CR 28 INTERCHANGE STUDY
PRELIMINARY REPORT

Portsmouth Bypass, Phase 1
SCI-823-6.81
PID 19415

PREPARED FOR:
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1.0 Introduction

A second Value Engineering (VE) Session for the entire Portsmouth Bypass project was held by ODOT in December 2007. This review was based on Stage 1 plans for Phase 1 and pre-Stage 1 plans for Phases 2 and 3. One of the alternatives generated by this VE Session was Alternative 2/30: *Adjust the profile to reduce the volume of excavation and waste material by allowing high fill culverts.* In September 2008, ODOT authorized HDR to study Alternative 2/30 to determine if there was merit to revising the profile in Phase 1 of the project to reduce the project's construction costs.

In December 2008, HDR submitted the Value Engineering Studies Final Report which presented the findings of HDR's analysis. These findings indicated that there would be a significant savings in construction cost if the Stage 1 profile were revised. HDR also reported that additional savings may be achieved by shifting the ramps at the CR 28 interchange toward the north to further reduce the amount of excavation within this interchange. As a more detailed interchange investigation was required to determine the potential savings of this option, this analysis was not included as part of the December report.

In March 2009, ODOT authorized HDR to revise the Stage 1 profile for Phase 1 and study the impacts of modifying the CR 28 interchange with the intent of reducing as much excavation and waste as possible. The current interchange design at CR 28 is situated within a large hill, located several hundred feet to the south of CR 28, resulting in significant amounts of excavation for the ramps (upwards of 1 million cy). This area also contributes a significant amount of the waste material generated in Phase 1. By utilizing more of the valley area associated with CR 28 for the interchange, it is desired to significantly reduce the amount of excavation, and ultimately waste material, at this location.

This report presents the results of the CR 28 Interchange Study, which explored two base alternatives: (1) maintain the Stage 1 interchange configuration, but shift the interchange/ramps to the north, closer to CR 28 and (2) change to a diamond interchange, with ramps on both sides of CR 28. Two versions of the diamond interchange were developed. One with CR 28 relocated to the south so as to center the interchange between the hills located to the north and south of the CR 28 valley, and one with CR 28 remaining in its existing location. Each base alternative will be compared to the Proposed Stage 2 profile with the Stage 1 interchange/ramp configuration.

The study area for this analysis extended from SR 823 Station 503+00 to Station 565+50. This section was selected to incorporate a large enough area to fit all the alternatives. The study area extends into project Phase 2, which is at the Stage 1 design level (Stage 1 not yet approved). As currently proposed, the CR 28 interchange bridge and areas north will be constructed as part of Phase 2. All of the alternatives studied were designed based on the Proposed Stage 2 mainline profile submitted to ODOT on April 14, 2009.

The alignments and profiles developed for this study were established to a planning level to ensure that the alternatives were viable and consistent. If an alternative is selected to replace the Stage 1 design, the alignments and profiles for that alternative may need to be slightly adjusted as part of the Stage 2 design. Included with this report for reference are scroll plots of each of the alternatives investigated, including proposed ramp profiles.

During this study, HDR used the following parameters to develop the interchange alternatives:

- Design Speed of SR 823 is 70 mph
- Ramp Design Speeds vary, with higher speeds near the gore areas and lower speeds at the stop controlled intersections
- Design Speed of CR 28 is 55 mph

- Set reduction of excavation as the target
- Minimize the bridge impacts
- Minimize additional project footprint
- Use a maximum grade of 4.5% on SR 823 (maximum used in Stage 1 plans)
- The maximum upgrade on any ramp is 6%; max downgrade on any ramp is 6% preferred, 8% max.
- Superelevation rates meet L&D Volume 1, Figure 202-7
- Superelevation transition rates meet L&D Volume 1, Figure 202-4
- Exit ramps meet Figures L&D Volume 1, 503-3a, 503-3b, and 503-3c
- Entrance ramps meet L&D Volume 1, Figures 503-2a, 503-2b, and 503-2c
- Stopping Sight Distance meets L&D Volume 1, Figure 201-1
- Horizontal Sight Distance meets L&D Volume 1, Figure 201-2
- Crest vertical curves meet L&D Volume 1, Figure 203-3
- Sag vertical curves meet L&D Volume 1, Figure 203-6

A benefit/cost ratio was generated for each of the alternatives utilizing the unit costs from the Phase 1 Revised Stage 1 Cost Estimate dated July 2008. Each benefit/cost analysis compares the Stage 1 horizontal design with the revised mainline (Stage 2) profile to the alternative being studied. The following unit costs were used in this report:

Excavation	$ 3.35 per cubic yard
Embankment	$ 0.74 per cubic yard
Waste Material	$ 1.10 per cubic yard
Asphalt Pavement	$ 102 per cubic yard
Bridge Impacts	$ 130 per square foot
Wick Drains	Determined through geotechnical analysis

2.0 Alternative 1 – Shift CR 28 Interchange/Ramps North

2.1 Description

This alternative shifted the current interchange layout to the north as much as possible to reduce the large volume of cut generated by the proposed ramps, which sit within the large hillside near Station 523+00. The modified ramps were designed to meet the same design speeds as those in the Stage 1 plans.

