

# *INTERCHANGE JUSTIFICATION STUDY*

*INTERSTATE 65 AT  
STATE ROUTE 109*

*ROBERTSON COUNTY*



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FOR THE  
TENNESSEE DEPARTMENT OF  
TRANSPORTATION  
PLANNING DIVISION

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# CHAPTER 1

## INTRODUCTION

### **A. Purpose of the Study**

The purpose of this interchange justification study is to determine the need and justification of providing a new interchange on I-65 just south of Lake Springs Road in Robertson County. The interchange will provide direct access to expanding industrial parks located on both sides of Interstate 65. The interchange would also provide the opportunity for a direct interstate connection for SR 109 in future phases. The proposed interchange is essential for efficient traffic flow in the surrounding area due to the adjacent interchanges and road network already operating near capacity. The study will determine the current and future needed improvements, analyze traffic conditions, develop functional layouts for the project, calculate construction costs for the alternates, and identify potential environmental, historical, and cultural concerns.

### **B. Description of Project Location**

The proposed project is located in a rural area of Robertson County just south of the current crossing of Lake Springs Road over I-65. The adjacent interchange to the south is SR-52 in Robertson County at a distance of 3.3 miles. The adjacent interchange to the north is located where US 31W crosses I-65 north of the Tennessee/Kentucky State Line at a distance of approximately 2.5 miles. The closest urban development, Portland, is located 5 miles east of the proposed project in Sumner County.

I-65 currently consists of a rural four-lane, controlled-access facility with a grass median and approximately 280 to 300 feet of right of way. SR-109 is a non-access controlled rural two-lane road with a pavement width of 24 feet and approximately 50 to 70 feet of right of way. SR-41 (US 31W) is a non-access controlled rural two-lane road with a pavement width of 24 feet and approximately 80 to 100 feet of right of way. Lake Springs Road is currently a non-access controlled rural two-lane road with a pavement width of 18 feet and approximately 50 to 60 feet of right of way.

### **C. Background**

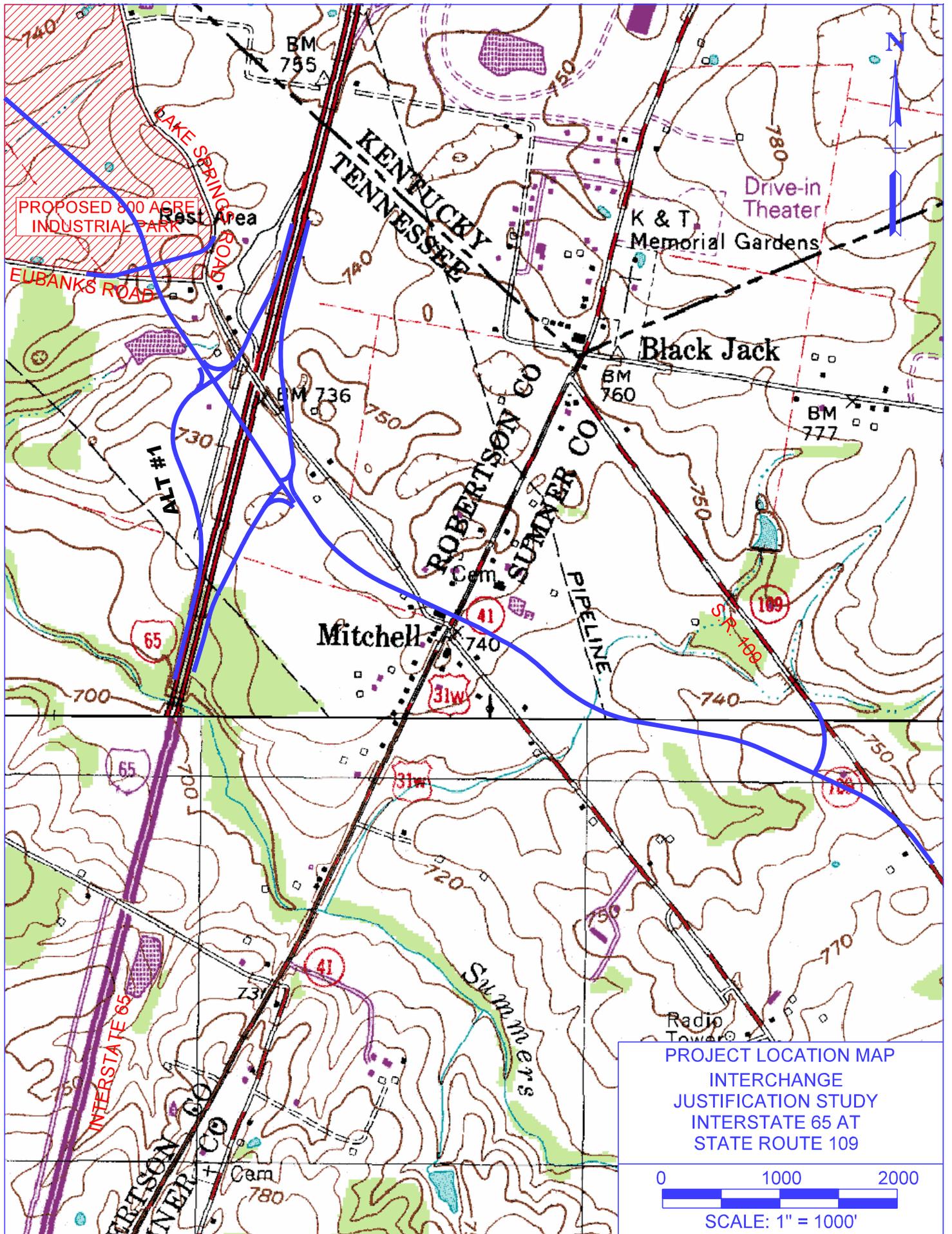
The provision of an interchange at this location would provide direct access between I-65 and a proposed 920-acre industrial park expansion located west of I-65 in an area bounded by Eubanks Road to the south, Payne Road to the west, Lake Springs Road to the east, and the Tennessee/Kentucky state line to the north. The interchange will provide I-65 access to the proposed western industrial park and an existing industrial park located to the east of I-65 off Fred White Drive. In addition, the proposed interchange will provide the opportunity to directly link with SR-109 as a future project.

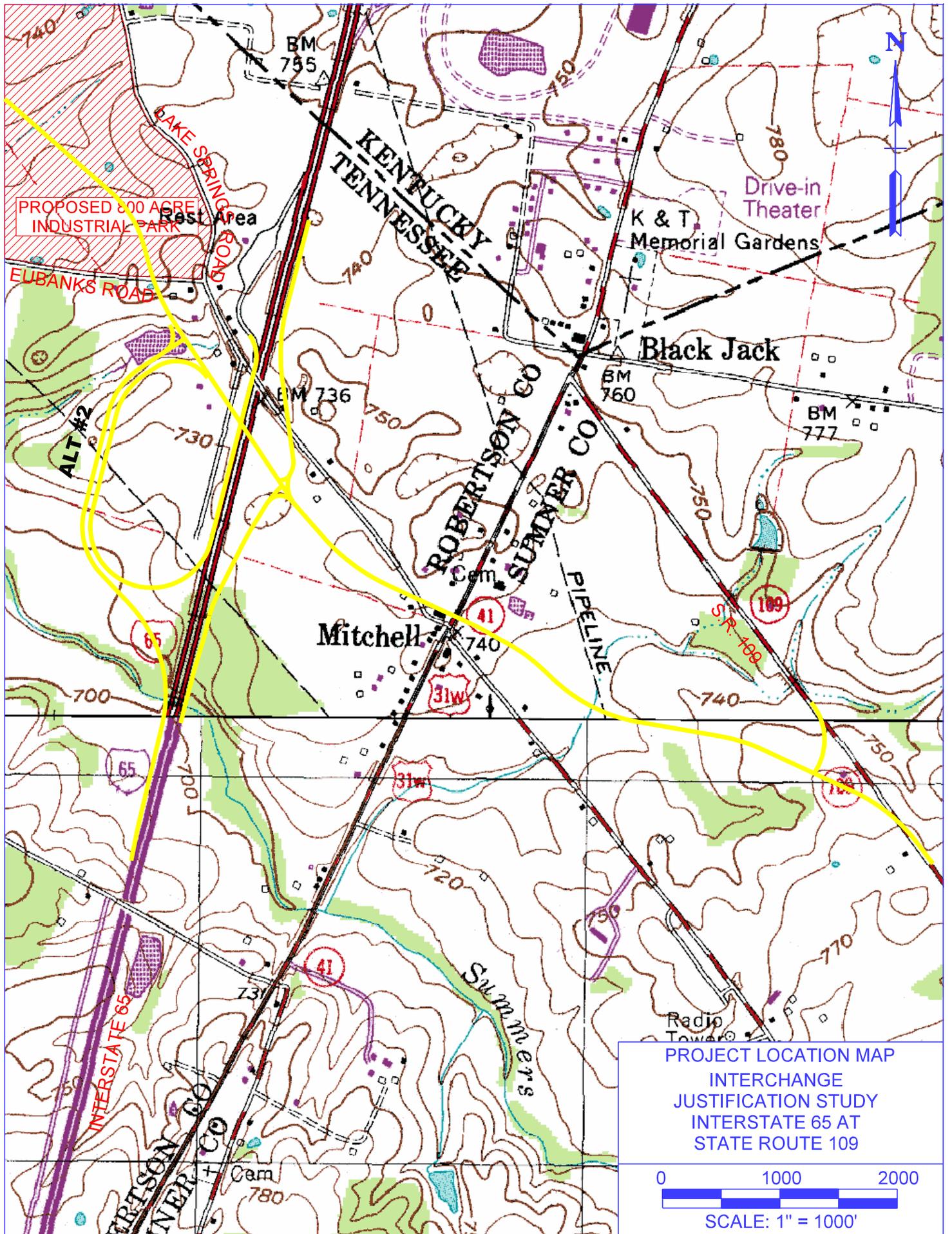
**D. Relationship To Previous Planning Studies**

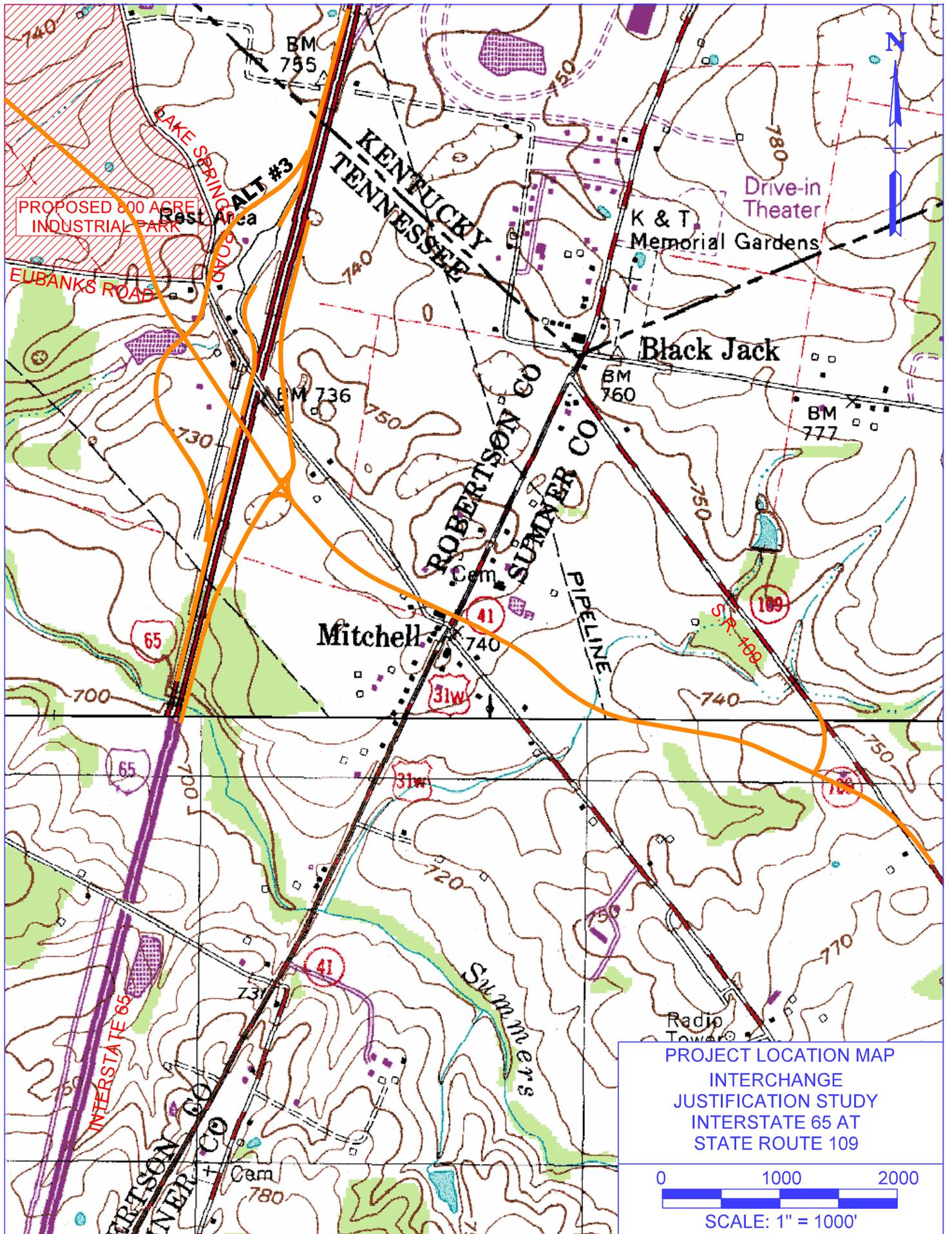
A telephone conversation with Robert Hoge of the Robertson County Planning Commission revealed that most of the area surrounding the proposed interchange is rural land and will likely become residential land in the future, with the exception of the industrial development mentioned above. Aside from that, Robertson County has no more specific land use plans involving the property surrounding the proposed interchange.

A previously initiated and subsequently discontinued Interchange Justification Study proposed locating an interchange where Highland Road currently crosses over I-65, approximately 0.85 miles to the south of this location. However, providing an interchange where Lake Springs Road currently crosses over I-65 provides more direct access to the industrial parks and also provides a direct link to SR-109. Another study (*Welcome Center Relocation Study, November 2005*) identified possible relocation sites for a new Welcome Center if the selected interchange requires the Welcome Center to be relocated. The study identified four possible sites along Southbound I-65 which range from the Kentucky-Tennessee State Line to approximately 16 miles south of the state line.





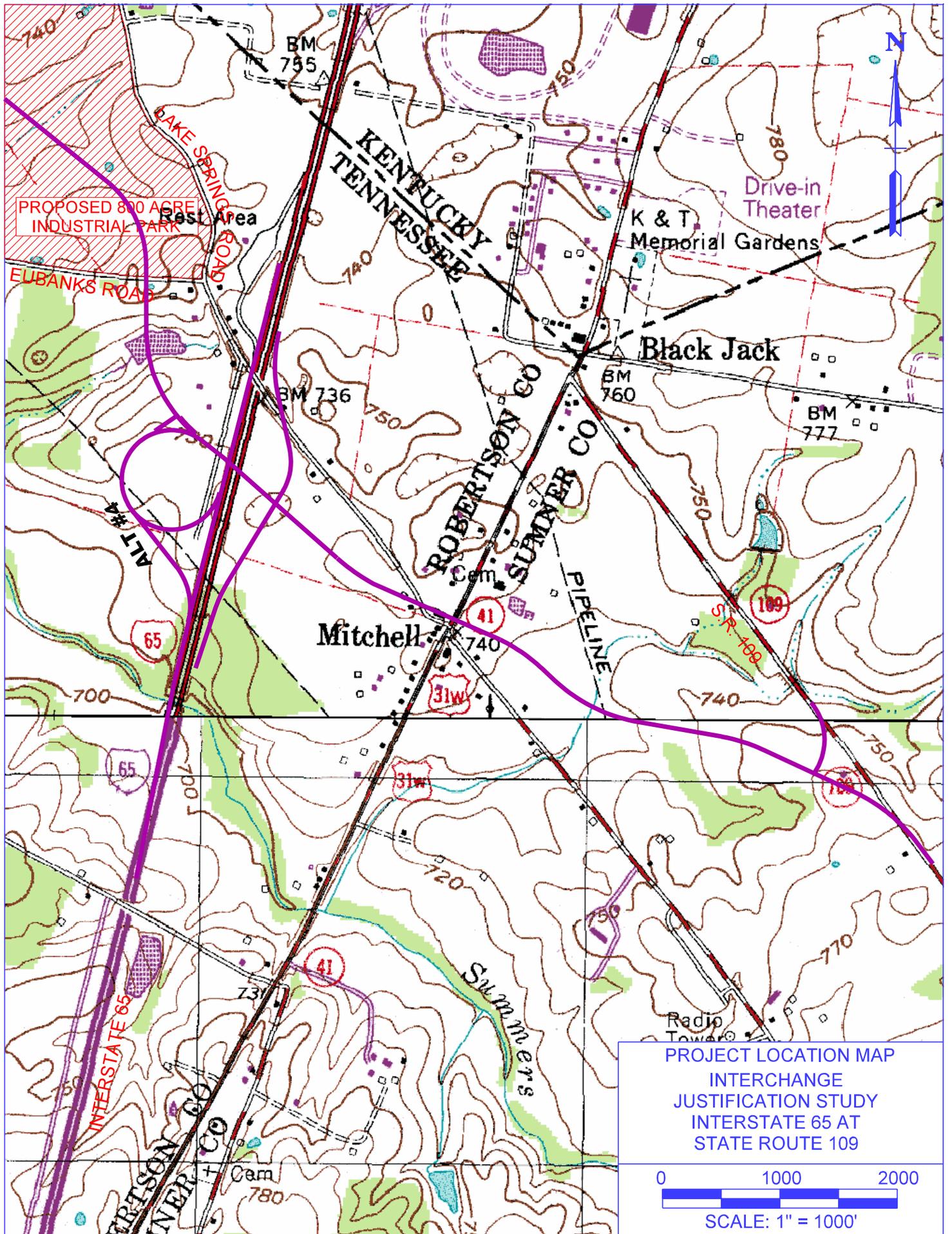




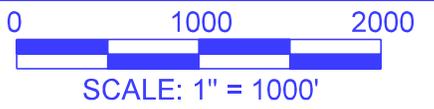
PROJECT LOCATION MAP  
 INTERCHANGE  
 JUSTIFICATION STUDY  
 INTERSTATE 65 AT  
 STATE ROUTE 109



SCALE: 1" = 1000'



PROJECT LOCATION MAP  
 INTERCHANGE  
 JUSTIFICATION STUDY  
 INTERSTATE 65 AT  
 STATE ROUTE 109



## CHAPTER 2

### PRELIMINARY PLANNING DATA

#### A. Land Use

Land use in the project area is primarily rural with scattered residential development. Relatively recent industrial development can be found off of Fred White Road. The currently planned 920-acre western industrial park, to be located west of I-65, in addition to the industrial acreage already under construction east of I-65 makes an interchange access to I-65 highly desirable. The access point may also serve to accelerate the area's residential and commercial development.

#### B. Proposed Improvement

Several alternates were presented for the proposed interchange at a preliminary field review. Four of these configurations were selected to be finalized as part of the Interchange Justification Study. Three of the alternatives preserve the rest area and all configurations provide an initial/ultimate scenario for the western industrial park and/or proposed SR 109.

Alternate #1 is a diamond interchange with a 2-lane on ramp that reduces to 1 lane before entering southbound I-65 traffic and a 2-lane off ramp for northbound traffic exiting I-65. The other ramps are 1-lane on and off ramps. This alternate configuration would require the relocation of the Tennessee Welcome Center.

Alternate #2 is a modified diamond interchange with a 2-lane on ramp that reduces to 1 lane before entering southbound I-65 traffic and a 2-lane off ramp for northbound traffic exiting I-65. A single lane loop ramp will be provided for southbound exiting traffic and 2-lane on ramp that reduces to 1 lane will serve traffic entering northbound I-65. The southbound (loop) off ramp is located 1600 feet south of the existing Tennessee Welcome Center on ramp. This configuration would allow the existing Tennessee Welcome Center to remain in place.

Alternate #3 is a diamond interchange with a 2-lane off ramp for northbound traffic exiting I-65 and 2-lane on ramp that reduces to 1 lane before entering northbound I-65. The southbound off ramp would also be 2-lanes to accommodate the volumes traveling to the existing rest area and SR 109. The southbound on ramp would collect the existing rest area traffic and SR 109 traffic before merging onto I-65 southbound.

Alternate #4 is a modified diamond interchange with a C-D Road to eliminate all weaving movements on I-65. The single lane C-D Road provides entrances and exits to the Welcome Center and SR 109. A single lane (loop) off ramp will provide for vehicles traveling to SR 109. This configuration also provides a 2-lane on ramp that reduces to 1 lane before merging onto the southbound C-D Road. The northbound I-65 exit ramp will provide 2-lanes due to the projected high ramp volumes. The northbound on-ramp is also 2 lanes that reduce to 1 lane before merging onto I-65. This configuration would allow the existing Tennessee Welcome Center to remain in place.

As part of this project Interstate 65 could be widened to 6-lanes from the Kentucky state line thru the interchange project limits. The 6-lane interstate would join the widening currently under construction in Kentucky from north of US 31W to the state line.

All alternates include the following design features that may be constructed as part of this project or as future projects:

- Six lane interstate from Kentucky State Line to south of the proposed interchange. (approximately 1.5 miles)
- Extending SR 109 from SR 41 (US 31W) to existing SR 109 east of SR 41. (approximately 0.9 miles)
- Adding turn lanes on SR-41 (US 31W) at the intersection with proposed SR 109.
- Widening of SR-41 (US 31W) to 5 lanes from SR-109 north to the Kentucky State Line to match improvements being made to US 31W north of the state line. (approximately 0.5 miles)

The plan sheets for the proposed alternative can be found in Appendix B. Alternate interchanges considered are located in Appendix F.

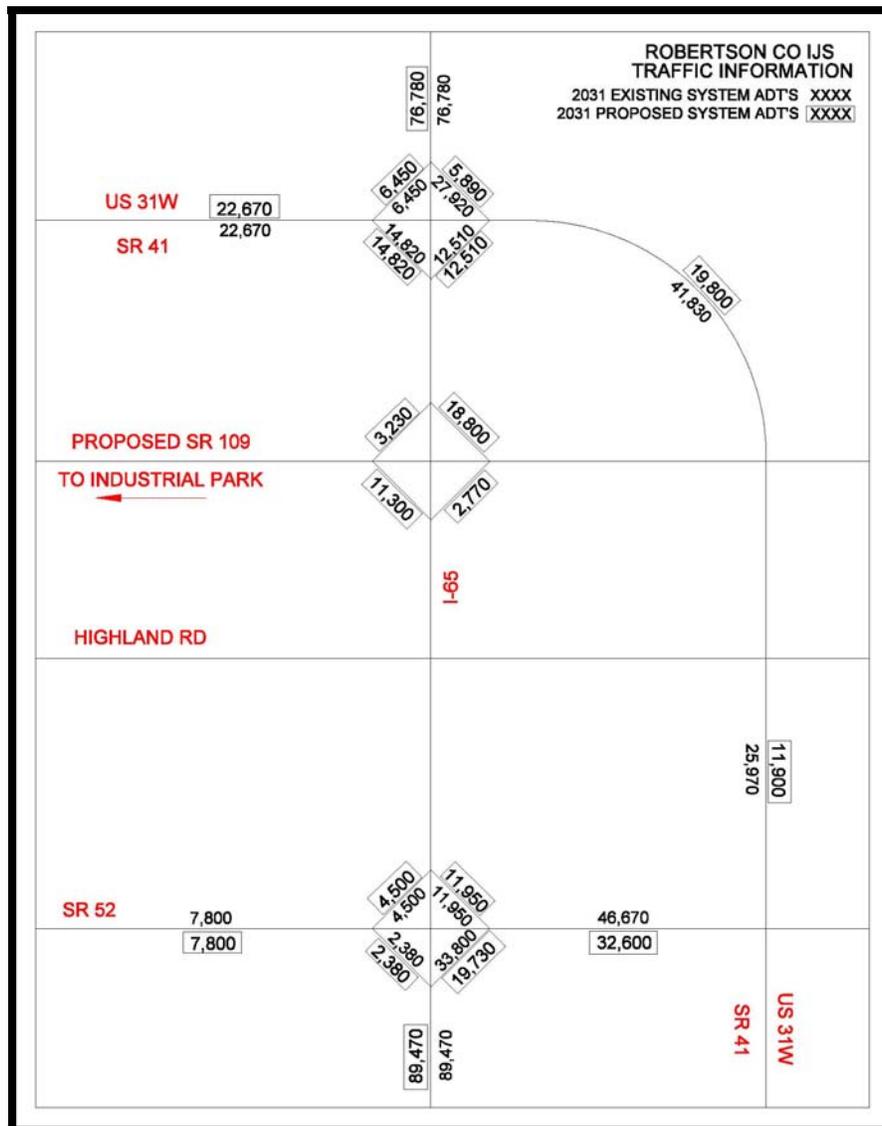
# CHAPTER 3

## ENGINEERING INVESTIGATIONS

### A. Traffic Operation

A level of service analysis was conducted to determine the relative performance of each alternate in 2011 and 2031, during the AM and PM Peak periods. Preliminary analysis on the existing 4-lane interstate indicated an acceptable level of service in 2011 but unacceptable levels of service would occur before the 2031 design horizon. Therefore, all analysis was performed using a 6-lane interstate. The findings of the analysis reveal that all interchanges within the study area will have a level of service no worse than B in 2011. However, by 2031, a relatively poor level of service will exist along the interstate due to high traffic volumes.

Comparing the 2031 existing and proposed system traffic volumes, the proposed interchange would redistribute traffic traveling to the industrial park and reduce the volumes along SR 52 and SR 41. The diagram below displays the system traffic volumes.



Alternate 1										
			AM PEAK				PM PEAK			
Location Description	Section Type	# of Lanes (Proposed)	Base Year (2011)		Design Year (2031)		Base Year (2011)		Design Year (2031)	
			6-Lane I-65		6-Lane I-65		6-Lane I-65		6-Lane I-65	
			Volume	LOS	Volume	LOS	Volume	LOS	Volume	LOS
<b>Northbound I-65</b>										
South of SR 109 Off Ramp	Freeway	3	2605	C	6213	F	3122	C	4469	E
SR 109 Off Ramp	Diverge	2	804	A	1605	C	222	A	575	B
North of SR 109 Off Ramp	Freeway	3	1801	B	4608	E	2900	C	3894	D
SR 109 On Ramp	Merge	1	428	B	969	F	648	C	1405	F
North of SR 109 On Ramp	Freeway	3	2229	B	5577	F	3548	D	5299	F
Rest Area Off Ramp	Diverge	1	233	A	305	F	233	B	305	F
<b>Southbound I-65</b>										
North of SR 109 Off Ramp	Freeway	3	3150	C	4664	F	2659	C	5067	F
SR 109 Off Ramp	Diverge	1	678	B	1470	C	427	B	958	D
South of SR 109 Off Ramp	Freeway	3	2472	C	3194	C	2232	B	4109	D
SR 109 On Ramp	Merge	2	171	C	449	D	757	C	1575	F
South of SR 109 On Ramp	Freeway	3	2643	C	3643	D	2989	C	5684	F
<b>SR 109</b>										
SB I-65 Ramp	Signal	-	-	B	-	D	-	A	-	B
NB I-65 Ramp	Signal	-	-	B	-	C	-	A	-	B
SR 41	Signal	-	-	B	-	C	-	B	-	C

Alternate 2											
			AM PEAK				PM PEAK				
Location Description	Section Type	# of Lanes (Proposed)	Base Year (2011)		Design Year (2031)		Base Year (2011)		Design Year (2031)		
			6-Lane I-65		6-Lane I-65		6-Lane I-65		6-Lane I-65		
			Volume	LOS	Volume	LOS	Volume	LOS	Volume	LOS	
<b>Northbound I-65</b>											
South of SR 109 Off Ramp	Freeway	3	2605	C	6213	F	3122	C	4469	E	
SR 109 Off Ramp	Diverge	2	804	A	1605	C	222	A	575	B	
North of SR 109 Off Ramp	Freeway	3	1801	B	4608	E	2900	C	3894	D	
SR 109 On Ramp	Merge	1	428	B	969	F	648	C	1405	F	
North of SR 109 On Ramp	Freeway	3	2229	B	5577	F	3548	D	5299	F	
Rest Area Off Ramp	Diverge	1	233	A	305	F	233	B	305	F	
<b>Southbound I-65</b>											
North of SR 109 Off Ramp	Freeway	3	3150	C	4664	F	2659	C	5067	F	
SR 109 Off Ramp	Weave	4	678	C	1470	E	427	B	958	E	
South of SR 109 Off Ramp	Freeway	3	2472	C	3194	C	2232	B	4109	D	
SR 109 On Ramp	Merge	2	171	C	449	D	757	C	1575	F	
South of SR 109 On Ramp	Freeway	3	2643	C	3643	D	2989	C	5684	F	
<b>SR 109</b>											
SB I-65 Ramp	Signal	-	-	A	-	D	-	A	-	B	
NB I-65 Ramp	Signal	-	-	B	-	C	-	A	-	B	
SR 41	Signal	-	-	B	-	C	-	B	-	C	

Alternate 3											
			AM PEAK				PM PEAK				
Location Description	Section Type	# of Lanes (Proposed)	Base Year (2011)		Design Year (2031)		Base Year (2011)		Design Year (2031)		
			6-Lane I-65		6-Lane I-65		6-Lane I-65		6-Lane I-65		
			Volume	LOS	Volume	LOS	Volume	LOS	Volume	LOS	Volume
<b>Northbound I-65</b>											
South of SR 109 Off Ramp	Freeway	3	2605	C	6213	F	3122	C	4469	E	
SR 109 Off Ramp	Diverge	2	804	A	1605	C	222	A	575	B	
North of SR 109 Off Ramp	Freeway	3	1801	B	4608	E	2900	C	3894	D	
SR 109 On Ramp	Merge	1	428	B	969	F	648	C	1405	F	
North of SR 109 On Ramp	Freeway	3	2229	B	5577	F	3548	D	5299	F	
Rest Area Off Ramp	Diverge	1	233	A	305	F	233	B	305	F	
<b>Southbound I-65</b>											
North of SR 109 Off Ramp	Freeway	3	3150	C	4664	F	2659	C	5067	F	
SR 109 Off Ramp	Diverge	1	678	B	1635	C	427	B	1123	C	
South of SR 109 Off Ramp	Freeway	3	2472	C	3194	C	2232	B	4109	D	
SR 109 On Ramp	Merge	2	171	C	614	D	757	C	1740	F	
South of SR 109 On Ramp	Freeway	3	2643	C	3643	D	2989	C	5684	F	
<b>SR 109</b>											
SB I-65 Ramp	Signal	-	-	B	-	D	-	A	-	B	
NB I-65 Ramp	Signal	-	-	B	-	C	-	A	-	B	
SR 41	Signal	-	-	B	-	C	-	B	-	C	

Alternate 4										
			AM PEAK				PM PEAK			
Location Description	Section Type	# of Lanes (Proposed)	Base Year (2011)		Design Year (2031)		Base Year (2011)		Design Year (2031)	
			6-Lane I-65		6-Lane I-65		6-Lane I-65		6-Lane I-65	
			Volume	LOS	Volume	LOS	Volume	LOS	Volume	LOS
<b>Northbound I-65</b>										
South of SR 109 Off Ramp	Freeway	3	2605	C	6213	F	3122	C	4469	E
SR 109 Off Ramp	Diverge	2	804	A	1605	C	222	A	575	B
North of SR 109 Off Ramp	Freeway	3	1801	B	4608	E	2900	C	3894	D
SR 109 On Ramp	Merge	1	428	B	969	F	648	C	1405	F
North of SR 109 On Ramp	Freeway	3	2229	B	5577	F	3548	D	5299	F
Rest Area Off Ramp	Diverge	1	233	A	305	F	233	B	305	F
<b>Southbound I-65</b>										
North of SR 109 Off Ramp	Freeway	3	3150	C	4664	F	2659	C	5067	F
SR 109 Off Ramp	Diverge	1	843	B	1661	C	592	B	1149	D
South of SR 109 Off Ramp	Freeway	3	2472	C	3194	C	2232	B	4109	D
SR 109 On Ramp	Merge	1	336	C	640	D	922	C	1766	F
South of SR 109 On Ramp	Freeway	3	2643	C	3643	D	2989	C	5684	F
<b>SR 109</b>										
SB I-65 Ramp	Signal	-	-	A	-	D	-	A	-	B
NB I-65 Ramp	Signal	-	-	B	-	C	-	A	-	B
SR 41	Signal	-	-	B	-	C	-	B	-	C

Adjacent Interchanges										
			Existing System		Proposed System		Existing System		Proposed System	
Location Description	Section Type		SR 52		SR 52		US 31W		US 31W	
			AM Peak	PM Peak						
			LOS	LOS	LOS	LOS	LOS	LOS	LOS	LOS
Southbound Ramp Approach	Signal		F	F	F	F	F	F	C	E
Eastbound Approach	Signal		F	F	F	F	F	C	D	B
Westbound Approach	Signal		F	F	F	F	F	F	D	E
	Signal									
Northbound Ramp Approach	Signal		F	F	E	F	F	F	C	F
Eastbound Approach	Signal		F	F	F	F	F	F	C	F
Westbound Approach	Signal		F	F	F	E	C	F	C	F

## **B. Access Analysis**

This study has been undertaken in accordance with the Federal Highway Administration's (FHWA) policy for granting new or modified interstate access. The FHWA policy, as described in FHWA Docket No. 89-23, "Additional Interchanges to the Interstate System" (Federal Register 55, No. 204, October 22, 1990), is provided in the following paragraphs along with comments for consideration.

