



District Department of Transportation

C Street NE Rehabilitation Project

Updated 65 Percent Design Technical
Analysis Incorporating Public Feedback

June 2018

C Street NE Rehabilitation Project Updated 65 Percent Design Technical Analysis Incorporating Public Feedback

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1.0 Executive Summary

The C Street NE Streetscape Project involves the redesign of C Street NE between 15th Street NE and 21st Street NE. The purpose and need for the project, which has remained consistent since the planning phase, is to improve safety and comfort for all right-of-way users while ensuring improved neighborhood connectivity and mobility for all modes within and through the study area. DDOT presented the 65% design for public and agency review in February 2018. As part of the 65% design plan review for the project, DDOT completed an updated traffic analysis in order to confirm and validate the traffic model. The limits of the updated analysis are for the full project area. As part of this analysis, DDOT discovered inconsistencies and model issues in previous analyses. Correcting and updating these analyses resulted in substantially different projected outcomes and led to recommended design changes in the corridor. These proposed changes were presented to the public in April 2018. Through the public engagement process, additional modifications to the 65% design plans are now being proposed in a June 2018 draft of the 65% streetscape design. The following report summarizes the findings and specific recommendations.

The June draft maintains most of the February draft conditions and addresses the public concerns on the April draft. From the February draft to the June draft, there are four primary changes: (1) signal separation of high volume right turns to separate from bicycle and pedestrian traffic at 21st Street NE, 19th Street NE, and 15th Street NE; (2) changes to bus stop configurations WB at 17th Street NE to address traffic safety and operations concerns and EB at 21st Street NE to respond to community access concerns; (3) changes to the 16th Street NE intersection to address safety concerns; and (4) the addition of new traffic signals along the corridor to address pedestrian safety concerns.

2.0 Project Background

DDOT has previously conducted studies in 2006 and 2010 along the C Street NE corridor between 21st Street and 15th Street. The goal of these studies was to develop a plan that would reduce vehicle speeds, improve multimodal conditions, reduce pedestrian crossing distances, and improve safety along C Street NE. A 2015 study set forth three design alternatives and recommended proceeding with Alternative C. This alternative removed one travel lane in each direction, installed a protected cycle track on each side, kept full-time parking in place, and installed bump-outs at all intersections within the study area, and had broad public consensus. Design work began using Alternative C and is currently at 65% design.

3.0 Key Issues

There are four primary areas of data validation and analysis as part of the 65% design review for the C Street NE project:

1. Peak Hour Vehicle Volumes
2. Vehicle Speeds in Corridor
3. Traffic Model Validation and Calibration
4. Bicycle and Pedestrian Signalization

3.1. Peak Hour Vehicle Volumes

The capacity reduction of the roadway was designed assuming traffic volume conditions in 2040 that are similar or less than the traffic volumes collected in 2015 as part of the study. However, traffic volumes collected from DDOT's permanent traffic count station on the east side of the Whitney Young (East Capitol Street) Bridge indicate that traffic volumes in the corridor have increased slightly over the last three years (see Figure 1 below).

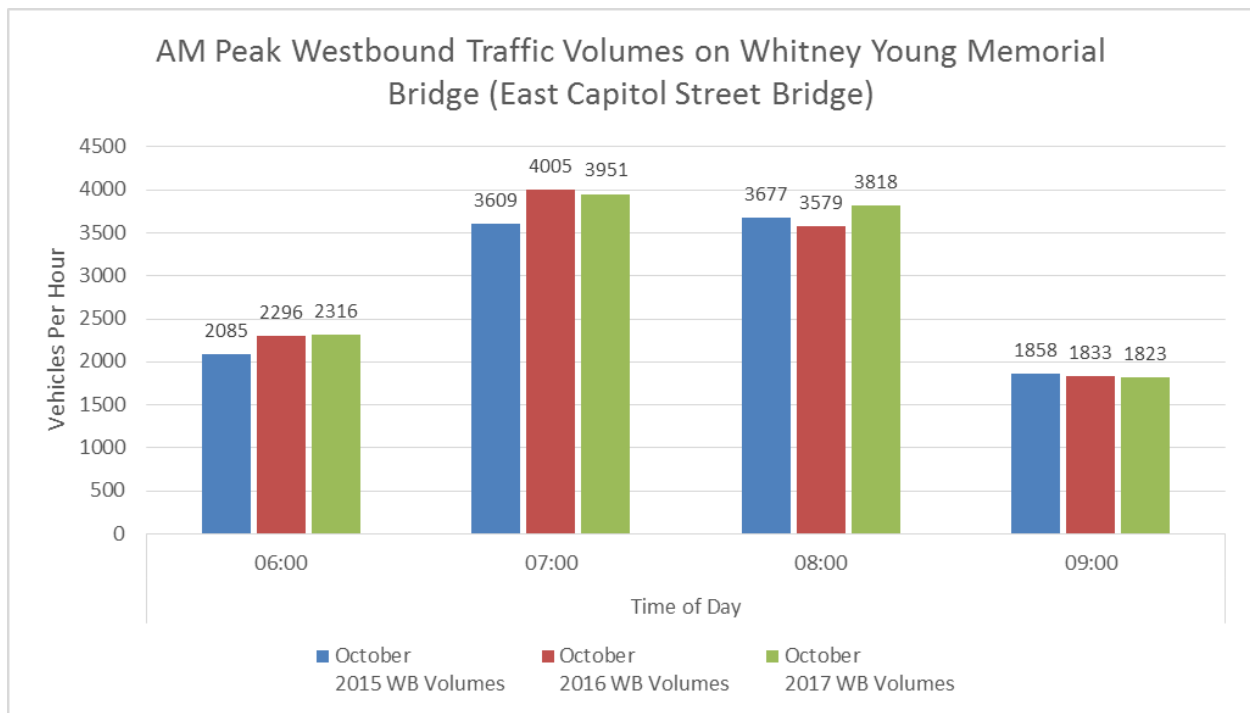


Figure 1: AM Peak Hour Total Vehicle Volumes

As part of the model validation, DDOT conducted updated turning movement counts along the corridor at key intersections as well, in order to determine whether travel patterns had changed in recent years. Data was collected from March 6-7, 2018, in keeping with DDOT data collection standards. A comparison of the AM and PM peak hour 2015 counts, 2018 counts and the predicted 2040 counts are shown in Appendix A. The turning volumes in the corridor have also remained consistent or slightly higher.

Baseline (2015) and Predicted (2040) AM Peak westbound volumes range from 2,000-2,200 through vehicles per hour along C Street. Under existing conditions, with three westbound lanes, this is a demand of approximately 666-733 vehicles per hour per lane. Under the proposed 65% design with reduction of one travel lane, demand would increase to approximately 1,000 to 1,100 vehicles per lane per hour. Typical signalized streets in the District can carry anywhere from 600 to 900 vehicles per lane per hour, depending on geometry, friction from parked cars or turning movements, and blockage conditions, such as bus stops.

The 2015 study projected 2040 AM Peak westbound volumes under the proposed alternative are consistent with, or somewhat lower than existing traffic volumes. However, they also include assumptions about traffic diversion onto smaller residential streets (D Street NE and Constitution Avenue NE) which reduces the 2040 volumes by approximately 110 vehicles per hour. These alternate routes are only accessible after passing through the intersection of 21st Street NE and C Street NE which is predicted to have a 950-foot queue in the 2015 Traffic Study. In addition, westbound left turns from C Street to 21st Street will be prohibited in the 65% design. Therefore, Constitution Avenue would be inaccessible due to median closures and turn restrictions. As a result, it is likely that the actual 2040 traffic volumes along C Street would be higher than those predicted in the 2015 study. More discussion of the potential AM Peak diversion routes can be found in the section “Potential Diversion Routes.”