2.2 Development

Each ramp was designed using the same degree of curvature (or lower) than those used in the Stage 1 plans. Some of the tangent sections in the Stage 1 ramp designs were reduced or eliminated; maximum use was made of back to back reverse spirals to eliminate short tangents between curves. Care was taken to ensure that all spirals were long enough to provide the proper rate of superelevation transition. All gore area geometry and acceleration/deceleration lengths were developed in accordance with the Location and Design Manual. For the shift, the initial controlling design factor was the northbound entrance ramp (Ramp B). The closer the ramp was located to CR 28, the steeper the profile grade became. Keeping this ramp under 6% controlled the overall location of the interchange.

Profiles were established by setting target points in the gore area to ensure proper drainage within the gore and were designed to meet the same or higher design speed as the horizontal alignment. The profiles also provided a smooth transition between the ramp and the CR 28 pavement.

Since the vast majority of the Phase 1 cross sections in cut had been modified by hand due to the geotechnical design, HDR developed a simplified template (criteria file) within Geopak that modeled the cut section to the end of the rock catchment area and then placed a constant backslope to the top of existing ground. The backslope was chosen after reviewing the hand-edited cross sections prepared in Stage 1 so that the quantity of earthwork measured with the backslope closely resembled the earthwork quantities from the Stage 1 slopes. The simple backslope criteria could be easily processed through Geopak for the redesigned interchange profiles.

In the areas where the ramps are located in cut, hand edited cross sections were used to provide a more accurate quantity since the ramps pass through the sides of the hill. Safety grading was used for the ramp interiors in both cut and fill conditions and exteriors when in a fill condition.

Bridge impacts were calculated on an additional square foot of deck basis since no additional spans were required. Impacts to the proposed wick drains were determined based on the height of the embankment fill, the thickness of the compressible layer, and the allowable time for consolidation to occur. The current wick drain spacing of 6 ft for the CR 28 ramps appears adequate for the proposed interchange configuration given that embankment heights are similar to those previously analyzed under the Stage 1 submittal. This spacing allows for completion of the embankments and for 90% of the consolidation to occur within the two-year earthwork placement phase of the construction schedule, with pavement placed during the next construction season.

2.3 Results and Benefit / Cost Analysis

Utilizing the established design criteria, the interchange was moved approximately 300 ft closer to CR 28. The intersection of the northbound ramps with CR 28 moved approximately 70 ft to the west from the Stage 1 location and the intersection angle was improved to 90 degrees. The southbound ramps intersected CR 28 very near to the location and angle of the Stage 1 design. The overall horizontal layout/configuration is essentially the same as the Stage 1 design.

The northbound ramps proved to be the critical profiles for the new configuration as the shift (in conjunction with the skew of SR 823 and CR 28) shortened the length of both ramps. The northbound exit ramp (Ramp A) maximum grade increased from -4.60% in the Stage 1 plans to -5.97%. The nearly 6% maximum exit grade flattens to 2.00% as it approaches the CR 28 intersection; more than sufficient deceleration length is available for vehicles to safely slow to the stop-controlled intersection with CR 28. The northbound entrance ramp (Ramp B) maximum grade increased from +5.10% in the Stage 1 plans to +5.87%. This entrance ramp enters the mainline near the bottom of a sag curve, resulting in a very flat entrance grade. This should negate most issues associated with the 5.87% upgrade along the ramp.

The southbound ramps provided a slightly flatter maximum grade than the Stage 1 plans with Ramps C and D using -4.12% and +4.27% respectively in place of the -5.00% and +5.00% used in Stage 1.

The shift of the interchange resulted in pulling a large portion of the ramps out of the hillside cut and significantly reducing the amount of excavation required (approximately 400,000 cy). Ramps B and C are now primarily at-grade or in fill. The following tables present the estimated differential savings and costs for Alternative 1 as compared to the Stage 1 plans modified with the Proposed Stage 2 profile. The items included represent the major cost influences. There are other minor items that will affect the exact cost difference (guardrail, stormsewer, etc.). However, these items can not be accurately estimated without conducting detailed design for the alternative; their impact on the evaluation is negligible.

Table 2-1: Alternative 1 Estimated Savings Differential**

Item	Proposed Stage 2	Shifted Interchange	Difference	Unit Cost	Savings
Excavation	3,904,149	3,471,273	433,000	$3.35	$1,451,000
Waste	4,106,837	3,596,020	511,000	$1.10	$562,000
Pavement (ramps)	13,120	11,560	1,560	$102	$159,000
			Total Excavation/Waste Savings		$2,172,000

Table 2-2: Alternative 1 Estimated Cost Differential**

Item	Proposed Stage 2	Shifted Interchange	Difference	Unit Cost	Cost
Embankment	382,934	395,944	13,000	$0.74	$10,000
Bridge Impacts	32,200	34,200	2,000	$130	$260,000
Wick Drains					$50,000
Engineering					$150,000
				Total Cost	$470,000

**Quantities for the differential are for the study area of SR 823 Station 503+00 to Station 565+50 only.

As illustrated in the tables above, the benefit/cost ratio for Alternative 1 is 4.6. The total savings realized by implementing Alternative 1 would be approximately $1.7 million. In conjunction with the proposed Stage 2 profile, total project savings over the Stage 1 design are estimated at $4.8 million.

