Section

10

PCD Project Plan

Traffic Study and Analysis

In accordance with Washington City Zoning Ordinance 29-2-103(10), the Traffic Study and Analysis completed by Orth-Rodgers Associates is included in this section.

Orth - Rodgers & Associates, Inc.
TRANSPORTATION ENGINEERS and PLANNERS

TRAFFIC ENGINEERING
AND DESIGN SERVICES

for

THE SIENNA HILLS COMMUNITY

Prepared for:

State of Utah

School and Institutional Trust Lands Administration

August 2004

1140 Town Center Dr, Ste 190 • Las Vegas, Nevada 89144
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EXECUTIVE SUMMARY

Orth-Rodgers & Associates (ORA) performed a traffic study for the project known as the Sienna Hills Master Planned Community (hereafter, Sienna Hills) involving the following tasks:

- Field review of the project site;
- Assessment of current traffic conditions;
- Trip generation and assignment of traffic generated by future land uses;
- Roadway and intersection conceptual design;
- Assessment of future traffic conditions; and
- Access management policy creation.

The project site area is 716 acres located east of the City of Washington, Utah, and is divided into 15 separate parcels. Each parcel has also been subdivided into separate land uses ranging from residential to commercial. The site is bounded to the north by Interstate 15, to the west by the proposed Washington Parkway, and to the south by Telegraph Road. Currently, the land to the east is undeveloped.

Regional access to the site will be provided by Interstate 15 through the future interchange of Washington Parkway at Milepost 13. Locally, Telegraph Road will provide east-west access to the site.

This is a new development on undeveloped property. There are no existing roadways located within the project limits. No analyses of the existing roadway conditions will need to be performed. It should be noted that North, Center, and South Road names are arbitrary names given to future roads for clarification throughout this report and may be changed at a later time. Further, the section of North Road located just east of the roundabout with Washington Parkway to just east of the next intersection along the North Road will be referred to hereafter as the "Business Corridor." For further clarification, see Figure 1 of this report.

Future volumes for the Sienna Hills project were based on the proposed land use divisions. The site generated traffic for this project was assumed to be the lone generator of the future traffic, for the majority of the interior streets. Tables 1-3 list the individual land uses and their corresponding AM peak hour, PM peak hour, and daily trips generated by each land use. The tables also list the appropriate Land Use Code from the Seventh Edition of the ITE Trip Generation publications.

With trip generation established the next step was the development of a trip distribution model for site-related traffic. Trip distribution was calculated considering the future traffic flows and the area network configuration. The percentages were then compared to those of the *Milepost 13 Planned Community Development* traffic study for consistency and accuracy. Trip distribution percentages are illustrated in Figure 2 and summarized below:

- 10% to/from the north on Washington Parkway
- 30% to/from the south on Interstate 15
- 20% to/from the north on Interstate 15
- 2.5% to/from the west on North Road
- 2.5% to/from the west on Center Road
- 5% to/from the west on South Road
- 15% to/from the west on Telegraph Road
- 15% to/from the east on Telegraph Road

The number of lanes along each link and at each intersection of the roadway network depended on the Level-of-Service (LOS) desired to accommodate the bi-directional volumes determined in the trip generation. The provisions set forth in the Highway Capacity Manual (HCM) and A Policy on Geometric Design of Highways and Streets (2001) produced by American Association of State Highway and Transportation Officials (hereafter, AASHTO 'Green Book') were maintained to assure the desired LOS "C." The lane configurations for the network are displayed in Figure 4 and summarized in the following two classifications:

- North Road Business Corridor:

  - Functional classification of Urban Collector was assumed;
  - 35 mph was assumed for a speed limit;
  - Two lanes in each direction with a TWLTL as a median;
  - A left turn, through, and shared through-right lane at each intersection;
  - Two-way stop controlled intersections from all approaches; and
  - Two lanes on the approach to the roundabout matching the 90 foot section at the roundabout.

- All other roads:

  - Functional classification of Rural Collector was assumed;
  - 35 mph was assumed for a speed limit;
  - One lane in each direction with centerline;
  - A left turn lane at each intersection with a shared through-right turn lane; and
  - Two-way stop controlled intersections.

A flared intersection is required to accommodate the additional left and right turn lane storage located at the interior intersections. The roundabouts located within the project limits were designed to the specifications set forth by the Federal Highway Administration's Roundabout Guide. Results showed that only one lane roundabouts were needed.

It is recommended that eleven foot lanes be used throughout the site, except for the "Business Corridor", where twelve-foot lanes are recommended. Further, ORA recommends a sfour-foot shoulder on all local collector roads. An eleven-foot two-way-left-turn-lane (TWLTL) is recommended for the "Business Corridor" of North Road. Assuming 33% of the approach volumes make left turns and 50/50 split of the bi-directional volumes, the amount of traffic traveling along the "Business Corridor" justifies the TWLTL. Further, ORA recommends that a left turn lane with at least 100 feet of storage be placed at every other intersection to accommodate any unexpected left turn movement peaks and future turn volumes. The intersections that require 125 feet of storage are the intersections of Washington Parkway with Center and South Roads. The proposed storage needs are shown in Table 4. The recommended lane configurations are displayed in Figure 4.

The minimum access spacing was determined by comparing the results of six different methods outlined in the Access Management Manual produced by the Transportation Research Board. After further analyses, ORA recommends that the full access intersections (all turns allowed) be spaced no closer than 870 feet.

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INTRODUCTION

Orth-Rodgers & Associates performed a traffic study for the project known as the Sienna Hills Master Planned Community (hereafter, Sienna Hills) involving the following tasks:

- Field review of the project site;
- Assessment of current traffic conditions;
- Trip generation and assignment of traffic generated by future land uses;
- Roadway and intersection conceptual design;
- Assessment of future traffic conditions; and
- Access management policy creation.

Project Background

The project site area is 716 acres located just east of the City of Washington, Utah, and is divided into 15 separate parcels. Each parcel has also been subdivided into separate land uses ranging from residential to commercial. The site is bounded to the north by Interstate 15, to the west by the proposed Washington Parkway, and to the south by Telegraph Road. Currently, the land to the east is undeveloped.

Regional and Local Access

A field review was conducted to note existing topography of the project site. This field review included review of Interstate 15 and Telegraph Road.

Regional access to the site will be provided by Interstate 15 through the future interchange of Washington Parkway at Milepost 13. Locally, Telegraph Road will provide east-west access to the site.

Methodology

This is a new community, therefore all future traffic will be generated from within the community. To this end, there will be no future background traffic; only site-generated traffic will be present. Therefore, the future peak hour volumes were determined by the ITE Trip Generation publications using the various land uses detailed by the client.

The Utah Department of Transportation (UDOT) has designed an interchange along Interstate 15 for Washington Parkway at Milepost 13. In this design Washington Parkway was designed from Interstate 15 to the roundabout located on Washington Parkway. The design of Washington

Parkway from the aforementioned roundabout to Telegraph Road has already been completed and will be taken into account in this traffic study. The peak hour volumes were then assigned to the roadway network based on the traffic patterns outlined in the *Milepost 13 Planned Community Development Traffic Study* performed by Alliance Consulting.

The roadway network was designed to accommodate the bi-directional volumes with a Level-of-Service (LOS) "C" or better by maintaining the provisions set forth in A Policy on Geometric Design of Highways and Streets (2001) produced by American Association of State Highway and Transportation Officials (hereafter, AASHTO 'Green Book') and the Highway Capacity Manual (2001). By definition, LOS ranges from "A" to "F" with delay starting at zero seconds per vehicle for Level "A" and progressively getting longer through Level "F". During peak hour conditions a LOS "C" (20 to 25 seconds of delay per vehicle) was considered acceptable.

The minimum access spacing was determined by comparing the results of six different methods outlined in the Access Management Manual produced by the Transportation Research Board. These methods are based on the criteria listed below:

- Safety;
- Stopping sight distance;
- Intersection sight distance;
- Right-turn conflict overlap;
- Influence distance; and
- Egress capacity.

The results of these methods were then compared and the method that resulted in the largest minimum spacing was accepted for this project's access spacing.