***It is in the national interest to maintain the Interstate System to provide the highest level of service in terms of safety and mobility. Adequate control of access is critical to providing such service. Therefore, new or revised access points to the existing Interstate System will be considered for approval only if:***

- 1. It is demonstrated that the existing interchanges and/or local roads and streets in the corridor can neither provide the necessary access nor be improved to satisfactorily accommodate the design year traffic demands while at the same time providing the access intended by the proposal.***

The proposed interchange will be flanked by industrial developments to the west and east side of I-65 on what is currently agricultural land. The industrial park (currently under construction) east of I-65, and the addition of a 920-acre industrial park expansion west of I-65 makes this interchange a necessity. In addition, Robertson County officials have indicated that this general area will experience residential development as well, but no known plans exists currently.

The industrial park will bring a significant increase in traffic volume to this area that will be further amplified as the surrounding agricultural land begins to develop with residential units. The industrial park is projected to generate 16,000 vehicles per day at full build out. There are currently 5 warehouses constructed in the western industrial park and the eastern park has 3 remaining lots to be developed. Without this interchange, access to the industrial park and the area surrounding the proposed project site will be via circuitous two lane routes. Motorists will experience significant increases in VMT, with an increased likelihood of vehicle crashes, and increases in vehicle emissions due to delays as a result of inadequate highway capacity.

Existing access options include using the existing I-65 interchange at US 31W, located approximately 2.5 miles north of the proposed project on the Kentucky side of the Tennessee/Kentucky State Line or the I-65 interchange at SR-52 at approximately 3.3 miles to the south of the proposed project in Robertson County.

The shortest route from the south is via the SR-52 interchange traveling east on SR-52, intersecting SR-41 and heading north to Lake Springs Road, traveling to the west to the project site for a distance of approximately 3.9 miles.

The shortest route from the north is via the US 31W interchange at Exit #2 in Kentucky, heading south to Lake Springs Road, traveling west on Lake Springs Road to the project site for a total distance of approximately 3.3 miles.

These alternative access routes to the industrial park expansion require traffic to use SR-41 (US 31W), which is already operating close to capacity and would have to be significantly improved to handle these large increases in traffic volumes.

2. ***All reasonable alternatives for design options, location and transportation system management type improvements (such as ramp metering, mass transit, and HOV facilities) have been assessed and provided for if currently justified, or provisions are included for accommodating such facilities if a future need is identified.***

Four alternates have been proposed, reviewed and evaluated during meetings with representatives from TDOT's Design and Planning Divisions. All alternates will accommodate 2011 traffic and some congestion will occur with the 2031 volumes.

Public transit is not available in Robertson County. The Long Range Transportation Plan for the Nashville Metropolitan Planning Organization mentions a study that was conducted identifying I-65 North from Nashville to Sumner County as one of five radial corridors having the greatest potential to support HOV facilities. SR-41 (US 31W) serves as the line between Robertson County and Sumner County. The I-65 corridor lies just to the west of the county line, within Robertson County. However, only parts of Robertson County are within the MPO boundary, and no specific plans for HOV lanes exist for the portion of I-65 affected by the proposed interchange project.

The results of the traffic analysis do not warrant the use of ramp metering. The issues surrounding the proposed project location relate more to access issues than to Transportation System Management.

3. ***The proposed access point does not have a significant adverse impact on the safety and operation of the interstate facility based on analysis of current and future traffic. The operational analysis for existing conditions shall, particularly in urbanized areas, include an analysis of sections of interstate to and including at least the first adjacent existing or proposed interchange on either side. Crossroads and other roads and streets shall be included in the analysis to the extent necessary to assure their ability to collect and distribute traffic to and from the interchange with new or revised access points.***

An operational analysis of current and future traffic was completed for all ramps and ramp termini within the limits of the interchange area. The proposed project site is currently located in a predominantly rural area. The interchange nearest the proposed new interchange site is approximately 2.5 miles to the north. The next closest existing interchange is located approximately 3.3 miles to the south. The adjacent interchanges are located a sufficient distance from the project, and will not be adversely affected by the proposed new interchange. The forecasted traffic shows capacity problems for the adjacent interchanges unrelated to the proposed new interchange. The analysis of the existing and proposed systems can be found with the Level of Service summaries (page 12). The adjacent interchanges will

experience capacity problems as 2031 approaches. The SR 52 interchange will experience Level of Service F but that is related to increased traffic volumes along SR 52 unrelated to the industrial park. The US 31W interchange level of service will remain similar to the existing system with some approaches improving due to the vehicles from the south using the new interchange.

Traffic analysis for 2011 indicated an acceptable level-of-service for all ramps, assuming that I-65 will be widened to 6 lanes. It is understood that market forces will dictate the rate at which the industrial park will become fully occupied. It is anticipated that the industrial park will develop gradually.

The level of service on northbound I-65 will be C or D in year 2011 with all alternates. All other locations within the interchange study area will operate at equal or better level of service.

There will be significant increases in traffic volume by 2031, and there will be a corresponding worsening of the level of service for each alternate interchange design. While the proposed interchange should not have a significant adverse impact upon the safety and operation of the interstate facility, significant increases in I-65 traffic volumes will bring about relatively poor I-65 levels of service by 2031. This would occur with or without the proposed new interchange.

- 4. The proposed access connects to a public road only and will provide for all turning movements. Less than “full interchanges” for special purpose access for transit vehicles, for HOV’s or onto park and ride lots may be considered on a case-by-case basis. The proposed access will be designed to meet or exceed current standards for Federal-Aid projects on the interstate system.***

Alternate #1 is a full diamond type interchange. Alternate #2 is of a modified diamond design with a loop ramp serving vehicles exiting southbound I-65 onto SR-109. Alternate #3 is a full diamond type interchange that provides slip ramps to and from the existing rest area. Alternate #4 is of a modified diamond with a C-D Road to provide all movements to SR 109 and Welcome Center. All interchange design will meet or exceed all American Association of State Highway and Transportation Officials (AASHTO) criteria and serve all traffic movements

- 5. The proposal considers and is consistent with local and regional land use and transportation plans. Prior to final approval, all requests for new revised access must be consistent with the metropolitan and/or statewide transportation plan, as appropriate, the applicable provisions of 23 CFR part 450 and the transportation conformity requirements of 40 CFR parts 51 and 93.***

The closest MPO is the Nashville Area Metropolitan Planning Organization, but the project site is not within the MPO boundary. Therefore, the MPO has no planning jurisdiction at the proposed site. However, the Sumner County portion of the MPO’s Long Range Transportation Plan identifies project #84 as a new interchange to be constructed in Robertson County on I-65 at a point where SR-

109 would intersect the interstate if it were extended from its current terminus at SR-41 (US 31W) in a northwesterly direction to I-65.

6. ***In areas where the potential exists for future multiple interchange additions, all requests for new or revised access are supported by a comprehensive Interstate network study with recommendations that address all proposed and desired access within the context of a long term plan.***

Implementation of the proposed interchange at Lake Springs Road will place a fifth interchange within Robertson County. This proposed interchange will become the primary I-65 access point to the new industrial park and the town of Portland located in Sumner County. Interchanges are currently located at I-65 and SR-257, I-65 and SR-76, I-65 and SR-25, and I-65 at SR-52. All interchanges are currently spaced approximately 4 to 6 miles apart.

7. ***The request for a new or revised access generated by new or expanded development demonstrates appropriate coordination between the development and related or otherwise required transportation system improvements.***

The primary objective of the proposed interchange is to provide safe and adequate transportation facilities for traffic projected to be generated by the industrial park and anticipated residential development.

8. ***The request for a new or revised access contains information relative to the planning requirements and the status of the environmental processing of the proposal.***

Environmental studies were not conducted during this phase, but the interchange vicinity contains a stream, commercial and residential residences, and agricultural land. Construction of Alternate #1 is expected to require the acquisition of seven residences and one rest area. Construction of Alternate #2 is expected to require the acquisition of six residences. Construction of Alternate #3 is expected to require the acquisition of eight residences. Construction of Alternate #4 is expected to require the acquisition of four residences. Acquisition of some acreage currently being used for agricultural operations would be necessary.

### **C. Cost**

The total estimated construction cost for each interchange alternate is detailed on pages 17-28. The cost for the standard diamond interchange (Alternate #1) is estimated at \$11,800,000 (requires the rest area to be relocated at an additional \$8,750,000). The estimated cost for Alternate #2 is \$13,700,000, the estimated cost for Alternate #3 is \$14,900,000, and Alternate #4 is \$13,300,000. The construction cost for widening the interstate to 6-lanes within the interchange construction limits (approximately 1.5 miles) was estimated to be \$10,200,000. A construction cost for the future projects along SR 109 and SR 41 widening was estimated at \$3,300,000.

**COST DATA SHEET (Itemized Cost Estimates)**

1/9/2007

**PROJECT:** Robertson County - Alt. 1 Interchange

**Right-of-Way**

	Acres=	Number	Rate	Costs
Land, Improvements, and Damages		30.97	N/A	\$284,065
Incidentals	Tracts=	12	\$2,500	\$30,000
Relocation Payments	Residences=	7		\$313,100
	Businesses=	0		\$0
	Non-Profits=	0		\$0
Contingences	Additional 20%			\$125,433
<b>Total Right-of-Way Costs</b>				<b>\$800,000</b>

**Utility Relocation**

Reimbursable	
Non-Reimbursable	\$860,000
Contingences (20%)	\$172,000
<b>Total Adjustment Cost</b>	<b>\$1,030,000</b>

**Construction**

**Interchange**

Clear and Grubbing	\$54,000
Earthwork	\$2,475,000
Pavement Removal	\$14,000
Drainage (Includes Erosion Control)	\$900,000
Structures	\$2,700,000
Railroad Crossing or Separation	\$0
Paving	\$2,320,000
Retaining Walls	\$0
Maintenance of Traffic	\$500,000
Topsoil	\$41,000
Seeding	\$20,000
Sodding	\$0
Signing	\$200,000
Signalization	\$360,000
Fence	\$75,000
Guardrail	\$45,000
Rip Rap of Slope Protection	\$0
Other Construction Items (8.5%)	\$596,000
Mobilization	\$469,000
<b>10% Eng. And Const.</b>	<b>\$1,077,000</b>
<b>Total Construction Cost</b>	<b>\$11,800,000</b>

**COST DATA SHEET (Itemized Cost Estimates)**

1/9/2007

**PROJECT:** Robertson County - Alt. 1 Interstate 65 widening

**Right-of-Way**

	Number	Rate	Costs
Land, Improvements, and Damages	Acres=	0.00 N/A	\$0
Incidentals	Tracts=	0	\$2,500
Relocation Payments	Residences=	0	\$0
	Businesses=	0	\$0
	Non-Profits=	0	\$0
Contingences	Additional 20%		\$0
<b>Total Right-of-Way Costs</b>			<b>\$0</b>

**Utility Relocation**

Reimbursable	
Non-Reimbursable	\$0
Contingences (20%)	\$0
<b>Total Adjustment Cost</b>	<b>\$0</b>

**Construction**

**Interstate 65 widening**

Clear and Grubbing	\$12,000
Earthwork	\$400,000
Pavement Removal	\$0
Drainage (Includes Erosion Control)	\$1,000,000
Structures	\$770,000
Railroad Crossing or Separation	\$0
Paving	\$5,000,000
Retaining Walls	\$0
Maintenance of Traffic	\$800,000
Topsoil	\$0
Seeding	\$30,000
Sodding	\$0
Signing	\$0
Barrier Wall	\$400,000
Fence	\$0
Guardrail	\$0
Rip Rap of Slope Protection	\$0
Other Construction Items (8.5%)	\$650,000
Mobilization	\$413,000
<b>10% Eng. And Const.</b>	<b>\$948,000</b>
<b>Total Construction Cost</b>	<b>\$10,400,000</b>

**COST DATA SHEET (Itemized Cost Estimates)**

1/9/2007

**PROJECT:** Robertson County - Alt. 1 SR 109 and US 31W

**Right-of-Way**

	Acres=	Number	Rate	Costs
Land, Improvements, and Damages		24.42	N/A	\$126,636
Incidentals	Tracts=	18	\$2,500	\$45,000
Relocation Payments	Residences=	0		\$0
	Businesses=	0		\$0
	Non-Profits=	0		\$0
Contingences	Additional 20%			\$34,327
<b>Total Right-of-Way Costs</b>				<b>\$200,000</b>

**Utility Relocation**

Reimbursable	
Non-Reimbursable	\$180,000
Contingences (20%)	\$36,000
<b>Total Adjustment Cost</b>	<b>\$220,000</b>

**Construction**  
SR 109 and US 31W

Clear and Grubbing	\$10,000
Earthwork	\$500,000
Pavement Removal	\$5,000
Drainage (Includes Erosion Control)	\$500,000
Structures	\$0
Railroad Crossing or Separation	\$0
Paving	\$1,300,000
Retaining Walls	\$0
Maintenance of Traffic	\$150,000
Topsoil	\$10,000
Seeding	\$10,000
Sodding	\$0
Signing	\$125,000
Signalization	\$0
Fence	\$0
Guardrail	\$25,000
Rip Rap of Slope Protection	\$0
Other Construction Items (8.5%)	\$224,000
Mobilization	\$134,000
<b>10% Eng. And Const.</b>	<b>\$300,000</b>
<b>Total Construction Cost</b>	<b>\$3,300,000</b>

**Preliminary Engineering (10%)** \$2,600,000

Rest Area Relocation \$8,750,000  
Existing Rest Area Removal \$300,000

**TOTAL COST** **\$39,000,000**

**COST DATA SHEET (Itemized Cost Estimates)**

1/9/2007

PROJECT: Robertson County - Alt. 2 Interchange

**Right-of-Way**

	Number	Rate	Costs
Land, Improvements, and Damages	Acres= 59.69	N/A	\$532,265
Incidentals	Tracts= 14	\$2,500	\$35,000
Relocation Payments	Residences= 6		\$313,100
	Businesses= 0		
	Non-Profits= 0		
Contingences	Additional 20%		\$176,073
<b>Total Right-of-Way Costs</b>			<b>\$1,100,000</b>

**Utility Relocation**

Reimbursable		
Non-Reimbursable		\$2,200,000
Contingences (20%)		\$440,000
<b>Total Adjustment Cost</b>		<b>\$2,600,000</b>

**Construction  
Interchange**

Clear and Grubbing	\$84,000	
Earthwork	\$2,840,000	
Pavement Removal	\$30,000	
Drainage (Includes Erosion Control)	\$1,000,000	
Structures	\$2,700,000	
Railroad Crossing or Separation	\$0	
Paving	\$3,000,000	
Retaining Walls	\$0	
Maintenance of Traffic	\$600,000	
Topsoil	\$55,000	
Seeding	\$25,000	
Sodding	\$0	
Signing	\$350,000	
Signalization	\$360,000	
Fence	\$100,000	
Guardrail	\$45,000	
Rip Rap of Slope Protection	\$0	
Other Construction Items (8.5%)	\$722,000	
Mobilization	\$541,000	
<b>10% Eng. And Const.</b>	<b>\$1,246,000</b>	
<b>Total Construction Cost</b>		<b>\$13,700,000</b>

**COST DATA SHEET (Itemized Cost Estimates)**

1/9/2007

PROJECT: Robertson County - Alt. 2 Interstate 65 widening

**Right-of-Way**

	Number	Rate	Costs
Land, Improvements, and Damages	Acres=	0.00 N/A	\$0
Incidentals	Tracts=	0	\$2,500
Relocation Payments	Residences=	0	\$0
	Businesses=	0	\$0
	Non-Profits=	0	\$0
Contingences	Additional 20%		\$0
<b>Total Right-of-Way Costs</b>			<b>\$0</b>

**Utility Relocation**

Reimbursable	
Non-Reimbursable	\$0
Contingences (20%)	\$0
<b>Total Adjustment Cost</b>	<b>\$0</b>

**Construction**

**Interstate 65 widening**

Clear and Grubbing	\$12,000
Earthwork	\$400,000
Pavement Removal	\$0
Drainage (Includes Erosion Control)	\$1,000,000
Structures	\$770,000
Railroad Crossing or Separation	\$0
Paving	\$5,000,000
Retaining Walls	\$0
Maintenance of Traffic	\$800,000
Topsoil	\$0
Seeding	\$30,000
Sodding	\$0
Signing	\$0
Barrier Wall	\$400,000
Fence	\$0
Guardrail	\$0
Rip Rap of Slope Protection	\$0
Other Construction Items (8.5%)	\$650,000
Mobilization	\$413,000
<b>10% Eng. And Const.</b>	<b>\$948,000</b>
<b>Total Construction Cost</b>	<b>\$10,400,000</b>

**COST DATA SHEET (Itemized Cost Estimates)**

1/9/2007

PROJECT: Robertson County - Alt. 2 SR 109 and US 31W

**Right-of-Way**

	Acres=	Number	Rate	Costs
Land, Improvements, and Damages		26.22	N/A	\$176,079
Incidentals	Tracts=	17	\$2,500	\$42,500
Relocation Payments	Residences=	0		\$0
	Businesses=	0		\$0
	Non-Profits=	0		\$0
Contingences	Additional 20%			\$43,716
<b>Total Right-of-Way Costs</b>				<b>\$300,000</b>

**Utility Relocation**

Reimbursable	
Non-Reimbursable	\$180,000
Contingences (20%)	\$36,000
<b>Total Adjustment Cost</b>	<b>\$220,000</b>

**Construction**  
SR 109 and US 31W

Clear and Grubbing	\$10,000
Earthwork	\$500,000
Pavement Removal	\$5,000
Drainage (Includes Erosion Control)	\$500,000
Structures	\$0
Railroad Crossing or Separation	\$0
Paving	\$1,300,000
Retaining Walls	\$0
Maintenance of Traffic	\$150,000
Topsoil	\$10,000
Seeding	\$10,000
Sodding	\$0
Signing	\$125,000
Signalization	\$0
Fence	\$0
Guardrail	\$25,000
Rip Rap of Slope Protection	\$0
Other Construction Items (8.5%)	\$224,000
Mobilization	\$134,000
<b>10% Eng. And Const.</b>	<b>\$300,000</b>
<b>Total Construction Cost</b>	<b>\$3,300,000</b>

<b>Preliminary Engineering (10%)</b>	<b>\$2,700,000</b>
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Rest Area Relocation	\$0
Existing Rest Area Removal	\$0

<b>TOTAL COST</b>	<b>\$33,800,000</b>
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**COST DATA SHEET (Itemized Cost Estimates)**

1/9/2007

PROJECT: Robertson County - Alt. 3 Interchange

**Right-of-Way**

	Acres=	Number	Rate	Costs
Land, Improvements, and Damages		36.04	N/A	\$236,902
Incidentals	Tracts=	14	\$2,500	\$35,000
Relocation Payments	Residences=	8		\$426,100
	Businesses=	0		
	Non-Profits=	0		
Contingences	Additional 20%			\$139,600
<b>Total Right-of-Way Costs</b>				<b>\$800,000</b>

**Utility Relocation**

Reimbursable	
Non-Reimbursable	\$930,000
Contingences (20%)	\$186,000
<b>Total Adjustment Cost</b>	<b>\$1,100,000</b>

**Construction  
Interchange**

Clear and Grubbing	\$74,000
Earthwork	\$3,800,000
Pavement Removal	\$27,500
Drainage (Includes Erosion Control)	\$690,000
Structures	\$2,700,000
Railroad Crossing or Separation	\$0
Paving	\$3,100,000
Retaining Walls	\$0
Maintenance of Traffic	\$800,000
Topsoil	\$52,000
Seeding	\$33,000
Sodding	\$0
Signing	\$400,000
Signalization	\$360,000
Fence	\$45,000
Guardrail	\$63,000
Rip Rap of Slope Protection	\$0
Other Construction Items (8.5%)	\$803,000
Mobilization	\$588,000
<b>10% Eng. And Const.</b>	<b>\$1,354,000</b>
<b>Total Construction Cost</b>	<b>\$14,900,000</b>

**COST DATA SHEET (Itemized Cost Estimates)**

1/9/2007

PROJECT: Robertson County - Alt. 3 Interstate 65 widening

**Right-of-Way**

	Number	Rate	Costs
Land, Improvements, and Damages	Acres=	0.00 N/A	\$0
Incidentals	Tracts=	0	\$2,500
Relocation Payments	Residences=	0	\$0
	Businesses=	0	\$0
	Non-Profits=	0	\$0
Contingences	Additional 20%		\$0
<b>Total Right-of-Way Costs</b>			<b>\$0</b>

**Utility Relocation**

Reimbursable	
Non-Reimbursable	\$0
Contingences (20%)	\$0
<b>Total Adjustment Cost</b>	<b>\$0</b>

**Construction**

**Interstate 65 widening**

Clear and Grubbing	\$12,000
Earthwork	\$400,000
Pavement Removal	\$0
Drainage (Includes Erosion Control)	\$1,000,000
Structures	\$770,000
Railroad Crossing or Separation	\$0
Paving	\$5,000,000
Retaining Walls	\$0
Maintenance of Traffic	\$800,000
Topsoil	\$0
Seeding	\$30,000
Sodding	\$0
Signing	\$0
Barrier Wall	\$400,000
Fence	\$0
Guardrail	\$0
Rip Rap of Slope Protection	\$0
Other Construction Items (8.5%)	\$650,000
Mobilization	\$413,000
<b>10% Eng. And Const.</b>	<b>\$948,000</b>
<b>Total Construction Cost</b>	<b>\$10,400,000</b>

**COST DATA SHEET (Itemized Cost Estimates)**

1/9/2007

PROJECT: Robertson County - Alt. 3 SR 109 and US 31W

**Right-of-Way**

	Acres=	Number	Rate	Costs
Land, Improvements, and Damages		23.99	N/A	\$149,531
Incidentals	Tracts=	17	\$2,500	\$42,500
Relocation Payments	Residences=	0		\$0
	Businesses=	0		\$0
	Non-Profits=	0		\$0
Contingences	Additional 20%			\$38,406
<b>Total Right-of-Way Costs</b>				<b>\$200,000</b>

**Utility Relocation**

Reimbursable				
Non-Reimbursable				\$180,000
Contingences (20%)				\$36,000
<b>Total Adjustment Cost</b>				<b>\$220,000</b>

**Construction**

SR 109 and US 31W

Clear and Grubbing				\$10,000
Earthwork				\$500,000
Pavement Removal				\$5,000
Drainage (Includes Erosion Control)				\$500,000
Structures				\$0
Railroad Crossing or Separation				\$0
Paving				\$1,300,000
Retaining Walls				\$0
Maintenance of Traffic				\$150,000
Topsoil				\$10,000
Seeding				\$10,000
Sodding				\$0
Signing				\$125,000
Signalization				\$0
Fence				\$0
Guardrail				\$25,000
Rip Rap of Slope Protection				\$0
Other Construction Items (8.5%)				\$224,000
Mobilization				\$134,000
<b>10% Eng. And Const.</b>				<b>\$300,000</b>
<b>Total Construction Cost</b>				<b>\$3,300,000</b>

**Preliminary Engineering (10%)** **\$2,900,000**

Rest Area Relocation \$0  
 Existing Rest Area Removal \$0

**TOTAL COST** **\$33,400,000**

**COST DATA SHEET (Itemized Cost Estimates)**

1/9/2007

PROJECT: Robertson County - Alt. 4 Interchange

**Right-of-Way**

	Acres=	Number	Rate	Costs
Land, Improvements, and Damages		52.63	N/A	\$201,208
Incidentals	Tracts=	15	\$2,500	\$37,500
Relocation Payments	Residences=	4		\$241,400
	Businesses=	0		
	Non-Profits=	0		
Contingences	Additional 20%			\$96,022
<b>Total Right-of-Way Costs</b>				<b>\$600,000</b>

**Utility Relocation**

Reimbursable	
Non-Reimbursable	\$2,345,000
Contingences (20%)	\$469,000
<b>Total Adjustment Cost</b>	<b>\$2,800,000</b>

**Construction  
Interchange**

Clear and Grubbing	\$68,000
Earthwork	\$2,600,000
Pavement Removal	\$15,000
Drainage (Includes Erosion Control)	\$1,000,000
Structures	\$2,700,000
Railroad Crossing or Separation	\$0
Paving	\$2,800,000
Retaining Walls	\$0
Maintenance of Traffic	\$600,000
Topsoil	\$250,000
Seeding	\$20,000
Sodding	\$0
Signing	\$350,000
Signalization	\$360,000
Fence	\$90,000
Guardrail	\$35,000
Rip Rap of Slope Protection	\$0
Other Construction Items (8.5%)	\$696,000
Mobilization	\$527,000
<b>10% Eng. And Const.</b>	<b>\$1,212,000</b>
<b>Total Construction Cost</b>	<b>\$13,300,000</b>

**COST DATA SHEET (Itemized Cost Estimates)**

1/9/2007

PROJECT: Robertson County - Alt. 4 Interstate 65 widening

**Right-of-Way**

	Number	Rate	Costs
Land, Improvements, and Damages	Acres=	0.00 N/A	\$0
Incidentals	Tracts=	0	\$2,500
Relocation Payments	Residences=	0	\$0
	Businesses=	0	\$0
	Non-Profits=	0	\$0
Contingences	Additional 20%		\$0
<b>Total Right-of-Way Costs</b>			<b>\$0</b>

**Utility Relocation**

Reimbursable	
Non-Reimbursable	\$0
Contingences (20%)	\$0
<b>Total Adjustment Cost</b>	<b>\$0</b>

**Construction**

**Interstate 65 widening**

Clear and Grubbing	\$12,000
Earthwork	\$400,000
Pavement Removal	\$0
Drainage (Includes Erosion Control)	\$1,000,000
Structures	\$770,000
Railroad Crossing or Separation	\$0
Paving	\$5,000,000
Retaining Walls	\$0
Maintenance of Traffic	\$800,000
Topsoil	\$0
Seeding	\$30,000
Sodding	\$0
Signing	\$0
Barrier Wall	\$400,000
Fence	\$0
Guardrail	\$0
Rip Rap of Slope Protection	\$0
Other Construction Items (8.5%)	\$650,000
Mobilization	\$413,000
<b>10% Eng. And Const.</b>	<b>\$948,000</b>
<b>Total Construction Cost</b>	<b>\$10,400,000</b>

**COST DATA SHEET (Itemized Cost Estimates)**

1/9/2007

PROJECT: Robertson County - Alt. 4 SR 109 and US 31W

**Right-of-Way**

	Acres=	Number	Rate	Costs
Land, Improvements, and Damages		29.11	N/A	\$201,208
Incidentals	Tracts=	17	\$2,500	\$42,500
Relocation Payments	Residences=	0		\$0
	Businesses=	0		\$0
	Non-Profits=	0		\$0
Contingences	Additional 20%			\$48,742
<b>Total Right-of-Way Costs</b>				<b>\$300,000</b>

**Utility Relocation**

Reimbursable				
Non-Reimbursable				\$180,000
Contingences (20%)				\$36,000
<b>Total Adjustment Cost</b>				<b>\$220,000</b>

**Construction**

SR 109 and US 31W

Clear and Grubbing				\$10,000
Earthwork				\$500,000
Pavement Removal				\$5,000
Drainage (Includes Erosion Control)				\$500,000
Structures				\$0
Railroad Crossing or Separation				\$0
Paving				\$1,300,000
Retaining Walls				\$0
Maintenance of Traffic				\$150,000
Topsoil				\$10,000
Seeding				\$10,000
Sodding				\$0
Signing				\$125,000
Signalization				\$0
Fence				\$0
Guardrail				\$25,000
Rip Rap of Slope Protection				\$0
Other Construction Items (8.5%)				\$224,000
Mobilization				\$134,000
<b>10% Eng. And Const.</b>				<b>\$300,000</b>
<b>Total Construction Cost</b>				<b>\$3,300,000</b>

<b>Preliminary Engineering (10%)</b>	<b>\$2,700,000</b>
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Rest Area Relocation	\$0
Existing Rest Area Removal	\$0

<b>TOTAL COST</b>	<b>\$33,100,000</b>
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**D. Environmental Concerns**

Formal environmental studies have not been conducted for this study. There are minor streams in the area that may need to be mitigated. Further studies will be necessary to determine any historic, archaeological, or ecological impacts of constructing an interchange.

**E. Bicycle and Pedestrian Considerations**

SR-109 will be constructed with a rural 4-lane cross-section including a 22 foot raised median with 10 foot paved outside shoulders. These improvements should provide improved pedestrian and bicycle accommodations, allowing additional bicycle and pedestrian connectivity and continuity.

