PSOMAS

Design Concept Report

Houghton Road 22nd Street to Valencia Road Road Widening

COT Job No. SR1B

COT Plan No. I-2007-001

August 2008

Submitted To:

City of Tucson

RTA Regional Transportation Authority

DESIGN CONCEPT REPORT

HOUGHTON ROAD
22ND STREET TO
VALENCIA ROAD
JOB N0. SR1B

Plan No. I-2007-001

Prepared For:

City of Tucson
Department of Transportation
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August 2008

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EXECUTIVE SUMMARY

The Houghton Road corridor project is a roadway reconstruction project to be built in the City of Tucson between Tanque Verde Road and Interstate 10 as part of the Regional Transportation Authority (RTA) plan. This segment of the roadway reconstruction will begin south of 22nd Street and extend 5.4 miles to north of Valencia Road, as shown in the Location Map (Figure i). This new roadway is planned to be funded mostly by money allocated by the RTA, as well as impact fees, bonds, and other funds.

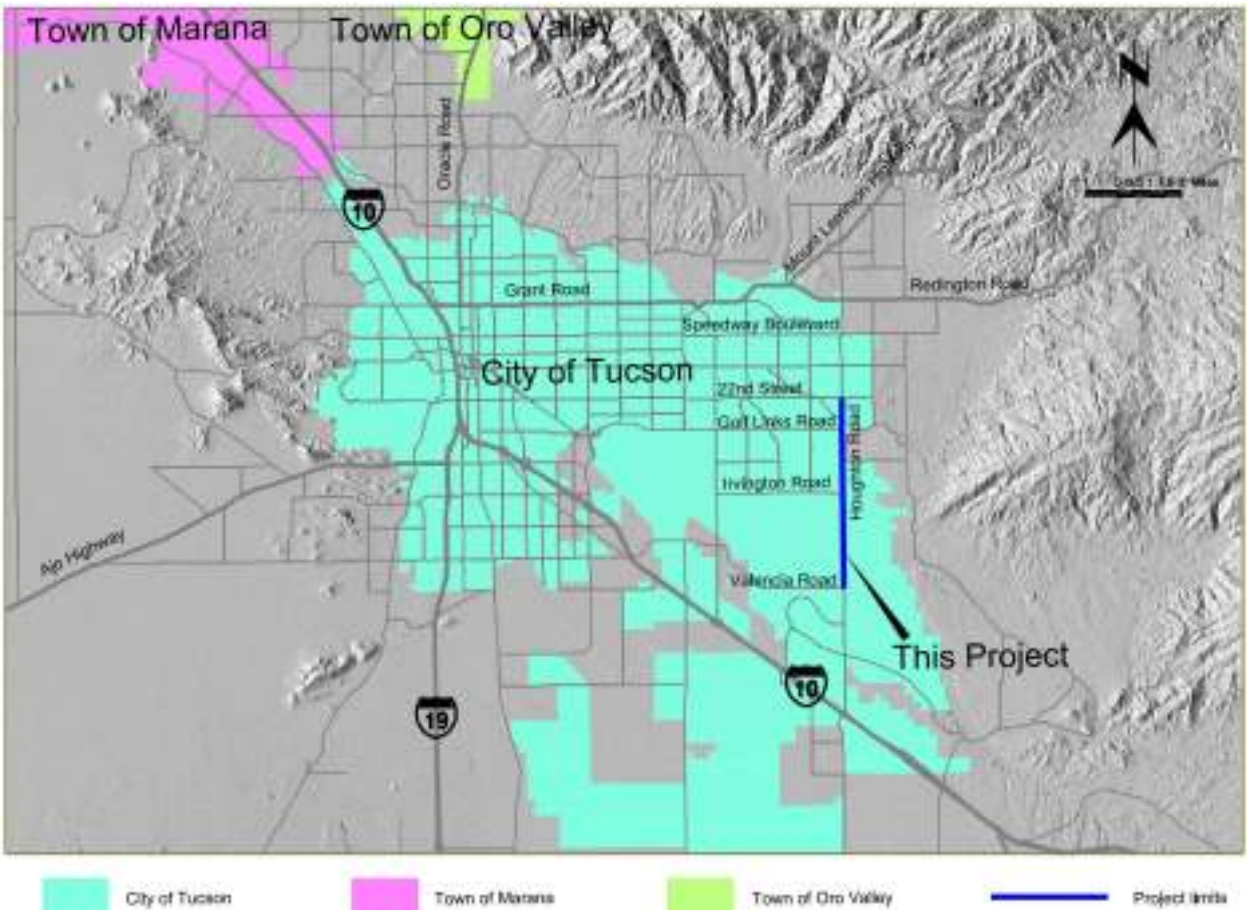

Figure i. Location Map

The work leading to this project included the *Houghton Road Corridor Study* (HRCS), prepared in October 2004 by Arizona Department of Transportation (ADOT) consultants at the City of Tucson's request, and the *Houghton Area Master Plan* (HAMP) adopted by the City of Tucson in June 2005. Both documents forecasted significant urban growth along the Houghton Road corridor and in southeast Tucson. The HRCS identified the roadway improvements, access management policies, and implementation timelines required to accommodate the projected growth and improve regional mobility. The 2006 RTA Plan took the findings of both of those studies and outlined the major characteristics of the project, which include widening and reconstructing the existing roadway to six lanes, providing drainage improvements, and adding facilities for pedestrians and bicycles. The new roadway will be a major north-south arterial corridor serving regional traffic, as well as residential and commercial land uses in the southeast area of the City of Tucson.

Based on the Average Daily Traffic volumes and peak-hour turning movement counts collected in March 2007, the volumes along most of the roadway are approximately 20,000 vehicles per day (VPD). From 22nd Street to Old Spanish Trail the ADT is 16,000 VPD, and from Golf Links Road to Escalante Road, volumes are over 25,000 VPD. As a result of population growth and continued development in the area, the traffic volumes along Houghton Road are anticipated to grow significantly between now and 2030. The projected volumes for this project were developed after analyzing two primary sources: the 2030 regional traffic model from the Pima Association of Governments (PAG) and the traffic forecasts included in the HRCS. Table i presents the current daily volumes, the projected volumes from PAG and the HRCS, and the recommended volumes from the Traffic Engineering Report.

Houghton Road between 22nd Street and Valencia Road will be a new six-lane roadway divided roadway with a landscaped median. The median will not be curbed in order to allow for water harvesting. The exceptions are at signalized intersections, where the median will be curbed through the storage and taper of the longest turn lane in order to control access, channelize drainage, and protect the signal poles and additional hardware. The outside edge of the roadway will be curbed between 22nd Street and Irvington Road. The use of curb was selected because the existing right-of-way is limited (generally 150 feet or less), and the area is relatively developed with screen walls, mailboxes, utility poles and other appurtenances near the edge of

the roadway. Therefore, curbs are necessary to channelize drainage and to separate pedestrians. South of Irvington Road, the outside of Houghton Road will be uncurbed. This area is less developed and the feasibility of obtaining additional right-of-way is higher. Cut ditches can also be used to convey drainage.

Table i. Projected 2030 Daily Volumes for Road Segments

		Existing	PAG*		HRCS (2004) **		Recommended	
Roadway	**Segment**	**2007**	**2030**	**Annual Growth**	**2030**	**Annual Growth**	**2030**	**Annual Growth**
Houghton Rd	22nd Street - Old Spanish Trail	15,988	36,595	3.7%	35,700	3.6%	36,595	3.7%
	Old Spanish Tr - Golf Links Rd	20,836	61,088	4.8%	47,000	3.6%	61,088	4.8%
	Golf Links Rd - Escalante Rd	25,169	74,532	4.8%	74,200	4.8%	74,532	4.8%
	Escalante Rd - Irvington Rd	19,924	72,937	5.8%	78,000	6.1%	72,937	5.8%
	IrvingtonRd - Drexel Rd	21,881	47,102	3.4%	82,000	5.9%	47,102	3.4%
	Drexel Rd - Poorman Rd	19,499	47,085	3.9%	75,500	6.1%	47,085	3.9%
	Poorman Rd - Valencia Rd	19,495	85,808	6.7%	57,100	4.8%	47,075	3.9%
Old Spanish Tr	W of Houghton Road	9,324	30,214	5.2%	25,900	4.5%	30,214	5.2%
	E of Houghton Road	5,187	9,476	2.7%	16,400	5.1%	9,476	2.7%
Golf Links Rd	W of Houghton Road	13,595	27,280	3.1%	31,500	3.7%	31,500	3.7%
	E of Houghton Road	726	-		1,000	1.4%	1,681	3.7%
Escalante Rd	W of Houghton Road	1,484	-		8,900	8.1%	3,059	3.2%
	E of Houghton Road	3,686	4,546	0.9%	7,600	3.2%	7,600	3.2%
Irvington Rd	W of Houghton Road	10,085	29,204	4.7%	11,300	0.5%	29,204	4.7%
	E of Houghton Road	148	60,054	29.8%	2,200	12.4%	60,054	29.8%
Drexel Rd	W of Houghton Road	-	-		13,100		3,062	
	E of Houghton Road	338	3,078	10.1%	41,400	23.3%	9,647	15.7%
Bilby Rd	W of Houghton Road	-					9,187	
	E of Houghton Road	3,225					19,831	8.2%
Poorman Rd	W of Houghton Road	-	27,016		11,900		3,062	
	E of Houghton Road	1,214	14,667	11.4%	50,900	17.6%	7,130	8.0%

* PAG forecasts obtained on 03/13/07. They do not represent the official volumes used for the 2030 Regional Transportation Plan
** These volumes correspond to Scenario 3 of the Houghton Corridor Study (HRCS, 2004). Kittelson also used the same volumes for the I-10 to Valencia analysis of Houghton Road (2007)

The design speed will be 50 mph with the posted speed limit at 45 mph. There will be three travel lanes in each direction, as well as multi-use lanes to enhance alternative modes such as bicycle movement. In addition, to further enhance alternative modes, there will be a concrete pedestrian walkway on the west side of the roadway and divided urban pathways, or a

greenway, on the east side of the roadway. The roadway pavement section will include rubberized asphalt to mitigate traffic noise.

The project will include the implementation of an access management plan to extend the service life of the roadway and improve safety and operations. It is recommended that traffic signals be spaced at one mile intervals, with full-access median openings every ½ mile and right-turn access only locations separated at least 1/8 mile. Directional median openings can be provided at ¼ mile intervals at key locations with high concentration of turning volumes. At certain locations, existing conditions may require minor deviations from this policy, but those deviations should be evaluated on a case-by-case basis.

Currently, the intersections of Houghton Road with Old Spanish Trail, Golf Links Road, Escalante Road, Irvington Road, and Bilby Road are signalized in the project area. The *Traffic Engineering Report* recommends new signals at the intersections of Houghton Road with Drexel Road and Poorman Road while keeping the existing signals at other intersections. The two proposed signals at Drexel Road and Poorman Road will be designed as Florida T intersections based on discussions with the Traffic Engineering Division, the anticipated land use in the surrounding area, future traffic volume projections, and the distance between Bilby Road to both intersections (½ mile).

The only major structure within this segment of Houghton Road is the bridge over the Pantano Wash, which will require the design of a new bridge to provide additional traffic capacity on Houghton Road over the Pantano Wash. The existing four-span, 350-foot bridge at this location carries one lane of traffic each in the northbound and southbound directions. Six bridge alternatives were evaluated for the bridge superstructure over the Pantano Wash. The recommended alternative includes widening the existing bridge for three-lane southbound traffic and constructing a new four-span, three-lane northbound bridge. The existing bridge deck will be widened six feet toward the west for a total bridge width of 53 feet. A new 57-foot wide bridge will be constructed just east and adjacent to the existing bridge using the same type of girders, same span lengths, pier and abutment alignments as the existing bridge. The new bridge structure will be constructed approximately two feet higher than the existing bridge to provide for adequate freeboard during the design flood.

The typical proposed right-of-way (ROW) for the Houghton Road alignment will be 200 feet, as provided for in the City of Tucson's *Major Streets and Routes Plan*. Where the proposed right-of-way cannot be acquired, drainage, slope or temporary construction easements will be pursued in order to accommodate the roadway. Based on the existing conditions, the required ROW acquisition for the project will consist of 20 new segments covering approximately 23 acres from several different property owners. Approximately half of the new ROW will be from parcels owned by the City of Tucson or the State Land Department. Although there is need for additional right-of-way along both sides of Houghton Road, approximately 60% of the acquisition will be on the west side, with 40% being on the east side.

The length of the Houghton Road corridor and the size of the overall project create the necessity of constructing the improvements in phases. Segment improvements (including the intersections) were deemed to be more efficient than separate intersection improvements because intersection transitions from six lanes back to two lanes would require long tapers (in excess of 2,000 feet) in each direction. Overall, the proposed phasing of the improvements along the entire Houghton corridor should consider the following principles:

1. Prioritize areas that maximize the benefits to the traveling public, such as segments that currently experience the most significant operational, safety, or access deterioration.
2. Minimize the construction impacts and the inconvenience to residents by constructing the improvements at a given location at the same time to avoid going back to the same area and avoiding having two construction segments close to each other with a non-construction area in between.
3. Be mindful of long lead-time issues such as permitting, utility relocations, and right-of-way negotiations.
4. Ensure consistency with the timeline for availability of RTA funds and ensure that funding from the first period is allocated to the most critical areas.

Based on those principles and the existing area conditions, the following preliminary sequencing (Figure ii) is recommended for the central segment of Houghton Road (22nd Street to Valencia Road):

Phase 1: Irvington Road to Valencia Road
Phase 2: 22nd Street to Escalante Road
Phase 3: Escalante Road to Irvington Road

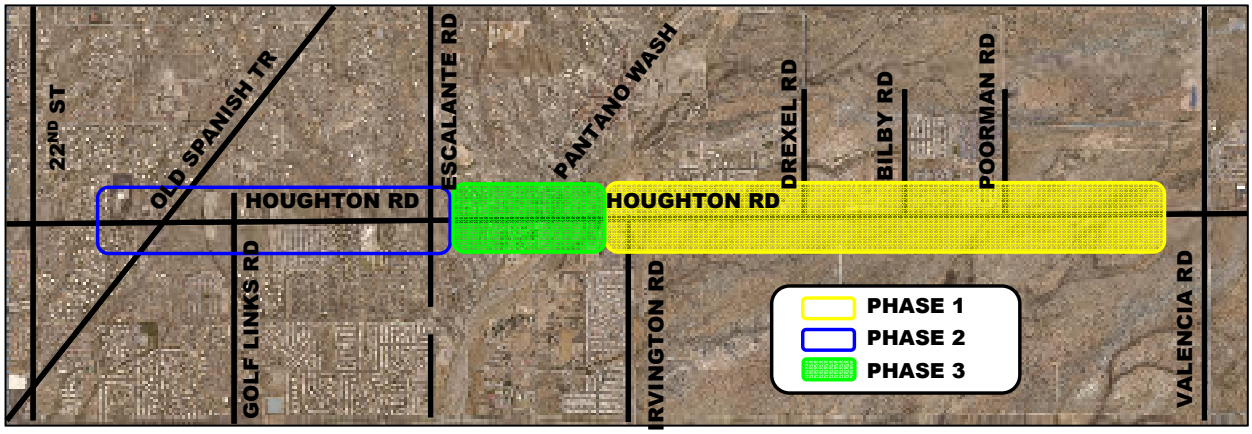

Figure ii. Proposed Houghton Road Construction Sequencing

Approximately $160 million in funds are available for the entire Houghton Road corridor from Tanque Verde to Interstate 10, with $95 million provided by RTA funding and the remainder provided by Pima County bond funds, City of Tucson and Pima County impact fees, and federal funding for the replacement of the Houghton Road bridge over the Union Pacific Railroad tracks. The estimated cost for this central segment of the Houghton Road corridor from 22nd Street to Valencia Road is $66.4 million, or approximately 42% of the total $160 million in funds available for the entire roadway corridor. The approximate cost by recommended construction phasing of the central segment is:

Phase 1: Irvington Road to Valencia Road - $30,678,462
Phase 2: 22nd Street to Escalante Road - $21,123,251
Phase 3: Escalante Road to Irvington Road - $14,562,602

As the funds for this project are allocated for the entire Houghton Road corridor, the assessment of construction phasing will also be dependent on the costs, as well as the other guiding principles for proposed phasing described above, for the north and south segments of the corridor.

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1. PROJECT OVERVIEW

The Regional Transportation Authority (RTA) transportation plan approved by voters in 2006 mandated the widening of the Houghton Road corridor between I-10 and Tanque Verde Road, as well as the addition of pedestrian and bicycle facilities. In order to facilitate the development of the corridor, the City of Tucson divided Houghton Road into three segments. This segment of the project extends from 22nd Street to Valencia Road (6 miles), as shown in the Location map (Figure 1). The other two segments of Houghton Road (22nd Street to Tanque Verde Road and Valencia Road to I-10) are being developed concurrently by other consultants.

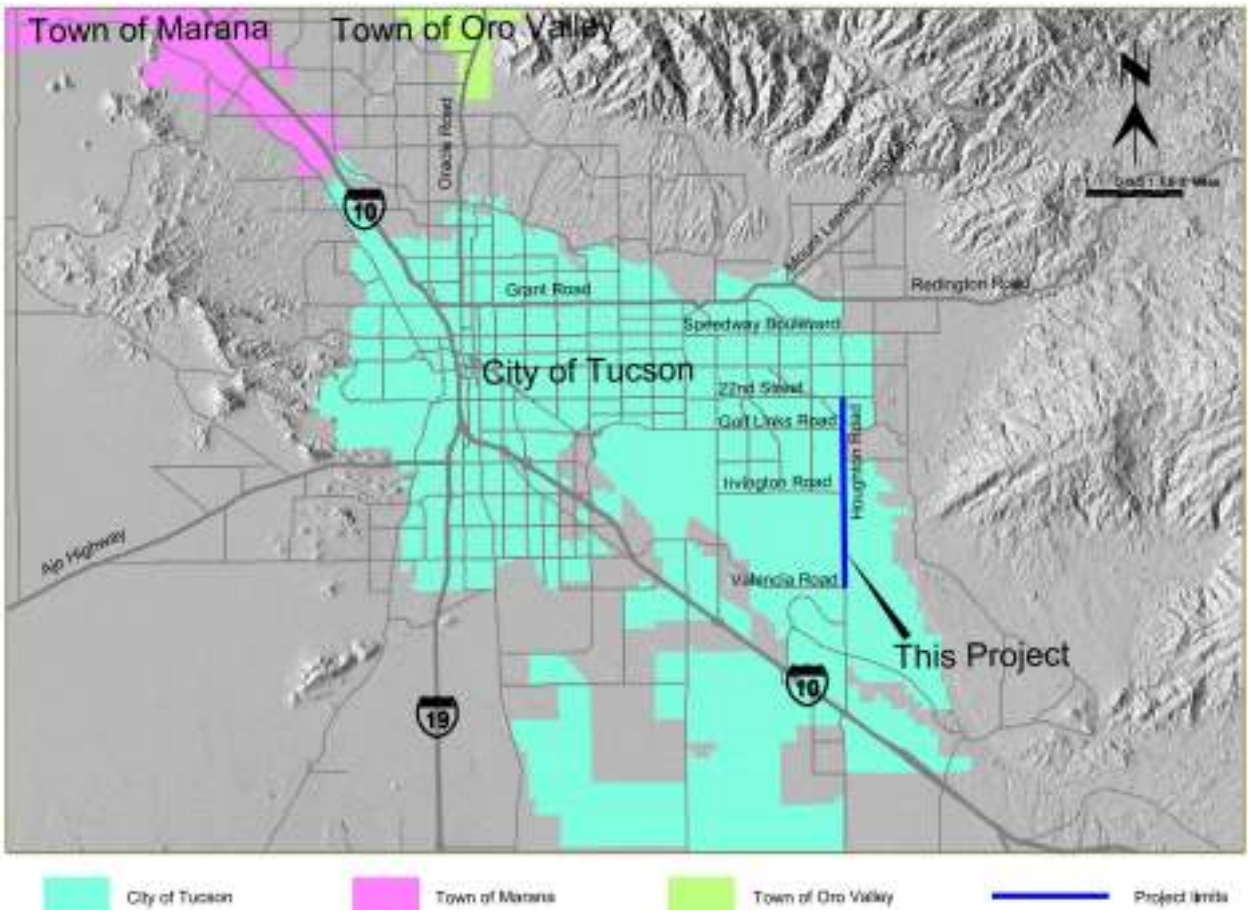


Figure 1. Location Map

The project is located within Sections 23, 24, 25, 26, 35, and 36, Township 14 South, Range 15 East; and Sections 1, 2, 11, 12, 13, and 14, Township 15 South, Range 15 East, Gila and Salt River Meridian.

The work leading to this project included the *Houghton Road Corridor Study*[1] (*HRCS*), prepared in October 2004 by Arizona Department of Transportation (ADOT) consultants at the City of Tucson's request, and the *Houghton Area Master Plan*[2] (*HAMP*) adopted by the City of Tucson in June 2005. Both documents forecasted significant urban growth along the Houghton Road corridor and in southeast Tucson. The *HRCS* identified the roadway improvements, access management policies, and implementation timelines required to accommodate the projected growth and improve regional mobility. The 2006 RTA Plan took the findings of both of those studies and outlined the major characteristics of the project, which includes widening the existing roadway to six lanes, providing drainage improvements, and adding facilities for pedestrians and bicycles. The new roadway will be a major north-south arterial corridor serving regional traffic, as well as residential and commercial land uses in the southeast area of the City of Tucson.

2. PROJECT DESCRIPTION

The Houghton Road project is a roadway reconstruction and widening project that will begin approximately 1,700 feet south of 22nd Street (at Via Alta Mira) and extend south 5.4 miles to approximately 1,600 feet north of the Valencia Road intersection. The road will be designed for 50 mph and will be posted at 45 mph. Houghton Road will be widened to a new six-lane divided roadway.

The improvements include three travel lanes and a paved shoulder in each direction with a depressed landscaped median. There will also be ADA-compliant pedestrian facilities on both sides of Houghton Road, including an urban pathway, or "greenway," along the east side of the road. The typical right-of-way for the roadway section of Houghton will be 200 feet, but additional right-of-way may be necessary in some locations to accommodate the greenway.

Median curbing will be used only in the vicinity of signalized intersections and median openings to control drainage, separate signal equipment, and improve access control. The rest of the median will be uncurbed in order to provide for water harvesting. Outside edges of pavement will be curbed north of Irvington Road due to drainage constraints and the overall level of existing development. South of Irvington, the road edge will typically not be curbed except in the vicinity of signalized intersections and at locations where drainage, right-of-way constraints, or other considerations make it necessary. Traffic signals will be provided along Houghton Road at the intersections of Old Spanish Trail, Golf Links Road, Escalante Road, Irvington Road, Drexel Road, Bilby Road, and Poorman Road.

Improvements to Houghton Road also include minor storm drain; new and extended cross culverts; retaining walls; the widening of the existing bridge and a new, parallel bridge over the Pantano Wash; landscaping; and utility relocations and installations. The roadway will be a limited-access facility, with median openings provided at major intersections and approximately every ½-mile. Guardrail will be provided at the approaches and departures to the bridges over the Pantano Wash.

At the intersection with Old Spanish Trail, Houghton Road will include dual-left turn lanes and a right-turn lane in the northbound and southbound directions. Improvements will also be made to Old Spanish Trail in order to include a left-turn lane, a through lane, and a right-turn lane in each approach.

At the intersection with Golf Links Road, Houghton Road will include a left-turn lane and a right-turn lane in the southbound direction and dual left-turn lanes in the northbound direction. Golf Links Road will include dual left-turn lanes, one through lane, and a right-turn lane at the intersection approach in the eastbound direction, as well as a left-turn lane, one through lane, and a right-turn lane at the intersection approach in the westbound direction.

At the intersection with Escalante Road, Houghton Road will include a left-turn lane and a right-turn lane in both the northbound and southbound directions. Escalante Road will include a left-turn lane and one through lane at the intersection approach in the eastbound direction, as well as a left-turn lane, one through lane, and a right-turn lane at the intersection approach in the westbound direction.

At the intersection with Irvington Road, Houghton Road will include dual-left turn lanes in the northbound direction, as well as one left-turn lane and one right-turn lane for southbound traffic. Irvington Road will include a dedicated left-turn lane on both approaches and an eastbound right-turn lane.

The intersection of Houghton Road with Drexel Road will be configured as a “Florida T” intersection to accommodate left-turn movements to and from Drexel Road. Florida T intersections are a special case where one of the main street through movements is allowed to operate continuously, even while the left turn movement from the minor street is being served. In this case, the southbound through movement on Houghton Road will be allowed to operate continuously, even during the westbound left turn movement. The exception is when an east-west pedestrian call is placed. The southbound through and westbound left-turn movements flow into their own lanes downstream of the intersection

At the intersection with Bilby Road, Houghton Road will include dual left-turn lanes in the southbound direction, as well as a u-turn lane and a right-turn lane in the northbound direction.

Bilby Road will include dual-left turn lanes and a right-turn lane at the intersection approach in the westbound direction.

The intersection of Houghton Road with Poorman Road will also be configured as a “Florida T” intersection to accommodate left-turn movements to and from Poorman Road. A left-turn lane will be provided on southbound Houghton Road to eastbound Poorman Road. A right-turn lane will also be provided on northbound Houghton Road to eastbound Poorman Road. Southbound through travel on Houghton Road will be able to continue uninterrupted through the intersection.

3. PROJECT AREA CHARACTERISTICS

3.1. Surrounding Topography and Terrain

The project area is a combination of relatively flat valley-bottom habitat in most areas, with stretches of rolling terrain. The road generally rises in grade from north to south, excluding the areas in the vicinity of the Pantano Wash. From 22nd Street to Golf Links Road, elevations range from 2,850 to 2,890 feet above mean sea level (msl). From Golf Links Road to Irvington Road, there is rolling terrain, including a significant terrain depression as the road approaches the Pantano Wash. Elevations in this section range from 2,770 to 2,880 feet above msl. Elevations from Irvington Road to Poorman Road rise at a fairly steady rate, from 2,800 to 2,920 feet above msl. Lastly, elevations from Poorman Road to Valencia Road range from 2,920 to 2,950 feet above msl.

3.2. Existing Roadway

This section of Houghton Road is mostly a three-lane uncurbed roadway including a two-way left-turn lane (TWLTL) between 22nd Street and Escalante Road, as shown in Figure 2. Other segments, such as Irvington Road to Seven Generations Way and Bilby Road to Poorman Road, also include a TWLTL. The rest of the roadway consists of only one lane in each direction. An additional climbing lane is also provided for northbound traffic between the Pantano Wash and Escalante Road.

In general, the travel lanes along Houghton Road are 12 feet. The road shoulders vary in surface and width. Most shoulders are paved, with widths ranging from three to eight feet, but there are areas where only graded shoulders are available. The areas with the narrow shoulders generally correspond to intersections where interim widening projects have been completed in order to provide turn lanes.

The posted speed limit is 45 mph between 22nd Street and Escalante Road, 50 mph from Escalante Road to Irvington Road, and 55 mph from Irvington Road to Valencia Road. The section between Escalante Road and Valencia Road has a night-time speed limit of 45 mph,

likely because there is no street lighting along Houghton Road, except at a few major intersections.

Figure 2. Existing Houghton Road Cross-Section

Additional turn lanes exist at the intersections of Houghton with major side streets. Table 1 shows the number of dedicated turn lanes and the corresponding storage lengths at each of the major intersections along this segment of Houghton Road. 22nd Street and Valencia Road are not included because they are part of the northern and southern segments of the corridor, respectively.

Table 1. Existing Intersection Characteristics

Cross-street	Number of dedicated turn lanes												Traffic Control
	NB			SB			EB			WB			
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	
Old Spanish Trail	1-150'	1	-	1-150'	1	-	1-95'	1	1-230'	1-105'	1	-	Signal
Golf Links	1-500'	1	-	1-330'	1	1-330'	1-500'	1	1-500'	1-110'	1	1-75'	Signal
Secrist Middle School	-	1	-	-	1	1-140'	1-300'	-	1-300'	-	-	-	Stop
Escalante Road	1-150'	1	-	1-100'	1	-	1-195'	1	-	1-195'	1	-	Signal
Keystone Road	1-85'	1	1-150'	1-200'	1	-	-	1	-	1-100'	1	-	Stop
Irvington Road	1-150'	1	-	1-110'	1	-	-	1	-	-	1	-	Signal
Civano Blvd	-	1	1-220'	1-180'	2	-	-	-	-	-	-	-	Stop
Seven Generations Way	-	1	1-220'	1-240'	1	-	-	-	-	1	-	1	Stop
Drexel Road	-	1	-	-	1	-	-	-	-	-	-	-	Stop
Bilby Road	-	1	1-180'	1-180'	1	-	-	-	-	1-255'	-	1-255'	Signal
Poorman Road	-	1	1-190'	1-210'	1	-	-	-	-	1-150'	-	-	Stop

3.3. Roadway Geometric Deficiencies

From 22nd Street to Valencia Road, Houghton Road follows an almost completely tangent horizontal alignment. However, two pairs of reverse horizontal curves (four curves total) are used to shift the roadway to the west at the Pantano Wash. Based on the as-built plans for project I-96-55 (Dooley-Jones, 1981)[3], all four of those curves have a radius of 2,865 feet, which satisfies the minimum radius requirement for a 50 mph design speed.

The Houghton Road profile, including grades and curve lengths, was approximated by fitting curves to replicate the existing grade using the digital topography file from aerial photogrammetry. A total of 28 vertical curves were identified and compared to the requirements in the 2004 *Policy on Geometric Design of Highways and Streets*[4] (commonly called the G*reen Book*) by the American Association of State Highway and Transportation Officials (AASHTO). Each curve was analyzed for compliance with a design speed of 50 mph, which would allow posting a 45-mph speed limit. Table 2 and the discussion below summarize the characteristics of the 28 vertical curves.

Five of the 28 curves do not meet the minimum requirement for sight visibility. Curve #2, a sag curve located between 22nd Street and Edna Place, has a length of 100 feet and a K value of 30, which provides enough sight distance for a design speed of 25 mph. Moving south, curve #12 is a sag curve located south of Sky Castle Way. Its length of 250 feet and K value of 91 correspond to a design speed of 45 mph. Curve #14 is a sag curve located just north of Escalante Road. Its length of 200 feet and K value of 69 correspond to a design speed of 40 mph. Curve #15 is a crest curve located at the intersection of Escalante Road with Houghton Road. Its curve length of 150 feet and K value of 70 correspond to a design speed of 45 mph. Curve #18 is a sag curve located north of Keystone Road. Its curve length of 400 feet and K value of 74 correspond to a design speed of 40 mph. Therefore, it is concluded that curves #2, #12, #14, #15, and #18 have substandard design speeds, which can be corrected by lengthening the curves, reducing the grades, or a combination of both. In addition, curve #2 is 100 feet long, which does not meet the minimum Pima County roadway design criteria length of three times the design speed.

Table 2. Characteristics of Existing Vertical Curves

Curve #	Location	Curve Type	Grade 1 (%)	Grade 2 (%)	Length (ft)	K value	Design Speed (mph)	K_{min} for 50 mph
1	Sta 264+90	Crest	0.80	-1.07	200	106	50	84
2	Sta 267+68	Sag	-1.07	2.23	100	30	25	96
3	Sta 272+03	Crest	2.23	0.74	200	134	55	84
4	Sta 286+42	Crest	2.85	1.13	200	116	55	84
5	Sta 292+72	Sag	1.13	3.59	500	203	70	96
OLD SPANISH TRAIL – STA 299+59								
6	Sta 300+59	Crest	3.59	-2.28	750	127	55	84
7	Sta 306+75	Sag	-2.28	-0.67	200	124	55	96
GOLF LINKS ROAD – STA 315+00								
8	Sta 322+90	Sag	-1.04	2.73	500	132	55	96
9	Sta 330+85	Crest	2.73	-3.27	900	150	55	84
10	Sta 339+97	Sag	-3.27	1.95	800	153	60	96
11	Sta 348+91	Crest	1.95	-1.68	600	165	60	84
12	Sta 358+63	Sag	-1.68	1.06	250	91	45	96
13	Sta 361+16	Crest	1.06	-0.18	150	120	55	84
14	Sta 365+27	Sag	-0.18	2.69	200	69	40	96
15	Sta 367+61	Crest	2.69	0.56	150	70	45	84
ESCALANTE ROAD - STA 367+93								
16	Sta 371+79	Crest	0.56	-1.63	400	182	60	84
17	Sta 380+42	Crest	-1.63	-6.55	700	142	55	84
18	Sta 391+88	Sag	-6.55	-1.19	400	74	40	96
19	Sta 396+79	Sag	-1.19	0.57	250	141	60	96
20	Sta 404+78	Crest	0.57	-0.69	800	636	80	84
21	Sta 410+06	Sag	-0.69	0.35	200	192	70	96
22	Sta 415+20	Sag	0.35	3.85	500	142	60	96
IRVINGTON ROAD – STA 421+50								
23	Sta 428+62	Crest	3.85	0.55	1500	454	80	84
24	Sta 455+08	Sag	0.55	1.52	150	154	60	96
25	Sta 472+32	Crest	2.19	1.38	200	245	65	84
DREXEL ROAD – STA 474+12								
26	Sta 517+40	Crest	0.71	0.00	200	284	70	84
27	Sta 524+81	Sag	0.00	0.52	200	386	80	96
POORMAN ROAD – STA 526+79								
28	Sta 531+57	Sag	0.52	1.18	150	227	75	96

In addition, the *Green Book* recommends that crest vertical curves with a high point and sag vertical curves with a low point have a K value of 167 or less in order to ensure positive drainage. A curve with a K value of 167 achieves 0.3% grade within 50 feet of the high point (or

low point). Curves #16, #20, #21, #26 and #27 do not meet the *Green Book* criteria for drainage, as they have K values well in excess of 167.

For tangent grades, the Pima County *Roadway Design Manual*[5] establishes a minimum grade of 0.5%. The maximum grade in mountainous areas, such as the approaches to the Pantano Wash, is 7%. The maximum grade break without a vertical curve is 0.5%. Although the as-built plans between Old Spanish Trail and Irvington Road (I-96-55) do not show any areas with grades less than 0.5%, the profile generated from the aerial photography shows a few areas with grades under 0.5%. The difference can be the result of the numerous overlays, interim improvements and other minor projects along Houghton Road over the past 25 years.

From the fitted profile, the grades of the tangent sections Sta 274+92 to Sta 283+90, Sta 361+91 to Sta 364+27, Sta 411+06 to Sta 412+70, Sta 485+25 to Sta 489+85, and Sta 518+40 to Sta 523+81 range from 0.0% to 0.5%. None of them is compliant with the Pima County roadway design standards; however, it should be noted that the roadway is not curbed, so drainage is not affected by these flatter slopes.

The analysis of the roadway alignments indicates that the Houghton Road vertical alignment currently has several deficiencies. A complete redesign is recommended to address them and to make the design speed of Houghton Road 50 mph.

3.4. Existing Right-of-Way

The existing right-of-way along Houghton Road varies throughout the project area between 105 feet and 245 feet, but is most commonly 150 or 175 feet. Beginning at the north end of the project, the existing right-of-way is approximately 105 feet, increasing to 150 feet approximately 1/8 mile south of 22nd Street. At 29th Street, the right-of-way increases from 150 feet to 175 feet and continues at this width to Golf Links Road. Between Golf Links Road and Escalante Road, the existing right-of-way varies from 145 feet to 175 feet.

Just south of Escalante Road, the right-of-way is 200 feet, then widens to 245 feet between Sta 380+50 and 386+50 in the vicinity of McGraw's Cantina. At the Pantano Wash the right-of-way is 150 feet. Between Irvington Road and Poorman Road, the existing right-of-way is 175 feet,

with 100 feet on the east side along Civano, Sierra Morado and Mesquite Ranch, and 75 feet on the west side. South of Poorman Road to Valencia Road, the existing right-of-way is 150 feet. The approximate existing right-of-way for Houghton Road is summarized in Table 3. A more detailed right-of-way description can be obtained from the *Right-of-Way Survey for Houghton Road from 22nd Street to Valencia Road*[6] completed by Psomas in August 2008.