EXISTING CONDITIONS

As stated earlier, this is a new project, therefore, there are no existing roadways located within the project limits. No analyses of the existing roadway conditions will need to be performed. It should be noted that North, Center, South, Far South, East, and West Road names are arbitrary names of future roads used for clarification throughout this report and will be changed at a later time. Further, the section of North Road located just east of the roundabout with Washington Parkway to just east of the next intersection along the North Road will be referred to hereafter as the "Business Corridor." This section is shown, along with the rest of the site map in Figure 1.

FUTURE TRAFFIC CONDITIONS

The projected year for build-out on this project is 2005.

Trip Generation

Future volumes for the Sienna Hills project were based on the proposed land use divisions. The site generated traffic for this project was assumed to be the lone generator of the future traffic. Tables 1-3 list the individual land uses and their corresponding AM peak hour, PM peak hour, and daily trips generated by each land use. The tables also list the appropriate Land Use Code from the Seventh Edition of the ITE Trip Generation publications.

Not to Scale

SITE MAP
SIENNA HILLS
CITY OF WASHINGTON, UTAH

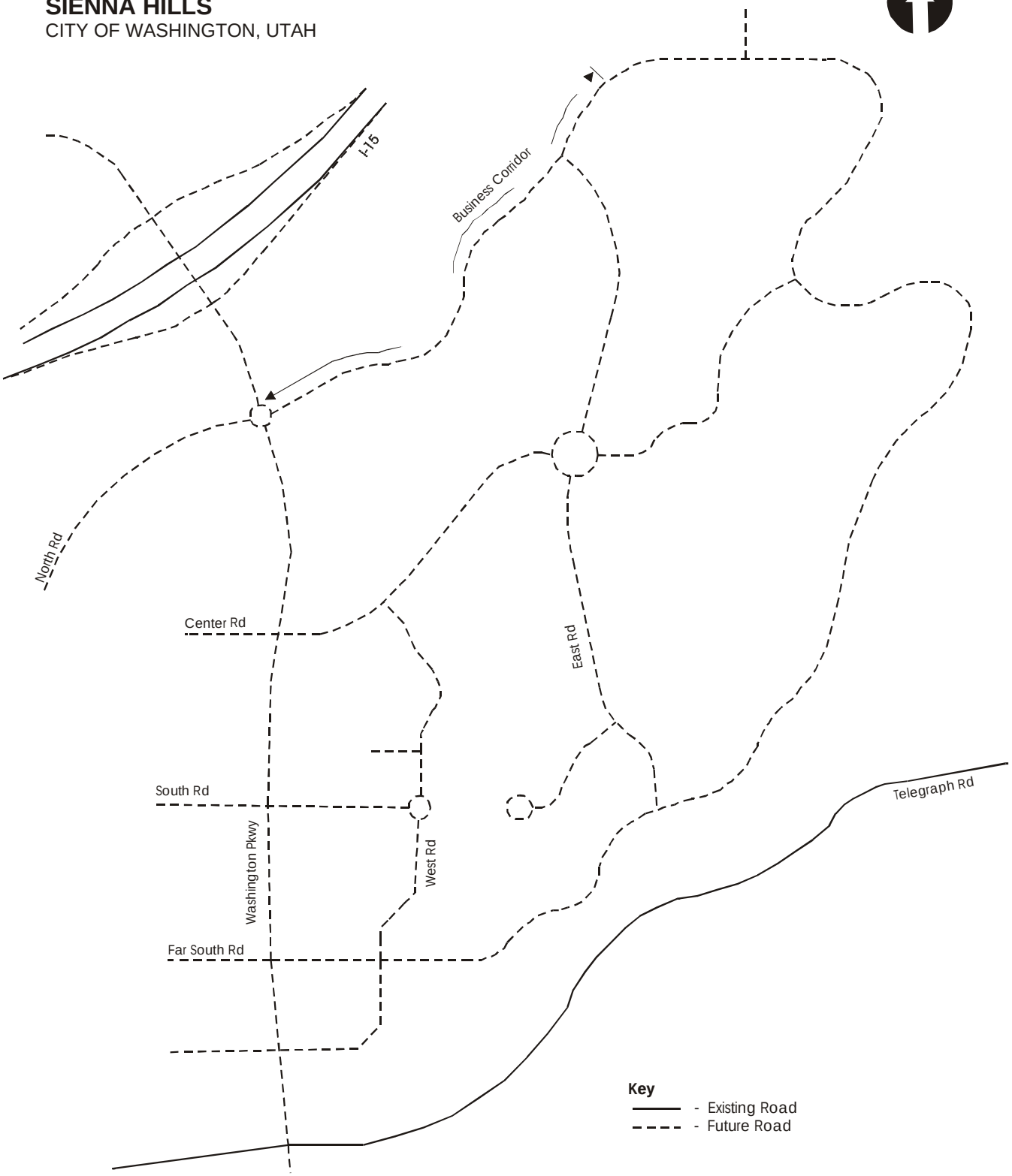


Figure 1: Site Map

Table 1: AM Peak Hour Trip Generation

AM PEAK HOUR

Parcel	Acres	Land Use (Code)	Units	Average Rate	Enter	Exit	Entering Vehicles	Exiting Vehicles
1	15.6	Apartment (220)	187 Dwelling Units	0.51	20%	80%	19	76
2	4.8	Apartment (220)	58 Dwelling Units	0.51	20%	80%	6	24
3	15.4	Single-Family Detached Housing (210)	77 Dwelling Units	0.75	25%	75%	14	43
4	59.3	Single-Family Detached Housing (210)	296 Dwelling Units	0.75	25%	75%	56	167
	1.3	Multipurpose Recreational Facility (435)	1.3 Acres	9.04	61%	39%	7	5
5	13.0	Single-Family Detached Housing (210)	39 Dwelling Units	0.75	25%	75%	7	22
6	42.1	Single-Family Detached Housing (210)	126 Dwelling Units	0.75	25%	75%	24	71
7	57.7	Single-Family Detached Housing (210)	173 Dwelling Units	0.75	25%	75%	32	97
8	49.0	Single-Family Detached Housing (210)	245 Dwelling Units	0.75	25%	75%	46	138
9		Supermarket (850)	100,000 Square Feet	3.25	61%	39%	198	127
		Motel (320)	200 Rooms	0.45	37%	63%	33	57
		Gasoline/Service Station with Convenience Market (945)	12,800 Square Feet	77.68	51%	49%	507	487
10		Building Materials & Lumber Store (812)	150,000 Square Feet	2.60	67%	33%	261	129
		Supermarket (850)	100,000 Square Feet	3.25	61%	39%	198	127
		Free-standing Discount Store (815)	100,000 Square Feet	0.84	68%	32%	57	27
		Shopping Center (820)	85,100 Square Feet	1.03	61%	39%	53	34
		Motel (320)	600 Rooms	0.45	37%	63%	100	170
		Fast Food Restaurant with Drive-through Window (934)	6,500 Square Feet	53.11	51%	49%	176	169
		High-Turnover (Sit Down) Restaurant (932)	16,700 Square Feet	11.52	52%	48%	100	92
11	12.3	Apartment (220)	148 Dwelling Units	0.51	20%	80%	15	60
		Elementary School (520)	51,000 Square Feet	4.69	54%	46%	129	110
		Library (590)	15,400 Square Feet	1.06	72%	28%	12	5
12	13.8	Apartment (220)	166 Dwelling Units	0.51	20%	80%	17	68
	4.5	Church (560)	33,600 Square Feet	0.72	54%	46%	13	11
		Recreational Community Center (495)	21,900 Square Feet	1.62	61%	39%	22	14
	2	Multipurpose Recreational Facility (435)	2 Acres	9.04	61%	39%	11	7
13	4.13	Shopping Center (820)	34,000 Square Feet	1.03	61%	39%	21	14
14	20.9	Apartment (220)	251 Dwelling Units	0.51	20%	80%	26	102
15		Business Park (770)	223,500 Square Feet	1.43	84%	16%	268	51
16	5	Shopping Center (820)	41,000 Square Feet	1.03	61%	39%	26	16
						Subtotal	2456	2519
						Internal Capture (15%)	*-368*	*-378*
						TOTAL	**2088**	**2142**

