2

Bus Rapid Transit Design

2.1 Purpose

The City of Gaithersburg desires to provide a combination of the highest quality design and operational provisions for the bus rapid transit system within the city. Conceptually, the City supports construction of a dual-lane BRT guideway, however, it recognizes that potential constraints on the focal segment of MD 355, between Odendhal Avenue and Summit Avenue may dictate that an alternative guideway treatment or design standard is necessary to achieve an effective design configuration and minimize property impacts adjacent to the roadway. A design evaluation is necessary to evaluate the feasibility of constructing one of several BRT guideway alternatives.

2.2 Focal Segment Conceptual Design Alternatives

Planning-level designs for the BRT on MD 355 in the Gaithersburg focal segment were developed and evaluated to provide critical information regarding the feasibility of each alternative. Sufficient right-of-way can likely be provided to construct a dual-lane median guideway on MD 355 both north and south of the focal segment (from Game Preserve Road to Odendhal Avenue and from Summit Avenue to O'Neill Drive). In response to the narrower right-of-way observed in the focal segment, and the concerns related to potential property impacts, several other alternatives were evaluated for the focal segment. These alternatives may address some property concerns, but introduce operational and functional changes that will need to be weighed against the lower impact to properties along the corridor. These tradeoffs will be documented in more detail with each alternative.

The four alternative BRT guideway options considered for the focal segment include:

- Dual-lane Median Guideway
- Single-lane Median Guideway
- Lane Repurposing
- Mixed Traffic

The Maryland State Highway Administration has defined a range of design criteria for median BRT guideways (Appendix A) and this range was applied to both the dual-lane and single-lane median guideway in the Gaithersburg focal segment. Each of these sub-alternatives represent different degrees of operational enhancement for the corridor, as well as encroachment on the adjacent properties for the dual- and single-lane median guideway alternatives. The name of each version reflects the scale of the design:

- Standard Design Dimensions - Uses SHA's preferred design criteria
- Minimum Design Dimensions - Uses SHA's minimum design criteria
- Reduced Impact Dimensions - Uses SHA's minimum design criteria, but also seeks to reduce impacts further by applying changes to existing lane configurations and sidewalk widths

Design layouts were produced for each of the BRT guideway alternatives at a conceptual level using aerial base mapping for the MD 355 focal segment; Gaithersburg, Montgomery County, and SHA GIS data; and the preliminary Gaithersburg BRT guideway cross-section dimensions (Appendix B). No detailed field survey has been conducted to identify existing roadway limits, property boundaries, building locations, utilities, or any other existing roadway design feature.

The design layouts are intended to provide a planning-level visualization of the potential roadway and BRT guideway alignment on the corridor, identify probable impacts, and provide a basis for estimating costs. The layouts illustrate the BRT guideway treatment, potential roadway alignment, intersection geometries, and roadway widening impacts on adjacent properties. The following sections describe each of the Gaithersburg MD 355 BRT design alternatives and their design implications in detail. Copies of the design layout concepts are included in Appendix B.

Where the planned roadway geometry shown on the design layout drawings exceeds the existing adjacent property boundaries, private property within the extents of the roadway envelope will need to be acquired as public property. The design layouts included in Appendix B highlight two types of significant property impacts: Building/Entire Property Impacts and Potential Building Impacts. Building/Entire Property Impacts refer to locations where the planned roadway geometry for a specific alternative will encroach on an existing building, which will likely necessitate dedication or acquisition of the entire property as public land. Potential Building Impacts refer to locations where the planned roadway geometry for a specific alternative could be located within five feet of an existing building. These are labeled "potential" impacts because the roadway or sidewalk design could possibly be modified during the detailed design process to adequately avoid impacting these building. On the design layout diagrams included in Appendix B, the Building/Entire Property Impacts are identified by purple shading, including a dashed purple outline around the entire property boundary, and the Potential Building Impacts are identified with blue shading.

Several design assumptions are common to all of the BRT design alternatives for the focal segment. These assumptions include the following:

- A BRT station will be located at the MD 355/Odendhal Avenue intersection
- A median station at Odendhal Avenue will provide far-side platforms, allowing BRT vehicles to travel through the traffic signal prior to stopping at the station.

- The single-lane guideway will operate with BRT vehicles using the guideway only in the peak direction, and BRT vehicles traveling in the opposite direction will travel in mixed traffic.
- Traffic signal control and full turning movement access will be maintained at the existing traffic signals on MD 355 at Odendhal Avenue, Chestnut Street, and Summit Avenue.
- The existing number of left turn lanes will be maintained on MD 355 at signalized intersections.
- The median guideway design will not provide median breaks at unsignalized intersections to allow left turns to and from side streets.
- Given existing property constraints and the desire to minimize property impacts in the focal segment, on-street bicycle facilities are not included in any of the design alternatives.

The roadway design layouts identify buildings that are likely to be significantly impacted by the roadway design. This is defined as buildings located within three feet of the proposed roadway edge. The layouts also identify buildings that are possibly impacted by the roadway design, where sidewalks still encroach on the buildings; however, these building impacts may be avoided through localized modifications to the sidewalk design intended to preserve the existing building. These roadway design layouts are conceptual, based on design assumptions developed specifically for the focal segment. Detailed roadway design will be required to determine a final roadway layout and define the actual degree of building or property impacts associated with the BRT in the City of Gaithersburg.

Dual-Lane Median Guideway Design

The dual-lane median guideway represents the highest level of BRT operational functionality for the corridor, entailing the greatest degree of roadway widening to both construct the guideway and maintain existing traffic capacity on the corridor. The City of Gaithersburg intends to support dual-lane median guideway on MD 355 outside of the focal segment, and consistency in the BRT design throughout the city is generally preferred.

Three separate design variations were evaluated for the dual-lane median guideway treatment on the MD 355 focal segment. These include standard, minimum, and reduced impact variations of the roadway design to incorporate the BRT guideway. Each variation provides a dual-lane median guideway separated from adjacent traffic lanes, but various design attributes, such as lane and BRT median separator widths, were adjusted in each variation to provide a range of design options for review. Copies of all the dual-lane median design layout concepts are included in Appendix B.

Dual-lane Median Guideway Standard Design Alternative

The dual-lane median guideway standard design is characterized by a roadway cross-section that provides preferred guideway lane widths (12 feet) and BRT median separator widths (six feet). Additionally, this alternative assumes that wide sidewalks and landscape buffers will be provided on both sides of the street.

A design layout drawing for this alternative is provided in Appendix B and identifies both building/entire property impacts and potential property impacts associated with the planned

roadway geometry. This design exceeds the existing roadway width and property boundaries throughout the corridor. The design layout indicates that portions of most properties along MD 355, from Odendhal Avenue to the Father Cuddy Bridge, will need to be acquired to achieve this design, and the roadway edge will encroach on several existing buildings between Odendhal Avenue and Chestnut Street. Even where buildings aren't significantly impacted, off-street parking on several properties appears to be affected. The roadway design also encroaches on a portion of the cemetery on the west side of MD 355 south of Dalamar Street, requiring acquisition of a property sliver along the roadway edge. Table 2-1 summarizes the number of buildings significantly impacted, buildings possibly impacted, and private parking lots significantly impacted, by the dual-lane median guideway standard design alternative.

Table 2-1: MD 355 Focal Segment – Dual-lane Guideway Standard Design Property Impacts

Location	Significant Building Impacts		Possible Building Impacts		Significant Parking Lot Impacts	
	East Side	West Side	East Side	West Side	East Side	West Side
Odendhal Avenue to Chestnut Street	2	1	0	1	5	4
Chestnut Street to Father Cuddy Bridge	1	0	1	2	0	1
Father Cuddy Bridge to Summit Avenue	0	0	0	1	1	0
Total Buildings/Properties	**3**	**1**	**1**	**4**	**6**	**5**

The design layout will require widening of the Father Cuddy Bridge to accommodate the eight travel lanes (six general traffic and two busway), BRT median separators (6 feet), and planned sidewalks (10 feet) specified. The existing bridge includes both a horizontal curve and super-elevation, which means the bridge has an angled cross-slope to reduce lateral vehicle drifting while traveling along the curve. As a result of these design attributes, any widening of the Father Cuddy Bridge likely will require full reconstruction of the bridge to provide adequate structural design and minimize potential railroad and roadway clearance conflicts below the bridge span.

On both the north and south sides of the Father Cuddy Bridge, the dual-lane median guideway standard design layout encroaches on steep roadside slopes. Significant retaining walls would need to be constructed (or reconstructed) on both sides of the road, north and south of the bridge, to support the design.

The dual-lane median guideway standard design would allow preferred BRT operations by providing two 12 foot bus lanes to allow buses traveling in both directions to operate unencumbered from interference from general traffic (except at intersections). Travel speeds along the corridor would be improved over existing bus service operating in the corridor. It is estimated that buses operating within a dual-lane median guideway standard design could maintain an average speed between 18 and 22 miles per hour, depending on time of day. The dual-lane guideway design allows for BRT station platforms to be constructed on both sides to serve each direction of travel. Stations can also be constructed on opposite sides of the intersection, improving BRT operations by providing far-side stops, and reducing the overall footprint within the intersection.

Dual-lane Median Guideway Minimum Design Alternative

The Dual-lane Guideway Minimum design is characterized by a roadway cross-section that provides the minimum guideway lane width (11 feet) and BRT median separator widths (two feet). This alternative assumes that sidewalks, but no landscape buffers, will be provided on both sides of the street.

A design layout drawing for this alternative is provided in Appendix B and identifies both building/entire property impacts and potential property impacts associated with the planned roadway geometry. This design generally exceeds the existing roadway width and property boundaries along the northern portion of the corridor. The design layout indicates that portions of many properties along MD 355, from Odendhal Avenue to the Father Cuddy Bridge, will need to be acquired to achieve this design, and the roadway edge will encroach on several existing buildings between Odendhal Avenue and Chestnut Street. Even where buildings aren't significantly impacted, off-street parking on several properties appears to be affected. The roadway design avoids direct impacts to the cemetery on the west side of MD 355 south of Dalamar Street. Table 2-2 summarizes the number of buildings significantly impacted, buildings possibly impacted, and private parking lots significantly impacted, by the Dual-lane Guideway Minimum design alternative.

Table 2-2: MD 355 Focal Segment – Dual-lane Guideway Minimum Design Property Impacts

Location	Significant Building Impacts		Possible Building Impacts		Significant Parking Lot Impacts	
	East Side	West Side	East Side	West Side	East Side	West Side
Odendhal Avenue to Chestnut Street	2	0	0	1	3	1
Chestnut Street to Father Cuddy Bridge	1	0	0	0	0	1
Father Cuddy Bridge to Summit Avenue	0	0	0	0	1	0
Total Buildings/Properties	**3**	**0**	**0**	**1**	**3**	**2**

Similar to the dual-lane median standard design the minimum design will require widening of the Father Cuddy Bridge to accommodate the eight travel lanes (six general traffic and two busway), BRT median separators (2 feet), and planned sidewalks (10 feet) specified. This expansion of the bridge will likely require a full reconstruction of the bridge. Additionally, retaining walls would need to be constructed (or reconstructed) to address the widening as well.

The dual-lane median guideway minimum design would allow reasonable BRT operations by providing two 11 foot bus lanes to allow buses traveling in both directions to operate unencumbered from interference from general traffic (except at intersections). Travel speeds along the corridor would be similar to those estimated for the standard design alternative, allowing the bus to maintain an average speed between 18 and 22 miles per hour, depending on time of day. This design alternative provides the same station benefits as the standard design alternative.

Dual-lane Median Guideway Reduced Impact Design Alternative

The dual-lane guideway reduced impact design is characterized by a roadway cross-section that provides the minimum guideway lane width (11 feet) and BRT median separator widths (two feet). This alternative modifies the number of vehicle travel lanes and sidewalk widths to minimize the need for roadway widening and reduce impacts to adjacent properties. To achieve reduced roadway widening and property impacts, the roadway design layout eliminates the following vehicle travel lanes:

- One southbound travel lane on MD 355, between Odendhal Avenue and Chestnut Street
- One northbound travel lane on MD 355, between Cedar Avenue/Fulks Corner Avenue and Brookes Avenue

A design layout drawing for this alternative is provided in Appendix B and identifies both building/entire property impacts and potential property impacts associated with the planned roadway geometry. This design still exceeds the existing roadway width and encroaches on some existing property boundaries because the existing intersection geometries are maintained at the signalized intersections, particularly along the northern portion of the corridor. The design layout avoids encroaching on properties wherever possible, but portions of several properties along MD 355 will need to be acquired to achieve this design. The roadway edge may encroach on several existing buildings between Odendhal Avenue and Chestnut Street, but several of these buildings may be retained with localized sidewalk modifications that reduce typical sidewalk width standards. The roadway design avoids direct impacts to the cemetery on the west side of MD 355 south of Dalamar Street and generally minimizes impacts to off-street parking. Table 2-3 summarizes the number of buildings significantly impacted, buildings possibly impacted, and private parking lots significantly impacted, by the dual-lane guideway reduced impact design alternative.

Table 2-3: MD 355 Focal Segment – Dual-lane Guideway Reduced Impact Design Property Impacts

Location	Significant Building Impacts		Possible Building Impacts		Significant Parking Lot Impacts	
	East Side	West Side	East Side	West Side	East Side	West Side
Odendhal Avenue to Chestnut Street	0	0	1	1	0	0
Chestnut Street to Father Cuddy Bridge	0	0	1	0	0	1
Father Cuddy Bridge to Summit Avenue	0	0	0	0	0	0
Total Buildings/Properties	**0**	**0**	**2**	**1**	**0**	**1**

The design layout will require no widening of the Father Cuddy Bridge. In addition to the dual-lane median guideway, two northbound travel lanes and three southbound travel lanes can be accommodated on the bridge without widening. The existing sidewalks, representing the minimum standard sidewalk, are retained. No significant roadway widening is required along the steeply sloped roadside north or south of the bridge, so new retaining walls should not be required.

The dual-lane median guideway reduced impact design would provide for similar BRT operations to the dual-lane median guideway standard and minimum design alternatives. This design would still provide two 11 foot bus lanes to allow buses traveling in both directions to operate unencumbered from interference from general traffic. Buses operating within a dual-lane median guideway reduced impact design could maintain an average speed between 18 and 22 miles per hour, depending on time of day. The reduced impact guideway design provides the same station benefits as the other two dual-lane guideway design alternatives.

Single-Lane Median Guideway Design

The single-lane median guideway represents an attempt to provide BRT operational functionality for the corridor, but also responds to the need for greater roadway widening associated with the dual-lane alternatives. The use of a single-lane guideway does come with some impacts to BRT operations as a result of dropping a bus lane to save property impacts. Two operational models can be utilized with the single-lane guideway. The lane could be reversible, only allowing buses traveling in one direction to take advantage of the exclusivity from general traffic. Buses traveling in the other direction would need to travel in general traffic. This is typically done along corridors where the traffic is peaked, resulting in heavier volumes in one direction in the morning and the other direction in the evening. The other operating alternative involve operating the single lane in both directions. This arrangement requires greater coordination of schedules and signals to ensure that two buses traveling in opposite directions do not occupy the same lane. Limitations of this operating model include service frequency and the length of the segment under consideration. At this time, a preferred operating model has not been selected.

Three separate design variations were evaluated for the single-lane median guideway treatment similar to the dual-lane alternatives. These include standard, minimum, and reduced impact variations of the roadway design to incorporate the BRT guideway. Each variation provides a single-lane median guideway separated from adjacent traffic lanes, but various design attributes, such as lane and BRT median separator widths, were adjusted in each variation to provide a range of design options for review. Copies of all the single-lane median design layout concepts are included in Appendix B.

Single-lane Median Guideway Standard Design Alternative

The single-lane guideway standard design is characterized by a roadway cross-section that provides preferred guideway lane widths (12 feet) and BRT median separator widths (six feet). Additionally, this alternative assumes that wide sidewalks and landscape buffers will be provided on both sides of the street.

A design layout drawing for this alternative is provided in Appendix B and identifies both building/entire property impacts and potential property impacts associated with the planned roadway geometry. This design exceeds the existing roadway width and property boundaries throughout the corridor. The design layout indicates that portions of most properties along MD 355, from Odendhal Avenue to the Father Cuddy Bridge, will need to be acquired to achieve this design, and the roadway edge will encroach on several existing buildings between Odendhal Avenue and Chestnut Street. Even where buildings aren't significantly impacted, off-street parking on several properties appears to be affected. The roadway design avoids

direct impacts to the cemetery on the west side of MD 355 south of Dalamar Street. Table 2-4 summarizes the number of buildings significantly impacted, buildings possibly impacted, and private parking lots significantly impacted, by the single-lane guideway standard design alternative.

Table 2-4: MD 355 Focal Segment – Single-lane Guideway Standard Design Property Impacts

Location	Significant Building Impacts		Possible Building Impacts		Significant Parking Lot Impacts	
	East Side	West Side	East Side	West Side	East Side	West Side
Odendhal Avenue to Chestnut Street	2	0	1	2	4	2
Chestnut Street to Father Cuddy Bridge	1	0	0	0	0	1
Father Cuddy Bridge to Summit Avenue	0	0	0	0	1	0
Total Buildings/Properties	**3**	**0**	**0**	**2**	**5**	**3**

While the single-lane standard design layout provides a narrower curb-to-curb width over the Father Cuddy Bridge compared to the dual-lane standard design, it will still require widening of the Father Cuddy Bridge to accommodate the seven travel lanes (six general traffic and one busway), BRT median separators (6 feet), and planned sidewalks (10 feet) specified. Similarly, retaining walls would need to be constructed (or reconstructed) on both sides of the road, north and south of the bridge, to support the design.

The single-lane median guideway standard design would result in an improvement in bus speeds when compared to existing bus service. However, a reversible busway would only allow buses in a single direction to operate unencumbered from interference from general traffic (except at intersections). Buses operating in the "peak" direction could achieve speeds comparable to those of the dual-lane standard design (18 to 22 miles per hour). In the opposite direction (non-peak), buses would operate in mixed traffic at speeds similar to existing conditions (11 to 15 miles per hour). This operational configuration would provide for improved travel times in the peak travel direction, and slightly improved travel times in the non-peak direction associated with stop spacing and other BRT system improvements. This type of design also requires that the non-peak bus be able to enter and exit the busway in a coordinated way. In this arrangement a southbound bus traveling in the non-peak direction would exit the guideway at Lakeforest Boulevard or Odendhal Avenue (depending on station location) and enter the general traffic lanes. The bus would then reenter the dual-lane busway south of Summit Avenue. The bus will need to receive a priority green signal when exiting the guideway to allow it to enter the general travel lanes.

A second option for BRT operations in a single-lane guideway would be to provide bi-directional bus travel that is coordinated. This operating model adds a level of complexity to bus operations to ensure that buses traveling in opposite directions do not enter the single-lane segment at the same time. Much like rail operations, this is accomplished through vehicle tracking and signal technology. Buses will typically be held at the last station prior to entering the single-lane segment. This operating model places a limitation on how many buses can be process through the single-lane segment in a given period of time, ultimately the BRT

frequency. Assuming that the bus is averaging 20 miles per hour in the busway and the single-lane segment in Gaithersburg is one mile long, it should take approximately three minutes to travel from end to end. Initial planning for the BRT envisions five minute peak frequency for the MD 355 corridor. This level of service should be achievable with this guideway type, but does not leave a lot of room for error. As further design occurs along the MD 355 corridor, operational considerations will need to be factored if a single-lane median guideway is advanced as the preferred alternative for Gaithersburg, or any other segment of the larger BRT corridor.

Station location for the single-lane guideway alternative would either result in curb-side stops along the general traffic lanes in the peak-direction alternative or a design similar to the dual-lane design alternative where stations are constructed on both sides of the guideway if the guideway is bi-directional.

Single-lane Median Guideway Minimum Design Alternative

The single-lane guideway minimum design is characterized by a roadway cross-section that provides the minimum guideway lane width (11 feet) and BRT median separator widths (two feet). This alternative assumes that sidewalks, but no landscape buffers, will be provided on both sides of the street.

A design layout drawing for this alternative is provided in Appendix B and identifies both building/entire property impacts and potential property impacts associated with the planned roadway geometry. This design generally exceeds the existing roadway width and property boundaries along the northern portion of the corridor. The design layout indicates that portions of many properties along MD 355, from Odendhal Avenue to the Father Cuddy Bridge, will need to be acquired to achieve this design, and the roadway edge will encroach on several existing buildings between Odendhal Avenue and Chestnut Street. Even where buildings aren't significantly impacted, off-street parking on several properties appears to be affected. The roadway design avoids direct impacts to the cemetery on the west side of MD 355 south of Dalamar Street. Table 2-5 summarizes the number of buildings significantly impacted, buildings possibly impacted, and private parking lots significantly impacted, by the single-lane guideway minimum design alternative.

Table 2-5: MD 355 Focal Segment – Single-lane Guideway Minimum Design Property Impacts

Location	Significant Building Impacts		Possible Building Impacts		Significant Parking Lot Impacts	
	East Side	West Side	East Side	West Side	East Side	West Side
Odendhal Avenue to Chestnut Street	0	0	1	0	1	1
Chestnut Street to Father Cuddy Bridge	1	0	0	0	0	0
Father Cuddy Bridge to Summit Avenue	0	0	0	0	0	0
Total Buildings/Properties	1	0	1	0	1	1

The widening associated with the single-lane minimum design will require reconstruction of the Father Cuddy Bridge to accommodate the seven travel lanes (six general traffic and one busway), BRT median separators (2 feet), and planned sidewalks (10 feet) specified.

On the east side of the road, both north and south of the Father Cuddy Bridge, the single-lane minimum roadway design layout encroaches on steep roadside slopes. Significant retaining walls would need to be constructed (or reconstructed) along the east side of the road to support the design.

The BRT operations for the single-lane median guideway minimum design would be very similar to the standard design alternative. The busway could operate in a single peak direction with the bus in the opposite direction traveling in mixed traffic, or as a bi-directional operation requiring additional coordination. The estimated bus speeds would be expected to be similar to those of the standard design within the busway (18 to 22 miles per hour). Station locations would be consistent across all the single-lane guideway design alternatives. The configuration is dependent on the operating structure chosen.

Single-lane Median Guideway Reduced Impact Design Alternative

The single-lane guideway reduced impact design is characterized by a roadway cross-section that provides the minimum guideway lane width (11 feet) and BRT median separator widths (two feet). This alternative modifies the number of vehicle travel lanes and sidewalk widths to minimize the need for roadway widening and reduce impacts to adjacent properties. To achieve reduced roadway widening and property impacts, the roadway design layout eliminates the following vehicle travel lanes:

- One southbound travel lane on MD 355, between Odendhal Avenue and Chestnut Street

A design layout drawing for this alternative is provided in Appendix B and identifies both building/entire property impacts and potential property impacts associated with the planned roadway geometry. This design largely conforms to the existing roadway limits, but portions of several properties along MD 355 will need to be acquired at signalized intersections where station platforms or turning lanes are required, particularly along the northern portion of the corridor. The roadway edge encroaches on one existing building at Chestnut Street, but the building may possibly be retained with localized sidewalk modifications that reduce typical sidewalk width standards. The roadway design avoids direct impacts to the cemetery on the west side of MD 355 south of Dalamar Street and generally minimizes impacts to off-street parking. Table 2-6 summarizes the number of buildings significantly impacted, buildings possibly impacted, and private parking lots significantly impacted, by the single-lane guideway reduced impact design alternative.

