2.4 Existing Traffic Operations

The existing traffic operations within the Traffic Analysis Study Area have been analyzed and documented to identify deficiencies and establish a baseline condition against which future conditions can be evaluated.

2.4.1 Background

Traffic flow, whether for cars, bicycles, or pedestrians, is characterized by metric called Level of Service (LOS). LOS is a quantitative score that goes from A to F. LOS A represents the best operating conditions or a free-flow system; LOS F represents the worst conditions or a congested system. In general, roadways are designed for LOS C. When the LOS falls below a C, travel speeds begin to drop and the mobility of a facility is degraded.

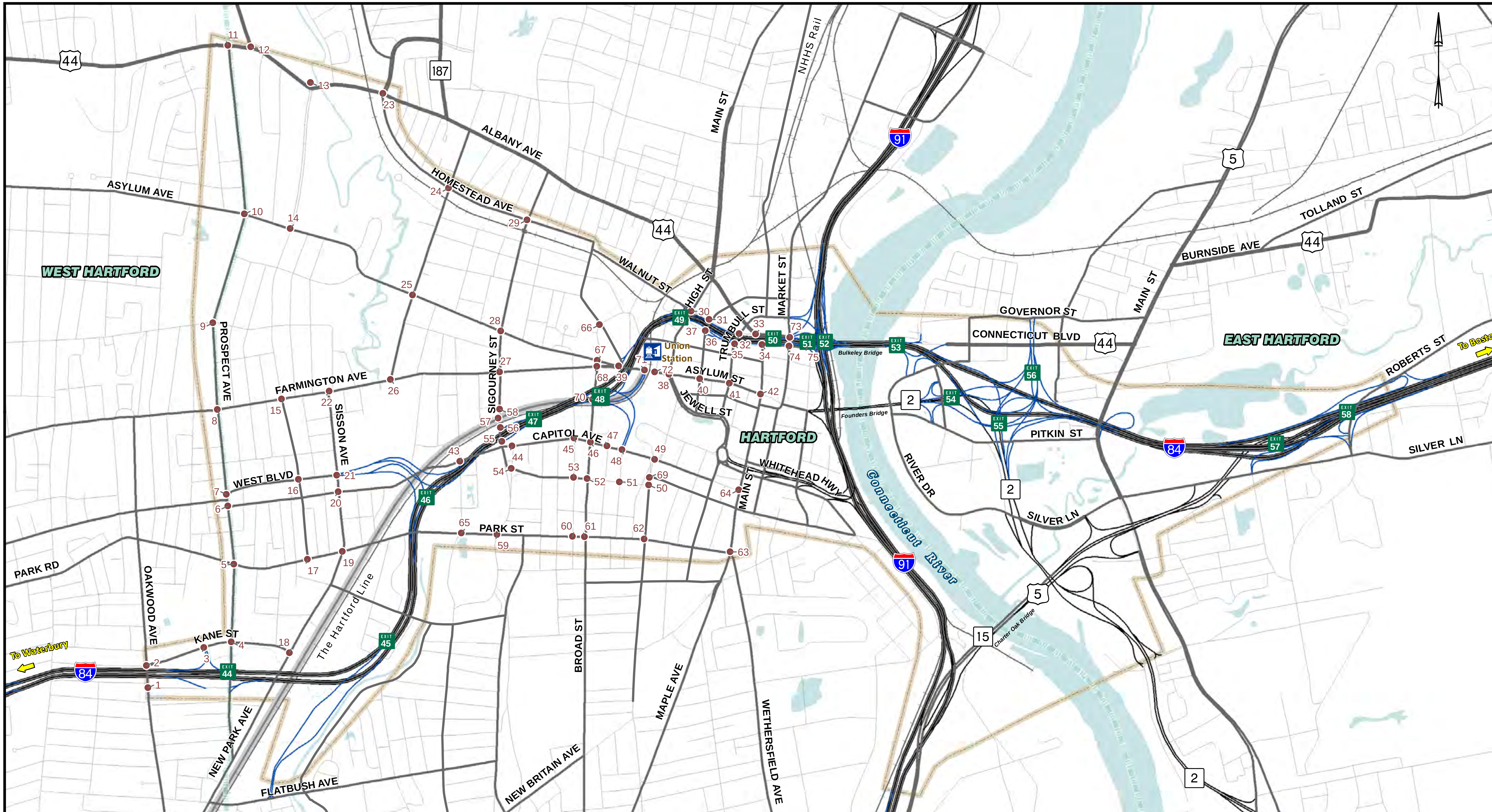
Level of Service is not the only metric used to rate road segments, but it is the most commonly used among transportation professionals since it can be applied to any type of transportation facility. On freeways, LOS is determined by the density of vehicles. At intersections, LOS is determined by the amount of delay a driver will experience on average. Freeway and intersection levels of service are the focus of this analysis.

2.4.2 Methodology / Criteria

Due the complexity of vehicle interactions within the study area, the analysis of existing traffic operations required the use of three different software suites: PTV Vissim 6.0, an in-depth microsimulation and visualization tool for all roadway classes; Trafficware Synchro 8 and SimTraffic 8, a macroscopic HCM-based intersection analysis tool and microsimulation intersection analysis tool, respectively; and McTrans HCS 2010, a macroscopic text-based program that uses Highway Capacity Manual (HCM) equations to derive freeway and ramp levels of service. Each software package has strengths and limitations, which are discussed below. An HCM-based approach is required by both the State and Federal Departments of Transportation.

The three different traffic models include different elements within the Traffic Analysis Study Area. The Vissim model focuses on the interactions between I-84 and major signalized intersections near the freeway. This model includes I-84 throughout the Traffic Analysis Study Area, all I-84 interchange ramps, and any local intersections that can be expected to back up onto the freeway or meter on-ramp traffic. All major signalized intersections and major east-west routes (non-freeway) within the Traffic Analysis Study Area were modeled using Synchro. The Traffic Analysis Study Area and intersections modeled using Synchro are illustrated in Figure 2-33, following. HCS analysis was undertaken for every freeway within the Traffic Analysis Study Area: I-84, I-91, CT 2, and CT 15.

As described in Section 2.2: Existing Traffic Data, accurate volumes, speeds, and origin-destination matrices are essential to traffic modeling. Obtaining this data for such a large study area presents a tremendous challenge. Direct measurements such as SkyComp (origin-destination matrices) and manual



LEGEND

- Synchro Study Intersection
- CTfastrak
- Railroad
- Traffic Analysis Area
- Town/City Limit
- Water
- I-84 Exit #
- Interstates
- I-84 Ramp
- Other Freeway
- Major Road
- Local Road

0 1,000 2,000 Feet

Sources of Data: City of Hartford, ESRI
http://www.ctfastrak.com/

The I-84 Hartford Project

Synchro Study Intersection Location Map

Date: 7/17/2015	Drawn By: TranSystems	Figure No: 2-33

turning counts provide a snapshot of a single day's traffic but there is no such thing as a typical day in the study area. A traffic crash anywhere in the region will impact traffic. Weather, construction, day of week, and time of year all play a role in traffic patterns. To ensure consistent results, correction factors from historical CTDOT's Traffic Monitoring Volume Information were developed and applied to field-measured counts.

As the manual turning counts were taken on different days, their traffic volumes do not always match on an intersection by intersection basis. In one case, there was a discrepancy of 190 vehicles between two adjacent intersections, a difference of nearly 30%. In cases like this, CTDOT Office of Planning 2013 turning counts, done as part of the CT*fastrak* project, were used to balance volumes. Similarly, SkyComp origin-destination data does not correspond exactly with the known freeway and ramp volumes, although it is generally close. The SkyComp results were balanced using the CDM Smith balanced count profile.

2.4.3 Vissim 6.0 Analysis

Overview

PTV Vissim is a multimodal four-dimensional microsimulation program based on an empirical driver behavior model. Version 6.00 was chosen because of its robust data collection abilities, improved interface, and because it was the most current version available at the time the model was created.

Strengths

Vissim is a powerful tool, capable of modeling the interaction of multiple modes of travel and classes of roadway. Unlike macrosimulation tools, Vissim models each vehicle or pedestrian, which allows for a level of detail conducive to photorealistic simulations. The software includes versatile signal controllers, customizable vehicle models and behavior, and video recording capabilities. It takes the grade of each road segment into account, along with the acceleration and braking characteristics of individual vehicles, to accurately model traffic speeds.

Unlike Synchro and HCS, which analyze traffic flow on a segmental basis, Vissim uses origin-destination data to better simulate weaving, lane use, and queuing. A vehicle entering the network will choose a route to its destination, much like a real driver, and will maneuver into the appropriate lane as far in advance of a turn as the modeler specifies.

Because each road segment is connected to and interacts with adjacent segments, congestion occurs in Vissim much the same as it does in reality. A bottleneck at one point will result in queues building upstream and reduced volumes downstream. Freeway congestion can affect secondary streets, and vice versa.

Limitations

Because Vissim is a stochastic program, multiple runs of the same model will produce varying results. It is critical to run each scenario multiple times and avoid outliers. Since the Vissim simulation is one connected network of roads, origin-destination data is essential in order to accurately model multi-lane roadways. Accurate speeds, vehicle distributions, and roadway geometry are also critical. Preparing the model itself is similarly time-consuming; a large model, containing miles of roadway, can take months or years for an engineer to build and calibrate. Traffic signals are especially hard to model, since there is no way to optimize timings or phasing, and the signal controller can only update once per second.

The non-deterministic nature of Vissim means that it does not comply with the HCM methodologies for freeway or intersection capacity. While it is possible to derive LOS from Vissim results, it will not necessarily be the same LOS that Synchro or HCS produces.

Finally, while Vissim is extraordinarily detailed, the intrinsic limits of microsimulation make it impossible to produce an exact replica of real-world traffic flow. Static vehicle routes mean that vehicles will follow their chosen route regardless of congestion. Rather than a continuously variable arrival rate, vehicle inputs are grouped into discrete time periods. Simulated driving behaviors, while advanced, do not replicate real-world drivers.

Vissim Model Development

The model's road network was drawn to scale on a geo-referenced background, using elevation data from the original I-84 construction plans, where available, and from Google Earth elsewhere. For the road network, the modeling limits extend beyond the Project Study Corridor so that queues would have more room to build, and vehicles had more distance to get in their preferred lanes. In the eastbound direction, I-84 is modeled from the Kane Street on-ramp past the Bulkeley Bridge, with a terminus just east of the off-ramp to Roberts Street (Exit 58). I-84 westbound is modeled from east of the Roberts Street on-ramp and extends to the Kane Street off-ramp (Exit 44).

The Vissim model also includes a detailed analysis of twelve signalized intersections and three unsignalized intersections at and near I-84 ramp termini. These intersections occasionally produce queues that impact traffic on I-84, and vice versa. The roadway network includes segments of I-91, Route 2, and Route 15; these freeways were included for potential future analysis of any alternatives that directly affect them. Although shoulders, parapets, and gore areas do not affect driver behavior in Vissim, they were included in the model to show edge-of-road and available space for maintenance and protection of traffic during construction. Bridge piers and abutments were added in critical locations such as the I-84 / I-91 interchange, as they are significant constraints to the highway geometry. Overhead signage, luminaires, and three-dimensional building models contribute to the model's visual accuracy and provide reference points when viewing the simulation.

On I-84 itself, speed decisions were placed on each segment of the freeway to match INRIX off-peak speed data. Reduced speed areas were placed around corners and curves. Along with the CTDOT standard speed distributions, 28 new distributions were added for speeds of 5 to 70 miles per hour. As previously noted, speeds in Vissim also depend on grade and vehicle power. CTDOT standard vehicle distributions, including weight and power, were used without modification.

Traffic control signals were coded with Synchro signal phasing, timings, coordination, and turning volumes. In total, twelve signalized intersections were modeled independently in Vissim, maintaining the same volumes and cycle lengths derived in Synchro. The three closely spaced intersections on Sigourney Street at I-84 were modeled using a single controller with nonstandard phasing, as exists in the field. Additional calibration was performed at the intersection of Asylum Street, Asylum Avenue, Farmington Avenue, Spring Street, and Garden Street, since Synchro had difficulty producing a model that could replicate real-world results.

Vissim Model Results and Conclusion

After careful calibration, traffic flow in the Vissim model closely matched conditions observed in the field.

Vissim Model Speed Results

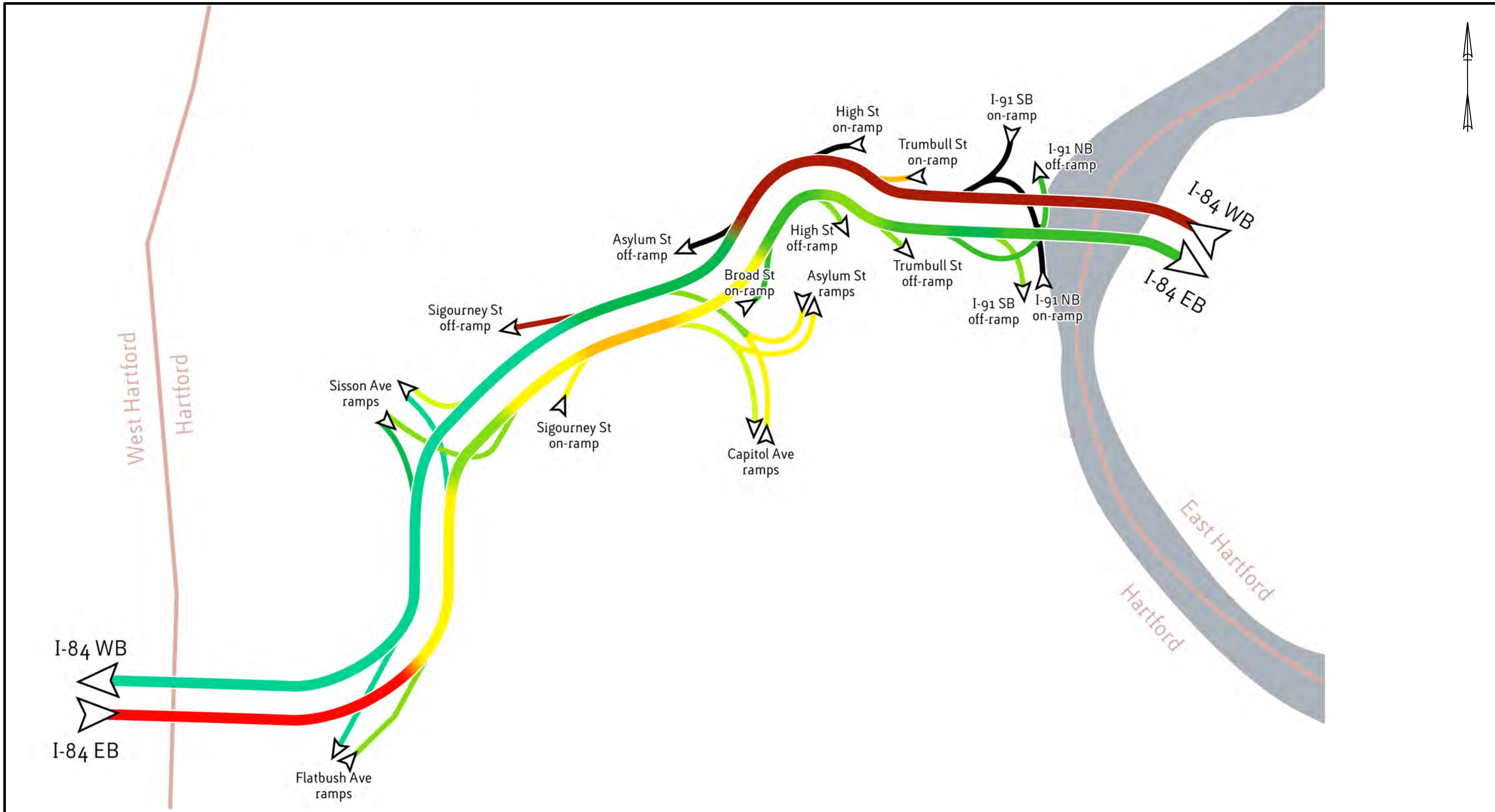
Average speeds for I-84 in Hartford in the morning and afternoon peaks are shown in Figure 2-34Figure 2-34, following, and Figure 2-35Figure 2-35, page 2-90, respectively. Note that speeds were collected lane-by-lane in 100-foot segments; while these diagrams summarize average speeds along a segment, like INRIX, more detailed data is also available. Speeds for the entire corridor are provided in Appendix A.2.8. More detailed results are provided in Appendix A.2.15.

In the morning peak, eastbound traffic is slowed west of the Flatbush Ave on-ramp. Speeds around 20 mph dominate in this area. The weave section between the Sigourney Street on-ramp and Exits 48A and 48B exhibits an average speed of 30 mph. Past this point, speeds quickly recover to uncongested levels.

Westbound traffic is very slow through East Hartford, hovering around 15 mph through the I-91 interchange and only increasing past the Asylum Street off-ramp (Exit 48). While the rightmost lane, a lane drop to Sigourney Street (Exit 47), remains congested, the adjacent lanes begin to move smoothly and speeds reach 60 mph soon thereafter.

Screenshot of Vissim Modeled Roadway

In the afternoon, average speeds are slower than in the morning. Eastbound traffic is backed up from West Hartford through Hartford, only improving marginally after crossing the Connecticut River. Westbound traffic is heavy throughout East Hartford and Hartford, only beginning to improve past the Flatbush Avenue off-ramp (Exit 45). Conditions at the I-91 interchange appear better in the model than in reality; this is due to the



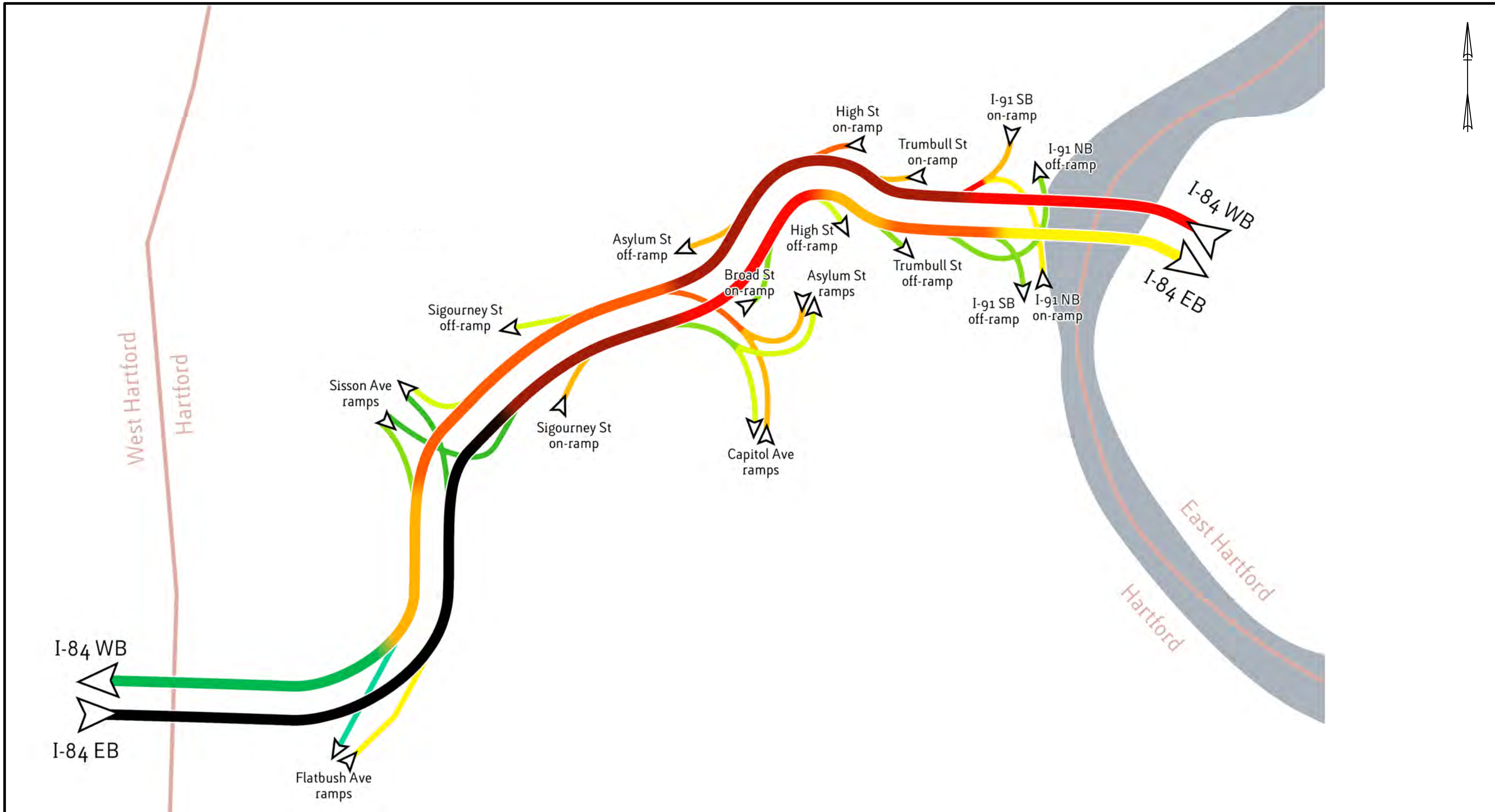
LEGEND

60 mph - 50 mph - 40 mph - 30 mph - 20 mph - 10 mph -
- 65 mph - 55 mph - 45 mph - 35 mph - 25 mph - 15 mph - 5 mph

The I-84 Hartford Project

Existing (2012) Vissim Average Speed Map – AM Peak

Date: 5/19/2014	Drawn By: TranSystems	Figure No: 2-34



LEGEND

60 mph - 50 mph - 40 mph - 30 mph - 20 mph - 10 mph

- 65 mph - 55 mph - 45 mph - 35 mph - 25 mph - 15 mph - 5 mph

The I-84 Hartford Project		
Existing (2012) Vissim Average Speed Map – PM Peak		
Date: 5/19/2014	Drawn By: TranSystems	Figure No: 2-35

simulation limits. In the field, congestion on I-91 backs up onto I-84 but the source of this congestion is outside the simulation limits for the Vissim model.

It is important to note that the average speeds produced by Vissim are typically lower than those recorded by INRIX. There are several reasons for this. First off, INRIX removes all traffic data it considers to be due to non-recurring congestion. Given the frequency of traffic incidents and special events in the Hartford area, congestion is often much more extensive than what INRIX shows. Second, planning volumes are typically based on the 30th busiest hour of the year, which is heavier than average conditions. Third, Vissim splits traffic inputs into discrete periods of time. The model experienced peak traffic for 90 minutes in the morning and 150 minutes in the afternoon, whereas real traffic arrival rates are continuously variable. Finally, since the vehicle routes in Vissim were static, vehicles in the model stayed on their paths regardless of congestion, whereas some real-world vehicles would divert to other routes.