2.4 Additional Information

With any design, there are additional elements to consider that can not be quantified in a benefit/cost analysis. With Alternative 1, the project footprint has been reduced; however, ODOT already owns most of the property impacted by this change. With the exception of an increase in the maximum profile grade on Ramps A and B to just under 6%, the design and layout essentially matches or improves upon the Stage 1 design with a significant reduction in ramp excavation and project waste.

Shown in Table 2-3 is a breakdown of the cut and fill volumes along the project for each of the three distinct sections for Stage 1, Proposed Stage 2, and Proposed Stage 2 with Interchange Alternative 1. The table shows all earthwork volumes for the project, including side roads. This provides a snapshot of the amount of material in each section and how much would need to move between sections. As indicated in the table, the section from SR139 to CR28 features the greatest amount of waste for the project. Raising the mainline and modifying the interchange results in an approximately 1.2 million cy reduction in the amount of waste in this section as compared to the Stage 1 design.

Table 2-3: Phase 1 Earthwork By Project Section (includes side roads)

	Stage1		
	*Cut	Fill	Delta
Start to Swauger Valley	2,591,950	1,601,750	990,200
Swauger Valley to SR139	510,600	1,012,000	-501,400
SR139 to CR28	3,587,300	689,500	2,897,800
Total	6,689,850	3,303,250	3,386,600

	Proposed Stage 2		
	*Cut	Fill	Delta
Start to Swauger Valley	2,192,000	2,126,500	65,500
Swauger Valley to SR139	377,200	1,157,000	-779,800
SR139 to CR28	3,019,900	789,550	2,230,350
Total	5,589,100	4,073,050	1,516,050

	Stage 2 w/Interchange Alternative 1**		
	*Cut	Fill	Delta
Start to Swauger Valley	2,192,000	2,126,500	65,500
Swauger Valley to SR139	377,200	1,157,000	-779,800
SR139 to CR28**	2,512,400	802,200	1,710,200
Total	5,081,600	4,085,700	995,900

*Cut with 15% swell factor applied (payment is based on raw excavation)

**Volumes are for Phase 1 only and do not include the additional interchange earthwork in Phase 2

3.0 Alternative 2A – Diamond With Relocated CR 28

3.1 Description

This alternative involved realigning CR 28 approximately 250 ft to the south so as to essentially center a diamond interchange between the hilltops located near SR 823 Station 523+00 and Station 548+00, maximizing the use of the CR 28 valley area. To minimize the project footprint and ramp excavation through any adjacent cuts, the ramp intersections with CR 28 were located as "tight" to the mainline as possible. The interchange was designed to meet current ODOT criteria.

3.2 Development

The minimum spacing between ramp intersections along CR 28 was controlled by left-turn lane deceleration and storage lengths. The controlling left-turn movement is from westbound CR 28 to southbound SR 823 with 110 vehicles per hour making the turn. Since there will only be 60 vehicles per hour opposing traffic in the design year and the intersection is not proposed to be signalized, a left-turn lane is not warranted according to the Location and Design Manual. CR 28 is a 55 mph roadway and for safety reasons, along with consistency with the overall Portsmouth Bypass design, the interchange was analyzed with minimal length left-turn lanes. Figure 401-9 states that the turn lane length shall meet either condition B or C, whichever is longest. With only 2 vehicles per 60 second cycle (Figure 401-10, no signal) storage length, condition B controls and the turning lane used was 285 ft long. The other left-turn lane will feature less traffic, so a similar length was used. This set the minimum centerline to centerline intersection spacing at 570 ft (285 ft+285 ft). The ultimate geometrics of the ramps resulted in the ramp intersections being 580 ft apart, which exceeded the minimum criteria.

The major design element for relocating CR 28 to the south was to meet the 55 mph design speed while holding as close as possible to the Stage 1 limits of work on CR 28. Each ramp was designed using current ODOT design criteria with the intention to stay as close as possible to the mainline without requiring a retaining wall, a "tight" interchange configuration. This would result in the least amount of excavation through the adjacent steep terrain. CR 28 was relocated by using a series of three reverse curves separated by back to back spirals. The section of CR 28 passing under SR 823 is a 1527 ft long 1 degree 45 minute curve. A tangent could not be used under SR 823 without extending the project limits along CR 28 significantly further east and west, as well as resulting in an undesirable broken back curve situation.