Table 2-6: MD 355 Focal Segment – Single-lane Guideway Reduced Impact Design Property Impacts

Location	Significant Building Impacts		Possible Building Impacts		Significant Parking Lot Impacts	
	East Side	West Side	East Side	West Side	East Side	West Side
Odendhal Avenue to Chestnut Street	0	0	0	0	0	0
Chestnut Street to Father Cuddy Bridge	0	0	1	0	0	0
Father Cuddy Bridge to Summit Avenue	0	0	0	0	0	0
Total Buildings/Properties	**0**	**0**	**1**	**0**	**0**	**0**

The design layout will require no widening of the Father Cuddy Bridge. In addition to the single-lane median guideway, three northbound travel lanes and three southbound travel lanes can be accommodated on the bridge without widening. The existing sidewalks, representing the minimum standard sidewalk, are retained. No significant roadway widening is required along the steeply sloped roadside north or south of the bridge, so new retaining walls should not be required.

The single-lane median guideway reduced impact design would provide similar BRT operating conditions to the single-lane standard and minimum designs (18 to 22 miles per hour). The other potential impact to travel speed could be the frequency of the service if it operates under a bi-directional guideway configuration. This is a limitation of any of the single-lane alternatives. Station location for this design alternative would be the same as the standard and minimum design alternatives for single-lane guideway design.

Lane Repurposing Guideway Design

The lane repurposing guideway design seeks to provide an improved bus experience by providing exclusive lanes, but at the expense of general traffic lanes to reduce road widening. This alternative modifies the number of vehicle travel lanes on the road to minimize the need for roadway widening and reduce impacts to adjacent properties. To achieve reduced roadway widening and property impacts, the roadway design layout eliminates the following vehicle travel lanes:

- One southbound travel lane on MD 355, between Odendhal Avenue and Chestnut Street
- One northbound travel lane on MD 355, between Summit Avenue and Brookes Avenue

A copy of the lane repurposing design layout concept is included in Appendix B.

Lane Repurposing Guideway Design Alternative

The lane repurposing guideway design is characterized by a roadway cross-section providing the minimum guideway lane width (11 feet) and no median separators between the BRT guideway and the vehicle travel lanes. This design essentially entails pavement marking modifications to the existing roadway to provide two dedicated BRT guideway lanes in the center of the road. The BRT guideway would be separated from vehicular traffic by a buffer

or stripe, potentially including flexible post-mounted delineators to provide physical separation.

This alternative modifies the number of vehicle travel lanes on the road to minimize the need for roadway widening and reduce impacts to adjacent properties. To achieve reduced roadway widening and property impacts, the roadway design layout eliminates the following vehicle travel lanes:

- One southbound travel lane on MD 355, between Odendhal Avenue and Chestnut Street
- One northbound travel lane on MD 355, between Summit Avenue and Brookes Avenue

A design layout drawing for this alternative is provided in Appendix B and identifies both building/entire property impacts and potential property impacts associated with the planned roadway geometry. This design largely conforms to the existing roadway limits, but portions of several properties along MD 355 will need to be acquired at signalized intersections where station platforms or turning lanes are required, particularly along the northern portion of the corridor. The roadway edge encroaches on one existing building at Chestnut Street, but the building may possibly be retained with localized sidewalk modifications that reduce typical sidewalk width standards. The roadway design avoids direct impacts to the cemetery on the west side of MD 355 south of Dalamar Street and generally minimizes impacts to off-street parking. Table 2-7 summarizes the number of buildings significantly impacted, buildings possibly impacted, and private parking lots significantly impacted, by the lane repurposing design alternative.

Table 2-7: MD 355 Focal Segment – Lane Repurposing Design Property Impacts

Location	Significant Building Impacts		Possible Building Impacts		Significant Parking Lot Impacts	
	East Side	West Side	East Side	West Side	East Side	West Side
Odendhal Avenue to Chestnut Street	0	0	0	0	0	0
Chestnut Street to Father Cuddy Bridge	0	0	1	0	0	0
Father Cuddy Bridge to Summit Avenue	0	0	0	0	0	0
Total Buildings/Properties	**0**	**0**	**1**	**0**	**0**	**0**

The design layout will require no widening of the Father Cuddy Bridge. In addition to the two BRT guideway lanes, two northbound travel lanes and three southbound travel lanes can be accommodated on the bridge without widening. The existing sidewalks, representing the minimum standard sidewalk, are retained. No significant roadway widening is required along the steeply sloped roadside north or south of the bridge, so new retaining walls should not be required.

The lane repurposing guideway design would provide for less than desirable BRT operations by providing two 11 foot bus lanes to allow buses traveling in both directions to operate, but without a physical separation from general traffic. The lack of a median separator and small

distance between busway and general purpose lanes will result in greater interference from general traffic. It is estimated that buses operating within repurposed lanes could maintain an average speed between 13 and 18 miles per hour, depending on time of day. The lane repurposing guideway design provides similar station benefits to the three dual-lane guideway design alternatives.

Mixed Traffic Guideway Design

A mixed traffic BRT design does not technically provide a guideway for the bus to operate in. The bus travels in the general traffic lanes and does not receive exclusivity from the impacts of congestion associated with traffic. This alternative requires no roadway construction or improvements. As part of the larger BRT system, the bus will likely receive signal priority along the corridor within the mixed traffic segments, but this benefit is limited because the bus can go no faster than the surrounding traffic. Consideration for how the bus will transition from a dedicated guideway to mixed traffic operations is important to provide for seamless bus operation.

Mixed Traffic Guideway Alternative

The mixed traffic guideway alternative is characterized by a roadway cross-section that provides no exclusive bus lane and keeps the existing traffic lane configuration, lane widths, and roadway geometry for the entire focal segment from Odendhal Avenue to Summit Avenue. This design assumes that the existing sidewalk widths will be retained throughout the entirety of the corridor as well.

A design layout drawing for this alternative is provided in Appendix B. This design conforms to the existing roadway limits, requiring no construction within the roadway and no property acquisition along the focal segment. In order to not have any property impact within the segment from Odendhal to Summit, a BRT station cannot be located at Odendhal because of the property impacts that would be required to expand the existing intersection. This design alternative would require that the station be located at Lakeforest Boulevard instead. Because no roadway widening is necessary, this design avoids direct impacts to the cemetery on the west side of MD 355 south of Dalamar Street and has no impacts to off-street parking. Table 2-8 summarizes the number of buildings significantly impacted, buildings possibly impacted, and private parking lots significantly impacted, by the mixed traffic design alternative.

Table 2-8: MD 355 Focal Segment – Mixed Traffic Design Property Impacts

Location	Significant Building Impacts		Possible Building Impacts		Significant Parking Lot Impacts	
	East Side	West Side	East Side	West Side	East Side	West Side
Odendhal Avenue to Chestnut Street	0	0	0	0	0	0
Chestnut Street to Father Cuddy Bridge	0	0	0	0	0	0
Father Cuddy Bridge to Summit Avenue	0	0	0	0	0	0
Total Buildings/Properties	**0**	**0**	**0**	**0**	**0**	**0**

The design layout will require no widening of the Father Cuddy Bridge. The existing lane configuration of three southbound and three northbound lanes would remain. The center raised median would also be retained. The existing sidewalks, representing the minimum standard sidewalk, are retained. No significant roadway widening is required along the steeply sloped roadside north or south of the bridge, so new retaining walls are not required.

BRT operations under the mixed traffic design alternative would realize no benefits in terms of speed and travel time. The bus would travel in the general traffic lanes from Odendhal Avenue to Summit Avenue, traveling at the same speed as the traffic along MD 355. The overall travel time for the entire route may be improved slightly through the benefit of receiving transit signal priority, but so would any traffic traveling with the bus. Generally, the entire corridor would be impacted by this mile long stretch of mixed traffic operations, resulting in an overall average speed between 11 and 15 miles per hour. This design alternative also means that the bus must exit and enter the BRT guideway at the boundary intersections of the focal segment. This operation will need to be coordinated by traffic signals to provide for safe and exclusive access to the BRT guideway by the BRT vehicles. Under the mixed traffic configuration, stations should either not be provided within the focal segment or should be provided along the curb-side of the road. If stations are constructed along the curb, the bus would need to transition from the curb lane from the center lane and would also be stopping in the general traffic lane, which would further impact traffic.

Summary of Alternatives

The following tables provides a quick summary of the property and infrastructure impacts of each alternative. Included in the table is a column that indicates whether the bus receives a benefit from the alternative through improved travel speeds.

Table 2-9: Summary of Land Impacts, Infrastructure Impacts, and Operating Speeds

Alternative	Property Impacts	Bridge Impacts	Slope Impacts	Improved bus speeds
Dual-lane Standard	✗	✗	✗	✓
Dual-lane Minimum	✗	✗	✗	✓
Dual-lane Reduced Impact	✓	✓	✓	✓
Single-lane Standard	✗	✗	✗	✓
Single-lane Minimum	✗	✗	✗	✓
Single-lane Reduced Impact	✓	✓	✓	✓
Lane Repurposing	✓	✓	✓	✓
Mixed Traffic	✓	✓	✓	✗

2.3 Focal Segment Conceptual Design Alternative Cross-sections

The focal segment from Odendhal Avenue to Summit Avenue is characterized by varying roadway geometry and design challenges in several different locations along the segment. The existing character of these areas was described in Chapter 1 of this report. The four smaller segments include the following areas:

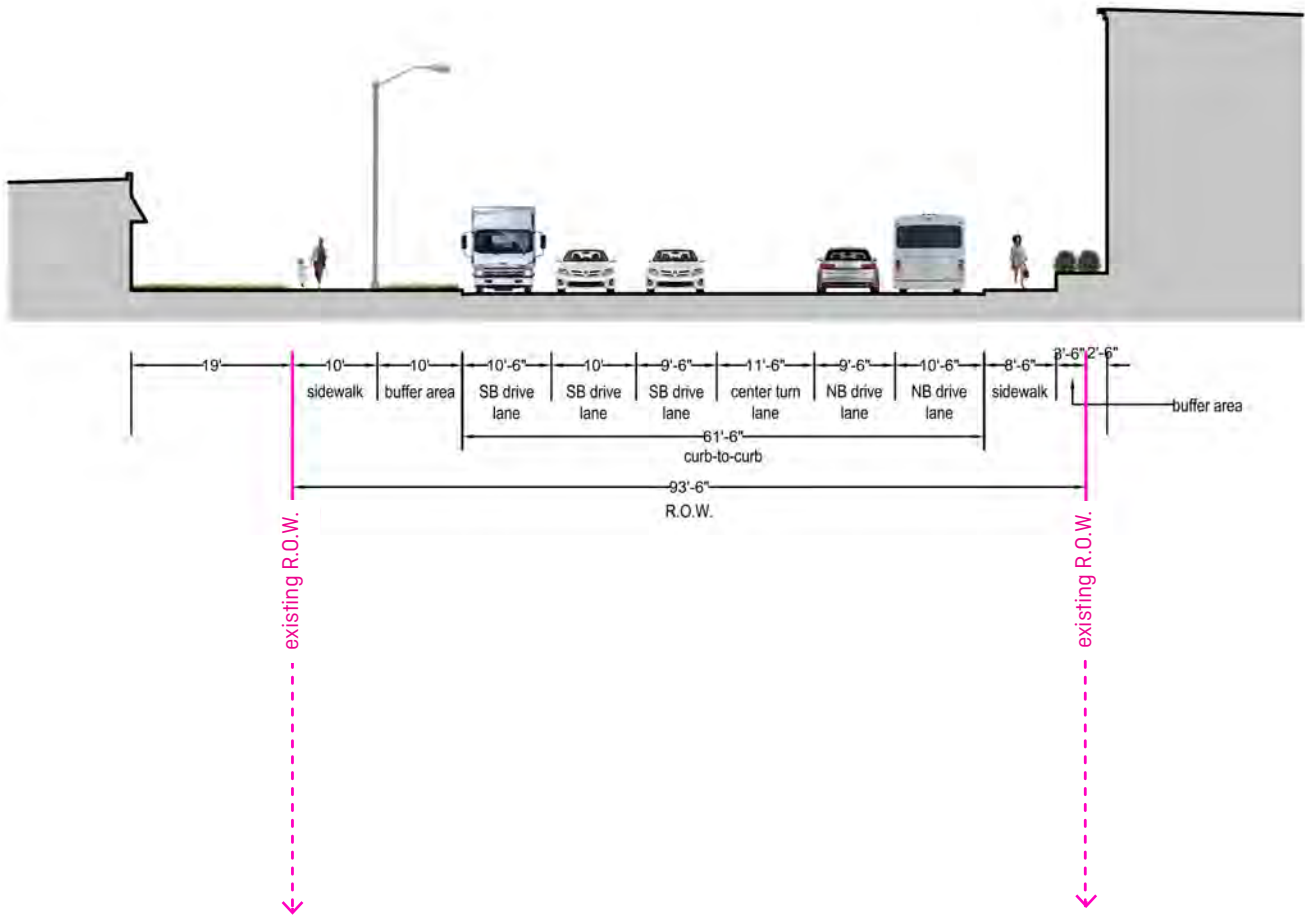
- Odendhal Avenue to Chestnut Street
- Chestnut Street to Father Cuddy Bridge
- Father Cuddy Bridge
- Father Cuddy Bridge to Summit Avenue

To show how the different BRT guideway alternatives would fit within the different character areas of the focal segment, five locations were identified where roadway cross-sections would be developed to identify the potential design changes and influences on existing roadside elements. Each of these locations represents distinct design characteristics within the segment and many present particular challenges related to building setbacks, existing roadway width, sensitive properties, or roadway structures. The five locations include:

- MD 355 south of Whetstone Drive
- MD 355 at Montgomery Avenue
- MD 355 between Brookes Avenue and Walker Avenue
- MD 355 at Father Cuddy Bridge
- MD 355 north of Desellum Avenue

The following pages display each location, the existing lane widths and configuration, and each of the eight design alternatives described above. Each cross-section shows the proposed lane, median, and sidewalk widths, changes in roadway alignment, and necessary curb-to-curb width and right-of-way. Also indicated on the cross-sections are any potential property impacts.

1 EXISTING CONDITIONS



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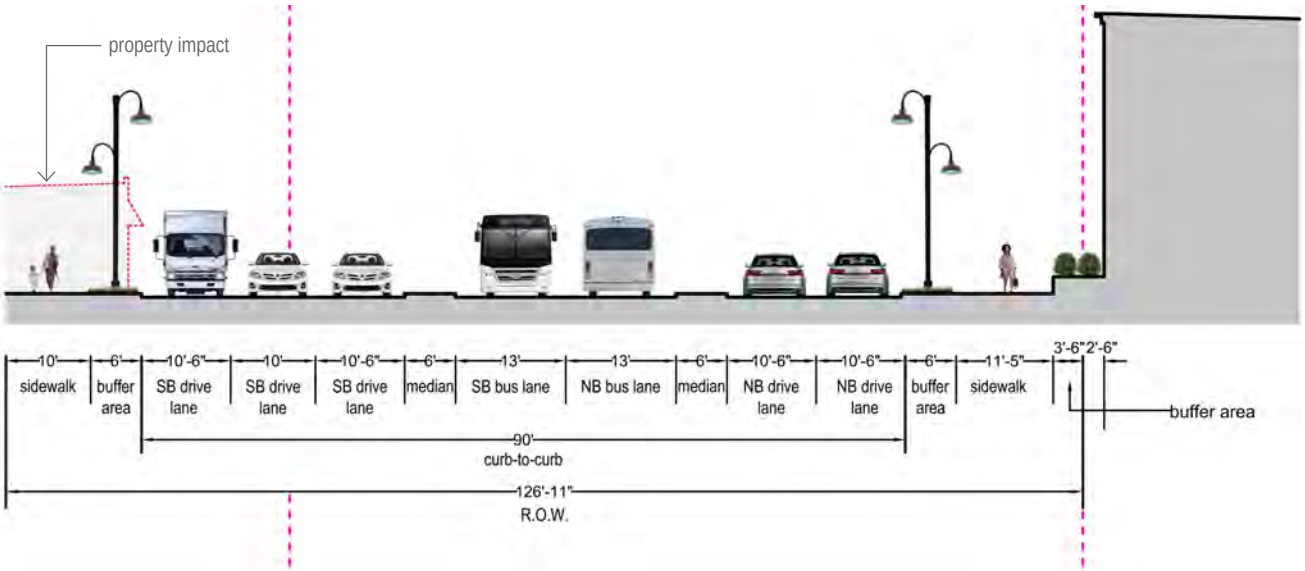

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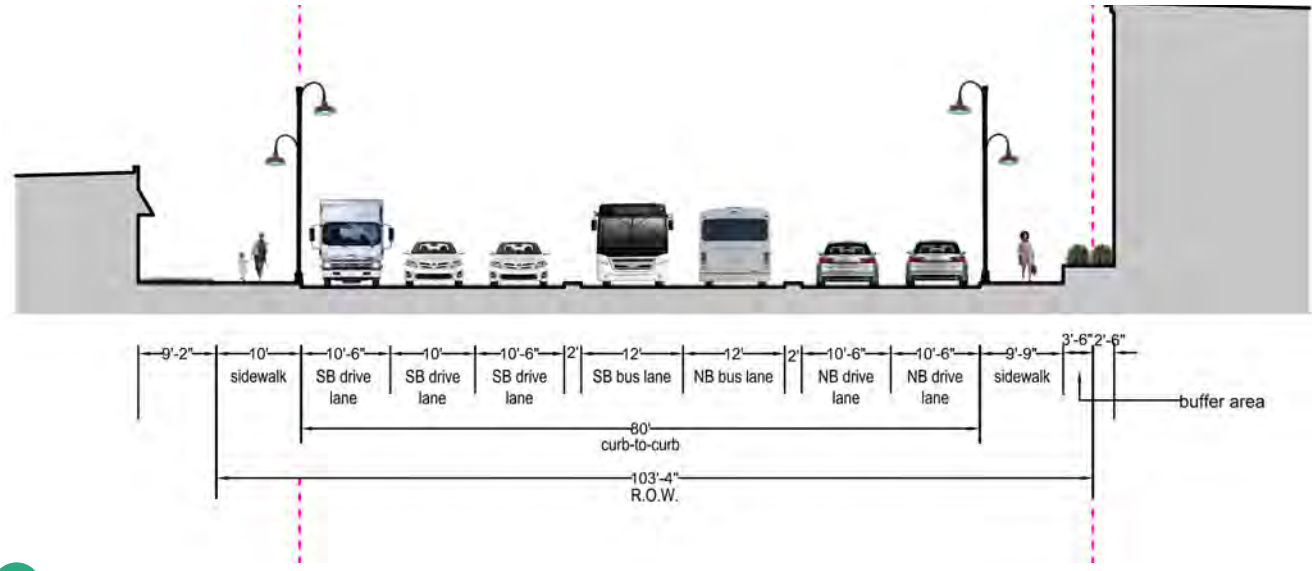

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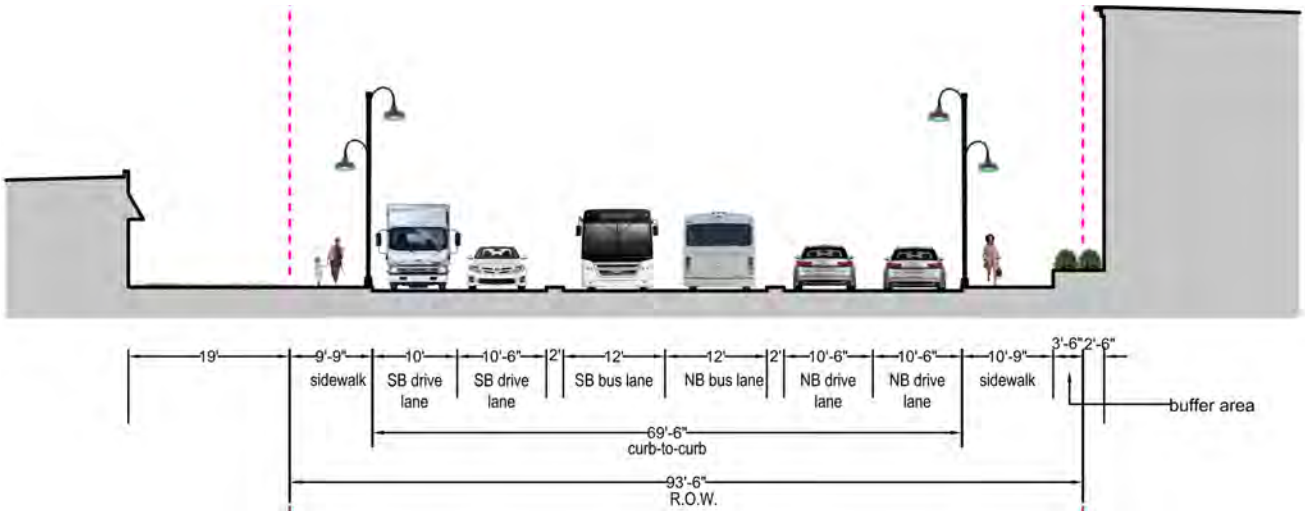

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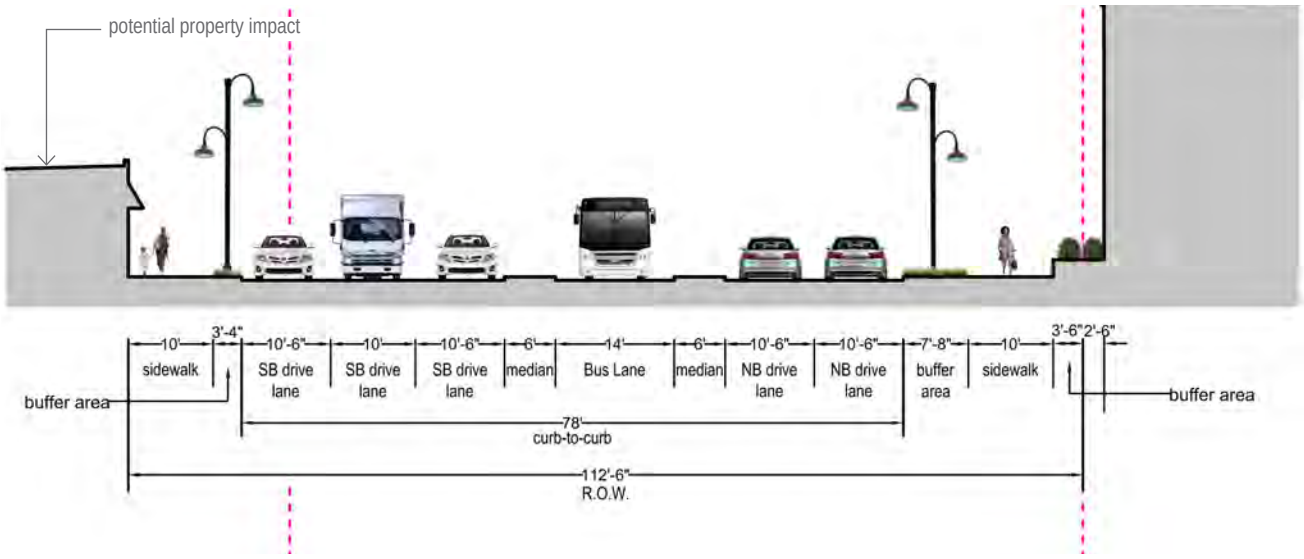

