APPENDIX B. MODELING GUIDANCE FOR INTERCHANGES, INTERSECTIONS, AND ROUNDABOUTS

of the

TRAFFIC NOISE MANUAL

North Carolina Department of Transportation
Traffic Noise and Air Quality Group

The table below provides detailed guidance on how to model a variety of interchanges, intersections, and roundabouts in TNM. The text in the table is based upon the National Cooperative Highway Research Program (NCHRP) Report 791 (2014) titled "Supplemental Guidance on the Application of FHWA's Traffic Noise Model (TNM).". Following this table are exhibits illustrating the guidance for some of the interchange/intersection/roundabout types listed in the table.

Modeling Guidance for Interchanges, Intersections and Roundabouts

Interchange/Intersection/ Roundabout Type	TNM Element	Guidance	For More Detailed Guidance, Refer to the Following Section of NCHRP Report 791
Normal Signalized Diamond Interchange	Entrance Ramp	The ramp should be modeled as a flow control (Onramp) acceleration roadway that starts at the beginning of the ramp, with 100% Vehicles Affected. The Speed Constraint should be 10 mph, based on *NCHRP Report 311.* If the ramp carries less than 3% heavy trucks, the Speed Constraint could be increased to 15 or 20 mph because automobiles can make the turn onto the ramp at a higher speed before beginning the acceleration along the ramp.	3.4.1.1
	Exit Ramp	Off ramps should model deceleration along the ramp. On the LAeq1h Hourly tab for the off-ramp roadway, set the speed for each individual segment of the off ramp to gradually step down from the modeled mainline speed down to 10 or 20 mph at the end of the ramp.	3.4.1.2
Folded Diamond SignalizedInterchange and other signalized interchanges with loops	Entrance Loop Ramp	The FHWA TNM roadway starts at the beginning of the loop ramp, just past the traffic signal. It should be designated as a flow control (Onramp) roadway with 100% Vehicles Affected and a Speed Constraint of 10 mph (based on *NCHRP Report 311* forheavy trucks) until the loop curve is reached (Segment A in exhibit). The ending speed is the posted loop ramp speed plus 5 mph (not to exceed design speed). Then, a new roadway of cruise segments should be used to model the loop ramp at the posted loop ramp speed plus 5 mph, not to exceed design speed (Segment B in exhibit). Then, at the end of the curve of the loop ramp, an acceleration (Onramp) roadway should be modeled with 100% Vehicles Affected and a Speed Constraint equal to the loop ramp posted speed plus 5 mph (not to exceed design speed). The final speed is the modeled mainline speed (Segment C in exhibit). Alternatively, if there are no nearby receptors in the interchange quadrant with the loop ramp, then the first two segments (Segments A and B) can be combined to be a flow control (Onramp) roadway with 100% Vehicles Affected and a Speed Constraint of 10 mph. The ending speed is the posted loop ramp speed plus 5 mph (not to exceed design speed).	3.4.2.1
	Entrance Diamond Ramp	This ramp should be modeled in the same manner as described for the regular diamond interchange.	3.4.2.2
	Exit Loop Ramp	From the beginning of the exit loop ramp to approximately the exit loop ramp gore (Segment D in exhibit), model deceleration along the off ramp. On the LAeq1h Hourly tab for this segment of the off ramp, set the speed for each individual segment of the off ramp to gradually step down from the modeled mainline speed to the posted loop ramp speed plus 5 mph (not to exceed design speed). For the remaining section of the loop off ramp (Segment E in the exhibit), model the exit loop ramp at the posted loop ramp speed plus 5 mph (not to exceed design speed).	3.4.2.3
	Exit Diamond Ramp	This ramp should be modeled in the same manner as described for the regular diamond interchange exit ramp.	3.4.2.4

