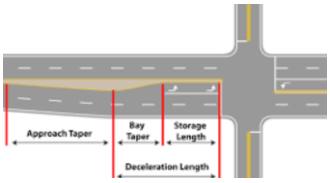
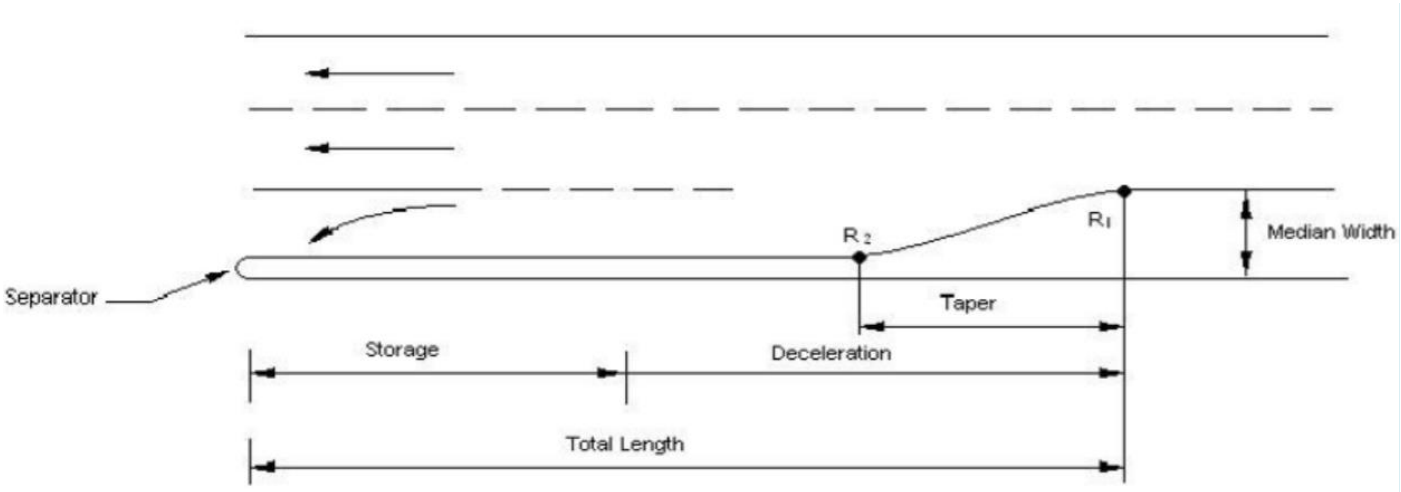
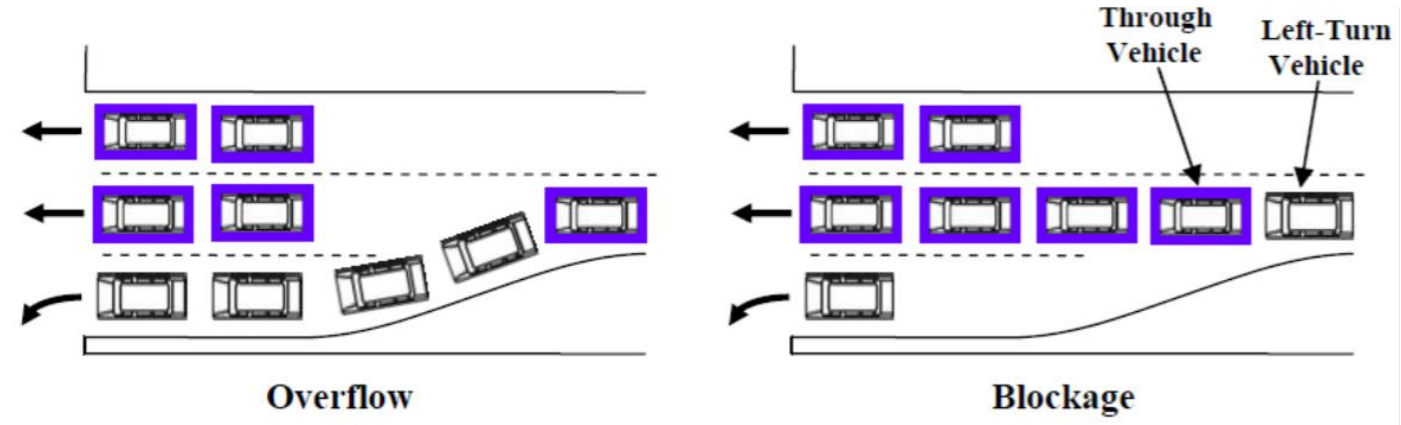
Left Turn Bay



Single Left Turn Lane



Overflow and Blockage



Available Methods

Existing Methods by Categories			Reference	Major Results
Rule of Thumb Methods			• TxDOT Roadway Design Manual • NCHRP Report 279 • NCHRP Report 348	• Equations (4) & (5)
Analytical-Based Methods	Unsignalized Intersections	Regression based	• Basha (1992) • Gard (2001)	• Equations (8) and (9) • Table 9
		Queuing theory based	• Lertworawanich et al. (2003)	• Table 10
		Vehicle arrivals in a given interval	• NDOR Roadway Design Manual (2005)	• Equations (13) to (15) • Table 11
	Signalized Intersections	Queuing theory based	• Oppenlander at al (1989)	• Equations (16) to (18) • Table 12
		DTMC based	• Kikuchi et al.(1993)	• Tables 13 and 13
		Vehicle arrivals in the red phase	• Kikuchi et al.(2004)	• Table 14
Simulation-Based Methods			• Oppenlander et al. (1994, 1996, 1999 and 2002) • Lakkundi et al. (2004)	• Tables 15 and 16 • Figures 7 and 8

Rule of Thumb Method

$$L = K\left(V/N_C\right)S \text{ for signalized intersection}$$

$$L = K\left[V/(3600/I)\right]S \text{ for unsignalized intersection}$$

- L= storage length (ft).
- V= left- turn flow rate during the peak hour (vph).
- K= a constant to reflect random arrival of vehicles (usually 2)
- N_c= number of cycles per hour (for signalized intersection)
- I = average vehicle waiting interval in seconds (for unsignalized intersection)
- S = average queue storage length per vehicle (average distance, front bumper- to – bumper of a car in queue).

Queuing Based Method: Signalized

$$n = (logP_n - log\,(1 - \lambda/\mu)/log(\lambda/\mu)$$

- n = number of vehicles in the queue.
- P_n=probability of n vehicles in the queue.
- λ = arrival rate, equivalent passenger cars per seconds (pcps).
- μ= service rate, equivalent passenger cars per second (pcps).

And, λ and μ can be estimated by following Equations:

$$\lambda = 1.1 \times V/3600$$

$$\mu = S \times (G/C)3600$$

- "1.1 "= adjustment factor for the equivalence of left- turn vehicles with a separate phase.
- V = left- turn volume, equivalent passenger cars per hour (pcph).
- S = lane saturation flow, equivalent passenger cars per hour of green (pcphg).
- G/C= ratio of green time to cycle length (cycle split) for the turning- lane phase.

Regression Based Method-Unsignalized

Since queuing is not prevalent

$$Q = f_2(D, G)$$

$$G = f_1(V)$$

- Q=maximum left-turn lane length, in vehicles.
- D= left- turn volume, in vehicles per intervals.
- G= total acceptable gap times in opposing traffic in a specific interval, sec.
- V= opposing traffic volume, in vehicles per interval.

The function f_1 and f_2 were derived by regression analysis and the general forms of these two equations were given in Equation (7).

$$G = f_1(V) = \alpha_1^G V^{\beta_1^G}$$