Vissim Model Level of Service Results

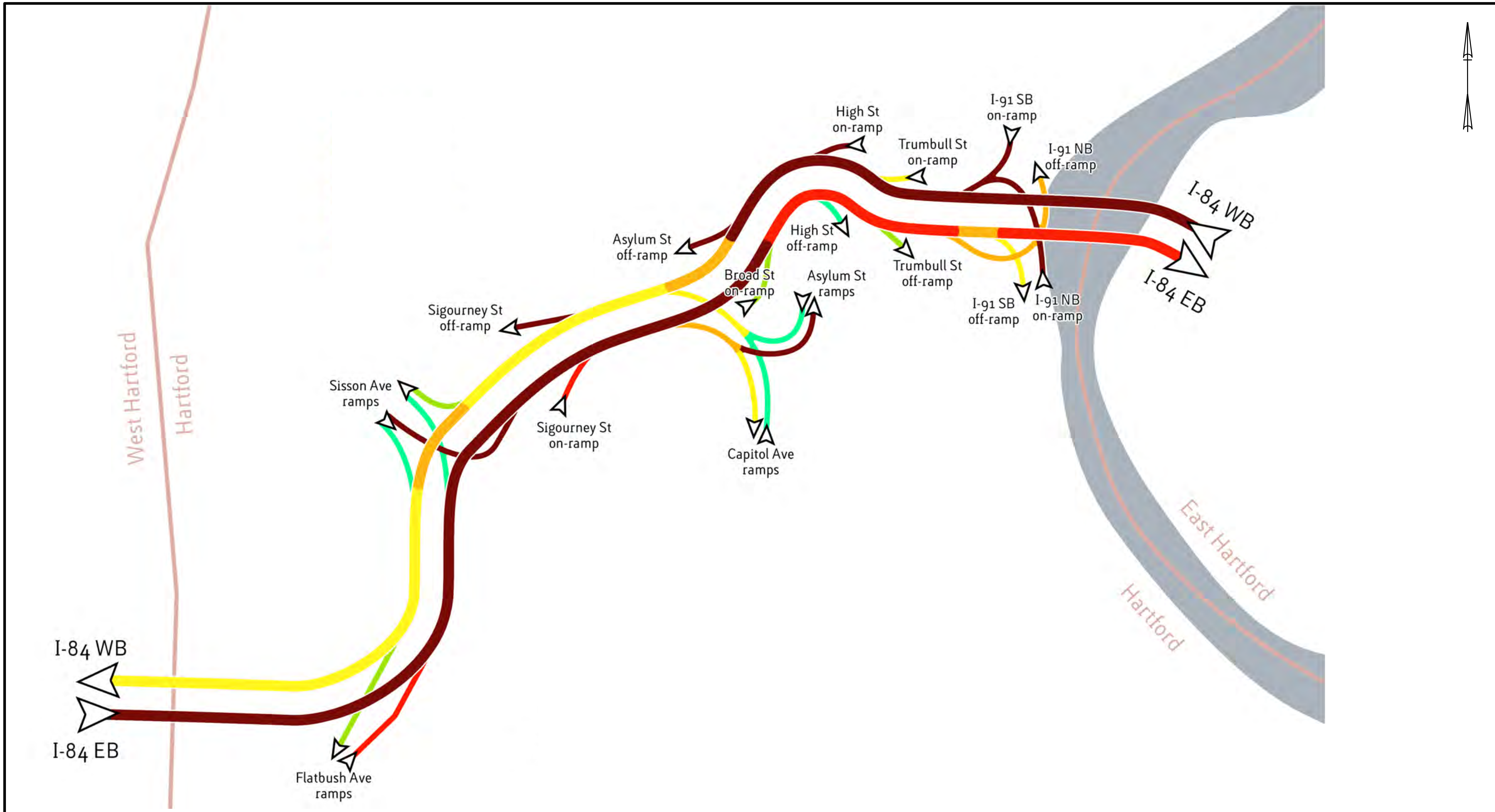
Density on I-84 through the Study Area was also analyzed in Vissim. The AM and PM LOS results for I-84 in Hartford are shown in Figure 2-36, following, and Figure 2-37, page 2-93, respectively. This density was then used to calculate Level of Service (LOS). In the morning peak, both directions of I-84, as well as several ramps, experience heavy congestion. I-84 eastbound operates at LOS F from West Hartford easterly to the Broad Street on-ramp, and then alternates between LOS E and D across the Connecticut River and into East Hartford. It is only after the CT 2 on-ramp that the LOS significantly improves. Westbound, traffic operates at LOS F from the East Hartford town line westerly to the Asylum Street off-ramp, and improves marginally thereafter, reaching LOS B after the Kane Street off-ramp (Exit 44).

The afternoon peak brings greater levels of traffic congestion. I-84 eastbound operates at LOS F from West Hartford through to the CT 2 on-ramp in East Hartford, and past this point, it never gets better than LOS D within the limits of the model. Westbound, the situation is similar, with LOS F traffic prevailing throughout East Hartford and Hartford, only improving to LOS E around the West Hartford town line.

Along with the main line, several ramps are influenced by this congestion. The on-ramps from I-91, in particular, are heavily congested during both peak periods. The High Street on-ramp is also congested in both peaks due to the heavy congestion and weaving at its terminus. Five off-ramps, including Asylum Street (Exit 48) and Sigourney Street (Exit 47), operate at LOS F during the morning peak. In the afternoon, six on-ramps operate at LOS F, including the ramp from I-91 southbound to I-84 westbound and the ramp from Asylum Street and Capitol Avenue.

Vissim Model Conclusion

Overall, the Vissim model is observed to accurately model the congestion that occurs on I-84 and nearby secondary streets on a day with moderately heavy traffic. With the model calibrated to existing



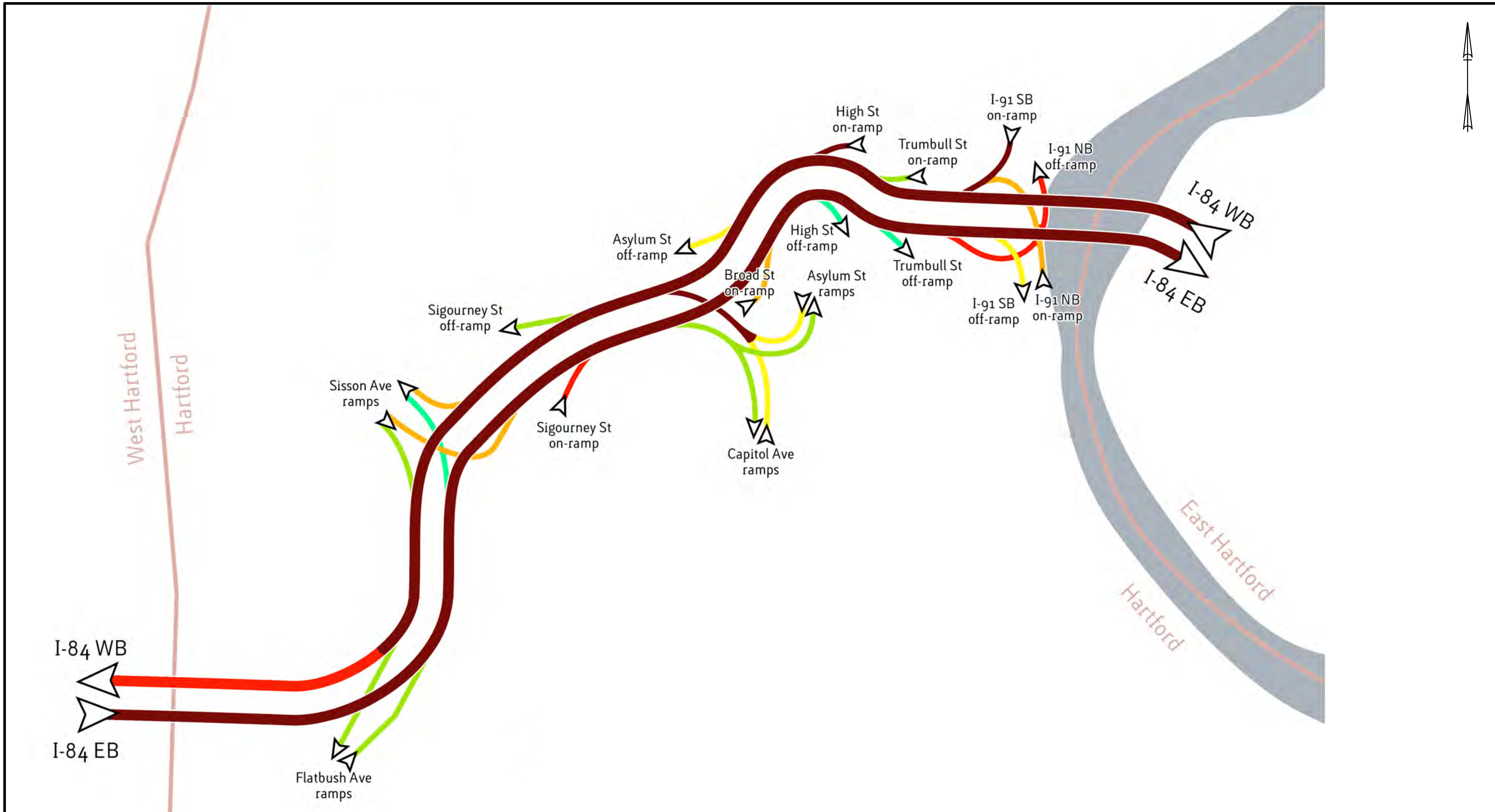
LEGEND

LOS A
LOS B
LOS C
LOS D
LOS E
LOS F

The I-84 Hartford Project

Existing (2012) Vissim Level of Service Map – AM Peak

Date: 5/19/2014	Drawn By: TranSystems	Figure No: 2-36



LEGEND

LOS A
LOS B
LOS C
LOS D
LOS E
LOS F

The I-84 Hartford Project

Existing (2012) Vissim Level of Service Map – PM Peak

Date: 5/19/2014	Drawn By: TranSystems	Figure No: 2-37

conditions, it can now be modified as needed to produce accurate and versatile simulations of no-build and future build traffic.

2.4.4 Synchro 8 Analysis

Overview

Trafficware's Synchro is an empirical macrosimulation modeler, primarily used for traffic control signals, but also capable of modeling unsignalized intersections. The SimTraffic module, available as a part of the Synchro suite, is a microsimulation program to analyze these same intersections. Version 8 was chosen as it follows the 2010 edition of the HCM and was the most current version available when the model was created. Unlike freeway analysis, where LOS is determined by the density of vehicles, intersection LOS is based on the amount of delay a driver will experience on average.

Strengths

Synchro analyzes signalized and unsignalized intersections using the HCM methodology, providing a deterministic, reproducible set of results for a given intersection. It has a streamlined interface to allow intersections to be coded in as little as a few minutes. After the requisite turning counts, lane arrangements, and signal timings have been set, this data can be sent directly to SimTraffic to perform a limited microsimulation of traffic flow.

When signal timings and phasing are known, they can be put directly into Synchro. When they are not known, timings and phasing can be optimized to minimize intersection delay. Multiple nearby intersections can be coordinated with an optimized offset in order to ensure good progression. This progression can be shown graphically on a time-space diagram.

SimTraffic, though not as detailed as Vissim, can produce a good approximation of the interaction between multiple intersections, including queue spillback and starvation.

Limitations

Since Synchro matches the HCM methodology, it looks at one intersection at a time, not considering interactions with nearby intersections. In some cases, such as with closely spaced intersections, acute angles between approaches, multi-lane roundabouts, or two-way left turn lanes, Synchro can produce results inconsistent with field data.

Synchro does not model freeway traffic, and thus cannot model the interaction between freeways and secondary roadways. Synchro offers only limited control over origin-destination data.

Driver behaviors are less flexible in Synchro than they are in Vissim, especially in merge areas. While SimTraffic can provide a more realistic picture of intersection operations, it does not produce LOS results, and multiple runs must be analyzed in order to avoid outliers.

Synchro Model Development

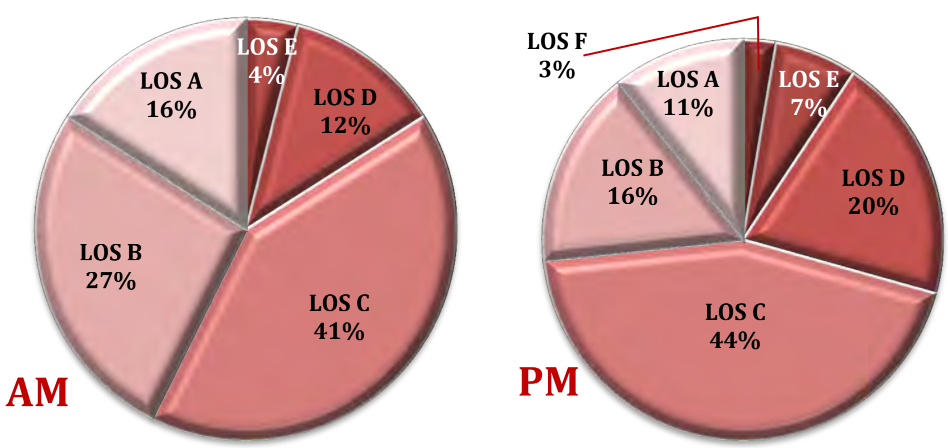
Where possible, real-world geometry, lane use, signal timings, turn restrictions, and speeds were replicated within Synchro. On Asylum Street westbound between Garden Street and Farmington Avenue, there exists a single, unstriped 36’ travel lane, which operates as one, two, or three lanes depending on the time of day and amount of congestion. This was modeled in Synchro as three lanes. This location was also modeled in Vissim in order to verify the Synchro results.

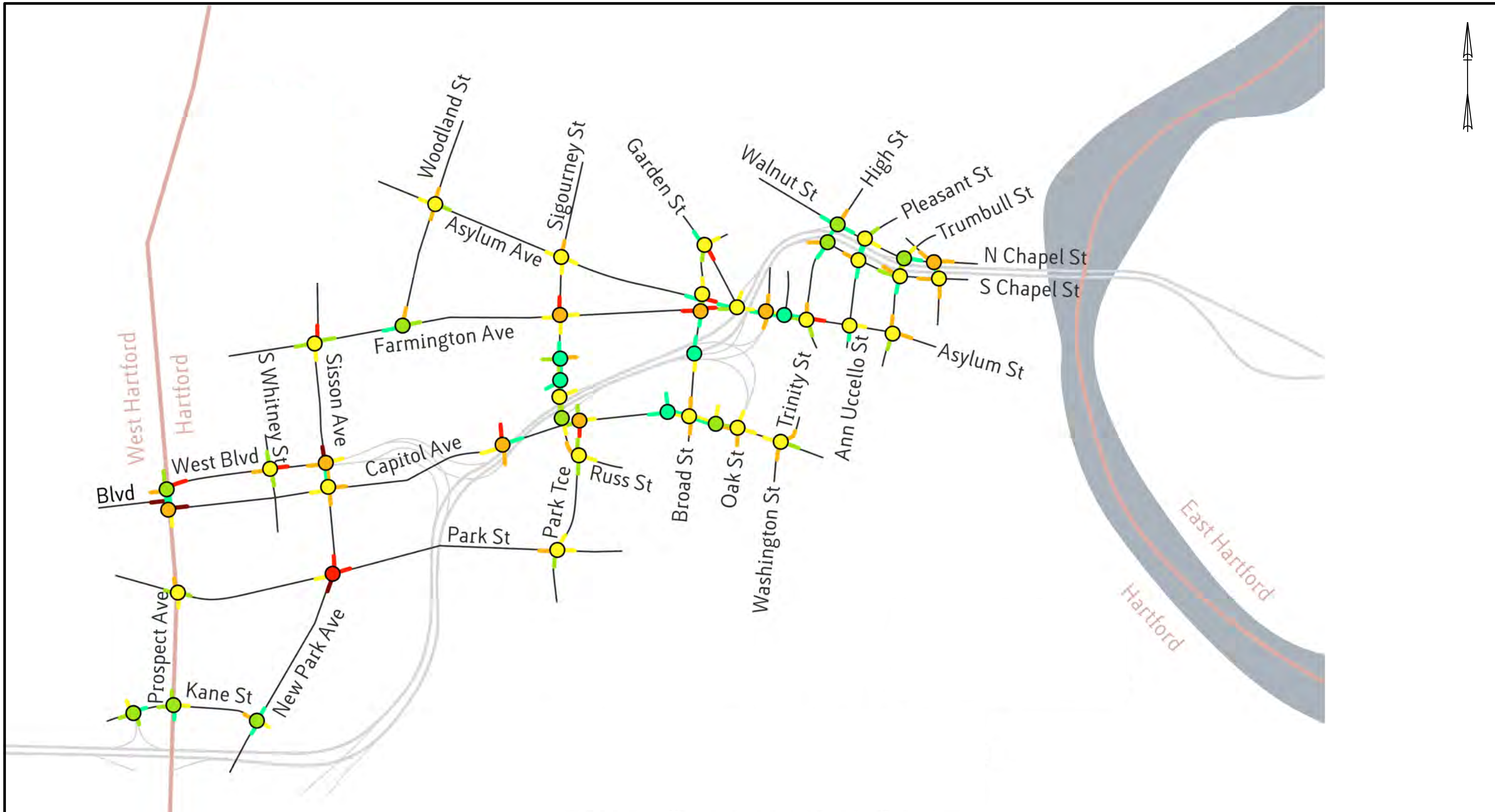
The City of Hartford runs a closed-loop computerized signal system, with phase lengths that change from cycle to cycle and adapt to traffic patterns; there is no single timing plan that exactly matches what is in the field. However, using the observed queue lengths as a target, signal timings were selected to produce the same overall results as the actual timings. Much of the field data was collected in 2012. To supplement the turning count movements, additional intersections were added to the Study Area and therefore additional field data was collected in 2014.

Synchro Model Results and Conclusion

Full Synchro results are provided in Appendix A.2.7. In summary, during the AM peak, 16% of the intersections studied operate at LOS D or worse, and during the PM peak, this figure climbs to 30%. In general, roadways are designed for LOS C. When the LOS falls below a C, travel speeds begin to drop and the mobility of a facility is degraded. Figure 2-38, below, summarizes the performance of all 75 intersections. Partial results for selected key intersections are shown in Figure 2-39, page 2-96, for the AM peak hour and in Figure 2-40, page 2-97, for the PM peak hour. As illustrated in the figures, Hartford’s intersections experience greater congestion in the afternoon than in the morning. For example, Figure 2-39 shows only three intersections that have at least one approach at LOS F; Figure 2-40 shows eight. In Appendix A.2.7, the trend is further illustrated with six intersections that have at least one approach at LOS F in the morning and fifteen intersections with at least one approach at LOS F in the evening.

Figure 2-38: Summary of Synchro Intersection Peak Hour Results





LEGEND

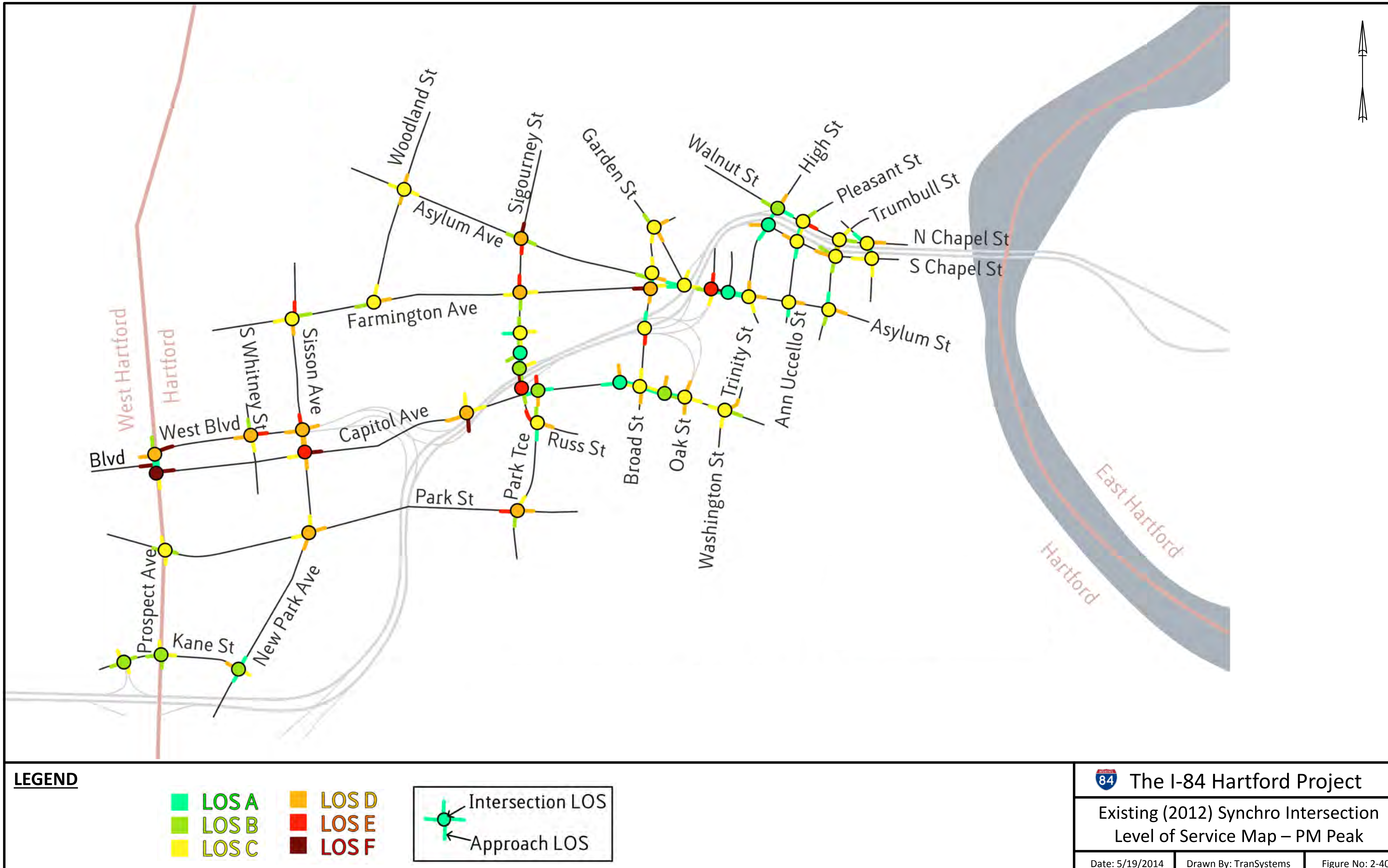
LOS A
LOS B
LOS C
LOS D
LOS E
LOS F

Intersection LOS
Approach LOS

The I-84 Hartford Project

Existing (2012) Synchro Intersection Level of Service Map – AM Peak

Date: 5/19/2014	Drawn By: TranSystems	Figure No: 2-39



The I-84 Hartford Project

Existing (2012) Synchro Intersection Level of Service Map – PM Peak

Date: 5/19/2014	Drawn By: TranSystems	Figure No: 2-40

It should be noted there are several exceptions to this trend. For example, the intersections along westbound-only North Chapel Street are busiest in the morning, carrying inbound traffic. Similarly, the intersection of Park Street and New Park Avenue is also busier in the morning, likely due to its location adjacent to an elementary school. The majority of the PM peak period is after the time period where activity related to the school would affect operations.

To further illustrate the congestion in Hartford, five intersections are summarized in Table 2-19, following. These intersections were selected as they are directly impacted by operations on I-84.The intersection of Sigourney Street and the I-84 eastbound on-ramp, for example, was included due to its heavy volumes and significant delays for southbound movements during evening hours. In the PM peak, the delay is over 85 seconds per vehicle with a LOS of F. This is also an excellent example of general traffic patterns observed in Hartford; inbound movements are busy during the AM peak, and outbound movements are busy in the PM peak.

As mentioned previously, Synchro's limitations can skew some results. One such case is the intersection of Asylum Street with Union Place, which is calculated to be a LOS A, even though it is frequently blocked in the PM peak by the queue from the Spruce Street intersection 170 feet to the west.

While Synchro's level of service does not indicate this interaction, its microsimulation package, SimTraffic, does. It was the SimTraffic queues that were calibrated to field conditions, and so the simulation timings and phasing are accurate, even if the calculated level of service is somewhat better than what exists in the field. To ensure the quality of the Synchro model as it relates to I-84, the most critical intersections at and near ramp termini were also modeled in Vissim, with results similar to Synchro.

Table 2-19: Summary of Selected Synchro Intersection Analysis

Intersection/Direction	AM Peak Hour		PM Peak Hour	
	LOS	Approach Delay (sec/veh)	LOS	Approach Delay (sec/veh)
Sigourney Street & I-84 Eastbound On-Ramp				
Northbound - Sigourney Street	C	27.2	B	19.7
Southbound - Sigourney Street	B	14.4	F	86.9
Overall	**B**	**18.5**	**E**	**56.8**
Sigourney Street & I-84 Westbound Off-Ramp				
Northbound - Sigourney Street	B	18.2	B	15.8
Southbound - Sigourney Street	B	11.3	A	8.1
Westbound - I-84 Eastbound Off-Ramp	C	24.0	C	21.2
Overall	**C**	**20.7**	**B**	**13.7**
Asylum Street & Garden Street & I-84 Westbound Off-Ramp				
Southbound - I-84 Westbound Off-Ramp	C	25.2	C	33.2
Eastbound – Asylum Street & Farmington Avenue	B	11.2	A	9.5
Westbound - Asylum Street	C	21.9	C	21.1
Overall	**C**	**21.4**	**C**	**20.8**
Broad Street/Cogswell Street & Asylum Avenue				
Northbound - Broad Street	B	16.7	A	7.5
Southbound - Cogswell Street	C	28.7	C	21.4
Eastbound - Asylum Avenue	A	5.5	B	14.8
Westbound - Asylum Avenue	E	60.7	D	40.9
Overall	**C**	**31.7**	**C**	**22.2**
Broad Street & Farmington Avenue				
Northbound - Broad Street	A	4.8	D	49.1
Southbound - Broad Street	B	10.9	B	15.4
Eastbound - Farmington Avenue	E	65.4	F	85.4
Westbound - Farmington Avenue	E	55.8	C	27.0
Overall	**D**	**35.8**	**D**	**49.7**

2.4.5 HCS 2010 Analysis

Overview

McTrans HCS 2010 is an empirical traffic analysis tool for freeways and secondary roads. It is built around the methodology of the 2010 edition of the HCM. The freeway analysis portion of HCS 2010 breaks a facility down into ramps, weaving segments, and basic segments. The use of HCS 2010 is required by the FHWA and CTDOT. Version 6.50 was used, as it was the most current version when the analysis was performed.

Strengths

Because it follows the HCM, HCS 2010 results are determinate and reproducible for any road segment. Very little input information is needed compared to a full traffic simulation. If the freeflow speed is not known, it can be approximated. The only origin-destination information required is for weaving segments. The software itself is simple to use and produces fast results for both design and analysis.

Limitations

Despite its ease of use, HCS 2010's simplicity means that its capabilities are limited. The HCM methodologies are very useful for determining level of service on isolated roadway segments, but although its empirical equations have corrections for two ramps in proximity, Hartford-area freeways have exits with such close spacing that HCS 2010 cannot analyze them as they are. For example, where multiple weaving segments overlap, HCS 2010 can only analyze one at a time; in reality, the actual LOS is likely to be worse than these calculations show.