Modeling Guidance for Interchanges, Intersections and Roundabouts

Interchange/Intersection/ Roundabout Type	TNM Element	Guidance	For More Detailed Guidance, Refer to the Following Section of NCHRP Report 791
Single-Point Signalized Urban Interchange (SPUI) - Full Modeling	Exit Ramp Entrance Ramp Crossing Road	SPUIs present potentially complex modeling scenarios. The mainline can be designed to pass over or under the turning movements. When passing under, the mainline traffic is largely shielded from the receivers by the ramp embankments or retaining walls. When the mainline traffic passes over the crossing road, mainline noise will dominate the exit ramp traffic's deceleration noise even more than at diamond interchanges because the SPUI ramp is closer to the mainline due to geometryof the interchange design. Also, in this configuration, the interchange movements are under the mainline deck and are shielded from the receivers. Due to the complexity of modeling this type of interchange, the TNM modeler is directed to the instruction and descriptive graphics contained in the NCHRP Report 791.	3.4.3.1
Single-Point Signalized Urban Interchange (SPUI) - Partial Modeling	Exit Ramp Entrance Ramp Crossing Road	Partial modeling of the interchange turning movements has the advantages of avoiding micro-modeling of all segments of all turning movements and avoiding modeling of 12 roadway segment intersecting points in the center deck area. A disadvantage is that partial modeling may slightly underestimate sound levels for receivers very close to the end of the exit ramp because the acceleration away from the signal for the left leg of the ramp is not modeled. While partial modeling is somewhat less complex than full modeling, sufficient guidance cannot be provided here, and the TNM modeler is directed to the instructions and descriptive graphics contained in the NCHRP Report 791 (beginning on page 20).	3.4.3.2

Modeling Guidance for Interchanges, Intersections and Roundabouts

Interchange/Intersection/ Roundabout Type	TNM Element	Guidance	For More Detailed Guidance, Refer to the Following Section of NCHRP Report 791
Unsignalized Intersection	Two-Way Stop	This situation involves a more heavily traveled main road and a lower volume secondary cross street. The main road should be modeled by FHWA TNM roadways in each direction at cruise speed (posted speed plus 5 mph, not to exceed design speed) with no acceleration or deceleration. Traffic on the secondary cross street does not need to be modeled if the volumes are low (less than 500 ADT). If the secondary cross street is modeled with traffic, the departure leg should be modeled with a flow control (Stop) acceleration roadway starting just past the mainline roadways using 100% Vehicles Affected and a Speed Constraint of 20 mph to represent speed as the vehicles exit the intersection. Ending speed is the posted speed plus 5 mph, not to exceed design speed. The secondary cross street approach leg should be modeled at the posted speed plus 5 mph (not to exceed the design speed); no modeling of reduced speeds for deceleration is needed if the approach speeds are 40-45 mph or less. A secondary road at a two-way stop is unlikely to have a higher speed.	3.4.4.1
	Four-Way Stop	The four-way stop may require more complete modeling if there are receivers near the intersection. One would model the acceleration away from the stop line in each of the four directions. Total modeling would require many intersecting points for the crossing roadways because FHWA TNM does not allow two roadways to cross without sharing a point with the same x, y, and z coordinates and may not be needed: If the scenario is modeled with one FHWA TNM roadway in each direction, there would be four points of intersection. If the scenario is modeled as two FHWA TNM roadways per direction of travel on one road and one FHWA TNM roadway per direction of travel on the other road, there would be eight intersecting points. If the scenario is modeled as two FHWA TNM roadways in each direction for each road, there would be 16 intersecting points. In all cases, the flow control (Stop) roadway would start at the stop line with 100% Vehicles Affected and a Speed Constraint of 0 mph. As illustrated in the SPUI discussion, the approaching traffic would be modeled as the posted speed plus 5 mph, not to exceed the design speed (modeled speed). If the modeled speed were as high as 60 mph, there would be over-prediction by 1–3 dB by not modeling the deceleration. A simpler approach is to partially model the movements of one of the roads and avoid all of the intersecting FHWA TNM points. In this case, model the road with the most traffic (or perhaps the most adjacent receivers) as continuous, with an FHWA TNM cruise speed roadway on the approach side connected at the stop line to a flow control (Stop) acceleration roadway that crosses through the intersection and proceeds downstream on the departing leg. The flow control (Stop) roadway would have a Speed Constraint of 0 mph and 100% Vehicles Affected. Under the simpler approach, the lesser road would be modeled as described above for the two-way stop: (1) on the departing leg, by a flow control (Stop) acceleration roadway starting just past the main roadways using 100%Vehicles Affected and a Speed Constraint of 20 mph to represent speed as the vehicles exit the intersection, (2) on the approach leg, by a constant-speed roadway at the modeled speed for that road. No modeling of reduced speeds for deceleration is needed unless the modeled speed is high (greater than 55 mph) and there are receptors near the intersection. For situations where the modeled speed is greater than 55 mph, use a gradual deceleration from the modeled speed down to zero mph. Begin the deceleration at the typical stopping distance for the modeled speed. This distance is approximately 300 feet for 60 mph (Source: https://nacto.org/docs/usdg/vehicle_stopping_distance_and_time_upenn.pdf).	3.4.4.2