The proposed curvature on relocated CR 28 aided in the design of some ramps and hurt others. Ramps B and C connect to the inside of the curve, which naturally directed the alignments in towards the mainline. Likewise, Ramps A and D are connected to the outside of the curve and are directed away from the mainline. The skew angle of the crossing of SR 823 and CR 28 resulted in Ramp D swinging out wider than Ramp A. Ramp C presented a design challenge since CR 28 led the ramp in toward the mainline while the mainline curves toward Ramp C in the area of proposed intersection. The result would be a short ramp if trying to keep the ramp tight to mainline or a very wide longer ramp that would result in significantly more excavation as well as extend the work limits on CR 28. Throughout, care was taken to ensure that all spirals were long enough to provide the proper rate of superelevation. All gore area geometry and acceleration/deceleration lengths were developed in accordance with the Location and Design Manual.

Profiles were carefully established to ensure proper drainage within the gore areas. The profiles were designed to meet the same or higher design speed as the horizontal alignment. Just as the CR28 horizontal curvature aided some ramps and hurt others, so did the proposed superelevation rate (0.04) on CR 28. The profiles for Ramps A and D benefited from being on the superelevation high side, while Ramps B and C were challenged by the cross slope on the low side. This is particularly the case with Ramp C, which because of the relatively short ramp length to maintain the "tight" design results in a relatively steep grade as it chases to catch the +4.0% mainline grade. The realignment of CR 28 allowed its vertical profile to be raised upwards of 13 ft at the intersections, which helped in the vertical design of all ramps. All profiles were set based on the SR 823 Proposed Stage 2 profile.

Since the vast majority of the Phase 1 cross sections in cut had been modified by hand due to the geotechnical design, HDR developed a simplified template (criteria file) within Geopak that modeled the cut section to the end of the rock catchment area and then placed a constant backslope to the top of existing ground. The backslope was chosen after reviewing the hand-edited cross sections prepared in Stage 1 so that the quantity of earthwork with the backslope closely resembled the earthwork quantities/design from the Stage 1 slopes. The simple backslope criteria could be easily processed through Geopak for the redesigned interchange profiles.

In the areas where the ramps are in cut south of CR 28, hand edited cross sections were used to provide a more accurate quantity for comparison with the existing design. Safety grading was used for the ramp interiors in both cut and fill conditions and exteriors when in a fill condition.

Bridge impacts were calculated on a square foot of deck basis for a new bridge since this alternative would require a different bridge location and length than used in the Stage 1 plans. Additional wick drain impacts were determined based on the height of the embankment fill, the thickness of the compressible layer, and the allowable time for consolidation to occur. The currently proposed wick drain spacing of 6 ft for the CR 28 ramps (and 7 ft for the mainline) does not appear adequate for the proposed interchange configuration given the modified embankment sections as well as the additional embankment fill required for the relocated CR 28. To keep with a two-year earthwork schedule, spacing will need to be a consistent 6 ft throughout the interchange. This spacing allows for completion of the embankments and for 90% of the consolidation to occur to allow for the pavement to be placed during the next construction season. It is noted that the largest impact to the cost of the wick drains is not so much the closer spacing, but the large additional area of embankment required for this alternative

3.3 Results and Benefit / Cost Analysis

The Relocated CR 28 alignment consists of two back to back reverse curves. All of the curves and spirals meet a 55 mph design speed. Normally, this would not be the most desired alignment. However the middle curve is 1547 ft long with a flat degree of curve. The length of this curve spreads the reverse curves so that a driver should have no discomfort traversing this alignment. The new alignment does not alter the overall geometric nature of existing CR 28 in the vicinity of the project area.

The ramps north of CR 28 proved to be the critical profiles for the diamond configuration. The southbound exit ramp (Ramp C) maximum grade increased from -5.00% in the Stage 1 design to -7.83%. The northbound entrance ramp (Ramp B) maximum grade increased from +5.10% at Stage 1 to +6.00%. While not desirable, the nearly 8% downgrade for Ramp C meets design criteria for an exit ramp. However, of special note for truck traffic, the 8% downgrade to the stop-controlled intersection with CR 28 is preceded by a 4.00% mainline downgrade, although it is near the beginning of the full 4.00% grade following a crest curve. Conversely, the 6.00% entrance grade ties into the beginning of the mainline crest curve for the +4.00% grade, which ultimately becomes a 2.60% downgrade. For Ramp C, the ramp length beyond the gore is 1000 ft, which exceeds the deceleration length required to go from 70 mph to a stop condition (861 ft, see L&D v1 Figure 503-3a and 3b). If a vehicle begins deceleration at the diverging taper, the vehicle should also be traveling slower than 70 mph at the gore.

Ramp grades are less of an issue on the south side of the interchange as the northbound exit ramp (Ramp A) increased in grade from -4.60% provided in Stage 1 to a – 5.37%. And the southbound entrance ramp (Ramp D) provided a flatter grade than the +5.00% used in Stage 1, with a +4.16% maximum grade.

A significant feature with this alternative is the reduction in the interchange bridge length and width compared with the current proposed design. Ramp acceleration and deceleration lanes have been removed from structure, reducing each of the dual bridges by one lane width. In addition, the raising of CR 28 allows for a reduced overall span length as the needed spill slopes would be shorter.