3.2. Vehicular Speed

In April 2018, DDOT collected additional speed data over 132 consecutive hours (5.5 days) in two locations on the corridor, one east of 21st Street NE on the ramp from the Whitney Young Bridge and one between 18th Street and 19th Street on C Street NE. This length of data collection allows for both peak and off peak conditions, including weekends. This data showed high rates of speeding and validated community concerns. Table 1 summarizes the analysis.

| Location | Posted Limit | Average Speed | 85 th Percentile Speed | Pace (most common) Speed | Speeds > 40 mph | Speeds > 55 mph |
|--|---------------------|---------------|-----------------------------------|--------------------------|-----------------------|--------------------|
| C Street east of 21 st Street NE | 25 mph ¹ | 36 mph | 43 mph | 53% travel 31-40 mph | 28% (19,000+ drivers) | 0.8% (554 drivers) |
| C Street between 18 th and 19 th Streets | 25 mph | 26 mph | 31 mph | 64% travel 21-30 mph | 0.8% (439 drivers) | N.A. |

Table 1: April 2018 Speed Data

Speeding is more frequent east of 21st Street NE, but there are a substantial number of vehicles traveling at high speeds within the corridor. This confirms the need for engineering solutions to manage speed.

3.3. Traffic Model Validation and Calibration

The 2015 study and subsequent 65% design which were based on the reduced volume predictions also did not account for several traffic model calibration issues which were noted during the recent review of the traffic model.

Once these issues were noted, DDOT had concern that proceeding with the 65% design could result in adverse impacts that run counter to the safety and operational goals of the project. These include major queuing across intersections and crosswalks along C Street NE, traffic diversions through smaller neighborhood streets, and the inability to provide adequate protection for cyclists using the new cycle tracks.

As part of the 65% design review, DDOT conducted an updated analysis examining potential modifications. Table 2 below identifies the issues with the previous traffic models and the potential implications for the corridor analysis.

¹ Note: the posted speed limit on East Capitol Street NE across the Whitney Young Memorial Bridge is 40 mph. The speed data collection point for this study was soon after the posted limit is reduced to 25 mph.

| Issue | Input Flaws | Why it is important | Potential Implications |
|---|---|--|---|
| Outdated traffic signal timing and phasing data. | <p>2015 analysis did not use current signal timing. In 2017, DDOT completed the first cycle of citywide traffic signal optimization, including the C Street corridor.</p> <p>DDOT also installed Leading Pedestrian Intervals (LPIs) at 17th, 18th, 19th & 21st Streets. LPIs are important pedestrian safety improvements at intersections with high turn volumes, but they further reduce time available for main line traffic.</p> | <p>Traffic signal optimization updated pedestrian signal timing to account for slower walking speeds, leading to additional time for cross street traffic and reduced time for C Street traffic.</p> | <p>Longer cross street signal phases increase projected queuing and vehicular delays on C Street.</p> |
| Saturation flow rate improperly applied. | <p>The Highway Capacity Manual indicates that the “Central Business District” input should be applied when there are the following characteristics, which are found in the C Street corridor:</p> <ul style="list-style-type: none"> • Narrow streets/lanes • Frequent parking maneuvers • Bus Stops and associated blockages • Small Radius Turns • Presence of shared thru/right or thru/left lanes • Relatively high pedestrian activity • Dense population | <p>Saturation flow rate is the rate at which previously queued vehicles can traverse an intersection approach under prevailing conditions.</p> | <p>A higher saturation flow rate will assume better operating conditions for C Street.</p> |

| Issue | Input Flaws | Why it is important | Potential Implications |
|---|---|--|---|
| Lane widths were not coded to match the concept design. | In general 12' lane widths were used along westbound C Street. However, the proposed lane configuration is generally one 11' lane and one 12' lane for westbound C Street. (The traffic model can only accept one lane width for each direction.) Due to the presence of parking, buses and the adjacent median, it is more reasonable to code the model using 11' lanes. | Narrower lane widths result in reduced travel speeds but they also reduce capacity. | Wider lane widths would show better operating conditions for C Street. |
| Bus blockages were not coded in the proper lanes for westbound C Street. | The 65% design places the bus stops in one of the two westbound travel lanes. Therefore, it is recommended that the bus blockage values apply to those lanes. | Bus blockages reduce capacity due to blockage of travel lanes. They can also have safety implications in congested conditions as vehicles stuck behind buses tend to make aggressive maneuvers that may result in side swipe collisions. | Although the D6 only operates on roughly 10 minute peak hour headways, if bus blockages are not coded into the model, outputs will indicate better operating conditions for C Street. |
| Roadway grades not coded according to field conditions. | Westbound C Street between 21st Street and 17th Street is uphill at approximately 3% grade in field conditions, which was not included in the model. | Uphill grades decrease vehicle capacity, particularly when starting from a stopped condition and particularly for heavy vehicles such as buses. | Uphill grades decrease saturation flow. If grades are not coded, better operations would be shown for C Street. |

Table 2: Summary of Issues with Previous Corridor Models

In order to evaluate operations with proper model settings, the analysis was re-run using the latest traffic model volumes and settings as well as using the 2015 traffic analysis models with updated settings.

| Scenario | | MOE ² | 17th St | | 18th St | | 19th St | | 21st St | |
|----------|--|------------------|---------|------|---------|------|---------|------|---------|------|
| | | | AM | PM | AM | PM | AM | PM | AM | PM |
| 1 | Baseline Condition (2015 volumes) | LOS ³ | E | C | A | A | C | B | D | C |
| | | Delay | 63.6 | 30.4 | 2.9 | 9.2 | 25.3 | 11.3 | 41.3 | 32.2 |
| 2 | 2015 Study Models Results (2040 volumes) | LOS | D | B | A | A | D | B | D | B |
| | | Delay | 41.4 | 12.8 | 2.1 | 1.8 | 47.2 | 19.5 | 52.1 | 15.6 |
| 3 | 2015 Study w/ Model Calibration (2040 volumes) | LOS | F | C | F | A | F | C | E | C |
| | | Delay | 143.9 | 34.8 | 100.7 | 9.6 | 228.4 | 21.4 | 79.0 | 21.7 |
| 4 | February Proposed 65% Design (baseline volumes) | LOS | F | C | F | D | F | C | F | E |
| | | Delay | 125.7 | 32.5 | 103.5 | 46.3 | 179.3 | 32.3 | 99.3 | 73.4 |

Table 3: Summary of Capacity Analyses (Overall Intersection Results)

Notably, the unmodified traffic study models did not predict any Level of Service “F”. However, there were multiple individual approaches showing volume-to-capacity greater than 1.0 including SB 17th Street and WB C Street at 17th, 18th, 19th and 21st. This indicates that there will be queuing and cycle failure on those approaches. This queuing was also predicted by the unmodified study traffic models during the AM Peak, including:

- 1,000 feet at 21st Street (increased from 370 feet under baseline condition)
- 925 feet at 19th Street (increased from 65 feet under baseline condition)
- 875 feet at 17th Street (increased from 515 feet under baseline condition)

Note that the queues at 19th and 17th Street will far exceed the storage length and spill back across the proposed unsignalized crossings at 17th Place and 20th Street and beyond. This condition results in cars blocking crosswalks and creates unsafe conditions for pedestrians. Intersection analysis was then modified to reflect proposed mitigation alternatives. The results of these efforts can be seen in

² MOE - Measures of Effectiveness

³ Level of Service (LOS) is a measure of intersection-level vehicle delay. LOS measures the seconds of delay the average vehicle can expect to experience approaching the intersection. Delays are assigned a letter grade from A to F, and F is used for any signalized intersection with greater than 80 seconds of delay.

Table 3. As shown, when the calibration settings are applied to the study traffic analysis models, there is a significant degradation in predicted operations during the AM Peak, resulting in LOS E and F at multiple intersections.

