

DESIGN EXCEPTION REPORT

**State Project No. 63-703
Relocation of I-91 NB Interchange 29 and
Widening of I-91 NB and State Route 5/15 NB to I-84 EB
Hartford and East Hartford, Connecticut**

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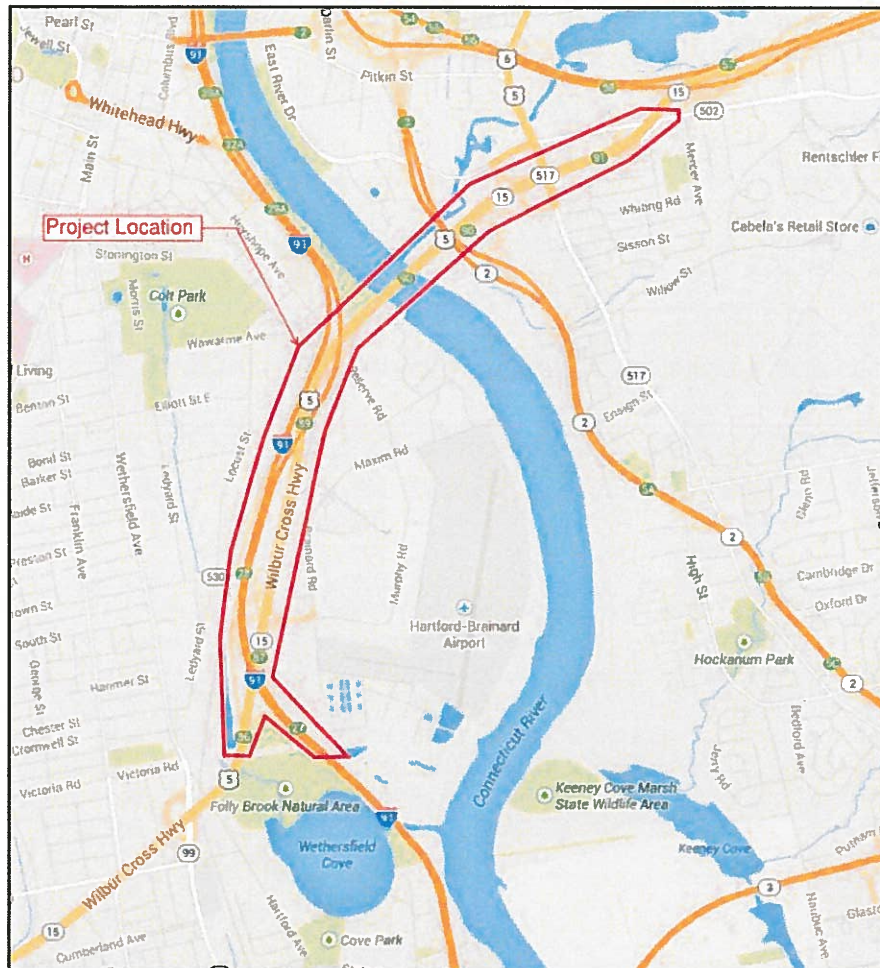
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1.0 PROJECT INFORMATION

1.1 LOCATION

This project begins on Interstate 91 (I-91) Northbound (NB) in the vicinity of Wethersfield Cove, extending northerly to Route 15 NB and ends approximately 625 feet north of Silver Lane before the Interstate 84 (I-84) Eastbound (EB) merge.



1.2 PURPOSE AND NEED

The purpose of the project is to address safety concerns associated with congestion and operational failures at Interchange 29 on I-91 Northbound.

1.3 DESCRIPTION

The I-91 NB Interchange 29 off-ramp is a single-lane configuration with a steep vertical grade that contributes to significant traffic delays due to the heavy volume of vehicles. In addition to the geometric deficiencies of the off-ramp, there is a heavy weave condition occurring on the Charter Oak Bridge at the end of the ramp where motorists attempt to access I-84 EB, Route 5/15 NB, Route 2, and Silver Lane. The existing traffic queues extend onto the I-91 NB mainline, taking up the right lane of the three-lane facility. The length of the queue varies, but has been observed to extend approximately 1.4 miles in the vicinity of Wethersfield Cove. The safety issues are compounded by drivers that routinely cut into the right-lane queue from the center lane, which further increases congestion on I-91 in this area.

The current design includes the widening of I-91 NB for approximately 4,300 feet to provide four lanes from Interchange 27 to 29. The widening is anticipated to relieve congestion and address safety concerns due to motorists entering the queue from the center lane of I-91 NB. The widening will require modifications to Bridge No. 00813 (I-91 over Route 15), Bridge No. 03613 (I-91 over a drainage crossing), Bridge No. 01466 (I-91 over the SB entrance ramp to I-91 SB and Route 15 SB), and Bridge No. 00480 (I-91 over Airport Road).

The geometric and congestion issues associated with the Interchange 29 off-ramp will require the removal and relocation of the existing ramp to just south of Bridge No. 05922 (I-91 over Route 5/15) in the form of a major diverge. The proposed left-exit ramp will consist of two lanes and require a new bridge over Route 15 SB. The proposed diverge requires the realignment of Route 15 NB and widening of the southern approach to the Charter Oak Bridge (Bridge No. 06000A, Route 15 NB over I-91, Reserve Road and rail line). The Charter Oak Bridge (Bridge No. 06000A) consists of a 12-foot left shoulder, three 12-foot travel lanes and a 12-foot right shoulder. In order to accommodate the two lanes from I-91 and Route 15, it is proposed to modify the existing pavement markings to provide a 4 foot left shoulder, four 11-foot travel lanes, and a 12-foot right shoulder.

Due to the proximity of a four-lane merge and lane drop at Interchange 90, it was determined that Route 15 would be widened to three travel lanes from north of the Charter Oak Bridge to the Silver Lane underpass, and provide a lane-drop prior to its merge with I-84 EB. The widening addresses congestion concerns on Route 15 and allows a more desirable distance from Interchange 29 to merge from three travel lanes to two prior to its merge with I-84 EB. This improvement will require the widening of Bridge No. 06043A (Route 15 over Route 5) and Bridge No. 05796 (Route 15 over Silver Lane).

The proposed widening of I-91 NB may affect a known entombed area of contaminated material located in the embankment between I-91 NB and Route 15 SB just to the north of Airport Road, as well as the environmental mitigation site located just south of Bridge No. 05922 (I-91 over Route 15, between I-91 NB, and Route 15 SB).

1.4 SCHEDULE

The current schedule anticipates milestone dates for:

- PD Plan Submittal January 2016
- Design Approval June 2016
- FDP November 2017
- DCD December 2017
- ADV January 2018
- Begin Construction May 2018

1.5 CRASH ANALYSIS

CTDOT collects and analyzes crash information on all state roadways and compiles the data into a list entitled *Suggested List of Surveillance Study Sites (SLOSSS)*¹. The objective of the list is to identify locations which have the “greatest promise” of crash reduction to give a “broad measure of overall needs of highway safety improvements”. The current list, dated 2011 – 2013, identifies a number of locations within the project area that require attention and safety improvements (see attached). These include I-91 northbound from the Interchange 27 Off-Ramp to Brainard Road (Mile Post 35.59) to the State Route 5/15 underpass (Mile Post 37.50). Sections of State Route 5/15 Northbound from the I-91 Northbound On-Ramp to I-84 Eastbound also appear on the list. Both of these areas correspond to the construction limits of the proposed project. A copy of the 2011 – 2013 SLOSSS appears in Figure 10 of the project’s Traffic Report.