## **CHAPTER 4**

### **SUMMARY AND CONCLUSIONS**

The preceding study was conducted to evaluate future traffic operations of a proposed new interchange on I-65 near the current crossing of Lake Springs Road. TDOT's Mapping and Statistics Office prepared a standard traffic package that included traffic forecasts for the preliminary configurations. This information was used to guide design considerations and for highway capacity level-of-service and vehicle delay analysis.

Four alternate designs were considered. Alternate #1 is a standard diamond interchange, Alternate #2 is a modified diamond interchange with a loop ramp for traffic exiting southbound I-65, and Alternate #3 is a standard diamond interchange that provides slip ramps for the existing rest area. Alternate #4 is a modified diamond interchange with a C-D Road along southbound I-65.

Alternate #1 eliminates the weaving segment with the existing Welcome Center due to it being relocated (possible sites identified in a previous study). Alternate #1 provides an ultimate fly-over ramp for northbound I-65 to westbound SR 109 traffic entering the industrial park

Alternate #2 provides a 1600-foot weaving area along I-65 for traffic exiting the Welcome Center and others using the loop ramp. This alternate allows the existing Welcome Center to remain in its current location. An ultimate fly-over ramp for northbound I-65 to westbound SR 109 can be constructed when traffic volumes meet the need.

Alternate #3 provides slip ramps for access to the Welcome Center. This alternate allows the existing Welcome Center to remain in its current location. The ramps are separated from I-65 by a barrier wall until all Welcome Center and ramp merging is completed. This alternate also provides for an ultimate fly-over ramp for northbound I-65 vehicles wanting to enter the western industrial park as traffic volumes meet the need.

Alternate #4 is a modified diamond interchange with a C-D Road to eliminate all weaving movements on I-65. The single lane C-D Road provides entrances and exits to the Welcome Center and SR 109. A single lane loop ramp will provide for vehicles traveling to SR 109. This configuration merges the SR 109 and Welcome Center traffic before merging onto southbound I-65. This configuration would allow the existing Tennessee Welcome Center to remain in place. This alternate also provides for an ultimate fly-over ramp for northbound I-65 vehicles wanting to enter the western industrial park.

Alternate #4 is the preferred alternate due to it eliminating all weaving along southbound I-65 by implementing a C-D Road that removes the closely spaced merging and diverging from the interstate allowing the movements to occur at lower speeds. This configuration improves the safety along I-65 and accommodates future growth within the area.

# **APPENDIX A**

## **PROJECTED TRAFFIC VOLUMES**

**TENNESSEE DEPARTMENT OF TRANSPORTATION  
PROJECT PLANNING DIVISION**

PROJECT NO.: \_\_\_\_\_ ROUTE: I-65  
 COUNTY: ROBERTSON CITY: \_\_\_\_\_  
 PROJECT PIN NUMBER: \_\_\_\_\_  
 PROJECT DESCRIPTION: EXISTING SYSTEM TRAFFIC FOR THE PROPOSED INTERCHANGE  
@ I-65 & S.R. 109.

**DIVISION REQUESTING:**

MAINTENANCE	<input type="checkbox"/>	PAVEMENT DESIGN	<input type="checkbox"/>
PLANNING	<input checked="" type="checkbox"/>	STRUCTURES	<input type="checkbox"/>
PROG. DEVELOPMENT & ADM.	<input type="checkbox"/>	SURVEY & DESIGN	<input type="checkbox"/>
PUBLIC TRANS. & AERO.	<input type="checkbox"/>	TRAFFIC SIGNAL DESIGN	<input type="checkbox"/>
YEAR PROJECT PROGRAMMED FOR CONSTRUCTION:	_____	OTHER _____	<input type="checkbox"/>
PROJECTED LETTING DATE:	_____		

**TRAFFIC ASSIGNMENT:**

BASE YEAR		DESIGN YEAR					DESIGN ROADWAY % TRUCKS		DESIGN AVERAGE DAILY LOADS	
ADT	YEAR	ADT	DHV	%	YEAR	DIR.DIST.	DHV	ADT	FLEX	RIGID
[1] 52,990	2011	78,660	8,879	11	2031	55-45	27	41		
[2] 12,230	2011	19,570	2,556	13	2031	50-50	11	16		

REQUESTED BY: NAME RON BAKER DATE 9/21/06  
 DIVISION PLANNING  
 ADDRESS 900 J. K. POLK BUILDING  
NASHVILLE TN 37243

REVIEWED BY: TONY ARMSTRONG Tony Armstrong DATE 9-28-06  
 TRANSPORTATION MANAGER 1  
 SUITE 1000, JAMES K. POLK BUILDING

APPROVED BY: BILL HART Bill Hart DATE 9.28.06  
 TRANSPORTATION MANAGER 2  
 SUITE 900, JAMES K. POLK BUILDING

**COMMENTS:**

- [1] I-65 TRAFFIC DATA
- [2] S.R. 109 TRAFFIC DATA

THIS TRAFFIC IS AN ADDITION TO THE PREVIOUS PROJECT PREPARED FOR YOU DATED 6-28-06 AND IS BASED ON THAT PROJECT. THIS IS THE EXISTING SYSTEM TRAFFIC FOR THE PROPOSED SYSTEM PROJECT DATED 6-28-06.

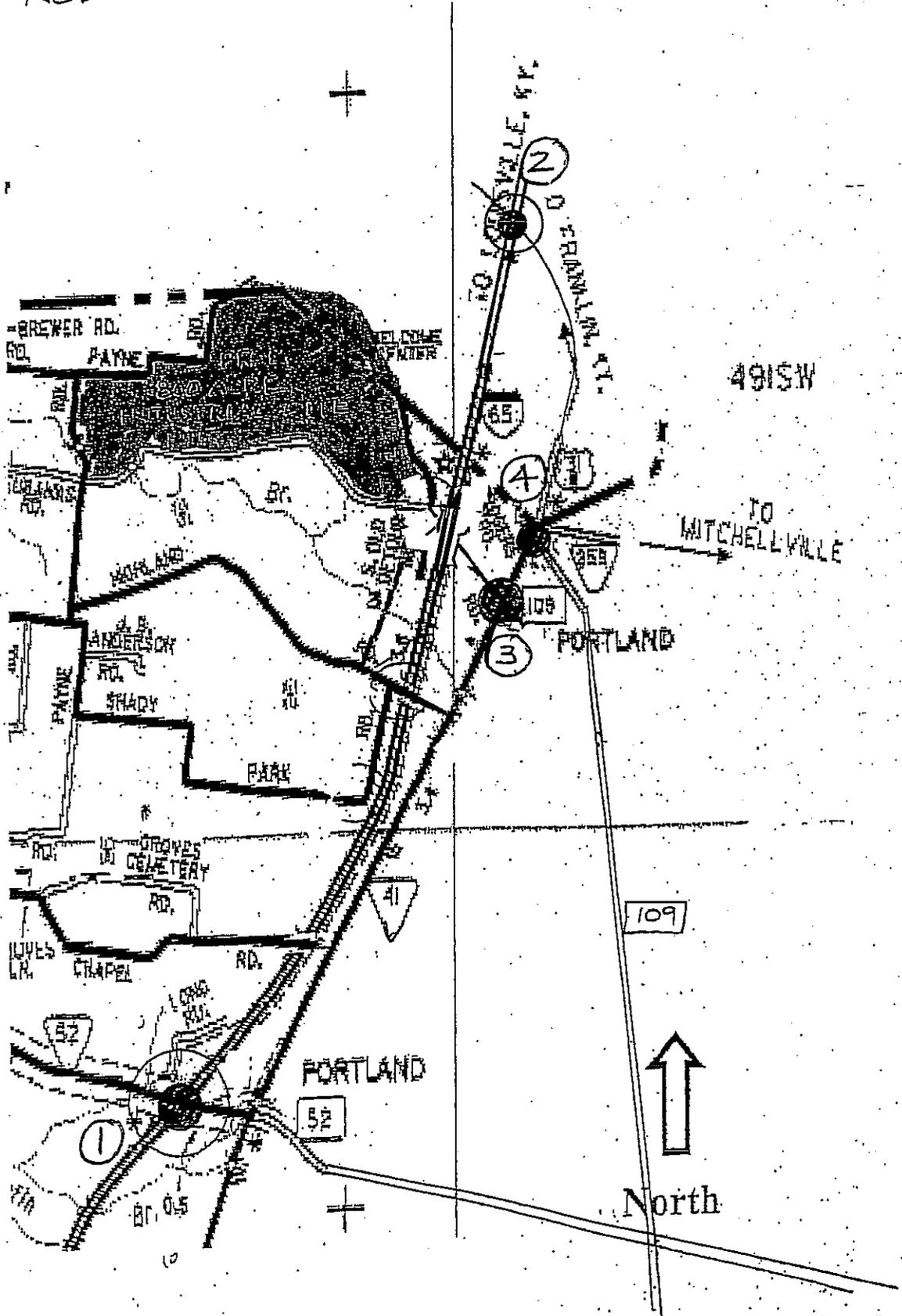
cc : STEPHEN SEWELL @ PALMER ENGINEERING

**DHV'S ARE NOT REQUIRED FOR SIDE ROADS LESS THAN 1000 ADT.**

NOTE: FOR BRIDGE REPLACEMENT PROJECTS, ADLs ARE NOT REQUIRED FOR ADTs OF 1000 OR LESS AND PERCENTAGE OF TRUCKS OF 7% OR LESS.  
 SEE ATTACHMENTS FOR TURNING MOVEMENTS AND/OR OTHER DETAILS.

# GENERAL LOCATION MAP

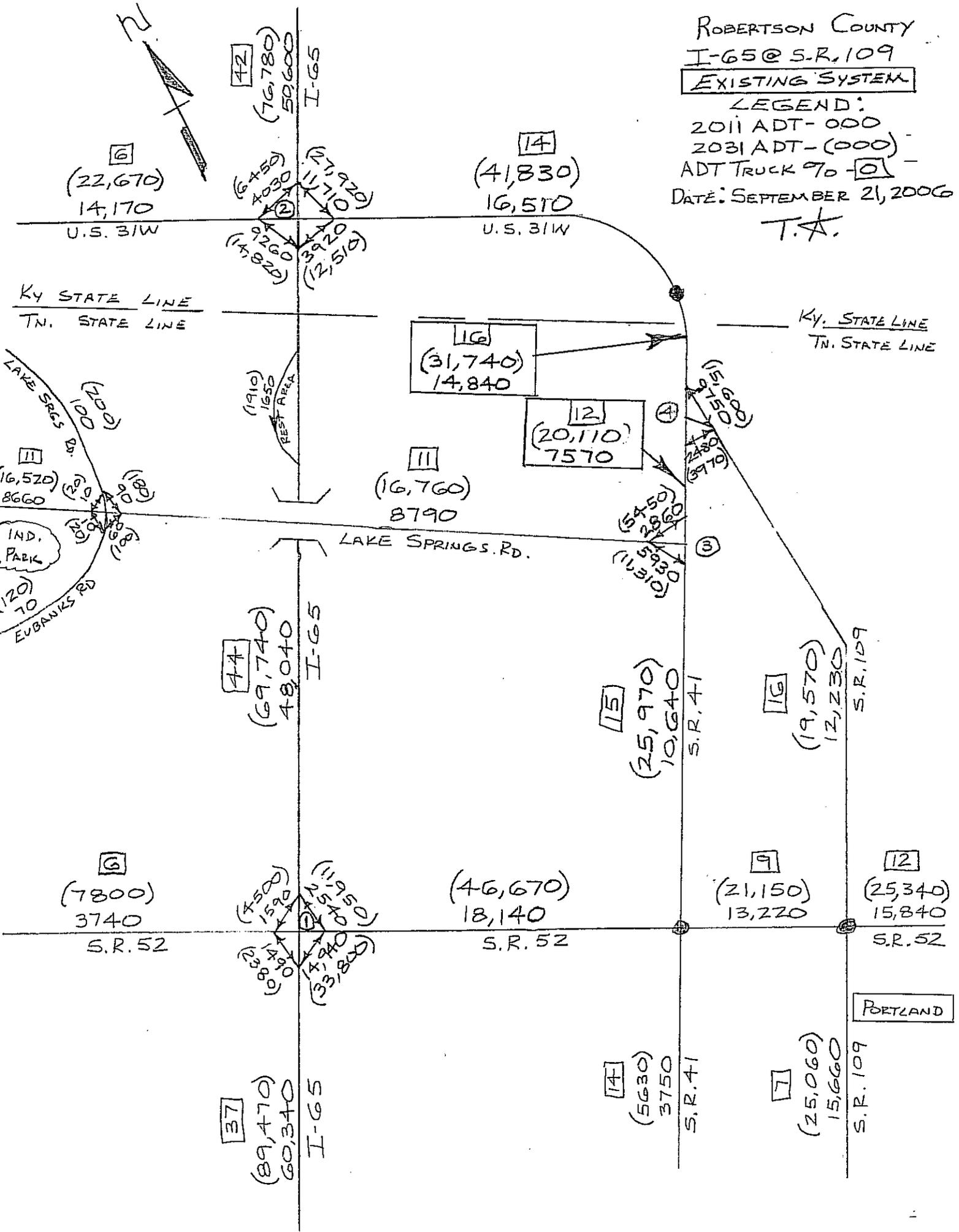
I-65 @ S.R. 109 (EXISTING SYSTEM)  
ROBERTSON COUNTY



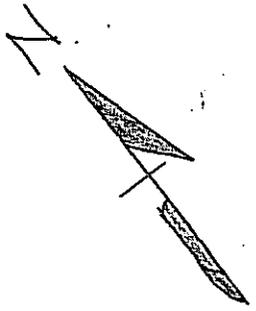
ROBERTSON COUNTY  
 I-65 @ S.R. 109  
**EXISTING SYSTEM**

LEGEND:  
 2011 ADT - 000  
 2031 ADT - (000)  
 ADT TRUCK % - [ ] -  
 DATE: SEPTEMBER 21, 2006

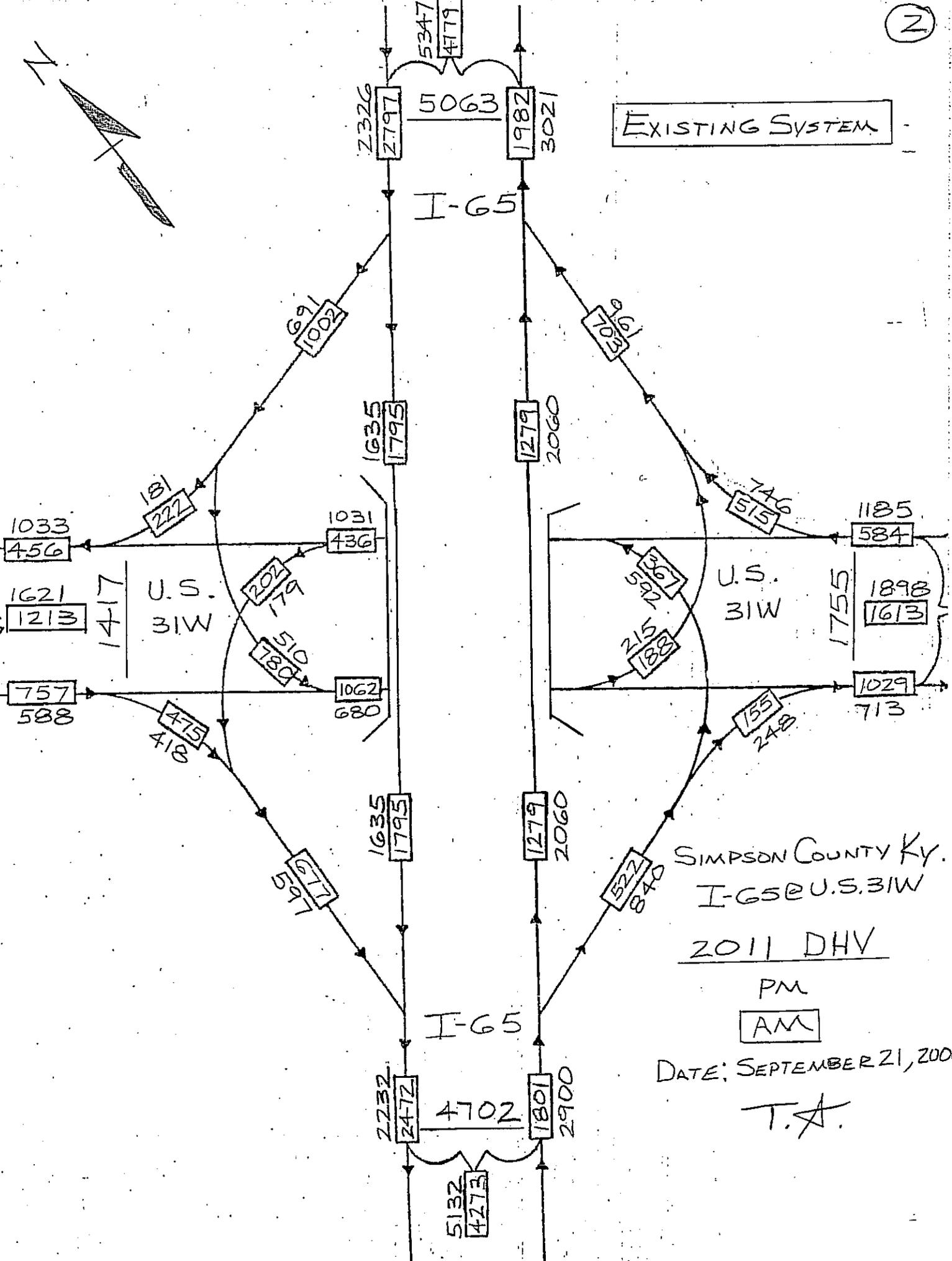
T.A.







EXISTING SYSTEM



2326 2797 5063 1982 3021

1635 1795

1279 2060

1033 456

1621 1213

757 588

1417 U.S. 31W

4715 418

202 179

510 780

1031 436

1062 680

1635 1795

1279 2060

307 592

215 188

746 515

U.S. 31W

155 248

1185 584

1755 1898 1613

1029 713

2732 2472 4702 1801 2900

5132 4273

522 840

SIMPSON COUNTY KY.  
I-65 @ U.S. 31W

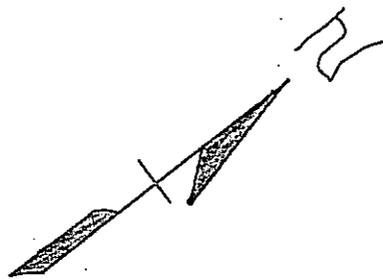
2011 DHV

PM

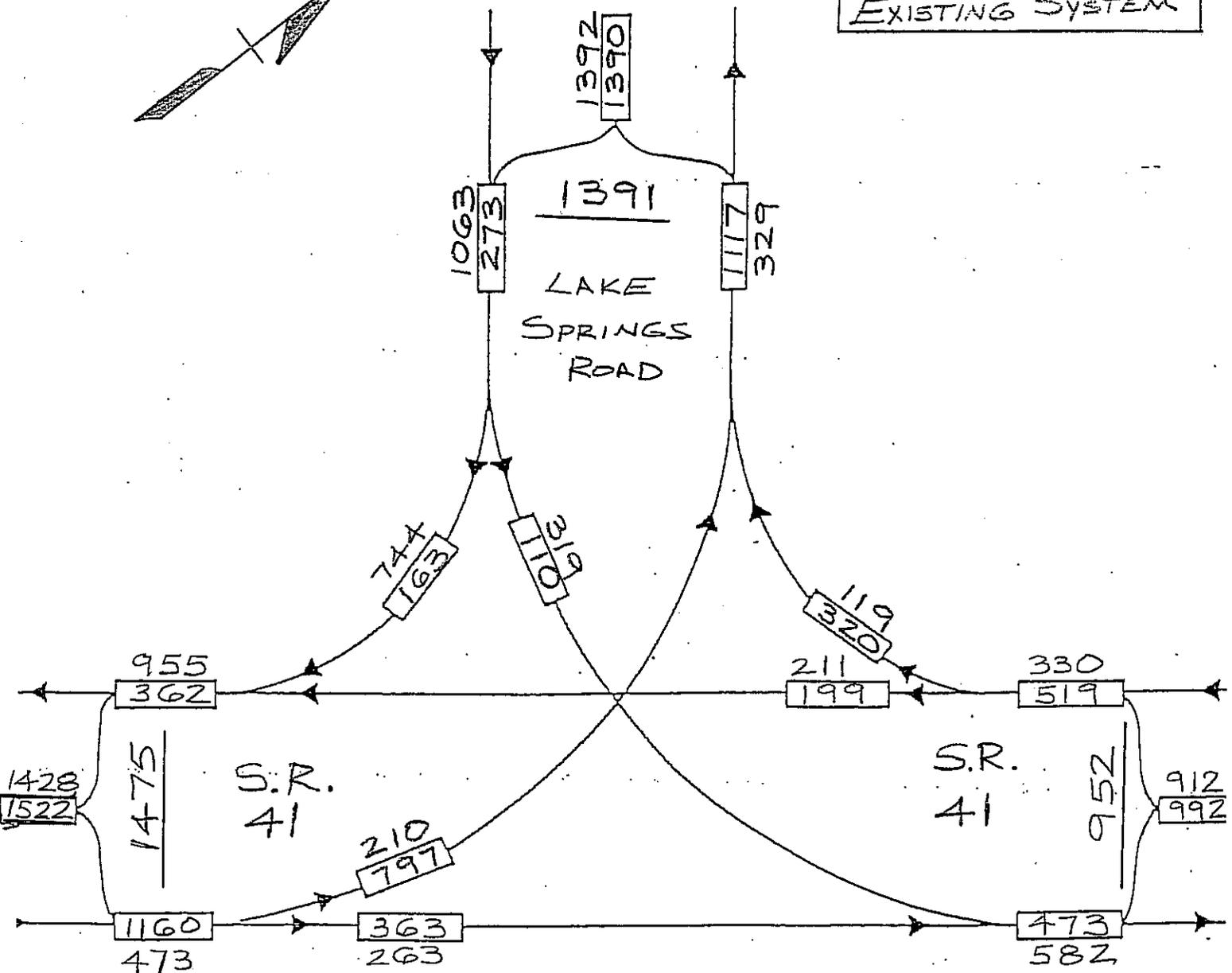
AM

DATE: SEPTEMBER 21, 2001

T.A.



EXISTING SYSTEM



ROBERTSON COUNTY  
LAKE SPGS. RD. @ S.R. 41

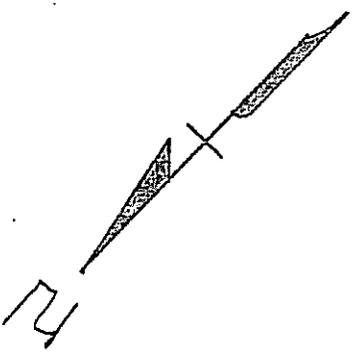
2011 DHV

PM

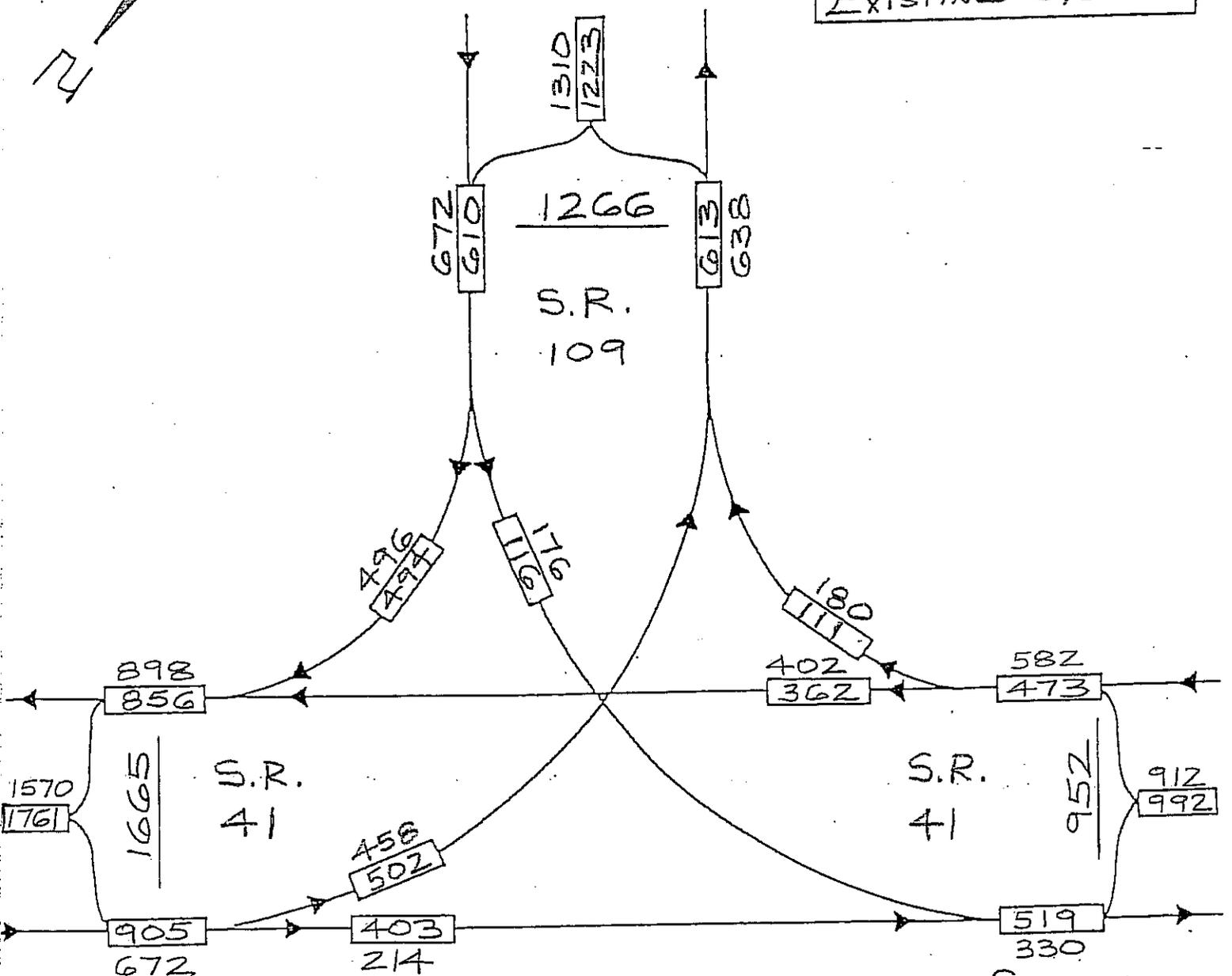
AM

DATE: SEPTEMBER 27, 2006

T.A.



EXISTING SYSTEM



ROBERTSON COUNTY  
S.R. 109 @ S.R. 41

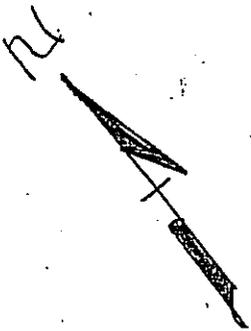
2011 DHV

PM

AM

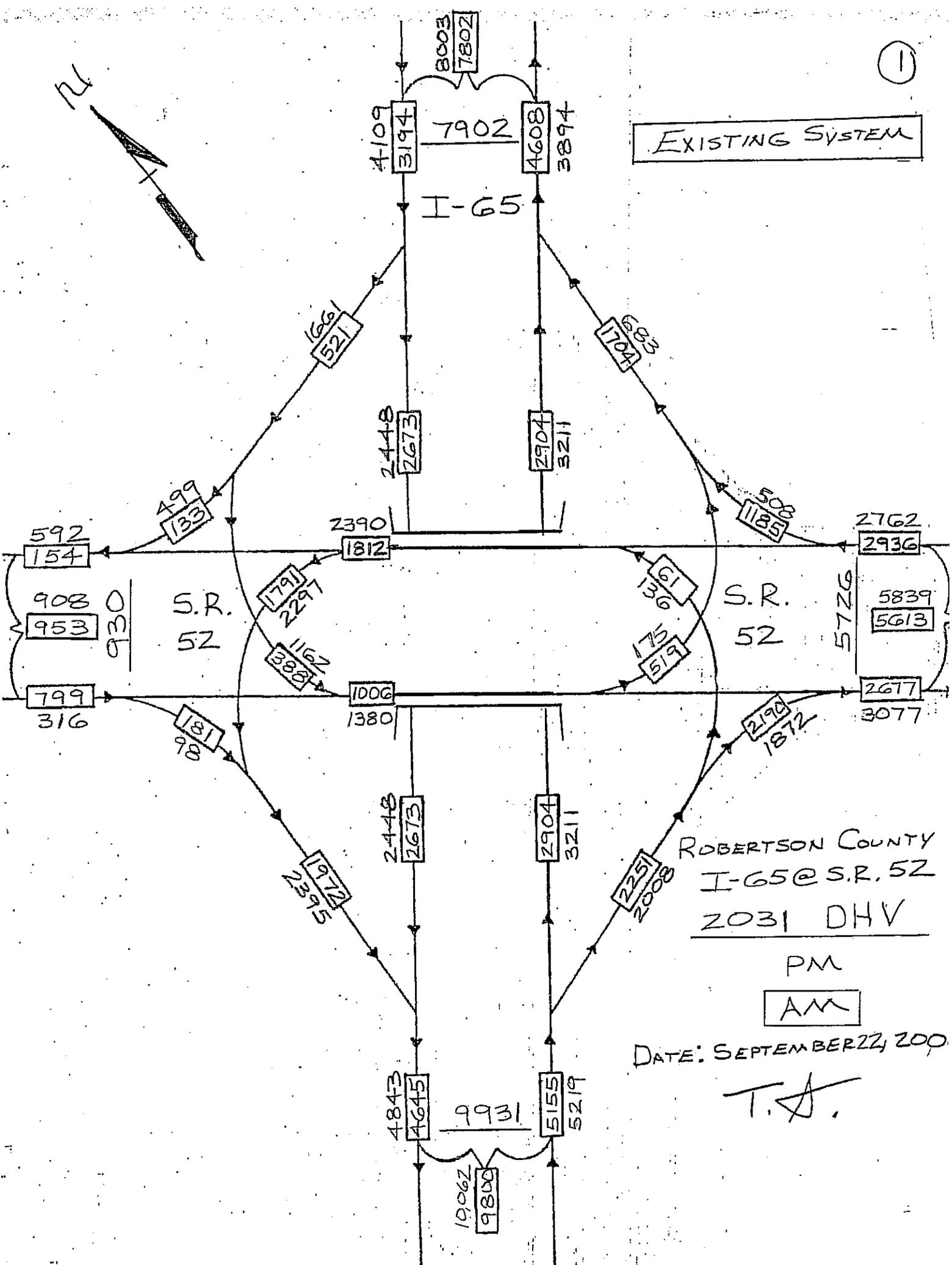
DATE: SEPTEMBER 27, 2006

T.A.



