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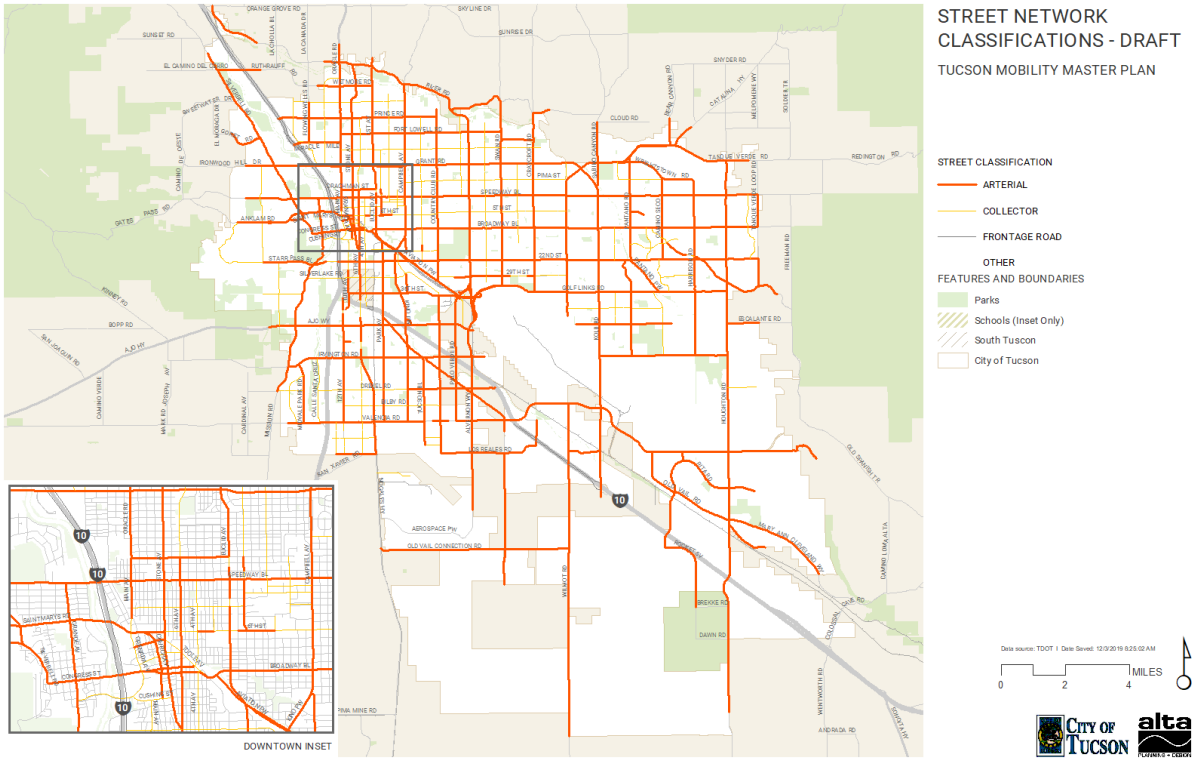
TUCSON STREET NETWORK ANALYSIS MEMO

Street Network Overview

Tucson has more than 2,300 miles of streets (excluding interstates). The majority of these streets (more than 75%) are local streets which carry relatively few vehicles at low travel speeds. This memo primarily focuses on Tucson's non-local streets, meaning its network of collectors, arterials, and frontage roads. These non-local streets total 550 miles— more than 1,700 lane miles— and include all the major corridors (excluding interstates) that move people around Tucson.

Functional Classification

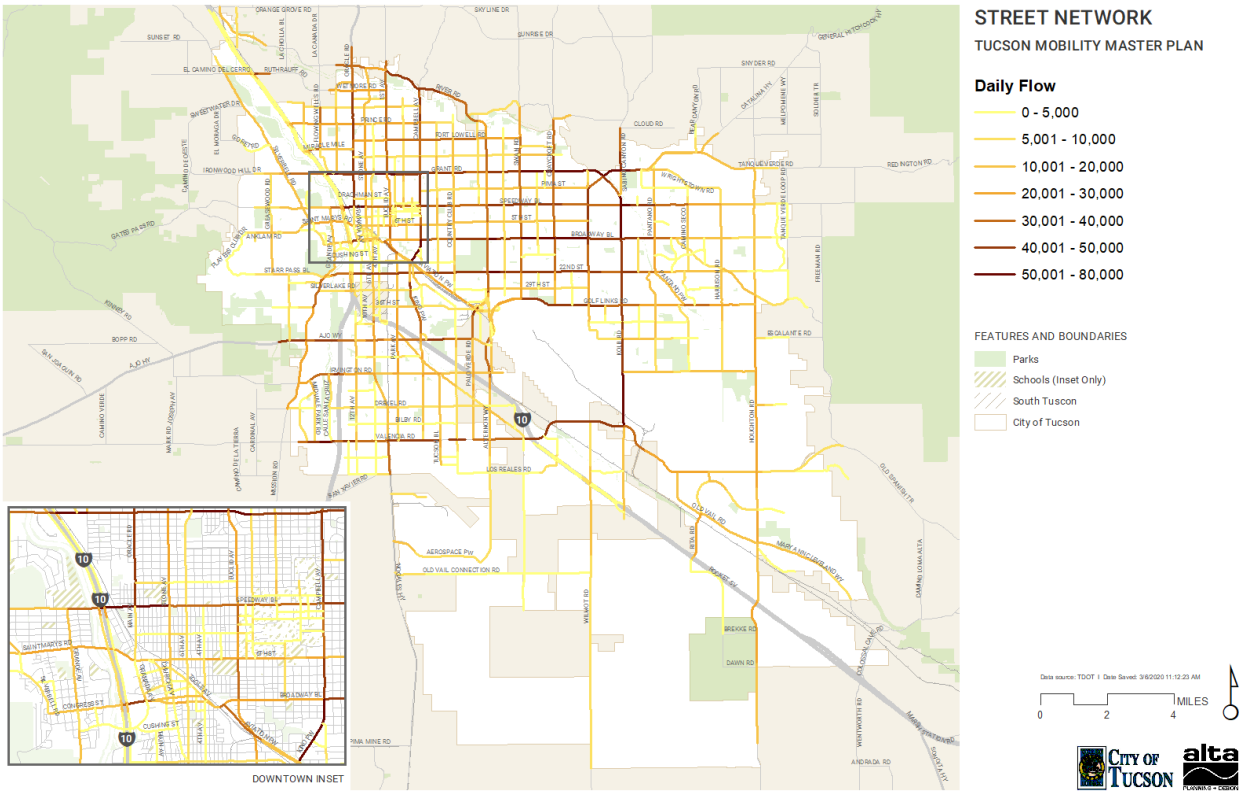
Tucson's non-local street network is principally comprised of arterial streets, which carry relatively large numbers of vehicles at higher speeds. Arterials account for 72% of all street miles and 82% of all lane miles among non-local streets. Collector streets, which have fewer travel lanes and lower speed limits, account for 23% of all non-local street miles. Frontage roads are just 5% of street miles, and their key appears to be serving as extended interstate on- and off-ramps.