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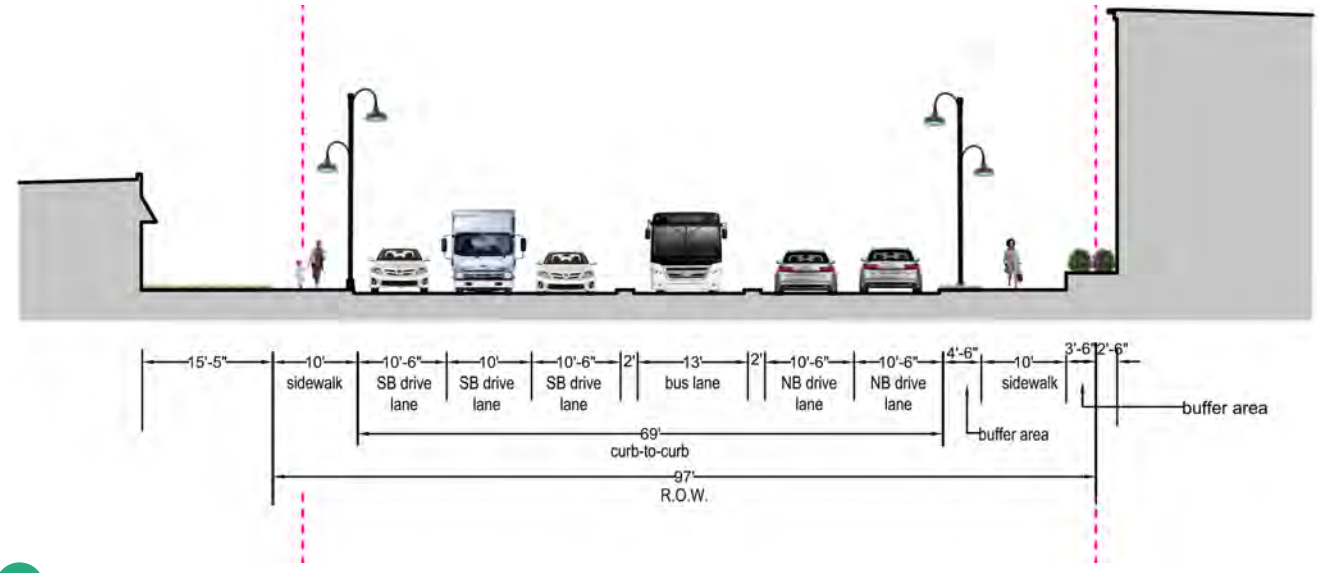

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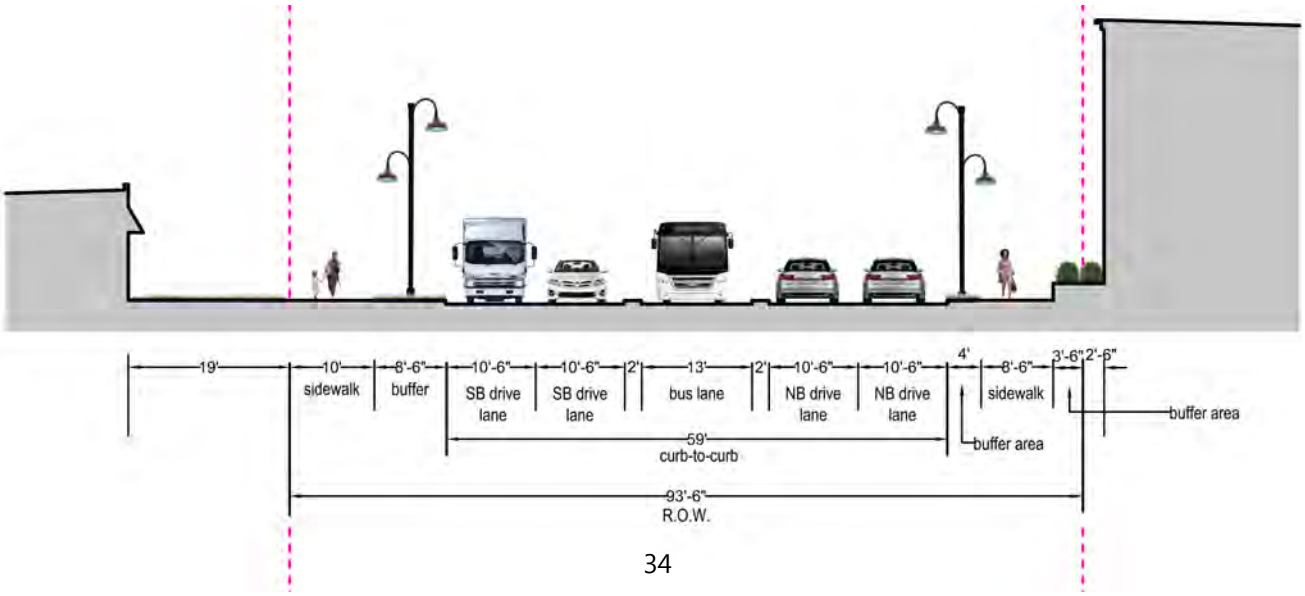

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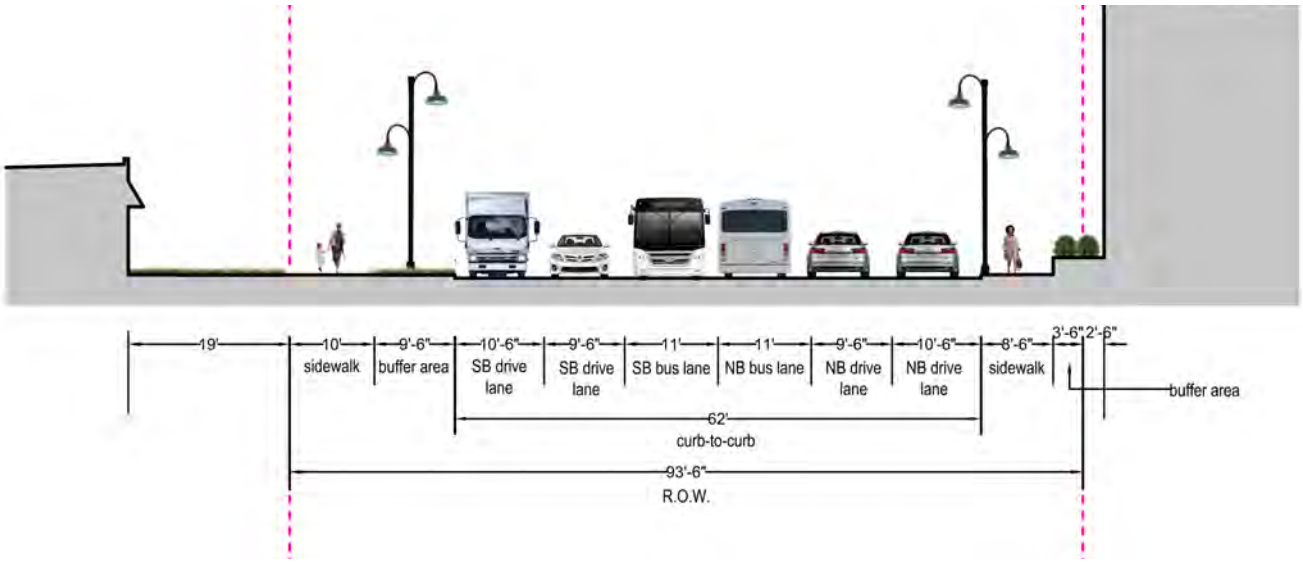

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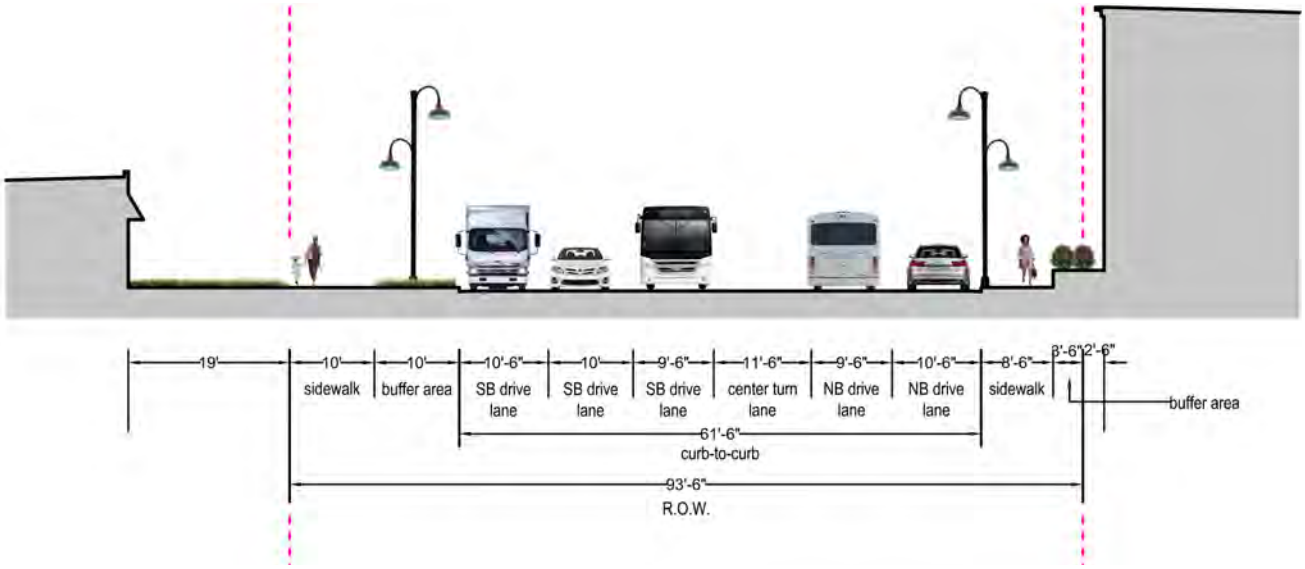

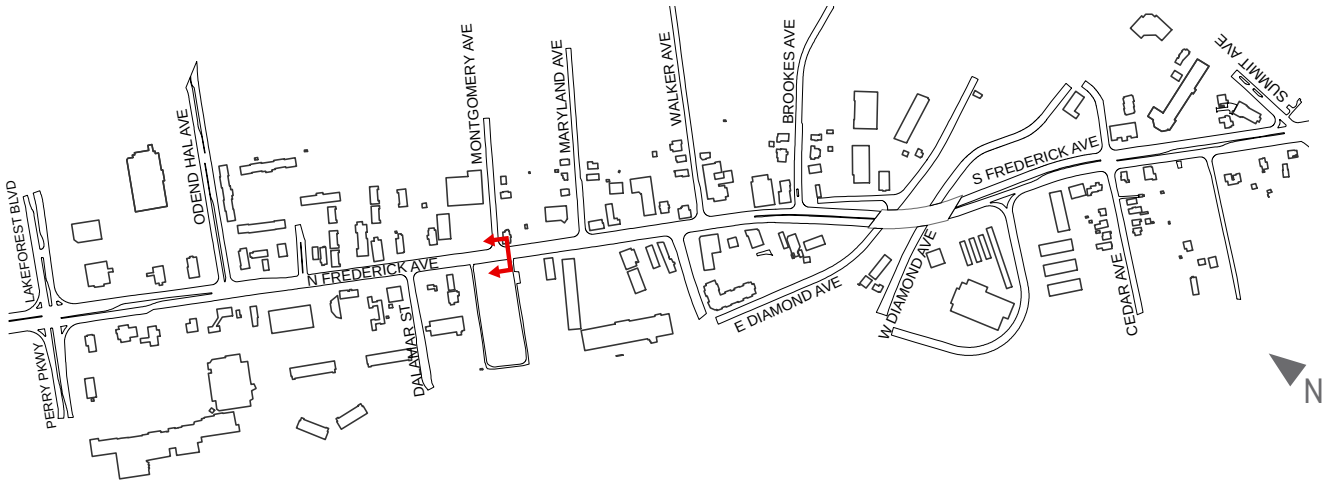

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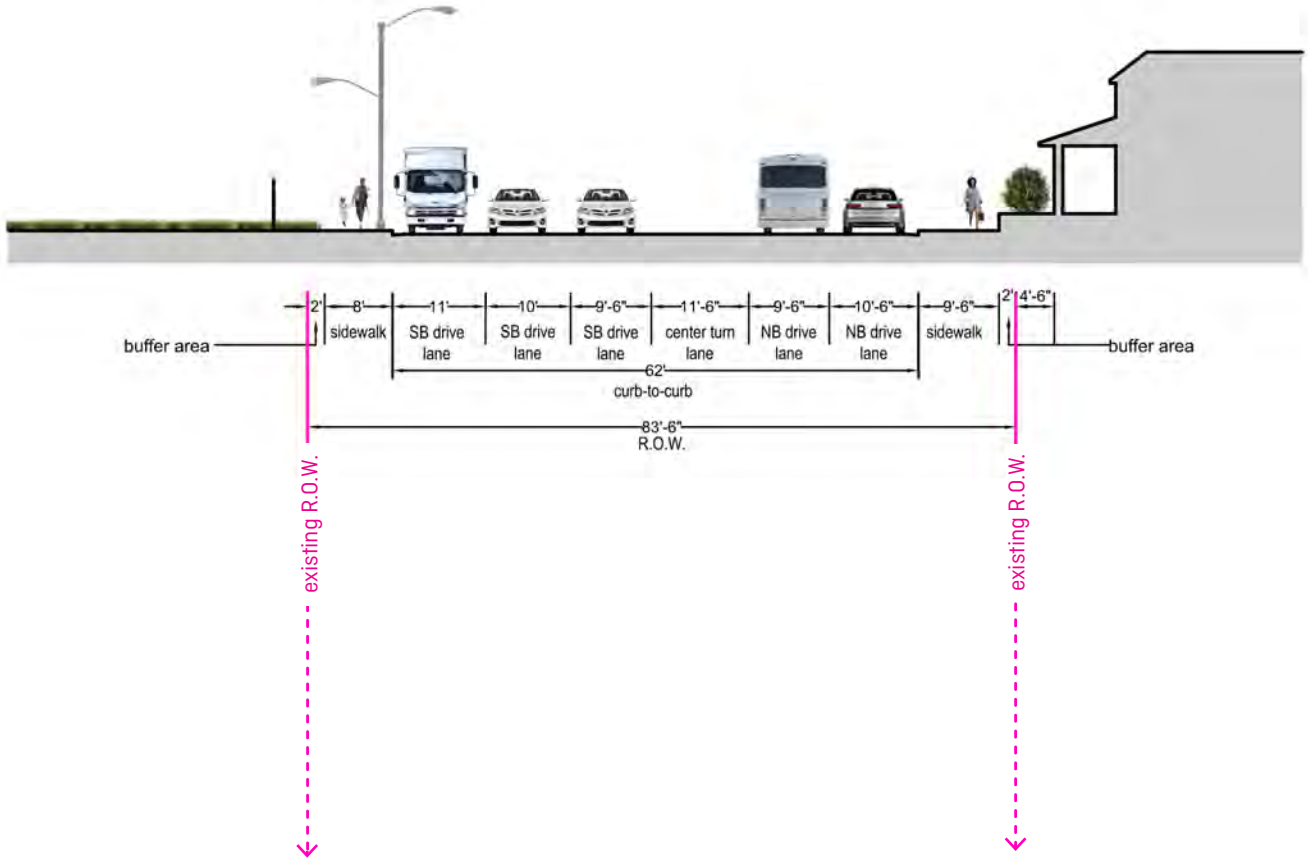

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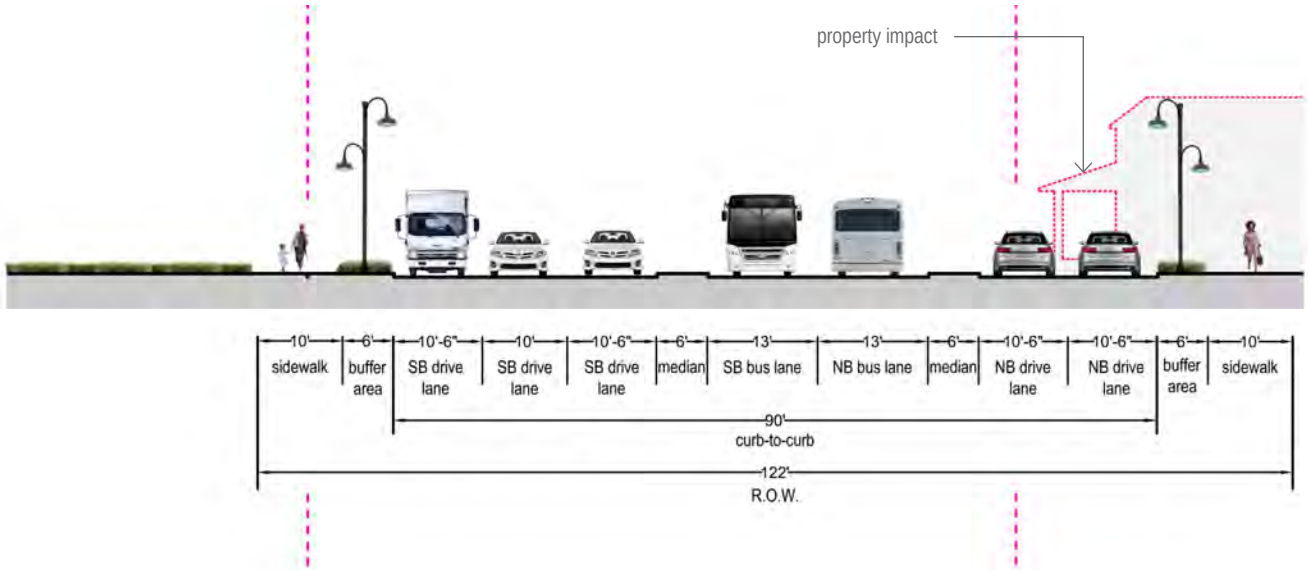

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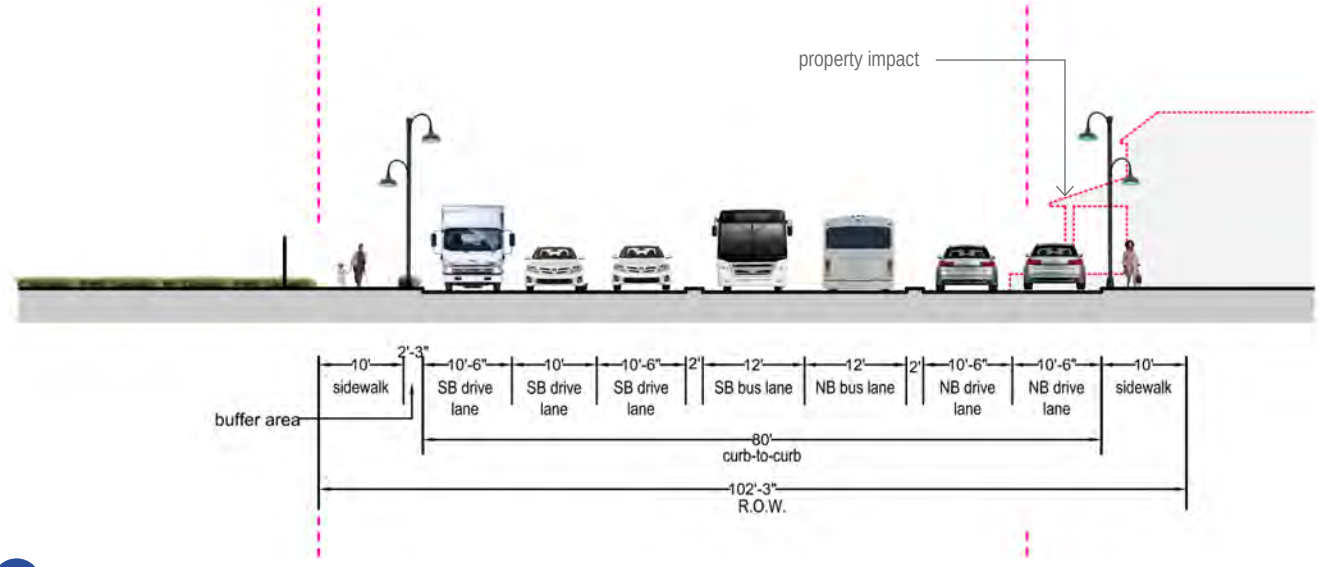

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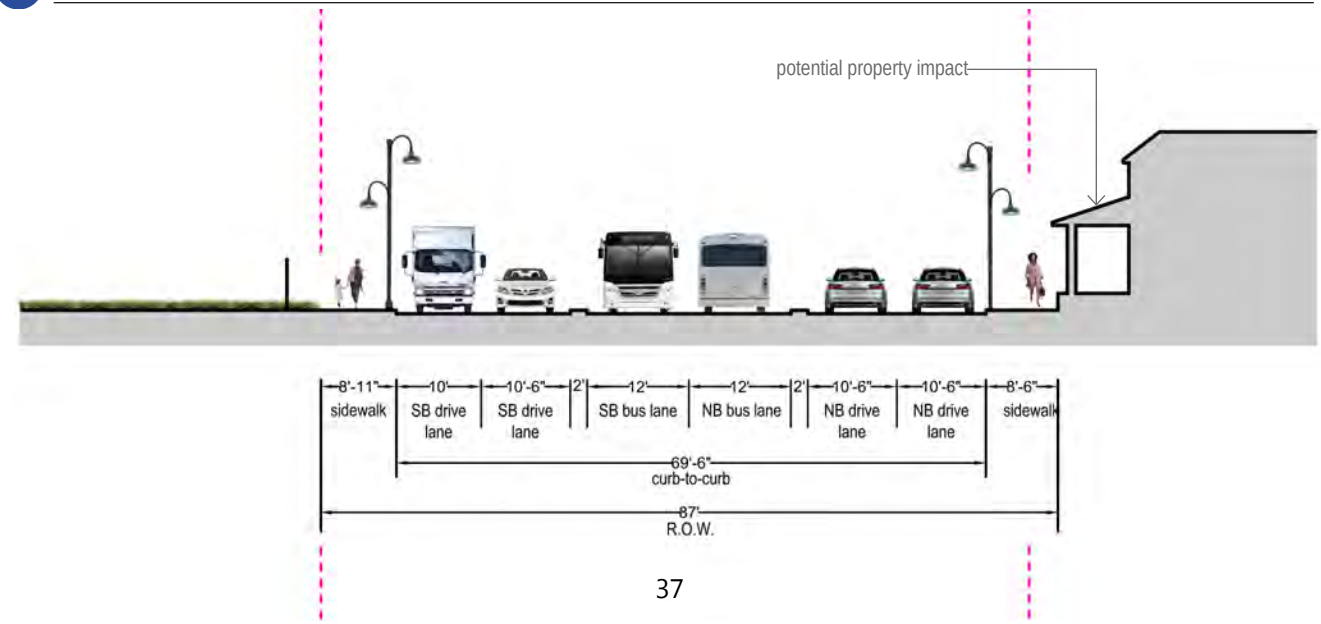

