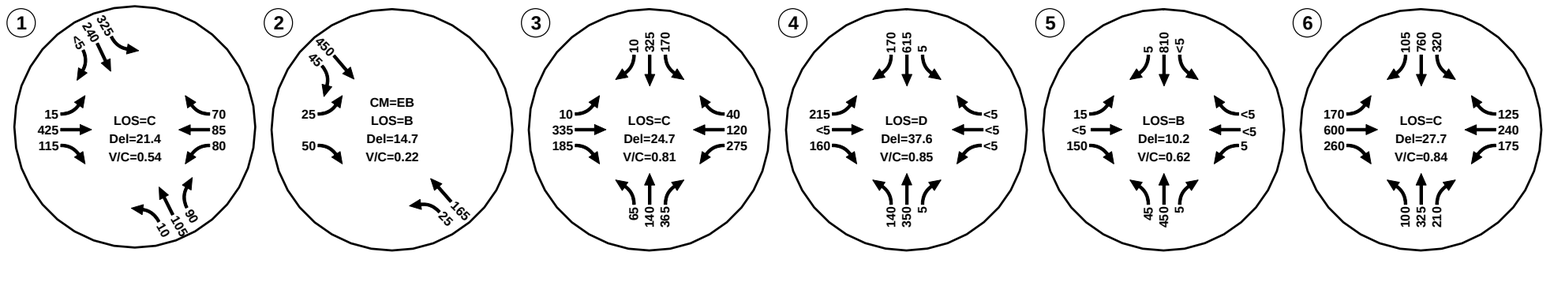
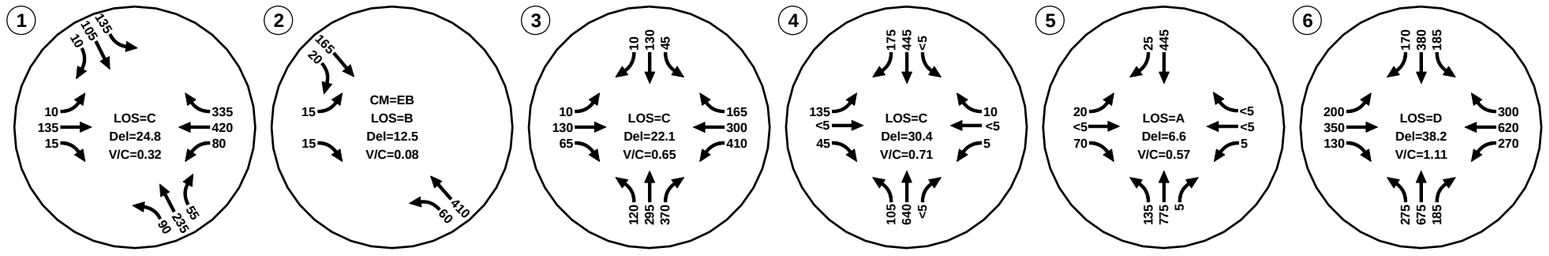
EXISTING LANE CONFIGURATION

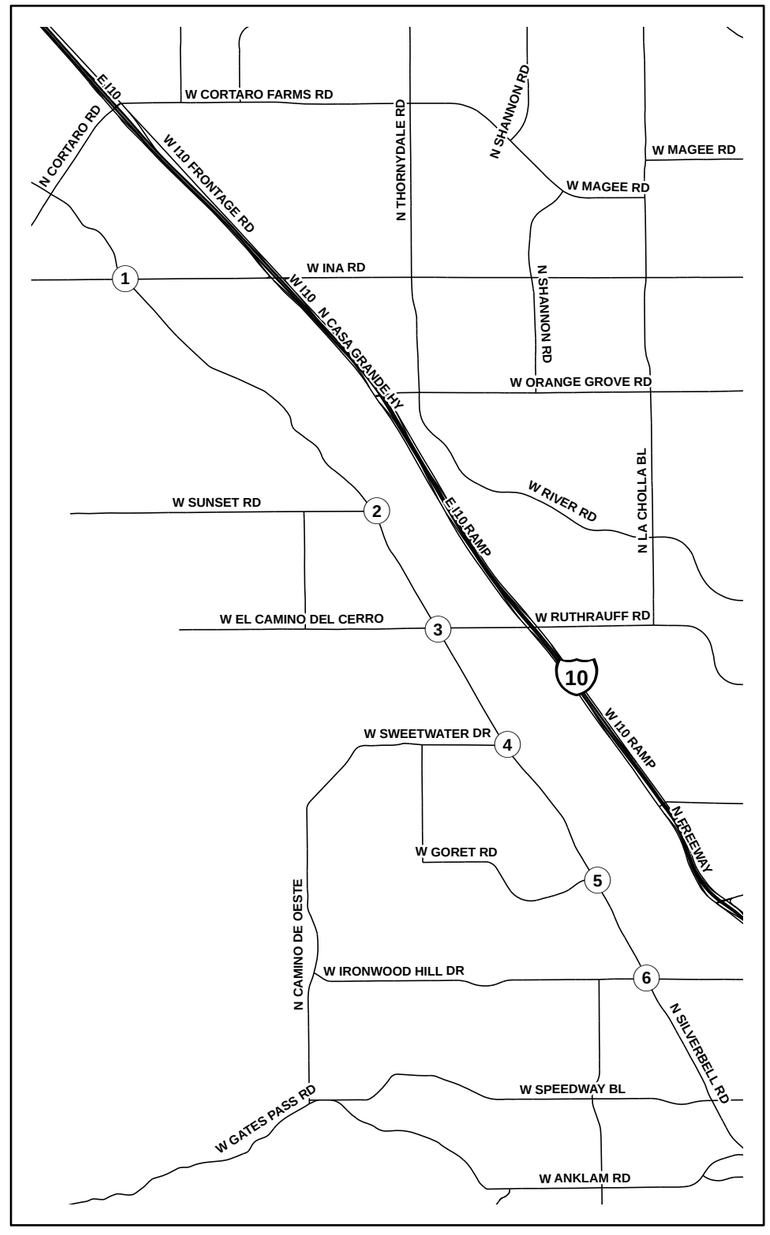


EXISTING AM PEAK PERIOD



EXISTING PM PEAK PERIOD





LEGEND

STOP SIGN

TRAFFIC SIGNAL

CM = CRITICAL MOVEMENT (UNSIGNALIZED)
LOS = INTERSECTION LEVEL OF SERVICE (SIGNALIZED)/CRITICAL MOVEMENT LEVEL OF SERVICE (UNSIGNALIZED)
Del = INTERSECTION AVERAGE CONTROL DELAY (SIGNALIZED)/CRITICAL MOVEMENT CONTROL DELAY (UNSIGNALIZED)
V/C = CRITICAL VOLUME-TO-CAPACITY RATIO

EXISTING LANE CONFIGURATION AND CAPACITY ANALYSIS RESULTS
PIMA COUNTY, ARIZONA

EXHIBIT **5**

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TRANSPORTATION ENGINEERING / PLANNING

2.5 HEAVY VEHICLE PERCENTAGE

Twenty-four hour vehicle classification counts were taken on May 19th, 2009 between El Camino Del Cerro and Sweetwater Drive. The results of the classification studies are summarized in Exhibit 6. In general, the observed heavy vehicle percentage is about 5%. Typical heavy vehicle percentages on arterials in Pima County range from 3% to 5%. FHWA defines heavy vehicles as those in the Categories "2 Axle 6 Tire" through "> 6 Axle Multi".

Exhibit 6 Silverbell Road Heavy Vehicle Percentage

Cars & Trailers	2 Axle Long	Bus	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Not Classified
70.6%	24.3%	0.3%	3.6%	0.4%	0.0%	0.5%	0.1%	0.0%	0.0%	0.0%	0.0%	4.8%

2.6 SIGNAL WARRANTS

Sunset Road is the major cross street with stop control along the study corridor. Included in the RTA funded transportation improvement plan is the extension of the Sunset Road east across the Santa Cruz River to I-10 and to River Road. Based on the peak-hour volumes taken at the Sunset Road intersection, the highest, 4th highest, and 8th highest eastbound volumes were 82 veh/h, 66 veh/h, and 49 veh/h, respectively. To meet MUTCD Signal Warrant 1 (Eight-Hour Vehicular Volume), the 8th highest side street volume needs to exceed 75 veh/h. To meet Warrant 2 (Four-Hour Vehicular Volume), the 4th highest side street volume would need to exceed 80 veh/h. As such, a signal control is not currently warranted at this intersection.

Hourly volumes were collected at all stop controlled minor side streets. Silverbell Tree Drive east of Silverbell Road has the highest daily volume among these side streets. The three highest volumes on Silverbell Tree Drive entering Silverbell Road were 88 veh/hr, 61 veh/hr and 58 veh/hr. These volumes are lower than the threshold volumes for the MUTCD warrants; therefore, no signals are currently warranted at any of the minor side streets.

2.7 CRASH HISTORY

Crash data for Silverbell Road from Ina Road to Grant Road was provided by the Tucson Police Department, Town of Marana Police Department, and Pima County Department of Transportation, for the 3-year period from January 1, 2006 to December 31, 2008. Crash data for each roadway segment and intersection were reviewed and are summarized in Exhibit 7A, 7B, 7C, 8A and 8B.

At Ina Road, Sunset Road, Sweetwater Drive and Goret Road, the crash rates are low relative to the average crash rate of 0.99 for signalized intersections within Pima County for the period from January 2005 to December 2007. The most frequent intersection crash types are rear-end and turning, which is typical for a high speed two-lane roadway. At Sweetwater Drive, 5 of the 6 rear-end crashes occurred on the southbound approach. At El Camino Del Cerro the typical crash types are turning and rear end and the crash rate is 1.33. Police reports indicate that most of the turning crashes at this intersection were caused by left-turners failing to yield to through traffic. Adding protected left turn phasing on Silverbell Road at El Camino Del Cerro should be considered and

may reduce the frequency of this type of crash. Grant Road intersection had the highest number of crashes and a crash rate of 1.18. Twenty-two of the 59 crashes were turning crashes. On the west leg of the Grant Road intersection, 7 of the 8 crashes are driveway related angle crashes. On the east leg, 15 of the 24 crashes are driveway related turning/angle crashes. Installing a raised median on Grant Road to prohibit the outbound left-turn movement from the nearby driveways would reduce the frequency of driveway related crashes.

The crash rate for each roadway segment, with the exception of segment between Goret Road and Grant Road, is below the average crash rate of 1.31 for roadway segments within Pima County for the period January 2005 to December 2007 [2]. On the segment between Goret Road and Grant Road, the crash rate is slightly higher than the regional average. No crashes were reported for the segment from Sunset Road to El Camino Del Cerro during the 3-year analysis period. Between Sweetwater Drive and Goret Road, 9 of the 16 crashes, including a fatality occurred at the Neosha Street intersection. The fatal head-on crash was the result of a southbound vehicle losing control and hitting a northbound vehicle. Between Goret Road and Grant Road, 13 of 33 crashes occurred within the northbound lane drop area that overlaps with the shopping center driveways. One bicycle related crash occurred at the Grant Road intersection which was the result of a northbound right-turning vehicle failing to yield to a northbound through bicycle.

Exhibit 7A Crash Data Summary (Jan. 1, 2006 – Dec. 31, 2008)

	Intersection							
	Ina Road		Sunset Road		El Camino Del Cerro		Sweetwater Drive	
Crash Type	Number	%	Number	%	Number	%	Number	%
Angle	4	29%	2	50%	6	17%	0	0%
Rear-end	6	50%	1	25%	11	31%	6	74%
Turning	0	0%	0	0%	17	47%	1	13%
Sideswipe	1	7%	0	0%	0	0%	0	0%
Single Vehicle	0	0%	1	25%	0	0%	1	13%
Ped/Bike	0	0%	0	0%	0	0%	0	0%
Backing	0	0%	0	0%	1	3%	0	0%
U-turn	0	0%	0	0%	0	0%	0	0%
Motorcycle	0	0%	0	0%	0	0%	0	0%
Head-on	1	7%	0	0%	0	0%	0	0%
Unknown	1	7%	0	0%	1	3%	0	0%
Total Crashs	13		4		36		8	
Daily Traffic	21,800		10,400		24,800		15,800	
Crash Rate[1,2]	0.55		0.35		1.33		0.46	
Fatal	0	0%	0	0%	0	0%	0	0%
Injury	3	23%	2	50%	11	31%	5	67%
Property Damage Only	10	77%	2	50%	25	69%	3	33%

1. Intersection crash rates refer to the number of crashes per million vehicles entering the intersection.

Rate = (number of 3-year crashes x 10^6)/(3 years x weekday entering volume x 365 days).

2. Segment crash rates refer to the number of crashes per million vehicles-miles of travel.

Rate = (number of 3-year crashes x 10^6)/(3 years x weekday volume x segment length x 365 days).

Exhibit 7B Crash Data Summary (Jan. 1, 2006 – Dec. 31, 2008) – Continued

	Intersection							
	Goret Road		Grant Road		Ironwood Hills Drive-Driveways West of Silverbell		Grant Road-Driveways East of Silverbell	
Crash Type	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Angle	0	0%	9	15%	7	88%	3	13%
Rear-end	5	71%	12	20%	0	0%	4	17%
Turning	1	14%	24	41%	0	0%	12	50%
Sideswipe	0	0%	7	12%	1	12%	2	8%
Single Vehicle	1	14%	1	2%	0	0%	1	4%
Ped/Bike	0	0%	1	2%	0	0%	0	0%
Backing	0	0%	2	3%	0	0%	0	0%
U-turn	0	0%	0	0%	0	0%	0	0%
Motorcycle	0	0%	1	2%	0	0%	0	0%
Head-on	0	0%	1	2%	0	0%	1	4%
Unknown	0	0%	1	2%	0	0%	1	4%
Total Crashs	7		59		8		24	
Daily Traffic	15,200		45,600		21,000		33,200	
Crash Rate[1,2]	0.42		1.18		0.34		0.66	
Fatal		0%	0	0%	0	0%	0	0%
Injury	2	29%	22	37%	2	25%	7	29%
Property Damage Only	5	71%	37	63%	6	75%	17	71%

1. Intersection crash rates refer to the number of crashes per million vehicles entering the intersection.

Rate = (number of 3-year crashes x 10^6)/(3 years x weekday entering volume x 365 days).

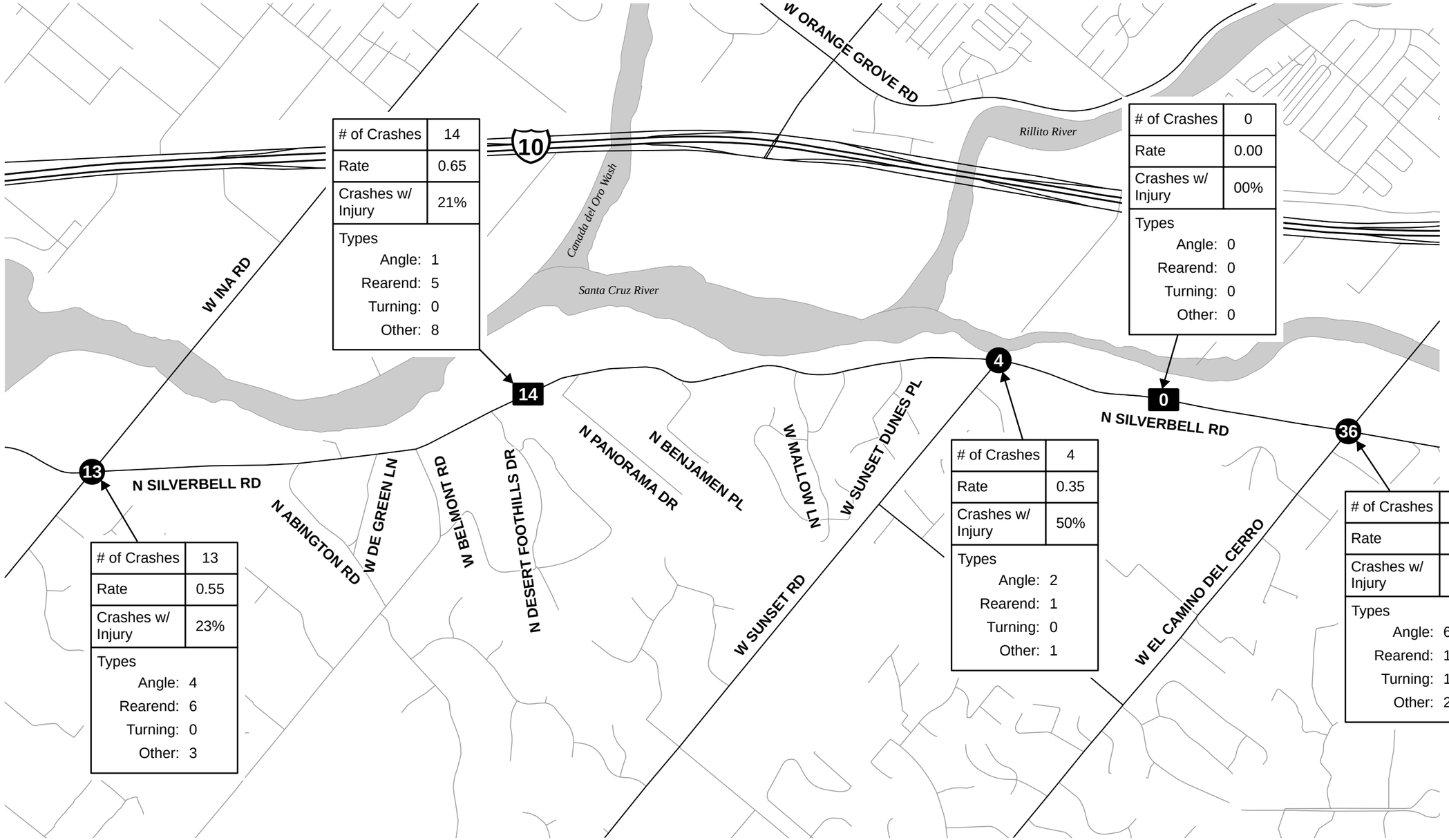
2. Segment crash rates refer to the number of crashes per million vehicles-miles of travel.

