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MEMORANDUM

To: Giovanni Zinn, City of New Haven
From: Lucy Gibson, PE, Senior Engineer
Date: Revised May 18, 2022

RE: State Street Redevelopment Traffic Analysis

This memorandum updates the traffic analysis that has been conducted in 2020 and included in a report, titled *State Street Traffic Analysis*, dated September 30, 2020. This report evaluted the traffic operations of the proposed reconfiguration of State Street to provide separated bicycle lanes and support transit oriented development adjacent to the State Street passenger rail station.

Since that report was completed, the proposed design for State Street has been modified. Additionally, changes in proposed access to the 275 South Orange Street development (New Haven Coliseum site) have been approved by the City since the 2020 report was completed.

This memorandum provides an updated and more detailed traffic analysis that reflects the above changes.

State Street Redevelopment Project

The City of New Haven is pursuing a project that will meet multiple goals related to transportation, sustainability, housing, and economic development. The City's Vision 2025 document articulates the City's goals for transportation, which guided this project:

> *The primary transportation goal is to encourage a modal shift in the city, from a population largely dependent on single-occupant vehicles to a population with a wide range of options including public transit, bike, and pedestrian systems. In general, transit and bike/pedestrian improvements must complement each other and accommodate needs of people of all ages and abilities.*

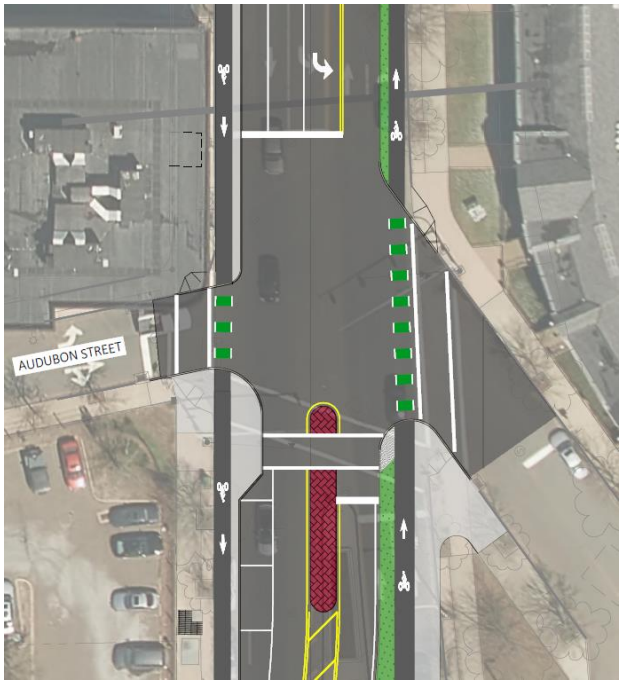
The proposed concept will transform an automobile-oriented corridor to a truly multimodal street, with high quality walking and biking infrastructure, more efficient and convenient transit operations, and greatly improved safety for all users.

Proposed Traffic Signal Operations

The following sections review the proposed design and traffic signal phasing/operations at each of the corridor intersections. The proposed intersection design and traffic operations are intended to provide a safe and comfortable environment for walking and biking, and will accommodate the expected peak hour vehicle traffic volumes. Current best practices in designing multimodal intersections have been applied to reduce the potential for conflicts. Particular attention is given to the traffic signal operations, and how they can reduce or prevent conflicts between bicycle riders and motorists. Each signalized intersection is discussed in the following sections, and includes the proposed layout, as well as a signal phasing diagram. In the signal phasing diagrams, State Street is shown as the north/south movement.

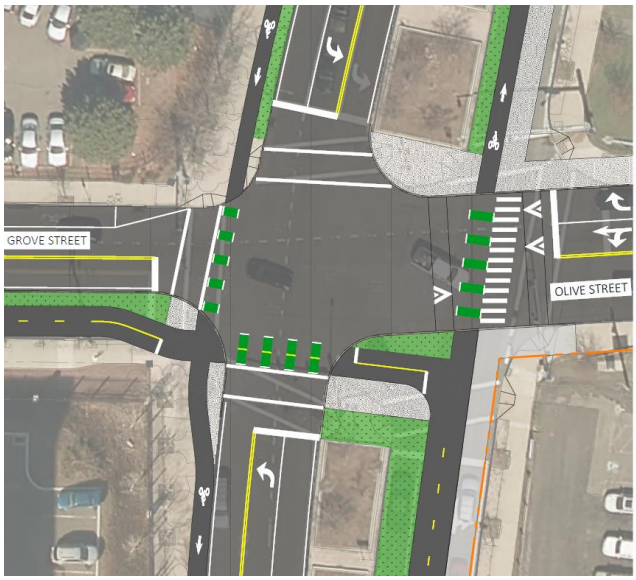
Audubon Street / State Street

Audubon Street has a one-way eastbound approach, and two-way westbound approach that serves a small parking area, with very low volume. This results in very little potential conflict between turning vehicle traffic and the bicyclists in the separated bicycle lanes. With one-way directional bike lanes proposed for each side of State Street, a separate signal phase for bicycle crossings is not required. Bicycles traveling in the separated bike lanes will ride with the traffic signal.



