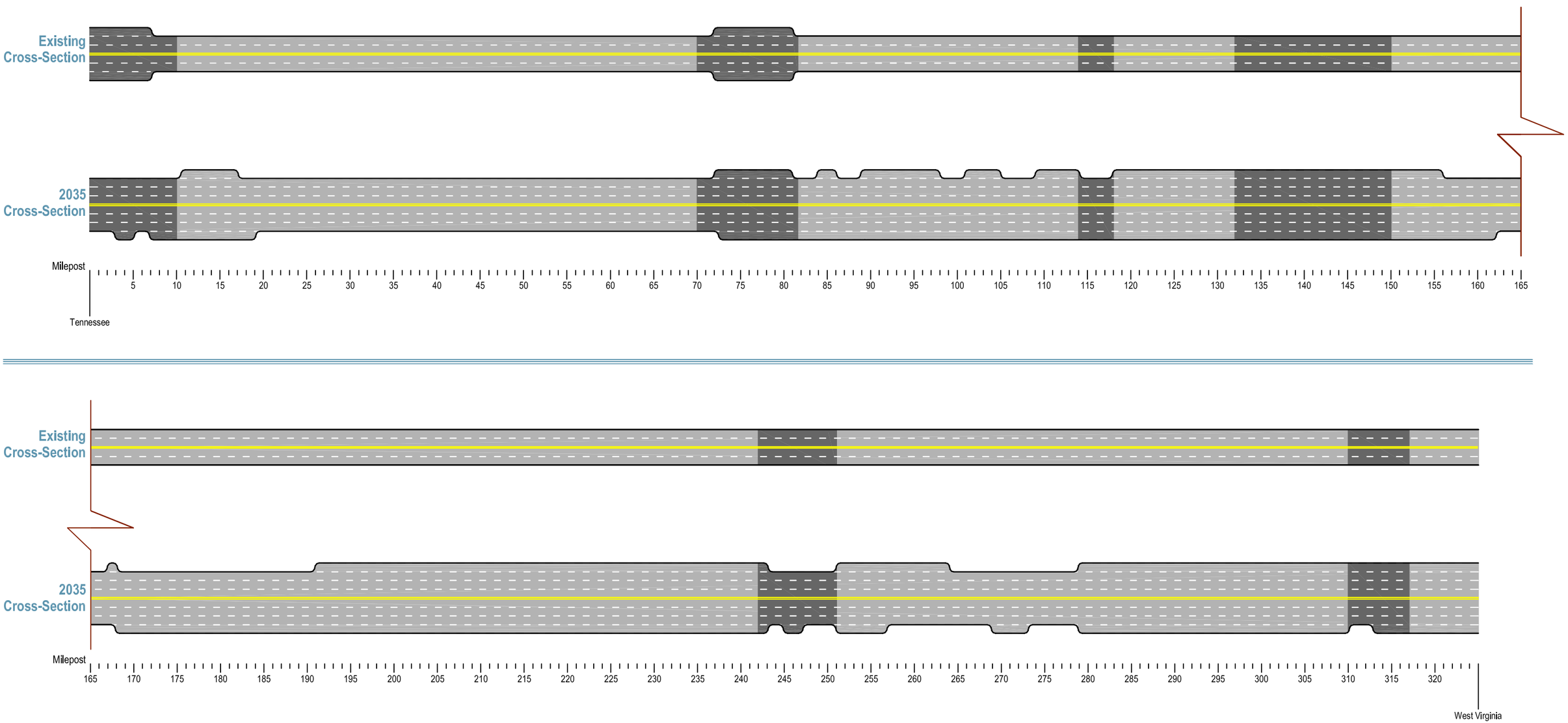


*Required to meet American Association of State Highway Transportation Officials (AASHTO) Level of Service Requirements.

Rural

Urban

I-81 2035 Basic Lane Requirements

Figure 3.3-1

I-81 CORRIDOR IMPROVEMENT STUDY

\richva\projects31698\graphics\figures\31698-lane-requirements.indd p.1

4

Conceptual Design Elements

Several conceptual design elements were developed in order to conduct the *I-81 Corridor Improvement Study*. These elements included roadway typical sections and roadway and interchange impact templates.

4.1 Roadway Typical Sections

Once the "Build" concepts were identified, typical roadway sections for the improvement concepts were developed to allow for approximation of cost and to be used to develop roadway impact templates for environmental analyses. (See Appendix for typical sections). The design criteria used to develop the typical sections are presented below. It is important to note that these criteria were used for the purposes of a Tier 1 analysis only. Additional details on these elements would occur if a "Build" concept (or portion of a "Build" concept) is advanced to Tier 2 and further refinement would occur as part of a design process.

4.1.1 Design Criteria

The design criteria employed in the development of typical section templates are criteria developed and mandated by the I-81 steering committee on June 20, 2000. (See Appendix for copy of VDOT memorandum). The memorandum mandated that:

1. Design Speed for the mainline would be 70 mph.
2. Functional Classification would be Rural Principal Arterial (GS-I)
3. Travel lane widths would be 12 feet wide
4. Full depth paved shoulders 12 feet wide would be provided on both sides of the roadway with identical cross slopes to the travel lanes.
5. Outside shoulder widths, cut and fill, would be 17 feet. The graded portion (5 feet) beyond the edge of paved shoulder shall be 5/8": 1' governed by the GS-II standard.

6. Median shoulder widths, cut and fill would be 17 feet. The graded portion (5 feet) beyond the edge of paved shoulder shall be 5/8": 1′ governed by the GS-II standard.
7. All interchanges would have a minimum of 1,200 feet acceleration lanes for on-ramps and 800 feet deceleration lanes for off-ramps. Lengths of acceleration lanes and deceleration lanes are to be in accordance with the latest standards except for minimum lengths as noted. Longer than standard lengths may be needed in special situations.
8. Any median 50 feet or less in width would have Concrete Median Barrier (Tall Wall) (50″) MB-12A, 12B, and 12C or MB-13 (Type I, II, III) as conditions dictate.
9. Concrete Median Barrier (Tall Wall) (50″) MB-12A, 12B, and 12C and MB-13 (Type I, II, III) (50″) depending on conditions would be considered for median widths ranging from 50-70 feet.
10. Piers for structures carrying routes over I-81 would be located to allow for a future lane on the mainline of I-81 (12′ paved shoulder).
11. Side slopes would be in accordance with CS-4E Standards.
12. Mainline bridges would be designed with 14 feet shoulders on both the inside and outside.
13. All bridge clearances over mainline I-81 would be 16′-6″ for the total paved cross-section. The total paved cross-section includes paved shoulders.
14. Rumble strips would be provided on both the inside and outside along the total length of I-81.