Table 2: PM Peak Hour Trip Generation

PM PEAK HOUR

Parcel	Acres	Land Use (Code)	Units	Average Rate	Enter	Exit	Entering Vehicles	Exiting Vehicles
1	15.6	Apartment (220)	187 Dwelling Units	0.62	65%	35%	75	41
2	4.8	Apartment (220)	58 Dwelling Units	0.62	65%	35%	23	13
3	15.4	Single-Family Detached Housing (210)	77 Dwelling Units	1.01	63%	37%	49	29
4	59.3	Single-Family Detached Housing (210)	296 Dwelling Units	1.01	63%	37%	188	111
	1.3	Multipurpose Recreational Facility (435)	1.3 Acres	9.04	29%	71%	3	8
5	13.0	Single-Family Detached Housing (210)	39 Dwelling Units	1.01	63%	37%	25	15
6	42.1	Single-Family Detached Housing (210)	126 Dwelling Units	1.01	63%	37%	80	47
7	57.7	Single-Family Detached Housing (210)	173 Dwelling Units	1.01	63%	37%	110	65
8	49.0	Single-Family Detached Housing (210)	245 Dwelling Units	1.01	63%	37%	156	92
9		Supermarket (850)	100,000 Square Feet	10.45	51%	49%	533	512
		Motel (320)	200 Rooms	0.47	54%	46%	51	43
		Gasoline/Service Station with Convenience Market (945)	12,800 Square Feet	96.37	50%	50%	617	617
10		Building Materials & Lumber Store (812)	150,000 Square Feet	4.49	47%	53%	317	357
		Supermarket (850)	100,000 Square Feet	10.45	51%	49%	533	512
		Free-standing Discount Store (815)	100,000 Square Feet	5.06	50%	50%	253	253
		Shopping Center (820)	85,100 Square Feet	3.75	48%	52%	153	166
		Motel (320)	600 Rooms	0.47	54%	46%	152	130
		Fast Food Restaurant with Drive-through Window (934)	6,500 Square Feet	34.64	52%	48%	117	108
		High-Turnover (Sit Down) Restaurant (932)	16,700 Square Feet	10.92	61%	39%	111	71
11	12.3	Apartment (220)	148 Dwelling Units	0.62	65%	35%	60	32
		Elementary School (520)	51,000 Square Feet	3.13	43%	57%	69	91
		Library (590)	15,400 Square Feet	7.09	48%	52%	52	57
12	13.8	Apartment (220)	166 Dwelling Units	0.62	65%	35%	67	36
	4.5	Church (560)	33,600 Square Feet	0.66	52%	48%	12	11
		Recreational Community Center (495)	21,900 Square Feet	1.64	29%	71%	10	26
	2	Multipurpose Recreational Facility (435)	2 Acres	9.04	29%	71%	5	13
13		Shopping Center (820)	34,000 Square Feet	3.75	48%	52%	61	66
14	20.9	Apartment (220)	251 Dwelling Units	0.62	65%	35%	101	54
15		Business Park (770)	223,500 Square Feet	1.29	23%	77%	66	222
16	5	Shopping Center (820)	41,000 Square Feet	3.75	48%	52%	74	80
						Subtotal	4124	3875
						Internal Capture (15%)	*-619*	*-581*
						TOTAL	**3506**	**3294**

Table 3: Daily Trip Generation

			DAILY					
Parcel	Acres	Land Use (Code)	Units	Average Rate	Enter	Exit	Entering Vehicles	Exiting Vehicles
1	15.6	Apartment (220)	187 Dwelling Units	6.72	50%	50%	628	628
2	4.8	Apartment (220)	58 Dwelling Units	6.72	50%	50%	195	195
3	15.4	Single-Family Detached Housing (210)	77 Dwelling Units	9.57	50%	50%	368	368
4	59.3	Single-Family Detached Housing (210)	296 Dwelling Units	9.57	50%	50%	1416	1416
	1.3	Multipurpose Recreational Facility (435)	1.3 Acres	90.38	50%	50%	56	56
5	13.0	Single-Family Detached Housing (210)	39 Dwelling Units	9.57	50%	50%	187	187
6	42.1	Single-Family Detached Housing (210)	126 Dwelling Units	9.57	50%	50%	603	603
7	57.7	Single-Family Detached Housing (210)	173 Dwelling Units	9.57	50%	50%	828	828
8	49.0	Single-Family Detached Housing (210)	245 Dwelling Units	9.57	50%	50%	1172	1172
9		Supermarket (850)	100,000 Square Feet	102.24	50%	50%	5112	5112
		Motel (320)	200 Rooms	5.63	50%	50%	563	563
		Gasoline/Service Station with Convenience Market (945)	12,800 Square Feet	963.70	50%	50%	6168	6168
10		Building Materials & Lumber Store (812)	150,000 Square Feet	45.16	50%	50%	3387	3387
		Supermarket (850)	100,000 Square Feet	102.24	50%	50%	5112	5112
		Free-standing Discount Store (815)	100,000 Square Feet	56.02	50%	50%	2801	2801
		Shopping Center (820)	85,100 Square Feet	42.94	50%	50%	1827	1827
		Motel (320)	600 Rooms	5.63	50%	50%	1689	1689
		Fast Food Restaurant with Drive-through Window (934)	6,500 Square Feet	496.12	50%	50%	1612	1612
		High-Turnover (Sit Down) Restaurant (932)	16,700 Square Feet	127.15	50%	50%	1062	1062
11	12.3	Apartment (220)	148 Dwelling Units	6.72	50%	50%	497	497
		Elementary School (520)	51,000 Square Feet	14.49	50%	50%	369	369
		Library (590)	15,400 Square Feet	54.00	50%	50%	416	416
12	13.8	Apartment (220)	166 Dwelling Units	6.72	50%	50%	558	558
	4.5	Church (560)	33,600 Square Feet	9.11	50%	50%	153	153
		Recreational Community Center (495)	21,900 Square Feet	22.88	50%	50%	251	251
	2	Multipurpose Recreational Facility (435)	2 Acres	90.38	50%	50%	90	90
13		Shopping Center (820)	34,000 Square Feet	42.94	50%	50%	730	730
14	20.9	Apartment (220)	251 Dwelling Units	6.72	50%	50%	843	843
15		Business Park (770)	223,500 Square Feet	12.76	50%	50%	1426	1426
16	5	Shopping Center (820)	41,000 Square Feet	42.94	50%	50%	880	880
						Subtotal	41001	41001
						Internal Capture (15%)	*-6150*	*-6150*
						TOTAL	**34851**	**34851**

It should be noted that the *Internal Capture (15%)* listed in each table refers to the trips that start and stop within the project limits. The ITE Trip Generation publications detail a study conducted that determined various internal capture rates ranging from 12% to 53%. A conservative value of fifteen percent was assumed.

Trip Distribution and Assignment

With trip generation established, the next step was the development of a trip distribution model for site-related traffic. Trip distribution was estimated, considering the future traffic flows and the area network configuration. The percentages were then compared to those of the *Milepost 13 Planned Community Development* traffic study for consistency and accuracy, and found to be acceptable. Trip distribution percentages are illustrated in Figure 2 and summarized below:

- 10% to/from the north on Washington Parkway
- 30% to/from the south on Interstate 15
- 20% to/from the north on Interstate 15
- 2.5% to/from the west on North Road
- 2.5% to/from the west on Center Road
- 5% to/from the west on South Road
- 15% to/from the west on Telegraph Road

- 15% to/from the east on Telegraph Road

The trips generated in the previous section were then assigned to roadways according to this distribution. The bi-directional volumes are displayed in Figure 3.

Intersection Design

The turning movements were estimated first by converting the bi-directional volumes into approach volumes at each intersection. The approach volumes were then assigned to turning movements by the aforementioned trip distribution. With the turning movements now known, the following movements warrant an exclusive turn lane as outlined in the 2000 Edition of the Highway Capacity Manual (HCM).

- All movements along the "Business Corridor"
- WBL at Center Road with Washington Parkway
- EBL at South Road with Washington Parkway

Due to the multiple driveways of the businesses along the "Business Corridor", a center two-way-left-turn lane (TWLTL) is recommended. The left turn lane storage requirements were determined for the signalized intersections for the Washington Parkway approaches using the Poisson Method (95% confidence level). The calculations are shown in Appendix 1 and Table 4 summarizes the left turn lane storage requirements per lane below.