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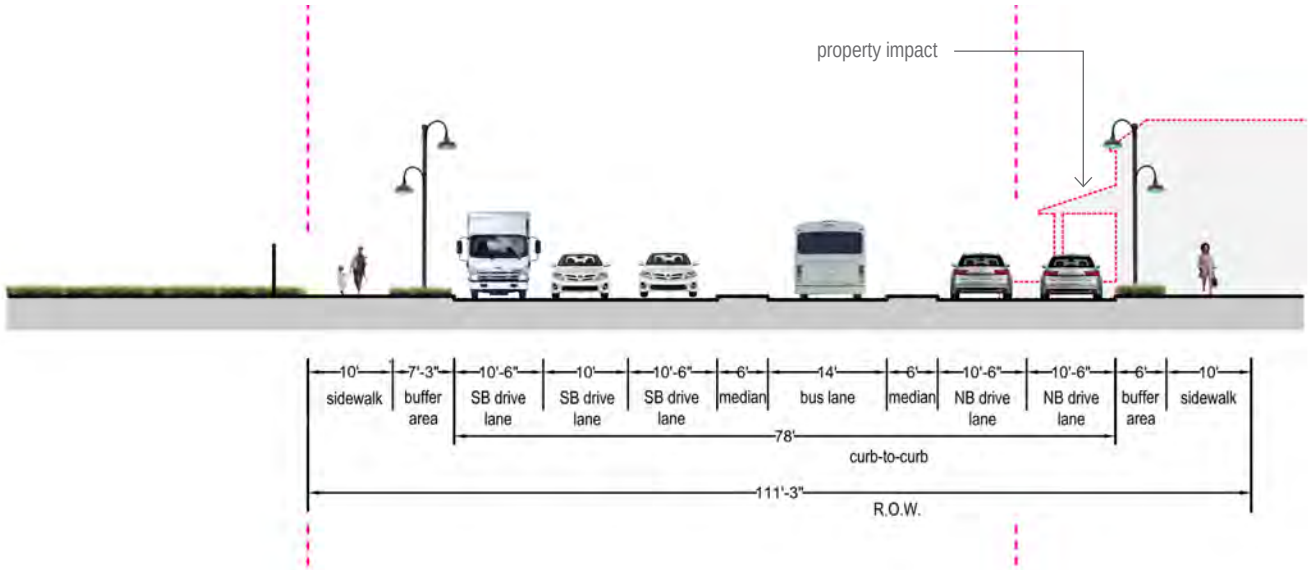

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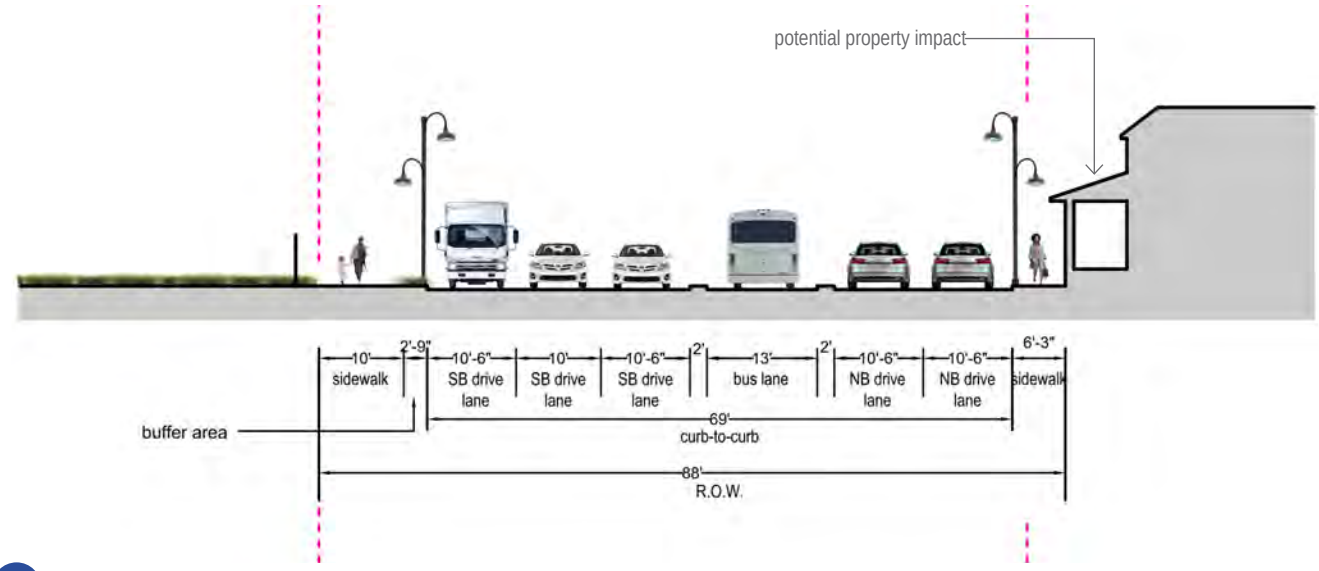

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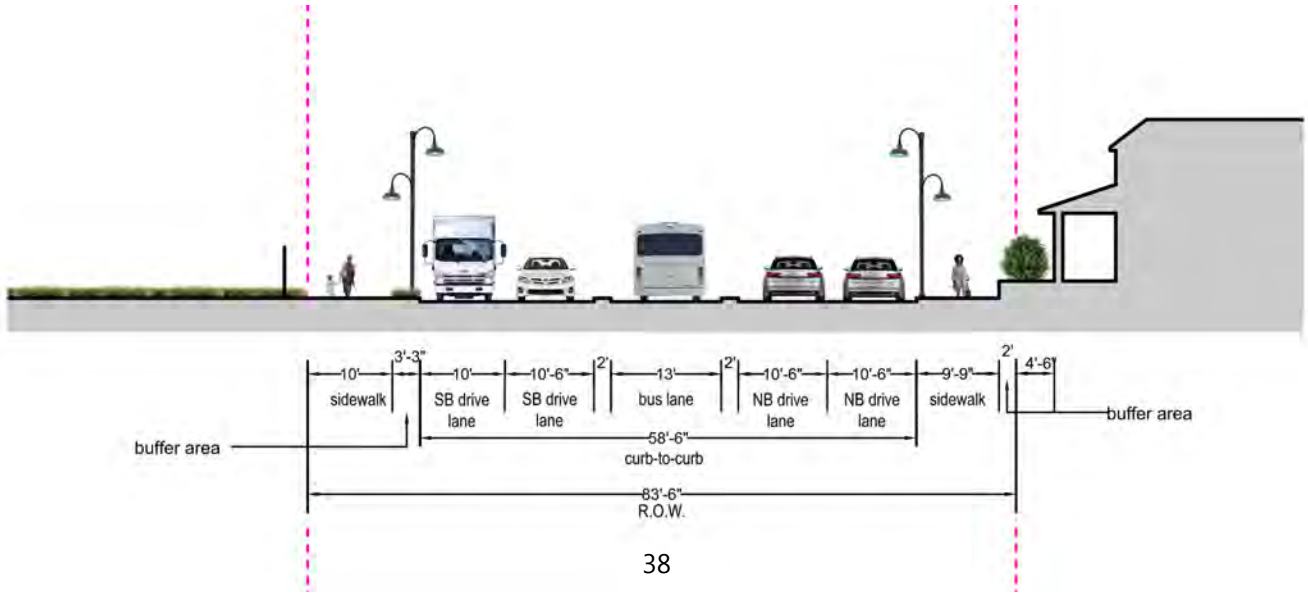

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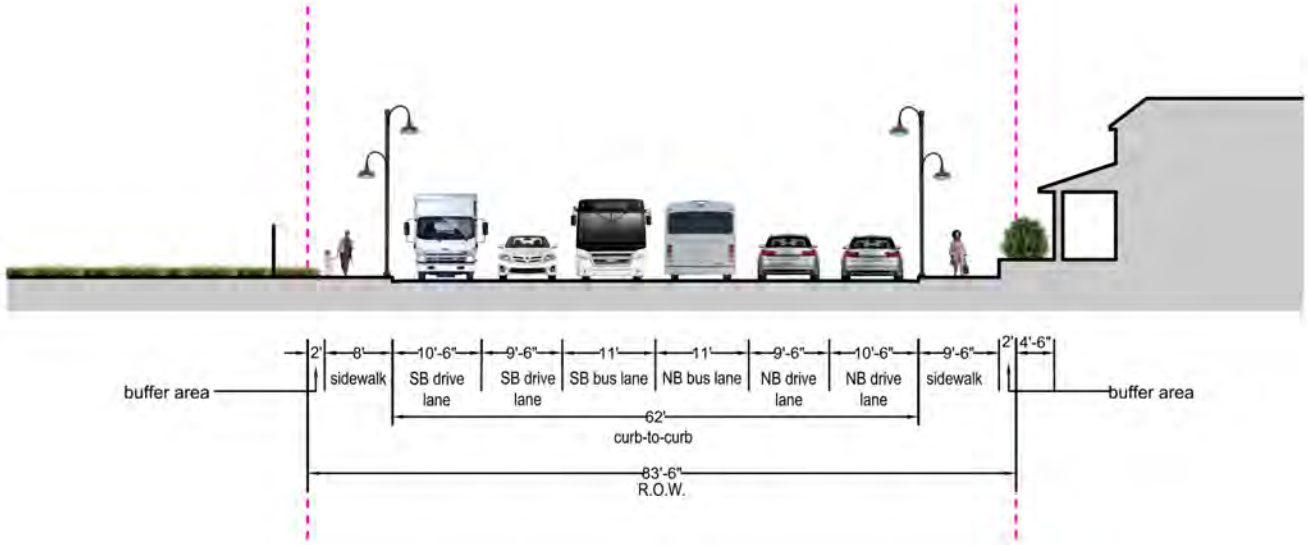

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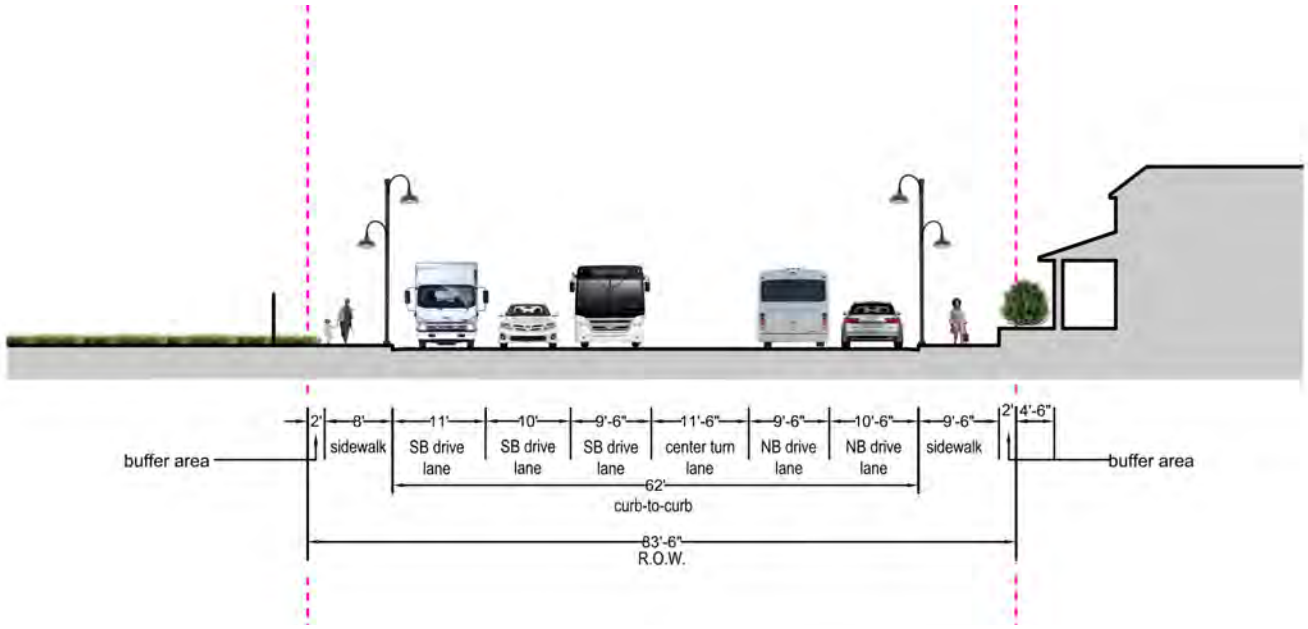

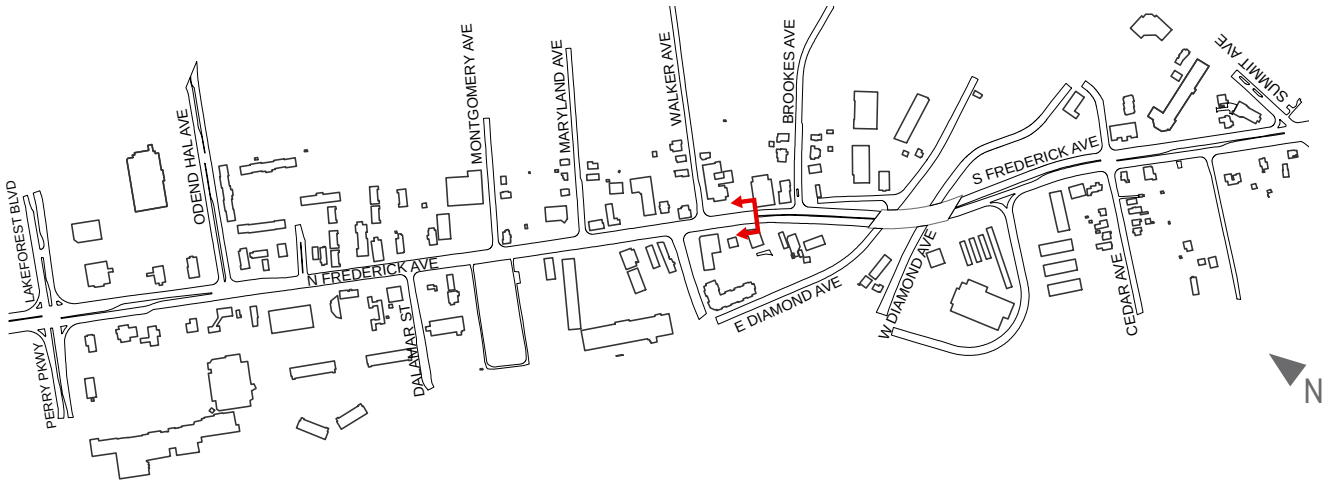

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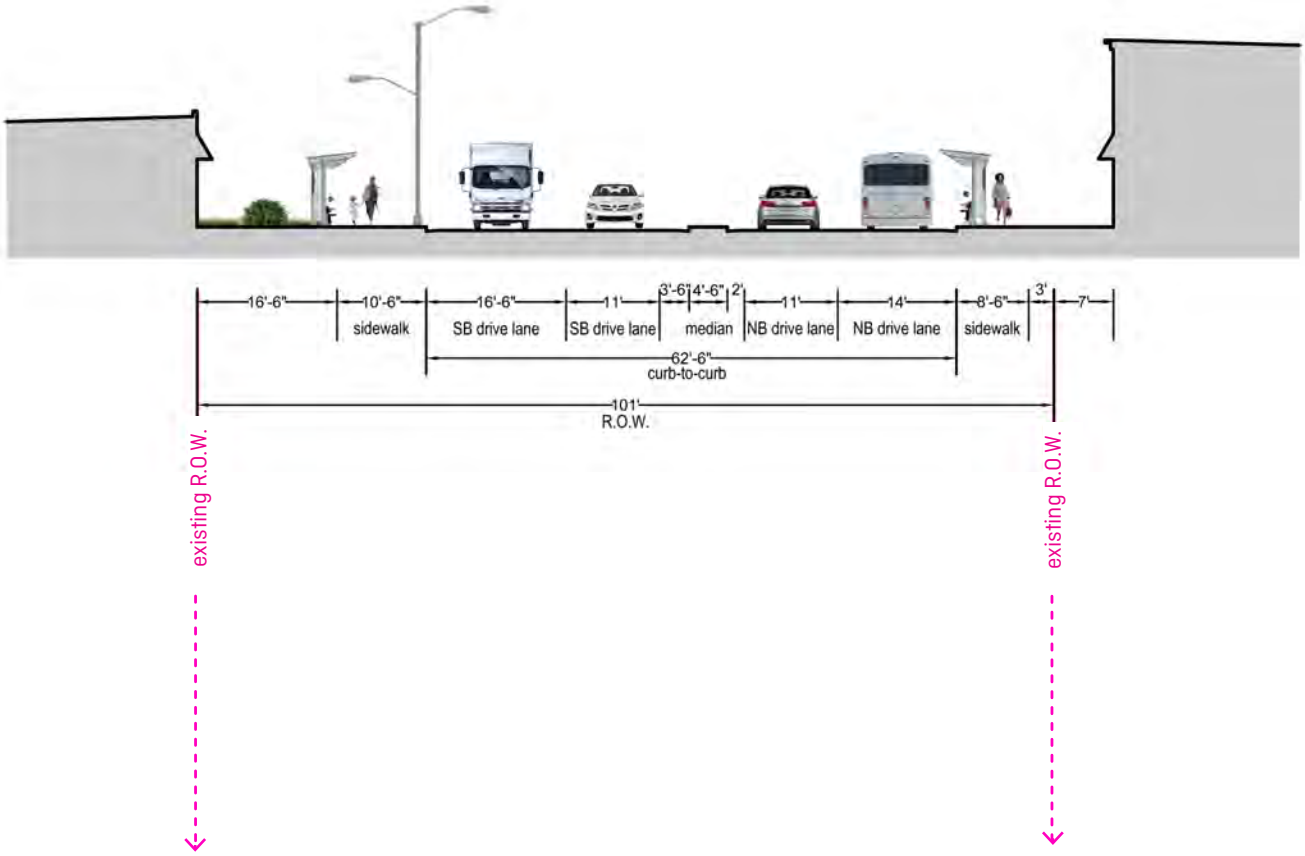

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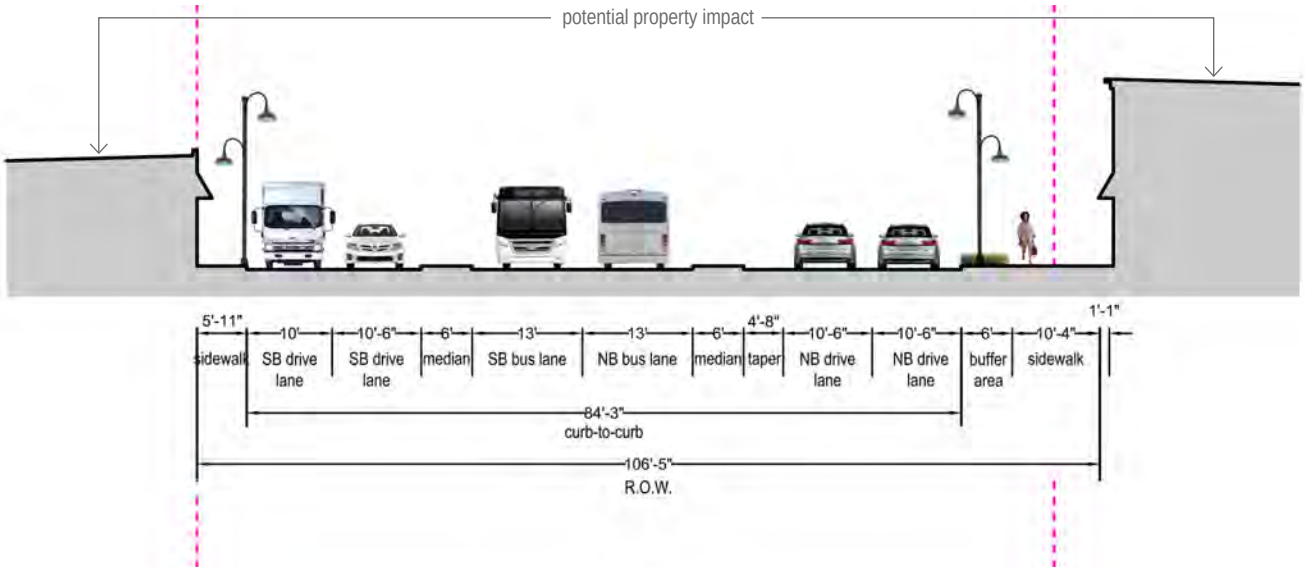

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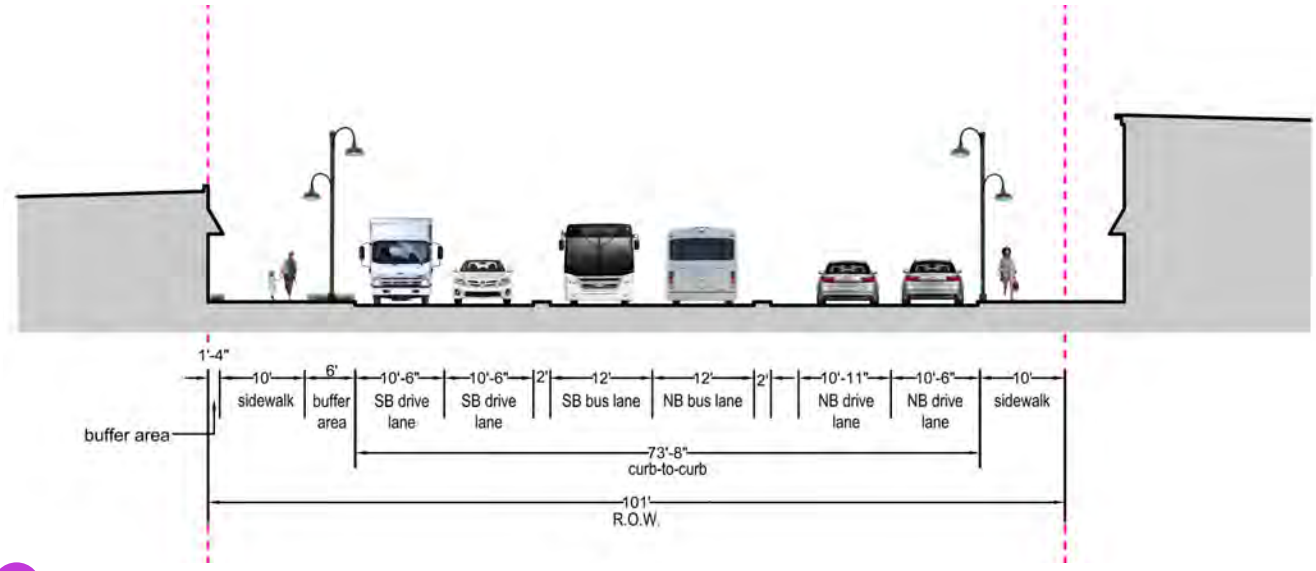

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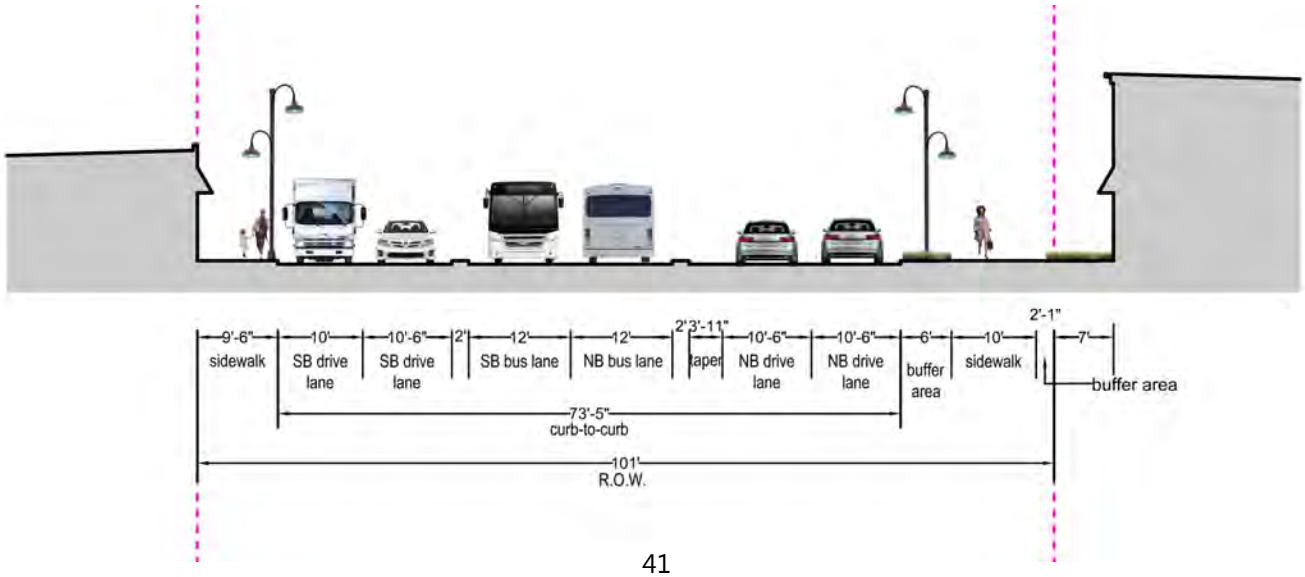