3.4. Bike and Pedestrian Safety/Signalization

While protected bicycle lanes provide additional comfort and safety for cyclists, they must be designed in a manner such that proper visibility of the cyclists is maintained and potential hazards at intersections are mitigated. The proposed bike lanes in the 65% Design are set back approximately 15 feet from the travel lanes and the crosswalks are set back another 7 feet from that point. Current DDOT bicycle facility design practices and national guidance encourage enhanced bicyclist protection from turning vehicles at intersections.⁴ Treatments such as through bicycle lanes, or “mixing zones”, allow turning vehicles to cross over the bike lane in advance of the intersection. Examples of these exist along L Street NW and M Street NW. At locations where high volumes of vehicles do cross bicycle lanes during their turning movements, protected-only turn phasing is typically used to eliminate the conflict. This type of design has been implemented at bicycle facilities along 15th Street NW, Pennsylvania Ave NW, and 1st Street NE.

In the study area, there are several signalized intersections which have significant right turn volumes operating in a permissive manner⁵ with the crosswalks and cycle track, according to the February 65% design. The 2015 AM Peak study traffic volumes for these turns are as follows:

- 21st Street – 530 westbound right turns
- 19th Street – 178 westbound right turns
- 15th Street – 346 westbound right turns

⁴ See in particular Massachusetts DOT’s Separated Bike Lane Planning & Design Guide discussion of bicycle signals, which recommends providing a separate signal phase when right turn volumes exceed 150 vehicles per hour (https://www.mass.gov/files/documents/2017/10/26/SeparatedBikeLaneChapter6_Signals_1.pdf, p. 107) and National Association of City Transportation Officials (NACTO) guidance to provide separated turning movements “where a predominant bicycle movement conflicts with a main motor vehicle movement during the same green phase.” (<https://nacto.org/publication/urban-bikeway-design-guide/bicycle-signals/bicycle-signal-heads/>)

⁵ “Permissive” means that turning movements are allowed whenever the traffic signal is solid green, also known as a “green ball”. “Protected” means that turning movements are only allowed on a green arrow, and would display a red arrow when turning movements are not permitted.

Given these heavy turning volumes and the high level of physical separation between vehicles and bicycles, it could be unsafe to operate these right-turns in a permissive mode. However, provision of protected-only movements at these locations would further degrade traffic operations under the February 65% Design, in particular at 19th Street where a right turn bay Bicycles could not be protected because one of the shared through-right lanes would have to be converted to a right-turn only lane in order to signal protect people riding bikes. This would result in only one westbound through lane, which would be unable to process 2,100 vehicles per hour.

In addition to bicycle safety concerns, the February 65% Design proposes unsignalized pedestrian crossings at 17th Place and 20th Street. In order to safely accommodate school children and neighborhood pedestrian traffic, these unsignalized crosswalks will likely need to be fully signalized. The addition of two closely-spaced signals will create more friction in the network, which would further degrade the predicted traffic operations.

4.0 Potential diversion routes

Several potential diversion routes were identified in the 2016 traffic study under the proposed C Street alternative, namely: Benning Road, NE, East Capitol Street, NE, D Street, NE and Constitution Avenue, NE. Among these alternate routes, only Benning Road is considered a Principal Arterial. East Capitol Street is classified as a Collector, while both Constitution Avenue and D Street are classified as Local Roads within the study limits. It should be noted that Constitution Avenue becomes a Minor Arterial west of the intersection of North Carolina Avenue and 14th Street. Without any modifications to the 65% design, DDOT would anticipate that additional traffic would seek these diversion routes. Modeling of diversion routes is a time and labor-intensive process. DDOT did not attempt to recalibrate the regional modeling of potential diversion from the 2016 study, but it is still instructive to understand this issue in more detail. The following sections examine diversion routes identified in the 2016 study and potential challenges.

4.1. D Street and Constitution Avenue

In addition to the functional classifications of these roadways, several additional characteristics are important to note. The portions of Constitution Avenue and D Street that parallel C Street between 21st Street and 14th Street are primarily residential areas with 4-ways stop signs (traffic signals are present at intersections of 17th & 19th Streets), narrow cross-sections (approximately 30'), full-time parking on

both sides of the street, and no center lines. This section of Constitution Avenue is designated as a school zone as well.

Access to these routes would still require drivers to pass through the intersection of 21st Street and C Street, NE. However, under the proposed 65% design westbound left turns will be restricted from C Street onto 21st Street. This means that Constitution Avenue would not be accessible until reaching 17th Street and making a left turn. From southbound 17th Street a driver making a right turn onto Constitution Avenue would only be able to go two blocks before Constitution Avenue becomes one-way eastbound at 15th Street and would then have to re-join North Carolina Avenue via northbound 15th Street. This would make Constitution Avenue detour unattractive.

Similarly, access to D Street via 21st Street is proposed to be eliminated through a separate traffic calming project that aims to reduce traffic on 21st Street cutting between Benning Road and C Street. The project would still allow for traffic to access D Street via Oklahoma Avenue but the push for traffic calming in this area would indicate a desire on the part of residents to reduce cut through traffic. Therefore, promoting this diversion would be in conflict with the traffic calming proposition.

Given these characteristics, Constitution Avenue and D Street are ill-suited to serve as diversion routes. This would likely force more traffic to stay on C Street, further exacerbating predicted congestion issues.

4.2. Benning Road and East Capitol Street

As noted previously, Benning Road is classified as a Principal Arterial and as such would be better suited as a proposed diversion route. That possibility should not be discounted; however, the Benning Road/H Street corridor provides access to areas further north in the Downtown Core than C Street, which are not necessarily the desired destinations of today's C Street users. The 2015 traffic analysis only predicts 25 vehicles per hour will divert from C Street to Benning Road during the AM Peak as a result of this project. Even if higher volumes were expected to divert, the Benning Road/H Street corridor is already near or exceeding capacity during the AM and PM peaks with notable queueing, particularly between the Maryland Avenue "Starburst" intersection and 21st Street.

East Capitol Street would appear to be the most reasonable and likely diversion route for traffic currently using C Street. In fact, the 2015 traffic analysis predicts approximately 70 vehicles per hour will divert to East Capitol Street during the AM Peak. Given the current operations on East Capitol Street this would not be an excessive volume of traffic to process. However, coupled with the explanation above

that Constitution Avenue and D Street are not suitable alternate routes, there would more likely be a predicted 110 vehicles per hour diverting to East Capitol Street for a total predicted diversion of 180 vehicles per hour. While East Capitol Street is currently able to process approximately 600 vehicles per hour between 17th Street and Lincoln Square (where only a single lane with bike lanes and on street parking are provided), it is unlikely that upwards of 780 vehicles per hour could be processed. One of the major limiting factors, in addition to the single lane cross-section, is that traffic along this stretch of East Capitol is required to traverse Lincoln Square which already suffers notable congestion due to the numerous conflicting traffic flows entering the square at any given point.

Lastly, based on the latest analysis using the predicted 2040 traffic volumes, a much larger fraction of the anticipated traffic volume would need to divert in order to attain acceptable operations along C Street under the 65% design conditions.

5.0 April Changes to the February 65% Design

After identifying the issues with the traffic modeling and analysis of the February 65% design, DDOT developed alternative approaches to mitigate traffic impacts while retaining multimodal safety improvements along the C Street NE corridor. These are discussed below and summarized in Table 4. Figures 2, 3, and 4 illustrate the proposed design changes; numbers in the following text correspond to the numbers on the figures. In addition to these alternative scenarios, DDOT considered and rejected further alternatives that had greater benefits for traffic flow but were deemed contrary to the purpose and need for the project. The potential changes were presented at the April 26th public meeting. The April design plan reflected the operational approach in Scenario A, but the flexibility to transition to Scenario B if necessary.

5.1. Scenario A

The first alternative seeks to accommodate high turning volumes throughout the corridor and provide greater protection for cyclists and pedestrians. In the eastbound direction, bump-outs would be reduced by approximately 8 feet at the southwest and southeast corners of the C Street and 21st Street (1). This in conjunction with PM parking restrictions will provide two eastbound travel lanes on C Street through the 21st street intersection from 4:00 PM to 6:30 PM. The bump-out on the northeast corner of the C Street and 19th street intersection would be removed and parking restricted in advance of the intersection to create a dedicated right-turn lane and protected bicycle phasing (2). Creation of the

right-turn lane would remove right-turning vehicles from the through traffic flow, increasing the safety for road users by reducing the potential for rear-end collisions and side-swipes and allowing for protected-only turning movements across the cycletrack. Bump-outs would be modified at the northwest and northeast corners of the C Street and 16th Street intersection and parking restricted in advance of the intersection to create a shared through/right-turn lane (3). Bump-outs will remain at all other locations.