Like Synchro, HCS 2010 analyzes each segment individually. The software may show a freeway segment at LOS A while an adjacent off-ramp is at LOS F; in reality, the ramp would queue onto the freeway and degrade its capacity. Consequently, when any roadway segment is congested, the results for surrounding segments can be incorrect.

The HCM's empirical equations do not cover posted speeds below 55 mph, nor do they apply to freeway segments with only a single through lane in each direction. The equations do not take into account the behavior of drivers, nor the vehicles they drive. The HCM does not look at horizontal curvature, sight distance restrictions, or traffic control at ramp termini. Freeways in and around Hartford are outliers that exceed the limits of the HCM methodology; McTrans recommends using microsimulation tools, such as Vissim, to get a better picture of these roads.

HCS 2010 Analysis Development

HCS was used to analyze I-84, I-91, CT 2, and CT 15 within Hartford and East Hartford. Each roadway was broken down into freeway segments, weaving segments, and ramp segments. On CT 2, where the mainline is reduced to one lane in each direction, the freeway segment was analyzed as a ramp. When available, weave analysis made use of origin-destination data from SkyComp; elsewhere, volumes were distributed proportionally. Speeds were taken from posted speed limits and advisory speeds, except for the segments of I-91 and I-84 in Hartford that are signed for 50 mph. HCS 2010 requires a minimum speed of 55 mph for freeways, so this speedwas used instead.

For locations with multiple overlapping weaves, the worst results were used. Similarly, for ramp analysis, adjacent on- or off-ramps may change results. HCS 2010 allows one adjacent ramp to be included, but in Hartford, there are typically two or more ramps within 1,500 feet. As with the weaving segments, multiple analyses were run, and the worst results were chosen.

HCS 2010 Analysis Results and Conclusion

Broadly speaking, freeway segment analysis yielded results that match INRIX speed data: in the morning peak, traffic is heaviest on I-84 eastbound in West Hartford, and I-84 westbound in East Hartford. In the evening peak, traffic in both directions is worst within Hartford. Full HCS 2010 results are given in Appendix A.2.6. The results show a wide variation in level of service from one segment to the next. For example, in the morning peak, the I-84 eastbound off-ramp to Trumbull Street was calculated to be LOS B, even though I-84 immediately upstream is LOS F. This is a consequence of HCS 2010's piece-by-piece approach, which tends to underestimate congestion in complex corridors. These results are considered inaccurate and should not be used for planning purposes.

2.5 Roadway Geometry Review

2.5.1 Introduction

The primary purpose of the Roadway Geometry Review Section of this Analysis, Needs, and Deficiencies Report is to evaluate existing conditions within the Project Study Corridor and identify locations that do not meet current highway design guidelines and related criteria. Evaluations include the degree to which these criteria are not met and their impacts on safety and traffic operations.

The focus of this review is the 2.5 mile corridor along I-84 from just east of Interchange 45 (Flatbush Avenue) in Hartford to Interchanges 51 & 52 (I-91) in Hartford. The eastbound and westbound I-84 mainline sections and associated entrance and exit ramps within the Project Study Corridor were evaluated. This includes Interchange 46 (Sisson Avenue), Interchange 47 (Sigourney Street), Interchange 48 (Capitol Avenue/Broad Street/Asylum Street), Interchange 49 (Ann Uccello Street/High Street), Interchange 50 (Main Street/Trumbull Street/Morgan Street), Interchange 51 (I-91 Northbound), and Interchange 52 (I-91 Southbound). Interchange 45 (Flatbush Avenue) is just outside the Project Study Corridor and was not evaluated.

The original highway mainline and interchange elements were constructed in the 1960s and, as such, were designed to the design standards and anticipated traffic volumes of the time. Over the past fifty years, interstate roadway design standards have evolved and traffic volumes within the study corridor, including large commercial vehicles, have significantly increased. As a result, congestion and the rate of reported crashes have also increased. Substandard geometric features affect traffic operations and contribute negatively to the highway's ability to safely carry traffic and, therefore, have been identified, evaluated, and compared to the most up-to-date standards established in the Connecticut Department of Transportation, *Highway Design Manual (2003 Edition including Revisions to February 2013*) (CTHDM) and American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets (6th Edition, 2011*).

2.5.2 Methodology

Based on multiple field visits, reviews of available design and record plans, and inspection reports, the existing geometric conditions of the I-84 mainline and interchanges within the Project Study Corridor were evaluated using the applicable design criteria. In addition, existing aerial photography and ground survey mapping of the existing conditions were used to further assess and verify the existing geometric conditions.

Controlling design criteria are those CTHDM highway design elements that are judged to be the most critical indicators of a highway's safety and its overall serviceability. The controlling design criteria used for this evaluation include the following:

- Posted Speed Limit
- Shoulder Width
- Travel and Auxiliary Lanes
- Maximum and Minimum Grades

- Horizontal Curvature
- Superelevation
- Stopping Sight Distance
- Vertical Curvature
- Cross Slopes
- Vertical Clearances
- Roadside Clear Zones

In addition to controlling design criteria, the following operational characteristics were evaluated and included for a comprehensive roadway geometry review:

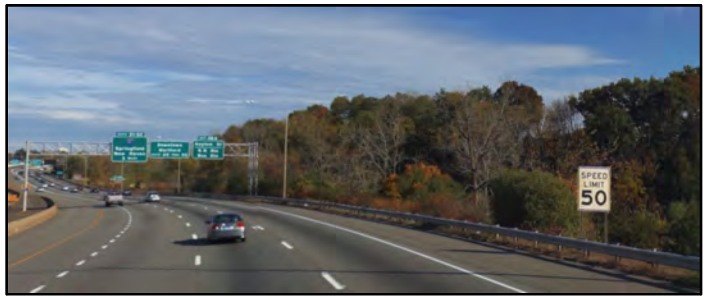
- Basic Number of Lanes and Lane Balance
- Interchange Spacing, Uniformity, and Decision Sight Distance
- Highway/Ramp Weaving
- Interchange Ramp Acceleration and Deceleration Lengths

Minimum design values for each controlling design criteria previously listed are predicated on roadway classifications and selected corresponding speed. Based on the Federal Functional Classification System, CTDOT classifies I-84 through the Project Study Corridor as an Urban Freeway (Built-up). For this study, the following geometric conditions for the mainline were reviewed based on recommended standards from the CTHDM (Figure 5A) for Urban Freeways (Built-up). Table 2-20, below, summarizes typical design criteria for various speeds applicable for this class of freeway for comparison purposes only.

Table 2-20: I-84 Mainline Design Criteria

Design Element	50 mph	55 mph
Travel Lane Width	12’	12’
Shoulder Width - Right	10’*	10’*
Shoulder Width - Left	10’*	10’*
Cross Slope - Travel Lane	1.5% - 2.0% for lanes adjacent to crown, 2.0% for lanes away from crown	1.5% - 2.0% for lanes adjacent to crown, 2.0% for lanes away from crown
Roadside Clear Zone	20’	22’
Stopping Sight Distance	425’	495’
Minimum Radius (e=6.0%)	840’	1065’
Maximum Superelevation	6%	6%
Maximum Grade	5%	5%
Minimum Grade	0.5%	0.5%
Vertical Clearance (Highway over Arterial/Freeway)	16’-3”	16’-3”
Vertical Clearance (Highway over Collector/Local)	14’-6”	14’-6”
Vertical Clearance (Highway over Non-Electrified RR)	20’-6”	20’-6”
*Where truck volumes exceed 250 DDHV, shoulder should be 12 feet		

Posted Speed Limit



Typical 50 mph Posted Speed Limit Signage along I-84

The posted speed limit for a facility creates a definite driver expectation of safe operating speed for the highway. Per CTHDM, the posted speed limit of a State highway is determined based upon several contributing factors, such as roadway geometrics, functional classification and type of area, type and density of roadside development, crash experience, pedestrian activity, and the 85th percentile speed for the facility. The 85th percentile speed is the speed below which 85 percent of vehicles travel on a given highway. CTHDM recommends that for new construction/major reconstruction projects, the facility should be designed to a speed equal to or greater than the anticipated posted or regulatory speed limit for the completed facility. This requirement recognizes the important relationship between likely travel speeds and the highway design.

Throughout the Project Study Corridor, the posted speed limit for the I-84 mainline is 50 mph. For highways that are classified as Urban Freeways (Built-up), the CTHDM recommends that the facility be designed for speeds ranging from 50-55 mph. For the purposes of this evaluation, the mainline was reviewed for compliance with the controlling design criteria using the posted speed of 50 mph. Design elements, including those that are non-compliant with the current design standards, are discussed in the following sections.

2.5.3 Review of Mainline Geometrics

The I-84 mainline was evaluated for compliance with the design criteria previously listed in Section 2.5.2 Methodology. The roadway deficiencies evaluated and described below will be used to help support the project Purpose & Need and will affect the development of future alternatives. It is assumed that future design efforts will further evaluate these design elements and recommend appropriate corrective measures. The results of the mainline review are summarized in Table 2-21, following.

Table 2-21: I-84 Mainline Review

Design Element*	CTHDM Section	Standard	Begin to Interchange 46		Interchange 46		Interchange 46 to Interchange 47		Interchange 47 to Interchange 48		Interchange 48 to Interchange 50		Interchange 50 to End	
Functional Classification		Urban Freeway	EB (Begin to Ex)	WB (Begin to En)	EB (Ex to En)	WB (En to Ex)	EB (46 En to 47 En)	WB (46 Ex to 47 Ex)	EB (47 Ex to 48 Ex)	WB (47 Ex to Broad)	EB (48 Ex to 50 Ex)	WB (Broad to 50 En)	EB (50 Ex to 50 En)	WB (50 En to 50 Ex)
Posted/Evaluated Speed	6-2.02	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph
Travel Lane Width	10-1.01	12'	12'	12'	12'	12'	12'	12'	12'	12'	12'	12'	12'	12'
Right Shoulder Width	10-1.02	10'**	8'-12'	9'-14'	4'-7'	3'-10'	2'-3'	2'-3'	3'	3'-8'	3'	2'-10'	3'-12'	3'-16'
Left Shoulder Width	10-1.02	10'**	6'-12'	4'-7'	3'-10'	3'-9'	2'-3'	2'-3'	2'	3'	2'-3'	4'-8'	2'-4'	3'-6'
Cross Slope Travel Lane	10-1.01	1.5% - 2.0% for lanes adjacent to crown, 2.0% for lanes away from crown	Banked	Banked	Banked	Banked	Banked	Banked	Banked	Banked	Banked	Banked	Banked	Banked
Roadside Clear Zone	13-2.0	20'	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stopping Sight Distance***	7-1.0	425'	354' H	355' H	370' H	343' H	341' H	342' H	257' H	>425'	254' H	303' H	304' H	>425'
Minimum Radius (e=6.0%)	8-2.02	840'	1,763'	1,763'	1,206'	1,146'	1,637'	1,637'	1,909'	4,874'	928'	982'	1,286'	1,231'
Maximum Superelevation	8-2.02	6.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	2.00%	2.00%	6.25%	6.25%	6.25%	6.25%
Maximum Grade	9-2.03	5.00%	2.50%	3.00%	3.20%	4.00%	1.84%	1.70%	3.98%	5.00%	2.70%	5.00%	5.00%	5.00%
Minimum Grade	9-2.03	0.50%	2.04%	0.82%	3.00%	2.88%	1.32%	1.12%	1.17%	0.50%	0.50%	N/A	0.01%	0.50%
Vertical Clearance - Highway over Arterial/Freeway	9-4.0	16'-3"	15'-1" (over Park)	18'-8"	13'-11" (under ramp)	15'-2" (under ramp)	15'-6" (over Sigourney)	14'-2" (over Sigourney)	>16'-3"	13'-10" (under Broad)	15'-8" (over Broad) 13'-6" (over Asylum)	14'-0" (under Asylum) 16'-2" (under High)	14'-7" (under Trumbull)	15'-10" (under platform)
Vertical Clearance - Highway over Collector/Local	9-4.0	14'-6"	N/A	N/A	N/A	N/A	14'-1" (over Laurel)	13'-7" (over Laurel)	>14'-6"	>14'-6"	N/A	N/A	N/A	N/A
Vertical Clearance - Highway over Non-Electrified RR	9-4.0	20'-6"	N/A	N/A	N/A	N/A	N/A	N/A	18'-1"	18'-3"	19'-2"	18'-4"	N/A	N/A

* CTHDM Controlling Design Criteria.
** Where truck volumes exceed 250 DDHV, a 12-foot wide shoulder is desirable.
*** Notation after distance is for limiting horizontal (H) or vertical (V) curvature.
Values depicted in red represent elements that are less than the minimum required for the posted speed limit and roadway classification.

Lane Width

Typical Section of I-84 - Minimum 12-Foot Travel/Auxiliary Lane Width

The traveled way is defined as the portion of roadway for the through movement of vehicles, exclusive of shoulders and auxiliary lanes. Auxiliary lanes are those portions of the roadway adjoining the traveled way for purposes supplementary to through traffic movement, such as for speed change, weaving, or truck climbing. There are several locations throughout the study area where auxiliary lanes are present on the mainline between interchange entrance and exit ramps. The minimum required travel/auxiliary lane width for a roadway is dependent upon the functional classification, traffic volumes, and rural/urban location of the roadway. The minimum required travel/auxiliary lane width of 12 feet is met throughout the I-84 mainline within the Project Study Corridor.

Shoulder Width

Per AASHTO, a shoulder is the portion of the roadway contiguous with the traveled way that accommodates stopped vehicles, emergency use, and lateral support of subbase, base, and surface courses. Roads with a narrow traveled way, narrow shoulders, and an appreciable traffic volume tend to provide poor service, have a relatively high crash rates, and need frequent and costly maintenance.

Advantages of well-designed and properly maintained shoulders are as follows:

- Space is provided away from the traveled way for vehicles to stop because of mechanical difficulties, flat tires, or other emergencies.
- Space is provided for evasive maneuvers to avoid potential crashes or reduce their severity.
- The sense of openness created by shoulders of adequate width contributes to driving ease and reduced stress.
- Space is provided for vehicles to pull over to allow emergency vehicles to pass.
- Highway capacity is improved because uniform speed is encouraged.
- Space is provided for maintenance operations such as snow removal.
- Space is provided to capture stormwater runoff, thus reducing the need for excessive drainage structures and preventing flooding and ponding on the highway.

It is desirable on heavily traveled, high-speed highways, and highways carrying a large number of trucks for the shoulder to be continuous and wide enough for a vehicle to be driven completely and safely off the traveled way. The full benefits of a shoulder may not be realized unless it provides a driver with refuge at any point along the traveled way. A continuous shoulder provides a sense of security such that almost all drivers making emergency stops will leave the traveled way.

Deficient Left and Right Shoulders along I-84

For State routes it is a requirement that all shoulders be paved. The minimum required shoulder width for a roadway is dependent upon the functional classification, traffic volumes, rural/urban location of the roadway, and if curbing is present. For the I-84 mainline throughout the Project Study Corridor, the CTHDM (Figure 5A) requires that both left and right shoulders be a minimum 10 feet wide with a desirable width of 12 feet where truck volumes exceed 250 Directional Design Hourly Volume (DDHV). Although the truck volumes exceed 250 DDHV within the I-84 Project Study Corridor, a minimum width of 10 feet was selected as the controlling design criteria considering urban conditions and adjacent land use.

Mainline shoulder widths within the Project Study Corridor were evaluated. Locations where the existing shoulder was found to be less than the required 10 foot width are depicted in Figure 2-41, following, and in Figure 2-42, page 2-109. Approximately 85% of the Project Study Corridor has shoulders of deficient width.

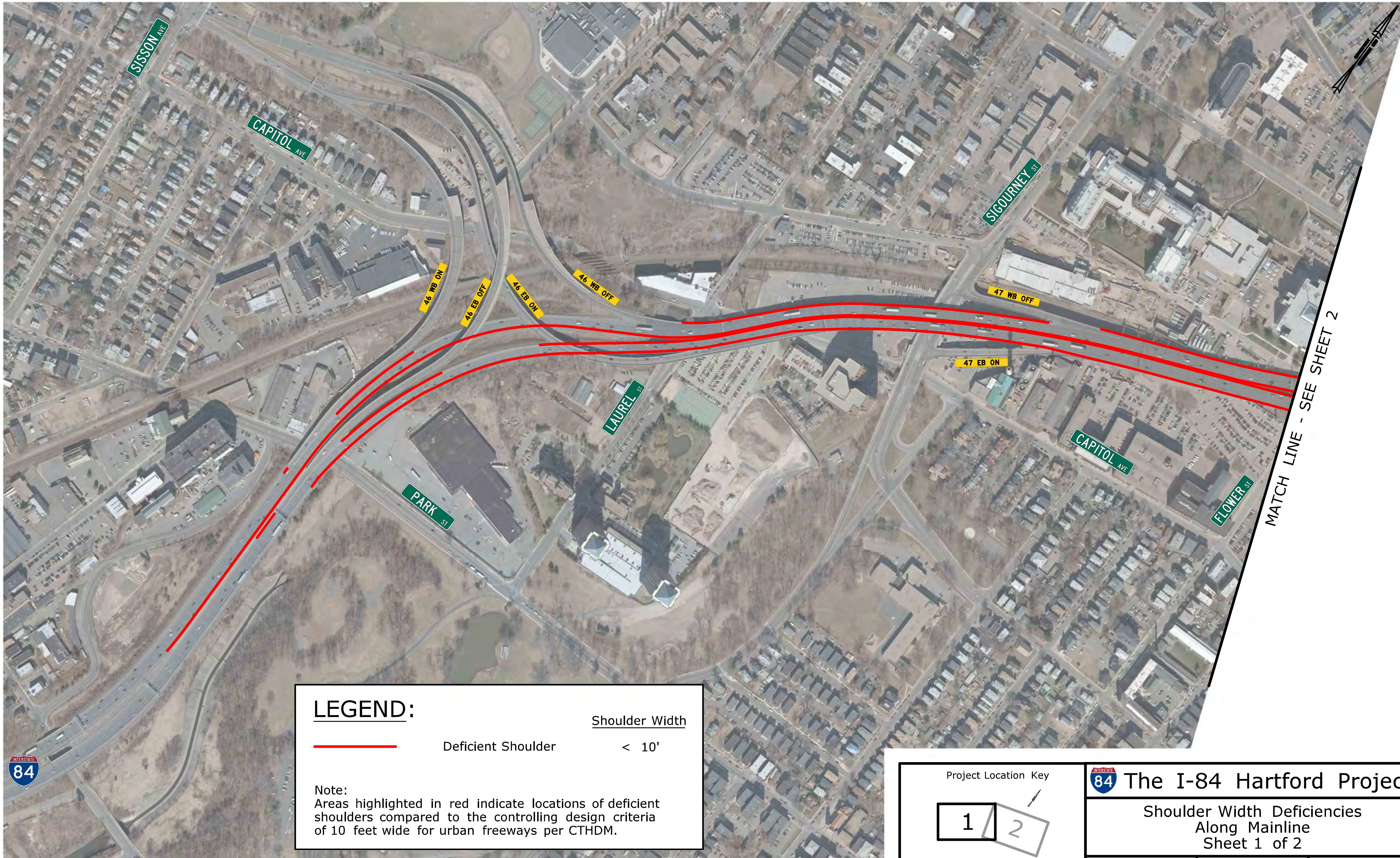
Horizontal Curvature

Per CTHDM (Figure 5A), for a speed of 50 mph, the minimum radius required for a simple curve is 840 feet. When compound curves are used on the mainline, it is required that the radius of the flatter circular arc not be more than 50% greater than that of the sharper arc.

All curves analyzed within Project Study Corridor for I-84 mainline meet or exceed the minimum required 840 foot radius. Additionally, there are several locations on the mainline where compound curves exist. Each location was evaluated for compliance with the 50% requirement and curves which exceeded this limitation are depicted in Table 2-22, below.

Table 2-22: Deficient Compound Curves

Mainline Location	Larger Radius (feet)	Smaller Radius (feet)	Increase in Radius (%)
I-84 Westbound at Sisson Avenue	1763	1146	54
I-84 Eastbound at Sigourney Street	5713	1659	244
I-84 Westbound at Sigourney Street	5759	1637	252
I-84 Westbound at Broad Street	9220	1412	553



LEGEND:

	Shoulder Width
Deficient Shoulder	< 10'

Note:
Areas highlighted in red indicate locations of deficient shoulders compared to the controlling design criteria of 10 feet wide for urban freeways per CTHDM.

Project Location Key

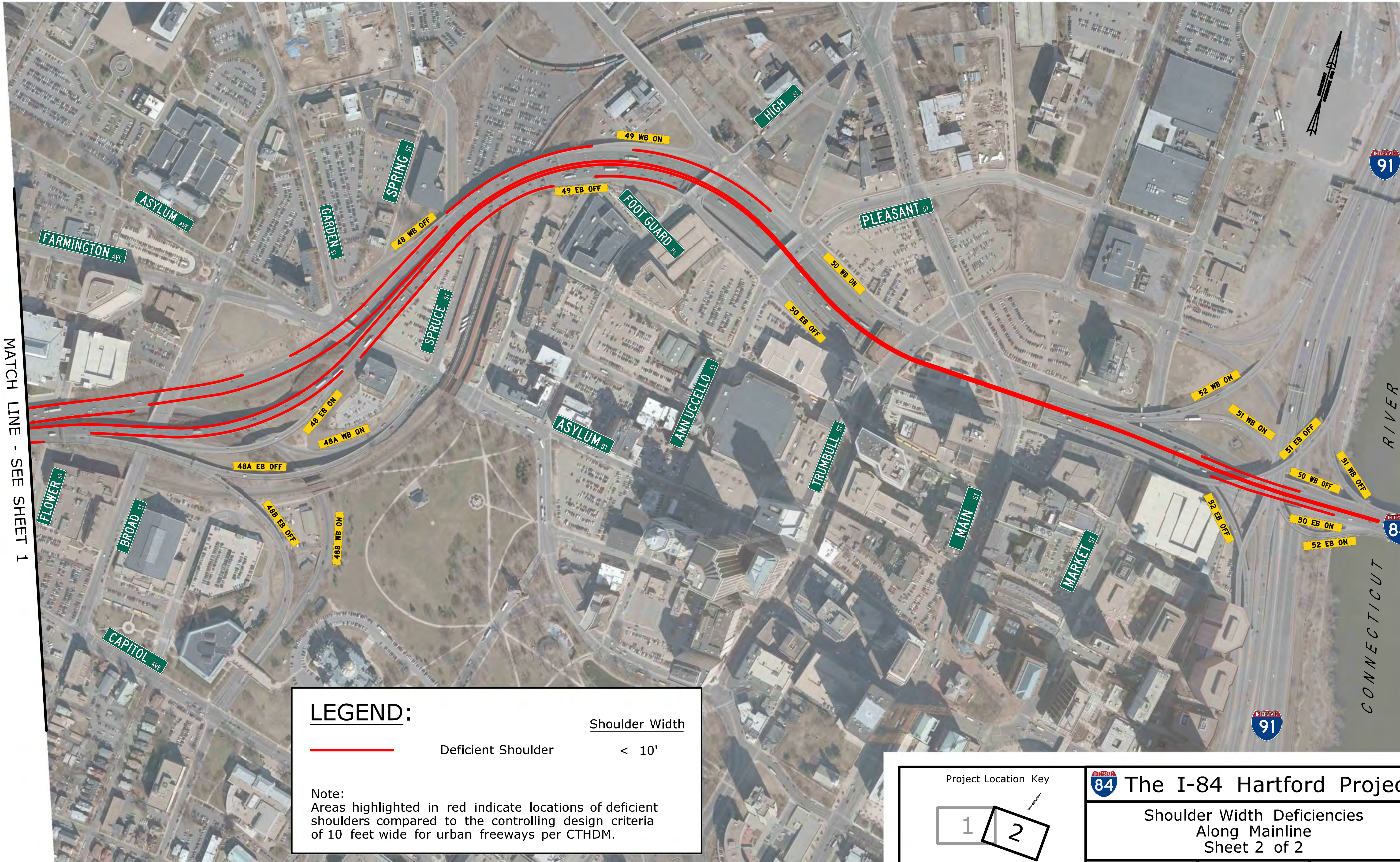
1 2

Not to Scale

The I-84 Hartford Project

Shoulder Width Deficiencies
Along Mainline
Sheet 1 of 2

Date: 1/20/2015 | Drawn By: JLD | Fig. No: 2-41



LEGEND:

		Shoulder Width
(red line)	Deficient Shoulder	< 10'

Note:
Areas highlighted in red indicate locations of deficient shoulders compared to the controlling design criteria of 10 feet wide for urban freeways per CTHDM.