Rate = (number of 3-year crashes x 10^6)/(3 years x weekday volume x segment length x 365 days).

Exhibit 7C Crash Data Summary (January 1, 2006 – December 31, 2008) – Continued

	Segment							
	Ina Rd.-Sunset Rd.		El Camino De Cerro-Sweetwater Dr.		Sweetwater Dr.-Goret Rd.		Goret Rd.-Grant Rd.	
Crash Type	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Angle	1	7%	0	0%	2	13%	6	18%
Rear-end	5	36%	6	67%	7	44%	7	21%
Turning	0	0%	0	0%	1	6%	10	30%
Sideswipe	0	0%	1	11%	0	0%	4	12%
Single Vehicle	8	57%	1	11%	4	25%	4	12%
Ped/Bike	0	0%	0	0%	0	0%	0	0%
Backing	0	0%	0	0%	0	0%	0	0%
U-turn	0	0%	1	11%	0	0%	0	0%
Motorcycle	0	0%	0	0%	0	0%	1	3%
Head-on	0	0%	0	0%	1	6%	0	0%
Unknown	0	0%	0	0%	1	6%	1	3%
Total Crashs	14		9		16		33	
Daily Traffic	6,600		14,700		11,800		16,400	
Length (mi)	3.00		1.15		1.39		0.96	
Crash Rate[1,2]	0.65		0.49		0.89		1.91	
Fatal	0	0%	0	0%	1	6%	0	0%
Injury	3	21%	3	33%	7	44%	10	30%
Property Damage Only	11	79%	6	67%	8	50%	23	70%

1. Intersection crash rates refer to the number of crashes per million vehicles entering the intersection.
Rate = (number of 3-year crashes x 10^6)/(3 years x weekday entering volume x 365 days).
2. Segment crash rates refer to the number of crashes per million vehicles-miles of travel.
Rate = (number of 3-year crashes x 10^6)/(3 years x weekday volume x segment length x 365 days).



# of Crashes	14
Rate	0.65
Crashes w/ Injury	21%
Types	
Angle:	1
Rearend:	5
Turning:	0
Other:	8

# of Crashes	0
Rate	0.00
Crashes w/ Injury	00%
Types	
Angle:	0
Rearend:	0
Turning:	0
Other:	0

# of Crashes	4
Rate	0.35
Crashes w/ Injury	50%
Types	
Angle:	2
Rearend:	1
Turning:	0
Other:	1

# of Crashes	36
Rate	1.33
Crashes w/ Injury	31%
Types	
Angle:	6
Rearend:	11
Turning:	17
Other:	2

# of Crashes	13
Rate	0.55
Crashes w/ Injury	23%
Types	
Angle:	4
Rearend:	6
Turning:	0
Other:	3

LEGEND

(#) # of Intersection Crashes

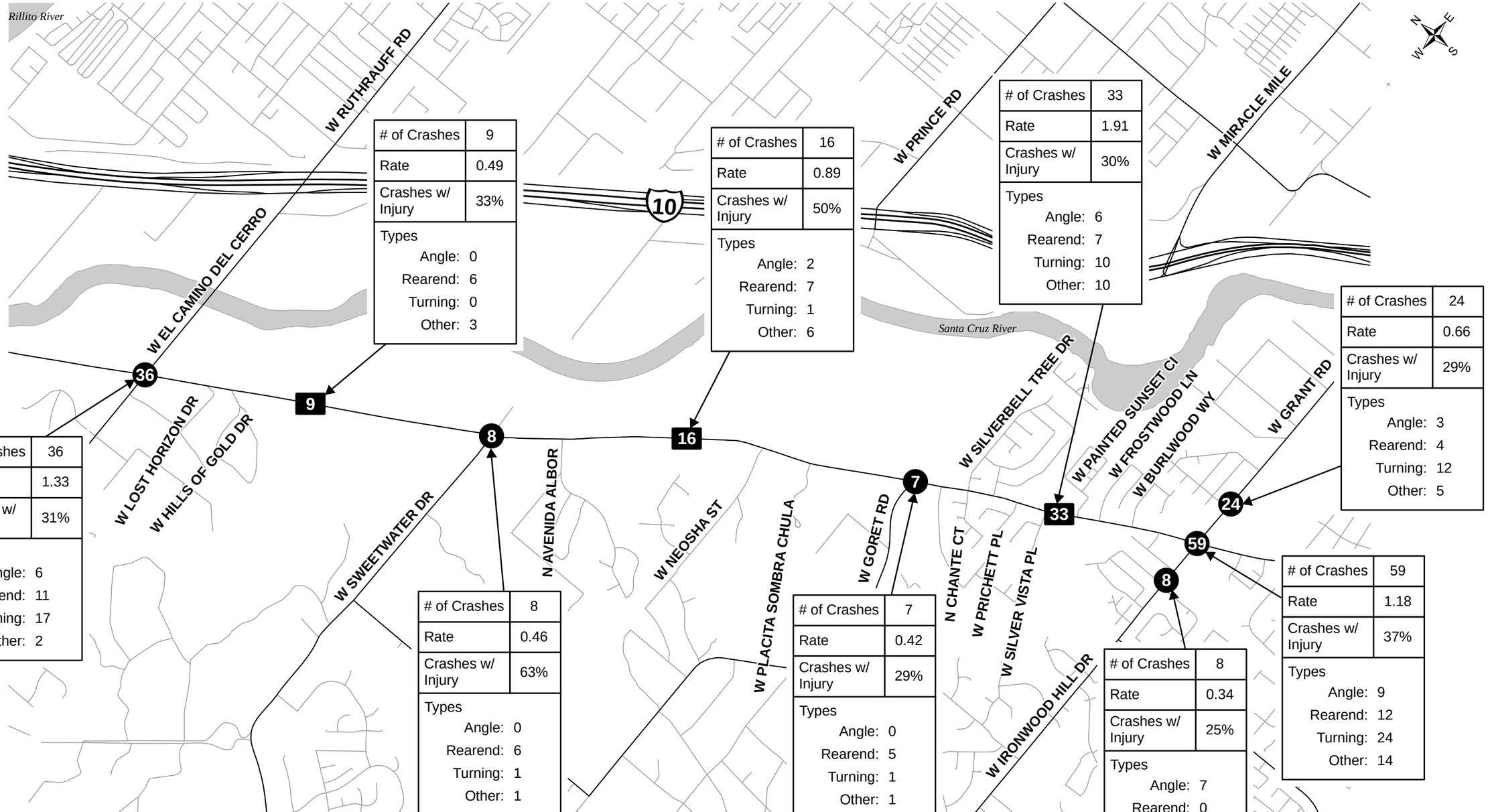
[#] # of Segment Crashes

Crash totals from 2006 thru 2008

SUMMARY OF CRASHES
PIMA COUNTY, ARIZONA

EXHIBIT **8A**

H:\profile\9589 - Silverbell Road DCR\data\GIS\Figures & Maps\TER Figures\Fig8a_Crashes-North.mxd



# of Crashes	9
Rate	0.49
Crashes w/ Injury	33%
Types	
Angle:	0
Rearend:	6
Turning:	0
Other:	3

# of Crashes	16
Rate	0.89
Crashes w/ Injury	50%
Types	
Angle:	2
Rearend:	7
Turning:	1
Other:	6

# of Crashes	33
Rate	1.91
Crashes w/ Injury	30%
Types	
Angle:	6
Rearend:	7
Turning:	10
Other:	10

# of Crashes	24
Rate	0.66
Crashes w/ Injury	29%
Types	
Angle:	3
Rearend:	4
Turning:	12
Other:	5

# of Crashes	36
Rate	1.33
Crashes w/ Injury	31%
Types	
Angle:	6
Rearend:	11
Turning:	17
Other:	2

# of Crashes	8
Rate	0.46
Crashes w/ Injury	63%
Types	
Angle:	0
Rearend:	6
Turning:	1
Other:	1

# of Crashes	7
Rate	0.42
Crashes w/ Injury	29%
Types	
Angle:	0
Rearend:	5
Turning:	1
Other:	1

# of Crashes	59
Rate	1.18
Crashes w/ Injury	37%
Types	
Angle:	9
Rearend:	12
Turning:	24
Other:	14

# of Crashes	8
Rate	0.34
Crashes w/ Injury	25%
Types	
Angle:	7
Rearend:	0
Turning:	0
Other:	1

LEGEND

(#) # of Intersection Crashes

[#] # of Segment Crashes

Crash totals from 2006 thru 2008

SUMMARY OF CRASHES (CONTINUED)
PIMA COUNTY, ARIZONA

EXHIBIT **8B**

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2.8 ALTERNATIVE MODES

Transit

Route 21 (West Congress/Silverbell) currently provides weekday and weekend service on Silverbell Road between St. Mary's Road and Goret Road. There are five bus stops between Grant Road and Goret Road. Bus headways range from 30 minutes during the daytime to 60 minutes in the evening. Currently, Sun Tran does not have any plans to expand transit service along Silverbell Road. In addition to Sun Tran buses, school buses also frequently use Silverbell Road during the morning and afternoon pickup hours. The following schools have bus pickup locations along the study corridor: Borton Elementary School, Robins Elementary School, Booth-Fickett Math/Science Magnet Middle School, Mansfeld Middle School, Maxwell Middle School, Palo Verde High Magnet School, and Tucson High School. The pickup locations along Silverbell Road are at Painted Sunset Circle, Xochipilli Drive, Hills of Gold Drive, Silverbell Arrow Drive, Burlwood Way, Prichett Place, and Neosha Street.

Bicycles

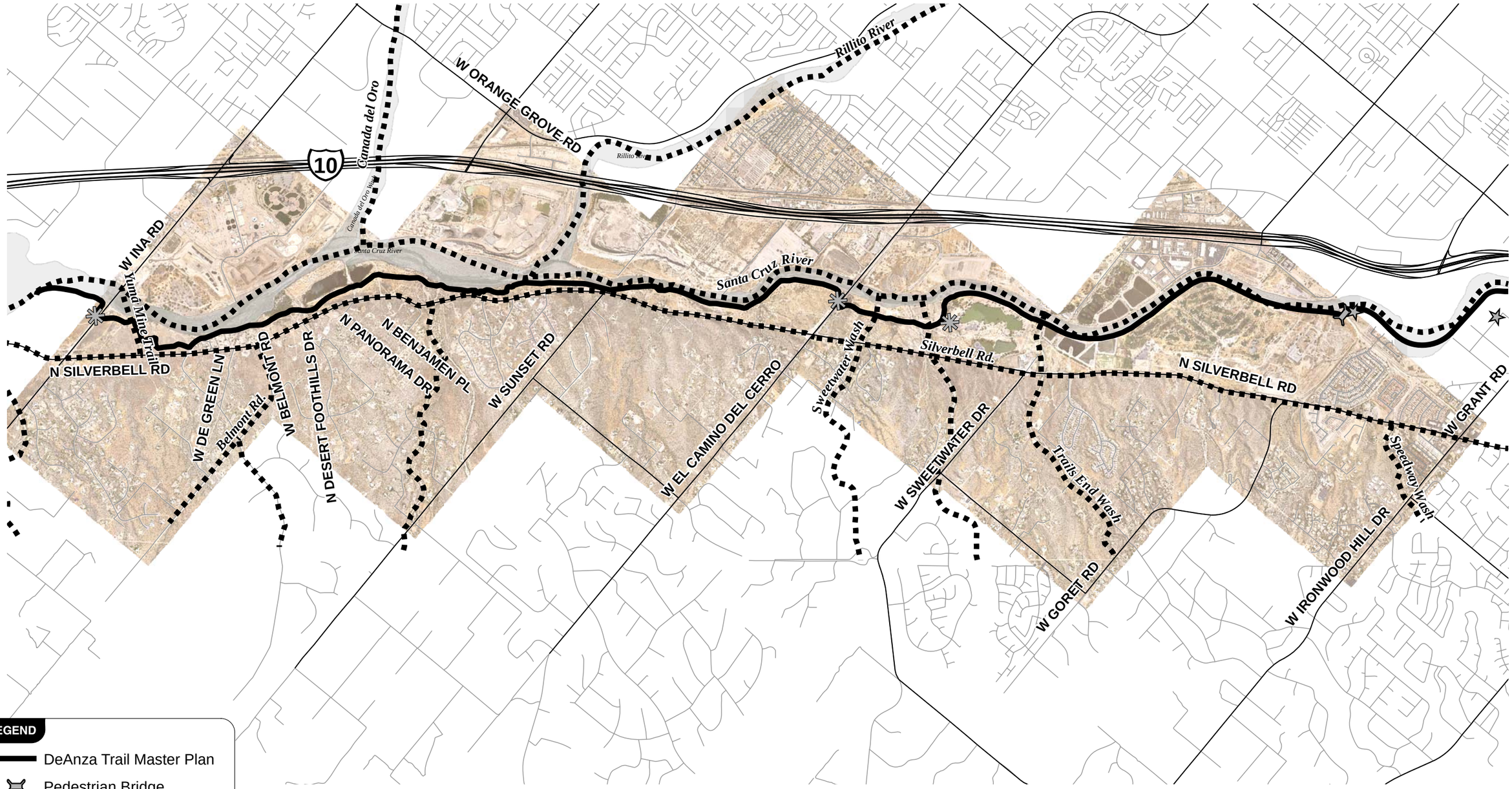
Silverbell Road, between Grant Road and Sunset Road and from Abington Road to Ina Road (3/4 mile) is designated as a bike route with striped shoulders. The shoulder width varies from 4-6 feet in these sections. The rest of the corridor, from Sunset Road to Abington Road, is not designated for bicycle use as the paved shoulder widths are only one foot. Still, the Silverbell Road corridor is a favorite for bicycle enthusiasts.

Pedestrians

Pedestrian facilities in the project area are limited primarily to unpaved, and in some segments, un-graded shoulders. Sidewalk does exist within the vicinity of the commercial properties at Grant Road. Cross walks are provided only at the signalized intersection. Due to the lack of pedestrian facilities, as well as the relatively low density of both residential and commercial development, pedestrian demand within the corridor is very low. Implementation of bicycle/pedestrian paths along both banks of the Santa Cruz River as part of the Pima County river park system is planned. The path along the west side of the river will be the officially designated De Anza Trail.

Trails

A number of unimproved equestrian/hiking trails are located within the roadway corridor and are illustrated in Exhibit 9. These include the shoulders of Silverbell Road itself, the Santa Cruz River, and several of the larger washes. Equestrian activity within the corridor primarily occurs west of Silverbell Road and within the Santa Cruz River. Due to limited shoulders, activity immediately adjacent to Silverbell Road is very limited. Crossing of Silverbell Road to get to the Santa Cruz River is a more frequent occurrence.