Crash data was also compiled from CTDOT’s Traffic Accident Viewing System (TAVS) for the three-year period from 2011 to 2013. The data was obtained for I-91 Northbound, and State Route 5/15 Northbound within the limits of the project. A total of 751 crashes were reported on I-91 Northbound between the Interchange 26 on-ramp and the Interchange 29A off-ramp. Of that, 559 of these were rear-end type crashes; 100 were sideswipe-same direction type crashes and 76 were fixed-object type crashes. The remaining 16 crashes were turning-same direction (4), moving object (6), overturn (4), backing (1) or unknown (1) type crashes. These crashes resulted in 1 fatality and 178 injuries.

Route 15 northbound had a total of 201 crashes occur between Interchange 85 – Silas Deane Highway (Route 99) and I-84 Eastbound in East Hartford. The most common types of crashes for the Route 15 Northbound segment are fixed objects (98), rear-ends (50) and sideswipes (43). The remaining ten (10) crashes were moving object (5), miscellaneous non-crash (3), sideswipe – opposite direction (1) and head-on (1). The four (4) most common contributing factors to crashes on this section of State Route 5/15 are driver lost control (73), following too closely (45), speed to fast for conditions (30) and improper lane change (23). Sixty-one (61) injuries and 3 fatalities were reported on this segment of State Route 5/15 northbound. One fatality occurred on the segment between Interchange 87 Off-ramp – Brainard Road to Interchange 89 Off-ramp – I-91 Northbound. Another fatality occurred on the segment between Interchange 89 On-ramp – I-91 Northbound to Interchange 90 Off-ramp – Route 2/Main St. The third fatality occurred along the Interchange 91 Off-ramp – Silver Lane to Interstate 84 Eastbound segment.

1.6 TRAFFIC VOLUMES

Traffic volumes for the project were developed by the CTDOT – Bureau of Policy & Planning, Office of Policy & Strategic Planning. Included were volumes for the morning peak hour of traffic, evening peak hour of traffic and average daily traffic (ADT) under the 2015 No-Build (existing) traffic condition; the 2039 No-Build traffic condition; and the 2039 Build traffic conditions. The volumes show I-91 northbound has an Average Daily Traffic (ADT) volume of 66,600 vehicles per day (VPD) and is anticipated to grow to 75,800 VPD in the Design Year 2039. The I-91 Northbound Off-Ramp at Interchange 29 currently has 1,790 vehicles per hour (VPH) during the peak hour of traffic. This is anticipated to grow to 2,100 VPH in the Design Year 2039 which is overcapacity for the single-lane ramp. Volumes on Route 5/15 Northbound on the Charter Oak Bridge show 43,000 VPD growing to 49,500 VPD in 2039. These volumes are depicted in Figures 3 (2015 No-Build), 4 (2039 No-Build) and 5 (2039 Build) of the project’s Traffic Report.

¹ “Pursuant to Title 23 United States Code Section 409, this data is not admissible and not discoverable in any federal or state court proceeding, and cannot be considered for any other purpose in any action for damages arising from an occurrence at a location addressed in this report.”

1.7 DESIGN STANDARDS AND CRITERIA

Based on the DOT Bureau of Planning, Interstate 91 and State Route 15 are classified as “Urban Principal Arterial – Non Access Expressway”. Design Criteria used to develop improvements for this project as well as other roads and ramps are in accordance with the requirements of the following publications:

1. Consultant Administration and Project Development Manual
2. Project Development Guide
3. Standard Specification for Roads, Bridges and Incidental Construction (Form 816) and Supplemental Specifications
4. Highway Design Manual
5. Location Survey Manual
6. Specifications for Aerial Photography and Photogrammetric Mapping
7. Specifications for Checking Photogrammetric Mapping
8. Policies and Procedures for Property Maps
9. Guide for Preparation of 13a-57 Plans
10. Bridge Design Manual
11. Bridge Design Standard Practices
12. Drainage Manual
13. HEC-18 Evaluating Scour at Bridges
14. Water Resources Coordination and Permit Processing Manual
15. On-Site Mitigation for Construction Activities
16. Connecticut Stormwater Quality Manual
17. Connecticut Guidelines for Soil Erosion and Sediment Control
18. Geotechnical Engineering Manual
19. Traffic Control Signal Design Manual
20. Utility Mailing List
21. ConnDOT Policy on the Accommodations of Utilities
22. Standard Roadway Drawings and List of Road Standards
23. Cost Estimating Guidelines
24. Design Aids (Factors for Estimating Quantities)
25. Product Use Status Lists
26. Index of Recurring Special Provisions and Index of Guide Special Provisions
27. Digital Project Development Manual
28. CTDOT InRoads V8i Guide
29. CTDOT AASHTOWare Project Estimator Procedures Guide
30. Design/Constructability Plan Review Guidelines
31. Public Involvement Guidance Manual
32. Bridge Welding Code, American Welding Society (D1.5)
33. All Publications of the American Society of Testing and Materials
34. All Publications of the American Welding Society
35. Steel Construction Manual – American Institute of Steel Construction
36. The National Electrical Manufacturer’s Association Requirements

37. Transportation Research Board "Highway Capacity Manual"
38. All Publications of the American Association of State Highway and Transportation Officials (AASHTO)
39. Manual on Uniform Traffic Control Devices
40. American Standard Practice for Roadway Lighting

In addition, the FHWA Conceptual Access Modification Report recently submitted for the project was developed in accordance with Federal Highway Administration (FHWA) policies and the May 2009 agreement between FHWA and CTDOT. The Conceptual Access Modification Report seeks to address the requirements of the revised document entitled Policy and Procedures for New or Revised Interstate Access Approval in Connecticut and to provide the information, documentation and analyses required to secure FHWA approval of the project. See Appendix A for design criteria for each roadway

2.0 PROPOSED EXCEPTIONS TO DESIGN CRITERIA

In accordance with The Department's Highway Design Manual, section 6.6.02, CME will request design exceptions for following items:

- Travel lane and shoulder widths
- Horizontal alignment
- Vertical curvature
- Stopping Sight Distance
- Superelevation
- Minimum vertical clearances

Many of the design exceptions are necessary to accommodate controls at existing conditions. As a rule, this project does not consider the existing conditions within the limits of construction as a design exception. Rather, the following narrative and tables identify only substandard designed elements along with their associated alternatives and cost ramifications.