Table 4: Left Turn Storage for Signalized Intersections

Intersection	Direction	Volume (VPH)	Cycle Length (sec)	95th Percentile Design Queue (ft)	Proposed Storage (ft)
Washington & Center	EB	53	60	60.73	100
	WB	131	60	115.35	125
Washington & South	EB	110	60	101.52	125
	WB	31	60	42.48	100
Washington & Far South	EB	38	60	48.56	100
	WB	53	60	60.73	100
Washington & West	EB	38	60	48.56	100
	WB	20	60	32.08	100

Although left turn lanes are not warranted throughout the rest of the site, ORA recommends that a left turn lane with 100 feet of storage be placed at each intersection to eliminate potential hazard areas and accommodate unexpected left turn peaks and future turn volumes. As stated in the AASHTO 'Green Book', by introducing left turn lanes, a designer can reduce the number of expected crashes by 20-65%. The recommended lane configurations are displayed in Figure 4.

Table 5 below was taken from Exhibit 10-28 of the HCM. It depicts the criteria used to determine the number of lanes at each intersection.

Table 5: Minor Street Service Volumes for T-Intersection Two-Way Stop Intersection

Major Street Bi-directional Volume (veh/hr)	Level - of- Service (LOS)				
	A	B	C	D	E
	Minor Street Approach Volume Threshold for Single-lane Approach (veh/hr)				
200	110	450	630	700	760
400	N/A	280	460	530	590
600	N/A	150	320	390	440
800	N/A	40	210	270	320
1000	N/A	N/A	120	180	230

The following assumptions are made with this table's numbers: minor street left and right turns are equal; major street left and right turns are 10% of the approach volume; peak-hour factor is 0.92; heavy vehicles is 2%; grade is 0%; conflicting pedestrian flow is very minor; no flared minor approach; no channelization; 50/50 split of major street traffic; two-lanes on the major street; and the major street has a left turn lane.

Network Lane Design

The number of lanes along each link and at each intersection of the roadway network depends on the Level-of-Service (LOS) desired to accommodate the bi-directional volumes determined in the trip generation. It was determined that the desirable LOS to design the network is LOS "C" or better. By definition, LOS ranges from "A" to "F" with delay starting at zero seconds per vehicle for Level "A" and progressively getting longer through Level "F". The provisions set forth in the Highway Capacity Manual (HCM) and AASHTO 'Green Book' were maintained to assure the desired LOS "C." The lane configurations for the network are displayed in Figure 4 and summarized for the following two classifications:

- North Road "Business Corridor":

  - Functional classification of Urban Collector was assumed;
  - 35 mph was assumed for a speed limit;
  - Two lanes in each direction with a TWLTL as a median;
  - A left turn, through, and shared right lane at each intersection;
  - Two-way stop controlled intersections from all business approaches; and
  - Two lanes on the approach to the roundabout matching the 90 foot section at the roundabout.

- All other roads:

  - Functional classification of Rural Collector was assumed;
  - 35 mph was assumed for a speed limit;
  - One lane in each direction with centerline;
  - A left turn lane at each intersection with a shared through-right turn lane; and
  - Two-way stop controlled intersections.

The roundabouts located within the project limits were designed to the specifications set forth by the FHWA Roundabout Guide and it was determined that only single-lane roundabouts were needed. It should be noted that this does not include the roundabout located at the intersection of Washington Parkway and North Road.

Due to the extra lanes present at each intersection, a design for a flared intersection configuration is recommended. The flared intersection allows for the extra space needed for the turn lanes at each intersection, but provides narrower roadways between each intersection. The narrower roadways will maintain the driver's expectations of the speed limit used in this community and thereby produce a safer environment throughout the community. The flared intersection design is shown in Figure 5.