LEGEND

- DeAnza Trail Master Plan
- Pedestrian Bridge
- Trail Access
- Historical Site
- Existing Trails

EXISTING AND PROPOSED TRAILS
PIMA COUNTY, ARIZONA

EXHIBIT **9**

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2.9 LIGHTING AND ITS

Current roadway lighting is limited to each of the signalized intersections and several unsignalized intersections (Avenida Alber, Christopher Columbus Park entrance, and Sunset Road). South of Grant Road, continuous roadway lighting is provided on Silverbell Road. The Town of Marana outdoor lighting code designates Silverbell Road as rural with lighting levels appropriate for residential or agricultural land uses. That portion of corridor within Pima County and the City of Tucson is designated an urban lighting area in which lighting levels associated with commercial and industrial activity, apartments, and suburban residential developments are allowed.

Each of the three jurisdictions follows different practices for the installation of continuous roadway lighting. The Town of Marana typically does not install continuous roadway lighting, but only lights signalized intersections. Pima County only installs continuous roadway lighting in areas with a relatively high density of access points and/or heavy vehicular access activity, heavy pedestrian activity, or where there is a history of nighttime crashes that may be mitigated with roadway lighting. While Pima County does not typically install continuous lighting on arterial roadways, lighting is often installed at higher-volume unsignalized intersections (side streets or driveways). Originally implemented in the late 1970's, the City of Tucson has a formal program to evaluate and prioritize roadway lighting needs. Over the last 30 years, the City has upgraded and expanded their roadway lighting system in order to improve public safety. The Tucson Comprehensive Roadway Illumination Study, which was last updated in 2003, recommends a program to add roadway lighting to 84 miles of arterials within the City over a 10-year period. The program includes the section of Silverbell Road from Grant Road to the city limits north of El Camino del Cerro. Inclusion of this section of Silverbell Road in the current arterial lighting program was significantly influenced by the presence of deficient roadway geometry. Lighting along El Camino del Cerro between I-10 and Silverbell Road is also planned.

The City of Tucson has fiber optic cable attached to the TEP poles running between Grant Road and Sweetwater Drive. While there are no specific plans to extend agency owned fiber optic cable within the corridor, City Communications has noted that it is desirable to link the City system with Marana. City of Tucson Traffic Engineering utilizes this fiber optic communications network to link its signals as well as the recently installed mesh radio system to the regional traffic signal operations center. Pima County and the Town of Marana routinely install fiber optic cable, or at a minimum the conduit and pull boxes, as part of their roadway CIP projects.

3. Future Conditions

Traffic demand on Silverbell Road will grow as development occurs within the corridor between I-10 and the Tucson Mountains and in the Town of Marana. The regional transportation improvement plan developed by the RTA and approved by voters includes the widening of the 8-mile section of Silverbell Road from Ina Road to Grant Road to a 3 or 4-lane divided desert parkway to add capacity and improve safety. Other planned improvements in the vicinity of Silverbell Road include extending Twin Peaks Road from Silverbell Road to I-10 in Marana, extending Sunset Road from Silverbell Road to I-10 and River Road, and grade separating the railroad crossings at Ina Road and Ruthrauff Road. Each of these improvements is included in the PAG regional traffic forecasting model, as well as the recently completed widening of I-10.

3.1 TRAFFIC PROJECTIONS

Future 30-year traffic demands were developed utilizing 2040 projections produced by the current Pima Association of Governments (PAG) regional traffic forecasting model. Traffic projections were prepared for three scenarios of the Sunset Road extension,

- Scenario 1 - Sunset Road extension not in place;
- Scenario 2 - Sunset Road extension to I-10 only;
- Scenario 3 - Sunset Road extension to River Road.

The 2040 traffic projections are presented in Exhibits 10A, 10B, and 10C and are summarized below.

- The extension of Sunset Road is projected to carry 17,000 vpd. The Sunset Road connection will not generate new trips on Silverbell Road, but will reroute trips that use Grant Road, Ina Road, and El Camino del Cerro to cross the Santa Cruz River.

- Traffic demand on Silverbell Road north of Sunset Road is expected to grow from 7,500 vpd to some 22,000 vpd (nearly 200% growth) over the next 30 years. Much of this growth will be generated by development in Marana, although significant growth is projected west of Silverbell Road in the vicinity of Sunset Road. While development along Silverbell Road will be limited, it will also contribute to overall corridor traffic growth. Traffic between Sunset Road and El Camino del Cerro is projected to more than double (120% growth) while lesser growth (60-80%) is expected to occur between El Camino del Cerro and Grant Road. PAG's predicted negative growth south of Grant Road was adjusted to reflect a small amount of growth (13%) over the 30 year period.

- Traffic growth on Ina Road west of Silverbell Road is projected to be relatively low (5%) when compared to Silverbell Road. This small amount of growth is influenced by the zoning along Ina Road that only allows for low density residential development.

- On Sunset Road, PAG predicts high traffic growth (300%) generated by future residential development west of Silverbell Road. Still, future traffic volumes on Sunset Road to the west are projected to reach only approximately 5,000 vpd.

- On El Camino Del Cerro, PAG predicts low growth to the west of Silverbell Road, which is reasonable considering that zoning along El Camino Del Cerro allows for only low density residential development and most of the surrounding area is already built out. On Grant Road, PAG predicts moderate growth to the west of Silverbell Road (2%) and almost no growth to the east of Silverbell Road. This is due to the moderate population growth of the surrounding area and the widened I-10 which will attract traffic from Silverbell Road.

- Goret Road, west of Silverbell Road, is also projected to have high traffic growth (230%) with volumes reaching some 6,700 vpd. PAG's current traffic forecasting model does not include Goret Road east of Silverbell Road, however, based on current development plans, 145 single family houses will be built in this area. This planned development could ultimately generate as many as 1,400 daily trips based on a typical residential trip rate of 10 trip ends/day (ITE Trip Generation Manual).

Using existing traffic factors and turning movement counts, as well as projected turning percentages produced by PAG, 2040 peak period turning volumes were developed and used in the analysis of intersection capacity requirements. These turning volumes are included with the intersection analysis results in Exhibits 13A, 13B, and 13C, respectively. Worksheets used to develop the future turning movement volumes are provided in Appendix E.

Exhibit 10A Traffic Projections – Scenario 1

Roadway	Segment	Existing ADT (year)	PAG		Assumed For This Study	
			2040	% Growth	2040	% Growth
Ina Rd	West	10,000(2007)	12,300	23%	12,300	23%
	East	16,500(2006)	18,900	15%	19,300	17%
Sunset Rd	West	1,400(2004)	4,800	240%	4,800	240%
	East	N/A	N/A	N/A	N/A	N/A
El Camino Del Cerro	West	7,700(2009)	8,300	8%	8,300	8%
	East	16,800(2009)	23,700	41%	23,700	41%
Sweetwater Dr	West	5,000(2007)	11,800	136%	11,800	136%
	East	N/A	N/A	N/A	600	N/A
Goret Rd	West	2,000(2005)	6,700	235%	6,700	235%
	East	N/A	N/A	N/A	1,400	N/A
Ironwood Hills Dr/Grant Rd	West	20,300(2006)	30,900	52%	31,500	55%
	East	33,300(2007)	34,000	2%	38,400	13%
Silverbell Rd	North of Ina	9,800(2005)	24,000	145%	24,000	145%
	South of Ina	6,500(2009)	22,100	240%	22,100	240%
	North of Sunset	9,300(2007)	21,100	127%	21,100	127%
	South of Sunset Rd	10,100(1999)	21,500	113%	21,500	113%
	North of El Camino Del Cerro	10,100(1999)	22,900	126%	22,900	126%
	El Camino Del Cerro – Sweetwater	15,600(2009)	28,500	83%	28,500	83%
	South of Sweet Water	11,500(2006)	20,700	80%	20,700	80%
	North of Goret	11,500(2006)	20,700	80%	20,700	80%
	South of Goret	16,800(2009)	23,300	39%	23,300	39%
	North of Ironwood Hill/Grant	16,800(2009)	28,400	69%	28,400	69%
	South of Ironwood Hill/Grant	21,200(2006)	20,600	-0.3%	24,800	17%

Exhibit 10B Traffic Projections – Scenario 2

Roadway	Segment	Existing ADT (year)	PAG		Assumed For This Study	
			2040	% Growth	2040	% Growth
Ina Rd	West	10,000(2007)	12,500	25%	12,500	25%
	East	16,500(2006)	16,800	2%	17,200	2%
Sunset Rd	West	1,400(2004)	5,500	293%	5,500	293%
	East	N/A	17,500	N/A	17,500	N/A
El Camino Del Cerro	West	7,700(2009)	7,600	-1%	8,000	4%
	East	16,800(2009)	17,800	6%	17,800	6%
Sweetwater Dr	West	5,000(2007)	12,300	146%	12,300	146%
	East	N/A	N/A	N/A	600	N/A
Goret Rd	West	2,000(2005)	6,700	235%	6,700	235%
	East	N/A	N/A	N/A	1,400	N/A
Ironwood Hills Dr/Grant Rd	West	20,300(2006)	31,400	55%	32,000	58%
	East	33,300(2007)	31,900	-4%	36,300	9%
Silverbell Rd	North of Ina	9,800(2005)	24,300	148%	24,300	148%
	South of Ina	6,500(2009)	23,100	255%	23,100	255%
	North of Sunset	9,300(2007)	22,400	141%	22,400	141%
	South of Sunset Rd	10,100(1999)	21,200	110%	21,200	110%
	North of El Camino Del Cerro	10,100(1999)	21,800	116%	21,800	116%
	El Camino Del Cerro – Sweetwater	15,600(2009)	29,500	89%	29,500	89%
	South of Sweet Water	11,500(2006)	21,300	85%	21,300	85%
	North of Goret	11,500(2006)	22,000	91%	22,000	91%
	South of Goret	16,800(2009)	23,700	41%	23,700	41%
	North of Ironwood Hill/Grant	16,800(2009)	28,700	71%	28,700	71%
	South of Ironwood Hill/Grant	21,200(2006)	19,600	-8%	23,800	13%

Exhibit 10C Traffic Projections – Scenario 3

Roadway	Segment	Existing ADT (year)	PAG		Assumed For This Study	
			2040	% Growth	2040	% Growth
Ina Rd	West	10,000(2007)	12,500	25%	12,500	25%
	East	16,500(2006)	16,900	2%	17,300	5%
Sunset Rd	West	1,400(2004)	5,600	300%	5,600	300%
	East	N/A	17,000	N/A	17,000	N/A
El Camino Del Cerro	West	7,700(2009)	7,500	-3%	8,000	4%
	East	16,800(2009)	18,100	8%	18,100	8%
Sweetwater Dr	West	5,000(2007)	12,300	146%	12,300	146%
	East	N/A	N/A	N/A	600	N/A
Goret Rd	West	2,000(2005)	6,700	235%	6,700	235%
	East	N/A	N/A	N/A	1,400	N/A
Ironwood Hills Dr/Grant Rd	West	20,300(2006)	31,400	55%	32,000	58%
	East	33,300(2007)	31,800	-5%	36,200	9%
Silverbell Rd	North of Ina	9,800(2005)	24,100	146%	24,100	146%
	South of Ina	6,500(2009)	22,200	242%	22,200	242%
	North of Sunset	9,300(2007)	21,800	134%	21,800	134%
	South of Sunset Rd	10,100(1999)	22,900	126%	22,900	126%
	North of El Camino Del Cerro	10,100(1999)	23,300	130%	23,300	130%
	El Camino Del Cerro – Sweetwater	15,600(2009)	29,500	89%	29,500	89%
	South of Sweet Water	11,500(2006)	21,700	89%	21,700	89%
	North of Goret	11,500(2006)	22,400	95%	22,400	95%
	South of Goret	16,800(2009)	23,900	42%	23,900	42%
	North of Ironwood Hill/Grant	16,800(2009)	28,900	72%	28,900	72%
	South of Ironwood Hill/Grant	21,200(2006)	19,600	-8%	23,800	12%

3.2 SIGNAL WARRANTS

For Scenario 1, no Sunset Road extension on the east side of Silverbell Road, the Signal Warrant 1 and 2 are met at the Sunset Road intersection using the projected 2040 peak-hour turning volumes. It is recommended that conduit and pullbox be installed at this intersection. If Sunset Road is not extended to I-10 as planned, Pima County transportation engineering staff should monitor the future traffic demand and safety at this intersection and install the signal control when needed. For the other two scenarios, the projected 2040 daily traffic on Sunset Road east of Silverbell Road will be over 17,000. Therefore, the signal control is required to accommodate the traffic demand at this intersection. The warrant analysis for the Scenarios 1 is provided in Appendix F.

3.3 CAPACITY AND LEVEL OF SERVICE ANALYSIS

3.3.1 Methodology

Future intersection and roadway lane requirements were determined based on the results of capacity and level of service analysis of the 2040 traffic forecasts. All three scenarios related to the Sunset Road extension were evaluated using Synchro. The following criteria were assumed for the intersection capacity and level of service analysis.

- Percentages of heavy vehicles are the same as existing conditions if greater than 2%, otherwise 2%.
- Peak-hour factors are the same as existing if lower than 0.92, otherwise 0.92.
- 4-phase signal operation with permitted/protected left-turn phasing, if needed.
- Cycle lengths are optimized to minimize intersection delay.
- Right-turns on red are permitted.
- Clearance interval (all red plus yellow) settings are the same as existing settings.
- Considering the wide signal spacing, Arrival Type 3, representing random arrivals, was assumed.

Intersection capacity analysis worksheets are provided in Appendix G. The intersection level of service analysis results of the three scenarios are summarized in Exhibits 11A, 11B, and 11C, respectively. The intersection level of service analysis results and the required lane configuration to provide LOS D or better are summarized in Exhibits 13A, 13B, and 13C.

3.3.2 Level of Service

Level of Service (LOS) is a qualitative measure used to describe how a roadway facility (an intersection or roadway section), operates under a given set of conditions. These conditions include, but are not limited to, vehicle and pedestrian volumes, number and width of lanes, grade, available shoulder and median widths, and the type of traffic control (traffic signal, stop sign, etc.) that is present. Six levels of service (LOS A through F) are defined by a traffic flow measure that is considered a primary indicator of how each facility type is operating. For signalized and unsignalized intersections, this measure is the average time (seconds) that vehicles are delayed (not running at normal operating speed) at the intersection. For arterials, the measure is the average travel speed of vehicles.

Considering that this section of Silverbell Road will have limited access with a relatively low frequency of driveways and side streets compared to a more commercialized arterial, such as Grant Road or Speedway Boulevard, the overall roadway level of service will be controlled by the operation of the signalized intersections. The LOS gradient for a signalized intersection is described as follows:

LOS	Average Delay per Vehicle (sec)
A	<= 10
B	>10-20
C	>20-35
D	**>35-55**
E	>55-80
F	>80

LOS Criteria

City of Tucson, Pima County, and Town of Marana roadway design guidelines require that improvements shall provide sufficient capacity so that roadway segments and intersections operate at LOS D or better based on the projected future traffic demand.

3.3.3 Roadway Segment Capacity

General roadway capacity requirements for Silverbell Road can be estimated using planning level roadway capacity thresholds adopted by PAG. PAG sets the capacities for 2- and 4-lane roadways at 21,400 and 43,000 vehicles per day (vpd). At a planning level, roadway lane requirements are typically determined based on 80% of the roadway capacity, which essentially reflects LOS D traffic operations. Applied to the PAG capacities, 2 and 4-lane roadways can carry approximately 17,100 and 34,400 vpd, respectively, at LOS D. Using these criteria, four through lanes on Silverbell Road will be required and to serve traffic demands projected for 2040 and beyond.

The RTA's transportation plan lists either a 3-lane or 4-lane options for the Silverbell Road section from El Camino Del Cerro to Ina Road. A 4-lane cross section is preferred for several reasons.

- The 2040 traffic projections on the section between El Camino Del Cerro and Ina Road range from 21,000 to 23,000 vpd. This demand level would result in LOS E or F on a 3-lane facility.
- The intersection capacity analysis indicated that two through lanes in each direction would be required at the Ina Road, Sunset Road, and El Camino Del Cerro intersections. This is essentially a 4-lane cross section.
- A 3-lane cross section would also likely require deceleration lanes for right-turn traffic at most side streets considering the high speed design on Silverbell Road. This is essentially a 4-lane cross section.
- The additional capacity provided by 4-lane cross section will allow for easier and safer access onto Silverbell Road from side streets and driveways.
- Frequent transitions from a 3-lane roadway to a 3-lane plus deceleration lanes or a 4-lane cross section at signalized intersections would result in a non-uniform roadway and would impact traffic flow.