Three speed studies were conducted during the Preliminary Engineering Phase of the project to determine the 85th percentile speed:

Based on this information, the chosen design speed for the project on I-91 NB and Route 5/15 NB is 70 mph. As a result, the existing horizontal and vertical geometry for all sections of I-91 Northbound within the project limits is substandard. This can mainly be attributed to the fact that I-91 was constructed in the late 1960's and the mainline geometry has not been upgraded since. Another consideration is that in some areas, I-91 Northbound and Southbound run parallel horizontally and vertically and no construction is proposed for 91 Southbound on this project.

Speed Study Location	85 th % Speed (mph)	Posted Speed (mph)
Route 15 NB at the I-91NB split	71	55
I-91NB at the Route 15 NB split	68	55
Route 15 SB north of Airport Road overpass	72	55

2.1 TRAVEL LANE AND SHOULDER WIDTHS

91NB Median Shoulder

Due to the proposed widened median barrier required for the sign structures along I-91 NB, the left shoulder width does not meet the minimum design criteria in the following location:

Location	Proposed Width (ft)	Standard Width
91NB Sta. 125+50 to 159+00	6-8 (varies)	12

91NB Median Shoulder Alternative

The current design maintains the existing yellow painted shoulder line of 91NB and offsets the lanes from there to calculate the widening. To accommodate a full width median shoulder (12') through this area, the roadway and structure widenings would need to be offset 6' further than the current design between stations 120+00 and 159+00. The following is a breakdown of the work required to eliminate this design exception.

- Widen and Raise I-91 NB&SB from station 110+00 to 159+00 (approx. \$22M)
 - Including the reconstruction of the exit 28 offramp to US5/RTE15SB which may require mainline geometry modifications to fit
- Demolish and Replace Bridge No. 00813 (NB&SB) over US5/RTE15 (approx. \$31M)
 - Widen an additional 14' for median shoulder and sight line
 - Raise 2' achieve standard minimum vertical clearance
- Demolish and Replace Bridge 01466 (NB&SB) over US5/RTE15SB and 91SB Ramps (approx. \$17M)
 - Widen an additional 14' for median shoulder and sight line
 - Raise 2' achieve standard minimum vertical clearance
- Demolish and Replace Bridge No. 00480 over Airport Road (approx. \$10.5M)
 - Widen an additional 14' for median shoulder
 - Raise 2' achieve standard minimum vertical clearance
- Modification of the existing entombed contaminated material area between 144+00 and 153+00. (approx. \$0.5M)
- Construct wall between I-91NB Sta. 153+00 and Bridge No. 05922 (91NB over US5/RTE15NB) to avoid wetland impacts. (approx. \$0.5M)

US5/RTE15NB Left Shoulder and Lane Widths

Additional lane(s) are being added to the Charter Oak Bridge without widening the Charter Oak Bridge itself. Consequently, the left shoulder width does not meet the minimum design criteria in all locations. Lane widths were reduced to 11' on Route 15 NB for the purpose of improving sight distance on the approach to the northeast abutment corner of Bridge 5922. Lane widths were reduced to 11' on Route 15 NB Exit 89 for the purpose of improving sight distance on the approach to the southwest abutment corner of Charter Oak Bridge. Additionally, the lanes being added to the Charter Oak Bridge along Route 5/15 NB also require a travel lane width that does

not meet the minimum design criteria in some areas. The following is a table outlining the substandard shoulders and lane widths:

Location	Proposed Width (ft)	Standard Width
SHOULDER WIDTH		
91NB to US 5/Route 15 NB 178+58.50 to 225+40.00	4-8 (varies)	12
LANE WIDTH		
US 5/ Route 15 NB Sta. 391+81 to 428+23.67	11-12 (varies)	12
I-91 NB to US 5/ Route 15 NB Relocation Exit 29 Sta. 177+68 to 221+50	11-12 (varies)	12
US 5/ Route 15 NB to I-91 NB Exit 89 Sta. 500+00 to 513+38.54	11-12 (varies)	12

US5/RTE15NB Left Shoulder and Lane Widths Alternative

The alternative approach to this would be to widen the northbound side of the Charter Oak Bridge (Bridge 06000A) enough to accommodate 2-12' shoulders and 4-12' lanes, totaling 72' which is a 12' increase. This new widening would affect the 1675' main span which is largely untouched in the current design. The following is a breakdown of the associated costs and additional requirements.

- Widen Charter Oak Bridge (approx. \$50.0M)
 - Variable widening of spans 1-4
 - 12' widening of remaining spans which will require permitting for construction over water
 - West Abutment and Pier 1 cap widening
- Demolish and Replace Pier and relocate North Abutment of Bridge No. 05922 (91NB over US5/RTE15NB) to provide standard shoulders and sight line (approx. \$18.2M)

The following impacts are anticipated to achieve the design standard for travel lane and shoulder widths:

- ROW—Metropolitan District property impacts adjacent to Exit 27; US Department of Agriculture in vicinity to western approach Charter Oak Bridge
- Environmental—embankment limits in wetlands adjacent to I-91 NB; Entombed Area and Mitigation Pond impacts; Pier widening in Connecticut River, additional wetlands in East Hartford
- Schedule—project schedule extended for permitting and construction schedule extended due to scale of work.
- Engineering—I91 Exit 28 horizontal geometry becomes more restrictive. Additional work on Charter Oak Bridge. Additional widening of Bridges 813, 1466 and 480. Additional profile impacts to Airport Road and twin culverts necessitating a relocation;
- Cost—\$150M to avoid design exception

2.2 HORIZONTAL ALIGNMENTS

Minimum Radii

Below is a chart showing where new alignments are required to tie into existing alignments that do not meet the required minimum radius. As a result, the new alignments are substandard in order to provide a comfortable transition.

Curve Location PC Sta. to PT Sta.	Design Speed (mph)	Posted Speed (mph)	Standard Radius (ft) @ e=5.8%	Existing/Proposed Radius (ft)	Best Case Design Speed (mph)
RTE 15 NB Exit 89 Ramp to I-91 NB					
503+10.417 to 510+36.216	70	55	2500	1500/1665	65
513+38.536 to 520+79.139	70	55	2500	1350/1665	65
I-91 NB Exit 28					
801+78.719 to 805+93.181	30	25	275	125/135	<25

Compound Curve Ratios

The following table outlines the instances of compound curves which do not meet the 1.5:1 ratio:

Curve Location PC Sta. to PT Sta.	Design Speed (mph)	Posted Speed (mph)	Proposed Radius (ft)	Minimum Compound Curve Ratio	Proposed Compound Curve Ratio
I-91 NB Exit 28 Off Ramp					
800+00.000 to 801+78.719	30	20	550	1.5:1	4.07:1
801+78.719 to 805+93.181	30	20	135		
801+78.719 to 805+93.181	30	20	135	1.5:1	44.44:1
805+93.181 to 810+27.322	30	20	6000		

US5/RTE15NB Exit 89 Alternative

In order to make this exit ramp standard for a 70MPH design speed, the minimum allowable radius for a 5.8% superelevation would be 2500' versus the provided 1665' along with a 255' tangent between the reverse curves for the 2.5s travel time required by the CTDOT HDM. Due to the sightline restriction caused by the north abutment of Bridge No. 05922, and the proposed widening of the west abutment of the Charter Oak Bridge, the following is offered as an alternative.