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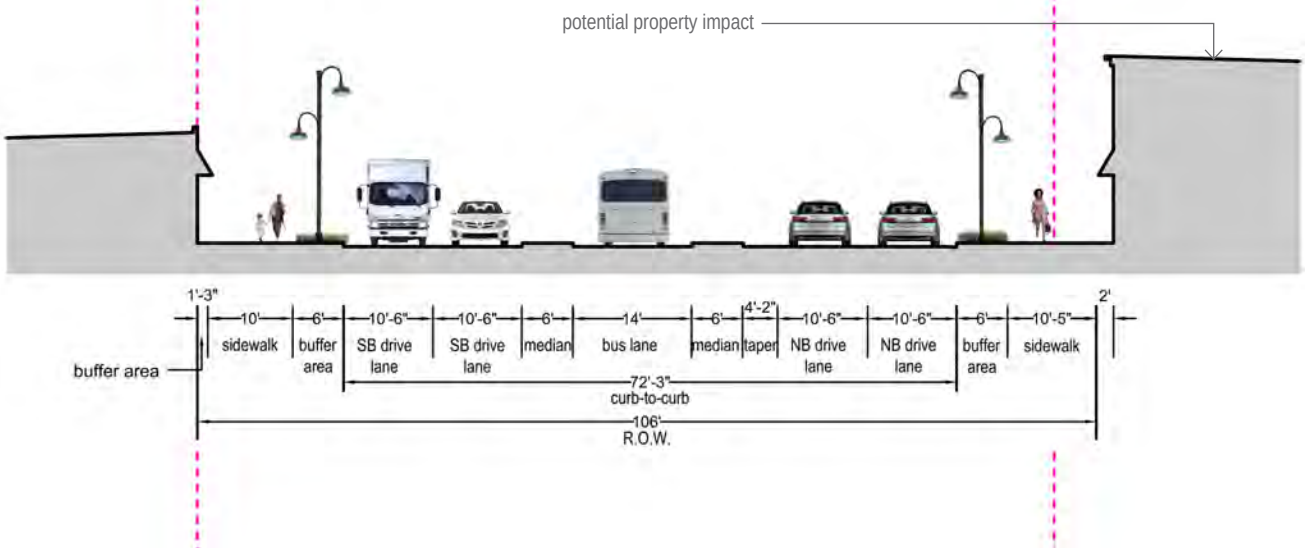

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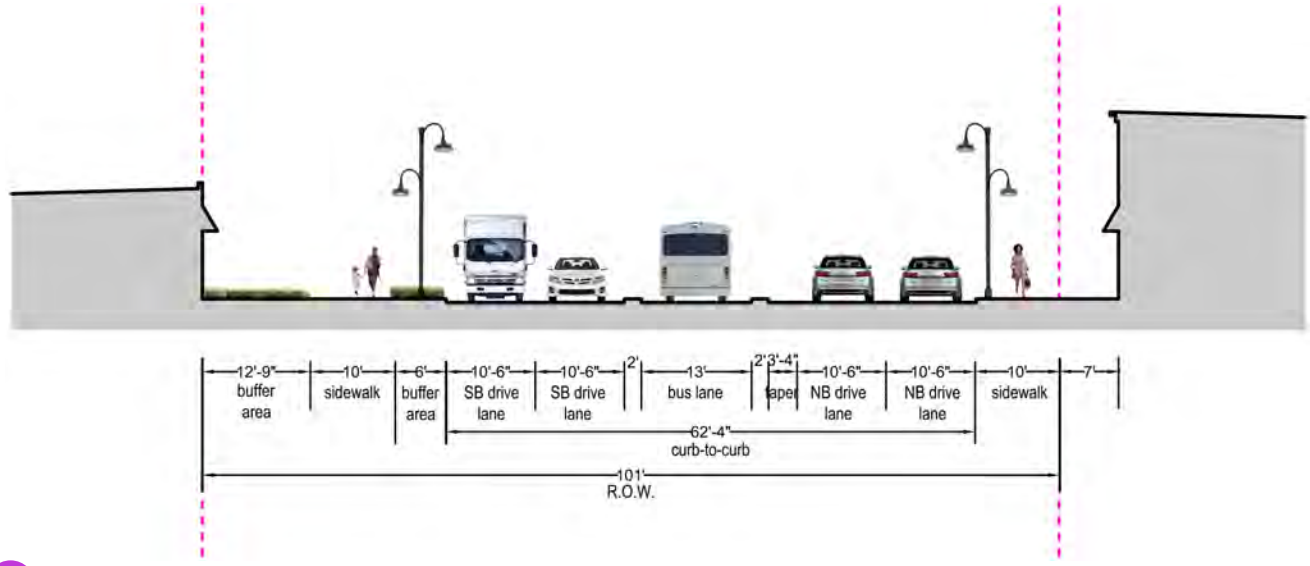

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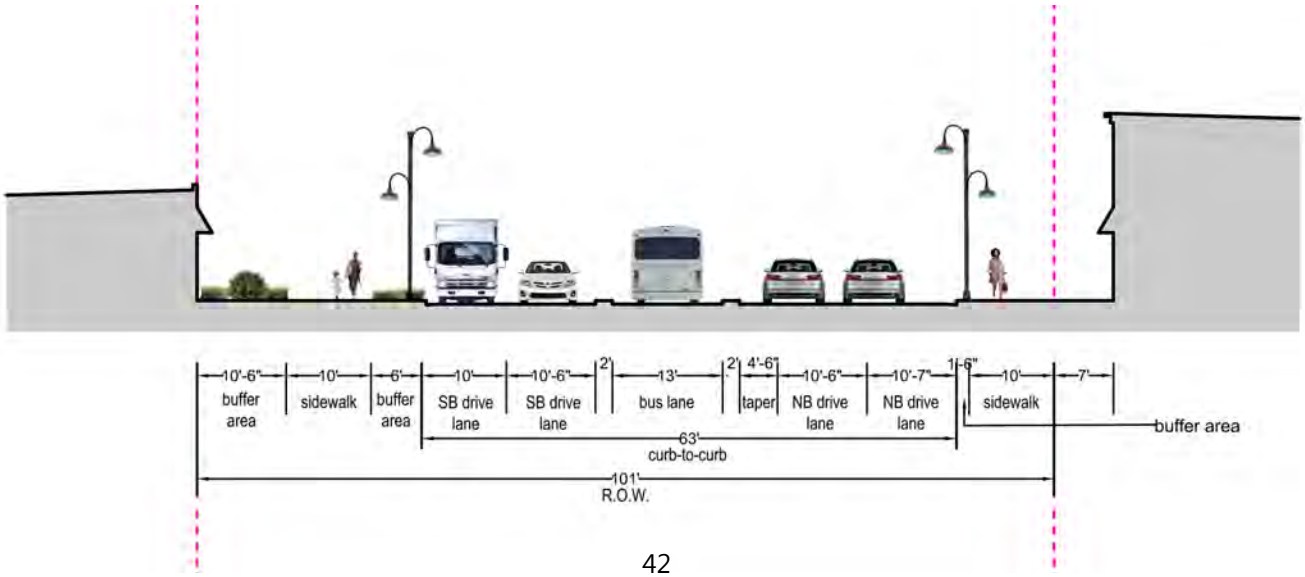

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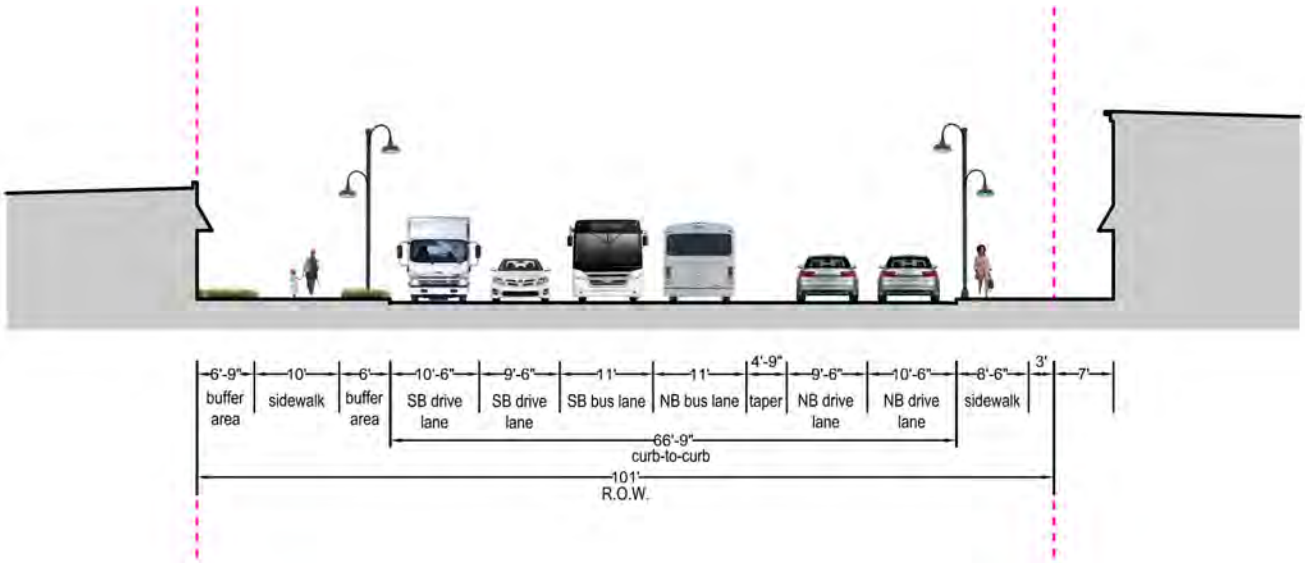

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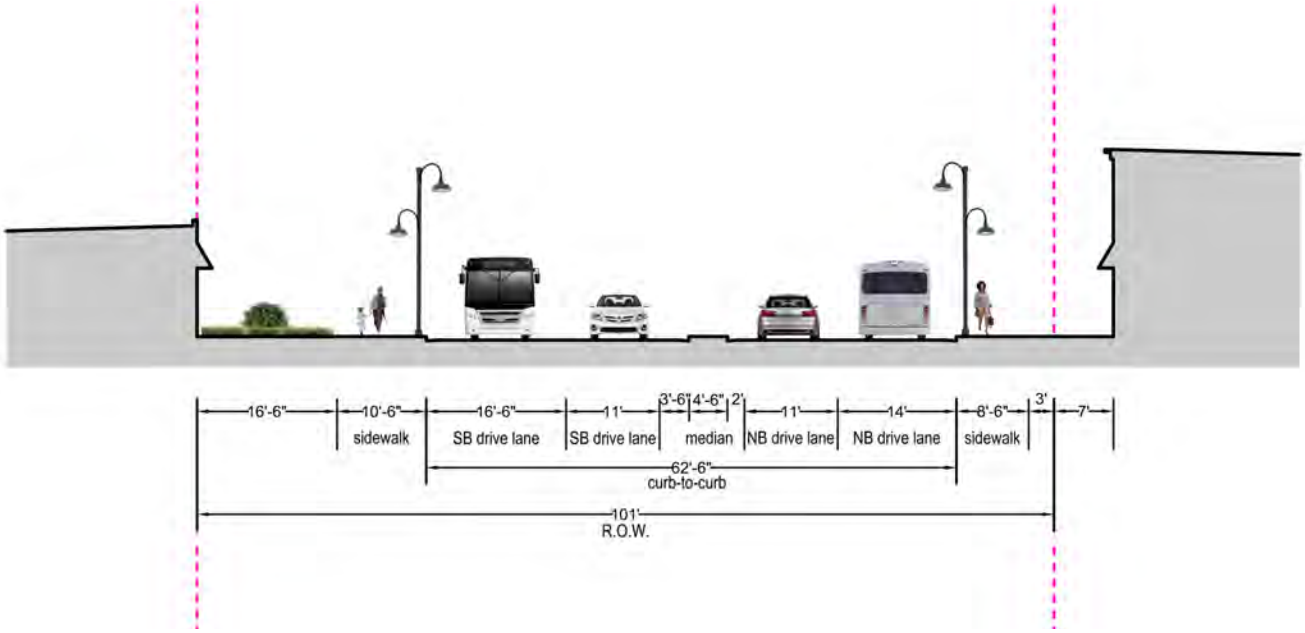

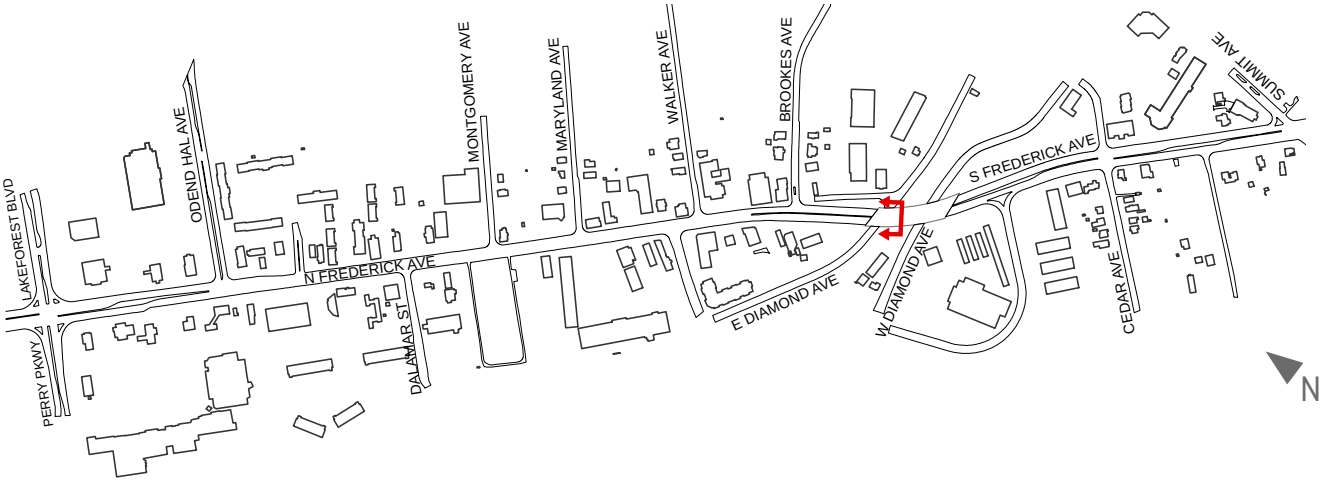

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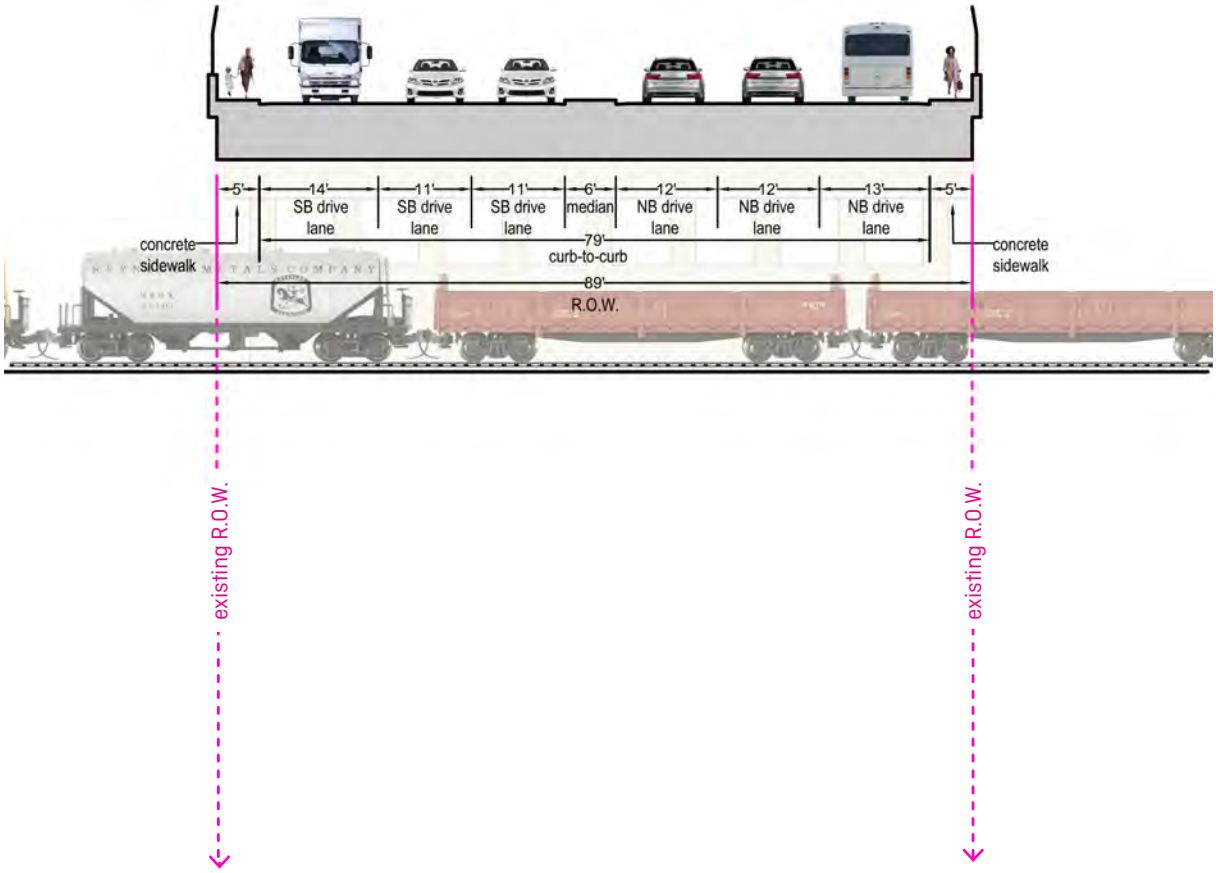

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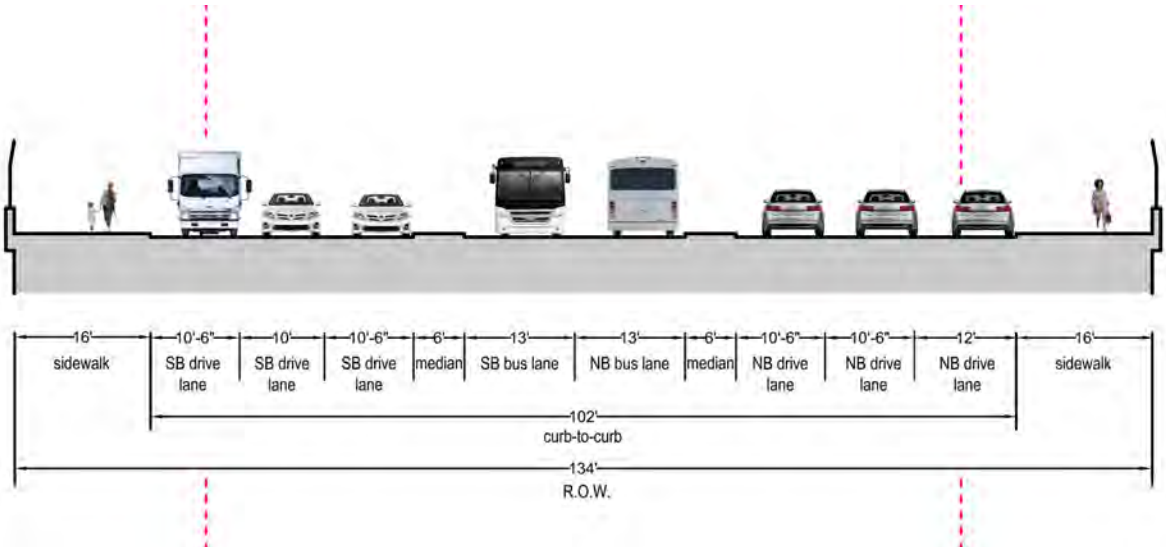

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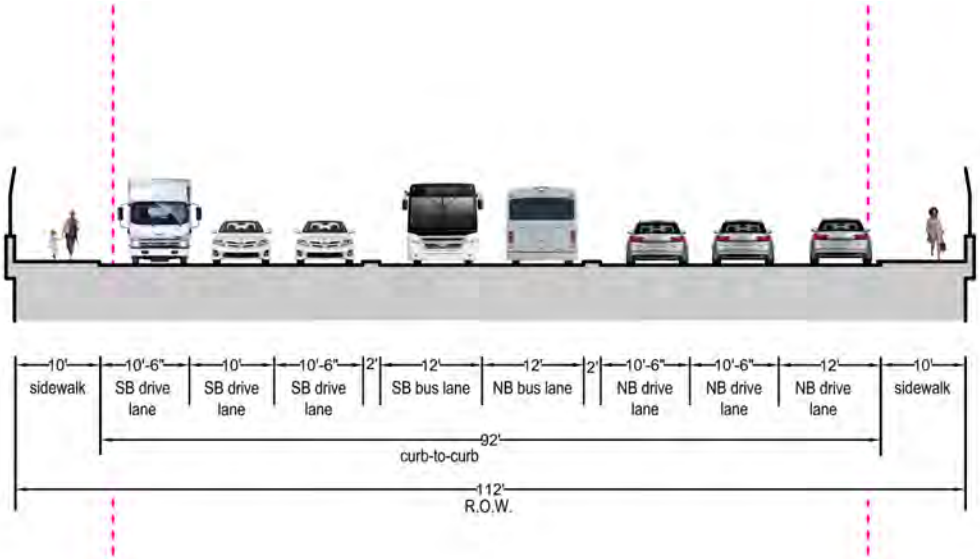