3.3.4 Intersection Capacity

The results of the intersection capacity analyses indicate that with the provision of sufficient turn lane capacity, a 4-lane cross section will provide satisfactory (LOS D or better) traffic operations for projected 2040 traffic demand. The average delays for each intersection approach and for the entire intersection generally fall within the range of delay used to define LOS A to C with some exceptions. This indicates that the intersection configurations provided in Exhibit 13A, 13B, and 13C will provide some excess capacity to serve additional traffic demand beyond that predicted for 2040. The traffic analysis results indicate that dual westbound left-turn lanes are required at the El Camino Del Cerro intersection if Sunset Road is not extended (Scenario 1). Dual northbound and southbound left-turn lanes will be required at Grant Road for all three scenarios. The intersection at Ina Road was recently reconstructed and opened in March 2009. The current lane configuration can accommodate the predicted 2040 traffic demand for all three scenarios.

Exhibit 11A Summary of Projected Future Traffic Conditions

Intersection	Approach	Movement / Approach	LOS and Average Delay (s/veh)					
			Scenario 1		Scenario 2		Scenario 3	
			AM	PM	AM	PM	AM	PM
Ina Rd / Silverbell Rd	EB	LT	B(18)	C(22)	B(18)	C(21)	B(18)	C(21)
		TH+RT	C(29)	C(22)	C(30)	C(22)	C(29)	C(22)
		Approach	C(29)	C(22)	C(29)	C(22)	C(29)	C(22)
	WB	LT	D(36)	B(13)	C(32)	B(13)	C(32)	B(13)
		TH	C(21)	B(20)	C(21)	B(19)	C(21)	B(19)
		RT	B(11)	B(14)	B(11)	B(14)	B(11)	B(14)
		Approach	C(24)	B(17)	C(22)	B(16)	C(22)	B(16)
	SB	LT	D(53)	D(42)	D(54)	D(37)	D(55)	C(33)
		TH+RT	C(34)	C(22)	C(35)	C(22)	C(35)	C(22)
		Approach	D(40)	C(29)	D(41)	C(27)	D(41)	C(25)
	NB	LT	C(22)	B(14)	C(22)	B(16)	C(22)	B(15)
		TH	C(25)	B(23)	C(25)	C(23)	C(25)	C(23)
		RT	C(24)	B(18)	C(24)	B(18)	C(24)	B(18)
		Approach	C(25)	C(21)	C(25)	C(21)	C(25)	C(21)
	Intersection		C(32)	C(21)	C(32)	C(21)	C(32)	C(21)
Sunset Rd / Silverbell Rd	EB	LT	B(17)	B(18)	C(23)	C(22)	C(21)	C(22)
		TH	N/A	N/A	C(26)	C(26)	C(25)	C(26)
		RT	B(18)	B(17)	C(25)	C(25)	C(24)	C(25)
		Approach	B(18)	B(17)	C(25)	C(25)	C(23)	C(24)
	WB	LT	N/A	N/A	C(23)	B(16)	C(22)	C(22)
		TH	N/A	N/A	C(22)	B(19)	C(21)	B(19)
		RT	N/A	N/A	C(22)	C(24)	C(21)	C(22)
		Approach	N/A	N/A	C(23)	C(21)	C(21)	C(22)
	SB	LT	N/A	N/A	B(11)	B(14)	B(10)	B(16)
		TH	A(5)	A(3)	B(12)	B(13)	B(13)	B(13)
		RT	A(5)	A(3)	B(9)	B(12)	B(11)	B(12)
		Approach	A(5)	A(3)	B(11)	B(13)	B(12)	B(13)
	NB	LT	A(7)	A(4)	B(15)	A(10)	B(14)	A(10)
		TH	A(4)	A(4)	B(15)	B(15)	B(14)	B(15)
		RT	N/A	N/A	B(15)	B(13)	B(14)	B(13)
		Approach	A(4)	A(4)	B(15)	B(14)	B(14)	B(14)
	Intersection		A(6)	A(5)	B(16)	B(16)	B(16)	B(17)

Exhibit 11B Summary of Projected Future Traffic Conditions - Continued

Intersection	Approach	Movement/ Approach	LOS and Average Delay (s/veh)					
			Scenario 1		Scenario 2		Scenario 3	
			AM	PM	AM	PM	AM	PM
El Camino Del Cerro /Silverbell Rd	EB	LT	B(15)	B(16)	B(13)	B(16)	B(13)	B(17)
		TH	D(36)	C(22)	C(27)	B(20)	C(29)	C(20)
		RT	C(23)	B(20)	B(19)	B(18)	B(20)	B(18)
		Approach	C(31)	C(21)	C(24)	B(19)	C(25)	B(19)
	WB	LT	D(47)	D(47)	D(50)	C(25)	D(46)	C(27)
		TH	C(25)	C(29)	B(20)	C(24)	C(22)	C(25)
		RT	C(23)	C(22)	B(18)	B(19)	B(20)	B(19)
		Approach	D(38)	C(34)	D(36)	C(23)	C(34)	C(24)
	SB	LT	D(47)	C(31)	C(29)	C(33)	D(42)	C(29)
		TH	D(38)	C(23)	C(27)	C(21)	C(33)	C(21)
		RT	C(22)	B(20)	B(18)	B(18)	B(20)	B(18)
		Approach	D(41)	C(25)	C(27)	C(24)	C(35)	C(23)
	NB	LT	C(26)	C(21)	C(24)	B(20)	C(26)	B(19)
		TH	C(26)	C(30)	C(22)	C(29)	C(26)	C(29)
		RT	C(21)	B(13)	B(16)	B(14)	C(16)	B(14)
		Approach	C(23)	C(23)	B(20)	C(23)	C(22)	C(23)
	Intersection		C(34)	C(28)	C(26)	C(23)	C(29)	C(23)
Sweetwater Dr /Silverbell Rd	EB	LT+TH	C(27)	B(14)	C(28)	B(16)	C(28)	B(16)
		RT	B(17)	B(13)	B(17)	B(15)	B(16)	B(15)
		Approach	C(23)	B(13)	C(23)	B(16)	C(23)	B(16)
	WB	LT	B(13)	B(11)	B(13)	B(12)	B(13)	B(12)
		TH+RT	B(15)	B(12)	B(15)	B(14)	C(34)	B(14)
		Approach	B(14)	B(12)	B(14)	B(14)	C(24)	B(14)
	SB	LT	B(14)	B(10)	B(14)	B(12)	B(16)	B(12)
		TH	C(28)	B(14)	C(26)	B(17)	C(34)	B(17)
		RT	B(17)	B(12)	B(17)	B(15)	B(18)	B(15)
		Approach	C(25)	B(13)	C(24)	B(16)	C(31)	B(16)
	NB	LT	D(46)	B(19)	D(50)	B(10)	C(27)	B(10)
		TH	B(10)	B(10)	B(10)	B(11)	B(10)	B(11)
		RT	A(9)	A(8)	A(9)	A(8)	A(9)	A(8)
		Approach	C(20)	B(12)	C(21)	B(11)	B(15)	B(11)
	Intersection		C(23)	B(12)	C(23)	B(13)	C(24)	B(13)

Exhibit 11C Summary of Projected Future Traffic Conditions - Continued

Intersection	Approach	Movement/ Approach	LOS and Average Delay (s/veh)					
			Scenario 1		Scenario 2		Scenario 3	
			AM	PM	AM	PM	AM	PM
Goret Rd /Silverbell Rd	EB	LT	B(17)	B(19)	B(20)	B(18)	B(17)	B(20)
		TH+RT	C(23)	B(19)	C(27)	B(18)	C(23)	B(20)
		Approach	C(22)	B(19)	C(27)	B(18)	C(22)	B(20)
	WB	LT	B(19)	B(19)	C(22)	B(19)	B(19)	B(20)
		TH+RT	B(17)	B(18)	B(20)	B(18)	B(17)	B(19)
		Approach	B(18)	B(19)	C(21)	B(18)	B(18)	B(19)
	SB	LT	A(6)	A(4)	A(6)	A(4)	A(6)	A(4)
		TH	B(10)	A(4)	B(10)	A(4)	B(11)	A(5)
		RT	A(6)	A(3)	A(6)	A(3)	A(6)	A(4)
		Approach	B(10)	A(4)	B(10)	A(4)	B(10)	A(5)
	NB	LT	C(28)	A(7)	D(35)	A(7)	C(28)	A(8)
		TH	A(8)	A(5)	A(8)	A(6)	A(8)	A(6)
		RT	A(7)	A(4)	A(6)	A(4)	A(7)	A(4)
		Approach	B(10)	A(6)	B(11)	A(6)	B(10)	A(6)
	Intersection		B(12)	A(6)	B(13)	A(6)	B(12)	A(7)
Ironwood Hills Dr /Grant Rd /Silverbell Rd	EB	LT	C(25)	D(49)	C(27)	D(48)	C(26)	D(48)
		TH	D(46)	C(26)	D(49)	C(29)	D(48)	C(29)
		RT	C(31)	C(23)	C(32)	C(25)	C(31)	C(25)
		Approach	D(39)	C(33)	D(40)	C(34)	D(39)	C(34)
	WB	LT	D(49)	C(25)	D(49)	C(26)	D(45)	C(26)
		TH	C(27)	D(44)	C(27)	D(49)	C(27)	D(48)
		RT	C(25)	D(37)	C(25)	D(39)	C(25)	D(38)
		Approach	C(33)	D(39)	C(34)	D(42)	C(32)	D(41)
	SB	LT	C(30)	D(48)	C(34)	D(50)	D(36)	D(48)
		TH	D(35)	C(27)	D(41)	C(25)	D(43)	C(25)
		RT	B(20)	C(23)	C(20)	C(22)	C(20)	C(22)
		Approach	C(32)	C(31)	D(36)	C(31)	D(38)	C(30)
	NB	LT	D(36)	C(34)	D(37)	C(31)	D(37)	C(31)
		TH	C(21)	D(44)	C(22)	D(51)	C(23)	D(49)
		RT	B(20)	C(23)	C(20)	C(22)	C(21)	C(22)
		Approach	C(23)	D(38)	C(24)	D(43)	C(25)	D(41)
	Intersection		C(33)	D(36)	C(35)	D(39)	C(35)	D(38)

4. Proposed Improvements

Proposed roadway improvements are based on the results of analysis of existing and future traffic operations, analysis of crash data, and roadway design guidelines from the City of Tucson, Pima County, and the Town of Marana. The following proposed roadway improvements are intended to provide the necessary capacity, roadway geometry, and multi-modal facilities to provide a high level of traffic operations and safety to serve existing and future traffic demand that is expected to increase by 100% or more over the next 20 to 30 years.

4.1 DESIGN PARAMETERS

The following roadway design criteria are recommended for this project:

Design Speed – The existing posted speed limit is 45 mph between Ina Road and Goret Road, 40 mph between Goret Road and Grant Road. A design speed of 50 mph is recommended between Ina Road and Goret Road and a design speed of 45 mph is recommended between Goret Road and Grant Road. The posted speed limit is recommended to be 45 mph between Ina Road and Goret Road, and 40 mph between Goret Road and Grant Road. The posted speed of 40 mph in the southern segment is consistent with the current land use and with the posted speed for the Silverbell Road section south of Grant Road.

Stopping Sight Distance – Stopping sight distance should be a minimum of 425 feet for a design speed of 50 mph based on the design criteria provided in the 2004 AASHTO Policy on Geometric Design of Highways and Streets [10].

Clear Zone – Clear zone should be a minimum of 20 feet based on the criteria for a 50 mph design speed provided in the 2004 update of the AASHTO Roadside Design Guide [11].

Median – Considering the design speed, future traffic demand, and access control requirements, a raised median is preferred over a flush median.

Median and Lane Widths – Considering that Silverbell Road is designated as a scenic route, in order to minimize the overall roadway cross section, the minimum median and lane widths defined by Pima County for environmentally sensitive roadways are preferred over the standard City of Tucson, Pima County, and Town of Marana widths. These include a 20-foot median, a 12-foot inside travel lane, an 11-foot outside travel lane, and a minimum paved shoulder of 5-feet not including a gutter pan.

Design Vehicle – Considering the functional classification of Silverbell Road as a principal arterial, the roadway should be designed to accommodate a WB-50 semi-trailer combination at a minimum with a WB-67 vehicle preferred. The design of median openings will use an appropriate design vehicle to accommodate U-turns by passenger cars as well as passenger vehicles pulling horse trailers.

4.2 ROADWAY CROSS SECTION

The analysis of future traffic demands indicates that a 4-lane divided section with bicycle and pedestrian facilities will provide sufficient roadway capacity to serve projected corridor traffic in 2040. A recommended typical cross section is provided in Exhibit 12.

4.3 INTERSECTIONS

Based on the capacity analysis results, the intersection lane configurations provided in Exhibits 13A, 13B, 13C are required.

4.4 MEDIAN OPENINGS AND ACCESS

AASHTO [10] considers a divided roadway with a raised median the preferred cross section for arterials with a design speed of 45 mph or greater, particularly with high volumes of through traffic. Several of the more important advantages and disadvantages of a raised median on an arterial include:

- Discourages strip development and encourages large planned development.
- Reduces mid-block crashes.
- Reduces vehicle conflicts at driveways.
- Reduces crash severity.
- Increases U-turn volume at median openings and intersections.
- Can reduce left-turn capacity at a signalized intersection.
- Restricts direct access to adjoining properties.

Considering that Silverbell Road will function as a principal arterial roadway, and as such the roadway design must provide a high level of traffic safety and operations, a raised median is appropriate.

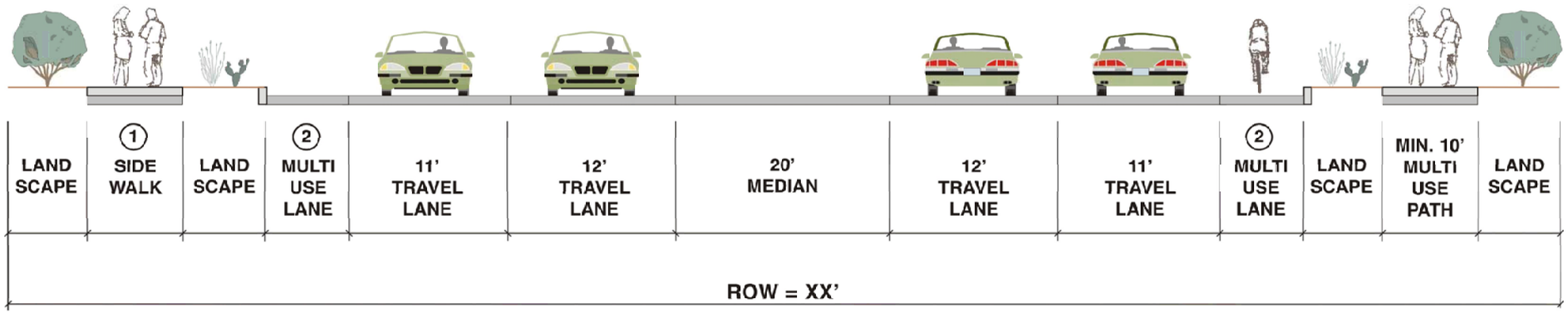
Currently there are 5 signalized intersections, 1 major cross street, 25 minor cross streets, 53 residential driveways, and 14 existing commercial driveways along Silverbell Road between Ina Road and Grant Road. Additional access points will also be required to serve future residential and commercial development within the corridor. The City of Tucson Transportation Access Management Guidelines and the Pima County Roadway Design Guidelines recommend that median openings should be spaced no closer than 660 feet on a suburban arterial and ¼ mile is preferred. Providing median openings within the functional limits of a signalized intersection is highly discouraged.

The spacing of traffic signals is dependent upon a number of factors, however, ½ mile is generally the accepted minimum for a principal arterial.

There are 90 minor cross streets and driveways within the study section. The need to maintain access must be balanced with the operational and safety requirements required for a principal arterial.

A proposed access plan, illustrated in Exhibits 14A, 14B, 14C, 14D, and 14E, minimizes the number of median openings while providing as much direct access to adjacent properties as possible while considering the median opening criteria specified by each agency for an arterial roadway. Where access is restricted to right-in/right-out only, frequently spaced U-turn opportunities will need to be provided. The proposed plan includes the access requirement for future developments (Driveways 4, 75 and 78), and also recommends that at several locations driveways serving adjacent individual residences be combined. These locations include: driveways 18 and 19, driveways 21 and 88, driveways 30, 85 and 86, driveways 40 and 41, driveways 43 and 44, driveways 54 and 70. It is also recommended that driveways 34 and 35 be removed because they are located too close to the El Camino Del Cerro/Silverbell Road intersection.

NOTE: CROSS-SECTION LOOKING NORTH



(1) MINIMUM 6' SIDEWALK.