- Relocate US5/RTE15 Exit 89 to a right-hand exit prior to Bridge No. 05922 and merge with I-91NB traffic from the right which will potentially impact the rail siding at the farmers market. Modifications to the profile of I-91NB north of Bridge 5922 as well as a wall would also be necessary to account for the grade change. (approx. \$5M)

I-91NB Exit 28 Alternative

This cloverleaf shaped exit to US5/RTE15SB is located in the narrow space bounded by I-91NB, US5/RTE15NB and the US5/RTE15SB to Brainard Road exit ramp. Rather than reconstructing these roadways, the alternative requires a relocation of the Exit 28 ramp altogether. Below is a breakdown of the associated changes and costs related to relocating 91NB Exit 28 to the Exit 27 location similar to what was proposed in the PDU alternate 4 routing traffic to Brainard Road.

- Reconstruct Ramp Terminus Intersection with Brainard Road (approx. \$0.5M)
- Reconstruct Airport Road and Brainard Road Intersection (approx. \$0.5M)
- Widen Airport Road (approx. \$1M)
- Reconstruct Bridge No. 00481, Airport Road over US5/RTE15 (approx. \$9.5M)
- Reconstruct Bridge No. 01466 (approx. \$17M)
- Reconstruct Bridge No. 00480 (approx. \$10.5M)

The following impacts are anticipated to achieve the design standard for horizontal alignments:

- ROW—Potential ROW on Brainard Road for Exit 28 Alternative and Farmers Market Property for Exit 89 Alternative
- Environmental—Miscellaneous wetlands adjacent to I-91 NB; Potential impacts to twin culverts and watercourse adjacent to widen Airport Road.
- Schedule—Bridge Reconstruction adds to both Design and Construction Schedules.
- Engineering—Changed traffic patterns on Route 15 NB Exit 89 to I-91 indicate negative impacts for weaving in Capitol Area.
- Cost—\$44M to avoid design exception

2.3 VERTICAL CURVATURE

The proposed vertical alignment will match the existing vertical alignment for a majority of the proposed reconstruction. However, the existing vertical alignment does not meet the minimum design standards at various locations. In addition, the new alignments tie into the existing alignments and in order to provide a comfortable transition these new alignments also do not meet the minimum stopping sight distance at various locations. The proposed vertical curves below do not meet the minimum required stopping sight distance in order to provide a transition as it ties into the existing alignment.

Curve Location PVC Sta. to PVT Sta.	Design Speed (mph)	Standard K-Value	Existing/ Proposed K-Value	Best Case Design Speed (mph)	Curve Type
RTE 15 NB Exit 89 Ramp to I-91 NB					
507+19.385 to 511+69.385	70	247	140/180	60	Crest
512+33.992 to 517+83.992	70	181	85/153	65	Sag
Airport Road					
42+75.000 to 45+75.000	35	49	45/38	30	Sag

US5/RTE15NB Exit 89 Alternative: Right Hand Merge

- The US5/RTE15NB alignment is constrained by the new bridge (exit 29 tie-in to Charter Oak Bridge Abutment) as well as the 4% maximum grade allowed by this project. Since it is critical that this alignment matches the Charter Oak Bridge prior to the west abutment, the

alternative would be to raise US5/RTE15NB. This will add a negligible amount of pavement reconstruction on this roadway but will require demolishing and replacing the pier and relocating the North Abutment of Bridge No. 05922 (91NB over US5/RTE15NB) to provide standard shoulders and improve the sight line issue caused by the Charter Oak Bridge abutment. (approx. \$18.2M)

- The gore between Exit 89 and 91NB is on a sag curve that meets the grade of Bridge No. 06117 just upstation. This tie-in results in a substandard vertical curve needed to maintain a traversable grade in the gore. The proposed alternate solution in this location is to raise I-91 NB between Bridge Nos. 05922 and 06117 to flatten the tie-in. (approx. \$2M)

Airport Road Alternative

Due to the drainage structure (culvert 06654) and utilities underneath Airport Road and proximity of the I-91NB underpass to the US5/RTE15 overpass, the recommended alternative is to raise I-91 NB and SB. The profile would be raised along the existing crest curve over airport road, and would tie in along the tangent section of highway adjacent to the entombed contaminated material. The following work would be required to meet design standards.

- Raise I-91 NB&SB from station 110+00 to 159+00 (approx. \$22M)
- Bridge Nos. 01466 and 00480 (approx. \$27.5M)
- Construct wall between I-91NB Sta. 153+00 and Bridge 05922 (91NB over US5/RTE15NB) to avoid wetland impacts. (approx. \$0.5M)

The following impacts are anticipated to achieve the design standard for vertical alignments:

- ROW—N/A
- Environmental—N/A
- Schedule—Bridge and Wall Reconstruction adds to both Design and Construction Schedules.
- Engineering—I-91 SB will be impacted by the bridge reconstruction. The right hand merge of Exit 89 will cause adverse traffic weave impacts to I-91 on the approach to the Capitol Area.
- Cost—\$70M to avoid design exception

2.4 STOPPING SIGHT DISTANCE (BASED ON LEVEL GRADES)

Location	Design Speed (mph)	Standard S.S.D. (ft)	Proposed S.S.D. (ft)	Existing S.S.D. (ft)	Best Case Design Speed (mph)
CT 15 NB Sta. 506+10 Bridge Abutment Obstruction	70	730	615.09	705.65	60
Entrance to I-91 SB & US 5/Rte. 15 SB Sta. 53+77 Barrier Obstruction	40	305	210	210	30
I-91 NB Sta. 121+75 Bridge parapet obstruction	70	730	597	623	60
I-91 NB Sta. 133+00 Bridge parapet obstruction	70	730	630	630	60

Alternative

- Relocate US5/RTE15 Exit 89 to a right-hand exit prior to Bridge 5922 and merge with 91NB traffic from the right. This would require modifications to 5922 and potentially impact the rail siding at the farmers market. This would also require modifications to the profile of 91NB north of bridge 5922. (approx. \$5M)
- Demolish and Replace Pier 1 and relocate North Abutment of Bridge 05922 (91NB over US5/RTE15NB) (approx. \$18.2M)
- Realign 91SB/US5/RTE15SB onramps underneath Bridge No. 01466 abutment to maximize sight distance (approx. \$1.3M)
- The 91 Median Shoulder Alternative in section 2.1 of this report has the sight line design exception alternative built into it. The estimate for that section included the 6 additional feet required for the median shoulder deficiency as well as the 8 additional feet required for the sight line impacted by the fascia parapets of Bridge Nos. 00813 and 01466. Also included, as a result of the bridge work is the raising of 91 NB and SB, Bridge No. 00480 reconstruction, and the wall upstation to avoid wetland impacts. This means that the same cost required to fix the travel lanes and shoulder widths, also applies in-full to the fix of the sight distance. (approx. \$81.5M)

The following impacts are anticipated to achieve the design standard for SSD:

- ROW—Metropolitan District property impacts adjacent to Exit 27; US Department of Agriculture in vicinity to western approach Charter Oak Bridge
- Environmental—Embankment limits in wetlands along I-91 NB; Entombed Area and Mitigation Pond impacts along I-91.
- Schedule—Bridge Reconstruction adds to both Design and Construction Schedules.
- Engineering—Changed traffic patterns result in negative impacts to weaves.
- Cost—\$106M to avoid design exception

2.5 SUPERELEVATION

The existing superelevation does not meet the minimum design criteria at many locations. The table below lists the locations of substandard superelevation in order to provide a comfortable transition.