Modeling Guidance for Interchanges, Intersections and Roundabouts

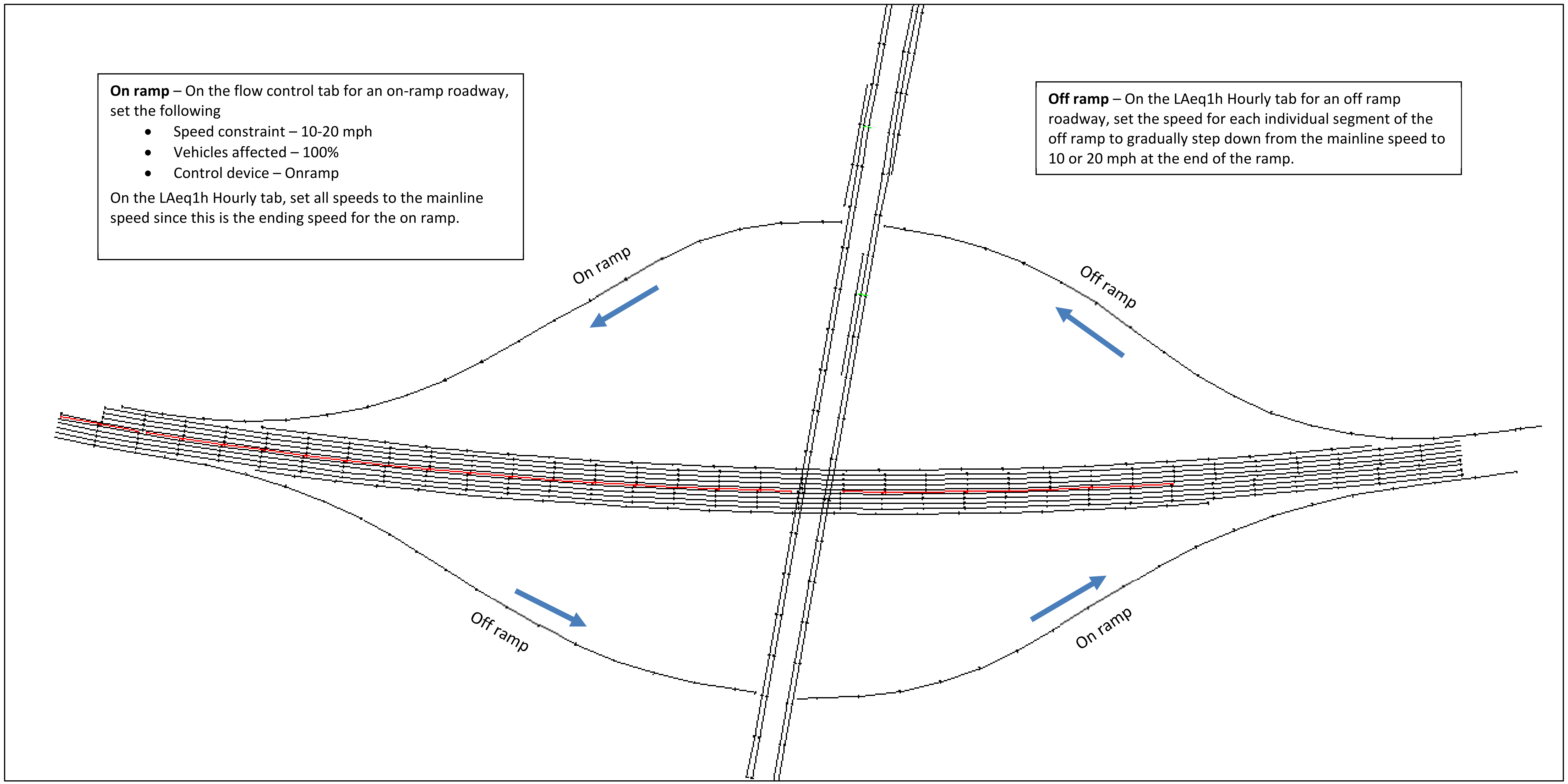
Interchange/Intersection/ Roundabout Type	TNM Element	Guidance	For More Detailed Guidance, Refer to the Following Section of NCHRP Report 791
Signalized Intersection	One-Way Roadway	Model the departing leg as a flow control (Signal) acceleration roadway starting either at the stop bar or approximately halfway back along the upstream queue. Using the queue length is optional and usually can be obtained from the project's traffic operations technical memorandum). Use 50% Vehicles Affected, a Speed Constraint of 0 mph, and a final speed of the posted speed plus 5 mph, not to exceed design speed. Other values for % Vehicles Affected may be used if desired, based upon information in the project's traffic operations technical memorandum. Model the approaching leg as a constant-speed roadway at the posted speed plus 5 mph, not to exceed design speed. The low-speed deceleration does not need to be modeled unless the modeled speed is high (greater than 55 mph) because of the dominance of noise from the percentage of traffic cruising through the signal and the percentage of traffic accelerating from a stopped condition on the upstream side of the intersection. (See Unsignalized Intersection 4-Way Stop for deceleration information).	3.4.5.1
	Two-Way Roadway	The degree to which a signalized intersection with two-way traffic on all legs needs to be modeled depends on the proximity of the receivers. As described for the four-way stop, total modeling would require many intersecting points for the crossing roadways because FHWA TNM does not allow two roadways to cross without sharing a point with the same x, y, and z coordinates and may not be needed. A <u>simpler approach</u> is similar to what was described for the four-way stop—partially model the movements of one of the roads and avoid all of the intersecting FHWA TNM points. The road with the most traffic (or perhaps the most adjacent receivers) would be modeled as continuous in each direction. A constant speed FHWA TNM roadway (or multiple roadways for multiple lanes) would be modeled on the approach, connected to a flow control (Signal) acceleration roadway (or roadways) that crosses through the intersection and proceeds downstream on the departing leg. The joining point would be either at the stop bar or approximately halfway up the expected queue, which could be several hundred feet from the stop line. Using the queue length is optional, and usually can be obtained from the project's traffic operations technical memorandum. The flow control (Signal) roadway would have a Speed Constraint of 0 mph and 50% Vehicles Affected. The intersecting road would be modeled as not crossing through the intersection. On the departing leg, a flow control (Signal) acceleration roadway would start just past the main roadways to avoid the intersecting points. This flow control (Signal) roadway would have 50% Vehicles Affected and a Speed Constraint of 20 mph to represent the speed as the vehicles exit the intersection. On the approach leg, a constant-speed roadway would be modeled at the posted speed plus 5 mph (not to exceed design speed); no modeling of reduced speeds for deceleration is needed. Other values for % Vehicles Affected may be used if desired, based upon information in the project's traffic operations technical memorandum. Unlike the one-way road case illustrated above, even at higher approach speeds, the difference between modeling a combination of deceleration and cruise and all cruise is small.	3.4.5.2