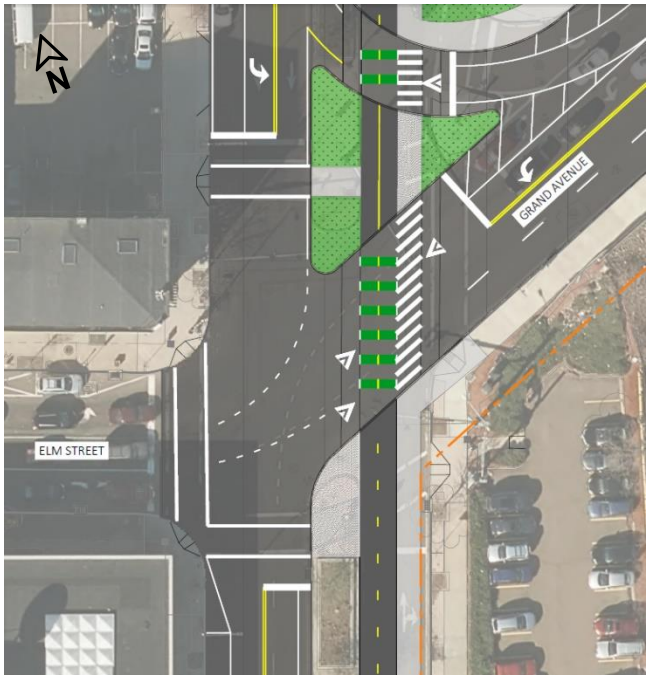
Grove Street/ Olive Street / State Street

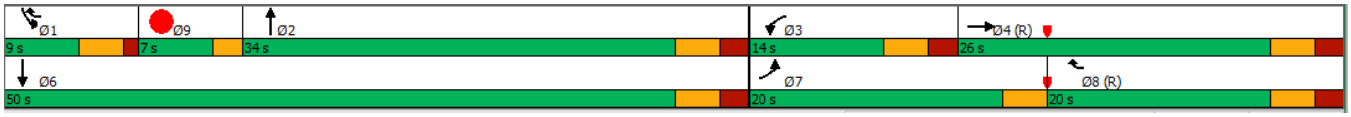
At this intersection, the proposed two-way bicycle lanes cross State Street and continue west on Grove Street to connect with the Farmington Canal Heritage Trail. One-way bike lanes will continue north on each side of State Street and extend southbound on State Street from the intersection. The proposed signal phasing provides a bicycle-only phase to allow all bicycle movements exclusively (symbolized by the red dot below). Protected left turn phases are provided for both directions on State Street to reduce risk of conflict with people walking or biking. A leading pedestrian interval (LPI) is provided for crossing State Street, shown below as a 4 second pedestrian phase.



Elm Street / Grand Avenue / State Street

This intersection will be reconfigured to provide an southbound left turn lane to compensate for the left turn restriction at Court Street. The forecasted volume of left turn demand at this location warrants a protected-only phase, which will reduce the potential for conflicts with bike traffic. The proposed phasing also includes a leading bike interval to reduce potential conflicts with northbound right turns. Bicycles can continue to cross Grand Avenue during the green phase for State Street. Protected-only left turn phases are also provided for Elm Street and Grand Avenue to reduce conflict with the crosswalks.

