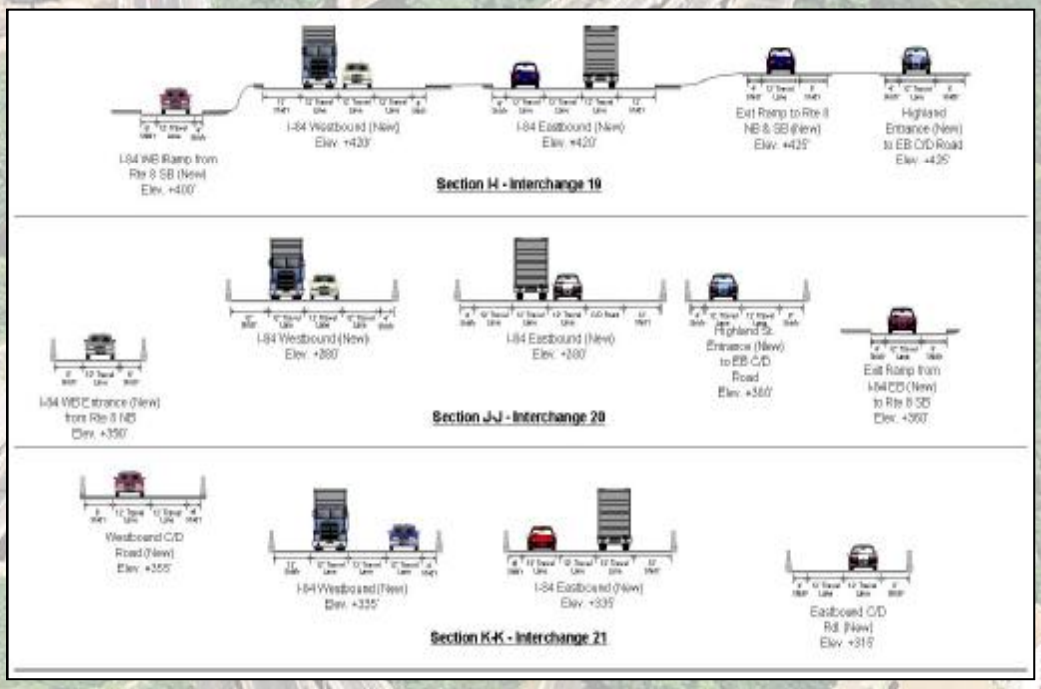
Technical Memorandum #2

Development of Alternatives Report

I-84 / Route 8 Waterbury Interchange Needs Study

State Project 151-301



ENGINEERS
PLANNERS
ECONOMISTS

Wilbur Smith Associates

In association with:

Fitzgerald & Halliday, Inc.
URS Corporation AES
Keville Enterprises, Inc.

Technical Memorandum #2

Development of Alternatives Report

I-84 / Route 8 Waterbury Interchange Needs Study

State Project 151-301

Prepared for:

Connecticut Department of Transportation

Prepared by:

ENGINEERS
PLANNERS
ECONOMISTS

Wilbur Smith Associates

In association with:

Fitzgerald & Halliday, Inc.
URS Corporation AES
Keville Enterprises, Inc.

March 2006

Table of Contents

Page

Table of Contents i

Table of Illustrations ii

Table of Tabulations iii

1 Summary of Future Needs 1-1
2 Development of Preliminary Alternatives 2-1
2.1 Meetings/Workshop 2-1
2.2 Conceptual Layout 2-2
2.3 Strengths, Weaknesses, Opportunities and Challenges 2-22
3 Analysis of Preliminary Alternatives 3-1
3.1 Traffic 3-1
3.1.1 No Build Alternative 3-2
3.1.2 Preliminary Alternative 1 3-3
3.1.3 Preliminary Alternative 2 3-3
3.1.4 Preliminary Alternative 3 3-3
3.1.5 Preliminary Alternative 4 3-6
3.1.6 Preliminary Alternative 5 3-8
3.2 Preliminary Cost Estimates 3-10
4 Screening of Preliminary Alternatives 4-1
4.1 Criteria for Ranking Alternatives 4-1
4.2 Weighting Factors for Criteria 4-2
4.3 Ranking of Preliminary Alternatives 4-3
4.3.1 Construction Cost 4-3
4.3.2 Life Cycle Cost 4-3
4.3.3 Constructability 4-5
4.3.4 Environmental Impact 4-6
4.3.5 Safety/Meets Design Standards. 4-13
4.3.6 Connectivity 4-14
4.3.7 Economic Development 4-14
4.3.8 Intermodal Connections 4-14
4.3.9 Traffic Operations/Capacity Accommodation 4-19
5 Conclusions 5-1
5.1 Screening of Preliminary Alternatives 5-1
5.2 Next Steps 5-2

Table of Figures

Figure 2-1: Preliminary Alternative 1 Concept 2-4
Figure 2-2: Preliminary Alternative 2 Concept 2-7
Figure 2-3: Preliminary Alternative 3 Concept 2-9
Figure 2-4: Preliminary Alternative 3 Typical Cross Sections 2-11
Figure 2-5: Preliminary Alternative 4 Concept 2-13
Figure 2-6: Preliminary Alternative 4 Typical Cross Sections 2-15
Figure 2-7: Preliminary Alternative 5 Concept 2-18
Figure 2-8: Preliminary Alternative 5 Typical Cross Sections 2-19
Figure 3-1: Preliminary Alternative 2 Capacity Analysis 3-4
Figure 3-2: Preliminary Alternative 3 Capacity Analysis 3-5
Figure 3-3: Preliminary Alternative 4 Capacity Analysis 3-7
Figure 3-4: Preliminary Alternative 4 Capacity Analysis 3-9

Table of Tabulations

Table 2-1: Preliminary Alternative 1 - Transportation System Management/ Transportation Demand Management/Transit 2-23
Table 2-2: Preliminary Alternative 2 - Safety and Operational Improvements 2-24
Table 2-3: Preliminary Alternative 3 - New I-84 Eastbound Mainline with Eastbound and Westbound C/D Roads 2-25
Table 2-4: Preliminary Alternative 4 - New I-84 Westbound Mainline with Eastbound C/D Road 2-26
Table 2-5: Preliminary Alternative 5 - New Eastbound & Westbound I-84 Mainlines with C/D Roads 2-27
Table 3-1: Civil Highway Items, Units of Measure and Unit Prices 3-13
Table 3-2: Conceptual Structural Costs for each Preliminary Alternative 3-16
Table 3-3: Summary of Preliminary Alternative Costs by Major Cost Items. 3-17
Table 4-1: Criteria Weight Factors 4-2
Table 4-2: Composite Scores for Environmental Criterion 4-13
Table 4-3: Geometric Deficiencies Addressed by Preliminary Alternatives 4-15
Table 4-4: Traffic Operations and Capacity Ranking 4-19
Table 4-5: Decision Matrix for I-84/Route 8 Interchange Preliminary Alternatives 4-20

1 Summary of Future Needs

This chapter provides a summary of future needs based on the deficiencies identified in the earlier Technical Memorandum #1. A majority of the deficiencies occur on the Interstate 84 (I-84) mainline and its associated interchange ramp system. Traffic volumes under existing conditions along I-84 are generally below capacity but as these traffic volumes increase in the future, the increasing demand is anticipated to exceed the capacity of the current system. Traffic operations, as well as the safety and life of the roadway structures, must be considered when addressing the future transportation needs of the study corridor.

The I-84 mainline between Exits 18 and 21 contains a number of left-hand on and off ramps in both the eastbound and westbound directions, which contributes to turbulence in flow and accidents. Closely spaced interchange ramps, insufficient acceleration and deceleration lanes, and other substandard roadway conditions further degrade roadway operations. A number of locations were identified along the I-84 corridor where there is substandard geometry and there is a sharp curvature at the entrance and exit ramps. Thirty-two percent of accidents occurring in the corridor involved trucks.

Future projections of traffic in year 2030 will place an intense burden on the roadway's ability to safely and efficiently move traffic. Traffic congestion will become a daily event and the likelihood of a greater number of accidents will increase. The I-84 and Route 8 Interchange area will become the major bottleneck in the region, and will impact travel times for both local and inter-regional trips.

The structures supporting I-84 and Route 8 are rated as in poor condition. A program of continuous maintenance would be necessary to keep these structures compliant with federal safety requirements. The future lifespan of the structures and cost of continued maintenance would be a major consideration when planning for the future of the highway system.

Finally, alternative travel options in the area are limited. Transit serving Waterbury works reasonably well but transit options beyond downtown Waterbury are limited. The Metro North commuter rail service is not highly utilized and demand for increased service options is relatively small. (Initiatives are underway (2006) to evaluate both the Waterbury Branch rail corridor and bus transit serving Waterbury.) Bicycle routes for shorter distance trips do not exist although planning efforts are underway to address this. Pedestrian movement and sidewalk development is extensive in the core of Downtown Waterbury, but connections outside of that area are poor. Making Waterbury more accessible to bicyclists and pedestrians can help mitigate the need for making short trips using automobiles.

2 Development of Preliminary Alternatives

This chapter details the development of preliminary alternatives for addressing the future needs of the I-84/Route 8 Interchange. Preliminary alternatives were developed through a series of workshops and discussions among the Project Consultant team, Connecticut Department of Transportation (ConnDOT), Council of Government of Central Naugatuck Valley (COGCNV), and the City of Waterbury.

2.1 Meetings/Workshop

A project workshop was held on May 5, 2005 to discuss ideas and share thoughts on the potential alternatives for the I-84/Route 8 Interchange. The workshop was attended by representatives of ConnDOT, the City of Waterbury, COGNV, and the Project Consultant team. Staff from various ConnDOT bureaus was present at the meeting to provide their insight.

The consultants used a "Smart Board" to draw the preliminary layouts of the alternatives. The Smart Board uses a Computer Aided Design (CAD) drawing as a base for sketching alternatives and converts the hand-drawn lines into computer images that were transferred to CAD after the meeting.

Attendees were divided into various working groups to address key areas – local access, interchange ramp capacity, mainline capacity, and alternative modes. Two groups studied mainline capacity. The group leaders presented their ideas on the "Smart Board" after discussions with representatives within the group. Several ideas and concepts were generated on the "Smart Board" by the groups which provided a basis to develop alternatives.

The group focusing on local access generated a concept that provides a connector road parallel to I-84 west of I-84 into downtown Waterbury. The group focusing on mainline capacity generated several variations of a concept showing a Collector-Distributor (C/D)/Frontage road parallel to I-84 to carry local traffic. The group focusing on alternative modes generated a concept that included a bus circulator service extending to the Waterbury Hospital.

Following the meeting, additional discussions were conducted with the ConnDOT staff to generate five preliminary conceptual alternatives for analysis purposes in addition to a No-Build scenario. The five preliminary alternatives were conceived to represent a range of costs and design complexity. They are as follows:

- Preliminary Alternative 1, TSM/TDM/Transit.

This alternative was conceived as a "minimum build" concept that would maximize the operation of the existing transportation system without any roadway construction.

- Preliminary Alternative 2, Safety and Operational Improvements

This alternative would make minor improvements to the local roadway system to increase safety, but would not reconstruct any of the I-84/Route 8 infrastructure.

- Preliminary Alternatives 3 and 4, "Partial Build" Additional Mainline Capacity Expansion

These two alternatives seek to address many of the deficiencies present in the existing corridor by rebuilding either the eastbound or westbound I-84 mainline. At the same time, they do maintain some of the existing mainline roadway structures, which could help to lower construction costs.

- Preliminary Alternative 5, "Full Build"

This alternative would involve total reconstruction of the I-84 corridor with new eastbound and westbound mainlines. The structures that would carry both the eastbound and westbound mainlines would be constructed to run parallel horizontally; the vertical stacking of the I-84 bridge over the Naugatuck River would be eliminated.

The following section describes the five preliminary alternatives in greater detail.

2.2 Conceptual Layout

Based on the findings from the needs and deficiencies analysis, the consultant team in coordination with CONNDOT and stakeholders developed five preliminary alternatives (in addition to a No Build) to address near and long term needs on I-84 and Route 8 within the study area. These preliminary alternatives range from minor improvements that would not involve any structural modifications to major improvements that require full reconstruction of the I-84 mainlines and ramps. These concepts are depicted at a 'preliminary' level of detail. That is, the basic horizontal and vertical alignments have been developed, but may be subject to significant revision based on the more detailed analysis that is to take place in the subsequent phase of this study. Descriptions of the various preliminary alternatives are presented in the following pages.

<u>Preliminary Alternative 1 – TSM/TDM/Transit</u>

The first alternative, Transportation System Management (TSM), Transportation Demand Management (TDM) and Transit considers ways of maximizing the efficiency and

effectiveness of the existing transportation system by improving transit, modifying signal timing and improving signage within the study area. This alternative would not involve the construction of any new structures; however, structural repairs would be required on both I-84 and Route 8 to keep the highways in safe operating condition over the next 25 years.

The modifications under Preliminary Alternative 1 are illustrated in Figure 2-1 and are described below:

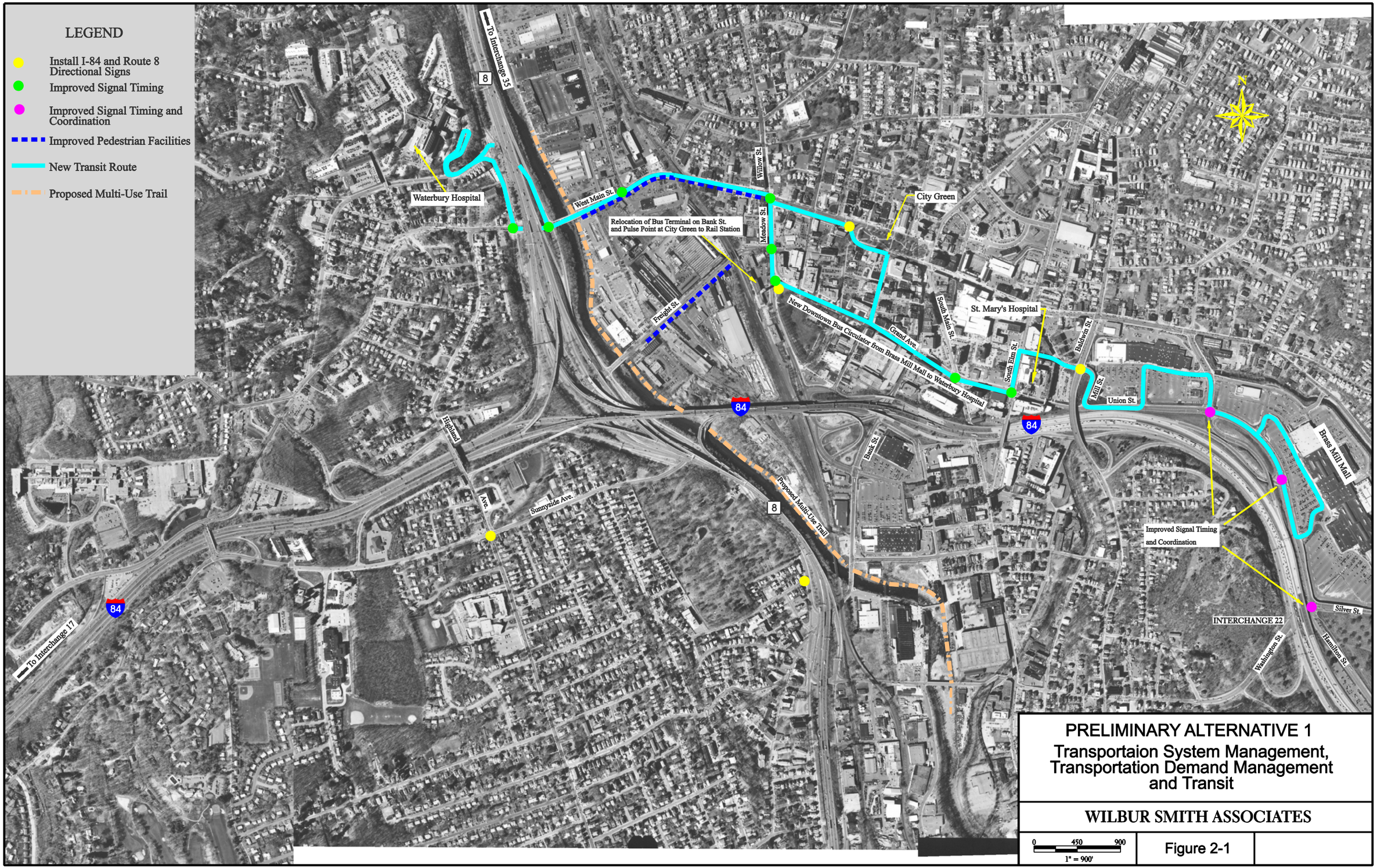
- A new bus circulator route would be introduced to operate between Brass Mill Mall and Waterbury Hospital to complement the existing bus system. This new bus route would be introduced primarily to improve downtown circulation so that bus riders can conveniently use one bus to get around the downtown area without having to change buses as is currently the case.

- The existing bus travel terminal at the parking lot on Bank Street may be relocated to the existing train station to improve inter-modal connections between bus and rail transit in the downtown area. (A separate study is being conducted by CTDECD to determine the need and feasibility of developing an intermodal center in Waterbury).

- In addition, pedestrian and bicyclist facilities would be improved particularly in the vicinity of the existing rail station so that pedestrians and bicyclists can easily and conveniently access both rail and bus transit systems.

- Signage/Wayfinding to I-84 and Route 8 would be enhanced at key locations to allow motorists to easily access the highway system from downtown Waterbury. These key locations include:
    - City Green
    - Intersection of Highland Avenue and Sunnyside Avenue
    - Intersection of Mill Street and Baldwin Street
    - Intersection of Bank Street and Meadow Street

- Signal timing and coordination would be improved at the Hamilton Avenue/Washington Street/Silver Lane intersection, Union Street/I-84 Entrance Ramp intersection and Union Street/I-84 Exit Ramp/Brass Mill Mall Drive intersection to reduce congestion and delays on the Union Street corridor. It is anticipated that the three intersections would operate at Level of Service (LOS) D or worse under future 2030 peak hour traffic conditions if no signal timing and coordination improvements are implemented.



PRELIMINARY ALTERNATIVE 1

Transportaion System Management, Transportation Demand Management and Transit

WILBUR SMITH ASSOCIATES

0 450 900

1" = 900'

Figure 2-1

Signal timing would also be improved at the West Main Street/Thomaston Avenue intersection, West Main Street/Willow Street intersection and Freight Street/Willow Street intersection to reduce congestion at these intersections. It is anticipated that the two intersections would operate at LOS D or worse under future 2030 peak hour traffic conditions if no signal timing and coordination improvements are implemented.

Preliminary Alternative 2 – Safety and Operational Improvements

The second alternative, Safety and Operational Improvements considers strategies geared to improving traffic operations and driver and pedestrian safety, particularly on the local roadway system within the study area. This alternative does not involve major structural modifications. The modifications would include the introduction of connector routes to enhance connectivity and traffic flow within the downtown area as well as improved pedestrian facilities to enhance safety.

The improvements included in this alternative are shown in Figure 2-2 and presented below:

- Two new local access routes would be constructed to enhance connectivity and traffic flow in the downtown area. The first access route shown as Location 1 in Figure 2 would connect West Main Street to Bank Street. This access route would run parallel to Route 8 on the east side of the I-84/Route 8 Interchange from West Main Street, through Freight Street, and pass underneath the I-84 mainlines to connect to Bank Street.

- The second access route shown as Location 2 in the figure would run parallel to I-84 on the north side, and link Sunnyside Avenue at the intersection with Riverside Street to Union Street at the intersection with Mill Street. This new access route would be two-way between Riverside Street and South Main Street and one-way eastbound from South Main Street to Mill Street. This access route from Sunnyside Avenue would pass underneath the I-84 mainlines at Interchange 20, pass over Meadow Street, intersect with South Main Street and Bank Street, and connect to Union Street.

- The Union Street segment between Mill Street and South Main Street would be converted to a one-way roadway in the westbound direction under this alternative to improve traffic flow at the intersection of Mill Street and Union Street.

- The existing I-84 exit ramp to Meadow Street would be removed to eliminate weaving on the I-84 eastbound mainline.

- Market Square would be terminated under this alternative.

- The existing Home Depot access route would be reconstructed as a two-way roadway to connect the intersection of Bank Street and Meadow Street to South Main Street. This new roadway is shown as Location 3 in Figure 2-2.

- Benedict Street would be maintained and connect to the new connector from the intersection of Bank Street and Meadow Street to South Main Street.