Modeling Guidance for Interchanges, Intersections and Roundabouts

Interchange/Intersection/ Roundabout Type	TNM Element	Guidance	For More Detailed Guidance, Refer to the Following Section of NCHRP Report 791
Roundabout	General Considerations	Roundabout design is largely governed by guidance in *NCHRP Report 672.* Key design factors are the entry, circulation, and exit speeds, which are determined by the radii of the curves leading into, going around, and leaving the round-about. For a single-lane roundabout with a center radius on the order of 90 ft or less, the typical entry and circulation speed is 20 mph. For a multilane roundabout with a larger radius, the typical entry and circulation speed is approximately 25 mph. This research showed that detailed noise modeling of all of the roundabout movements is generally not needed. However, if a modeler chooses to model all the movements, he/she is directed to the methodology illustrated in Section 3.4.6 of NCHRP Report 791.	3.4.6
	One-Lane Circulatory Roadway	Approach Leg. The approach to the roundabout may be modeled by a constant speed equal to the posted speed plus 5 mph (not to exceed design speed) up to the beginning of the splitter island/crosswalk. Then, one 25-mph segment would be used to represent the entry leg, ending at the entry point to the circulatory road. Inner Circulatory Road. The traffic on the inner circulatory road does not need to be modeled. The noise from the accelerating traffic departing the roundabout will dominate the overall sound levels. Departure Leg. For the departure leg, a one-segment constant-speed roadway would be modeled at a speed of 25 mph. It would start at the exit point from the inner circulatory road and end at the end of the reverse curve typically at the end of the splitter island/crosswalk. Then, a flow control (Onramp) acceleration roadway would be modeled from the point downstream to the end of the modeled site. The roadway would have a Speed Constraint of 25 mph and 100% Vehicles Affected with the posted speed plus 5 mph (not to exceed design speed) as the final speed.	3.4.6.1
	Two-Lane Circulatory Roadway	A roundabout with a two-lane inner circulatory road may be modeled in essentially the same way as a one-lane inner circulatory road. Because of the slightly higher speed typical of the two-lane case (20 to 25 mph instead of 15 to 20 mph on the smaller diameter one-lane road and the greater circumference), there might be a desire to model the inner circulatory road, especially if receivers are immediately adjacent. However, if the inner road's entry and approach legs are each modeled, then the inner road itself does not need to be modeled with traffic, especially because of the noise of vehicles accelerating away from the roundabout.	3.4.6.3