4.2 Impact Templates

Consistent with a tiered approach, potential impacts in the I-81 corridor are presented in terms of potential impacts from the narrowest highway footprint and the widest highway footprint. Referred to as Minimum Width and the Maximum Width, these footprints represent concepts that were based on transportation needs identified in Chapter 2, *Purpose and Need*. The width of the variable Minimum Width footprint ranges from roughly 240 feet to 430 feet depending on the location. In comparison, the Maximum Width footprint ranges from 240 feet to 540 feet. For comparative purposes, potential impacts were also calculated for the Add 2-Lanes concept footprint and Add 8-Lanes concept footprint.

When evaluating at the number of lanes needed to address the needs along I-81, a “no toll” and “no rail” base condition was assumed for the purpose of developing the impact templates. This base condition represents the highest traffic volumes and therefore the greatest number of lanes that may be needed on I-81. Variations in tolling and rail assumptions could decrease the number of lanes needed on I-81.

Approximately 37 percent of the total lane miles along I-81 need only one additional lane in each direction (see the *Transportation Technical Report*). Both the Minimum Width and Maximum Width template have one additional lane in each direction (two additional lanes total) in those locations where one additional lane in each direction is needed. As shown in Chapter 5 of the DEIS, the typical 2-lane cross-section adds two lanes in the median of I-81 to the extent possible.

Approximately 61 percent of the total lane miles along I-81 need at least two additional lanes in each direction (see the *Transportation Technical Report*).[3] In these sections, two different cross-sections were developed to reflect various types of improvement concepts under consideration with different operating conditions (*i.e.,* separation of cars from commercial vehicles, non-separated lanes, etc.): a 4-lane cross-section (adding two lanes in each direction) and an 8-lane cross-section (adding four lanes in each direction).

The 4-lane cross-section adds two additional in each direction, widening in the median of I-81 as much as possible, and then widening to the outside where needed. This cross-section, which does not provide a physical separation between vehicle types, is used for the Minimum Width template in those locations where more than one lane is needed in each direction. It reflects the smallest potential construction footprint. The 8-lane cross-section adds four additional lanes in each direction. It is used for the Maximum Width template in those locations where more than one lane is needed in each direction. It provides barrier separated lanes, with all of the widening occurring to the outside of the I-81 travel lane to reflect the largest potential construction footprint.

See Appendix for the Minimum Width and Maximum Width templates.

Interchange Templates

Interchange templates were prepared for diamond and cloverleaf configurations in order to assess the environmental impacts associated with changes to the existing I-81 interchanges. A determination regarding which interchange template was most appropriate for each of the 91 interchanges was made based on the analysis of 2035 projected traffic volumes.

The interchange templates were developed to encompass all potential impacts associated with the reconstruction of the mainline roadway section, reconstruction of interchange ramps, substantial geometric modification, additions of auxiliary and collector-distributor lanes (*i.e.*, lanes adjacent to and separated from the mainline on cloverleaf interchanges for vehicles exiting and entering the mainline), and the construction of new bridges. (See Appendix for Interchange layouts.)

[3] The remaining two percent of total lane miles (37 percent + 61 percent = 98 percent) does not need any additional lanes. This occurs between Milepost 0 and 7.

Diamond Interchanges

The total length of a diamond interchange is approximately 4,600 feet. The template includes four travel lanes in each direction with 1,200-foot acceleration lanes and 800-foot deceleration lanes with 300-foot tapers. The ramps are spaced 600 feet apart for proper turn lane lengths and signing. A cross street width of 36 feet was assumed to accommodate a single through lane in each direction and left turn lanes at the ramp junctions.

Cloverleaf Interchanges

The total length of a cloverleaf interchange is approximately 21,200 feet. Much larger than a diamond template, the additional length is needed to accommodate lane transitions, weaving maneuvers, and signage requirements. Additional width is also included in this template to accommodate additional area for the construction of dual C/D roads and separation of these C/D roads from the interstate.

Table 4-1 below summarizes the elements that comprise the Minimum Width and Maximum Width impact templates. If one or more "Build" concepts are advanced, the footprint of any of the selected concepts should fall between the two templates. The width of the variable Minimum Width template ranges from roughly 240 feet to 430 feet depending on the location. In comparison, the Maximum Width template ranges from 240 feet to 540 feet.

Table 4.1-1 Elements of Impact Templates

Impact Template	Areas Where 2 Lanes Needed	Areas Where 4 Lanes Needed	Interchanges
Minimum Width Template	2-lane Cross-section	4-lane Cross-section	Minimum Cloverleaf/ Minimum Diamond
Maximum Width Template	2-lane Cross-section	8-lane Cross-section	Maximum Cloverleaf/ Minimum Diamond

Rail Impact Template

Many of the improvement concepts included in this study involve rail improvements. Therefore, an impact template was developed for the 13 rail improvement sections that comprise Rail Concept 3. As described in Chapter 3, Rail Concept 3 was chosen as the most appropriate rail concept to combine with roadway concepts because it provides the most diversion of freight from truck to rail per dollar of investment. The rail template, generally 100 feet wide, represents the limits of potential rail construction.

5
Approximation of Costs

The methodology for preparing approximation of costs for the roadway and rail improvement concepts is described in the following sections.

5.1 Methodology

5.1.1 Roadway Costs

A preliminary order of magnitude construction cost estimate was prepared for each of the improvement concepts that included a roadway element utilizing VDOT's Preliminary Cost Estimating System (PCES) Version 2.0. The PCES estimates contain provisions for right-of-way and easement acquisition, bridge construction, utility relocation costs and engineering costs. Construction costs were based on linear foot or per mile costs, reflecting the geometric detail available in this Tier 1 study.

Within the PCES base estimate, there is a mileage factor for two-lane roadway, four-lane roadway, and loop and ramp construction. This factor is based on data that shows that it costs approximately 1.8 times as much to build a mile of 4-lane roadway (or loop/ramp) as it costs to build a mile of 2-lane roadway. Also within the base estimate is a common cost factor, which takes into account VDOT geometric standards for rural versus urban design. This represents that some items common on most projects do not vary greatly among similar projects. A different value of the common cost factor was developed for each functional classification.

The base estimate includes a lane width factor with a standard lane of 10 feet. Therefore, a 12-foot lane increases the per mile costs 1.2 times the standard. Other base estimate factors not used for this study were for small projects, surface treatment, and crossovers.

Individual items for the base estimates were used for the interchange summaries such as right turn lanes, left turn lanes, curb and gutter (CG-6 or 7), sidewalk, raised median, new signal, and signal adjustments.

The individual item for large drainage structures was added for each estimate. This is used to estimate the cost of box culverts and storm water management ponds. The item of "unusual construction costs" was also used providing costs for landscaping, lighting, and wetlands mitigation.

The advertisement date factor allows for inflation to be applied for the number of years between today and the construction advertising date, based on 3.89 percent inflation per year. For this study, costs are provided in 2005 and 2015 dollars. This allows for cost comparison among alternatives and for cost estimation at the anticipated completion of construction, should a "build" concept (or portion of a "build" concept) be advanced through Tier 2 and design.