Table 3. Existing Right-of-Way

From	To	Left R/W - East (ft)	Right R/W - West (ft)	Total R/W (ft)
22nd St	268+64	30	75	105
268+64	288+53 29th St	75	75	150
288+53 29th St	300+00 Old Spanish Tr	75	100	175
300+00 Old Spanish Tr	315+00 Golf Links Rd	100	75	175
315+00 Golf Links Rd	318+39	100	55	155
318+39	319+39	100	85	185
319+39	321+62	100	70	170
321+62	322+22	75	70	145
322+22	341+49	75	100	175
341+49	367+93 Escalante Rd	75	75	150
367+93 Escalante Rd	380+50	100	100	200
380+50	386+50	120	125	245
386+50	394+33	100	75	175
394+33	413+09	75	75	150
413+09	420+75 - Irvington Rd	75	100	175
420+75 - Irvington Rd	526+79 - Poorman Rd	100	75	175
526+79 - Poorman Rd	Valencia Rd	75	75	150

3.5. Drainage Characteristics

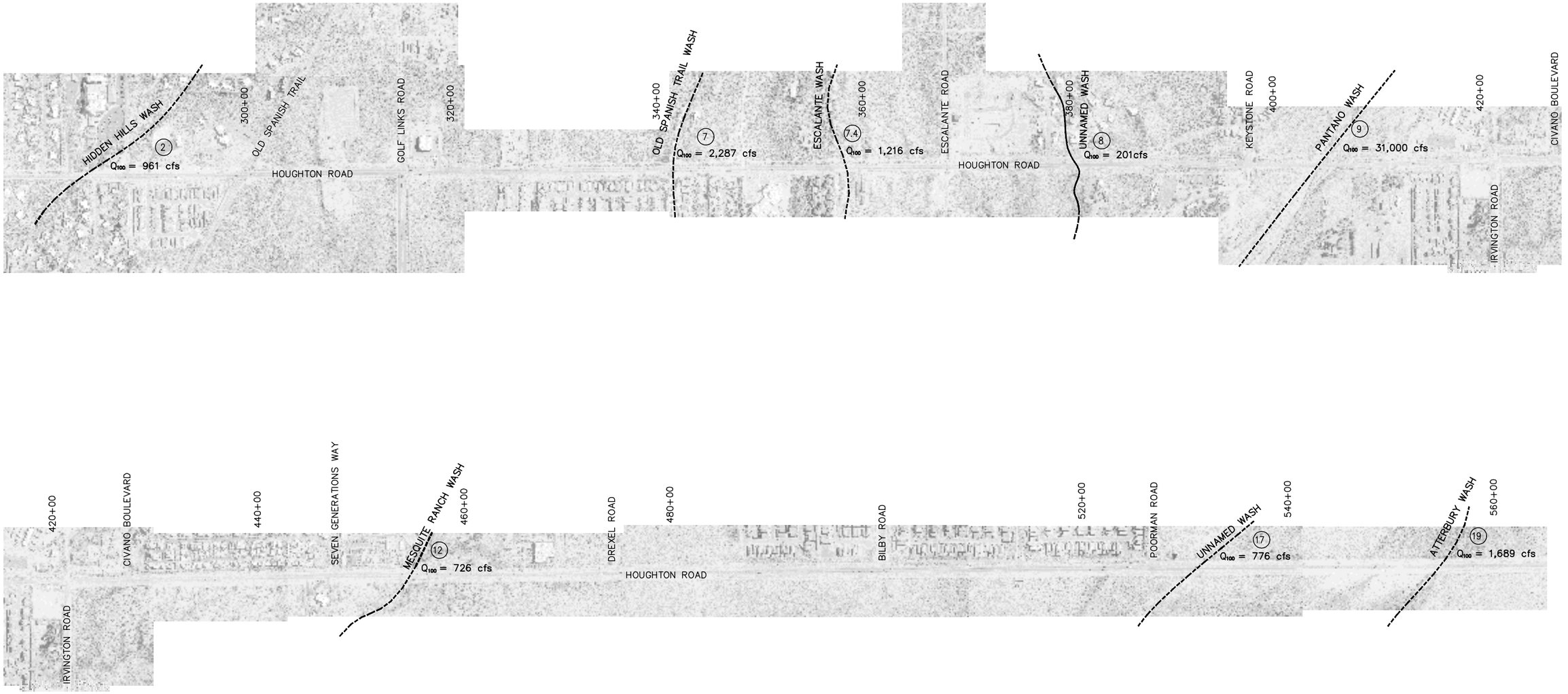
The Pantano Wash is the only identified major wash that intersects the proposed Houghton Road alignment. The existing bridge over the Pantano Wash was constructed in 1981. This four-span structure is approximately 350 feet long and carries one lane of traffic each in the northbound and southbound directions. The existing cross-section of the channel at the bridge location is a trapezoidal section with bank protection along the east and west banks. The approximate bottom width of the channel at the bridge location is 280 feet, and the 100-year discharge is 31,000 cfs. Other relatively significant washes include the Hidden Hills (100-yr

discharge = 961 cfs), Old Spanish Trail (2,287 cfs), Escalante (1,216 cfs), Mesquite Ranch (726 cfs) and Atterbury (1,689 cfs) Washes. Adjacent to the northern boundary of the project is the Este Wash (1106 cfs), there are numerous smaller watercourses that cross the proposed alignment, primarily in shallow channels and as sheet flow and through existing culverts. The washes typically flow from the southeast to the northwest. In general, the washes north of Old Spanish Trail are tributaries to the Tanque Verde Creek, while washes south of Old Spanish Trail are tributaries to the Pantano Wash.

Existing drainage structures are currently in place at 21 roadway and wash intersections along Houghton Road. Table 4 summarizes the hydraulic analysis of the existing culverts, as described in the draft drainage report prepared for this project[7]. Figure 3 shows the major washes in the project area.

Table 4. Existing Drainage Crossings

CP	Approximate Station	Wash Name	Location	Type
1	267+50	Este Wash	South of 22nd	Dip Section
2	284+50	Hidden Hills Wash	North of Discovery Dr.	Dip Section
4	307+50	Eastview Wash	North of Golf Links	CMP 30"
4	319+50	Unnamed Wash	South of Golf Links	3-45” x 29” CMP
5	323+50	Unnamed Wash	North of Corte Madera Final	36" CMP
7	341+50	Old Spanish Trail Wash	North of Emily Dr.	2-8'x5'
7.2	353+50	Unnamed	North of Sky Castle Way	36" CMP
7.4	359+00	Escalante Wash	South of Sky Castle Way	2- 72" CMP
7.6	365+00	Unnamed Wash	North of Escalante	24" CMP
7.6	366+00	Unnamed Wash	North of Escalante	36" CMP
8	369+00	Unnamed Wash	South of Escalante	18" CMP
8	374+00	Unnamed Wash	North of Boulderfield Dr.	36" CMP
8	380+00	Unnamed Wash	South of Boulderfield Dr.	3- 24" RCP
9	405+00	Pantano Wash	North of Irvington	Bridge
10	422+00	Unnamed Wash	Under Irvington intersection	36" CMP
12	455+00	Mesquite Ranch Wash	South of Seven Generations Way	10"x8' RCB
16	523+00	Unnamed Wash	North of Poorman Rd	2 CMP
17	532+50	Unnamed Wash	North of Poorman Rd	24"x36" CMP
17	540+50	Unnamed Wash	North of Poorman Rd	Unknown
18	549+50	Unnamed Wash	North of Poorman Rd	Unknown
19	554+50	Atterbury Wash	North of Valencia	Dip Section



SCALE: 1" = 1000'

PSOMAS

800 E. Wetmore Road, Suite 110
Tucson, AZ 85719
(520) 292-2300 (520) 292-1290 fax
www.psomas.com

FIGURE 3

HOUGHTON ROAD
FINAL DESIGN CONCEPT REPORT
22ND STREET TO VALENCIA ROAD
EXISTING MAJOR WASHES

PROJ NO: 06099-01 SCALE: HORIZ 1" = 250'
DATE: 08/08

Per the Federal Emergency Management Agency (FEMA), Houghton Road is located within Zone X (unshaded) and Zone AE (FIRM Panel 04019C2259K, Effective Date February 2, 1999 and FIRM Panel 04019C2270K, Effective Date February 8, 1999). Per the FIRM Panel legend, Zone X (unshaded) denotes areas outside of the 500-year floodplain, and Zone AE denotes base flood elevations have been determined. The majority of the project lies within Zone X except the Pantano Wash, which is in Zone AE.

3.6. Signalization and Lighting

Currently, there are a total of seven traffic signals along this segment of Houghton Road. The signals at Golf Links Road and 22nd Street are mast-arm mounted. The other five signals, located at Old Spanish Trail, Escalante Road, Irvington Road, Bilby Road, and Valencia Road, are span-wire signals. Most of the span-wire signals (except for Valencia Road and Old Spanish Trail) were installed recently, and were chosen instead of the more expensive mast arm installation in anticipation of this project. In addition, an emergency signal is being constructed for the Fire Station at Seven Generations Way. As of August 1, 2008, the signal had not started operation yet.

There is no street lighting along this segment of Houghton Road, except for safety lighting at the signalized intersections listed above.

3.7. Existing Utilities

Document research was conducted to obtain available and pertinent utility data including as-built plans and base maps for existing utilities within the proposed project limits. Two bluestake tickets were obtained (#2007021201373 and #20070301248) in February and March 2007 in order to identify potential conflicts. In addition, a utility coordination kickoff meeting was conducted onsite on March 5, 2007. Representatives from the City of Tucson, Psomas, TBE, Southwest Gas, Tucson Water, Tucson Electric Power (TEP), Pima County Wastewater Management (PCWWM), and Cox Communications attended the meeting. A list of contacts for the utility companies in the project area is included in Table 5.

Table 5. Utility Contact List

Agency	Utility	Contact	Phone
City of Tucson Inet	Fiber Optic	Bob Morten	(520) 791-3191
Cox Communications	Cable TV	Debbie Mason	(520) 629-8435
Pima County Wastewater Mgmt	Sanitary Sewer	Maps and Records	(520) 740-6602
Qwest Communications	Telephone and Fiber Optic	Matthew Thompson	(520) 292-8255
Southwest Gas	Natural Gas	Shari Olsen	(520) 794-7216
Tucson Electric Power	Electric	Cynthia Garcia	(520) 918-8246
Tucson Water	Water (Potable and Reclaimed)	Pete Kosanske	(520) 791-5080

The utility base map for the project was developed by TBE using record information and conducting Quality Level B (QLB) designation of utilities along the corridor. QLB uses a variety of geophysical locating equipment to detect, verify, and designate the location of subsurface utilities. The findings of the utility mapping process were documented in the *Houghton Road Utility Plans*[8] prepared by TBE and submitted to the City of Tucson in November 2007. Those plans are included in Appendix 1.

The following utilities were located within or near the project area: water, reclaimed water, storm drain, natural gas, sanitary sewer, electric, cable television, and telephone. Although those utilities are discussed in detailed below, the following key facilities will likely impact the development of the roadway project:

- Tucson Electric Power (TEP) – Major transmission overhead lines located along the east side of Houghton Road between Old Spanish Trail and Irvington Road, as well as distribution overhead lines on the east side of Houghton Road north of Old Spanish Trail and between Irvington Road and Drexel Road, and overhead lines on the west side of Houghton Road from Drexel Road to Valencia Road.
- Tucson Water - 24-inch potable water line that runs on the east side of Houghton Road from Old Spanish Trail to Golf Links Road and on the west side of the road from Golf Links Road to Valencia Road.
- Southwest Gas – 12-inch natural gas high pressure line running the length of the project on the east side of the road.

Water – Tucson Water

A 16-inch potable water line runs on the east side of Houghton Road south from 22nd Street to Old Spanish Trail and becomes a 24-inch line at Old Spanish Trail. The 24-line continues south to Golf Links Road with six-inch feeder lines tying in from Edna Place, Via Alta Mira, Via del Mar, and Discovery Drive. A second six-inch parallel line begins on the east side of Houghton Road at Discovery Drive and continues south to Old Spanish Trail, with an eight-inch feeder line from 29th Street and a six-inch feeder line from Madrona Canyon Drive. The six-inch line turns west along Old Spanish Trail.

The Danforth Reservoir, a 27.5 acre Tucson Water facility, is located along the eastern right-of-way between Golf Links Road and Old Spanish Trail. A 36-inch line parallel to the 24-inch water main begins at that facility and turns west along the north side of Golf Links Road. An eight-inch water main also runs along Golf Links Road along the south side of the road.

The 24-inch main line continues south of Golf Links Road but transitions to the west side of Houghton Road and continues south to Escalante Road. A second six-inch main begins at Golf Links Road and runs within the existing Houghton Road, also on the west side. This six-inch line runs south to Pantano Trail. Feeder lines tying into the water main include a six-inch feeder at Corte Madera Fina, an eight-inch feeder at Falcon Point Drive, an eight-inch feeder at Emily Drive, and a six-inch feeder at Sky Castle Way.

At Escalante Road, a 12-inch water main runs west on the north side of Escalante Road and another 24-inch main runs east on the south side of the road. The 24-inch main line continues south on the west side of Houghton Road to Irvington Road. This water main crosses the Pantano Wash on the existing bridge. An eight-inch feeder at Honey Mesquite Drive ties into this water main.

The 24-inch water main continues south from Irvington Road on the west side of Houghton Road. Twelve-inch feeders tie into the water main at Civano Boulevard, Seven Generations Way, and a property 525 feet north of Drexel Road. A reclaimed water main begins at Seven Generations Way and continues south along the east side of Houghton Road to 1300 feet south of Drexel Road. The line is 12 inches in diameter north of Drexel Road and 24 inches to the south.

The 24-inch potable water main continues south to Poorman Road on the west side of Houghton Road from Drexel Road. A second parallel 12-inch main begins at Drexel Road and extends south for 750 feet before turning to the west. A 12-inch feeder at Bilby Road, an eight-inch feeder at Forest Glen Street, and a 12-inch feeder at Poorman Road tie into the mainline.

The 24-inch water main continues on the west side of Houghton Road south from Poorman Road to Valencia Road

Storm Drain – City of Tucson

A 10-foot wide storm drain box runs underground for 360 feet along the east side of Houghton Road south of Golf Links Road in front of CVS Pharmacy. This storm drain turns west and crosses Houghton Road. In addition, two storm drain pipes, one on the north bank and one on the south bank, empty into the Pantano Wash. Multiple drainage pipes also cross side streets and driveways and will be analyzed for replacement during design.

Natural Gas - Southwest Gas

One 12-inch steel gas high pressure line and one combination two- and four-inch line each run south from 22nd Street on the east side of Houghton Road to Old Spanish Trail. There are feeders to the 12-inch line at Edna Place, Via del Mar, and Discovery Drive. The smaller gas line connects to a two-inch line running along Old Spanish Trail. The 12-inch high pressure line continues south to Golf Links Road. A four-inch line begins 565 feet north of Golf Links Road and turns west along the north side of that road.

The 12-inch main continues south along the east side of Houghton Road to Escalante Road. A second four-inch line begins north of Corte Madera Fina and runs south for 950 feet to Falcon Point Drive. Another four-inch line feeds Emily Drive and runs south for 1270 feet to a feeder at Sky Castle Way.

A four-inch line from the east runs along the south side of Escalante Road and turns south to parallel the 12-inch high pressure line running on the east side of Houghton Road. Both lines continue south on the east side of the road to just north of Keystone Road. A feeder line is located at Boulderfield Drive. The four-inch line from Escalante ends just north of Keystone

Road. The high pressure main continues south to Irvington Road, crossing under the Pantano Wash east of the existing bridge. A four-inch gas line begins west of Houghton Road 480 feet north of Honey Mesquite Drive and turns south to parallel the mainline on the east side of the roadway. This line feeds a line crossing Houghton Road and running west along the south side of Irvington Road.

Both the four-inch line, which becomes a six-inch line south of Civano Boulevard, and the 12-inch high pressure line continue south along the east side of Houghton Road to Valencia Road. A two-inch line parallels the two others on the east side of the road for 1,275 feet south of Civano Boulevard. Feeder lines are located at Civano Boulevard, Seven Generations Way, Bilby Road, Forest Glen Street, and Poorman Road.

The 12-inch high pressure natural gas line is located within 10-foot utility easements the length of the project from 22nd Street to Valencia Road. These easements are typically located from 75 feet to 85 feet (10-foot wide total) east of the section line

Sanitary Sewer - Pima County Wastewater Management

South of 22nd Street from Edna Place, an eight-inch sewer pipe runs south along the east side of Houghton Road for 310 feet. It then crosses Houghton Road to the west and runs south for 550 feet on the west side of the road. This stretch of sewer line connects to other eight-inch sewer along side streets at Edna Place, Via Alta Mira, and Via del Mar from the east, as well as at one location from the west between Edna Place and Via Alta Mira.

Two parallel eight-inch sewer lines run south from Discovery Drive. One runs under the east side of Houghton Road and ends at 29th Street. The other runs parallel to the west side of Houghton Road and connects to an eight-inch sewer along Madrona Canyon Drive. An eight-inch sewer runs from the west along Corte Madera Fina and ends at the western edge of pavement of Houghton Road.

Just south of Secrist Middle School, one eight-inch sewer line runs from Sky Castle Way 370 feet along the west side of Houghton Road. An eight-inch sewer runs along Escalante Road on the north side and crosses Houghton Road.

South of Boulderfield Drive, one eight-inch sewer approximately 900 feet long runs south on the east side of Houghton Road. It connects to an eight-inch sewer serving the Highland Trails subdivision east of Houghton Road. A 14-inch sewer crosses Houghton south of Keystone Road at the Saguaro Canyon subdivision.

The 21-inch Pantano sewer interceptor parallels the west side of Houghton Road 850 feet north of Irvington. It runs 660 feet and crosses Houghton diagonally from northwest to southeast, then runs south along the east side of Houghton Road for 540 feet as an 18-inch, with a feed from Civano Boulevard.

Electric - TEP

TEP has two types of lines along the project area: major transmission lines (138 KV) and distribution lines. The transmission line runs from 22nd Street to Irvington Road on the east side of the road. Between Old Spanish Trail and Irvington Road the line is supported by large steel poles with diameters ranging between 3 and 8 feet, with the largest diameter poles located near the power station south of Golf Links Road and near Irvington Road. The costs for relocating transmission lines on steel poles are generally very significant and therefore their relocation is considered cost-prohibitive for this project. From Old Spanish Trail to 22nd Street the transmission line is supported on wooden poles and has underbuilt distribution lines (Figure 4). This section of the line is very close to the existing edge of pavement and will likely require relocation for the widening regardless of the alignment chosen.

Figure 4. Electric Lines – South of 22nd Street

All TEP distribution lines on the Houghton Road corridor are typically three-phase electric. From 22nd Street to Old Spanish Trail, overhead distribution lines run on the east side of Houghton Road (as shown in Figure 4) with underground feeders to Edna Place, Via Alta Mira,

and Via del Mar. Underground electric also runs along the east side of Houghton Road from Discovery Drive to Old Spanish Trail. An overhead feeder is located along 29th Street, and underground feeder is located along Madrona Canyon Drive. Underground electric lines run along Old Spanish Trail both east and west from Houghton Road and turn into overhead electric lines 935 feet west of Houghton.

From Old Spanish Trail to Golf Links Road, underground electric lines run along the east edge of pavement. Underground electric lines run along Golf Links Road west of Houghton Road on both the north and south edges of pavement. Overhead electric lines run along the north side of Golf Links west of Houghton Road.

From Golf Links Road to Escalante Road, underground electric lines are located under the east side of Houghton Road. A second run of underground electric lines are located along the west side of the road between Corte Madera Fina and Watson Drive. Underground electric lines feed to Emily Drive, Sky Castle Way, and Secrist Middle School. Underground electric lines are also along the south side of Escalante Road east of Houghton.

From Escalante Road to Irvington Road, underground electric lines are on both sides of the roadway to McGraw's Cantina. The line on the east side continues to Irvington Road and crosses the Pantano Wash on the existing bridge. A third set of underground electric lines on the east side runs to Boulderfield Drive. Underground electric lines feed to Keystone Road. A fourth set of underground electric lines on the west side of Houghton Road extend from Honey Mesquite Drive to Irvington Road. Overhead electric lines cross Houghton Road to the west south of Irvington Road, as well as diagonally across the Irvington Road intersection from southeast to northwest and run west along Irvington Road's north side.

From Irvington Road to Drexel Road, underground electric lines run along the east side of Houghton Road. These lines end just south of Irvington Road and tie into overhead electric lines that continue on the east side. The overhead electric lines extend the entire stretch from Irvington Road to Drexel Road along the east side of the road. Underground electric lines feed to Civano Boulevard. In addition, underground electric lines begin 260 feet south of Civano Boulevard on the east side of Houghton Road and extend 1200 feet south. Underground electric lines also feed to Seven Generations Way.

The overhead electric lines cross to the west side of Houghton Road at Drexel Road and run south to Valencia Road. Underground electric lines feed to Bilby Road, and there is a 185-foot underground electric run south of Bilby Road. Underground electric lines also feed Forest Glen Street and Poorman Road.

Cable - Cox Communications

From 22nd Street to Old Spanish Trail underground cable feeders are located at Edna Place, Via Alta Mira, and Via del Mar. In addition, cable runs along the south side of Old Spanish Trail and crosses Houghton south of Old Spanish Trail and Old Spanish Trail west of Houghton Road. Cable also runs 500 feet south along the west side of Houghton Road from Old Spanish Trail.

From Golf Links Road to Escalante Road, cable runs on the west side of Houghton Road between Corte Madera Fina and Falcon Point Drive and between Watson Drive and 360 feet south of Sky Castle Way.

From Escalante Road to Irvington Road, cable runs parallel to Escalante Road and crosses Houghton Road on the south side of the intersection. It then runs south to just north of Keystone Road along the east side of Houghton Road. There is also a cable run parallel to Houghton Road on the west side of the road between Honey Mesquite Drive and Irvington Road. This run crosses Irvington Road on the west side of the intersection.

From Irvington Road to Drexel Road, cable runs along the east side of Houghton Road starting 260 feet south of Civano Boulevard to Seven Generations Way, with a feed to Seven Generations Way.

From Drexel Road to Poorman Road, cable runs along the south side of Bilby Road and crosses Houghton Road to the west. In addition, cable also runs on the west side of Houghton Road from 290 feet north of Forest Glen Street to 375 feet south of Forest Glen Street.

Telephone - Qwest

Underground telephone conduits from 22nd Street to Golf Links Road are located on the east side of Houghton Road with feed to Edna Place, Via Alta Mira, Via del Mar, and 22nd Street. An underground telephone line also runs along the south side of Old Spanish Trail. Underground fiber optic telephone begins 700 feet north of Golf Links Road and runs along the east side of Houghton Road, crossing the south and west legs of the Golf Links intersection and ending at the northwest corner of the intersection.

From Golf Links Road to Escalante Road, two telephone conduits continue south on the east side of the road with feeds to Corte Madera Fina, Watson Drive, Pantano Trail and Secrist Middle School. Another underground telephone line follows the west side of Houghton Road from Falcon Point Drive to Secrist Middle School. In addition, a feeder crosses Houghton Road to the west just south of Sky Castle Way and runs south for 255 feet. A 70-foot run of underground fiber optic telephone is located on the east side of road south of Corte Madera Fina.

From the northeast corner of the Escalante Road intersection, underground conduit runs west along Escalante Road. From the southeast corner, conduit runs east along Escalante Road. Four conduit runs are along the east side of Houghton Road south from Escalante Road. A feeder line crosses Houghton Road to the west about 320 feet south of Escalante Road and continues to the south about 1030 feet. One conduit run on the east side feeds Boulderfield Drive, while the other three runs continue south and eventually combine to one run just south of McGraw's Cantina. A 145-foot stretch of underground fiber optic telephone is located north of Keystone Road on east side of Houghton. The telephone conduit crosses the Pantano Wash on the existing bridge and continues south to Irvington.

Underground conduit crosses Houghton Road south of Irvington Road and continues west on the south side of Irvington Road. The conduit continues on the east side of the road south to Drexel Road. A second conduit run begins south of Civano Boulevard and continues south for 835 feet. Another begins 100 feet south of the previous run and extends south for 260 feet. There is a feed to Seven Generations Way, as well as a 200-foot run on the west side of Houghton Road opposite of Seven Generations Way (for Tucson Fire Department).

The main conduit run crosses Houghton Road to the west side just north of Drexel Road and continues on that side all the way to Valencia Road. Feeder runs exist at Bilby Road, Forest Glen Street and Poorman Road. In addition, a 170-foot stretch of overhead telephone crosses Houghton Road south of Poorman Road. An underground fiber optic line also runs adjacent to the telephone line on the west side of Houghton Road from 200 feet north of Bilby Road to Valencia Road. A fiber optic connection exists to Bilby Road.

3.8. Existing Vegetation and Landscaping

Native plant inventories were conducted between July 9 and July 31, 2007. These surveys consisted of a drive-by overview assessment of the area, and a pedestrian survey during which protected native plants were inventoried.

The project area occurs within the Arizona Upland subdivision of the Sonoran Desertscrub biotic community (Turner and Brown 1994), which is characterized by high temperatures and generally low precipitation. The project area includes a portion of Pantano Wash and other natural drainages where dense wash vegetation is present. Sonoran desertscrub is near its upper elevation limit in the project area; desertscrub gives way to semidesert grassland to the south and the east of Tucson and to chaparral and other higher elevation vegetation communities in the Rincon Mountains to the east. Within the Houghton Road right-of-way north of Irvington Road, interspersed areas of residential landscaping and natural desertscrub extend into the right-of-way. South of Irvington Road, much of the existing native vegetation has been cleared and native and non-native grasses and annuals are dominant. Between Drexel Road and Poorman Road, a paved path exists along the Sierra Morado and Mesquite Ranch subdivisions. The path is landscaped with indigenous native plants such as foothills palo verde, whitethorn acacia, creosote, triangle leaf bursage, and brittlebush.

Vegetation within the project area includes components of the creosote-bursage series, the palo verde-cacti-mixed shrub series, and the riparian scrubland community, intermixed with non-native annual vegetation (especially where grading of the road shoulder has occurred). Often, the same plant species are present in each vegetation series, which are differentiated based primarily on relative species dominance and vertical structure complexity (i.e., density and

height of tree species). These distinctions are generally apparent along the Houghton Road corridor, with the palo verde-cacti-mixed shrub series most evident on the rolling hill topography between 22nd Street and Golf Links Road. South of Golf Links Road the topography transitions to flats generally characterized by the creosote bush-bursage series, though components of palo verde-cacti-mixed shrub series are scattered throughout. Also, portions of the corridor are devoid of most vegetation or are dominated by non-native annuals. Several small washes and the Pantano Wash cross the road corridor. These areas are characterized by riparian shrubland/xeroriparian vegetation, where tree and shrub species such as mesquite, palo verde, acacia, and desert broom (*Baccarris* spp.) dominate. The primary characteristics of each vegetation series is described below.

Creosote- bursage series

The creosote-bursage series is characterized by areas of low relief where the vegetative structure is open and simple. The dominant plant species are typically creosote (*Larrea tridentata*) interspersed with triangle-leaf bursage (*Ambrosia deltoidea*) and/or white bursage (*Ambrosia dumosa*). In the project area, bursage is notably absent and the creosote is particularly lush and dense.

Palo verde-cacti-mixed scrub series

The palo verde-cacti-mixed scrub series is characterized by a combination of palo verde (*Cercidium* spp.), whitethorn acacia (*Acacia constricta*), and mesquite (*Prosopis* spp.) trees; ocotillo (*Fouqueria splendens*); saguaro (*Carnegiea gigantea*), cholla (*Opuntia* spp.), barrel (*Ferocactus* spp.), hedgehog (*Echinocereus* spp.) cacti, and other succulents; and creosote, bursage (*Ambrosia* spp.), and a variety of other shrubs.

Riparian scrubland community

The riparian scrubland community is represented in the project area by a complex of xeroriparian shrub and tree species that are associated with major washes and line the banks of smaller washes in the project area. This community is often comprised of species that are present in adjacent uplands, although xeroriparian vegetation is often more dense and lush because of increased access to moisture. This xeroriparian vegetation provides an element of vertical structure for birds attracted to dense thickets and high perches.

3.9. Biological Resources

To identify the range of biological resources and the ecological setting within the project area, a biological reconnaissance survey was conducted between July 9 and July 31, 2007. The survey consisted of a drive-by overview assessment of the area to evaluate ecological context and the distribution of wildlife habitats and a pedestrian survey.

3.9.1. Wildlife

The project area includes a combination of developed and undeveloped lands along an existing transportation corridor. Natural areas that provide habitat for various wildlife species are more prevalent south of Irvington Road; north of Irvington Road the corridor becomes more urbanized, with residential and commercial developments on both sides of Houghton Road. Wildlife habitats within the developed portions of the project area are comprised of native and landscaped non-native vegetation with interspersed xeroriparian corridors. While there is typically less native plant and animal diversity within these developed areas, some species, particularly small mammals and reptiles, are more tolerant of human disturbance and development.

Undeveloped lands within the project area have a higher habitat value for wildlife than lands associated with human development. The undeveloped natural areas and xeroriparian corridors in the vicinity of the project area allow for a moderate degree of wildlife movement, as well as connectivity between habitat types used for foraging, cover, and reproduction. Wildlife that is likely to occur in the project area includes small mammals, reptiles, and birds. Medium-sized mammal species such as javelina (*Tayassu tajacu*) or coyote (*Canis latrans*) may forage in the project vicinity and move through the project area. Both javelina and coyote are considered to be nuisance wildlife in urban settings. The lack of permanent water sources precludes the presence of many species associated with aquatic or wet riparian habitats.

Wildlife species likely to be present in the study area include reptiles such as the side-blotched lizard (*Uta stansburiana*), whiptail lizards (*Aspidoscelis* spp.), zebra-tailed lizard (*Callisaurus draconoides*), and rattlesnakes (*Crotalus* spp.). The desert tortoise (*Gopherus agassizii*) has been documented within three miles of the project area. Suitable foraging habitat is present; however, roadway traffic, urbanization, and a lack of suitable shelter sites would indicate that if

the tortoise is present adjacent to the project area, it would occur in low density areas (no species-specific surveys have been conducted in the project area). Birds in the project area would include such species as the cactus wren (*Campylorhunchus brunneicapillus*), curve-billed thrasher (*Toxostoma curvirostre*), phainopepla (*Phainopepla nitens*), canyon towhee (*Pipilo fuscus*), Gila woodpecker (*Melanerpes uropygialis*), Gambel's quail (*Callipepla gambelii*), great-horned owl (*Bubo virginianus*), and red-tailed hawk (*Buteo jamaicensis*). The western burrowing owl (*Athene cunicularia hypugea*) has been documented within three miles of the project area and suitable habitat within open desert scrub vegetation is present; however, species-specific surveys for the burrowing owl in the project area have not been conducted.

Mammals expected to occur in the project area include the cactus mouse (*Peromyscus eremicus*), white-throated woodrat (*Neotoma albigula*), desert cottontail (*Sylvilagus audobonii*), black-tailed jackrabbit (*Lepus californicus*), javelina, and coyote. Many species of bats likely forage throughout the project area, especially in association with wash corridors. Bats such as the cave myotis (*Myotis velifer*), pallid bat (*Antrozous pallidus*), and Mexican free-tailed bat (*Tadarida brasiliensis mexicana*) that may be present in the project area may roost in caves and mines located as far away as the Rincon Mountains. These bat species and others may also roost in association with buildings or bridges in the project area. These bats forage for insects that are generally available throughout the project area, although limited potential roost sites (e.g., bridges and box culverts) are present. No bridges or box culverts in the project area are known to provide bat roost sites, though these have not been surveyed for the presence of bats. The distribution of the lesser long-nosed bat includes the project area. This species feeds primarily on the nectar of columnar cacti and agaves. No lesser long-nosed bat roost sites are known from the greater project vicinity, and foraging habitat in the project area is of limited quality with saguaros present in low density and no agaves having been recorded.

3.9.2. Special Status Species

The term special status species in this report refers to species that are listed under the federal Endangered Species Act of 1973 (16 U.S.C. 1531–1544, as amended) and managed by the US Fish and Wildlife Service, as well as species that are not protected under the Endangered Species Act but have been given special status designations by other state and federal agencies to allow for active management of those species.

A list of threatened, endangered, proposed, candidate, and conservation agreement species for Pima County was obtained from the US Fish and Wildlife Service. The Arizona Game and Fish Department's On-line Environmental Review Tool was used to obtain a list of special status species that have been documented in the project vicinity. Table 6 summarizes the current US Fish and Wildlife Service list of threatened, endangered, proposed, candidate, and conservation agreement species potentially occurring in Pima County and the list of special status species that have been documented by the Arizona Game and Fish Department as occurring within three miles of the project area. A general description of the habitat requirements for each of these species is also provided, as well as an evaluation of the potential for any of these species to be present in the project area (suitable habitat is present in the project area for highlighted species). Suitable habitat for one listed endangered species, the lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*), is present in the project area, as indicated below.

Table 6. Special Status Species Potentially Occurring in the Project Area

Species Name	Status[a]	Habitat Requirements	Habitat Present?
Plants			
Acuna cactus (*Echinomastus erectocentrus* var. *acunensis*)	ESA C	Restricted to well-drained knolls and gravel ridges between major washes in palo verde-saguaro associations in the Arizona Uplands subdivision of Sonoran desertscrub from 1,300 to 2,000 feet.	No suitable habitat present. Outside species' elevation range.
Gooddings onion (*Allium goodingii*)	CA	Forested drainage bottoms and moist north facing slopes of mixed conifer and spruce fir above 7,500 feet.	No suitable habitat present. Outside species' elevation range.
Huachuca water umbel (*Lilaeopsis schaffneriana* ssp. *recurva*)	ESA LE	Cienegas, perennial low-gradient springs, and other wetlands from 3,500 to 6,500 feet.	No suitable habitat present. Outside species' elevation range.
Kearney blue star (*Amsonia kearneyana*)	ESA LE	West-facing drainages in the Baboquivari Mountains from 3,600 to 3,800 feet.	No suitable habitat present. Outside species' elevation range.
Nichol Turk's head cactus (*Echinocactus horizonthalonius* var. *nicholii*)	ESA LE	Sonoran desertscrub on dissected alluvial fans at the foot of limestone mountains and on inclined terraces and saddles on limestone mountainsides from 2,400 to 4,100 feet.	No suitable habitat present. Outside species' range; this species is restricted to the Vekol and Waterman Mountains.
Pima pineapple cactus (*Coryphantha scheeri* var. *robustispina*)	ESA LE	Sonoran desertscrub or semidesert grassland communities from 2,300 to 5,000 feet.	Outside species' known range; this species' range primarily includes areas south of Interstate 10.

Table 6. Special Status Species Potentially Occurring in the Project Area (Cont)

Species Name	Status[a]	Habitat Requirements	Habitat Present?
Stag-horn cholla (*Opuntia versicolor*)	SR	Deeper sandy soils of canyons, washes, and well-watered areas of flats and valleys from 1,000 to 4,000 feet.	Species has been documented within 3 miles of the project area. Suitable habitat is present; this species was not documented in the project area during the native plant inventory.
Tumamoc globeberry (*Tumamoca macdougalii*)	USFS S BLM S SR	Along arroyos and sandy washes below 3,000 feet in desert grasslands, Sinaloan thornscrub, and Sonoran desertscrub.	Species has been documented within 3 miles of the project area. Suitable habitat is present.
Invertebrates			
San Xavier talussnail (*Sonorella eremita*)	CA	Deep, limestone rockslides with outcrops of limestone and decomposed granite from 3,850 to 3,920 feet.	No suitable habitat present. Outside species' distribution and elevation range.
Fish			
Desert pupfish (*Cyprinodon macularius*)	ESA LE WSCA	Shallow waters of springs, small streams, and marshes below 5,000 feet. Tolerates saline and warm water. Currently known only from reintroduced populations.	No suitable habitat present.
Gila chub (*Gila intermedia*)	ESA LE WSCA	Pools, springs, cienegas, and streams of the Gila River Basin from 2,000 to 3,500 feet.	No suitable habitat present.
Gila topminnow (*Poeciliopsis occidentalis occidentalis*)	ESA LE WSCA	Small streams, springs, and cienegas in vegetated shallows below 4,500 feet.	No suitable habitat present.
Reptiles and Amphibians			
Chiricahua leopard frog (*Rana chiricahuensis*)	ESA LT WSCA	Streams, rivers, backwaters, ponds, or stock tanks in oak or pine woodlands, chaparral, or grasslands in montane regions of central and southeastern Arizona from 3,281 to 8,890 feet.	No suitable habitat present. Outside species' elevation range.
Lowland leopard frog (*Rana yavapaiensis*)	USFS S WSCA	Habitat generalist occurring in aquatic habitats in desertscrub, grassland, and pine-oak woodland in central and extreme northwestern Arizona from 800 to 5,500 feet.	Species has been documented within 3 miles of the project area. No suitable habitat present; there are no aquatic habitats present in the project area.
Northern Mexican gartersnake (*Thamnophis eques megalops*)	USFS S WSCA	Densely vegetated habitat surrounding cienegas, stock tanks, permanent streams, marshes, and headwaters from 3,000 to 6,200 feet in central, south central, and southeastern Arizona.	Species has been documented within 3 miles of the project area. No suitable habitat present; there are no aquatic habitats present in the project area
Sonoyta mud turtle (*Kinosternon sonoriense longifemorale*)	ESA C	Ponds and streams near 1,100 feet.	No suitable habitat present. Outside species' range.