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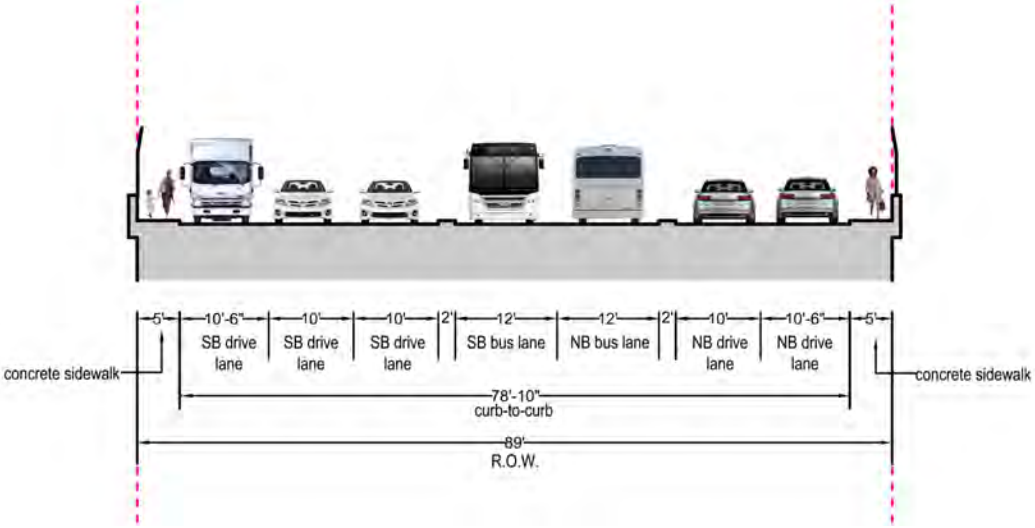

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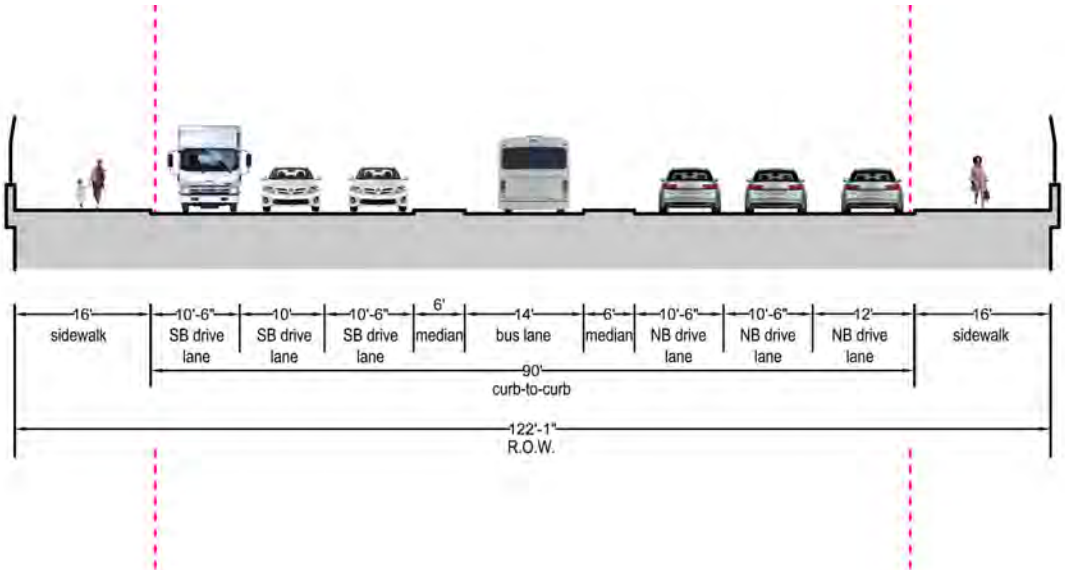

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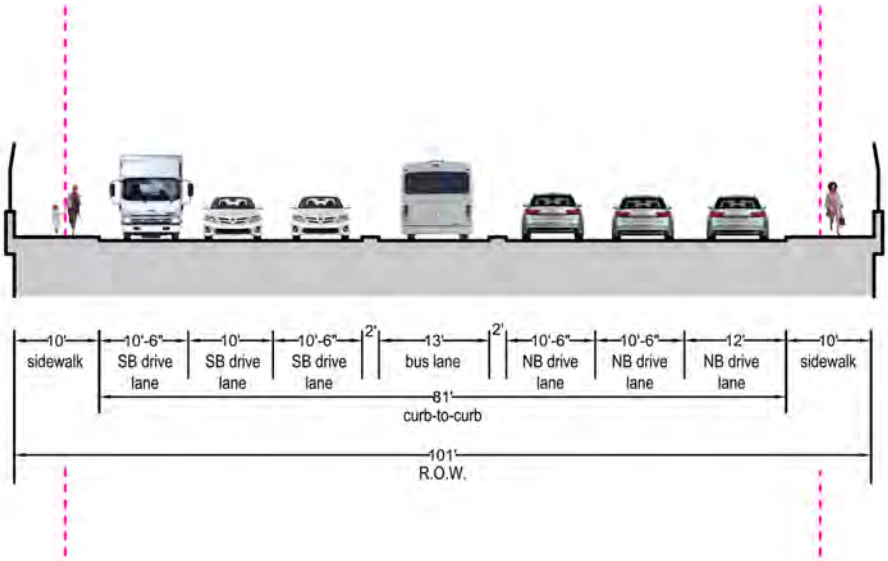

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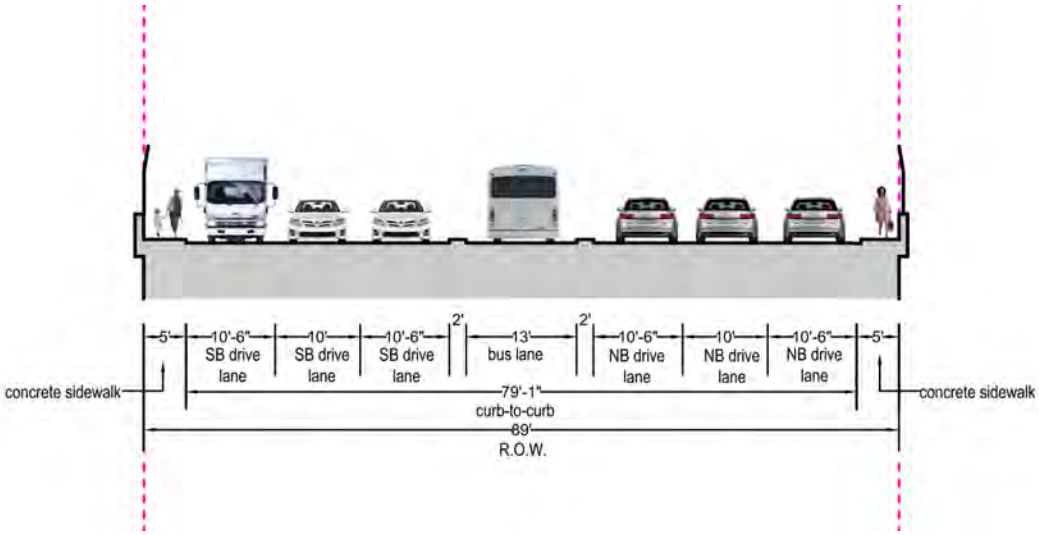

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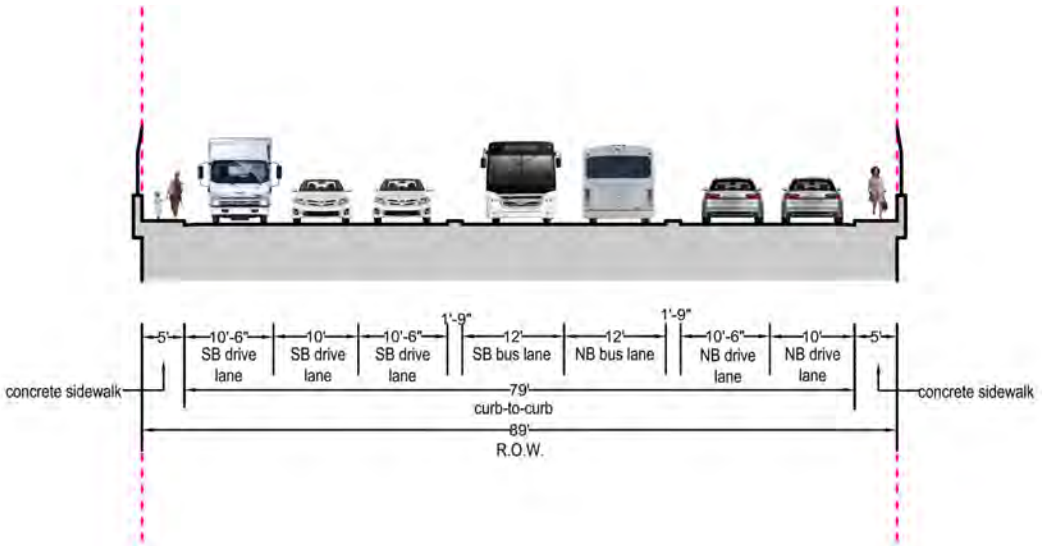

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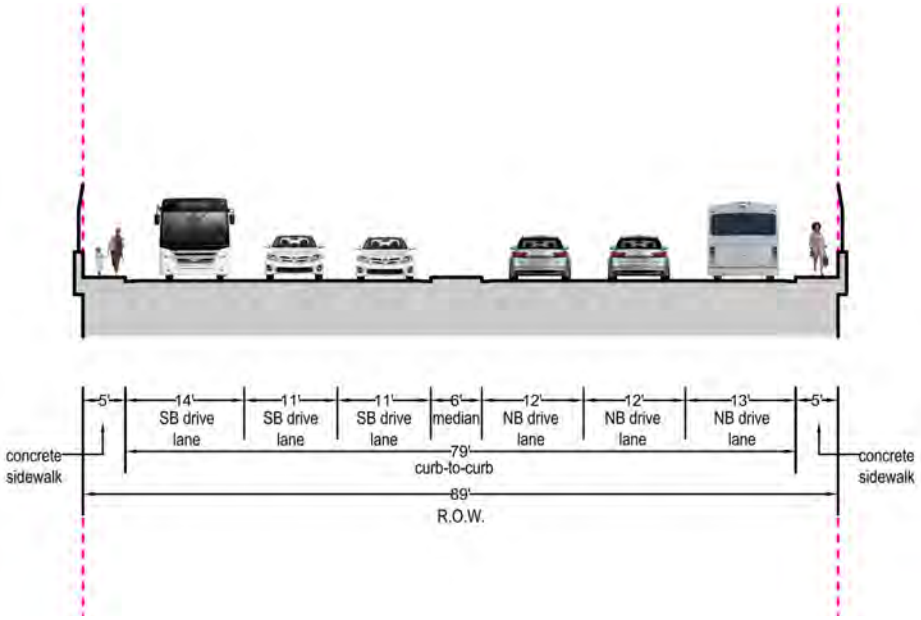

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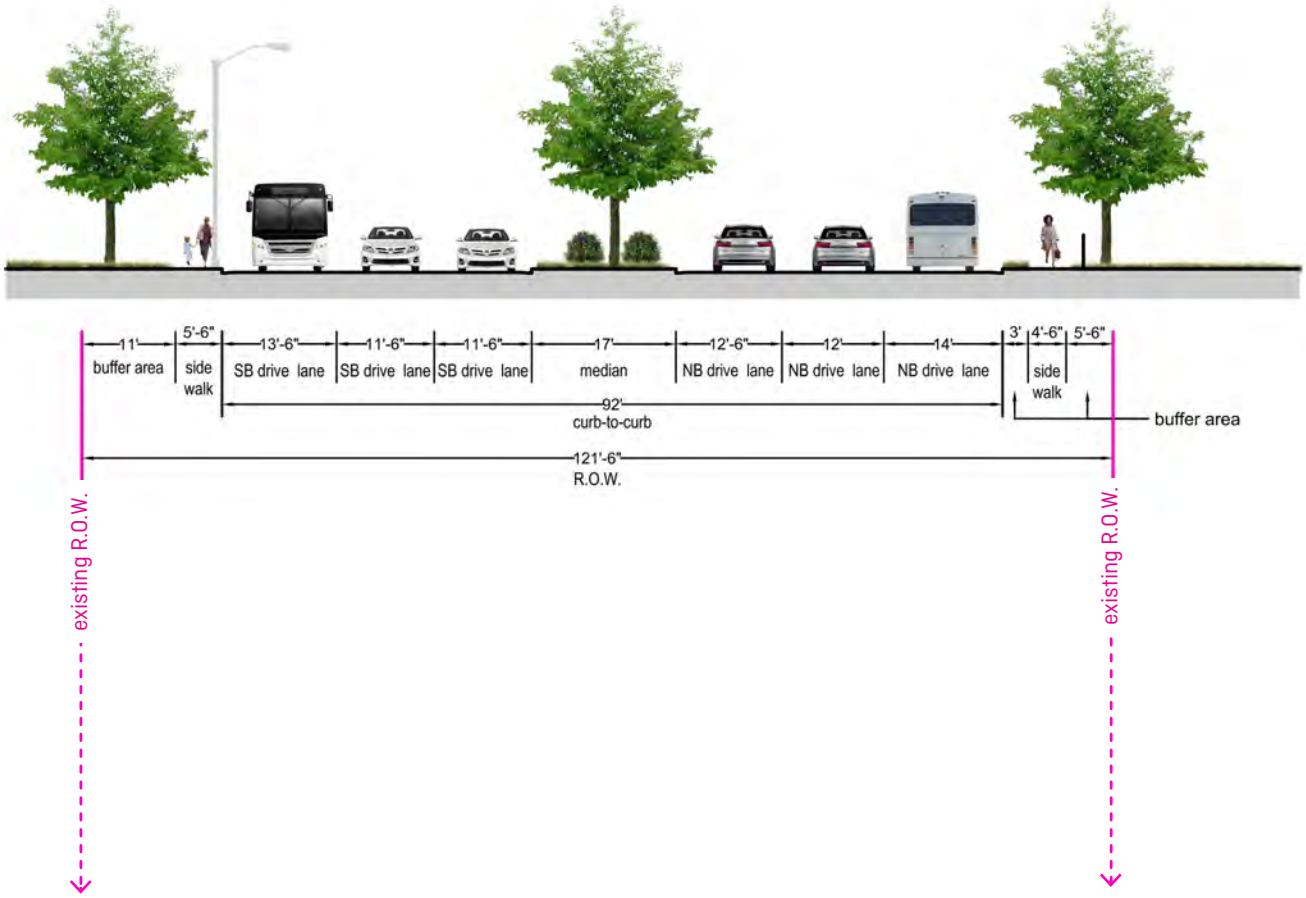

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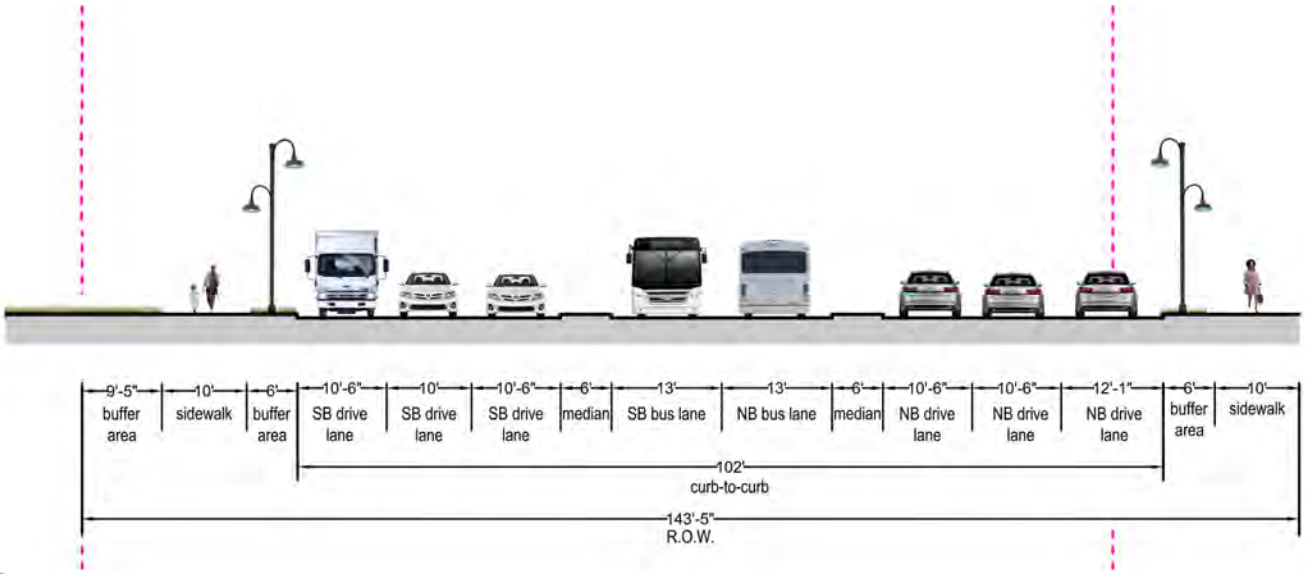

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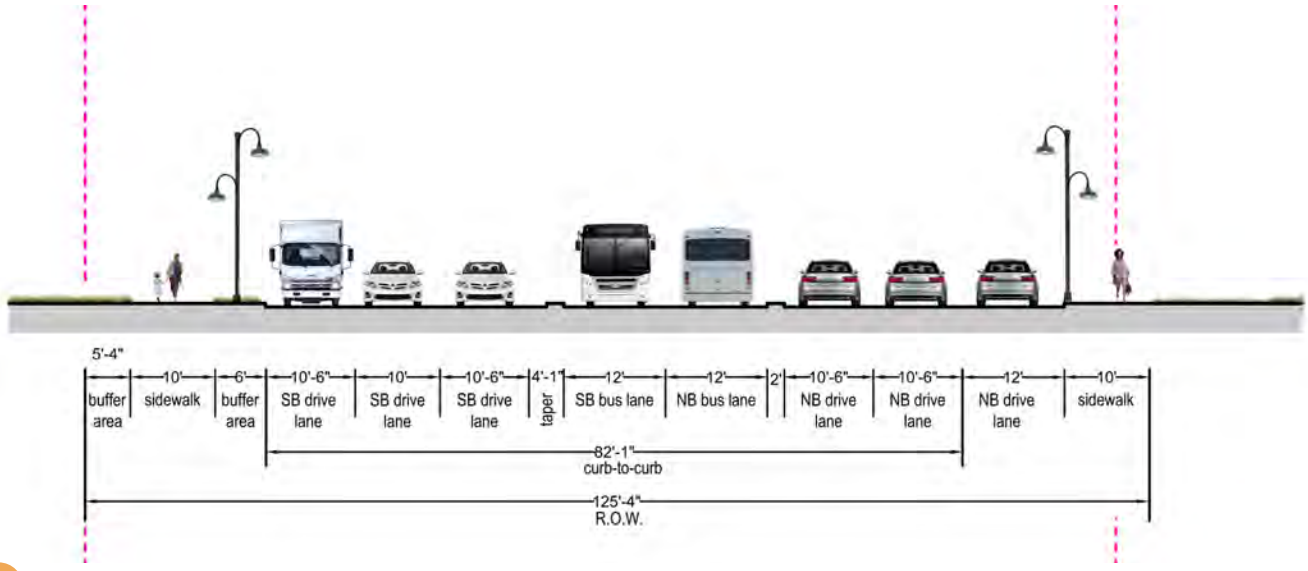

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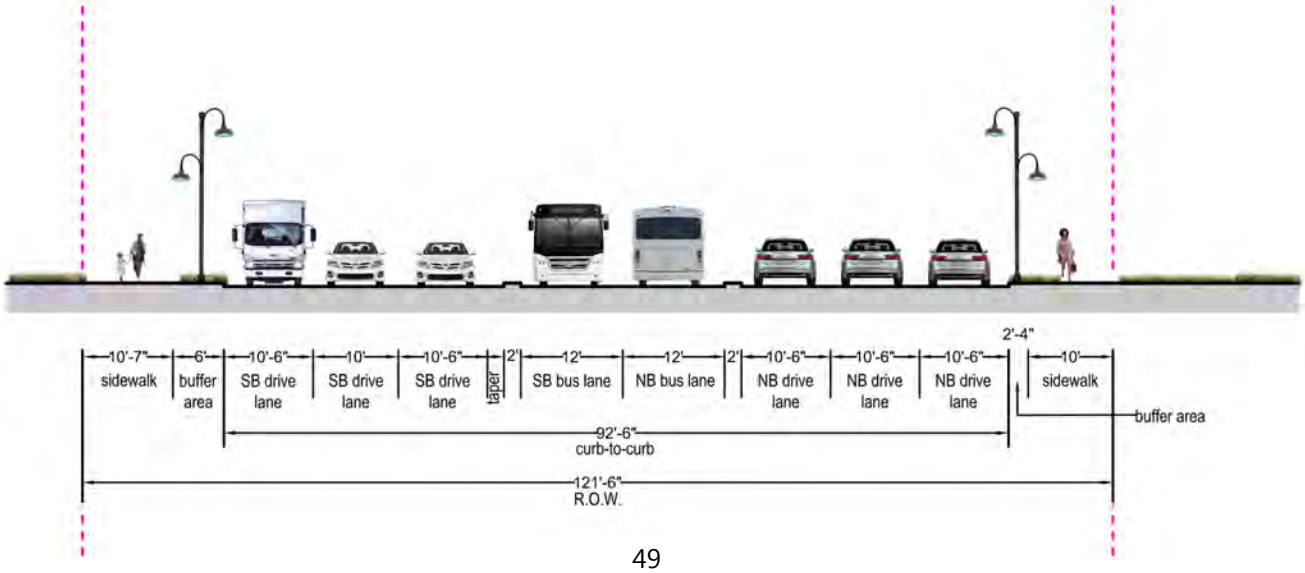

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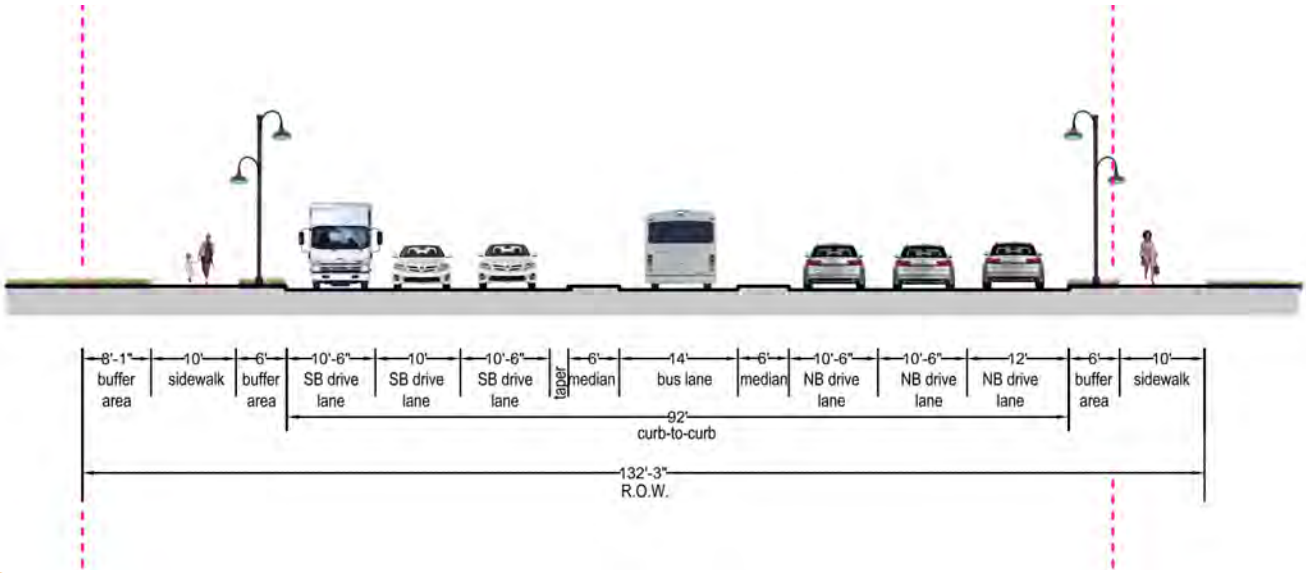