FUNCTIONAL CLASS	MILES	% MILES	LANE MILES	% LANE MILES
Arterial	377	72%	1,402	82%
Collector	118	23%	263	15%
Frontage Road	27	5%	52	3%

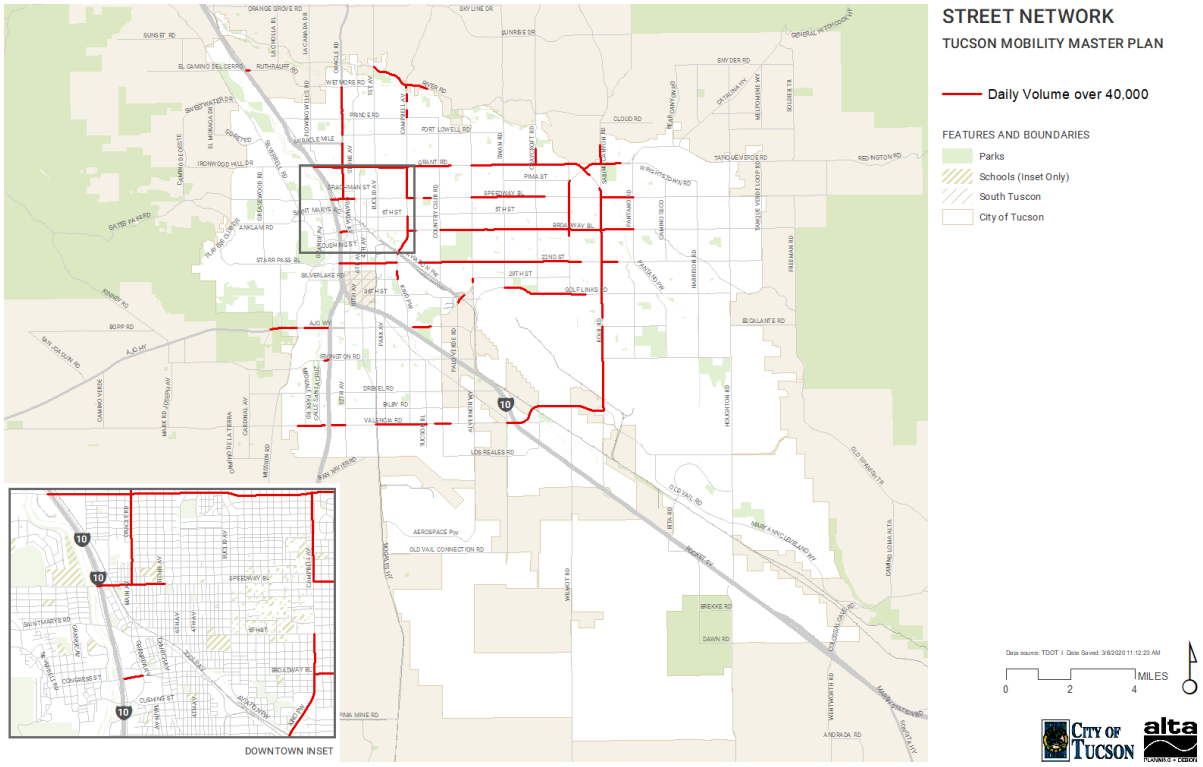
Traffic Volumes

High daily traffic volumes are concentrated among a small number of Tucson's streets. More than 60% of Tucson's street miles serve under 10,000 vehicles per day. Only 13% of street miles carry more than 30,000 vehicles per day.



DAILY VOLUME	STREET MILES	% STREET MILES	LANE MILES	% LANE MILES
0 - 5,000	122.8	15.5%	247.17	10.9%
5,000 - 10,000	369.28	46.5%	770.53	34.0%
10,000 - 15,000	77.6	9.8%	238.74	10.5%
15,000 - 20,000	55.13	6.9%	191.97	8.5%
20,000 - 25,000	32.45	4.1%	122.87	5.4%
25,000 - 30,000	24.66	3.1%	106.44	4.7%
30,000 - 35,000	29.03	3.7%	133.42	5.9%
35,000 - 40,000	26.68	3.4%	138.94	6.1%
40,000 - 45,000	27.52	3.5%	153.28	6.8%
45,000 - 50,000	17.59	2.2%	93.34	4.1%
50,000 +	12.19	1.5%	70.54	3.1%

Tucson's highest daily traffic volumes are seen on a small stretch of Speedway Blvd just east of Interstate 10, where volumes reach nearly 80,000 vehicles per day. A 1.5-mile stretch of Grant Road between Craycroft Rd and Tanque Verde Rd sees just over 60,000 vehicles per day. Otherwise, all volumes fall below 60,000 vehicles per day, and as the map on the next page shows, volumes over 40,000 vehicles per day are isolate on a small share of roads.



Arterials carry by far the heaviest daily traffic volumes in Tucson, with an average daily volume (weighted by segment length) of more than 21,500 vehicles.

FUNCTIONAL CLASS	AVG DAILY VOLUME
Arterial	21,506
Collector	6,867
Frontage Road	2,953
Other	4,957

Frontage roads carry a weighted average of 3,000 vehicles per day, but small portions immediately at interstate ramps carry more than 10,000 or even 20,000 vehicles per day. Based on this data, frontage roads appear to mostly serve as interstate access and exit points and see very small volumes otherwise.

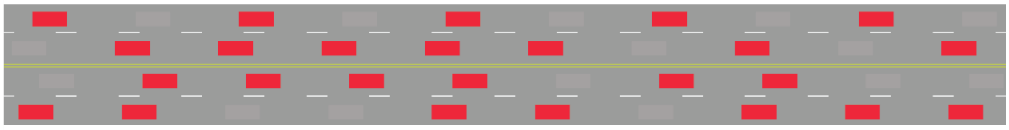
Traffic Congestion and Reliability

In managing the street network in Tucson for today and the future, it is important to understand the current volume of traffic on the City's streets and the maximum capacity those streets are designed for. Using data from the Pima Association of Governments' (PAG) regional travel demand model, volume/capacity (V/C) ratios were calculated for all of Tucson's major streets during the morning peak period (6:30 - 8:30 am), midday (8:30 am – 4:00 pm), the evening peak period (4:00 – 6:00 pm), and night (6:00 pm – 6:30 am). It should also be noted that the PAG regional travel demand model is calibrated for traffic volumes in October. Traffic volumes may be significantly lower at other times of year, such as summer when the University of Arizona is out of session and visitor numbers are lower.

The V/C ratio compares the number of cars traveling on a street to the maximum number of cars that street can carry. For example, a V/C ratio of 0.5 indicates that the street carries half the total number of cars as its capacity can hold. A V/C ratio under 0.6 generally equates to level of service (LOS) A, meaning that drivers experience no delay. A V/C ratio between 0.6 and 0.8 generally equates to LOS B/C, meaning drivers may be slightly restricted but still experience minimal, if any delay. Above a V/C ratio of 0.8 notable congestion may develop and drivers may experience decreased speeds and delays.