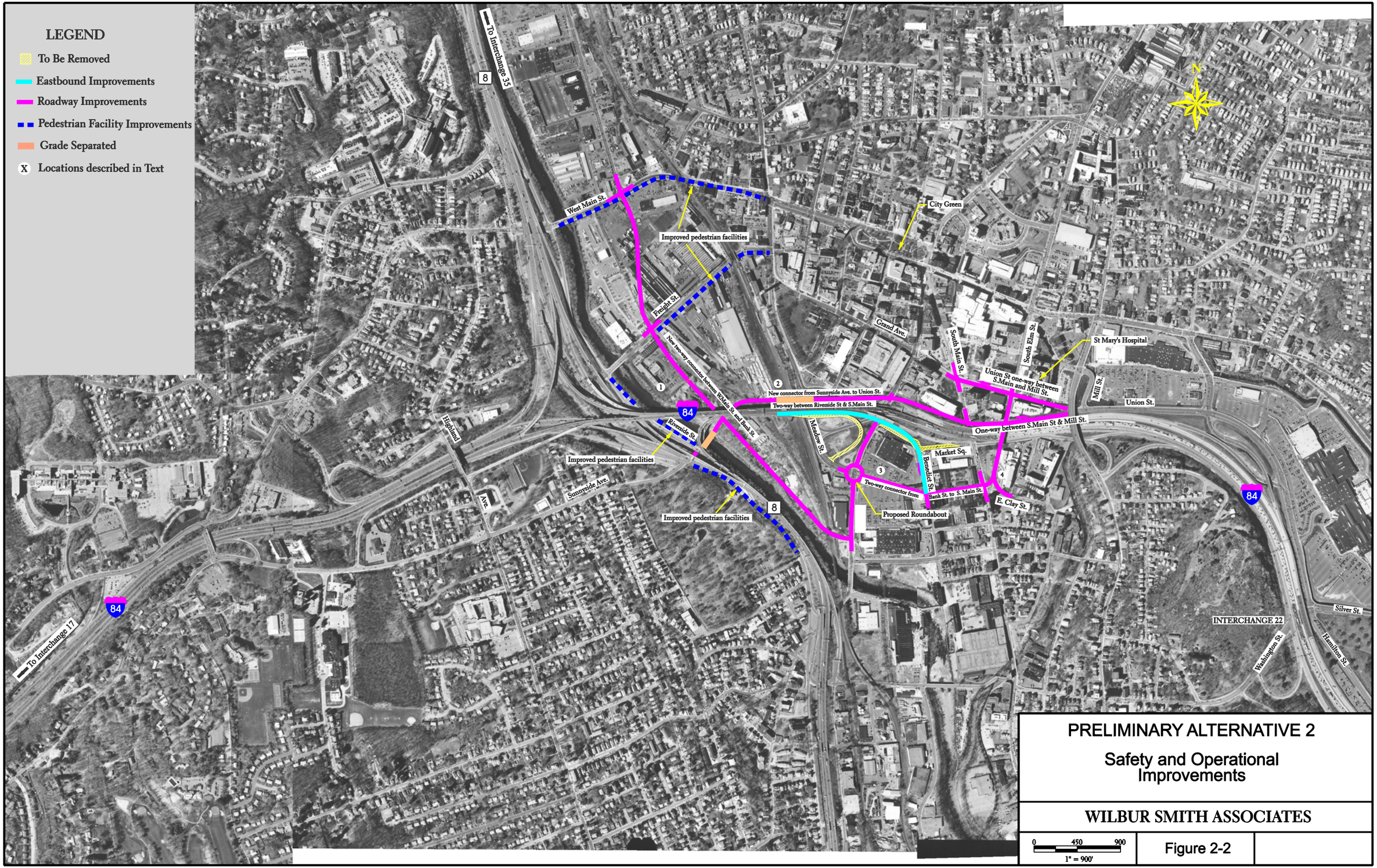
- A new roundabout would be provided at the intersection of Meadow Street with Bank Street.

- The intersection of South Elm Street and East Clay Street would be reconstructed with East Clay Street realigned to connect to South Elm Street as a T-intersection as shown at Location 4, to ensure that the new Home Depot access route/South Main Street intersection is a four-legged intersection.

- Improved pedestrian facilities would be provided along Freight Street, West Main Street, and Riverside Street.

Preliminary Alternative 3 – Partial Build - New I-84 Eastbound Mainline

Preliminary Alternative 3 would be the first of three alternatives that consider enhancing and expanding mainline capacity and safety. Preliminary Alternative 3 would be a partial build alternative because it does not require the full replacement of either the I-84 or Route 8 mainlines. Under this alternative, the existing Route 8 mainlines and I-84 westbound mainline would remain in place, while the existing I-84 eastbound mainline would be removed and replaced with a new mainline. The new eastbound mainline would be constructed parallel to the I-84 westbound mainline to eliminate the geometric complexities associated with a stacked interchange such as steep ramp grades. The new I-84 eastbound mainline would typically consist of three 12 foot travel lanes and would generally be at a higher elevation than the westbound mainline. Preliminary Alternative 3 would include two Collector-Distributor (C/D) roads running parallel to the I-84 eastbound and westbound mainlines. These new C/D roads would serve to reduce congestion on the I-84 mainline by separating local traffic going to/from downtown Waterbury from traffic going through Waterbury to points further east or west. With the exception of the entrance ramp from Route 8 northbound to I-84 westbound, all other left hand ramps would be eliminated to reduce weaving and congestion on the I-84 mainlines.


LEGEND
To Be Removed
Eastbound Improvements
Roadway Improvements
Pedestrian Facility Improvements
Grade Separated
X Locations described in Text
To Interchange 35
8
West Main St.
Improved pedestrian facilities
City Green
Freight St.
Grand Ave.
South Main St.
South Elm St.
St Mary's Hospital
Union St one-way between S.Main and Mill St.
Mill St.
Union St.
New two-way connector between W.Main St. and Bank St.
New connector from Sunnyside Ave. to Union St.
Two-way between Riverside St & S.Main St.
84
Highland
Riverside St.
Meadow St.
One-way between S.Main St & Mill St.
Market Sq.
Benedict St.
Improved pedestrian facilities
Sunnyside Ave.
Two-way connector from Bank St. to S. Main St.
E. Clay St.
Proposed Roundabout
Improved pedestrian facilities
Ave.
To Interchange 17
INTERCHANGE 22
Silver St.
Washington St.
Hamilton St.
N
PRELIMINARY ALTERNATIVE 2
Safety and Operational Improvements
WILBUR SMITH ASSOCIATES
0 450 900
1" = 900'
Figure 2-2

The primary eastbound design concepts of Preliminary Alternative 3 are illustrated in Figure 2-3 and follow generally from west to east. The "Locations" described below are associated with white circled numerals in the figures:

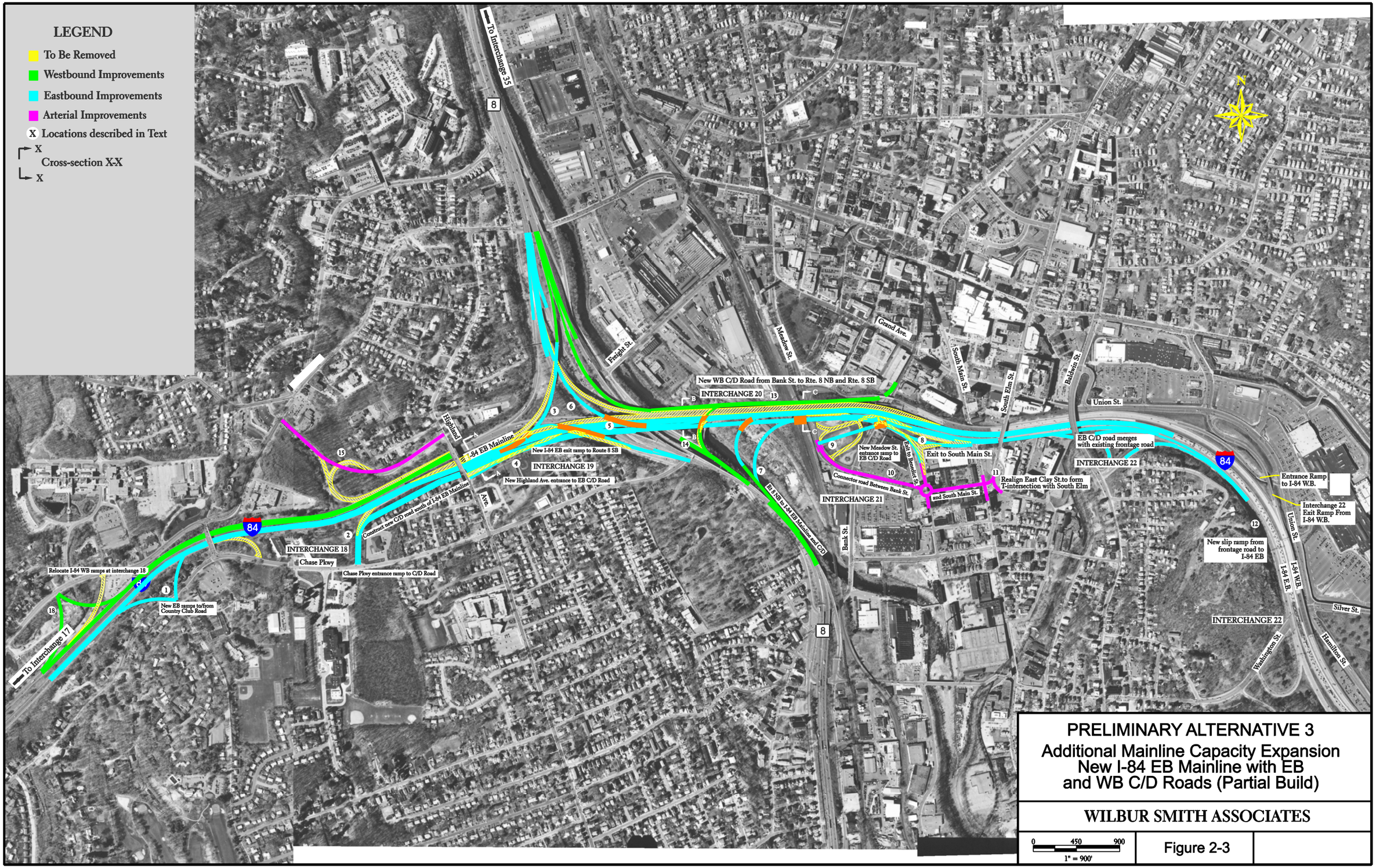
- At Interchange 18, the existing Chase Parkway exit ramp from I-84 eastbound would be eliminated. New entrance and exit ramps from/to Country Club Road would be constructed at Interchange 17. The new ramps at Interchange 17 are shown as Location 1 in Figure 2-3.

- At Interchange 18, the existing Chase Parkway entrance ramp to I-84 eastbound would be eliminated. The Chase Parkway entrance ramp would be realigned to form the new C/D road running parallel to I-84 eastbound, shown as Location 2 in Figure 2-3.

- At Interchange 19, the left hand exit ramp from I-84 eastbound to Route 8 northbound would be eliminated and replaced with a right hand exit ramp. This new exit ramp would pass over the I-84 eastbound mainline and split into two legs, with the left leg connecting to Route 8 northbound and the right leg connecting to Route 8 southbound. The new exit ramps at Interchange 19 are depicted as Location 3. A typical roadway cross-section at Interchange 19 is also shown in Figure 2-4.

- At Interchange 19, the Highland Street entrance ramp to I-84 eastbound would be terminated and would be reconstructed to connect to the new eastbound C/D Road. The new entrance ramp is shown as Location 4 in Figure 2-3.

- Further east at Interchange 19, a slip ramp shown as Location 5 in Figure 2-3 would be provided on the new I-84 eastbound mainline to connect to the new eastbound C/D Road.



PRELIMINARY ALTERNATIVE 3

Additional Mainline Capacity Expansion
New I-84 EB Mainline with EB
and WB C/D Roads (Partial Build)

WILBUR SMITH ASSOCIATES

0 450 900
1" = 900'

Figure 2-3

- At Interchange 20, the left hand entrance ramp from Route 8 southbound would be eliminated. In place of the left hand entrance ramp, a right hand entrance ramp would be constructed at Location 6 as shown in Figure 2-3. This new entrance ramp would pass over the I-84 eastbound mainline and split into two legs with the left leg connecting to the new I-84 eastbound mainline and the right leg connecting to the new eastbound C/D Road.

- Likewise, the existing entrance ramp from Route 8 northbound to I-84 eastbound would be eliminated. A new ramp would be introduced south of the gore area on Route 8 northbound. The new ramp shown as Location 7 in Figure 2-3 would split into two legs to connect to the eastbound I-84 mainline and C/D Road respectively. The new I-84 eastbound entrance ramp from Route 8 northbound would pass over the new C/D Road to connect to I-84 eastbound. A typical roadway cross-section at Interchange 20 is shown in Figure 2-4.

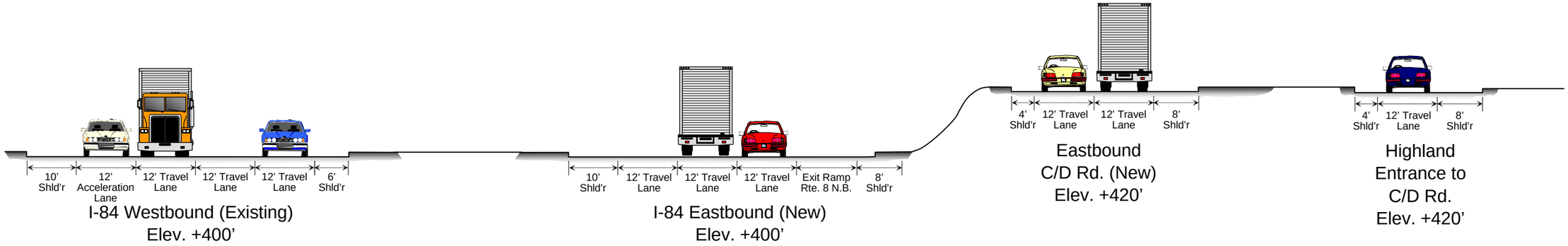
- At Interchange 21, both existing I-84 eastbound exit and entrance ramps to/from Meadow Street as well as the exit ramp to South Main Street would be eliminated. In place of the eliminated exit ramps at this interchange, a new exit ramp would be constructed from the new eastbound C/D Road. The new exit ramp is depicted as Location 8 in Figure 2-3. This new exit ramp would split into two legs with the left leg connecting to South Main Street and the right leg connecting to Benedict Street. A new entrance ramp shown at Location 9 would also be constructed from Meadow Street to connect to the new eastbound C/D road. This new entrance ramp from Meadow Street would pass over the new Benedict Street exit ramp to connect to the eastbound C/D Road. A typical roadway cross-section at Interchange 21 is illustrated in Figure 2-4.

- The existing Home Depot access drive at Interchange 21 would be reconstructed as a two-way roadway to connect the intersection of Bank Street and Meadow to South Main Street. This new access route is shown as Location 10 in Figure 2-3.

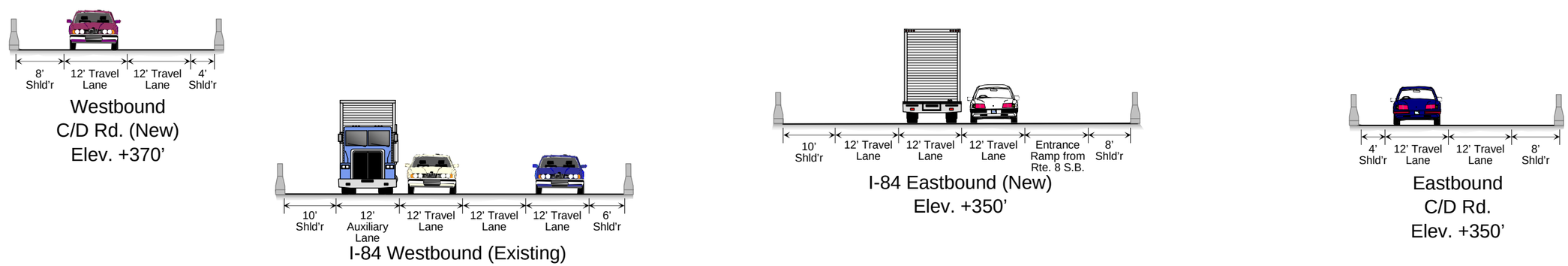
- The intersection of South Elm Street and East Clay Street would be reconstructed with East Clay Street realigned to connect to South Elm Street as a T-intersection. The realignment at this intersection is shown as Location 11 in Figure 2-3.

- At Interchange 23, a new slip ramp would be constructed on the existing eastbound frontage road to connect to I-84 eastbound. This new slip ramp shown at Location 12 (inset within Figure 2-3) would be located west of the exit ramp to Washington Street.

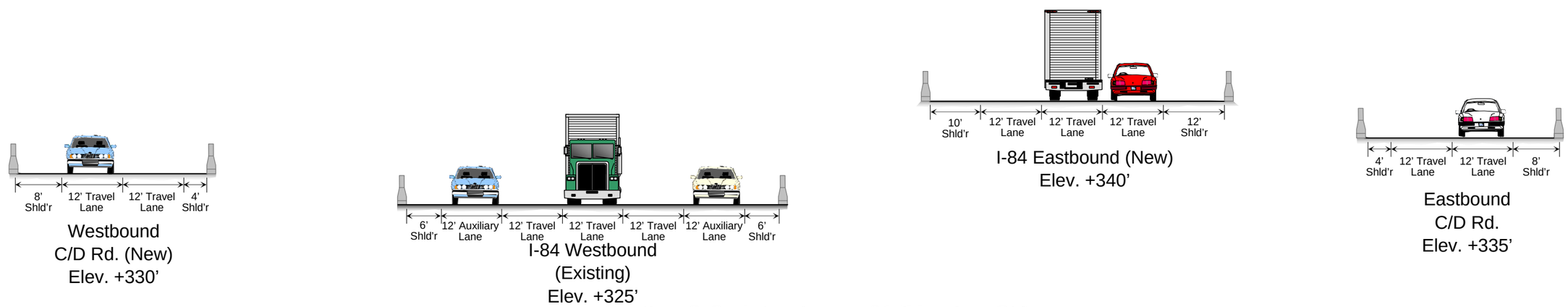
Highlights of Preliminary Alternative 3 traveling westbound along I-84 from Interchange 23 are also illustrated in Figure 2-3 and presented below. The “Locations” described below are associated with white circled numerals in the figures:



Section A-A - Interchange 19 (Route 8)



Section B-B - Interchange 20 (Route 8)



Section C-C - Interchange 21 (Meadow St.)

ENGINEERS
PLANNERS
ECONOMISTS
Wilbur Smith Associates

PRELIMINARY ALTERNATIVE 3 CROSS SECTIONS

Interstate 84 & Rte 8

FIGURE 2-4

- At Interchange 21, a new westbound C/D Road would be constructed from the existing right hand entrance ramp to I-84 westbound. The new westbound C/D Road is shown as Location 13 in Figure 2-3. The existing left hand entrance ramp from Bank Street to I-84 westbound would be eliminated.

- At Interchange 20, a new right hand ramp shown at Location 14 in Figure 2-3 would be constructed from the new westbound C/D Road to Route 8 southbound. The new exit ramp would pass over the existing I-84 westbound mainline and the new eastbound I-84 mainline and C/D road to connect to Route 8 southbound. Beyond this exit ramp, the westbound C/D Road would transition into an on-ramp to Route 8 northbound.

- At Interchange 18, the existing exit ramp from I-84 westbound connecting to West Main Street and Highland Avenue would be eliminated (Figure 2-3). A new two-way connector shown at Location 14 would be constructed between West Main Street and Highland Avenue to facilitate traffic flow between these roadways.