The westbound left-turn bay at 17th Street (4) and the eastbound left-turn bay at 19th Street (5) would also be extended to prevent turning vehicles from blocking through traffic. Finally, in order to prevent bus blockages, westbound bus stops at 17th Street (6) and 18th Street (7) would be relocated into the parking lanes. This would prevent bus blockages at these locations and prevent sideswipe and rear-end conflicts between vehicles attempting to pass buses picking up or discharging passengers.

The addition of a dedicated westbound right-turn lane at 19th Street would allow for right-turns to operate under protected-only phasing with no turns on red permitted. Protection would also be provided at 21st Street and 15th Street. This adds another degree of protection for cyclists by removing conflicts with that movement. The February 65% design also contains two unsignalized pedestrian crosswalks at 17th Place (8) and 20th Street (9). Adding signalization to these intersections will provide pedestrians with protection for crossing C Street. Finally, the traffic pattern at 21st Street will be modified to allow dual southbound left turns by separating pedestrian and vehicle traffic.

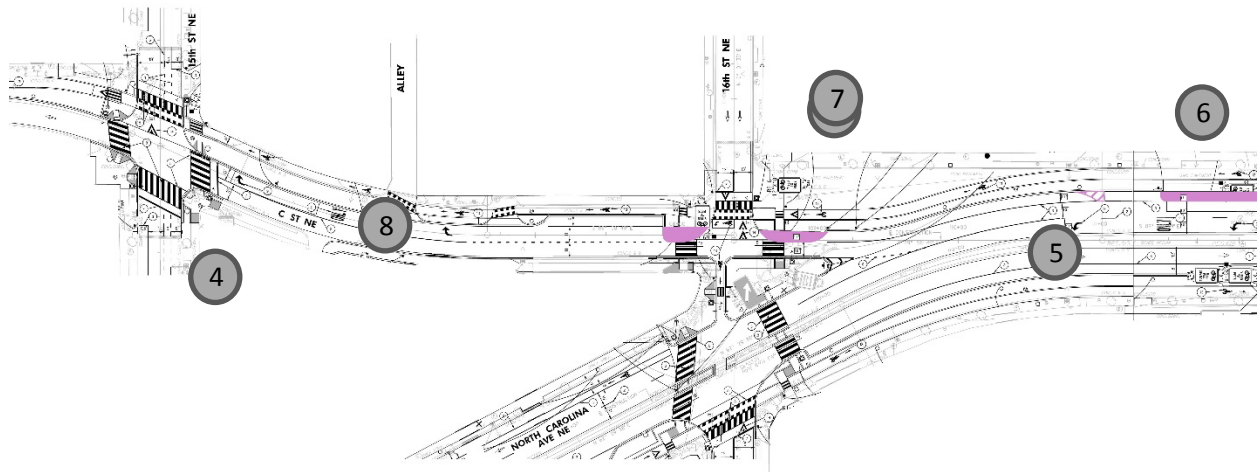
5.2. Scenario B

In addition to the proposed geometric and traffic signal changes in Scenario A, the second proposed alternative contains more geometric improvements which are designed to be adaptive to the future needs of the corridor. Bump-outs would not be constructed along the length of the corridor, but full-time parking will remain in place at project open. Therefore, Scenario B would initially operate identically to Scenario A. If after project open traffic operations are unacceptable, westbound street parking may be restricted from 7:00 AM – 9:30 AM. This would allow for three westbound lanes during AM peak, but reduce the number of travel lanes to two during all other times. Even with the removal of the bump-outs, the average crossing distance is still reduced by approximately 30 feet. Westbound bump-outs on C Street would remain at 21st Street and 20th Street, and eastbound bump-outs on C Street will remain at all locations except 21st Street. Therefore, only two lanes of traffic would enter C

Street at 21st Street. Additionally, all bump-outs proposed in the current 65% design could be installed at a future date pending further evaluation from DDOT.

| Scenario | Travel Lanes | Crossing Distance | Bike Facilities | Turning Facilities | Street Parking |
|--------------------------------|--|-------------------|---|--|--|
| Existing (Baseline) | 3 Westbound 2 Eastbound | 90 Feet | Bike lane in travel lanes | No dedicated turn lanes | 82– 8AM-6PM 103 – Rest of Day |
| Original 65% Plan | 2 Westbound 1 Eastbound | 45 Feet | Cycle track with no protection from right-turns | Left-turn bays at 17 th St and 19 th St | 98 – All Day |
| Modified 65% Plan – Scenario A | 2 Westbound 1 Eastbound | 45 Feet | Cycle track with signal protection from right-turns | Extended left-turn bays; Right-turn bays at 16 th St and 19 th St | 72 – 4PM-6:30PM 80 – Rest of Day |
| Modified 65% Plan – Scenario B | 2 Westbound 1 Eastbound (3 Westbound lanes in AM peak if needed) | 50 Feet | Cycle track with signal protection from right-turns | Extended left-turn bays; Right-turn bays at 16 th St and 19 th St | 72 – 4PM-6:30PM 80 – Rest of Day 57 – 7AM-9:30AM (if needed) |

Table 4: Comparison of Alternatives

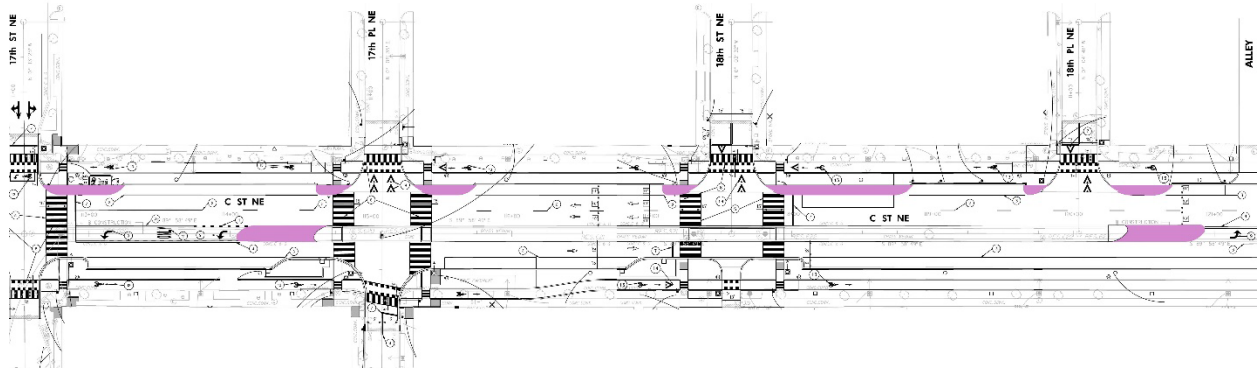


LEGEND:


 Proposed Median Reduction/Bump-Out Removal

d.
District Department of Transportation

Figure 2: April Modifications to February 65% Design—15th Street NE to 16th Street NE



LEGEND:

 Proposed Median Reduction/Bump-Out Removal

d.
District Department of Transportation

Figure 3: April Modifications to February 65% Design—17th Street NE to 18th Place NE