①

EXISTING SYSTEM



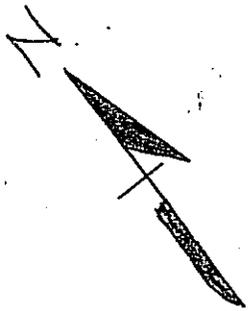
ROBERTSON COUNTY  
 I-65@S.R. 52  
 2031 DHV

PM  
 AM

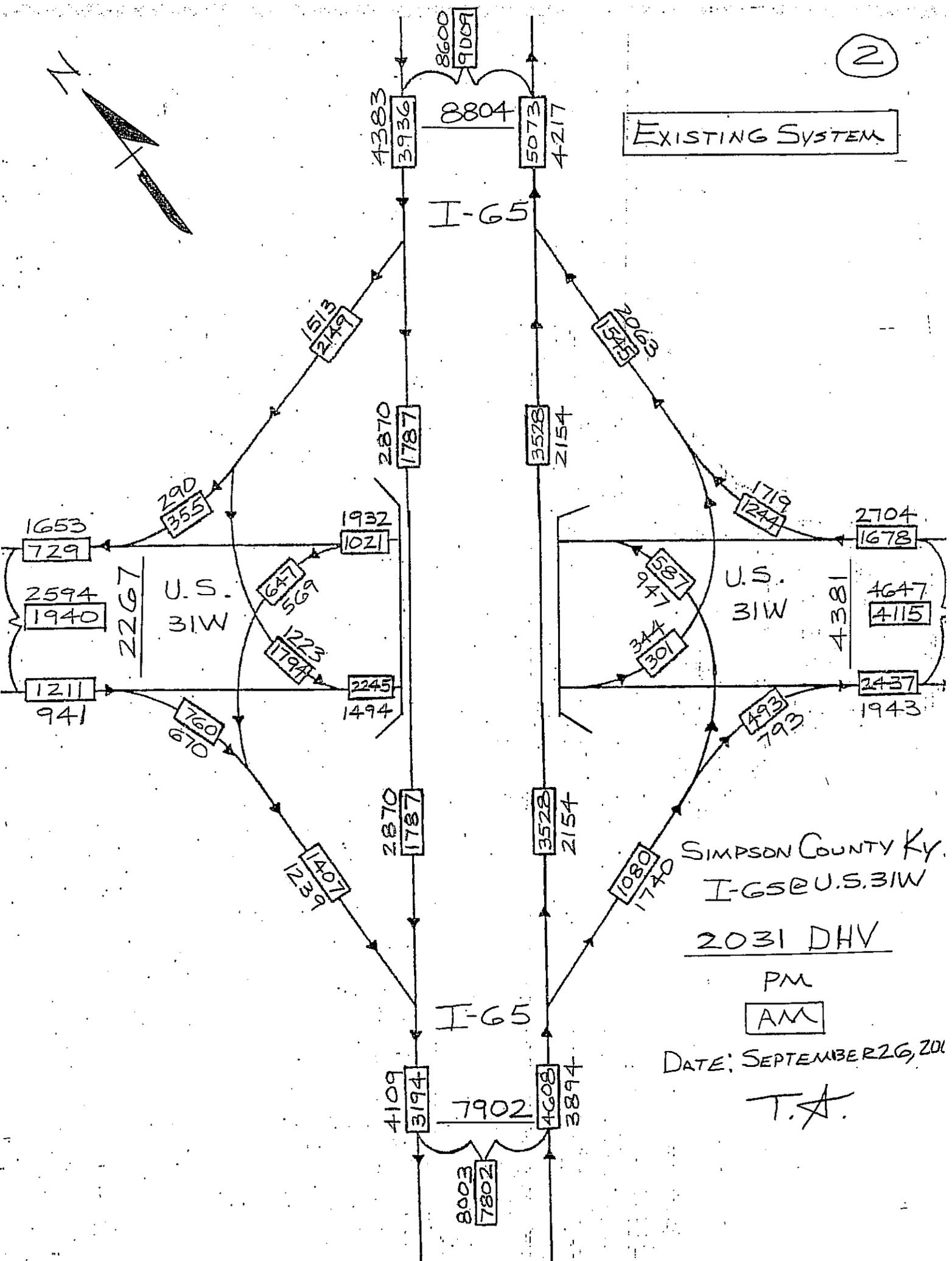
DATE: SEPTEMBER 22, 200

T.A.

2



EXISTING SYSTEM



SIMPSON COUNTY Ky.  
I-65 @ U.S. 31W

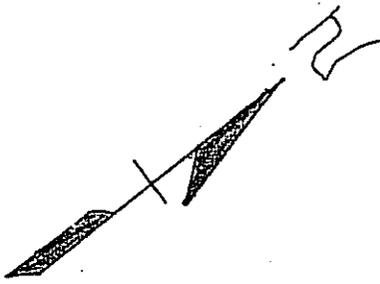
2031 DHV

PM  
AM

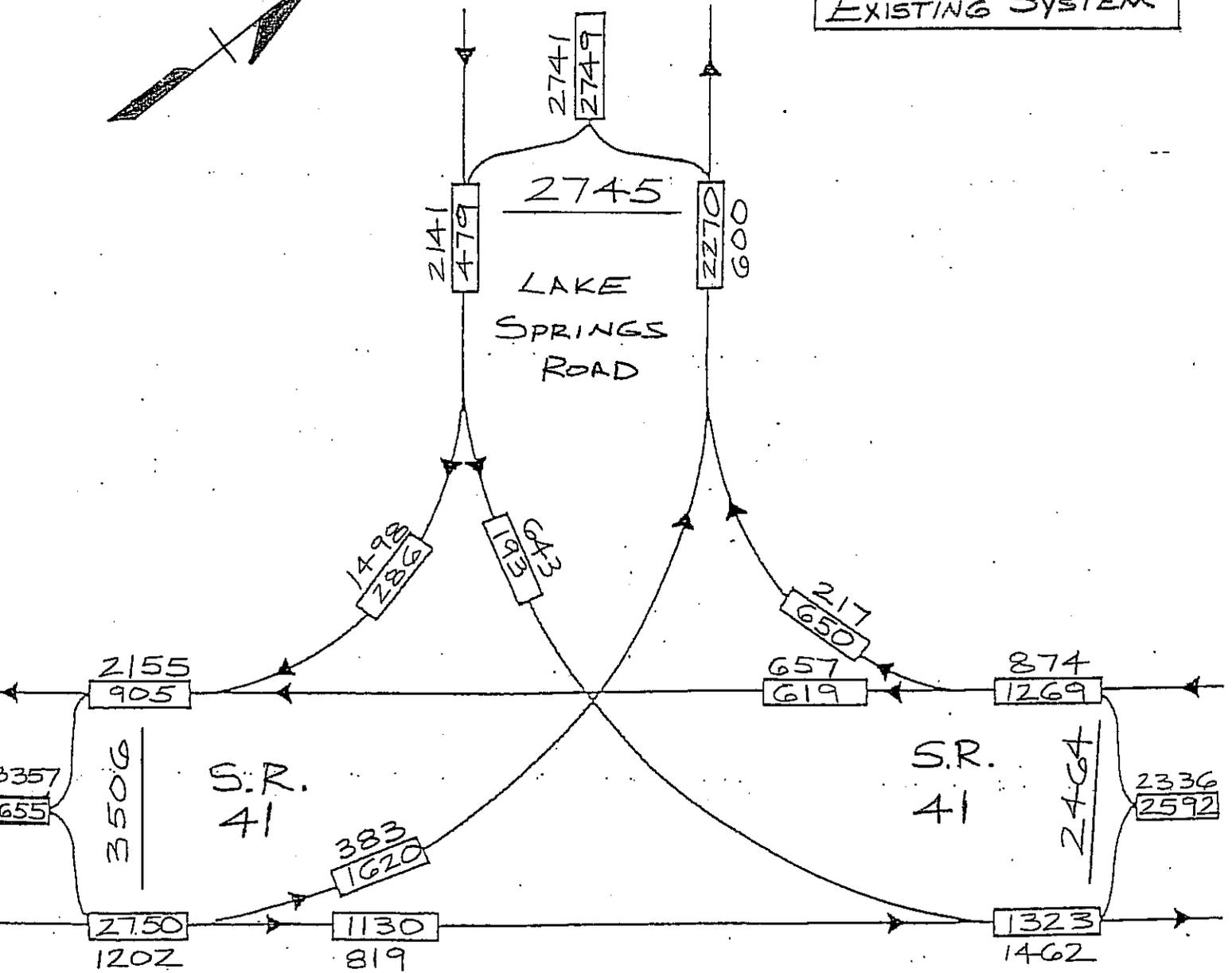
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T.A.

3



EXISTING SYSTEM



ROBERTSON COUNTY  
LAKE SPGS. RD. @ S.R. 41

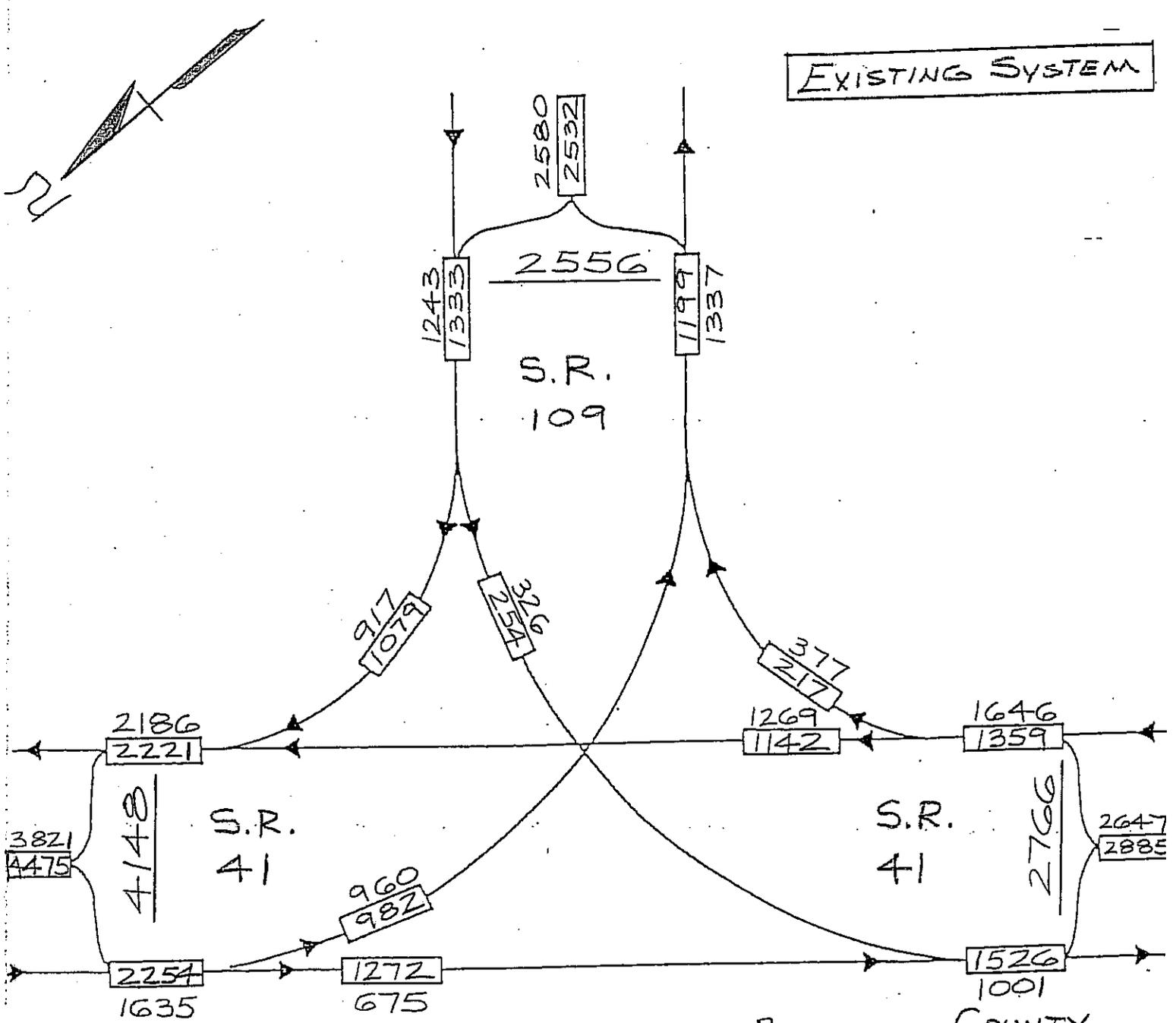
2031 DHV

PM

AM

DATE: SEPTEMBER 27, 2006

T.A.



EXISTING SYSTEM

S.R.  
109

S.R.  
41

S.R.  
41

ROBERTSON COUNTY  
S.R. 109 @ S.R. 41

2031 DHV

PM  
AM

DATE: SEPTEMBER 27, 2006

T.A.

**TENNESSEE DEPARTMENT OF TRANSPORTATION  
PROJECT PLANNING DIVISION**

PROJECT NO.: \_\_\_\_\_ ROUTE: I-65  
 COUNTY: ROBERTSON CITY: \_\_\_\_\_  
 PROJECT PIN NUMBER: \_\_\_\_\_  
 PROJECT DESCRIPTION: PROPOSED INTERCHANGE @ I-65 & S.R. 109

[1] I-65 AVERAGE TRAFFIC DATA.

[2] S.R. 109 AVERAGE TRAFFIC DATA.

**DIVISION REQUESTING:**

MAINTENANCE	<input type="checkbox"/>	PAVEMENT DESIGN	<input type="checkbox"/>
PLANNING	<input checked="" type="checkbox"/>	STRUCTURES	<input type="checkbox"/>
PROG. DEVELOPMENT & ADM.	<input type="checkbox"/>	SURVEY & DESIGN	<input type="checkbox"/>
PUBLIC TRANS. & AERO.	<input type="checkbox"/>	TRAFFIC SIGNAL DESIGN	<input type="checkbox"/>
YEAR PROJECT PROGRAMMED FOR CONSTRUCTION:	_____	OTHER _____	<input type="checkbox"/>
PROJECTED LETTING DATE:	_____		

**TRAFFIC ASSIGNMENT:**

BASE YEAR	DESIGN YEAR						DESIGN ROADWAY % TRUCKS		DESIGN AVERAGE DAILY LOADS	
	ADT	YEAR	ADT	DHV	%	YEAR	DIR. DIST.	DHV	ADT	FLEX
[1] 56,190	2011	87,240	9,596	11	2031	55-45	27	40		
[2] 9,160	2011	20,280	2,636	13	2031	65-35	11	16		

REQUESTED BY: NAME RON BAKER DATE 4/10/06  
 DIVISION PLANNING  
 ADDRESS 900 J. K. POLK BUILDING  
NASHVILLE TN 37243

REVIEWED BY: TONY ARMSTRONG Tony Armstrong DATE 6.28.06  
 TRANSPORTATION MANAGER 1  
 SUITE 1000, JAMES K. POLK BUILDING

APPROVED BY: BILL HART Bill Hart DATE 6.28.06  
 TRANSPORTATION MANAGER 2  
 SUITE 900, JAMES K. POLK BUILDING

**COMMENTS:**

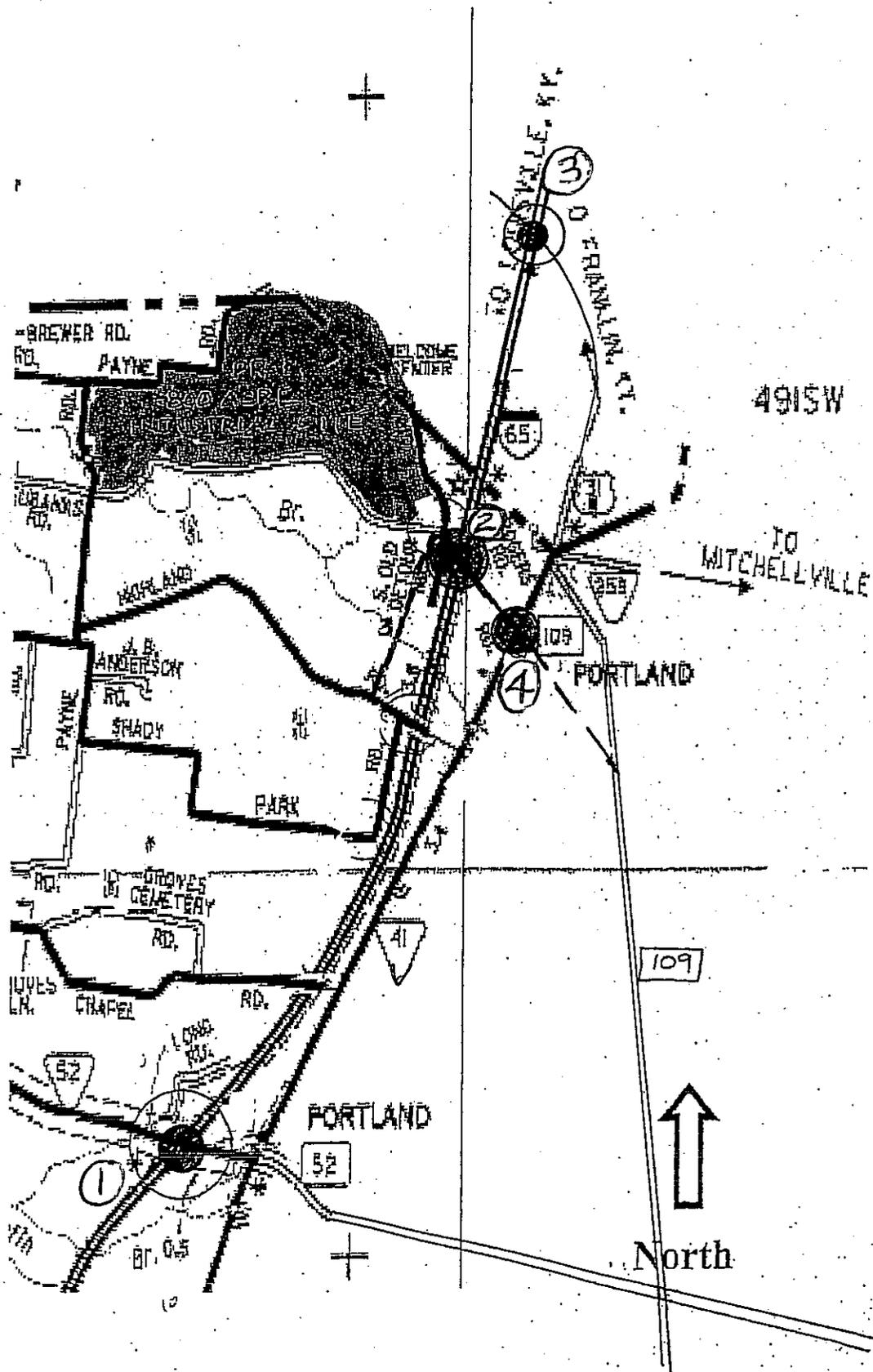
THIS PROJECT BASED ON 2005 CYCLE COUNTS, 2-12 HOUR [JUNE 2006] TURNING MOVEMENT COUNTS. THE FUTURE TRAFFIC INCLUDES TRAFFIC FOR THE 920 ACRE INDUSTRIAL PARK THAT IS UNDER CONSTRUCTION ON THE WEST SIDE OF I-65. FUTURE TRAFFIC ALSO BASED ON THE NASHVILLE COMPUTER ASSIGNMENT MPO MODEL. DUE TO THE USE OF THE MODEL THE GROWTH RATE ON I-65 WAS LOWERED. FUTURE TRAFFIC FOR THE INDUSTRIAL PARK & I-65 WERE LOWERED COMPARED TO THE PREVIOUS PROJECT DATED 5-9-05.

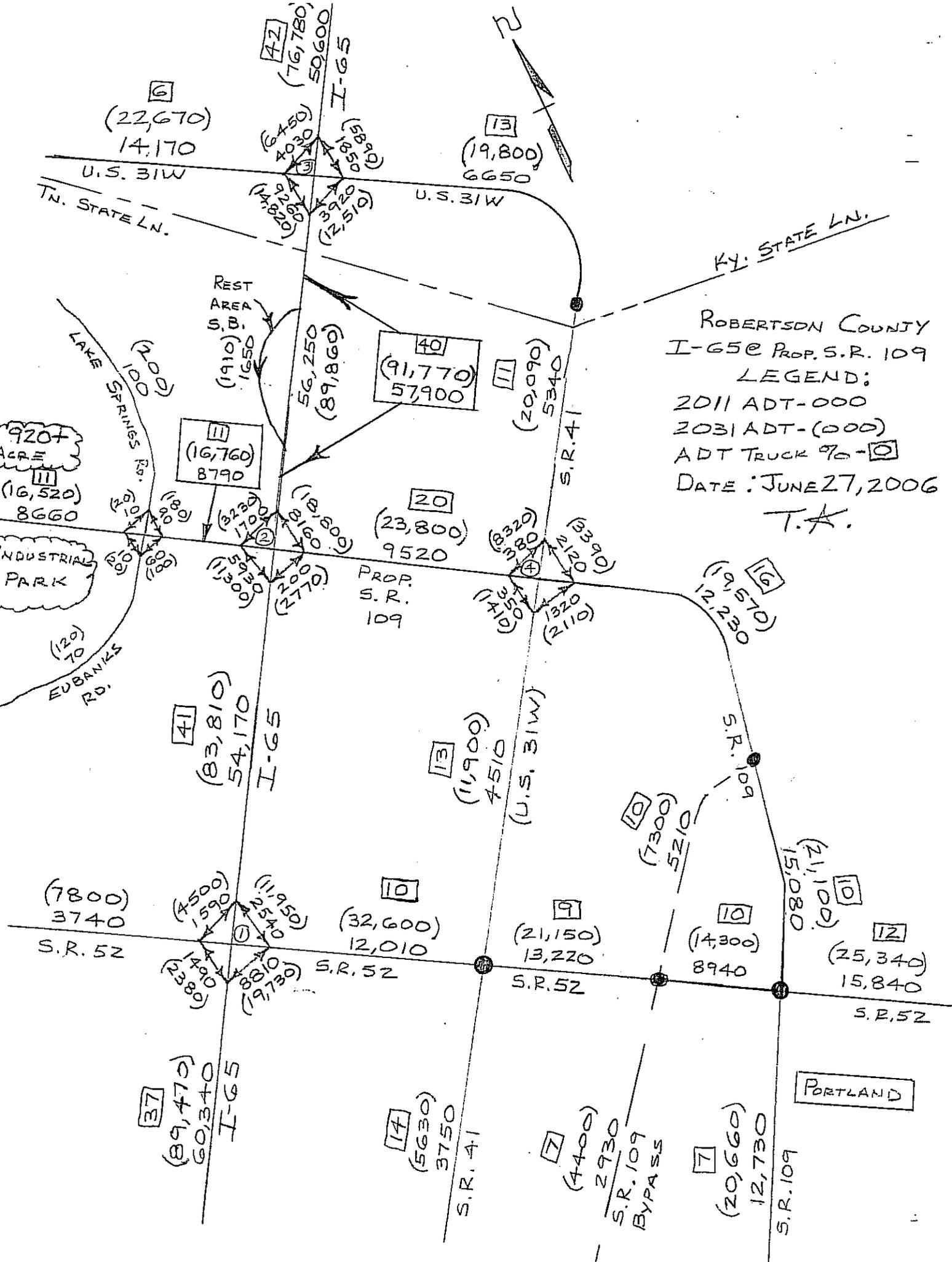
**DHV'S ARE NOT REQUIRED FOR SIDE ROADS LESS THAN 1000 ADT.**

NOTE: FOR BRIDGE REPLACEMENT PROJECTS, ADLs ARE NOT REQUIRED FOR ADTs OF 1000 OR LESS AND PERCENTAGE OF TRUCKS OF 7% OR LESS.  
 SEE ATTACHMENTS FOR TURNING MOVEMENTS AND/OR OTHER DETAILS.

# GENERAL LOCATION MAP

I-65 @ S.R. 109 PROPOSED INTERCHANGE  
ROBERTSON COUNTY





ROBERTSON COUNTY  
 I-65 @ PROP. S.R. 109  
 LEGEND:

2011 ADT-000  
 2031 ADT-(000)  
 ADT TRUCK %-[ ]  
 DATE: JUNE 27, 2006

T.A.

[6]  
 (22,670)  
 14.170

[13]  
 (19,800)  
 6650

[40]  
 (91,770)  
 57.900

[11]  
 (16,760)  
 87.90

[20]  
 (23,800)  
 9.520

920+  
 ACRE  
 [11]  
 (16,520)  
 86.660

INDUSTRIAL  
 PARK

[41]  
 (83,810)  
 54.170

[13]  
 (11,900)  
 4.510

[10]  
 (32,600)  
 12.010

(7800)  
 37.40

[9]  
 (21,150)  
 13.220

[10]  
 (7300)  
 5.210

[10]  
 (14,300)  
 8.940

[10]  
 (21,100)  
 15.080

[12]  
 (25,340)  
 15.840

[37]  
 (89,470)  
 60.340

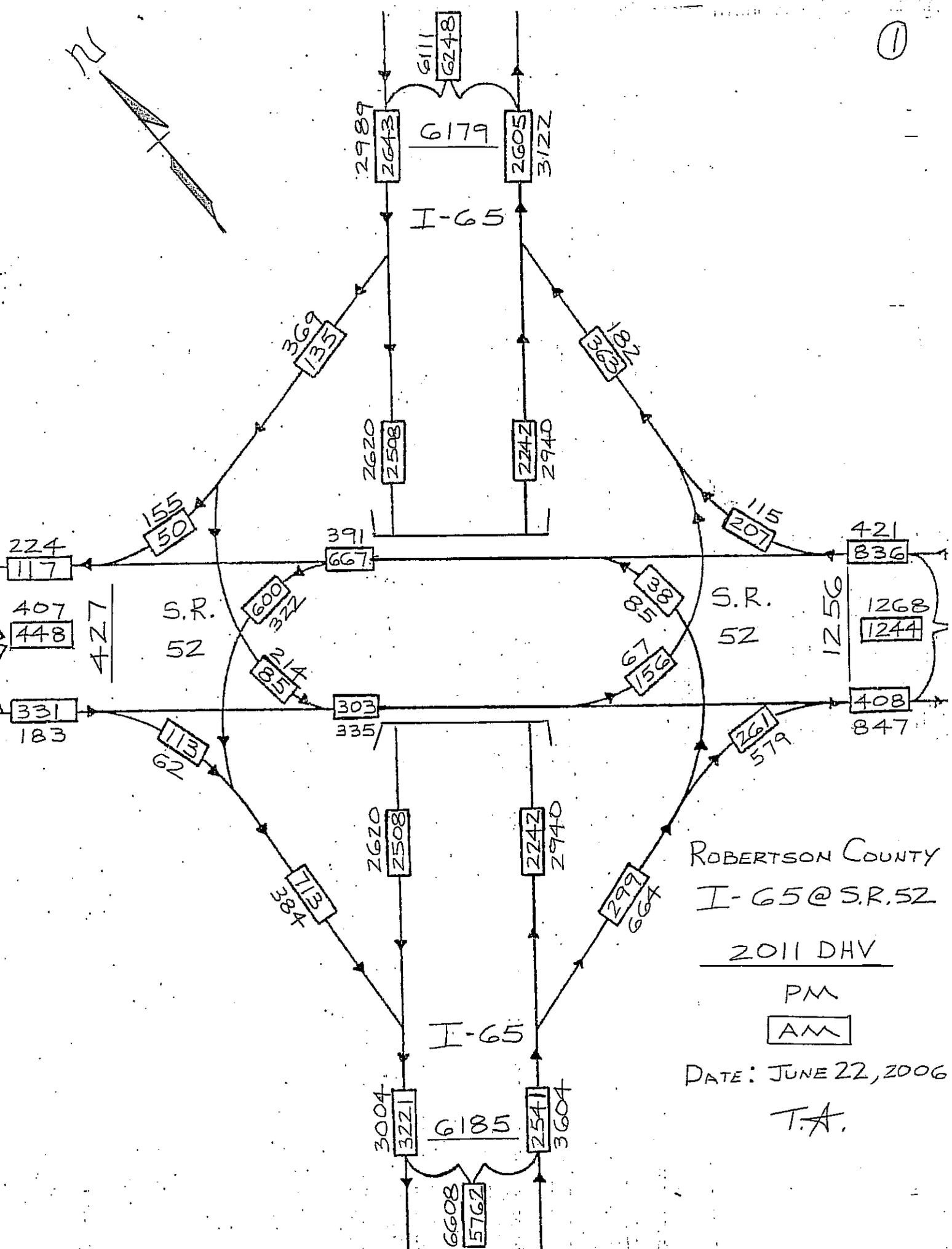
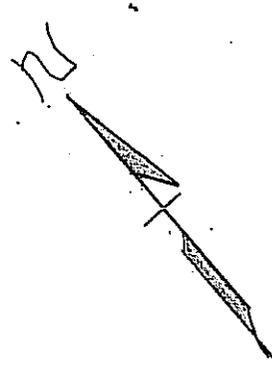
[14]  
 (5630)  
 3.750

[7]  
 (4400)  
 2.930

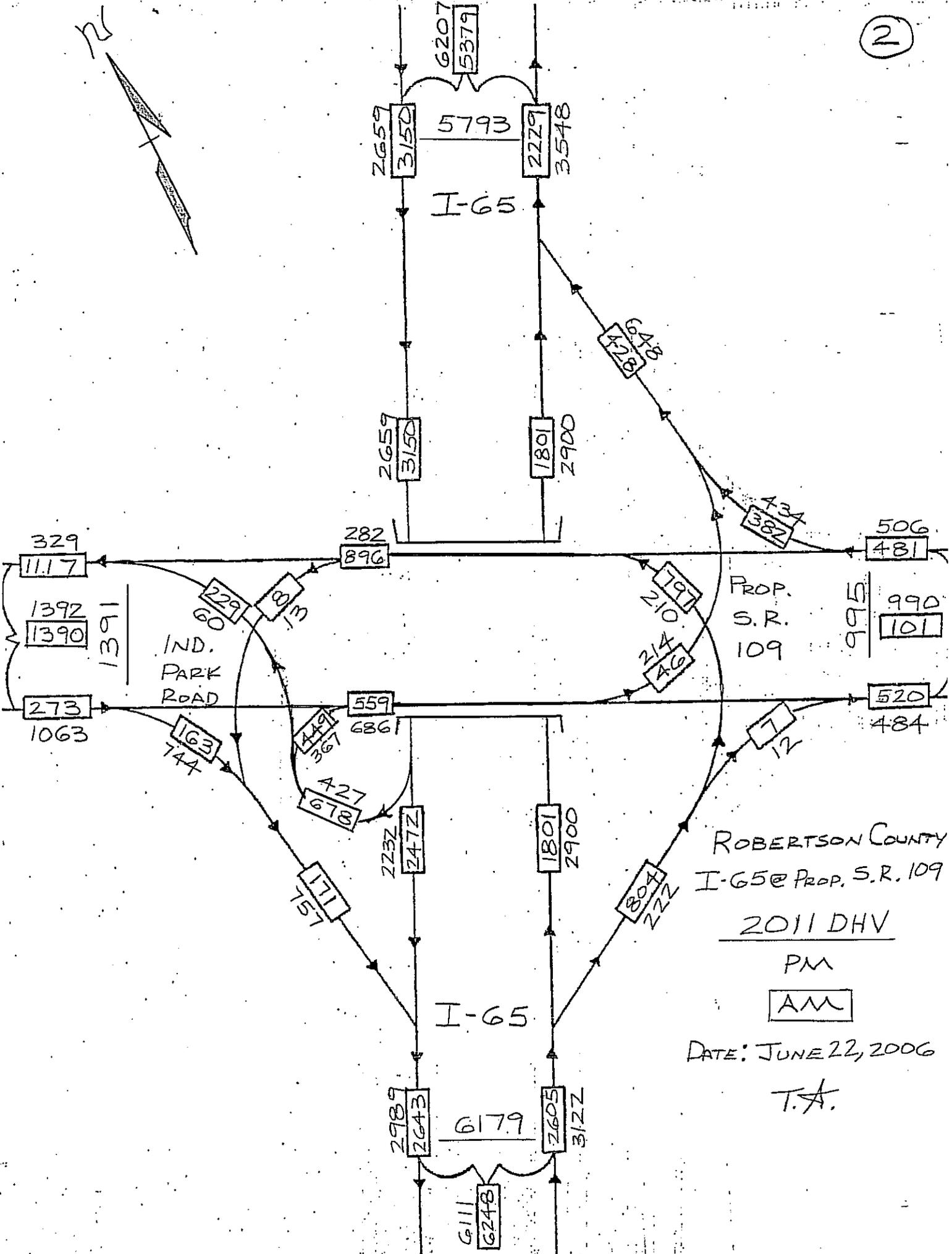
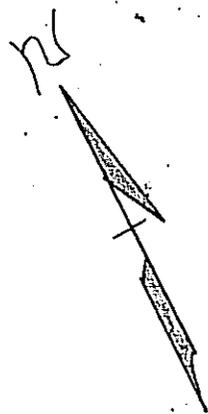
[7]  
 (20,660)  
 12.730

PORTLAND

①



ROBERTSON COUNTY  
 I-65@S.R.52  
 2011 DHV  
 PM  
 AM  
 DATE: JUNE 22, 2006  
 T.A.