Relocating CR 28 and placing the diamond interchange essentially midway between the adjacent hills significantly reduces the excavation required and also reduces the waste volume by using more fill material. The following tables present the estimated differential savings and costs for Alternative 2A as compared to the Stage 1 plans modified with the Proposed Stage 2 profile. The items included represent the major cost influences. There are other minor items that will affect the exact cost difference (guardrail, stormsewer, etc.). However, these items can not be accurately estimated without conducting detailed design for the alternative; their impact on the evaluation is negligible.

Table 3-1: Alternative 2A Estimated Savings Differential**

Item	Proposed Stage 2	Diamond Interchange	Difference	Unit Cost	Savings
Excavation	3,904,149	3,306,218	598,000	$3.35	$2,003,000
Waste	4,106,837	3,210,495	896,000	$1.10	$986,000
Pavement (ramps)	13,120	10,160	2,960	$102	$302,000
Bridge Impacts	32,200	21,250	10,950	$130	$1,424,000
			Total Excavation/Waste Savings		$4,715,000

Table 3-2: Alternative 2A Estimated Cost Differential**

Item	Proposed Stage 2	Diamond Interchange	Difference	Unit Cost	Cost
Embankment	382,934	591,656	209,000	$0.74	$155,000
Wick Drains					$1,000,000
Engineering					$250,000
				Total Cost	$1,405,000

**Quantities for the differential are for the study area of SR 823 Station 503+00 to Station 565+50 only.

As illustrated in the tables above, the benefit/cost ratio for Alternative 2A is 3.4. The total savings realized by implementing Alternative 2A would be approximately $ 3.3 million. In conjunction with the proposed Stage 2 profile, total project savings over the Stage 1 design are estimated at $6.4 million. A portion of this savings is associated with Phase 2.

3.4 Additional Information

With any design, there are additional elements to consider that can not be quantified in a benefit/cost analysis. With Alternative 2A, while the overall project footprint has been reduced, additional impacts on the north side of CR 28 are present, including a potential residential relocation due to Ramp C. In addition, there may be additional environmental impacts not yet identified. While these issues may ultimately be minor, they do add a level of unknown risk with this alternative.

An improvement with maintenance of traffic along CR 28 over the Stage 1 design is present with this alternative, as most of the CR 28 work can be constructed without impacting existing traffic. In addition, the predominant traffic turning movement along CR 28 (from CR 28 Westbound to SR 823 Northbound) would become a right-turn movement (1,500 vehicles per day in the design year) with this alternative.

Shown in Table 3-3 is a breakdown of the cut and fill volumes along the project for each of the three distinct sections for Stage 1, Proposed Stage 2, and Proposed Stage 2 with Interchange Alternative 2A. The table shows all earthwork volumes for the project, including side roads. This provides a snapshot of the amount of material in each section and how much would need to move between sections. As indicated in the table, the section from SR139 to CR28 features the greatest amount of waste for Phase 1. Because a significant portion of the interchange earthwork has been moved from Phase 1 into construction Phase 2, there is a significant reduction in project waste for Phase 1. Raising the mainline and modifying the interchange results in an approximately 1.6 million cy reduction in the amount of waste in this section as compared to the Stage 1 design. The impact to haul lengths, earthwork unit costs, and additional waste for Phase 2 were not evaluated as part of this study. Based on a January 2008 cost estimate, Phase 2 currently has over 12 million cy of waste; the diamond interchange ramps north of CR 28 would add to this amount.

Table 3-3: Phase 1 Earthwork By Project Section (includes side roads)

	Stage1		
	*Cut	Fill	Delta
Start to Swauger Valley	2,591,950	1,601,750	990,200
Swauger Valley to SR139	510,600	1,012,000	-501,400
SR139 to CR28	3,587,300	689,500	2,897,800
Total	6,689,850	3,303,250	3,386,600

	Proposed Stage 2		
	*Cut	Fill	Delta
Start to Swauger Valley	2,192,000	2,126,500	65,500
Swauger Valley to SR139	377,200	1,157,000	-779,800
SR139 to CR28	3,019,900	789,550	2,230,350
Total	5,589,100	4,073,050	1,516,050

	Stage 2 w/Interchange Alternative 2A**		
	*Cut	Fill	Delta
Start to Swauger Valley	2,192,000	2,126,500	65,500
Swauger Valley to SR139	377,200	1,157,000	-779,800
SR139 to CR28**	2,091,700	792,800	1,298,900
Total	4,660,900	4,076,300	584,600

*Cut with 15% swell factor applied (payment is based on raw excavation)

**Volumes are for Phase 1 only and do not include the additional interchange earthwork in Phase 2

4.0 Alternative 2B – Diamond With Existing CR 28

4.1 Description

This alternative involved redesigning the ramps for the CR 28 interchange into a diamond configuration without realigning CR 28. To minimize the footprint and ramp excavation through any cuts, the ramp intersections with CR 28 were located as "tight" to the mainline as possible. The interchange was designed to meet current ODOT criteria.