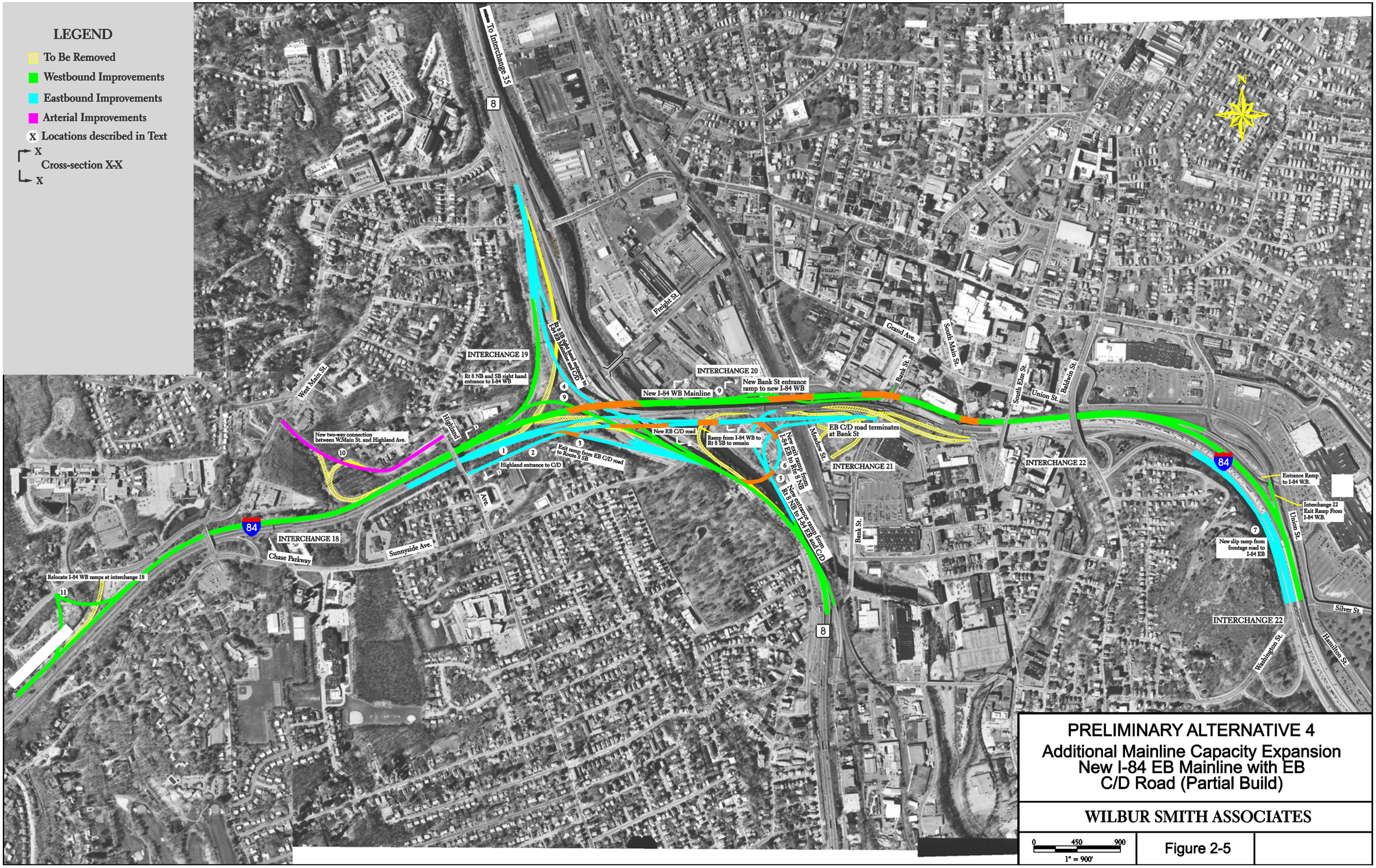
- At Interchange 18, the existing entrance ramp from Chase Parkway to I-84 westbound would be eliminated. New entrance and exit ramps from/to Chase Parkway would be constructed in the vicinity of the existing Interchange 18 entrance ramp to allow ample space for traffic from Route 8 northbound to weave to take the exit ramp. The new ramps are depicted at Location 15, Figure 2-3.

Preliminary Alternative 4 – Partial Build - New I-84 WB Mainline

Preliminary Alternative 4 is the second alternative that considers enhancing and expanding mainline capacity and safety. Like Preliminary Alternative 3, Preliminary Alternative 4 is also a partial build alternative. Under this alternative, the existing I-84 eastbound and Route 8 northbound and southbound mainlines would remain in place. The I-84 westbound mainline would be rebuilt west of Route 8, though the existing mainline roadway east of Route 8 remains in place as a connection serving traffic going to Route 8. A new I-84 westbound mainline would be constructed at the same elevation as the existing eastbound mainline. A new eastbound C/D Road would also be constructed parallel to the I-84 eastbound mainline to separate local traffic going to downtown Waterbury from traffic going through Waterbury to parts further east, thus reducing congestion on the I-84 eastbound mainline. The new I-84 westbound mainline would typically consist of three 12 foot travel lanes with 12 foot outer shoulders.

Highlights of Preliminary Alternative 4, traveling eastbound along I-84 from Interchange 18 are illustrated in Figure 2-5 and described below. The “Locations” described below are associated with white circled numerals in the figures:

- At Interchange 18, the Chase Parkway entrance ramp to I-84 eastbound would remain in place (Figure 2-5).


LEGEND
To Be Removed
Westbound Improvements
Eastbound Improvements
Arterial Improvements
X Locations described in Text
X
Cross-section X-X
X
To Interchange 35
8
Freight St.
INTERCHANGE 19
Rt 8 NB and SB right hand entrance to I-84 WB
Rt 8 SB right hand entrance to I-84 WB Mainline and C/D
INTERCHANGE 20
New I-84 WB Mainline
New Bank St entrance ramp to new I-84 WB
Grand Ave.
South Main St.
Bank St.
South Elm St.
Union St.
Baldwin St.
West Main St.
Highland
New two-way connection between W.Main St. and Highland Ave.
New EB C/D road
Ramp from I-84 WB to Rt 8 SB to remain
EB C/D road terminates at Bank St
Meadow St.
Exit ramp from EB C/D road to Route 8 SB
Highland entrance to C/D
New exit ramp from I-84 EB to Rte 8 SB
New entrance ramp from Rt 8 SB to I-84 EB and C/D
INTERCHANGE 21
INTERCHANGE 22
84
Entrance Ramp to I-84 W.B.
Interchange 22 Exit Ramp From I-84 W.B.
Ave.
INTERCHANGE 18
Chase Parkway
Sunnyside Ave.
Relocate I-84 WB ramps at interchange 18
New slip ramp from frontage road to I-84 EB
Silver St.
INTERCHANGE 22
Washington St.
Hamilton St.
PRELIMINARY ALTERNATIVE 4
Additional Mainline Capacity Expansion
New I-84 EB Mainline with EB
C/D Road (Partial Build)
WILBUR SMITH ASSOCIATES
0 450 900
1" = 900'
Figure 2-5

- At Interchange 19, east of the Highland Avenue overpass, the outer lane of the I-84 eastbound mainline would transition to become the new eastbound C/D Road as shown by Location 1 in Figure 2-5. A typical roadway cross-section at Interchange 19 is shown in Figure 2-6.

- At Interchange 19, the left hand exit ramp from I-84 eastbound to Route 8 northbound would be eliminated. This movement would be replaced by a new ramp, described in detail in the discussion of Location 6 below (Figure 2-5).

- At Interchange 19, the Highland Avenue entrance ramp to I-84 eastbound would be realigned to connect to the new eastbound C/D Road, shown at Location 2 in Figure 2-5.

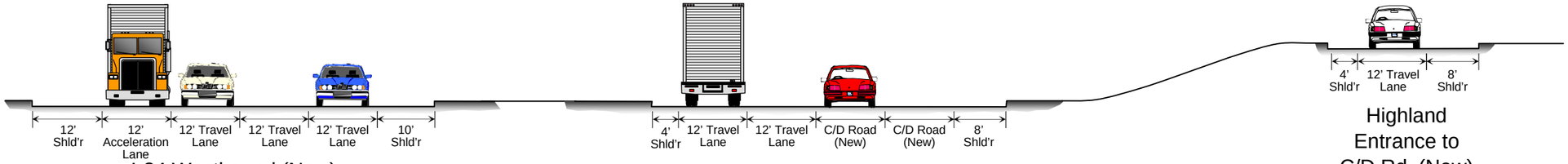
- Further east at Interchange 19, a slip ramp would be introduced on the new eastbound C/D Road to connect to Route 8 southbound. This ramp is shown as Location 3 in Figure 2-5. This ramp would pass over the Highland Avenue entrance ramp to the C/D Road.

- At Interchange 20, the left hand entrance ramp from Route 8 southbound to I-84 eastbound would be eliminated and replaced with a right hand entrance ramp. The new entrance ramp shown at Location 4 in Figure 2-5 would pass underneath both new and existing I-84 mainlines and split into two legs with one leg connecting to I-84 eastbound and the other leg connecting to the C/D Road running parallel to the I-84 eastbound mainline. A typical roadway cross-section is shown in Figure 2-6.

- Further east, the entrance ramp from Route 8 northbound to I-84 eastbound would be eliminated. A new entrance ramp would be constructed further south on Route 8 northbound. This new ramp would split into two legs with one leg connecting to I-84 eastbound and the other leg connecting to the new eastbound C/D Road. The new entrance ramps are depicted at Location 5 in Figure 2-5.

- At Interchange 20, in the vicinity where the new entrance ramp from Route 8 northbound connects to I-84 eastbound and the new C/D Road, a new right-hand exit ramp shown at Location 6 would be constructed from the C/D Road to Route 8 northbound to replace the eliminated ramp at Interchange 19. Therefore, motorists traveling eastbound on I-84 would have to get onto the eastbound C/D Road in order to connect to Route 8 northbound. This new eastbound C/D Road-Route 8 northbound exit ramp would pass over both legs of the Location 5 ramp (Figure 2-5).

- At Interchange 21, both existing I-84 eastbound exit and entrance ramps to/from Meadow Street as well as the exit ramp to South Main Street would be eliminated (Figure 2-5).

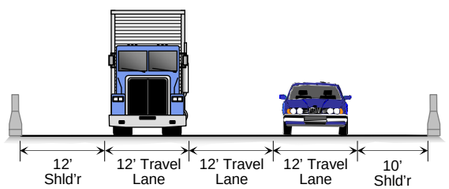


I-84 Westbound (New)
Elev. +400'

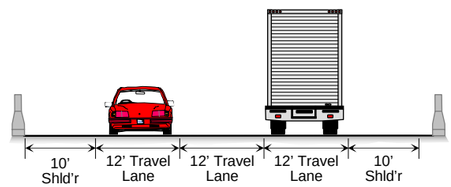
I-84 Eastbound (Existing) - Elev. +400'

Highland
Entrance to
C/D Rd. (New)
Elev. +440'

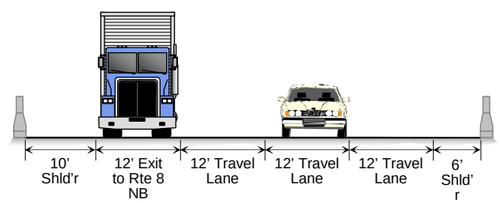
Section D-D - Interchange 19 (Route 8)



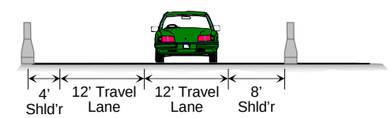
I-84 Westbound (New) - Elev. +365'



I-84 Eastbound (Existing) - Elev. +365'

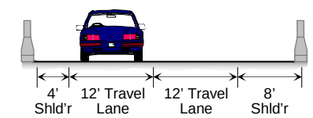


I-84 Westbound (Existing) - Elev. +335'



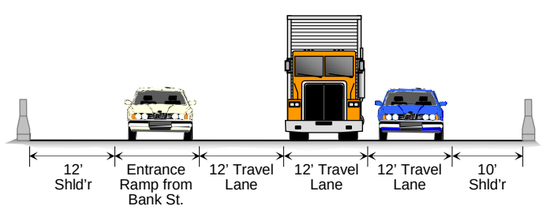
Entrance Ramp
to I-84 EB
(New)
Elev. + 365'

Entrance Ramp to
C/D Rd. EB (New)
Elev. + 365'

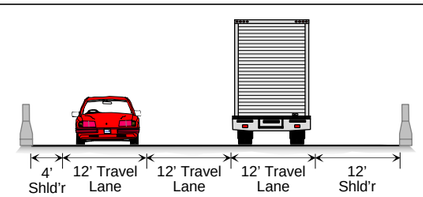


Eastbound
C/D Rd. (New)
Elev. +375'

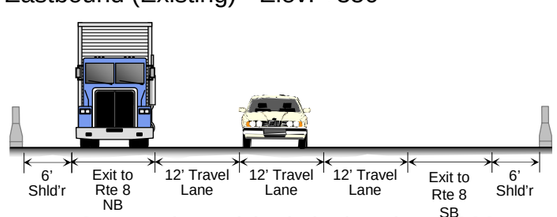
Section E-E - Interchange 20 (Route 8)



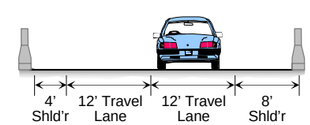
I-84 Westbound (New) - Elev. +350'



I-84 Eastbound (Existing) - Elev. +350'



I-84 Westbound (Existing) - Elev. +320



Eastbound
C/D Rd. (New)
Elev. +370'

Section F-F - Interchange 21 (Meadow St.)

Wilbur Smith Associates
ENGINEERS
PLANNERS
ECONOMISTS

PRELIMINARY ALTERNATIVE 4 CROSS SECTIONS

Interstate 84 & Rte 8

FIGURE 2-6

- The new eastbound C/D Road would eventually connect at grade to Bank Street (Figure 2-5).

- At Interchange 23, a new slip ramp shown as Location 7 (Figure 2-5, inset) would be constructed on the existing eastbound frontage road to connect to I-84 eastbound. This new slip ramp would be located west of the exit ramp to Washington Street.

Highlights of Preliminary Alternative 4 traveling westbound on I-84 from Interchange 23 are illustrated in Figure 2-5 and described below. The "Locations" described below are associated with white circled numerals in the figures:

- The existing I-84 westbound mainline west of Route 8 would be maintained as a roadway connecting local traffic from downtown Waterbury to ramps for Route 8 northbound and southbound.

- At Interchange 21, the existing right entrance ramp from Bank Street would be realigned to connect to both the new I-84 westbound mainline and to the existing mainline (now an extension of the ramps to northbound and southbound Route 8). The Bank Street entrance ramp to the new I-84 westbound mainline would pass underneath the new I-84 westbound mainline and connect to this mainline on the right side as shown at Location 8 in Figure 2-5. The left hand entrance ramp from Bank Street to the existing westbound mainline roadway would be maintained (thereby directing this ramp traffic to Route 8 northbound and southbound.

- At Interchange 20, the existing I-84 westbound mainline exit ramps to Route 8 northbound and southbound would be maintained.

- At Interchange 19, the existing left hand entrance ramp from Route 8 northbound to I-84 westbound would be realigned to merge with the existing entrance ramp from Route 8 southbound and eventually to the new I-84 westbound mainline as shown in Figure 2-5, at Location 9.

- At Interchange 18, the existing exit ramp from I-84 westbound which connects to both West Main Street and Highland Avenue would be eliminated. A new two-way connector, shown at Location 10 (Figure 2-5) would be constructed between West Main Street and Highland Avenue to facilitate traffic flow between these roadways.

- At Interchange 18, the existing entrance ramp from Chase Parkway to I-84 westbound would be eliminated. New entrance and exit ramps from/to Chase Parkway would be constructed in the vicinity of the existing entrance ramp. These ramps are shown at Location 11 in Figure 2-5.

Preliminary Alternative 5 – Full Build

Preliminary Alternative 5 is the third alternative that considers enhancing and expanding mainline capacity and safety. Unlike Preliminary Alternatives 3 and 4, Preliminary Alternative 5 is a full build alternative. Under this alternative, both existing I-84 eastbound and westbound mainlines would be removed and replaced with new mainlines running parallel to each other. However, both Route 8 mainlines would remain in place under Preliminary Alternative 5.

Two new C/D roads would also be constructed parallel to and outside of the new I-84 mainlines. The new C/D roads would serve to separate local traffic going to/ from downtown Waterbury from traffic going through Waterbury to points further east or west, thus reducing congestion and weaving on the mainlines. All left hand ramps would be removed to eliminate weaving on the I-84 mainlines.

Preliminary Alternative 5 represents a viable alternative in the event that a life cycle cost analysis does not support the economic feasibility of a partial build system. The full build alternative would also allow more flexibility than Preliminary Alternatives 3 and 4 during the design process to address geometric and capacity deficiencies such as close interchange spacing, lane geometry, curve radii, ramp and mainline grades.

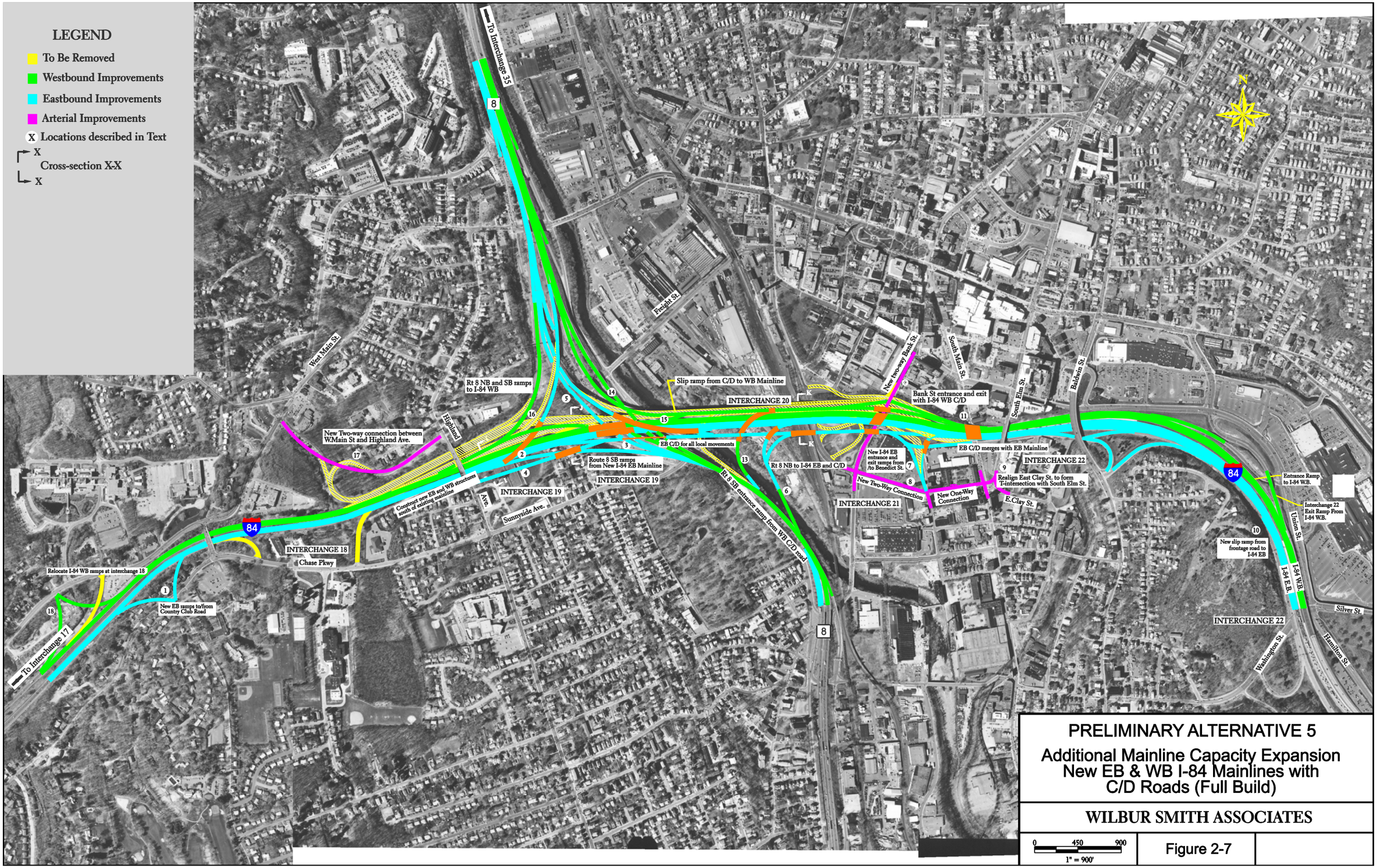
Highlights of Preliminary Alternative 5 traveling eastbound along I-84 from Interchange 18 are illustrated in Figure 2-7 and described below. The "Locations" described below are associated with white circled numerals in the figures:

- At Interchange 18, the existing Chase Parkway exit ramp from I-84 eastbound would be eliminated. New entrance and exit ramps from/to Country Club Road would be constructed at Interchange 17. These new ramps are shown as Location 1 in Figure 2-7.

- At Interchange 18, the existing Chase Parkway entrance ramp to I-84 eastbound would be eliminated. A typical roadway cross-section at Interchange 18 is shown in Figure 2-8.

- At Interchange 19, east of the Highland Avenue overpass, the Route 8 northbound and southbound exit ramps would be removed. A new right-hand eastbound exit ramp, shown at Location 2 in Figure 2-7 would split up into two legs to replace the existing exit ramps. The left leg of the new exit ramp would connect to Route 8 northbound while the right leg would connect to Route 8 southbound. A typical roadway cross-section at Interchange 19 is shown in Figure 2-8.

- At Interchange 19, east of the new off-ramps to northbound and southbound Route 8, a right-hand slip ramp would become a C/D Road along I-84 eastbound to connect to downtown Waterbury. The new slip ramp and C/D road are shown near Location 3 in Figure 2-7.



