Background:

TPAU is often requested to provide estimated storage for an unsignalized intersection. The ability to reasonability estimate the 95th percentile queue length is critical to the operational and safety of the unsignalized intersection. There are several methodologies to estimate the queue length for left turn lane.

1. The current unsignalized intersection capacity method from the 2000 Highway Capacity Manual demonstrates that the probability distribution of queue lengths for major left turn or any minor movement at an unsignalized intersection is a function of the capacity of the movement and the volume of traffic being served during the analysis period.
2. The rule of thumb (Two-Minute Rule) is often used to estimate the queue at an unsignalized intersection by using the queue that would result from two-minute stoppage of the turning demand volume. This method does not consider the magnitudes and impacts of the conflicting flows on the size of the queue.
3. Harmelink Curves show the storage length for major left runs based on the speed, the percentage of the left turns in the advancing volume, the advancing volume, and the opposing volume.

The purpose of this paper is to compare these three methods above and recommend a best methodology in estimating the left turn storage length. There is a recent study of estimation of maximum queue lengths at unsignalized intersections by John T. Gard. This study needs to be checked with Oregon actual observed data before using.

Study data:

The study data includes six different unsignalized intersections. Each one has different lane configuration, percent truck on the mainline and the minor roads, and speed on the mainline. (See Figures 1 and 2). The study also looks at the different peak hour factor (PHF) on the minor approaches and major left turn to see a discrepancy between the queues.

Analysis Results:

1. ***Major street left turn:***

   The Table 1 shows that the two-minute rule & Harmelink Curves demand queue exceeds the 95% queue from the HCM2000 method. The queue lengths in Table 1 were rounded up to nearest 25 feet. Under the same category of PHF, the HCM2000 methodology shows no difference in the major left turn queue length when the ratio of the major left turn to the opposing volume (in %) varies between 1% and 15%. The HCM2000 methodology may underestimate the major left turn queue compared to Two-Minute Rule and Harmelink Curves. With a large major left turn volume and opposing volume, the Harmelink Curves methodology can not estimate the major left turn queue.

With a discrepancy in the peak hour factors (PHF), the Two-Minute Rule and Harmelink Curves methodologies provide a discrepancy in the major left turn queue, less PHF greater major left turn queue. The HCM2000 methodology shows no difference until the major left turn volume and opposing volume get large.

Table 1. Major left turns queue length[1]

	Major Left Turn Volume (Veh)	Opposing Volume (Veh)	Ratio of major Left turns to opposing Volume (%)	0.6 PHF on major left turn & minor approaches			0.9 PHF on major left turn & minor approaches		
				HCM Unsignalized (feet)	Two minute Rule (feet)	Harmelink Curves (feet)	HCM Unsignalized (feet)	Two minute Rule (feet)	Harmelink Curves (feet)
US 97/GRANDVIEW DR	65	1070	6.1	25	225	275	25	150	150
ORE 22/DALLAS-RICKREALL	970	440	220	2000	2975	N/A	575	2000	N/A
ORE 22/ ORE 51	383	1254	30.5	750	1175	N/A	275	775	N/A
US 101/MARLIN DR	83	545	15.2	25	325	250	25	225	175
US97/SW QUARRY	15	1170	1.3	25	50	100	25	50	75
US97 REROUTE/N. CANAL	20	605	3.3	25	75	50	25	50	50

[1] The queue lengths were rounded up to nearest 25 feet.

2. ***Minor approach queues:***

The Harmelink Curves methodology can not estimate any minor approach queues. The Table 2 shows the minor left, left/right, and left/through/right queues. Even with low minor street left-turn volumes, the queues become quite large due to all of the conflicts from other movements. The Two-Minute Rule is less effective, and may underestimate the storage requirement. Under the same category of PHF, all the

volume conditions where the 95% queue from the HCM2000 method exceeds the queue estimated by the Two-Minute Rule; the minor left, left/right, and left/through/right movements are experiencing a long delay.

The minor right turn has same conflict points like the major left turn, so the Two-Minute Rule is most effective methodology to estimate the minor right turn queue.

Table 2. Minor approach queue[1]

	Minor L, LR, LTR Volume (Veh)	Conflicting Volume (Veh)	0.6 PHF on major left turn & minor approaches		0.9 PHF on major left turn & minor approaches	
			HCM Unsignalized (feet)	Two minute Rule (feet)	HCM Unsignalized (feet)	Two minute Rule (feet)
US 97/GRANDVIEW DR	110 (LR)	2820	475	325	275	225
ORE 22/DALLAS-RICKREALL	10 (L)	1975	---- (left turn capacity is zero)	50	---- (left turn capacity is zero)	25
ORE 22/ ORE 51	9 (LTR)	3607	525	25	200	25
US 101/MARLIN DR	89 (LTR)	1410	350	250	100	175
US97/SW QUARRY	15 (LR)	2590	150	50	25	50
US97 REROUTE/N. CANAL	135 (LTR)	1265	---- (left/through/right capacity is zero)	375	175	250

[1] The queue lengths were rounded up to nearest 25 feet.

Summary:

In summary, for the major left turn and the minor right turn queues at an unsignalized intersection, the Two-Minute Rule gives a conservative storage length. For the minor approach queue at an unsignalized intersection, because of all of conflicts from other movements, the Two-Minute Rule may underestimate the left turn, the shared left/right lane, and the shared left/through/right lane queue compared to HCM2000. Since there is no proper methodology to estimate the minor left, shared left/right, shared left/through, and shared left/through/right queues; the Two-Minute Rule will still be used till there is actual observed data to validate John T. Gard equations.

Recommendation:

The Two-Minute rule will be used to estimate the major left turn queue and the minor approach queues at unsignalized intersections.

Reference:

Estimation of Maximum Queue Lengths at Unsignalized Intersection. John T. Gard, ITE Journal/November 2001.