4.2 Development

As described with Alternative 2A, minimum ramp intersection spacing along CR 28 was based on the left-turn lane lengths. Ultimately, the geometric layout of the ramps resulted in a slightly larger spacing than required (580 ft vs. 570 ft).

Horizontally all of the ramps fit smoothly between SR 823 and CR 28. Care was taken to ensure that all spirals were long enough to provide the proper rate of superelevation. All gore area geometry and acceleration/deceleration lengths were developed in accordance with the Location and Design Manual.

Profiles were carefully established to ensure proper drainage within the gore areas. The profiles were designed to meet the same or higher design speed as the horizontal alignment.

Because existing CR 28 sits over 40 ft below proposed SR 823 mainline at its closest point, each of the ramps had to traverse a significant vertical climb to tie into the mainline. For ramps on the western half of the interchange, the climb is even greater as CR 28 is on a downgrade from east to west. This resulted in long ramps and steeper grades for all ramps, as compared to Alternative 2A. For the northern ramps, chasing the 4.00% mainline grade resulted in both ramps extending into the next mainline horizontal curve and nearly reaching the crest of the mainline's vertical curve at the top of the grade. The southbound exit ramp (Ramp C) has a proposed -8.00% grade and the other three ramps were at or just below a 6.00% grade.

4.3 Results

After examining the layout of this alternative as compared with Alternative 2A, it became apparent that Alternative 2A would provide significantly more reduction in excavation and waste between the two, which was the goal of this study. Alternative 2B would feature considerable excavation volumes both north and south of CR 28, and featured less desirable vertical geometry. As a result, Alternative 2B was dismissed from further consideration with Alternative 2A providing the better solution for a diamond style interchange in this study. No earthwork or cost items were further developed for Alternative 2B.

5.0 CR 28 Interchange Study Summary

This report presents the results of an engineering study examining the potential modification of the proposed CR 28 Interchange design so as to reduce project excavation and waste. The general area of the interchange contributes the greatest amount of waste material generated in Phase 1. By utilizing more of the valley area associated with CR 28 for the interchange, it is desired to significantly reduce the amount of excavation at this location. Two base alternatives were examined: (1) maintain the Stage 1 interchange configuration, but shift the interchange/ramps to the north, closer to CR 28 and (2) change to a diamond interchange, with ramps on both sides of CR 28. The diamond interchange with CR 28 relocated to the south (Alternative 2A) so as to center the interchange between the hill tops located to the north and south of the CR 28 valley was used for the final analysis.

It is noted that while the analyses presented herein were thorough, they do not represent final design cost analyses. When reviewing the savings and costs presented in this report, the magnitude of the numbers are what is important. The exact numbers may change if any of these alternatives are incorporated into the final design of the project, based on a more detailed design. In general, a conservative approach was undertaken so as to not over estimate any potential cost savings.

Table 5-1 is a summary of each alternative with their benefit/cost ratio and the estimated savings. The approximately $1.6 million in savings difference between the two alternatives can be primarily attributed to the interchange bridge cost, which is significantly reduced by Alternative 2A. Table 5-2 summarizes the major advantages and disadvantages of each interchange option.

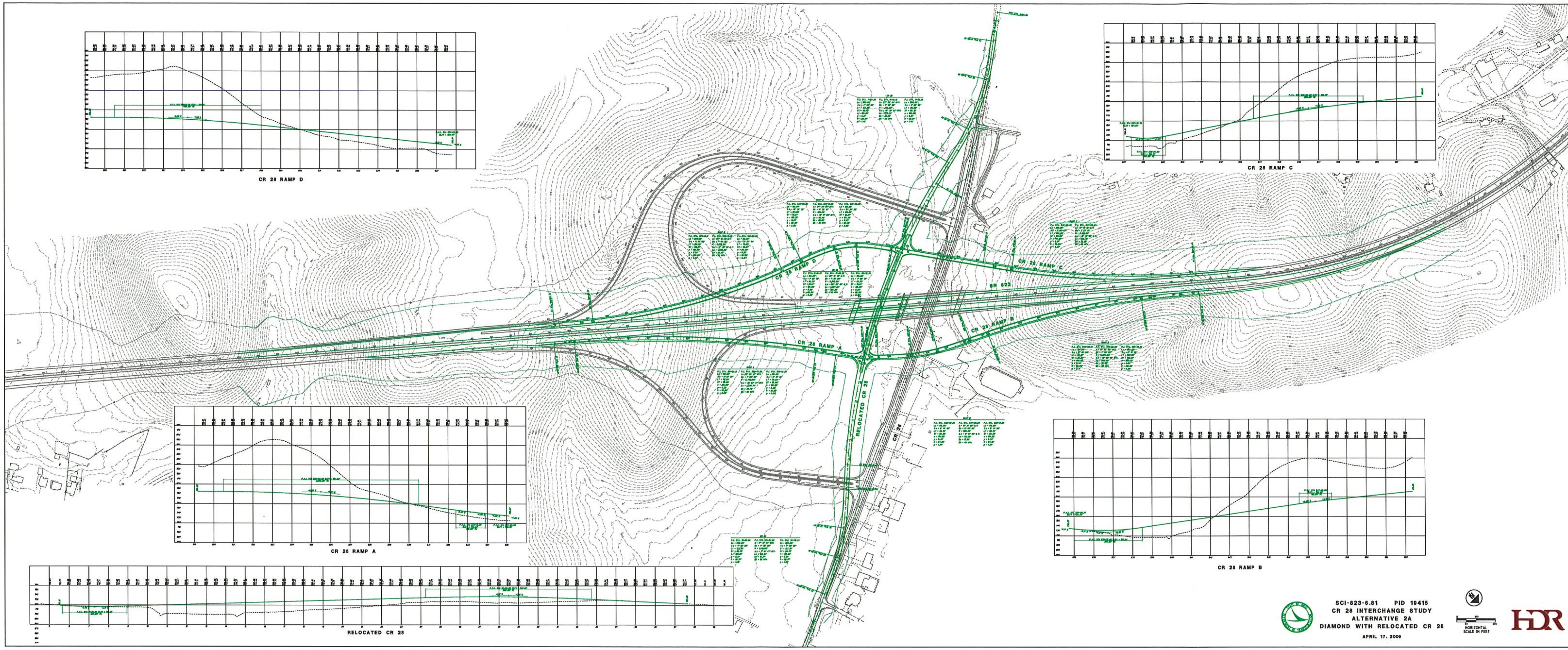
Table 5-1: Value Engineering Study Results