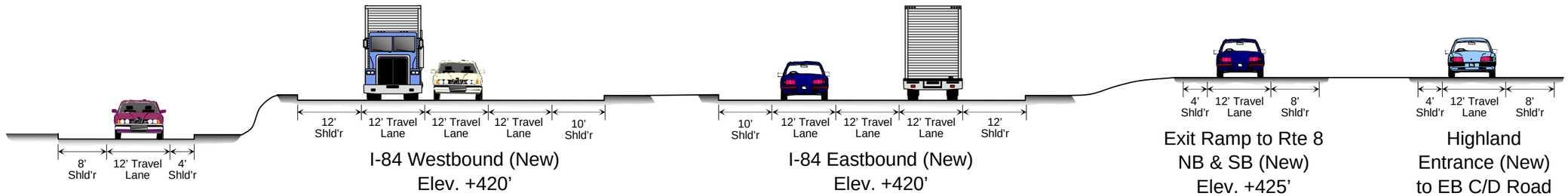
PRELIMINARY ALTERNATIVE 5

Additional Mainline Capacity Expansion New EB & WB I-84 Mainlines with C/D Roads (Full Build)

WILBUR SMITH ASSOCIATES

0 450 900
1" = 900'

Figure 2-7



I-84 WB Ramp from Rte 8 SB (New) Elev. +400'

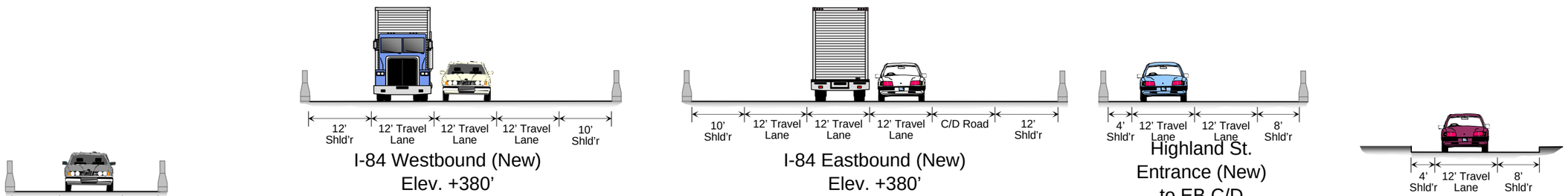
I-84 Westbound (New) Elev. +420'

I-84 Eastbound (New) Elev. +420'

Exit Ramp to Rte 8 NB & SB (New) Elev. +425'

Highland Entrance (New) to EB C/D Road Elev. +425'

Section I-I - Interchange 19 (Route 8)



I-84 WB Entrance (New) from Rte 8 NB Elev. +350'

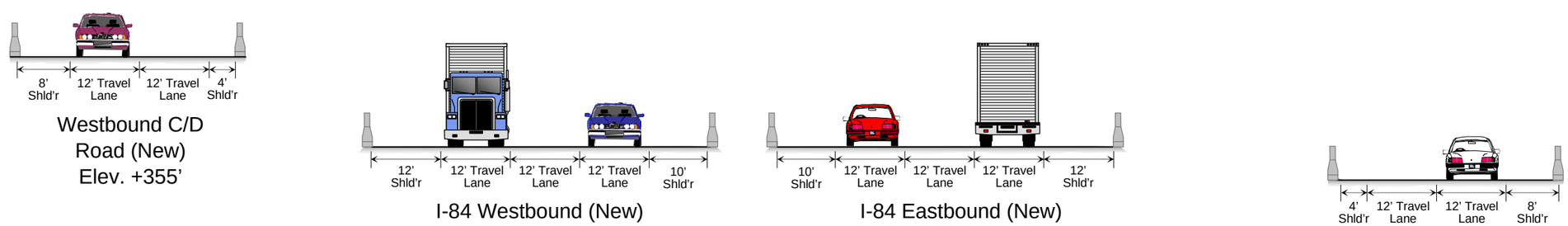
I-84 Westbound (New) Elev. +380'

I-84 Eastbound (New) Elev. +380'

Highland St. Entrance (New) to EB C/D Road Elev. +380'

Exit Ramp from I-84 EB (New) to Rte 8 SB Elev. +360'

Section J-J - Interchange 20 (Route 8)



Westbound C/D Road (New) Elev. +355'

I-84 Westbound (New) Elev. +335'

I-84 Eastbound (New) Elev. +335'

Eastbound C/D Rd. (New) Elev. +315'

Section K-K - Interchange 21 (Meadow St.)

PRELIMINARY ALTERNATIVE 5 CROSS SECTIONS

Interstate 84 & Rte 8

ENGINEERS PLANNERS ECONOMISTS

Wilbur Smith Associates

FIGURE 2-8

- At Interchange 19, the existing entrance ramp from Highland Avenue to I-84 eastbound would be removed. A new entrance ramp shown at Location 4 in Figures 2-9 and 2-10 would be constructed to connect to the new eastbound C/D Road.

- At Interchange 20, the left hand entrance ramp from Route 8 southbound to eastbound I-84 would be eliminated and replaced with a right hand entrance ramp. The new right hand entrance ramp would be constructed to pass over both I-84 eastbound and westbound mainlines and split into two legs, with the left leg connecting to I-84 eastbound and the right leg connecting to the new eastbound C/D Road. The new entrance ramp from Route 8 southbound is shown as illustration 5 in Figure 2-7.

- At Interchange 20, the entrance ramp from Route 8 northbound to I-84 eastbound would be replaced with a new ramp constructed further south. The new ramp would split into two legs with the left leg passing over the new eastbound C/D Road to connect to I-84 eastbound and the right leg connecting to the new eastbound C/D Road. The new entrance ramps are shown at Location 6 in Figure 2-7.

- At Interchange 21, the exit ramps to Meadow Street and South Main Street as well as the entrance ramp from Meadow Street would be removed. Access to the downtown area would be provided instead by an exit ramp from the new eastbound C/D Road which splits into two legs to connect to South Main Street and Benedict Street. A new entrance ramp would also be constructed from Benedict Street to merge with the eastbound C/D and then to I-84 eastbound. The new entrance and exit ramps are depicted around Location 7 in Figure 2-7.

- At Interchange 21 the existing Home Depot access drive would be reconstructed to connect the intersection of Bank Street and Meadow Street to South Main Street as depicted with Location 8 in Figure 2-7. This new access roadway would intersect with the new exit and entrance ramps to and from Benedict Street. The access roadway would be two-way between Bank Street and the new ramps and one-way westbound between South Main Street and the new Benedict ramps.

- The intersection of South Elm Street and East Clay Street would be reconstructed by realigning East Clay Street to connect to South Elm Street at a T-intersection. See Location 9 in Figure 2-7.

- At Interchange 23, a new slip ramp shown as Location 10 (Figure 2-7, inset) would be constructed on the existing eastbound frontage road to connect to I-84 eastbound. This new slip ramp would be located west of the exit ramp to Washington Street.

Highlights of Preliminary Alternative 5 traveling westbound on I-84 from Interchange 23 are illustrated in Figure 2-7 and described below. The "Locations" described below are associated with white circled numerals in the figures:

- At Interchange 21, west of the South Elm Street overpass, the existing exit ramp to Meadow Street would be removed. A new C/D Road would be constructed off the right side of I-84 westbound mainline. A new exit ramp would in turn be constructed off the new C/D Road to connect to Bank Street as shown by Location 11 in Figure 2-7. In addition, an entrance ramp from Bank Street would be constructed to connect to the C/D Road further west. Bank Street under this alternative would be reconstructed as a two-way roadway at Location 12.

- At Interchange 20, the existing left hand exit ramp from I-84 westbound to Route 8 southbound would be eliminated. A new exit ramp shown at Location 13 (Figure 2-7) would be constructed from the new westbound C/D Road to connect to the Route 8 southbound. The new exit ramp would pass over both new I-84 eastbound and westbound mainlines as well as the new eastbound C/D Road to connect to Route 8 southbound.

- Further west at Interchange 20, the existing exit ramp from I-84 westbound to Route 8 northbound would be removed. The new westbound C/D Road would eventually split into two ramps. One ramp would transition into Route 8 northbound to serve as a connection between I-84 westbound and Route 8 northbound (Location 14, Figure 2-7). The other ramp, a slip ramp (shown at Location 15 in Figure 2-7) would be constructed from the new westbound C/D Road to the I-84 westbound mainline to serve motorists traveling further west.

- At Interchange 19, the existing left hand entrance ramp from Route 8 northbound to I-84 westbound would be realigned to connect to the new I-84 westbound mainline as a right hand entrance ramp. The existing right hand entrance ramp from Route 8 southbound would be realigned to merge with the new entrance ramp from Route 8 northbound. The two entrance ramps at Interchange 19 are shown at Location 16 in Figure 2-7.

- At Interchange 18, the existing exit ramp from I-84 westbound which connects to both West Main Street and Highland Avenue would be eliminated. A new two-way connector would be constructed between West Main Street and Highland Avenue to facilitate traffic flow between these roadways. The new two-way connector is shown at Location 17 in Figure 2-7.

- At Interchange 18, the existing entrance ramp from Chase Parkway to I-84 westbound would be eliminated. New entrance and exit ramps to/from Chase Parkway would be constructed in the vicinity of the existing entrance ramp, as pictured at Location 18 in Figure 2-7.

2.3 Strengths, Weaknesses, Opportunities and Challenges

One strategic planning technique to help compare and contrast the differences between alternatives is to consider Strengths, Weaknesses, Opportunities and Challenges. This analysis provides a holistic view of each alternative, so that each can be considered based on all its merits and faults as well as larger external influences and forces. Table 2-1 through Table 2-4 below provide this comparison.

Table 2-1: Preliminary Alternative 1 - Transportation System Management/Transportation Demand Management/Transit

Strengths	Weaknesses
• New bus circulator improves downtown transit circulation • Increases intermodal connectivity, especially for transit-dependent • Improved pedestrian facilities, especially access to train station • Improved signage • Optimized signal timing and coordination reduces downtown congestion • Requires minimal right of way, construction, capital resources relative to other alternatives • Very low level of environmental, right-of-way impact anticipated	• Alone, would not address overall purpose and need • Safety deficiencies on freeways not addressed • Poor traffic operations on freeways will continue into the future
Opportunities	**Challenges**
• May enhance/encourage transit use • Could encourage compact, "new urbanist" type development downtown with better available transit	• Environmental and Right of Way impacts, though minimal, will still need to be addressed • Transit improvements will need to compete for limited federal funds with other transit projects. However, it is likely that the capital funds needed will be lower than all other alternatives. • Maintenance of obsolete infrastructure will continue indefinitely with attendant increases in maintenance needed over time

Table 2-2: Preliminary Alternative 2 - Safety and Operational Improvements

Strengths	Weaknesses
• Improved pedestrian facilities, especially access to train station • New connector roadways and intersection improvements improve local vehicle circulation on surface streets and reduce need for such trips to access highways • Requires minimal right of way, construction, and capital resources relative to Preliminary Alternatives 3, 4, and 5 • Closure of one I-84 interchange ramp provides modest safety and operations benefit to I-84 eastbound mainline • Minimal of environmental impact anticipated • Reduces congestion at some local intersections	• Alone, would not address overall purpose and need • Safety deficiencies on freeways minimally addressed • Poor traffic operations on freeways will generally continue into the future
Opportunities	**Challenges**
• Can enhance viability of economic development through local access improvements • New connector roads may offer new frontage for recreation or public/private development	• Environmental and Right of Way impacts, though modest compared to Preliminary Alternatives 3, 4, and 5 will still need to be addressed • Maintenance of obsolete infrastructure will continue indefinitely with attendant increases in maintenance needed over time • Procuring funding for this alternative will be a challenge though it's likely a lesser challenge than under Preliminary Alternatives 3, 4 and 5.

Table 2-3: Preliminary Alternative 3 - New I-84 Eastbound Mainline with Eastbound and Westbound C/D Roads

Strengths	Weaknesses
• New I-84 eastbound mainline reduces the geometric and traffic flow deficiencies associated with a stacked interchange • New C/D Roads will directly reduce conflicts and safety deficiencies with separation of local traffic from mainline through traffic • Relocation of several ramps reduce weaves by increasing distances between ramps • Some left-hand ramps eliminated • New ramps will enhance local access to/from I-84 • Some improvements to local arterial intersections will increase safety and convenience for motorists • Overall capital cost likely to be lower than Preliminary Alternative 5 (full build)	• Existing structures may not be structurally adequate to accept modifications • Retaining the use of some existing mainline infrastructure limits ideal ramp placement • Existing deficiencies on the westbound I-84 mainline (substandard shoulders, interchange spacing, etc.) would not be addressed
Opportunities	**Challenges**
• Can enhance viability of economic development through local access improvements • New connector roads may offer new frontage for recreation or public/private development • Removal of some vehicular traffic on surface streets through improved access to freeways may enhance downtown street environment • Project will fit into the larger context of widening I-84 between the New York State line and Hartford • Replacement of eastbound mainline will reduce maintenance needs in short term for that facility	• Environmental and Right of Way impacts will likely be greater than those from Preliminary Alternatives 1 and 2, and at a similar level of magnitude to those from Preliminary Alternative 4. Regardless, impacts will still need to be addressed • Maintaining traffic during construction • Maintenance of obsolete infrastructure that is not replaced under this alternative (specifically, existing westbound mainline) will continue indefinitely with attendant increases in maintenance needed over time • Procuring funding for this alternative will be a challenge. It will be an incrementally greater challenge than under Preliminary Alternatives 1 and 2, in the same general level of magnitude as Preliminary Alternative 4, and likely lower than Preliminary Alternative 5.

Table 2-4: Preliminary Alternative 4 - New I-84 Westbound Mainline with Eastbound C/D Road

Strengths	Weaknesses
• New I-84 westbound mainline reduces the geometric and traffic flow deficiencies associated with a stacked interchange • New eastbound C/D Road will directly reduce conflicts and safety deficiencies with separation of local traffic from mainline through traffic • Relocation of several ramps improve weaves by increasing distances between ramps • Some left-hand ramps eliminated • New ramps will enhance local access to/from I-84 • Some improvements to local arterial intersections will increase safety and convenience for motorists • Overall capital cost likely to be lower than Preliminary Alternative 5 (full build)	• Existing structures may not be structurally adequate to accept modifications • Retaining the use of some existing mainline infrastructure limits ideal ramp placement • Existing deficiencies on the eastbound I-84 mainline (substandard shoulders, interchange spacing, etc.) would not be addressed • Poor structural condition of the I-84 eastbound main span is not improved • Westbound ramp spacing deficiency between exits 21 and 20 is not addressed • Existing 2-lane segment of I-84 eastbound is not addressed
Opportunities	**Challenges**
• Removal of some vehicular traffic on surface streets through improved access to freeways may enhance downtown street environment • Project will fit into the larger context of widening I-84 between the New York State line and Hartford • Replacement of westbound mainline will reduce maintenance needs in short term for that facility	• Environmental and Right of Way impacts will likely be greater than those from Preliminary Alternatives 1 and 2, and at a similar level of magnitude to those from Preliminary Alternative 3. Regardless, impacts will still need to be addressed. • Maintaining traffic during construction • Maintenance of obsolete infrastructure that is not replaced under this alternative (specifically, existing eastbound mainline) will continue indefinitely with attendant increases in maintenance needed over time • Procuring funding for this alternative will be a challenge. It will be an incrementally greater challenge than under Preliminary Alternatives 1 and 2, in the same general level of magnitude as Preliminary Alternative 3, and likely lower than Preliminary Alternative 5.

Table 2-5: Preliminary Alternative 5 - New Eastbound & Westbound I-84 Mainlines with C/D Roads

Strengths	Weaknesses
• Total reconstruction of both I-84 mainlines (westbound and eastbound) will more effectively address deficiencies associated with existing stacked interchange • New C/D Roads will directly reduce conflicts and safety deficiencies with separation of local traffic from mainline through traffic • Relocation of several ramps improve weaves by increasing distances between ramps • Most left-hand ramps eliminated • New ramps will enhance local access to/from I-84 • Some improvements to local arterial intersections will increase safety and convenience for motorists	• Several design exceptions for grades, ramp spacing, etc. may still be necessary, despite all-new mainline construction • Overall capital cost likely to be substantially higher than all other alternatives, though this difference might be offset by lower maintenance costs over time • Highest level of environmental and right-of-way impact of all alternatives anticipated
Opportunities	**Challenges**
• Removal of some vehicular traffic on surface streets through improved access to freeways may enhance downtown street environment • Can enhance viability of economic development through local access improvements • Project will fit into the larger context of widening I-84 between the New York State line and Hartford • Replacement of both mainlines will reduce overall maintenance needs for those facilities	• Environmental and Right of Way impacts will likely be greater than those from all other alternatives and will still need to be addressed. • Maintaining traffic during construction • Procuring funding will be the greatest challenge for this alternative compared to all others

3 Analysis of Preliminary Alternatives

Traffic analysis was performed for each of the preliminary alternatives. Methodologies in the Highway Capacity Manual for estimating Level Of Service (LOS) on the freeways, interchange ramps and arterial intersections were used for this analysis. This approach was deemed sufficient for the purpose of estimating relative improvements in each of the alternatives over the no-build scenario. More detailed analysis will be performed on these alternatives selected to move forward in the study process.

In addition to the traffic analysis, conceptual level (order-of-magnitude) cost estimates were developed to gauge the approximate costs of constructing and maintaining the transportation system defined in each alternative. As with traffic, costs will continue to be refined and detail added for alternatives related to move forward through the study process.

3.1 Traffic

A study of capacity is important in determining the ability of a specific roadway, intersection, or freeway to accommodate traffic under various levels of service. "Level of Service" (LOS) is a qualitative measure describing the degree of traffic congestion. Criteria considered when determining LOS of a roadway or intersection include speed and travel time, traffic interruption, freedom of maneuverability, safety, driving comfort and convenience, and delay.

In general there are six levels of service describing flow conditions:

Level of Service A, the highest LOS, describes a condition of free flow, with low volumes and high speeds.

Level of Service B represents a stable traffic flow with operating speeds beginning to be restricted somewhat by traffic conditions.

Level of Service C, which is normally utilized for design purposes, describes a stable condition of traffic operation. It entails moderately restricted movements due to higher traffic volumes, but traffic conditions are not objectionable to motorists**.**

Level of Service D reflects a condition of more restrictive movements for motorists and the influence of congestion becomes more noticeable. It is generally considered the lower end of "acceptable" service.

Level of Service E is representative of the actual capacity of the roadway or intersection and involves delay to all motorists due to congestion.

Level of Service F, the lowest LOS, is described as forced flow and is characterized by volumes greater than the theoretical roadway capacity. Complete congestion occurs, and in extreme cases, the volume passing a given point drops to zero. This is considered as an unacceptable traffic operating condition.

As part of this study, an LOS analysis of each alternative was performed for freeway mainline and C/D road segments; ramp junctions; and freeway weaving conditions under future (2030) peak hour conditions. Traffic analyses for this study were based on the 2000 Highway Capacity Manual[1] and conducted using the Highway Capacity Software (HCS).

3.1.1 No Build Alternative

The No Build Alternative was analyzed in Technical Memorandum 1 and the results of the traffic analysis indicated several freeway segments, weave sections, and ramp junctions that are anticipated to operate at LOS E or LOS F. These locations are listed below:

Freeway Segments

I-84 eastbound between Interchanges 17 and 23
I-84 westbound between Interchanges 17 and 18, Interchanges 21 and 23

Weaving Areas

I-84 eastbound between Chase Parkway and Route 8 southbound
I-84 eastbound between Route 8 northbound and Meadow Street
I-84 westbound between Bank Street and Route 8 northbound
I-84 westbound between Bank Street and Route 8 southbound
I-84 westbound between Route 8 southbound and Highland Avenue (Interchange 18)

Ramp Junctions

All entrance and exit ramps along I-84 eastbound
All entrance and exit ramps along I-84 westbound

The No Build alternative has inadequate capacity to accommodate future (2030) traffic volumes during the A.M. and P.M. peak hour conditions. In addition, the presence of left hand on and off ramps and short weaving sections in the downtown portion create poor operating conditions along the highway.

[1] Highway Capacity Manual 2000, Transportation Research Board, Washington, D.C.

3.1.2 Preliminary Alternative 1

Alternative 1 is similar to the No Build condition and has no geometric improvements on I-84 in either direction. Therefore, the freeway segment, weave and ramp junction deficiencies highlighted under the No Build condition would remain the same under Alternative 1.

3.1.3 Preliminary Alternative 2

Under Alternative 2, there are no major geometric improvements to the I-84 mainline except the elimination of the exit ramp on I-84 eastbound to Meadow Street at Interchange 21. The removal of this ramp would eliminate the weave between Route 8 northbound and Meadow Street. However, the freeway segment level of service deficiency at this location would not be addressed with the elimination of the exit ramp as illustrated in Figure 3-1. All remaining freeway, weave and ramp junction deficiencies highlighted under the No Build condition would not be addressed under this alternative.