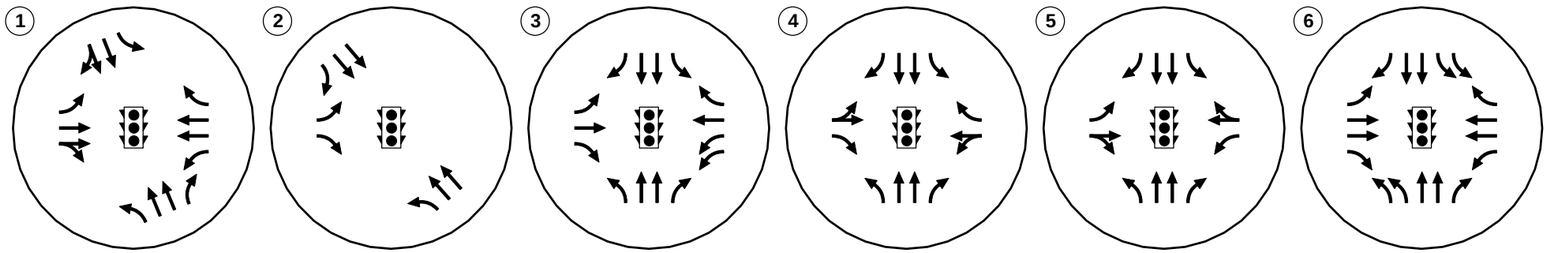
(2) MINIMUM 6' WIDE MULTI USE LANE WITHIN THE CITY OF TUCSON AND PIMA COUNTY
MINIMUM 7' WITHIN THE TOWN OF MARANA.

TYPICAL CROSS SECTION
PIMA COUNTY, ARIZONA

EXHIBIT **12**

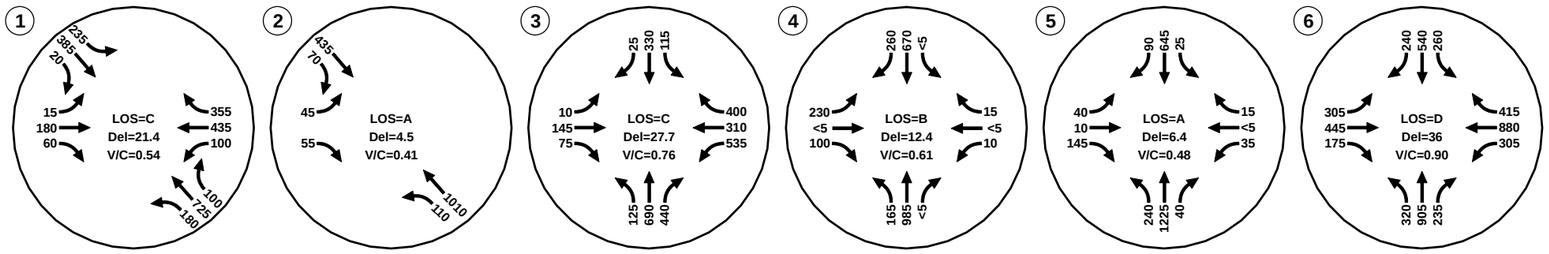
KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING

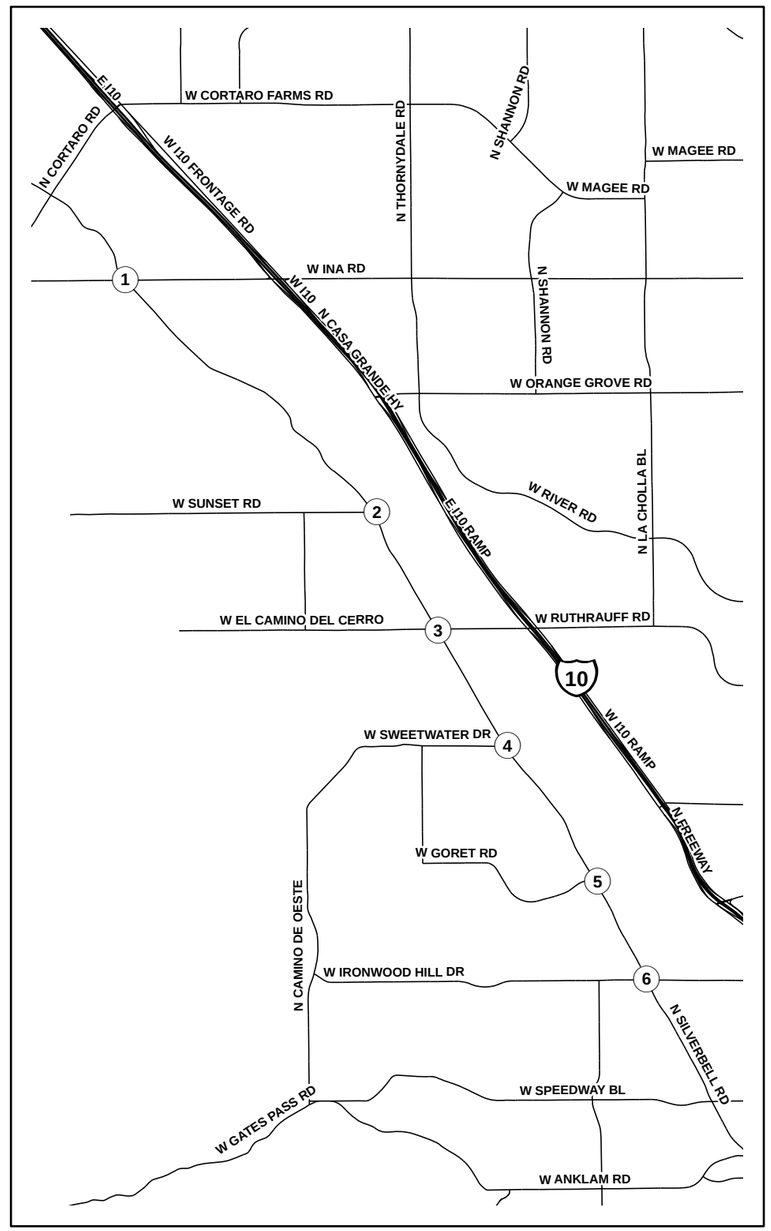
2040 LANE CONFIGURATION



2040 AM PEAK PERIOD

2040 PM PEAK PERIOD





LEGEND

TRAFFIC SIGNAL

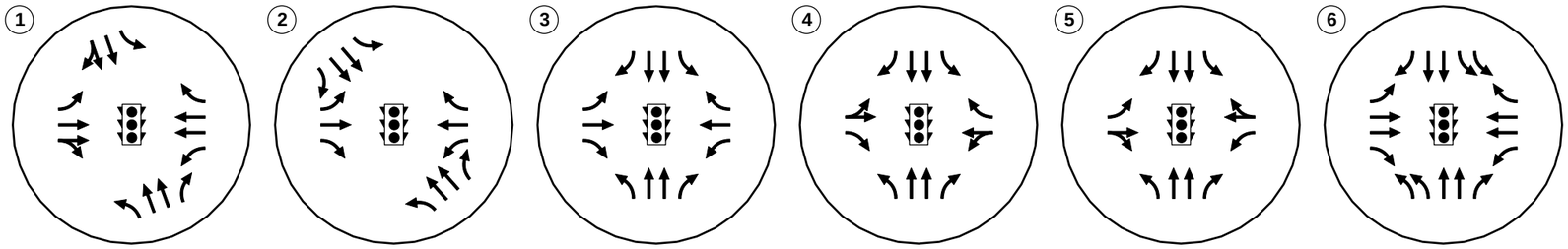
LOS = INTERSECTION LEVEL OF SERVICE (SIGNALIZED)/CRITICAL MOVEMENT LEVEL OF SERVICE (UNSIGNALIZED)
Del = INTERSECTION AVERAGE CONTROL DELAY (SIGNALIZED)/CRITICAL MOVEMENT CONTROL DELAY (UNSIGNALIZED)
V/C = CRITICAL VOLUME-TO-CAPACITY RATIO

PROPOSED INTERSECTION LANE CONFIGURATION
2040 ANALYSIS RESULTS, NO SUNSET ROAD EXTENSION

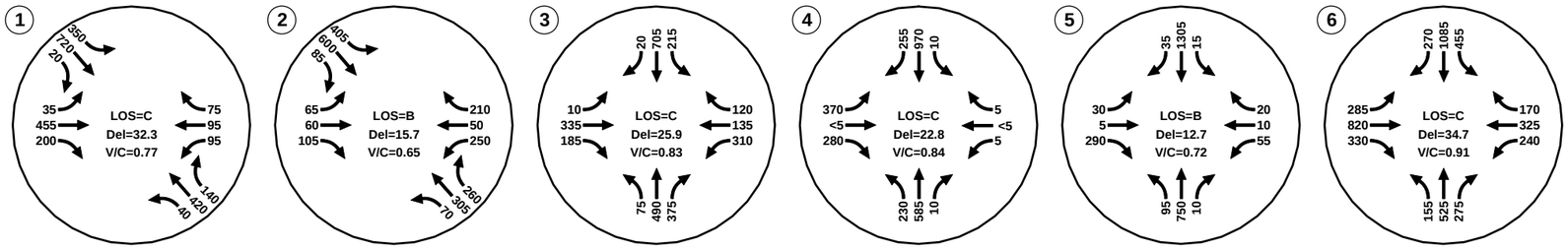
EXHIBIT **13A**

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING

2040 LANE CONFIGURATION



2040 AM PEAK PERIOD



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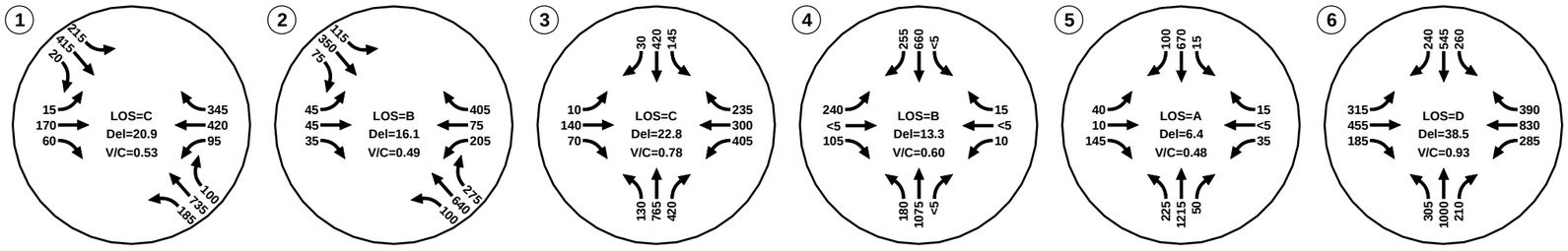
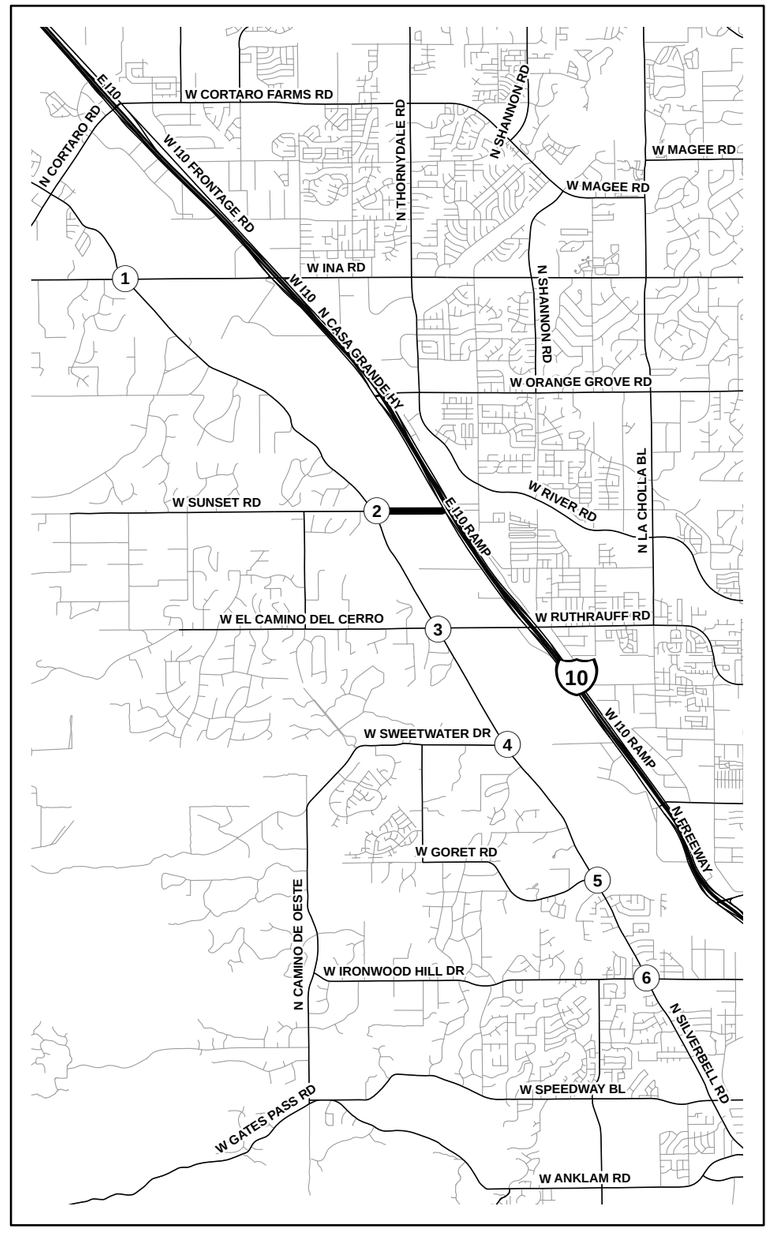




LEGEND

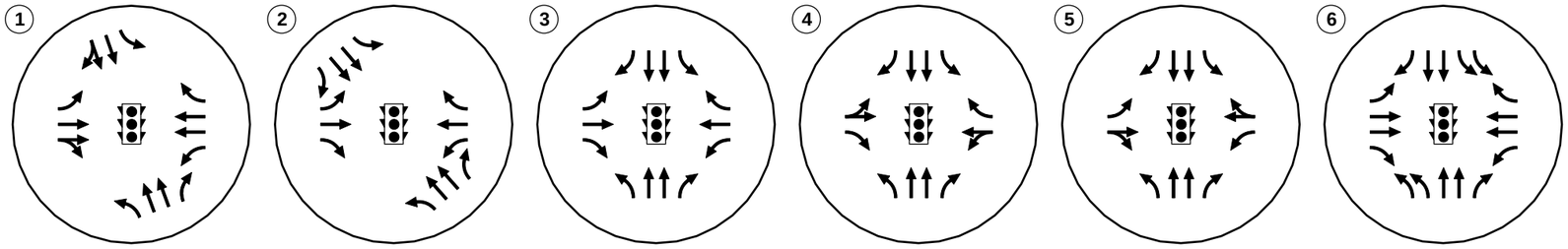
TRAFFIC SIGNAL

LOS = INTERSECTION LEVEL OF SERVICE (SIGNALIZED)/CRITICAL MOVEMENT LEVEL OF SERVICE (UNSIGNALIZED)
Del = INTERSECTION AVERAGE CONTROL DELAY (SIGNALIZED)/CRITICAL MOVEMENT CONTROL DELAY (UNSIGNALIZED)
V/C = CRITICAL VOLUME-TO-CAPACITY RATIO

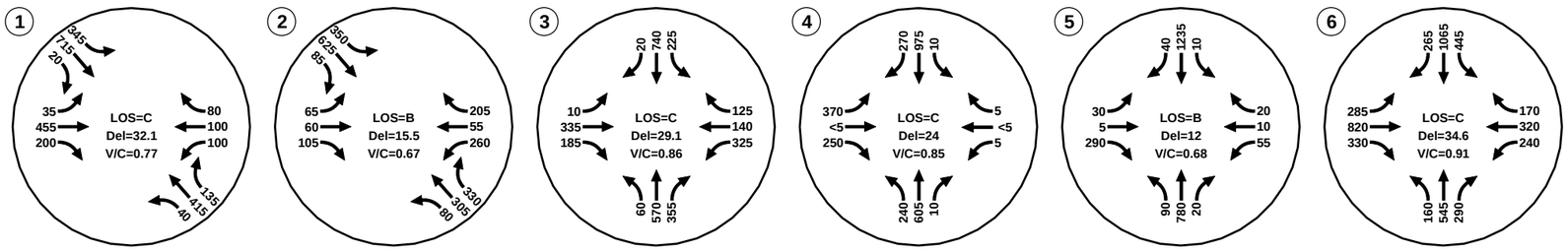
PROPOSED INTERSECTION LANE CONFIGURATION
2040 ANALYSIS RESULTS, SUNSET ROAD EXTENDS TO I-10