Project Location Key

1 2

Not to Scale

The I-84 Hartford Project

Shoulder Width Deficiencies Along Mainline Sheet 2 of 2

Date: 1/20/2015 | Drawn By: JLD | Fig. No: 2-42

Superelevation

Superelevation is the amount of cross slope or "bank" provided on a horizontal curve to counterbalance the centrifugal force of a vehicle traversing the curve. The maximum rate of superelevation depends on several factors including climatic conditions, terrain, type of area (rural or urban), and highway functional classification. Safety and operational concerns related to inadequate superelevation are similar to those of horizontal alignment. Inadequate superelevation can result in vehicles skidding as they travel through a curve, which may potentially result in a run-off-road crash. Trucks and other large vehicles with high centers of mass are more likely to roll over on curves with inadequate superelevation.

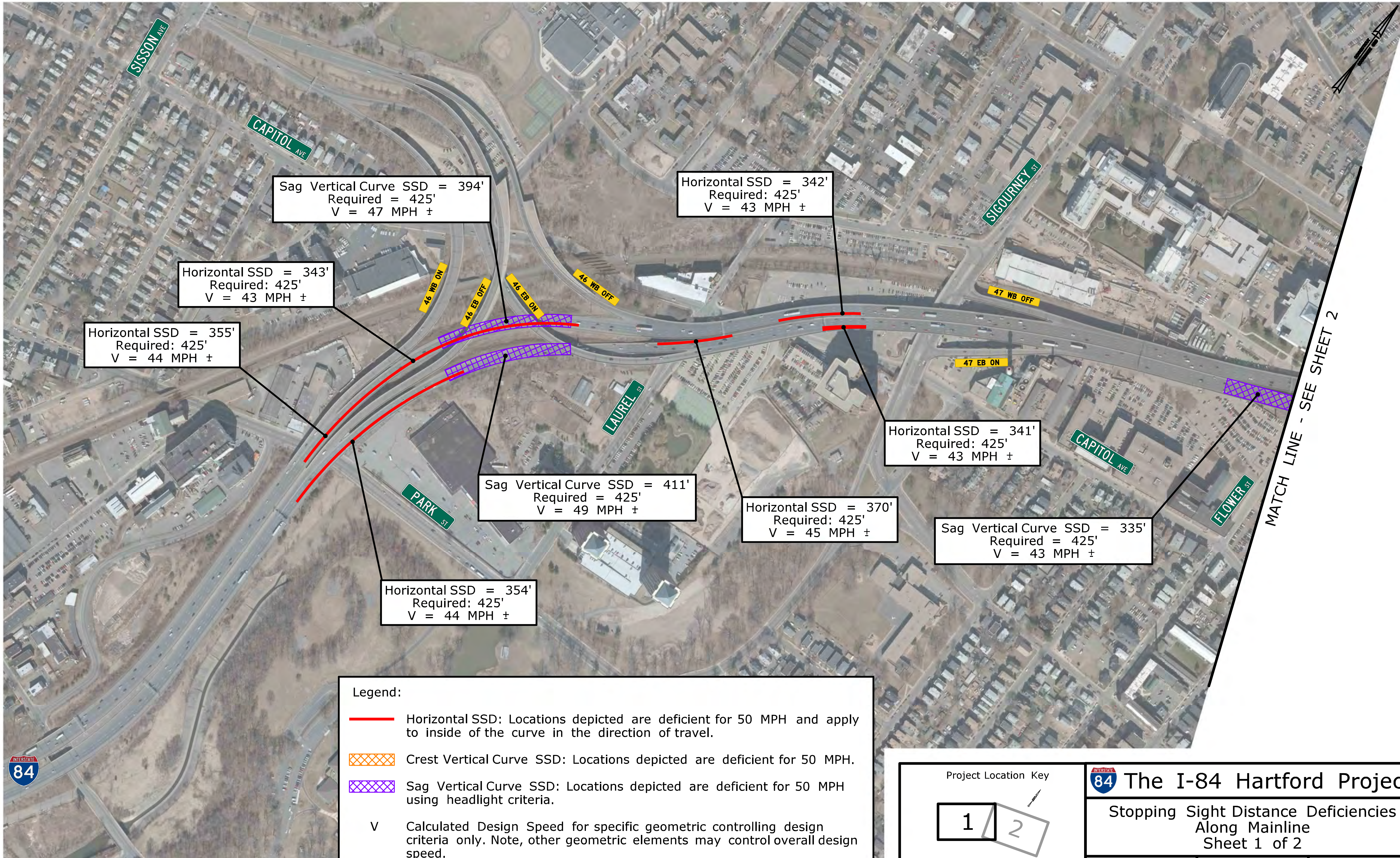
Per CTHDM (Figure 5A), the maximum superelevation rate for the mainline is 6%. Based on available data, the I-84 mainline conforms to this requirement. It should be noted that when the highway was originally constructed in the 1960s, the common acceptable unit of measurement for roadway cross slope was in terms of inches per foot. A maximum superelevation rate of ¾ inch per foot, which is equivalent to 6.25%, was used because it was easier for the construction contractor to build. Although this value provides more superelevation (i.e., a steeper banked section) than the current maximum superelevation rate, the curves within the study corridor with a superelevation rate of 6.25% are not considered deficient.

Stopping Sight Distance

Stopping sight distance (SSD) is the length needed for a driver to see an object, make a decision to apply the brake, then apply the brake and come to a complete, controlled stop. SSD is significantly influenced by vertical alignments and objects that restrict the line of sight on the inside of horizontal curves. Higher-speed facilities, such as expressways, require longer distances to stop and, thusly, a more forgiving design than lower-speed facilities. The CTHDM (Figure 5A) requires a minimum SSD of 425 feet for a speed of 50 mph.

For horizontal curves, physical obstructions such as bridge piers, bridge parapets, barrier curbs, back slopes, and vegetation can limit sight distance on the inside of the curve. The existing mainline within the Project Study Corridor was evaluated for SSD on each horizontal curve. The SSDs on several horizontal curves were found to be deficient, generally due to bridge parapets and barrier curbs obstructing a driver's view and limiting sight distance along the inside of the curve. These deficiencies are depicted in Figure 2-43, following, and in Figure 2-44, page 2-112.

Typical Horizontal and Vertical Curvature Combination Affecting Sight Distance



Legend:

- Horizontal SSD: Locations depicted are deficient for 50 MPH and apply to inside of the curve in the direction of travel.
- Crest Vertical Curve SSD: Locations depicted are deficient for 50 MPH.
- Sag Vertical Curve SSD: Locations depicted are deficient for 50 MPH using headlight criteria.
- V Calculated Design Speed for specific geometric controlling design criteria only. Note, other geometric elements may control overall design speed.

Project Location Key

1 2

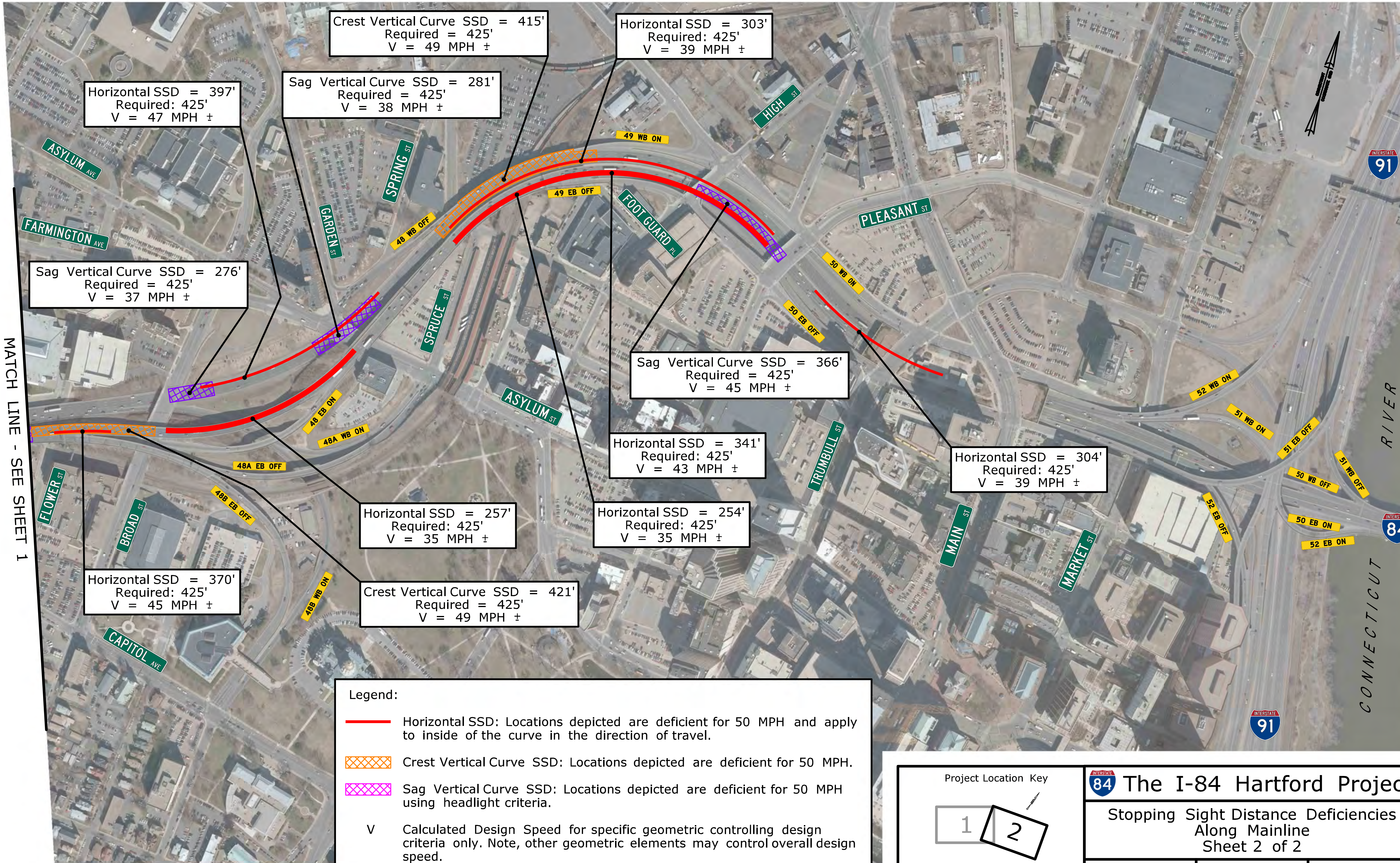
Not to Scale

84 The I-84 Hartford Project

Stopping Sight Distance Deficiencies Along Mainline

Sheet 1 of 2

Date: 1/20/2015	Drawn By: JLD	Fig. No: 2-43



Legend:

- Horizontal SSD: Locations depicted are deficient for 50 MPH and apply to inside of the curve in the direction of travel.
- Crest Vertical Curve SSD: Locations depicted are deficient for 50 MPH.
- Sag Vertical Curve SSD: Locations depicted are deficient for 50 MPH using headlight criteria.
- V — Calculated Design Speed for specific geometric controlling design criteria only. Note, other geometric elements may control overall design speed.

Project Location Key

1 2

Not to Scale

The I-84 Hartford Project

Stopping Sight Distance Deficiencies Along Mainline Sheet 2 of 2

Date: 1/20/2015 | Drawn By: JLD | Fig. No: 2-44

The length of vertical curves is dependent on an acceptable rate of change between the two tangent grades. Higher-speed roadways require longer curves, whereas lower-speed roadways have shorter minimum curve lengths. Crest vertical curves, commonly referred to as "hills," are designed to provide a driver sufficient SSD over the crest for the intended speed. Sag vertical curves, commonly referred to as "valleys," are designed so that a vehicle's headlights can illuminate the roadway ahead during nighttime conditions. The distance of the illuminated roadway should be equal to the required SSD for the intended speed.

Each existing mainline vertical curve within the Project Study Corridor was analyzed for deficiencies. Crest curves were evaluated based on minimum stopping sight distance, while sags were evaluated upon headlight sight distance. Deficiencies are depicted in Figure 2-43, page 2-111, and in Figure 2-44, page 2-112.

Maximum and Minimum Grades

Roadway grades significantly impact vehicular operations and safety, particularly for large trucks. The maximum longitudinal grade requirement for a roadway is primarily dependent upon the functional classification of the road, while the minimum grade is typically based upon providing enough pitch to facilitate adequate surface drainage.

For the I-84 mainline throughout the Project Study Corridor, the CTHDM (Figure 5A) requires a maximum grade of 5% and a minimum grade of 0.5%. The maximum grade is based on I-84's functional classification: Urban Freeway (Built-up). The existing I-84 profile grades meet these requirements with the exception of the platform section between Trumbull Street and Main Street, where the grade is essentially flat. However, since this section is not exposed to rainwater, the minimum grade requirement for drainage is not applicable. The maximum grades on I-84 occur between Myrtle Street and High Street where the highway rises up to clear the Amtrak railroad tracks. There is also a 5% grade on I-84 westbound between Flower Street and Broad Street to clear the Amtrak railroad tracks in front of the Aetna campus.

Cross Slopes

A roadway cross slope is the cross-sectional grade intended to convey surface water away from the travel lanes. Per the CTHDM (Figure 5A), the roadway cross slope for tangent sections is required to be between 1.5% - 2.0% for lanes adjacent to the crown and 2.0% for lanes away from the crown. All tangent sections along the existing mainline within the Project Study Corridor were evaluated for cross slope and no major deficiencies were found.

Vertical Clearances

Deficient Vertical Clearance on I-84 Eastbound

Vertical clearance is the distance above a roadway that is free from obstructions. The minimum vertical clearances for a roadway depend on the functional classification and the facility type. Table 2-23, below, provides design values from the CTHDM for the various highway functional classifications and facility types. These minimum vertical clearances, which apply to the entire roadway width, were used to evaluate the grade-separated intersections within the Project Study Corridor.

Table 2-23: Minimum Vertical Clearances

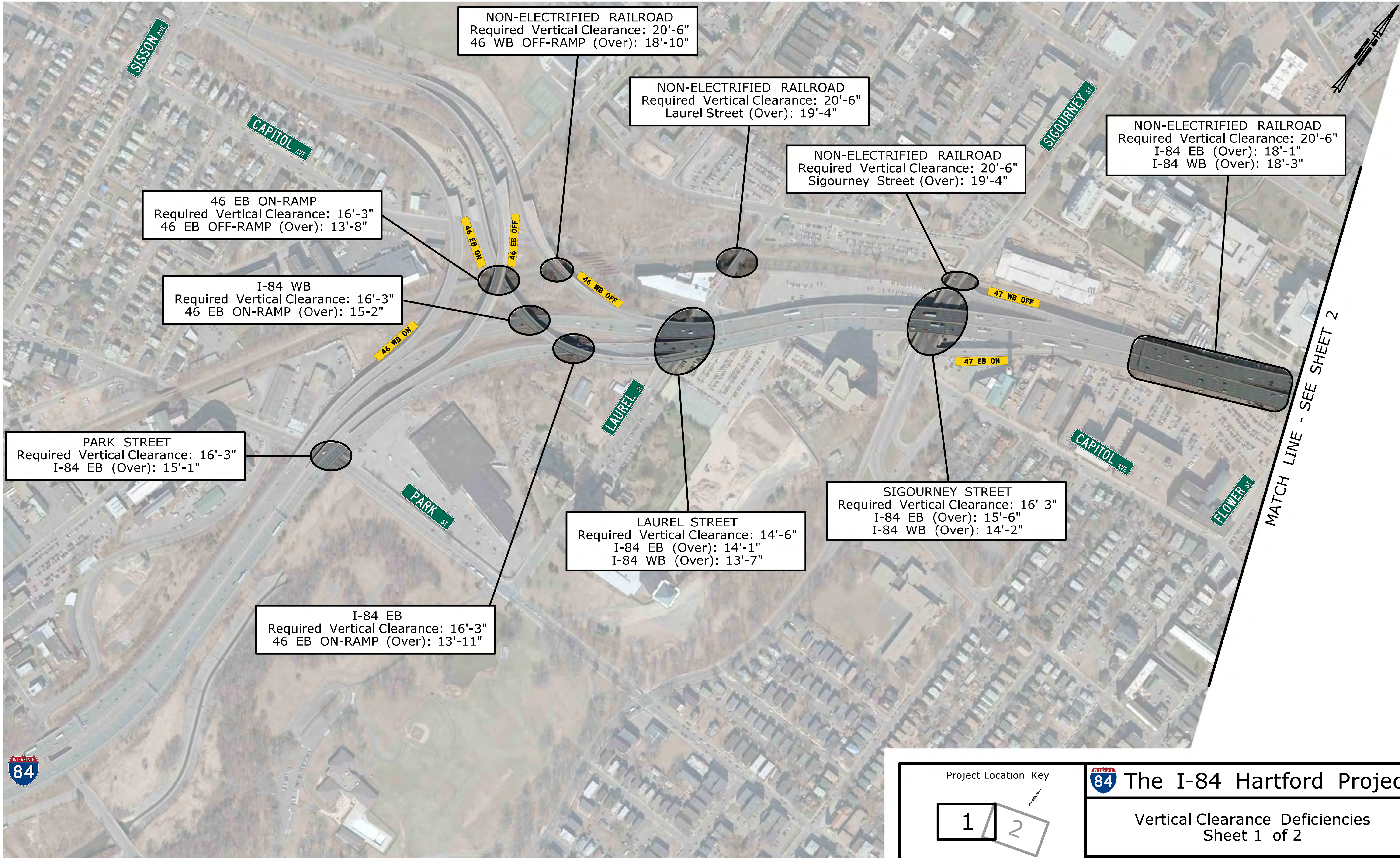
Classification Type	Minimum Vertical Clearance
Freeway/Expressway/Arterial under	16’-3”
Parkway/Collector/Local under	14’-6”
Railroad under Highway (electrified)	22’-6”
Railroad under Highway (non-electrified)	20’-6”
Railroad under Freeway (see below note)	23’-0”
Highway under Overhead Signs	18’-0”
Highway under Pedestrian Bridge	17’-6”

Note: Connecticut General Statutes, Section 13b-251 requires a clearance of 22’-6” over electrified railroads. The 23’-0” value is recommended but not required.

The existing mainline was evaluated using bridge inspection reports provided by the Department against the minimum required clearances for the study area. It was found that there were multiple bridge structures which do not provide adequate vertical clearances and have visible damage from impacts, as shown in Table 2-24, following. Vertical clearance deficiencies are depicted in Figure 2-45, page 2-116, and in Figure 2-46, page 2-117.

Table 2-24: Visible Damage from Bridge Inspection Reports

Description (Damage Location)	Bridge No.	Comment
I-84 Westbound over Park Street	03399A	Minor scrapes/gouges on girder flange
I-84 Eastbound over Park Street	03400A	Scrapes on girder flange
46 Eastbound Off-Ramp over 46 Eastbound On-Ramp/RR	03400C	Flanges bent/dented/gouged
46 Westbound Off-Ramp over Capitol/RR	03402A	Flanges bent/gouged and bowed web
Sigourney St. over Capitol Avenue	03023	Flange has minor scrapes/dent
I-84 Eastbound over local roads/RR	03160A	Isolated gouges in flanges/webs
I-84 Westbound over Sigourney Street	03160B	Flanges have bends and scrapes. Flange damaged and repaired during CT*fastrak* construction 2014/2015.
Pedestrian Walk over 48B On-Ramp	03385	Flanges bent/twisted/gouged
Amtrak RR over 48B On-Ramp	03305	Flanges have random dents
Broad Street over I-84 Westbound	03302	Flanges scraped/gouged/dented, web stiffeners and lateral bracing are bent, and girder web dented
Asylum Street over I-84 Westbound	01764	Gouge in cover plate
I-84 Eastbound over Asylum Street/Amtrak RR	01765	Diaphragm member bowed/bent, flanges and stiffener plate scraped/gouged, and previous damage to stiffener/connection plate weld repaired
I-84 Westbound over Amtrak/local roads	01766	Girder flanges have minor scrapes
Hartford Platform Center over I-84	06559B	Girder flanges have minor to moderate scrapes
I-91 Off (839) over 52 Eastbound Off-Ramp	01428B	Girder web has minor gouges, flange has scrapes
52 Westbound On-Ramp over I-91 Off-Ramp (186)	05921	Flanges have minor scrapes from construction
I-91 Southbound over I-84 & 50 Eastbound On-Ramp	01428A	Flanges - minor scrapes and gouges
52 Eastbound On-Ramp over I-91 Northbound/50 Westbound On-Ramp	01428D	Flanges are bent/dented
50 Westbound Off-Ramp over I-91	06048	Prestressed concrete deck units/flanges are scraped
50 Eastbound On-Ramp over I-91	06049	Prestressed concrete deck units are scraped



Project Location Key

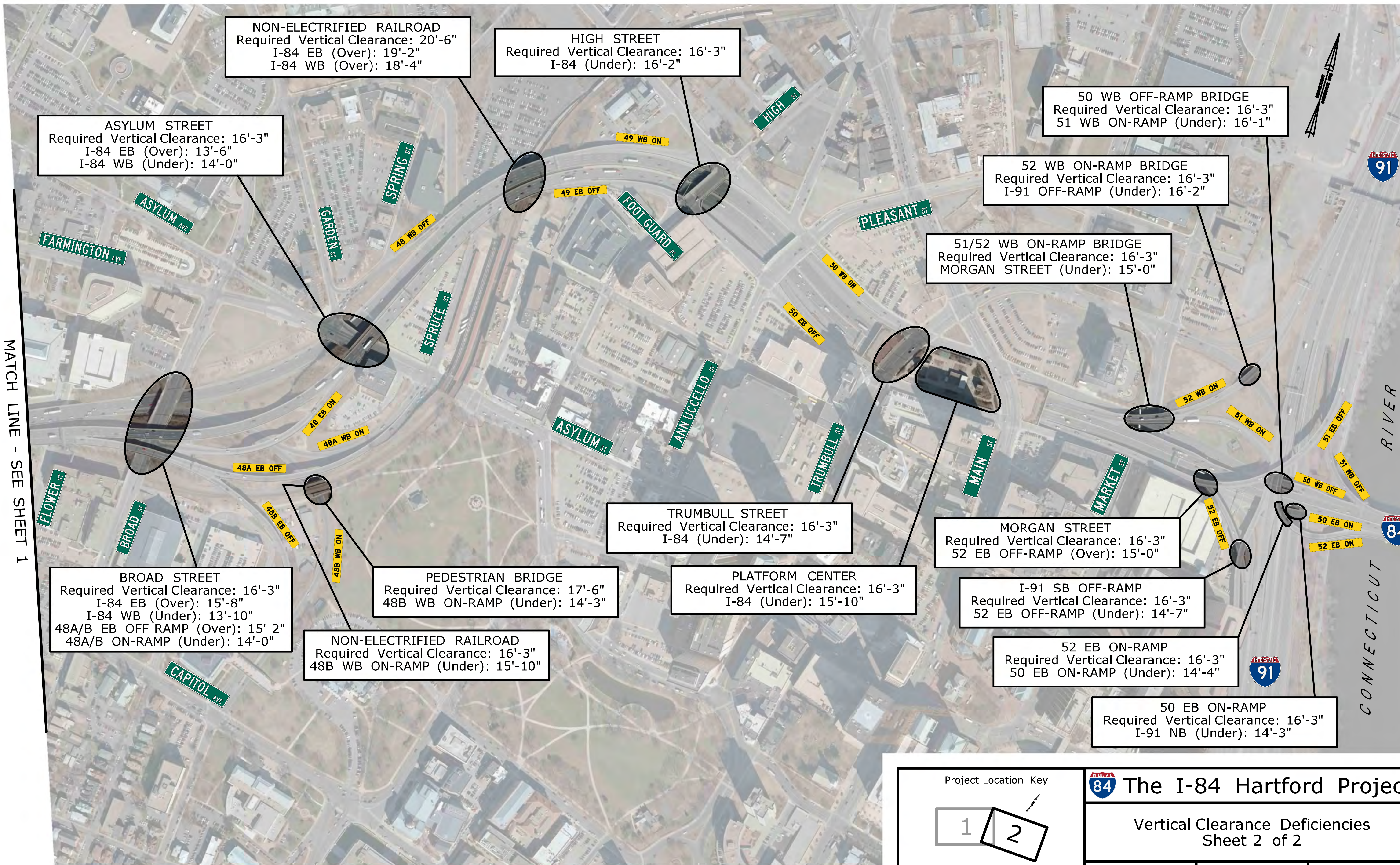
1 2

Not to Scale

84 The I-84 Hartford Project

Vertical Clearance Deficiencies
Sheet 1 of 2

Date: 1/20/2015	Drawn By: JLD	Fig. No: 2-45



Project Location Key

1 2

Not to Scale

The I-84 Hartford Project

Vertical Clearance Deficiencies
Sheet 2 of 2

Date: 1/20/2015 | Drawn By: JLD | Fig. No: 2-46

Roadside Clear Zones

Longitudinal Concrete Barrier along Both Sides of Mainline

Per AASHTO, clear zone is used to designate the unobstructed, traversable area provided beyond the edge of the traveled way for the recovery of 80-85% of errant vehicles. The clear zone distance for the I-84 mainline is measured from the edge of the travel way, whereas the clear zone distance for a highway ramp is measured from the edge of pavement. Typically, the clear zone width beyond the edge of pavement is a relatively flat, turfed area suitable for the recovery of errant vehicles. The desired minimum width is dependent upon traffic volumes, speeds, and roadside geometry.