Bridge estimates were developed based on a price per square foot using three categories, simple, moderate and complex. Contingencies, construction engineering and removal of existing bridges were added into the bridge estimates.

Interchange estimates were prepared for the three interchange types developed for the Tier 1 study. Estimates were prepared for standard diamond, standard cloverleaf and SPUI interchange concepts. These costs were based on lane miles per interchange type and include additional cost for contingencies.

Estimated construction costs are provided in Table 5.1-1.

Table 5.1-1 Approximation of Roadway Construction Cost

Concepts	Cost – 2005 ($ in billions)	Cost – 2015 ($ in billions)
No-Build	$0.0	$0.0
TSM	$0.08	$0.1
Add 1 lane	$5.1	$7.5
Add 2 lanes	$7.8	$11.4
Add 3 lanes	$11.2	$16.4
Uniform 6 lanes	$4.9	$7.2
Uniform 8 lanes	$7.5	$11.0
Separated #1	$11.2 – $12.7	$16.4 – $18.6
Separated #2	$11.2 - $13.0	$16.4 – $19.0
Separated #3	$9.3 - $10.8	$13.6 – $15.8
Separated #4	$11.2 – $13.0	$16.4 – $19.0
Separated #5	$11.2 - $13.0	$16.4 – $19.0

5.1.2 Rail Costs

Rail improvement costs were developed with the assistance of the Department of Rail and Public Transportation (DRPT), Norfolk Southern Railroad and Rail Solution, a rail advocacy group that proposed Rail Concept 4 during the Scoping Process of this study. The costs (in millions) are broken down into rail infrastructure costs and rolling stock costs (vehicles). The cost estimates are based on Norfolk Southern engineering guidelines. Curvature costs are designed to reduce curvature and improve rail superelevation (the banking of rail lines to allow trains to travel through a curve at higher speeds) throughout much of the corridor. Phase 1 improvements would allow a higher volume of intermodal train traffic to use the corridor. They include items such as new rail sidings (places for trains to pull off the main track to allow passage of another train), some double-tracking, and improvements to rail signal and communication systems. Table 5.1-2 illustrates the rail costs included in the rail concepts considered in this study.

Table 5.1-2 Rail Improvement Concept Costs (in millions)

Concept #	Description	2005 Rail infrastructure costs (source)	2005 Rail rolling stock costs (source)	2005 Total Costs	2015 Total Costs
Rail Concept 1	Rail improvements mainly to the B line on the Piedmont Line between Manassas and Front Royal, VA. (Phase 1 improvements)	Phase 1 = $111 [1]	$0	$111	$163
Rail Concept 2	Improvements on Piedmont Line starting at Danville, north to Lynchburg, to Manassas, to Front Royal, north to State line. (Phase 1 improvements)	Phase 1 = $267 [2]	$229 (2)	$496	$727
Rail Concept 3	Improvements on Piedmont Line starting at Danville, north to Lynchburg, to Manassas, to Front Royal, north to State line, and including minor improvements to the Shenandoah Line.	$280 [3]	$229 (3)	$509	$746
Rail Concept 4	TBD	$3,700	unknown	$3,700	$5,421

Sources of information:
1 Star Solutions proposal, page E-1, September 5, 2003
2 "The Northeast-Southeast-Midwest Corridor Market Analysis" by Reebie Associates, Virginia Department of Rail and Public Transportation, December 2003, Appendix 7 - Attachment E table showing $39.1 Column A + $227.5 Column B for total of $266.6
3 NSRR spreadsheet "Pilot Project Capital Improvements 8-20-04" from Steve Eisenach, NS.

The following tables illustrate more detailed breakdowns of the rail costs for each concept shown in Tables 5.1-3 – 5.1-5. The breakdowns detail the track improvements and the locations of those improvements where available, however no breakdowns for rolling stock are presented.

Rail Concept 1

Table 5.1-3 Rail Concept 1 Detailed Cost Breakdown

Piedmont Line	Specific Improvements	Estimated Costs (millions $)
Phase 1 – Manassas to Front Royal		
	▪ 2nd line south of Manassas for staging ▪ Grade for future 3rd rail to Haymarket ▪ 10 miles of double track to Haymarket ▪ Additional sidings between Marshall and Front Royal ▪ Improve signals/communication between Marshall and Front Royal	$ 55
Phase 1 - Front Royal north to State Line		
	▪ Add double tracking ▪ New universal crossovers ▪ Capacity improvements	$ 56
Rolling Stock		$ 0
Totals		$111.0

Source: Star Solutions proposal, page E-1, September 5, 2003

Rail Concept 2

Table 5.1-4 Rail Concept 2 Detailed Cost Breakdown

Improvements (Columns A+B) by Location	Specific Improvements	Estimated Costs (millions $)
Hagerstown, MD to Front Royal, VA:		
	▪ Superelevation and curvature ▪ Add three new sidings ▪ Extend three existing sidings ▪ New 800 foot Shenandoah bridge	$ 71.0
Front Royal to Manassas, VA		
	▪ Superelevation and curvature ▪ Add four sidings ▪ Train control signals	$ 55.6
Manassas to Lynchburg, VA	▪ Superelevation and curvature	$ 77.1
Lynchburg, VA to NC state line		
	▪ Superelevation and curvature ▪ Grade separation and bridges	$ 63.1
Totals		$266.8

Source: "Northeast-Southeast-Midwest Corridor Marketing Study", Reebie Associates for Virginia

Rail Concept 3

Table 5.1-5 Rail Concept 3 Detailed Cost Breakdown

Rail Division/Location	Specific Improvements	Estimated Costs (millions $)
WV State Line to Riverton Jct.		
	▪ Extend 4,774' Berryville siding to 11,000'	$3.93
	▪ Install 2nd main track with traffic control north of Riverton and upgrade existing Marshrun siding	$10.44
	▪ Major line change at Riverton Jct.	$44.70
	▪ Super-elevation work, major & minor line changes	$13.56
Riverton Jct. to Manassas, VA		
	▪ New 11,000' siding B-5.6 to B-7.7	$5.63
	▪ New 11,000' siding B13.0 to B-15.3	$7.22
	▪ Extend 7,400' Allison siding to 11,000' and upgrade siding	$4.87
	▪ New 11,000' siding B-31.0 to B-33.3	$6.57
	▪ New 11,000' siding B-41.6 to B-43.7	$11.02
	▪ Install traffic control	$16.50
	▪ Roadbed stabilization B-0.0 to B-25.0	$0.50
	▪ Curve super-elevation work, major & minor line changes	$29.00
Manassas to Lynchburg,	▪ Curve super-elevation work, major & minor line changes	$ 8.80
Lynchburg, VA to Danville		
	▪ Double-track MP-222.2 to 232.5	$24.62
	▪ Curve super-elevation work, major & minor line changes	$2.50
Walton to Bristol		
	▪ Extend 6,189' Gunton Park siding to 11,000'	$4.02
	▪ Extend 10,000' Duncan siding to 11,000'	1.58
	▪ Extend 5,740' Marion siding to 10,500'	$9.07
	▪ Extend 5,796' Washington siding to 11,000'	$3.54
	▪ Curve super-elevation work	$39.40
Contingencies		$32.5
Totals		$279.9

Sources:
"Northeast-Southeast-Midwest Corridor Marketing Study", Reebie Associates for Virginia
NSRR spreadsheet "Pilot Project Capital Improvements 8-20-04" from Steve Eisenach, NS.