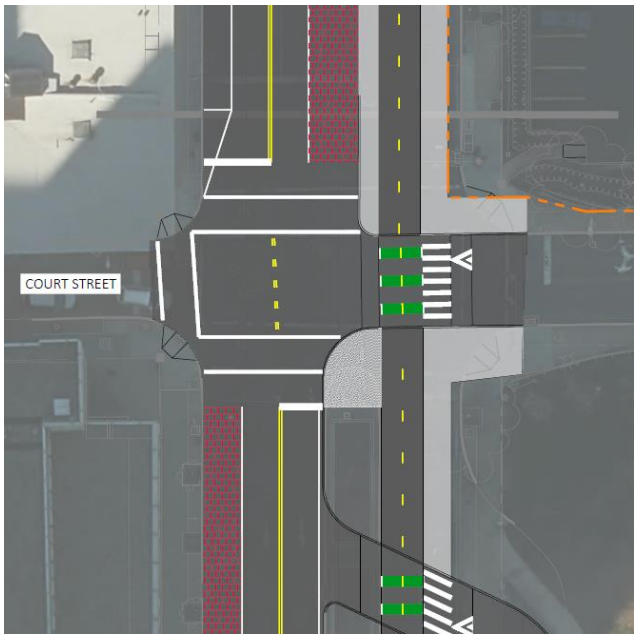


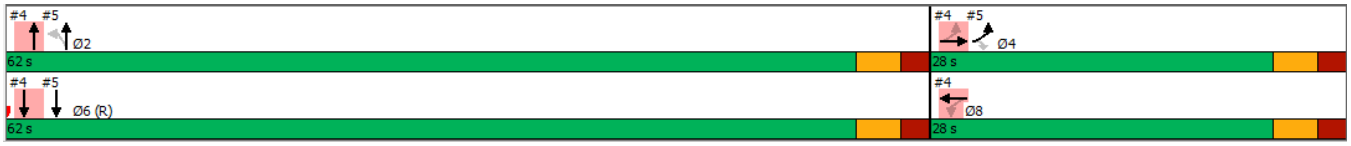


Court Street / State Street and Pitkin Tunnel / State Street

This intersection will provide one vehicle travel lane in each direction and one lane for buses in each direction to provide space for buses serving State Street Station. Southbound left turns are proposed to be restricted in this proposal. For purposes of the traffic analysis, left turns that currently happen at Court Street are assumed to turn left at Grand Avenue. Because of the turn restrictions, and low northbound right turn volumes, a leading bike interval is not required at Court Street.

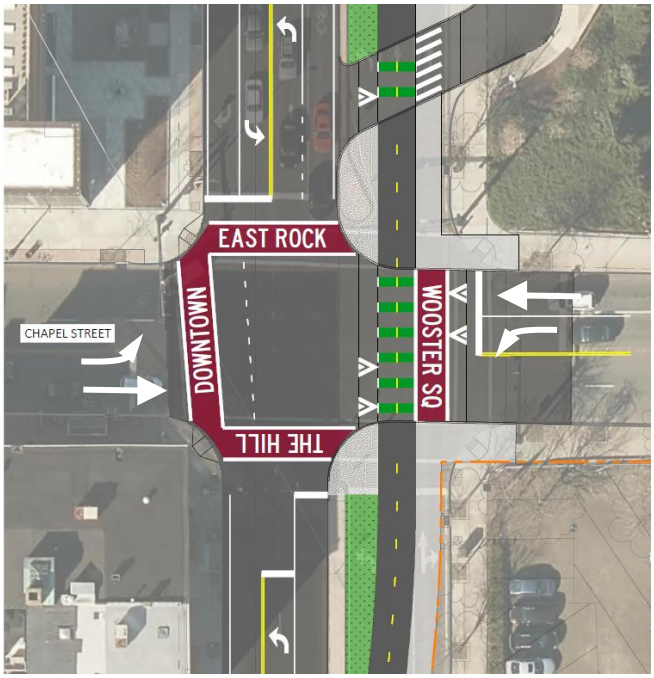
There are no turning traffic conflicts with the bike lanes at the Pitkin Tunnel intersection, which operates on the same controller as Court Street signal. It is recommended that these be separated, and an exclusive left turn phase as well as an LPI considered for the Pitkin Tunnel intersection to reduce potential conflicts.





Chapel Street / State Street

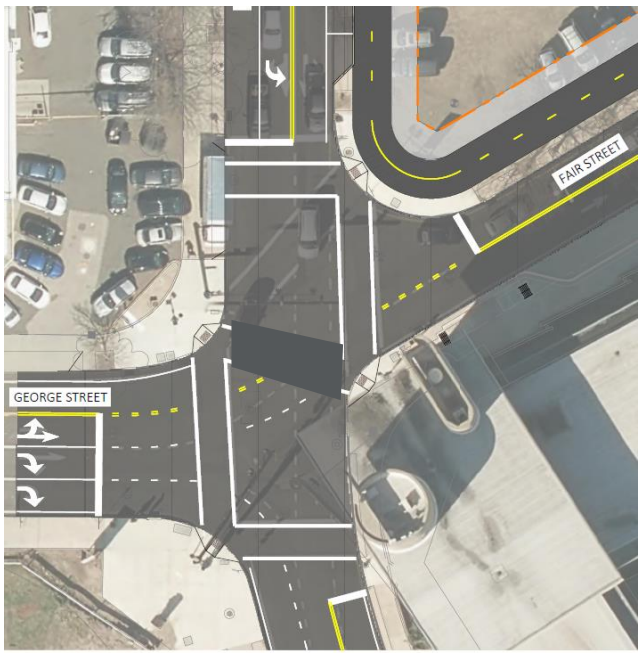
The Chapel Street intersection with State Street will have exclusive left turn lanes on all four approaches. The signal phasing will operate with protected-only left turns for both directions on State Street, followed by a leading bike interval concurrent with southbound through traffic. Bike movements can continue to happen concurrently with the north/south phase, as there are very low right turning volumes. There will be a leading pedestrian interval for pedestrians crossing State Street, as left turns from Chapel Street are permissive.