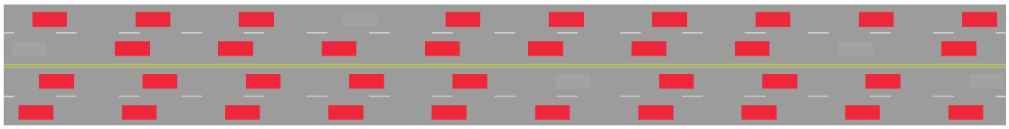
UNDER 60% CAPACITY

A V/C ratio of 0.6 or under generally equates to level of service (LOS) A, meaning that drivers experience no delay.



60 - 80% CAPACITY

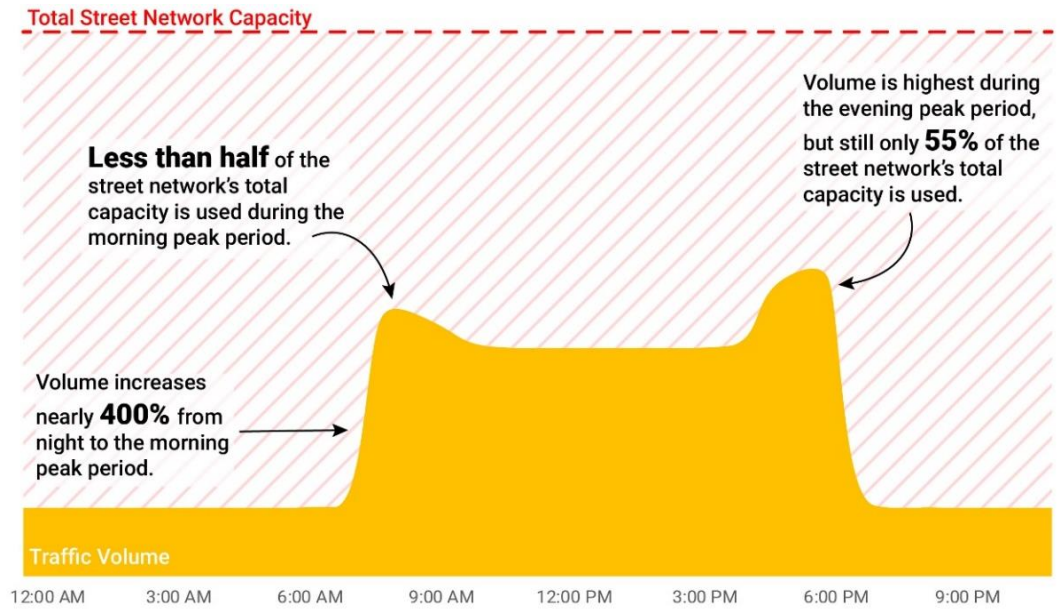
A V/C ratio between 0.6 and 0.8 generally equates to LOS B/C, meaning drivers may be slightly restricted but still experience minimal, if any, delay.



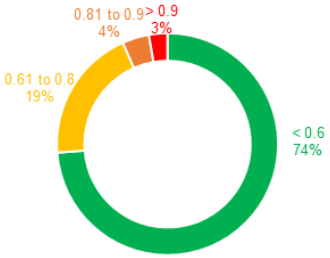
80 - 100% CAPACITY

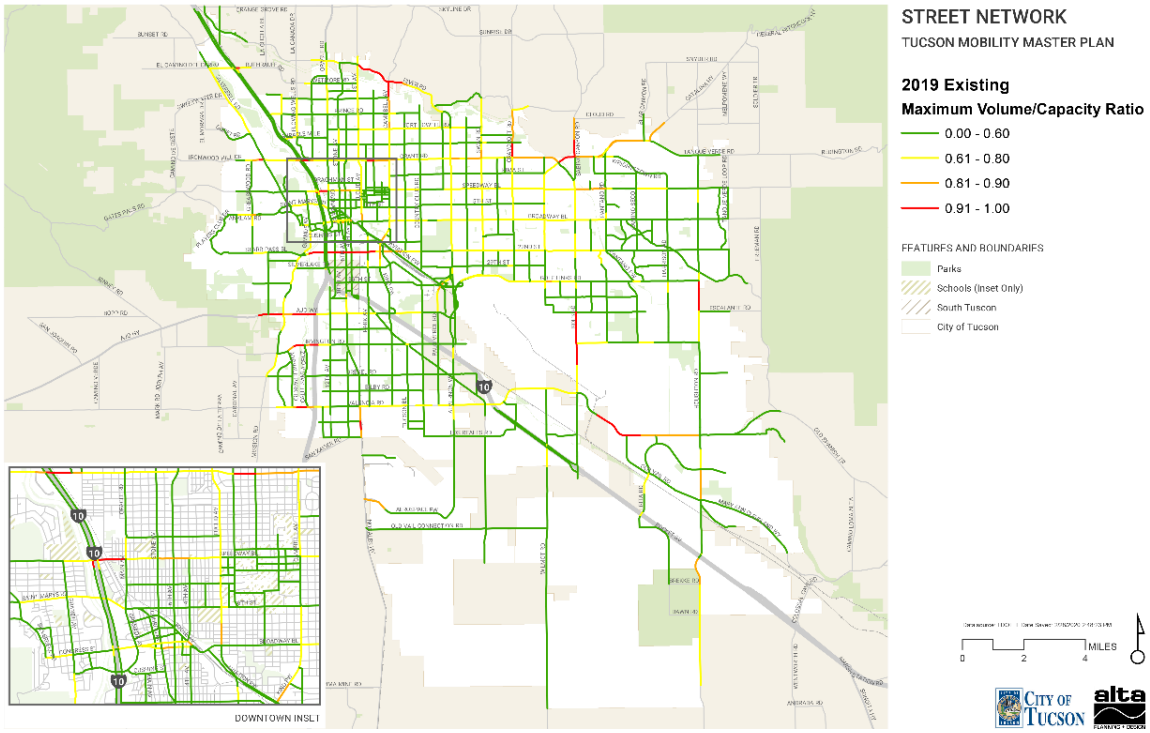
At a V/C ratio between over 0.8, congestion is likely to begin developing, and drivers may experience decreased speeds and delays, especially as the ratio approaches closer to 1.0.

Looking at the overall street network in Tucson, there appears to be significant excess capacity across the entire day. Traffic volumes are highest during the morning and evening peak periods, with the evening peak period seeing slightly higher volumes in Tucson. Even during the busiest times of day, though, only around half of the street network's total capacity is being used (47% of capacity is used during the morning peak period and 55% is used during the evening peak period). At other times of the day, there is even more excess capacity.



Few streets in Tucson carry close to the maximum volume of traffic they are designed for, even at the busiest times of day. Looking at the maximum V/C ratio for every major street across the day, only 7% (36 miles) of streets exceed 0.8 at any point during the day.