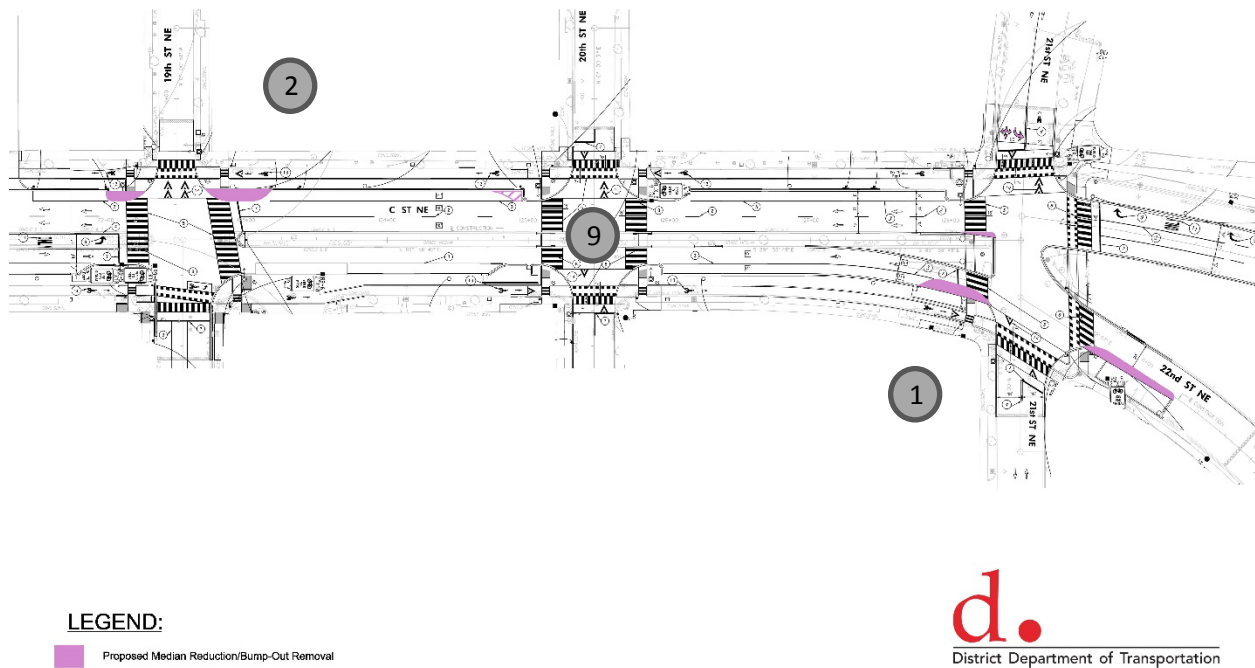


Figure 4: April Modifications to February 65% Design—19th Street NE to 21st Street NE

6.0 June Revisions to 65% Design

DDOT received feedback at the April 26th public meeting and in following weeks. Concerns about the April design focused on several concerns, including:

- Existing driver behavior in the corridor requires physical infrastructure to reinforce design changes. *This concern emphasized the need for retention of physical curb extensions in the February design.*
- A right turn lane at 19th Street would remove parking. This concern resulted in revised design for the 1900 block of C Street.
- A right turn lane at 19th Street would encourage additional right turns to use this route. This concern resulted in minimizing the storage length of the right turn bay to achieve the safety benefits of a separated turn phase without encouraging additional volume than currently utilizes this route.

- Reconfiguration of 16th Street would remove parking. This concern resulted in revised design for the 1600 block of C Street.
- Elimination of the bus bulb at 18th Street would degrade transit operations and widen pedestrian crossings. *This resulted in maintaining the bus bulb as presented in February.*
- The eastbound far side bus stop at 21st Street would limit neighborhood access, especially from Kingman Park. *This resulted in restoring the near side bus stop as currently exists.*

The following summarizes the June 65% design plan and Table 5 provides an intersection by intersection comparison of the February, April, and June design evolution.

- A westbound right-turn lane will be added at 19th Street during all times of day. This will reduce the near-side westbound bump-out but keep in place the far-side bump-out, preventing vehicles from using it as a through lane. The illustration of this change is depicted in Figures 7, 8, and 9, which are located in Appendix B.
- The far-side bus stop at 17th Street will be moved out of the travel lane. This will reduce the far-side westbound bump-out. The illustration of this change is depicted in Figures 10 and 11, which are located in Appendix B.
- The intersections of C Street and 20th Street and C Street and 17th Place will be signalized to protect crossing pedestrians.
- A westbound right-turn bay will be added at 16th Street. This will reduce the near-side westbound bump-out but keep in place the far-side bump-out, preventing vehicles from using it as a through lane. Only one lane will be designated for through traffic on C Street at 16th Street. The illustration of this change is depicted in Figures 12 and 13, which are located in Appendix B.
- Provision of dual-left turns at the 21st Street intersection will require two eastbound lanes on C Street during PM peak (3:30 – 7:00 PM). This will result in minor modifications to the median island. The near-side bus stop will remain in the eastbound travel/parking lane.
- The left-turn bays for eastbound traffic at 19th Street and westbound traffic at 17th Street will be lengthened. This does not have any impact on pedestrian protection but will improve traffic operations.

All bump-outs will remain at the intersections of C Street and 20th Street, 18th Place, 18th Street, and 17th Place. Eastbound bump-outs will remain at all intersections. The retention of these bump-outs will minimize pedestrian crossing distances along the length of the corridor.

| Location/Direction | | February Design Plans | April Design Plans | June Design Plans |
|-------------------------|-----------|-------------------------------------|---|--|
| 21 st Street | Westbound | 2 through lanes + 1 right turn lane | Same as February design | Same as February design |
| | Eastbound | 1 through lane | 2 through lanes to account for SB LT from Oklahoma | 2 through lanes + bus stop relocated to near side |
| 20 th Street | Westbound | 2 through lanes | Same as February design + signal to be added for pedestrian safety | Same as February design + signal to be added for pedestrian safety |
| | Eastbound | 1 through lane | Same as February design + signal to be added for pedestrian safety | Same as February design + signal to be added for pedestrian safety |
| 19 th Street | Westbound | 2 through lanes | 2 through lanes + 1 right turn lane near side parking + far side bulb out removed | 2 through lanes + 1 right turn lane near side parking + far side bulb out restored |
| | Eastbound | 1 through lane + 1 left turn lane | Same as February design | Same as February design |
| 18 th Place | Westbound | 2 through lanes | 2 through lanes + bulb outs removed | February design restored |
| | Eastbound | 1 through lane | Same as February design | Same as February design |
| 18 th Street | Westbound | 2 through lanes | 2 through lanes + bulb outs removed | February design restored |
| | Eastbound | 1 through lane | Same as February design | Same as February design |
| 17 th Place | Westbound | 2 through lanes | 2 through lanes + bulb outs removed + signal added for pedestrian safety | Same as February design + signal added for pedestrian safety |
| | Eastbound | 1 through lane | Same as February design | Same as February design |
| 17 th Street | Westbound | 2 through lanes + left turn lane | 2 through lanes + left turn lane + bus bulb removed | 2 through lanes + left turn lane + bus bulb removed, near side bulb out restored. |
| | Eastbound | 1 through lane | Same as February design | Same as February design |
| 16 th Street | Westbound | 1 through lane | 1 through lane + bulb outs removed + parking removed | 1 through lane + 1 right turn lane + parking restored |
| 15 th Street | Westbound | 1 through lane + 1 right turn lane | Same as February design | Same as February design |

Table 5: Design changes from February, April, and June designs.