3.1.4 Preliminary Alternative 3

Alternative 3 represents a partial build alternative with a new I-84 eastbound mainline and introduction of C/D Roads. As a result of the geometric improvements introduced under this alternative, some of the operational deficiencies highlighted under the No Build condition would be addressed; however a new weave would be created under this alternative in the eastbound direction on I-84. The traffic operational improvements under Alternative 3 are illustrated in Figure 3-2 and are described as follows:

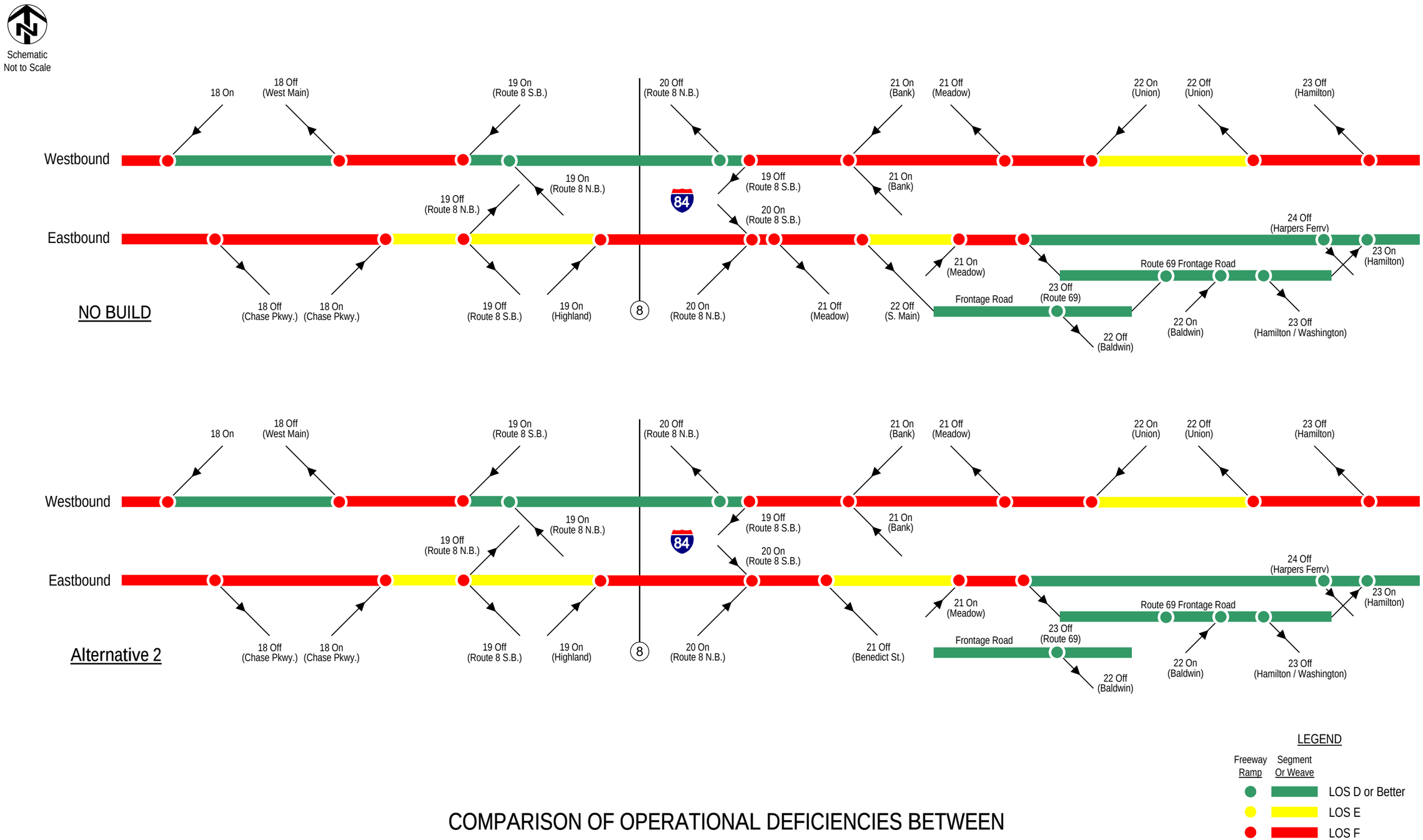
Freeway Segments

In the eastbound direction on I-84, all freeway segments operating at LOS E or LOS F under the No Build condition would operate at LOS D or better under Alternative 3. This improvement would be a result of increased capacity on the new I-84 eastbound mainline as well as the introduction of a new eastbound C/D Road.

In the westbound direction, the level of service deficiencies identified under the No-Build condition would not be addressed.

Weaving Areas

Under Alternative 3, the weave areas highlighted under the No Build condition would not be addressed. In addition, a new weave is created on I-84 eastbound between the C/D Road entrance ramp and Harper's Ferry exit which would operate at LOS E.

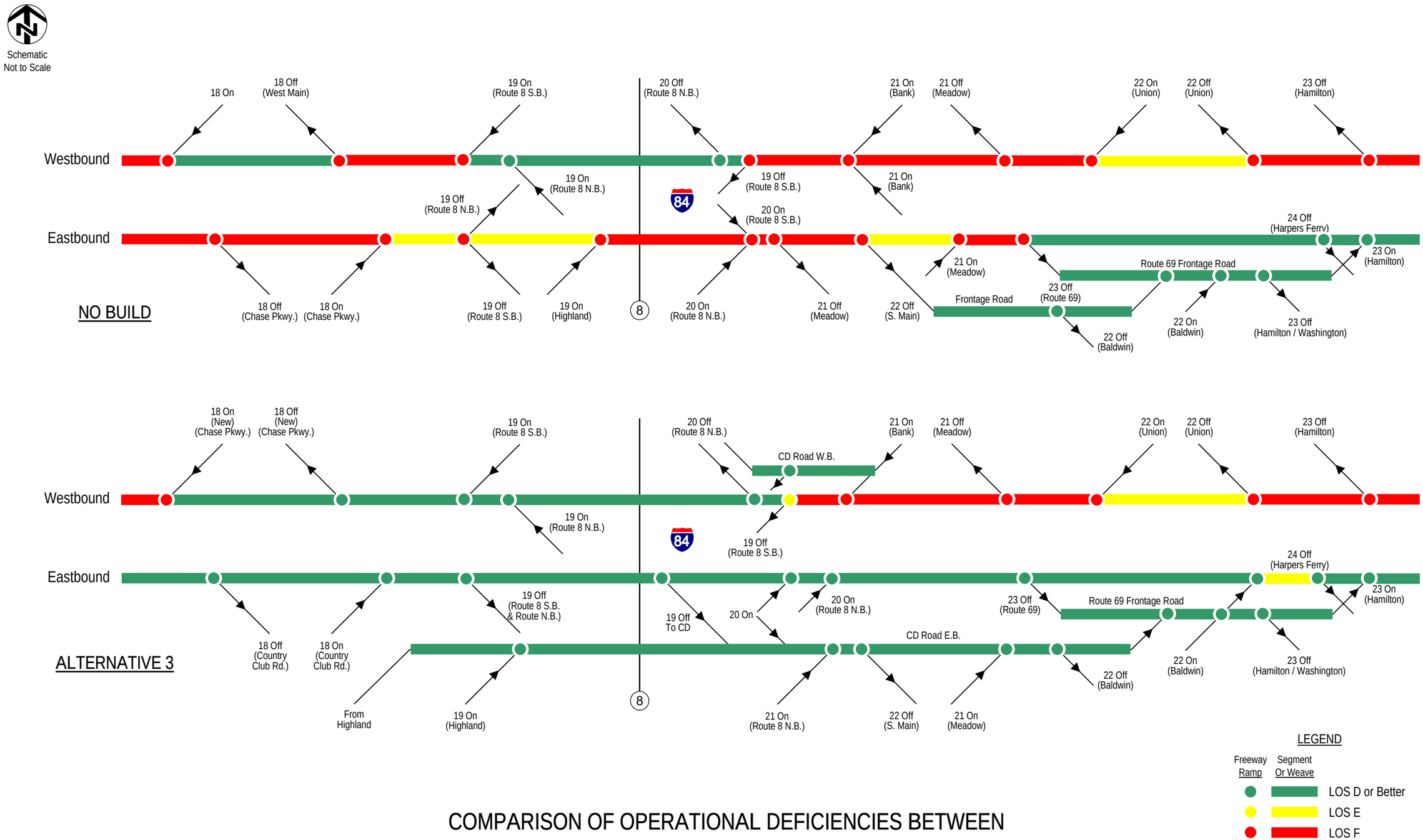


COMPARISON OF OPERATIONAL DEFICIENCIES BETWEEN 2030 NO BUILD AND 2030 PRELIMINARY ALTERNATIVE 2

I-84 / ROUTE 8 NEEDS AND DEFICIENCIES STUDY

Wilbur Smith Associates
ENGINEERS
PLANNERS
ECONOMISTS

FIGURE 3-1



COMPARISON OF OPERATIONAL DEFICIENCIES BETWEEN 2030 NO BUILD AND 2030 PRELIMINARY ALTERNATIVE 3

I-84 / ROUTE 8 NEEDS AND DEFICIENCIES STUDY

Wilbur Smith Associates
ENGINEERS PLANNERS ECONOMISTS

FIGURE 3-2

Ramp Junctions

In the eastbound direction on I-84, all ramps operating at LOS E and LOS F under the No Build condition would be improved to acceptable levels of service under Alternative 3 as illustrated in Figure 3-2. These improvements are due to enhanced mainline capacity with the introduction of additional freeway lanes and a new eastbound C/D Road.

In the westbound direction on I-84, the ramp junction to Route 8 northbound would be improved to an acceptable level of service (LOS D or better) under Alternative 3. This improvement is due to the new westbound C/D Road introduced at this location.

3.1.5 Preliminary Alternative 4

Alternative 4 represents a partial build alternative with a new I-84 westbound mainline and introduction of C/D Roads. As a result of the geometric improvements introduced under Alternative 4, some of the operational deficiencies highlighted under the No Build condition would be addressed; however a new weave would be created under this alternative in the westbound direction on I-84.

The traffic operation improvements under this alternative are illustrated in Figure 3-3 and are described as follows:

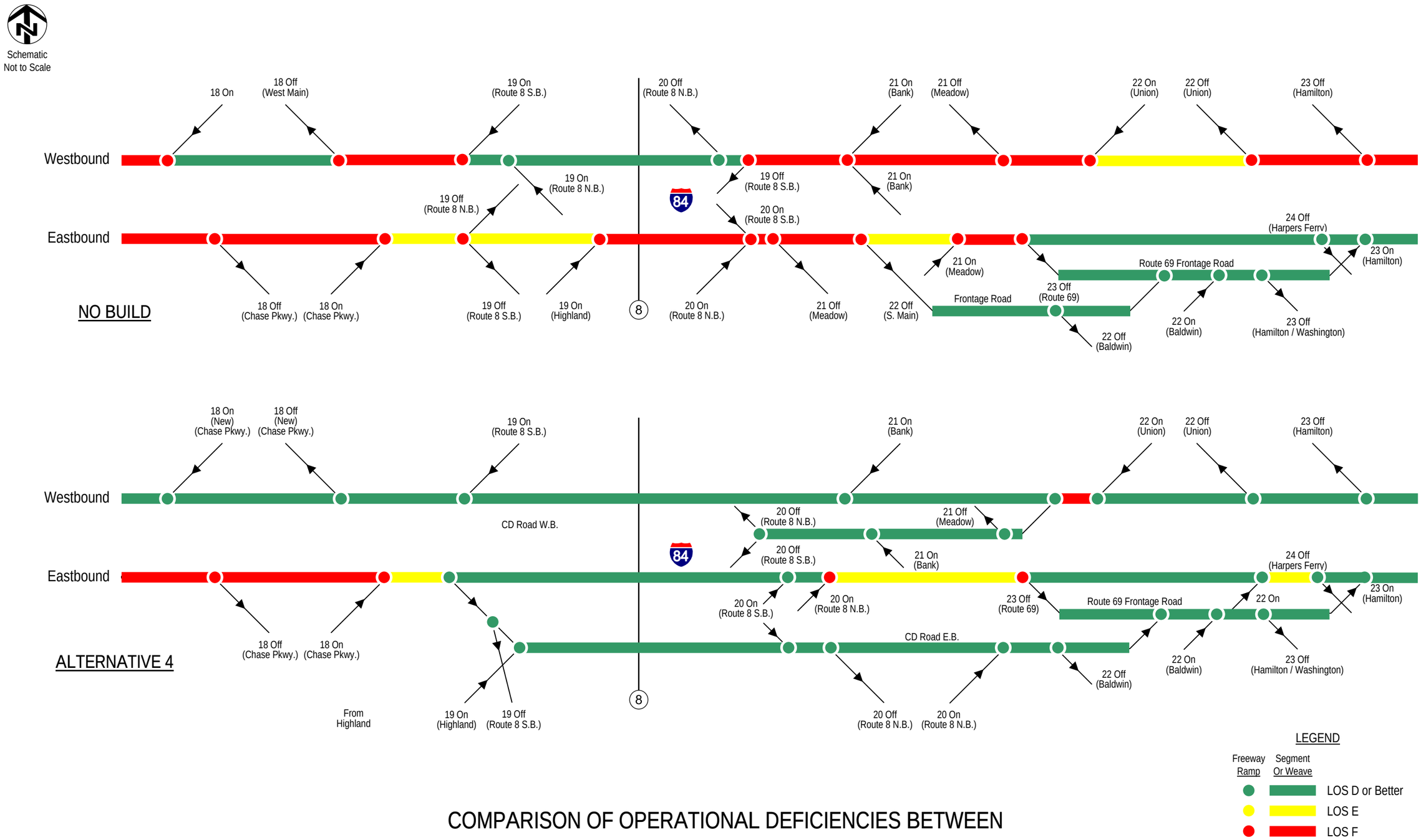
Freeway Segments

In the eastbound direction on I-84, the freeway segment between interchange 19 and 20 would be improved to an acceptable level of service. This improvement is a result of a new eastbound C/D Road at Interchange 19.

In the westbound direction, all freeway segments with the exception of the segment between interchange 20 and 21 would be improved to acceptable levels of service (LOS D or better). These improvements are a result of enhanced capacity on the new westbound mainline and the introduction of a new westbound C/D Road.

Weaving Areas

Under Alternative 4, there would be no level of service improvements at the weave areas highlighted under the No Build condition. Under this alternative, a new weave would be created on I-84 westbound between Union Street entrance ramp and the westbound C/D Road. This new weave segment would operate at LOS F.



COMPARISON OF OPERATIONAL DEFICIENCIES BETWEEN 2030 NO BUILD AND 2030 PRELIMINARY ALTERNATIVE 4

I-84 / ROUTE 8 NEEDS AND DEFICIENCIES STUDY

Wilbur Smith Associates
ENGINEERS PLANNERS ECONOMISTS

FIGURE 3-3

Ramp Junctions

In the eastbound direction on I-84, the ramp junction to Route 8 southbound at Interchange 19 would be improved to an acceptable level of service (LOS D or better) under Alternative 4. This improvement is due to a new eastbound C/D Road introduced at this location.

In addition, the entrance ramp at Interchange 23 from Hamilton Avenue would be improved to an acceptable level of service (LOS D or better) due to the introduction of a slip ramp from the Route 69 frontage road to I-84 eastbound.

In the westbound direction on I-84, all ramps operating at LOS E and LOS F under the No Build condition would be improved to acceptable levels of service under Alternative 4 as illustrated in Figure 3-3. These improvements are due to enhanced mainline capacity on the new I-84 westbound mainline and the new westbound C/D Road.

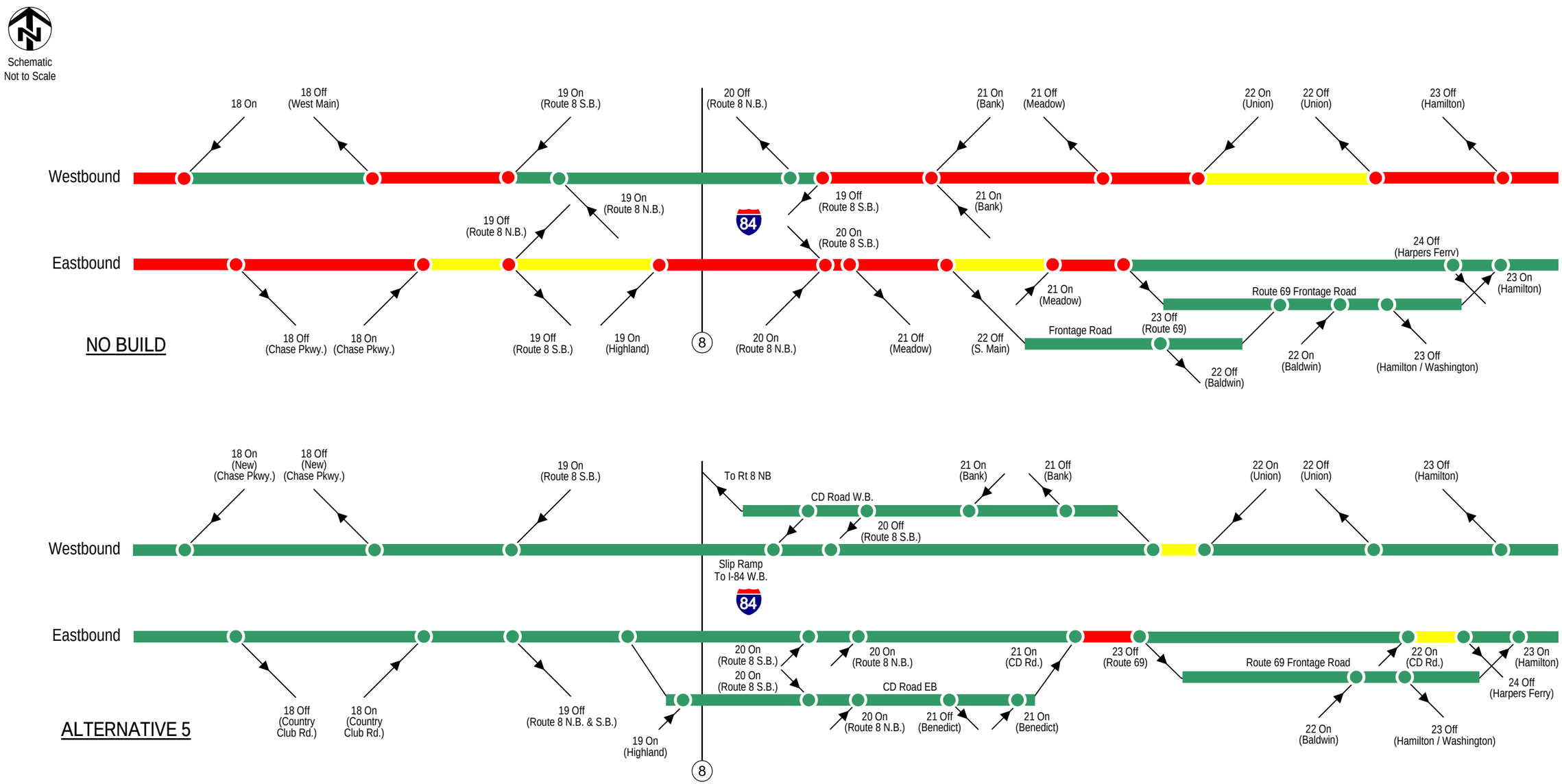
3.1.6 Preliminary Alternative 5

Alternative 5 represents a full build alternative with a new I-84 eastbound and westbound mainline and C/D Roads. In addition all left hand ramps are eliminated under this alternative. As a result of these geometric improvements, all operational deficiencies highlighted under the No Build condition are addressed. However, three new weave segments would be created under this alternative.

The traffic operational improvements under this alternative are illustrated in Figure 3-4 and are described as follows:

Freeway Segments

All freeway segments under this alternative would operate at an acceptable level of service (LOS D or better) due to the enhanced capacity on the new I-84 mainlines and the introduction of new C/D Roads.



COMPARISON OF OPERATIONAL DEFICIENCIES BETWEEN 2030 NO BUILD AND 2030 PRELIMINARY ALTERNATIVE 5

I-84 / ROUTE 8 NEEDS AND DEFICIENCIES STUDY

Wilbur Smith Associates
ENGINEERS PLANNERS ECONOMISTS

FIGURE 3-4

Weaving Areas

Under Alternative 5, there would be no level of service improvements at the weave areas highlighted under the No Build condition. However, three new weave sections are created under this alternative. These weave segments are indicated below with the level of service:

- I-84 westbound between Union Street entrance ramp and westbound C/D Road would operate at LOS E.
- I-84 eastbound between C/D Road entrance ramp and Route 69 frontage road would operate at LOS F due to a short weaving area and high volumes.
- I-84 eastbound between C/D Road entrance ramp and Harper's Ferry exit would operate at LOS E.

Ramp Junctions

All ramp junctions under this alternative would operate at LOS D or better due to the enhanced capacity on the new I-84 mainlines and the introduction of new C/D Roads.

3.2 Preliminary Cost Estimates

Discussion of Preliminary Civil Highway Costs and Assumptions

For each of the five preliminary alternatives, construction costs were developed for the following civil highway construction items as applicable:

- Earthwork and Embankment Items
- Drainage and Hydraulics Items
- Pavement and Subgrade Items
- Traffic Signals and Traffic Safety Related Items
- Roadside Safety Items
- Buses & Bus Shelters
- Stage Construction and Work Zone Safety Items
- Impact Mitigation

Costing Assumptions and Justification

Unit costs for each of the various civil highway items are based on several sources, namely, the Connecticut Department of Transportation Preliminary Cost Estimating Guidelines dated January 2005, ConnDOT Weighted Unit Pricing documents, past experience, and professional judgment.

Quantities for earthwork and embankment items were developed from the measurement of overall lengths of roadway on embankment, the width of various roadway types based on standard cross sectional dimensions (a.k.a. 12 foot travel lanes, inside and outside shoulders up to 10 feet wide and inside and outside berms up to 4 feet), and assumed

heights of embankment. The preliminary alternatives depict various roadways crossing over or under other roadways within the corridor. It was assumed that there is a 22-foot difference in elevation between roadways that cross one another. Additionally, it was assumed that along the length of various roadways there is a transition in height from one crossing level to another and a varied height above the existing ground elevation to various roadway crossing elevations.