The CTHDM (Figure 13-2A), provides clear zone values as a function of speed, traffic volume, and the rate of fill slopes with a positive or negative shelf. Each application of the clear zone distance should be evaluated individually. The minimum recommended clear zone distance for a posted speed of 50 mph is 20 feet, per CTHDM (Figure 13-2A). The majority of the mainline within the Project Study Corridor does not achieve this requirement due to the urban location and because the majority of the highway is supported by bridges. In general, it is not practicable to provide a lateral clear zone on a bridge because the additional width would require a significant expenditure.

There are several areas where leading-end bridge parapets are within the clear zone. These blunt ends are protected with an impact attenuator consisting of either a guiderail transition or a barrel array. Leading-end guiderail end-anchorages are located outside the clear zone.

There are several areas where the I-84 substructure pier columns are within the clear zone of local roads. Laurel Street has pier columns along both edges of road and within a raised median. These vertical obstructions are located 1.5 feet or greater beyond the curbline, which is required in an urban environment. However, this 1.5 foot minimum clearance is required for the placement of utility poles and is not considered a clear zone, but an “operational offset”.

Basic Number of Lanes and Lane Balance

Per AASHTO, designation of the basic number of lanes is fundamental to establishing the number and arrangement of lanes on a freeway. Consistency should be maintained in the number of lanes provided along any route of arterial character. Stating it another way, the basic number of lanes is defined as a minimum number of lanes designated and maintained over a significant length of a route, irrespective of changes in traffic volume and lane balance needs. The basic number of lanes is a constant number of lanes assigned to a route, exclusive of auxiliary lanes.

I-84 was evaluated to determine the basic number of lanes within the Project Study Corridor. The results are depicted in Figure 2-47, page 2-121 and in Figure 2-48, page 2-122. From Waterbury to the Massachusetts State Line (approximately 60 miles), I-84 has three basic lanes in each direction, with the exception of the Project Study Corridor. I-84 eastbound provides three basic lanes leading up to the overhead sign support just east of the Sigourney Street eastbound on-ramp. At this point, the third I-84 basic lane becomes an auxiliary lane for I-91. I-84 does not regain the third basic lane until it merges with the I-84 eastbound on-ramp from Route 2 in East Hartford, a distance of approximately 2.5 miles.

I-84 westbound provides three basic lanes leading up to the Bulkeley Bridge, where an overhead sign support designates the third basic lane as an "exit only" lane for Main Street. I-84 westbound regains the third basic lane at the Capitol Avenue/Asylum Street left-hand on-ramp, a distance of approximately 1.4 miles.

These changes in the basic number of lanes within the Project Study Corridor violate the recommendation made by AASHTO regarding the need to maintain consistency in the basic number of lanes for a facility.

I-84 Eastbound – Two Basic Lanes & One Dedicated I-91 Lane with Two Lane Off-Ramp for Exit 48A&B

Lane balance is an important operational characteristic that affects traffic flow. Per AASHTO, to facilitate efficient traffic operation through and beyond an interchange, there should be balance in the number of traffic lanes on the freeway and ramps. Generally, the number of lanes in the freeway mainline should not be reduced by more than one lane at an exit or increased by more than one lane at an entrance. Sudden lane discontinuities generate unnecessary weaving and maneuvering by drivers. This disrupts traffic flow and contributes to driver confusion and traffic accidents.

As applied to interchange design, auxiliary lanes may be provided to comply with the principle of lane balance. Operational efficiency may be improved by using a continuous auxiliary lane between the entrance and exit terminals where interchanges are closely spaced. They also can play an important role in the ability of the freeway system to efficiently and safely accommodate higher traffic volumes without the addition of basic freeway lanes.

The following auxiliary lanes were identified within the Project Study Corridor along I-84 eastbound:

- Sisson Avenue On-Ramp (Exit 46) to Asylum Street Off-Ramp (Exit 48A)
- Sigourney Street On-Ramp (Exit 47) to Capitol Avenue Off-Ramp (Exit 48B)
- Broad Street On-Ramp (Exit 48) to I-91 Northbound On-Ramp (Exit 51)
- I-84 Basic Lane at Sigourney Street reassigned to I-91 Southbound Off-Ramp (Exit 52)

The following auxiliary lanes were identified within the Project Study Corridor along I-84 westbound:

- I-91 Northbound (Exit 51) On-Ramp to Sisson Avenue Off-Ramp (Exit 46)
- I-91 Southbound (Exit 52) On-Ramp to Sigourney Avenue Off-Ramp (Exit 47)
- High Street On-Ramp (Exit 49) to Asylum Street Off-Ramp (Exit 48)

I-84 was evaluated for compliance with the lane balance principle within the Project Study Corridor. Locations that did not conform are depicted in Figure 2-47, following and in Figure 2-48, page 2-122. Generally, I-84 throughout the Project Study Corridor utilizes a series of continuous auxiliary lanes between entrance and exit ramps to comply with the lane balance principle; however, the following locations were found to be non-compliant:

- I-84 eastbound – two eastbound auxiliary lanes are dropped at the Asylum Street/Capitol Avenue exit ramps (48A/B Eastbound Off)
- I-84 westbound – two westbound auxiliary lanes are added at the I-91 Northbound/Southbound entrance ramps (51 &52 Westbound On-Ramps)

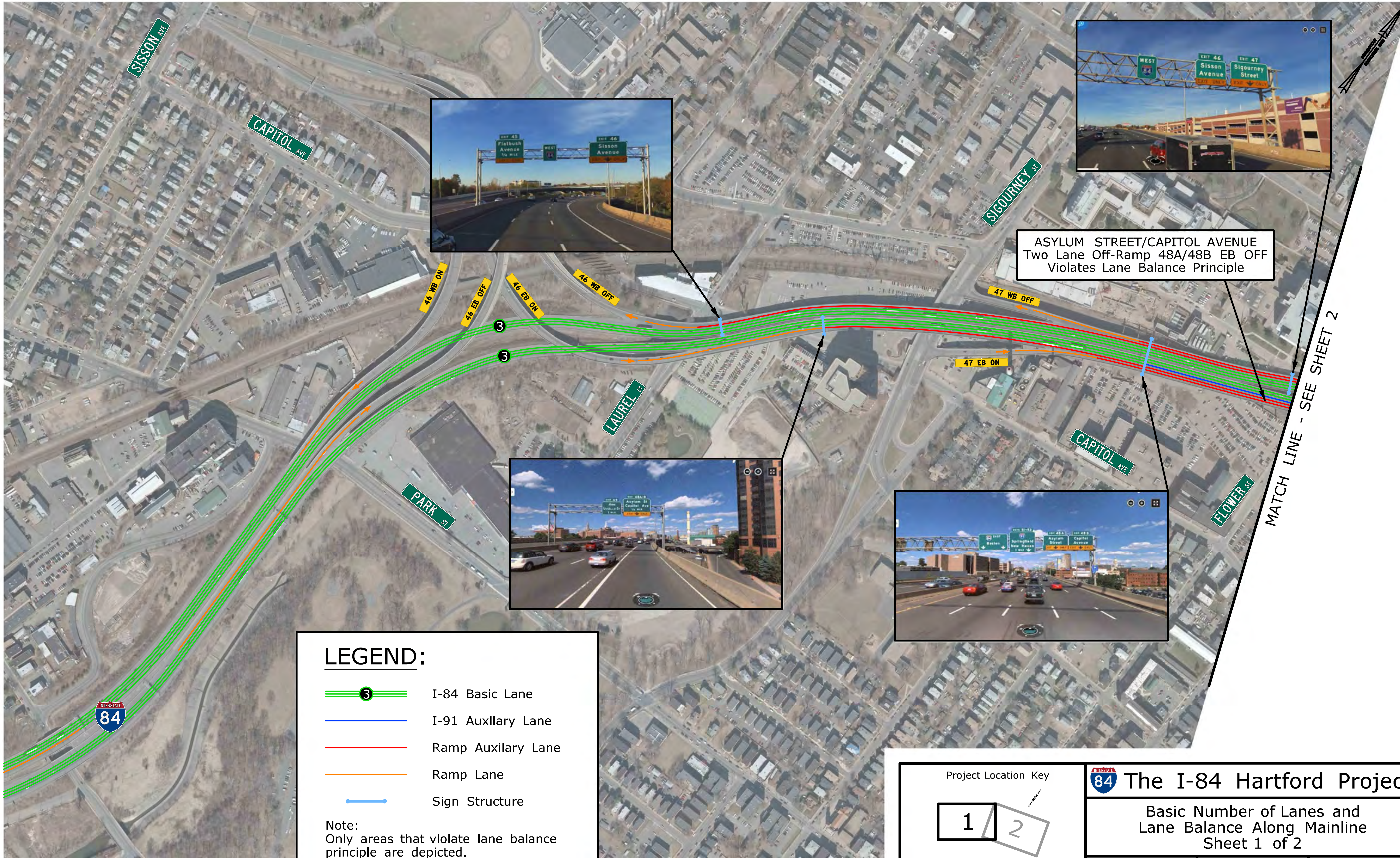
Interchange Spacing, Uniformity, and Decision Sight Distance

The spacing of interchanges has a major effect on the operation of a facility. AASHTO recommends a minimum interchange spacing of one mile in urban areas. This minimum distance between ramp junctions depends to a large degree on whether effective signing can be provided to inform, warn, and control drivers as well as to provide sufficient distance for vehicles to safely maneuver on and off the highway.

Interchanges should also be uniform to the maximum extent possible, especially in urban areas where they are typically more closely spaced. An inconsistent arrangement of ramps between successive interchanges may cause driver confusion, resulting in drivers slowing down in high speed lanes and making unexpected maneuvers.

Additionally, AASHTO recommends that, in locations where a driver needs to make complex or instantaneous decisions, where information is difficult to perceive, or when unexpected or unusual maneuvers are needed, that decision sight distance (DSD) should be provided. DSD is the distance needed for a driver to detect an unexpected or otherwise difficult-to-perceive information source or condition in a roadway environment that may be visually cluttered, recognize the condition or its potential threat, select an appropriate speed and path, and initiate and complete complex maneuvers. DSD offers drivers additional margin for error and affords them sufficient length to maneuver their vehicles at the same or reduced speed, rather than to just stop. In urban locations where the mainline geometry is typically complex and interchanges are closely spaced, it is desirable to provide DSD approaching an exit or entrance ramp.

In terms of uniformity, exit and entrance ramps on the left-hand side of the traveled way are an example of an inconsistent interchange arrangement. These types of ramps violate driver expectancy and therefore should be avoided whenever possible. I-84 throughout the Project Study Corridor has



LEGEND:

- I-84 Basic Lane
- I-91 Auxilary Lane
- Ramp Auxilary Lane
- Ramp Lane
- Sign Structure

Note:
Only areas that violate lane balance principle are depicted.

Project Location Key

1 2

Not to Scale

The I-84 Hartford Project

Basic Number of Lanes and
Lane Balance Along Mainline
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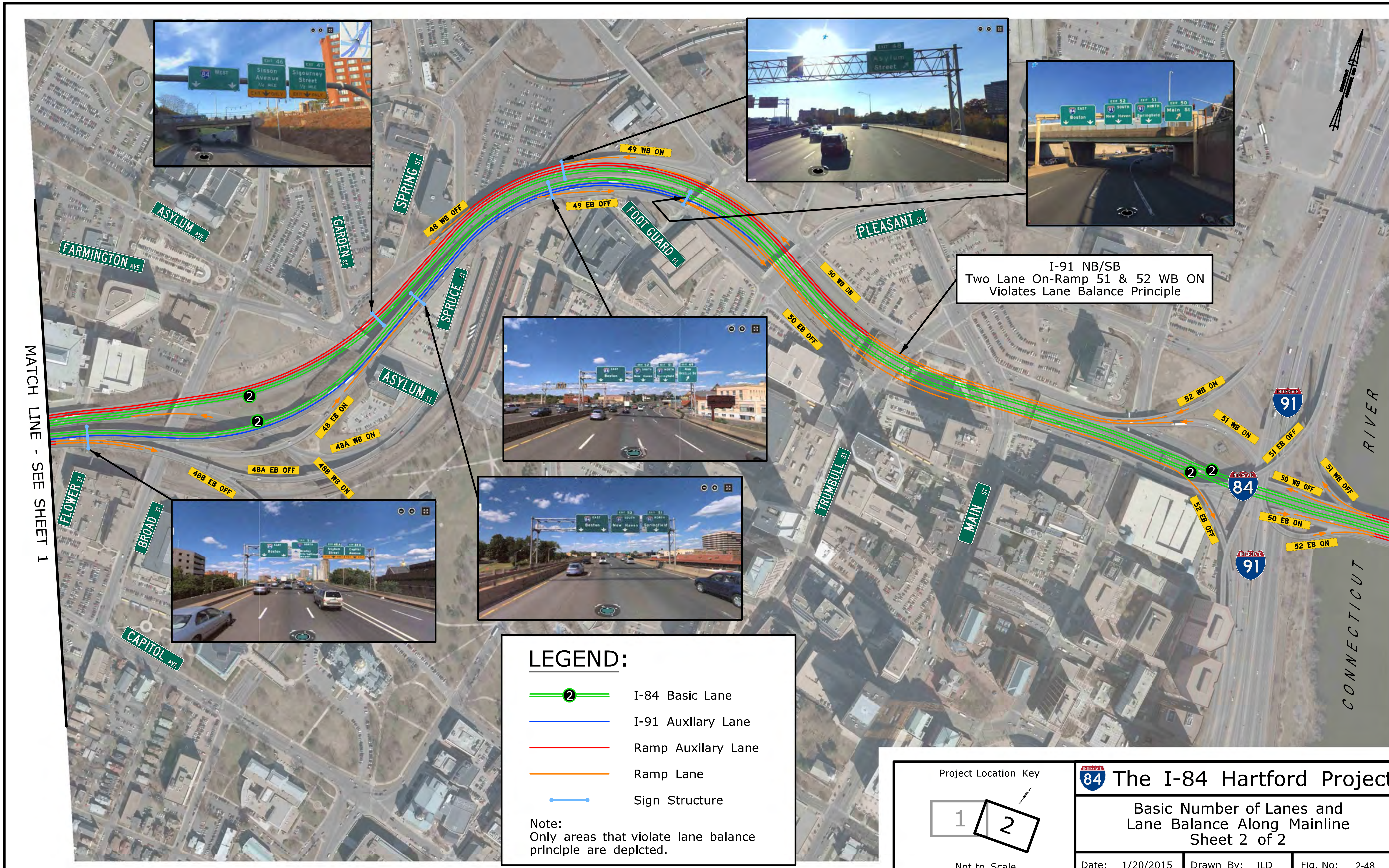
I-91 NB/SB
Two Lane On-Ramp 51 & 52 WB ON
Violates Lane Balance Principle
MATCH LINE - SEE SHEET 1
49 WB ON
49 EB OFF
48 WB OFF
48 EB ON
48A WB ON
48A EB OFF
48B EB OFF
48B WB ON
50 WB ON
50 EB OFF
52 WB ON
51 WB ON
51 EB OFF
50 WB OFF
51 WB OFF
50 EB ON
52 EB OFF
52 EB ON
ASYLUM AVE
FARMINGTON AVE
SPRING ST
GARDEN ST
SPRUCE ST
FOOT GUARD PL
PLEASANT ST
ASYLUM ST
FLOWER ST
BROAD ST
CAPITOL AVE
TRUMBULL ST
MAIN ST
CONNECTICUT RIVER
91
84
LEGEND:
I-84 Basic Lane
I-91 Auxilary Lane
Ramp Auxilary Lane
Ramp Lane
Sign Structure
Note:
Only areas that violate lane balance principle are depicted.
Project Location Key
1
2
Not to Scale
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Basic Number of Lanes and
Lane Balance Along Mainline
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Drawn By: JLD
Fig. No: 2-48

three left-hand exit and entrance ramps that do not adhere to the uniformity principle as depicted in Figure 2-47, page 2-121, Figure 2-48, page 2-122, and identified below:

- I-84 Eastbound 46 (Left Hand Off-Ramp) to Sisson Avenue
- I-84 Westbound 45 (Left Hand Off-Ramp) to Flatbush Avenue (Ramp is just outside of the Project Study Corridor)
- I-84 Westbound 48A/B (Left Hand On-Ramp) from Asylum Street/Capitol Avenue

The successive spacing, uniformity, and DSD for ramps within the Project Study Corridor have been evaluated against the recommended design values provided in AASHTO/CTHDM. The results of the evaluation are depicted in Table 2-25 and Table 2-26, following.

Table 2-25: I-84 Eastbound Ramps

Terminal	Type	Left Hand Terminal	Decision Sight Distance to Ramp (1,030' Required)	Recommended Separation Distance (feet)	Measured Separation Distance (feet)
46 OFF	Exit-Entrance	Yes	>1,030	500	2,690
46 ON			>1,030		
46 ON	Entrance-Entrance		>1,030	1,000	1,210
47 ON			575		
47 ON	Entrance-Exit		575	2,000	950
48A&B OFF			>1,030		
48A&B OFF	Turning		>1,030	600	620
48B OFF			450		
48A&B OFF	Exit-Entrance		>1,030	500	1,550
48 ON			550		
48 ON	Entrance-Exit		550	2,000	1,200
49 OFF			200		
49 OFF	Exit-Exit		200	1,000	900
50 OFF			400		
50 OFF	Exit-Exit		400	1,000	500
51 OFF			750		
51 OFF	Exit-Exit		750	1,000	2,200
52 OFF			>1,030		
52 OFF	Exit-Entrance		>1,030	500	950
50 ON			>1,030		
50 ON	Entrance-Entrance		>1,030	1,000	35
52 ON			>1,030		

Values depicted in **RED** represent values led than the minimum recommended

Table 2-26: I-84 Westbound Ramps

Terminal	Type	Left Hand Terminal	Decision Sight Distance to Ramp (1,030' Required)	Recommended Separation Distance (feet)	Measured Separation Distance (feet)
51 OFF			>1,030		
	Exit-Exit			1,000	**160**
50 OFF			>1,030		
50 OFF			>1,030		
	Exit-Entrance			500	1,370
51/52 ON			>1,030		
51/52 ON			>1,030		
	Entrance-Entrance			1,000	1,600
50 ON			**790**		
50 ON			**790**		
	Entrance-Entrance			1,000	**875**
49 ON			**600**		
49 ON			**600**		
	Entrance-Exit			2,000	**545**
48 OFF			**640**		
48 OFF			**640**		
	Exit-Entrance			500	1,365
48A&B ON		**Yes**	**980**		
48A&B ON		**Yes**	**980**		
	Entrance-Exit			2,000	**1,090**
47 OFF			>1,030		
47 OFF			>1,030		
	Exit-Exit			1,000	2,000
46 OFF			**1,010**		
46 OFF			**1,010**		
	Exit-Entrance			500	2,075
46 ON			**750**		
Values depicted in **RED** represent values led than the minimum recommended					

Highway/Ramp Weaving

There are several weaving sections within the study corridor. A weave section is a highway segment where vehicles trying to exit the facility are competing with vehicles trying to enter the facility. The weave becomes constrained when the mixing volumes are heavy and the weave section is relatively short. Constrained weaves are a source of congestion because mainline vehicles reduce their speed to find an acceptable gap between the vehicles entering the mainline. For multilane highways, the speed differential between the free-flow vehicles (vehicles not exiting the highway) and the weaving vehicles can lead to rear-end and sideswipe accidents.

On I-84 eastbound, the first weave section begins at the Sigourney Street on-ramp. The on-ramp enters the highway as an auxiliary lane that is designated as an exit-only for Asylum Street / Capitol Street (Exit 48A/B) with an overhead sign structure at its merge with I-84. The weave length is approximately 2,150 feet long. The minimum distance between an on-ramp and off-ramp is 2,000 feet; however, a preliminary traffic analysis for this section determined that a distance of over one mile would be needed between the ramps to improve the traffic operation. There is another weaving section within the aforementioned section. The Sigourney Street eastbound on-ramp merges to the right of the Sisson Avenue auxiliary lane. This lane add becomes an exit-only lane for Capitol Avenue (Exit 48B) approximately 950 feet after the merge with I-84. Between these ramps, the outside basic lane for I-84 eastbound is designated as an I-91 auxiliary lane. I-84 eastbound vehicles entering from the Sigourney Street on-ramp must make three lane changes (two within 950 feet) to reach the I-84 through lanes. This weaving action creates a significant amount of friction between the ramps, auxiliary lanes, and the mainline.

The final eastbound weaving section is between the Broad Street on-ramp and the I-91 interchange. The Broad Street on-ramp enters the highway as a lane-add to the right of the I-91 auxiliary lane. The lane-add is immediately signed as an exit-only lane for I-91 south (Exit 51), and the I-91 auxiliary lane becomes an exit-only lane for I-91 north (Exit 52). I-84 eastbound vehicles entering from Broad Street must make two lane changes while negotiating the sharp horizontal curve, steep vertical downgrade and the weaving vehicles from the auxiliary lane and I-84. The distance between the Broad Street on-ramp and the I-91 north off-ramp is approximately 1,800 feet. There are also two lower volume off-ramps within this section, Ann Uccello Street (Exit 49) and Main Street (Exit 50).

For I-84 westbound, the first weaving segment is between the High Street on-ramp and the Asylum Street off-ramp (Exit 48). The High Street on-ramp enters the mainline as an auxiliary lane that ends as an exit only lane at Asylum Street, a distance of approximately 500 feet. The Asylum Street off-ramp has the highest morning peak hour volume within the study corridor, whereas the High Street on-ramp is significantly lower. The traffic queues for the Asylum Street off-ramp extend well beyond the on-ramp from High Street. The traffic queue essentially acts like a barrier to the vehicles entering the highway, causing significant friction to both traffic streams.

The westbound weaving sections are between the left-hand on-ramp from Capitol Avenue/Asylum Street and the exit-only lane drops at Sigourney Street (Exit 47) and Sisson Avenue (Exit 46). This maneuver is prohibited with signage prior to the merge with the highway; however, without a physical barrier to prevent the move, many vehicles attempt it. Within a distance of approximately 1,100 feet, vehicles attempt to cross four lanes of traffic to reach the Sigourney Street off-ramp. The distance between the Capitol Avenue/Asylum Street on-ramp and the Sisson Avenue off-ramp is approximately 4,100 feet.

2.5.4 Interchange Ramp Review

Methodology

The Project Study Corridor includes eight full or partial interchanges consisting of multiple ramps of varying lengths and complexities. These interchanges are listed in Table 2-1 which is included in Section 2.1.1: Mainline and Interchange Ramps.

Per AASHTO, the term "ramp" includes all types, arrangements, and sizes of turning roadways that connect two or more legs at an interchange. A ramp is typically characterized as a transition segment between facilities. On-ramps provide a long enough distance for vehicles to accelerate to an acceptable speed prior to entering the highway, whereas off-ramps provide enough distance to decelerate from highway speeds to a complete stop or to the first governing geometric constraint. Ramps can adversely influence operating conditions on freeways if the demand for their use is excessive or if their design is deficient. In urbanized areas, high turning volumes and close spacing between adjacent ramp terminals may result in congestion on the crossroad that affects traffic on the ramp and may spill back onto the mainline freeway. These effects may include queue spillback, stop-and-go travel, heavy weaving volumes, and poor traffic signal progression.

The design speed of a ramp is dependent on the mainline design speed, the type of interchange (system vs. service), and the type of connection (direct vs. semi-direct). Recommended ramp speeds are depicted in Table 2-27, below, and were used to evaluate the existing ramp conditions. For direct connections, the ramps should be designed to handle speeds between the mid and high ranges but not less than 40 mph. For semi-direct connections, the ramps should be designed to handle speeds between the mid and high ranges but not less than 30 mph. These values apply to the sharpest, or controlling, ramp curve, usually on the ramp proper. These speeds do not pertain to the ramp terminals, which should be properly transitioned and provided with speed change facilities adequate for the highway speed involved.

Table 2-27: Interchange Ramp Design Speed

Mainline Speed (mph)	50
Ramp Speed (mph)	
High Range (85%)	45
Mid Range (70%)	35
Low Range (50%)	25

The existing geometry of each entrance ramp was used to calculate an existing ramp speed. Typically, this speed is controlled by the minimum horizontal radius, vertical curvature, and the stopping sight distance of the ramp. For on-ramps, acceleration lengths were obtained using the speed differential between the calculated speed of the ramp and the posted speed of the mainline.

Off-ramps were evaluated to determine if the existing deceleration lengths were adequate. The required deceleration length is the distance needed for a vehicle to safely decelerate from the mainline traveling speed. This distance may be required to decelerate to a lower speed curve on the ramp or to make a complete stop. Since the majority of the off-ramps within the Project Study Corridor experience heavy vehicular volume with corresponding queues that routinely back up the ramps, deceleration distance was measured to the back of the queues instead of the intersection stop bar.