6.1. Capacity Analysis Summary

A capacity analysis was performed using Synchro 10 and Highway Capacity Manual (HCM) methodology for each of the study intersections under 6 scenarios: 1) existing field conditions and 2015 volumes; 2) the original 2015 traffic study analysis and predicted 2040 volumes; 3) the 2015 traffic study analysis with proper model calibration and predicted 2040 volumes; 4) the original 65% design with opening year traffic volumes; 5) Scenario A with opening year traffic volumes; 6) Scenario B with opening year traffic volumes; and 7) the June proposed design with opening year traffic volumes. The measures of effectiveness evaluated include average control delay, volume to capacity (v/c) ratio, and level of service (LOS). The scenarios are presented with corresponding LOS results in Table 6 (Scenarios 1-4 were previously presented in Table 2).

| Scenario | | MOE | 17th St | | 18th St | | 19th St | | 21st St | |
|----------|---|-------|---------|------|---------|------|---------|------|---------|------|
| | | | AM | PM | AM | PM | AM | PM | AM | PM |
| 1 | Baseline Condition (2015 volumes) | LOS | E | C | A | A | C | B | D | C |
| | | Delay | 63.6 | 30.4 | 2.9 | 9.2 | 25.3 | 11.3 | 41.3 | 32.2 |
| 2 | 2015 Study Models Results (2040 volumes) | LOS | D | B | A | A | D | B | D | B |
| | | Delay | 41.4 | 12.8 | 2.1 | 1.8 | 47.2 | 19.5 | 52.1 | 15.6 |
| 3 | 2015 Study w/ Model Calibration (2040 volumes) | LOS | F | C | F | A | F | C | E | C |
| | | Delay | 143.9 | 34.8 | 100.7 | 9.6 | 228.4 | 21.4 | 79.0 | 21.7 |
| 4 | February 2018 Proposed 65% Design (Opening year volumes) | LOS | F | C | F | D | F | C | F | E |
| | | Delay | 125.7 | 32.5 | 103.5 | 46.3 | 179.3 | 32.3 | 99.3 | 73.4 |
| 5 | April 65% Design – Scenario A (Opening year volumes) | LOS | F | D | C | B | F | C | F | C |
| | | Delay | 103.3 | 44.3 | 22.3 | 16.7 | 90.8 | 20.5 | 94.1 | 29.0 |
| 6 | April 65% Design – Scenario B (Opening year volumes) | LOS | C | D | A | B | B | B | F | C |
| | | Delay | 27.2 | 44.3 | 1.6 | 16.7 | 14.5 | 19.8 | 94.1 | 29.0 |
| 7 | June 65% Design – (Opening year volumes) | LOS | F | D | C | B | F | C | F | C |
| | | Delay | 105.1 | 40.5 | 21.3 | 10.7 | 86.0 | 21.7 | 94.2 | 30.0 |

Table 6: Summary of Capacity Analyses (Overall Intersection Results)

7.0 Conclusion and Recommendation

The findings show that within the study area, the unaltered proposed February 65% design would result in severe levels of queuing, delay, and overall congestion for a roadway designated as a minor arterial. Since the 2015 study, traffic volumes have not further declined in recent years and in some locations are

increasing. The June recommended mitigations to the proposed 65% design will help alleviate this congestion and reduce neighborhood diversions without sacrificing the safety and aesthetic benefits that are at the heart of this project.

Table 5 summarizes the design changes and Table 6 summarizes the operational changes. The June plan addresses the community concerns raised around the April plans and reinstates bulb outs throughout the westbound direction, retains residential parking, and adds signal protections for people walking and biking throughout the corridor.

With the June revisions to the 65% design, DDOT will proceed to finalize the design and prepare the project for construction. The several months spent in revisions to the 65% design is not typical for DDOT's project development process. Despite these design iterations, the target for design completion is late 2018 and the project could break ground for construction in late 2019, pending funding availability and the construction contracting process.