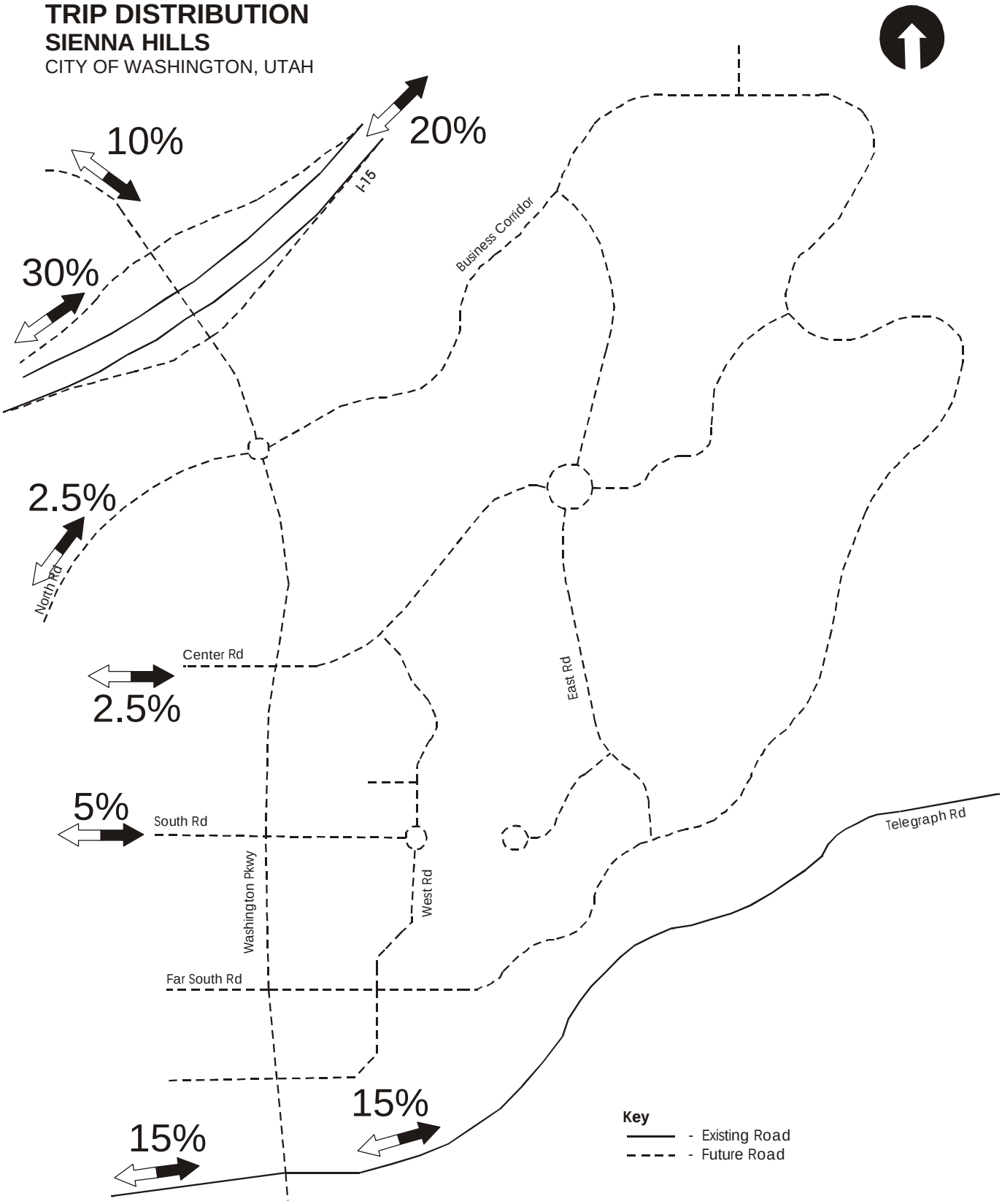


Figure 2: Trip Distribution

Not to Scale

BI-DIRECTIONAL SITE VOLUMES
SIENNA HILLS
CITY OF WASHINGTON, UTAH

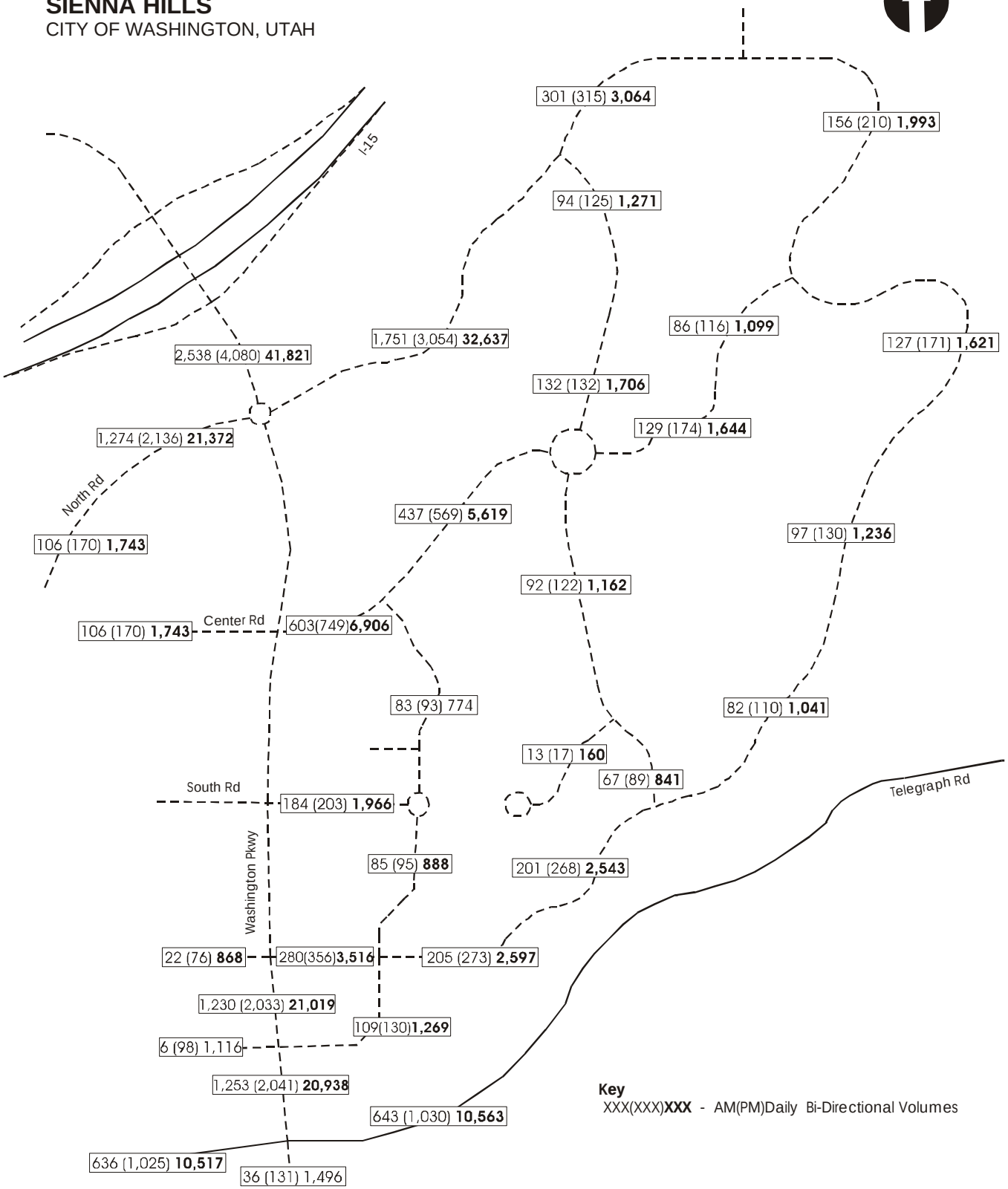


Figure 3: Project Bi-Directional Volumes

LANE CONFIGURATIONS
SIENNA HILLS
CITY OF WASHINGTON, UTAH

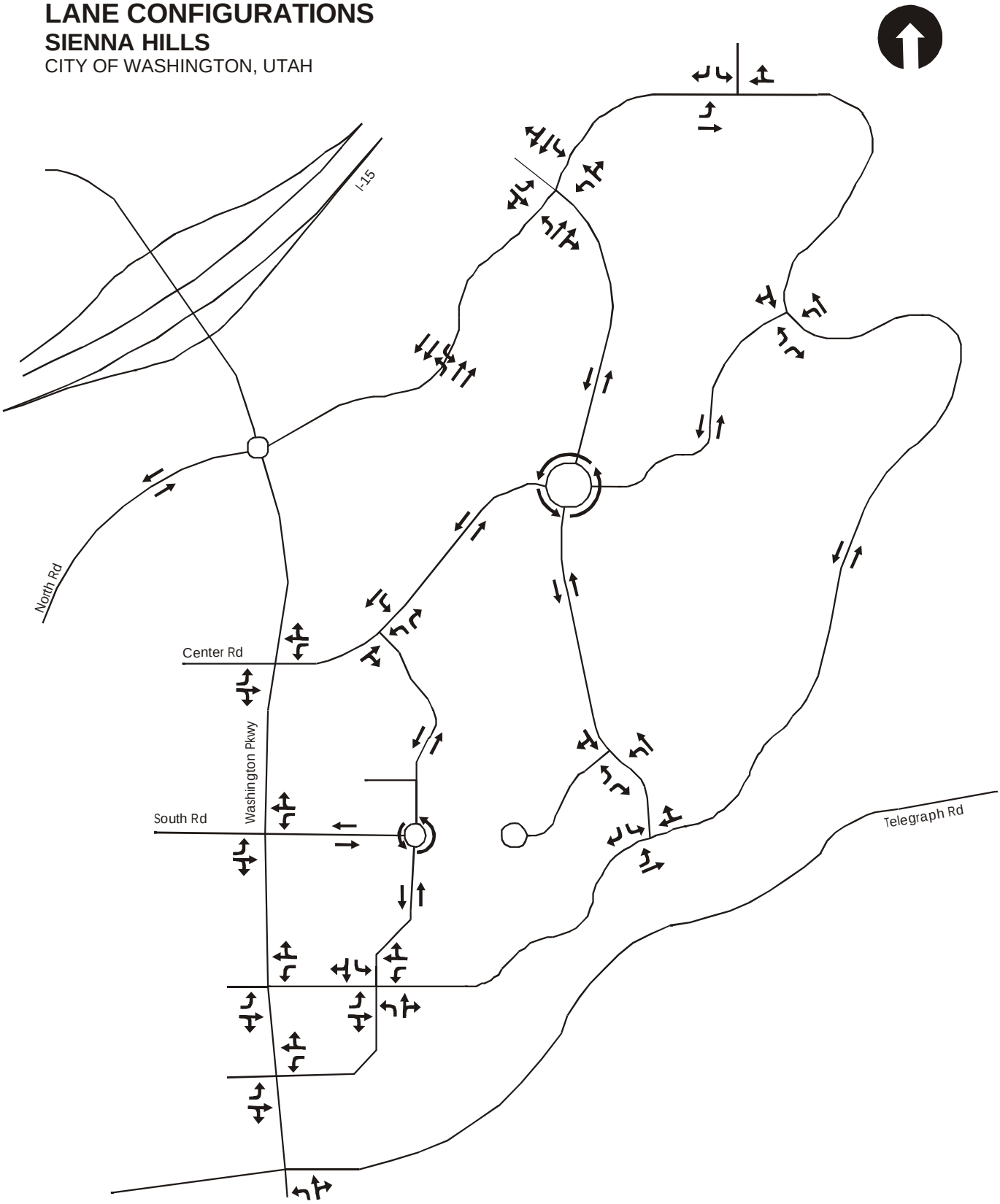
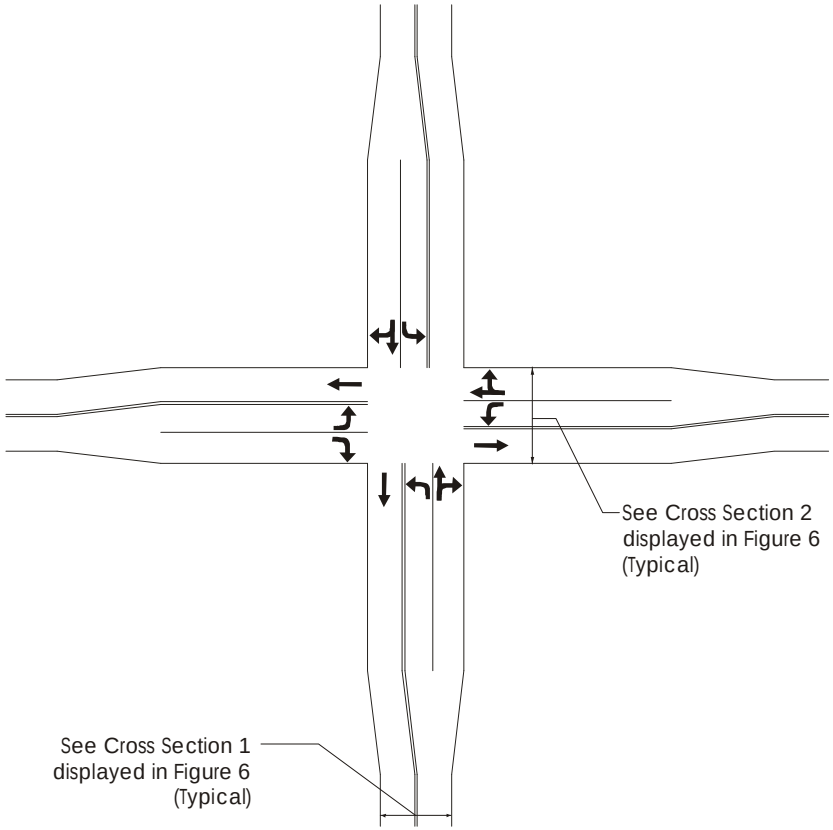