Table 6. Special Status Species Potentially Occurring in the Project Area (Cont)

Species Name	Status[a]	Habitat Requirements	Habitat Present?
Sonoran desert tortoise (*Gopherus agassizii* [Sonoran population])	WSCA	Rocky slopes and bajadas in Mojave desertscrub, Sonoran desertscrub, semidesert grassland, and interior chaparral communities throughout central, southern, and western Arizona from 500 to 5,300 feet.	Species has been documented within 3 miles of the project area. Suitable foraging habitat is present; however, there is a lack of suitable shelter sites in the project area.
Birds			
California brown pelican (*Pelecanus occidentalis californicus*)	ESA LE	Transient to the lower Colorado River and large bodies of water in central Arizona at various elevations.	No suitable habitat present.
Masked bobwhite (*Colinus virginianus ridgewayi*)	ESA LE WSCA	Desert grasslands with diversity of dense native grasses, forbs, and brush from 1,000 to 4,000 feet.	No suitable habitat present.
Mexican spotted owl (*Strix occidentalis lucida*)	ESA LT WSCA	Statewide in mature montane forest and woodland, old-growth mixed-conifer, and pine-oak forests on steep slopes and canyons from 4,100 to 9,000 feet.	No suitable habitat present.
Southwestern willow flycatcher (*Empidonax traillii extimus*)	ESA LE WSCA	Cottonwood-willow and tamarisk vegetation communities along rivers and streams below 8,500 feet.	No suitable habitat present.
Western burrowing owl (*Athene cunicularia hypugea*)	BLM S	Grasslands, steppes, deserts, prairies, and agricultural lands from 650 to 6,140 feet. Sometimes in open areas such as vacant lots near human habitation, golf courses, or airports; often associated with burrowing mammals.	Species has been documented within 3 miles of the project area. Suitable habitat is present.
Yellow-billed cuckoo (*Coccyzus americanus*)	ESA C WSCA	Large blocks of riparian woodlands (cottonwood, willow, or tamarisk galleries) below 6,500 feet.	Species has been documented within 3 miles of the project area. No suitable habitat present.
Mammals			
Cave myotis (*Myotis velifer*)	BLM S	Found primarily in desertscrub communities with creosote, brittlebush, palo verde, and cacti, sometimes up to elevations of pine-oak communities, with most occurrences between 300 and 5,000 feet. Roost in mine shafts, tunnels, and caves, and are also found under bridges. Winter roosts in Arizona are wet mine tunnels above 6,000 feet.	Species has been documented within 3 miles of the project area. Suitable foraging habitat is present; potential roost sites in the project area includes the bridge over Pantano Wash.
Jaguar (*Panthera onca*)	ESA LE WSCA	A variety of habitats from Sonoran desertscrub up to subalpine fir forests, but are most often sighted in Madrean-Evergreen woodlands, shrub-invaded semidesert grasslands, and along river bottoms.	No suitable habitat present.

Table 6. Special Status Species Potentially Occurring in the Project Area (Cont)

Species Name	Status[a]	Habitat Requirements	Habitat Present?
Lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*)	ESA LE	Desert grassland and scrubland up to oak transition areas with columnar cacti or agave below 6,000 feet. Roosts in caves, mines, tunnels, and occasionally old buildings.	Species has been documented within 3 miles of the project area. Suitable foraging habitat is present, although saguaros are not common in the project area and agaves are not present..
Mexican long-tongued bat (*Choeronycteris mexicana*)	WSCA	Occur in the summer in mesic areas in canyons of mixed oak-conifer forests in mountains as far north as the Santa Catalina Mountains and as far west as the Baboquivari Mountains, with most occurrences between 4,000 and 6,000 feet. Roost in caves, mines, rock shelters, and sink holes.	Species has been documented within 3 miles of the project area. Suitable foraging habitat is present, although saguaros are not common in the project area and agaves are not present..
Ocelot (*Leopardus* (=*Felis*) *pardalis*)	ESA LE WSCA	Humid tropical and subtropical forests, savannahs, and semiarid thornscrub below 8,000 feet.	No suitable habitat present.
Sonoran pronghorn (*Antilocapra americana sonoriensis*)	ESA LE WSCA	Arizona Upland and Lower Colorado River Valley Sonoran desertscrub in broad alluvial valleys south of Interstate 8 from the western boundary of the Cabeza Prieta Wildlife Refuge east to State Route 85.	No suitable habitat present. Outside species' range.

Sources: US Fish and Wildlife Service list of threatened, endangered, proposed, candidate, and conservation agreement species potentially occurring in Pima County, <http://arizonaes.fws.gov/>, accessed August 20, 2007.
Arizona Game and Fish Department On-line Environmental Review Tool Receipt No. 20070426002729

[a] *Status Definitions: ESA=Endangered Species Act, C=Candidate, CA=Conservation Agreement, LE=Listed Endangered, SR=Salvage Restricted, USFS=US Forest Service, S=Sensitive, BLM=US Bureau of Land Management LT=Listed Threatened, WSCA=Wildlife of Special Concern in Arizona (AGFD Draft 3/16/96)*

3.9.3. Critical Habitat

Critical habitat that has been designated or proposed by the US Fish and Wildlife Service for the conservation of threatened and endangered species receives special legal protection under the Endangered Species Act. The project area does not occur within any designated or proposed critical habitat.

3.10. Archaeological and Historic Resources

Two Class III cultural resources surveys conducted by Tierra Right of Way Services along Houghton Road encompassed the project area. One survey covered the area between Speedway Boulevard and Old Spanish Trail[9]; the second survey extended between Old

Spanish Trail and Valencia Road[10]. No historic properties were identified during either survey, and no additional archaeological investigations were recommended for the project area.

Any new right-of way, temporary construction easements, or staging areas outside the original study area required by the project should be surveyed for cultural resources.

3.11. Visual Resources

The existing Houghton Road corridor from 22nd Street to Valencia Road has open vistas to all four surrounding Tucson mountain ranges, rolling to flat topography, prevalent native vegetation, and high voltage overhead power lines. Houghton Road is designated as a Scenic Route as part of the City of Tucson *Major Streets and Routes (MS&R) Plan*[11].

The City of Tucson MS&R Plan defines a Scenic Route as "somewhat rural in character with varied topography, native vegetation, or scenic vistas." This definition accurately describes Houghton Road. The visual appearance of a Scenic Route should contribute to a pleasant driving experience, which the MS&R Plan deems "important to the overall image of Tucson."

More than a quarter of the corridor is currently undisturbed, as the entire west side of Houghton Road south of Irvington is undeveloped. High-density residential development with typical lot sizes of 1/10 acres, such as Civano, Mesquite Ranch, Sierra Morado, maintain a 30-foot natural undisturbed buffer adjacent to the right-of-way line. In places such as Mesquite Ranch, this buffer has been enhanced with additional native plants, so that an overall appearance of a natural character is still maintained. Although newer development is evident, it blends with the natural character of the undeveloped land. Views to the closest mountain range, the nearby Rincon Mountains, are maintained for most of the corridor length.

The area from Escalante Road to Irvington Road has the most varied visual character, with the Pantano Wash traversing the central portion of this segment. A large riding stable is situated just north of the Pantano Wash on the west side. Tucson McGraw's Cantina is to the north of the stables on a high bluff overlooking the wash. Throughout this mile, the adjacent land rises high above the road, as well as below the road, especially in the vicinity of the Pantano Wash (Figure 5).

Figure 5. Houghton Road Looking North at Pantano Wash

Houghton Road is a major recreational link to features in the Catalina Mountains, including Mount Lemmon Recreational Area, Sabino Canyon, Saguaro National Park East and Colossal Cave to the east. Views to the Rincon Mountains are constant throughout the corridor, while views to the Tucson Mountains are intermittent.

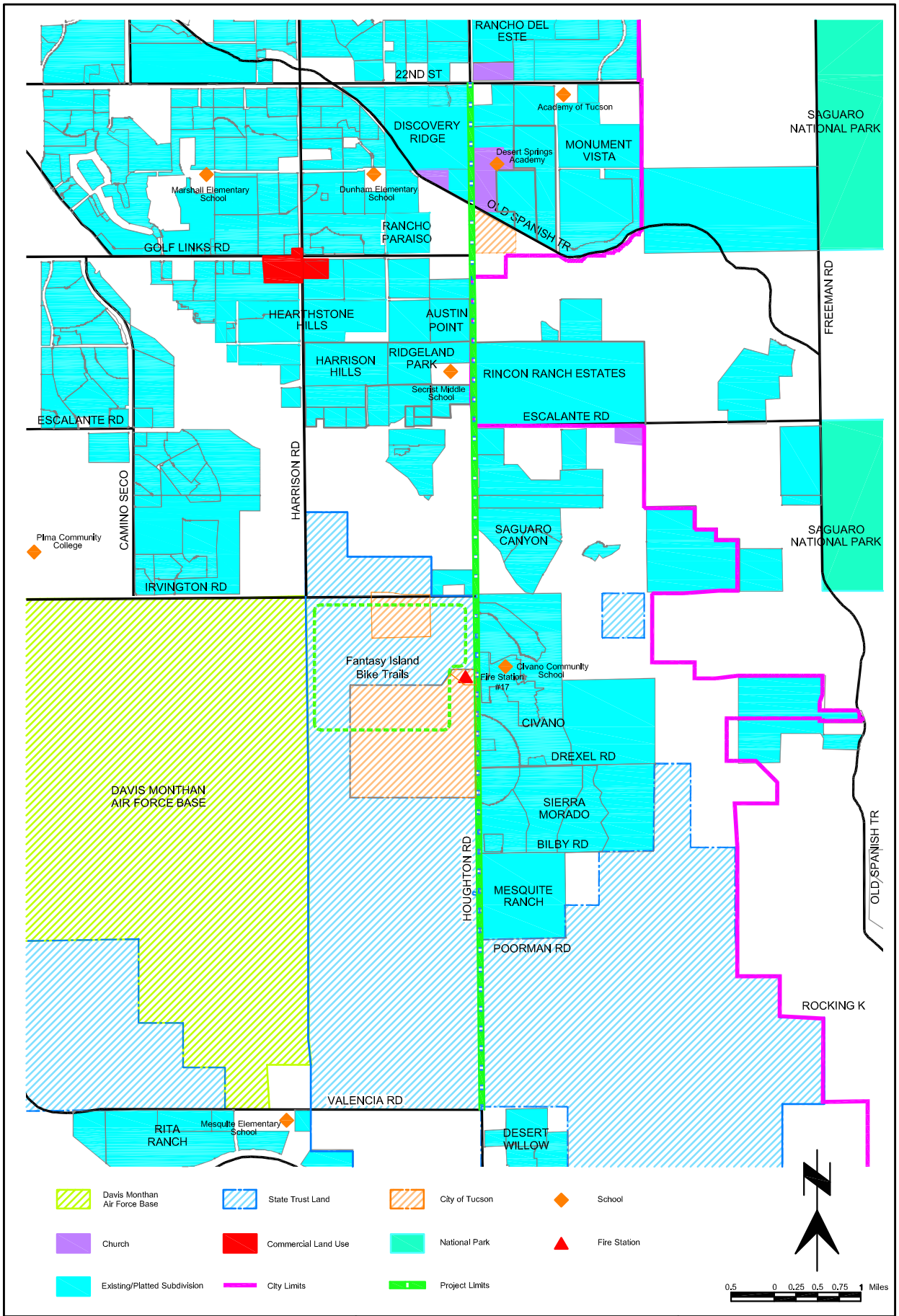
3.12. Existing Land Use

The existing land uses along Houghton Road between 22nd Street and Valencia Road are mostly residential subdivisions and vacant state trust land. There are also a few residential developments in the planning or construction phases along both sides of the roadway. Figure 6 illustrates the existing land uses in the project area.

From 22nd Street to Irvington Road, residences on large lots dominate the land use on the east side of Houghton Road, while the land uses on the west side are mostly low- to medium-density residential subdivisions. The major residential subdivisions and institutional land uses include:

Major Residential Subdivisions

- Discovery Ridge
- Austin Point



HOUGHTON ROAD FINAL DESIGN CONCEPT REPORT	FIGURE 6 EXISTING LAND USE	PSOMAS 800 E. Wetmore Road, Suite 110 Tucson, AZ 85719 (520) 292-2300 (520) 292-1290 fax www.psomas.com

- Rancho Del Este
- Monument Vista
- Rancho Paraiso
- Ridgeland Park
- Hearthstone Hills
- Harrison Hills
- Rincon Ranch Estates
- Saguaro Canyon

Institutional Uses

- 5 Schools: Academy of Tucson High School, Desert Springs Academy, Dunham Elementary School, Marshall Elementary School, Secrist Middle School
- 4 churches near the Old Spanish Trail/Houghton Road intersection
- Tucson Water and TEP facilities near Golf Links Road

From Irvington Road to Valencia Road, land west of Houghton Road is mostly vacant land owned by the State of Arizona or the City of Tucson. Davis Monthan Air Force Base is one mile west of Houghton Road. On the east side, there are a few residential subdivisions adjacent to the road. The major residential subdivisions and institutional land uses include:

Residential Subdivisions

- Civano
- Sierra Morado
- Mesquite Ranch
- Desert Willow Estates
- Rita Ranch

Institutional Uses

- Davis Monthan Air Force Base
- Civano Community School
- Tucson Fire Department Station 17

In the southern part of the area, the land between Poorman Road and Valencia Road is exclusively owned by the State of Arizona, while all the land on the west side of Houghton Road between Irvington Road and Poorman Road is owned either by the State or the City of Tucson. There are many other parcels of land throughout the project stretch that are owned by the State of Arizona. All the land owned by the State adds up to approximately 2,150 acres. In addition, Pima County owns about 20 acres along Houghton Road (west of Houghton Road between the Pantano Wash and Irvington Road), and the City of Tucson is in possession of 400 acres of land (east of Houghton Road between Old Spanish Trail and Golf Links Road, and west of Houghton Road south of Irvington Road)

3.13. Future Land Use

The southeast area of Tucson is a rapidly growing area. The Regional Transportation Plan estimates that the Pima County population will grow from 1 million today to 1.5 million by 2030. The area in the vicinity of Houghton Road and the Rincon Valley are expected to be two of the areas that will accommodate that growth in population.

The future development of this area will be guided by the *Houghton Area Master Plan* (*HAMP*), a study conducted by the City of Tucson Department of Urban Planning and Design and adopted by the Mayor and Council on June 7, 2005. *HAMP* is an area plan that covers 16.9 square miles, over 75% of which is currently owned by the Arizona State Land Trust and establishes the policy to guide growth and development in accordance with the City of Tucson General Plan. The boundaries of the *HAMP* are Irvington Road to the north, Harrison Road to the west, and the City of Tucson's boundaries to the east and south (approximately three miles east of Houghton and one mile north of I-10, respectively).

The *HAMP*'s goal is to plan for growth that respects the character of the area and its natural resources. Figure 7 presents the conceptual land use and circulation plan for the *HAMP*, which includes a mix of residential densities, commercial, educational and recreational facilities, and significant areas of open space. The area is to be developed with neighborhoods that feed to villages, with the villages feeding to a Town Center to encourage mix-use and higher density development at the core (Figure 8, from *HAMP*).

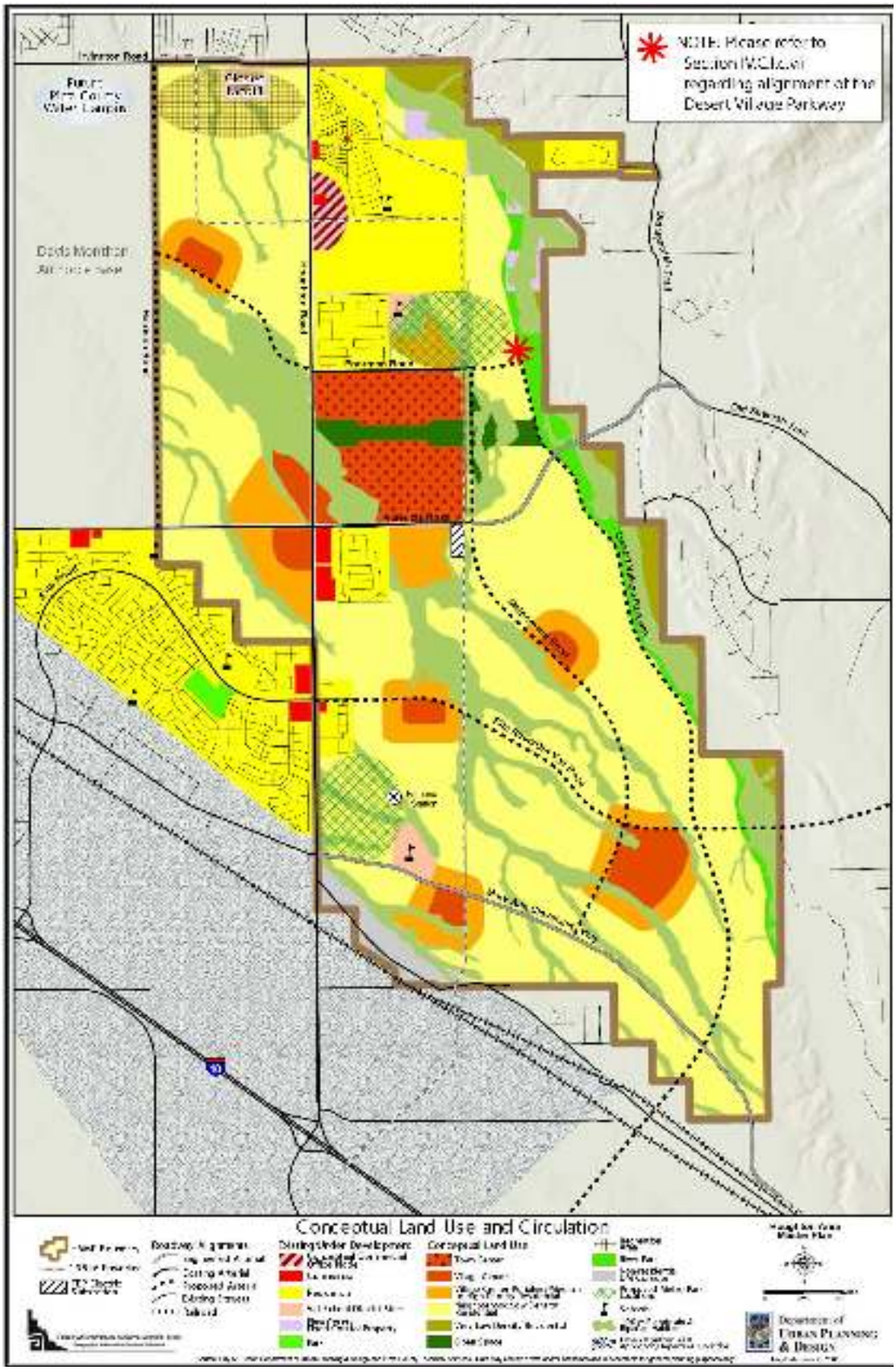


Figure 7. HAMP Land Use and Circulation Concept

The largest undeveloped area within this project's limits consists of three sections of land on the west side of Houghton between Irvington Road and Valencia Road. The majority of it is expected to develop as low-density residential, but there are two planned nodes of medium- to high-density residential.

On the east side, the area between Poorman Road and Valencia Road is proposed as the Town Center for the *HAMP*. The Town Center would offer a broad range of goods and services, employment opportunities, and civic uses. Potential uses within the Town Center include a regional mall, a retail main street, or a pedestrian district. It may include a plaza, green, or square. Higher density residential development is appropriate in and near the Town Center. The area east of Houghton Road around Drexel Road is also designated as a commercial/office node. There are plans currently underway to develop a medical center in this parcel.

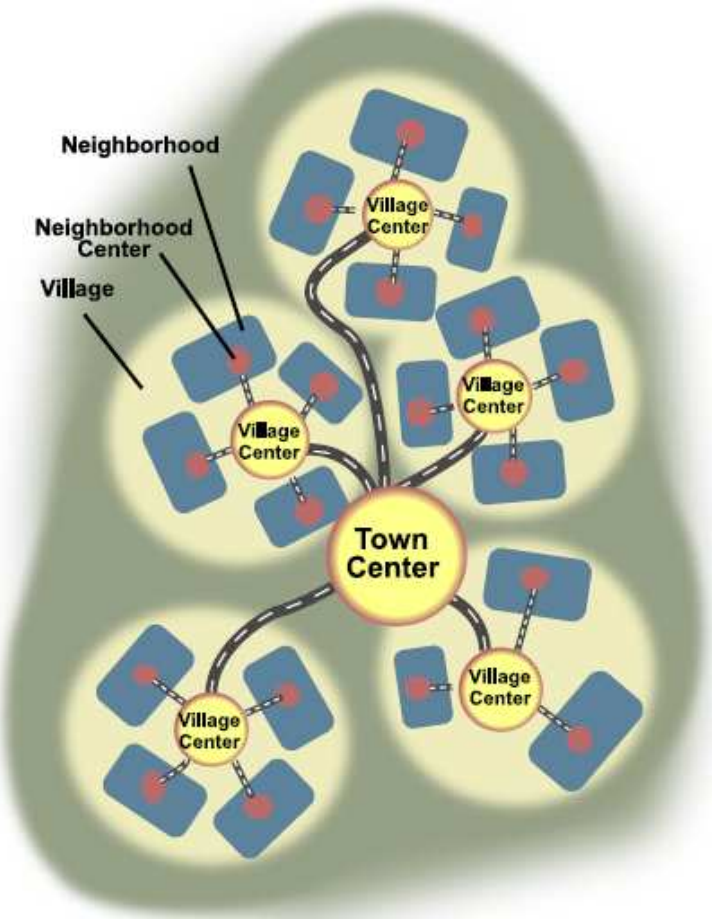


Figure 8. Components of a Planned Community

In addition, according to the *HRCS*, a 180-acre site at the southwest corner of Houghton Road and Old Spanish Trail has been identified as a potential major retail location. Continued development is also expected in Civano and Sierra Morado, both of which are located on the east side of Houghton Road between Irvington Road and Bilby Road.

3.14. Current Zoning

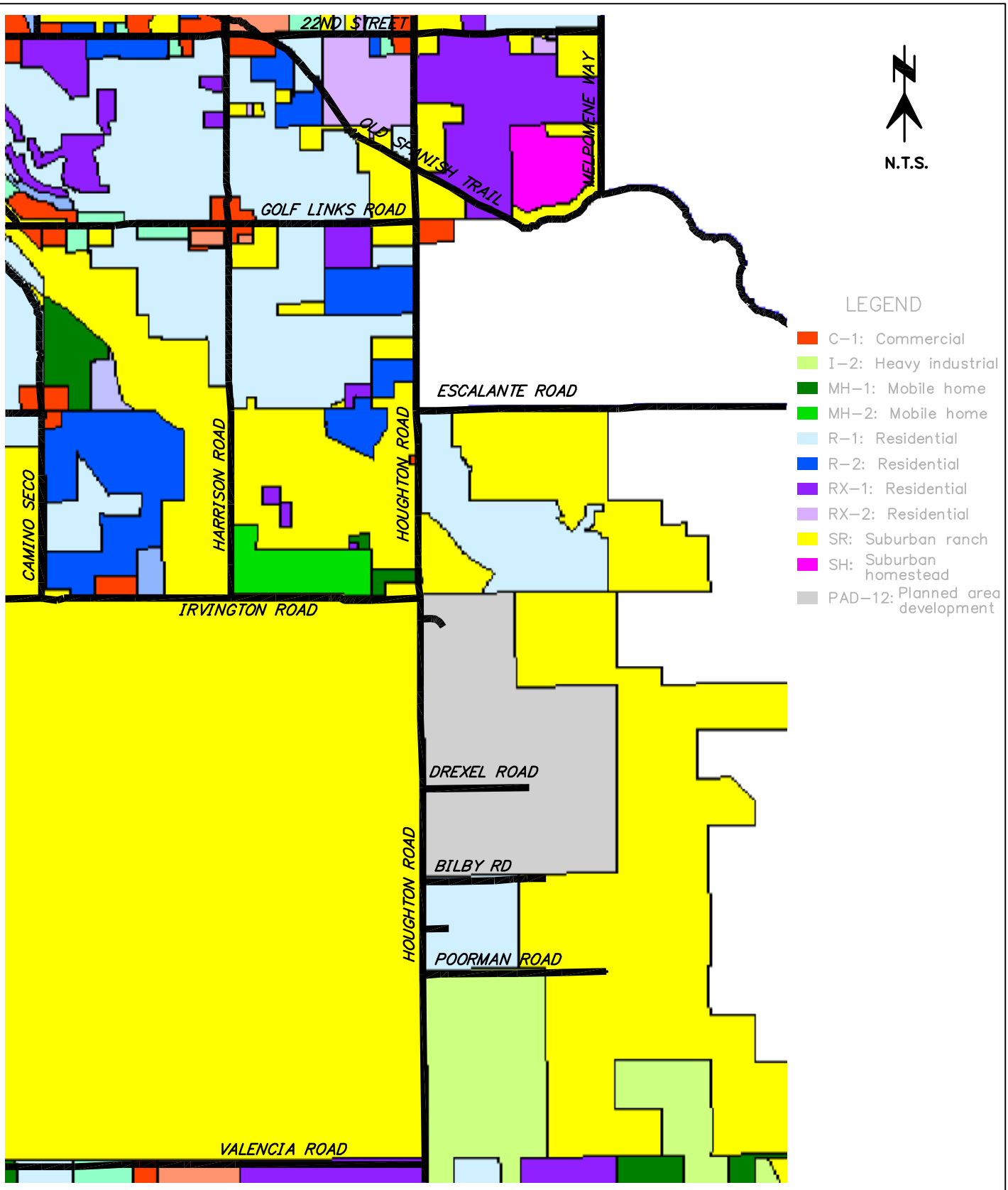
Figure 9 shows the current zoning for the area bounded by 22nd Street, Camino Seco, Valencia Road, Old Spanish Trail, and Freeman Road, while Table 7 lists the approximate acreage of the major zoning classification found in the immediate area surrounding Houghton Road.

Table 7. Zoning in the Area of Houghton Road

Zoning	Description	Approx Area (Acres)
C-1	Commercial	30
I-2	Heavy industrial	410
MH-1	Mobile home	20
PAD	Planned Area Development (Civano, Sierra Morado)	800
R-1	Residence, lots >7,000 SF	290
R-2	Residence, lots >5,000 SF	110
RX-1	Residence, lots >36,000 SF	40
RX-2	Residence, lots >16,000 SF	110
SR	Suburban ranch, lots >144,000 SF	1,780

As shown in the table, the vast majority of the land in the vicinity of Houghton Road is currently zoned for residential uses. The largest single zoning designation is Suburban Ranch (SR), a classification reserved for very low-density residential uses. SR zoning dominates the area south of Escalante Road. The next largest zoning classification is Planned Area Development (PAD), which includes all of Civano and Sierra Morado.

Non-residential zonings include heavy industrial (I-2) and commercial zone (C-1). The industrial zoning is concentrated between Poorman Road and Valencia Road along the east side of Houghton Road. The commercial zones are located at the 22nd Street intersection, at the Golf Links intersection (the CVS pharmacy in the southeast corner), and at McGraw's Cantina.



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Tucson, AZ 85719
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ZONING MAP
HOUGHTON ROAD ALIGNMENT

FIGURE 9

3.15. Potentially Affected Community Facilities

There are six schools within this project's area of influence. Academy of Tucson High School is a private school ½-mile east of Houghton Road on 22nd Street. Soleng Tom Elementary School is approximately ½-mile northeast of the 22nd Street/Houghton Road intersection. Desert Springs Academy is an elementary school located 600 feet east of Houghton Road on 29th Street. Dunham Elementary School is ½-mile west of Houghton Road on 29th Street. Civano Community School is an elementary school located within the Civano subdivision on Mira Lane.

Secrist Middle School is a public school adjacent to Houghton Road's west right-of-way ¼-mile north of Escalante Road. On August 30, 2007, the City of Tucson and the design team met with Tucson Unified School District (TUSD) and Pima County representatives to discuss potential circulation and pedestrian connectivity improvements. Based on input from the participants, a concept drawing was developed and distributed for review. The concept drawing (Figure 10) was revised and redistributed on November 30 to reflect improvements suggested by TUSD.

Figure 10. Secrist Middle School Concept Circulation Plan

The revised concept drawing includes a signalized pedestrian crossing of Houghton Road, modifications to the parking areas, a median opening for outbound buses, a directional median opening for inbound vehicles, and circulation changes to the parent drop-off area.

There are also churches located in the project area that will benefit from the roadway improvements. 22nd Street Baptist Church is located at the northeast corner of Houghton Road and 22nd Street. Pantano Christian Church is located at the northeast corner of Houghton Road and 29th Street. Two smaller churches, Mount Olive Lutheran Church of Tucson and Sahuaro Baptist Church of Tucson, are located on Houghton Road between 29th Street and Old Spanish Trail. Another small church, Saguaro Evangelical Free Church, is located approximately 800 feet west of Houghton Road on Old Spanish Trail. Bethel Baptist Church of Tucson is located at the southwest corner of the intersection of Escalante Road with Melpomene Way.

Tucson Fire Department's (TFD) Station 17 is also within the limits of the project, as it is located on the west side of Houghton Road directly across from Seven Generations Way. As of August 2008, an emergency signal is currently under construction at this location. However, the current signal is only expected to be an interim solution and will likely be relocated with the widening of Houghton Road.

The design team and the City of Tucson project manager met with TFD officials at the fire station on October 8, 2007 to identify any potential concerns associated with the project and develop a permanent solution to the traffic needs. Based on input from the participants, a concept drawing (Figure 11) was developed and distributed for review. The main issues addressed in the concept drawing are:

1. Realignment of the emergency vehicle exit to improve its alignment with Seven Generations Way. This includes the addition of a full-access median opening at this location.

2. Construction of an emergency signal to allow fire vehicles to easily exit the station. The signal could be preempted by fire truck operators and would also include safety lighting and advanced warning flashers to let motorists know when the signal will be activated.

3. An internal connection between the two access points to the fire station.

Figure 11. Concept Drawing for TFD Fire Station #17

Fantasy Island, a recreational area heavily used by mountain bikers, is also located immediately adjacent to the project at the southwest corner of Houghton Road and Irvington Road. Fantasy Island includes over 16 miles of desert trails on 640 acres (Township 15S, Range 15E, Section 11) of undeveloped land owned by the State of Arizona and the City of Tucson.

Two other facilities adjacent to Houghton Road include a TEP substation located south of Golf Links on the east side of Houghton Road, and Tucson Water's Danforth reservoir, located between Old Spanish Trail and Golf Links Road along the east side of Houghton Road.

3.16. Public Lands within the Project Area

The public lands adjacent to the Houghton Road project include:

- 28 acres owned by the City of Tucson at the southeast corner of Houghton Road and Old Spanish Trail (Tucson Water's Danforth reservoir)

- 19 acres owned by the Tucson Unified School District (TUSD) at the site of Secrist Middle School
- 20 acres owned by Pima County south of the Pantano Wash on the west side of Houghton Road.
- 215 acres owned by the Arizona State Land Trust at the southwest corner of Houghton Road and Irvington Road
- 370 acres owned by the City of Tucson south of Irvington Road on the west side of Houghton Road
- 1,800 acres owned by the Arizona State Land Trust between Drexel Road and Valencia Road.

3.17. Tribal Lands

There are no tribal lands within the project area.

3.18. Intergovernmental and Development Agreements

An intergovernmental agreement (IGA) between the City of Tucson and the Regional Transportation Authority is in place for the design and construction of the Houghton Road improvements. In addition, approximately 0.9 miles of Houghton Road (between Escalante Road and Golf Links Road) are within Pima County jurisdiction. Although an agreement is not in place yet, an IGA will be executed between the two entities prior to construction, as Pima County will contribute $20 million for the construction of the segment between Golf Links Road and I-10.

There is also an IGA between the City of Tucson and the Pima County Parks and Recreation Department for the greenway along the east side of the Houghton Road corridor. These two entities will enter into a Memorandum of Understanding (MOU) to use $1 million of County Parks bonds for the acquisition of right-of-way for the greenway.

4. TRAFFIC AND SAFETY DATA

Existing and future traffic conditions have been documented in the *Traffic Engineering Report*[12] for this project. The contents of this report and other traffic information are summarized below.

4.1. Existing Conditions

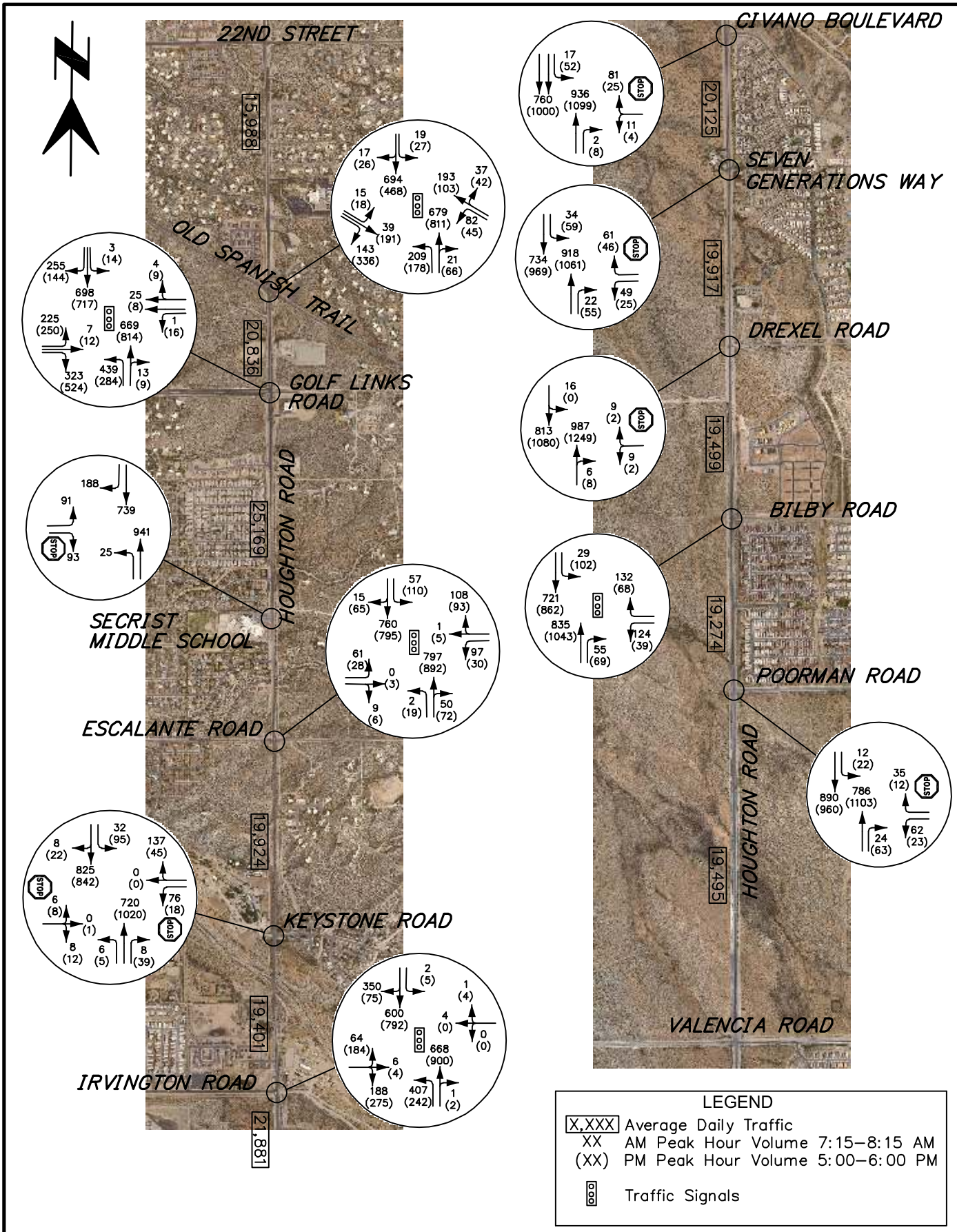
4.1.1. Existing Traffic Volumes

Average Daily Traffic (ADT) volumes and peak-hour turning movement counts were collected on March 1, 2007 at key locations along the corridor. The results of the counts, the turn lane configuration, and the existing traffic control are summarized in Figure 12. The detailed 24-hour counts and turning movement counts are included in the *Traffic Engineering Report.*

Given that traffic volumes in Tucson are typically higher in the December to March period, these counts are considered to reflect the critical volumes experienced by users. Therefore, no seasonal adjustments were made.