8.0 Appendix A: Comparison of Count Data

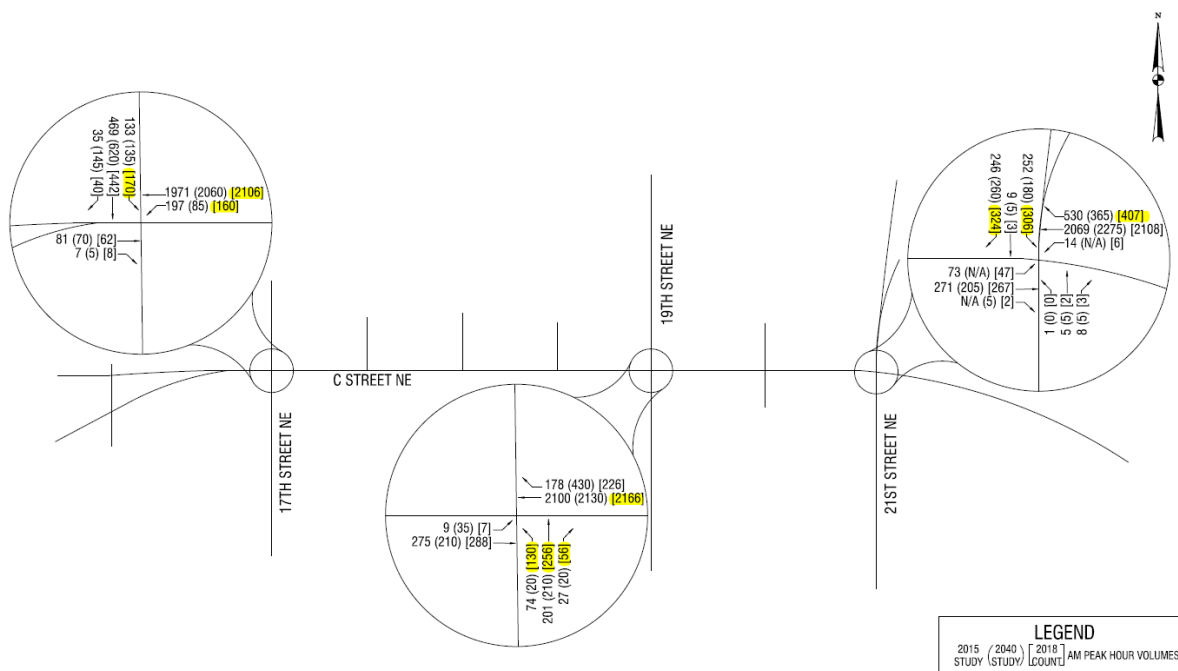


Figure 5: AM Count Comparisons

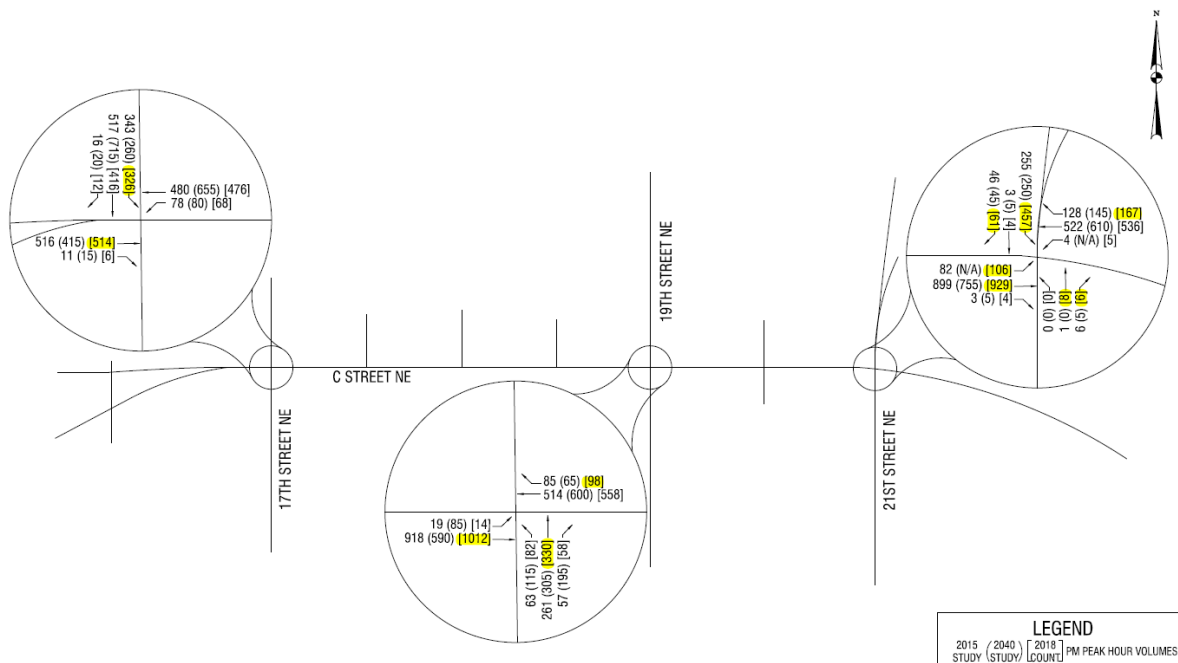


Figure 6: PM Count Comparisons

9.0 Appendix B: June Design Modification Comparisons

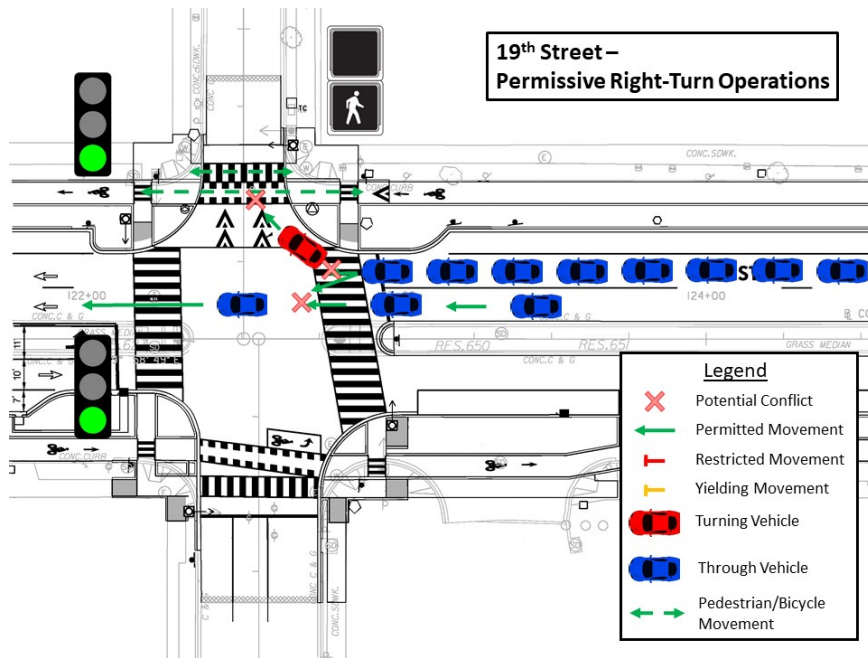


Figure 7: February 65% Design 19th Street Westbound Operations

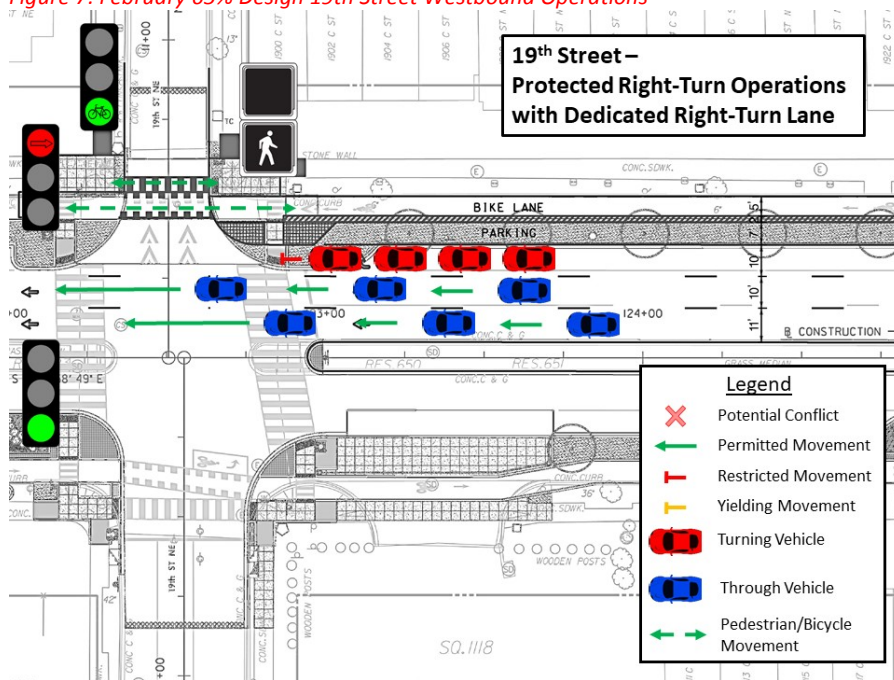


Figure 8: Modified 19th Street Westbound Operations, Bike/Through Vehicle Phase

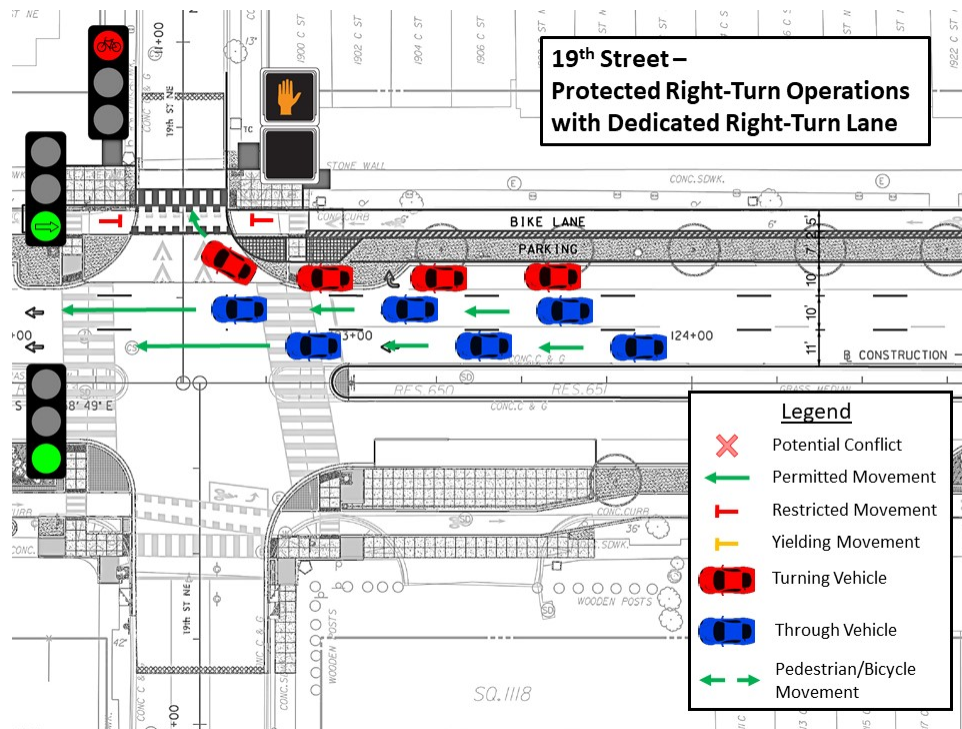


Figure 9: Modified 19th Street Westbound Operations, Right Turn/Through Vehicle Phase