Rail Concept 4

The source of this cost estimate is a 1999 NS Corporation study that calculated a $2.3 billion cost for improvements to the Shenandoah Line. Using this as a starting point, Rail Solutions added 16 miles of double track and a second bridge over the Potomac River, and inflated to 2005 dollars, resulting in $3.7 billion.

5.1.3 Combination Costs

Table 5.1-6 summarizes the approximation of costs for combination concepts based on the stand-alone concept costs identified above.

Table 5.1-6 Approximation of Cost

Concepts	Cost - 2005 ($ in billions)	Cost - 2015 ($ in billions)
Combination #1	$5.6	$8.2
Combination #2	$8.3	$12.2
Combination #3	$11.7	$17.1
Combination #4	$5.4	$7.9
Combination #5	$8.0	$11.7

A

Appendix A

- VDOT Design Guideline Memorandum
- Typical Sections
- Impact Templates
- Cost Summary Sheets

VDOT Design Guidelines Memorandum

RDP Mr. R. H. Cary
Salem District

COMMONWEALTH of VIRGINIA

DEPARTMENT OF TRANSPORTATION
1401 EAST BROAD STREET
RICHMOND, 23219-2000

June 20, 2000

CHARLES D. NOTTINGHAM
COMMISSIONER

J. T. MILLS
STATE LOCATION AND DESIGN ENGINEER

MEMORANDUM

To - Mr. D. H. Marston
Mr. F. C. Altizer, Jr.
Mr. D. C. Morrison
Mr. M. K. Brittle
Mr. P. A. Sensabaugh, Jr.
Mr. W. B. Coburn
Mr. S. B. Buston
Mr. J. D. Bishop
Mr. J. D. Brugh
Mr. J. A. Echols
Mr. J. W. White, Jr.
Mr. J. R. Van Lear
Mr. D. F. Komara
Mr. J. A. Copp
Mr. R. M. Hubble
Mr. R. J. Yates
Mr. J. B. Diamond
Mr. G. J. Lovins
Ms. N. C. Widgen
Mr. P. A. Thompson
Mr. D. R. Harris
Mr. R. H. Cary
Mr. T. L. Jackson

06-26-00A09:24 RCVD

Re: **Design Guidelines for the Widening of I-81**

As you know, we are in the process of widening and making associated improvements to the I-81 corridor from Bristol north to the West Virginia line (325 miles). To ensure that consistency is maintained in this endeavor, the attached set of guidelines have been developed.

These guidelines have been discussed with the involved districts and have been reviewed by the Federal Highway Administration (FHWA). Comments and recommendations from these entities have been incorporated into these guidelines.

CCRDP

Adherence to these guidelines during the plan development process is required. Any variation will need the written concurrence from the Chief Engineer or myself.

J. T. Mills
State Location and Design Engineer

Attachment

Cc: Mr. Charles D. Nottingham
Mr. J. G. Browder, Jr.
Mr. Roberto Fonseca-Martinez
Ms. Joyce Curtis
Mr. K. E. Lantz, Jr.
Ms. I. O. Kastenhofer
Mr. J. S. Givens
Mr. M. T. Kerley
Mr. C. H. Rasnick
Mr. C. H. Robson, Jr.
Mr. C. F. Boles, III
Mr. M. Mirshahi

DESIGN GUIDELINES FOR THE DEVELOPMENT OF I-81 R/W AND CONSTRUCTION PLANS

The following guidelines have been established to assist all those involved in the design of Construction plans for the Improvement of the I-81 Corridor.

- Design Speed for Mainline I-81 shall be 70 mph.
  Note: Designers should refer to the study documents covering the project area to aid in the identification of existing areas along the I-81 corridor where the mainline geometrics do not meet the current standards for 70 mph.

- The Functional Classification of I-81 is Rural Principle Arterial (GS-1).

- Travel lane widths for I-81 are to be 12 feet wide.

- Two 12 feet wide travel lanes in each direction shall be maintained on the mainline at all times with a minimum of 1 foot offset to the Barrier Service during construction unless otherwise approved by the District Construction Engineer.

- At least one travel lane in each direction shall be maintained on the crossroads at all times. The width of travel lane is to be approved by the District Construction Engineer.

- All interchanges are to remain functional during construction activities.

- 12 feet full depth paved shoulders shall be provided on each side of the roadway with identical cross slopes to the travel lanes.

- Outside shoulder widths, cut and fill, shall be 17 feet. The graded portion (5 feet) beyond the edge of the paved shoulder shall be 5/8":1' governed by the GS-11 Standard.

- Median shoulder widths, cut and fill, shall be 17 feet. The graded portion (5 feet) beyond the edge of the paved shoulder shall be 5/8':1' governed by the GS-11 Standard.

- All Interchanges will have a <u>minimum</u> of 1200 feet acceleration lanes for on-ramps and 800 feet deceleration lanes for off-ramps. Lengths of acceleration lanes and deceleration lanes are to be in accordance with the latest standards except for minimum lengths as noted. Longer than standard lengths may be needed in special situations.

Revised: April 7, 2000

- Any median 50 feet or less in width is to have Concrete Median Barrier (Tall Wall) [50"] MB-12A, 12B, and12C or MB-13 (Type I, II, or III) as conditions dictate.

- Concrete Median Barrier (Tall Wall) [50"] MB-12A, 12B, and12C and MB-13 (Type I, II, or III) (50") depending of conditions is to be considered for median widths ranging from 50-70 feet.

- Piers for structures carrying routes over I-81 shall be located to allow for a future lane on the mainline of I-81 (12' paved shoulder).

- Sides slopes shall be in accordance with CS-4E Standards.

- Mainline Bridges should be designed so they can be widened economically in the future.

- Mainline Bridges will be designed with 14 feet shoulders on both the inside and outside.

- All Bridge Clearances over Mainline I-81 are to be 16'-6" for the total paved cross-section. The total paved cross-section includes paved shoulders.

- Rumble strips are to be provided on both the inside and outside shoulders along the total length of I-81.

Notes:

Designers should be aware of any Agricultural Forestal District (AFD)[Resident Engineers are responsible for maintaining these records and the renewal dates for the AFD's] within their project limits.