Only 15 streets across Tucson have more than one mile of segments operating above 80% of capacity at any point during the day.

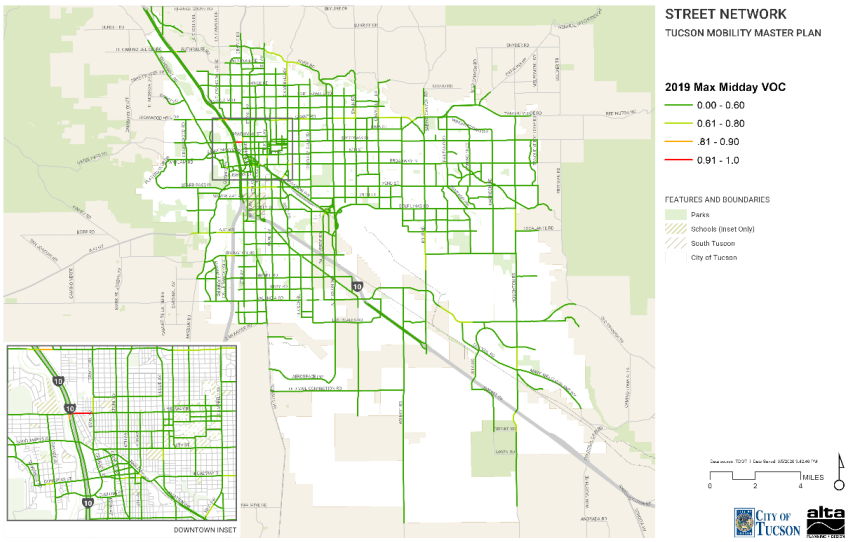
STREET NAME	MILES WITH V/C RATIO > 0.8
22ND ST	2.25
AJO WY	1.03
CAMPBELL AV	1.29
CRAYCROFT RD	1.57
GRANT RD	3.85
HOUGHTON RD	2.87
IRVINGTON RD	1.09
KINO PW	1.17

STREET NAME	MILES WITH V/C RATIO > 0.8
KOLB RD	1.68
NOGALES HY	1
RIVER RD	1.87
SABINO CANYON RD	1.25
SPEEDWAY BL	1.75
TANQUE VERDE RD	1.2
VALENCIA RD	4.34

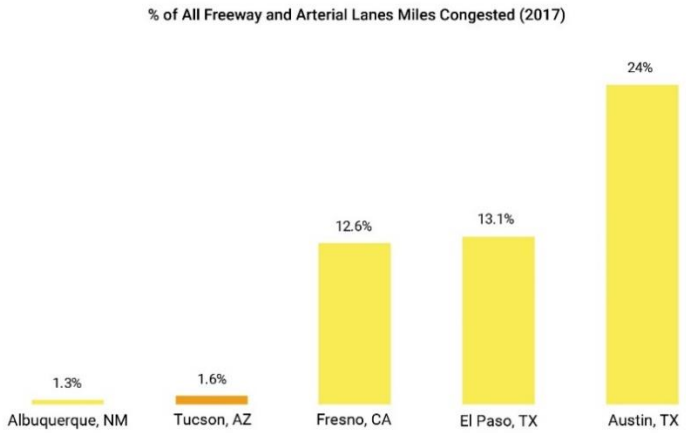
Tucson's arterials have the highest V/C ratios of any classification— not surprising considering that they carry the most traffic. Arterials have an average maximum V/C ratio (weighted by segment length) of 0.5, meaning that the average arterial carries half the number of cars it's designed for at the busiest time of day. Outside peak hours, streets typically have much lower V/C ratios. Tucson's collectors have a weighted average maximum V/C ratio of 0.32, meaning that at the busiest time of day, the average collector serves less than one-third of the maximum number of vehicles it could carry. Less than one mile (.54 miles) of collectors operate above 80% capacity at peak periods.

	AVG MAX V/C	V/C < 0.6		V/C 0.61 - 0.8		V/C 0.81 - 0.9		V/C > 0.9	
		Street miles	*%*	*Street miles*	*%*	*Street miles*	*%*	*Street miles*	*%*
Arterial	0.5	237.3	62.9%	105.2	27.9%	20.6	5.5%	14.4	3.8%
Collector	0.32	115.4	98.0%	1.9	1.6%	0.2	0.2%	0.4	0.3%
Frontage Rd	0.17	25.9	97.4%	0.6	2.1%	0.0	0.1%	0.1	0.4%

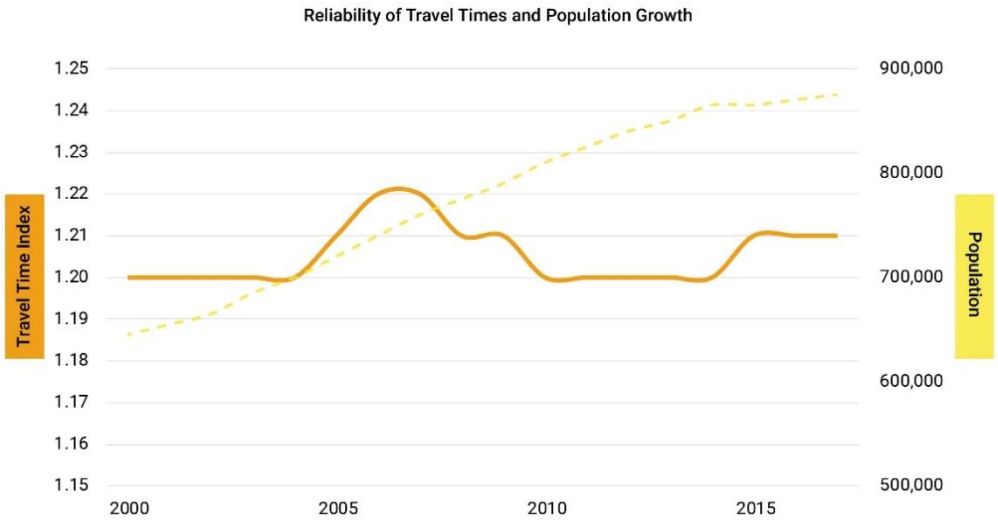
Outside of the morning and evening peak periods, almost no streets operate above 80% of their capacity. Less than one mile of streets have a V/C ratio above 0.8 during the midday period (8:30 AM – 4:00 PM) and 97% of all streets operate at less than 60% capacity.



Compared to many of its peer cities, a very small portion of Tucson's street network (only examining freeways and arterial streets) is congested. This data from the 2019 Urban Mobility Report prepared by the Texas Transportation Institute defines congestion as any period where a street's average travel speed drops below 75% of its free-flow speed. The Tucson urban area, which includes portions of Pima County outside of Tucson's city limits, has a much smaller share of freeway and arterial lanes miles that are congested (1.6%) compared to peer cities like Fresno, CA (12.6%); El Paso, TX (13.1%); and Austin, TX (24%). Out of 32 urban areas with a population between 500,000 and 1 million included in the dataset, Tucson had the third lowest portion of congested lane miles— only Albuquerque, NM and New Haven, CT were lower.