Queue lengths were available from three sources: Synchro, Vissim, and SkyComp. Queue lengths calculated in Synchro were significantly lower than those observed in the field, even for 2040 design year volumes, since the program analyzes each intersection individually and neglects complex interactions between intersections. In the Vissim simulations, ramp queues routinely extended onto the I-84 mainline and merged with mainline queues, and thus cannot be easily measured. SkyComp ramp queue lengths are derived from actual field observations, and are therefore considered the most accurate. Although 2040 no-build queues are not available for SkyComp, traffic growth rates are projected to be relatively flat, so the current SkyComp queue lengths were also used for the design year analysis.

The results of this evaluation, shown in Table 2-28, following, indicate that the Exit 47 westbound off-ramp, Exit 48B eastbound off-ramp, and Exit 48 westbound off-ramp do not provide sufficient deceleration distances to the SkyComp observed queue lengths. For these ramps, the queue lengths back up onto the mainline, leaving stopped vehicles adjacent to the mainline travel lanes. All other ramps within the Project Study Corridor, other than those locations noted, provide ample deceleration distance to the SkyComp observed queue lengths.

CTHDM recommends that the minimum paved width of a one-way, one-lane ramp should be 26 feet. This cross section consists of a 12 foot traveled way, a 4 foot left shoulder and a 10 foot right shoulder when viewed in the direction of travel. It should be noted that the current ramp pavement marking requirements differ from what was required when I-84 was originally constructed: the previous requirements consisted of a 14 foot traveled way, 4 foot left shoulder and 8 foot right shoulder.

Table 2-28: Deceleration Lengths

Intersection Location	2013 95th Percentile Queue Length		2040 95th Percentile Queue Length	
Interchange 46 Eastbound and Westbound Off-Ramps at Sisson Avenue/ West Boulevard	487’	Yes	468’	Yes
Interchange 47 Westbound Off-Ramp at Sigourney Street	*1,300’	**No**	*1,300’	**No**
Interchange 48B Eastbound Off-Ramp at Capitol Avenue/Oak Street	400’	**No**	540’	**No**
Interchange 48A Eastbound Off-Ramp at Asylum Street/Spruce Street	293’	Yes	431’	Yes
Interchange 48 Westbound Off-Ramp at Asylum Street	*2,500’	**No**	*2,500’	**No**
Interchange 49 Eastbound Off-Ramp at High Street/Chapel Street South	71’	Yes	81’	Yes
Interchange 50 Eastbound Off-Ramp at Trumbull Street/Chapel Street South	251’	Yes	269’	Yes
Interchange 50 Westbound Off-Ramp at Market Street/North Morgan Street	183’	Yes	222’	Yes

Note: “Yes” indicates that deceleration lengths are sufficient based on indicated queue; “**No**” indicates that deceleration lengths are deficient based on indicated queue.

* Observed 2014 SkyComp queue length utilized in place of 95th percentile values

The results of these evaluations are described in the following sections and summarized in Table 2-29, following. Each interchange and its ramps are described in detail in the following section. The section focuses on assessing individual ramp geometric designs, widths, and acceleration/deceleration lengths.

Table 2-29: Interchange Ramp Review

Design Element	CTHDM Section	CTDOT Standard	Interchange 46 (Sisson Avenue)				Interchange 47 (Sigourney Street)	
			46 EB OFF	46 EB ON	46 WB ON	46 WB OFF	47 EB ON	47 WB OFF
			To Sisson	From Sisson	From Sisson	To Sisson	From Sigourney	To Sigourney
Functional Classification/Ramp Type	-	Urban Freeway	Directional	Directional	Directional	Directional	Semi-Directional	Semi-Directional
Posted Speed (Mainline)	6-2.02	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph
Posted Speed (Ramp)	-	-	None	30 mph	30 mph	None	None	25 mph[1]
Evaluated Speed	12-4.01	35 mph / 40 mph	40 mph	40 mph	40 mph	40 mph	35 mph	35 mph
Controlling Criteria Speed[2]	-	-	**30 mph**	**25 mph**	**30 mph**	**30 mph**	35 mph	35 mph
Travel Lane Width	12-4.02	12'	14'	14'	14'	14'	12'	12'
Right Shoulder Width	12-4.02	10'	**6'**-10'	**2'**-35'	**3'**-10'	**2'-6'**	**3'**	**3'**
Left Shoulder Width	12-4.02	4'	**3'**-7'	4'	6'-40'	**2'-3'**	**3'**	**3'**
Cross Slope Travel Lane & Right Shoulder	12-4.02 Fig. 12-4B	1.5%	2%	1%	2%	N/A	2%	2%
Cross Slope Left Shoulder	12-4.02 Fig. 12-4B	4%	Same as travel lane	Same as travel lane	Same as travel lane	Same as travel lane	Same as travel lane	Same as travel lane
Roadside Clear Zone	13-2.0	14'	Acceptable	Acceptable	Acceptable	Acceptable	N/A	N/A
Acceleration or Deceleration Length/Available Length	12-3.0	Variable Depending on Grade (Criteria/Actual)	315'/>315'	N/A (Auxiliary Lane)	450'/>450'	N/A (Auxiliary Lane)	N/A (Auxiliary Lane)	435'/**0'**[3]
Stopping Sight Distance[4]	7-1.0	250' / 305'	**212' H**	**175' H**	**207' H**	**225' H**	291' H	293' V
Minimum Radius (e=6.0%)	8-2.02	385' / 510'	**480'**	**400'**	550'	635'	1000'	5130'
Maximum Superelevation	8-2.02	6%	6.0%	6.0%	6.0%	6.0%	N/A	N/A
Maximum Grade	12-4.04	5-7% / 4-6%	4.0%	3.9%	4.1%	1.4%	4.9%	5.1%
Minimum Grade	9-2.03	0.5%	2.3%	3.2%	1.5%	0.9%	1.0%	1.0%
Vertical Clearance - Overhead Sign	9-4.0	18'-0"	N/A	N/A	N/A	N/A	Adequate	Adequate
Vertical Clearance - Highway over Arterial/Freeway	9-4.0	16'-3"	**13'8" (over 46 EB On)**	**13'8" (under 46 EB Off) 13'-11" (over I-84 EB) 15'-2" (over I-84 WB)**	N/A	N/A	N/A	N/A
Vertical Clearance - Highway over Collector/Local	9-4.0	14'-6"	>14'-6"	>14'-6"	>14'-6"	>14'-6"	N/A	N/A
Vertical Clearance - Highway over Non-Electrified RR	9-4.0	20'-6"	>20'-6"	>20'-6"	>20'-6"	>20'-6"	N/A	N/A

1. Ramp advisory speed warning sign
2. Controlling criteria speed is maximum allowable speed based upon deficiencies in stopping sight distance or curvature.
3. 2040 95th percentile queue extends beyond the painted ramp gore, rendering the deceleration length deficient.
4. Notation after distance is for limiting horizontal (H) or vertical (V) curvature.

Values depicted in **red** represent elements that are less than the minimum required for the evaluated speed and roadway classification.

Table 2-29 (ctd.): Interchange Ramp Review

Design Element	CTHDM Section	CTDOT Standard	Interchange 48 (Capitol Avenue/Asylum Street)					
			48B EB OFF	48A EB OFF	48 EB ON	48B WB ON	48A WB ON	48 WB OFF
			To Capitol	To Asylum	From Broad	From Capitol	From Asylum	To Asylum
Functional Classification/Ramp Type	-	Urban Freeway	Semi-directional	Semi-directional	Semi-Directional	Semi-directional	Semi-directional	Semi-Directional
Posted Speed (Mainline)	6-2.02	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph
Posted Speed (Ramp)	-	-	30 mph[1]	30 mph[1]	None	None	None	25 mph[1]
Evaluated Speed	12-4.01	35 mph	35 mph	35 mph	35 mph	35 mph	35 mph	35 mph
Controlling Criteria Speed[2]	-	-	**25 mph**	35 mph	**30 mph**	**25 mph**	**30 mph**	**30 mph**
Travel Lane Width	12-4.02	12'	12'	12'	14'	14'	14'	12'
Right Shoulder Width	12-4.02	10'	**3'**	**6'**	**3'**-10'	10'	**2'-7'**	**2'-6'**
Left Shoulder Width	12-4.02	4'	**3'**-8'	6'	**2'**-4'	**2'-3'**	**2'**	6'
Cross Slope Travel Lane & Right Shoulder	12-4.02 Fig. 12-4B	1.5%	Banked	Banked	Banked	Banked	Banked	1%
Cross Slope Left Shoulder	12-4.02 Fig. 12-4B	4%	N/A	Same as travel lane	Same as travel lane	Same as travel lane	Same as travel lane	4%
Roadside Clear Zone	13-2.0	14'	Acceptable	Acceptable	N/A	Acceptable	Acceptable	Acceptable
Acceleration or Deceleration Length/Available Length	12-3.0	Variable Depending on Grade (Criteria/Actual)	N/A (Auxiliary Lane)	N/A (Auxiliary Lane)	N/A (Auxiliary Lane)	N/A (Auxiliary Lane)	N/A (Auxiliary Lane)	435'/**0'**[3]
Stopping Sight Distance[4]	7-1.0	250'	**180' V**	290' H	**240' H**	**155' H**	**209' V**	**207' V**
Minimum Radius (e=6.0%)	8-2.02	385'	410'	830'	500'	410'	400'	N/A
Maximum Superelevation	8-2.02	6%	6.0%	6.0%	6.0%	6.0%	6.0%	N/A
Maximum Grade	12-4.04	5-7%	3.5%	5.9%	2.2%	5.0%	4.6%	4.7%
Minimum Grade	9-2.03	0.5%	0.8%	0.5%	**0.2%**	3.8%	1.0%	0.5%
Vertical Clearance - Overhead Sign	9-4.0	18'-0"	**17'8"**	**17'8"**	N/A	N/A	N/A	N/A
Vertical Clearance - Highway over Arterial/Freeway	9-4.0	16'-3"	**15'-2"**	**15'-2"**	>16'-3"	>16'-3"	>16'-3"	N/A
Vertical Clearance - Highway over Collector/Local	9-4.0	14'-6"	N/A	>16'-3"	N/A	**14'-0"**	**14'-0"**	N/A
Vertical Clearance - Highway over Non-Electrified RR	9-4.0	20'-6"	24'-8"	N/A	N/A	**15'-10" (under RR) 14'-3" (under ped. bridge)**	N/A	N/A

1. Ramp advisory speed warning sign
2. Controlling criteria speed is maximum allowable speed based upon deficiencies in stopping sight distance or curvature.
3. 2040 95th percentile queue extends beyond the painted ramp gore, rendering the deceleration length deficient.
4. Notation after distance is for limiting horizontal (H) or vertical (V) curvature.

Values depicted in **red** represent elements that are less than the minimum required for the evaluated speed and roadway classification.

Table 2-29 (ctd.): Interchange Ramp Review

Design Element	CTHDM Section	CTDOT Standard	Interchange 49 (High Street)		Interchange 50 (Main Street/Trumbull Street/Morgan Street)			
			49 EB OFF	49 WB ON	50 EB OFF	50 EB ON	50 WB ON	50 WB OFF
			To High	From High	To Trumbull	From Morgan	From Trumbull	To Market
Functional Classification/Ramp Type	-	Urban Freeway	Semi-Directional	Semi-Directional	Semi-Directional	Semi-Directional	Semi-Directional	Semi-Directional
Posted Speed (Mainline)	6-2.02	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph
Posted Speed (Ramp)	-	-	25 mph[1]	None	30 mph[1]	None	None	None
Evaluated Speed	12-4.01	35 mph	35 mph	35 mph	35 mph	35 mph	35 mph	35 mph
Controlling Criteria Speed[3]	-	-	**20 mph**	35 mph	35 mph	35 mph	**25 mph**	**30 mph**
Travel Lane Width	12-4.02	12'	14'	14'	12'	12'	12'	12'
Right Shoulder Width	12-4.02	10'	**2'-4'**	**2'-8'**	**2'**-10'	**1'**-10'	10'	**3'**
Left Shoulder Width	12-4.02	4'	**2'**-8'	**3'**	6'	**3'**	**2'**	**3'**
Cross Slope Travel Lane & Right Shoulder	12-4.02 Fig. 12-4B	1.5%	1%	1%	2%	2%	2%	2%
Cross Slope Left Shoulder	12-4.02 Fig. 12-4B	4%	Same as travel lane	Same as travel lane	Same as travel lane	Same as travel lane	Same as travel lane	Same as travel lane
Roadside Clear Zone	13-2.0	14'	N/A	N/A	N/A	N/A	N/A	N/A
Acceleration or Deceleration Length/Available Length	12-3.0	Variable Depending on Grade (Criteria/Actual)	435'/**0'**	N/A (Auxiliary Lane)	285'/**0'**	N/A (Auxiliary Lane)	550'/**250'**	N/A (Auxiliary Lane)
Stopping Sight Distance[4]	7-1.0	250'	**150' H**	300' H	270' V	**210' V**	**181' V**	**215' V**
Minimum Radius (e=6.0%)	8-2.02	385'	475'	600'	640'	800'	780'	2280'[7]
Maximum Superelevation	8-2.02	6%	N/A	N/A	6%	N/A	3%	N/A
Maximum Grade	12-4.04	5-7%	5.4%	3.8%	5.5%	4.7%	7.0%	5.0%
Minimum Grade	9-2.03	0.5%	1.0%	3.0%	1.9%	**0.4%**	0.6%	0.5%
Vertical Clearance - Overhead Sign	9-4.0	18'-0"	N/A	N/A	N/A	N/A	N/A	N/A
Vertical Clearance - Highway over Arterial/Freeway	9-4.0	16'-3"	N/A	N/A	>16'-3"	**14'-3" (over I-91) 14'-4" (under 52 EB On)**	>16'-3"	**16'-1" (over 51 WB On)**
Vertical Clearance - Highway over Collector/Local	9-4.0	14'-6"	N/A	N/A	N/A	N/A	N/A	N/A
Vertical Clearance - Highway over Non-Electrified RR	9-4.0	20'-6"	N/A	N/A	N/A	N/A	N/A	N/A

1. Ramp advisory speed warning sign
2. Controlling criteria speed is maximum allowable speed based upon deficiencies in stopping sight distance or curvature.
3. Notation after distance is for limiting horizontal (H) or vertical (V) curvature.
4. CTDOT Project #0063-0375 reconstruction plans show an initial S-curve with radii between 200' and 280' when the Exit 50 WB off-ramp deviates from the I-84 WB mainline. Each curve has a length less than 50' and the tangent between the curves is greater than 100'. Due to the short length of this S-curve, drivers use the off-ramp as a taper style exit in reality. For the purposes of this table, the following curve of a 2280' radius is displayed since the initial S-curve radii would falsely indicate a deficiency.

Values depicted in **red** represent elements that are less than the minimum required for the evaluated speed and roadway classification.

Table 2-29 (ctd.): Interchange Ramp Review

Design Element	CTHDM Section	CTDOT Standard	Interchange 51 (I-91 Northbound)			Interchange 52 (I-91 Southbound)		
			51 EB OFF	51 WB ON	51 WB OFF	52 EB OFF	52 EB ON	52 WB ON
			To I-91 NB	From I-91 NB	To I-91 NB	To I-91 SB	From I-91 SB	From I-91 SB
Functional Classification/Ramp Type	-	Urban Freeway	Directional	Directional	Directional	Directional	Directional	Directional
Posted Speed (Mainline)	6-2.02	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph	50 mph
Posted Speed (Ramp)	-	-	35 mph/30 mph[1]	None	25 mph[2]	35 mph/25 mph[1]	25 mph[2]	35 mph[2]
Evaluated Speed	12-4.01	40 mph	40 mph	40 mph	40 mph	40 mph	40 mph	40 mph
Controlling Criteria Speed[3]	-	-	**30 mph**	**25 mph**	**25 mph**	**25 mph**	**15 mph**	40 mph
Travel Lane Width	12-4.02	12'	14'	12'-14'	12'	14'	14'	14'
Right Shoulder Width	12-4.02	10'	10'	**6'**-10'	**2'**-10'	**3'-6'**	**4'**	10'
Left Shoulder Width	12-4.02	4'	6'	**3'**-6'	4'-6'	**3'**	4'	6'
Cross Slope Travel Lane & Right Shoulder	12-4.02 Fig. 12-4B	1.5%	2%	2%	1.5%	N/A	2%	1.5%
Cross Slope Left Shoulder	12-4.02 Fig. 12-4B	4%	Same as travel lane	Same as travel lane	Same as travel lane	N/A	Same as travel lane	Same as travel lane
Roadside Clear Zone	13-2.0	14'	N/A	N/A	N/A	N/A	N/A	N/A
I-84 Acceleration or Deceleration Length/Available Length	12-3.0	Variable Depending on Grade (Criteria/Actual)	N/A (Auxiliary Lane)	N/A (Auxiliary Lane)	N/A (Auxiliary Lane)	N/A (Auxiliary Lane)	N/A (Auxiliary Lane)	N/A (Auxiliary Lane)
I-91 Acceleration or Deceleration Length/Available Length	12-3.0	Variable Depending on Grade (Criteria/Actual)	N/A (Auxiliary Lane)	N/A (Auxiliary Lane)	385'/>385'	N/A (Auxiliary Lane)	N/A (Auxiliary Lane)	N/A (Auxiliary Lane)
Stopping Sight Distance[4]	7-1.0	305'	**218' H**	**188' H**	**165' H**	**175' H**	**105' V**	325' H
Minimum Radius (e=6.0%)	8-2.02	510'	**455'**	**330'**	**355'**	**355'**	**180'**	680'
Maximum Superelevation	8-2.02	6%	6%	6%	6%	N/A	6%	6%
Maximum Grade	12-4.04	4-6%	5.3%	5.6%	3.1%	N/A	4.9%	2.2%
Minimum Grade	9-2.03	0.5%	**0.4%**	0.9%	0.8%	N/A	1.2%	1.0%
Vertical Clearance - Overhead Sign	9-4.0	18'-0"	N/A	N/A	N/A	N/A	N/A	N/A
Vertical Clearance - Highway over Arterial/Freeway	9-4.0	16'-3"	>16'-3"	**16'-1" (under 50 WB Off)**	N/A	**14'-7" (under I-91 SB Off)**	**14'-4" (over 50 EB On)**	**16'-2" (over I-91 Off)**
Vertical Clearance - Highway over Collector/Local	9-4.0	14'-6"	N/A	N/A	N/A	>14'-6"	N/A	N/A
Vertical Clearance - Highway over Non-Electrified RR	9-4.0	20'-6"	N/A	N/A	N/A	N/A	N/A	N/A

1. For Exits 51/52 EB off, there is a regulatory speed limit sign posted at 35 mph. The Exit 51EB off-ramp has a ramp advisory speed warning sign for 30 mph. The Exit 52 EB off-ramp has a ramp advisory speed warning sign for 30 mph.
2. Ramp advisory speed warning sign
3. Controlling criteria speed is maximum allowable speed based upon deficiencies in stopping sight distance or curvature.
4. Notation after distance is for limiting horizontal (H) or vertical (V) curvature.

Values depicted in **red** represent elements that are less than the minimum required for the evaluated speed and roadway classification.

Interchange 46 (Sisson Avenue)

Figure 2-49: Interchange 46 (Sisson Avenue)

Interchange 46 is a three-legged directional service interchange connecting the I-84 mainline with Sisson Avenue. The interchange layout is unchanged from its original construction in the 1960s. The interchange provides local access to the Hartford neighborhoods of the West End and Parkville and to the adjacent town of West Hartford. The interchange consists of four direct connection ramps which cross over the railroad, *CTfastrak,* Capitol Avenue, and Forest Street on elevated viaduct structures. The four ramps combine to form a divided, two-way, at-grade roadway prior the ramp terminal at the four-way signalized intersection with Sisson Avenue and West Boulevard. The eastbound off-ramp is a left-hand exit from the I-84 mainline which does not meet driver expectancy. Generally, the eastbound on- and westbound off-ramps carry high traffic volumes, the westbound on- and eastbound off-ramps carry mid-level traffic volumes.

The original design provided for a combined system and service interchange with connections to a planned freeway (CT 189) in addition to local access at Sisson Avenue. The ramps were constructed with additional width to accommodate this connection from the I-84 mainline across the railroad, CT*fastrak*, and Capitol Avenue. Each ramp has a 'stub' where the freeway connection would have continued to the north. Plans to construct the planned freeway were abandoned in 1970s, eliminating the system interchange component.

Interchange 46 – Eastbound On-Ramp 'Stub'

Service interchanges are not typically designed with directional ramps because high speed connections are not generally warranted, especially in urban areas. Direct connection ramps are, by design, high speed and high volume connections meant to convey a significant volume of traffic to another high speed facility (typically another highway). In order to meet driver expectancy, direct connection ramps should provide a high range design speed of 40 mph, as defined in Table 2-27: Interchange Ramp Design Speed, page 2-127. However, based on the existing geometric features, none of the four ramps provide design speeds of 40 mph. The eastbound on-ramp meets criteria for 25 mph, the eastbound off-ramp and westbound off-ramps meet criteria for 30 mph, and the westbound on-ramp meets criteria for 35 mph. The limiting design element in all cases is SSD on horizontal curves, where a driver's sight lines are obstructed by bridge parapets or barrier curbs. Additionally, the minimum horizontal curve radius on the eastbound on-ramp is deficient for 40 mph. The two on-ramps of Interchange 46 have posted speed limits of 30 mph. The two off-ramps do not have posted speed limits or ramp advisory speed warning signs.

The ramp widths were evaluated against the CTHDM minimum overall width of 26 feet (with a 12 foot travel lane, 4 foot left shoulder and 10 foot right shoulder). All four ramps were found to have segments that do not meet the minimum overall width requirement. The ramps each have a 14 foot travel lane with left and right shoulders lower than the required values. These narrow shoulder widths contribute to the SSD deficiencies as the view-obstructing objects (bridge parapet or barrier curb) are closer to the travel lane.

The eastbound off-ramp deceleration lane has a parallel-type design which does not meet CTDOT's current policy (CTHDM 12-3.01.01), but are allowed where site restrictions exist. The deceleration length is of sufficient length to both the governing geometric control (a horizontal curve with a design speed of 40 mph) and the design year queue length from the ramp terminal intersection at Sisson Avenue (as discussed previously). The eastbound on-ramp joins the I-84 mainline as an auxiliary lane which extends to the Interchange 48 off-ramp. Therefore, sufficient acceleration distance is provided.

The westbound off-ramp exits the I-84 mainline as an auxiliary lane drop. The available deceleration distance to the 2040 95th percentile queue from the terminal intersection is sufficient. The westbound on-ramp acceleration lane is of sufficient length to allow acceleration from the governing geometric control (a horizontal curve with a design speed of 45 mph).

Interchange 47 (Sigourney Street)

Figure 2-50: Interchange 47 (Sigourney Street)

Interchange 47 is a partial-diamond service interchange consisting of an eastbound on-ramp and a westbound off-ramp. Each semi-direct ramp connects the I-84 mainline with Sigourney Street at signalized intersections. The interchange layout is unchanged from its original construction in the 1960s. The interchange provides local access to the Hartford neighborhoods of Asylum Hill and Frog Hollow. The Aetna office campus, with approximately 4,500 employees, is located immediately to the north of the interchange. Each ramp descends from the I-84 viaduct to Sigourney Street (which is elevated above the railroad, CTfastrak, and parking). The entirety of each ramp is located on a bridge structure. Generally, both ramps carry high amounts of traffic, particularly during AM and PM peak periods. The CTHDM recommends that incomplete interchanges, such as Interchange 47, be avoided if practical as the missing movements may cause driver confusion.

Due to their short length, the two ramps of Interchange 47 function as transition zones between the I-84 mainline and the local street network. The ramp design speeds vary throughout the length of the ramps, between the mainline design speed and a stop condition at the signalized terminal intersections. The design elements were assessed to determine the necessary acceleration/deceleration lengths and to assess compliance with the minimum mid range design speed of 35 mph, as defined in Table 2-27: Interchange Ramp Design Speed, page 2-127. The geometric design element of note on the westbound off-ramp is the crest vertical curve where the ramp bifurcates from the I-84 mainline. This vertical curve provides stopping sight distance for 40 mph and sufficient deceleration distance is provided from the painted gore for this element. The geometric design element of note on the eastbound on-ramp is the available stopping sight distance on the horizontal curve approaching the I-84 mainline. The stopping sight distance, limited by the bridge parapet/barrier curb, meets criteria for 35 mph. The westbound off-ramp has a 25 mph ramp advisory speed warning sign. The eastbound on-ramp does not have a posted speed limit or advisory speed warning sign. Overall, the two ramps meet desired criteria for available stopping sight distance and minimum horizontal curvature.

The ramp widths were evaluated against the CTHDM minimum overall width of 26 feet (with a 12 foot travel lane, 4 foot left shoulder and 10 foot right shoulder). Both ramps fail to meet the minimum width requirements due to the insufficient left and right shoulder widths.