Curve Location PC Sta. to PT Sta.	Design Speed (mph)	Radius (ft)	Standard Superelevation (%)	Proposed Superelevation (%)	Best Case Design Speed (mph)
<u>I-91 NB to RTE 15 NB</u>					
177+67.921 to 181+97.999	70	2800	5.5%	3.4%	45
181+97.999 to 191+12.308	70	3330	5.0%	3.4%	50
<u>RTE 15 NB to Charter Oak Bridge</u>					
403+56.645 to 409+16.729	70	2050	6.0%	4.2%	50
413+60.136 to 417+91.192	70	2755	5.6%	4.2%	55
417+91.192 to 428+23.666	70	3800	4.6%	3.4%	55
<u>RTE 15 NB Exit 89 Ramp to I-91 NB</u>					
503+10.417 to 510+36.216	70	2050	6.0%	5.8%	60
513+38.536 to 520+79.139	70	2050	6.0%	4.2%	45
<u>I-91 NB Exit 27</u>					
10+00.000 to 16+88.961	50	1100	5.8%	4.9%	40

Note: The Charter Oak Bridge was built with a superelevation of 4.2%, while survey shows an existing 3.4% superelevation rate. The proposed superelevation has to tie into the existing 3.4% superelevation rate. The new superelevation rate is insufficient in order to provide a comfortable transition as it ties into the substandard existing superelevation rate.

Alternative

In order to provide the necessary superelevation design on the western approaches to the Charter Oak Bridge, the length and radius of the curves would need to be increased.

- Increase radius of US5/RTE15NB Exit 89 from 1665' to 2500' (+835')
 - Completely Demolish and Replace Bridge No. 05922 (91NB over US5/RTE15NB), not only the pier and north abutment as previously discussed. The cost of reconstructing the pier and northern abutment was estimated to cost \$18M, reconstructing the entire bridge results in an increase of \$2M. (approx. \$20M)
 - This alternative may also include the right-hand Exit 89 merge onto I-91NB traffic which is described in the section 2.4. The superelevation of the right-hand curve of Exit 89 can be adjusted, however, the left-hand curve that ties into Bridge No. 06117 will need to remain substandard to tie into the existing bridge and 91NB. For this reason, this alternative does not relocate exit 89 south of Bridge No. 05922.
- Increase radius of US5/RTE15NB under reconstructed Bridge No. 05922 and at western Charter Oak Bridge approach from 2050' to 2500' (+450') (approx. \$1.5M)
- Shift new bridge to the west, no cost beyond current design
- Shift US5/15SB to the west
 - Reconstruct wall and pavement widening (approx. \$1.5M)
- Shift 1 mile of 91SB onramp and 91SB Mainline to the west from reserve road underpass to Airport Road (approx. \$11M)

The following impacts are anticipated to achieve the design standard for superelevations:

- ROW—Metropolitan District property impacts adjacent to Exit 27; US Department of Agriculture in vicinity to western approach Charter Oak Bridge
- Environmental—N/A
- Schedule—Bridge 5922 Reconstruction adds to both Design and Construction Schedules.
- Engineering—Considerable staging issues for bridge replacement. Changed traffic patterns result in negative impacts to weaves.
- Cost—\$34M to avoid design exception

2.6 VERTICAL CLEARANCES

Construction is proposed beneath the following bridges in order to meet minimum vertical clearance (MVC) of 16'-0" over a freeway, as described below:

- Lowering approximately one thousand (1,000) feet of US5/RTE15 NB and SB under I-91 at Bridge No. 00813
- Lowering the Airport Road on-ramp to US5/RTE15 SB and I-91 SB under Bridge No. 01466

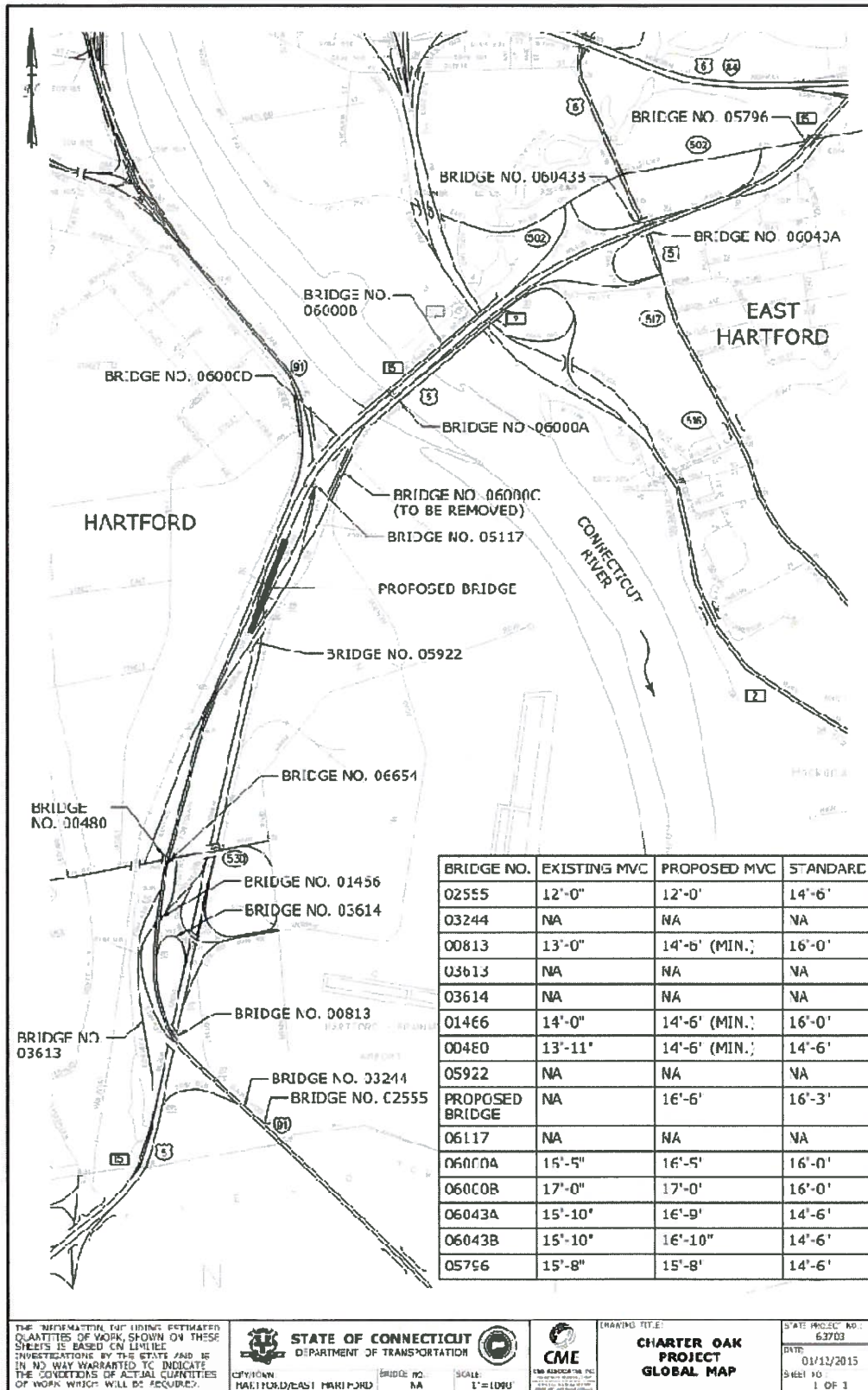
The profile revisions of US 5/Route 15 under Bridge No. 00813 and the Ramp under Bridge No. 01466 do not meet the standard of 16'-0" over a freeway. The alternatives outlined in section 2.1 of this report which raises 91NB and 91SB along the southern end of this project would eliminate the need for this design exception. The following is a list of the work and associated costs.