The length, width and height determinations were combined to arrive at cubic volumes of earthwork for each roadway segment. The segments were totaled and assumption was made that 60 % of the total volume of earthwork was on filled embankment and 40% of the total volume of earthwork was existing ground to be excavated.

Of the excavated earthwork volume 15% was assumed to be rock excavation. Of the excavated material deemed to be non-rock excavation or earth excavation, 5% of the earth excavation was assumed to be contaminated with hydrocarbon deposits and 0.5% was assumed to be hazardous waste containing PCB deposits.

The excavation and redistribution of on-site (waste) earthwork materials is generally considered to be less expensive by volume than the location, hauling and placement of off-site (borrow) earthwork materials. Proper handling, treatment and disposal of contaminated and hazardous earth materials can be very expensive, especially in a historically active manufacturing city such as Waterbury.

At this early stage of alternative development, details concerning the existence of rock, contaminated and hazardous soils, unsuitable materials (muck), and borrow quantities versus waste quantities, are not available. In order to provide a conservative buffer of potential project costs, volumes of these expensive items were assumed to be present and required.

Drainage and hydraulic items include the construction of new closed drainage systems, expansion and renovation of existing closed drainage systems, and the construction of new and/or extended cross culverts. Based on the Departments estimating procedure, costs for new and expanded drainage systems are based on overall square foot surface areas of the roadway pavement. Similar length and width calculations were made as described in the earthwork text above. New roadways were assumed to require new drainage systems and widened or resurfaced existing roadways were assumed to require expansion and renovation of existing drainage systems.

Pavement and sub-grade items include bituminous pavement, formation of sub-grade (fine grading and accurate surveying of top of embankment), sub-base (processed aggregate material between the top of earth embankment and bottom of bituminous pavement) and concrete pavement. Quantities for the various pavement and sub-grade items were developed similar to the earthwork items described above.

Traffic signals and traffic safety features such as pavement markings and signage were quantified based on specific intersection requirements and overall area calculations measured from the various preliminary alternatives.

Roadside safety items including concrete median barrier, curbing and guiderail were calculated using the overall lengths of various roadways and professional judgment as to the extent of usage. Median barrier was assumed to be required on 15% of the overall length of mainline roadways. Curbing was assumed to be required the length of all turning roadways, ramps and local streets. Guiderail was assumed to be required on 20% of the overall length of all roadway segments.

Costs for busses and bus shelters were quantified using planning level cost data from ConnDOT.

Stage construction and work zone safety refers to the planned and safe transition of construction from existing facility to newly completed facility and vice versa. Transitional traffic cross-overs, temporary paved embankments, and interim lane configurations are included under this item. Proper barricades, physical barriers and warning devices provide work zone safety to the contractors' manpower and equipment. A lump sum cost was assigned to each preliminary alternative based on anticipated construction complexity and professional engineering judgment. Estimated stage construction values vary from $100,000 to $3,000,000 for Preliminary Alternatives 1 and 5, respectively.

Impact mitigation refers to the set aside of dollars for the mitigation of unavoidable environmental and/or social impacts attributed to the construction of the proposed alternative. It is anticipated that even with the most sensitive and responsible approach to the development of this project corridor some level of unavoidable impact will result to one or more protected resources. A conservative lump sum value was estimated based on anticipated construction complexity, anticipated footprint and professional engineering judgment. Estimated mitigation values vary from $100,000 to $1,000,000 for Preliminary Alternatives 1 and 5, respectively.

Unit costs for the civil highway costs are described in Table 3-1 below:

Table 3-1: Civil Highway Items, Units of Measure and Unit Prices

Item Description	Units	UNIT Price
Highway Items		
Earth Excavation	CY	$20.00
Rock Excavation	CY	$50.00
Unsuitable Material Excavation (Muck)	CY	$10.00
Contaminated Soil Excavation (Hydrocarbons)	CY	$70.00
Hazardous Waste Excavation (Pcb's)	CY	$450.00
Borrow	CY	$18.00
New Drainage System	SY	$20.00
Existing Drainage Upgrade	SY	$7.00
Superpave	TON	$70.00
Concrete Base Course Widening	CY	$260.00
Milling of Bituminous Concrete (0 To 4")	SY	$4.00
Concrete Pvmt. Replacement For Roadway (Full Depth)	CY	$580.00
Subbase	CY	$28.00
Major Pipe Culverts	LF	$750.00
Concrete Box Culverts	LF	$975.00
Concrete Median Barrier	LF	$50.00
Concrete Sidewalk	SY	$65.00
Major Traffic Signal Modifications	EA	$50,000
New Traffic Signal	EA	$70,000
Roadway Lighting (Expressway & Ramps)	LF	$55.00
Concrete Curbing	LF	$28.00
Guiderail	LF	$48.00
Buses	Ea	$500,000
Bus Shelters	Ea	$50,000
Signing & Striping (Estimated)	LS	Varies*
Stage Construction Items (Estimated)	U	Varies*
Impact Mitigation (Estimated)	U	Varies*

* Estimated item costs vary from one alternative to another based on the extent and complexity of the proposals.

3.2.2 Discussion of Conceptual Structure Costs and Assumptions

For each of the five Preliminary Alternatives, costs were developed for proposed bridges, miscellaneous structures, demolition, and repair. The results are summarized in Table 3.2.2, and are discussed further in the following narrative. It is important to note that the costs tabulated for structures are inclusive of all items associated with the complete structure including deck pavement, railings, lighting, pavement markings, etc. Highway costs detailed previously do not include the pavement, railings, lighting, and pavement markings within the specified limits of the various bridge structures detailed herein.

Proposed Bridges

A raw structure cost of $250 per square foot of deck area was used for the proposed bridges. This cost was based on several sources, namely, the Connecticut Department of Transportation Preliminary Cost Estimating Guidelines dated January 2005, bid tabulations for the recently awarded New Haven Harbor Crossing Improvements Contract C2, current estimates for the New Haven Harbor Crossing Improvements Contract B (Pearl Harbor Memorial Bridge), past experience, and professional judgment.

The 2005 CDOT Preliminary Cost Estimating Guidelines state that new bridges should be estimated at $210 per SF. However, it should be noted that this number has not changed from the 2002 Guidelines. After adjusting for inflation from 2002 at 5% per year, the resulting cost is $243 per SF. Actual individual items may have had a higher inflationary cost (chiefly fuel, Portland cement, and structural steel).

Bid tabulations for Contract C2 resulted in structure costs between approximately $250 and $475 per SF. The ramp structures varied between $280 and $475 per SF, while the mainline single span structure was $250 per SF.

Current estimates for the Contract B approach spans are in the range of $170 per SF for the ramp structure, and $120 to $160 per SF for the mainline structure. However, these structures, particularly the mainline structures, are similar, wide structures, resulting in economies of scale which will likely be absent from the subject project. In addition, site access and construction staging for Contract B is anticipated to be considerably less complex than the subject project.

While the above data vary somewhat, when economies of scale and ease of construction are taken into account, at this time it would seem prudent to use $250 per SF for all proposed bridges.

Miscellaneous Structures

These structures include primarily retaining walls and culverts. Since the scope of this study did not allow for laying these structures out in detail, a lump sum cost for each alternative was assumed based on professional judgment and past experience.

Demolition

Demolition cost was estimated as $60 per SF of deck area. The 2005 CDOT Preliminary Cost Estimating Guidelines state that Removal of Superstructure should be estimated at approximately $50 per SF for removal over water or rail, which constitutes the majority of the structures to be removed. An additional $10 per SF was estimated for substructure demolition.

Repair

A prior phase of this study investigated a condition assessment for all existing structures associated with the general area of this interchange, and assigned required repairs to each structure over a future 20 year period. In this phase, costs were assigned to each repair type based on broad assumptions.

Repair types were classified as Routine Maintenance, Deck Patching, Deck Replacement, Substructure Patching, Complete Painting, Spot Painting, Bearing Replacement, Repair Impact Damage to Beams, Safety Walk Retrofit, and Seismic Retrofit. Estimates of costs for significant repair types such as Deck Patching, Deck Replacement, Complete Painting, Spot Painting, and Safety Walk Retrofit were developed, while nominal costs per SF were assigned for the other types of repairs based on past experience and professional judgment.

- Deck Patching – the 2005 CDOT Guidelines suggest using $2000 per CY for full depth patching. Assuming an 8" thick deck, this translates into approximately $50 per SF of deck area.
- Deck Replacement – the 2005 CDOT Guidelines suggest using $100 per SF of deck area, which was used for this study.
- Complete Painting – based on experience, this item was estimated to be approximately $20 per SF of painted area, including containment required for lead-based paints. A typical 5' deep steel plate girder with 18" wide flanges represents approximately 14.5 SF of painted area; adding 20% to account for details results in 17.4 SF of painted area; using a typical 8.5' spacing yields roughly 2 SF of painted area per SF of deck area. Therefore a cost of $40 per SF of deck area was used.
- Spot Painting – this was estimated to be 5% of the area of complete painting, resulting in a cost of $2 per SF of deck area.
- Safety Walk Retrofit – based on recent weighted unit bid prices, this retrofit item is approximately $170 per linear foot. For a typical 50' wide bridge with two parapets, this translates to approximately $7 per SF of deck area.

Table 3-2: Conceptual Structural Costs for each Preliminary Alternative

	Proposed Bridges	Miscellaneous Structures	Demolition	Repair	TOTAL (Rounded)
Preliminary Alternative 1	$0	$0	$0	$120,570,741	**$120,600,000**
Preliminary Alternative 2	$10,370,833	$10,000,000	$0	$120,570,741	**$140,900,000**
Preliminary Alternative 3	$192,777,750	$55,000,000	$24,118,182	$81,787,328	**$353,700,000**
Preliminary Alternative 4	$167,825,000	$62,500,000	$42,180,430	$114,249,486	**$386,800,000**
Preliminary Alternative 5	$267,927,000	$57,500,000	$49,735,959	$37,158,495	**$412,300,000**

Source: Wilbur Smith Associates and URS Corporation

3.2.3 Discussion of Conceptual Lump Sum Items and Additional Items

For each of the five Preliminary Alternatives, costs were developed for Lump Sum Items including the following:

- Clearing And Grubbing (2% Of Subtotal A)
- Maintenance & Protection Of Traffic (3% Of Subtotal A)
- Mobilization (7.5% Of Subtotal A)
- Minor Items (15% Of Subtotal A)
- Health And Safety Support Costs (2% Of Subtotal A)

Subtotal A refers to the sub total of all described roadway and structural costs assigned to each preliminary alternative. Maintenance & Protection of Traffic refers to the costs associated with providing proper traffic delineation thru the use temporary pavement markings, signage, development of safe work zones and traffic policing.

Additionally, for each of the five Preliminary Alternatives, costs were also developed for Additional Items including the following:

- Incidentals (7% Of Subtotal B)
- Contingencies (5% Of Subtotal B)
- Preliminary Engineering (8%Of Subtotal B)
- Utility Cost (3% Of Subtotal B)
- Right-Of-Way (Estimated)

Subtotal B refers to the sub total of all applicable Lump Sum Items assigned to each preliminary alternative. Professional judgment was used to estimate right of way costs at this time.

Costing Assumptions and Justification

Percentages used in determination of various lump sum and additional items were derived from the 2005 ConnDOT Preliminary Cost Estimating Guidelines as well as previous guidelines dated 2002.

3.2.4 Conceptual Cost Estimates

Conceptual cost estimates including all structural and civil items have been developed for each alternative. These costs are in 2005 dollars given the preliminary stage at which alternative development and phasing schedules are at. As the alternatives continue to be refined throughout this study, future year costs will be developed and reported in a financial plan for the project. In addition these cost estimates do not include any environmental mitigation that might be necessary to construct these alternatives. As alternatives are refined, such costs will be estimated as appropriate.

Refer to Table 3-3 for tabulation of all costs attributed to each conceptual alternative.

Table 3-3: Summary of Preliminary Alternative Costs by Major Cost Items.

	Alternate 1	Alternate 2	Alternate 3	Alternate 4	Alternate 5
Civil Highway Costs	$3,200,000	$65,900,000	$58,100,000	$174,200,000	$190,400,000
Structural Bridge Costs	$120,600,000	$140,900,000	$353,700,000	$386,800,000	$412,300,000
Subtotal A	**$123,800,000**	**$206,800,000**	**$411,800,000**	**$561,000,000**	**$602,700,000**
Lump Sum Items	$36,500,000	$61,000,000	$121,500,000	$165,500,000	$177,800,000
Subtotal B	**$160,300,000**	**$267,800,000**	**$533,300,000**	**$726,500,000**	**$780,500,000**
Additional Items	$36,900,000	$61,800,000	$122,700,000	$167,100,000	$179,500,000
Total Cost	**$197,200,000**	**$329,600,000**	**$656,000,000**	**$893,600,000**	**$960,000,000**
Total Cost (Rounded)	**$197,000,000**	**$330,000,000**	**$656,000,000**	**$894,000,000**	**$960,000,000**

(2005 dollars)

As evidenced by the table above, costs for the various preliminary alternatives are most greatly affected by the significant structural bridge costs associated with each alternate. Under alternate schemes 1 and 2 the structural costs are attributed primarily to maintaining the aging bridges that exist today and are proposed to remain in the future. Even the no-build alternative (not shown) would require the same minimum investment of structural bridge maintenance dollars as described in preliminary alternative 1, roughly $120,600,000 over the next 20 years.

Preliminary Alternative 2 requires an extensive network of new and improved safety and operational improvements throughout the local street network which is reflected in the significant civil highway costs.

Preliminary Alternatives 3 and 4 are somewhat similar in civil highway and structural bridge costs even though they are markedly different in how they approach the partial reconstruction of the existing I-84 corridor. As with Preliminary Alternatives 1 & 2, Preliminary Alternatives 3 & 4 continue to carry substantial structural bridge maintenance and repair costs associated with continued use of many of the existing bridge structures in the corridor.

Preliminary Alternative 5 is the most expensive alternative and this fact can be attributed to the near complete reconstruction of the I-84/Rte 8 corridor. It should be noted that for the added expense, Preliminary Alternative 5 is also far less dependant on the aging existing bridge structures in the future.

4 Screening of Preliminary Alternatives

4.1 Criteria for Ranking Alternatives

ConnDOT, FHWA, COGCNV, City of Waterbury and consultant staff met on September 8, 2005 to review criteria for ranking alternatives. The process for developing the screening criteria and the relative weighting of each was a collaborative effort that resulted in the following list:

- **Construction Cost.** Construction Cost is defined as the cost of all the construction phases of a project. It is generally based upon the sum of the construction contracts (both materials and labor) along with other direct construction costs. It also includes the cost of right-of-way acquisition and the cost of design/permitting as a percentage of total construction cost.

- **Life Cycle Cost**. Life Cycle Cost is defined as the amortized annual cost of owning, operating, and maintaining a transportation facility over its useful life. This figure considers long-term costs of each alternative after construction has been completed, since year-to-year expenditures could vary greatly. Infrastructure that is many years old will have greater life cycle costs from maintenance than would new infrastructure.

- **Constructability.** Constructability considers the construction process and the need to balance design and environmental constraints while constructing something that can reasonably and feasibly be built. Constructability includes the process of planning and executing a Maintenance and Protection of Traffic (MPT) program that manages traffic operations during construction activities. The MPT plan considers which lanes accommodate traffic while construction is safely ongoing in the corridor.

- **Environmental Impact.** Environmental Impact considers the net change (positive or negative) in the condition of human health and the physical, natural and social environment associated with the project. Environmental impacts of the project would be evaluated in greater detail after this planning phase ends with documentation as required under the National Environmental Policy Act (NEPA) and the Connecticut Environmental Policy Act (CEPA).

- **Safety/Meets Design Standards**. This criterion is a measure of a roadway system's ability to safely and efficiently accommodate traffic. Safety refers to those conditions that can cause death or injury to people, and damage to or loss of equipment or property. "Meets Design Standards" quantifies the degree to which a transportation alternative meets current ConnDOT and AASHTO design standards. The alternatives address safety and design standards to a varying degree, depending on how much construction is proposed.

- **Connectivity.** Connectivity refers to the ease of travel between two points, e.g., the degree to which streets or areas are interconnected and easily accessible to one another.

- **Economic Development**. This criterion is a measure of a project's ability to strengthen an area's economy and employment base. Employers, manufacturers and developers consider an area's accessibility to the national and world transportation network and local job market when determining where to invest in new facilities. Alternatives that improve local arterial roadways and the national highway system would likely have more influence in increasing economic development potential for an area.

- **Intermodal Connections.** Intermodal Connections refers to the use of multiple types of transportation to reach one destination. It includes combining the use of trains and buses, automobiles, bicycles, and pedestrian transport on a given trip.

- **Traffic Operations/Capacity Accommodation.** This criterion refers to a transportation alternative's ability to manage demand and increase capacity to serve that transportation demand, whether through additional lanes or services, or through efficiency improvements.

4.2 Weighting Factors for Criteria

During the September 8, 2005 meeting, decisions were made regarding the weighting factors for each criterion described above; since consensus found that some issues were more important than others. Therefore, weights for each criterion were defined on a scale from 1 to 5. The highest weighting score of 5 was assigned to Safety/Meets Design Standards, whereas the lowest weighting of 3 was assigned to Construction Cost and Intermodal Connections. Table 4-1 shows the relative weights for each criterion.

Table 4-1: Criteria Weight Factors

Criteria	Weight
Construction Cost	3
Life Cycle Cost	4
Constructability	4
Environmental Impact	3.5
Safety/Meets Design Standards	5
Connectivity	4
Economic Development	3.5
Intermodal Connections	3
Traffic Operations/Capacity Accommodation	4.5

Source: Wilbur Smith Asscociates

4.3 Ranking of Preliminary Alternatives

Based on the analyses completed coupled with professional judgment, each alternative was given a 1 to 5 score (1 being the lowest and 5 being the highest) based on its ability to satisfy each criterion. To come up with a total score for ranking, each score was multiplied by the criterion's weighting factor and all weighted scores summed for each alternative. The scores were determined as follows:

4.3.1 Construction Cost

For the construction cost criterion, the higher the score given translates to the less expensive the alternative. It should be noted that the construction cost used in ranking the preliminary alternatives represent order of magnitude cost and is by no means a final cost estimate. The construction cost will be refined as this project advances.

Costs for the various preliminary alternatives are most greatly affected by the significant structural bridge costs associated with each alternate. Under Preliminary Alternatives 1 and 2 the structural costs are attributed primarily to maintaining the aging bridges that exist today and are proposed to remain in the future, equating to roughly $120,500,000 over the next 25 years. While this is not an insignificant sum of money, it is the least expensive option and therefore, Preliminary Alternative 1 was given a score of 5.

Preliminary Alternative 2 consists of expanding the arterial roadway network and improving safety and operations throughout the local street network. Since this alternative has some significant civil costs, a score of 4 was given.

Preliminary Alternatives 3 and 4 are somewhat similar in civil highway and structural bridge costs even though they are markedly different in how they approach the partial reconstruction of the existing I-84 corridor. As with Preliminary Alternatives 1 & 2, Preliminary Alternatives 3 & 4 continue to carry substantial structural bridge maintenance and repair costs associated with continued use of many of the existing bridge structures in the corridor. Since Preliminary Alternatives 3 and 4 are similar in cost, and being substantially more expensive than Preliminary Alternatives 1 and 2, they were both given a score of 2.

Preliminary Alternative 5 is the most expensive alternative and this fact can be attributed to the near complete reconstruction of the I-84/Rte 8 corridor. It should be noted that for the added expense, Preliminary Alternative 5 is also far less dependant on the aging existing bridge structures in the future. Preliminary Alternative 5 was given a score of 1.

4.3.2 Life Cycle Cost

For the life cycle cost criterion, the higher the score given translates to a lower life cycle cost score. Life cycle cost refers to the maintenance cost associated with each Preliminary Alternative over the 50-year period beyond 2030.

Preliminary Alternative 1 includes transit improvements, modifying signal timing, and improving signage; therefore, there are no proposed bridges, miscellaneous structures, or demolition costs associated with this alternative. Repair to all bridges within the study limits was assumed using 2005 prices. It is estimated that the life cycle score for this alternative is a 1. This is primarily based on the fact that this alternative retains the existing stacked viaducts, which are non-redundant structures, which by definition are structures whereby a single failure, such as a fatigue crack in a weld, could cause the total collapse of at least a portion of the structure, which is obviously a drawback. In addition, these particular structures are difficult and expensive to repair, maintain, and improve, because of the difficulty involved in order to stage the work. This score also takes into account the fact that multiple cycles of repair are anticipated on all structures during the lifetime of potential replacement structures.

Preliminary Alternative 2 involves only minor structural improvements. Two new bridges are proposed, with only minimal requirements for miscellaneous structures anticipated. No demolition costs are associated with this alternative. The repair costs for this alternative are the same as for Preliminary Alternative 1. For the same reasons as discussed under Preliminary Alternative 1, the life cycle score for this alternative is also estimated to be a 1.