ILLUSTRATIONS OF VARIOUS INTERCHANGES, INTERSECTIONS, AND ROUNDABOUTS MODELED IN TNM

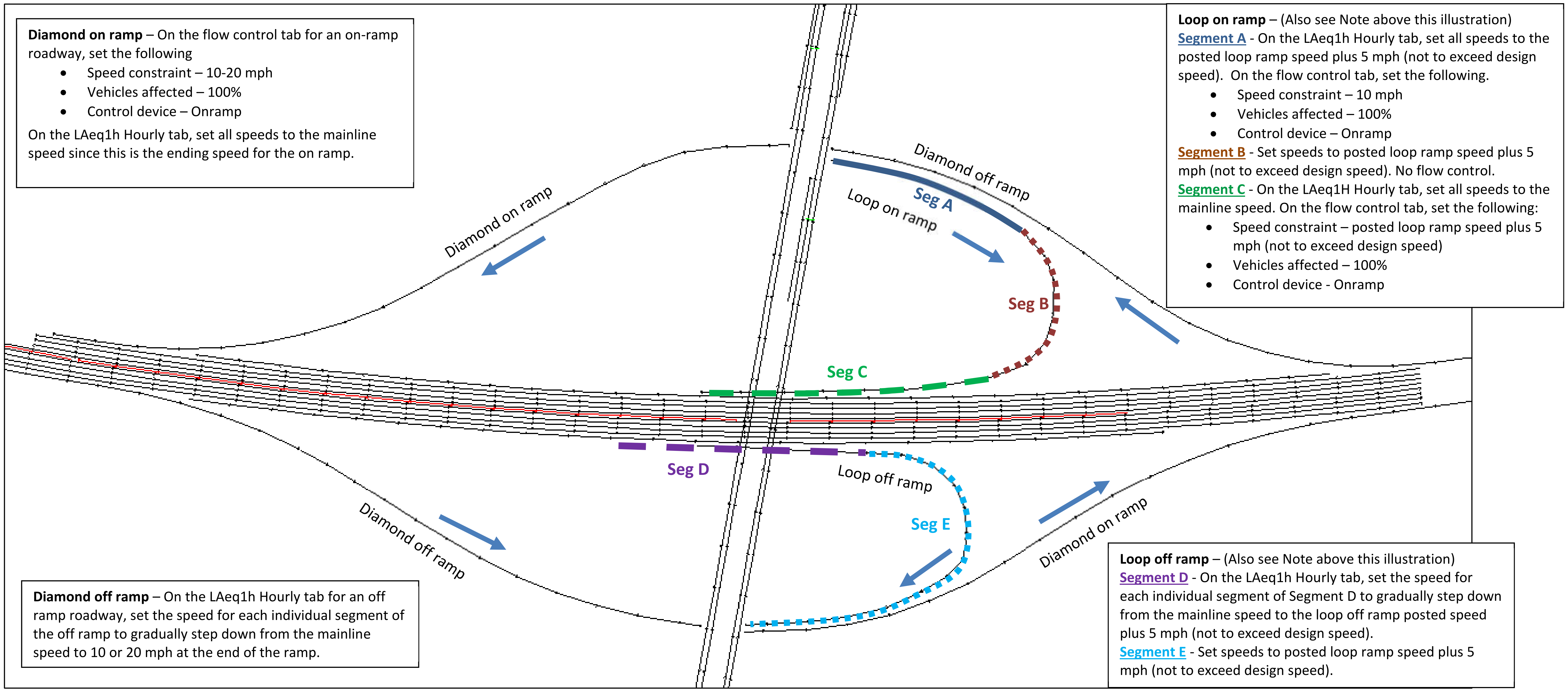
Diamond Signalized Interchange



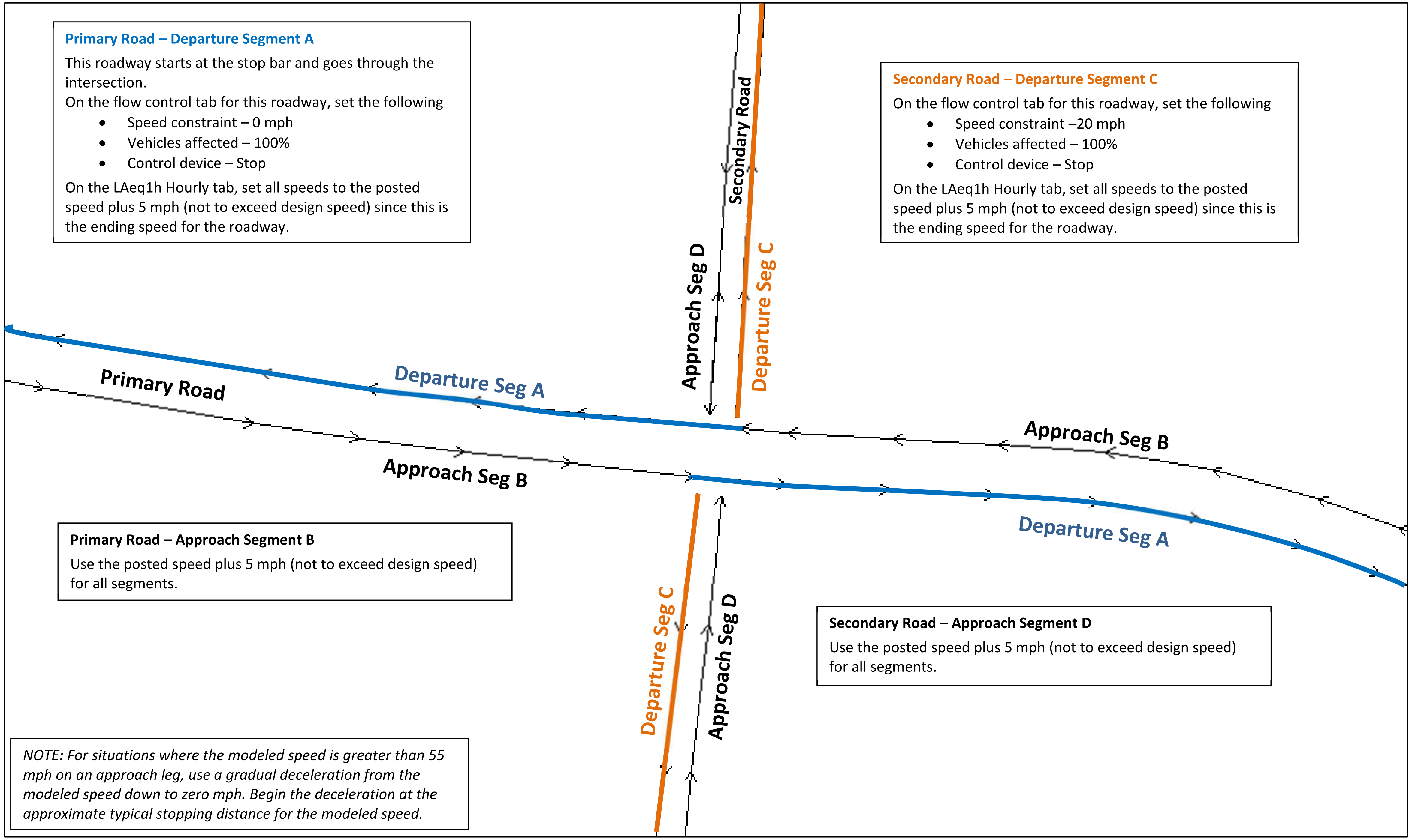
Folded Diamond Signalized Interchange

A folded diamond signalized interchange has one pair of entrance and exit ramps in the traditional diamond layout (diamond ramps) and the other pair as loop ramps onto and off of the mainline. The guidance below can apply to other signalized interchanges that have diamond ramps and loop ramps. The diamond on ramp and off ramp are modeled the same as for the Diamond Signalized Interchange.