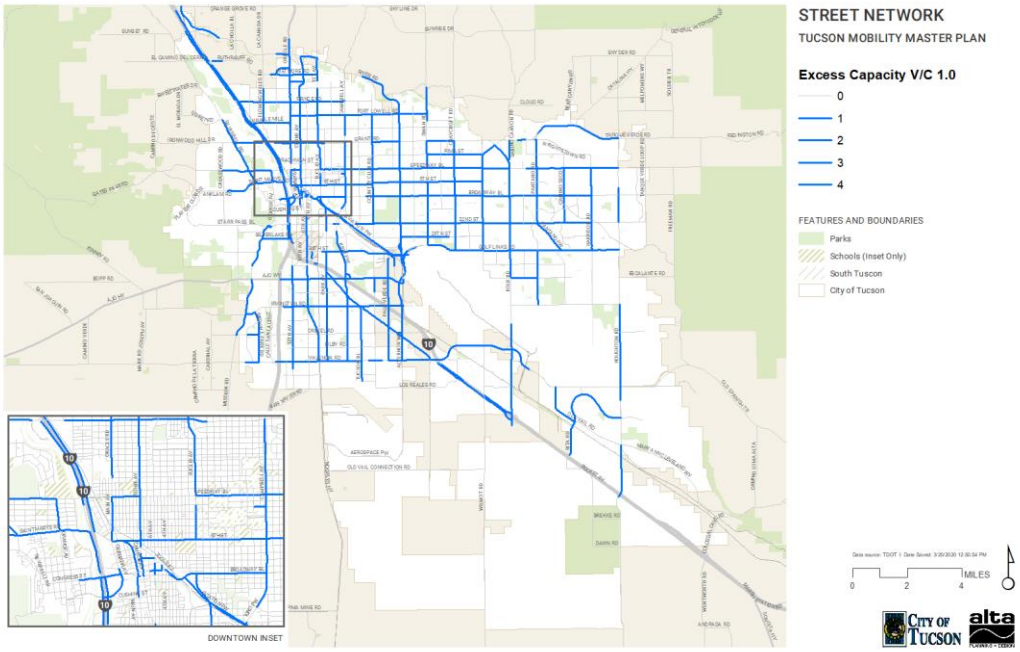


The 2019 Urban Mobility Report also examines the reliability of urban area's arterials and freeways. Travel time index compares travel times during peak periods vs. free-flow conditions. A travel time index of 1.2 indicates that a trip that takes 20 minutes outside of the peak period would take 24 minutes during the peak period. Tucson's arterials and freeways have remained steadily reliable since 2000. The travel time index has been between 1.2 to 1.22 for every year from 2000 to 2017, even though the Tucson urban area's population increased by 33% during the same time period.

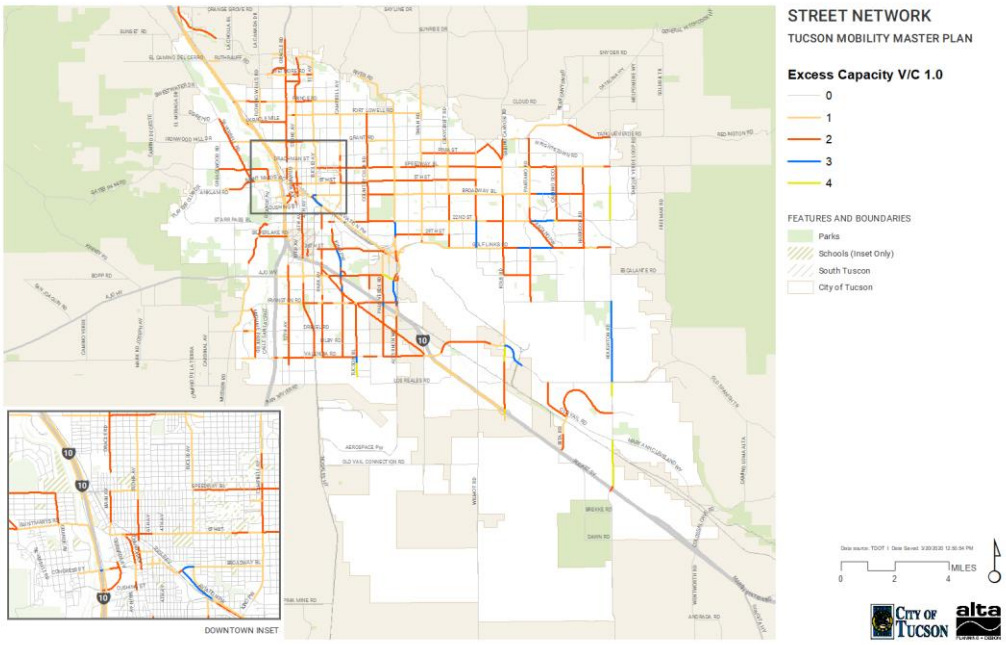


Excess Capacity

The PAG's travel demand model indicates that there is significant excess road capacity. This analysis explores the magnitude of that excess. The map below represents streets where, if at least one travel lane was removed, the street would still function under a V/C of 1.0 during the busiest time of day. Using this threshold, a total of 256 miles of streets have excess capacity of at least one lane—nearly half of all street miles. While an initial examination of V/C ratios is a strong indicator of where travel lanes potentially be removed, it should be noted that these decisions would ultimately require more detailed traffic analysis.



The map below shows the number of lanes that could be removed and the street would still operate at a V/C under 1.0 during the busiest time of the day. In total, this analysis counts 423.3 excess lane miles in Tucson's major street network, representing nearly 24% of all major street lane miles.



Further, of all street miles assessed to have excess lane capacity, more than half showed excess capacities of at least two lanes.

# Excess Lanes	Street Miles	Share
1	111.96	43.7%
2	126.88	49.5%
3	12.06	4.7%
4	5.35	2.1%

The vast majority of total excess capacity is found within arterials. Nearly 85% of all streets with excess capacity are arterials, and over 88% of all excess lane miles are arterial lane miles. Further, 58% of all arterial street mileage shows excess lane capacity, and this analysis shows that over one quarter of all arterial lane miles could be excess capacity.

It should be noted, however, that 87% of all collector streets are two-way streets with a single lane in each direction. Excess capacity was not calculated for these streets because they already have a minimum one lane in a direction.