The ADT along most of the project was approximately 20,000 vehicles per day (VPD), except for the 22nd Street to Old Spanish Trail segment, which had an ADT of 16,000 VPD, and the Golf Links Road to Escalante Road segment, which experienced volumes of over 25,000 VPD.

The turning movement counts at the major intersections in the project area were also conducted from 6:15 AM to 8:15 AM and 4:00 PM to 6:00 PM. From the counts, the peak hours were found to be from 7:15 to 8:15 AM and from 5:00 to 6:00 PM, respectively. The percentage of daily traffic in the peak hour (K) ranged between 9 and 10% for the entire corridor. The peak hour factor (PHF) was between 0.84 and 0.97 in the morning but was higher in the evening peak (0.92 to 0.99), indicating that volumes are equally heavy during each 15-minute period of the evening peak hour. The directional distribution during the morning peak is nearly balanced north of Keystone Road and south of Bilby Road. However, between Keystone Road and Bilby Road, traffic is heavier in the direction leading to Irvington Road (i.e. northbound between Bilby Road and Irvington Road). In the evening, traffic is consistently heavier in the northbound direction.



HOUGHTON ROAD

FINAL DESIGN CONCEPT REPORT

FIGURE 12

EXISTING TRAFFIC VOLUMES (2007)

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4.1.2. Existing Level of Service

The existing Level of Service (LOS) was analyzed for Houghton Road and its intersections. Level of Service (LOS) is a quality measure describing operational conditions within a traffic stream, generally in terms of travel speed (for arterials), density (for freeways), and delays (for intersections). LOS ranges from A to F, with A representing the best operating conditions and F representing the worst.

The LOS of road segments is frequently evaluated by comparing the daily volumes to the thresholds specified in the *Florida 2002 Quality/Level of Service Handbook*[13]. According to the tables in the handbook, a two-lane arterial can accommodate as many as 16,900 VPD at LOS E (State Arterial in urban area, less than two signals per mile), while a similar four-lane roadway can handle up to 35,700 VPD. Table 8 presents the current LOS for each segment of Houghton Road and the major side streets within the project limits. As shown, Houghton Road is currently operating at a LOS F for the majority of the project area. All the major side streets operate at acceptable LOS.

Table 8. Existing LOS for Roadway Segments

Roadway	Segment	# Lanes	Average Daily Traffic (ADT)*	LOS
Houghton Road	22nd Street to Old Spanish Trail	2	15,988	D
	Old Spanish Trail to Golf Links Road	2	20,836	F
	Golf Links Road to Escalante Road	2	25,169	F
	Escalante Road to Keystone Road	2	19,924	F
	Keystone Road to Irvington Road	2	19,401	F
	Irvington Road to Civano Boulevard	2	21,881	F
	Civano Blvd to Seven Generations Wy	2	20,125	F
	Seven Generations Wy to Drexel Rd	2	19,917	F
	Drexel Road to Bilby Road	2	19,499	F
	Bilby Road to Poorman Road	2	19,274	F
	Poorman Road to Valencia Road	2	19,495	F
Old Spanish Trail	W of Houghton Road	2	9,324	C
	E of Houghton Road	2	5,187	C
Golf Links Road	W of Houghton Road	4	13,595	B
Escalante Road	W of Houghton Road	2	1,484	B
	E of Houghton Road	2	3,686	B
Irvington Road	W of Houghton Road	2	10,085	C
Drexel Road	E of Houghton Road	2	338	B
Bilby Road	E of Houghton Road	4	3,225	A
Poorman Road	E of Houghton Road	2	1,214	B

** Daily volumes for side streets are based on the application of the K factor to the peak hour volumes*

The LOS at existing intersections along the alignment of Houghton Road was also analyzed for both the AM and PM peak hours, and is summarized in Table 9.

Table 9. Existing Intersection LOS

		Old Spanish Trail						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS	B	B	A	B	C	C	F	B	B	A	B	B	Signal	C
	Delay	16.7	16.6	4.8	18.8	20.7	20.7	123.5	14.5	14.5	7.8	14.9	14.9		25.4
PM	LOS	B	B	A	B	B	B	B	D	D	B	B	B		C
	Delay	14.1	17.5	6.8	15.5	12.8	12.8	17.4	35.7	35.7	13.3	11.2	11.2		21.1

		Golf Links Road						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS	E	D	A	D	C	C	F	B	B	B	D	A	Signal	D
	Delay	73.3	40.6	8.3	36.0	33.1	33.1	129.6	12.3	12.3	18.7	45.4	3.8		44.5
PM	LOS	D	C	C	C	B	B	E	B	B	B	D	A		C
	Delay	49.7	27.5	29.2	25.2	16.4	16.4	74.0	18.9	18.9	18.4	44.7	3.4		35.0

		Secrist Middle School Driveway						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS	F		C				B						2-Way Stop	N/A
	Delay	66.0		18.2				10.6							N/A
PM	LOS														
	Delay														

		Escalante Road						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS	C	A	A	C	A	A	A	B	B	C	B	B	Signal	B
	Delay	20.3	0.1	0.1	21.9	5.8	5.8	5.5	13.5	13.5	22.5	12.8	12.8		13.6
PM	LOS	D	C	C	D	B	B	A	B	B	B	A	A		B
	Delay	38.3	25.7	25.7	36.8	12.0	12.0	3.3	11.1	11.1	11.8	9.9	9.9		11.4

		Keystone Road						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS	E	E	E	F	C	C	A			A			2-Way Stop	N/A
	Delay	35.5	35.5	35.2	80.7	20.3	20.3	9.9			9.6				N/A
PM	LOS	F	F	F	F	C	C	B			B				N/A
	Delay	62.4	62.4	62.4	66.8	23.3	23.3	10.1			12.4				N/A

		Irvington Road						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS	E	E	E	D	D	D	F	A	A	B	E	E	Signal	E
	Delay	55.2	55.2	55.2	38.0	38.0	38.0	213.5	7.1	7.1	11.0	56.9	56.9		69.9
PM	LOS	F	F	F	A	A	A	F	C	C	B	E	E		E
	Delay	106.8	106.8	106.8	0	0	0	102.7	20.1	20.1	11.6	63.4	63.4		59.4

		Civano Boulevard						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS				E		E				B			2-Way Stop	N/A
	Delay				35.3		35.3				10.6				N/A
PM	LOS				D		D				B				N/A
	Delay				32.6		32.6				12.1				N/A

Table 9. Existing Intersection LOS (Cont)

		Seven Generations Way						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS				D		D				B			2-Way Stop	N/A
	Delay				31.1		31.1				10.7				N/A
PM	LOS				D		D				B				N/A
	Delay				34.6		34.6				12.3				N/A

		Drexel Road						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS				D		D				A	A		2-Way Stop	N/A
	Delay				27.6		27.6				0.7	0.8			N/A
PM	LOS				E		E								N/A
	Delay				35.2		35.2								N/A

		Bilby Road						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS				C		A		B	A	A	B		Signal	B
	Delay				20.9		9.1		13.9	1.7	9.9	10.2			12.2
PM	LOS				C		B		B	A	F	A			B
	Delay				31.9		10.6		10.4	1.0	146.4	6.7			15.4

		Poorman Road						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS				E		C				A			2-Way Stop	N/A
	Delay				46.7		16.6				9.9				N/A
PM	LOS				E		C				B				N/A
	Delay				47		22.6				12.1				N/A

As shown, several movements at stop-controlled intersections operate at LOS E or F during the morning and evening peaks (movements experiencing LOS F are highlighted). The most notable case is Keystone Road, where four movements experience LOS F. This situation is common for minor street intersections and is caused by a combination of two factors:

- High turning volumes onto the major street.
- High through volumes per lane on the major street, which reduces the number of available gaps.

Overall, the signalized intersections operate at LOS D or better, with the exception of Irvington Road, which experiences LOS E. The longest delays are experienced by drivers turning left from Houghton Road onto Old Spanish Trail (AM NB), Golf Links Road (AM NB), Irvington Road (AM and PM NB), and Bilby Road (PM SB). This is a result of the high left-turning volumes and the high volume of opposing through traffic. As an example, there are over 400 northbound left turns at both Golf Links Road and at Irvington Road during the morning peak hour.

4.1.3. Traffic Safety

Psomas obtained crash data for Houghton Road between 22nd Street and Valencia Road from the Arizona Department of Transportation (ADOT) for the latest available five-year period, which extended from May 2001 to April 2006. During the five-year study period there were a total of 197 crashes in the study area: 163 crashes at major intersections and 34 crashes on road segments between intersections.

Table 10 shows the crashes at the major intersections (none of the other intersections had more than one crash in the five-year period). Nearly 60% of the intersection crashes were rear-end crashes. The next most common type of crash was angle collisions, followed by left-turn and single-vehicle crashes. The highest number of crashes took place at the intersection of Houghton Road with Old Spanish Trail. It should be noted that this intersection is skewed 30°, which exceeds the 20° recommended in the Pima County *Roadway Design Manual*, due to right-of-way constraints.

Table 10. Intersection Crash Type Summary

Intersection	Angle	Left Turn	Sideswipe	Rear End	Single Vehicle	Head-On	Other	Total Crashes
Old Spanish Trail	6	4	2	41	2	0	1	**56**
Golf Links Rd	4	7	1	24	3	0	0	**39**
Escalante Rd	3	3	0	17	1	0	4	**28**
Irvington Rd	5	2	0	6	8	1	3	**25**
Drexel Rd	0	0	0	5	0	0	0	**5**
Poorman Rd	8	1	0	1	0	0	0	**10**
TOTAL	**26**	**17**	**3**	**94**	**14**	**1**	**8**	**163**

Tables 11 and 12 present the crash rates and crash severity for intersections and road segments, respectively. The ADT used to calculate the crash rates is from 2004 because that year represents the middle of the analysis period. The severity index weights fatal and injury accidents more heavily than property damage only crashes.

Table 11. Intersection Crash Rate and Severity

Intersecting Street	Fatality	Incapacitating Injury	Non-Incapacitating Injury	Possible Injury	No Injury	Total Crashes	Severity Index	Entering Veh/Day (2004)	Crash Rate (per MVE)
Old Spanish Trail	0	3	7	11*	35	**56**	1.58	29,024	1.06
Golf Links Rd	0	3	7	7	22	**39**	1.73	33,254	0.64
Escalante Rd	0	1	2	6	19	**28**	1.46	23,938	0.64
Irvington Rd	1	0	6	5*	13	**25**	1.63	25,584	0.54
Drexel Rd	0	2	1	0	2	**5**	3.12	16,475	0.17
Poorman Rd	0	0	7	2	1	**10**	1.90	17,735	0.31
TOTAL	**1**	**9**	**30**	**31**	**92**	**163**	**1.67**		

**Includes one crash with unknown injuries.*

Table 12. Road Segment Crash Rate and Severity

Road Segment	Fatality	Incapacitating Injury	Non-Incapacitating Injury	Possible Injury	No Injury	Total Crashes	Severity Index	Entering Veh/Day	Segment Length (mi)	Crash Rate (per MVM)
22nd St to Old Spanish Tr	0	0	1	2	6	**9**	1.33	15,988	0.52	0.60
Old Spanish Tr to Golf Links Rd	0	0	1	0	1	**2**	1.50	20,836	0.08	0.63
Golf Links Rd to Escalante Rd	0	2	1	2	2	**7**	2.80	21,132	0.80	0.23
Escalante Rd to Irvington Rd	0	0	1	1	6	**8**	1.25	16,509	0.80	0.33
Irvington Rd to Drexel Rd	0	0	0	1	0	**1**	2.00	17,547	0.80	0.04
Drexel Rd to Poorman Rd	0	0	0	2	1	**3**	1.67	16,004	0.80	0.13
Poorman Rd to Valencia Rd	0	1	1	1*	1	**4**	2.70	16,368	0.80	0.17
TOTAL	**0**	**3**	**5**	**9**	**17**	**34**	**1.84**			

**Includes one crash with unknown injuries.*

From Table 11, the only intersection with a high severity index is Drexel Road at Houghton Road. However, this may not be a representative sample because the number of crashes is small at this location, and the severity index is heavily influenced by the two incapacitating injury crashes. The fatality at the intersection of Irvington Road and Houghton Road took place in December 2002 when a vehicle failed to yield the right-of-way, resulting in an angle crash. A traffic signal, which is one of the improvements that reduces the likelihood of severe angle crashes, was installed at this location in 2004.

The crash rate for most intersections (except for Old Spanish Trail) was lower than the County average. However, the severity indices were very close to or above the County averages. As shown in Table 12, 50% of the 34 roadway segment crashes did not result in injuries. Several were single vehicle or sideswipe crashes, consistent with the type of crashes expected at non-intersection locations.

In conclusion, the number and severity of crashes along the project is within the typical levels for arterial roadways in southern Arizona. However, crash reductions can be achieved by the construction of roadway improvements. The most prevalent type of crash (rear end) can be minimized by the addition of turn lanes and by improving the sight visibility along the roadway. As an example, 4 of the 5 crashes at Drexel Road where rear-ends in the southbound direction that could be corrected by the addition of a dedicated left turn lane. Left turn and angle crashes can be prevented by the addition traffic signals (90% of crashes at Poorman Road were left turn or angle crashes) or by providing street lighting (1 out of every 4 crashes were at night). Finally, single vehicle crashes can be prevented by adding or widening the paved shoulders and flattening the slopes within the clear zone.

4.1.4. Alternative Modes

Although Houghton Road is currently a primarily auto-oriented corridor, there are some alternative mode facilities in the project area. The pedestrian facilities consist of short segments of sidewalks and shared-use paths that lack connectivity among them. The longest continuous path exists on the east side between Poorman Road and the northern end of Sierra Morado (0.8 miles), along Mesquite Ranch and Sierra Morado. Plans for the continuation of this path through the proposed medical center at Drexel Road have already been prepared as well.

The bicycle facilities in the area include the shared-used path described above, as well as bike routes for most of the project. The only area without bike routes is between the Pantano Wash and Seven Generations Way. Both recreational and competitive cycling are important activities in this area, primarily because of its scenic character and proximity to attractions such as Saguaro National Park and Fantasy Island (refer to Section 3.15)

Currently there is no transit service on Houghton Road. However, Golf Links Road, 22nd Street, and Harrison Road have SunTran bus service within one mile of the project. Route 7 on 22nd Street and Route 17 on Golf Links Road operate on 30-minute headways on weekdays and one-hour headways on weekends. Route 83 runs as an express route on Golf Links Road with one bus in the morning and one bus in the afternoon on weekdays. Route 180 runs along Harrison Road, with two buses in the morning and two in the evening during weekdays. The closest park and ride lots are located at Camino Seco and Broadway Boulevard, and at Speedway Boulevard and Harrison Road.

4.2. Future Conditions

The land use and transportation conditions along the corridor were analyzed for the 2030 horizon year. 2030 was selected to match the PAG planning horizon and to reflect the life cycle of roadway projects.

4.2.1. Traffic Volumes

As a result of population growth and continued development in the area, the traffic volumes along Houghton Road are anticipated to grow significantly between now and 2030. The projected volumes for this project were developed after analyzing two primary sources: the 2030 regional traffic model from PAG and the traffic forecasts included in the *HRCS*. Table 13 presents the current daily volumes, the projected volumes from PAG and the *HRCS*, and the recommended volumes from the *Traffic Engineering Report.*

Table 13. Projected 2030 Daily Volumes for Road Segments

		Existing	PAG*		HRCS (2004) **		Recommended	
Roadway	**Segment**	**2007**	**2030**	**Annual Growth**	**2030**	**Annual Growth**	**2030**	**Annual Growth**
Houghton Rd	22nd Street - Old Spanish Trail	15,988	36,595	3.7%	35,700	3.6%	36,595	3.7%
	Old Spanish Tr - Golf Links Rd	20,836	61,088	4.8%	47,000	3.6%	61,088	4.8%
	Golf Links Rd - Escalante Rd	25,169	74,532	4.8%	74,200	4.8%	74,532	4.8%
	Escalante Rd - Irvington Rd	19,924	72,937	5.8%	78,000	6.1%	72,937	5.8%
	IrvingtonRd - Drexel Rd	21,881	47,102	3.4%	82,000	5.9%	47,102	3.4%
	Drexel Rd - Poorman Rd	19,499	47,085	3.9%	75,500	6.1%	47,085	3.9%
	Poorman Rd - Valencia Rd	19,495	85,808	6.7%	57,100	4.8%	47,075	3.9%
Old Spanish Tr	W of Houghton Road	9,324	30,214	5.2%	25,900	4.5%	30,214	5.2%
	E of Houghton Road	5,187	9,476	2.7%	16,400	5.1%	9,476	2.7%
Golf Links Rd	W of Houghton Road	13,595	27,280	3.1%	31,500	3.7%	31,500	3.7%
	E of Houghton Road	726	-		1,000	1.4%	1,681	3.7%
Escalante Rd	W of Houghton Road	1,484	-		8,900	8.1%	3,059	3.2%
	E of Houghton Road	3,686	4,546	0.9%	7,600	3.2%	7,600	3.2%
Irvington Rd	W of Houghton Road	10,085	29,204	4.7%	11,300	0.5%	29,204	4.7%
	E of Houghton Road	148	60,054	29.8%	2,200	12.4%	60,054	29.8%
Drexel Rd	W of Houghton Road	-	-		13,100		3,062	
	E of Houghton Road	338	3,078	10.1%	41,400	23.3%	9,647	15.7%
Bilby Rd	W of Houghton Road	-					9,187	
	E of Houghton Road	3,225					19,831	8.2%
Poorman Rd	W of Houghton Road	-	27,016		11,900		3,062	
	E of Houghton Road	1,214	14,667	11.4%	50,900	17.6%	7,130	8.0%

* PAG forecasts obtained on 03/13/07. They do not represent the official volumes used for the 2030 Regional Transportation Plan

** These volumes correspond to Scenario 3 of the Houghton Corridor Study (HRCS, 2004). Kittelson also used the same volumes for the I-10 to Valencia analysis of Houghton Road (2007)

The main difference between the PAG and *HRCS* numbers is that PAG assumed that the proposed Desert Village Parkway (DVP) will connect to Houghton Road at Irvington Road, while the *HRCS* assumed that the main connection would be at Poorman Road. After consultation with the City of Tucson Traffic Engineering Division (TED), it was decided to select Irvington Road as the connection point because the land uses around Poorman Road may not be conducive to the construction of a major six-lane roadway. In addition, an extension to the west of Houghton Road at Poorman Road would be difficult due to natural constraints, while Irvington Road already connects to Kolb Road. As a result, the PAG forecasts became the base of the 2030 recommended volumes for the project. The following additional assumptions were made with the City of Tucson Traffic Engineering Division (TED) to develop the 2030 recommended volumes:

- The traffic on the segment of Houghton Road between Poorman Road and Valencia Road was reduced to reflect the elimination of a minor connection to the DVP shown in the PAG model. The new growth for the segment is consistent with the segment to the north and with the segment south of Valencia Road (by Kittelson and Associates).
- Escalante Road will continue to be discontinuous west of Houghton Road because of an existing wash crossing. To the east, the growth will be similar to the rate on Houghton Road because of its connectivity to Old Spanish Trail.
- The high growth rate on Irvington Road (29.8%) is based on the assumption that DVP will connect to it from the east by 2030.
- The volumes for Drexel Road East of Houghton Road were based on the site traffic in the *Sierra Morado Traffic Impact Study*[14]. To the west, a minor access to the Arizona State Land Trust area was projected.
- Bilby Road will have a minor connection to the DVP (replacing the connection at Poorman Road on the PAG model) and will be extended to the west to connect to Harrison Road.
- The traffic growth on Poorman Road reflects the volume generated from the Town Center, but excludes connectivity to DVP.

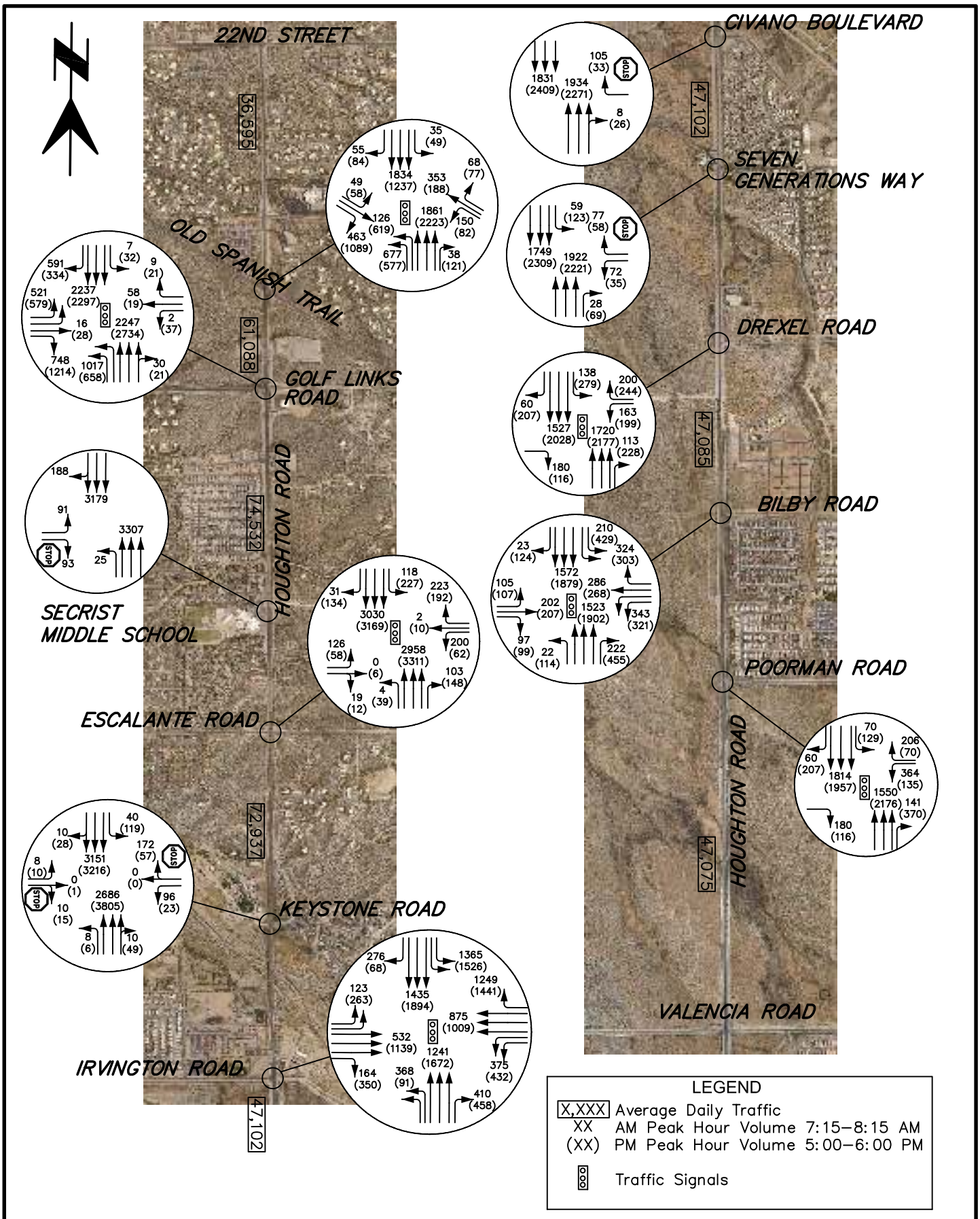
The peak hour volumes for the intersections in the study area were developed using the existing K values (percent of daily traffic in the peak hour) and the growth rates derived for each road

segment (Table 13). Figure 13 illustrates the projected turning movement volumes and the assumed lane configurations at major intersections on Houghton Road with ADT's at each road segment. It is anticipated that Houghton Road between Golf Links Road and Irvington Road will experience the highest traffic volume. In the meantime, the segment between 22nd Street and Old Spanish Trail will carry a significantly lower volume of traffic.

4.2.2. Signalization Analysis

A planning level analysis for signalization was conducted for all major unsignalized intersections along Houghton Road. Civano Boulevard was not analyzed since it is very close to Irvington Road and will be right-in / right-out only. In the analysis, condition B of Warrant 3 in Manual on Uniform Traffic Control Devices (MUTCD)15 was used with the projected peak-hour volumes. Designated right-turn lanes were excluded from the analysis for all the minor streets because right turns are much easier to perform than left turns or through movements, and as such a signal should not be justified based on right-turn volumes unless special conditions are present. As a result, all minor streets were assumed to be one lane.

The intersections at the Secrist Middle School driveway, Keystone Road, Drexel Road, and Poorman Road meet the warrants for a signal. Signals are recommended for the intersections of Drexel Road and Poorman Road with Houghton Road because they are on the one-mile grid and will carry traffic volumes well above the warrant threshold. Florida T configurations should be considered at these intersections because of the current traffic patterns and expected land use west of Houghton Road. At the intersections of Houghton Road with Keystone Road and the Secrist Middle School driveway, the analysis showed that traffic on both side streets will experience significant delays during peak hours in 2030. However, it is anticipated that if delays become excessive some left-turning traffic from the Secrist Middle School driveway will make right turns out of the school and then u-turn at Escalante Road, which is only 1/3 mile away. On the other hand, Keystone Road is ½-mile from both Irvington Road and Escalante Road; therefore, even though the HRCS recommend one-mile interval between traffic signals, it is recommended that Keystone Road be monitored closely in the future to determine if installing a signal would be appropriate.



HOUGHTON ROAD
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FIGURE 13
PROJECTED 2030 TRAFFIC VOLUMES

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4.2.3. Future Level of Service

Table 14 presents the arterial LOS for each segment of Houghton Road and the major side streets based on the assumption that Houghton Road will be a six-lane roadway by 2030. The LOS thresholds are from the *Florida Quality and Level of Service Tables*[4]. According to those thresholds, Houghton Road will operate at LOS B between 22nd Street and Old Spanish Trail and LOS C between Irvington Road and Valencia Road. All of the side streets (with the exception of the DVP) would also operate at LOS C or better with the proposed lane configuration.

Table 14. 2030 LOS for Roadway Segments

Roadway	Segment	Lanes	2030 ADT	LOS*
Houghton Rd	22nd Street - Old Spanish Trail	6	36,595	B
	Old Spanish Tr - Golf Links Rd	6	61,088	Oversaturated
	Golf Links Rd - Escalante Rd	6	74,532	Oversaturated
	Escalante Rd - Irvington Rd	6	72,937	Oversaturated
	IrvingtonRd - Drexel Rd	6	47,102	C
	Drexel Rd - Poorman Rd	6	47,085	C
	Poorman Rd - Valencia Rd	6	47,075	C
Old Spanish Tr	W of Houghton Road	4	30,214	C
	E of Houghton Road	2	9,476	C
Golf Links Rd	W of Houghton Road	4	31,500	C
	E of Houghton Road	2	1,681	B
Escalante Rd	W of Houghton Road	2	3,059	B
	E of Houghton Road	2	7,600	C
Irvington Rd	W of Houghton Road	4	29,204	B
	E of Houghton Road	6	60,054	Oversaturated
Drexel Rd	W of Houghton Road	2	3,062	B
	E of Houghton Road	2	9,647	C
Bilby Rd	W of Houghton Road	2	9,187	B
	E of Houghton Road	4	19,831	B
Poorman Rd	W of Houghton Road	2	3,062	B
	E of Houghton Road	2	7,130	C

* Based on the Florida Quality and LOS Tables for Urban State Highway Arterials with less than 2 signals per mile

The only segments over capacity would be Houghton Road between Old Spanish Trail and Irvington Road, and DVP (Irvington Road) east of Houghton Road. This is because the Florida tables specify a capacity of 53,500 VPD based on certain assumptions regarding access control and the amount of turning movements. In reality, significantly higher capacities can be achieved if the following strategies are implemented:

- Strong access management
- Signal priority for Houghton Road (requires uniform signal spacing)
- Provision of dedicated turn lanes at all locations with significant turning volumes

The future LOS at intersections along the alignment of Houghton Road was also analyzed for both the AM and PM peak hours using Synchro and is summarized in Table 15.

As shown in the table, all the signalized intersections will experience Level of Service D or better during peak hours in 2030 except the intersection of Houghton Road with Irvington Road, which will operate at LOS E and F in the AM and PM peak hour, respectively. The most significant delays will take place in the evening, when all the through movements will experience delays in excess of two minutes. The poor operational performance at the intersection of Houghton Road with Irvington Road is due to the fact that connecting Desert Village Parkway to Irvington Road will add a significant amount of traffic from the area east of Houghton Road. Some alternatives that could be explored once the DVP project materializes include the construction of a grade separated intersection at this location or the provision of additional minor connection points to DVP at locations such as Drexel Road, Poorman Road, or Valencia Road.

At unsignalized intersections, left turns onto Houghton Road from Keystone Road, Seven Generations Way, and Secrist Middle School will experience LOS F during peak hours. This occurs relatively frequently at side streets where traffic attempts to perform left turns onto heavily traveled six-lane arterials. The situation may be mitigated by drivers accepting gaps in two stages (moving to the median and then waiting another gap to merge in their desired direction of travel) or deciding to make a right turn followed by a u-turn at the nearest median opening. However, the situation should be monitored as volumes increase, particularly at Keystone Road, where the possibility of signalization should be considered despite the fact that the spacing to the adjacent signalized intersections (1/2 mile to both Escalante Road and Irvington Road) is less than the recommended spacing in both the *HAMP* and *HRCS*.

Table 15. 2030 Intersection LOS

		Old Spanish Trail						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS	D	D	A	D	E	C	D	B	A	E	E	B	Signal	D
	Delay	48.4	41.0	0.5	41.0	74.4	23.1	51.3	18.6	6.3	73.1	56.6	11.4		38.2
PM	LOS	C	E	A	E	C	B	E	D	B	F	D	B		D
	Delay	21.2	74.6	3.6	63.1	28.7	11.3	67.2	39.7	10.4	125.5	46.8	11.0		40.0

		Golf Links Road						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS	F	D	A	D	F	D	F	B	B	B	E	A	Signal	D
	Delay	124.8	44.6	1.2	55.0	91.0	38.1	134.2	17.9	17.9	11.6	60.3	5.2		51.8
PM	LOS	E	D	A	E	E	D	E	A	A	D	E	A		C
	Delay	63.1	39.0	6.2	72.3	60.8	54.6	69.7	5.5	5.5	49.9	71.7	1.8		34.9

		Secrist Middle School Driveway						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS	F		F				F						2-Way Stop	N/A
	Delay	N/A		57.6				105.4							N/A
PM	LOS														N/A
	Delay														N/A

		Escalante Road						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS	D	D	D	E	D	D	B	D	A	D	B	A	Signal	C
	Delay	52.7	37.8	37.8	79.5	39.5	38.0	11.0	35.2	3.7	52.0	10.4	0.0		25.5
PM	LOS	E	D	D	E	D	D	E	D	A	C	B	A		C
	Delay	69.2	47.1	47.1	72.6	51.0	37.7	69.3	46.9	2.7	35.0	18.9	1.4		33.1

		Keystone Road						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS	F		D	F		F	F			F			2-Way Stop	N/A
	Delay	N/A		25.7	N/A		59.7	63.9			55.8				N/A
PM	LOS	F	F	F	F		F	F			F				N/A
	Delay	N/A	N/A	N/A	N/A		62.1	67.6			N/A				N/A

		Irvington Road						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS	E	E	D	F	F	A	D	F	F	F	D	B	Signal	E
	Delay	59.8	67.3	51.1	118.6	131.6	7.4	53.3	106.6	145.1	102.6	45.3	15.6		76.2
PM	LOS	F	F	E	F	F	C	D	F	F	F	F	C		F
	Delay	80.4	221.4	72.4	204.2	160.2	28.4	42.3	172.8	129.5	228.5	133.1	22.2		149.2

		Civano Boulevard						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS						C							2-Way Stop	N/A
	Delay						19.2								N/A
PM	LOS						C								N/A
	Delay						18.6								N/A

Table 15. 2030 Intersection LOS (Cont)

		Seven Generations Way						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS				F		F				D			2-Way Stop	N/A
	Delay				289.9		289.9				25.2				N/A
PM	LOS				F		F				F				N/A
	Delay				252.9		252.9				77.5				N/A

		Drexel Road						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS			B	E		B		A	A	C	A	A	Signal	A
	Delay			17.7	60.8		10.1		5.1	0.2	26.7	0.0	0.0		6.7
PM	LOS			C	E		A		A	A	D	A	A		A
	Delay			20.2	66.3		9.9		8.7	0.6	52.2	0.0	0.0		9.4

		Bilby Road						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS	C	D	A	C	D	E	A	B	A	D	C	A	Signal	C
	Delay	33.7	39.0	6.7	34.7	44.6	62.4	6.2	10.4	2.3	45.0	24.5	4.1		24.6
PM	LOS	E	D	A	D	E	F	B	C	A	D	C	A		D
	Delay	55.7	54.8	9.8	51.6	68.1	138.8	19.5	20.1	9.0	54.4	30.6	1.7		35.6

		Poorman Road						Houghton Road						Traffic Control	Intersection LOS
		EB			WB			NB			SB				
		L	T	R	L	T	R	L	T	R	L	T	R		
AM	LOS			C	D		A		B	A	B	A	A	Signal	B
	Delay			21.7	54.8		8.5		12.6	0.3	19.9	0.0	0.0		10.6
PM	LOS			B	E		B		B	A	B	A	A		A
	Delay			19.3	68.3		13.3		13.6	1.8	18.9	0.0	0.0		8.4

Civano Boulevard was modeled as a right-in and right-out only access because of its proximity (550 feet) to Irvington Road. In addition, traffic entering Civano will be able to access using Seven Generations Way or even the proposed signal at Drexel Road.

5. DESIGN STANDARDS AND CRITERIA

The following information is the criteria that have been used as a basis for this report. Design criteria are based on the standard requirements of the City of Tucson Department of Transportation, Pima County Department of Transportation, the American Association for State Highway and Transportation Officials, the Arizona Department of Transportation, and the Federal Highway Administration (FHWA).

5.1. Geometric and Design Standards

City of Tucson Department of Transportation (TDOT):

- *Active Practice Guidelines*, 2002.
- *Transportation Access Management Guidelines for the City of Tucson, Arizona*, March 2003.
- *Traffic Signal Design Manual*, 1st edition, May 2003.
- *Standards Manual for Drainage Design and Floodplain Management in Tucson,* Arizona Revised July 1998
- *Water Harvesting Guidance Manual*, October 2005.

Pima County Department of Transportation and Regional Flood Control District (PCDOT, PCRFCD):

- *Roadway Design Manual*, 2nd edition, December 2003.
- *Drainage and Channel Design Standards for Local Drainage*, May 1984.
- *Storm Drain Design, Guidelines and Standard Plans*, March 1981.
- *Pima County Street Lighting Manual and ITS Conduit Design Guide*, August 2003.

City of Tucson Department of Transportation (TDOT) and Pima County Department of Transportation (PCDOT):

- *Standard Details for Public Improvements*, 2003.
- *Standard Specifications for Public Improvements*, 2003.
- *Pavement Marking Design Manual*, 1st Revision, October 2002.

- *Traffic Signing Design Manual*, May 2002.

Arizona Department of Transportation (ADOT):

- *Roadway Design Guidelines*, February 2004.
- *Construction Standard Drawings (C-Series)*, November 2007.
- *Structures Section Standard Drawings (B-Series)*, June 1994 and current revisions.
- *Signing and Marking Standard Drawings*, March 2002.
- *Signals and Lighting Standard Drawings*, March 2004.
- *Bridge Design and Detailing Manual*, 1994 Edition.
- *Bridge Practice Guidelines*, 2002 edition will be used with the City of Tucson's prior approval.

American Association of State Highway and Transportation Officials (AASHTO):

- *A Policy on Geometric Design of Highways and Streets* ("Green Book"), 5th edition, 2004 and current revisions.
- *Roadside Design Guide*, 2002 and current revisions.
- *Guide for the Development of Bicycle Facilities,* 3rd edition, 1999.
- *Standard Specifications for Highway Bridges*, 17th Edition.

Illuminating Engineering Society of North America

- *Illuminating Engineering Society of North America Report RP-8-00*, 2000.