The eastbound on-ramp joins the I-84 mainline as an auxiliary lane which extends to the Interchange 48 off-ramp. Therefore, sufficient acceleration distance is provided. The westbound off-ramp exits the I-84 mainline as an auxiliary lane drop. The 2040 95th percentile queue length extends beyond the ramp gore onto the I-84 mainline. Therefore, sufficient deceleration distance is not provided.

Interchange 48 (Capitol Avenue, Broad Street, and Asylum Street)

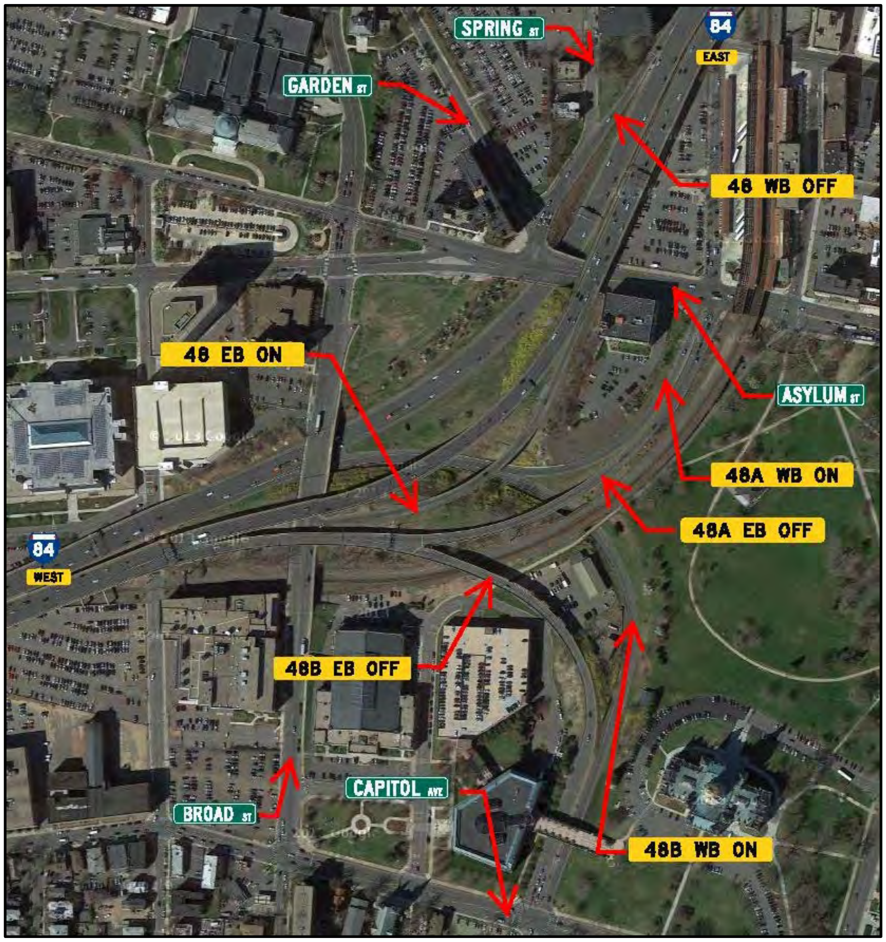


Figure 2-51: Interchange 48 (Capitol Avenue, Broad Street, and Asylum Street)

Interchange 48 is a complex service interchange providing access to the Hartford neighborhoods of Frog Hollow and Asylum Hill as well as South Downtown and Downtown areas. The interchange provides access to the State Capitol, Hartford Hospital, and many other commercial and cultural resources. Interchange 48 consists of six semi-direct ramps, including three on- and three off-ramps. The eastbound on- and westbound off-ramps form a split partial-diamond interchange. The eastbound on-ramp begins at a signalized intersection at Broad Street and climbs to meet the I-84 mainline at the bridge structure over Asylum Street. The westbound off-ramp separates from I-84 following the bridge over the railroad and terminates at a signalized intersection with Asylum Street and Garden Street. Spring Street, a one-way, southbound roadway, intersects the off-ramp prior to the terminal intersection.

The remaining four ramps are connections from I-84 to Asylum Street or Capitol Avenue. The eastbound off- and westbound on-ramps of Interchange 48 each split following their bifurcation from the I-84 mainline. The ramps serving Asylum Street are signed as Interchange 48A and the ramps serving Capitol Avenue are signed as Interchange 48B. The eastbound off-ramps are predominantly elevated, passing over Broad Street, the railroad and other ramps. The westbound on-ramps are predominantly at-grade roadways, passing under elevated sections of I-84, the railroad and other ramps. The westbound on-ramp enters I-84 on the left as a lane addition, which does not meet driver expectancy.

Interchange 48 was originally constructed as a combined service/system interchange with a planned freeway connection to the east (I-491) as well as local access. However, the planned highway was never constructed. The interchange was substantially reconfigured in the 1980s and 1990s, with the removal and replacement of several ramps. The westbound on- and eastbound off-ramps to Asylum Street were added, as was the eastbound on-ramp from Broad Street. Eastbound and westbound on-ramps in the northwest quadrant (from Farmington Avenue and Broad Street respectively) were removed.

Generally, the eastbound off- and westbound on-ramps to and from Capitol Avenue and Asylum Street carry mid-level traffic volumes, when combined (as at their split from the I-84 mainline) the total volume is high. The eastbound on-ramp from Broad Street and the westbound off-ramp to Asylum Street carry high traffic volumes. Within the local street system, Interchange 48 acts as an incomplete interchange at each ramp terminal intersection. At no location is complete access to I-84 provided. This can lead to driver confusion as they search for the proper location to enter the freeway.

The Interchange 48 ramps were evaluated as semi-direct connections, which should provide design speeds not less than 35 mph, as defined in Table 2-27: Interchange Ramp Design Speed, page 2-127. The eastbound off- and westbound on-ramps to/from Capitol Avenue do not provide the 35 mph design speed. The eastbound off-ramp to Capitol Avenue meets design criteria for 25 mph. The limiting design element is the stopping sight distance provided by the sag vertical curve adjacent to the Legislative Office Building garage. All other geometric elements of the ramp meet criteria for 35 mph or higher. The eastbound off-ramp to Asylum Street meets design criteria for 35 mph. The westbound on-ramp from Capitol Avenue meets design criteria for 25 mph. The limiting design element is the stopping sight distance available along the horizontal curve underneath the railroad bridge. Additionally, the sag vertical curve near the Legislative Office Building garage provides stopping sight distance which meets design criteria for 30 mph. All other geometric elements of the ramp meet criteria for 35 mph or higher. The westbound on-ramp from Asylum Street meets design criteria for 30 mph. The limiting design element is the stopping sight distance provided by the sag vertical curve where the ramp passes under the eastbound on-ramp from Broad Street. All other geometric elements of the ramp meet criteria for 35 mph or higher. The eastbound off-ramps both have ramp advisory speed warning signs for 30 mph. The westbound on-ramps do not have ramp advisory speed warning signs.

The eastbound on-ramp from Broad Street and the westbound off-ramp to Asylum Street serve as transition zones between mainline I-84 and the signalized terminal intersections. The design elements were assessed to determine the necessary acceleration/deceleration lengths and to assess compliance with the minimum mid range design speed of 35 mph, as defined in Table 2-27: Interchange Ramp Design Speed, page 2-127. Both ramps meet design criteria for 30 mph. The limiting design element for the eastbound on-ramp is the stopping sight distance provided by the horizontal curve where the ramp spans over the westbound on-ramps. All other geometric elements of the ramp meet criteria for 35 mph or higher. The limiting design element of the westbound off-ramp is the stopping sight distance provided by the sag vertical curve where the ramp bifurcates from the I-84 mainline. All other geometric elements of the ramp meet criteria for 35 mph or higher. The westbound off-ramp has a ramp advisory speed warning sign for 25 mph.

The ramp widths were evaluated against the CTHDM minimum overall width of 26 feet (with a 12 foot travel lane, 4 foot left shoulder and 10 foot right shoulder). All six Interchange 48 ramps fail to meet the minimum width requirements due to the deficient shoulder widths, see Table 2-28, page 2-132 for details.

The eastbound off-ramps separate from the mainline as a two-lane auxiliary lane drop. There is sufficient deceleration length from the painted ramp gore to both the controlling geometric features and to the 2040 95th percentile back of queue from the terminal intersections. The westbound on-ramps join the I-84 mainline as a lane addition, which becomes a basic lane of the I-84 mainline. Therefore, the acceleration distance is sufficient. The eastbound on-ramp from Broad Street joins the I-84 mainline as an auxiliary lane which extends to the Interchange 52 off-ramp. Therefore, sufficient acceleration distance is provided. The westbound off-ramp exits the I-84 mainline as an auxiliary lane drop. The 2040 95th percentile queue length extends beyond the ramp gore onto the I-84 mainline. Therefore, sufficient deceleration distance is not provided.

Interchange 49 (Ann Uccello Street and High Street)

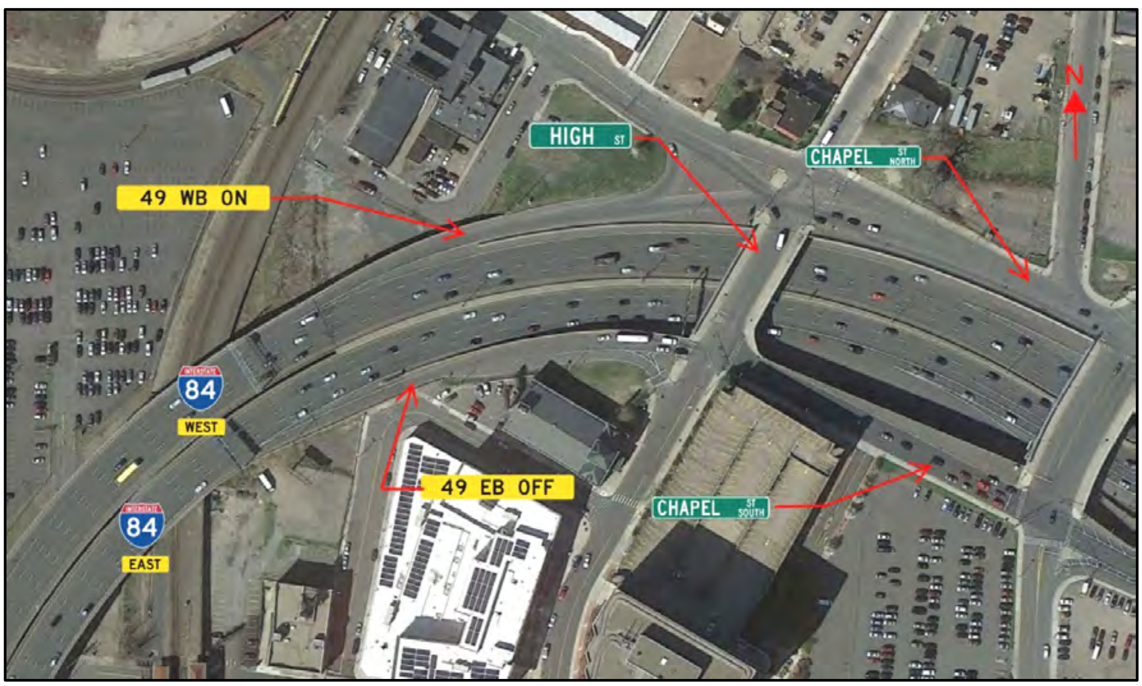


Figure 2-52: Interchange 49 (Ann Uccello Street and High Street)

Interchange 49 is a partial-diamond service interchange consisting of an eastbound off-ramp and a westbound on-ramp. The eastbound off-ramp connects the I-84 mainline with High Street and the westbound on-ramp connects the I-84 mainline with the intersection of High Street, Walnut Street and Chapel Street North. The interchange was reconstructed in the late 1980s/early 1990s, but the general layout of the ramps remains consistent with the initial construction in the 1960s. The interchange provides local access to the Hartford neighborhood of Clay-Arsenal and the Downtown and Downtown North areas. The ramps terminate at High Street with signalized intersections. Access to Ann Uccello Street is provided via a frontage road (Chapel Street South/North). Each ramp ascends from the I-84 mainline to the local streets above. Retaining walls are used to transition the grade separation between the ramps, the mainline and adjacent local streets. Generally, the westbound on-ramp carries mid-level traffic volumes and the eastbound off-ramp has low traffic volumes.

Due to their short lengths, the two semi-direct ramps function as transition zones between the I-84 mainline and the local street network. The ramp speeds transition between the mainline running speed and the signalized intersections. The design elements were assessed to determine the necessary acceleration/deceleration lengths and to assess compliance with the minimum mid range design speed of 35 mph, as defined in Table 2-27: Interchange Ramp Design Speed, page 2-127. The limiting design element on the eastbound off-ramp is the stopping sight distance at the horizontal curve where the ramp departs mainline I-84. This design element meets criteria for 20 mph, which falls below the minimum mid range ramp design speed of 35 mph. The limiting design element on the westbound on-ramp is the stopping sight distance at the horizontal curve where the ramp meets the I-84 mainline. This design element meets criteria for 30 mph. The eastbound off-ramp has a ramp advisory speed warning sign for 25 mph. The westbound on-ramp does not have a ramp advisory speed warning sign.

The ramp widths were evaluated against the CTHDM minimum overall width of 26 feet (with a 12 foot travel lane, 4 foot left shoulder and 10 foot right shoulder). Both ramps fail to meet the minimum width requirements due to the deficient shoulder widths. These deficient shoulders contribute to the limited stopping sight distances because the view-obstructing elements (typically barrier curb) are closer to the travel lane.

Acceleration and deceleration lengths were assessed based on the documented geometric controlling criteria. The eastbound off-ramp departs the mainline with a horizontal curve where the available stopping sight distance meets criteria for 20 mph. A deceleration lane is not provided prior to the ramp bifurcation. Therefore, the deceleration distance for the eastbound off-ramp is deficient. The westbound on-ramp enters the mainline as an auxiliary lane which extends to the Interchange 48 off-ramp. Sufficient acceleration distance is provided; however, the weave distance between the on-ramp and off-ramps does not meet minimum standards for length and level of service.

Interchange 50 (Main Street - US 44, Trumbull Street, and Morgan Street)

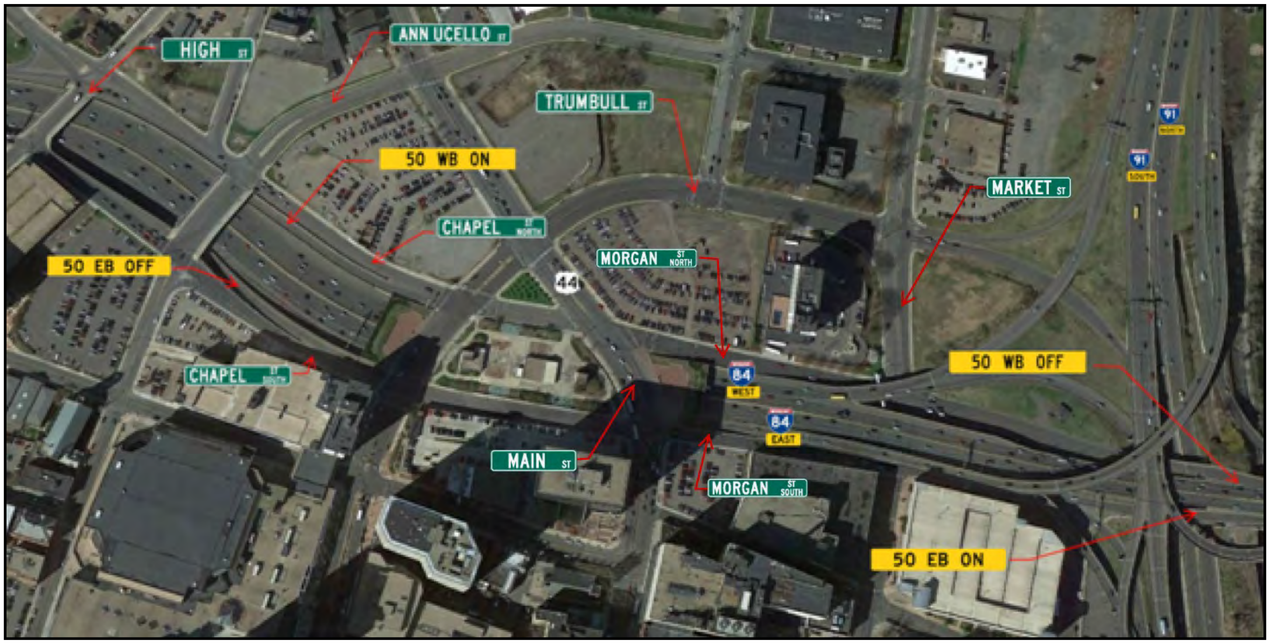


Figure 2-53: Interchange 50 (Main Street - US 44, Trumbull Street, and Morgan Street)

Interchange 50 is a split diamond service interchange with four semi-direct ramps. The interchange was substantially reconstructed in the late 1980s/early 1990s to remove three ramps to/from Ann Uccello Street. The interchange provides local access to the Downtown and North Downtown areas in Hartford. The western half of the interchange includes an eastbound off-ramp and a westbound on-ramp. The eastbound off-ramp climbs from the I-84 mainline to merge with Chapel Street South just prior to the signalized intersection with Trumbull Street. Drivers are prohibited from turning right onto southbound Trumbull Street by regulatory signing. The westbound on-ramp descends from the signalized intersection of Chapel Street South and Trumbull Street to the I-84 mainline. Retaining walls are used to transition the grade separation between the ramps, the mainline and adjacent local streets. Generally, both the eastbound off- and westbound on-ramps carry low traffic volumes.

The eastern half of the interchange includes an eastbound on-ramp and a westbound off-ramp. The eastbound on-ramp climbs from the signalized intersection of South Morgan Street and the I-91 southbound on-ramp to the I-84 mainline. The westbound off-ramp bifurcates from the I-84 mainline at the western limit of the Bulkeley Bridge and descends to the signalized intersection of Market Street and North Morgan Street. There is a driveway curb-cut on the westbound off-ramp serving maintenance access to the incident management sub-station. This driveway serves very low volumes but the inclusion of a driveway on an off-ramp does not meet driver expectancy.

The eastern and western halves of the interchange are connected by one-way frontage roads. West of Main Street, the frontage roads are named Chapel Street North and South, east of Main Street the road names change to North Morgan Street and South Morgan Street. The frontage roads continue westerly and terminate at the Interchange 49 on- and off-ramps. Generally, the eastbound on- and westbound off-ramps carry high traffic volumes.

Due to their short lengths, the four ramps of Interchange 50 function as transition zones between the I-84 mainline and the local street network. The design elements were reviewed to determine the necessary acceleration/deceleration lengths and to assess compliance with the minimum mid range design speed of 35 mph, as defined in Table 2-27: Interchange Ramp Design Speed, page 2-127. The eastbound on- and off-ramps meet the minimum design criteria for 35 mph.

The westbound off-ramp meets design criteria for 35 mph with the exception of the vertical sag curve at the signal-controlled intersection with Market Street, which is good for 30 mph. The westbound on-ramp does not meet the minimum design criteria for 35 mph. The limiting design element is the stopping sight distance provided by the sag vertical curve as the ramp descends to meet I-84 mainline, which is good for 25 mph. The eastbound off-ramp has a 30 mph ramp advisory speed warning sign. The other three ramps do not have advisory speed warning signs.

The ramp widths were evaluated against the CTHDM minimum overall width of 26 feet (with a 12 foot travel lane, 4 foot left shoulder and 10 foot right shoulder). The right shoulder width for the eastbound off-ramp is deficient. The other three ramps for Interchange 50 have deficient left and right shoulder widths.

Existing acceleration and deceleration lengths were reviewed based on the controlling geometric criteria. The sag vertical curve at the eastbound off-ramp bifurcation is good for 35 mph with no deceleration lane. Therefore, vehicles exiting the highway must decelerate within the general purpose lanes, which is a deficiency. The eastbound on-ramp enters the mainline as an auxiliary lane which extends to the Interchange 55 off-ramp. Therefore, sufficient acceleration distance is provided. The westbound off-ramp departs the I-84 mainline as an auxiliary lane drop and there are no deficiencies associated with deceleration to the end of intersection queue. The westbound on-ramp joins the mainline following a sag vertical curve which provides stopping sight distance for 25 mph. Sufficient acceleration length is not provided from this geometric feature to the end of the acceleration lane.

Interchange 51/52 (Interstate 91)

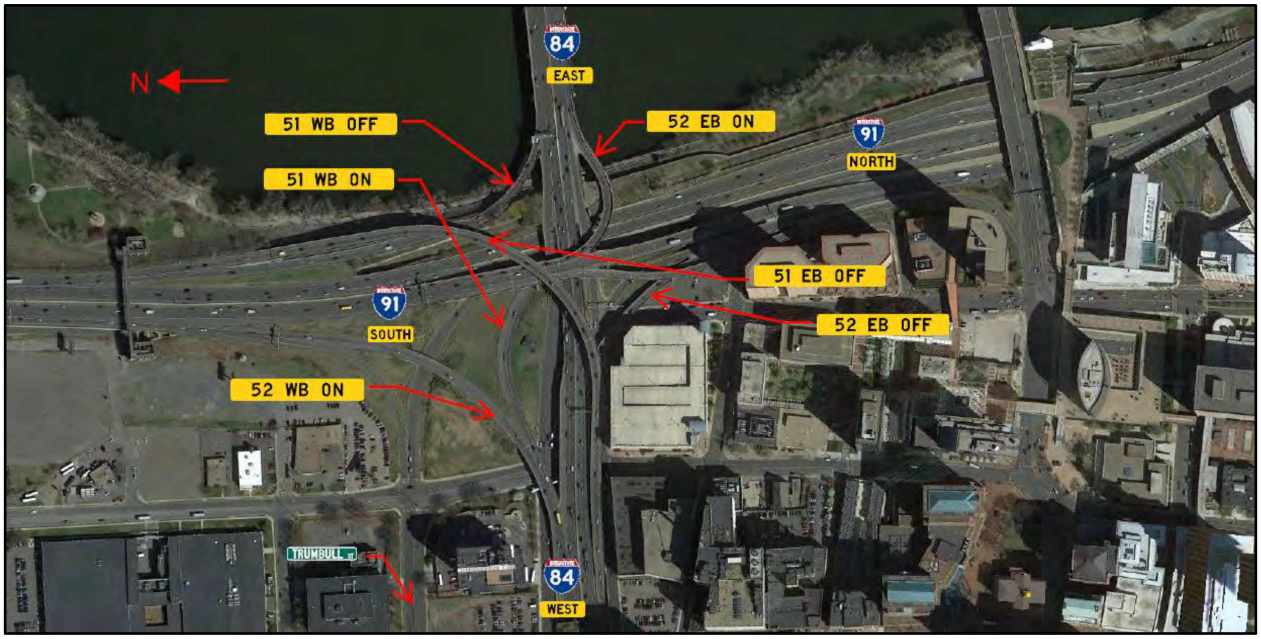


Figure 2-54: Interchanges 51 and 52 (Interstate 91)

Interchanges 51 and 52 have been evaluated as one four-level stack system interchange providing connections between I-84 and I-91. Serving nearly 275,000 vehicles per day, the interchange of I-84 and I-91 is Connecticut's busiest. This interchange carries both local and regional traffic, and is especially significant for destinations to the west and north of the city, as there are no other freeways in the area. All long-distance traffic between I-84 to the west and I-91 to the north must pass through this interchange. As a direct junction between two major interstates, the I-84 / I-91 interchange is a crucial crossroads for interstate travel and for New England as a whole.

Connections are provided for six of the eight potential maneuvers, the interchange lacks a connection from I-91 northbound to I-84 eastbound and from I-84 westbound to I-91 southbound. These connections are provided indirectly via the Charter Oak Bridge and the Wilbur Cross Highway through East Hartford. I-84 Interchange 51 connects I-84 to I-91 northbound. Interchange 52 connects I-84 to I-91 southbound. The interchange is signed as Interchange 32A and 32B on I-91. The I-84 eastbound on-ramp from I-91 southbound and the I-84 westbound on-ramp from I-91 northbound both leave I-91 as left-hand exits, which do not meet driver expectancy.

Interchanges 51 and 52 consist of six directional ramps. The ramps were assessed for compliance with the minimum design speed of 40 mph for direct connection ramps. Of the six ramps, only the westbound on-ramp from I-91 southbound (Interchange 52) meets the minimum design speed for a direct connection ramp. The I-84 eastbound off-ramp to I-91 northbound (Interchange 51) meets design criteria for 30 mph. The limiting design element is the stopping sight distance controlled by the inside bridge parapet where the ramp flies over I-84 and I-91. The horizontal curve radius meets criteria for 35 mph. All other geometric features meet criteria for the minimum direct connection design speed of 40 mph. The I-84 eastbound off-ramp to I-91 southbound (Interchange 52) meets design criteria for 25 mph. The limiting design element is the stopping sight distance controlled by the inside bridge parapet where the ramp crosses over Columbus Boulevard. The horizontal curve radius meets criteria for 30 mph. The eastbound on-ramp from I-91 southbound (Interchange 52) meets design criteria for 20 mph. The limiting design element is the stopping sight distance controlled by the inside bridge parapet where the ramp is carried above I-91 northbound. The horizontal curve radius is sufficient for 25 mph.