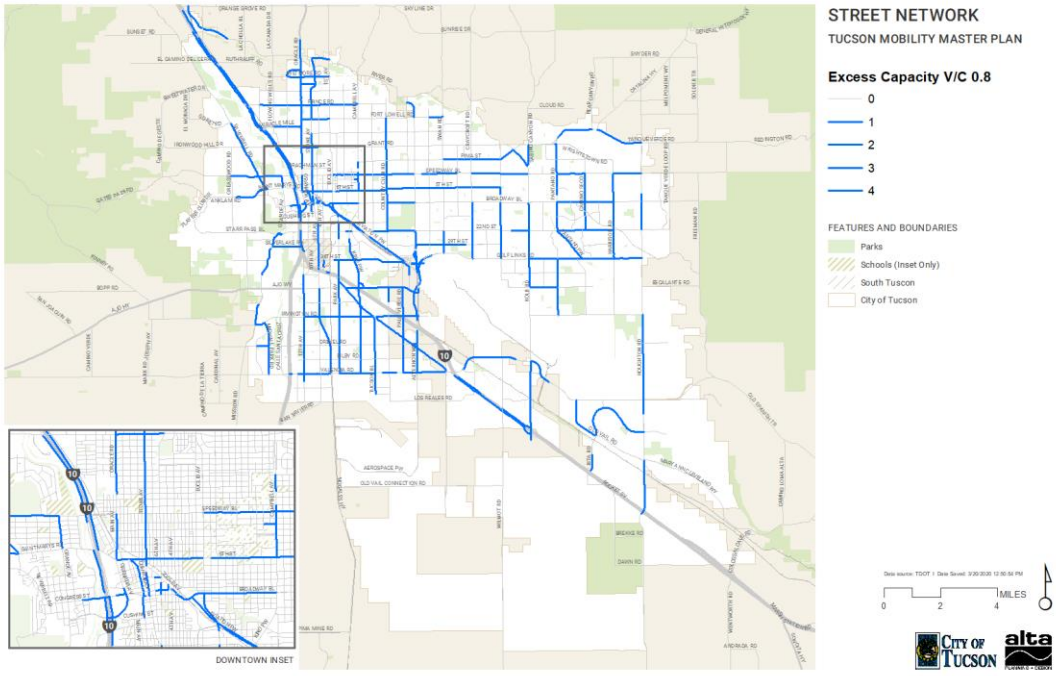
Additionally, more than 83% of all frontage road street miles have excess capacity, and this analysis shows nearly half of all frontage road lane miles could be excess capacity—although that's an overall relatively low number of total lane miles.

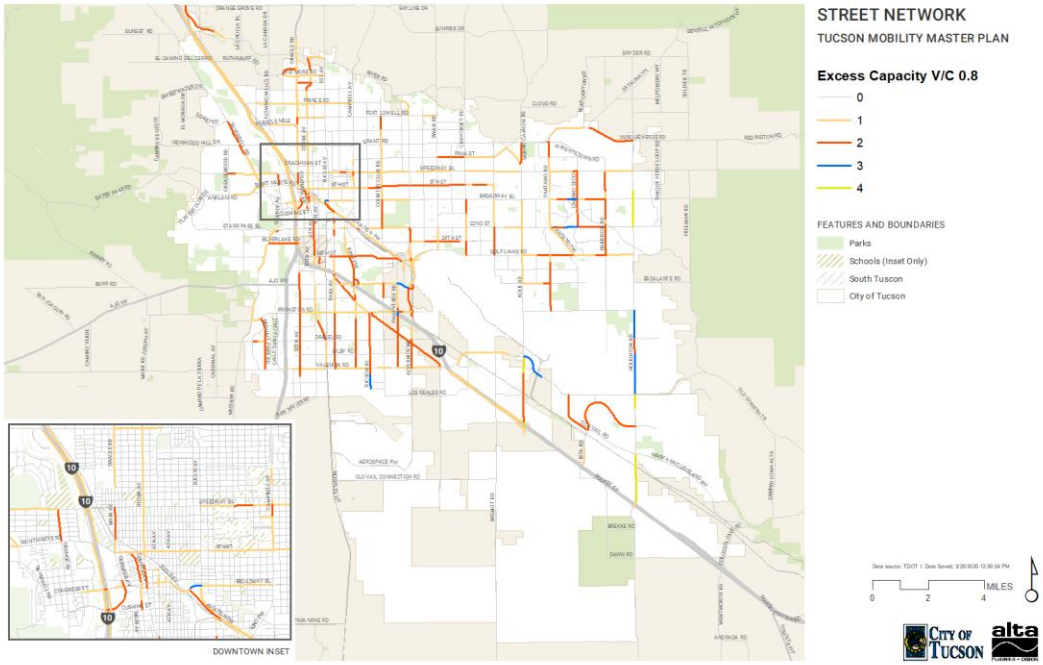
	Excess Street Miles	Total Street Miles	Share of All Excess Street Miles	Share of FC's Total Street Miles
Arterial	219.26	377.47	85.5%	58.1%
Collector	14.05	117.83	5.5%	11.9%
Frontage	22.1	26.55	8.6%	83.2%
Other	0.84	27.48	0.3%	3.1%

	Excess Lane Miles	Total Lane Miles	Share of All Excess Lane Miles	Share of FC's Total Lane Miles
Arterial	374.34	1402.02	88.4%	26.7%
Collector	25.38	262.72	6.0%	9.7%
Frontage	22.1	52.63	5.2%	42.0%
Other	1.48	53.53	0.3%	2.8%

Excess Capacity - 0.8 V/C

It's important to consider that capacity reductions resulting in V/C ratios nearing 1.0 may not be ideal, even though those V/C ratios only occur for a brief point at the busiest times of day. And so, the same analysis was run to understand excess lane capacity but with the goal of maintaining V/C ratios under 0.8. Considering this lower V/C ratio, the analysis counts 288.03 excess lane miles in Tucson's major street network, representing nearly 16% of all major street lane miles. Additionally, 194 miles of streets have excess of at least one lane capacity under the 0.8 V/C standard—over 35% of all street miles.





When using a 0.8 V/C ratio standard, a smaller share of streets with excess capacity have at least two excess lanes—just over 40%, compared to 56% at the 1.0 V/C ratio standard.

# Excess Lanes	Street Miles	Share
1	114.36	58.9%
2	69.79	36.0%
3	5.63	2.9%
4	4.3	2.2%

The vast majority of total excess capacity is still found within arterials. Over 82% of all streets with excess capacity are arterials, and nearly 85% of all excess lane miles are arterial lane miles at the 0.8 V/C standard—just slighting lower than the 1.0 V/C standard. However, at the 0.8 V/C standard, a significantly lower share of total arterial street miles and lane miles are now excess capacity. Frontage road excess capacity is relatively similar between the two V/C standards.

	Excess Street Miles	Total Street Miles	Share of All Excess Street Miles	Share of FC's Total Street Miles
Arterial	159.49	377.47	82.2%	42.3%
Collector	13.15	117.83	6.8%	11.2%
Frontage	20.6	26.55	10.6%	77.6%
Other	0.84	27.48	0.4%	3.1%

	Excess Lane Miles	Total Lane Miles	Share of All Excess Lane Miles	Share of FC's Total Lane Miles
Arterial	244.25	1402.02	84.8%	17.4%
Collector	21.7	262.72	7.5%	8.3%

Frontage	20.6	52.63	7.2%	39.1%
Other	1.48	53.53	0.5%	2.8%

Excess Capacity: What Are the Implications?