Institute of Transportation Engineers

- *Trip Generation*, 7th Edition, 2003 and current revisions.

Transportation Research Board

- *Highway Capacity Manual*, 2000.

US Department of Transportation, Federal Highway Administration (FHWA):

- *Manual on Uniform Traffic Control Devices*, 2003 and current revisions.

5.2. Slope Standards

Preferred slopes for this project are 4:1 or flatter within the clear zone. Beyond the clear zone, 3:1 cut and fill slopes are used. For permanent slopes in compacted fill and cut slopes in native soil, erosion control measures for different slopes are shown in the table below, from the *Geotechnical Engineering Report (Final)*[16] prepared for this project.

Table 16. Recommended Slopes

Slope (horizontal : vertical)	Recommended Treatment
5:1 to 3:1	Re-vegetate
3:1 to 2:1	Rip-rap over filter fabric
2:1 to 1.5:1	Grouted rip-rap or 6-inch thick grout over filter fabric, with integrated tow-down at base of slope having a minimum depth of ¼ the total slope height
Steeper than 1.5:1	Stability analysis required, or structural retaining wall

Earthwork and roadway grading should be performed in accordance with Sections 203 and 205 of the Standards and Specifications. A ground compaction factor of 0.1 feet is estimated for existing subgrade soils. A shrinkage factor of 15% is estimated for on-site soils compacted to 95% of the material's Standard Proctor dry density. This figure does not include any material lost in transit or oversized material or material unsuitable for use, or compaction greater than 95%.

5.3. Pavement Structure

Per the *Pavement Design Summary (Final)*[17] prepared for this project, flexible pavement designs were performed in accordance with AASHTO procedures, as modified by ADOT and PCDOT. Calculations were based on laboratory results of test borings and assumed traffic projections. Major design parameters of the calculations are summarized below:

22nd Street to Drexel Road

Design ESAL's:	9,310,533
Design Subgrade Resilient Modulus (psi):	26,000

Drexel Road to Valencia Road

Design ESAL's:	5,856,471
Design Subgrade Resilient Modulus (psi):	13,927

Pavement Layer Coefficients

Rubberized Asphalt Concrete (RAC):	0.44
Asphalt Concrete (AC):	0.44
Aggregate Base Course (ABC):	0.14

Results of the design structural calculations are summarized in Table 17 below, along with the City of Tucson minimum structural numbers and AC thickness.

Table 17. Pavement Design Structural Calculations

Pavement Area	Calculated SN	COT Minimum SN*	COT Minimum AC Thickness (in)*	COT Minimum AB Thickness (in)*
Houghton Rd. from 22nd to Drexel	3.34	3.04	5"	6"
Houghton Rd. from Drexel to Valencia	3.97	3.04		

* 5" AC and 6"ABC are the minimum requirements for Arterial Roadways per the City's Active Practice Guidelines

5.4. Design Speed

The design speed for Houghton Road was determined in discussions with City of Tucson staff. The variables considered in the selection of the design speed included:

- Roadway functional classification
- Surrounding existing and projected land use
- Clear zone requirements and the possibility of using curbs for access control and drainage
- Vertical alignment implications including sight distance, right-of-way availability, and amount of earthwork
- Relationship to the need for street lighting.

Based on those considerations, a design speed of 50 mph was selected for the entire segment of Houghton Road. The recommended design speed and posted speed for Houghton Road and the intersecting streets are summarized in Table 18.

Table 18. Recommended Design and Posted Speeds

Roadway	Design Speed (mph)	Posted Speed (mph)
Houghton Road	50	45
Old Spanish Trail	45 (west of Houghton Rd)	40 (west of Houghton Rd)
	50 (east of Houghton Rd)	45 (east of Houghton Rd)
Golf Links Road	45 (west of Houghton Rd)	40 (west of Houghton Rd)
	30 (east of Houghton Rd)	25 (east of Houghton Rd)
Escalante Road	30 (west of Houghton Rd)	25 (west of Houghton Rd)
	50 (east of Houghton Rd)	45 (east of Houghton Rd)
Irvington Road	50 (west of Houghton Rd)	45 (west of Houghton Rd)
	30 (east of Houghton Rd)	25 (east of Houghton Rd)
Bilby Road	45	25

5.5. Drainage Design

Where available, existing approved discharges were identified for use in the roadway design. Existing *Tucson Stormwater Management Study (TSMS)* and approved drainage report discharges are identified within the drainage report for this project. In cases were approved discharges were not available, peak discharges for both onsite and offsite watersheds were calculated per Pima County standards outlined in the *Hydrology Manual for Engineering Design*[18]. The same Pima County methodologies used to calculate the existing conditions discharges were used to calculate the developed conditions discharges.

The hydrologic analysis for the offsite watersheds impacting the project was performed using the procedures outlined in the Pima County *Hydrology Manual for Engineering Design and Floodplain Management*[19]. The Pima County methodology was utilized because the offsite watersheds originate in Pima County. A comparison between the methodologies showed the Pima County methodology as more conservative than the City of Tucson methodology.

The design storm for cross drainage analysis is the 100-year, one-hour storm. To provide 100-year all-weather access, culvert crossings have been designed to convey the 100-year event beneath the roadway.

The design storm for pavement drainage analyses is the 10-year, one-hour storm to meet spread criteria and the 100-year, one-hour storm to ensure less than one foot of ponding within the roadway. Evaluation of spread will ensure that a minimum of 20 feet per direction remains clear during the 10-year design storm along the six-lane section of Houghton Road. Four-lane side streets will keep 10 feet per direction clear during the 10-year storm.

The Design Storm (36,000 cfs), 100-year storm (31,000 cfs) and 50-year storm (24,490 cfs) were used in analyzing the scour and freeboard of the Pantano Wash bridge. The Design Storm and 100-year storm discharges are from the Floodplain Management Ordinance No. 1985-FC1 for Pima County, Arizona. The 50-year storm was calculated using the suburban ratio (Q_{50} = 0.79 x Q_{100}) relating more frequent floods to the 100-year flood found in Table 4.5 of the City of Tucson *Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona*[20] (COT SMDDFM). The 100-year storm was utilized in the calculation of bridge freeboard while the Design Storm was used in the calculation of scour.

Scour was analyzed using COT SMDDFM equations in Section 6 Erosion and Sedimentation. Total pier scour was determined by summing low flow thalweg depth, general scour, and pier scour and then adding a 30% factor of safety. General scour along existing soil cement was then calculated by summing low flow thalweg depth, and general scour and then adding a 30% factor of safety.

Freeboard calculations were completed using both the City of Tucson methodologies and Arizona Department of Transportation *Roadway Design Guidelines*[21]. In the existing bridge conditions the available freeboard to the low chord of the bridge are below the City of Tucson and the ADOT freeboard requirement. The proposed bridge alternatives provided approximately 2 feet of freeboard.

5.6. Access Control

The following access management policy will be implemented based on the proposed roadway function and the recommendations from the *HAMP* and the *HRCS*:

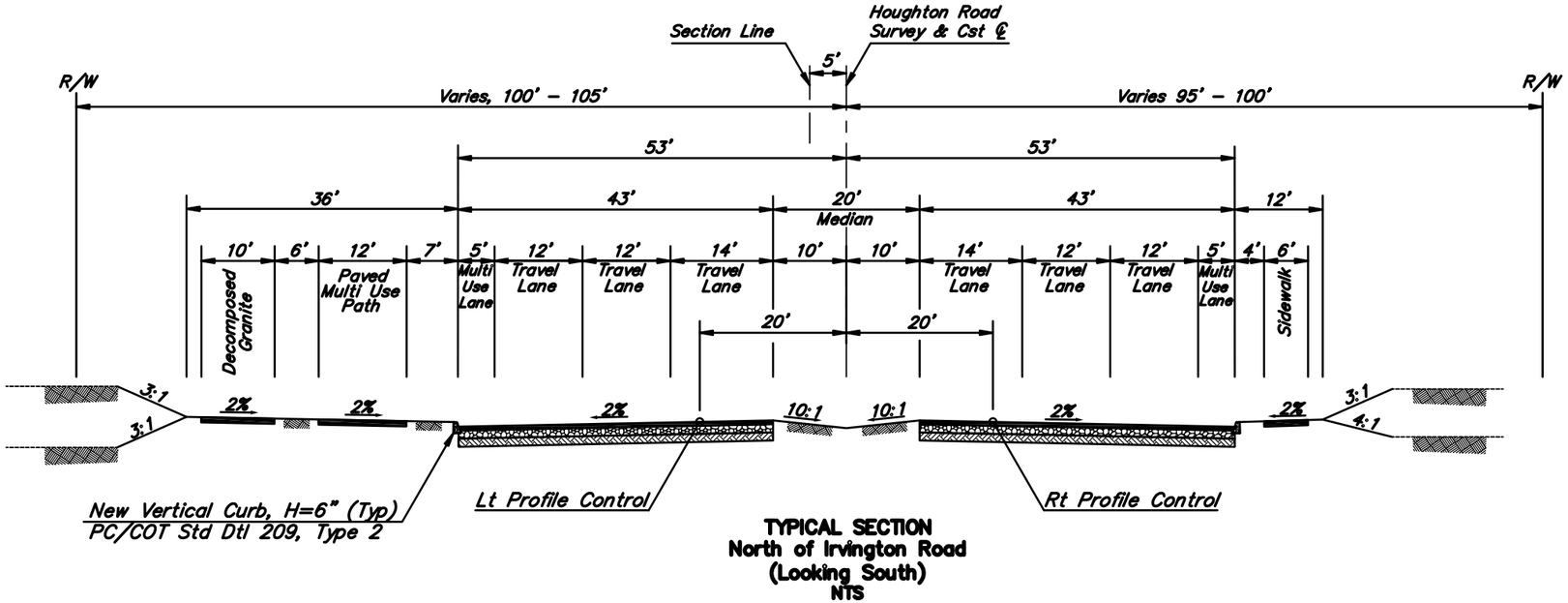
- Signal Spacing – 1 mile (5,280 feet)
- Median Opening Spacing – ½ mile (2,640 feet)
- Right turn only access –1/8 mile (660 feet)

5.7. Cross Section Elements

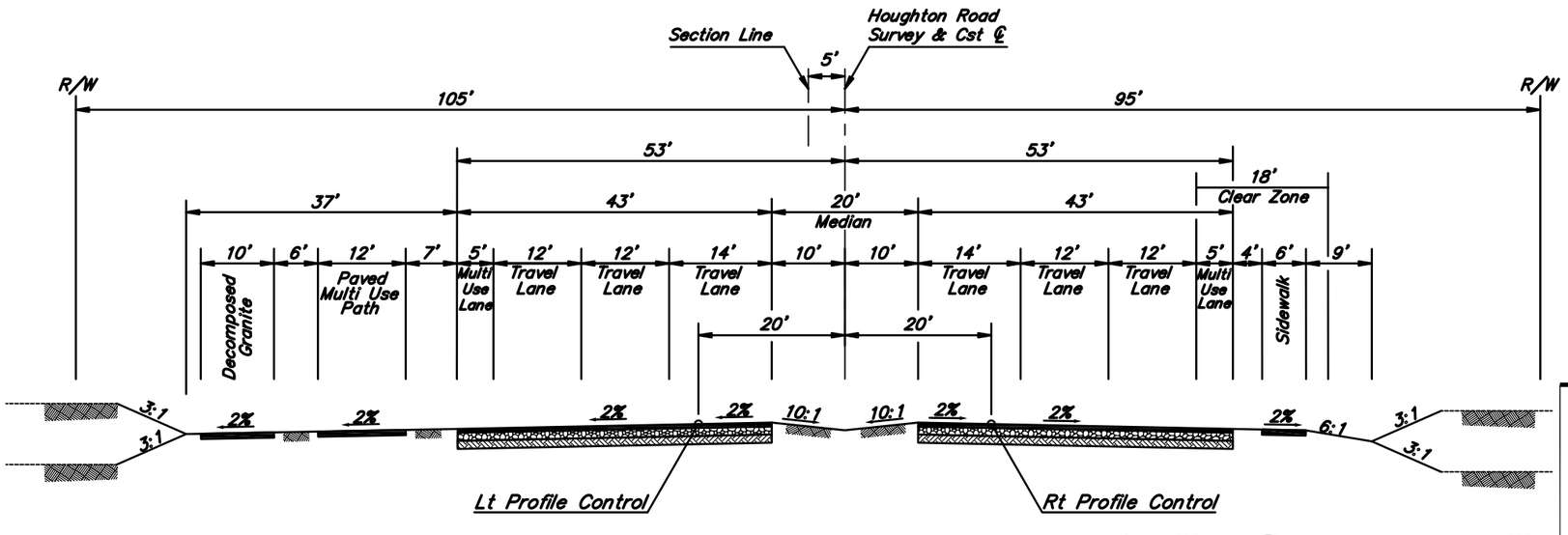
The elements of the roadway section for Houghton Road are described below. Figure 14 (next page) illustrates the typical sections for the project.

Houghton Road Six-Lane Typical Section

Median:	20 feet (typ)
	36 feet (approaching dual left turn lanes)
Inner Travel Lane:	14 feet (including 2-foot inside shoulder)
Middle Travel Lane:	12 feet
Outer Travel Lane:	12 feet
Multi-Use Lane:	5 feet
Graded Shoulder (east side):	7 feet
Graded Shoulder (west side):	4 feet
Multi-Use Path (east side):	12 feet
Pedestrian Path (east side):	10 feet
Buffer (between multi-use and pedestrian paths):	6 feet
Sidewalk (west side):	6 feet
Bus Pullouts:	12 feet
Turn lanes / auxiliary lanes:	12 feet
Clear zone (6:1 or flatter slopes)	18 feet foreslopes, 20 feet backslopes
(4:1 to 6:1 slopes)	24 feet foreslopes, 18 feet backslopes
Median cross slope	10:1
Roadway cross-slope	2%



TYPICAL SECTION
North of Irvington Road
(Looking South)
NTS



TYPICAL SECTION
South of Irvington Road
(Looking South)
NTS

PSOMAS
800 E. Wetmore Road, Suite 110
Tucson, AZ 85719
(520) 292–2300 (520) 292–1290 fax
www.psomas.com

FIGURE 14

HOUGHTON ROAD
FINAL DESIGN CONCEPT REPORT
22ND STREET TO VALENCIA ROAD
TYPICAL SECTIONS

PROJ NO: 06099–01 SCALE: NTS
DATE: 08/08

As shown in the typical sections, the median will not be curbed in order to allow for water harvesting. The exceptions are at signalized intersections, where the median will be curbed through the storage and taper of the longest turn lane in order to control access, channelize drainage, and protect the signal poles and additional hardware.

The outside edge of the roadway will be curbed between 22nd Street and Irvington Road. The use of curb was selected because the existing right-of-way is limited (generally 150 ft or less), and the area is relatively developed with screen walls, mailboxes, utility poles and other appurtenances near the edge of the roadway. Therefore, curbs are necessary to channelize drainage and to separate pedestrians.

South of Irvington Road, the outside of Houghton Road will be uncurbed. This area is less developed and the feasibility of obtaining additional right-of-way is higher. Cut ditches can also be used to convey drainage.

5.8. Roadway Geometrics

Roadway geometrics for Houghton Road are based on a 50 mph design speed.

Design Vehicle: WB-50 (Houghton Road)
B-40 (side streets)
P (U-turns)

Minimum Horizontal Radius: 926 feet

Minimum Horizontal Curve Length: 500 feet

Maximum Superelevation Rate: 4%

Maximum Angle Break in Horizontal Tangent Alignment: 1°08'00"

Horizontal Taper Rate: 50:1

Vertical Grade:	0.5% minimum grade 7% max (foothill area)
Grade Breaks:	0.5% max for Houghton Road 4% max at side streets 8% max on drives 1% max at match points in drives
Vertical Curves:	Minimum length of 150 feet (= 3 x design speed) K_{min}= 96 for sag curves K_{min} = 84 for crest curves K_{max} = 167 (for drainage, type I or III curves only)
Driveway Width:	Match to existing New one-way – 16 feet New two-way – 24 feet
Minimum Curb Return Radii:	Arterial - 30 feet (COT *Access Management Guidelines)* Other side streets and drives – 25 feet

5.9. Right-of-Way

The typical proposed right-of-way for the proposed Houghton Road alignment will be 200 feet, as provided for in the City of Tucson's *Major Streets and Routes Plan*. Where the proposed right-of-way cannot be acquired, drainage, slope or temporary construction easements will be pursued in order to accommodate the roadway.

The Houghton Road construction centerline will be offset five feet to the west of the of the right-of-way centerline except near the Pantano Wash bridge, where the centerline offset will vary to accommodate terrain conditions. Shifting the centerline to the west is necessary in order to provide room for the dual paths along the east side of Houghton Road.

6. MAJOR DESIGN FEATURES

6.1. Horizontal and Vertical Alignment

This segment of the Houghton Road corridor will begin approximately 1,700 feet south of 22nd Street and extends 5.40 miles to approximately 1,600 feet north of Valencia Road. The north end of the project will tie into the 22nd Street to Speedway Boulevard segment of the corridor, while the south end will tie into the Valencia Road to I-10 segment of Houghton Road.

Because Houghton Road is located along the section line, no horizontal curves are currently included in its alignment. However, the construction centerline shifts at several places and does not coincide with the section line. Instead, it generally runs 5 feet west of but parallel to the section line. The construction centerline was shifted for the following reasons:

1. To minimize impacts to the overhead utilities to the east of the existing road, particularly the high voltage (138 KV) TEP transmission line.
2. To facilitate right-of-way acquisition by acquiring right-of-way from one side of Houghton Road for the majority of the project. The east side of the road is more developed than the west side through most of the project.
3. To reduce the amount of earthwork, and to (in certain areas) avoid constructing large retaining walls on both sides of the road.
4. To facilitate construction by allowing the construction of the southbound lanes while the existing road remains open.
5. To provide enough room to accommodate the dual paths (the greenway) on the east side of the road. This will also allow the preservation of the existing multi-use path along Mesquite Ranch and Sierra Morado (on the east side of Houghton Road).

In the area between Escalante Road and the Pantano Wash, the construction centerline shifts further west (23 feet from the section line) in order to avoid construction of costly soil-nailing and mechanically stabilized earth (MSE) walls on both sides of the road just north of the Pantano Wash (near McGraw's Cantina). The construction centerline then tapers back to coincide with the centerline at the Pantano Wash, which allows the continued use of the existing bridge. Through this section (Escalante to Pantano Wash), the median is reduced to 16 feet, and the

multi-use and pedestrian paths are reduced to ten feet and eight feet, respectively, in order to minimize the roadway envelope and reduce the height of the retaining walls required.

From Irvington Road south approximately 1,000 feet, the construction centerline shifts to 10 feet west of the section line. This was done due to earthwork considerations and to allow the construction of a drainage channel along the east side of the road.

For side streets, there are a few minor horizontal curves on Old Spanish Trail and on Irvington Road east of Houghton Road.

The vertical alignment generally follows the existing ground closely except at the following locations:

1. The drainage concentration points where the road profile needs to be raised to accommodate the culverts.
2. Areas where the profile needs to be raised or lowered from the existing ground to minimize the earth work.
3. Segments where the grades need to be modified to provide positive drainage or to ensure adequate sight distance.

The new bridge at the Pantano Wash will be located upstream of the existing bridge, and therefore will have a higher water surface elevation associated with the design flow. As a result, the road profile for the northbound direction (which will use the new bridge) will be up to three feet higher than the southbound profile at the Pantano Wash.

The preliminary plan and profile sheets for Houghton Road and the side streets are included for reference in Appendix 2.

6.2. Access Control

Access management is the process that provides access to adjoining properties while simultaneously preserving the flow of traffic on the surrounding road system in terms of safety, capacity and speed. Applying the principles of access management to an arterial corridor like Houghton Road provides the following benefits:

- Preserves the mobility along the corridor
- Extends the service life of the roadway (in terms of capacity)
- Reduces the number of vehicular conflict points, thus improving safety
- Encourages organized growth along the corridor

In order to implement access management along this project, it is necessary to first identify the existing location and intensity of the existing access points and then compare those to the guidelines in the *HRCS* and the *HAMP*.

As discussed in the *Traffic Engineering Report* for the project, there are a total of 60 access locations along this section of Houghton Road. Approximately 80% of those access points are located in the northern three miles of the project (22nd St to Irvington Road), while only 20% are located in the southern three miles (Irvington Road to Valencia Road). Approximately 14 access locations are unpaved and most likely non-permitted turnouts.

For access management, the *HRCS* recommends having primary intersections at one-mile intervals, and progressively increasing the spacing of secondary intersections from ¼ mile, to ½ mile, and ultimately to one mile with few exceptions. It also recommends not allowing any new private direct access onto Houghton Road. The HAMP recommends spacing new intersections on Houghton no closer than ½ mile, with signalized intersections no closer than one mile, and median openings at least ¼ mile apart. It also advocates prohibiting new driveway access onto Houghton Road.

The access control design criteria described in Section 5.6 (one mile between signals, ½ mile between median openings and 1/8 mile between right-only access points) was developed based on the considerations presented above, as well as analyzing the present and future access needs along Houghton Road. Table 19 presents a list of proposed access locations.

Table 19. Proposed Access Locations

#	Approximate Station	Intersecting Street	Type of Access	Spacing to Next Access Point (ft)	Spacing to Next Median Opening (ft)
1	262+00	22nd Street	Full Access	920	2,652
2	271+20	Edna Place	Right In - Right Out	626	1,732
3	277+46	Via Alta Mira	Right In - Right Out	272	1,106
4	280+18	Via Del Mar	Right In - Right Out	270	834
5	282+88	Pantano Christian Church	Right In - Right Out	564	564
6	285+37	Discovery Road	Right In - Right Out	315	315
7	288+52	29th Street	Full Access	192	1,108
8	290+44	Madrona Canyon Drive	Right In - Right Out	916	916
9	290+60	Mt Olive Lutheran Church	Right In - Right Out	685	900
10	297+45	Sahuaro Baptist Church	Right In - Right Out	215	215
11	299+60	Old Spanish Trail	Full Access	989	1,540
12	309+49	Unnamed Street	Right In - Right Out	551	551
13	315+00	Golf Links Road	Full Access	369	1,703
14	318+69	Unnamed Street	Right In - Right Out	955	1,334
15	326+12	Corte Madera Fina	Right In - Right Out	591	591
16	328+24	Unnamed Street	Right In - Right Out	1,991	379
17	332+03	Falcon Point Drive	Full Access	565	1,612
18	337+68	Watson Drive	Right In - Right Out	572	1,047
19	343+40	Emily Drive	Right In - Right Out	475	475
20	348+15	Secrist Middle School / Pantano Trail	Directional Median Opening	265	1,978
21	350+80	Secrist Middle School Bus Dwy	Right In - Right Out	150	1,713
22	352+30	Secrist Middle School Bus Dwy	Median Cut	362	1,563
23	355+20	Unnamed Street	Right In - Right Out	1,273	1,273
24	355+92	Sky Castle Way	Right In - Right Out	361	1,201
25	359+53	Unnamed Street	Right In - Right Out	840	840
26	367+93	Escalante Road	Full Access	1,167	2,954
27	379+60	McGraw's Cantina/Boulderfield Drive	Directional Median Opening	1,787	1,787
28	397+47	Keystone Drive	Full Access	1,275	2,388
29	410+22	Unnamed Street	Right In - Right Out	247	1,113
30	412+69	Unnamed Street	Right In - Right Out	866	866
31	416+61	Honey Mesquite Drive	Right In - Right Out	159	474
32	418+20	Mesquite Cove Commercial Driveway	Right In - Right Out	315	315
33	421+35	Irvington Road	Full Access	563	2,603
34	426+98	Civano Boulevard	Right In - Right Out	2,040	2,040
35	444+63	Unnamed Street	Right In - Right Out	275	275
36	447+38	Seven Generations Wy/Fire Station	Full Access	1,837	2,678
37	465+75	Unnamed Street	Right In - Right Out	841	841
38	474+16	Drexel Road	Full Access	2,642	2,642
39	500+58	Bilby Road	Full Access	1,345	2,621
40	514+03	Forest Glen	Directional Median Opening	1,276	1,276
41	526+79	Poornan Road	Full Access	2,662	2,662
42	553+41	N/A	Full Access	2,640	2,640
43	579+81	Valencia Road	Full Access		

Full Access Location
Directional Median Opening

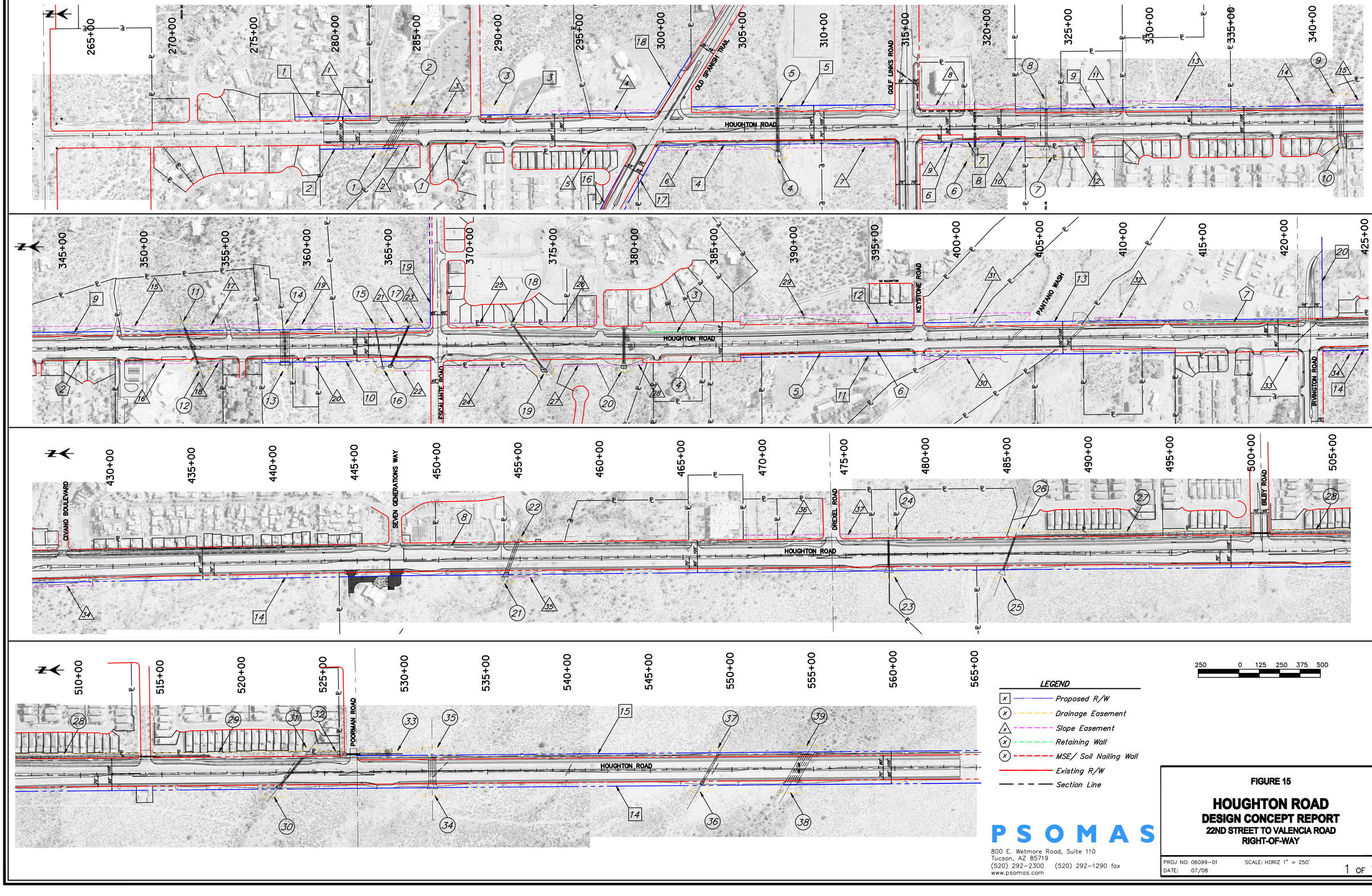
Because of existing conditions some deviations from the access management policy will likely be necessary. The most notable of those include:

1. The need for signals at Old Spanish Trail and Bilby Road
2. The construction of a directional median opening at Secrist Middle School for buses and private vehicles.
3. The addition of directional median openings serving Boulderfield Drive, McGraw's Cantina, and Forest Glen Road. These are necessary either because of prior commitments by Pima County or to reduce travel distances where conflicts are not anticipated. These median openings provide refuge and allow turns from Houghton Road, but prohibit left turns onto Houghton Road.

6.3. Right-of-Way

In order to accommodate the proposed roadway cross-section, it will be necessary to acquire new right-of-way (ROW), slope easements, and drainage easements. As previously discussed, the typical right-of-way will be 200 feet, although more will be required in the vicinity of major intersections to accommodate turn lanes, signal equipment, and pedestrian facilitates. The existing right-of-way along the corridor is summarized in the *Right-of-Way Survey for Houghton Road* completed by Psomas in August, 2008. Based on the existing conditions, the required ROW acquisition for the project was determined and is summarized in Table 20 and Figure 15.

The new right-of-way for the Houghton Road project will consist of 22 new segments covering approximately 25 acres from several different property owners, as indicated in the table. Approximately half of the new ROW will be from parcels owned by the City of Tucson or the State Land Department. ROW will also need to be acquired from several churches along the Houghton Road alignment. Of the 25 acres of ROW, 22 acres will be along Houghton Road, while the remaining three acres will be required along the major side streets in order to improve their intersections with Houghton Road. Although there is need for additional right-of-way along both sides of Houghton Road, approximately 60% of the acquisition will be on the west side, with 40% being on the east side. It should also be mentioned that despite the significant number of takes required, none of the acquisitions will include a building structure.



250 0 125 250 375 500

LEGEND

- *Proposed R/W*
- *Drainage Easement*
- *Slope Easement*
- *Retaining Wall*
- *MSE/ Soil Nailing Wall*
- *Existing R/W*
- *Section Line*

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FIGURE 15

HOUGHTON ROAD
DESIGN CONCEPT REPORT
22ND STREET TO VALENCIA ROAD
RIGHT-OF-WAY

PROJ NO: 06099-01 SCALE: HORIZ 1" = 250'
DATE: 07/08

Table 20. Proposed Right-of-Way

HOUGHTON ROAD							
Begin Station	**Side**	**R/W ID #**	**Depth (Ft)**	**Length (Ft)**	**Area (SF)**	**Area (Ac)**	**Ownership**
277+40	Lt	1	25	465	11,625	0.27	3 Private parcels
178+92	Rt	2	25	475	11,875	0.27	1 Private parcel
288+80	Lt	3	25	1,070	26,750	0.61	2 Churches
299+94	Rt	4	25	1,430	35,750	0.82	2 Private Parcels
301+76	Lt	5	35	1,250	43,750	1.00	City of Tucson
315+90	Rt	6	45	250	11,250	0.26	1 Private Parcel
318+39	Rt	7	15	100	1,500	0.03	1 Private Parcel
319+39	Rt	8	30	280	8,400	0.19	1 Private Parcel
321+65	Lt	9	25	4,560	114,000	2.62	TEP/Unisource, 1 Church, 5 Private Parcels
357+10	Rt	10	25	1,040	26,000	0.60	3 Private Parcels
386+50	Rt	11	25	2,670	66,750	1.53	Pima County, 2 Private Parcels
394+36	Lt	12	25	280	7,000	0.16	1 Private Parcel
397+79	Lt	13	25	2,300	57,500	1.32	Pima County, 1Private Parcel
422+24	Rt	14	25	14,180	354,500	8.14	State of AZ, City of Tucson
527+00	Lt	15	25	3,700	92,500	2.12	State of AZ
			TOTAL LT		353,125	**8.11**	
			TOTAL RT		516,025	**11.85**	
			TOTAL		869,150	**19.95**	

SIDE STREETS							
Begin Station		**ID #**	**Depth (Ft)**	**Length (Ft)**	**Area (SF)**	**Area (Ac)**	**Ownership**
OST 11+37	Lt	16	0-15	570	6,220	0.14	1 Private Parcel
OST 11+97	Rt	17	25	700	17,500	0.40	2 Private Parcels
OST 20+81	Lt	18	25	410	10,250	0.24	1 Church
Escalante 21+12	Lt	20	15	880	13,200	0.30	1 Church
Irvington 21+10	Rt	21	150	500	75,000	1.72	1 Private Parcel
			TOTAL		122,170	**2.80**	

In addition to new ROW, slope easements will be needed to accommodate the roadway's side slopes at various locations. A total of 30 slope easements covering an area of approximately 14 acres are anticipated. Likewise, 36 new drainage easements covering slightly over 5 acres will be needed in order to provide enough room for inlet and outlet treatments, as well as regrading of the washes that cross Houghton Road. Both the drainage and slope easements are presented in Table 21.

Table 21. Proposed Slope and Drainage Easements

SLOPE EASEMENTS						
Begin Station	Side	Slope Esmt ID #	Depth (Ft)	Length (Ft)	Area (SF)	Area (Ac)
279+16	Lt	1	15	290	4,350	0.10
283+72	Rt	2	15	130	1,950	0.04
285+07	Lt	3	15	310	4,650	0.11
293+20	Lt	4	20	640	12,800	0.29
295+13	Rt	5	20	300	6,000	0.14
299+63	Rt	6	30	690	20,700	0.48
307+59	Rt	7	25	670	16,750	0.38
315+74	Lt	8	30	720	21,600	0.50
315+90	Rt	9	30	270	8,100	0.19
319+63	Rt	10	30	310	9,300	0.21
324+08	Lt	11	20	400	8,000	0.18
324+45	Rt	12	30	140	4,200	0.10
328+08	Lt	13	40	680	27,200	0.62
338+05	Lt	14	25	300	7,500	0.17
342+13	Lt	15	35	960	33,600	0.77
348+10	Rt	16	25	460	11,500	0.26
352+92	Lt	17	35	510	17,850	0.41
353+91	Rt	18	25	80	2,000	0.05
359+08	Lt	19	35	430	15,050	0.35
359+80	Rt	20	25	120	3,000	0.07
364+60	Lt	21	35	90	3,150	0.07
365+35	Rt	22	60	210	12,600	0.29
366+73	Lt	23	35	70	2,450	0.06
368+22	Rt	24	40	560	22,400	0.51
368+53	Lt	25	30	340	10,200	0.23
373+12	Lt	26	30	460	13,800	0.32
375+07	Rt	27	40	390	15,600	0.36
379+74	Rt	28	40	80	3,200	0.07
386+50	Lt	29	55	1,070	58,850	1.35
397+77	Rt	30	25	470	11,750	0.27
397+81	Lt	31	55	650	35,750	0.82
408+28	Lt	32	20	250	5,000	0.11
417+74	Rt	33	30	300	9,000	0.21
422+24	Rt	34	25	650	16,250	0.37
454+54	Rt	35	20	135	2,700	0.06
468+73	Lt	36	25	490	12,250	0.28
474+64	Lt	37	25	250	6,250	0.14
			TOTAL		477,300	**10.96**

DRAINAGE EASEMENTS						
Begin Station	Side	Drainage Esmt ID #	Depth (Ft)	Length (Ft)	Area (SF)	Area (Ac)
282+30	Rt	1	35	110	3,850	0.09
283+57	Lt	2	65	150	9,750	0.22
288+82	Lt	3	60	150	9,000	0.21
306+49	Rt	4	90	110	9,900	0.23
306+49	Lt	5	20	110	2,200	0.05
318+63	Rt	6	140	100	14,000	0.32
322+75	Rt	7	100	170	17,000	0.39
322+98	Lt	8	60	110	6,600	0.15
341+03	Lt	9	75	110	8,250	0.19
341+03	Rt	10	80	70	5,600	0.13
351+72	Lt	11	60	120	7,200	0.17
352+71	Rt	12	75	120	9,000	0.21
357+93	Rt	13	55	105	5,775	0.13
357+93	Lt	14	35	110	3,850	0.09
363+40	Lt	15	35	120	4,200	0.10
363+95	Rt	16	60	140	8,400	0.19
365+53	Lt	17	35	120	4,200	0.10
371+94	Lt	18	30	120	3,600	0.08
373+87	Rt	19	90	120	10,800	0.25
378+93	Rt	20	80	80	6,400	0.15
453+54	Rt	21	55	100	5,500	0.13
454+48	Lt	22	35	85	2,975	0.07
477+07	Rt	23	40	110	4,400	0.10
477+14	Lt	24	50	100	5,000	0.11
483+93	Rt	25	50	120	6,000	0.14
484+87	Lt	26	50	120	6,000	0.14
486+07	Lt	27	30	1,380	41,400	0.95
501+02	Lt	28	30	1,270	38,100	0.87
514+32	Lt	29	30	940	28,200	0.65
521+23	Rt	30	50	130	6,500	0.15
523+68	Lt	31	55	90	4,950	0.11
524+58	Lt	32	30	165	4,950	0.11
527+00	Lt	33	30	400	12,000	0.28
531+00	Rt	34	50	120	6,000	0.14
531+00	Lt	35	50	120	6,000	0.14
547+53	Rt	36	40	100	4,000	0.09
548+70	Lt	37	30	100	3,000	0.07
552+81	Rt	38	50	150	7,500	0.17
554+02	Lt	39	40	130	5,200	0.12
			TOTAL		347,250	**7.97**

6.4. Drainage

A drainage report[7] to analyze offsite and proposed onsite drainage has been prepared for this proposed Houghton Road project and is summarized below.