EXHIBIT **13B**

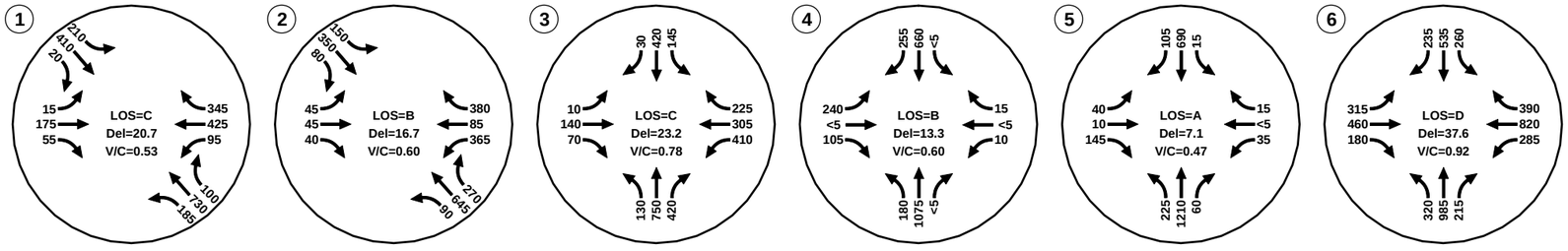
2040 LANE CONFIGURATION

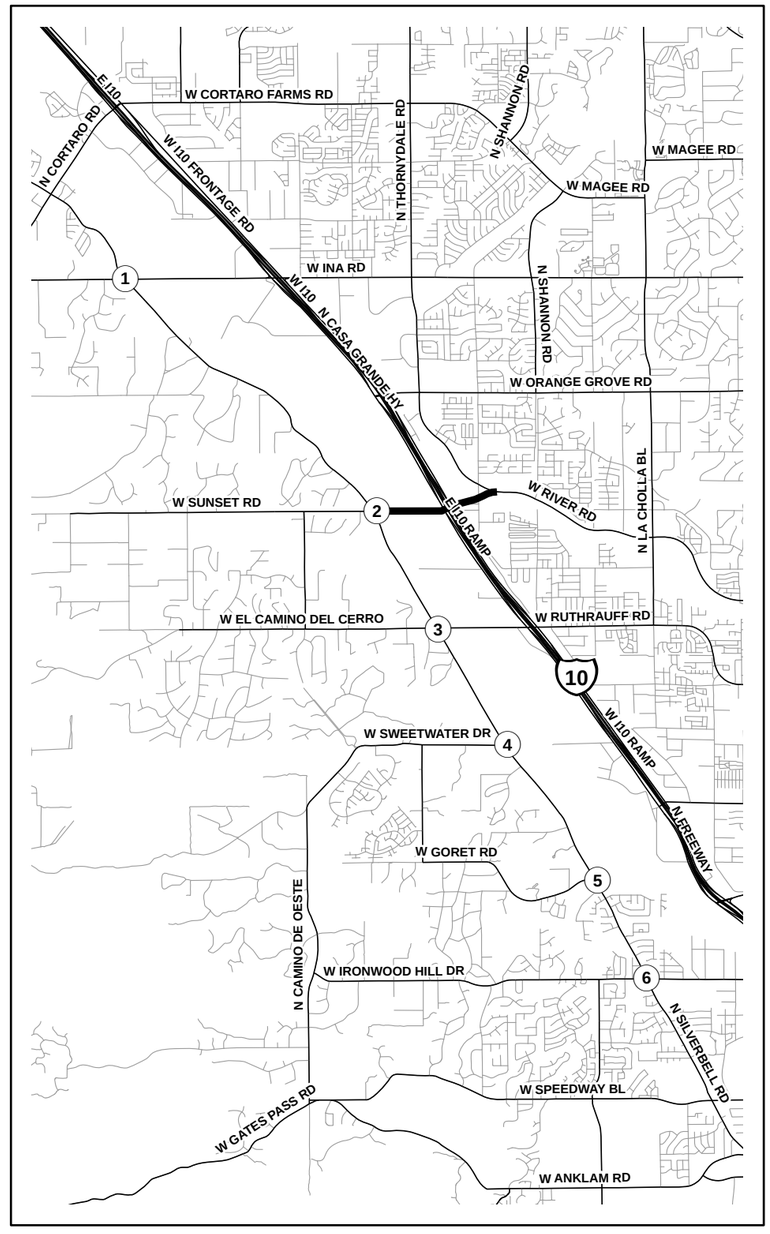


2040 AM PEAK PERIOD



2040 PM PEAK PERIOD





LEGEND

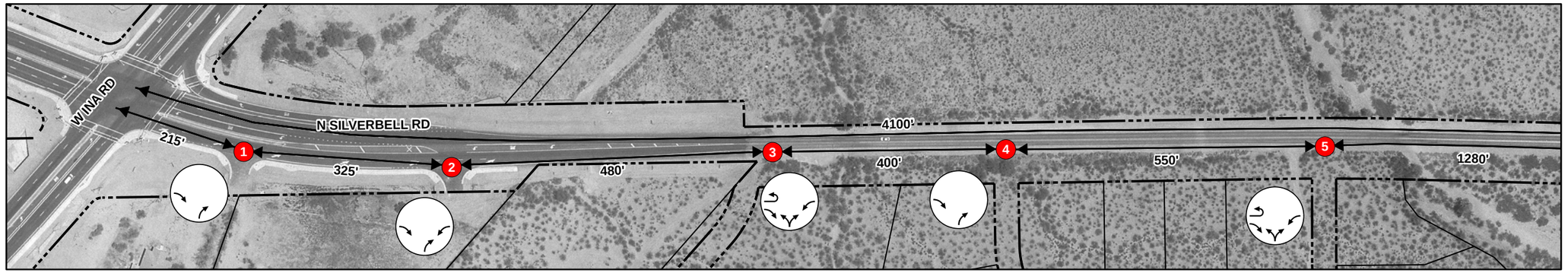
TRAFFIC SIGNAL

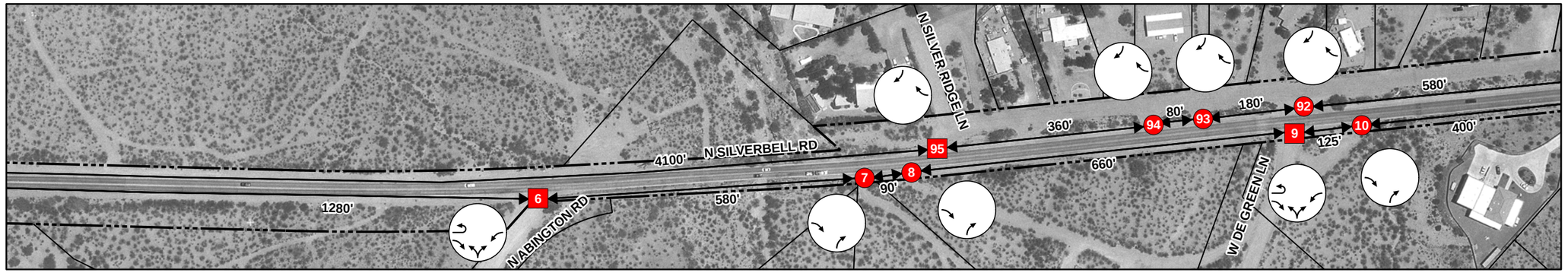
LOS = INTERSECTION LEVEL OF SERVICE (SIGNALIZED)/CRITICAL MOVEMENT LEVEL OF SERVICE (UNSIGNALIZED)
Del = INTERSECTION AVERAGE CONTROL DELAY (SIGNALIZED)/CRITICAL MOVEMENT CONTROL DELAY (UNSIGNALIZED)
V/C = CRITICAL VOLUME-TO-CAPACITY RATIO

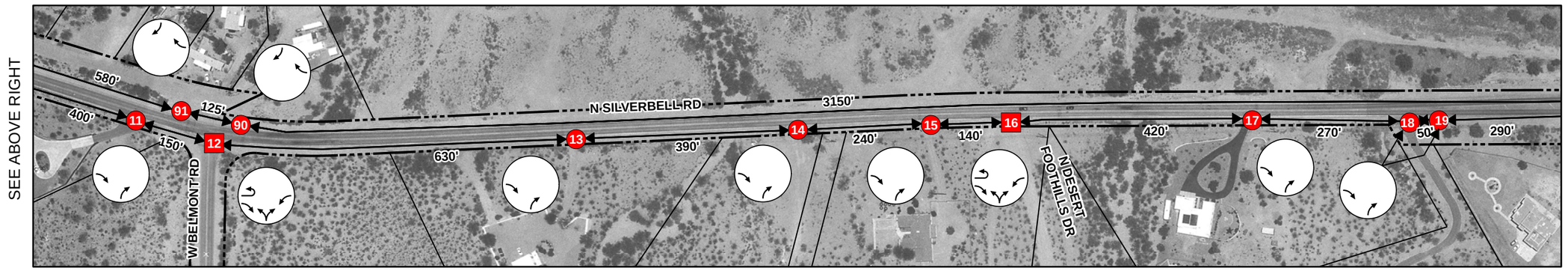
PROPOSED INTERSECTION LANE CONFIGURATION
2040 ANALYSIS RESULTS, SUNSET ROAD EXTENDS TO RIVER ROAD

EXHIBIT **13C**

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING







LEGEND

- Driveway
- Side Street
- Relocated Driveway
- Distance
- ROW
- Property

0 100 200 400 Feet

EXISTING ACCESS POINTS AND PROPOSED MEDIAN OPENING LOCATIONS
PIMA COUNTY, ARIZONA

EXHIBIT **14A**

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING

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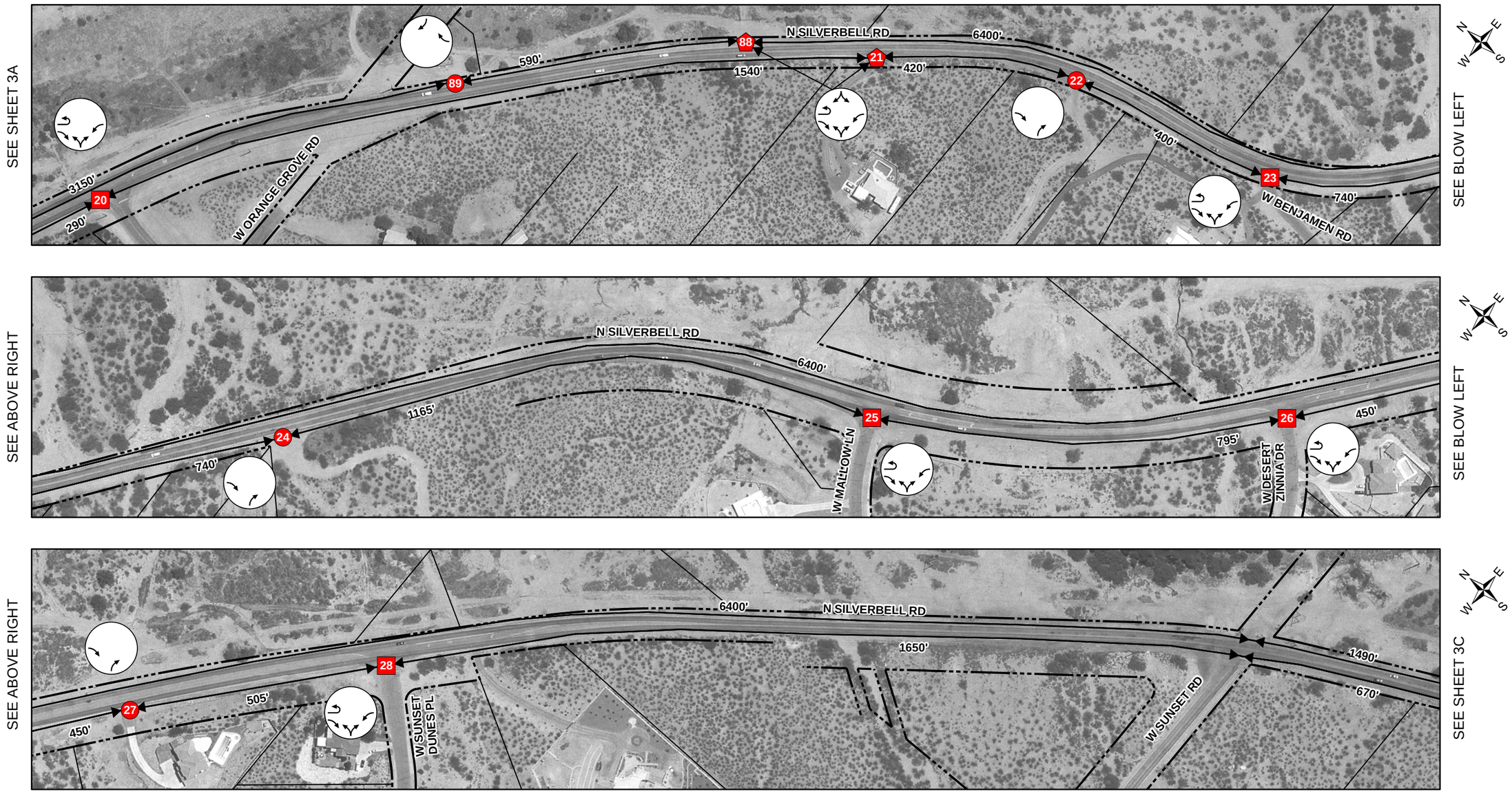

LEGEND

- Driveway
- Side Street
- Relocated Driveway
- Distance
- ROW
- Property

EXISTING ACCESS POINTS AND PROPOSED MEDIAN OPENING LOCATIONS
PIMA COUNTY, ARIZONA

EXHIBIT **14B**

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING

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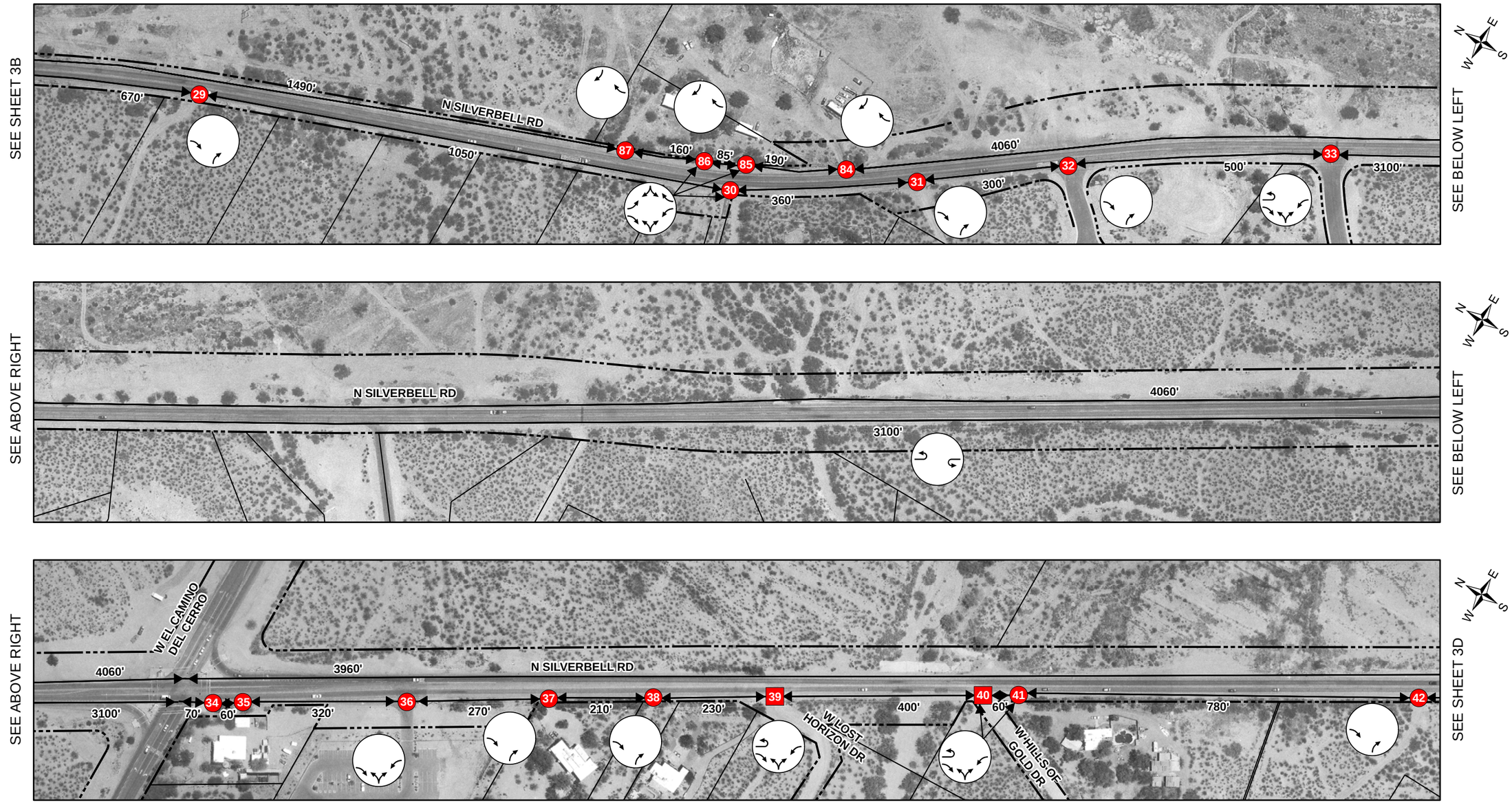