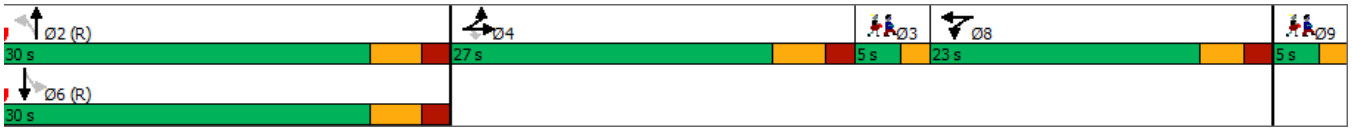


Fair Street / George Street / State Street

The signal phasing for this intersection will provide a north/south phase with permissive left turns, and split phasing for Fair Street and George Street. Pedestrian crossings will be concurrent with State Street and Fair Street phases, and an LPI is provided for each crossing. The two-way separated bike lanes do not cross at this intersection.

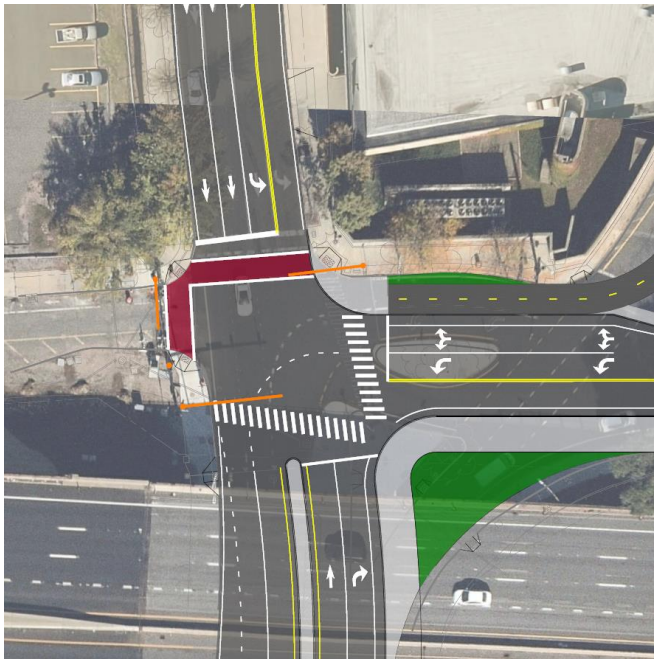
It is recommended that realignment of George Street be considered in the future when redevelopment of the parcel on the northwest corner is proposed. This would also allow provision of a northbound left turn pocket lane, enabling this movement. These changes would greatly increase the efficiency of the intersection, allowing concurrent through movements.





Water Street / State Street

This intersection will see significant changes with additional bikeway crossings, and closure of the Frontage Road approach to vehicular traffic. The proposed signal phasing will have an exclusive phase for pedestrian and bicycle crossings. This could be combined into a single phase, or use an leading bike interval and then full pedestrian phase.



Traffic Analysis

With the significant change from the existing configuration and operations of State Street, and the closely spaced coordinated signal system, the analysis included traffic simulation for the future conditions using Synchro/ SimTraffic software. Both the AM and PM peak hours were modeled.

Analysis Volumes

Traffic counts were collected for the corridor intersections in June, 2019. Additional counts were conducted in April, 2022, which show the morning peak hour is 15% lower than the 2019 counts, and afternoon peak hour volumes are 3% lower than 2019. Two traffic volume scenarios were analyzed with the proposed design changes:

- 2025 Design Volume – Existing and proposed conditions are analyzed with volumes based on the 2019 traffic counts, and include traffic projected from the following developments in the area:
    - 34 Fair Street
    - Audubon Square
    - 87 Union Street
    - 275 South Orange Street, Phase 1

  This scenario provides the design volumes that will be used to evaluate signal operations, queueing, and other design criteria, and should form the basis of design for the signalization design for this project.

- 2040 Traffic Growth Sensitivity Test- This scenario was developed as a test case to determine how the reconfigured State Street would perform with inflationary traffic growth of 0.5% per year over 20 years.

While this outcome is contrary to the goals of the City to expand mode shares of walking, biking and transit, it has been provided at the request of City staff as a point of information.