6.4.1. Cross Drainage

Washes in the project area typically flow from the southeast to the northwest. In general, the washes north of Old Spanish Trail are tributaries to the Tanque Verde Creek, while washes south of Old Spanish Trail are tributaries to the Pantano Wash. The proposed culvert crossings for this project were sized based solely on available headwater using the 100-year design discharge. Drainage structures were located and sized for the safe and efficient conveyance of on-site runoff, and are presented below in Table 22. Roadside drainage swales will direct offsite flow to the proposed culverts.

Table 22. Summary of Proposed Culverts

Concentration Point	Approximate Station	Discharge (cfs)	Type	Length (ft)	Slope	Velocity (fps)	Required Headwater (ft)
2*	283+66	961	4-10' x 4' Box	199	0.012	13.83	4.84
3.5	307+04	213	3-48" Circular	260	0.026	16.15	4.19
4	319+14	271	3-44" x 27" Ellipse	175	0.008	13.96	7.81
5	323+53	279	2- 6' x 4' Box	213	0.030	17.75	4.74
7**	341+58	2,287	3-12' x 8' Box	175	0.010	17.01	8.76
7.2	352+83	113	2-48" Circular	223	0.012	11.45	3.65
7.4	358+53	1,216	5-10' x 4' Box	184	0.035	19.28	4.75
7.6	364+29	19	1-36" Circular	224	0.061	15.53	2.21
7.6	365+58	147	3-36" Circular	261	0.045	18.19	3.96
7.8	373+53	119	2-48" Circular	305	0.044	18.65	3.76
8a	379+34	201	3-48" Circular	211	0.030	16.46	4.05
9	405+00	31,000	**Pantano Wash Bridge**				
12	454+47	726	2-10' x 6' Box	195	0.005	12.10	6.38
13	477+62	107	3-36" Circular	164	0.003	7.37	3.18
14	485+00	89	2-36" Circular	200	2.210	13.55	3.71
15	Existing across Bilby Rd	83	3-30" Circular	125	0.015	10.34	3.05
15***	Existing across Forest Glen	42	3-24" Circular	108	0.015	8.83	2.25
16	522+87	112	2-48" Circular	210	0.004	7.69	3.62
17****	Proposed across Poorman Road	75	4-24" Circular	85	0.005	7.14	2.75
17	531+60	776	4-10' x 4' Box	162	0.005	10.00	4.20
18	548+62	235	1-10' x 4' Box	188	0.006	11.22	4.77
19	554+10	1,689	6-10' x 5' Box	187	0.003	9.68	5.34

* *Combined with flows from 3a*
** *Combined with flows from 6*
*** *Sub-watershed of 15*
**** *Sub-watershed of 17*

6.4.2. Pantano Wash Bridge

The results of the methodology used to calculate scour as described by the design criteria in Section 5.0 show that the total pier scour for the Pantano Wash bridge would be 26 feet, and total general scour along the soil cement would be 7 feet in the design storm (36,000 cfs). This depth is above both the maximum scour depth of the bridge (2727.33 feet) and the tipping elevation of the bridge (2696.33 feet). Long-term scour over a 50-year period (1936 to 1986) was approximated to be two feet per the Pantano Wash Bed Profile 1936 versus the 1986 Pima County Department of Transportation and Flood Control District Maps. Scour was then evaluated from 1982 to 2007 based on channel inverts from the as-built (I-96-55) and 2007 survey data for this project.

Due to differences between the as-built plans and the physical bridge, the actual erosion depth was verified by a field investigation. Test pits were excavated on September 14, 2007 to determine the depth to the soil cement bank protection. From the field investigation it was determined that scour ranged from three to 3.5 feet at the upstream end of the spur dike on the north and south sides, respectively, and 4 to 6 feet further downstream just east of the bridge on the south and north sides, respectively. With the field investigation confirming the scour depth at the spur dike embankment, reinforcement of soil cement is recommended, as well as the implementation of a grade control structure to account for long-term scour. Scour by the pier based on the field investigations shows the magnitude of scour occurring at the piers is less than that occurring at the spur dike, where the large contraction occurs. Thus, the piers' previous determination as scour-stable for long-term conditions is valid under the condition that the spur dikes continue to be maintained.

It is recommended from a detailed scour analysis for the Pantano Wash that the construction of a 6-foot grade control structure and provision of additional toe-down of the spur dikes to restore them to the designed depth of 10 foot are required in order to ensure the long-term stability of the bridge.

Six alternatives were considered for the Pantano Wash bridge. The six proposed bridge alternatives were modeled to calculate available freeboard. A brief description of each alternative is summarized below and more fully described in the structures discussion of this section. Table 23 summarizes the results of the freeboard calculations.

- **Alternative 1** – Widen the existing bridge from 47 feet to 65 feet and add an additional traffic lane in each direction for a total of four lanes. This alternative would only be a temporary solution since a second bridge would be required to provide a six-lane section.

- **Alternative 2** – Widen the existing bridge from 47 feet to 53 feet and add an additional traffic lane for a total of three lanes dedicated to southbound traffic. Construct a new 57-foot wide three-lane, four-span bridge to the east of the existing bridge. This new bridge would be dedicated to northbound traffic. The new bridge would be constructed approximately two feet higher to account for the higher Water Surface Elevation (WSEL) associated with the bridge location upstream of the existing bridge. The structure would have four spans to match the existing bridge and align the piers.

- **Alternative 2A** – This alternative is the same as Alternative 2, except the new bridge would be a three-span structure (two piers), instead of a four-span structure. The resulting misalignment of the piers between the two structures results in a higher WSEL at the new bridge.

- **Alternative 3** – Same as Alternative 2, but the existing bridge superstructure will be raised a total of approximately two feet to increase the freeboard during the design flood. This requires the selective demolition of the existing bridge superstructure and portion of the tops of the columns, reconstruction of the existing bridge superstructure to include higher concrete columns, the reuse of the existing girders, and a new concrete deck. A new bridge structure would be constructed just east of the existing bridge. The new bridge would be constructed approximately two feet higher to account for the higher Water Surface Elevation (WSEL) associated with the bridge location upstream of the existing bridge. The structure would have four spans to match the existing bridge and align the piers.

- **Alternative 3A** – This alternative is the same as Alternative 3, except that the new bridge to the east of the existing bridge will be a three-span structure (two piers) instead

of a four-span structure. The resulting misalignment of the piers between the two structures results in a higher WSEL at the new bridge.

- **Alternative 4** – Demolish the existing bridge to include columns and drilled shafts down to five feet below the channel bottom, and construct two new three-span bridges side by side with three lanes per bridge.

Table 23. Pantano Wash Hydraulic Analysis of Bridge Alternatives

Existing Bridge Information

Low Chord 2773.72 feet

Storm	Cross-Section Information			Freeboard Required, COT (ft)	Available Freeboard (= Bridge Chord – WSEL)
	Q (cfs)	V (ft/s)	WSEL (ft)		Low Chord (ft)
Q_{100}	31,000	14.29	2771.8	2.2	**1.9**

Design Alternative**	Cross-Section Information					Freeboard Required	Available Freeboard (= Bridge Chord – WSEL)	
(Q_{100} year storm)	Proposed Low Cord @ Exst Bridge	Proposed Low Chord @ New Bridge (ft)	V (ft/s)	WSEL (ft) @ Existing Bridge	WSEL @ New Bridge	COT (ft)	Low Chord @ Existing Bridge (ft)	Low Chord @ New Bridge (ft)
1	2773.7	-	14.29	2771.8	-	2.2	**1.9**	**-**
2	2773.7	2775.7	11.52	2771.8	2773.55	2.2	**1.9**	**2.2**
2a	2773.7	2775.7	11.25	2771.39	2774.2	2.2	**2.3**	**1.5**
3	2775.7	2775.7	11.52	2771.8	2773.55	2.2	**3.9**	**2.2**
3a	2775.7	2775.7	11.25	2771.39	2774.2	2.2	**4.3**	**1.5**
4	-	2776.0	11.52	-	2773.55	2.2		**2.4**

*** 1 - Widen existing bridge*
2 - Existing bridge with new bridge upstream 2' higher (3 pier bridge)
2a - Existing bridge with new bridge upstream 2' higher (combined to 5 pier bridge)
3 - Raise existing bridge and add new bridge upstream at same elevation (3 pier bridge)
3a - Raise existing bridge and add new bridge upstream at same elevation (combined to 5 pier bridge)
4 - Two new bridges at same elevation

Based on the findings of the preceding analysis, Alternative 2 is preferred due to the expected lower construction cost and minimum impact on the Pantano Wash. A more detailed analysis of the alternatives is presented under Section 6.8 (structures).

6.4.3. Jurisdictional Delineation

A preliminary jurisdictional delineation (JD) for the project was prepared by Logan Simpson Design (LSD) in August 2008 and is included as Appendix 3. The JD has been reviewed by the City of Tucson and will be submitted to the Army Corps of Engineers for concurrence.

There are 10 ephemeral washes located within the boundary of area surveyed. Seven of these washes are presumed to be potentially jurisdictional. The jurisdictional limits along these drainage locations were determined using guidelines for delineating Waters of the United States (WOUS), which include assessing the presence or absence of the following characteristics: a clear, natural line impressed on the bank; shelving; changes in character of soil; destruction of terrestrial vegetation; presence of litter and debris, wracking, vegetation matted down, bent or absent, sediment sorting, leaf litter disturbed or washed away; scour; deposition; multiple observed flow events; bed and banks; water stains; and change in plant community. The seven washes classified as potential WOUS have jurisdictional widths ranging from two feet to 250 feet, as indicated in Table 24.

Table 24. Preliminary List of Potential Jurisdictional Waters

Wash	Station	Location	Q_{100} (cfs)	Jurisdictional width
Hidden Hills	283+65	1600' N of OST	961	6-8'
OST	341+60	1/2 Mi S of Golf Links	2,287	8-15'
Escalante	358+50	1000' N of Escalante	1,216	15-30'
#8-Unnamed	379+65	1200' S of Escalante	201	10-12'
Pantano	404+00	N of Irvington	31,000	250' (Bridge)
Mesquite Ranch	454+50	2000' N of Drexel	726	3-12'
Atterbury	554+10	1/2 Mi N of Valencia	1,689	2-3'

It is anticipated that a 404 permit will be required for this project; however, given the uncertainty of the guidance for JD's and 404 permits at this time due to recent and potentially impending court decisions, the determination of the need for and type of permit required will be made during the design process.

6.4.4. Pavement Drainage

Pavement runoff will be drained through proposed scuppers, catch basins and curb openings to storm drain pipes and swales along the proposed roadway and discharged outside the project boundaries. Inlets were located per spread criteria and location of profile breaks, intersections and median changes. The 10-year storm was used for calculation of pavement drainage flows. The outside edge of Houghton Road will be curbed north of Irvington Road. The median will be uncurbed to harvest and retain the rainwater that naturally falls on it. This will be used to sustain the native vegetation planted in this corridor and add to the aesthetic of a "desert parkway." This system will conform to the roadway alignment and will be constructed in accordance with City of Tucson regulations with emphasis on the flow spread within a public roadway. Erosion protection will be sized for outlet protection. Full pavement drainage, design information including preliminary side street drainage, along with calculation sheets is provided in the Hydrologic and Hydraulics Report for Houghton Road

Collector channels which transport pavement drainage to cross-culverts also collect flow from the watersheds that would otherwise pond against the roadway and direct it into the cross-culverts. To keep the channels within the existing right-of-way, the channel design top widths were kept to less than 12 feet. The channels are summarized in Table 25.

Adjacent to channel 10S and 11S, an underground box storm drain system is proposed to transport flow from the watersheds and pavement drainage to the Pantano Wash. The proposed storm drain box culvert would be eight feet wide by five feet high and would run approximately 3,300 feet from north of Seven Generations Way to the Pantano Wash. As flow is collected along watershed 11S, the channel inlets into the storm drain four times, each time at the point where the capacity of the channel reaches the 12-foot maximum top width. There the channel stops and inlets into the storm drain. The channel then restarts until it reaches channel capacity at a 12-foot top width and again inlets into the storm drain and repeats. This is so the top width does not exceed the right-of-way. An additional inlet is provided at the northern extent of watershed 10. Additionally, a storm drain inlet was provided at station 289+00. These inlets are described in Table 26. A complete table of the storm drain systems is provided in the Hydrologic and Hydraulic Report for Houghton Road. Hydraulic grade lines will be shown on the roadway design and storm drain design plan sets. Supporting calculations can be found in the Hydrology and Hydraulics Report.

Table 25. Summary of Channel Design

Channel Number	Q_{des} (cfs)	Manning's n	Depth (ft)	Total Depth (ft)	Flow Velocity (ft/s)	Slope (%)	Side Slope (H:V)	Bottom Width (ft)	Channel Top Width (ft)
2N	27	0.03	1.19	1.41	2.97	0.50	3 to 1	4	11.13
2S	3	0.03	0.39	0.46	1.61	0.50	3 to 1	4	6.34
3a S	3	0.03	0.29	0.35	2.35	1.50	3 to 1	4	5.74
3b N	47	0.03	1.20	1.47	5.17	1.50	3 to 1	4	11.20
3b S	17	0.03	0.72	0.88	3.92	1.50	3 to 1	4	8.33
3.5 N	22	0.03	0.71	0.89	5.01	2.50	3 to 1	4	8.24
3.5 S	8	0.03	0.54	0.65	2.72	1.00	3 to 1	4	7.21
4N	7	0.03	0.58	0.69	2.01	0.50	3 to 1	4	7.50
4S	5	0.03	0.43	0.52	2.41	1.00	3 to 1	4	6.58
5N	3	0.03	0.31	0.37	2.01	1.00	3 to 1	4	5.88
5S	13	0.03	0.50	0.64	4.56	3.00	3 to 1	4	7.03
6N	37	0.03	0.97	1.21	5.46	2.10	3 to 1	4	9.85
7N	8	0.03	0.62	0.73	2.08	0.50	3 to 1	4	7.73
7S	17	0.03	0.64	0.80	4.36	2.10	3 to 1	4	7.86
7.2 N	2	0.03	0.19	0.23	1.89	1.60	3 to 1	4	5.13
7.2 S	4	0.03	0.33	0.40	2.63	1.60	3 to 1	4	5.99
7.4 N	2	0.03	0.27	0.32	1.31	0.50	3 to 1	4	5.63
7.4 S	2	0.03	0.26	0.31	1.28	0.50	3 to 1	4	5.57
7.6 N	5	0.03	0.48	0.57	1.82	0.50	3 to 1	4	6.90
7.6 S	147	0.03	3.00	3.63	7.00	1.00	1 to 1	4	10.00
7.8 N	75	0.03	1.56	1.94	6.71	1.80	2 to 1	4	10.26
7.8 S	11	0.03	0.54	0.66	3.65	1.80	3 to 1	4	7.21
8a N	6	0.03	0.38	0.47	2.99	1.80	3 to 1	4	6.26
8a S	1	0.03	0.14	0.17	1.66	1.80	3 to 1	4	4.82
8b S	189	0.03	3.08	3.69	6.04	0.70	2 to 1	4	16.32
10S*	30	0.03	1.47	1.74	2.93	0.50	2 to 1	4	9.89
11S*	54	0.03	1.98	2.34	3.44	0.50	2 to 1	4	11.91
12N	15	0.03	0.73	0.88	3.23	1.00	3 to 1	4	8.40
12S	15	0.03	0.59	0.74	4.27	2.20	3 to 1	4	7.57
13S	18	0.03	0.93	1.11	2.85	0.60	3 to 1	4	9.57
14S	91	0.03	2.47	2.97	5.69	0.80	1 to 1	4	8.94
15S	7	0.03	0.61	0.72	2.07	0.50	3 to 1	4	7.66
16S	134	0.03	3.42	4.06	5.29	0.50	1 to 1	4	10.84
17N	75	0.03	2.53	3.01	4.55	0.50	1 to 1	4	9.05
17S	47	0.03	1.54	1.84	4.29	0.80	2 to 1	4	10.15
18S	171	0.03	3.87	4.60	5.63	0.50	1 to 1	4	11.74
19S	34	0.03	1.21	1.45	3.66	0.80	3 to 1	4	11.23

Note: Total Depth =Depth of flow + freeboard. Top width is at depth of flow

** These channels include inlets to the storm drain system. Detail shown in storm drain system.*

Table 26: Summary of Storm Drain System Design

Culvert	C.P. Downstream	C.P. Upstream	Culvert Size	Culvert Length (ft)	Inlet Length	Inlet Station	Q_{des} (cfs)	Slope (%)	V_{pipe} (fps)
System 1									
1	Outfall	G1	8' x 5' Box	1442	2 grates*	421+95	223	0.5	10.80
2	G1	G2	8' x 5' Box	548	2 grates	427+28	177	0.5	7.13
3	G2	G3	4' x 5' Box	1049	3 grates	431+82	147	0.5	9.67
4	G3	G4	4' x 5' Box	1049	3 grates	436+20	98	0.5	6.11
5	G4	G5	4' x 5' Box	1049	3 grates	440+58	49	0.5	4.30
System 2 (CP 3b 289+00 Stormdrain System)									
1	Outfall	MH	48" RCP	486	MH	284+30	100	1	10.02
2	MH	Grates	48" RCP	19	5 grates	289+20	96	1	9.27
3	MH	CB3b	24" RCP	12	20'	289+20	4	1	3.13

** From combined CP29B and CP31B flows*

6.5. Earthwork Considerations

The vertical alignment of Houghton Road will result in both cut and fill sections at different locations. However, the overall project will require approximately 315,000 CY of net borrow in order to raise the profile at drainage crossings and to maintain sufficient utility cover. The preliminary breakdown by segment is as follows:

- North end to Escalante Rd: 45,000 CY Cut - 85,000 CY Fill - Net 40,000 CY Borrow
- Escalante to Irvington Rd: 15,000 CY Cut - 175,000 CY Fill - Net 160,000 CY Borrow
- Irvington Rd to South end: 23,000 CY Cut - 138,000 CY Fill - Net 115,000 CY Borrow

Project Total 83,000 CY Cut - 398,000 CY Fill - Net 315,000 CY Borrow

Retaining walls will also be required at several locations where the terrain drops off or rises within or very close to the roadway prism. The location and approximate length and height of the retaining walls required are summarized in Table 27 and illustrated in Figure 15 (with the proposed right-of-way).

Table 27. Potential Retaining Wall Locations

Approx Begin Station	Side	Wall ID#	Approx Length (Ft)	Approx Height (Ft)
285+75	Rt	1	200	2-5
343+90	Rt	2	410	2-5
380+90	Lt	3	320	3-7
393+00	Rt	6	400	6-12
414+00	Lt	7	690	8-15
447+75	Lt	8	420	3-7
Approx Begin Station	**Side**	**Wall ID#**	**Approx Length (Ft)**	**Approx Height (Ft)**
381+60	Rt	4-Soil-Nail	250	15-22
386+40	Rt	5-MSE	700	20-35

Three types of earth retention systems are being considered for this project: retaining walls, mechanically stabilized earth (MSE) Walls, and soil-nailed walls.

Cantilevered Concrete Retaining Walls

These structural earth retaining structures rely on bending strength of the concrete wall to resist the forces exerted by the retained soil and any surcharge effects. Cantilevered cast-in-place reinforced concrete retaining walls are most efficiently used for walls up to and including approximately 15 feet. Above this height, stem and foundation sizes grow quickly. These walls are constructed from the bottom up, and are used in fill situations where the wall is designed to support roadway embankment fills with little or no soil behind the wall. Traditionally, the cantilevered concrete wall system is the most widely used system in the Tucson area.

MSE Walls

MSE walls are an earth stabilizing system which relies on the friction between straps and the earth behind the wall to resist the forces exerted by the retained soil. MSE walls utilize layers of compacted earth separated by either metal/polymer straps or grids which lay flat within the backfill behind the rear face of the wall. The wall panels are constructed by attaching pre-cast or cast-in-place concrete to the geogrid system. The base width of the stabilized earth wall is approximately 70% of the height of the wall. MSE walls are relatively simple to build and are very efficient for high walls in fill conditions. Placing utilities in backfill areas is limited because of

interference between utility lines and the geogrid system. Even if utility lines were placed in the backfill without interference to the geogrid system, any future excavation to maintain or to repair utility lines in the backfill would impair the structural integrity of the wall.

Soil-Nailed Walls

Soil nailing is a relatively new slope stabilization technique in the United States, but there have been many successful soil nailed projects constructed within the Tucson and Pima County area in the past ten years. A soil nailed wall is an in-situ retaining structure, constructed by successive excavation phases from the top down, while placing conventional reinforcing bars in the soil, as one progresses along the excavation. The bars are placed in a predetermined borehole grid, and grouted in place with non-shrink grout. The nails are placed in sub-horizontal layers, in which the spacing is a function of the construction method used. The facing, either vertical or inclined, is generally constructed on shotcrete, whose role is to locally retain the soil between the nails. Wall stability is achieved through the use of frictional forces between the grout shafts and the surrounding soil and the ability of the reinforced shotcrete face to span between the nails.

Construction of a soil-nailed wall progresses incrementally in a top-down fashion by repeating three stages of construction. The first construction stage begins with the natural soil being excavated to a depth, typically four to six feet, at which the exposed face is deemed temporarily stable. Stage two consists of drilling boreholes at a grid spacing, depth and inclination angle, followed by the insertion of a reinforcing bar and non-shrink grout into each borehole. The last stage involves attaching a mesh of reinforcing steel between the nails, and spraying shotcrete on the newly exposed face of the excavation. The shotcrete is reinforced to span between the nails and the nails are connected to the shotcrete mass, effectively hiding the nails. Artificial rock may be applied to the shotcrete or the shotcrete may be hand-sculpted, colored, and textured to resemble natural soil outcroppings, or weathered rock, etc.

The stability of the completed wall depends on the geometry of the wall, strength and geometry/inclination of the nails, and the strength properties of the soil. The nails extend beyond the theoretical failure surface of the embankment into which the nails are inserted. The embedment of the nails can be estimated to extend 70% to 100% of the total slope height to be stabilized. Soil-nailed walls are ideally suited for cut areas.

Three specific locations within the project limits will require relatively high walls. Structural Concepts reviewed those areas with cross-sections provided by Psomas, and identified the following recommended treatments:

Wall 1 from Stations 381+50 to 384 +00

The walls along this length (250 feet) may be classified into two groups: the low wall group and high wall group. It is recommended that the low walls (less than 15 feet high) be reinforced concrete cantilevered type retaining walls using the ADOT standards for their construction.

The higher walls (between 12 feet and 19 feet high) are located in cut areas (Figure 16) and are best constructed from the top of the wall downward. The most efficient earth retention system for these conditions is soil-nailed walls. Construction easements may be required for the installation of the embedded nails since they may extend 70% to 100% of the total slope to be stabilized.

Figure 16. Cut Area at Station 384+00 Looking North

Wall 2 from Stations 386+50 to 397 +00

All the walls along this 1000-foot segment are fill walls and may be classified into the low to medium height group between 4-foot and 15-foot high and the high group exceeding 15-foot.

For walls in the medium height group, reinforced concrete cantilevered retaining walls or MSE walls may be used for this group. Construction easements will be required for construction where the rights-of-way are in close proximity to the wall. Mechanically stabilized earth walls are best suited for walls in the high group. Construction easements will be required to install the metal/polymer straps within the backfill zones behind the walls.

Wall 3 from Stations 414+00 to 421 +00

The walls along this length are all classified as fill walls (Figure 17), with heights in the 12-foot range. Reinforced concrete cantilevered retaining walls or MSE walls are best suited for this condition. However, due to the proximity of the wall and the rights-of-way, construction easements will be required for their construction.

Figure 17. Fill Area at Station 387+00 Looking South

6.6. Intersections

Thirteen major streets intersect Houghton Road within the project limit. Median openings will be provided at these intersections allowing access to and from the crossing streets. The exception is at the Civano Boulevard intersection, where a median opening will not be provided due to its proximity to Irvington Road (550 feet).

Turn lane needs for intersections along Houghton Road at major side streets were evaluated based on 2030 traffic operations analysis, and using the turn lane guidelines in the *Transportation Access Management Guidelines for the City of Tucson*.[22]

Based on the warrants, turn lanes will be beneficial at all intersections; however, additional operational and physical considerations (such as right-of-way availability) need to be evaluated in order to recommend turn lane configurations. Table 28 presents the locations and storage of the proposed turn lanes to be constructed with this project. The configurations shown are based on the 95th percentile queues from the 2030 traffic analysis but are modified to account for conditions such as right-of-way availability, proximity to other intersections, and other physical constraints.

Table 28. Recommended Turn Lane Locations and Storage

Cross-street	NB		SB		EB		WB		Traffic Control
	LT	RT	LT	RT	LT	RT	LT	RT	
Old Spanish Trail	2-350'	1-200'	1-250'	1-200'	1-250'	1-600'	1-250'	1-200'	Signal
Golf Links	2-500'	-	1-200'	1-cont	2-400'	1-cont	1-150'	1-150'	Signal
Falcon Point Drive	1-150'	-	1-150'	-	1-cont	-	-	-	Stop
Secrist M.S./Pantano Trail	1-150'	-	1-150'	-	1-100'	1-100'	-	1-cont	Stop
Escalante Road	1-250'	1-200'	1-400'	1-200'	1-200'	-	1-200'	1-200'	Signal
McGraw's/Boulderfield Drive	1-150'	-	1-150'	-		1-cont		1-cont	Stop
Keystone Road	1-150'	-	1-300'	-	1-150'	-	1-250'	-	Stop
Irvington Road*	2-250'	-	2-600'	1-200'	2-250'	1-400'	1-150'	1-150'	Signal
Civano Blvd	-	-	-	-	-	-	-	1-cont	Stop
Seven Generations Way	-	1-200'	1-250'	-	-	-	1-cont	1-200'	Stop
Drexel Road	-	1-250'	1-300'	1-200'	-	1-cont	1-cont	1-300'	Signal
Bilby Road	1-300'	1-300'	2-300'	1-300'	1-200'	1-200'	2-300'	1-350'	Signal
Forest Glen Road	-	-	1-150	-	-	-	-	1-cont	Stop
Poorman Road	-	250	1-300'	1-200'	-	1-cont	1-cont	1-200'	Signal

** 2030 recommendations are different from immediate construction needs due to the uncertainty in regards to the Desert Village Parkway connection*

It should be noted that dual left-turn lanes are recommended for the heaviest turn movements to/from Houghton Road. Those locations include northbound Houghton Road at Old Spanish Trail, Golf Links and Irvington Road, southbound left turns at Bilby Road, eastbound left turns at Golf Links Road and Irvington Road, and westbound left turns at Bilby Road.

According to the RTA website, bus service will be provided on Houghton Road starting in 2011-2012 between Broadway Boulevard and Rita Road. In an effort to accommodate transit vehicles, bus pullouts are preliminarily proposed for Houghton Road on the far side of the following intersections (on both directions):

- Old Spanish Trail
- Golf Links Road
- Secrist Middle School
- Escalante Road
- Irvington Road
- Seven Generations Way
- Drexel Road
- Bilby Road
- Poorman Road

6.7. Utilities

As discussed in Section 3.7, several utilities are present in the Houghton Road right-of-way. Figure 18 illustrates the location of the major utilities in relation to the proposed roadway alignment. Individual utilities are discussed below.

Water – Tucson Water

Currently, the Tucson Water mains typically are located outside the existing roadway; however, with the widening of the roadway to six lanes with this project, the water mains will fall within the roadway prism. North of Golf Links Road, the 24-inch potable water main will be located under the northbound lanes, while between Golf Links Road and the southern boundary the line will be located near the edge of the southbound lanes. The 12-inch/24-inch reclaimed water line that begins at Seven Generations Way would be located under the northbound lanes. Although

cover information for the water line has not been reviewed, extensive relocations are not anticipated because the roadway profile will generally stay at its current elevation or be raised. Still, minor modifications are likely.

In addition, the water mains will traverse multiple proposed cross-culverts along the length of the roadway corridor. Each water line crossing will need to be analyzed for vertical conflicts with the proposed culverts and a determination made with Tucson Water on the need for water line lowering and shutdown timing.

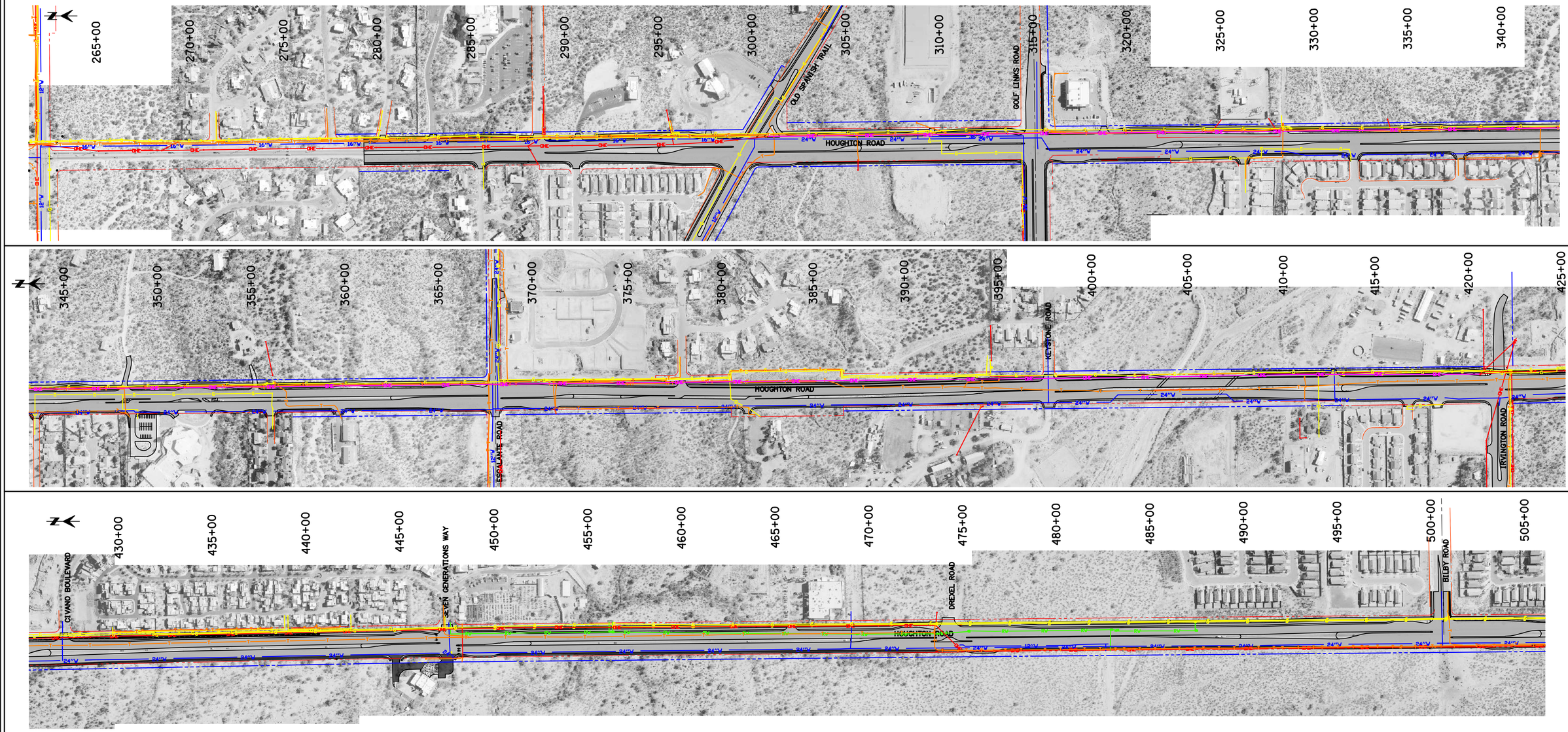
Right-of-way will also be needed from the Danforth reservoir facility located on the east side of Houghton Road between Old Spanish Trail and Golf Links Road.

Storm Drain

A storm drain system on the east side of Houghton Road south of Golf Links Road that includes three 44"x27" elliptical pipes will be extended to discharge on the west side of the proposed Houghton Road widening. Two storm drain pipes that empty into the Pantano Wash will likely conflict with the new bridge abutments and will be analyzed for relocation and replacement during design. Multiple drainage pipes also cross side streets and driveways and will be analyzed for replacement or extension during design.

Natural Gas - Southwest Gas

The 12-inch steel gas high pressure line and the multiple polyethylene gas lines on the east side of Houghton Road will typically be located under the dual pathways of the proposed roadway. The area between the Pantano Wash and Seven Generations Way will require a detailed analysis during design because existing overhead electric, a drainage collection channel, an eight-foot wide proposed storm drain box, and the gas lines will all be located between the edge of the road and the right-of-way. In this DCR the drainage elements have been placed as to minimize conflicts with the mapped gas main, but potholing will be necessary during design to accurately determine the gas line's horizontal and vertical position in this area.



LEGEND

- *Water*
- *Gas*
- *Telephone*
- *WAPA*
- *Overhead Electric*
- *Reclaimed Water*
- *Proposed R/W*
- *Existing R/W*

250 0 125 250 375 500

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FIGURE 18

HOUGHTON ROAD

FINAL DESIGN CONCEPT REPORT

22ND STREET TO VALENCIA ROAD
MAJOR EXISTING UTILITIES

PROJ NO: 06099-01 SCALE:HORIZ 1" = 250'
DATE: 08/08

There also are feeders to the 12-inch line at Edna Place, Via del Mar, and Discovery Drive. These gas mains will cross multiple proposed cross-culverts along the length of the roadway corridor, and each gas line crossing will need to be analyzed for vertical conflicts with the proposed culverts.

Since the 12-inch high pressure natural gas line is located within a 10-foot utility easement outside of the existing right-of-way (but inside of the proposed right-of-way), the costs of lowering or relocating the lines will likely have to be borne by the project.

Sanitary Sewer - Pima County Wastewater Management

Sewer lines currently parallel to and outside the existing Houghton Road pavement will typically be located under the roadway once it is widened. Sewer lines running parallel to Houghton Road will traverse multiple cross-drainage culverts and will need to be analyzed for vertical conflicts.

An eight-inch sewer line between Discovery Drive and Madrona Canyon Drive on the west side of Houghton Road may conflict with a proposed retaining wall. A sewer manhole of an eight-inch sewer line just south of Secrist Middle School may be in conflict with new curb line and proposed new two 48-inch reinforced concrete pipes. South of Boulderfield Drive, an eight-inch sewer running south on the east side of Houghton Road for 600 feet will be located between the proposed east curb line and the paved path.

The twenty-one inch Pantano sewer interceptor that parallels the east side of Houghton Road may be in conflict with the proposed drainage collection channel between Irvington and Civano Boulevard.

Electric - TEP

From 22nd Street to Old Spanish Trail, overhead electric lines on the east side of Houghton Road will be within the new roadway and will need to be relocated. These lines include a 138 KV transmission line with a distribution underbuilt supported on wooden poles. Although it would be highly desirable to preserve this section of the transmission line in place, relocation will be necessary because the lines fall well within the proposed roadway pavement and it would be impossible to shift the roadway enough to avoid the poles without affecting properties and

structures on the west side of the road. Underground electric also in this stretch will be located under the widened road and will cross a proposed pipe culvert. A power pole located 800 feet west of Houghton Road at Old Spanish Trail may require relocation.

The 138 KV transmission line supported on large steel poles runs along the east side of Houghton Road between Old Spanish Trail and Irvington Road. The road alignment was developed with the intent of avoiding relocation of the existing poles, which range between three and eight feet in diameter. Therefore, relocation of this section of the transmission line and its poles is not anticipated. However, pole protection or delineation will be required.

From Old Spanish Trail to Golf Links Road, underground electric lines run along the east edge of pavement. Underground electric also in this stretch will be located under the widened road and will cross a proposed pipe culvert.