Tucson's excess major street capacity presents a number of opportunities, including:

Maintenance Costs: On average, a mile of urban roadway costs $24,000 per year in maintenance. With as many as 423 existing excess lane miles, that could mean up to $10 million per year in excess costs to maintain unneeded roadway capacity.

Bus Lanes: Many corridors showing excess lanes are major transit corridors. Lanes on these roads could be repurposed as bus-only lanes to speed up transit service and improve reliability without causing major congestion.

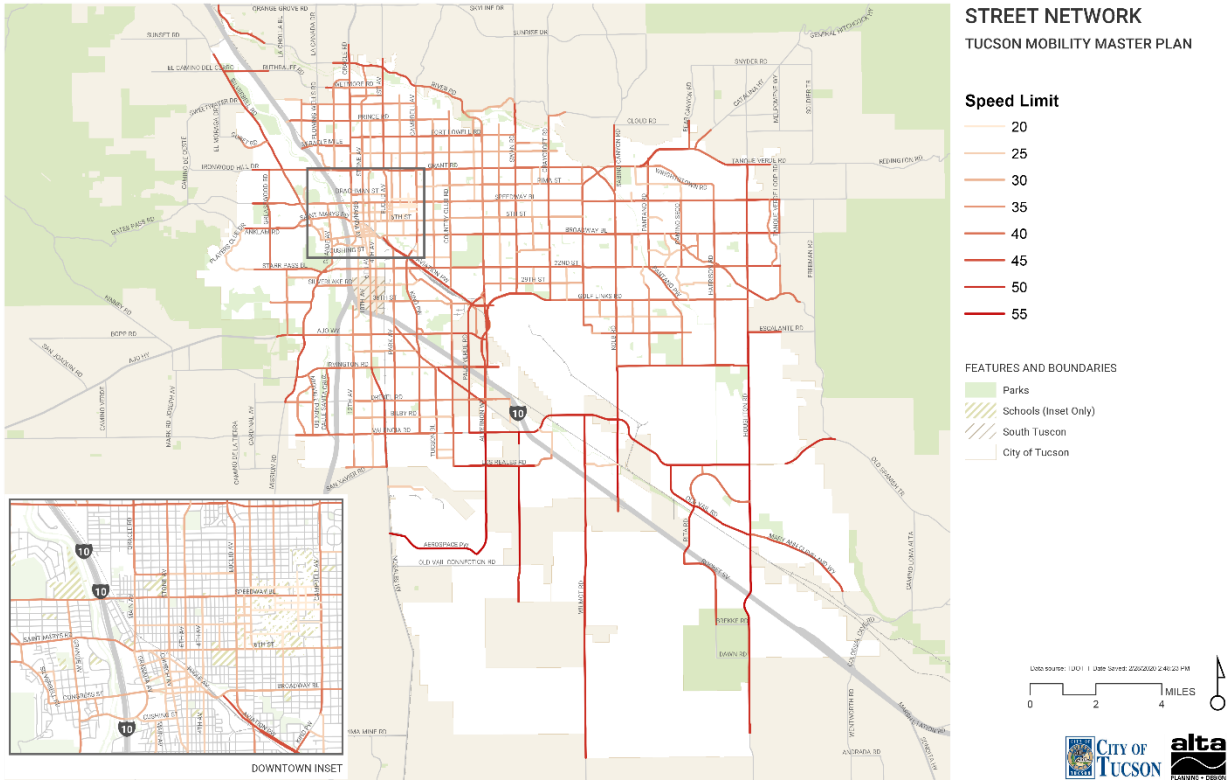
Bicycle Lanes: Excess lanes could be repurposed as dedicated and protected bicycle lanes.

Crossing Distance: Excess lanes mean excess street width and excess pedestrian crossing distances. Shorter crossing distances have also been shown to improve vehicle yielding rates for pedestrians. Reducing excess lanes could create shorter and safer crossings.

Vehicle Speeds: Wider streets have been shown to lead to higher vehicle speeds, regardless of speed limits. Eliminating excess lanes to narrow the right-of-way could decrease speeds, improving safety for all users and lessening the severity of crashes.

Impervious Surfaces: Tucson's potentially 423 excess lane miles equate to 25,000,000 excess square feet of impervious surface that traps heat and worsens stormwater drainage in rain events. For perspective, that's equal to paving over all of Tucson's downtown—twice.

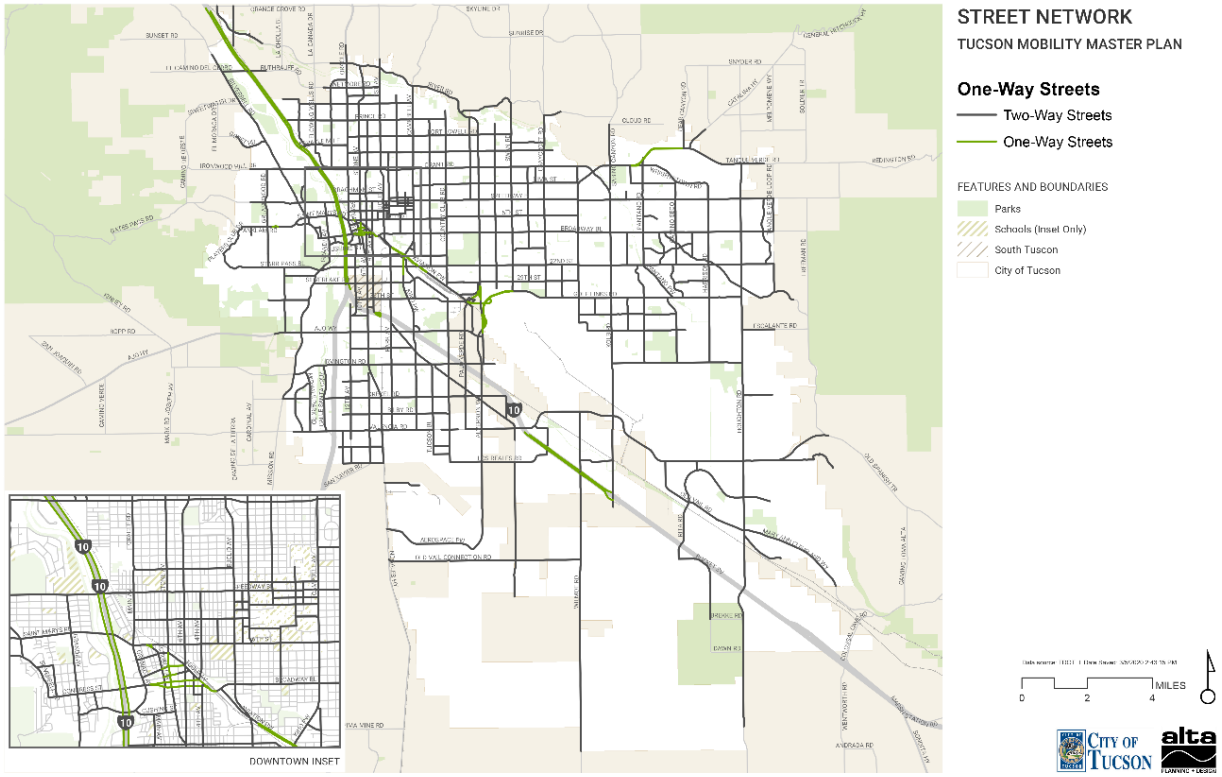
Speed Limits



Among non-local streets, Tucson's speed limits follow a general "bullseye" pattern radiating out from the central business district, with lower speeds in the core and higher speed on the fringes. The map above also reveals larger pockets of lower-speed streets in the neighborhoods east of downtown and the 12th Ave and 6th Ave corridors stretching south of downtown. Overall, 55% of major street miles in Tucson have speed limits above 40 miles per hour, and 62% of lane miles are above 40 miles per hour.