Turning movement volume diagrams are attached to this memorandum.

Level of Service and Capacity

The traffic operations analysis is focused on the signalized intersections from Audubon Street in the north to Water Street in the south. At each intersection, the number and type of vehicle lanes, traffic signal timings and turning movement counts are used to determine the vehicular Level of Service (LOS), which is a qualitative measure of traffic congestion based on the average delay for a motorist. LOS A defines minimum traffic delay and is an indication that there is underutilized roadway capacity during the peak hour. LOS F represents high levels of traffic delay. The table below, excerpted from the Highway Capacity Manual, provides LOS criteria for signalized and unsignalized intersections.

Table1: Level of Service

Level of Service	Average Stopped Delay (seconds/vehicle)
A	0.0–10.0
B	10.1–20.0
C	20.1–35.0
D	35.1–55.0
E	55.1–80.0
F	>80.0

Source: Highway Capacity Manual, 2000. Transportation Research Board.

One weakness of using vehicular level of service as a primary measure of traffic operations is that the use of a letter grade scale implies that “A” is the best condition. LOS A or B means that there is excess vehicle capacity, which has negative consequences such as speeding, endangering people walking or biking. There are no national standards for LOS, and cities or states have discretion to adopt LOS targets that reflect their unique constraints and their tolerance for traffic congestion. For an urban street network, the Volume-to-Capacity ratio for each approach is a better indicator of intersection operations and focuses more on the ability of the intersection to process the peak hour volumes rather than on the delay experienced by a motorist.

Pedestrian operations are also included, which are based on delay, and affected by signal timing and signal cycle length. They are reported on a scale of A through F, similar to the vehicular level of service. There is a safety aspect to considering pedestrian delay, as when people have long waiting times to cross at a signal, they are more likely to make a risk-taking action, such as crossing away from a crosswalk (i.e. midblock) or crossing before the pedestrian walk signal is provided. The table below shows the pedestrian levels of service based on pedestrian delay.

Table2: Level of Service

LOS	Delay (seconds/person)
A	0.0–10.0
B	10.1–20.0
C	20.1–30.0
D	30.1–40.0
E	40.1–60.0
F	>60.0

Synchro Analysis Results

The analysis results for the three scenarios are attached to this memo. The scenarios are labeled as follows:

- 2025 No Build
- 2025 Build
- 2040 No Build
- 2040 Build

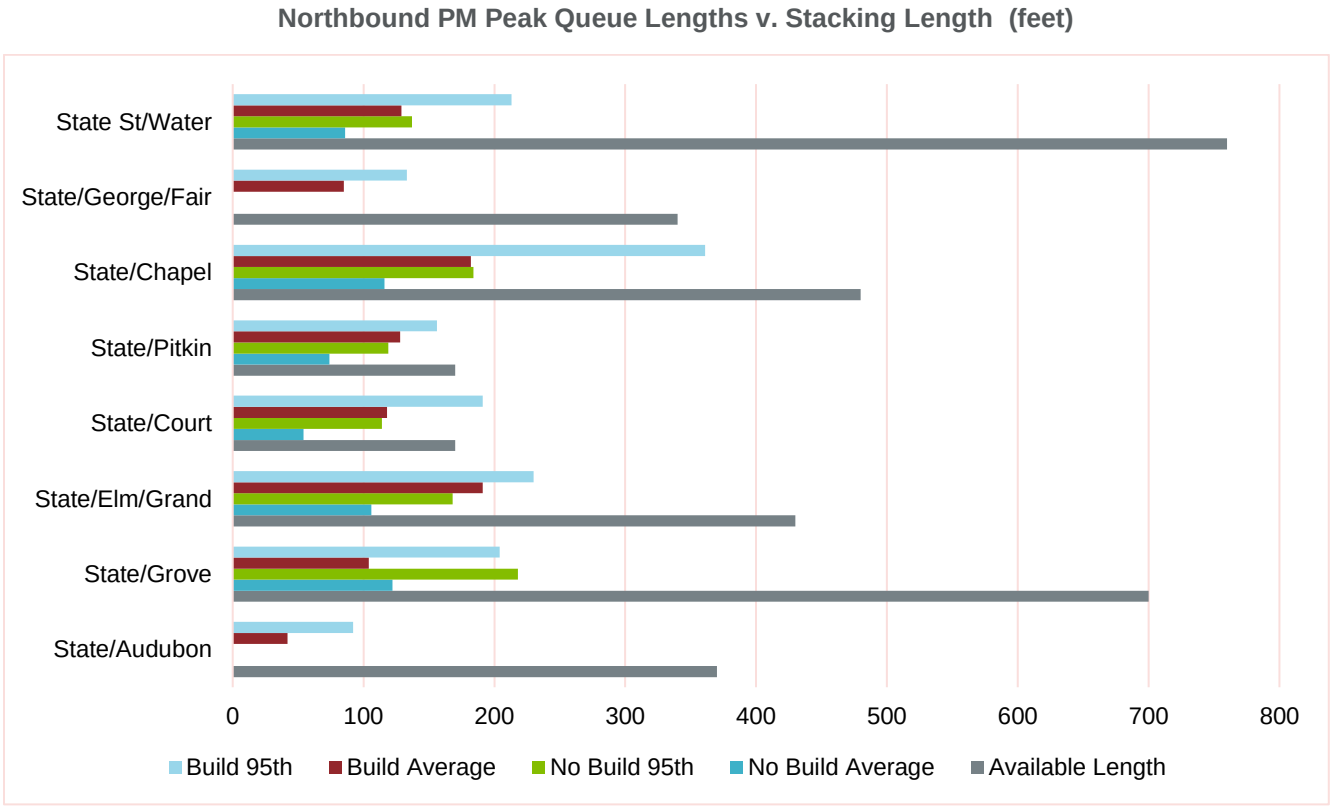
The results show that all intersections have an overall level of service of D or better, and the great majority of major approaches also have LOS D or better. The exceptions are at State/Grand/Elm, during the PM peak hour.