Additional Traffic Data Counts shall only be obtained at the direction of the Department's Transportation Planning Division.

I-81 is scheduled to have a fiber optic cable installed along the length of the corridor.

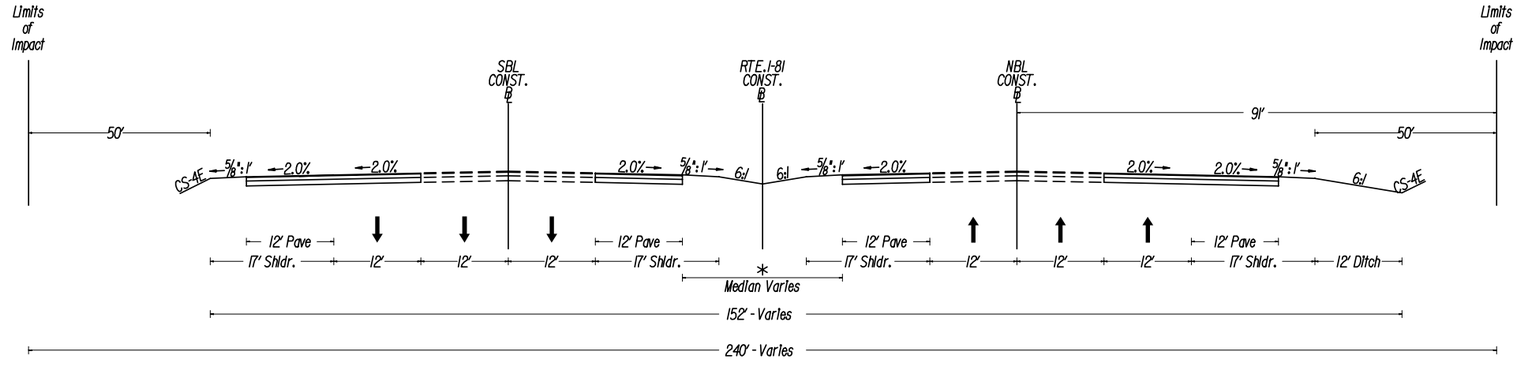
Route 81 Corridor Improvement Study DESIGN CRITERIA VDOT Project Nos: 0081-961-111, 0081-962-116, 0081-968-123

VDOT PPMS Nos: 67587, 67588, 67589

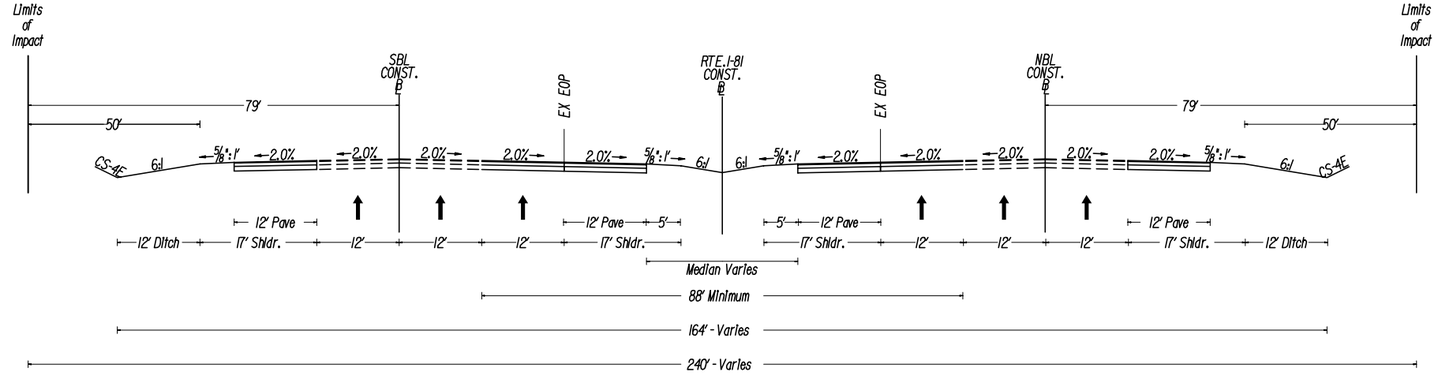
Classification	Design speed (mph)	Lane Width (Feet)	Rt. Paved Shoulder Width (Feet)	Rt. Graded Shoulder Width (Feet)	Rt. Shldr. W/ GR (Feet)	Lt. Paved Shoulder Width (Feet)	Lt. Graded Shoulder Width (Feet)	Lt. Shldr. W/ GR (Feet)	Min.Radius (Feet)	Max Super Elev. (%)	Max Grade (%)*	Stopping Distance Desirable (Feet)	Stopping Distance Minimum (Feet)	Crest K Value (Des.)	Crest K Value (Min.)	Sag K Value (Des.)	Sag K Value (Min.)	Width of Ditch (Front Slope)	Slope
Rural Principle Arterial-Freeway (GS-1)	70	12	12	12	17	12	12	17	1821	8	4	850	730	540	290	220	150	12' @ 6:1	CS-4B
Urban Other Principle Arterial (GS-5, with Shoulder Design)	45	12	8	10	13	8	10	13	732	4	7	400	365	120	80	90	70	6' @ 4:1	CS-4E
Urban Other Principle Arterial (GS-5, with Curb and Gutter)	45	12	CG-6	-	-	CG-6	-	-	732	4	7	400	365	120	80	90	70	n/a	2:1 Max.
Urban Other Principle Arterial (GS-5, with Shoulder Design)	35	12	8	10	13	8	10	13	420	4	8	265	255	50	40	50	50	6' @ 4:1	CS-3 or CS 3B
Urban Minor Arterial (GS-6, with Curb and Gutter)	45	12	CG-6	-	-	CG-6	-	-	732	4	7	400	360	120	80	90	70	n/a	2:1 Max.
Urban Minor Arterial (GS-6, with Shoulder Design)	45	12	8	10	13	8	10	13	732	4	7	400	360	120	80	90	70	10' @ 6:1	CS-4E
Interchange Ramp (GS-RM)	45	16	8	11	14	3	6	9	602	8	5	400	365	120	80	90	70	10' @ 6:1	CS-4E
Interchange Ramp (GS-RM)	35	16	6	11	14	4	6	9	350	8	6	265	255	50	40	50	50	10' @ 6:1	CS-4E
Interchange Ramp (GS-RM)	30	16	6	11	14	4	6	9	251	8	7	200	200	30	30	40	40	10' @ 6:1	CS-4E
Interchange Ramp (GS-RM)	25	18	6	11	14	4	6	9	172	8	7	155	155	20	20	30	30	10' @ 6:1	CS-4E
Interchange Ramp/Loop (GS-RM)	35	16	4	6	9	4	6	9	350	8	6	265	255	50	40	50	50	10' @ 6:1	CS-4E
Interchange Ramp/Loop (GS-RM)	30	16	4	6	9	4	6	14	251	8	6	200	200	30	40	40	40	10' @ 6:1	CS-4E
Rural Collector Road System (GS-3)	50	12	6	8	11	3	8	11	764	8	7	475	400	160	120	110	90	10' @ 6:1	CS-4C
Rural Collector Road System (GS-3,with Curb and Gutter)	50	12	CG-6	-	-	CG-6	-	-	764	8	7	475	400	160	120	110	90	n/a	CS-4C
Rural Local Road System (GS-4)	40	12	1	8	11	1	8	11	465	8	10	325	305	80	60	70	60	6' @ 4:1	CS-3A
Rural Local Road System (GS-4)	40	11	1	9	9	1	9	9	465	8	10	325	305	80	60	70	60	4' @ 3:1	CS-1
Rural Local Road System (GS-4)	40	10	1	9	9	1	9	9	465	8	10	325	305	80	60	70	60	4' @ 3:1	CS-1
Rural Local Road System (GS-4)	30	12	1	8	11	1	8	11	251	8	10	200	200	30	30	40	40	4' @ 3:1	CS-3
Rural Local Road System (GS-4)	25	9	1	7	7	1	7	7	108	8	11	125	125	10	10	20	20	4' @ 3:1	CS-1
Urban Collector Road System (GS-7,with Shoulder Design)	50	12	3	8	11	3	8	11	955	4	8	475	400	160	120	110	90	6' @ 4:1	2:1 Max.
Urban Collector Road System (GS-7,with Curb and Gutter Design)	50	12	CG-6	-	-	CG-6	-	-	955	4	8	475	400	160	120	110	90	n/a	2:1 Max.
Urban Local Road (GS-8)	30	10	3	4	7	1	4	7	302	4	11	200	125	10	10	20	20	4' @ 3:1	CS-4B
Service Road (GS-9)	20	10	0	5	5	0	5	5	127	8	11	125	125	10	10	20	20	3' @ 3:1	2:1 Max.