ROBERTSON COUNTY  
I-65 @ Prop. S.R. 109

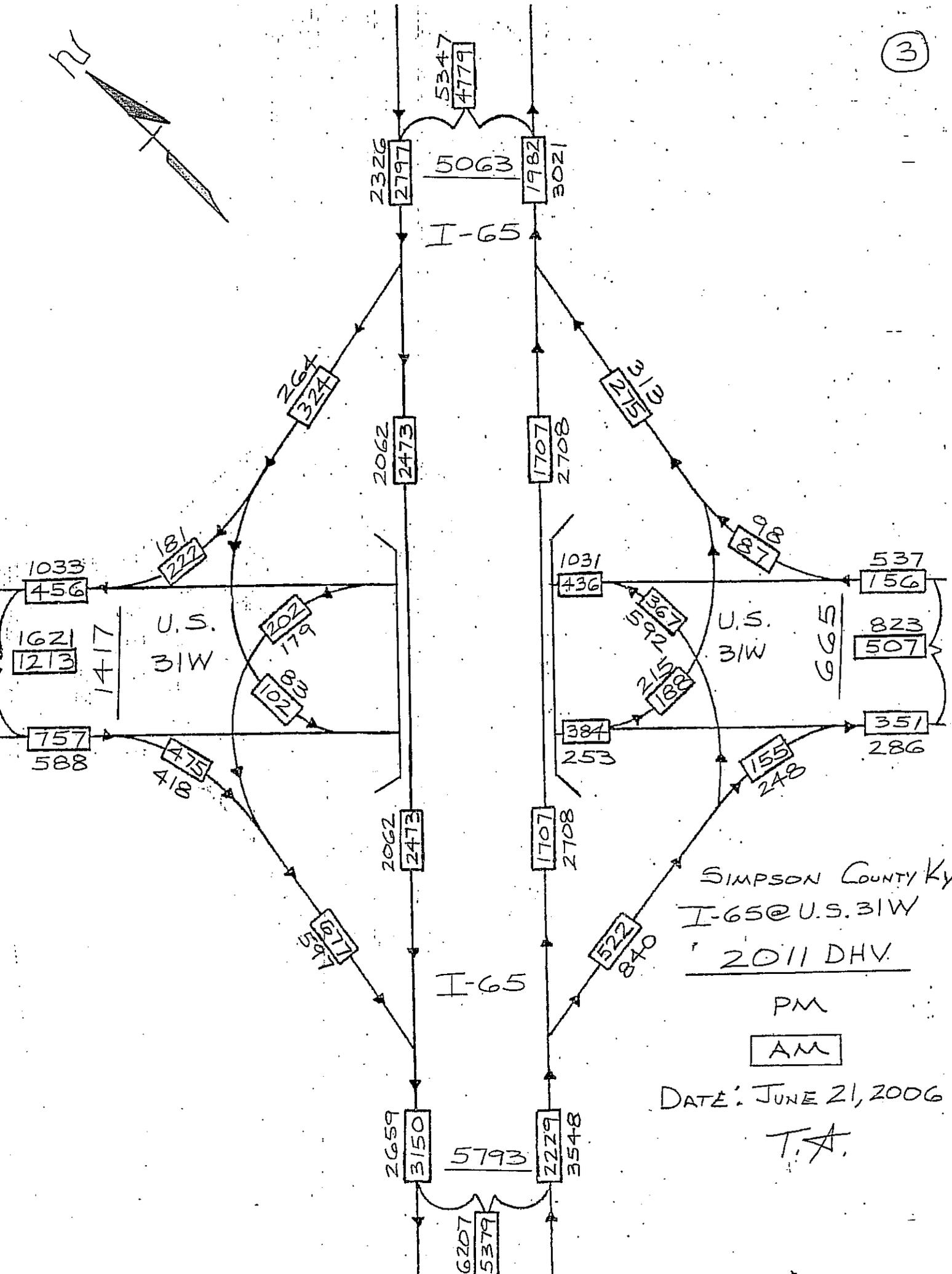
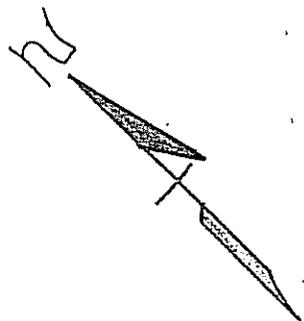
2011 DHV

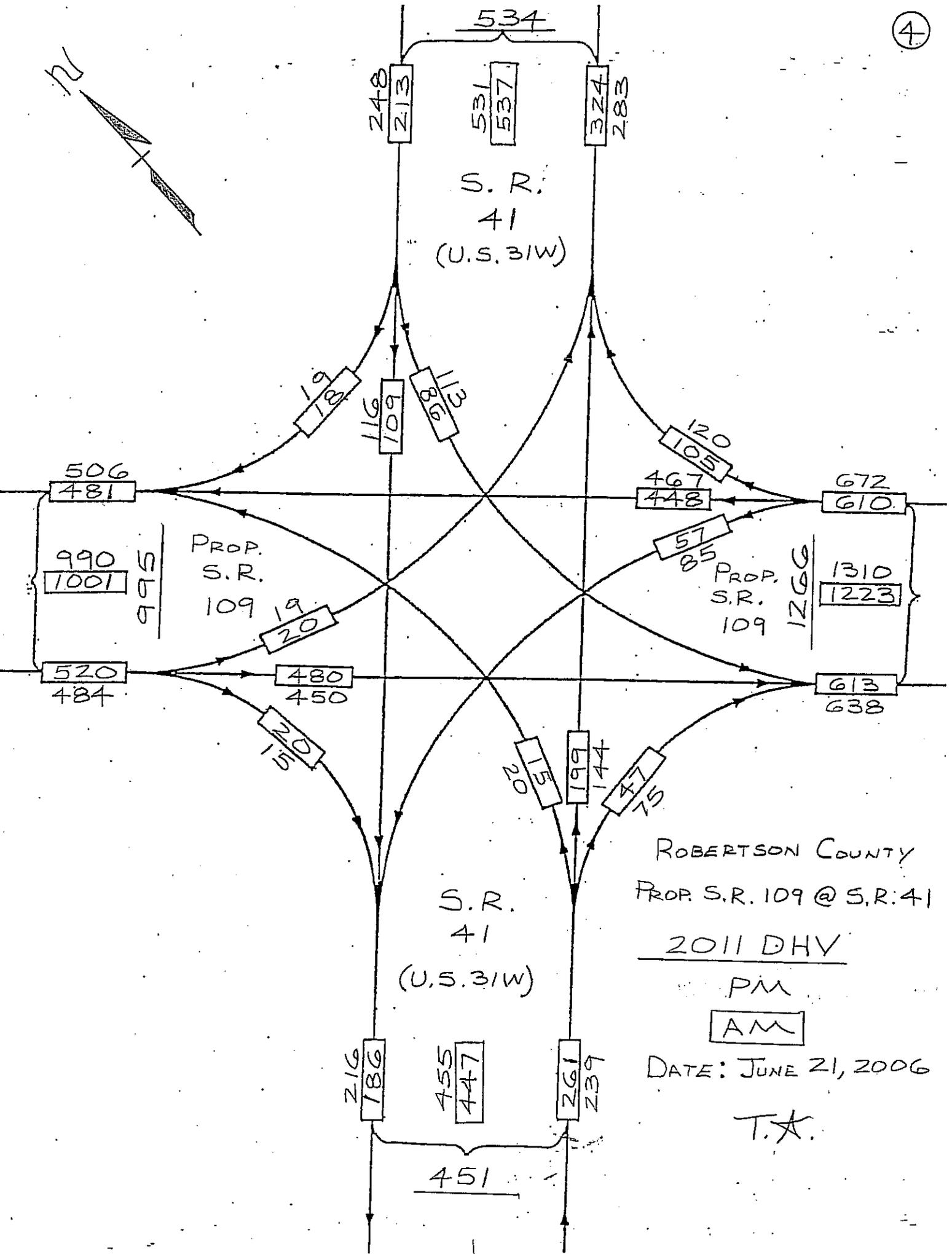
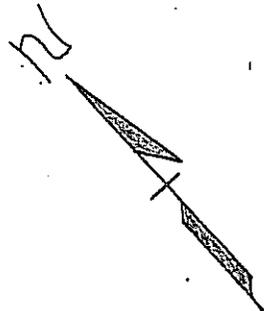
PM

AM

DATE: JUNE 22, 2006

T.A.





U. R.  
41  
(U.S. 31W)

PROP.  
S.R.  
109

PROP.  
S.R.  
109

U. R.  
41  
(U.S. 31W)

ROBERTSON COUNTY  
PROP. S.R. 109 @ S.R. 41

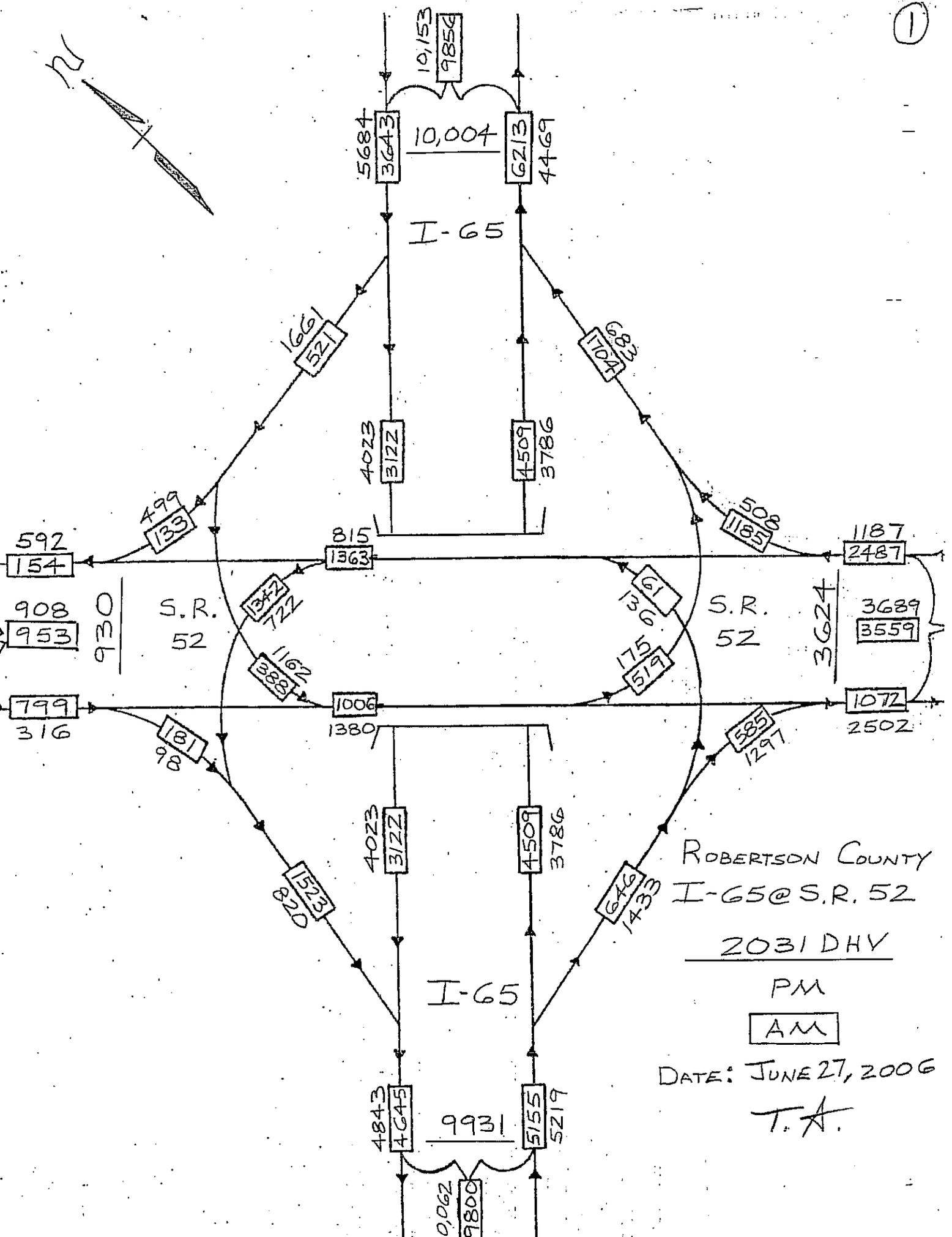
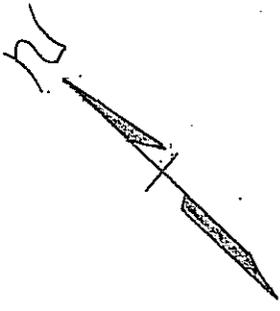
2011 DHV

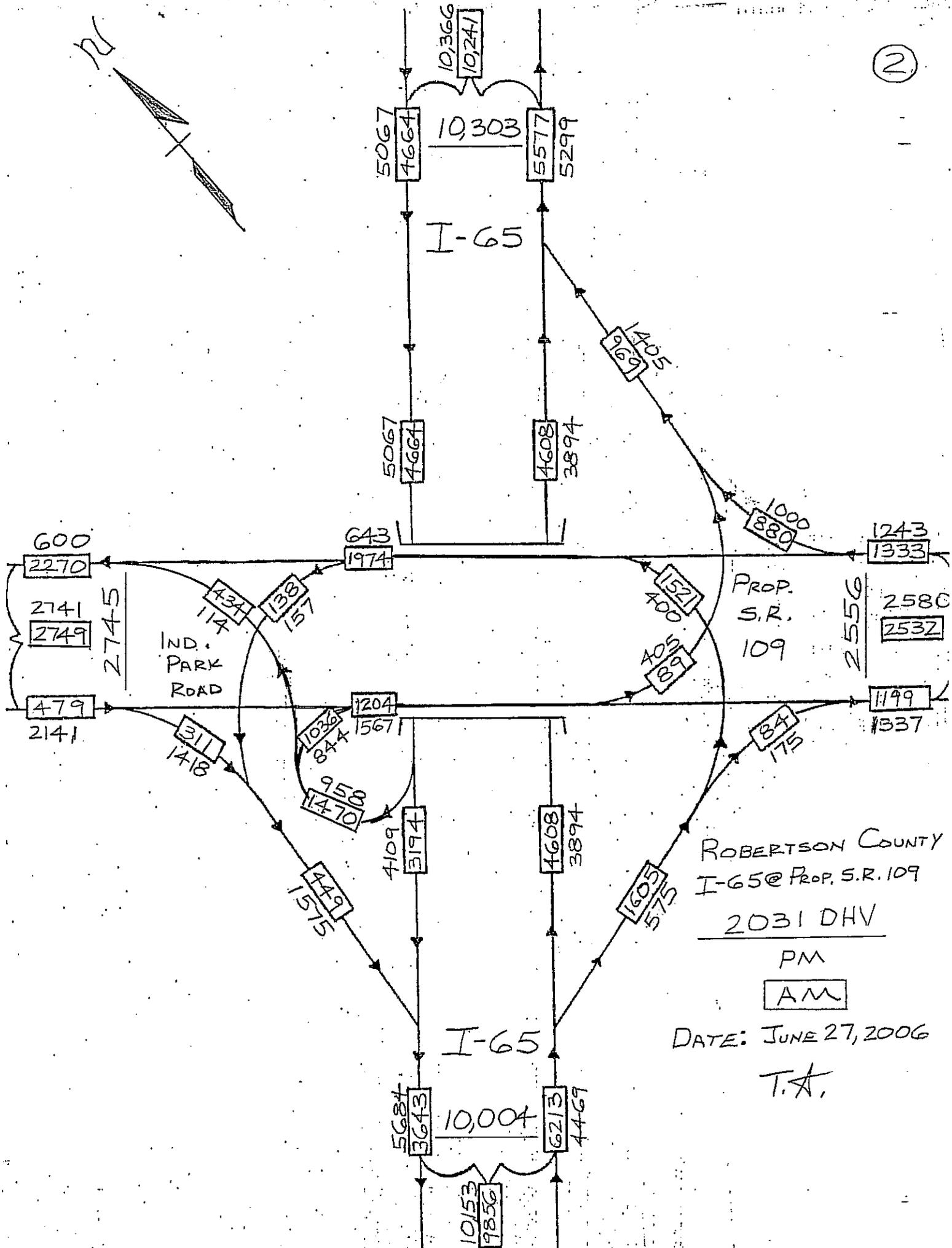
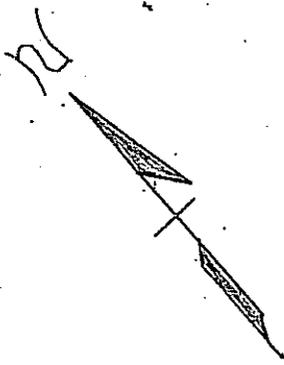
PM

AM

DATE: JUNE 21, 2006

T.A.





ROBERTSON COUNTY  
 I-65 @ Prop. S.R. 109

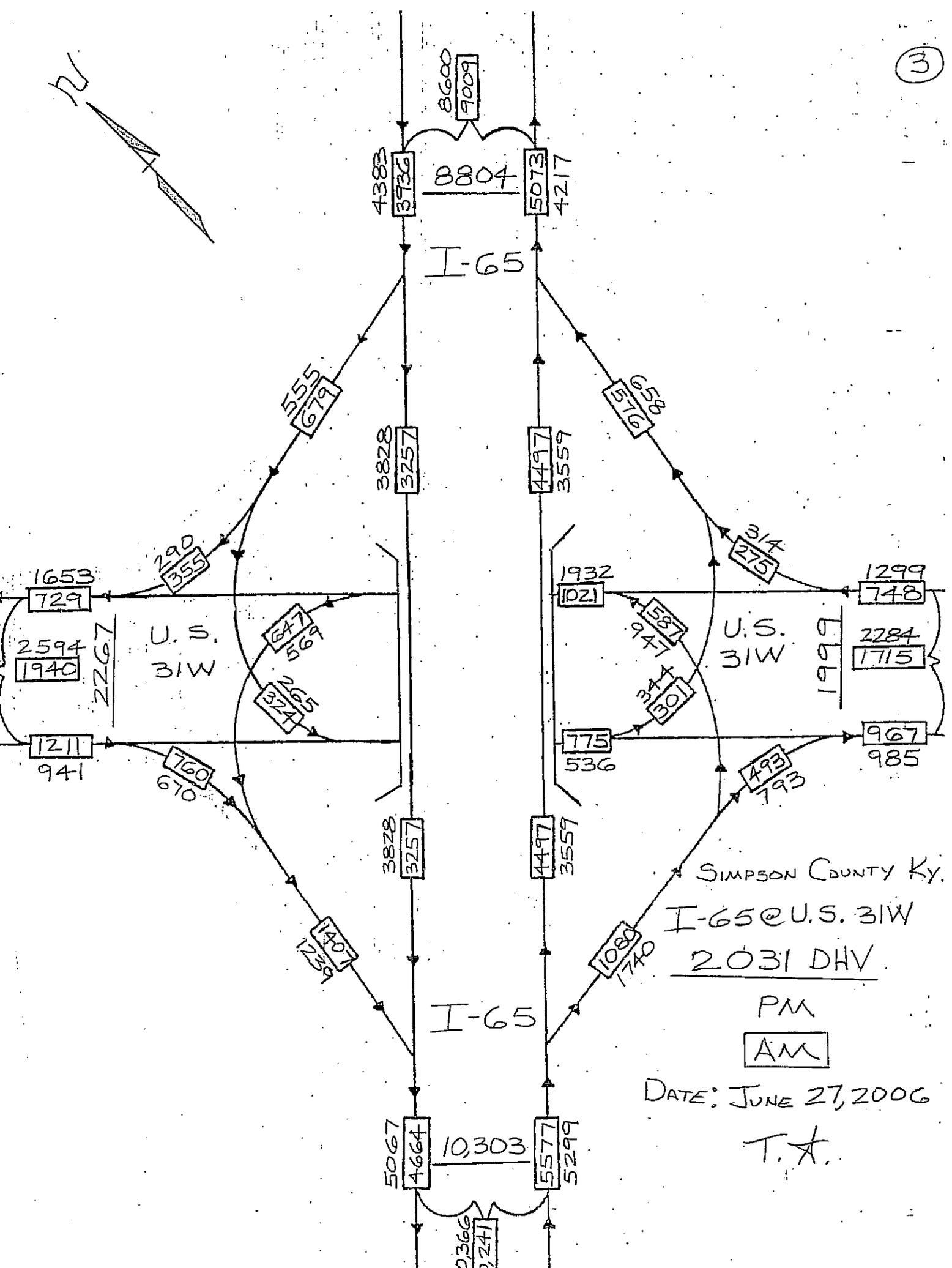
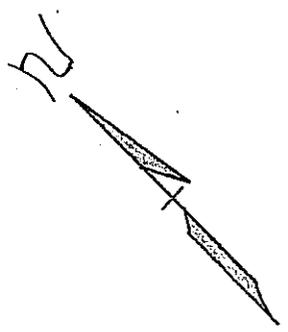
2031 DHV

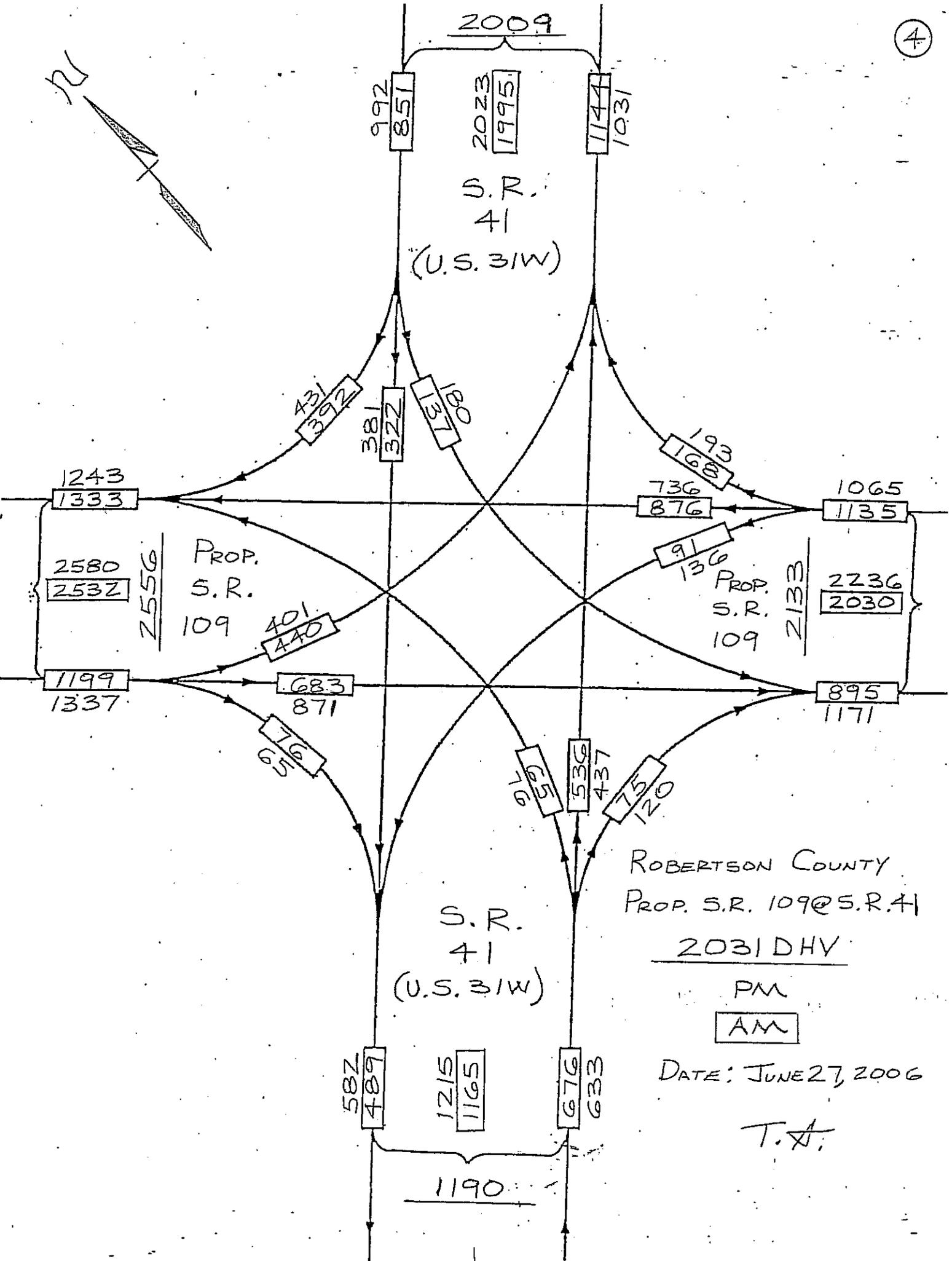
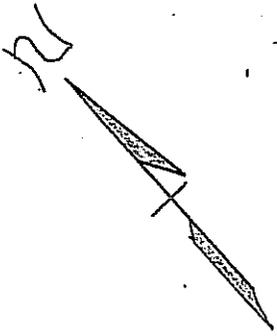
PM

AM

DATE: JUNE 27, 2006

T.A.





U.S. 31W  
41  
(U.S. 31W)

PROP. S.R. 109

PROP. S.R. 109

S.R. 41  
(U.S. 31W)

ROBERTSON COUNTY  
PROP. S.R. 109@S.R.41

2031 DHV

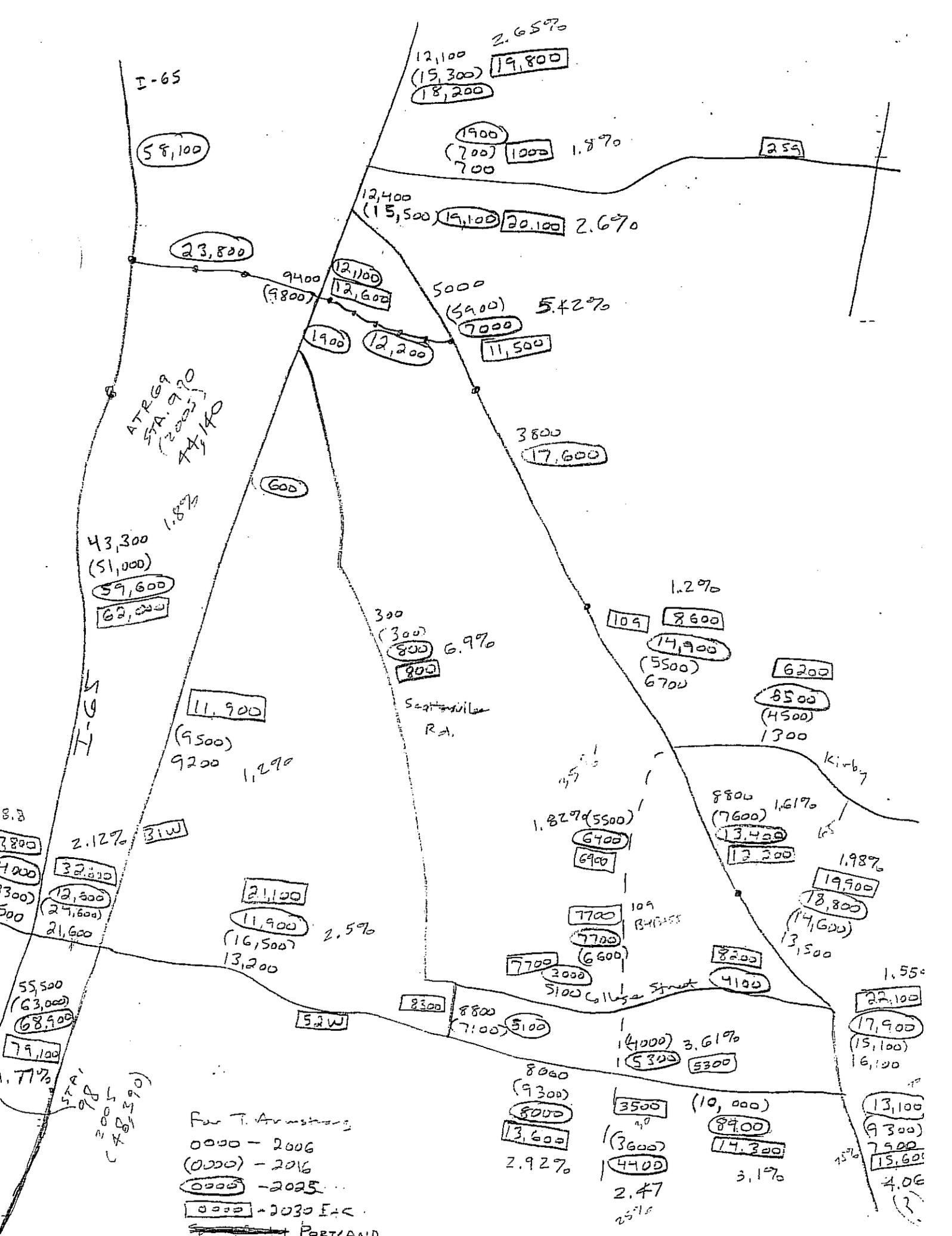
PM

AM

DATE: JUNE 27, 2006

T.A.