It should be noted that the structural repair necessary under Preliminary Alternatives 1 and 2 would not be as extensive in comparison to the partial and full build alternatives. The repair work required in Preliminary Alternatives 1 and 2 is necessary to keep the highways operational for the period of time after Year 2030. Typically bridges are designed to be relatively maintenance free for up to 50 years after construction, at least with regard to major structural rehabilitation. Preliminary Alternatives 1 and 2 would continue to need periodic and costly structural repair over the 50 years after 2030 to keep in safe operating condition. In other words, the life cycle cost for these alternatives relative to the alternatives that replace existing structures with new structures is very high – translating into a low score.

Preliminary Alternative 3 is a partial build alternative that involves retaining the I-84 WB mainline viaduct, constructing a new I-84 EB mainline viaduct, and constructing C/D viaducts and ramp structures. Extensive requirements for miscellaneous structures are anticipated. Costs were estimated for those structures being demolished. Repair costs were those from Preliminary Alternative 1, less the repair costs of the structures being demolished. The non-redundant viaducts described under Preliminary Alternative 1 are being retained (although no longer stacked), and while some of the remaining structures are being replaced, others are being retained. Therefore, the life cycle score for this alternative is estimated to be a 3.

Preliminary Alternative 4 is also a partial build alternative that involved retaining the stacked I-84 EB and WB viaduct; the use of the existing WB viaduct is proposed to be as a C/D road. A new I-84 WB mainline is proposed, as are C/D viaducts and ramp structures. Extensive requirements for miscellaneous structures are anticipated. Costs

were estimated for those structures being demolished. Repair costs were those from Preliminary Alternative 1, less the repair costs of the structures being demolished. The non-redundant viaducts described under Preliminary Alternative 1 are being retained, and while some of the remaining structures are being replaced, others are being retained. Therefore, the life cycle ranking for this alternative is estimated to be a 2.

Preliminary Alternative 5 is a full-build alternative, which involves demolishing both viaduct stacks and constructing new I-84 EB and WB viaducts, new C/D viaducts, and new ramp structures. Extensive requirements for miscellaneous structures are anticipated. Costs were estimated for those structures being demolished. Repair costs were those from Preliminary Alternative 1, less the repair costs of the structures being demolished. This alternative involves replacing more structures than any of the others; however, several existing structures are being retained. The life cycle ranking for this alternative is estimated to be a 5.

4.3.3 Constructability

For the construction cost criterion, the higher the score given translates to the less expensive the alternative.

Preliminary Alternative 1 maximizes the operation of the existing transportation system without any structural modifications to the highway and local roadway network. This alternative involves transit, signal timing and signage improvements. Since Preliminary Alternative 1 does not require any structural modifications to I-84 and the local roadway system, this alternative is rated highest in terms of constructability and is therefore given the highest ranking of 5.

Preliminary Alternative 2 involves expansion of the local roadway network and improvements to traffic operations and safety on the local roadway network but does not require any major structural modifications to I-84. This alternative is also given a ranking of 5.

Preliminary Alternatives 3 and 4 are partial build alternatives, which involve maintaining portions of the existing I-84 mainline and constructing new mainline spans. These alternatives would pose significant challenges to construction since the existing system of piers are not capable of supporting new ramp connections. Additionally, the piers cannot be easily modified and are not oriented in a way that would allow proper geometric design of new ramps. Finally, these alternatives would require complex and costly traffic management programs to handle traffic while construction is ongoing. For these reasons, these alternatives are both given a ranking of 1.

Preliminary Alternative 5 represents a full build alternative which involves the replacement of both I-84 eastbound and westbound mainlines. Preliminary Alternative 5 presents some construction challenges, since this alternative involves the demolishing and reconstruction of both I-84 mainlines; however, new construction parallel to the existing highway minimizes disruption to the existing transportation system and offers

greater flexibility to follow state and federal highway design standards. This alternative is therefore given the lowest ranking of 3.

4.3.4 Environmental Impact

For the environmental impact criterion, the higher the score given translates to the lower the environmental impact.

This score was determined by considering a number of socioeconomic and environmental issues and broadly estimating at a conceptual level the potential magnitude of impacts on a 1 through 5 scale. A composite score was then calculated for overall environmental impact. It is important to recognize that the impact assessment is a planning level analysis only, and was conducted by comparing conceptual design alternatives depicted on aerial photos to existing GIS mapped resources. No field reconnaissance, ground verification, or quantifying techniques were employed. Additionally, only mapped and/or known socioeconomic and environmental resources were considered in this analysis. For instance, archaeological sites may potentially exist in the study area; however, a much more labor intensive data collection and research effort would be required in order to identify potential locations, an effort that is beyond the scope of this planning level analysis. As the project Route 8/I-84 Improvement Project advances, these conceptual design alternatives will be refined to avoid and minimize impacts to environmental resources to the greatest extent practicable. A more detailed environmental impacts investigation will be conducted upon further refinement of alternatives.

No Build Alternative

The No Build will have little or no effect (score of 5) on just about all socioeconomic and environmental resources; however, under the No Build condition the existing traffic congestion and circulation problem that currently plagues Waterbury and the surrounding transportation system will continue to exist and will only become exacerbated over time, thereby further clogging infrastructure and adding to increased safety problems and delays. Since virtually the entire study area is comprised of an environmental justice (EJ) population, it is very likely that this EJ population would be increasingly affected in an adverse manner by the increased traffic and circulation problems if no improvements are made – resulting in a score of 3. Additionally, increased traffic congestion over time will only exacerbate air quality issues due to increased vehicle residence time in the study area (i.e., slower traffic along I-84 and back-ups on inner city streets will increase idling time of vehicles in the area, thereby contributing to greater air emissions in the localized area).

TDM/TSM/Transit Alternative (Preliminary Alternative 1)

This alternative does not involve any structural modifications and therefore has limited impacts to socioeconomic and environmental resources. The addition of a new bus circulator route along existing city streets in the downtown business district is seen as

having a potential beneficial effect on community and institutional resources in the area as it enables more people to access these downtown destinations. The new bus route also benefits EJ populations since the new route provides a greater level of mobility within an area that qualifies entirely as an EJ population. These benefits are reflected in a score of 5. The alternative may have a low level of impact on historic resources because the new bus circulator route passes predominantly through the Downtown Waterbury National Register Historic District and bus frequency could be perceived by some as having an indirect affect on the overall historic character and setting of the district. Since no major improvements are being made to Route 8, I-84, or the existing City street network under this alternative, traffic congestion is still anticipated to be a problem and could potentially cause a slight degradation of air quality over the long term.

Circulation/Operations/Safety (Preliminary Alternative 2)

The most notable impacts associated with this alternative will be attributed to the new local access routes/connector roads that would be constructed.

Environmental Resources - Potential impacts to surface water, floodplains, hazardous materials risk sites, air quality, and noise are possible with this alternative.

Surface Water: A new bridge over the Naugatuck River is required to accommodate the Sunnyside Avenue to Union Street connection. It is unknown at this time if there will be a need to place piers in the river to support the bridge. Additionally, a large portion of the improvements are located within the 500-year floodplain of the Naugatuck River, with one of the connector roads paralleling the river for a short distance. The aforementioned improvements have a low potential to affect surface water quality and result in a score of 4.

Floodplains: Refer to the comments made for surface water. Because piers could be located in the floodway and/or the 100-year floodplain associated with the Naugatuck River, a low potential exists for floodplain impacts.

Hazardous Materials Risk Sites: The new connector road from West Main Street to Bank Street is located entirely within an industrially zoned section of Waterbury located along the eastern bank of the Naugatuck River and adjacent to a large rail yard. It is likely that contamination exists in this area. The new connector road also directly impacts an industrial facility located just north of Freight Street that is a known Toxic Release Inventory Site, suggesting that detailed site investigations and remediation may be warranted. This is the only conceptual alternative that directly impacts a known hazardous materials site. For the aforementioned reasons, this alternative was ranked as having the greatest potential to affect hazardous materials sites and given a score of 1.

Air Quality: Several intersections will likely have to be analyzed to determine the potential for air quality impacts given the new traffic circulation through the area. Impacts are not anticipated to be significant and a score of 3 is given.

Noise: Roadway improvements in the vicinity of a residential neighborhood just to the southeast of Home Depot may require that this residential area be assessed to ascertain whether or not increased noise levels are an issue. A score if 3 is given.

Socioeconomic Resources - There will likely be a low level of impact to most of the socioeconomic resource categories. In general, scores of 5 are given. Potentially larger or more noticeable impacts may occur with respect to historic resources, and Section 4(f) resources. These impacts are as follows:

Historic Resources: The Sunnyside Avenue to Union Street connection passes directly adjacent to the small Bank Street National Register Historic District and appears to pass close to a potentially eligible historic structure located on South Main Street. These historic resources will need to be evaluated in more detail and coordination with SHPO will be necessary in order to determine the nature of the impact. Also, a second potentially eligible historic structure located in the neighborhood southeast of the Home Depot could potentially be impacted by improvements in that area. A score of 3 was given.

Section 4(f) Resources: The potential exists for constructive use impacts to the historic resources mentioned above, which do qualify as Section 4(f) resources. A score of 4 was given.

Partial Build 1 – New Westbound (Preliminary Alternative 3)

Environmental Resources - Potential impacts to surface water, floodplains, wetlands, hazardous materials risk sites, air quality, and noise are possible with this alternative.

Surface Water: The alternative involves the demolition of one existing bridge/ramp and the construction of three bridges/ramps over the Naugatuck River to facilitate access between I-84 and Route 8. It is unknown at this time if there will be a need to place piers in the river to support the bridges/ramps. Additionally, a portion of the improvements are located within the 500-year floodplain of the Naugatuck River. The aforementioned improvements have the potential to affect surface water quality and a score of 1 is given.

Floodplains: Refer to the comments made for surface water. Because piers could be located in the floodway and/or the 100-year floodplain associated with the Naugatuck River, a potential exists for floodplain impacts. A score of 1 is given.

Wetlands: It appears from the mapping that the conceptual alternative may affect a wetland drainage swale located in the vicinity of the new C/D Road south of the I-84 EB Mainline near Interchange 18 and Sunnyside Avenue. This impact could possibly be avoided upon refinement of the alternative but for this planning level analysis, a potential for minor impact is assumed. A score of 3 is given.

Hazardous Materials Risk Sites: Some of the work would occur within an industrially zoned section of Waterbury located along the eastern bank of the Naugatuck River and

adjacent to a rail corridor. It is likely that contamination exists in this area. Compared to Preliminary Alternative #2, a much smaller portion of Preliminary Alternative #3 is located in the hazardous materials risk area, therefore, a lower level of potential impact is assigned to Preliminary Alternative #3 in the accompanying planning level impacts matrix. A score of 2 is given.

Air Quality: Several intersections will likely have to be analyzed to determine the potential for air quality impacts given the new traffic circulation through the area. Impacts are not anticipated to be significant. A score of 4 is given.

Noise: There are two locations where potential noise impacts may occur. Improvement Area 2 on Figure 3 depicts construction of a new C/D Road near Interchange 18. This conceptual C/D Road would bring traffic closer to a number of homes in the residential area west of Chase Park and north of Sunnyside Avenue. Also, the new Bank Street to South Main Street connection and associated round-about will bring more traffic into the residential neighborhood located just southeast of Home Depot. Noise modeling in these areas will need to be conducted to determine the potential for impacts. Overall, this alternative has the potential to affect the greatest number of noise sensitive receptors because of the proximity of proposed improvements to residential areas and a score of 1 is given.

Socioeconomic Resources - There will likely be no impact to most of the socioeconomic resource categories from this alternative. In general, scores of 5 are given. There is a potential for minor impacts to EJ populations and a potentially larger, more notable impact respect to residential property takes. These impacts are as follows:

EJ Populations: This alternative involves some construction activity within the neighborhood located southeast of Home Depot. This neighborhood qualifies as an EJ population based on a review of Census data. For this reason, there is the potential for a low level of impact to this population, especially during project construction. A score of 4 is given.

Residential Property Takes: This alternative impacts the greatest number of residential structures. The most significant impact is in the area just west of Chase Park in the neighborhood north of Sunnyside Avenue. In this area alone it appears that 10 to 15 homes may be directly impacted. There is also the potential for house takes in the neighborhood southeast of Home Depot where the round-about is proposed. For this reason, this alternative was ranked as having the potential for the greatest amount of impact in terms of residential property takes. A score of 1 is given.

Visual and Aesthetics: The undertaking is a major construction activity that will occur over an extended period of time. There will be constant construction equipment and activity in the area for many years into the future. Additional structure in the area will likely contribute to generally poor aesthetics and a score of 2 is given.

Partial Build 2 – New Eastbound (Preliminary Alternative 4)

Environmental Resources - Potential impacts to surface water, floodplains, hazardous materials risk sites, air quality, and noise are possible with this alternative.

Surface Water: The alternative involves the construction of several new bridges/ramps over the Naugatuck River to facilitate access between I-84 and Route 8. It is unknown at this time if there will be a need to place piers in the river to support the bridges/ramps. Additionally, a portion of the improvements are located within the 500-year floodplain of the Naugatuck River. The aforementioned improvements have the potential to affect surface water quality. A score of 1 is given.

Floodplains: Refer to the comments made for surface water. Because piers could be located in the floodway and/or the 100-year floodplain associated with the Naugatuck River, a potential exists for floodplain impacts. A score of 1 is given.

Hazardous Materials Risk Sites: Some of the work would occur within an industrially zoned section of Waterbury located along the eastern bank of the Naugatuck River and adjacent to a rail corridor. It is likely that contamination exists in this area. Compared to Preliminary Alternative #2, a much smaller portion of Preliminary Alternative #4 is located in the hazardous materials risk area, therefore, a lower level of potential impact is assigned to Preliminary Alternative #4 in the accompanying planning level impacts matrix.

Air Quality: Several intersections will likely have to be analyzed to determine the potential for air quality impacts given the new traffic circulation through the area. Impacts are not anticipated to be significant. A score of 4 is given.

Noise: Traffic will be located closer to homes in the residential area west of Chase Park and north of Sunnyside Avenue (but not as close as proposed under the Preliminary Alternative #3 concept) which could alter the existing noise environment by increasing noise levels in the area. Noise modeling in this area will need to be conducted to determine the nature of the impact. A score of 3 is given.

Socioeconomic Resources - Overall, this alternative will have a relatively low level of impacts on socioeconomic resources. Generally, scores of 4 are given with the exception of the following:

Property Takes: This alternative impacts the greatest number of non-residential structures, including churches, parking garages and commercial buildings. For this reason, this alternative was ranked as having the potential for the greatest amount of impact in terms of property takes. A score of 1 is given.

Visual and Aesthetics: The undertaking is a major construction activity that will occur over an extended period of time. There will be constant construction equipment and

activity in the area for many years into the future. Additional structure in the area will likely contribute to generally poor aesthetics and a score of 1 is given.

Full Build – Preliminary Alternative 5

Environmental Resources

Potential impacts to surface water, floodplains, wetlands, hazardous materials risk sites, air quality, and noise are possible with this alternative.

Surface Water: The alternative involves the demolition of several existing bridges/ramps over the Naugatuck River and the construction of several new bridges/ramps over the Naugatuck River to facilitate access between I-84 and Route 8. It is unknown at this time if there will be a need to place piers in the river to support the new bridges/ramps. Additionally, a portion of the improvements are located within the 500-year floodplain of the Naugatuck River. The aforementioned improvements have the potential to affect surface water quality.

Floodplains: Refer to the comments made for surface water. Because piers could be located in the floodway and/or the 100-year floodplain associated with the Naugatuck River, a potential exists for floodplain impacts.

Wetlands: It appears from the mapping that Preliminary Alternative #5 may affect a wetland located to the west of the new two way connection between West Main Street and Highland Avenue, designated as Improvement Area 16 on Figure 5 Sheet 1. Preliminary Alternative Concepts #3 and #4 also involve roadwork in this area but the work associated with those two alternative concepts appears to be entirely within the existing right-of-way, whereas the work area for Preliminary Alternative #5 appears to bow west into the wetland area. This impact could possibly be avoided upon refinement of the alternative but for this planning level analysis, a potential for minor impact is assumed. A score of 3 is given.

Hazardous Materials Risk Sites: Some of the work would occur within an industrially zoned section of Waterbury located along the eastern bank of the Naugatuck River and adjacent to a rail corridor. It is likely that contamination exists in this area. Compared to Preliminary Alternative #2, a much smaller portion (mainly pier footprints) of Preliminary Alternative #5 is located in the hazardous materials risk area, therefore, a lower level of potential impact is assigned to Preliminary Alternative #5 in the accompanying planning level impacts matrix. A score of 2 is given.

Air Quality: Several intersections will likely have to be analyzed to determine the potential for air quality impacts given the new traffic circulation through the area. Impacts are not anticipated to be significant. A score of 4 is given.

Noise: Traffic will be located closer to homes in the residential area west of Chase Park and north of Sunnyside Avenue (but not as close as proposed under the Preliminary

Alternative #3 concept) which could alter the existing noise environment by increasing noise levels in the area. Traffic patterns in the vicinity of the neighborhood to the southeast of Home Depot will also be altered. Noise modeling in these areas will need to be conducted to determine the nature of impacts. Because of the potential to also affect noise receptors located southeast of the Home Depot, Preliminary Alternative Concept #5 is ranked as having a slightly higher potential for noise impact than Preliminary Alternative #4 but less than Preliminary Alternative #3. A score of 2 is given.

Socioeconomic Resources - There will likely be some level of impact to most of the socioeconomic resource categories from this alternative. In general, scores of 3 are given. Potentially larger or more noticeable impacts may occur with respect to residential property, visual and aesthetic resources, historic resources, Section 4(f) resources, and community and institutional resources. These impacts are as follows:

Residential Property Takes: This alternative will result in direct impacts to a few houses located just east of Chase Park and west of the Naugatuck River. The impact is not as severe as that potentially associated with Preliminary Alternative #3. A score of 2 is given.

Visual and Aesthetics: The undertaking is a major construction activity that will occur over an extended period of time. There will be constant construction equipment and activity in the area for many years into the future. The existing transportation infrastructure – namely the stacked highway across the Naugatuck River - will be replaced by new infrastructure that will drastically change views in the area. Whether these changes are beneficial will depend on the architectural design of the new structure. Since it is assumed that a lower profile structure will be constructed, the positive aesthetic impacts will generally outweigh the negative visual impacts due to construction activities and a score of 4 is given.

Historic Resources: The alternative has the potential to indirectly affect the Bank Street National Register Historic District as well as a nearby potentially eligible historic structure. These historic resources will need to be evaluated in more detail and coordination with SHPO will be necessary in order to determine the nature of the impact. A score of 2 is given.

Section 4(f) Resources: The alternative will result in a direct impact to Chase Park. The new Route 8 SB ramp from the new I-84 EB mainline is proposed to pass right through the athletic fields associated with the Park. There may also be some constructive use impacts to the historic resources mentioned above, which are also Section 4(f) resources. This alternative will likely require a full Section 4(f) Evaluation and extensive coordination with the FHWA. A score of 1 is given.

Community and Institutional Resources: Refer to the discussion relative to Section 4(f) impacts to Chase Park. A score of 1 is given.

Table 4-2 lists the composite scores used in the decision matrix.

Table 4-2: Composite Scores for Environmental Criterion

Issue	No Build	TDM/TSM/ Transit	Circulation/ Operations/ Safety	Partial Build 1 New Westbound	Partial Build 2 New Eastbound	Full Build
	Alternatives					
Residential Property Takes	5	5	4	1	1	2
Environmental Justice	3	5	5	4	4	3
Visual/Aesthetic Resources	5	5	5	2	1	4
Historic Resources	5	5	5	5	4	2
Public 4(f) and 6(f) Lands	5	5	4	5	4	1
Community and Institutional Resources	5	5	5	5	4	1
Socioeconomic Rating Average	**4.7**	**5.0**	**4.7**	**3.7**	**3.0**	**2.2**
Surface Water	5	5	4	1	1	1
Groundwater	5	5	5	5	5	5
Floodplains	5	5	4	1	1	1
Public Water Supplies	5	5	5	5	5	5
Wetlands	5	5	5	3	5	3
Endangered Species	5	5	5	5	5	5
Hazardous Materials Risk Sites	5	5	1	2	2	2
Farmland Soils	5	5	5	5	5	5
Air Quality	1	1	3	4	4	4
Noise	1	2	3	1	3	2
Environmental/Natural Resource Average	**4.2**	**4.3**	**4**	**3.2**	**3.6**	**3.3**
ROUNDED AVG SOCIOEC & ENVIRONMENT	**4**	**5**	**4**	**3**	**3**	**3**

Source: Fitzgerald and Halliday, Inc.

4.3.5 Safety/Meets Design Standards.

For the safety/meets design standards criterion, the higher the score given translates to the lower the negative impact.

The safety of a roadway has much to do with the standards by which it has been designed. When I-84 was designed almost 50 years ago, design standards were different than they are today. The volume of traffic that the highway was expected to carry was far less than is realized today. In addition, the standards for ramp spacing and other geometric conditions were less stringent. The result of these factors is that highway safety is compromised because the design of the highway could not anticipate the complexities that today's traffic levels brings.