Figure 4: Lane Configurations

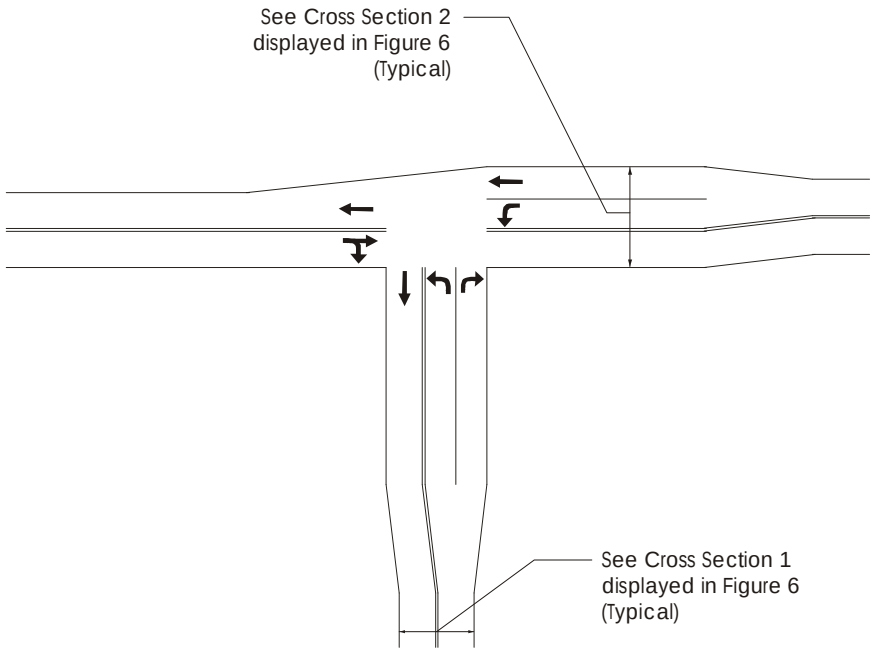
TYPICAL FLARED INTERSECTION DESIGN

SIENNA HILLS

CITY OF WASHINGTON, UTAH



FOUR-LEG FLARED INTERSECTION



THREE-LEG FLARED INTERSECTION

Figure 5: Typical Flared Intersection Design

Lane Widths

Due to the high amount of proposed residential land use throughout this project site and the proximity of the proposed regional pedestrian trail, the presence of pedestrians is assumed to be prevalent throughout this project's roadway network. Further, the project site is located in terrain with rolling hills, which produces potential conflict between pedestrians and vehicles due to sight distance issues. With this in mind, ORA recommends that every step should be taken to assure the safety of the interaction between pedestrians and vehicles. Parkways are suggested between the edge-of-traveled-way and pedestrian paths. This will cause a modification of the typical sections.

As outlined in the AASHTO 'Green Book', the width of each lane is dependent on the functional classification, design speed, and the volume of traffic the lanes will carry. With the factors determined in the preceding sections, it is recommended that 11-foot lanes be used throughout the site, except for the "Business Corridor" where twelve-foot lanes are recommended. Further, we recommend a four-foot shoulder along all local collector roads. The TWLTL located on the "Business Corridor" is recommended to be 12 feet wide to allow for turn movements and storage. The 12-foot width is within the limits specified in the AASHTO 'Green Book' for typical cross-sections. The cross sections have been developed considering the City of Washington Standard Drawing 140, but include some modifications. These cross sections are shown in Figures 6 and 7. It should be noted that there is a parkway present in the "Local" cross sections to enhance the traffic calming design of this development. It has been determined that there is 90 feet of right-of-way available. The "Local" cross sections only require a minimum of 43 feet of right-of-way (if no parkway is present), and therefore, adequate right-of-way is available to accommodate traffic calming measures, such as a parkway between the sidewalks and curb-and-gutter. This cross section is intended to accommodate through traffic. As specific development driveways are determined, a flared approached to major driveways should be considered to accommodate left turns.

If the number of lanes and street widths outlined in the previous section are maintained, LOS "C" or better will be obtained throughout the network.

Roundabout Transition

Due to presence of the roundabout located at the intersection of Washington Parkway with North Road, the cross section is limited to 90 feet of right-of-way. The proposed cross section located east of the roundabout is shown as the "Business Corridor" and detailed in Figure 7. This section also requires 90 feet of right-of-way, but the lane and median widths change. A transition from the roundabout approach to the proposed "Business Corridor" cross section is needed to accommodate the change in widths.

The Manual on Uniform Traffic Control Devices states the following equation to determine the length of transition for an 85^{th} percentile speed at or over 45 mph. This equation follows:

$$L = W * S$$

In this equation, 'W' represents the width of transition and 'S' represents the design speed. For this scenario, the width of transition was equated to two feet (due to the symmetrical transition) and the design speed was conservatively set to 45 mph. This equation yields a transition length of 90 feet. To further ensure adequate transition length, ORA recommends a transition length of 100 feet. See Figures 7 for the cross sections at each end of this transition and Figure 8 for the transition detail.

Not to Scale

LOCAL ROAD CROSS SECTIONS
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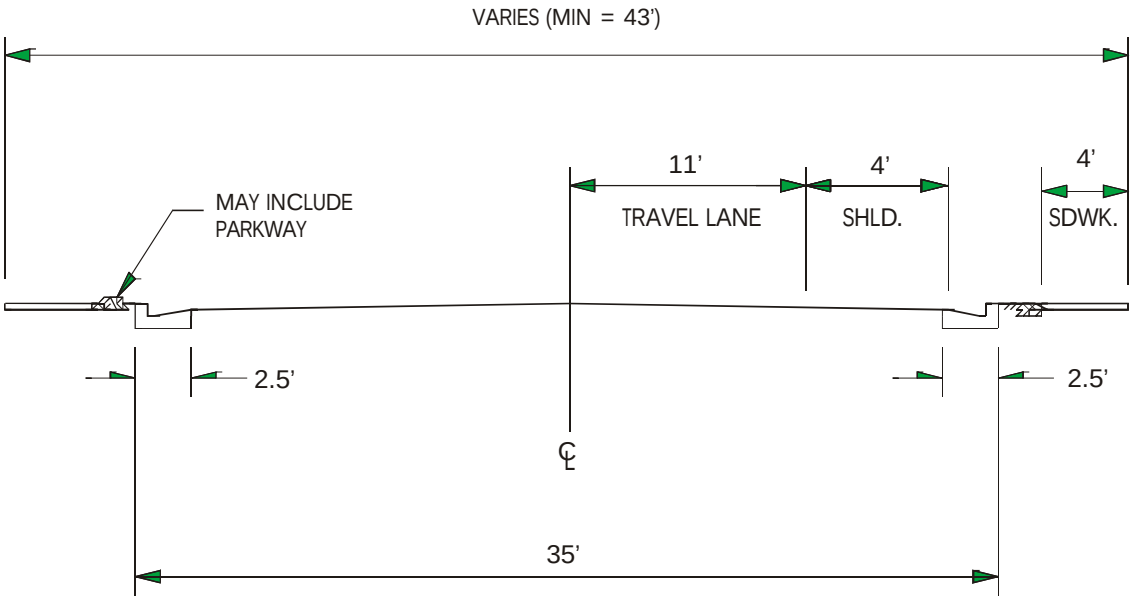
LOCAL ROADS