* Max. Grade provided for Rolling Terrain(4 to 6 %)
Max. Grade for steeper Mountanous Terrain add 1% to Rolling Terrain values
Max. Grade for Level Terrain deduct 1% from Rolling Terrain values

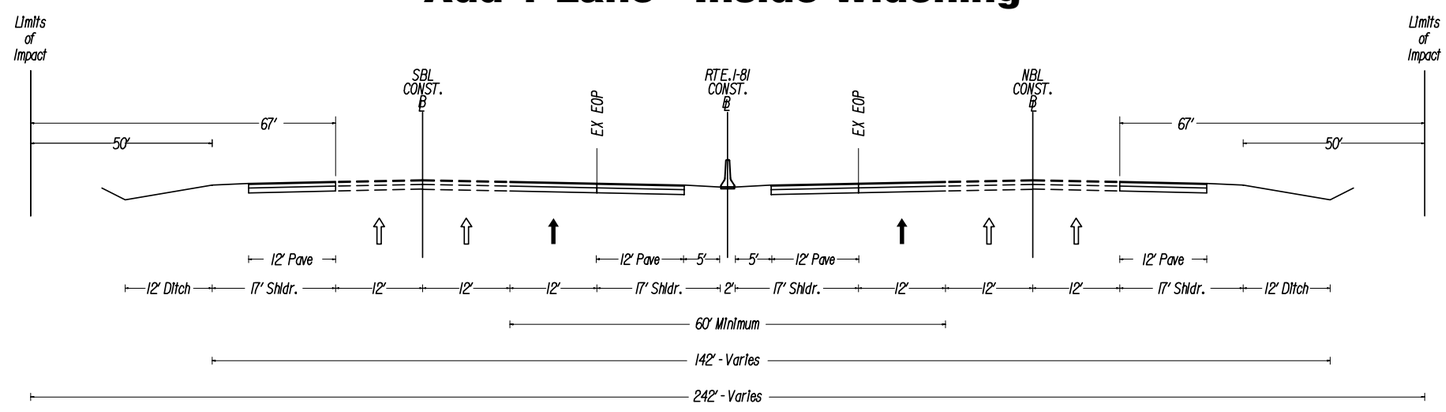
Typical Sections



Add 1 Lane - Outside Widening



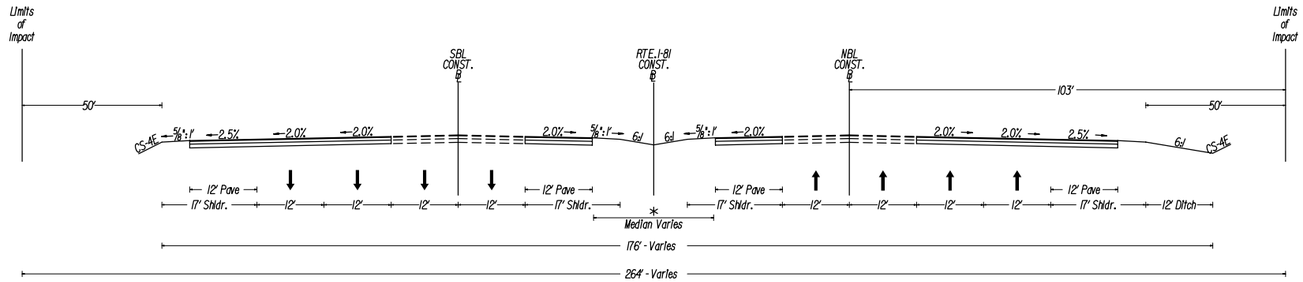
Add 1 Lane - Inside Widening



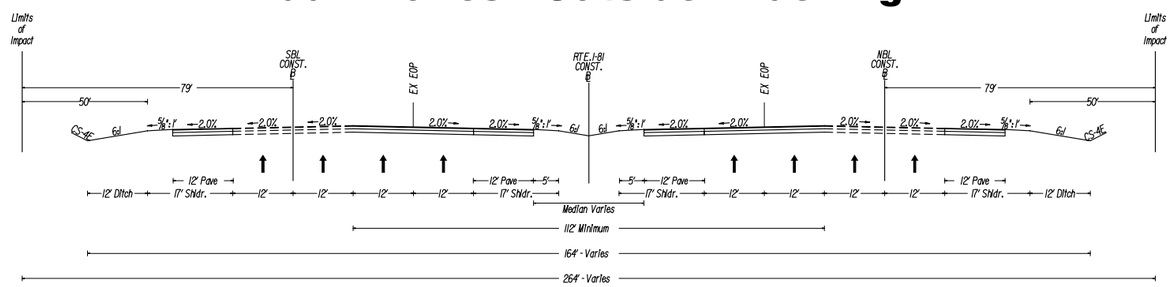
Add 1 Lane - With Barrier

Add 1 Lane Concept

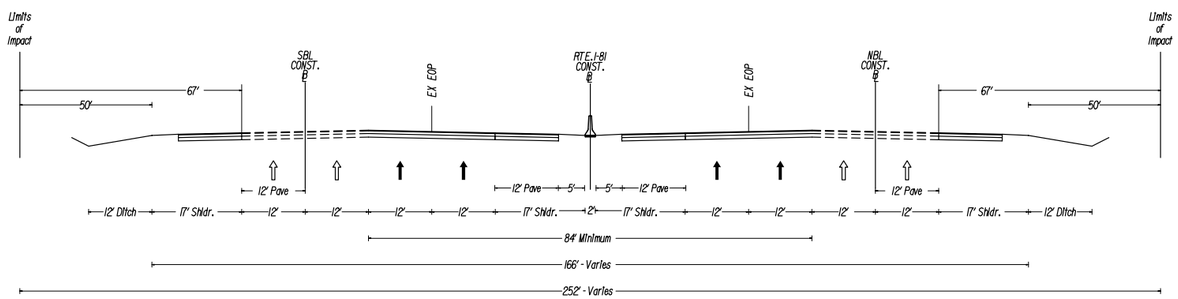