- Widen and Raise I-91 NB&SB from station 110+00 to 159+00 (approx. \$22M)
- Demolish and Replace Bridge No. 00813 (NB&SB) over US5/RTE15 (approx. \$31M)
 - Widen an additional 14' for median shoulder and sight line
 - Raise 2' achieve standard minimum vertical clearance
- Demolish and Replace Bridge 01466 (NB&SB) over US5/RTE15SB and 91SB Ramps (approx. \$17M)
 - Widen an additional 14' for median shoulder and sight line
 - Raise 2' achieve standard minimum vertical clearance
- Modification of the existing entombed contaminated material area between 144+00 and 153+00. (approx. \$0.5M)
- Construct wall between I-91NB Sta. 153+00 and Bridge No. 05922 (91NB over US5/RTE15NB) to avoid wetland impacts. (approx. \$0.5M)

The following impacts are anticipated to achieve the design standard for vertical clearance:

- ROW—Potential takes to adjacent properties along I-91 NB/SB Station 110+00 to 159+00
- Environmental— Potential wetland and entombed area along I-91 NB/SB Station 110+00 to 159+00
- Schedule—Bridge and wall design and construction will increase total schedule.
- Engineering—Staging issues will result in significant short term impacts though improvements to both directions will increase safety long term.
- Cost—\$71M to avoid design exception.

See the following page for the Minimum Vertical Clearance Map of bridges located on this project.



3.0 SUMMARY

A common engineering challenge in Connecticut is the improvement of urban highway interchanges that are developed on all sides by sensitive property and existing limits that were built to design criteria that does not fit with today's vehicle and driver characteristics. In most cases, the proposed design increases safety and mobility over the existing highway by improving engineering standards for geometric design. The current design is a balance between the impacts of the construction and the cost effectiveness of the overall project.

The following is a list of the most significant impacts:

- **ROW Impacts**

The scope of work required to revise the existing horizontal and vertical geometry to current design standards would require the relocation of US5/RTE15NB south of Bridge No. 05922. The significance of this relocation lies in the proximity to the Farmers Market railroad siding. A ramp widening to the east side of the corridor here would impact the current right of way and possibly the railroad alignment itself.

- **Environmental Impacts--Entombed Material, Swales, Wetlands and Connecticut River.**

Increasing shoulders and travel lanes to the current standard width would result in environmental impacts and cost increases throughout the Hartford section of this project. The existing entombed material and man-made wetland to the north is a sensitive area of this project. A retaining wall would be needed in this area due to the widened roadway which would encroach into the entombed area and displace a portion of the wetland.

- **Schedule Impacts--Main Span widening of Charter Oak Bridge**

In order to add a lane and maintain a full 12' wide lanes and shoulders would result in the full length widening of the Charter Oak Bridge which would increase the construction duration and impacts to commuters and regional travelers. The permitting process, design and construction duration would significantly lengthen the schedule.

Redesigning the existing geometry to current design standards would require raising 91NB and 91SB and the full reconstruction of all bridges in the corridor resulting in a significant increase of the construction duration as well as the overall project cost.

- **Engineering Impacts**

I-91 NB Exit 28 Ramp Geometry

I-91 NB Culvert Rehabilitation

Reconstruction and widening of Bridge 6000A

Railroad Relocation

- **Cost to Avoid Design Exceptions**

Throughout the body of this document, the costs presented have been on a per-design-exception basis. The following is an all-encompassing cost estimate using the same approximate values outlined in this report. This means that this estimate includes all structural and roadway reconstruction that is required in the elimination of all design exceptions but with each element only being estimated once.

- **2.1: Travel Lane and Shoulder Widths**

- Widen and Raise I-91 NB&SB from station 110+00 to 159+00 (approx. \$22M)
 - Reconstruct Bridge Nos. 00813, 01466, and 00480 (approx. \$58.5M)
 - Wetland Wall (approx. \$0.5M)
 - Reconstruct Pier and Abutment of Bridge 05922 (approx. \$18.2M)
 - Widen Charter Oak Bridge (approx. \$50M)
 - Modification of the existing entombed contaminated material area between 144+00 and 153+00. (approx. \$0.5M)
- 2.2: Horizontal Alignments: Minimum Radii and Curve Ratios
 - Relocated US5/RTE15NB Exit 89 South of Bridge No. 05922
 - Reconstruct 91NB between bridge nos. 05922 and 06117 (approx. \$5M)
 - Reconstruct Pier and Abutment of Bridge 05922 (cost included)
 - Relocated I-91NB Exit 28
 - Includes Intersection Reconstructions and Airport road widening (approx. \$2M)
 - Reconstruct Bridge No. 00481 (approx. \$9.5M)
 - Reconstruct bridge nos. 00480, 01466, and 00813 (cost included)
- 2.3: Vertical Curvature: Crest and Sag Curves
 - Relocated US5/RTE15NB Exit 89 South of Bridge No. 05922 (cost included)
 - Widen and Raise I-91 NB&SB from station 110+00 to 159+00 (cost included)
 - Reconstruct Bridge Nos. 01466 and 480 (cost included)
 - Wetland Wall (cost included)
- 2.4: Stopping Sight Distance
 - Realign 91SB/US5/RTE15SB onramps underneath Bridge No. 01466 abutment to maximize sight distance (Approx. \$1.3M)
 - Relocated US5/RTE15NB Exit 89 South of Bridge No. 05922 (cost included)
 - Reconstruct Pier and Abutment of Bridge 05922 (cost included)
 - Widen and Raise I-91 NB&SB from station 110+00 to 159+00 (cost included)
 - Reconstruct Bridge Nos. 00813, 01466, and 00480 (cost included)
- 2.5: Superelevation
 - Complete reconstruction of Bridge No. 05922 (additional \$2M)
 - Relocated US5/RTE15NB Exit 89 South of Bridge No. 05922 (cost included)
 - Increase radius of US5/RTE15NB under bridge no 05922 (approx. \$1.5M)