From Old Spanish Trail to Escalante Road, underground electric lines under the east side of Houghton Road will cross multiple culverts. From Escalante Road to Irvington Road, underground electric lines on both sides of the road to McGraw's Cantina will cross multiple pipe culverts.

The overhead electric lines east of Houghton Road between Irvington Road and Civano Boulevard are also likely to require pole relocations in order to accommodate the roadway and the proposed eight-foot wide storm drain box.

Between Civano Boulevard and Drexel Road, the poles fall in the vicinity of the paths along the east side of Houghton Road, but extensive relocations are not anticipated as the paths could be meandered around the poles. A similar situation will exist south of Drexel Road, where the poles shift to the west side of Houghton Road.

Cable - Cox Communications

Between Watson Drive and 360 feet south of Sky Castle Way, the cable run on the west side of Houghton Road crosses a proposed box culvert at Old Spanish Trail Wash 180 feet north of Emily Drive and may require lowering of the line.

From Escalante Road to Irvington Road, the cable along the east side of Houghton between Irvington Road and 300 feet north of Keystone Road crosses a proposed pipe culvert at an unnamed wash 150 feet south of Boulderfield Drive and may require a line lowering.

Telephone - Qwest

Underground telephone conduits from 22nd Street to Irvington Road on the east side of Houghton Road cross multiple culverts and may require line lowerings. Underground conduit south of Irvington Road will be within the new roadway and also crosses a box culvert south of Seven Generations Way. This crossing may require a line lowering.

Three conduits run south from Drexel Road to Poorman Road along the west curb line and cross multiple culverts, as does the fiber optic line. These crossings will be analyzed for vertical conflicts.

6.8. Structures

The only major structure within this segment of Houghton Road is the bridge over the Pantano Wash. This project will require the design of a new bridge system to provide additional traffic capacity on Houghton Road over the Pantano Wash. The existing four-span, 350-foot bridge at this location carries one lane of traffic each in the northbound and southbound directions.

6.8.1. Bridge Foundation

Drilled shaft foundations are the best method to protect against deep scour. They have been used almost exclusively in Arizona on major bridge projects for more than 25 years. Neither spread footings nor steel piles can economically protect against the extreme depths of scour that are anticipated at this site. Drilled shafts can be constructed with little or no excavation in the channel bottom and do not require dewatering where ground water is encountered. Most contractors have the equipment necessary to construct either four-foot or five-foot diameter shafts, which are the sizes anticipated for this project.

6.8.2. Superstructure Alternatives

Six bridge alternatives were evaluated for the bridge superstructure over the Pantano Wash. A discussion of those alternatives follows.

Alternative 1: Widen existing bridge for four-lane traffic (2 lanes in each direction)

Description

The existing bridge deck will be widened nine feet in both the east and west directions for a total bridge width of 65 feet. An additional AASHTO Type IV girder will be provided eight feet away from the existing perimeter girder lines. The existing pier cap is wide enough to accommodate the two additional girders (as shown in Figure 19). Along the east edge of the bridge, a new 32-inch F-shaped concrete barrier will be provided. Along the west edge of the bridge, a pedestrian barrier will be provided adjacent to a four-foot wide pedestrian walkway. A double concrete barrier will separate opposing traffic. The pedestrian walkway will be protected from southbound traffic with a new concrete barrier. A double concrete barrier will separate the two lanes of southbound and northbound traffic. This alternative requires the demolition and reconstruction of four wing walls. The existing approach slabs will be widened accordingly.

Figure 19. Existing Pantano Wash Bridge

Advantages

- In minimal construction time, the capacity of this bridge can be doubled to four lanes of traffic.

- This alternative also represents the lowest first cost of providing additional bridge capacity.

Disadvantages

- Since no detour around the bridge site is provided, the construction activities required to widen the bridge will require severe traffic restrictions and stoppages in each direction.
- The existing bridge, even after widening, does not provide the required six lanes of traffic as required by the City of Tucson and would only act as a temporary bridge until such time as the full six-lane bridge structures can be constructed.

Estimated Probable Cost

The estimated probable cost for Alternative 1 is approximately **$559,000.**

Alternative 2: Widen existing bridge for three-lane southbound traffic and construct new four-span, three-lane northbound bridge

Description

The existing bridge deck will be widened six feet toward the west for a total bridge width of 53 feet. An additional AASHTO Type IV girder will be provided eight feet from the existing west perimeter girder. The existing pier cap is wide enough to accommodate the additional girder. Along the east edge of the bridge, a new 32-inch F-shaped concrete barrier will be provided. Along the west edge of the bridge, a pedestrian barrier will be provided adjacent to a pedestrian walkway, which is approximately 6.25 feet wide. The pedestrian walkway will be protected from southbound traffic with a new concrete barrier. The east wing walls at either end of the existing bridge will be demolished. New wingwalls and approach slabs will be added to accommodate the widened bridge and the new bridge.

The existing concrete deck was recently overlaid with three inches of asphaltic concrete to improve the riding surface. The most recent Bridge Inspection Report, dated December 20, 2005, noted that the under side of the concrete deck has fine to medium transverse cracking with accompanying efflorescence, which indicates that the existing concrete deck may be cracked full depth. This cracking is allowing water intrusion into the deck as evidenced by the efflorescence. The original deck was detailed to be 6¾"-inch thick; however, recent bridge deck

thickness requirements require that the concrete deck be at least eight inches thick. It is recommended that the existing asphalt be removed from the bridge deck to allow the existing deck to be prepared to receive a two-component polymer-modified, cementitious, trowel-grade mortar overlay. Since the new widened portion of the deck will be eight inches thick, the thickness of the overlay will be approximately 1¼ inches. This overlay will protect the existing reinforcing steel from corrosion and extend the service life of the deck.

A new 57-foot wide bridge will be constructed just east and adjacent to the existing bridge using the same type of girders, same span lengths, pier and abutment alignments as the existing bridge. The new bridge structure will be constructed approximately two feet higher than the existing bridge to provide for adequate freeboard during the design flood. The clear distance between the north and southbound structures will be 13 feet.

Advantages

- Widening the existing bridge to accommodate three lanes of southbound traffic and constructing a new 57-foot wide bridge to accommodate three lanes of northbound traffic can achieve the full six lanes of traffic as required by the City of Tucson.
- No traffic detour is required as the new bridge can be constructed while the existing bridge is in full service. Once the new bridge is finished, traffic can be diverted to the new bridge while the existing bridge is widened. Once the widening of the existing bridge is completed, the full six-lane bridge section can be opened to traffic.
- The new bridge can be constructed without phasing or traffic considerations since there are no conflicts with the existing bridge during construction.

Disadvantages

- The four-span design is slightly less efficient than a three-span structure from a structural standpoint. However, from a hydraulic standpoint aligning the piers would result in a lower water surface elevation.

Estimated Probable Cost

The estimated probable cost for Alternative 2 is approximately **$2,459,000**, including the cost of the deck overlay**.**

Alternative 2A: Widen existing bridge for three-lane southbound traffic and construct new three-span, three-lane northbound bridge

Description

This alternative is the same as Alternative 2, except that the new bridge will be a three-span structure with AASHTO Type V girders resulting in approximate span lengths of 116'-8" each. Four five-foot diameter drilled shafts at each of the two piers will support the new bridge. The advantages and disadvantages of this alternative are the same as for Alternative 2. It should be noted that the piers for the existing and the new bridge would not be aligned since the new bridge is a three-span structure and the existing bridge is a four-span structure. As a result, the flow area will be reduced, and the water surface elevation (WSEL) will go up, reducing the available freeboard.

Estimated Probable Cost

The estimated probable cost for Alternative 2A is approximately **$2,422,000**, which includes the cost of the deck overlay.

Alternative 3: Same as Alternative 2, but raise existing bridge for increased freeboard; provide new four-span, three-lane bridge

Description

This alternative assumes that the existing bridge be raised approximately two feet to provide additional freeboard during the design event and match the elevation of the upstream bridge. The existing bridge deck will be carefully demolished such that all 24 of the AAHSTO Type IV girders may be saved and re-used. The existing concrete abutment, wingwalls, approach slabs, and pier caps will be demolished. Approximately two feet from the tops of the existing concrete columns will be removed, exposing the reinforcing steel. The tops of the columns will be re-constructed such that new pier and abutment caps will be approximately two feet higher than the existing caps. New re-designed pier and abutment caps will be constructed. A new type IV girder will be installed near the west end of the caps and a new re-designed concrete deck will be constructed for a 53-foot wide bridge. The concrete barriers and pedestrian barrier are the same as Alternative 2.

A new 57-foot wide, four-span, three-lane bridge will be constructed just east and adjacent to the existing bridge using the same type of girders, same span lengths, and pier and abutment alignments as the existing bridge. The new bridge structure will be constructed approximately two feet higher than the existing bridge to provide additional freeboard during the design event and match the elevation of the upstream bridge.

Advantages

- By widening the existing bridge to accommodate three lanes of southbound traffic and constructing a new 57-foot wide bridge to accommodate three lanes of northbound traffic, this alternative provides the full six lanes of traffic as required by the City of Tucson.
- No traffic detour is required as the new bridge can be constructed while the existing bridge is in full service. Once the new bridge is finished, traffic can be diverted to the new bridge while the existing bridge superstructure is constructed. Once the existing bridge modifications are completed, the full six-lane bridge section can be opened to traffic.
- The new bridge can be constructed without phasing or traffic considerations since there are no conflicts with the existing bridge during construction.

Disadvantages

- Careful demolition and removal large portions of concrete of the existing bridge superstructure can be costly and time-consuming and requires specialized equipment to break up heavy concrete sections safely and efficiently. This type of demolition also creates dust and noise issues.
- To keep the riverbed from becoming littered with concrete and reinforcing steel waste, the contractor will be required to erect steel nets to intercept falling debris.

Estimated Probable Cost

The estimated probable cost for Alternative 3 is approximately **$3,005,000.**

Alternative 3A: Same as Alternative 3, but raise existing bridge for increased freeboard; provide new three-span, three-lane bridge

Description

This alternative is the same as Alternative 3, except that the new bridge to the east of the existing bridge will be a three-span structure instead of a four-span structure. The advantages and disadvantages are the same as for Alternative 3. It should be noted that the piers for the existing and the new bridge would not be aligned since the new bridge is a three-span structure and the existing bridge is a four-span structure. As a result, the flow area will be reduced, and the water surface elevation (WSEL) will go up, reducing the available freeboard.

Estimated Probable Cost

The estimated probable cost for Alternative 3A is approximately **$2,983,000.**

Alternative 4: Completely remove existing bridge and construct two new three-span bridges

Description

The existing bridge structure will be completely removed including the drilled shafts to at least five feet below the channel bed. Two new side-by-side bridge structures, each 57 feet wide, will be constructed to accommodate three lanes of traffic each in the north and southbound directions. Each bridge will be constructed of three equal spans of approximately 116'-8", using AASHTO Type V girders, and each bridge will offer the required freeboard during the design flood. The three-span arrangement was selected to miss the locations of the existing drilled shaft locations of the existing four-span bridge. This will also separate construction zones at the riverbed location during the concurrent demolition of the existing drilled shafts and the construction of the new drilled shafts.

Advantages

- This alternative provides the full six lanes of traffic as required by the City of Tucson and provides the required freeboard during the design flood event.
- It also provides two new structures in both directions, each with an anticipated service life of 50 years.

- No traffic detour is required as the existing bridge can be in service while the new northbound bridge is constructed. Once the northbound bridge is finished, traffic can be diverted to the new bridge while the existing bridge is demolished, and the new southbound bridge is constructed. When the new southbound bridge is completed, the full six-lane bridge section can be opened to traffic.

Disadvantages

- Demolition and removal of the existing bridge superstructure and substructure is costly and time-consuming, and requires specialized equipment to break up and dispose of heavy concrete sections safely and efficiently. This type of demolition also creates dust and noise issues.
- To keep the riverbed from becoming littered with concrete and reinforcing steel waste, the contractor will be required to erect steel nets to intercept falling debris and to continually keep the river bed free of debris.

Estimated Probable Cost

The estimated probable cost for Alternative 4 is approximately **$3,734,000.**

6.8.3. Provisions for Utilities

The existing bridge carries various utility lines suspended from under the bridge deck in between the girder lines. Similar provisions can be made to carry additional utility lines across the river on the new bridges by suspending them from the deck and between the girders where they are accessible but not visible. Alternatives 3, 3A, and 4 require that these existing utilities be temporarily removed and rerouted during bridge construction and reinstalled under the new bridge deck.

6.8.4. Architectural Treatments

Artistic concepts have not been established at this time but are considered to be important aspects of the project and will be incorporated into the bridge design. This bridge project will be highly visible from the surrounding neighborhoods and adjacent roadways. Each of the alternatives provides bicycle and pedestrian access to the bridge. For these reasons, artistic and aesthetic aspects of design will be given a high priority.

6.8.5. Structural Recommendation

The matrix included in Table 29 compares the most relevant attributes of the design alternatives considered. Though slightly more expensive than Alternative 2A by $37,000, Alternative 2 is the recommended bridge alternative because it provides sufficient freeboard while minimizing the disturbance to the Pantano Wash.

Table 29. Pantano Wash Bridge Alternative Matrix

		Total Travel Lanes	Min Freeboard under Q_{100}	Construction Phasing	Utility Impacts	Wash Impacts	Probable Cost	Remarks
ALTERNATIVE	1	4	1.9'	Severe traffic restrictions. Bridge would be widened while in service	None	Minimal. No work in the wash.	$559,000	Temporary solution, cannot be expanded to 6-lanes
	2	6	1.9' Exst Bridge 2.2' New Bridge	Minimal impact. Construct new bridge while existing one serves traffic	None	Limited. New shafts for the northbound bridge	$2,459,000	Refurbish existing bridge deck and increase deck thickness to 8 inches
	2a	6	2.3' Exst Bridge 1.5' New Bridge	Same as Alt. 2	Same as Alt. 2	Same as Alt. 2	$2,422,000	Misalignment of piers would raise the water surface elevation during the design storm. Refurbish existing deck same as Alternative 2.
	3	6	3.9' Exst Bridge 2.2' New Bridge	Minimal impact. Construct new bridge while existing one serves traffic, then move traffic to new bridge, rebuild existing bridge	Temporary re-routing of utilities to raise existing bridge deck	Moderate. New shafts for the northbound bridge, possible debris from deck demolition of southbound bridge	$3,005,000	
	3a	6	2.3' Exst Bridge 1.5' New Bridge	Same as Alt. 3	Same as Alt. 3	Same as Alt. 3	$2,983,000	Misalignment of piers would raise the water surface elevation during the design storm
	4	6	2.45' New bridges	Minimal impact. Construct new bridge while existing one serves traffic, then move traffic to new bridge, demolish existing bridge, build second new bridge	Relocation of utilities to new bridge	High. Possible debris from demolition of existing bridge, new shafts for two new bridges	$3,734,000	Requires demolition of existing bridge

Figure 20 shows the proposed bridge cross-section for Alternative 2, while the bridge schematic drawings are included in the roadway plan set. The following considerations will also be part of the design of Alternative 2:

Existing Bridge

The existing steel traffic barriers will be removed from each side of the bridge, and the three inches of asphaltic concrete overlay will be removed from the existing concrete deck. The deck will be roughened and sealed with an epoxy adhesive material followed by a polymer concrete overlay to bring the total deck thickness to eight inches. The existing deck will be widened westward from 47 feet to 53 feet by adding one additional Type IV AASHTO girder to the west side of the bridge to accommodate three lanes of southbound traffic. The existing pier and abutment structures are currently long enough to accommodate the additional girder and deck widening. Along the west edge of the bridge, a pedestrian barrier will be provided adjacent to a 6'-3¼" wide pedestrian walkway. The pedestrian walkway will be protected from southbound traffic with a new concrete barrier. Along the east edge of the bridge, a new 32-inch F-shaped concrete barrier will be provided. No new drilled shafts or columns will be required. The east wingwalls at each end of the bridge will be removed to accommodate the widening of the bridge deck and approach slabs. New wing walls will be constructed at the edge of the widened bridge deck and approach slabs at each end of the bridge.

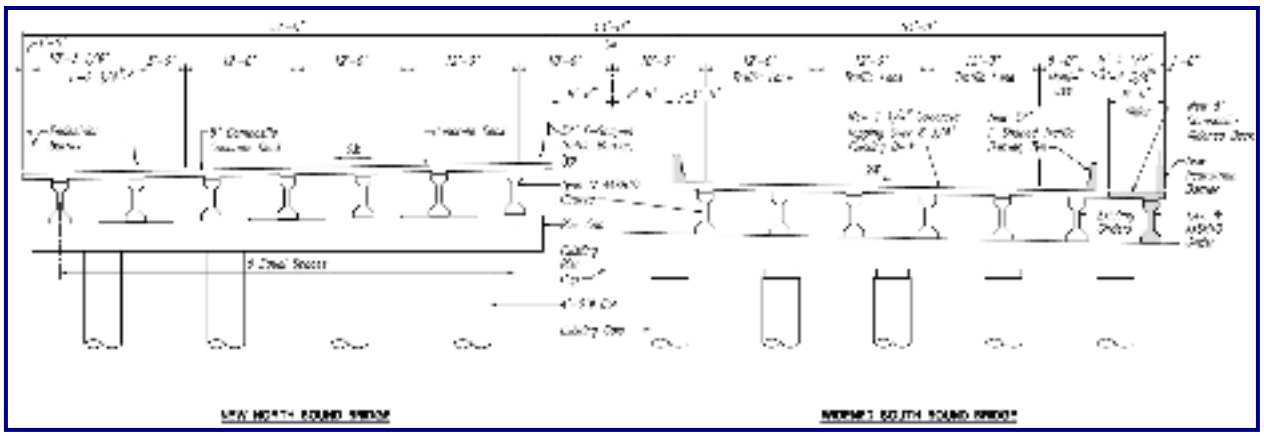

Figure 20. Proposed Pantano Wash Bridge Cross Section

New Bridge

A new 57-foot wide three-lane bridge will be constructed 13 feet east of the existing bridge using the same type of girders, span lengths, pier and abutment alignments as the existing bridge. This new structure will be dedicated to three lanes of northbound traffic, and will be constructed approximately two feet higher than the existing bridge to provide for adequate freeboard during

the design flood. Wingwalls parallel to the edge of the deck will be incorporated into each of the two new abutments. New approach slabs will also be constructed at each abutment.

6.9. Pavement Design

Based upon the structural number calculations described in the *Pavement Design Summary (Final)* and summarized by the design criteria outlined in Section 5.3, the following alternative pavement sections, can be considered for design:

Table 30. Pavement Design Alternatives

Pavement Area	Calculated SN	COT Minimum SN*	Control SN	Alt	RAC (in)	AC (in)	ABC (in)	SN
Houghton Rd. from 22nd to Drexel	3.34	3.04	3.34	A		6.0	6.0	3.48
				B	2.0	4.0	6.0	3.48
Houghton Rd. from Drexel to Valencia	3.97	3.04	3.97	A		6.5	8.0	3.98
				B	2.0	4.5	8.0	3.98
				C		7.0	7.0	4.06
				D	2.0	5.0	7.0	4.06

* 5" AC and 6"ABC are the minimum requirements for Arterial Roadways per the City's Active Practice Guidelines

The use of alternative B is recommended in both cases, for the following reasons:

- The 2 inches of RAC will help reduce the tire noise. Alternatives A and C do not include RAC.
- The ratio of RAC+AC to ABC is between 1:1 and 1:1.75 as recommended in the *Pima County Roadway Design Manual* to balance the structural section.

6.10. Signalization

Currently, the intersections of Houghton Road with Old Spanish Trail, Golf Links Road, Escalante Road, Irvington Road, and Bilby Road are signalized in the project area. The *Traffic Engineering Report* recommends new signals at the intersections of Houghton Road with Drexel

Road and Poorman Road while keeping the existing signals at other intersections. In addition, although a signal is not recommended at Keystone Road at this time, volumes and operations should be monitored periodically to determine if the installation of a signal is necessary despite the fact that it would violate the access management plan.

The two proposed signals at Drexel Road and Poorman Road will be designed as Florida-T intersections based on discussions with the Traffic Engineering Division, the anticipated land use in the surrounding area, future traffic volume projection, and the distance between Bilby Road to both intersections (½ mile).

Florida T-Intersections are a special case where one of the main street through movements is allowed to operate continuously, even with the T-intersection left turn movement. In this case, the southbound through movement on Houghton Road will be allowed to operate continuously, even during the westbound left turn movement. The exception is when an east-west pedestrian call is placed. The southbound through and westbound left-turn movements flow into their own lanes downstream of the intersection. The Florida-T intersection at Poorman Road is depicted in Figure 21.

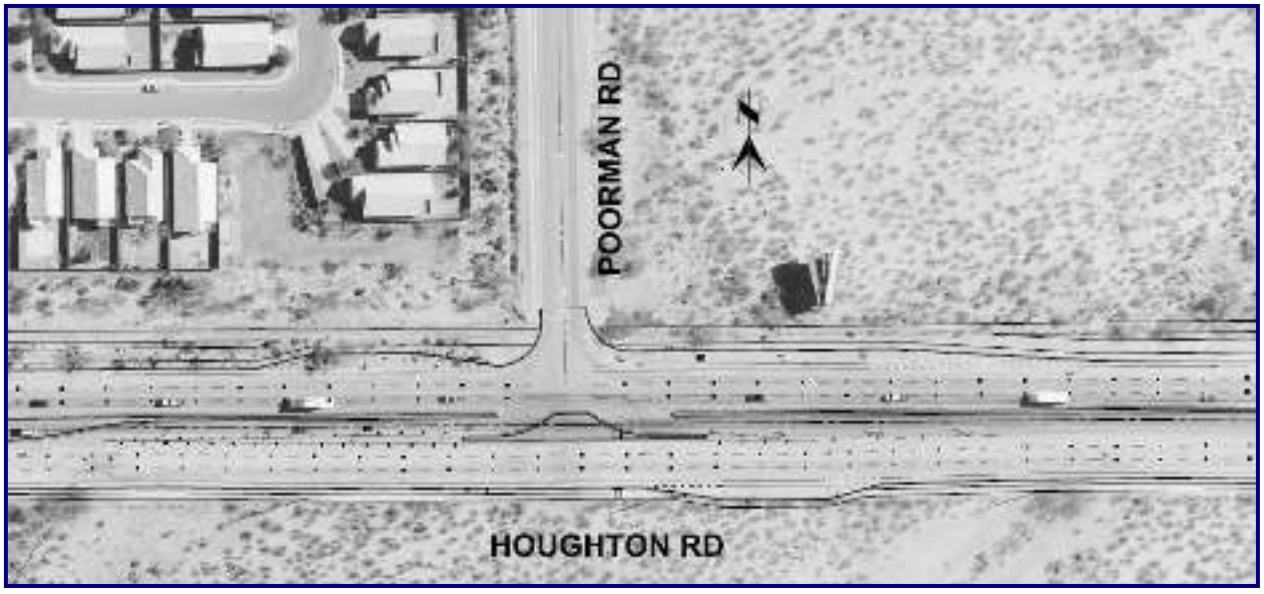

Figure 21. Concept Plan for Florida-T intersection at Poorman Road

In addition, a pedestrian signal is being considered at Secrist Middle School, and a permanent emergency signal is also under consideration for Fire Station 17 at Seven Generations Way to allow fire vehicles to easily exit the station when a call is placed. The interim signal currently being constructed at the Fire Station will require relocation of poles and other signal equipment to accommodate the wider section of Houghton Road.

6.11. Lighting

Street lighting for the entire Houghton Corridor is not recommended for consistency with its desert parkway character, cost considerations, and to minimize light pollution. However, safety lighting will be required at signalized intersections. It is also recommended that intersection safety lighting be installed at median opening locations in order to improve night-time visibility.

Intersection lighting shall use 120 volt, 400 watt high pressure sodium luminaires with horizontal cut-off lenses meeting Pima County/City of Tucson specifications. Other criteria for lighting include:

- Street lighting design should meet or exceed average illuminance per AASHTO's publication, *An Informational Guide for Roadway Lighting*, 1984.
- Poles should be positioned beyond the AASHTO clear zone requirement, whenever possible.
- Light distribution shall satisfy the *Pima County Outdoor Lighting Code*, 2006.
- All installations should meet National Electric Code requirements.
- Installations shall be in conformance with *Roadway Lighting – Illuminating Engineering Society of North America*, ANSI/IESNA RP-8, 2000.

6.12. Construction Issues

The length of the Houghton Road corridor and the size of the overall project create the necessity of constructing the improvements in phases. This section provides preliminary ideas on the sequence of improvements. Segment improvements (including the intersections) were deemed to be more efficient than separate intersection improvements. This is due to the fact

that intersection transitions from six lanes back to two lanes would require long tapers (in excess of 2,000 feet) in each direction.

Overall, the proposed phasing of the improvements along the entire Houghton corridor should consider the following principles:

1. Prioritize areas that maximize the benefits to the traveling public – Road segments that currently experience the most significant operational, safety, or access deterioration should be addressed early to provide the largest improvement possible.

2. Minimize the construction impacts and the inconvenience to residents – All the improvements required at a given location should be constructed at the same time to avoid going back to the same area (i.e., provide all the turn lanes, travel lanes and landscaping at the same time). In addition, avoid having two construction segments close to each other with a non-construction area in between, as this would cause a loss of efficiency and irritate users. Instead, if construction is done concurrently in two areas, choose areas far apart where drivers are less likely to use both segments on its way to/from work or other trips. For example, a driver is less likely to use both the segment between I-10 and Rita Road and Golf Links to 22nd Street than two adjacent or nearby segments.

3. Be mindful of long lead-time issues – These includes items such as permitting, utility relocations, and right-of-way negotiations. Construction schedules need to be realistic in relation to the timeframes required to obtain environmental clearances, 404 permits, right-of-way acquisitions, and relocation commitments from utility companies.

4. Ensure consistency with the timeline for availability of funds. Most of the funds for this project come from the RTA. The RTA's cash flow is set up in such a way that a portion of the funds will be available in the first period (FY2007-2011), while the remaining moneys will become available in the FY2017-2021 timeframe (period 3). Therefore funding from the first period should be allocated to the most critical areas.

Based on those principles, the following preliminary recommended sequencing (Figure 22) is recommended for the central segment of Houghton Road (22nd Street to Valencia Road):

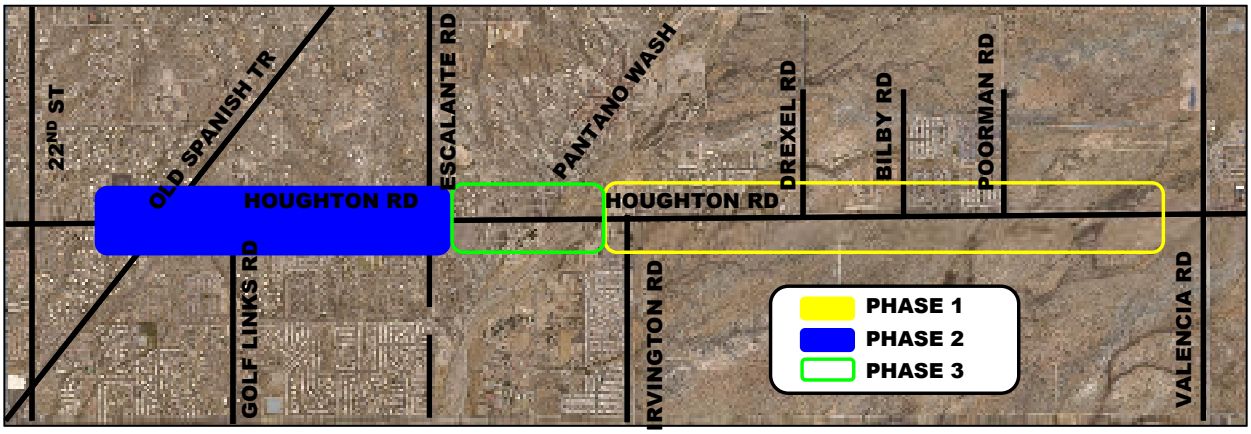

Figure 22. Proposed Houghton Road Construction Sequencing

1. Irvington Road to Valencia Road (3 miles)

This segment has high traffic volumes (over 20,000 vehicles per day) and serves several large, well-established subdivisions. The end points at Irvington Road and Valencia Road define this as a logical, independent segment for the purposes of detours, permitting, and traffic volumes, as both roadways connect to Kolb Road.

A significant amount of right-of-way would be required (approximately 12 acres), but the entire area to be acquired is owned either by the City of Tucson or the State Land Department, which should facilitate the acquisition. Still, in order to construct this segment first, right-of-way acquisition should begin early in the design process. There are only two washes that have been identified as potential JDs, but the jurisdictional widths are very small (3-12'Mesquite Ranch Wash, 2-3' Atterbury Wash), which reduces the likelihood of requiring a 404 permit.

2. 22nd Street to Escalante Road (1.25 miles)

This segment has the highest existing traffic along the project (25,000 VPD) by over 20%, and the highest projected traffic. There are circulation issues in the vicinity of Secrist Middle School, neighborhood cut-through traffic on Emily Drive, and excessive delays into and out of the Austin Point subdivision. However, there are four washes that could be considered jurisdictional in this segment (Este, Hidden Hills, Old Spanish Trail and Escalante), which could delay the permitting process. In addition, there is a significant amount of right-of-way to be obtained from a variety of public and private owners, and significant utility relocations would be required, especially north of Old Spanish Trail. Therefore, it is recommended that this segment be constructed second to allow sufficient time to negotiate right-of-way and obtain the required permits. The construction should include the intersections at both ends of the segment.

3. Escalante Road to Irvington Road (1 mile)

This segment will require the addition of a second bridge over the Pantano Wash, as well as a grade control structure and retrofitting of the existing spur dikes. The 404 permitting process for this improvement could take significant time (depending on whether the disturbance qualifies for a Nationwide or Individual permit). In addition, this segment will require several large retaining walls that will create a significant cost for a relatively short stretch of roadway. Furthermore, if phases 1 and 2 are already completed, traffic on Houghton can quickly be routed to Golf Links Road and Irvington Road and then to Harrison Road to mitigate potential delays.

Table 31 presents a comparison of the most important elements associated with improving each segment.

Table 31. Construction Sequencing Matrix

	Irvington Road to Valencia Road	22nd Street to Escalante Road	Escalante Road to Irvington Rd
Existing Traffic Volume (veh/day)	21,881	25,169	19,924
Length (mi)	3 miles	2 miles	1 mile
Land Use	Master Planned subdivisions (Civano, Sierra Morado, Mesquite Ranch), State Land, City. Well spaced access points	Most developed section, mixture of old and new subdivisions. Closely spaced access points	Rural uses or low density subdivisions, few access points
Permitting	2 potential JD - Mesquite Ranch and Atterbury Washes	2 potential JDs - an unnamed wash and the Pantano Wash	4 potential JDs - Este, Hidden Hills, Old Spanish Trail, Escalante
Utilities	Moderate relocations, mostly between Irvington and Civano Blvd	Overhead electric relocations north of Old Spanish Trail, minor other relocations	Minor modifications
Right-of-Way	Approx 12 acres, City and State are only owners	Approx 8 acres, over 15 private owners, 4 churches, City, TEP	Approx 3 acres, 4 private owners and Pima County
Remarks	* Includes Irvington Intersection * Regional Connectivity at both ends	*Includes Escalante Intersection * Circulation issues around Secrist need attention	Extensive walls, large earthwork volume
Recommended Construction Order	1	2	3

6.13. Design Exceptions

No design exceptions have been identified at this time.

7. SOCIAL, ECONOMIC, AND ENVIRONMENTAL CONSIDERATIONS

7.1. Biological Resources

The analysis of potential impacts on biological resources in the project area is limited to the special status species that were identified as potentially occurring in the project area in Section 3.0.

Protected Native Plants

The City of Tucson Native Plant Preservation Ordinance restricts the removal of the native plant species that are on the City's list of protected native plants. Protected native plant species that were documented in the project area during the native plant inventory include the following: two desert night-blooming cereus (*Peniocereus greggi*), 291 fishhook barrel cactus (*Ferocactus Wislizeni*), 23 saguaro (*Carnegiea gigantea*), 114 prickly pear cactus (*Opuntia* spp), eight pincushion cactus (*Mammillaria* spp), 31 cholla cactus (*Opuntia* spp), 127 blue palo verde (*Cercidium floridum*), 42 catclaw acacia (*Acacia greggii var. arizonica*), 94 desert hackberry (*Celtis pallida*), 18 desert willow (*Chilopsis linearis*), 286 foothills palo verde (*Cercidium microphyllum*), 604 whitethorn acacia (*Acacia constricta*), 348 velvet mesquite (*Prosopis velutina*), 19 greythorn (*Zizyphus obtusifolia var. canescens*), seven Kearney condalia (*Condalia warnockii var. kearneyana*), 22 ocotillo (*Fouquieria splendens*), 2 fourwing saltbush (*Atriplex canescens*), three wolfberry (*Lycium* spp), and 20 soaptree yucca (*Yucca elata*). As part of the project, protected native plants will be inventoried and salvaged if feasible. Any losses will be mitigated in accordance with the City of Tucson's Native Plant Preservation Ordinance.

Wildlife

Roadway improvements could result in a wider roadway that is a barrier to wildlife movements and increased threat for wildlife that may attempt to cross. Existing and planned drainage structures along Houghton Road will be evaluated during design for enhancements that could facilitate wildlife movements across the improved roadway.

Special Status Species

A Biological Evaluation will be prepared that addresses the potential impacts of the project on threatened and endangered species. Potential impacts based on preliminary project information are identified below.

- *Tumamoc Globeberry*: This species could potentially occur along drainages that occur in the project area. Individual plants may be impacted during construction. No Tumamoc globeberry were located during native plant inventories, though no species-specific surveys were conducted for this well-camouflaged plant.

- *Sonoran Desert Tortoise*: Rocky slopes, the preferred habitat of the desert tortoise, are not present in the project area, and no suitable shelter sites are present. Low-quality habitat that is suitable for foraging occurs throughout the project area; therefore, the Sonoran desert tortoise could occur in the project area and there is the potential for desert tortoises to be present during construction. AGFD guidelines that describe the procedures for handling Sonoran desert tortoises can be used to relocate any desert tortoises present during construction out of harm's way. Because any desert tortoises present in the construction area can be safely relocated, no impacts to the Sonoran desert tortoise are anticipated. AGFD's *Guidelines for Handling Sonoran Desert Tortoises Encountered on Development Projects* will be followed if a desert tortoise is encountered during roadway construction activities.

- *Western Burrowing Owl*: The western burrowing owl typically occurs in open areas or along agricultural canals and is associated with old rodent burrows. No western burrowing owls were observed in the project area during site visits, though species-specific surveys were not conducted for this species. No impacts are anticipated.

- *Cave Myotis*: Cave myotis forage widely for insects and have been documented within three miles of the project area; therefore, suitable foraging habitat for this species is present in the project area. Potentially suitable roosting habitat is present at the bridge over Pantano Wash and possibly at large box culverts; cave myotis are known to use cliff swallow nests and bridges for roosting. No impacts to this species are anticipated,

although temporary impacts to roosting habitat could occur if the bridge over Pantano Wash is indeed used for roosting.

- *Lesser Long-Nosed Bat*: This species is found in association with agave and columnar cacti, such as saguaro cacti. This endangered bat feeds on the nectar of saguaro blossoms. Suitable foraging habitat for the lesser long-nosed bat is present throughout the project area, although saguaro cacti are not common in the project area and agaves were not recorded from the roadway corridor. The 23 saguaro cacti that are present in the project area will be evaluated and if feasible, salvaged and replanted as part of this project. Any losses will be mitigated in accordance with the City of Tucson's Native Plant Preservation Ordinance. The amount of foraging habitat (i.e., number of saguaro cacti) disturbed as a result of the project is negligible relative to the total available habitat in the general area and a significant amount of foraging habitat will remain in the project vicinity during and after project construction. Therefore, no impacts to lesser long-nosed bats are anticipated. The bridge over the Pantano Wash will be evaluated for the presence of bats within one year of construction.

- *Mexican Long-Tongued Bat*: The project area provides foraging habitat for Mexican long-tongued bats because columnar cacti are present; however, suitable roost sites are not present in the project area or immediate project vicinity. As previously mentioned, saguaro cacti in the project area will be evaluated and if feasible, salvaged and replanted as part of this project. Any losses will be mitigated in accordance with the City of Tucson's Native Plant Preservation Ordinance. Due to this bat's mobility and the location and temporary nature of the roadway improvements, no impacts to this bat species are anticipated.