1190



I-65  
 58,100

12,100  
 (15,300) 19,800  
 18,200  
 2.65%

1900  
 (700) 1000 1.87%

255

12,400  
 (15,500) 19,100 20,100 2.67%

23,800

9400  
 (9800) 12,100  
 12,600

5000  
 (5900) 5.42%  
 7000  
 11,500

ATR 69  
 57A. 970  
 (2000)  
 44,140

1900 12,200

3800  
 17,600

600

43,300 1.87%  
 (51,000)  
 59,600  
 62,000

300  
 (300) 800 6.97%  
 800

1.27%  
 109 8600  
 14,900  
 (5500) 6700

6200  
 8500  
 (4500) 1300

Scotts Mill Rd.

11,900  
 (9500) 9200 1.27%

8800 1.61%  
 (7600) 13,400  
 13,200

1.82% (5500)  
 6700  
 6900

1.98%  
 19,900  
 18,800  
 (14,600) 13,500

8.3  
 3800  
 4000  
 3300  
 500  
 2.12%  
 31W  
 32,000  
 12,600  
 (24,600) 21,600

21,100  
 11,900 2.57%  
 (16,500) 13,200

109  
 7700  
 (7700) (6600)  
 7700 3000

8200  
 4100

1.55%  
 27,100  
 17,900  
 (15,100) 16,100

8300  
 8800  
 (7100) 5100  
 14,000 3.61%  
 15,300 5300

8000  
 (9300) 8000  
 13,600 2.92%  
 3500  
 (3600) 4400  
 2.47

(10,000) 8900  
 14,300 3.17%

13,100  
 (9300) 7500  
 15,600 4.06%

For T. Armstrong  
 0000 - 2006  
 (0000) - 2016  
 0000 - 2025  
 0000 - 2030 EAC

PORTLAND

# **APPENDIX B**

## **FUNCTIONAL LAYOUTS**

Index of Sheets  
 SHEET NO. DESCRIPTION

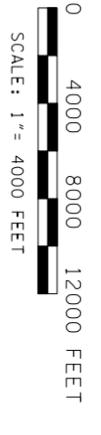
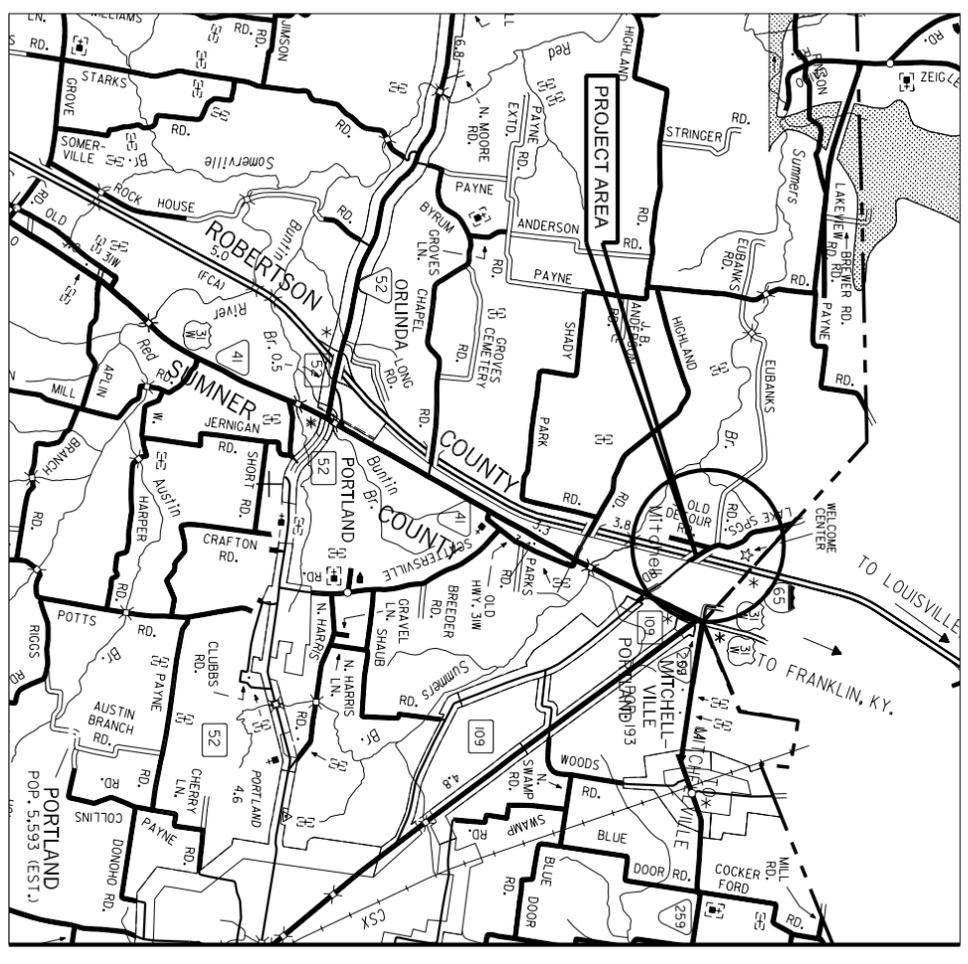
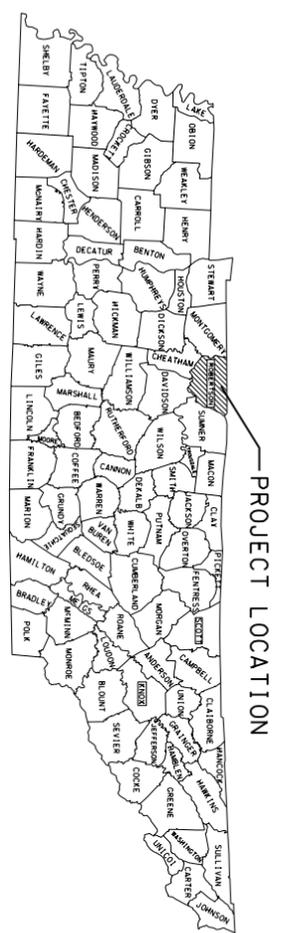
STATE OF TENNESSEE  
 DEPARTMENT OF TRANSPORTATION  
 BUREAU OF PLANNING AND DEVELOPMENT

**ROBERTSON COUNTY**

INTERCHANGE JUSTIFICATION STUDY  
 I-65 @ STATE ROUTE 109

STATE HIGHWAY NO. F.A.H.S. NO.

TENN.	YEAR	SHEET NO.
FED. AID PROJ. NO.		1
STATE PROJ. NO.		



**SPECIAL NOTES**

PROPOSALS MAY BE REJECTED BY THE COMMISSIONER IF ANY OF THE UNIT PRICES CONTAINED THEREIN ARE OBVIOUSLY UNBALANCED, EITHER EXCESSIVE OR BELOW THE REASONABLE COST ANALYSIS VALUE.

THIS PROJECT TO BE CONSTRUCTED UNDER THE STANDARD SPECIFICATIONS OF THE TENNESSEE DEPARTMENT OF TRANSPORTATION DATED MARCH 1, 1995 AND ADDITIONAL SPECIFICATIONS AND SPECIAL PROVISIONS CONTAINED IN THE PLANS AND IN THE PROPOSAL CONTRACT

TDOT ROAD SP. SV. 2 \_\_\_\_\_  
 DESIGNER \_\_\_\_\_ CHECKED BY \_\_\_\_\_

P. E. NO. \_\_\_\_\_

**TRAFFIC DATA**

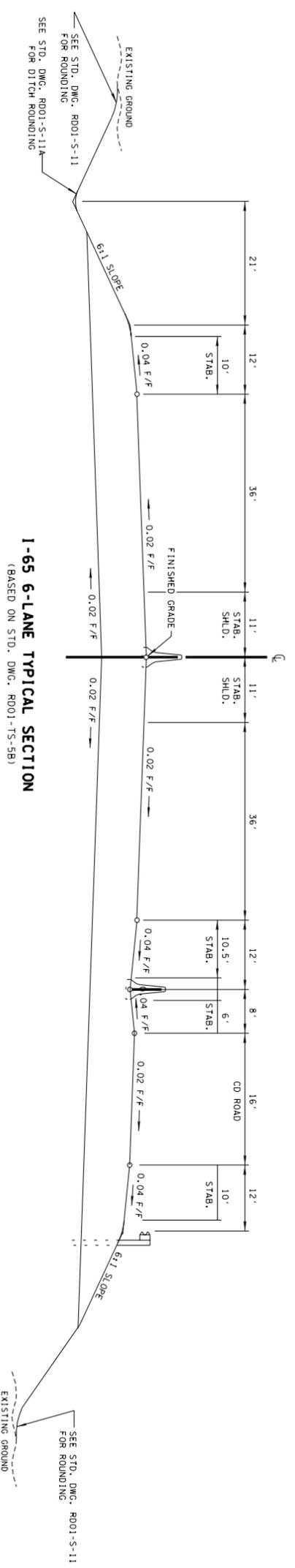
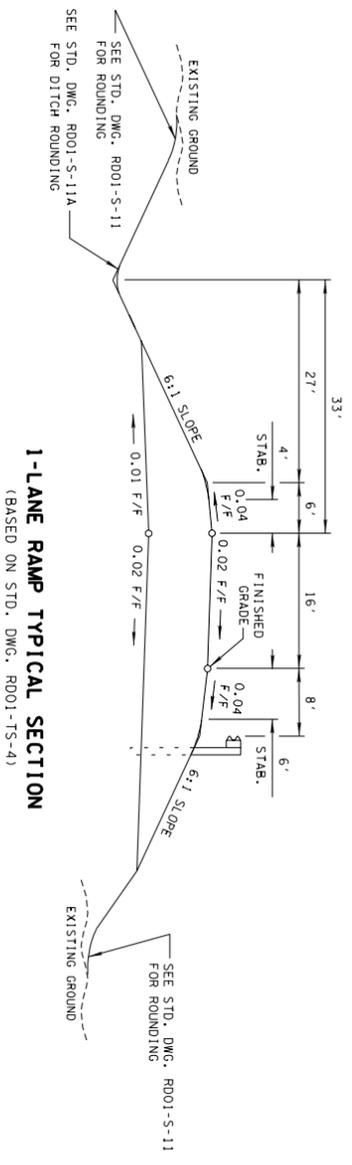
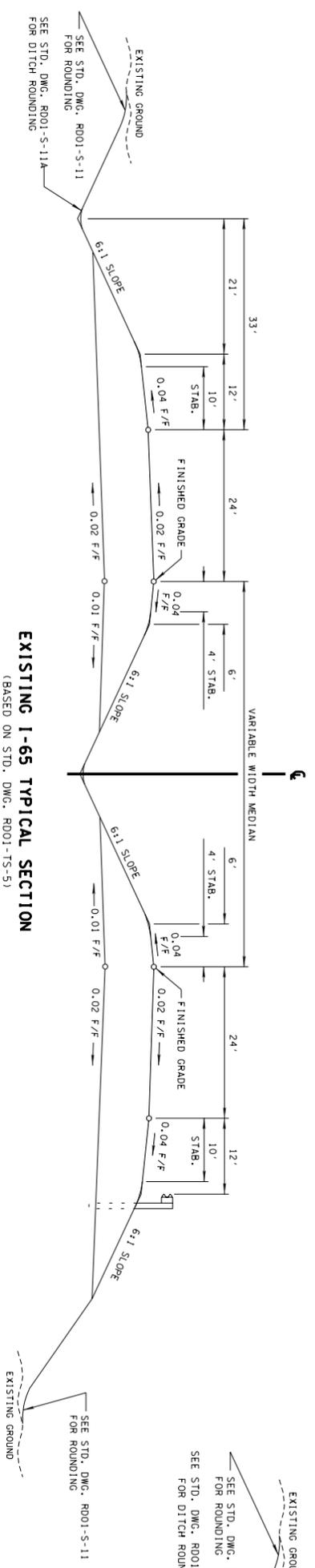
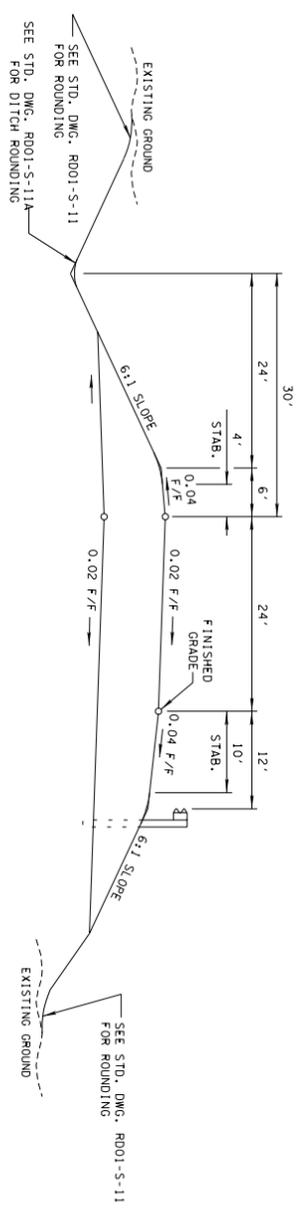
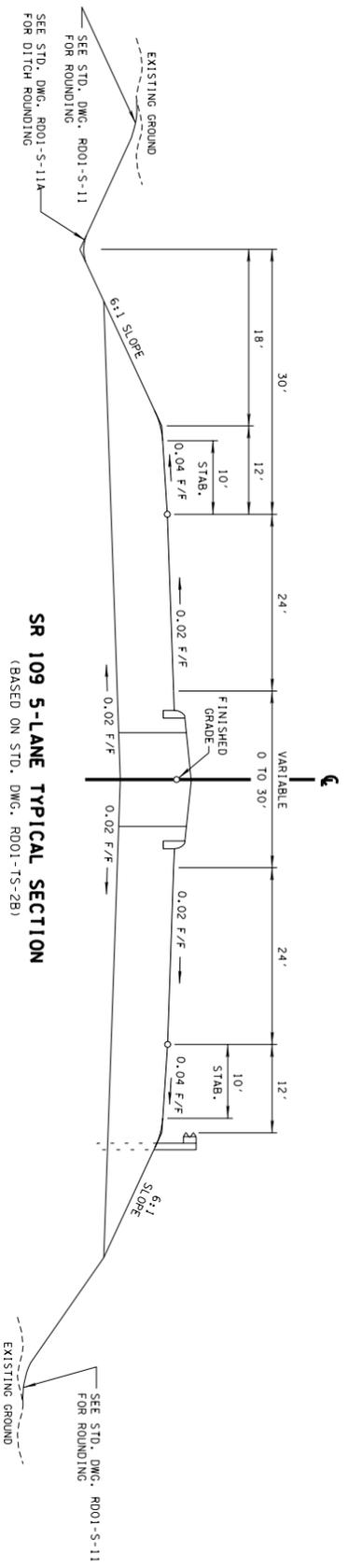
ADT ( )	
ADT (20 )	
DHV (20 )	
D	-
T (ADT)	%
T (DHV)	%
V	MPH

APPROVED: \_\_\_\_\_ DATE: \_\_\_\_\_  
 DIRECTOR, DESIGN DIVISION

APPROVED: \_\_\_\_\_ DATE: \_\_\_\_\_  
 COMMISSIONER

U.S. DEPARTMENT OF TRANSPORTATION  
 FEDERAL HIGHWAY ADMINISTRATION

APPROVED: \_\_\_\_\_ DATE: \_\_\_\_\_  
 DIVISION ADMINISTRATOR



TYPE	YEAR	PROJECT NO.	SHEET NO.
			2

STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION  
BUREAU OF PLANNING & DEVELOPMENT

ROBERTSON COUNTY

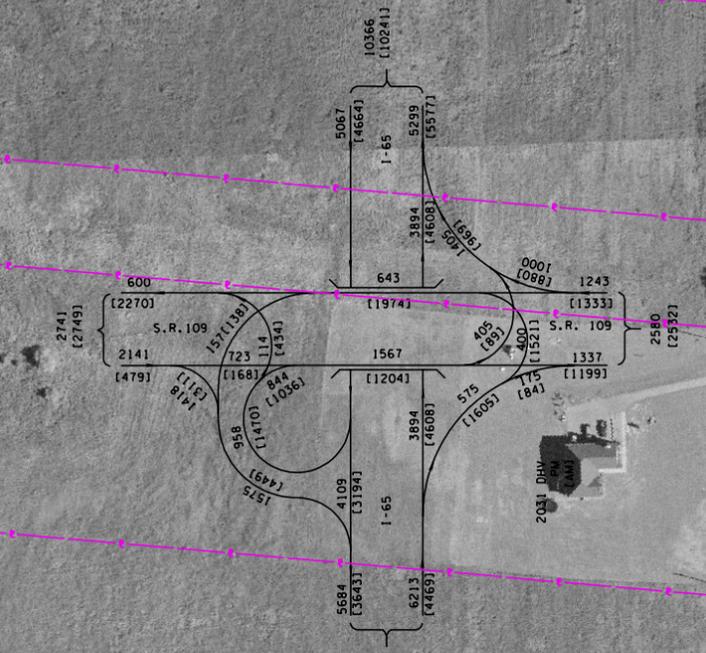
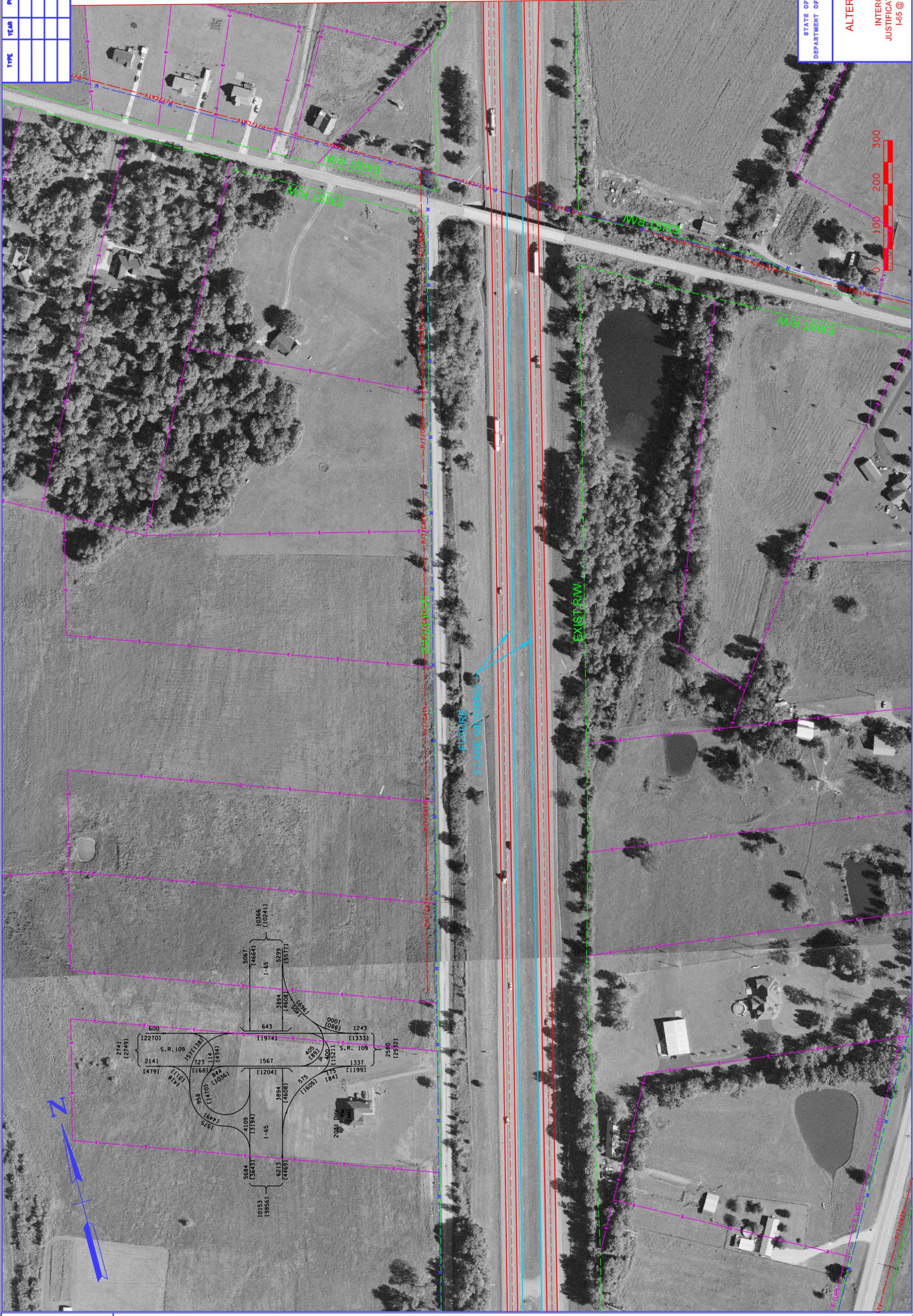
INTERCHANGE  
JUSTIFICATION  
STUDY  
SR 109

TYPE	YEAR	PROJECT NO.	SHEET NO.
			1

MATCHLINE SEE SHEET #2

STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

ALTERNATE 4  
INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109



TYPE	YEAR	PROJECT NO.	SHEET NO.
			2

MATCHLINE SEE SHEET #3

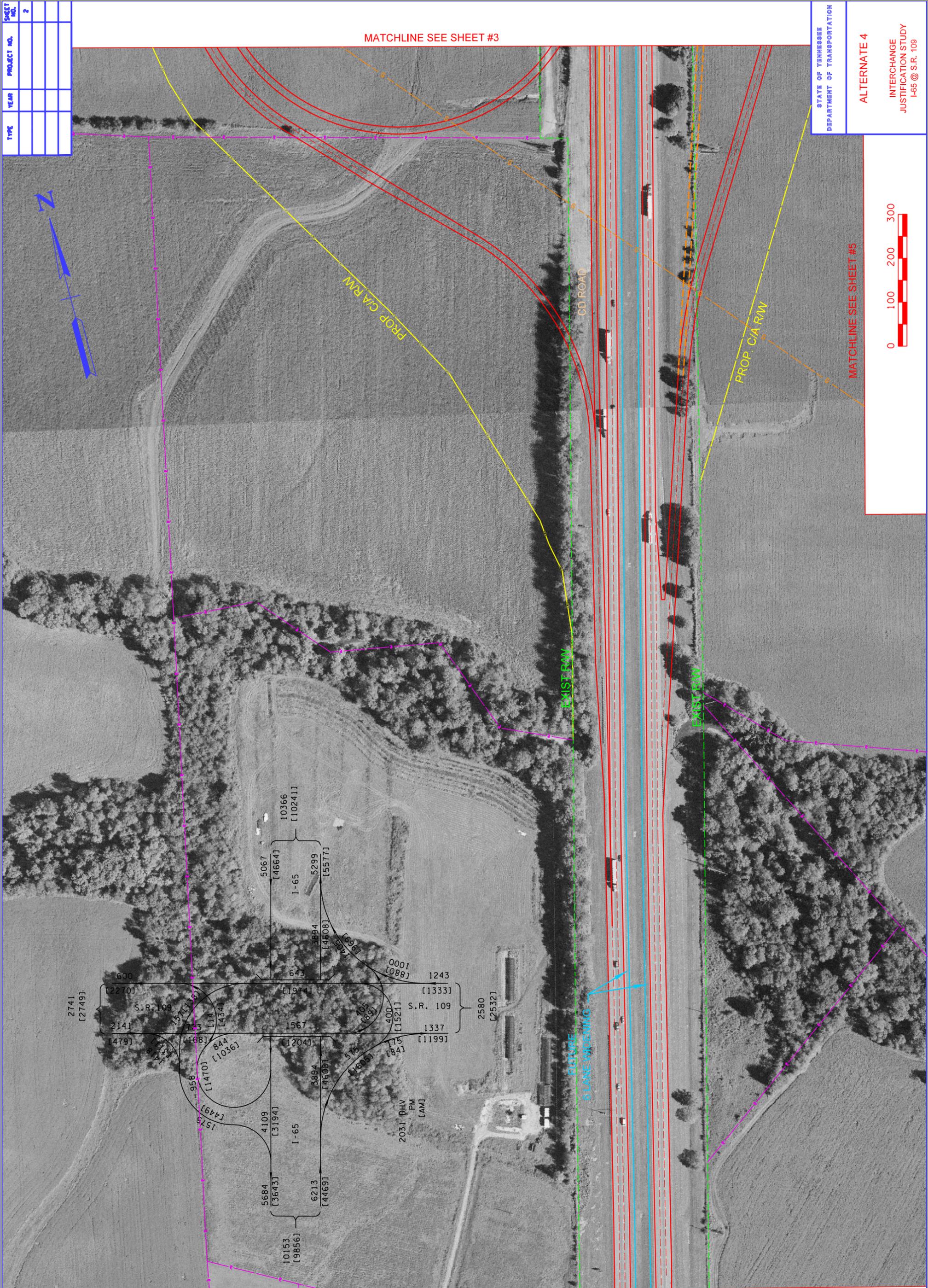
STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

ALTERNATE 4

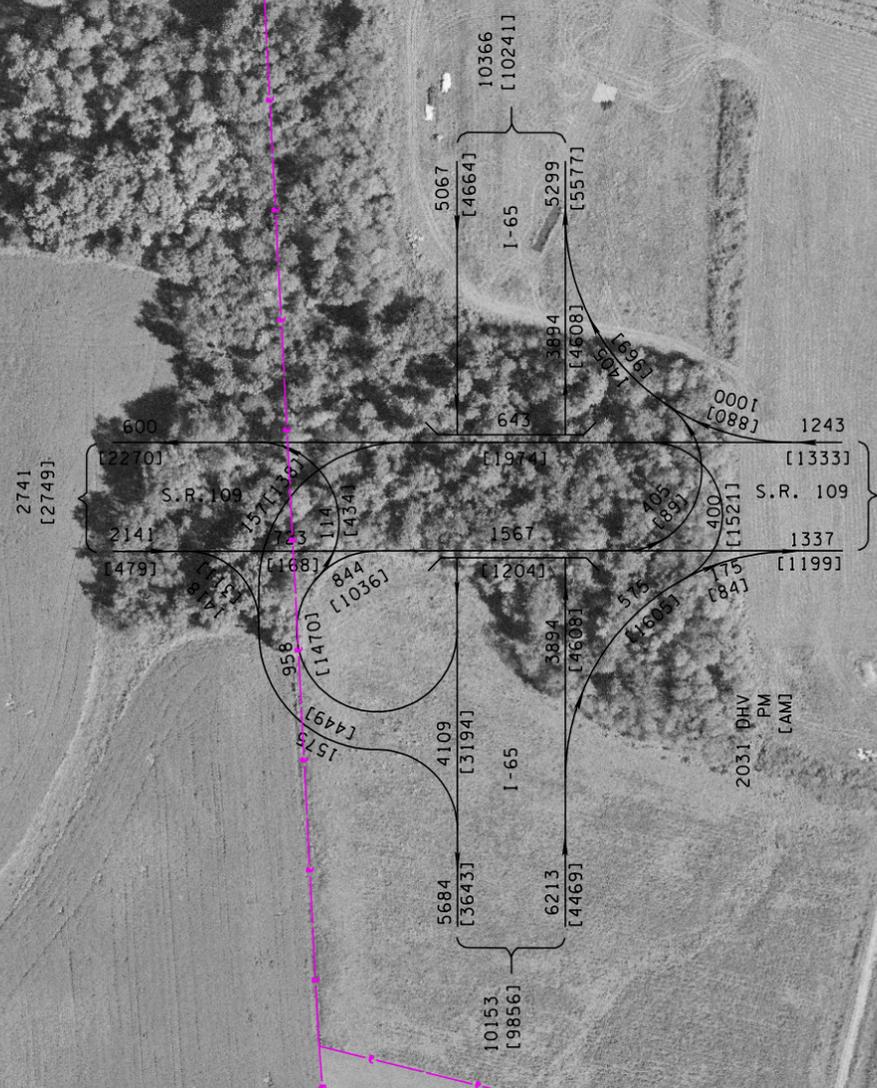
INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109