- Shift US5/15SB to the west, Reconstruct wall and pavement widening (approx. \$1.5M)
- Shift 91SB onramp and 91SB Mainline to the west (approx. \$11M)

- 2.6: Minimum Vertical Clearance
 - Reconstruct bridge nos. 01466 and 00813 (cost included)

Despite the proposed design exceptions, this project addresses the critical safety concerns related to the congestion and operational limitations of the existing Interchange 29 of 91NB. The design exceptions that have been proposed in the preliminary design have been included to limit the duration of construction thereby mitigating the length of disruption to the travelling public, as well as avoiding significant environmental and rights of way impacts.



Submitted By:



Date: 5/18/16


Dale Spencer, P.E.
Project Manager

Recommended for Approval By:

Date: 05/18/16

Sebastian Cannamela, P.E.
Project Manager


Susan M. Libatique
2016.05.18
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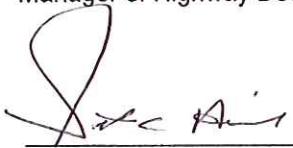
Date: 5/18/16

Susan Libatique, P.E.
Principal Engineer



Date: 5-19-16

Timothy M. Wilson, P.E.
Manager of Highway Design



Date: 5-24-16

Scott A. Hill, P.E.
Engineering Administrator

Approved By:



Date: 5/24/16

for
Amy Jackson-Grove
Federal Highway Administration

APPENDIX A: DESIGN VALUES

Road Name	Interstate 91 Northbound	
Classification	Urban Principal Arterial Interstate	
General Section	Three Lanes	
Design Information		
	Design Standards	Project Values
Design Speed	65-70 MPH	70 MPH
Number of Lanes (each direction)	3	3
Lane Width (ft)	12'	12'
Left Shoulder Width (ft) (Min. - Desirable)	12'	6'-12'
Right Shoulder Width (ft) (Min. - Desirable)	12'	10'-12'
Min. Radius (e max. = 6%)(ft)	2050'	2565'
Max. Superelevation Rate (%)	6%	4.80%
Stopping Sight Distance (ft) Desirable	730'	745'
Max. Grade (%)	4%	2.55%
Median Width (ft) (Min.- Desirable)	≤ 66'	18'-38'
ADT (2039 one way)	-	65800
Controlled Access	Yes	Yes
<p>(1) On four Lane Freeways (2) Desirable width (12ft.) when truck traffic exceeds 250 DDHV (3) Horizontal curve based on Min. SSD (4) Vertical curve based on SSD (5) Waiver required - existing condition at project limit</p>		

Road Name	Route 15 Northbound West of Charter Oak Bridge	
Classification	Urban Principal Arterial Expressway	
General Section	Two Lanes	
Design Information		
	Design Standards	Project Values
Design Speed	70 MPH	70 MPH
Number of Lanes (each direction)	2	2
Lane Width (ft)	12'	11'-12'
Left Shoulder Width (ft) (Min. - Desirable)	12'	4'-12'
Right Shoulder Width (ft) (Min. - Desirable)	12'	4'-12'
Min. Radius (e max. = 6%) (ft)	2050'	2050'
Max. Superelevation Rate (%)	6%	4.20%
Stopping Sight Distance (ft) Desirable	730'	691'
Max. Grade (%)	6%	3.50%
Median Width (ft) (Min. - Desirable)	8'-20'	16'
ADT (2039 one way)	-	47100
Controlled Access	Yes	Yes
<p>(1) On four Lane Freeways (2) Desirable width (12ft.) when truck traffic exceeds 250 DDHV (3) Horizontal curve based on Min. SSD (4) Vertical curve based on SSD (5) Waiver required - exsiting condition at project limit</p>		

Road Name	Route 15 Northbound East of Charter Oak Bridge	
Classification	Urban Principal Arterial Expressway	
General Section	Two Lanes	
Design Information		
	Design Standards	Project Values
Design Speed	70 MPH	45 MPH
Number of Lanes (each direction)	2	2
Lane Width (ft)	12'	11'-12'
Left Shoulder Width (ft) (Min. - Desirable)	12'	4'-12'
Right Shoulder Width (ft) (Min. - Desirable)	12'	12'
Min. Radius (e max. = 6%)(ft)	2050'	1919.33'
Max. Superelevation Rate (%)	6%	5.80%
Stopping Sight Distance (ft) Desirable	730'	404'
Max. Grade (%)	6%	3.25%
Median Width (ft) (Min.- Desirable)	8'-20'	22'-30'
ADT (2039 one way)	-	40500
Controlled Access	Yes	Yes
<p>(1) On four Lane Freeways (2) Desirable width (12ft.) when truck traffic exceeds 250 DDHV (3) Horizontal curve based on Min. SSD (4) Vertical curve based on SSD (5) Waiver required - existing condition at project limit</p>		

Road Name	Route 15 Southbound	
Classification	Urban Principal Arterial Expressway	
General Section	Two Lanes	
Design Information		
	Design Standards	Project Values
Design Speed	70 MPH	70 MPH
Number of Lanes (each direction)	2	2
Lane Width (ft)	12'	12'
Left Shoulder Width (ft) (Min. - Desirable)	2'-4'	10'
Right Shoulder Width (ft) (Min. - Desirable)	4'-8'	4'
Min. Radius (e max. = 6%) (ft)	2050'	3348'
Max. Superelevation Rate (%)	6%	5.80%
Stopping Sight Distance (ft) Desirable	730'	736'
Max. Grade (%)	6%	3.50%
Median Width (ft) (Min.- Desirable)	8'-20'	16'
ADT (2039 one way)	-	21600
Controlled Access	Yes	Yes
<p>(1) On four Lane Freeways (2) Desirable width (12ft.) when truck traffic exceeds 250 DDHV (3) Horizontal curve based on Min. SSD (4) Vertical curve based on SSD (5) Waiver required - existing condition at project limit</p>		

Road Name	Interstate 91 Northbound Exit 28	
Classification	Ramp (Exit)	
General Section	One Lane	
Design Information		
	Design Standards	Project Values
Design Speed	25 MPH	25 MPH
Number of Lanes (each direction)	1	1
Lane Width (ft)	12'	12'
Left Shoulder Width (ft) (Min. - Desirable)	4'	4'
Right Shoulder Width (ft) (Min. - Desirable)	10'	10'
Min. Radius (e max. = 6%) (ft)	190'	135'
Max. Superelevation Rate (%)	6%	6.00%
Stopping Sight Distance (ft) Desirable	155'	177'
Max. Grade (%)	6-8%	5.50%
ADT (2039 one way)	-	1600
Controlled Access	Yes	Yes
Deceleration Length (ft)	590'	816'
<p>(1) On four Lane Freeways (2) Desirable width (12ft.) when truck traffic exceeds 250 DDHV (3) Horizontal curve based on Min. SSD (4) Vertical curve based on SSD (5) Waiver required - existing condition at project limit</p>		