The I-84 westbound off-ramp to I-91 northbound (Interchange 51) meets design criteria for 25 mph. The limiting design element is the stopping sight distance controlled by the inside bridge parapet where the ramp crosses the Connecticut River. The horizontal curve radius meets design criteria for 30 mph. The I-84 westbound on-ramp from I-91 northbound (Interchange 51) meets design criteria for 25 mph. The limiting design element is the stopping sight distance controlled by the I-91 substructure elements where the ramp passes underneath I-91 southbound. The horizontal curve radius meets design criteria for 30 mph. All ramps have either posted speed limit signs or ramp advisory speed warning signs. See Table 2-29, page 2-130, for further information.

The ramp widths were evaluated against the CTHDM minimum overall width of 26 feet (with a 12 foot travel lane, 4 foot left shoulder and 10 foot right shoulder). Four of the six ramps have shoulder width deficiencies, which are detailed in Table 2-28, page 2-130. In many locations, the narrow shoulder widths contribute to stopping sight distance deficiencies due to the reduced horizontal offsets to the bridge parapets.

Acceleration and deceleration lengths were assessed based on the controlling geometric criteria. The eastbound off-ramp to I-91 northbound (Interchange 51) departs I-84 as an auxiliary lane drop. Therefore, sufficient deceleration distance is provided. The ramp merges with the westbound off-ramp before joining I-91 northbound as a lane addition. Therefore, sufficient acceleration length is provided. The eastbound off-ramp to I-91 southbound (Interchange 52) departs I-84 as an auxiliary lane drop. Therefore, sufficient deceleration length is provided. The ramp merges with a local street on-ramp before joining I-91 as a lane addition. Therefore, sufficient acceleration length is provided. The eastbound on-ramp from I-91 southbound (Interchange 52) departs I-91 with a parallel-type deceleration lane which does not meet CTDOT's current policy. Sufficient deceleration distance to the 20 mph curve is provided. However, if mainline vehicles do not enter the deceleration lane at the beginning, the deceleration length would be severely deficient due to the significant speed differential between the mainline and the ramp. The ramp bifurcation is on a bridge structure where the gore nose is protected with an impact-attenuating barrel array, which is often hit by vehicles. The ramp enters I-84 as an auxiliary lane which extends to Interchange 53. Therefore, sufficient acceleration distance is provided.

The I-84 westbound off-ramp to I-91 northbound (Interchange 51) departs I-84 as an auxiliary lane drop. Therefore, sufficient deceleration distance is provided. The ramp merges with the I-84 eastbound off-ramp before joining I-91 northbound as a lane addition. Therefore, sufficient acceleration length is provided. The I-84 westbound on-ramp from I-91 northbound (Interchange 51) departs I-91 as an auxiliary lane drop. Therefore, sufficient deceleration distance is provided. The ramp enters I-84 as an auxiliary lane which extends to Interchange 46. Therefore, sufficient acceleration length is provided. The westbound on-ramp from I-91 southbound departs I-91 as an auxiliary lane drop. Therefore, sufficient deceleration length is provided. The ramp enters I-84 as an auxiliary lane which extends to the Interchange 47 off-ramp. Therefore, sufficient deceleration length is provided.

2.6 Existing Structural Conditions

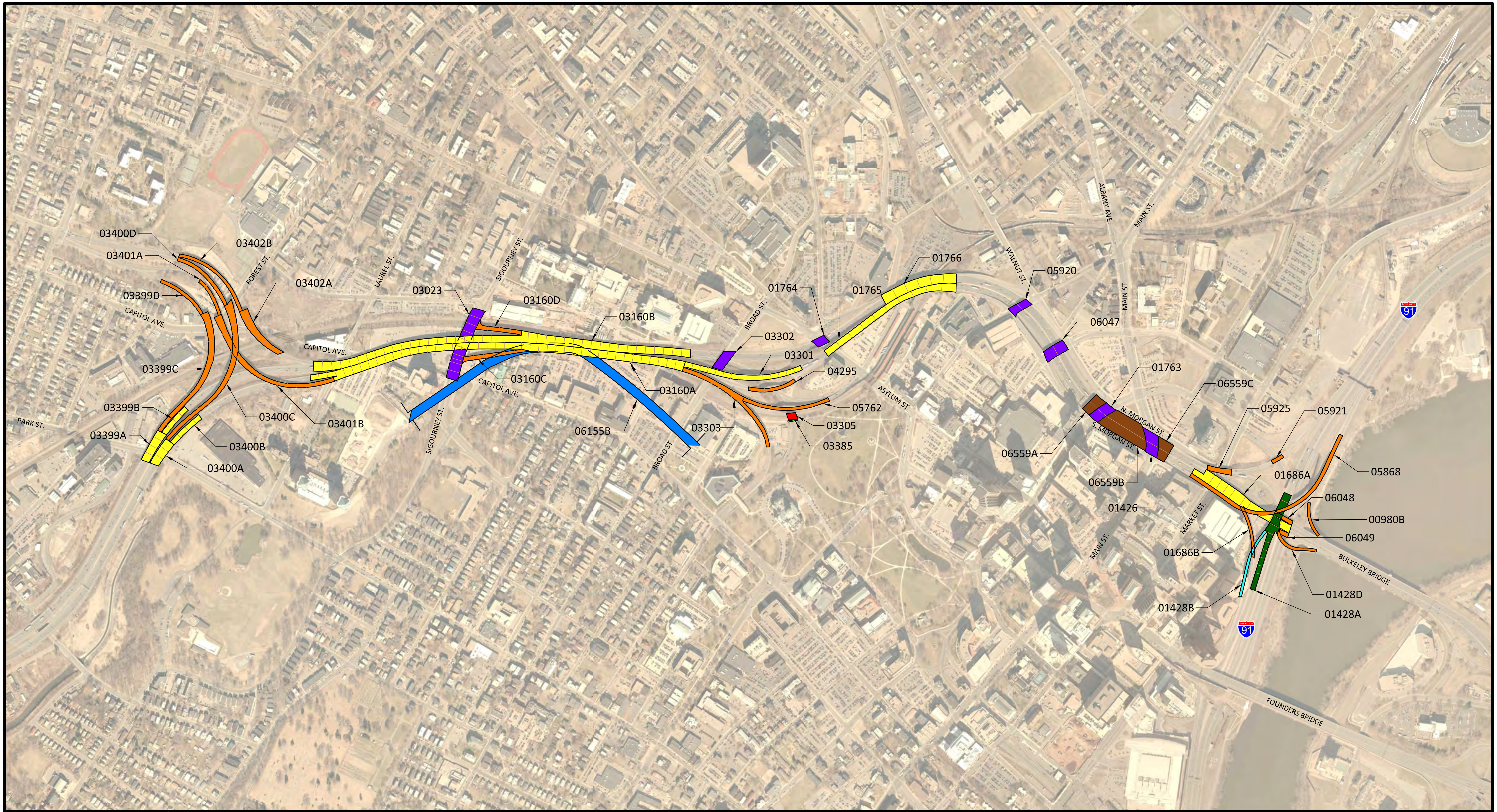
The existing condition of the structures within the Project Study Corridor was assessed and documented utilizing 2011-2013 bridge inspection reports.

2.6.1 General Description of Bridges

A total of 45 bridges in the Corridor from Park Street to I-91 Interchange, have been assessed in this report. These bridges carry or underpass the I-84 mainline, I-91 mainline, ramps, local city streets and The Hartford Line/CT*fastrak*. A detail summary of bridges within the Corridor is included in Appendix A.1. The Hartford Line runs roughly parallel to the I-84 through the Project Study Corridor. The rail line crosses from the north to the south side of the highway near Flower Street and crosses again from south to north near Church Street.

Most of the highway bridges in the Corridor were built in the 1960s and many have undergone rehabilitation since. Some bridges were constructed during a series of improvement projects in the 1980s. Typically, the highway bridges in the corridor have concrete decks with steel multi-girder superstructures simply supported on reinforced concrete piers, and almost all of the bridges have bituminous concrete overlay with membrane waterproofing. The old simply supported design of these bridges required deck joints at every substructure unit. It is important to note that these deck joints are located in the most vulnerable position on any bridge. Situated at surface level, these joints have been subjected to the impact and vibration of traffic and have been exposed not only to the effects of natural elements such as water, dirt, and UV rays, but also to those of chemicals such as deicing salts and petroleum derivatives. All the aforementioned external effects have contributed to deck joint leakages underneath these structures causing severe rust and section loss at beam ends. In addition to having deck joints at all substructure units, some of these bridges have other problematic details such as pin and hangers and steel pier caps, which also show severe rusting and section losses due to deck joint leakages.

Figure 2-55, following, illustrates the location and identification numbers of the bridges in the corridor. Table 2-30, page 2-149, shows general information regarding the year built and rehabilitation projects. A detailed report of the bridge condition assessment is included in Appendix A.1.



FEATURE CARRIED

I-84 Mainline	Railroad	I-91 Mainline
I-84 Ramps	Pedestrian	I-91 Ramps
City Streets	Park River Conduit	Platform

Not to Scale

The I-84 Hartford Project

Bridge Location Map

Date: 06/27/2014 | Drawn By: TSC | Fig. No: 2-55

Table 2-30: Bridge Construction and Rehabilitation Data

Bridge No.	No. of Spans	Original Construction Project No.	Year Construction Completed	Rehabilitation Project No.	Year Rehabilitation Construction Completed
00980B	2	63-153	1964	-	-
01426	2	-	1963	-	-
01428A	13	-	1961	-	-
01428B	11	-	1961	63-375	1993
01428D	5	63-158, 63-162	1961	-	-
01686A	14	63-133, 63-162	1961	63-675	-
01686B	8	63-116	1961	-	-
01763	2	63-136	1964	63-364	
01764	1	63-167	1966	63-364	1984
01765	10	63-137, 63-167	1966	63-364, 63-479, 63-565	1984, 1995, 2000
01766	6	63-137	1964	63-364, 63-375, 63-590	1984, 1993, 2006
03023	11	63-159	1964	63-338, 63-624	1982, 2007
03160A	44	63-138	1965	63-304, 63-393, 63-488, 63-527, 63-648	1975, 1990, 1993, 2000, 2011
03160B	42	63-138	1965	63-304, 63-393, 63-488, 63-527, 63-648	1975, 1990, 1993, 2000, 2011
03160C	6	63-138	1965	63-304, 63-393, 63-527, 63-648	1975, 1990, 2000, 2011
03160D	4	63-138	1965	63-304, 63-393, 63-527, 63-648	1975, 1990, 2000, 2011
03301	15	63-175	1966	63-648	2011
03302	1	63-175	1966	63-364	1984
03303	15	63-175	1966	63-409, 63-648	1989, 2011
03305	1	-	1966	63-670	Underway
03385	1	-	1966	-	-
03399A	4	63-141	1969	155-145	2000
03399B	4	63-141	1969	155-145	2000
03399C	14	63-141, 63-192	1969	155-145, 63-622	2000, 2011
03399D	6	63-192	1969	155-145	2000
03400A	3	63-141	1969	155-145	2000
03400B	4	63-141	1969	155-145	2000
03400C	15	63-141, 63-192	1969	155-145, 63-638	2000, 2011

Table 2-30(ctd.): Bridge Construction and Rehabilitation Data

Bridge No.	No. of Spans	Original Construction Project No.	Year Construction Completed	Rehabilitation Project No.	Year Rehabilitation Construction Completed
03400D	7	63-192	1969	155-145	2000
03401A	5	63-192	1969	155-145	1988, 2000
03401B	16	63-141, 63-192	1969	63-304, 155-145, 63-627	1975, 2000, 2011
03402A	6	63-141, 63-192	1969	155-145	2000
03402B	10	63-192	1969	155-145	2000
04295	3	63-307	1980	-	-
05762	5	-	1987	63-409	1989
05868	9	63-375	1993	63-639	1998, 2012
05920	2	63-136	1964	63-375	1993
05921	1	63-375	1993	-	-
05925	2	63-375	1993	-	-
06047	2	63-375	1993	-	-
06048	3	63-375	1993	-	1976
06049	2	63-375	1993	-	-
06559A	2	63-474	1996	-	-
06559B	2	63-474	1996	-	-
06559C	2	63-474	1996	-	-

2.6.2 Existing Structural Conditions

In 1968, the Federal-Aid Highway Act directed the states to maintain an inventory of federal-aid highway bridges. According to National Bridge Inspection Standards (NBIS) today, condition ratings are used to describe an existing bridge compared with its condition if it was new. Each bridge component is assigned a condition rating based on inspection findings. These inspection ratings are based on the materials and physical condition of the deck, superstructure and the substructure. General condition ratings range from 0 (failed condition) to 9 (excellent). Bridge condition assessments are defined in Table 2-31, below.

Table 2-31: NBIS Condition Rating Scale

Code	Descriptions
9	Excellent Condition – No maintenance or rehabilitation concerns
8	Very Good Condition – No maintenance or rehabilitation concerns. No problems noted.
7	Good Condition – Potential exist for minor maintenance. Some minor problems noted.
6	Satisfactory Condition – Potential exist for major maintenance. Structural elements shown minor deterioration.
5	Fair Condition – Potential exist for minor rehabilitation. All primary structural elements are sound but may have minor section loss*, cracking, spalling or scour.

Table 2-31 (ctd.): NBIS Condition Rating Scale

Code	Descriptions
4	Poor Condition – Potential exist for major rehabilitation. Advance section loss, deterioration, spalling, or scour.
3	Serious condition – Rehabilitation or repair required immediately. Loss of section, deterioration, spalling, or scour have seriously affected primary structural components. Local failures possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	Critical Condition – Need for immediate repairs or rehabilitation is urgent. Advance deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1	"Imminent" Failure Condition – Bridge is closed to traffic but corrective action may put back in light service. Major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability.
0	Failed Condition – Bridge is out of service and is beyond corrective action.

* The term “section loss” is defined in The Bridge Inspector’s Reference Manual (BIRM) Publication No. FHWA NHI 03-001 as the loss of a (bridge) member’s cross-sectional area usually by corrosion or decay. A “spall” is a depression in a concrete member resulting from the separation and removal of a volume of the surface concrete. Spalls can be caused by corroding reinforcement, friction from thermal movement, and overstress. The term “scour” refers to the erosion of streambed or bank material around bridge supports due to flowing water.

In addition to the individual component ratings, an overall Structural Evaluation has been established for each bridge in NBIS. Structural Evaluation is an appraisal rating that describes an overall rating of the bridge structure. This is dependent on the separately rated conditions of the structural components (deck, superstructure, and substructure) and the load carrying capacity of the bridge. This is the truest measure in the NBIS of the structural fitness of a bridge.

Table 2-32, below, shows Condition Ratings and Overall Structural Evaluation for each bridge in the I-84 Corridor according to 2011-2013 inspection reports. Figure 2-56, page 2-154, shows Structural Evaluation of each bridge in the corridor. For a detail condition assessment of the bridges, see Appendix A.1

Table 2-32: Bridge Condition Ratings and Overall Structural Evaluation

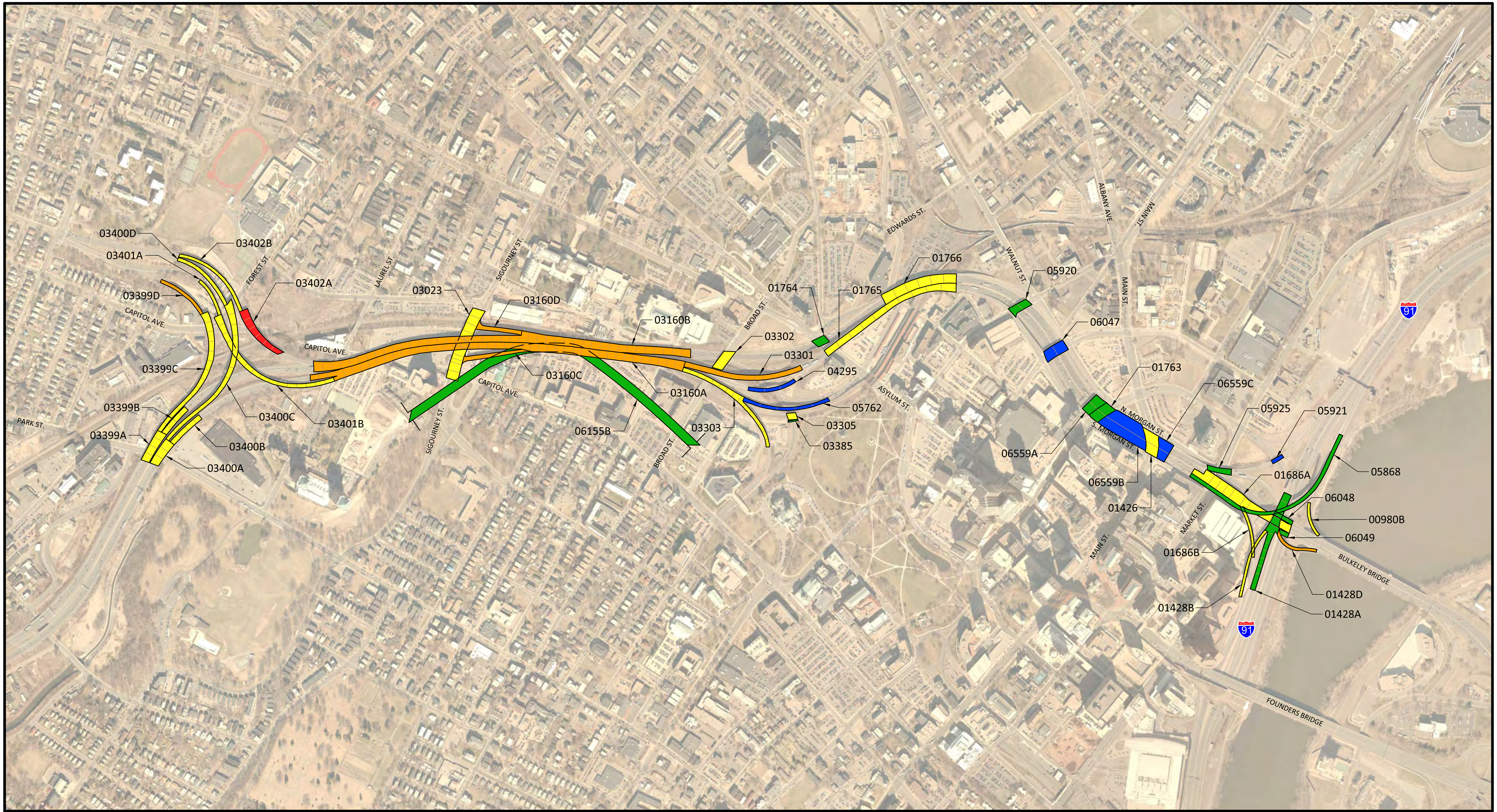
Bridge No.	Feature Carried/Crossed	# of Spans	Length	Deck Area	Deck	Superstructure	Substructure	Culvert	Structural Evaluation
00980B	I-84 TR 826 over Connecticut River	2	263	6,970	6	5	6	N	5
01426	US Route 44 EB and Main Street over I-84 and Morgan Street Ramp	2	205	22,038	6	6	5	N	5

Table 2-32 (ctd.): Bridge Condition Ratings and Overall Structural Evaluation

Bridge No.	Feature Carried/Crossed	# of Spans	Length	Deck Area	Deck	Superstructure	Substructure	Culvert	Structural Evaluation
01428A	I-91 SB over Ramp D & F, I-84, US Route 44	13	951	40, 988	7	6	6	N	6
01428B	I-91TR 839 over I-91 – 153, I-84 – 825, US Route 44 EB	11	769	21,147	7	5	6	N	5
01428D	I-91 TR 840 over I-91 NB, US Route 44 EB, Railroad and Connecticut River	5	408	12,924	7	5	4	N	4
01686A	I-84 over Market Street and I-91 NB	14	870	74,552	5	5	5	N	5
01686B	I-84 TR 825 over US Route 44 EB and Columbus Boulevard	8	525	13,916	4	5	5	N	5
01763	Trumbull Street over I-84 and Access Ramps I-91	2	189	17,483	6	6	6	N	6
01764	Asylum Street over I-84 WB	1	85	7,692	6	6	6	N	6
01765	I-84 EB over Amtrak and Local Roads	10	1271	83,895	4	5	6	N	5
01766	I-84 WB over Amtrak and Local Roads	6	810	62,377	4	5	6	N	5
03023	Sigourney Street over Capitol Avenue, Amtrak, and Aetna Parking Lot	11	654	70,000	5	5	5	N	5
03160A	I-84 EB over Amtrak and Local Roads	44	3252	225,464	6	4	5	N	4
03160B	I-84 WB over Aetna Parking Lot, Amtrak, and Local Roads	42	3177	209,469	6	4	5	N	4
03160C	I-84 WB on ramp over Aetna Parking Lot	6	415	13,860	7	4	5	N	4
03160D	I-84 EB off-ramp 115 over Amtrak and Aetna Parking Lot	4	307	10,910	7	4	5	N	4
03301	I-84 EB over Broad Street, I-84 Ramp 191, and Parking Lot	15	974	46,256	6	4	5	N	4
03302	Broad Street over I-84 WB and I-84 Ramp 191	1	128	10,560	6	6	5	N	5
03303	I-84 EB Ramp 190 over Broad Street and Amtrak	15	1131	39,700	6	5	5	N	5
03305	Amtrak over I-84 Ramp 191 and I-84 WB on-ramp from Capitol Avenue	1	90	4,973	7	5	6	N	5
03385	Pedestrian Walkway over I-84 Ramp 191	1	78	858	7	6	6	N	6
03399A	I-84 WB over Park Street	4	296	25,130	6	5	5	N	5
03399B	I-84 WB over Parking Lot	4	296	14,060	6	5	6	N	5
03399C	I-84 WB TR 824 over Capitol Avenue and Amtrak	14	1187	55,028	4	5	5	N	5
03399D	I-84 TR 824 over Parking Lot	6	458	12,595	5	4	5	N	4
03400A	I-84 EB over Park Street and Parking Lots	3	226	20,254	6	5	5	N	5

Table 2-32 (ctd.): Bridge Condition Ratings and Overall Structural Evaluation

Bridge No.	Feature Carried/Crossed	# of Spans	Length	Deck Area	Deck	Superstructure	Substructure	Culvert	Structural Evaluation
03400B	I-84 EB over Parking Lot	4	339	16,136	6	5	6	N	5
03400C	I-84 TR 823 over Capitol Avenue, Forest Street, and Amtrak	15	1439	62,908	4	6	5	N	5
03400D	I-84 TR 823 over Parking Lot	7	599	16,473	4	5	5	N	5
03401A	SR 503 EB over Parking Lot	5	342	9,405	6	5	5	N	5
03401B	SR 503 EB over Capitol Avenue, Laurel Street, Forest Street, and Amtrak	16	1337	56,281	5	5	5	N	5
03402A	SR 503 WB over Capitol Avenue and Amtrak	6	500	27,075	5	3	3	N	3
03402B	SR 503 WB over Forest Street and Parking Lot	10	756	20,790	6	5	5	N	5
04295	I-84 EB On-Ramp 186 over I-84 Exit 48 On-Ramp	3	290	9,193	7	7	7	N	7
05762	I-84 EB Ramp 299 (off-ramp to Asylum Street) over I-84 WB Ramp 191	5	603	16,824	7	7	7	N	7
05868	W-N Turning Roadway over I-84/I-91 Ramps and Connecticut Southern Railroad	9	1726	58,136	7	7	6	N	6
05920	High Street over I-84 and on-off-ramps for Trumbull Street	2	180	12,510	7	7	6	N	6
05921	I-84 TR 841 over I-91 Ramp 186	1	106	3,583	7	7	7	N	7
05925	I-84/91 TR 841/858 over US Route 44 WB and Market Street	2	211	9,242	7	7	6	N	6
06047	Ann Uccello Street over I-84 and Ramps	2	206	19,879	7	7	7	N	7
06048	US Route 44 WB over I-91 NB, C-D Roadway and Ramps	3	154	5,359	7	6	6	N	6
06049	US Route 44 EB over I-91 NB, I-91 Collector and S-W Roadway	2	132	5,082	7	7	6	N	6
06559A	Hartford Platform West over I-84	2	179	15,834	7	7	6	N	6
06559B	Hartford Platform over I-84	2	175	67,375	7	7	6	N	6
06559C	Hartford Platform East over I-84	2	175	15,925	7	7	7	N	7
			Total Deck Area (sf.):	**1,501,113**					



NBI APPRAISAL RATING

- Very Good(8)
- Good(7)
- Satisfactory(6)
- Fair(5)
- Poor(4)
- Serious(3)

Not to Scale

84 The I-84 Hartford Project

Existing
Bridge Conditions
Map

Date: 06/27/2014 | Drawn By: TSC | Fig. No: 2-56