LEGEND

- Driveway
- Side Street
- Relocated Driveway
- Distance
- ROW
- Property

EXISTING ACCESS POINTS AND PROPOSED MEDIAN OPENING LOCATIONS
PIMA COUNTY, ARIZONA

EXHIBIT **14C**

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING

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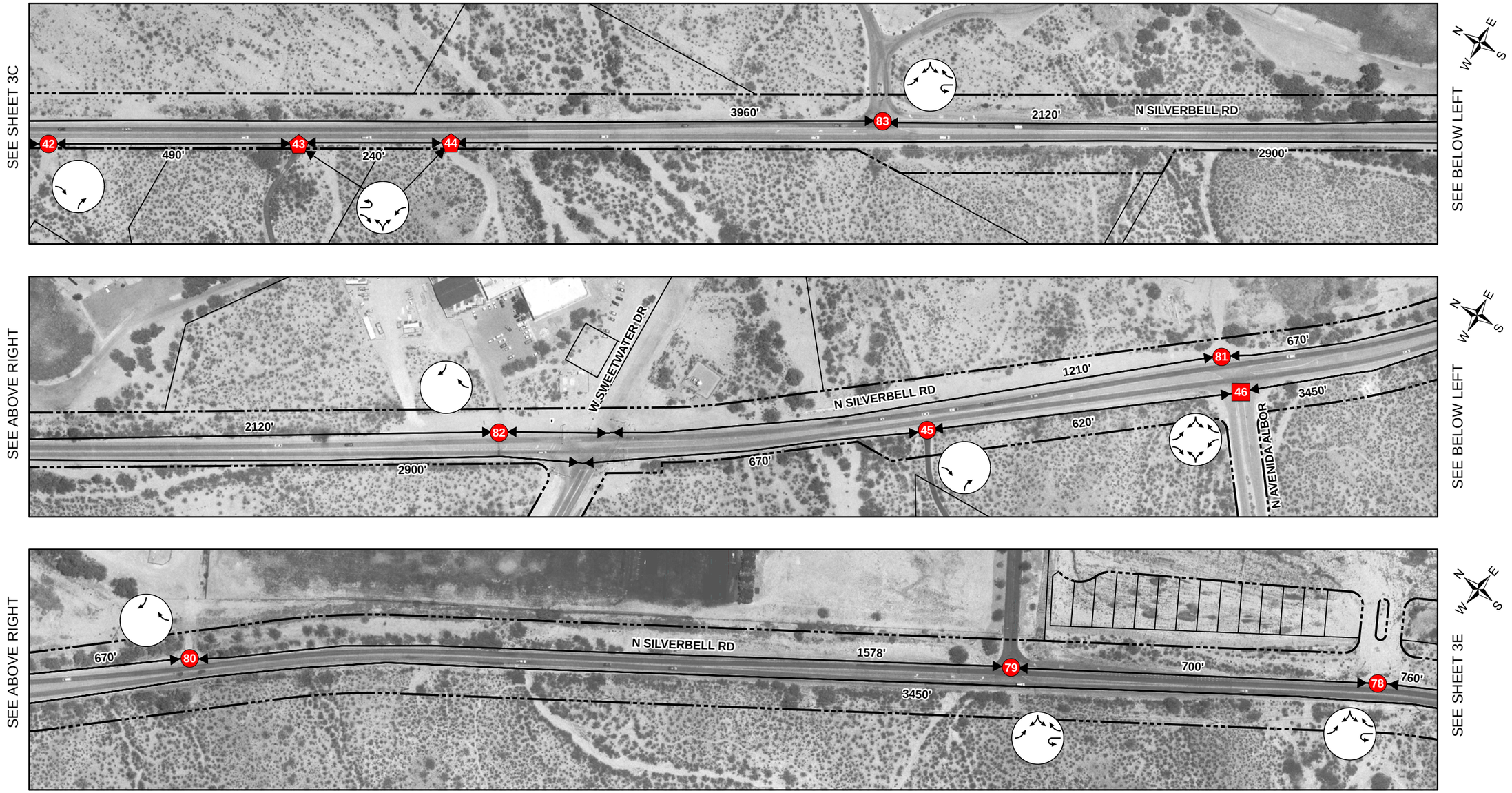

LEGEND

Driveway	Distance
Side Street	ROW
Relocated Driveway	Property

0 100 200 400 Feet

EXISTING ACCESS POINTS AND PROPOSED MEDIAN OPENING LOCATIONS
PIMA COUNTY, ARIZONA

EXHIBIT **14D**

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING

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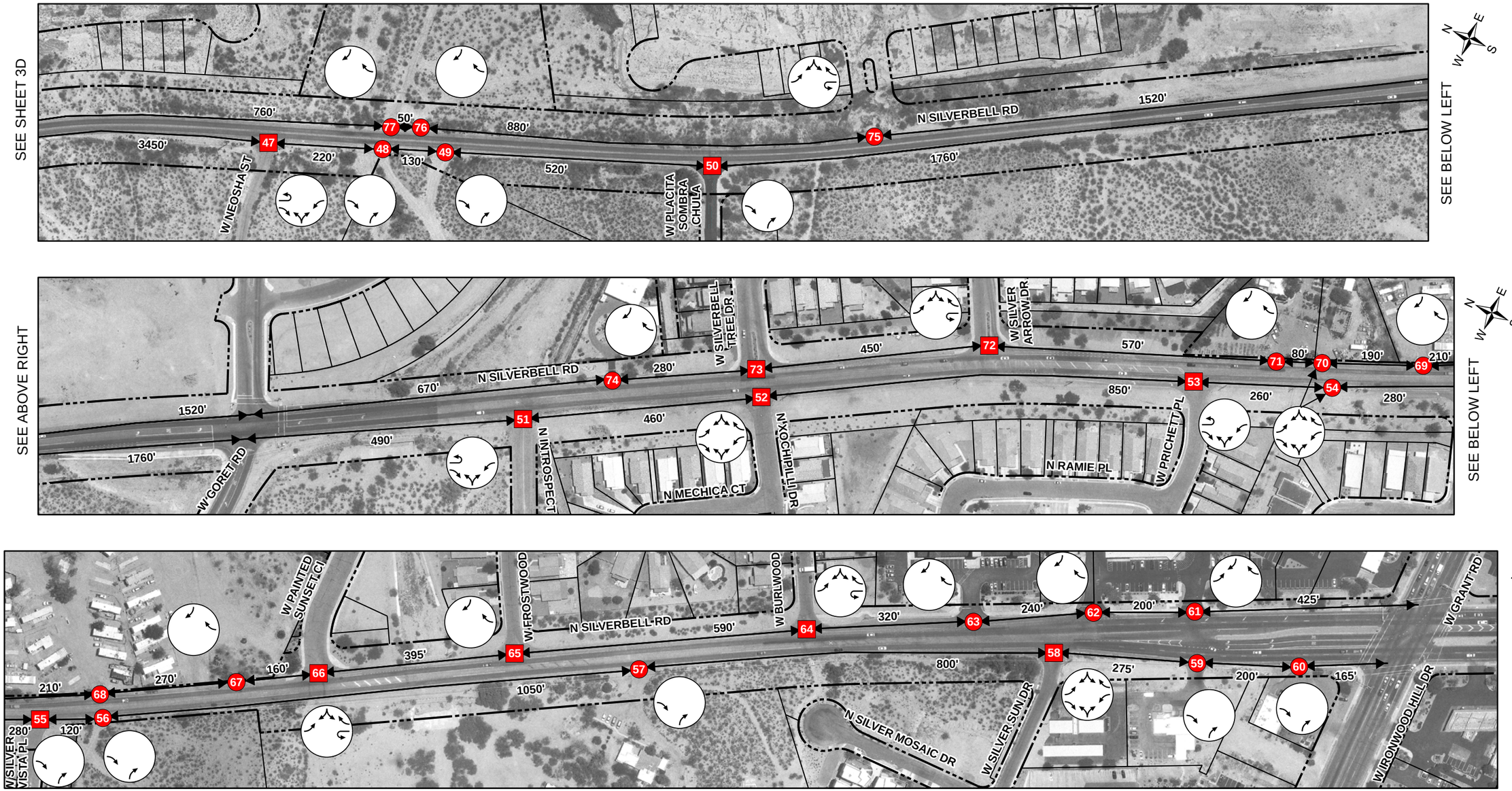

LEGEND

- Driveway
- Side Street
- Relocated Driveway
- Distance
- ROW
- Property

0 100 200 400 Feet

EXISTING ACCESS POINTS AND PROPOSED MEDIAN OPENING LOCATIONS
PIMA COUNTY, ARIZONA

EXHIBIT **14E**

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING

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4.4 RIGHT-TURN DECELERATION LANES

Signalized Intersections

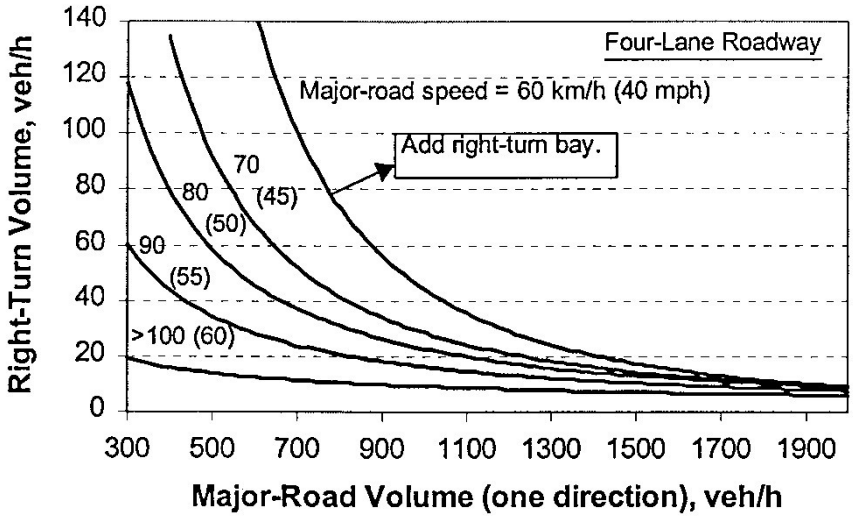
Exclusive right-turn lane requirements at signalized intersections were determined based on the capacity and level of service analysis. As shown in Exhibits 13A, 13B, and 13C, northbound and southbound right-turn lanes will be required at all existing signalized intersections as well as at Sunset Road which will be signalized. Eastbound and westbound right-turn lanes are recommended at Sunset Road, El Camino del Cerro, and Grant Road. No additional exclusive right-turn lanes are required at the recently reconstructed intersection at Ina Road.

Unsignalized Intersections

Exclusive right-turn deceleration lane requirements at unsignalized intersections (side streets and driveways) were evaluated using the methodology described in NCHRP Report 457, Evaluating Intersection Improvements: An Engineering Study Guide [12]. This methodology considers the right-turn volume, mainline volume, number of mainline lanes, and speed in determining the need for a deceleration lane. The methodology is provided in Exhibit 15. Only those side streets with daily traffic volumes exceeding 100 were evaluated. Peak-hour right-turn volumes were estimated based on the potential presence of a future median opening. Where median openings are recommended, the right-turn volume was assumed to be one-half of the total inbound volume. Where a median opening is not expected to be provided, all inbound traffic are right turns. The evaluation assumed a speed limit of 45 mph from Ina Road to Goret Road and a speed limit of 40 mph from Goret Road to Grant Road.

The evaluation results, summarized in Exhibit 16, indicate that right-turn deceleration lanes should be considered at six locations, all of which are located between Goret Road and Grant Road. Note that at each of these six locations, the estimated right-turn volumes only slightly exceed the turn lane threshold. At none of the locations evaluated is a deceleration lane clearly warranted. Provision of a deceleration lane at Christopher Columbus Park should be considered since heavy traffic does occur during special events throughout the year.

Exhibit 15 Right-Turn Deceleration Lane Evaluation Methodology (Source: NCHRP Report 457)



4.5 TRAFFIC SIGNAL WARRANTS

Although a signal is not currently warranted, expected traffic growth on both Silverbell Road and Sunset Road will justify the installation of a signal at that location. Signal warrant worksheets for projected 2040 traffic demands are provided in Appendix F. Since a signal at this intersection may be warranted before either the planned widening of Silverbell Road or the extension of Sunset Road occurs, traffic conditions at this location should be monitored annually. Currently, there does not appear to be a need for pedestrian signals, however, mid-block HAWK signals should be considered when warranted. The need for a HAWK signal at Introspect Drive where a charter school is located should be evaluated during the design phase of the Silverbell Road widening project. City of Tucson criteria for the installation of HAWK signals is included in the City of Tucson Transportation Access Management Guidelines and are included in Appendix H.

4.6 QUEUING ANALYSIS

A queuing analysis was conducted to determine turn-lane storage requirements at signalized intersections based on projected 2040 traffic demands. The recommended storage lengths represent the 95th percentile queue lengths generated by the Synchro model and the minimum requirements per Pima County, City of Tucson and Town of Marana design guidelines. The speed limit of the proposed Sunset Road extension is assumed to be 35 mph. The recommended minimum storage lengths are provided in Exhibit 17A, 17B, and 17C. At unsignalized intersections, the minimum turn lane storage length should be 150 feet. Detailed queuing information on which the storage recommendations are based are provided in Appendix I.