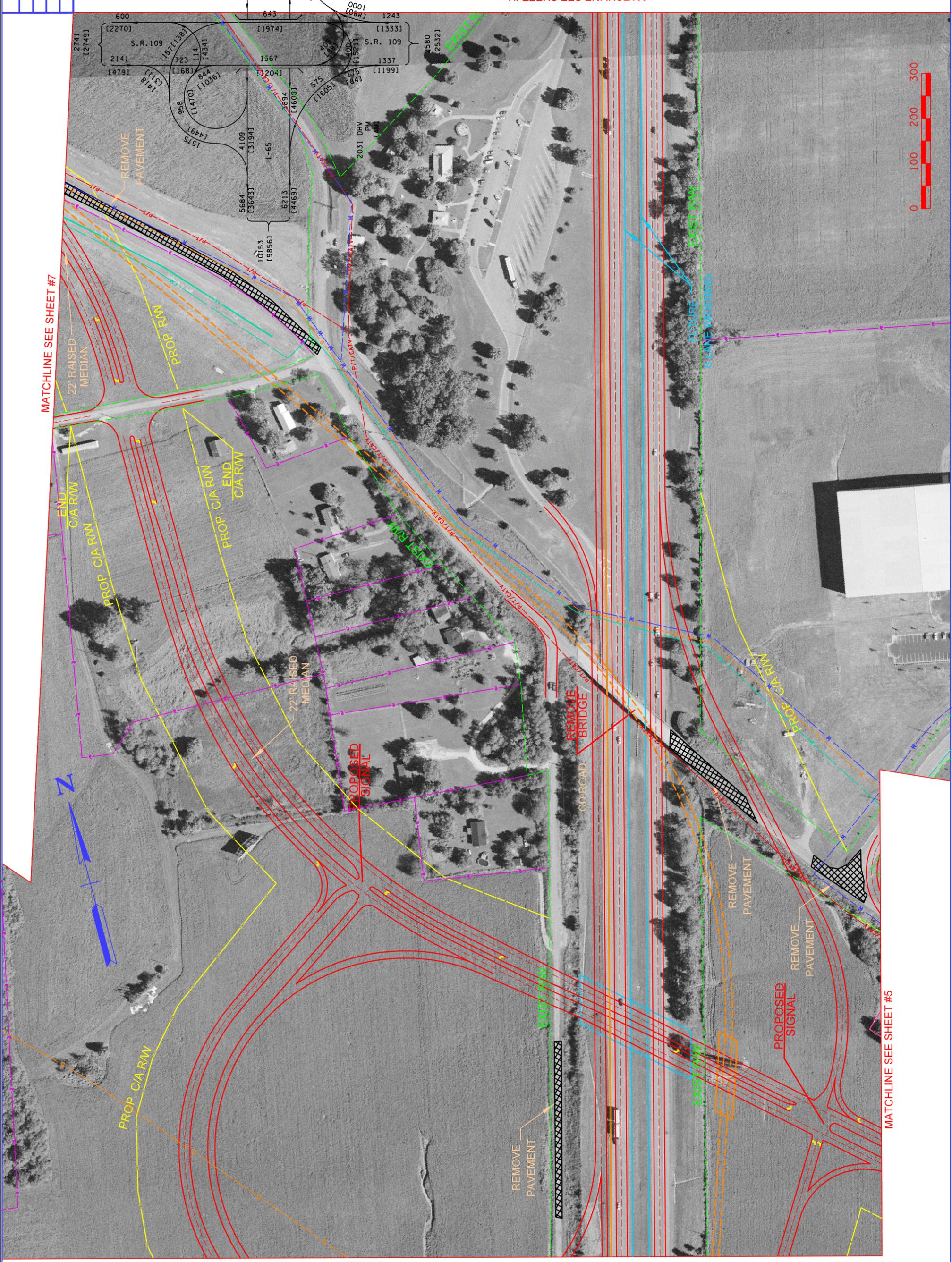
MATCHLINE SEE SHEET #5



MATCHLINE SEE SHEET #2



TYPE	YEAR	PROJECT NO.	SHEET NO.
			3



MATCHLINE SEE SHEET #4

MATCHLINE SEE SHEET #7

MATCHLINE SEE SHEET #2

MATCHLINE SEE SHEET #5

TYPE	YEAR	PROJECT NO.	SHEET NO.
			4



STATE OF TENNESSEE  
 DEPARTMENT OF TRANSPORTATION

**ALTERNATE 4**  
 INTERCHANGE  
 JUSTIFICATION STUDY  
 I-65 @ S.R. 109

MATCHLINE SEE SHEET #3

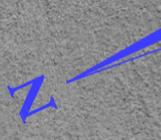
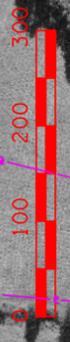
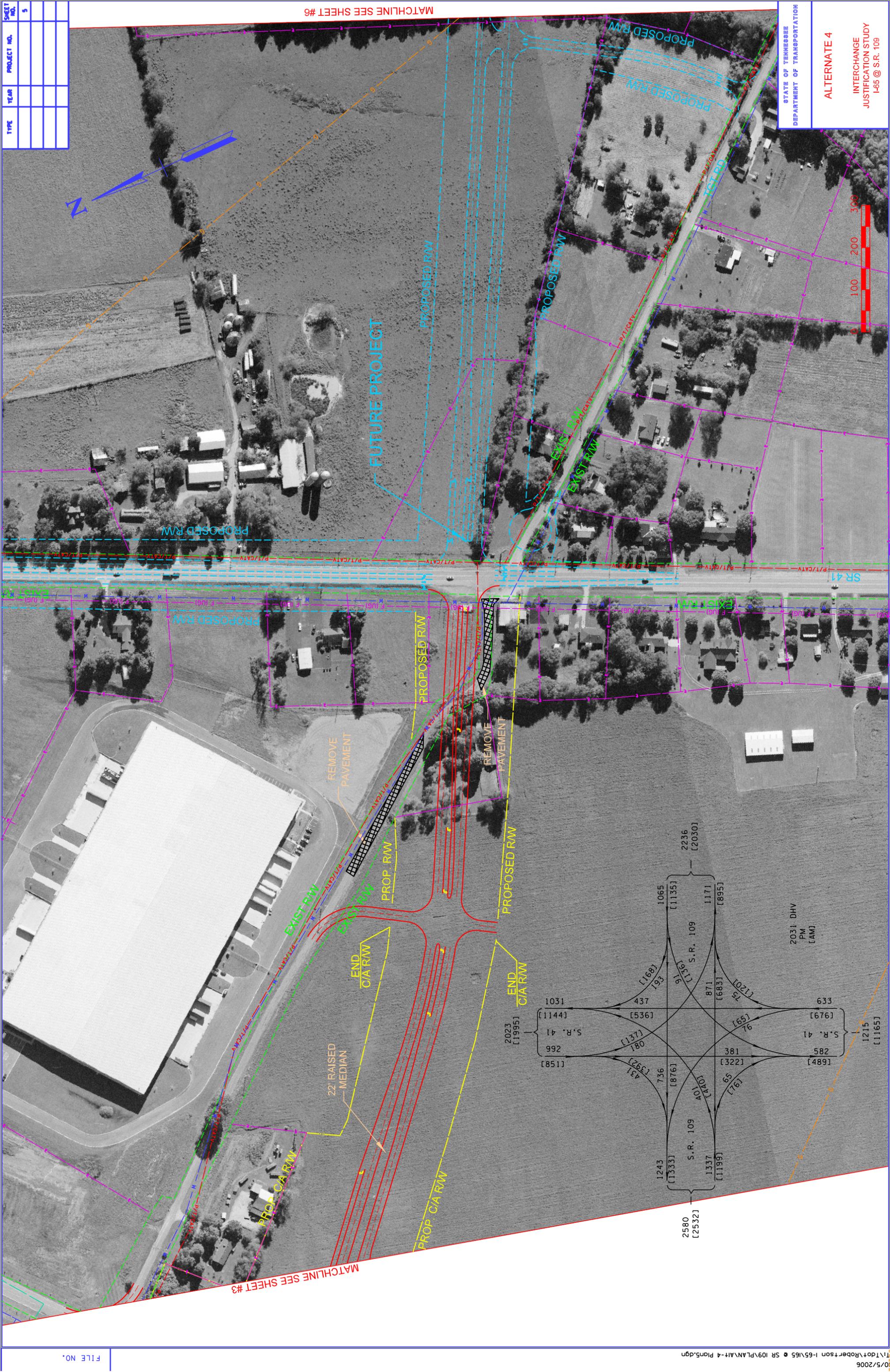
TYPE	YEAR	PROJECT NO.	SHEET NO.
			5

MATCHLINE SEE SHEET #6

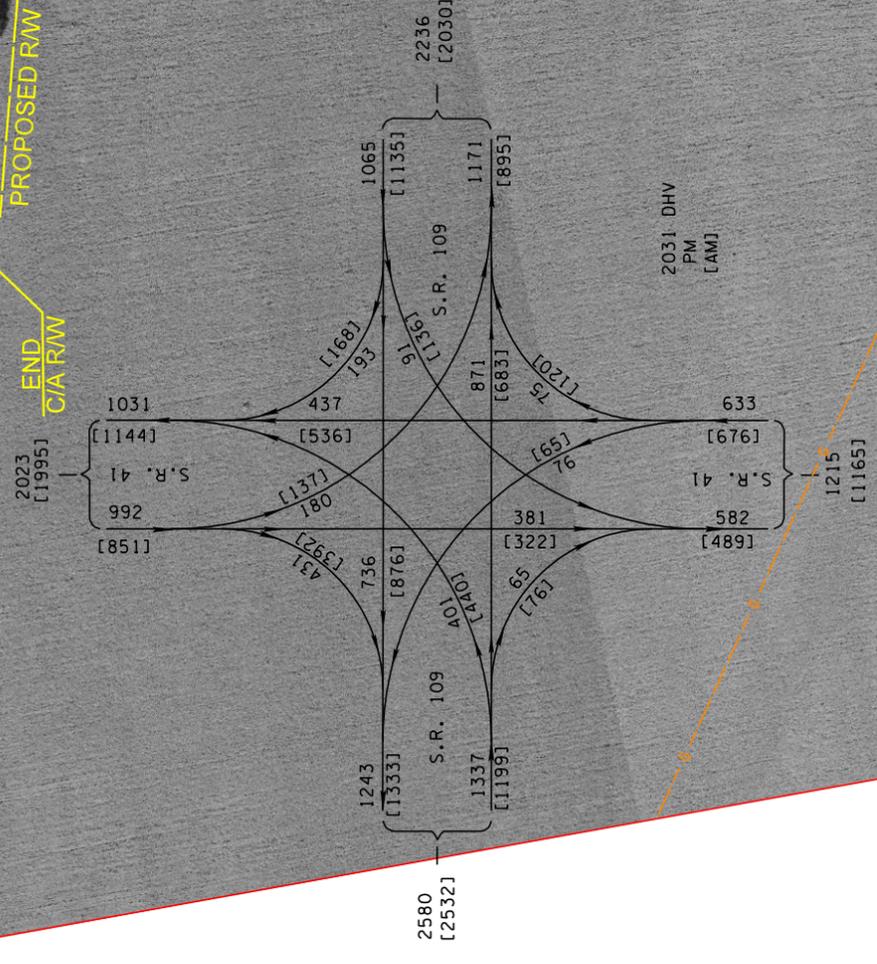
STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

ALTERNATE 4

INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109

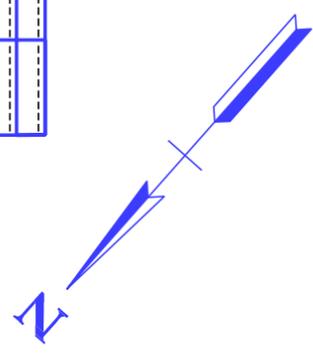


MATCHLINE SEE SHEET #3





TYPE	YEAR	PROJECT NO.	SHEET NO.
			7



MATCHLINE SEE SHEET #3

PROP. ROW

PROP. ROW

FUTURE

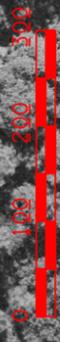
FUTURE

FUTURE

STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

ALTERNATE 4

INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109



# **APPENDIX C**

## **MINUTES OF MEETINGS**

**Meeting Report  
I 65 at SR 109  
Robertson County**

**February 23, 2005**

A meeting was held February 23, 2005 at the James K. Polk Building in Nashville, Tennessee. Attendees at the meeting were:

**Bill Hart, TDOT Planning  
Mike Updike, TDOT Planning  
Ron Baker, TDOT Planning  
David Lindeman, Palmer Engineering  
Gary W. Sharpe, Palmer Engineering**

Significant points of the discussion are summarized below:

- **The number and potential impacts of the numerous natural gas transmission lines in the area, including the proximity of the project to the natural gas pumping station was discussed. It was noted that there were other utilities in the area but there was only minimum discussion of the topic.**
- **The future widening of I 65 was discussed. Direction was given that alternatives should consider four lanes in each direction for future I 65 recognizing that initial widening of I 65 would most likely be to the inside but that accommodations should be made in the design to accommodate the addition of an outside lane and shoulder.**
- **The discussion of alternatives evolved to three alternatives for further discussion. It was decided to maintain the “orange” alternate which involved a connection from US 31W to an interchange at Highland Road as described in the July 2004 Interchange Justification Study submitted to TDOT by Palmer Engineering.**

**The discussion of alternatives further evolved to consideration of the “blue” line as presented and a modified version of the “blue” line that provided for greater separation with the existing Tennessee Welcome Center. It was agreed to prepare a “modified blue” line to reflect this scenario. The basis for a “modified blue” line was to minimize effects of a short weaving section between the interchange and the Welcome Center. The blue alternative would require relocation of the Welcome Center while the modified blue alternative would allow the Welcome Center to remain at its current location.**

The options that impacted the Welcome Center were discounted after discussion of those options and the options for relocating the Welcome Center. Some of the discussion involved opportunities for re-designing the ramp configurations of the Welcome Center and/or incorporating the Welcome Center into the ramp movements of the interchange, the use of a single point urban diamond, the opportunity for finding a suitable location for relocating the Welcome Center, and the potential cost of replacing the Welcome Center. The net result of these discussions was to eliminate the “green” and “yellow” alternates from further consideration.

The “red” alternate was eliminated from consideration because of the most significant impacts to the natural gas transmission lines.

- It was requested that loop ramps meet a minimum design speed of 40 mph.
- A “flyover” was to be shown but as an ultimate design in an “initial-ultimate” scenario.
- The connection for SR 109 to US 31W/SR 41 was discussed. It was noted that ideally, a grade-separated connection was desirable. However, discussion of potential right of way concerns and other property impacts eventually resulted in the decision to use an at-grade intersection of US 31W/SR 41. It also was decided to shift the location of the “blue” line for SR 109 to north of its proposed location to somewhere nearer the “red” line to minimize property impacts. A tie to existing SR 109 was to be provided.
- It also was discussed that this project most likely would be developed as an initial-ultimate concept with 3 lanes initially throughout and then developed to 5 lanes when traffic volumes increased to the point that the “flyover” was needed for northbound I 65 to the Industrial Park movement.
- It also was discussed that an Interchange Justification Study would be required for project.

**2<sup>nd</sup> Field Review Meeting**  
**June 14, 2005**  
**I-65 @ SR-109, Robertson County**

A meeting was held June 14, 2005 at the James K. Polk building in Nashville, Tennessee.

1. The MPO study area only covers the area to the Sumner County Line. However, the MPO is considering improving SR-840 as an alternate north-south route from I-40 in Nashville to I-65. The TDOT traffic figures do not reflect traffic volume growth due to the possibility of SR-109 being used as a SR-840 substitute and represent forecasts based upon historic growth rates for the subject intersections and roadway facilities.
2. It was noted that the Mayor of Robertson County and the Portland city engineer were both invited to this meeting, but were not in attendance.
3. There was a significant amount of discussion concerning the kind of access management policy that should be required for tying in rural collector roads. SR-109 should have more stringent access controls due to the importance of the road and the significant development pressure that will occur in the vicinity of the interchange.
4. There is a possibility of SR-109 serving as a substitute for the proposed 840 corridor. There is a need for a high type facility due to the possibility of heavy traffic.
5. Alternate 1:
  - The proposed design is a somewhat tight diamond that would eliminate the existing welcome center.
  - The ultimate design includes a flyover toward the industrial park that can be constructed at a future date as traffic volumes warrant. The proposed design will accommodate the later addition of the flyover.
  - Two sites were preliminarily investigated for replacing the welcome center.
  - This alternate incorporates a cul-de-sac at TGT Road and Fred White Road.
  - The design should consist of a 5 lane typical cross section with a 250 foot right-of-way which would taper back into a divided 4 lanes beyond the interchange area.
  - David Lindeman suggested that a partial cloverleaf design might work better but it would have a larger price tag. There is a need to keep the cost reasonable.
  - Specifically, the access point for Lake Spring Road and Eubank Road should be pulled back from the interchange for proper access spacing.

6. Alternate 2:
  - The design accommodated keeping the existing welcome center and has the provision of a flyover loop.
  - No grade separation is needed at SR-41.
  - The current Industrial park access to SR-109 is too close to the proposed interchange and can be terminated in a cul-de-sac. The second industrial park access on SR-41 is adequate and should provide adequate ingress and egress.
  - As with Alternate A, the Lake Springs and Eubank Road access point needs to be moved further away from the proposed interchange, possibly tying in along property lines.
  - Again, the project should be planned for 250 feet of right-of-way.
7. Now that there are project alternates, there is a need for public involvement. A meeting should be held with local officials prior to the public meeting to get their input before going to the public with the alternates. It is anticipated that the meeting with public officials should take place during the first week of July. Officials from Robertson, Sumner, and Davidson Counties should be invited.
8. TDOT will contact the local officials.
9. Additional discussion centered around whether or not Palmer Engineering should continue with the IJS or should the completion of the IJS be delayed in order to do an APR that would encompass improvements to SR-109 from SR-41 to the Portland Bypass.
10. Palmer Engineering is to do the cost estimates for the basic alternates with a footnote to the cost of the welcome center and the flyover. Charlie Graves can provide an estimate of the cost for the welcome center.
11. In all cases there is a need for a right turn lane from westbound SR-109 to the northbound I-65 ramp.
12. US 41 should be 5 lanes from the State Line to proposed SR-109.

## Attendance

<u>Name</u>	<u>Organization</u>	<u>Email</u>
Ron Baker	TDOT	<a href="mailto:ron.baker@state.tn.us">ron.baker@state.tn.us</a>
Ralph Comer	TDOT	<a href="mailto:ralph.comer@state.tn.us">ralph.comer@state.tn.us</a>
Dennis Cook	TDOT	<a href="mailto:dennis.cook@state.tn.us">dennis.cook@state.tn.us</a>
Bill Hart	TDOT	<a href="mailto:bill.hart@state.tn.us">bill.hart@state.tn.us</a>
Bob Kennedy	Palmer Engineering	<a href="mailto:bkennedy@palmernet.com">bkennedy@palmernet.com</a>
David Lindeman	Palmer Engineering	<a href="mailto:dlindeman@palmernet.com">dlindeman@palmernet.com</a>
Chuck Rychen	TDOT	<a href="mailto:charles.rychen@state.tn.us">charles.rychen@state.tn.us</a>
Steve Sewell	Palmer Engineering	<a href="mailto:ssewell@palmernet.com">ssewell@palmernet.com</a>
Gary Webber	TDOT	<a href="mailto:gary.webber@state.tn.us">gary.webber@state.tn.us</a>

## **Proposed I-65 at SR-109 Interchange Local Officials Meeting Notes**

A meeting was held on July 11, 2005 (10:00am) at the James K. Polk building (downtown Nashville), to gather input about the proposed interchange to be located at I-65 and SR-109 from the City of Portland, Sumner County and Robertson County officials. The primary purpose of the meeting was to provide local officials with information and to determine the local officials priorities.

1. Ken Webber, Mayor of Portland stated that Portland had a current population of 10,000 according to a recent special census.
2. David Lindeman began the meeting discussing the current Interchange Justification Study (IJS), recent project history, and previous IJS efforts TDOT had studied.
3. The group was made aware that a current project widens SR 41 from SR 76 to SR 52. The group was also made aware that the public rejected the previous Southern Bypass.
4. Traffic Simulations for Alternates 1 and 2, initial and ultimate were shown and explained to the group.
5. Steve Allen stated that 2028 traffic forecasts have been based on the best available land use information and that the MPO model only has 6 lanes on I-65, so the IJS and all studies need to use 6 lanes as a given.
6. Charlie Graves stated that the industrial park would most likely be expanded with more warehouses.
7. Concerns were expressed about the weaving movement associated with the Kentucky Welcome center and the proposed northbound interchange ramp. It was explained that this weave had been analyzed.
8. Bill Hart stated that they have received many calls from local citizens concerning the Highland Road interchange location. However, that location has been rejected in favor of the SR-109 location.
9. Portland Vice Mayor Luther Bratton stated there are concerns about the existing industrial park traffic onto SR-109 and concerns about future truck traffic using the interchange from I-65 crossing SR-41 and driving down SR-109. Local officials are thinking that SR-109 should be widened from Portland to the proposed new interchange.
10. Mayor Ken Webber expressed an interest in providing an adequate facility from SR-109 to the industrial park.
11. There was discussion concerning the 840 North Corridor, which is a proposal that may not happen for many years. In the interim period, SR-109 will serve as a substitute for the 840 North Corridor. SR-109 should not be initially built with 2 lanes but should be 4 lanes from the start. The Average Daily Traffic (ADT) on the proposed facility is forecasted to be 10,000 ADT in 2008 and 16,000 ADT in 2028. Therefore, the group felt that constructing SR-109 as a 4 lane facility was justified.
12. Vice Mayor Bratton expressed an interest in a master plan for an expanded project to include all anticipated improvements.

13. It was suggested that local officials write the Tennessee Commissioner of Transportation to request a feasibility study to encompass the improvements necessary for transportation facilities from the proposed SR-109 at I-65 interchange to SR 76 (south of Portland).
14. State Senator Diane Black suggested that a public meeting was needed to discuss these issues and plans need to be established before development precludes the opportunity to make needed improvements.
15. Vice Mayor Bratton stated that there is an opportunity to coordinate with local efforts via land dedications while there is still time.
16. The current IJS seems to cover most of the pertinent issues in Robertson County but many of the other issues concerning SR-109 to Portland are on the Sumner County side.
17. There was some discussion concerning whether or not the present welcome center site was large enough to accommodate future expansions. Charlie Graves was of the opinion that the present site is not large enough.
18. There was discussion concerning the need for a flyover from southbound I-65 to westbound SR-109.
19. The timeframe for implementing a more comprehensive plan was discussed. It was stated that it would be a minimum of 5 years before construction could start.

## **ATTENDANCE**

<b><u>Name</u></b>	<b><u>Organization</u></b>	<b><u>Email Address</u></b>
Ken Weber	City of Portland	<a href="mailto:kmayor@cityofportlandtn.gov">kmayor@cityofportlandtn.gov</a>
Luther Bratton	City of Portland	<a href="mailto:Bratton@Realtracs.com">Bratton@Realtracs.com</a>
Brian Goodwin	City of Portland	<a href="mailto:portlandengineering@yahoo.com">portlandengineering@yahoo.com</a>
Dennis Cook	TDOT	<a href="mailto:dennis.cook@state.tn.us">dennis.cook@state.tn.us</a>
Kim Keelor	TDOT PIO	<a href="mailto:kim.keelor@state.tn.us">kim.keelor@state.tn.us</a>
Mike Updike	TDOT Planning	<a href="mailto:mike.updike@state.tn.us">mike.updike@state.tn.us</a>
Ron Baker	TDOT Planning	<a href="mailto:ron.baker@state.tn.us">ron.baker@state.tn.us</a>
Gary Webber	TDOT Planning	<a href="mailto:gary.webber@state.tn.us">gary.webber@state.tn.us</a>
Bill Hart	TDOT Planning	<a href="mailto:bill.hart@state.tn.us">bill.hart@state.tn.us</a>
Glenda Tyus	TDOT Planning	<a href="mailto:Glenda.tyus@state.tn.us">Glenda.tyus@state.tn.us</a>
Steve Allen	TDOT Planning	<a href="mailto:steve.allen@state.tn.us">steve.allen@state.tn.us</a>
Charles T. Graves	TDOT Planning	<a href="mailto:Charles.Graves@state.tn.us">Charles.Graves@state.tn.us</a>
Diane Black	State Senator	<a href="mailto:sen.diane.black@legislature.state.tn.us">sen.diane.black@legislature.state.tn.us</a>
Howard Bradley	Robertson County	<a href="mailto:hrbrad@bellsouth.net">hrbrad@bellsouth.net</a>
Mark B. Hurley	Robertson Co. Hwy.	
Scotty Parker	Sumner Co. Highway	
R. J. Thompson	Sumner Co, Exec.	<a href="mailto:hthompson@sumner.tn.org">hthompson@sumner.tn.org</a>
Stephen Sewell	Palmer Engineering	<a href="mailto:ssewell@palmernet.com">ssewell@palmernet.com</a>
Bob Kennedy	Palmer Engineering	<a href="mailto:bkennedy@palmernet.com">bkennedy@palmernet.com</a>
David Lindeman	Palmer Engineering	<a href="mailto:dlindeman@palmernet.com">dlindeman@palmernet.com</a>



U.S. Department  
of Transportation

**Federal Highway  
Administration**

Tennessee Division

Mr. Steve Allen  
Project Planning Director  
Tennessee Department of Transportation  
James K. Polk Building  
Nashville, TN 37243

Subject: Interchange Justification Study  
Interstate 65 @ State Route 109  
Robertson County

Dear Mr. Allen:

Our office has reviewed the subject interchange justification study (IJS). Our comments are enclosed. Comments #1 and #2 lead us to believe there are probably more desirable alternatives to providing the desired access.

Adding an interchange at the proposed location presents several complications because it is located in close proximity to two welcome centers and a large development in the northeast quadrant. This proximity presents difficulties in signing. Also, due to closely-spaced ramps, the location introduces undesirable merging and/or weaving movements on the mainline, which do not currently exist. Alternative 3 makes a reasonable effort in addressing the signing and operational issues in the southbound direction only. However, the IJS makes virtually no mention or analysis concerning signing or the operational effects approaching the northbound welcome center, located in Kentucky.

Lastly, at the proposed interchange location, a desperately needed loop ramp can't be built without taking a large business. The operation of the entire interchange would benefit greatly by providing a loop ramp or semi-direct connection to serve the northbound to westbound movement.

640 Grassmere Park Rd,  
Ste 112  
Nashville, TN 37211

April 17, 2006

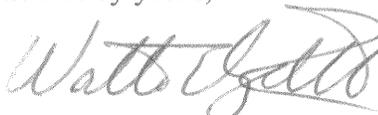
In Reply Refer To: HFO-TN



In accordance with Point 2 of the Federal Register (Vol. 63, No. 28), all reasonable design alternatives need to be assessed prior to making a decision on this desired access. We request that the Department identify alternatives that address our enclosed comments. We will be glad to work with your staff to assist in this effort.

If you or your staff have any questions please contact me at 781-5774.

Sincerely yours,

A handwritten signature in cursive script, appearing to read "Walter Boyd".

Walter Boyd, P.E.  
Field Operations Team Leader

cc: Paul Degges, TDOT Chief Engineer  
Ed Cole, TDOT Chief of Environment and Planning  
Mark Holloran, TDOT Assistant Chief Engineer

## FHWA Comments on I-65 at SR 109 IJR, April 18, 2006

1. The proposed northbound entrance ramp is in extremely close proximity (1000 feet  $\pm$ ) to the Kentucky Welcome Center exit ramp. This is a highly undesirable condition that introduces new safety, operational, and signing concerns where none exist today. An alternative(s) should be developed that eliminates these deficiencies.
2. The I-65 northbound to SR 109 westbound movement is predicted to serve 2215 vph. This level of demand warrants a loop ramp or some other type of direct or semi-direct movement, rather than a left turn at a signal. An alternative(s) need to be developed that adequately serves this heavy movement.
3. The typical section of SR 109 is shown as a 5-lanes throughout. Given the volumes and types of traffic (heavy truck movements), the typical section should consist of a non-traversable (raised) median through the interchange to a distance of approximately 1000' on each side of the ramp terminals. Also, none of the alternatives show the extent of the limited access control. Please identify the distances and type of proposed access control.
4. Entrance ramps for service level interchanges should be reduced to one-lane prior to entering the Interstate. This is especially the case when the Interstate is only two (or even three) basic lanes in a single direction.
5. Traffic analysis is based upon the assumption that I-65 will be upgraded to six lanes through the project area. The document needs to explain the planning status of this widening project and its predicted timing with a new interchange. If expansion to six lanes will occur after the anticipated completion of the interchange, or if no such expansion is planned, then the traffic analysis needs to be based on the Interstate being four lanes. Also, the IJR should discuss the status of Kentucky's project to widen from four to six lanes, and describe what, if any, effects this has on the IJR. Furthermore, given the possible effect on signing for the Kentucky Welcome Center, we recommend that the Department coordinate with the Kentucky Transportation Cabinet.
6. Page 10: Describe the status of current and anticipated known future development east and west of the proposed interchange (acres developed, type of industry, jobs created). Both sides already have some development completed.
7. Page 11: All new IJR's need to assess any effects on the adjacent interchanges. Please elaborate on whether future capacity problems at the two adjacent interchanges affect the proposed interchange, i.e. will traffic avoid these interchanges and spill over to the proposed interchange, and will the proposed interchange help relieve congestion at the adjacent interchanges?
8. The welcome centers are assets that should be retained if at all possible. We are in general agreement with the southbound ramp configuration shown in Alternative 3. Alternative 1 is highly undesirable because it eliminates the welcome center. Alternative 2 is highly undesirable because of the ramp configurations adjacent to the Interstate mainline.

**FHWA Review Meeting**  
**May 17, 2006**  
**I-65 @ SR-109, Robertson County**

A meeting was held May 15, 2006 at the James K. Polk building in Nashville, Tennessee. The purpose of this meeting was to address comments that FHWA had concerning the IJS Report.

1. TDOT suggested an Incremental Analysis on I-65 to determine the breakdown year for the Interstate. Steve spoke with Paul Degges and we will fund the interchange itself and do the widening under a future IM project. The breakdown year will be listed in the report. We're looking at it from a corridor standpoint, Kentucky will bring their six lanes down to the state line and TDOT will tie to Kentucky's section.
2. A weave analysis to determine LOS for NB On Ramp and Kentucky Welcome Center. A braided weave would also be considered if problems occurred.
3. Suggested a raised median along SR 109 between I-65 ramps and SR 41 intersection
4. Suggested Access Control along both sides of interstate a minimum distance of 300' on the east side (investigate property) and on the west side to local road connection.
5. Reduce 2 lane ramps to one lane before merging onto I-65. FHWA thought the two lane entrance ramp was adversely affecting the interstate- felt single lane would be a better solution.
6. Mention future construction plans that Kentucky has for 6-laning interstate in report & MPO plans
7. Discuss other interchange effects due to proposed interchange.
8. Revise Traffic data to reflect SR 109 traffic.
9. Separate Cost for I-65 widening from state line thru project limits

## **Attendance**

<b>Name</b>	<b>Organization</b>
David Lindeman	Palmer Engineering
Stephen Sewell	Palmer Engineering
Steve Allen	TDOT
Charlie Graves	TDOT
Ron Baker	TDOT
Mike Updike	TDOT
Glenda Tyus	TDOT
Walter Boyd	FHWA

**3<sup>rd</sup> Review Meeting**  
**August 22, 2006**  
**I-65 @ SR-109, Robertson County**

A meeting was held August 22, 2006 at the James K. Polk building in Nashville, Tennessee.

The meeting displayed 5 new single line alternates that could developed into possible alternatives. Each alternate was discussed and one alternate was carried forward and included in the IJS Report. This alternate will be the fourth alternate developed in detail and included in the report.

Each alternate included in the report would need to address the comments the FHWA raised on the previous alternates. These comments can be found in previous meeting notes.

## **Attendance**

<b><u>Name</u></b>	<b><u>Organization</u></b>
Ron Baker	TDOT
Bill Hart	TDOT
Steve Allen	TDOT
Charlie Graves	TDOT
David Lindeman	Palmer Engineering
Stephen Sewell	Palmer Engineering

**4th Field Review Meeting  
September 20, 2006  
I-65 @ SR-109, Robertson County**

A meeting was held September 20, 2006 at the James K. Polk building in Nashville, Tennessee.

1. The four alternates included in the IJS report were presented to the group along with traffic simulations for the alternates.
2. A modified alternate four was determined to be the preferred alternate for the report.
3. The modifications to Alternate four are as follows:
  - a. Place all southbound exit ramps on a C-D Road.
  - b. Provide 1 access point on SR 109 between northbound ramp and SR 41 intersection. Approximately 1000' from either intersection.
  - c. Extend access control to intersections adjacent the ramps.
  - d. Place raised median (22 feet wide) throughout access control section of SR 109.
  - e. Dash and label SR 41 and SR 109 extended as future projects to be constructed.
  - f. Revise paving cost estimates to be based on recent unit bids provided by TDOT.
  - g. Revise adjacent interchange analysis to be based on existing system traffic volumes TDOT will provide following the meeting.