FLARED INTERSECTION

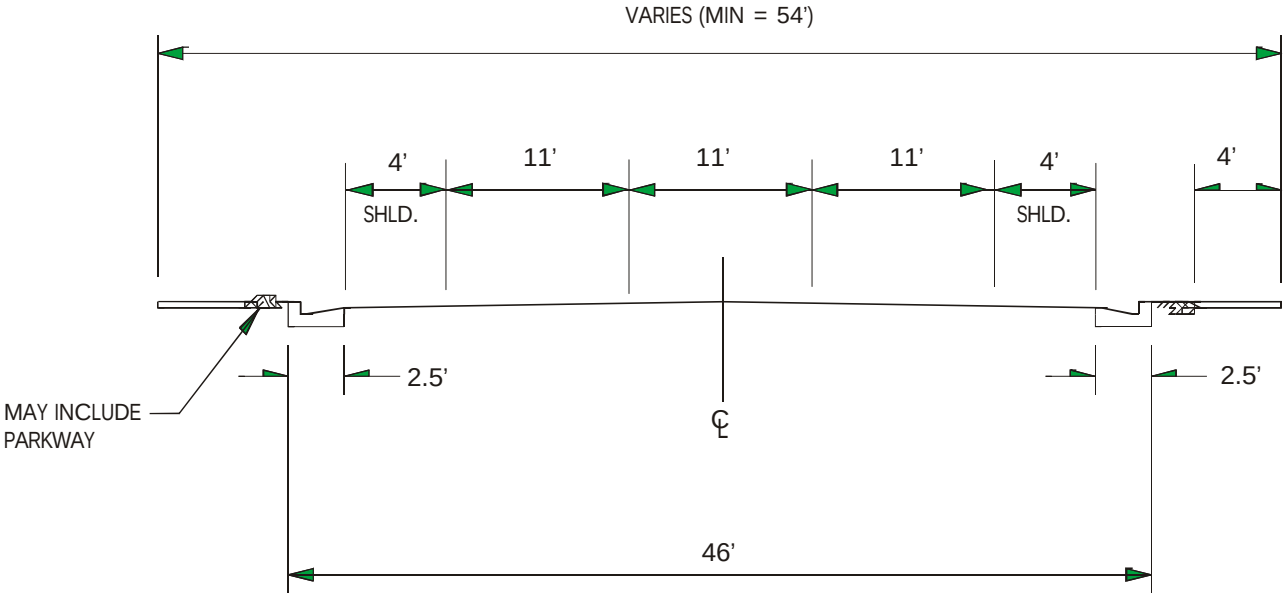


Figure 6: Local Road Cross Sections

BUSINESS CORRIDOR CROSS SECTIONS
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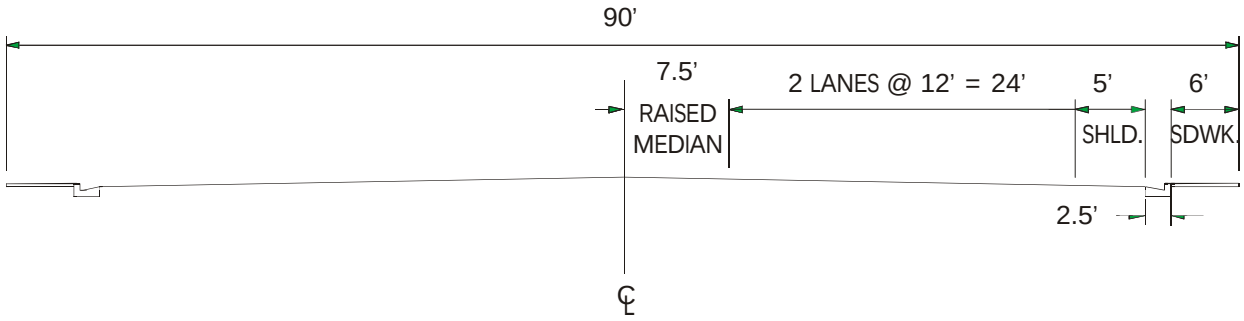
ROUNDABOUT APPROACH (START OF TRANSITION)



BUSINESS CORRIDOR (END OF TRANSITION)

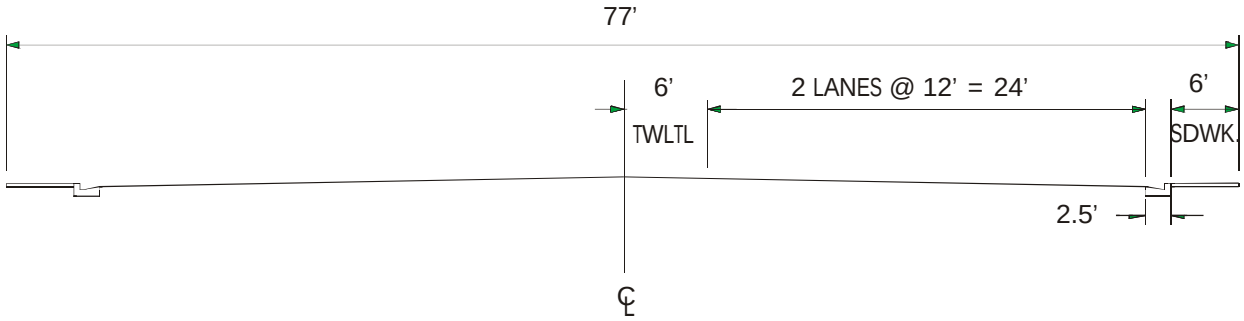


Figure 7: Business Corridor Cross Sections

Not to Scale

NORTH ROAD ROUNDABOUT TRANSITION
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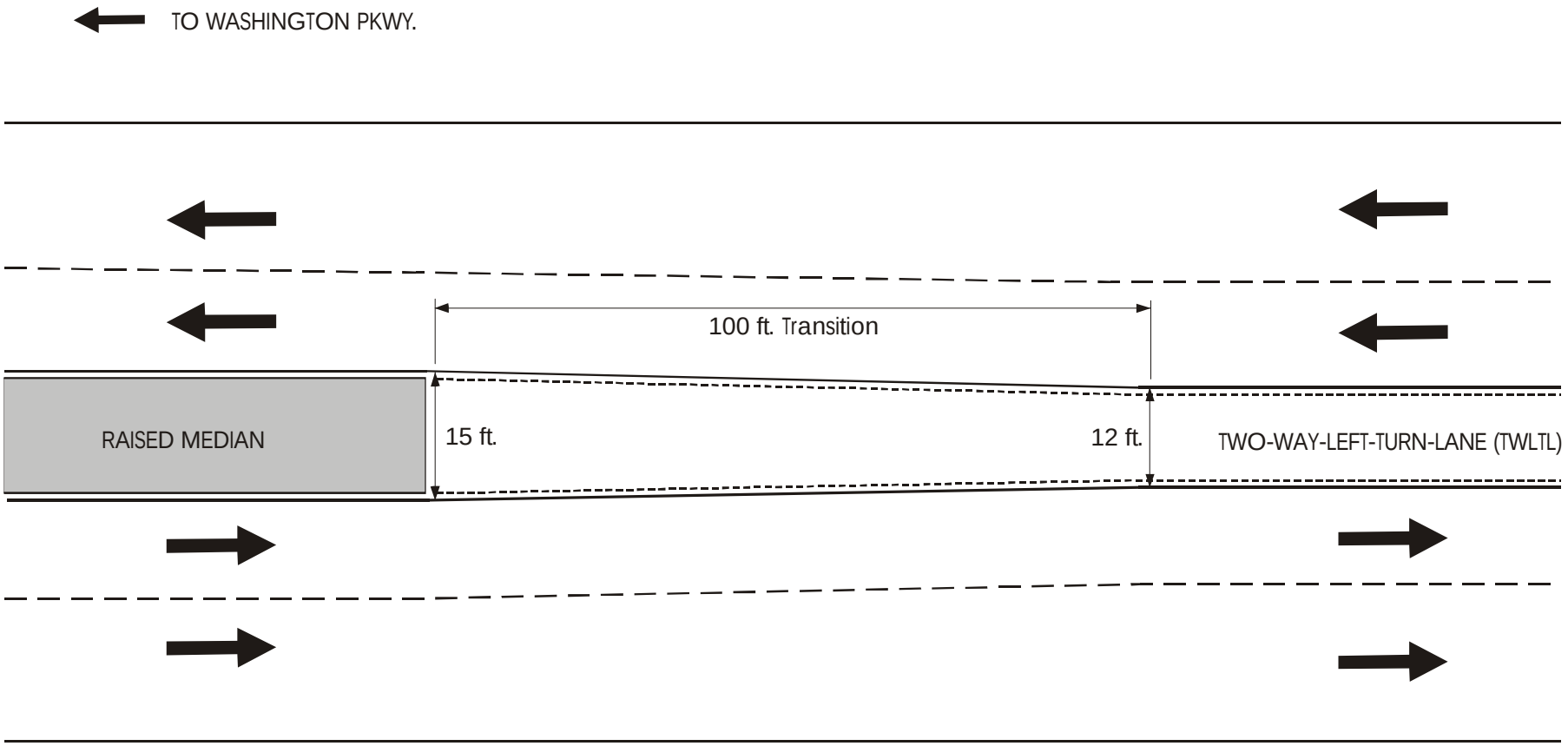