Typical Sections



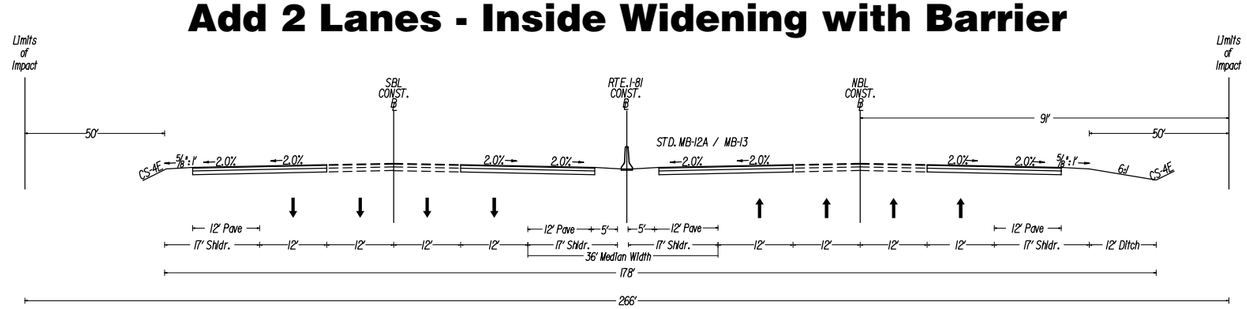
Add 2 Lanes - Outside Widening



Add 2 Lanes - Inside Widening



Add 2 Lanes - Inside Widening with Barrier

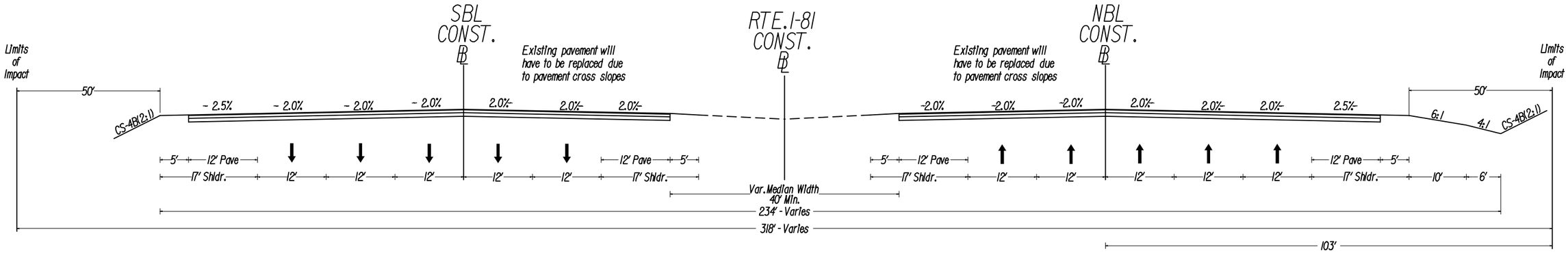


Add 2 Lanes - 1 Inside and 1 Outside

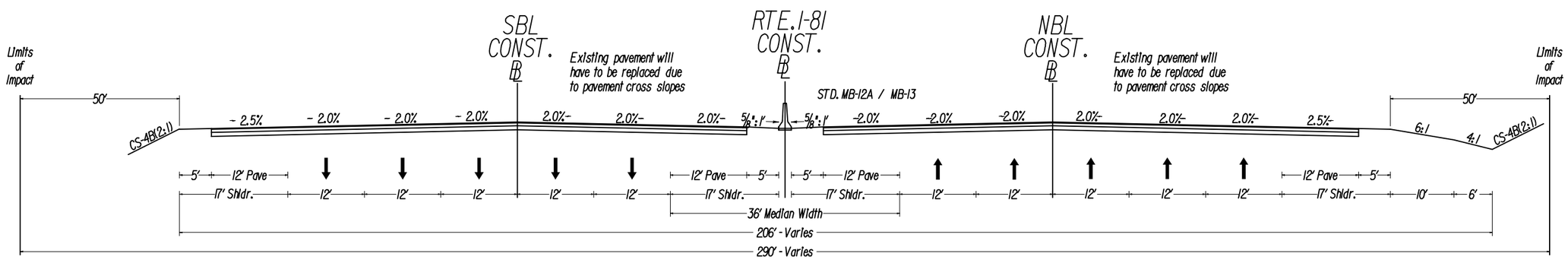
North

Add 2 Lanes Concept

Typical Sections



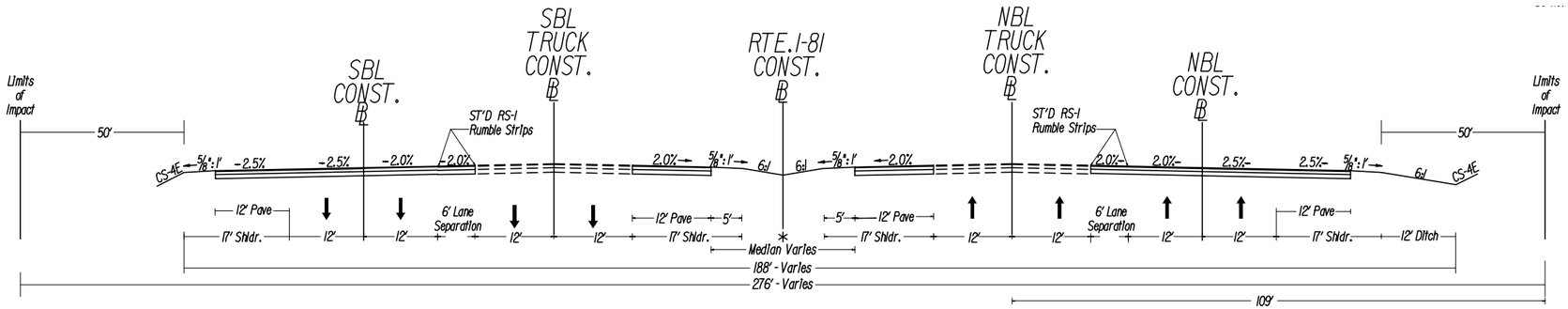
Add 3 Lanes - Outside Widening



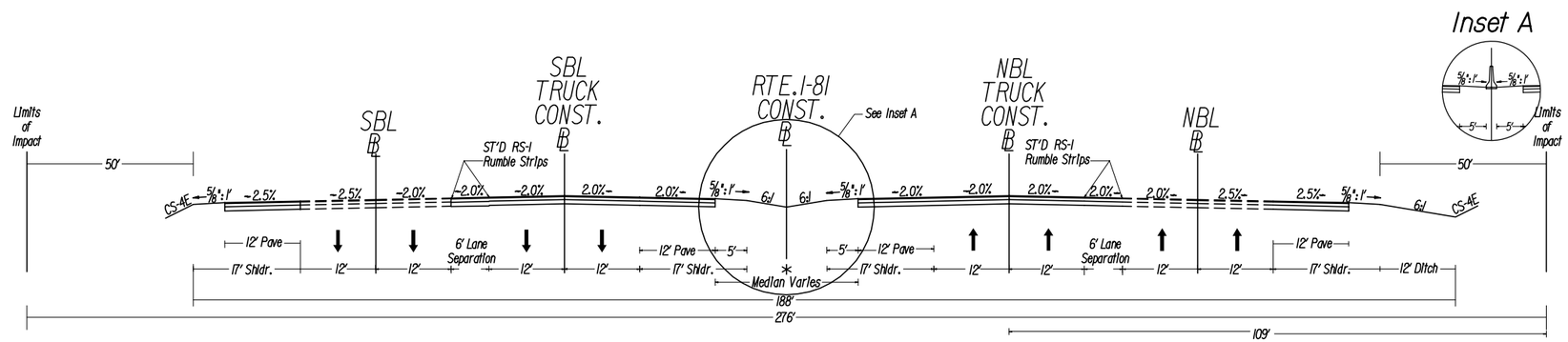
Add 3 Lanes - Inside and Outside Widening