The rating for this criterion was based on the number of geometric and safety deficiencies addressed by each of the alternatives. Preliminary Alternative 1 is similar to the No Build condition with few or minimal geometric changes on I-84 and therefore, these alternatives do not directly address deficiencies on the interstate itself. A score of 1 is given.

Preliminary Alternative 2 is slightly improved over Preliminary Alternative 1 because of the elimination of the Interchange 22 eastbound exit ramp. The close spacing of the Interchange 21 and 22 exit ramps contributes to the safety deficiencies along this segment of I-84. A score of 2 is given.

Preliminary Alternatives 3 and 4 are similar in that they both separate local and through traffic by creating a C/D road system to complement the freeway mainlines. Eliminating the weaving movements that result from the mix of local and through traffic should have

significant benefits to safety; however, not all of the substandard roadway geometry could be corrected under these two alternatives. Scores of 3 are given to both.

Preliminary Alternative 5 (Full Build) addresses the most deficiencies stated in the Deficiencies and Needs Technical Memorandum, as least along I-84. A score of 5 was given.

Table 4-3 lists the deficiencies that are addressed by each of the five preliminary alternatives. A composite score was determined and is listed at the end of the table. This score was used in the decision matrix presented later in this chapter.

4.3.6 Connectivity

Preliminary Alternative 2 improves local connections within Waterbury and consists of new roadways and intersections in the downtown along with two new connector roads. Preliminary Alternative 1 improves transit connectivity and signal timing in the downtown area but does not provide new local road connections. Preliminary Alternative 4 provides better connectivity than the No-Build with the use of collector-distributor (C/D) roads along I-84, but some of the ramp connections from I-84 eastbound to the downtown (Meadow Street) are eliminated. Preliminary Alternatives 3 and 5 have new C/D roads serving the downtown area and the local access to Meadow Street, Bank Street, and South Main Street is maintained. In addition, Preliminary Alternatives 3 and 5 have a new two-way connector road between Meadow Street and South Main Street to improve circulation.

4.3.7 Economic Development

The Naugatuck Valley Development Corporation has economic development initiatives near the Jackson Street and Freight Street corridors. This initiative would be best served by Preliminary Alternative 2, which was given a ranking of 5. Preliminary Alternative 5 also supports economic development in the downtown area by rebuilding the I-84/Route 8 structure and approaches on I-84 and improving access and circulation. Preliminary Alternatives 3 and 4 involve partial build of the interchange and therefore, are not highly rated in this category. Preliminary Alternative 1 was given a ranking of 2 due to improvements to bicycle, pedestrian and transit access.

4.3.8 Intermodal Connections

This criterion is addressed most thoroughly by Preliminary Alternative 1, mainly due to the improved bicycle, pedestrian and transit connections made throughout the study area. Preliminary Alternative 2 shows improved pedestrian facilities along Riverside Street, West Main Street, and Freight Street; therefore, it was given a rating of 3. Preliminary Alternatives 3, 4, and 5 improve access into downtown and consequently are all given rankings of 2.

Table 4-3: Geometric Deficiencies Addressed by Preliminary Alternatives

Substandard Condition	Highway & Direction	Area of Interest	Deficiency Addressed By:				
			Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
Ramp Grades	I- 84 Westbound	Interchange 21 exit ramp					✓
	I- 84 Westbound	Interchange 19 entrance ramp				✓	✓
	Route 8 Southbound	Interchange 31 entrance ramp					
Ramp Superelevation	Route 8 Northbound	Interchange 31 exit ramp to I-84			✓	✓	✓
	I-84 Westbound	Interchange 20 to Route 8			✓		✓
Entrance Ramp Acceleration Length	I-84 Eastbound	Interchange 20 Entrance Ramp (right)			✓	✓	✓
	I-84 Westbound	Interchange 21 Entrance Ramp (left)			✓		✓
	I-84 Westbound	Interchange 21 Entrance Ramp (right)					✓
	I-84 Eastbound	Interchange 22 Entrance Ramp			✓	✓	✓
	I-84 Westbound	Interchange 22 Entrance Ramp					✓
	Route 8 Southbound	Interchange 31 Entrance Ramp from Riverside St.					
Exit Ramp Deceleration Length	I-84 Westbound	Interchange 20 Exit ramp			✓	✓	✓
	I-84 Eastbound	Interchange 21 Exit ramp to South Main Street			✓		✓
	I-84 Westbound	Interchange 22 Westbound Exit ramp					✓
Interchange Ramp Spacing	I-84 Eastbound	Interchange 18 Entrance Ramp to Interchange 19 Exit Ramp (Right Ramp)			✓		✓
	I-84 Eastbound	Interchange 19 Exit Ramp (on Right) to Interchange 19 Exit Ramp (Left Ramp)			✓	✓	✓
	I-84 Eastbound	Interchange 19 Entrance Ramp to Interchange 20 Entrance Ramp (Left Ramp)			✓	✓	✓
	I-84 Eastbound	Interchange 20 Entrance Ramp (Left Ramp) to Interchange 20 Entrance Ramp (Route 8 NB)					✓
	I-84 Eastbound	Interchange 20 Entrance Ramp (Route 8 NB) to Interchange 21 Exit Ramp (Meadow St)			✓	✓	✓
	I-84 Eastbound	Interchange 21 Exit Ramp (Meadow St) to Interchange		✓	✓	✓	✓

Substandard Condition	**Highway & Direction**	**Area of Interest**	**Deficiency Addressed By:**				
			Alt. 1	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**
		22 Exit Ramp (South Main St)					
Interchange Ramp Spacing	I-84 Eastbound	Interchange 22 Entrance Ramp to Interchange 23 Exit Ramp			✓	✓	✓
	I-84 Westbound	Interchange 21 Entrance Ramp (from Right) to Interchange 21 Entrance Ramp (Left Ramp)			✓		✓
	I-84 Westbound	Interchange 21 Entrance Ramp (from Left) to Interchange 20 Exit Ramp			✓		✓
	I-84 Westbound	Interchange 20 Exit Ramp to Interchange 19 Exit Ramp			✓		✓
	I-84 Westbound	Interchange 19 Entrance Ramp (from Left) to Interchange 19 Entrance Ramp (Right Ramp)				✓	✓
	Route 8 Northbound	Interchange 30 Entrance Ramp to Interchange 31 Exit Ramp					
	Route 8 Northbound	Interchange 31 Exit Ramp to Interchange 32 Exit Ramp					
	Route 8 Northbound	Interchange 32 Exit Ramp to Interchange 33 Exit Ramp (Left Ramp)					
	Route 8 Northbound	Interchange 33 Entrance Ramp (84 WB) to Interchange 33 Entrance Ramp (84 EB)					
	Route 8 Northbound	Interchange 33 Entrance Ramp (84 EB) to Interchange 33 Entrance Ramp (Riverside St)					
	Route 8 Northbound	Interchange 34 Entrance Ramp to Interchange 35 Exit Ramp					
	Route 8 Southbound	Interchange 35 Entrance Ramp to Interchange 34 Exit Ramp					
	Route 8 Southbound	Interchange 33 Exit Ramp to Interchange 32 Exit Ramp					
	Route 8 Southbound	Interchange 32 Exit Ramp to Interchange 31 Exit Ramp					
	Route 8 Southbound	Interchange 31 Entrance Ramp (from I-84 EB) to Interchange 31 Entrance Ramp (from Riverside St)					

Substandard Condition	**Highway & Direction**	**Area of Interest**	**Deficiency Addressed By:**				
			Alt. 1	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**
Interchange Ramp Spacing	Route 8 Southbound	Interchange 31 Entrance Ramp (from Riverside St) to Interchange 31 Entrance Ramp (from I-84 WB)					
Mainline Lane Discontinuity	I-84 Eastbound	Interchange 19 Exit Ramp (to Route 8 SB)			✓		✓
	I-84 Eastbound	Interchange 21 Exit Ramp (to Meadow St.)			✓		✓
	I-84 Westbound	Interchange 20 Exit Ramp				✓	✓
	I-84 Westbound	Interchange 19 Exit Ramp				✓	✓
	I-84 Westbound	Interchange 18 Exit Ramp				✓	✓
	Route 8 Northbound	Interchange 31 Exit Ramp					
	Route 8 Southbound	Interchange 34 Exit Ramp					
	Route 8 Southbound	Interchange 32 Exit Ramp (Left Ramp)					
Left-Hand Ramps	I-84 Eastbound	Interchange 19 exit ramp			✓	✓	✓
	I-84 Eastbound	Interchange 20 entrance ramp			✓	✓	✓
	I-84 Westbound	Interchange 19 entrance ramp				✓	✓
	I-84 Westbound	Interchange 21 entrance ramp			✓	✓	✓
	Route 8 Northbound	Interchange 33 exit ramp					
	Route 8 Northbound	Interchange 33 entrance ramps (from I-84 eastbound and I-84 westbound)					
	Route 8 Southbound	Interchange 31 exit ramp					
	Route 8 Southbound	Interchange 32 exit ramp					
Shoulder Width	I-84 Eastbound	Interchange 19 Exit Ramp to Interchange 19 Entrance Ramp			✓		✓
	I-84 Eastbound	Interchange 20 Entrance Ramp (from Route 8 NB) to Interchange 21 Exit Ramp (to Meadow St)			✓		✓
	I-84 Eastbound	Interchange 22 Exit Ramp to Interchange 23 Exit Ramp			✓		✓
	I-84 Westbound	Interchange 22 Entrance Ramp to Interchange 19 Exit Ramp				✓	✓

Substandard Condition	**Highway & Direction**	**Area of Interest**	**Deficiency Addressed By:**				
			Alt. 1	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**
Shoulder Width	I-84 Westbound	Interchange 18 Exit Ramp to Interchange 18 Entrance Ramp				✓	✓
	Route 8 Northbound	Interchange 30 Entrance Ramp to Interchange 31 Exit Ramp					
	Route 8 Northbound	Interchange 32 Exit Ramp to Interchange 31 Entrance Ramp					
	Route 8 Southbound	Interchange 31 Entrance Ramp to Interchange 30 Exit Ramp					
		Composite Score	**1**	**2**	**4**	**3**	**5**

4.3.9 Traffic Operations/Capacity Accommodation

For the Traffic Operations/Capacity Accommodation criterion, freeway segments, weave areas and ramp junctions with LOS E and LOS F were identified as traffic operational deficiencies. The number of operational deficiencies for each preliminary alternative was collated and used as a basis of ranking the alternatives. For this criterion, a higher score translates to a positive impact.

Preliminary Alternative 1 does not result in any highway operational improvements from the No Build condition. In all, there would be 29 traffic operational deficiencies under this alternative. Since Alternative 1 has the highest number of traffic operational deficiencies, this alternative is given the lowest ranking of 1.

Preliminary Alternative 2 would not result in any operational improvements to the I-84 mainline. The number of operational deficiencies identified under this alternative would be 29 and is therefore also given a ranking of 1.

Preliminary Alternative 3 results in some traffic operational improvements on I-84 particularly in the eastbound direction. The total number of traffic operational deficiencies recorded under this alternative would be 23. This alternative is therefore given a score of 2.

Preliminary Alternative 4 results in some traffic operational improvements on I-84 particularly in the westbound direction. There are a total of 10 deficiencies identified under this alternative which translates to a score of 4.

Preliminary Alternative 5 results in only 3 operational deficiencies on I-84. Since Alternative 5 has the fewest number of deficiencies, this alternative is given the highest ranking of 5.

The final result of the effort for ranking alternatives is found in Table 4-4 below.

Table 4-4: Traffic Operations and Capacity Ranking

	Number of Deficiencies			
	No Build/Alt 1/Alt 2	Alt 3	Alt 4	Alt 5
LOS F	29	14	8	1
LOS E	2	9	2	2
Total	31	23	10	3
Rank (1 to 5)	**1**	**2**	**4**	**5**

Table 4-5: Decision Matrix for I-84/Route 8 Interchange Preliminary Alternatives

Grading Criteria	Criteria Relative Weighting (1-5)	No Build		Preliminary Alternative 1: TDM/TSM/ Transit		Preliminary Alternative 2: Circulation/ Operations/ Safety		Preliminary Alternative 3: Partial Build 1 New Westbound		Preliminary Alternative 4: Partial Build 2 New Eastbound		Preliminary Alternative 5: Full Build	
		Rating (1-5)	Weighted Rating	Rating (1-5)	Weighted Rating	Rating (1-5)	Weighted Rating	Rating (1-5)	Weighted Rating	Rating (1-5)	Weighted Rating	Rating (1-5)	Weighted Rating
Construction Cost	3	5	15	5	15	4	12	2	6	2	6	1	3
Life Cycle Cost	4	1	4	1	4	1	4	3	12	2	8	5	20
Constructability	4	5	20	5	20	5	20	1	4	1	4	3	12
Environmental Impact	3.5	4	14	5	17.5	4	14	3	10.5	2	7	3	10.5
Safety/Meets Design Standards	5	1	5	1	5	2	10	3	15	3	15	5	25
Connectivity	4	1	4	1	4	5	20	4	16	4	16	4	16
Economic Development	3.5	1	3.5	2	7	5	17.5	3	10.5	3	10.5	4	14
Intermodal Connections	3	1	3	5	15	3	9	2	6	2	6	2	6
Traffic Operations / Capacity Accommodation	4.5	1	4.5	2	9	2	9	3	13.5	4	18	5	22.5
Total Scores		73		96.5		115.5		93.5		90.5		129	
Ranking of Alternatives		6		3		2		4		5		1	

5 Conclusions

5.1 Screening of Preliminary Alternatives

The matrix presented in the previous chapter is intended to synthesize all of the analyses performed on each of the preliminary alternative concepts and suggest a ranking for use in selecting three concepts for more detailed analyses. The matrix was set up to reflect the stated purpose and need of the study by using criteria that related to measurable goals and objectives. The matrix is a tool that should be used as a general guideline only. Ultimately the entire study team should determine, through careful consideration of the information gathered and analyzed in this study, the Preliminary Alternatives that best satisfy the goals and objectives of the study. The ranking delivered by this analysis, from highest to lowest, is as follows:

1. Preliminary Alternative 5 – Full Build
2. Preliminary Alternative 2 – Safety and Operational Improvements
3. Preliminary Alternative 4 – Partial Build (New I-84 Westbound Mainline)
4. Preliminary Alternative 3 – Partial Build (New I-84 Eastbound Mainline)
5. Preliminary Alternative 1 – TSM/TDM/Transit
6. No-build

Based on the ratings given for each criterion, Preliminary Alternative 5 came out as the top ranking alternative. This had much to do with the alternative's ability to strongly satisfy the safety and traffic operations criteria, which were recognized by the study team as high priority objectives. In addition, a completely new structure carrying I-84, while costly to construct, would offer much lower maintenance costs over the total life of the structure. Improving the substandard geometric conditions and providing additional capacity to handle traffic demand should have a positive influence on economic development within the city, the region, and because I-84 is a vital link for interstate freight movement, the state in general.

Preliminary Alternative 2 is the second highest ranked alternative, which has much to do with the fact that improved connectivity and resulting positive local economic development can be achieved with relatively low capital investment. This alternative would also likely have very little environmental impact associated with any new construction on local roadway connections.

Preliminary Alternative 4 ranked third due to the added capacity and improved traffic operations. The separation of local and through traffic movements will have a very positive impact on the safety and capacity of the system; however, it is unlikely that the existing eastbound 2-lane constraint will be able to be improved under this alternative. In most other cases, Preliminary Alternative 4 performs similarly to Preliminary Alternative

3, although the life cycle cost would be slightly higher due to the additional existing structures that would need to be maintained into the future.

Preliminary Alternative 3 ranked the fourth highest amongst the five preliminary alternatives. This alternative did not prove to be exceptionally strong in any particular area, although it did receive a good balance between cost and performance. The construction of a new eastbound structure and C/D road system corrects a good number of deficient ramps, replaces the poorly rated bridge span over the Naugatuck River, adds capacity where it is needed the most (eastbound), and is generally less costly than building a completely new interchange.

Preliminary Alternative 1 ranked the lowest of the five alternatives. The expansion of transit services and improved bicycle and pedestrian connections alone does very little to meet the purpose and need of the study. That is not to say however that these improvements are not important. These types of improvements would be best paired with a major interchange improvement to enhance the intermodality of the transportation system and provide more travel options to customers.

The No-build scenario was added to the matrix to determine what ranking might be achieved by leaving the transportation system the way it is today, with continued maintenance as needed. It is clear that the No-Build scenario would not address the purpose and need for this initiative, and is the least desirable outcome of this study. The age of the existing structure translates to increasing maintenance costs as the years go by; therefore, a no-build scenario does not imply that the state will avoid a major investment. As traffic demand increases over the next 25 years, the existing transportation system's weaknesses will be fully exploited and chronic congestion and impaired safety will be a major dilemma.

5.2 Next Steps

The next step in the study process is to further develop three alternatives, adding detail in terms of physical layout constructability, traffic operations, environmental impact, cost estimating and visualization. Although the No Build scenario ranks the lowest with regard to addressing the study purpose and need, it is essential that it be carried forward in the analysis. The reason for including the No Build scenario in the overall analysis of alternatives is two-fold: first, the No Build is a benchmark in terms of performance by which all alternatives are measured against; and second, the No Build scenario is a requirement of NEPA/CEPA (National Environmental Policy Act of 1969 and Connecticut Environmental Policy Act) which is a federal mandate that will assess the environmental impacts associated with any transportation alternative recommended by this study process.

At this time, at least two logical choices for alternatives to advance to the next phase are evident. In addition to the No Build scenario, the top two alternatives are as follows:

1. Preliminary Alternative 5 (Full Build) because it is the highest ranking alternative and generally addresses the purpose and need of the study;

2. A combination of Preliminary Alternatives 1 and 2 because Preliminary Alternative 2 ranked second highest and the components of Preliminary Alternative 1 are naturally complementary, addressing non-motorized transportation and transit;

According to the decision matrix, Preliminary Alternative 4 is the third likely candidate for advancement to the next phase of the study. When comparing Preliminary Alternative 3 to Preliminary Alternative 4, the rankings produced are very similar with Preliminary Alternative 4 ranking slightly higher. However, a structural review conducted as part of this study revealed a number of problems related to the reuse of existing substructure and superstructure. First, the existing viaduct is a non-redundant structure, meaning a single failure, such as a fatigue crack in a weld, could cause the total collapse of at least a portion of the structure. Secondly, the arrangements of piers that carry the I-84 superstructure prevent optimal reconstruction of ramps by restricting the clearance necessary to accommodate these structures. Thirdly, some of the existing structure is rated poorly and must undergo periodic repair to keep it in safe operating condition. ConnDOT has a continuing program for the maintenance of bridges, and the annual costs of this program are substantial. Lastly, the existing structures do not lend themselves to expansion. This means that rotational forces introduced by reconnecting ramps or additional lanes could exceed safe limits and cause the entire structure to fail. For these three reasons, it is not recommended that either partial build alternative be advanced to the next phase of the study.

It is recommended that Preliminary Alternative 5 be used as a basis for developing a full build concept. Further evaluation will be conducted to develop the specifics of such an alternative and it is envisioned that a majority of the existing structure would be eliminated. The full build concept, as further developed, may have some significant differences in the way the interchanges are configured, how Route 8 deficiencies are addressed, and possibly even the way the I-84 mainline is constructed. Consequently, a full build alternative will be evaluated in more detail in the next phase of this study to develop a plan that is practical, implementable and would address the multitude of deficiencies stated in the study purpose and need.

In summary, the analysis performed to date has revealed that the alternatives that should be considered for advancement to the next phase are as follows:

- No Build (leave the system as it exists today);
- A combination of TDM/TSM/Transit and Safety and Operational Improvements (Preliminary Alternatives 1 and 2); and,
- Full Build Concept (some form of Preliminary Alternative 5).

Based on the preliminary screening analysis, a full rebuild of the I-84/Route 8 Interchange appears to be the preferred alternative for the following reasons:

- High number of accidents on I-84;
- Substandard geometric condition on mainline and ramps;
- Poor operating conditions on the system in 2030 due to forecasted increases in traffic;
- Poor condition of the structures supporting the roadway;
- Inability of the system to accommodate capacity expansion; and
- High cost of future maintenance of the system.

Further discussions and workshops will take place to determine the specifics of each alternative and to work out the remaining issues at a conceptual level. The study team will then take several months to gain a more in-depth understanding of the structural and operational issues of each alternative. A detailed analysis would be important in assessing the ability of each alternative to address the following goals identified at the beginning of the study;

- Improve Safety at the Route 8/I-84 Interchange;
- Address operational and structural deficiencies;
- Accommodation of future traffic growth; and
- Financial feasibility.

Simulation modeling will be used to get a real-world approximation of traffic flow through the system. Photosimulation and 3-dimensional rendering will be used to demonstrate the horizontal and vertical relationships of the various structural element of the system. A more detailed environmental impact review will take place once the configuration is defined. Finally, conceptual engineering and refined cost estimation will be performed to better understand the constructability and financial feasibility of each alternative.