Figure 8: Roundabout Approach Transition

Access Management

The minimum access spacing was determined by comparing the results of six different methods outlined in the Access Management Manual produced by the Transportation Research Board. These methods detail the analysis for access spacing of full access intersections, unless stated otherwise. Full access intersections allow all turns to be made to and from each approach. The spacing determined is measured from centerline to centerline. The following sections outline the procedures used to determine the spacing for each of these methods.

Stopping Sight Distance

Minimum stopping sight distance is the minimum distance needed to allow drivers to react to a potential conflict and come to a stop. In an ideal situation, the vehicle shall clear one intersection before responding to vehicles entering or leaving the next intersection. This method is dependent on speed and grade of the roadway. Assuming the 45 mph design speed, Table 9-5 of the Access Management Manual produces a minimum access spacing of 365 feet.

Intersection Sight Distance

In this method, the access spacing is determined by the distance a driver must see and consider clear of approaching vehicles to enter the roadway. This method is dependent on design speed and the direction of turn. Table 9-6 of the Access Management Manual yields a minimum access spacing of 500 feet for full access intersections and 433 feet for right-turn-only intersections. To assure that both specifications are met, 500 feet will be used as the access spacing for both left and right turns in the Intersection Sight Distance method.

Right-Turn Conflict Overlap

Right-turn conflict overlaps occur when a driver is required to respond to more than one access at a time. This method determines the distance required between access intersections that allows the driver to focus on one intersection at a time. At a design speed of 45 mph, the minimum access spacing for right-turn conflict overlap is 350 feet, as shown in Table 9-7 of the Access Management Manual.

Influence Distance

This method compensates for distance required for a vehicle to react and slow down when following a vehicle that is turning right into an access intersection. It is desired to have the reaction time and decelerating distances occur without the presence of a preceding access intersection. Assuming an acceptable spill-back rate of 10% and the design speed of 45 mph, Table 9-8 of the Access Management Manual shows a minimum access spacing for influence distance to be 380 feet.

Egress Capacity

When two access intersections are too closely spaced, a vehicle in one intersection can restrict the movements of a vehicle in the other. This phenomenon is compensated for in the Egress Capacity method. This method determines the spacing between intersections such that a vehicle in one intersection will not hinder the movements of a vehicle of another intersection. This method is dependent solely on design speed. With the project's design speed of 45 mph, Table 9-9 of the Access Management Manual requires a minimum access spacing of 870 feet.

Below, Table 6 summarizes the minimum access spacing of the previous six sections.

Table 6: Comparing Different Methods of Access Spacing

Method	Access Spacing (feet)
Stopping Sight Distance	365
Intersection Sight Distance	500
Right-Turn Conflict Overlap	350
Influence Distance	380
Egress Capacity	870

As shown in Table 6, the Egress Capacity method for determining access spacing is the controlling method. Therefore, it is ORA's recommendation that all access intersections be spaced at least 870 feet from the nearest access intersection.

CONCLUSIONS

Orth-Rodgers & Associates (ORA) has performed a traffic study for the project known as Sienna Hills, a proposed community land development located on the east side of Washington, Utah. The project area consists of 716 acres and is divided into 15 parcels, which are further divided into various land uses. The site is bounded to the north by Interstate 15, to the west by the proposed Washington Parkway, and to the south by Telegraph Road. Currently, the land to the east is undeveloped.

This is a new project, therefore, there are no existing roadways located within the project limits. Therefore, no analyses of the existing roadway conditions were performed. This report detailed only the analysis of the future year conditions.

Future volumes for the Sienna Hills project were based on the proposed land use divisions. The site generated traffic for this project was assumed to be the lone generator of the future traffic. Tables 1-3 list the individual land uses and their corresponding AM peak hour, PM peak hour, and daily trips generated by each land use. The tables also list the appropriate Land Use Code from the Seventh Edition of the ITE Trip Generation Publications.

With trip generation established, the next step was the development of a trip distribution model for site-related traffic. Trip distribution was calculated considering the future traffic flows and the area network configuration. The percentages were then compared to those of the *Milepost 13 Planned Community Development* traffic study for consistency and accuracy. Trip distribution percentages are illustrated in Figure 2.

The provisions set forth in the Highway Capacity Manual (HCM) and AASHTO 'Green Book' were maintained to assure the desired LOS "C" when designing the lane configurations for the network. These lane configurations are displayed in Figure 4 and summarized in the following two classifications:

- North Road "Business Corridor":

  - Functional classification of Urban Collector was assumed;
  - 35 mph was assumed for a speed limit;
  - Two lanes in each direction with a TWLTL as a median;
  - A left turn, through, and shared right lane at each intersection;
  - Two-way stop controlled intersections from all business approaches; and

- Two lanes on the approach to the roundabout matching the 90 foot section at the roundabout.

➢ All other roads:

- Functional classification of Rural Collector was assumed;
- 35 mph was assumed for a speed limit;
- One lane in each direction with centerline;
- A left turn lane at each intersection with a shared through-right turn lane; and
- Two-way stop controlled intersections.

The roundabouts located within the project limits were designed to the specifications set forth by the FHWA Roundabout Guide and determined that only one lane roundabouts were needed.

Eleven-foot lanes were recommended for use throughout the project site, except for the "Business Corridor" where twelve-foot lanes are recommended. Further, ORA recommends a four-foot shoulder on all local collector roads. A twelve-foot two-way-left-turn-lane (TWLTL) is recommended for the "Business Corridor" of North Road. Assuming 33% of the approach volumes make left turns and 50/50 split of the bi-directional volumes, the amount of traffic traveling along the "Business Corridor" justifies the TWLTL. Further, ORA recommends that a left turn lane with at least 100 feet of storage be placed at every other intersection to accommodate any unexpected left turn movement peaks and future turn volumes. The intersections that require 125 feet of storage are the intersections of Washington Parkway with Center and South Roads. The proposed storage needs are shown in Table 4. The recommended lane configurations are displayed in Figure 4.

The minimum access spacing for full intersections (allowing all turns) was determined by comparing the results of six different methods outlined in the Access Management Manual produced by the Transportation Research Board. These analyses determined that the access intersections be spaced no closer than 870 feet, centerline to centerline.

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3. Trip Generation, 7th Edition, Institute of Transportation Engineers, Washington, D.C., 2003.
4. Traffic Engineering Handbook, 5th Edition, Institute of Transportation Engineers, Washington D.C., 1999.
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APPENDIX 1: LEFT TURN STORAGE CALCULATIONS

Intersection	Direction	Volume (VPH)	Cycle Length (sec)	95th Percentile Design Queue (ft)	Proposed Storage (ft)
Washington & Center	EB	53	60	60.73	100
	WB	131	60	115.35	125
Washington & South	EB	110	60	101.52	125
	WB	31	60	42.48	100
Washington & Far South	EB	38	60	48.56	100
	WB	53	60	60.73	100
Washington & West	EB	38	60	48.56	100
	WB	20	60	32.08	100

* : Each location contains two lanes of length shown