Exhibit 16 Right-Turn Deceleration Lane Evaluation Results

Cross Street	Dirn.	Inbound Peak Hour Volume AM(PM)	Est. Peak Hour Right-Turn Vol AM(PM)	2040 Mainline Directional Volume AM(PM)	Warrant met?
New development, South of Ina	SB	8(8)	8(8)	1015(570)	No
Abington Rd	SB	4(49)	2(25)	1015(570)	No
Belmont Rd	SB	24(48)	12(24)	1015(570)	No
Desert Foothill Dr	SB	9(19)	5(10)	1015(570)	No
Panorama Dr	SB	9(21)	5(11)	1015(570)	No
Mallow Ln	SB	9(20)	5(10)	1000(540)	No
Desert Zinnia Dr	SB	9(16)	5(8)	1000(540)	No
Sunset Dune Pl	SB	11(14)	6(7)	1000(540)	No
Aveniada Albor	SB	27(64)	14(32)	1250(780)	No
Neosha St	SB	10(23)	5(12)	1250(780)	No
Xochipilli Dr	SB	12(33)	6(17)	1650(850)	No
Silverbell Tree Dr East Leg	NB	30(72)	15(36)	855(1490)	Yes
Silver Arrow Dr East Leg	NB	22(71)	11(36)	855(1490)	Yes
Prichett Pl	SB	4(22)	2(11)	1650(850)	No
Silver Vista Pl	SB	18(14)	18(14)	1650(850)	Yes
Painted Sunset Cl	NB	15(41)	8(21)	855(1490)	Yes
Frostwood Ln	NB	13(19)	13(19)	855(1490)	Yes
Burlwood Way	NB	7(54)	4(27)	855(1490)	Yes
Silver Sun Dr	SB	28(35)	14(18)	1650(850)	No

Exhibit 17A Turn-Lane Storage Requirements – Scenario 1

Intersection	Turning Bay	2040 Design Vol	Estimated Queue, ft	Recommended Minimum Storage, ft	Comment
Ina Rd / Silverbell Rd	EB LT	34	30	150	Minimum Requirement
	WB LT	122	92	150	Minimum Requirement
	WB RT	355	121	150	Minimum Requirement
	SEB LT	345	229	230	
	NWB LT	181	86	150	Minimum Requirement
	NWB RT	154	46	150	Minimum Requirement
Sunset Rd / Silverbell Rd	EB LT	72	41	110	Minimum Requirement
	EB RT	132	55	110	Minimum Requirement
	SEB RT	109	18	150	Minimum Requirement
	NWB LT	112	39	150	Minimum Requirement
El Camino Del Cerro / Silverbell Rd	EB LT	12	13	150	Minimum Requirement
	EB RT	186	51	150	Minimum Requirement
	WB LT	535	235x2	235x2	Dual Left-Turn Lanes
	WB RT	398	64	150	Minimum Requirement
	SB LT	368	311	315	Consider Dual Left-Turn Lanes
	SB RT	23	17	150	Minimum Requirement
	NB LT	125	77	150	Minimum Requirement
	NB RT	489	256	260	
Sweetwater Dr /Silverbell Rd	EB RT	240	60	150	Minimum Requirement
	WB RT	15	9	110	Minimum Requirement
	SB LT	12	15	150	Minimum Requirement
	SB RT	282	51	150	Minimum Requirement
	NB LT	225	185	185	
	NB RT	10	8	150	Minimum Requirement
Goret Rd / Silverbell Rd	EB LT	41	33	110	Minimum Requirement
	WB LT	53	50	110	Minimum Requirement
	SB LT	23	12	150	Minimum Requirement
	SB RT	91	13	150	Minimum Requirement
	NB LT	239	125	150	Minimum Requirement
	NB RT	42	9	150	Minimum Requirement
Ironwood Hills Dr / Grant Rd / Silverbell Rd	EB LT	304	273	275	
	EB RT	325	216	220	
	WB LT	303	225	225	
	WB RT	415	321	325	
	SB LT	436	119x2	285x2	Existing Storage
	SB RT	262	58	110	Minimum Requirement
	NB LT	322	98x2	225x2	Available Space for Dual Left-Turn Lanes
	NB RT	252	56	110	Minimum Requirement

Exhibit 17B Turn-Lane Storage Requirements - Scenario 2 (Continued)

Intersection	Turning Bay	2040 Design Vol	Estimated Queue, ft	Recommended Minimum Storage, ft	Comment
Ina Rd / Silverbell Rd	EB LT	34	30	150	Minimum Requirement
	WB LT	94	64	150	Minimum Requirement
	WB RT	344	115	150	Minimum Requirement
	SEB LT	349	241	245	
	NWB LT	184	88	150	Minimum Requirement
	NWB RT	138	44	150	Minimum Requirement
Sunset Rd / Silverbell Rd	EB LT	64	42	110	Minimum Requirement
	EB RT	105	38	110	Minimum Requirement
	WB LT	250	139	140	
	WB RT	406	122	125	
	SEB LT	404	163	165	
	SEB RT	87	28	150	Minimum Requirement
	NWB LT	102	57	150	Minimum Requirement
	NWB RT	274	52	150	Minimum Requirement
El Camino Del Cerro / Silverbell Rd	EB LT	12	11	150	Minimum Requirement
	EB RT	185	43	150	Minimum Requirement
	WB LT	405	224	225	Consider Dual Left-Turn lanes
	WB RT	236	47	150	Minimum Requirement
	SB LT	217	139	150	Minimum Requirement
	SB RT	29	18	150	Minimum Requirement
	NB LT	132	73	150	Minimum Requirement
	NB RT	422	121	150	Minimum Requirement
Sweetwater Dr /Silverbell Rd	EB RT	279	80	150	Minimum Requirement
	WB RT	15	10	110	Minimum Requirement
	SB LT	11	14	150	Minimum Requirement
	SB RT	257	50	150	Minimum Requirement
	NB LT	229	189	190	
	NB RT	10	8	150	Minimum Requirement
Goret Rd / Silverbell Rd	EB LT	41	35	110	Minimum Requirement
	WB LT	53	59	110	Minimum Requirement
	SB LT	16	11	150	Minimum Requirement
	SB RT	102	13	150	Minimum Requirement
	NB LT	225	142	150	Minimum Requirement
	NB RT	51	10	150	Minimum Requirement
Ironwood Hills Dr / Grant Rd / Silverbell Rd	EB LT	316	279	280	
	EB RT	330	208	210	
	WB LT	287	217	220	
	WB RT	392	308	325	
	SB LT	453	136x2	285x2	Existing Storage
	SB RT	272	53	110	Minimum Requirement
	NB LT	303	90x2	225x2	Available Space for Dual Left-Turn Lanes
	NB RT	277	53	110	Minimum Requirement

Exhibit 17C Turn-Lane Storage Requirements - Scenario 3 (Continued)

Intersection	Turning Bay	2040 Design Vol	Estimated Queue, ft	Recommended Minimum Storage, ft	Comment
Ina Rd / Silverbell Rd	EB LT	34	30	150	Minimum Requirement
	WB LT	98	67	150	Minimum Requirement
	WB RT	345	116	150	Minimum Requirement
	SEB LT	346	235	245	
	NWB LT	183	86	150	Minimum Requirement
	NWB RT	136	43	150	Minimum Requirement
Sunset Rd / Silverbell Rd	EB LT	65	41	110	Minimum Requirement
	EB RT	107	37	110	Minimum Requirement
	WB LT	366	188	190	
	WB RT	379	106	110	Minimum Requirement
	SEB LT	351	132	150	Minimum Requirement
	SEB RT	85	29	150	Minimum Requirement
	NWB LT	90	49	150	Minimum Requirement
	NWB RT	328	50	150	Minimum Requirement
El Camino Del Cerro / Silverbell Rd	EB LT	12	11	150	Minimum Requirement
	EB RT	185	45	150	Minimum Requirement
	WB LT	412	245	245	Consider Dual Left-Turn lanes
	WB RT	227	47	150	Minimum Requirement
	SB LT	227	182	180	
	SB RT	29	20	150	Minimum Requirement
	NB LT	129	70	150	Minimum Requirement
	NB RT	422	119	150	Minimum Requirement
Sweetwater Dr /Silverbell Rd	EB RT	250	44	150	Minimum Requirement
	WB RT	15	27	110	Minimum Requirement
	SB LT	11	15	150	Minimum Requirement
	SB RT	272	52	150	Minimum Requirement
	NB LT	238	177	180	
	NB RT	10	8	150	Minimum Requirement
Goret Rd / Silverbell Rd	EB LT	41	37	110	Minimum Requirement
	WB LT	53	50	110	Minimum Requirement
	SB LT	16	10	150	Minimum Requirement
	SB RT	106	13	150	Minimum Requirement
	NB LT	224	126	150	Minimum Requirement
	NB RT	60	11	150	Minimum Requirement
Ironwood Hills Dr / Grant Rd / Silverbell Rd	EB LT	316	279	280	
	EB RT	330	202	205	
	WB LT	283	203	205	
	WB RT	388	302	325	
	SB LT	440	145x2	285x2	Existing Storage
	SB RT	266	53	110	Minimum Requirement
	NB LT	319	95x2	225x2	Available Space for Dual Left-Turn Lanes
	NB RT	289	55	110	Minimum Requirement

4.7 ALTERNATIVE MODES

Transit

Currently fixed-route transit service is not available along Silverbell Road corridor north of Goret Road. While Sun Tran has no current plans to extend transit service along the corridor, implementation of expanded service is planned by Marana. In order to better accommodate existing service, bus pullouts should be included on the north and south legs of the Grant Road intersection, if possible. When transit service is extended further north on Silverbell Road, the need for bus pullouts will need to be assessed. At a minimum, sufficient right-of-way should be obtained at existing signalized intersections and at Sunset Road to accommodate the installation of pullouts.

Bicycles and Pedestrians

The Regional Transportation Plan designates Silverbell Road as a priority corridor for bicycles and pedestrians. The roadway widening will include bicycle lanes on both sides of the roadway. The lane widths will adhere to the requirements of each agency, however should provide a minimum of five feet of paved surface.

Pedestrians

Although existing pedestrian activity within the Silverbell Road corridor is very light, it is expected that pedestrian demand will increase as recreational facilities along the east side of the roadway are expanded. Provision of safe pedestrian facilities within the corridor will promote their usage, primarily for recreational and leisure purposes. Considering the future land uses that are expected to develop within the corridor, large pedestrian generating developments will not occur. Therefore, there will not be a need to provide full pedestrian connectivity (i.e. both sides of the roadway) along the entire corridor or frequent pedestrian crossings. While the pedestrian facilities to be installed within the corridor will be determined collaboratively with each of the three jurisdictions and the public, the rural character of this section of Silverbell Road lends itself to the provision of a hardened (concrete or asphalt) multiuse pedestrian/bicycle path along the east side of the roadway. This path would provide connectivity to the planned Santa Cruz River Parkway/De Anza Trail, as well as other planned recreational development. In the vicinity of the retail developments that currently exist at Grant Road and are planned at Ina Road, provision of concrete sidewalk along the west side of the roadway should also be considered. For instance, sidewalk provided between Goret Road and Grant Road, where high density residential developments exist or are planned, might be well used by residents.

Safe pedestrian crossings will be provided at signalized intersections. Due to the high speeds that traffic will be operating at, all pedestrian crossings should be signalized. Additional HAWK crossings can be considered at locations where warranted by pedestrian demand. The crossing demand at the existing school, Luz Academy, located on Introspect Drive should be evaluated during the design phase of the project.

Equestrians

Preliminary discussions with horse owners within the corridor indicate that provision of safe crossings to provide access to the Santa Cruz River will be important. Considering that it appears that the grade differential in the washes will not allow for the installation of large drainage structures that will accommodate horses, crossings will have to be provided at signalized intersections. In other installations in the region (i.e. River Road) pedestrian push buttons are provided at a height that can be reached by a mounted rider. Horse paths will need to be provided along the east and west sides of the roadway to provide access to the signalized intersections and then to the Santa Cruz River. Further discussion with horse owners in the area will be required to develop an appropriate solution.

4.8 LIGHTING AND ITS

Based on the current City of Tucson roadway lighting program, Silverbell Road improvements will need to accommodate the installation of continuous lighting from Sunset Road to Grant Road. Continuous roadway lighting would not be installed, nor is it required, north of Sunset Road per the policies and practices of Pima County and the Town of Marana. Considering that one of the goals of the project is to maintain the rural feel of this section of the Silverbell Road corridor and that there is a distinct difference in the level of development north of Goret Road, the need to install roadway lighting north of Goret Road should be re-assessed by the City, particularly since this project will correct all deficient roadway geometry. Installation of lighting at unsignalized intersections that have higher traffic volumes, such as Belmont Road, as well as key destinations, including Christopher Columbus Park, should be considered in lieu of continuous roadway lighting.

The existing City of Tucson fiber optic cable will need to be relocated by COT Communications if the TEP poles need to move. The roadway improvements will need to accommodate the installation of conduit and pull boxes for extension of the City of Tucson and Town of Marana fiber optic infrastructure. Considering that wireless technology is fast becoming the primary means for ITS communications, connection of the traffic signals to the fiber optic backbone may not be required. The design team will need to work with COT Communications and Traffic Engineering, as well as the Town of Marana regarding the communications needs for the traffic control system along Silverbell Road. If conduit is installed for street lighting, conduit for future fiber optic cable could be installed in a joint trench.

5. Conclusions and Recommendations

- While the timeline for growth within the Silverbell Road Corridor and surrounding area is contingent on a number of factors, in the next 30 years, traffic demand is projected to double south of Sunset Road and triple north of Sunset Road, reaching some 29,000 vpd and 22,000 vpd, respectively.
- Based on planning roadway service volume levels developed by PAG, 4-lane roadways can carry 34,400 vpd, and 2-lane roadways can carry 17,100 vpd while operating at LOS D, which is the design level of service for arterials in the City of Tucson, Pima County, and Marana. Based on this criteria and on the projected 2040 traffic demands, a 4-lane roadway from Grant Road to Ina Road will be required. A more detailed capacity and level of service analysis of the six major intersections on Silverbell Road indicates that four lanes with appropriate turn-lane capacity will adequately serve the projected future traffic demands considering the roadway segment and intersection capacity requirement, a 4-lane section is recommended.
- The recommended lane configuration at the Ina Road, Sunset Road, El Camino Del Cerro, Sweetwater Drive, Goret Road, and Grant Road are provided in Exhibits 14A, 14B, and 14C. Recommended minimum turn lane storage requirements is provided in Exhibit 17A, 17B and 17C. Considering the skew of the intersections, channelized northbound and southbound right-turn lanes with yield controls are recommended at the Sunset Road/Silverbell Road and El Camino Del Cerro/Silverbell Road.
- A review of the crash data covering the most recent 3-year period indicates that with the exception of three locations, crash rates at intersections and on roadway segments are below regional averages. One fatality occurred during this period at Neosha Street. In general, widening the roadway, improving the roadway geometry, and providing a raised median for access control will reduce the potential for rear-end, turning, and single vehicle crashes. In the interim, the City of Tucson should consider implementing protected left-turn phasing at El Camino del Cerro to reduce the potential for turning crashes. Improved access control provided by a raised median will reduce the crash potential at the shopping center driveways near Grant Road.
- The proposed access plan provided in Exhibits 14A through 14E is intended to appropriately address the access requirements of existing and future developments while providing the level of access control required on a principal arterial to ensure a high level of traffic operations and safety. The proposed location of median openings follows adopted City of Tucson, Pima County, and Marana access management guidelines. Limiting outbound left-turn movements at driveways and side streets will require that frequent U-turn opportunities be provided. Consolidation of some single residence driveways is recommended at several locations.
- Considering future traffic growth, a traffic signal will be warranted at Sunset Road. Pima County should monitor traffic conditions annually at this intersection to determine when installing a signal is appropriate. No additional traffic signals are warranted based on existing traffic conditions, nor are any other signals anticipated based on future development within the corridor.

- The design team should coordinate with COT Communications and Traffic Engineering and the Town of Marana to determine the need to install fiber optic communications conduit.
- Based on current City of Tucson roadway lighting improvement program, continuous lighting is planned for the section from Sunset Road to Grant Road. Considering that the need for continuous lighting was primarily based on deficient roadway geometry which will be corrected with the roadway improvements, and since one of the project objectives is to maintain the rural feel of the Silverbell Road corridor, the City should re-evaluate the lighting requirements. Installation of continuous lighting from Goret Road to Grant Road would be consistent with the section to the south of Grant Road. Lighting at high volume unsignalized intersections (Belmont Road) and key destinations (Christopher Columbus Park) should be considered.
- Based on existing and potential future transit service on Silverbell Road, install northbound and southbound bus pull outs at Grant Road and provide sufficient right-of-way at other signalized intersections for future pull outs.
- A proposed roadway cross section that includes minimum travel lane and median widths per the Pima County Environmentally Sensitive Roadway Design Guide is recommended.
- Recommended pedestrian facilities include a hardened multi-use path extending from Ina Road to Grant Road on the east side of Silverbell Road. Provision of sidewalk on the west side of Silverbell Road between Goret Road and Grant Road should be considered. While pedestrian signals (HAWKs) are not currently required, the need for a signal at Introspect Drive where a charter school is located should be evaluated. Bicycle facilities should include paved shoulders within the roadway as well as the multi-use path. Equestrian trails should be provided on both sides of Silverbell Road to provide safe access to signalized intersections and the Santa Cruz River.
- The recommended posted speed limit is 45 mph between Ina Road and Goret Road and 40 mph between Goret Road and Grant Road.
- While the evaluation of right-turn traffic at unsignalized intersections indicates that installation of deceleration lanes at seven locations is slightly warranted, considering that a 4-lane roadway will provide excess capacity relative to projected 2040 demand, installation of these lanes is not recommended. However, a deceleration lane should be provided at Christopher Columbus Park since heavy traffic does occur during special events throughout the year.

References

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4. Comprehensive Roadway Illumination Study - Phase IV, City of Tucson, TransCore, January 2003.
5. 2030 Regional Transportation Plan, Pima Association of Governments, Adopted by PAG Regional Council – June 29, 2006.
6. Institute of Transportation Engineers. *Trip Generation, 8th Edition*. 2008.
7. Pima County Roadway Design Manual, Pima County Department of Transportation, December 2003.
8. City of Tucson Major Streets & Routes Plan, Tucson Department of transportation, January 2000.
9. Transportation Access Management Guidelines for the City of Tucson, Arizona, March 2003.
10. AASHTO Policy on Geometric Design of Highways and Streets, 2004.
11. AASHTO Roadside Design Guide, 2004.
12. NCHRP Report 457, Evaluating Intersection Improvements: An Engineering Study Guide.