7.2. Air Quality

The Pima Association of Governments is the designated air quality planning agency and the metropolitan planning organization for the greater Tucson region. The design of this project has been included in the *Transportation Improvement Plan (TIP) for 2008-2012*[23], while the construction of the project is part of the *2030 Regional Transportation Plan (RTP)*[24], which is included in the 2030 Regional Transportation Plan.

The *Clean Air Act* Amendments of 1990 require that the TIP conform to the State's air quality implementation plan's (SIP) purpose of eliminating or reducing the severity and number of violations of the *National Ambient Air Quality Standards* (NAAQS) and achieving expeditious attainment of such standards and that TIP activities will not cause or contribute to any new violation of any standard in any area; increase the frequency or severity of any existing violations of any standard in any area; or delay timely attainment of any standard or any required interim emission reductions or other milestones in any area.

In April 2000, the EPA promulgated a final rule that re-designated the Tucson Air Planning Area to attainment for the carbon monoxide NAAQS and approved a maintenance plan that will insure that the area remains in attainment.

The PAG Regional Council and the US Department of Transportation made an air quality conformity determination for the 2030 Regional Transportation Plan in 2006. This finding was made following the procedures outlined in the federal transportation conformity rule (40 CFR Part 93) and the State of Arizona conformity rule (R18-2-1401 et seq.).

By the adoption of the 2008-2012 TIP, the PAG Regional Council found that the Regional Transportation Improvement Program for FY2008-2012 is in conformity with the State Improvement Plan and also affirmed that the TIP is consistent with the 2030 Regional Transportation Plan.

In addition, the *Houghton Road Corridor Study* states that air quality tends to be better when the traffic congestion is less. The improvements recommended to the corridor will tend to reduce the carbon monoxide levels by improving the roadway LOS. Regional air quality impacts have been thoroughly addressed in the RTP and should not be considered an issue for the Houghton Road project.

7.3. Noise

Noise studies for the Houghton Road corridor have not been completed at this time. The City of Tucson's policy per the *Active Practice Guidelines* [25] is that the preferred method of traffic noise

abatement is to pave the roadway with rubberized asphalt pavement. Based on discussions with City staff, it has been determined that the Houghton Road project will utilize rubberized asphalt pavement. Advantages of rubberized asphalt pavement include:

- It reduces traffic noise between 3 and 4 dBA, depending on site conditions.
- It is less costly than constructing noise barrier walls, landscaped earthen berms, or depressed roadways.
- It doe not interrupt the views from the residences, attract graffiti, create any safety hazards for vehicles, or interfere with the Tucson Police Department's crime surveillance program.
- Its effectiveness is not reduced by the need to provide access for driveways, alleys, side streets, and drainage ways.
- No additional right-of-way is required.

In general, rubberized asphalt pavement is the most cost-effective means of providing traffic noise reduction.

7.4. Hazardous Materials

A specific hazardous materials study of the project area has not been conducted as part of the project. However, a preliminary Hazardous Materials evaluation was conducted as part of the *Houghton Road Corridor Study (HCRS),* which covers the area of his project. The preliminary evaluation found a total of seven sites in the area ranging in priority from low to high, as presented in Table 32.

As indicated, the study found two high priority sites, booth located near the intersection of Houghton Road and Irvington Road. High priority sites were classified as such because they can entail high remediation costs and can involve coordination with multiple regulatory agencies at both State and Federal levels. They may also involve soil and/or groundwater contamination requiring an extensive long-term remediation effort to meet regulatory cleanup goals.

Two mid-priority sites were also identified. The two sites, which are located within ½ mile of Irvington Road, included underground storage tanks that due to the nature of operations had the

potential to impact soil or groundwater beneath the site. However, those sites are not currently listed as hazardous materials release sites.

There were also three low-priority sites that were classified as such because they have either been remediated, have been investigated and not found to need remediation, or are unlikely to require large-scale remediation. All the sites are also within one mile of Irvington Road.

Table 32. Possible Hazardous Materials Sites (from HRCS)

Site	US EPA #	Priority	Reason
Houghton/Irvington Landfill SW Corner of Houghton/Irvington	AZD983469701	High	SCL
Talano Property 10251 E Irvington Rd	AZD983469701	High	RCRIS, FINDS, CERCLIS, SCL
Pima County Automotive Services 4700 S Houghton Rd	FAC # 0-006569	Mid	UST
Antoni Chmielowiec 10155 E Irvington Rd	AZR000030262 FAC # 0-001152	Mid	UST Removed/Not closed
Pantano Stables 4450 S Houghton Rd	AZ000594259	Low	WWF
Orban Excavating 10800 S Houghton Rd	N/A	Low	Mines
Global Solar Energy 5575 S Houghton Rd	AZR0000133951	Low	RCRIS, FINDS

SCL - State Contaminant List, RCRIS - Resource Conservation and Recovery Information System
FINDS - Facility Index System, UST - Underground Storage Tanks
CERCLIS - Comprehensive environmental Response, Compensation and Liability Information System

Based on the previous discussion, it is anticipated that a Phase I Environmental Assessment study will be needed prior to the construction of the project. Additional studies may be recommended, and these will be completed as needed. This effort, and any necessary mitigation, will be completed prior to construction.

7.5. Historic/Cultural Resources

Two Class III cultural resources surveys conducted by Tierra Right of Way Services for Houghton Road determined that there were no historic properties within the project corridor. No additional archaeological investigations were recommended for the project area. Any new right-of-way, temporary construction easements, or staging areas required by the project and located outside the original study area should be surveyed for cultural resources.

7.6. Visual/Aesthetic Resources

Landscape standards applicable to the Houghton Road corridor include those specified in the City of Tucson Zoning Code, specifically Chapters 18.72, 18.73, and 18.73. These include regulations and guidelines regarding native plant preservation, landscaping, and roadway frontage standards.

The Zoning Code defines the philosophy of the City of Tucson MS&R Plan, which articulates that “Tucson has a unique physical setting and climate which are major factors in attracting visitors and residents. Their key image of the City is derived from the views along major routes. Streets which are heavily traveled, those that lead from transportation terminals to hotels and resorts, and those that lead to recreational facilities are routes which provide the basic impression of Tucson’s character. The set of development guidelines for these routes will preserve the visual appearance from the roadway while allowing a range of uses and densities." Goals of the MS & R Plan that specifically apply to the Houghton Road improvements include:

- Preservation of views of prominent mountain ridge lines that form the limits of scenic viewsheds and provide a natural backdrop for sensitively designed development.
- Preservation of viewsheds which provide the observer with a visual perspective of the areas in terms of foreground, middle ground, and background,
- Preservation of the scenic quality of the desert and mountain environment through the retention of native vegetation and natural topography.
- Preservation of view windows through an aesthetic screening or siting of developmental elements incompatible with the natural qualities of the surrounding area.

The landscape goals stated in the Zoning Code and the MS&R Plan are to make the final appearance as natural as possible, rather than introducing a new character. As a result, a primary goal of the project will be to enhance and amplify the natural beauty of the corridor. Potential methods for achieving these goals include:

- Utilizing plants indigenous to the area. Specimen plants salvaged from the right-of-way as part of the native plant preservation process will be planted so as to have the highest visibility.
- Following the environmental zone design principle of appropriate plant selection and placement, based on the function, water requirement, and most suitable environmental exposure of the plant materials.
- Planting trees and shrubs so that they do not interfere with service lines, traffic sight lines, and the property rights of adjacent property owners.
- Grouping, clustering, and unevenly spacing plants to prevent the creation of an unnatural appearance in the landscape.
- Designing earth berms to transition to existing grades and to not exceed a slope ratio of 2:1. The berms should be adequately covered with plant material, groundcovers, or rip-rap to control erosion.
- Designing retaining walls, sound walls, and concrete channels to blend with the landscape, using earth colors and materials.

All water use for landscaping and enhancement will conform to the Arizona Groundwater Code (Title 45, Chapter 2) and the adopted groundwater management plan for the Tucson Active Management Area. Landscaping will be watered by a water-conserving, underground irrigation system that incorporates rain sensors and is capable of seasonal adjustments. Reclaimed water will be used for irrigation, if available. Plantings should be integrated with the improvement plans for the site to make maximum use of site stormwater runoff for irrigation purposes. A preliminary landscape concept for the project is presented in Figure 23.

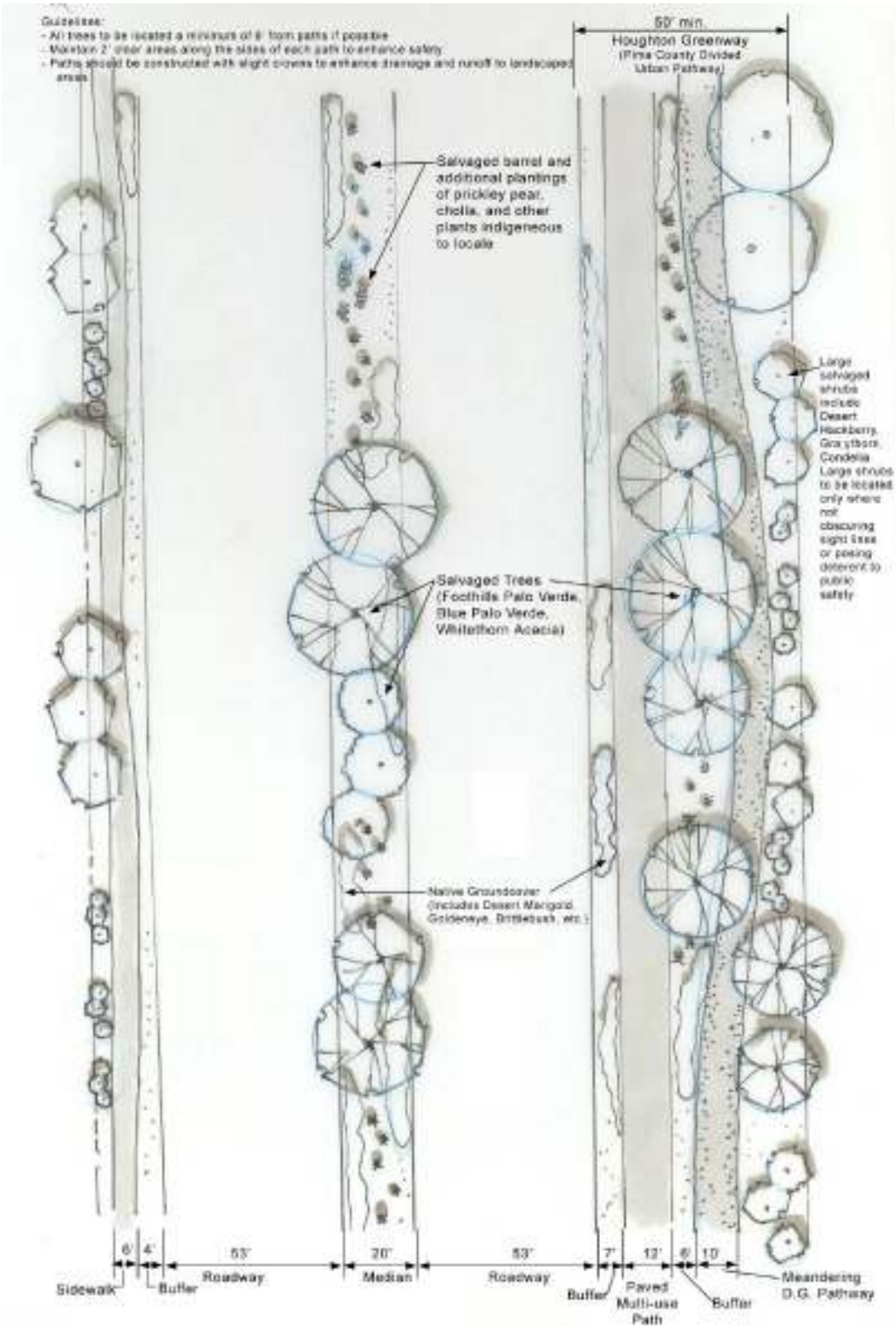

Figure 23. Preliminary Landscape Concept

This project will include a public art component. Project features that lend themselves to having public art integrated into them include retaining walls, which will occur when existing slopes are cut to accommodate the increased road width, safety railings, and the drainage channels. Rather than having free standing pieces of art, art will be integrated into the project features. Art can also be incorporated into safety treatments for projects such as safe routes to schools. Figure 24 identifies potential art locations along the project.

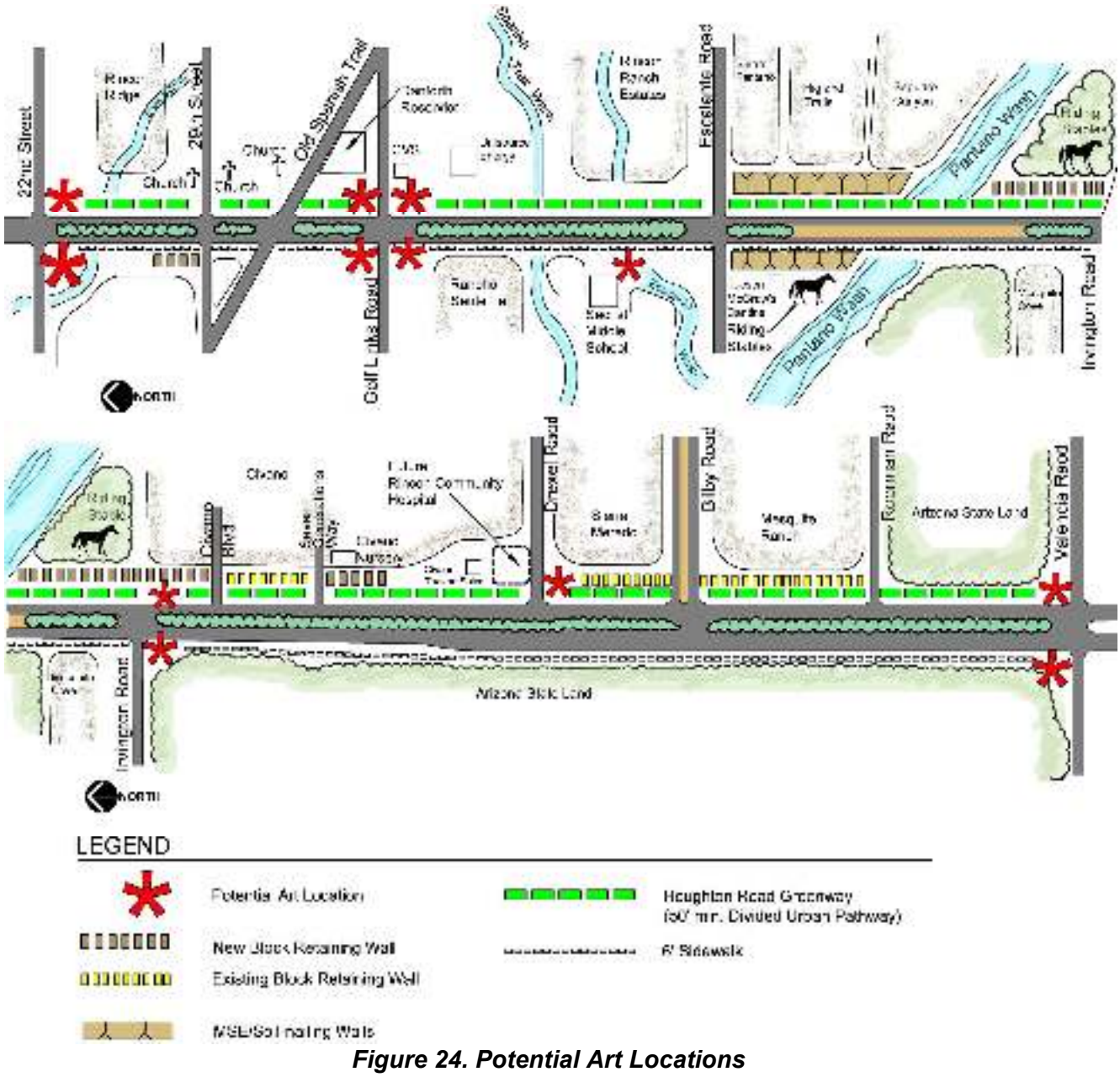

Figure 24. Potential Art Locations

7.7. Neighborhood Impact

Neighborhoods along the Houghton Road corridor will see improved traffic circulation due to the access management plan being implemented with this project. Median openings will typically be provided on ½-mile intervals, helping separate conflict points and providing refuge for vehicles attempting to turn from Houghton Road.

The most significant benefits are expected in the vicinity of Emily Drive, which currently experiences a significant amount of cut-through traffic from people who use it as an alternative to connect to Bonanza Avenue and Golf Links Road while avoiding Houghton Road. The access management plan and improved capacity will reduce congestion along Houghton, thus reducing the need to use neighborhood streets.

Some challenges will be experienced by Civano residents, as Civano Boulevard will be limited to right turns only due to its proximity to Irvington Road, making Seven Generations Way the only full-access point to Houghton Road. However, the impact will be mitigated by the good internal connectivity within the site. Civano Boulevard connects to Drexel Road, which will be signalized, allowing one more point of access into Civano. Likewise, Metropolitan Drive (another minor collector within Civano) connects to Bilby Road, adding one more signalized access location.

7.8. Community Resource Impact

The only school with direct access onto Houghton Road is Secrist Middle School, located ¼ mile north of Escalante Road. Circulation at Secrist Middle School will be greatly improved by the project, which will include revisions to the school entrances, parking areas, and pedestrian crossings (see Figure 10). Revisions include combining the main entrance and exit to one location; providing a southbound right-turn lane and a northbound left-turn into the school's main driveway; eliminating left turns out of the main driveway; providing a directional median opening for buses exiting the bus driveway; relocating the school crosswalk away from major vehicular conflict points; and adding a pedestrian signal

Churches located on Houghton Road will also see improved circulation from the roadway improvements. Pantano Christian Church, located at the northeast corner of Houghton Road and 29th Street, will benefit from a full access median opening at the intersection. Mount Olive Lutheran Church of Tucson and Sahuaro Baptist Church of Tucson ,located on Houghton Road between 29th Street and Old Spanish Trail, will also see reduced back-ups during church services as access to both churches will be right-in, right-out only with convenient u-turn opportunities within ¼ mile of the church sites. The Eastside Assembly of God will also be easily accessible from the intersection of Houghton Road and Escalante Road.

Tucson Fire Department's Station 17 will also benefit from the project, as an emergency signal will be provided to allow fire vehicles easier access to/from Houghton Road (see Figure 11). The signal will be located across from Seven Generations Way and will require a minor realignment of the fire station's entrance.

8. PUBLIC INVOLVEMENT

The public involvement process has been a joint effort of Gordley Design Group, the City of Tucson, and Psomas. In supporting the project goals and objectives, the project team recognizes that conveying and collecting accurate and easy-to-understand information is vital to the public involvement effort and the success of the project. Members of the public are provided with a basic understanding of the project to help them provide input and express their concerns. The project team has maintained contacts with residents, neighborhood associations, businesses, elected officials and other individuals and entities. Public outreach efforts focus on information exchange with the public that affords an opportunity for understanding what is important to the public at an early stage and for seeking ways to respond to citizen issues as an integral part of the design concept process. The following specific strategies have been used in order to involve residents, businesses and other project stakeholders:

- Open houses
- Project website
- Citizen Design Review Committee
- Meetings with individual stakeholders or groups

Open houses have been used on this project in order to present information to the public and obtain feedback. Two have been conducted to date, and one more is anticipated during the DCR stage to present the status of the project. The public meetings are publicized through news releases distributed to the appropriate media and through display advertisements placed with the *Tucson Citizen* and *The Arizona Daily Star* a minimum of 15 days prior to each meeting. Meeting announcements are mailed to the project contact list of approximately 8,500 addresses, which comprise project area residents and businesses, as well as elected officials. Corresponding information is posted on the dedicated project Web site (*www.houghtonroad.info*). Sign-in sheets are provided to record attendance at the meetings, and attendees are asked to submit comments by mail, e-mail, comment form, or the Web site. Comments submitted during a two-week period following each meeting are documented and summarized for the project team, and questions receive a response.

First Open House

The first round of open houses took place on June 6, 2007 at Secrist Middle School and on June 13 at the Desert Sky Middle School. There were 145 attendees at the June 6, 2007 open house and 60 attendees at the June 13, 2007 open house. Exhibits with typical cross-sections, existing traffic volumes, and aerial photos of the area where used to discuss the key project issues.

One hundred and sixteen comments were received through comment forms and e-mail. The most common issues commented on included (starting with the most common):

- Build six lanes (don't start with a four-lane road)
- Noise concerns
- General access issues - turn lanes, median openings, signals, turn arrows
- Need for pedestrian facilities, bike lanes and trails
- Access to/from Austin Point
- Landscaping/art/views
- Access to McGraw Cantina
- Construction timeline/phasing
- Improvements at Secrist Middle School
- Property acquisition concerns

Second Open House

The second public open house took place on November 8, 2007 at the Secrist Middle School. Its purpose was to present the initial alignment concept to the residents of the area and receive feedback. M.J. Dillard (Project Manager for the City) and Alejandro Angel (Project Manager for Psomas) delivered a power point presentation with an overview of the project, the feedback received in the first open house, how the project team was incorporating the public comments received, and introduction of the alignment concept. The presentation was followed by a question and answer session.

Three stations were available for with displays of the proposed roadway alignment, access management, and intersection layout overlaid on an aerial photo. The approximately 141

attendees were able to see the exhibits and discuss any specific questions with members of the design team (Figure 25).

Figure 25. November 8, 2007 Open House

Thirty comment forms were received during the open house or the following two-week comment period. The most common comments were related to the following:

- Design and posted speed limit
- Noise abatement
- Access locations
- Light pollution
- Bicycles and pedestrians
- Bus service

Project website

Project information is also available online at *www.houghtonroad.info*. Some of the information available includes aerial maps, traffic volumes, typical road sections, power point presentations

delivered at open houses or to the Citizens Design Review Committee, the comments received at the open houses, and meeting summaries. Contact information for the City of Tucson project manager and frequently asked questions are also available on the website.

Citizen Design Review Committee (CDRC)

The project team has also actively interacted with a CDRC appointed by Ward IV to accompany the development of the design concepts for the central and southern segments of Houghton Road. There are between 10 and 15 CDRC members representing areas such as Civano, Harrison East, Desert Willow, Mesquite Ranch, Rita Ranch and South Harrison, among others. Approximately 10 meetings between the project team and the CDRC have been since May 2007 at the Clements Center.

Meetings with other stakeholders

The City of Tucson, Psomas, and Gordley Design have met with several public stakeholders at their request during the development of the project. The meetings have ranged from informational meetings to discussions of the design at specific locations. To date, the project team has met with Secrist Middle School Representatives, Tucson Fire Department Station 17, Civano and Mesquite Ranch Neighborhood Associations, McGraw's Cantina, and Highland Trails, among others.

9. AGENCY COORDINATION

Coordination between the City of Tucson and the design team has been ongoing since the beginning of the project. Progress meetings are held monthly and in preparation for public meetings in order to ensure that the schedule is maintained and that no design issues are overlooked.

Close coordination will also be required with Pima County Department of Transportation (PCDOT). A 7/8-mile stretch of Houghton Road between Golf Links Road and Escalante Road is located within Pima County jurisdiction. The City of Tucson will administer the design and construction for the project, including the portion within Pima County's jurisdiction. PCDOT will review the design concept report and plans for the project. An Intergovernmental Agreement (IGA) will be developed between the City and Pima County prior to construction to clarify funding responsibilities.

An IGA is already in place between the City of Tucson and the Regional Transportation Authority for the development of this project. There is also an IGA between City and County Parks Departments for the greenway. The City's Department of Transportation will enter into a Memorandum of Understanding (MOU) to use $1 million of County Parks Bonds towards this project.

In addition, the City of Tucson, Pima County and Psomas have met with Tucson Unified School District (TUSD) and Secrist Middle School officials as Secrist Middle School is also located within Pima County's stretch of Houghton Road. Coordination with TUSD officials will be ongoing as plans for improving circulation at the school are finalized.

Coordination has been ongoing and will continue with Pima County Regional Flood Control District (PCRFCD) regarding improvements to the Pantano Wash channel. Ongoing coordination will be required with the Federal Emergency Management Agency (FEMA) regarding jurisdictional delineations and 404 permitting.

Utilities such as Tucson Water, Tucson Electric Power, Southwest Gas, Cox Communications, and Qwest have been contacted to obtain as-built utility information and to determine utilities'

plans with the project area. Coordination will continue through the planning and design process. The 30% preliminary project plans will be submitted to the utility companies when the DCR is completed.

10. ALTERNATIVES

During the development of the design concept several alternatives were considered for different aspects of the project. Some of the most notable alternative analyses included:

Typical Section Alternatives

Three design alternatives were considered for the roadway typical section during the design planning process:

1) A four-lane typical section without outside curb
2) A six-lane typical section without outside curb
3) A six-lane typical section with outside curb

A detailed discussion of these alternatives is located in the Traffic and Safety Data section of this report (Section 4), and in Section 5.7 (Cross-Sectional Elements). The analysis indicated that traffic demand would require a six-lane section. Outside curb was selected north of Irvington Road to channelize drainage and because of the area's higher level of development. South of Irvington Road the outside of the road will be uncurbed to maintain natural drainage patterns. The median will not be curbed in order to allow for water harvesting. The exceptions are signalized intersections, where the median will be curbed through the storage and taper of the longest turn lane in order to control access, channelize drainage, and protect the signal poles and additional hardware.

Pantano Wash Bridge Alternatives

Six design alternatives were considered for the bridge system over the Pantano Wash. Detailed discussion of these alternatives is located in the Major Design Features section of this report (Section 6.8, structures). Alternative 2, which consisted of maintaining the existing bridge and constructing a second bridge for northbound traffic, was selected due to its lower cost and reduced construction and utility impacts.

Alternatives for Earth Retention Systems

Different types of treatments for areas that required earth retention systems where presented in Section 6.5, Earthwork Considerations. In general, concrete retaining walls were selected for

walls less than 10 to 15 feet high, while MSE walls and soil-nailed walls were recommended for walls over 15 feet in fill and cut areas, respectively.

Pavement Design Alternatives

The use of rubberized asphalt for pavement noise mitigation was also considered in place of a standard asphalt mix. Discussion of the pavement criteria used for this project is located in the Design Criteria section of this report (Section 5.3, Pavement Structure), and the pavement alternatives considered are discussed in the Major Design Features section (Pavement Design, Section 6.9). In addition, a discussion of noise mitigation is located in the Social, Economic, and Environmental Considerations section of this report.

11. CONCLUSIONS AND RECOMMENDATIONS

Under current conditions, the section of Houghton Road between Old Spanish Trail and Valencia Road is over capacity, particularly the segment between Golf Links Road and Escalante Road. With southeast Tucson continuing to develop, the traffic demand on Houghton Road will grow significantly. The traffic analysis found that in the design year (2030) Houghton Road will serve between 45,000 and 75,000 vehicles per day (volumes will vary by segment). Because of its role as the primary mobility corridor in east Tucson, it is necessary to ensure that Houghton Road will be able to handle the increased vehicular volumes while also serving users of alternative modes. Implementation of the following items is recommended to maintain mobility and access along Houghton Road:

- Improve Houghton Road to a six-lane desert parkway between 22nd Street and Valencia Road. Avoid the use of vertical curb on the median in order to maximize water harvesting and maintain the scenic character of the area. The design speed for the project should be 50 mph, with a posted speed limit of 45 mph.

- Avoid making interim improvements to a four-lane section to later add two more lanes, as the four-lane road would likely have a very short service life and the additional construction would increase neighborhood impacts.

- Provide multi-use lanes on both sides of the road, construct a sidewalk on the west side of Houghton Road, and develop the greenway (an urban dual path system) on the east side of the road. These improvements will improve the pedestrian and bicyclist experience. Bus pullouts should also be constructed near residential, commercial, educational, and employment centers along the corridor to serve the proposed SunTran Houghton Road route.

- Implement an access management plan to extend the service life of the roadway and improve safety and operations. It is recommended that traffic signals be spaced at one-mile intervals, with full-access median openings every ½ mile and right-turn access only locations separated at least 1/8 mile. Directional median openings can be provided at ¼

mile intervals at key locations with high concentration of turning volumes. At certain locations, existing conditions may require minor deviations from this policy, but those deviations should be evaluated on a case-by-case basis.

- A significant amount of right-of-way (approximately 23 acres) and easements (19 acres) will be required as part of the project. It is recommended that negotiations begin as soon as possible with the major land owners (such as the State Land Department) to obtain the width required (200 feet) to build the ultimate improvements. In addition, request dedication of the recommended right-of-way for new rezonings, development plans and subdivision plats.

- The existing Pantano Wash bridge is in good condition and should stay in place to serve the southbound direction of the ultimate six-lane roadway. A new 57-foot wide bridge should be constructed upstream to serve the northbound direction. Further hydraulic evaluation and planning of the Pantano Wash is now in progress to identify improvements that can mitigate a degradation of the toe down on the existing soil-cement spur dike system.

- Maintain the existing signalized intersections and add new traffic signals at Drexel Road (to serve Civano, Sierra Morado and a new medical center) and at Poorman Road (to serve Mesquite Ranch and the Town Center). The use of Florida T signals is recommended at those locations in order to minimize the negative impacts to the through traffic on Houghton Road.

- The construction of the improvements should be phased in a manner that maximizes the benefits to the community, minimizes construction impacts, and considers the scheduling constraints related to funding availability, permitting requirements and utility relocations. The preliminary construction sequencing recommendation is 1) start with the segment between Irvington Road and Valencia Road; 2) continue with the 22nd Street to Escalante Road segment, and 3) fill in the gap between Escalante Road and Irvington Road.

- Overall, it is anticipated that the funds allocated by the RTA to Houghton Road ($160 M) will be sufficient to complete the project, as this segment, which represents 40-45% of the corridor length, is expected to cost $63.9 million, or approximately 40% of the funds available for the project. However, given that the funds are allocated for the entire corridor, this assessment will depend on the estimated costs for the segments to the north and south of this project.

12. COST ESTIMATE

Table 33 presents the major cost categories for the Houghton Road project. An itemized preliminary project cost estimate is included in Appendix 5.

Table 33. Project Cost Summary

ITEM DESCRIPTION	DCR PROJECTED COST
Roadway Construction	$34,372,860.00
Drainage	$9,116,050.00
Utility Relocations and Modifications	$1,500,000.00
Signing	$200,000.00
Striping	$220,000.00
Lighting	$300,000.00
Landscaping	$1,100,000.00
Traffic Signals	$2,100,000.00
Subtotal Roadway Construction Costs	**$48,908,910.00**
Contingencies (20%)	$9,781,782.00
Design Fees (7%)	$3,423,623.70
Right-of-Way	$3,450,000.00
Easements	$800,000.00
PROJECT TOTAL	**$66,364,315.70**

The approximate cost by recommended construction phasing of the central segment is:

Phase 1: Irvington Road to Valencia Road - $30,678,462
Phase 2: 22nd Street to Escalante Road - $21,123,251
Phase 3: Escalante Road to Irvington Road - $14,562,602

13. BUDGET CONSIDERATIONS

Financing for the Houghton Road corridor will come from several sources including the Regional Transportation Authority (RTA), impact fees, bonds and other funds. The RTA plan identified a total of $160,642,000 in funds available for Houghton Road between I-10 and Tanque Verde Road (13 miles). Widening to six lanes is projected south of Old Spanish Trail, while four lanes are anticipated north of Old Spanish Trail. $95.3 million of that amount will come from the half-cent tax approved by voters in 2006. The RTA funding is expected to be available in periods 1 (FY 2007-FY 2011) and 3 (FY 2017-FY 2021) of the plan.

The remaining $65.3 million funds come from impact fees already in reserved or anticipated for the future, as well as $1 million for the greenway from vote-approved Pima County Bonds for Parks and Recreation, City of Tucson funds, and Pima County contributions. There is also additional federal funding to replace the Houghton Road bridge over the Union Pacific Railroad tracks.

Houghton Road is also identified in the *2030 Regional Transportation Plan (RTP)* published by PAG. The segment from Old Vail Road to Old Spanish Trail (Plan ID#262.98) is proposed for the late period with a budget of $41,250,000. The RTP considers the greenway between Valencia Road and Old Spanish Trail as separate projects (Plan ID#211.03 and 212.03) with a combined cost of $1.9 Million in the medium period. Finally, the *2008-2012 Transportation Improvement Plan (TIP),* which allocates committed funding for the next five years, includes $4.5 Million in funds for the design of the segment between Valencia Road and Old Spanish Trail in FY 2008-10.

Overall, it is anticipated that the funds allocated by the RTA to Houghton Road ($160 M) will be sufficient to complete the project, as this segment, which represents 40-45% of the corridor length, is expected to cost $66.4 million, or approximately 42% of the funds available for the project. However, given that the funds are allocated for the entire corridor, this assessment will depend on the estimated costs for the segments to the north and south of this project.

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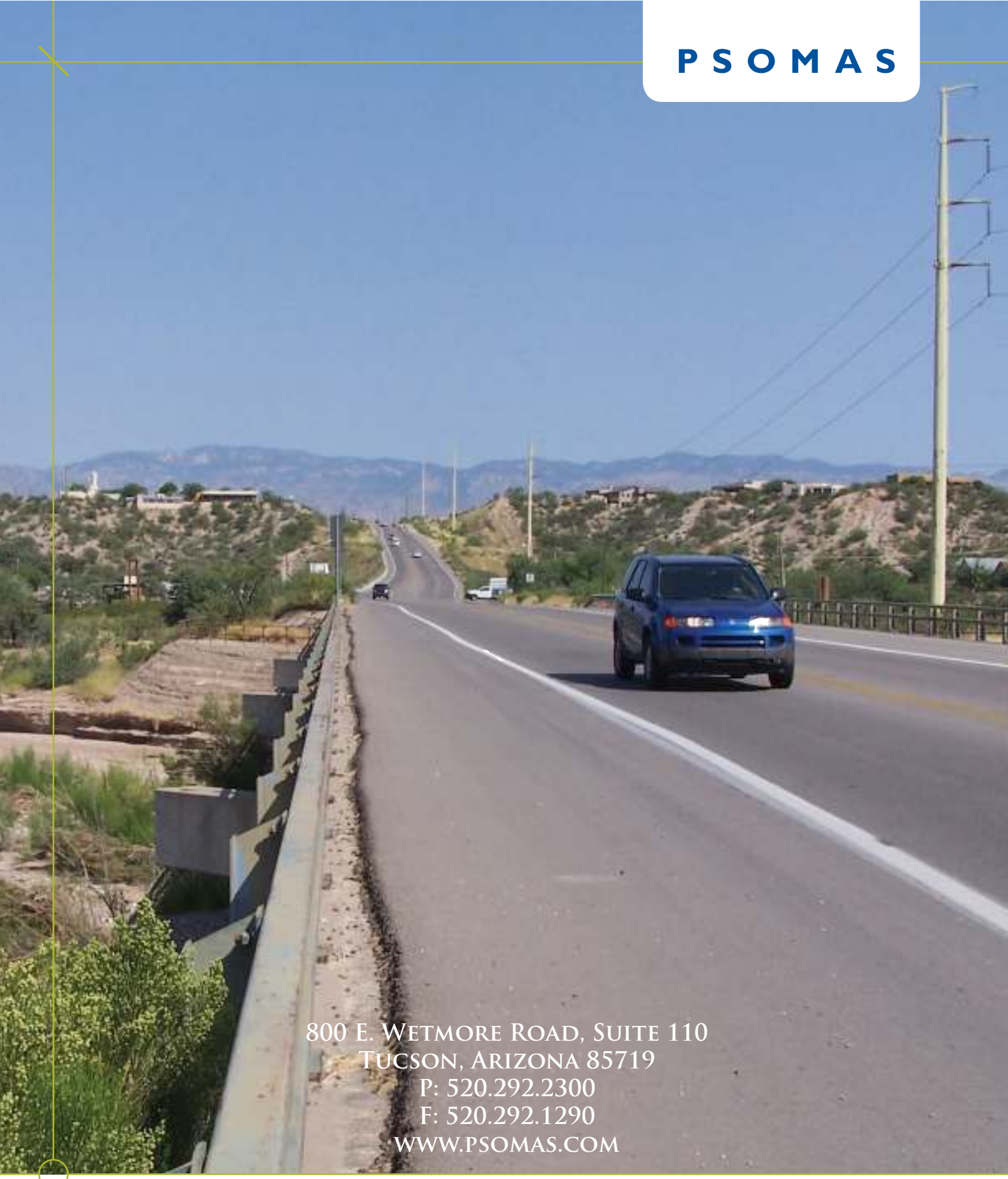

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