Alternative	Description	Benefit/Cost	Estimated Total Savings
1	Shift interchange toward CR 28	4.6	$1,700,000
2A	Diamond interchange	3.4	$3,300,000

Table 5-2: Major Advantages/Disadvantages Summary

Interchange Option	Advantages	Disadvantages
Stage 1 Design	• Approved Stage 1 geometry • Maximum ramp grade is 5.2% • Environmental cleared	• Highest earthwork cost and waste • Highest total cost • Largest project footprint
Alternative 1 – Shifted Interchange	• Saves $1.7M compared to Stage 1 • Stays within existing project footprint • Two ramps with reduced grades • Reduces waste compared to Stage 1*	• Two 6% ramp grades
Alternative 2A – Diamond Interchange	• Lowest cost and waste for Phase 1 • Smallest project footprint • Improved CR 28 MOT • Highest CR 28 to SR 823 traffic movement now a right turn	• Exit ramp grade approaches 8%; +6% entrance ramp ties into +4% mainline • Additional right-of-way impacts • Significant fill settlement required* • Additional waste added to Phase 2*

*cost included in analysis


CR 28 RAMP D
CR 28 RAMP C
CR 28 RAMP D
CR 28 RAMP C
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CR 28 RAMP A
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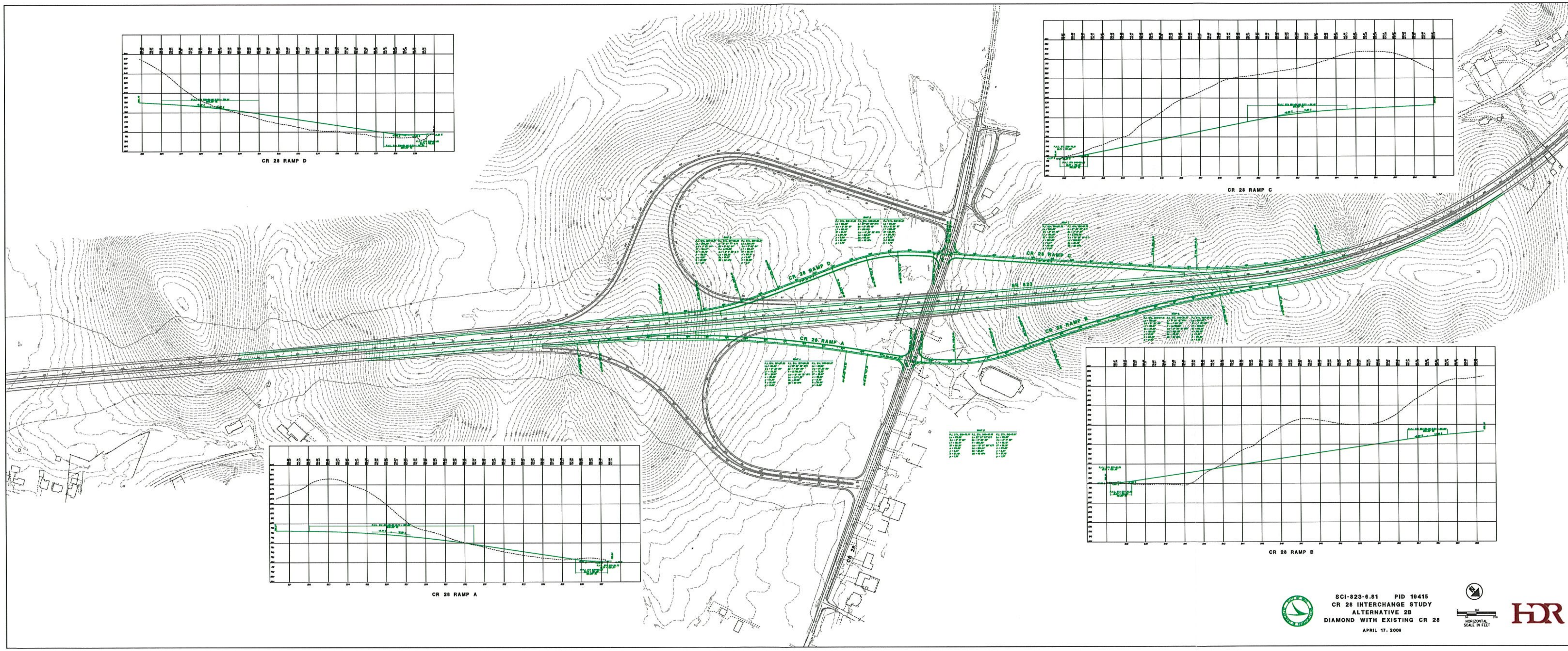
HORIZONTAL
SCALE IN FEET
HDR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SCI-823-6.81 PID 19415
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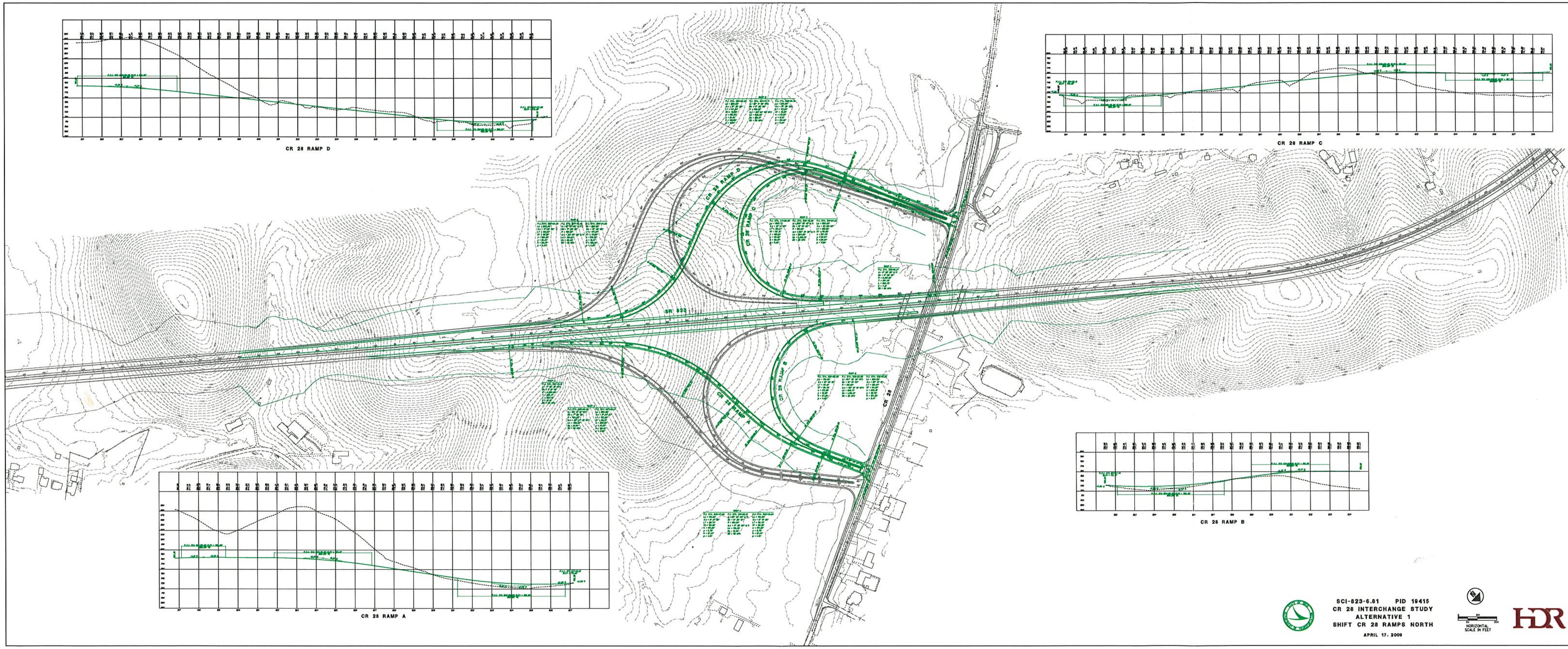
APRIL 17, 2009
HORIZONTAL
SCALE IN FEET
HDR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ALTERNATIVE 1
SHIFT CR 28 RAMPS NORTH
APRIL 17, 2009
HORIZONTAL
SCALE IN FEET
HDR