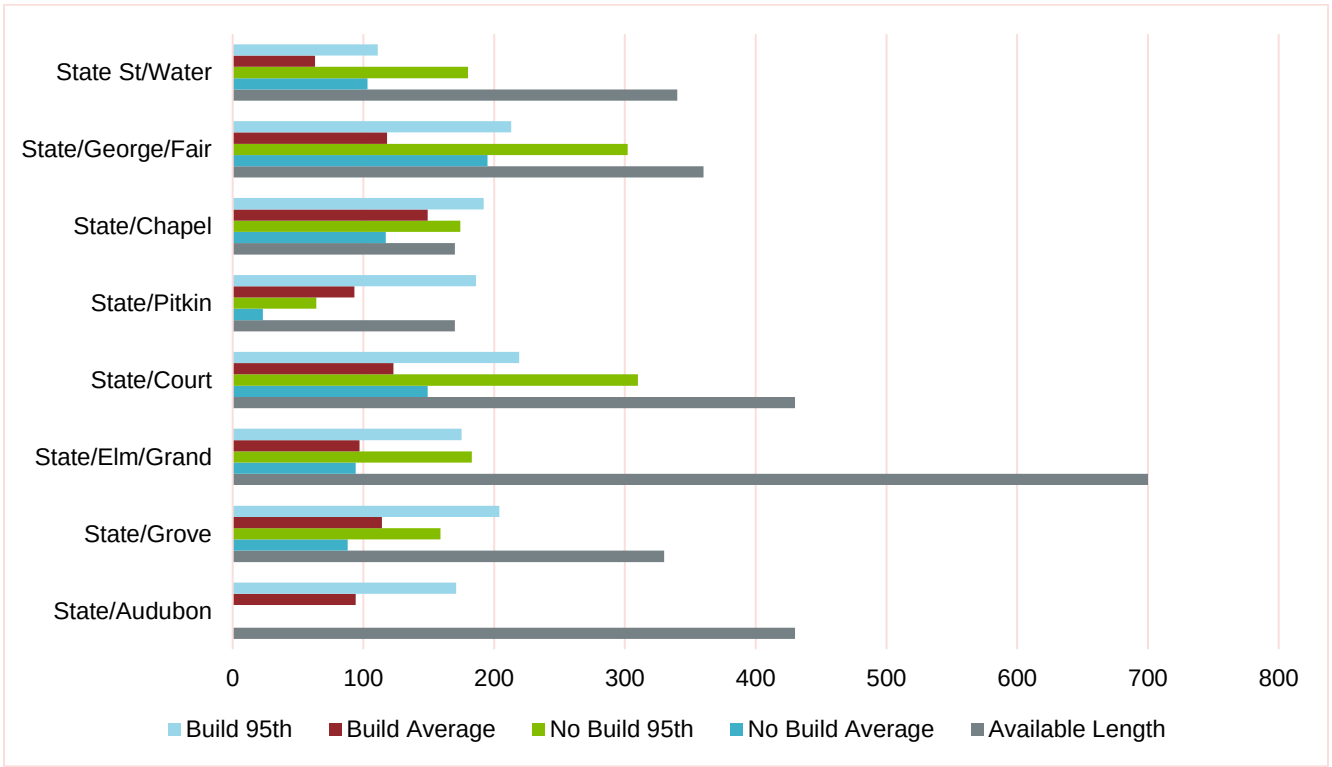
SimTraffic Model Analysis Results

The SimTraffic module of Synchro software was used to evaluate the signal coordination and queueing for the proposed conditions, as this can have a significant effect on operations. Overall, the 2025 Build scenario performs very well. The model shows occasional queues blocking intersections, but these episodes are fleeting, and represent typical peak hour urban traffic conditions. All vehicles are able to enter and move through the network during the peak hour. The following sections discuss queueing and the blocking for each scenario during the PM peak hour, as this is the critical scenario.