Add 3 Lanes Concept

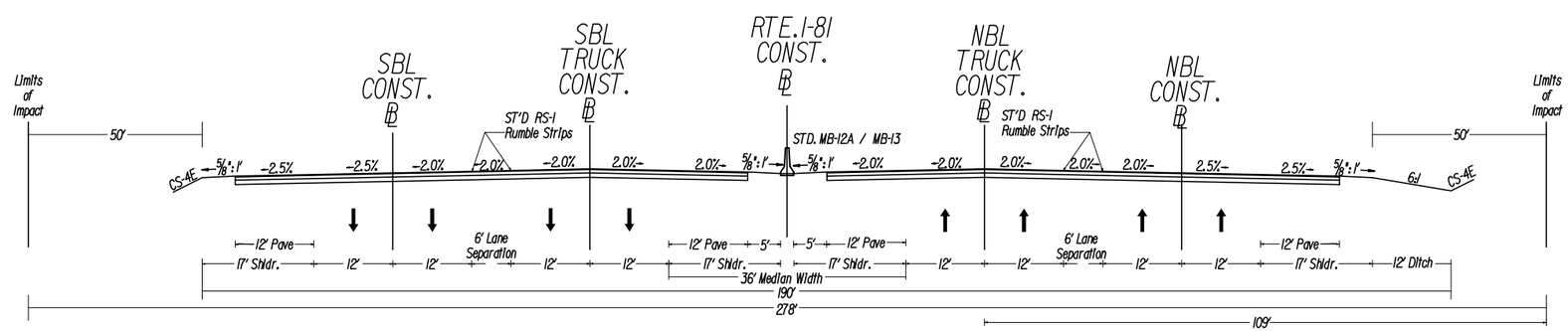
Typical Sections



Separated Lane Concept Outside Widening



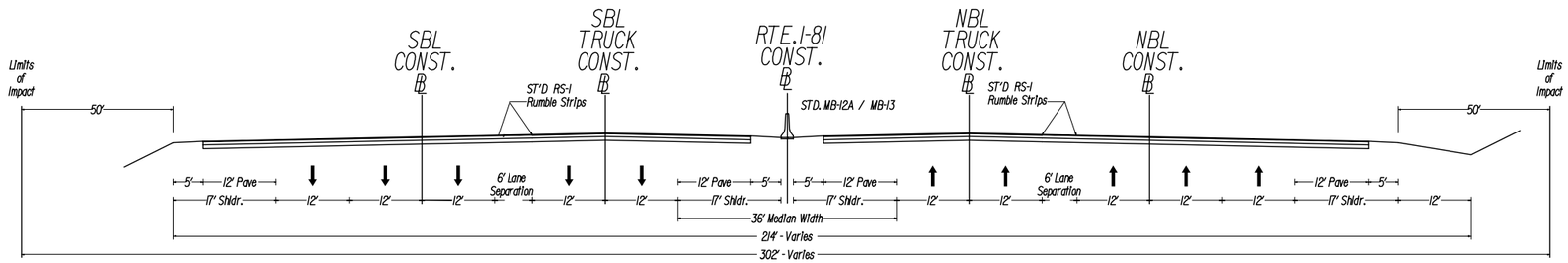
Separated Lane Concept Inside Widening



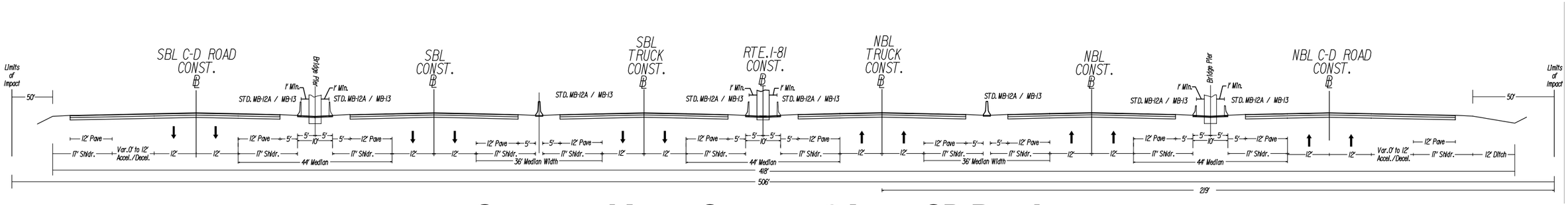
Separated Lane Concept Combination Widening

Truck Separated Lane Concept

Typical Sections



Separated Lane Concept Additional Lane



Separated Lane Concept 2 Lane CD Roads

Truck Separated Lane Concept

Typical Sections

Impact Templates