Road Name	Relocated Interstate 91 Northbound Exit 29	
Classification	Connector	
General Section	2 Lane	
Design Information		
	Design Standards	Project Values
Design Speed	70 MPH	65 MPH
Number of Lanes (each direction)	2	2
Lane Width (ft)	12'	12'
Left Shoulder Width (ft) (Min. - Desirable)	4'	12'
Right Shoulder Width (ft) (Min. - Desirable)	10'	12'
Min. Radius (e max. = 6%) (ft)	2050'	2800'
Max. Superelevation Rate (%)	6%	4.20%
Stopping Sight Distance (ft) Desirable	730'	738'
Max. Grade (%)	3-5%	3.25%
Median Width (ft) (Min.- Desirable)	-	-
ADT (2039 one way)	-	25500
Controlled Access	Yes	Yes
<p>(1) On four Lane Freeways (2) Desirable width (12ft.) when truck traffic exceeds 250 DDHV (3) Horizontal curve based on Min. SSD (4) Vertical curve based on SSD (5) Waiver required - existing condition at project limit</p>		

Road Name	US 5/Route 15 Northbound Exit 89	
Classification	Connector	
General Section	Two Lane Exit Ramp	
Design Information		
	Design Standards	Project Values
Design Speed	70 MPH	60 MPH
Number of Lanes (each direction)	2	2
Lane Width (ft)	12'	11'-12'
Left Shoulder Width (ft) (Min. - Desirable)	4'	12'
Right Shoulder Width (ft) (Min. - Desirable)	10'	12'
Min. Radius (e max. = 6%) (ft)	2050'	1665'
Max. Superelevation Rate (%)	6%	5.80%
Stopping Sight Distance (ft) Desirable	730'	643'
Max. Grade (%)	3-5%	3.10%
Median Width (ft) (Min.- Desirable)	-	-
ADT (2039 one way)	-	23100
Controlled Access	Yes	Yes
<p>(1) On four Lane Freeways (2) Desirable width (12ft.) when truck traffic exceeds 250 DDHV (3) Horizontal curve based on Min. SSD (4) Vertical curve based on SSD (5) Waiver required - existing condition at project limit</p>		

Road Name	US 5/Route 15 Northbound Exit 90 to Route 2	
Classification	Ramp (Exit)	
General Section	Two Lane	
Design Information		
	Design Standards	Project Values
Design Speed	35 MPH	35 MPH
Number of Lanes (each direction)	2	2
Lane Width (ft)	12'	12'
Left Shoulder Width (ft) (Min. - Desirable)	4'	5.5'-11'
Right Shoulder Width (ft) (Min. - Desirable)	10'	12.5'-13'
Min. Radius (e max. = 6%) (ft)	385'	412'
Max. Superelevation Rate (%)	6%	5.90%
Stopping Sight Distance (ft) Desirable	250'	708'
Max. Grade (%)	4-6%	3.64%
ADT (2039 one way)	-	4800
Controlled Access	Yes	Yes
Deceleration Length (ft)	490'	645'
<p>(1) On four Lane Freeways (2) Desirable width (12ft.) when truck traffic exceeds 250 DDHV (3) Horizontal curve based on Min. SSD (4) Vertical curve based on SSD (5) Waiver required - existing condition at project limit</p>		

Road Name	US 5/Route 15 Northbound Exit 90 to Main Street	
Classification	Urban Principal Arterial Other	
General Section	One Lane Exit Ramp	
Design Information		
	Design Standards	Project Values
Design Speed	30-45 MPH	45 MPH
Number of Lanes (each direction)	1	1
Lane Width (ft)	12'	12'
Left Shoulder Width (ft) (Min. - Desirable)	4'	4.25'-7'
Right Shoulder Width (ft) (Min. - Desirable)	10'	8'-11.5'
Min. Radius (e max. = 6%) (ft)	665'	675'
Max. Superelevation Rate (%)	4%	4.90%
Stopping Sight Distance (ft) Desirable	360	1103'
Max. Grade (%)	7%	3.60%
ADT (2039 one way)	-	4200
Controlled Access	Yes	Yes
Deceleration Length (ft)	390'	456'
<p>(1) On four Lane Freeways (2) Desirable width (12ft.) when truck traffic exceeds 250 DDHV (3) Horizontal curve based on Min. SSD (4) Vertical curve based on SSD (5) Waiver required - existing condition at project limit</p>		

Road Name	On-Ramp from Main St. to US 5/Route 15 Northbound	
Classification	Ramp (Entrance)	
General Section	One Lane	
Design Information		
	Design Standards	Project Values
Design Speed	40 MPH	30 MPH
Number of Lanes (each direction)	1	1
Lane Width (ft)	12'	12'
Left Shoulder Width (ft) (Min. - Desirable)	4'	8'
Right Shoulder Width (ft) (Min. - Desirable)	10'	8'-14'
Min. Radius (e max. = 6%) (ft)	510'	292'
Max. Superelevation Rate (%)	6%	4.90%
Stopping Sight Distance (ft) Desirable	305'	>305'
Max. Grade (%)	4-6%	2.85%
ADT (2039 one way)	-	1500
Controlled Access	Yes	Yes
Acceleration Length (ft)	1000'	>1000'
<p>(1) On four Lane Freeways (2) Desirable width (12ft.) when truck traffic exceeds 250 DDHV (3) Horizontal curve based on Min. SSD (4) Vertical curve based on SSD (5) Waiver required - existing condition at project limit</p>		

Road Name	US 5/Route 15 Northbound Exit 91	
Classification	Ramp (Exit)	
General Section	One Lane	
Design Information		
	Design Standards	Project Values
Design Speed	40 MPH	50 MPH
Number of Lanes (each direction)	1	1
Lane Width (ft)	12'	14'-16'
Left Shoulder Width (ft) (Min. - Desirable)	4'	4'-8'
Right Shoulder Width (ft) (Min. - Desirable)	10'	10'-12'
Min. Radius (e max. = 6%) (ft)	510'	445'
Max. Superelevation Rate (%)	6.00%	6.00%
Stopping Sight Distance (ft) Desirable	305'	534'
Max. Grade (%)	4-6%	2.00%
ADT (2039 one way)	-	3600
Controlled Access	Yes	Yes
Deceleration Length (ft)	440'	>440'
<p>(1) On four Lane Freeways (2) Desirable width (12ft.) when truck traffic exceeds 250 DDHV (3) Horizontal curve based on Min. SSD (4) Vertical curve based on SSD (5) Waiver required - existing condition at project limit</p>		