Queueing

The following charts show the 50th and 95th percentile queue lengths at each intersection for the PM peak hour generated by SimTraffic. The 95th percentile queue represents an extreme condition that is typically a short-lived event. The first chart below shows all northbound queues, and the second shows all southbound queues.


Northbound PM Peak Queue Lengths v. Stacking Length (feet)
State St/Water
State/George/Fair
State/Chapel
State/Pitkin
State/Court
State/Elm/Grand
State/Grove
State/Audubon
0
100
200
300
400
500
600
700
800
Build 95th
Build Average
No Build 95th
No Build Average
Available Length


Southbound PM Peak Queue Lengths v. Stacking Length (feet)
State St/Water
State/George/Fair
State/Chapel
State/Pitkin
State/Court
State/Elm/Grand
State/Grove
State/Audubon
0
100
200
300
400
500
600
700
800
Build 95th
Build Average
No Build 95th
No Build Average
Available Length

In most locations, the 50th and 95th percentile queues are within the available stacking distance. The 95th percentile queues slightly exceed stacking distance at Chapel and Pitkin Tunnel for the southbound direction, and at Court for the northbound direction.

SimTraffic Delay and Travel Time Measures

The SimTraffic reports, attached to the report, show network-wide measures of vehicle-miles traveled, vehicle-hours traveled, and vehicle delay. The table below compares these measures for the 2025 No Build and Build scenarios.

SimTraffic Travel Time and Delay Results

	AM No Build	AM Build	PM No Build	PM Build
Distance (vehicle-miles)	1358	1373	1876	1860
Travel Time (vehicle-hours)	121.1	119.8	174.8	193.8
Delay (seconds per vehicle)	61	59.9	92.1	112.8

These results show that in the morning peak hour, delay is reduced in the Build scenario, where the benefits of improved signal coordination and consistent signal cycle lengths offset increased delays at a few locations due to the lane reassignments. In the PM peak hour, vehicle delay is modeled to increase by about 10%. This increase should be weighed against the substantial benefits of improved safety and access for other modes of transportation.

SimTraffic also provides average delays at each intersection, which provide an indication of where the most significant changes are experienced.

Intersection Delays from SimTraffic Models (seconds per vehicle)

Intersection	AM No Build	AM Build	Delta	PM No Build	PM Build	Delta
State/Audubon	12	5	-7	11	9	-2
State/Grove/Olive	17	20	3	20	33	13
State/Elm/Grand	22	21	-1	25	43	18
State/Court	11	6	-5	14	12	-2
State/Pitkin	12	10	-2	21	16	-5
State/Chapel	30	29	-1	32	31	-1
State/George/Fair	27	28	1	32	37	5
State/Water	22	14	-8	20	15	-5

Discussion

The foregoing traffic analysis indicates that the reconfiguration of State Street will serve the City of New Haven very well under expected future traffic volumes. The project will result in numerous benefits, including safety, reduction of harmful crashes, an enhanced and vibrant public streetscape, safe and comfortable low carbon emission transportation options, and space to address stormwater treatment within the public right-of-way. The bicycle level of traffic stress will change from a 4, which is the highest stress category, to a 1, the lowest stress category.

The proposed project performs well for peak hour vehicular traffic volumes expected in near term. The average delay per vehicle shown in SimTraffic are comparable to those shown in Synchro, which would compare to levels of service in the D to E range during the PM peak hour, and less delay other times of the day.

Based on experience with major street redesign projects that are intended to improve multimodal access and the public realm, it can be expected that, as urban growth and development unfolds, motorists will tend to using other routes, other modes, or avoid traveling during the afternoon peak hours.

In the unlikely event that afternoon peak hour traffic volumes grow despite the City's efforts to expand use of walking, biking and transit, there are a number of options that the City can consider at that time to further encourage healthier alternatives by strengthening the biking, walking and transit networks.