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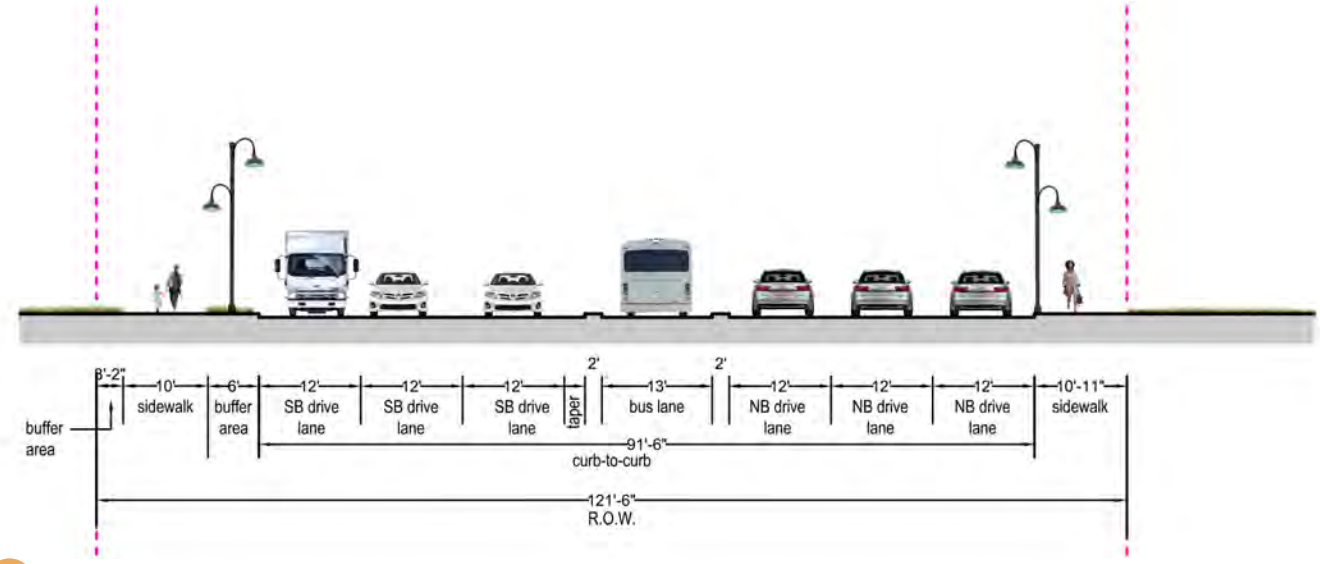

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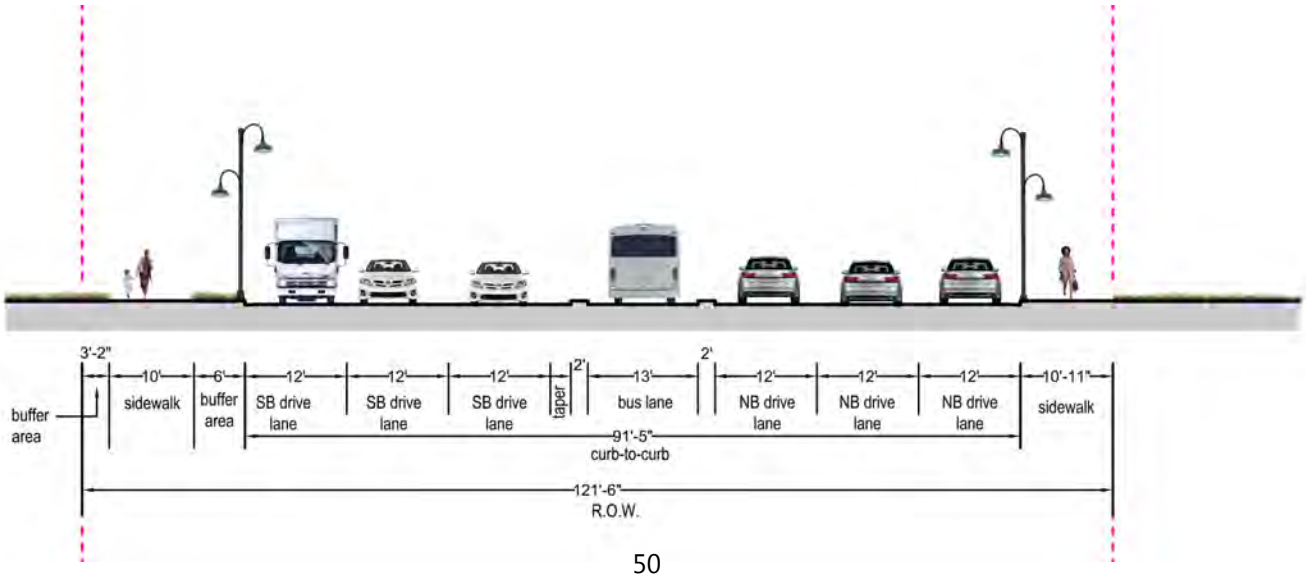

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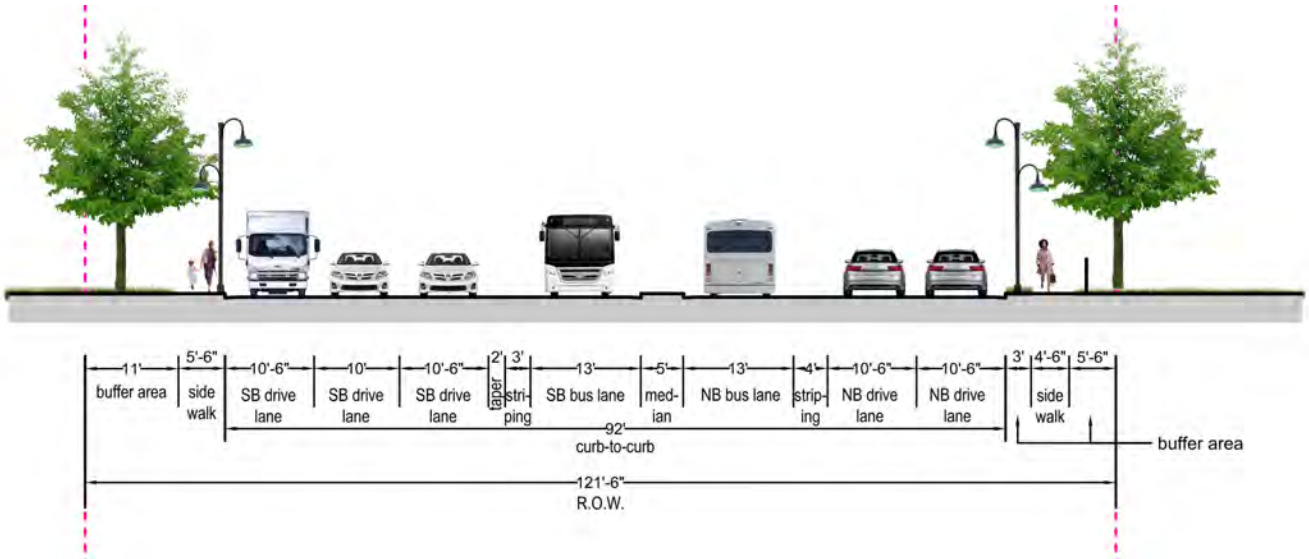

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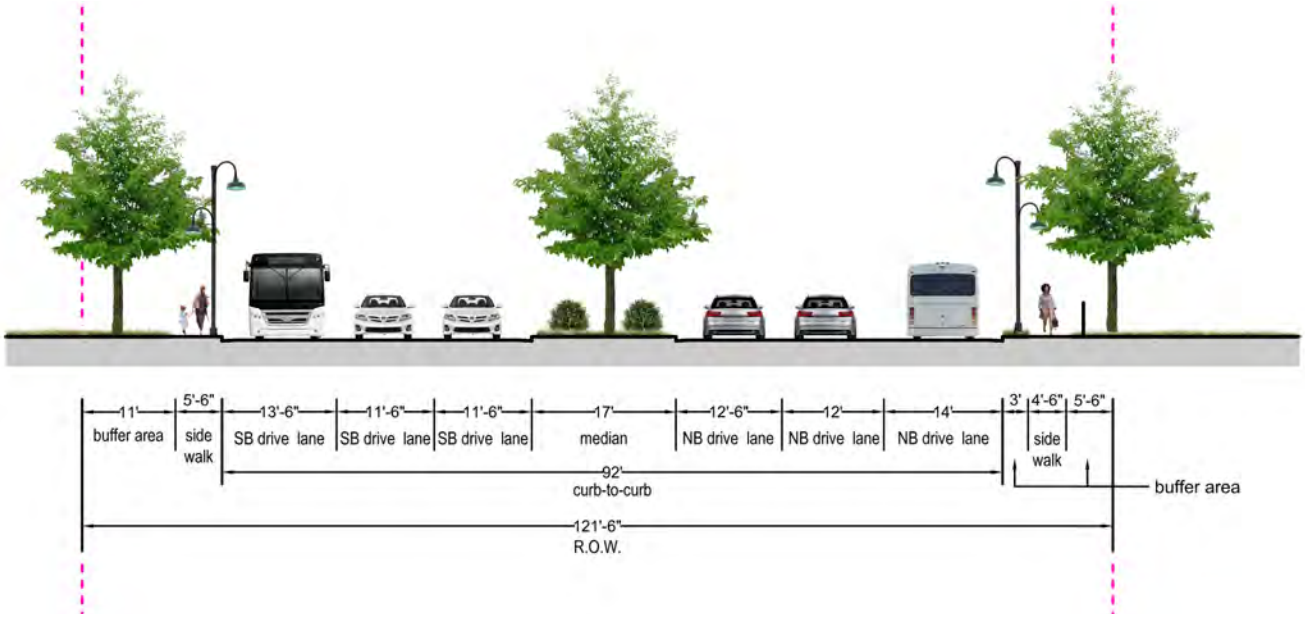


2.4 Traffic Operations Analysis

The BRT will provide an attractive alternative to driving for residents, employees, and visitors in the City and reduce future traffic demands on the MD 355 corridor. Ultimately, the city expects the BRT will attract significant ridership to support long-term redevelopment along MD 355.

The City of Gaithersburg recognizes that it is important to maintain acceptable traffic operations on MD 355 to support regional access to and through the City. The scope of this study does not include development of long-term ridership or traffic operational projections associated with redevelopment on MD 355, but it is important to evaluate the projected traffic conditions for near-term BRT completion and how each BRT design option is likely to affect traffic operations on MD 355. The BRT design will modify the roadway and intersection design on MD 355 throughout the city, but the focal segment of MD 355 is the likely to be most impacted by the preferred BRT design. To understand the likely traffic operations impacts of the various BRT guideway design options, a traffic operations analysis of the focal segment was performed for each option and a comparison of the results is provided in this section.

Available traffic volume data from the Maryland State Highway Administration and City of Gaithersburg provide the basis for developing traffic projections and conducting traffic analysis for the MD 355 corridor. SHA conducted turning movement traffic counts in 2013 and 2014 for the three signalized intersections in the focal area, and these traffic volumes provide the basis for traffic forecasts and analysis. The existing traffic volume data is summarized in Figure 2-1.

Figure 2-1: Existing Focal Segment Peak Hour Traffic Volumes

Some of the BRT design alternatives include several elements that are likely to affect traffic operations, including the following:

- Modifies lane geometry on the MD 355 focal segment, including lane elimination
- Eliminates left turn access from unsignalized side streets onto MD 355
- Modifies traffic signal timings to support BRT operations on MD 355

A 2025 planning horizon was selected to represent the near-term built condition of the BRT in Gaithersburg. Traffic volume projections were developed for both existing conditions and for each of the BRT design alternatives in the 2025 planning horizon using the Metropolitan Washington Council of Governments (MWCOG) Version 2.3 Travel Model[6].

The 2025 mixed traffic scenario assumes no physical modifications to the corridor will be completed and, thus, represents the baseline for comparison with the other future condition alternatives. Figure 2-2 summarizes the baseline future traffic volume projections associated with the mixed traffic scenario.

[6] 2025 traffic volumes were developed by applying the MWCOG travel model forecasted growth rates from 2010 to 2020 to the 2013-14 peak hour traffic counts data for the study intersections.

Figure 2-2: 2025 Future Baseline BRT Peak Hour Traffic Volumes

All other future BRT alternatives involve modifications to the roadway that will influence traffic on the focal segment. Traffic volume projections for the future BRT alternatives reflect two important influences on traffic volumes for the corridor:

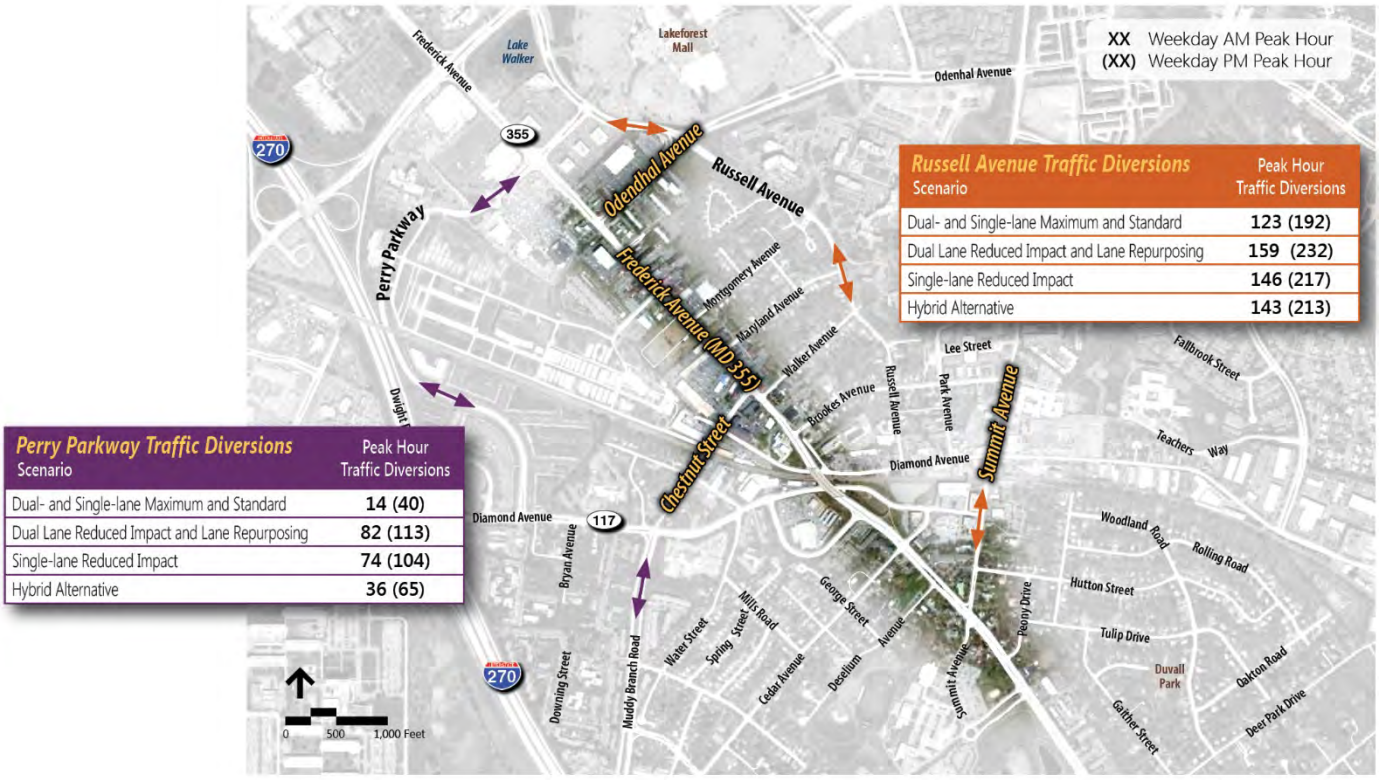
- Diversions to alternative corridors related to reduced roadway capacity
- Median guideways will eliminate left turn access to and from some side streets

Changes in the number of lanes provided along the focal segment will reduce the overall roadway capacity and are likely to result in some traffic diversions to parallel corridors. Potential traffic diversions were calculated for individual portions of the MD 355 focal segment based on the number of traffic lanes provided in each BRT design alternative and traffic volume screenline analysis derived from the MWCOG travel demand forecast model, using NCHRP-255 refinement methodologies. These potential diversions were then additionally factored based on relative travel time differences between MD 355 and the alternative corridors during peak conditions. The resulting traffic volume diversions from the MD 355 focal segment to parallel corridors range from approximately one to three percent of individual traffic movement volumes. These diversions were applied to the signalized intersection traffic volume forecasts, but only for traffic using public streets and exclude traffic entering or exiting properties.

Peak hour traffic volume data for approximately eight unsignalized intersections on the MD 355 focal segment were reviewed to identify left turn movement traffic volumes impacted by

future BRT median guideways. Where left turn access will be eliminated, projections for the left turn traffic volumes to divert along alternative routes were developed. After implementation of a BRT median guideway, existing left turn traffic to or from unsignalized intersections within the focal segment will likely turn at one of the signalized intersection to take an alternative route to their destinations. These diversions may involve using other roadways or performing a U-turn at the closest signalized intersection. Left turn traffic volume diversion estimates were developed for a total of 181 and 300 vehicles during the weekday morning and weekday evening peak hours, respectively. The left turn diversions were applied to the peak hour signalized intersection traffic volume projections. Figure 2-3 summarizes the anticipated traffic volume diversions to alternative routes associated with each BRT alternative.

Figure 2-3: Gaithersburg BRT-related Traffic Volume Diversions



The evaluation criteria used to analyze area intersections and roadways in this traffic evaluation are based on two methodologies: the Critical Lane Volume (CLV) standards adopted by the Maryland State Highway Administration, Montgomery County, and City of Gaithersburg for evaluation of adequate public facilities and the 2010 Highway Capacity Manual (HCM)[7]. The Critical Lane Volume methodology is used for signalized intersections and the HCM Multilane Highway analysis methodology for roadway segments.

Level of Service (LOS) is the term used to denote the different operating conditions which occur on a given roadway segment under various traffic volume loads. Under the CLV

[7] Transportation Research Board, Highway Capacity Manual, Washington, D.C., 2010

methodology, LOS is a quantitative calculation of the greatest conflicting traffic volumes, considering the intersection geometry, and representing the critical intersection capacity.

The CLV analysis was conducted for the three signalized intersections within the focal segment: MD 355 at Odendhal Avenue, MD 355 at Chestnut Street, and MD 355 at Summit Avenue. The CLV methodology calculates a peak hour volume for opposing left-turn and through/right-turn movements, adjusted by a set of factors which account for the lane geometry, signal phasing, and right-turn operations. The highest opposing volumes on the northbound/southbound directions and eastbound/westbound directions are considered the critical lane volumes. Where split signal phasing is present, such as the MD 355/Summit Avenue intersection, the traffic volumes for both opposing approaches are considered critical. The aggregate of the highest north/south and east/west critical lane volume values is compared to critical lane volume thresholds for level-of-service adopted by SHA. Table 2-10 provides a summary of the CLV methodology level-of-service thresholds. The level-of-service threshold considered acceptable for signalized intersections in the City of Gaithersburg is a critical lane volume per hour value of 1,450 (LOS D).

Table 2-10: CLV Level-of-service Thresholds

Level of Service	CLV Methodology (Critical lane volume per hour expressed in vehicles)
A	< 1,000
B	1,000 - 1,150
C	1,150 - 1,300
D	1,300 - 1,450
E	1,450 - 1,600
F	1,600

The HCM Multilane Highway analysis methodology was used to evaluate the roadway segment performance for two segments of MD 355 within the focal segment: Odendhal Avenue to Chestnut Street and Chestnut Street to Summit Avenue. The roadway characteristics for each segment are distinct and the roadway analysis reflects variations in traffic volume associated with the northern and southern portions of the focal segment

Traffic volume projections for MD 355 in each direction were derived from the intersection traffic volume forecasts used for the CLV analysis. For each roadway segment, the higher peak hour approach volume from either of the bordering signalized intersections was used for the multilane segment volume. The multilane highway analysis uses the ideal free flow speed of the roadway, peak hour traffic volume, and roadway geometry characteristics to calculate the roadway's traffic density in passenger cars per mile per lane (pc/mi/ln) for each travel direction. The HCM provides thresholds for LOS based on traffic density, as summarized in Table 2-11 for a corridor with the lowest allowable free flow speed like MD 355.

Table 2-11: HCM Multilane Highway Level of Service Thresholds

Level of Service	Density (pc/mi/ln)
A	>0-11
B	>11-18
C	>18-26
D	>26-35
E	>35-45
F	>45

The intersection and roadway traffic operations analysis was completed for the Existing, 2025 BRT Mixed Traffic, and 2025 BRT Alternatives conditions. The results of the intersection and roadway capacity analyses are summarized in Tables 2-12 and 2-13. The detailed traffic operations analysis worksheets and results are included in Appendix C.

Table 2-12: Signalized Intersection Critical Lane Volume LOS Results Summary

Condition/Time Period	MD 355 at Odendhal Avenue		MD 355 at Chestnut Street		MD 355 at Summit Avenue	
	CLV	LOS	CLV	LOS	CLV	LOS
Existing Condition						
Weekday AM Peak Hour	1,088	B	931	A	889	A
Weekday PM Peak Hour	927	A	825	A	880	A
2025 BRT Mixed Traffic						
Weekday AM Peak Hour	1,299	C	1,136	B	1,063	B
Weekday PM Peak Hour	1,107	B	1,006	B	1,053	B
2025 BRT Dual-lane Standard						
Weekday AM Peak Hour	1,316	D	1,147	B	1,063	B
Weekday PM Peak Hour	1,241	C	1,025	B	1,049	B
2025 BRT Dual-lane Minimum						
Weekday AM Peak Hour	1,316	D	1,147	B	1,063	B
Weekday PM Peak Hour	1,241	C	1,025	B	1,049	B
2025 BRT Dual-lane Reduced Impact						
Weekday AM Peak Hour	1,283	C	1,147	B	1,057	B
Weekday PM Peak Hour	1,110	B	1,025	B	1,042	B
2025 BRT Single-lane Standard						
Weekday AM Peak Hour	1,316	D	1,147	B	1,063	B
Weekday PM Peak Hour	1,241	C	1,025	B	1,049	B
2025 BRT Single-lane Minimum						
Weekday AM Peak Hour	1,316	D	1,147	B	1,063	B
Weekday PM Peak Hour	1,241	C	1,025	B	1,049	B
2025 BRT Single-lane Reduced Impact						
Weekday AM Peak Hour	1,283	C	1,147	B	1,063	B
Weekday PM Peak Hour	1,110	B	1,025	B	1,049	B
2025 BRT Lane Repurposing						
Weekday AM Peak Hour	1,283	C	1,147	B	1,057	B
Weekday PM Peak Hour	1,110	B	1,025	B	1,042	B

The signalized intersection traffic operations analysis results for each intersection are similar for many of the alternatives. The differences between the results for the various future BRT alternatives generally reflect traffic volume shifts associated with modifications to lane geometry or eliminated left turns at unsignalized intersections.

In general, the BRT design alternatives maintain the existing intersection lane geometry, including turn lanes, which will limit the potential impact on the progression of through traffic in the corridor. Eliminating turning lanes at signalized intersections on MD 355 is likely to cause significant additional vehicular delay, queuing, and safety issues, creating an unacceptable traffic operational condition.