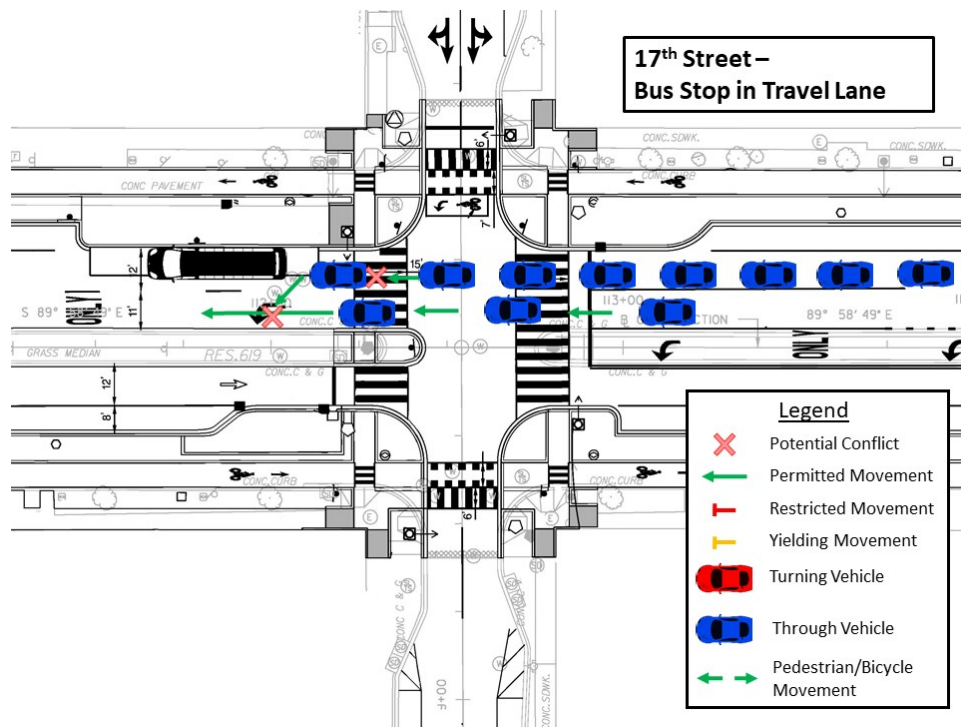


Figure 10: 65% Design 17th Street Westbound Operations

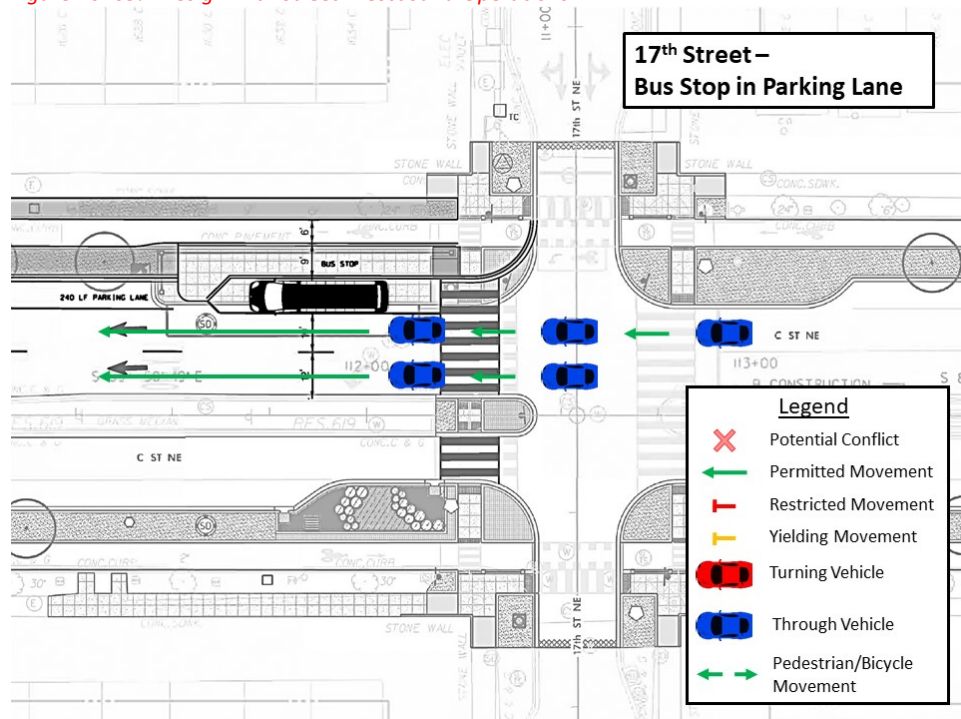


Figure 11: June Modified 17th Street Westbound Operations

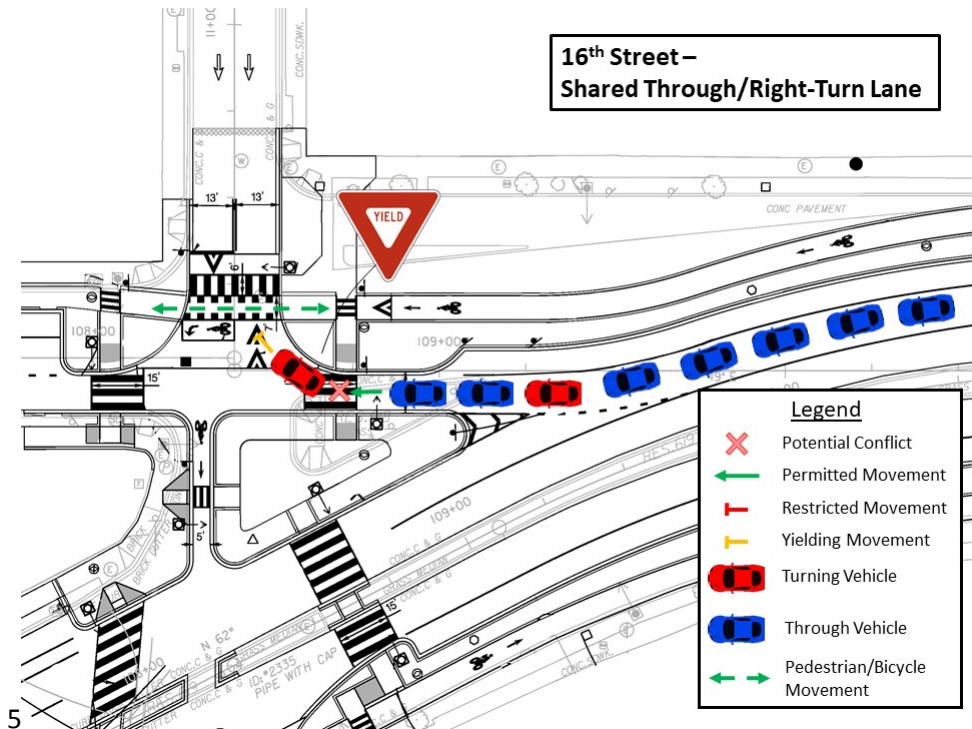


Figure 12: 65% Design 16th Street Westbound Operations

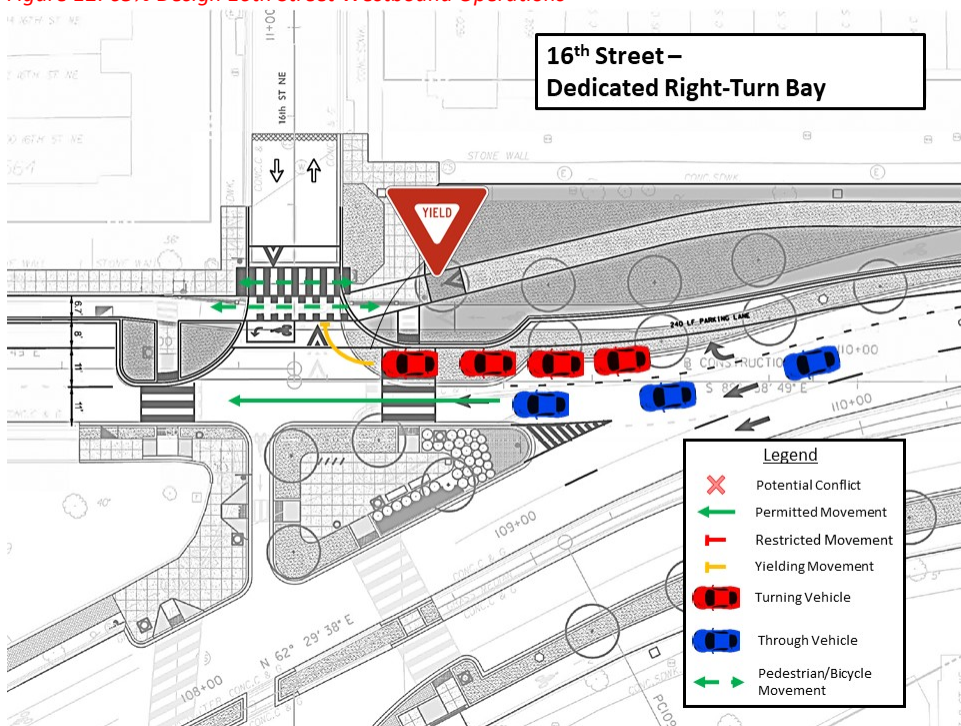


Figure 13: June Modified 16th Street Westbound Operations