SPEED LIMIT	MILES	% MILES	LANE MILES	% LANE MILES
20	3.95	1%	7.90	0%
25	55.15	11%	113.60	7%
30	49.88	10%	129.04	8%
35	116.06	23%	382.01	23%
40	142.38	29%	626.60	38%
45	72.58	15%	231.16	14%
50	36.16	7%	106.64	6%
55	20.3	4%	67.80	4%

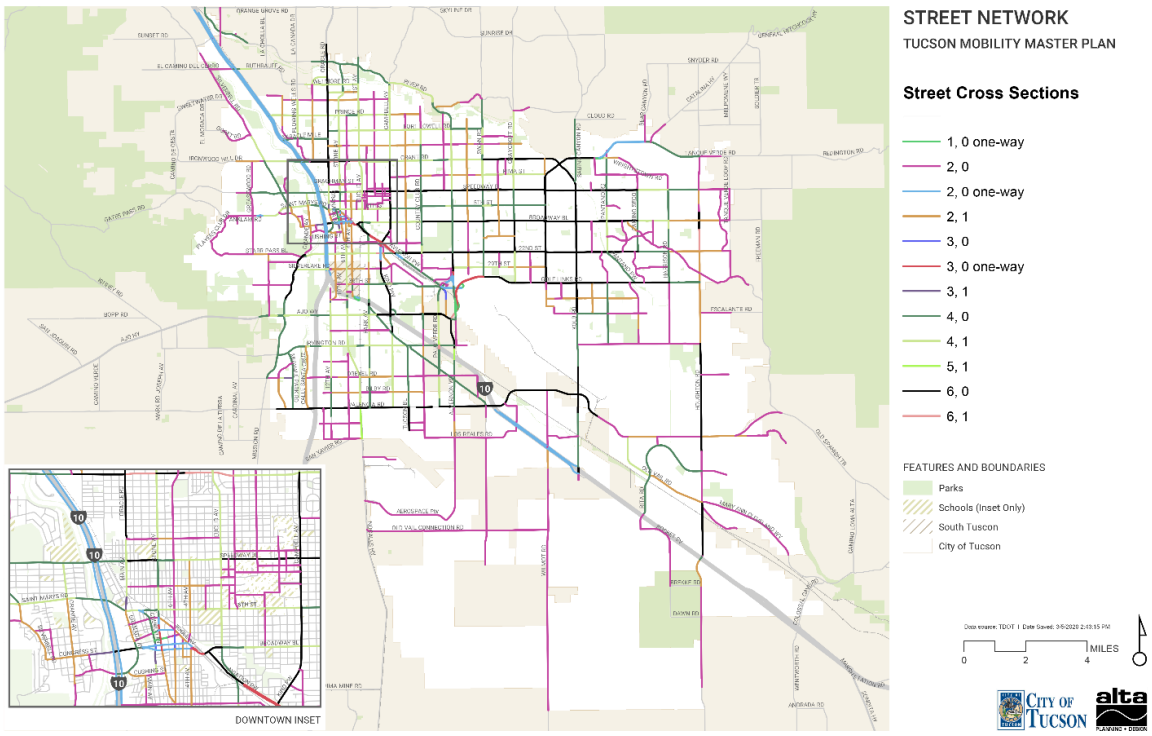
One-Way vs Two-Way



Among non-local streets, Tucson has very few streets classified as one-way, and all non-frontage road streets outside of downtown that are classified as one-way are, in fact, divided roadways. Major one-way streets downtown include the frontage roads, Stone Ave, Alameda St, Pennington St, Congress St and Broadway Blvd.

	MILES	% MILES	LANE MILES	% LANE MILES
One-Way Street	45.81	8%	94.9	5%
Two-Way Street	504.05	92%	1,679.2	95%

Cross Sections



Among non-local streets, Tucson's street network is composed of 12 different combinations of travel lanes and center turn lanes, referred to here as cross section types. The most common cross section is a single lane in each direction of travel (34 percent of all street miles). However, the most lane miles fall under three lanes in each direction, with no center turn lane. Streets with two lanes in each direction and streets with two lanes in each direction plus a center turn lane are the next most-common cross section types. Just over one quarter of all major streets in Tucson have a center turn lane.

CROSS SECTION TYPE	MILES	% MILES	LANE MILES	% LANE MILES
1, 0 one-way	3.12	0.6%	3.12	0.2%
2, 0	186.29	33.9%	372.58	21.0%
2, 0 one-way	36.30	6.6%	72.60	4.1%
2, 1	64.95	11.8%	129.90	7.3%
3, 0	0.65	0.1%	1.95	0.1%
3, 0 one-way	6.39	1.2%	19.17	1.1%
3, 1	0.90	0.2%	2.70	0.2%
4, 0	90.26	16.4%	361.04	20.4%
4, 1	76.76	14.0%	307.04	17.3%
5, 1	1.49	0.3%	7.45	0.4%
6, 0	80.42	14.6%	482.52	27.2%
6, 1	2.33	0.4%	13.98	0.8%

Tucson's 5-1 streets (three lanes in one direction, two in the other and a center turn lane) are the city's most congested, although there are only 1.5 total miles of this type of cross section. Streets with three

lanes in each direction, three lanes in each direction plus a center turn lane and two lanes in each direction plus a center turn lane also have higher maximum vehicle/capacity (VOC) levels.

CROSS SECTION TYPE	MEDIAN MAX V/C	MEDIAN SPEED LIMIT
1, 0 one-way	0.482	40
2, 0	0.301	30
2, 0 one-way	0.424	40
2, 1	0.384	30
3, 0	0.279	25
3, 0 one-way	0.464	45
3, 1	0.479	30
4, 0	0.432	40
4, 1	0.571	35
5, 1	0.865	45
6, 0	0.631	40
6, 1	0.570	40

No surprisingly, streets with more lanes carry higher volumes.

NO. OF LANES	AVG WEIGHTED DAILY VOLUME	AVG WEIGHTED DAILY VOLUME/LANE
1	4,887	4,887
2	6,934	3,467
3	15,254	5,085
4	22,414	5,604
5	33,112	6,622
6	39,087	6,515