The signalized intersection traffic analysis results indicate that all of the study intersections currently operates at acceptable LOS and are anticipated to operate at acceptable LOS during the both peak hours under all future BRT alternatives. All of the BRT alternatives exhibit similar CLV results, and these results do not strongly indicate an advantage for any particular alternative.

The traffic analysis results indicate that adequate traffic lane capacity will be available to accommodate future traffic volume projections at the focal segment intersections. However, the CLV results do not necessarily reflect the level of congestion and queuing observed on the MD 355 corridor during some peak periods. The actual operations of MD 355, particularly at the MD 355/Odendhal Avenue and MD 355/Chestnut Avenue intersections, may be significantly influenced by factors not accounted for in this methodology, such as the narrow lane geometry and turning movements or other disruptive traffic activity associated with numerous commercial land uses on the corridor. Due to overall growth in traffic volume on MD 355, all future scenarios are likely to result in some elevated traffic congestion and queuing at the signalized intersections.

Table 2-13: Roadway Segment Capacity Analysis Results Summary

Condition/Time Period	MD 355 Southbound				**MD 355 Northbound**			
	Odendhal Ave to Chestnut Street		Chestnut Street to Summit Ave		Odendhal Ave to Chestnut Street		Chestnut Street to Summit Ave	
	Density	LOS	Density	LOS	Density	LOS	Density	LOS
Existing Condition								
Weekday AM Peak Hour	26.7	D	16.7	B	12.7	B	4.9	A
Weekday PM Peak Hour	15.8	B	10.3	A	32.1	D	12.8	B
2025 Mixed Traffic								
Weekday AM Peak Hour	32.0	D	20.0	C	15.2	B	5.9	A
Weekday PM Peak Hour	19.0	C	12.3	B	38.5	E	19.4	C
2025 BRT Dual-lane Standard								
Weekday AM Peak Hour	29.9	D	17.5	B	15.0	B	5.9	A
Weekday PM Peak Hour	17.1	B	10.3	A	36.6	E	13.0	B
2025 BRT Dual-lane Minimum								
Weekday AM Peak Hour	29.9	D	17.5	B	15.0	B	5.9	A
Weekday PM Peak Hour	17.1	B	10.3	A	36.6	E	13.0	B
2025 BRT Dual-lane Reduced Impact								
Weekday AM Peak Hour	43.7	E	20.0	C	14.6	B	8.9	A
Weekday PM Peak Hour	25.0	C	11.9	B	35.7	E	22.4	C
2025 BRT Single-lane Standard								
Weekday AM Peak Hour	29.9	D	17.5	B	15.0	B	5.9	A
Weekday PM Peak Hour	17.1	B	10.3	A	36.6	E	13.0	B
2025 BRT Single-lane Minimum								
Weekday AM Peak Hour	29.9	D	17.5	B	15.0	B	5.9	A
Weekday PM Peak Hour	17.1	B	10.3	A	36.6	E	13.0	B
2025 BRT Single-lane Reduced Impact								
Weekday AM Peak Hour	43.7	E	20.1	C	14.6	B	5.9	A
Weekday PM Peak Hour	25.0	C	12.0	B	35.7	E	15.0	B
2025 BRT Lane Repurposing								
Weekday AM Peak Hour	43.7	E	20.0	C	14.6	B	8.9	A
Weekday PM Peak Hour	25.0	C	11.9	B	35.7	E	22.4	C

The results of the traffic operations analysis indicate that the MD 355 roadway segments within the focal segment currently operate at acceptable LOS in both directions during all peak periods. The segment from Odendhal Avenue to Chestnut Street, in both the southbound and northbound directions, currently experiences the greatest congestion (represented by the highest traffic density) during peak hours.

The results indicate that elevated traffic density will occur on the roadway segments under any of the BRT design alternatives, but the segments will continue to operate at acceptable levels of service for most time periods. However, the segment from Odendhal Avenue to Chestnut Street will experience elevated traffic congestion crossing into the LOS E range, which is considered an unacceptable condition, under multiple BRT alternatives during both the weekday morning and evening peak hours. This condition reflects both overall growth in

traffic volume on the corridor by 2025 and modified lane geometry on this segment in some of the BRT alternatives.

The Odendhal to Chestnut segment will operate under LOS E conditions in the northbound direction during the weekday evening peak hour for all future BRT alternatives. None of the BRT alternatives plan to reduce the overall northbound lane capacity, so these results primarily reflect projected overall growth in regional traffic volume. The LOS E results for the northbound direction are generally on the lowest end of the LOS E range (35-37 pc/mi/ln), except for the mixed traffic alternative, which is projected to operate at higher levels of traffic density and congestion.

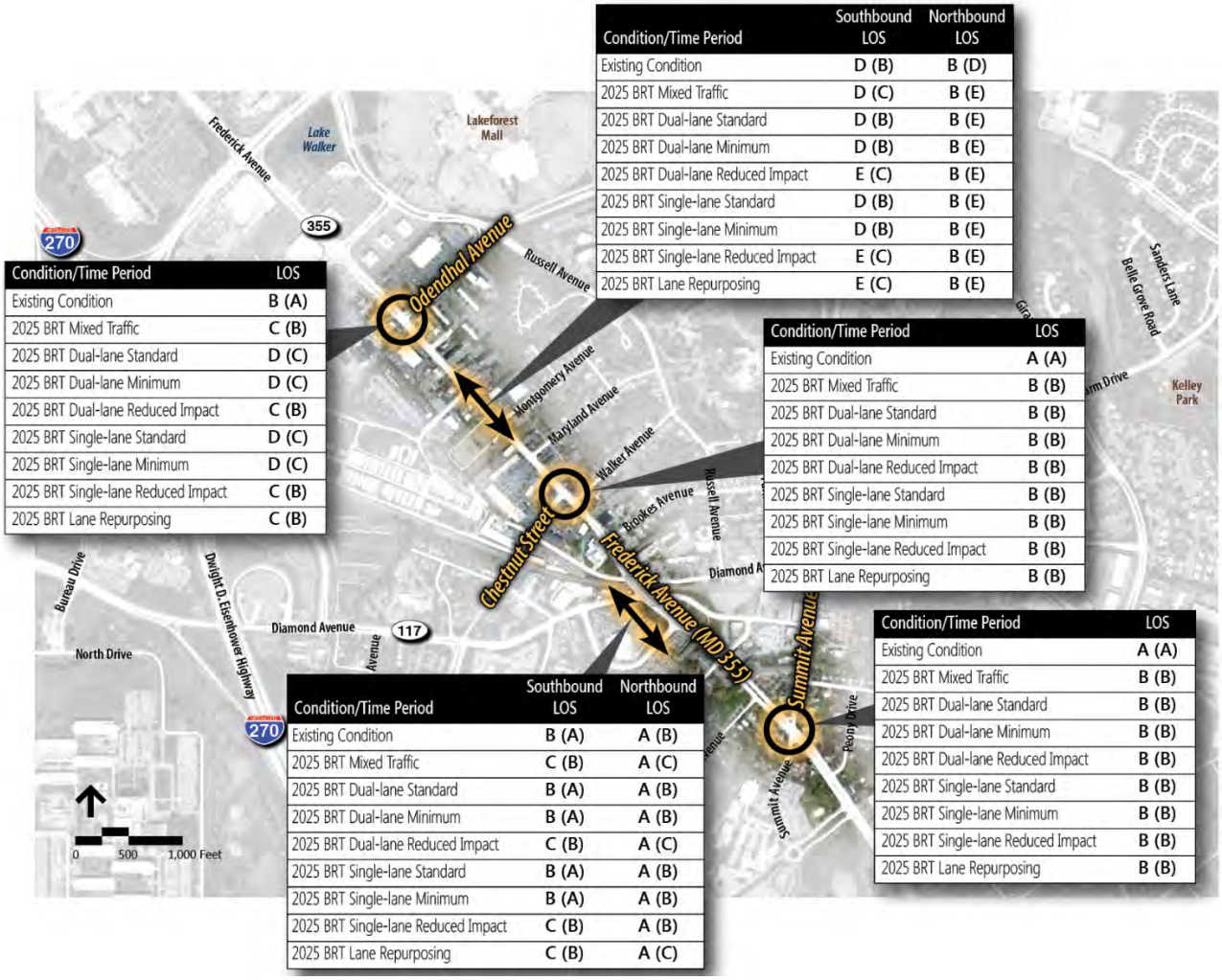
In the southbound direction, the Odendhal to Chestnut segment will operate at LOS D for many of the BRT alternatives during the weekday morning peak hour. However, this segment is projected to experience LOS E conditions under the following BRT alternatives:

- Dual-lane Reduced Impact
- Single-lane Reduced Impact
- Lane Repurposing

The LOS E results for these three alternatives are all near the upper limit of the LOS E range, which suggests traffic operations under these alternatives will approach the roadway's total capacity (45 pc/mi/ln) as defined by the HCM. These results suggest the southbound segment from Odendhal Avenue to Chestnut Street will operate with significantly greater vehicular delay, queuing, merging/weaving challenges, and potentially induce additional traffic diversions onto local and residential streets during the weekday morning peak hour. The BRT alternatives associated with these result were designed to minimize property impacts on the corridor, but are likely to result in significant degradation of traffic operations on the corridor during both the weekday morning peak hour.

Figure 2-4 visually summarizes the Level of Service results for both the signalized intersection and roadway segment evaluations.

Figure 2-4: MD 355 Focal Segment Level of Service Results



Condition/Time Period	Southbound LOS	Northbound LOS
Existing Condition	D (B)	B (D)
2025 BRT Mixed Traffic	D (C)	B (E)
2025 BRT Dual-lane Standard	D (B)	B (E)
2025 BRT Dual-lane Minimum	D (B)	B (E)
2025 BRT Dual-lane Reduced Impact	E (C)	B (E)
2025 BRT Single-lane Standard	D (B)	B (E)
2025 BRT Single-lane Minimum	D (B)	B (E)
2025 BRT Single-lane Reduced Impact	E (C)	B (E)
2025 BRT Lane Repurposing	E (C)	B (E)

Condition/Time Period	LOS
Existing Condition	B (A)
2025 BRT Mixed Traffic	C (B)
2025 BRT Dual-lane Standard	D (C)
2025 BRT Dual-lane Minimum	D (C)
2025 BRT Dual-lane Reduced Impact	C (B)
2025 BRT Single-lane Standard	D (C)
2025 BRT Single-lane Minimum	D (C)
2025 BRT Single-lane Reduced Impact	C (B)
2025 BRT Lane Repurposing	C (B)

Condition/Time Period	LOS
Existing Condition	A (A)
2025 BRT Mixed Traffic	B (B)
2025 BRT Dual-lane Standard	B (B)
2025 BRT Dual-lane Minimum	B (B)
2025 BRT Dual-lane Reduced Impact	B (B)
2025 BRT Single-lane Standard	B (B)
2025 BRT Single-lane Minimum	B (B)
2025 BRT Single-lane Reduced Impact	B (B)
2025 BRT Lane Repurposing	B (B)

Condition/Time Period	LOS
Existing Condition	A (A)
2025 BRT Mixed Traffic	B (B)
2025 BRT Dual-lane Standard	B (B)
2025 BRT Dual-lane Minimum	B (B)
2025 BRT Dual-lane Reduced Impact	B (B)
2025 BRT Single-lane Standard	B (B)
2025 BRT Single-lane Minimum	B (B)
2025 BRT Single-lane Reduced Impact	B (B)
2025 BRT Lane Repurposing	B (B)

Condition/Time Period	Southbound LOS	Northbound LOS
Existing Condition	B (A)	A (B)
2025 BRT Mixed Traffic	C (B)	A (C)
2025 BRT Dual-lane Standard	B (A)	A (B)
2025 BRT Dual-lane Minimum	B (A)	A (B)
2025 BRT Dual-lane Reduced Impact	C (B)	A (C)
2025 BRT Single-lane Standard	B (A)	A (B)
2025 BRT Single-lane Minimum	B (A)	A (B)
2025 BRT Single-lane Reduced Impact	C (B)	A (B)
2025 BRT Lane Repurposing	C (B)	A (C)

2.5 Cost Estimates

Planning-level cost estimates for each of the BRT design layout alternatives were developed using the conceptual design attributes from each layout and 2015 unit cost data developed specifically for the Montgomery County RTS. The cost estimate methodology is consistent with the methodology VHB developed for the Montgomery County Department of Transportation's (MCDOT) updated 2015 BRT Cost Estimates supporting the Montgomery County Transit Task Force BRT financing process.

Basis of Estimate – BRT Conceptual Design Layouts

Estimates of capital costs are often based on a preliminary engineering or more advanced level of design. The Gaithersburg BRT design layouts provide some basis for estimating the cost of each alternative, but these designs represent a high-level feasibility-oriented concept for each alternative, without the benefit of key information required for detailed design, such as field survey, geotechnical data, below-grade utility information, or structural data required for detailed design and cost estimation. Given the early and very preliminary nature of these design concepts, there is more potential variability in cost estimates. The City of Gaithersburg

should be aware of the substantial likelihood of changes as designs are advanced for any of the proposed design alternatives during the Facility Planning/Design Process, and an appropriate contingency was applied to all cost estimates, consistent with the approach adopted for MCDOT.

Capital Cost Estimate Methodology

The capital cost estimate methodology was originally developed for MCDOT's Countywide BRT cost estimate and most recently updated in July 2015 for revised BRT cost estimates provided to the Montgomery County Transit Task Force. Basic templates for BRT guideway and station areas reflecting the recommendations for operational quality provided in the *Approved and Adopted Countywide Transit Corridors Functional Master Plan* were developed to provide consistency in capital cost estimates for a range of BRT design elements. Additional costs related to widening existing streets, utility relocation, bridges, retaining walls and intersection improvements were also developed for locations where implementation of the recommended treatments were likely to necessitate this additional construction.

To estimate the unit prices applied to the BRT components, 2015 cost data from the Federal Transit Administration, Maryland State Highway Administration, Montgomery County, and other relevant transportation resources were compiled, reviewed, and adopted. Standard templates for BRT design components, such as the dual-lane median guideway, number of travel lanes included in roadway widening, or traffic signal reconstruction, were developed based on the aggregated cost of the materials, including asphalt, concrete, drainage structures, landscaping, etc. Costs associated with each template were converted to cost per linear foot, square foot, or item. Lengths, areas, and quantities for each of these components of the BRT system were calculated from the Gaithersburg BRT design layouts.

For stations, templates for the layout of the stations (including left-turn lanes at intersections) and station elements (canopies, fare vending machines, benches, etc.) were developed. The station costs calculated for this cost estimate include the overall cost to reconstruct traffic signals and the entire roadway within several hundred feet of the station area. The station costs account for the guideway type (which influences the number of platforms) and number of traffic lanes.

For guideways, per linear foot costs were developed (including curbing, drainage and stormwater management, paving, etc.) The costs for the basic elements of guideway and stations were developed in collaboration with MCDOT's Division of Transportation Engineering staff. Additional elements (e.g., utility relocation, signal modifications, bridge work, and retaining walls) were then applied to the corridor estimates as appropriate using per linear foot or per location estimates.

The need to acquire private property for the necessary public right of way to accommodate the BRT and roadway modifications was also considered. Using city and state GIS data resources, additional right-of-way beyond that currently publicly-owned land was estimated using parcel-data along each corridor. Assessed property and building value data provided by the City of Gaithersburg were used to produce cost estimates for specific parcel and building acquisitions. The limits of disturbance associated with each BRT design layout on the focal segment were used to identify portions of properties that must be acquired to construct each alternative. Outside of the focal segment, a uniform right-of-way width of 140

feet was applied along the centerline of MD 355, and the costs for any portions of properties within the recommended right-of-way were calculated. For properties where existing buildings are impacted, the cost for the entire property was calculated.

From these assumptions, a 2015 capital cost estimate for MD 355 in the City of Gaithersburg was produced. In general, a 50-percent contingency is applied to all capital costs to account for the planning-level uncertainty associated with specific design details to be addressed in the future.

Gaithersburg MD 355 Capital Cost Estimate

Capital cost estimates were produced for the each of the BRT design alternatives on MD 355 in the City of Gaithersburg. These cost estimates are provided in 2015 dollars. The following assumptions were used to produce the cost estimates for the various alternatives:

- Dual-lane median BRT guideways were assumed for MD 355 north of Odendhal Avenue and south of Summit Avenue for all alternatives
- BRT guideway selection in the focal segment was based on the planning-level design layouts for each alternative
- Assumptions regarding the amount of roadway widening required for various parts of the corridor are based on typical dimensions for the BRT guideway compared to existing available median space and the focal segment planning-level design layouts.
- All signalized intersections and traffic signals where median guideway is planned are assumed to require reconstruction to relocate signal infrastructure and accommodate new intersection geometry
- Utility poles are assumed to require relocation anywhere the roadway will be widened
- Full bridge reconstruction in the focal segment is assumed for alternatives that indicate the roadway cross-section will exceed the bridge width
- A total of five BRT stations, as identified in the *Countywide Transit Corridors Functional Master Plan,* were included in the cost estimates for all alternatives
- The Brookes Avenue station was not included in the cost estimate because of significant concerns about the utilization and feasibility of this station
- The mixed traffic alternative is assumed to require no land acquisition or major construction elements in the focal segment

The capital cost estimates for MD 355 in the City of Gaithersburg are summarized in Table 2-14. Copies of the detailed cost estimate worksheets and unit cost data assumptions used to calculate the overall BRT facility costs are included in Appendix D.

Table 2-14: 2015 Gaithersburg BRT Capital Cost Estimate Summary

BRT Design Condition	Costs			Total Cost
	Game Preserve Road to Odendhal Avenue	Focal Segment (Odendhal Avenue to Summit Avenue)	Summit Avenue to O'Neill Drive	
Dual-lane Standard				
Design/Construction	$71,581,700	$88,771,300	$49,599,200	$209,952,200
Land Acquistion	$6,506,867	$23,698,031	$11,463,295	$41,668,194
Total	**$78,088,567**	**$112,469,331**	**$61,062,495**	**$251,620,394**
Dual-lane Minimum				
Design/Construction	$72,895,000	$80,704,300	$49,599,200	$203,198,500
Land Acquistion	$7,544,497	$6,395,706	$12,846,710	$26,786,913
Total	**$80,439,497**	**$87,100,006**	**$62,445,910**	**$229,985,413**
Dual-lane Reduced Impact				
Design/Construction	$72,895,000	$42,774,700	$49,599,200	$165,268,900
Land Acquistion	$7,544,497	$3,039,497	$12,846,708	$23,430,702
Total	**$80,439,497**	**$45,814,197**	**$62,445,908**	**$188,699,602**
Single-lane Standard				
Design/Construction	$72,895,000	$79,881,300	$49,599,200	$202,375,500
Land Acquistion	$7,544,497	$13,945,753	$12,846,708	$34,336,958
Total	**$80,439,497**	**$93,827,053**	**$62,445,908**	**$236,712,458**
Single-lane Minimum				
Design/Construction	$72,895,000	$77,415,200	$49,599,200	$199,909,400
Land Acquistion	$7,544,497	$2,550,287	$12,846,708	$22,941,493
Total	**$80,439,497**	**$79,965,487**	**$62,445,908**	**$222,850,893**
Single-lane Reduced Impact				
Design/Construction	$72,895,000	$37,350,600	$49,599,200	$159,844,800
Land Acquistion	$7,544,497	$1,449,934	$12,846,708	$21,841,139
Total	**$80,439,497**	**$38,800,534**	**$62,445,908**	**$181,685,939**
Lane Repurposing				
Design/Construction	$79,246,500	$29,232,700	$52,801,200	$161,280,400
Land Acquistion	$7,544,493	$1,406,273	$12,846,708	$21,797,474
Total	**$86,790,997**	**$30,638,973**	**$65,647,908**	**$183,077,878**
Mixed Traffic				
Design/Construction	$81,237,000	$1,872,400	$52,801,200	$135,910,600
Land Acquistion	$7,544,493	$0	$12,846,708	$20,391,201
Total	**$88,950,644**	**$1,872,400**	**$65,647,908**	**$156,470,952**

The capital cost estimates indicate that the overall capital costs for the BRT alternatives in the City of Gaithersburg range from $156.5 million to $251.6 million. The Dual-lane Standard and Single-lane Standard alternatives represent the highest cost options. The Single-lane Reduced Impact, Lane Repurposing, and Mixed Traffic alternatives represents the lowest cost options.

2.6 BRT Alternatives Comparison

The following table provides a comparison of how each of the design alternatives described above rates in terms of traffic impacts, BRT operations, and property impacts. Those alternatives that rate well receive a solid circle while those receiving a hollow circle score poorly. Alternatives that fall somewhere between a high score and a low score receive a partially-filled circle, with the partially filled left half being better than the partially filled right half. In addition to the scoring, each alternative's total capital cost is included in the table.

Table 2-15: Comparison of BRT Alternatives

	BRT Operations		Traffic Operations				Property Impacts	Cost ($ million)
	Operating Speed	Stop Locations	Traffic Density/ Congestion	Intersection Capacity	Unsignalized Turning Movements	Land Use Access/ Egress		
Dual-lane Standard	●	●	●	●	○	○	○	$251.6
Dual-lane Minimum	●	●	●	●	○	○	○	$230.0
Dual-lane Reduced	●	●	○	●	○	○	◑	$188.7
Single-lane Standard	◐	◐	●	●	○	○	○	$236.7
Single-lane Minimum	◐	◐	●	●	○	○	◑	$222.9
Single-lane Reduced	◐	◐	○	●	○	○	◐	$181.7
Lane Repurposing	◑	○	○	●	○	○	◐	$183.1
Mixed Traffic	○	◑	◐	●	●	●	●	$156.5

● ◐ ◑ ○

Better ⟷ Worse

2.7 Summary of Findings

A review of the different BRT alternatives show that each of the four alternatives have their pluses and minuses. The mixed traffic alternative may provide the least amount of property impacts resulting in no potential property acquisitions or access impacts, and retaining the existing roadway operations along the focal segment. This alternative would result in a BRT that travels at the same speed as general traffic throughout the focal segment and an overall slower speed for the whole BRT corridor. Additionally, there are some traffic impacts.

The lane repurposing alternative appears to provide the fewest benefits. While it does limit property impacts substantially, the resulting negative impact to BRT operations due to the minimal separation between vehicles and buses cannot be overlooked. There are few traffic benefits and numerous impacts resulting from limitations on turning movements and access.

The various single-lane median guideway designs provide reasonable BRT operations. Decisions about whether these design alternatives would operate as peak-directional or bi-directional have different impacts on overall bus speeds and system capacity. Impacts to traffic are not great, but the reduced impact alternative does limit intersection delay. This alternative also results in fewer property impacts than the minimum or standard alternative.

The dual-lane median guideway designs provide the greatest BRT operations benefit of all the alternatives presented. However, these benefits come with a fairly high property impact cost associated with the wider curb-to-curb widths. The reduced impact design does lessen the need to acquire additional property and provides the least impact to intersection delay of the three dual-lane alternatives.

Based on this assessment the minimum and reduced impact alternatives for the dual-lane and single-lane guideway options provide good BRT operations and fewer property impacts than the standard design alternatives. The impacts to traffic congestion will likely be worse in the reduced impact alternatives because of the loss of travel lanes. Further assessment of whether a hybrid alternative that applies more than one of the described alternatives to various segments of the focal segment as opposed to all of MD 355 from Odendhal Avenue to Summit Avenue to achieve a greater balance of the impacts will be explored in the next chapter.