Mode Shift

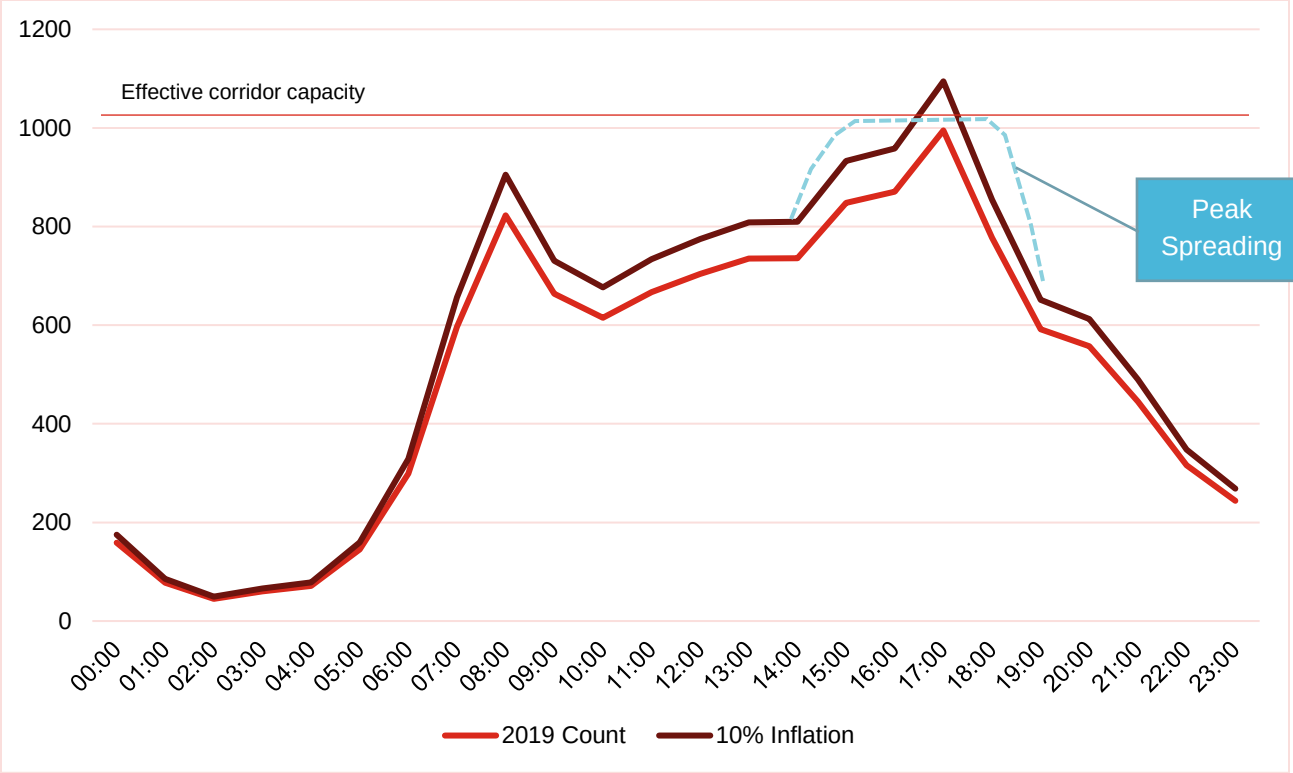
Congested conditions on State Street, combined with high quality and comfort streets for walking and biking, will encourage those wishing to avoid congested driving on State Street to instead make a trip by walking or biking. With the redevelopment plans underway in downtown New Haven, it is likely that a greater number of "every day" services will be available within walking distance of jobs and housing downtown. This land use effect is among the most powerful resulting in mode shift. Transit service improvements are also very likely over the next 20 years, both for passenger rail and CT bus. When combined with high quality and comfort streets for walking or biking, and well designed bus stops, mode shift to transit is also likely.

Address Network Inefficiencies

The operations and traffic flows on State Street are made more inefficient by the presence of several one-way streets, most notably Elm Street. If this street and others were converted to two-way operations, many vehicular trips could take shorter routes, reducing volumes on some of the capacity-critical State Street intersections.

Peak Spreading

Traffic counts conducted along State Street in 2019 show that volumes have a sharp peak in the afternoon peak hour. The more recent counts show even lower morning peak hour traffic, but similar afternoon volumes. As downtown New Haven continues to grow and develop, and exceeds the practical capacity of the reconfigured State Street, peak spreading is a likely outcome, where individuals decide to alter their trip making behavior to make earlier or later trips on State Street.



Congestion Tolerance

In most successful and vibrant cities, traffic congestion is a fact of life, and not a sign of failure. Recurring congestion that is limited to the afternoon peak hour is something that individuals can plan around. Traffic congestion is not out of character in a dense, historic multimodal network, such as that in New Haven.

Conclusions

The proposed reconfiguration of State Street will create a safe, welcoming and efficient street for all modes of travel, and will provide adequate vehicle capacity and levels of service for current and expected traffic volumes. It is consistent with stated planning goals of the City of New Haven.