NOTE: For a loop on-ramp or off-ramp, if there are no nearby receptors and the loop ramp volume is low, the instructions for Segment B of the loop on ramp can be applied to Segments A and C of the loop on ramp and the instructions for Segment E of the loop off-ramp can be applied to Segment D.

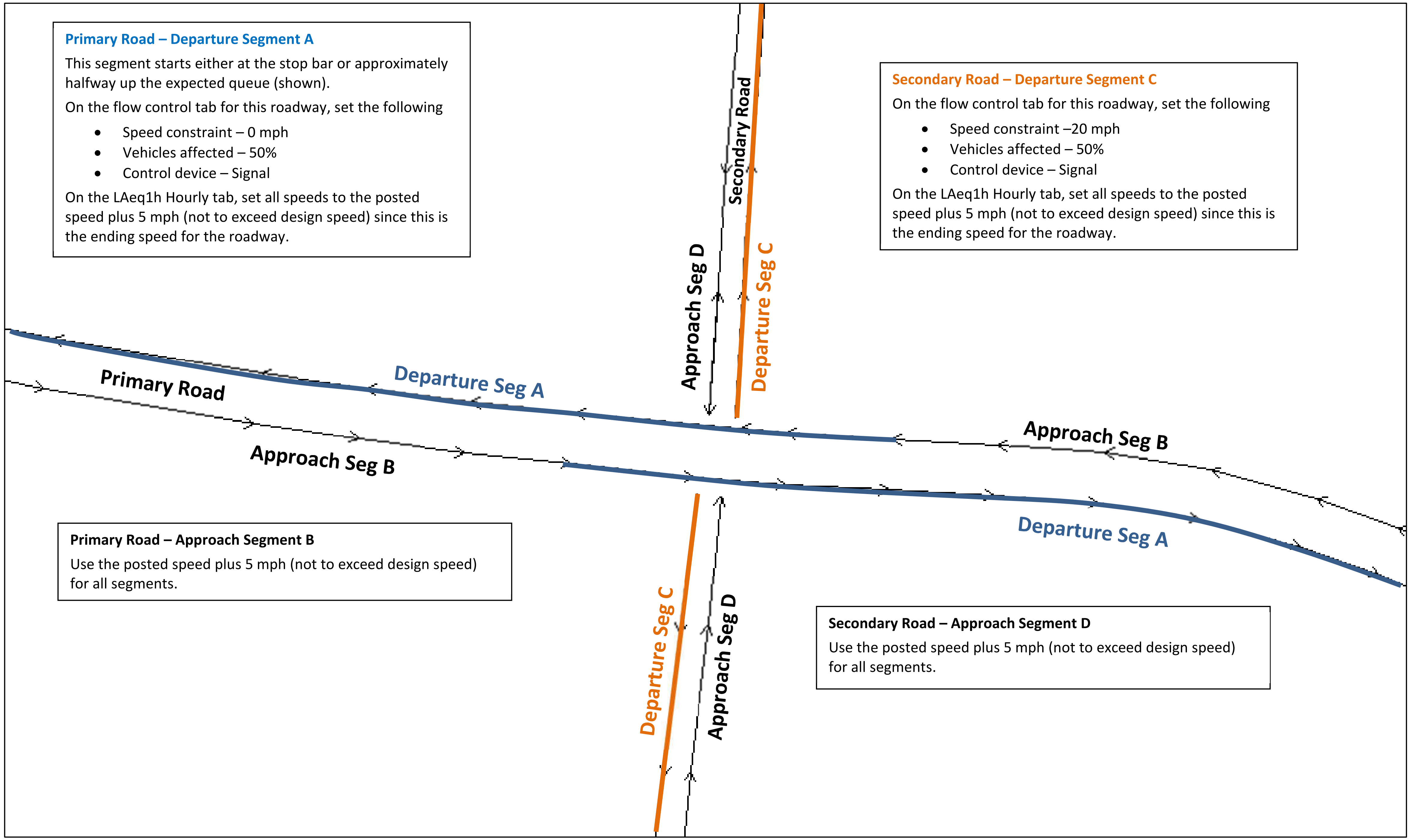


Unsignalized Intersection with 4-Way Stop



Signalized Intersection with 2-Way Roads

The "simpler approach" described in the table above is illustrated here. This approach is similar to modeling the Unsignalized Intersection with 4-Way Stop.



Roundabout – One-Lane Circulatory Roadway