**Attendance**

<b><u>Name</u></b>	<b><u>Organization</u></b>	<b><u>Email</u></b>
Steve Allen	TDOT	<a href="mailto:steve.allen@state.tn.us">steve.allen@state.tn.us</a>
Ron Baker	TDOT	<a href="mailto:ron.baker@state.tn.us">ron.baker@state.tn.us</a>
Bill Hart	TDOT	<a href="mailto:bill.hart@state.tn.us">bill.hart@state.tn.us</a>
Mike Updike	TDOT	<a href="mailto:mike.updike@state.tn.us">mike.updike@state.tn.us</a>
Charlie Graves	TDOT	<a href="mailto:charlie.graves@state.tn.us">charlie.graves@state.tn.us</a>
David Lindeman	Palmer Engineering	<a href="mailto:dlindeman@palmernet.com">dlindeman@palmernet.com</a>
Stephen Sewell	Palmer Engineering	<a href="mailto:ssewell@palmernet.com">ssewell@palmernet.com</a>

# **APPENDIX D**

## **TRAFFIC ANALYSIS DATA**

# 2011 AM Alt 1

Northbound I-65

HCS+: Basic Freeway Segments Release 5.2

Stephen Sewell  
Palmer Engineering  
400 Shoppers Drive  
PO Box 747  
Winchester, Ky 40392  
Phone: 859-744-1218 Fax: 859-744-1266  
E-mail: ssewell@palmernet.com

Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	2605	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	724	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1356	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1356	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	19.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

Stephen Sewell  
Palmer Engineering  
400 Shoppers Drive  
PO Box 747  
Winchester, Ky 40392  
Phone: 859-744-1218 Fax: 859-744-1266  
E-mail: ssewell@palmernet.com

Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	1801	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	2		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	804	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane	0	ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	600	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	6300	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent	
Volume, V (vph)	1801	804	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	500	223	167	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2792	1014	930	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.450$  Using Equation 0  
 FD  
 $v = v + (v - v) P = 1814$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$	2792	7200	No
Fi F			
$v$	1814	4400	No
12			
$v = v - v$	1778	7200	No
FO F R			
$v$	1014	4400	No
R			

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 1.9$  pc/mi/ln  
 R 12 D

Level of service for ramp-freeway junction areas of influence A

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.259$   
 S  
 Space mean speed in ramp influence area,  $S = 62.7$  mph  
 R  
 Space mean speed in outer lanes,  $S = 76.8$  mph  
 0  
 Space mean speed for all vehicles,  $S = 67.0$  mph

---

HCS+: Basic Freeway Segments Release 5.2

Stephen Sewell  
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400 Shoppers Drive  
PO Box 747  
Winchester, Ky 40392  
Phone: 859-744-1218 Fax: 859-744-1266  
E-mail: ssewell@palmernet.com

Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	1801	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	500	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	937	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	937	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	13.4	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis Diverge  
Number of lanes in freeway 3  
Free-flow speed on freeway 70.0 mph  
Volume on freeway 1801 vph

Off Ramp Data

Side of freeway Right  
Number of lanes in ramp 2  
Free-Flow speed on ramp 55.0 mph  
Volume on ramp 804 vph  
Length of first accel/decel lane 1000 ft  
Length of second accel/decel lane 0 ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist? Yes  
Volume on adjacent ramp 600 vph  
Position of adjacent ramp Downstream  
Type of adjacent ramp On  
Distance to adjacent ramp 6300 ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	1801	804	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	500	223	167	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2792	1014	930	pcph

Estimation of V12 Diverge Areas

$$L = \text{(Equation 25-8 or 25-9)}$$

$$EQ$$

$$P = 0.450 \text{ Using Equation 0}$$

$$FD$$

$$v = v + (v - v) P = 1814 \text{ pc/h}$$

$$12 \quad R \quad F \quad R \quad FD$$

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$	2792	7200	No
$F_i \quad F$			
$v$	1814	4400	No
12			
$v = v - v$	1778	7200	No
$FO \quad F \quad R$			
$v$	1014	4400	No
R			

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 1.9 \text{ pc/mi/ln}$

$$R \quad 12 \quad D$$

Level of service for ramp-freeway junction areas of influence A

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.259$

$$S$$

Space mean speed in ramp influence area,  $S = 62.7 \text{ mph}$

$$R$$

Space mean speed in outer lanes,  $S = 76.8 \text{ mph}$

$$0$$

Space mean speed for all vehicles,  $S = 67.0 \text{ mph}$

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	2229	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	619	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1160	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1160	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	16.6	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2229	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	233	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	428	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2229	233	428	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	619	65	119	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3455	294	663	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.660$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 2381$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	3455	7200	No
$v$ 12	2381	4400	No
$v = v - v$ FO F R	3161	7200	No
$v$ R	294	2100	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 6.7$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence A

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.324$   
 S  
 Space mean speed in ramp influence area,  $S = 60.9$  mph  
 R  
 Space mean speed in outer lanes,  $S = 76.5$  mph  
 0  
 Space mean speed for all vehicles,  $S = 65.0$  mph

---

Southbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3150	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	875	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1639	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1639	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.2	mi/h
Number of lanes, N	3	
Density, D	23.7	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	3	
Free-flow speed on freeway	70.0	mph
Volume on freeway	2472	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	55.0	mph
Volume on ramp	678	vph
Length of first accel/decel lane	1200	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent
Volume, V (vph)	2472	678	vph
Peak-hour factor, PHF	0.90	0.90	
Peak 15-min volume, v15	687	188	v
Trucks and buses	25	9	%
Recreational vehicles	2	0	%
Terrain type:	Rolling	Rolling	
Grade	0.00 %	0.00 %	%
Length	0.00 mi	0.00 mi	mi
Trucks and buses PCE, ET	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	

Driver population factor,  $fP$       1.00    1.00  
Flow rate,  $v_p$                       3832    855                      pcph

---

Estimation of V12 Diverge Areas

---

$L =$             (Equation 25-8 or 25-9)  
EQ  
 $P = 0.625$  Using Equation 5  
FD  
 $v = v + (v - v) P = 2715$  pc/h  
12 R    F R    FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	3832	7200	No
$v$ 12	2715	4400	No
$v = v - v$ FO F R	2977	7200	No
$v$ R	855	2200	No

---

Level of Service Determination (if not F)

---

Density,                       $D = 4.252 + 0.0086 v - 0.009 L = 16.8$  pc/mi/ln  
R                              12                      D  
Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

Intermediate speed variable,                       $D = 0.245$   
S  
Space mean speed in ramp influence area,     $S = 63.1$  mph  
R  
Space mean speed in outer lanes,               $S = 76.3$  mph  
0  
Space mean speed for all vehicles,               $S = 66.5$  mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2472	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	687	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1286	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1286	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	18.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2472	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	171	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	1500	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2472	171	1500	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	687	48	417	v
Trucks and buses	25	9	0	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	1.000	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3832	216	1667	pcph

---

Estimation of V12 Merge Areas

---

$L = 7696.21$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.695$  Using Equation 3  
 FM  
 $v = v(P) = 2662$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	4048	7200	No
FO			
v	2878	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 21.6$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.280$   
 S  
 Space mean speed in ramp influence area,  $S = 62.2$  mph  
 R  
 Space mean speed in outer lanes,  $S = 67.6$  mph  
 0  
 Space mean speed for all vehicles,  $S = 63.6$  mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2643	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	734	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1375	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1375	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	19.6	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

2011 PM  
Alt 1

Northbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	3548	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	986	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1846	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1846	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	67.3	mi/h
Number of lanes, N	3	
Density, D	27.4	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2900	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	2		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	222	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane	0	ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	600	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	6300	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2900	222	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	806	62	167	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4495	280	757	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.450$  Using Equation 0  
 FD  
 $v = v + (v - v) P = 2177$  pc/h  
 12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	4495	7200	No
$v$ 12	2177	4400	No
$v = v - v$ FO F R	4215	7200	No
$v$ R	280	4400	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 5.0$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence A

Speed Estimation

---

Intermediate speed variable,  $D = 0.193$   
 S  
 Space mean speed in ramp influence area,  $S = 64.6$  mph  
 R  
 Space mean speed in outer lanes,  $S = 71.6$  mph  
 0  
 Space mean speed for all vehicles,  $S = 68.0$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2900	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	806	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1509	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1509	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.8	mi/h
Number of lanes, N	3	
Density, D	21.6	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2900	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	648	vph	
Length of first accel/decel lane	1200	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	1200	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2900	648	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	806	180	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4495	817	221	pcph

---

Estimation of V12 Merge Areas

---

$L = 2144.17$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.552$  Using Equation 2  
 FM  
 $v = v(P) = 2479$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	5312	7200	No
FO			
v	3296	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 23.3$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.294$   
 S  
 Space mean speed in ramp influence area,  $S = 61.8$  mph  
 R  
 Space mean speed in outer lanes,  $S = 64.5$  mph  
 0  
 Space mean speed for all vehicles,  $S = 62.8$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3122	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	867	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1625	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1625	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.3	mi/h
Number of lanes, N	3	
Density, D	23.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3548	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	233	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	648	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3548	233	648	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	986	65	180	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	5499	294	1004	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.609$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 3464$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	5499	7200	No
$v$ 12	3464	4400	No
$v = v - v$ FO F R	5205	7200	No
$v$ R	294	2100	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 16.0$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.324$   
 S  
 Space mean speed in ramp influence area,  $S = 60.9$  mph  
 R  
 Space mean speed in outer lanes,  $S = 72.8$  mph  
 0  
 Space mean speed for all vehicles,  $S = 64.8$  mph

---

Southbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	2659	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	739	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1384	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1384	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	19.8	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	3	
Free-flow speed on freeway	70.0	mph
Volume on freeway	2232	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	55.0	mph
Volume on ramp	427	vph
Length of first accel/decel lane	1200	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent
Volume, V (vph)	2232	427	vph
Peak-hour factor, PHF	0.90	0.90	
Peak 15-min volume, v15	620	119	v
Trucks and buses	25	9	%
Recreational vehicles	2	0	%
Terrain type:	Rolling	Rolling	
Grade	0.00 %	0.00 %	%
Length	0.00 mi	0.00 mi	mi
Trucks and buses PCE, ET	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	3460	538	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.649$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 2434$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	3460	7200	No
$v$ 12	2434	4400	No
$v = v - v$ FO F R	2922	7200	No
$v$ R	538	2200	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 14.4$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.216$   
 S  
 Space mean speed in ramp influence area,  $S = 63.9$  mph  
 R  
 Space mean speed in outer lanes,  $S = 76.7$  mph  
 0  
 Space mean speed for all vehicles,  $S = 67.3$  mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2232	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	620	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1161	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1161	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	16.6	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2232	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	757	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	1500	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2232	757	1500	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	620	210	417	v
Trucks and buses	25	9	0	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	1.000	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3460	955	1667	pcph

---

Estimation of V12 Merge Areas

---

$L = 7696.21$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.695$  Using Equation 3  
 FM  
 $v = v(P) = 2404$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	4415	7200	No
FO			
v	3359	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 25.0$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.323$   
 S  
 Space mean speed in ramp influence area,  $S = 61.0$  mph  
 R  
 Space mean speed in outer lanes,  $S = 68.0$  mph  
 0  
 Space mean speed for all vehicles,  $S = 62.5$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2989	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	830	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1555	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1555	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.6	mi/h
Number of lanes, N	3	
Density, D	22.3	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

2011 AM  
Alt 2

Northbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	2605	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	724	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1356	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1356	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	19.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	1801	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	2		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	804	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane	0	ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	600	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	6300	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent	
Volume, V (vph)	1801	804	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	500	223	167	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2792	1014	930	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.450$  Using Equation 0  
 FD  
 $v = v + (v - v) P = 1814$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$	2792	7200	No
Fi F			
$v$	1814	4400	No
12			
$v = v - v$	1778	7200	No
FO F R			
$v$	1014	4400	No
R			

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 1.9$  pc/mi/ln  
 R 12 D

Level of service for ramp-freeway junction areas of influence A

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.259$   
 S  
 Space mean speed in ramp influence area,  $S = 62.7$  mph  
 R  
 Space mean speed in outer lanes,  $S = 76.8$  mph  
 0  
 Space mean speed for all vehicles,  $S = 67.0$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	1801	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	500	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	937	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	937	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	13.4	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	1801	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	428	vph	
Length of first accel/decel lane	850	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	1200	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	1801	428	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	500	119	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	0.881
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2792	540	221	pcph

---

Estimation of V12 Merge Areas

---

L = 1565.05 (Equation 25-2 or 25-3)  
 EQ  
 P = 0.578 Using Equation 2  
 FM  
 $v = v(P) = 1614 \text{ pc/h}$   
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	3332	7200	No
FO			
v	2154	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 16.7 \text{ pc/mi/ln}$   
 R R 12 A

Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

Intermediate speed variable, M = 0.261  
 S  
 Space mean speed in ramp influence area, S = 62.7 mph  
 R  
 Space mean speed in outer lanes, S = 67.6 mph  
 0  
 Space mean speed for all vehicles, S = 64.3 mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2229	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	619	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1160	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1160	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	16.6	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2229	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	233	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	428	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2229	233	428	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	619	65	119	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3455	294	663	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.660$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 2381$  pc/h  
 12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	3455	7200	No
$v$ 12	2381	4400	No
$v = v - v$ FO F R	3161	7200	No
$v$ R	294	2100	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 6.7$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence A

Speed Estimation

---

Intermediate speed variable,  $D = 0.324$   
 S  
 Space mean speed in ramp influence area,  $S = 60.9$  mph  
 R  
 Space mean speed in outer lanes,  $S = 76.5$  mph  
 0  
 Space mean speed for all vehicles,  $S = 65.0$  mph

---

Southbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3150	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	875	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1639	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1639	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.2	mi/h
Number of lanes, N	3	
Density, D	23.7	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Freeway Weaving Release 5.2

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Operational Analysis

Analyst: STEPHEN SEWELL  
Agency/Co.: PALMER ENGINEERING  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Dir of Travel: I-65 SB  
Weaving Location: REST AREA AND SB OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Inputs

Freeway free-flow speed, SFF 70 mph  
Weaving number of lanes, N 4  
Weaving segment length, L 1200 ft  
Terrain type Rolling  
Grade %  
Length mi  
Weaving type A  
Volume ratio, VR 0.23  
Weaving ratio, R 0.19

Conversion to pc/h Under Base Conditions

	Non-Weaving		Weaving		
	V	V	V	V	
	A-C	B-D	A-D	B-C	
Volume, V	2312	0	678	160	veh/h
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	
Peak 15-min volume, v15	642	0	188	44	v
Trucks and buses	25	0	10	10	%
Recreational vehicles	0	0	0	0	%
Trucks and buses PCE, ET	2.5	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.727	1.000	0.870	0.870	
Driver population adjustment, fP	1.00	1.00	1.00	1.00	
Flow rate, v	3532	0	866	204	pc/h

Weaving and Non-Weaving Speeds

	Weaving	Non-Weaving
a (Exhibit 24-6)	0.15	0.00
b (Exhibit 24-6)	2.20	4.00
c (Exhibit 24-6)	0.97	1.30
d (Exhibit 24-6)	0.80	0.75
Weaving intensity factor, Wi	0.76	0.38
Weaving and non-weaving speeds, Si	49.07	58.56
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)	1.23	
Maximum number of lanes, Nw (max) (Exhibit 24-7)	1.40	

Type of operation is Unconstrained

\_\_\_\_\_Weaving Segment Speed, Density, Level of Service and Capacity\_\_\_\_\_

Weaving segment speed, S 56.04 mph  
 Weaving segment density, D 20.53 pc/mi/ln  
 Level of service, LOS C  
 Capacity of base condition, cb 7962 pc/h  
 Capacity as a 15-minute flow rate, c 5791 pc/h  
 Capacity as a full-hour volume, ch 5212 pc/h

\_\_\_\_\_Limitations on Weaving Segments\_\_\_\_\_

	If Max Exceeded See Note		
	Analyzed	Maximum	Note
Weaving flow rate, Vw	1070	2800	a
Average flow rate (pcphpl)	1150	2400	b
Volume ratio, VR	0.23	0.35	c
Weaving ratio, R	0.19	N/A	d
Weaving length (ft)	1200	2500	e

Notes:

- a. Weaving segments longer than 2500 ft. are treated as isolated merge and diverge areas using the procedures of Chapter 25, "Ramps and Ramp Junctions".
- b. Capacity constrained by basic freeway capacity.
- c. Capacity occurs under constrained operating conditions.
- d. Three-lane Type A segments do not operate well at volume ratios greater than 0.45. Poor operations and some local queuing are expected in such cases.
- e. Four-lane Type A segments do not operate well at volume ratios greater than 0.35. Poor operations and some local queuing are expected in such cases.
- f. Capacity constrained by maximum allowable weaving flow rate: 2,800 pc/h (Type A), 4,000 (Type B), 3,500 (Type C).
- g. Five-lane Type A segments do not operate well at volume ratios greater than 0.20. Poor operations and some local queuing are expected in such cases.
- h. Type B weaving segments do not operate well at volume ratios greater than 0.80. Poor operations and some local queuing are expected in such cases.
- i. Type C weaving segments do not operate well at volume ratios greater than 0.50. Poor operations and some local queuing are expected in such cases.

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2472	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	687	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1286	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1286	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	18.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2472	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	171	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	1500	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2472	171	1500	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	687	48	417	v
Trucks and buses	25	9	0	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	1.000	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3832	216	1667	pcph

---

Estimation of V12 Merge Areas

---

$L = 7696.21$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.695$  Using Equation 3  
 FM  
 $v = v(P) = 2662$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	4048	7200	No
FO			
v	2878	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 21.6$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.280$   
 S  
 Space mean speed in ramp influence area,  $S = 62.2$  mph  
 R  
 Space mean speed in outer lanes,  $S = 67.6$  mph  
 0  
 Space mean speed for all vehicles,  $S = 63.6$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

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Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2643	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	734	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1375	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1375	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	19.6	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

2011 PM  
Alt 2

Northbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	3548	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	986	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1846	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1846	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	67.3	mi/h
Number of lanes, N	3	
Density, D	27.4	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2900	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	2		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	222	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane	0	ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	600	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	6300	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2900	222	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	806	62	167	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4495	280	757	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.450$  Using Equation 0  
 FD  
 $v = v + (v - v) P = 2177$  pc/h  
 12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	4495	7200	No
$v$ 12	2177	4400	No
$v = v - v$ FO F R	4215	7200	No
$v$ R	280	4400	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 5.0$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence A

Speed Estimation

---

Intermediate speed variable,  $D = 0.193$   
 S  
 Space mean speed in ramp influence area,  $S = 64.6$  mph  
 R  
 Space mean speed in outer lanes,  $S = 71.6$  mph  
 0  
 Space mean speed for all vehicles,  $S = 68.0$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2900	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	806	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1509	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1509	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.8	mi/h
Number of lanes, N	3	
Density, D	21.6	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2900	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	648	vph	
Length of first accel/decel lane	1200	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	1200	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2900	648	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	806	180	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4495	817	221	pcph

---

Estimation of V12 Merge Areas

---

$L = 2144.17$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.552$  Using Equation 2  
 FM  
 $v = v(P) = 2479$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	5312	7200	No
FO			
v	3296	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 23.3$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.294$   
 S  
 Space mean speed in ramp influence area,  $S = 61.8$  mph  
 R  
 Space mean speed in outer lanes,  $S = 64.5$  mph  
 0  
 Space mean speed for all vehicles,  $S = 62.8$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3122	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	867	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1625	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1625	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.3	mi/h
Number of lanes, N	3	
Density, D	23.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3548	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	233	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	648	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3548	233	648	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	986	65	180	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	5499	294	1004	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.609$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 3464$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	5499	7200	No
$v$ 12	3464	4400	No
$v = v - v$ FO F R	5205	7200	No
$v$ R	294	2100	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 16.0$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.324$   
 S  
 Space mean speed in ramp influence area,  $S = 60.9$  mph  
 R  
 Space mean speed in outer lanes,  $S = 72.8$  mph  
 0  
 Space mean speed for all vehicles,  $S = 64.8$  mph

---

Southbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	2659	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	739	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1384	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1384	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	19.8	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Freeway Weaving Release 5.2

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Operational Analysis

Analyst: STEPHEN SEWELL  
Agency/Co.: PALMER ENGINEERING  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Dir of Travel: I-65 SB  
Weaving Location: REST AREA AND SB OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Inputs

Freeway free-flow speed, SFF 70 mph  
Weaving number of lanes, N 4  
Weaving segment length, L 1200 ft  
Terrain type Rolling  
Grade %  
Length mi  
Weaving type A  
Volume ratio, VR 0.31  
Weaving ratio, R 0.10

Conversion to pc/h Under Base Conditions

	Non-Weaving		Weaving		
	V	V	V	V	
	A-C	B-D	A-D	B-C	
Volume, V	3029	0	1470	165	veh/h
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	
Peak 15-min volume, v15	841	0	408	46	v
Trucks and buses	25	0	10	10	%
Recreational vehicles	0	0	0	0	%
Trucks and buses PCE, ET	2.5	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.727	1.000	0.870	0.870	
Driver population adjustment, fP	1.00	1.00	1.00	1.00	
Flow rate, v	4627	0	1878	210	pc/h

Weaving and Non-Weaving Speeds

	Weaving	Non-Weaving
a (Exhibit 24-6)	0.15	0.00
b (Exhibit 24-6)	2.20	4.00
c (Exhibit 24-6)	0.97	1.30
d (Exhibit 24-6)	0.80	0.75
Weaving intensity factor, Wi	2.94	0.45
Weaving and non-weaving speeds, Si	30.25	56.34
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)	1.56	
Maximum number of lanes, Nw (max) (Exhibit 24-7)	1.40	
Type of operation is	Constrained	

\_\_\_\_\_Weaving Segment Speed, Density, Level of Service and Capacity\_\_\_\_\_

Weaving segment speed, S            44.42 mph  
 Weaving segment density, D        37.79 pc/mi/ln  
 Level of service, LOS                E  
 Capacity of base condition, cb      7377 pc/h  
 Capacity as a 15-minute flow rate, c 5365 pc/h  
 Capacity as a full-hour volume, ch 4828 pc/h

\_\_\_\_\_Limitations on Weaving Segments\_\_\_\_\_

	If Max Exceeded See Note		
	Analyzed	Maximum	Note
Weaving flow rate, Vw	2088	2800	a
Average flow rate (pcphpl)	1678	2400	b
Volume ratio, VR	0.31	0.35	c
Weaving ratio, R	0.10	N/A	d
Weaving length (ft)	1200	2500	e

Notes:

- a. Weaving segments longer than 2500 ft. are treated as isolated merge and diverge areas using the procedures of Chapter 25, "Ramps and Ramp Junctions".
- b. Capacity constrained by basic freeway capacity.
- c. Capacity occurs under constrained operating conditions.
- d. Three-lane Type A segments do not operate well at volume ratios greater than 0.45. Poor operations and some local queuing are expected in such cases.
- e. Four-lane Type A segments do not operate well at volume ratios greater than 0.35. Poor operations and some local queuing are expected in such cases.
- f. Capacity constrained by maximum allowable weaving flow rate: 2,800 pc/h (Type A), 4,000 (Type B), 3,500 (Type C).
- g. Five-lane Type A segments do not operate well at volume ratios greater than 0.20. Poor operations and some local queuing are expected in such cases.
- h. Type B weaving segments do not operate well at volume ratios greater than 0.80. Poor operations and some local queuing are expected in such cases.
- i. Type C weaving segments do not operate well at volume ratios greater than 0.50. Poor operations and some local queuing are expected in such cases.

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	2232	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	620	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1161	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1161	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	16.6	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2232	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	757	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	1500	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2232	757	1500	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	620	210	417	v
Trucks and buses	25	9	0	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	1.000	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3460	955	1667	pcph

---

Estimation of V12 Merge Areas

---

$L = 7696.21$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.695$  Using Equation 3  
 FM  
 $v = v(P) = 2404$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	4415	7200	No
FO			
v	3359	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 25.0$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.323$   
 S  
 Space mean speed in ramp influence area,  $S = 61.0$  mph  
 R  
 Space mean speed in outer lanes,  $S = 68.0$  mph  
 0  
 Space mean speed for all vehicles,  $S = 62.5$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2989	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	830	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1555	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1555	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.6	mi/h
Number of lanes, N	3	
Density, D	22.3	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

2011 AM  
Alt 3

Northbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	2605	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	724	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1356	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1356	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	19.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	1801	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	2		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	804	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane	0	ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	600	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	6300	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	1801	804	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	500	223	167	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2792	1014	930	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.450$  Using Equation 0  
 FD  
 $v = v + (v - v) P = 1814$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	2792	7200	No
$v$ 12	1814	4400	No
$v = v - v$ FO F R	1778	7200	No
$v$ R	1014	4400	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 1.9$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence A

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.259$   
 S  
 Space mean speed in ramp influence area,  $S = 62.7$  mph  
 R  
 Space mean speed in outer lanes,  $S = 76.8$  mph  
 0  
 Space mean speed for all vehicles,  $S = 67.0$  mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	1801	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	500	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	937	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	937	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	13.4	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	1801	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	428	vph	
Length of first accel/decel lane	850	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	1200	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	1801	428	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	500	119	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	0.881
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2792	540	221	pcph

---

Estimation of V12 Merge Areas

---

L = 1565.05 (Equation 25-2 or 25-3)  
 EQ  
 P = 0.578 Using Equation 2  
 FM  
 $v = v(P) = 1614 \text{ pc/h}$   
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	3332	7200	No
FO			
v	2154	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 16.7 \text{ pc/mi/ln}$   
 R R 12 A

Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

Intermediate speed variable, M = 0.261  
 S  
 Space mean speed in ramp influence area, S = 62.7 mph  
 R  
 Space mean speed in outer lanes, S = 67.6 mph  
 0  
 Space mean speed for all vehicles, S = 64.3 mph

---

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	2229	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	619	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1160	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1160	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	16.6	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2229	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	233	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	428	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2229	233	428	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	619	65	119	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3455	294	663	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.660$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 2381$  pc/h  
 12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	3455	7200	No
$v$ 12	2381	4400	No
$v = v - v$ FO F R	3161	7200	No
$v$ R	294	2100	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 6.7$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence A

Speed Estimation

---

Intermediate speed variable,  $D = 0.324$   
 S  
 Space mean speed in ramp influence area,  $S = 60.9$  mph  
 R  
 Space mean speed in outer lanes,  $S = 76.5$  mph  
 0  
 Space mean speed for all vehicles,  $S = 65.0$  mph

---

Southbound I-65

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	3150	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	875	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1639	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1639	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.2	mi/h
Number of lanes, N	3	
Density, D	23.7	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.



---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.615$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 2767$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	3832	7200	No
$v$ 12	2767	4400	No
$v = v - v$ FO F R	2769	7200	No
$v$ R	1063	2200	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 17.2$  pc/mi/ln  
 R 12 D

Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.264$   
 S  
 Space mean speed in ramp influence area,  $S = 62.6$  mph  
 R  
 Space mean speed in outer lanes,  $S = 76.5$  mph  
 0  
 Space mean speed for all vehicles,  $S = 66.0$  mph

---

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	2472	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	687	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1286	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1286	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	18.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2472	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	336	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	1500	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2472	336	1500	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	687	93	417	v
Trucks and buses	25	9	0	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	1.000	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3832	424	1667	pcph

---

Estimation of V12 Merge Areas

---

$L = 7696.21$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.695$  Using Equation 3  
 FM  
 $v = v(P) = 2662$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	4256	7200	No
FO			
v	3086	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 23.1$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.296$   
 S  
 Space mean speed in ramp influence area,  $S = 61.7$  mph  
 R  
 Space mean speed in outer lanes,  $S = 67.6$  mph  
 0  
 Space mean speed for all vehicles,  $S = 63.2$  mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2643	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	734	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1375	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1375	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	19.6	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

2011 PM  
Alt 3

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	3548	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	986	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1846	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1846	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	67.3	mi/h
Number of lanes, N	3	
Density, D	27.4	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB OFF RAMP  
Junction: SR 109  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2900	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	2		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	222	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane	0	ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	600	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	6300	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2900	222	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	806	62	167	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4495	280	757	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.450$  Using Equation 0  
 FD  
 $v = v + (v - v) P = 2177$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	4495	7200	No
$v$ 12	2177	4400	No
$v = v - v$ FO F R	4215	7200	No
$v$ R	280	4400	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 5.0$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence A

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.193$   
 S  
 Space mean speed in ramp influence area,  $S = 64.6$  mph  
 R  
 Space mean speed in outer lanes,  $S = 71.6$  mph  
 0  
 Space mean speed for all vehicles,  $S = 68.0$  mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2900	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	806	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1509	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1509	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.8	mi/h
Number of lanes, N	3	
Density, D	21.6	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2900	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	648	vph	
Length of first accel/decel lane	1200	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	1200	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2900	648	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	806	180	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4495	817	221	pcph

---

Estimation of V12 Merge Areas

---

$L = 2144.17$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.552$  Using Equation 2  
 FM  
 $v = v(P) = 2479$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	5312	7200	No
FO			
v	3296	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 23.3$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.294$   
 S  
 Space mean speed in ramp influence area,  $S = 61.8$  mph  
 R  
 Space mean speed in outer lanes,  $S = 64.5$  mph  
 O  
 Space mean speed for all vehicles,  $S = 62.8$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	3122	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	867	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1625	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1625	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.3	mi/h
Number of lanes, N	3	
Density, D	23.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3548	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	233	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	648	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3548	233	648	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	986	65	180	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	5499	294	1004	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.609$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 3464$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	5499	7200	No
$v$ 12	3464	4400	No
$v = v - v$ FO F R	5205	7200	No
$v$ R	294	2100	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 16.0$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.324$   
 S  
 Space mean speed in ramp influence area,  $S = 60.9$  mph  
 R  
 Space mean speed in outer lanes,  $S = 72.8$  mph  
 0  
 Space mean speed for all vehicles,  $S = 64.8$  mph

---

Southbound I-65

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	2659	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	739	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1384	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1384	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	19.8	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2232	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	592	vph	
Length of first accel/decel lane	1200	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No		
Volume on adjacent ramp		vph	
Position of adjacent ramp			
Type of adjacent ramp			
Distance to adjacent ramp		ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent
	Ramp		
Volume, V (vph)	2232	592	vph
Peak-hour factor, PHF	0.90	0.90	
Peak 15-min volume, v15	620	164	v
Trucks and buses	25	9	%
Recreational vehicles	2	0	%
Terrain type:	Rolling	Rolling	
Grade	0.00 %	0.00 %	%
Length	0.00 mi	0.00 mi	mi
Trucks and buses PCE, ET	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	3460	747	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.639$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 2481$  pc/h  
 12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	3460	7200	No
$v$ 12	2481	4400	No
$v = v - v$ FO F R	2713	7200	No
$v$ R	747	2200	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 14.8$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence B

Speed Estimation

---

Intermediate speed variable,  $D = 0.235$   
 S  
 Space mean speed in ramp influence area,  $S = 63.4$  mph  
 R  
 Space mean speed in outer lanes,  $S = 76.8$  mph  
 0  
 Space mean speed for all vehicles,  $S = 66.7$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2232	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	620	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1161	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1161	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	16.6	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	3	
Free-flow speed on freeway	70.0	mph
Volume on freeway	2232	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	55.0	mph
Volume on ramp	922	vph
Length of first accel/decel lane	1000	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1500	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	3000	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent	
Volume, V (vph)	2232	922	1500	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	620	256	417	v
Trucks and buses	25	9	0	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	1.000	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3460	1163	1667	pcph

---

Estimation of V12 Merge Areas

---

L = 7696.21 (Equation 25-2 or 25-3)  
 EQ  
 P = 0.695 Using Equation 3  
 FM  
 $v = v(P) = 2404$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	4623	7200	No
FO			
v	3567	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 26.5$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.349$   
 S  
 Space mean speed in ramp influence area,  $S = 60.2$  mph  
 R  
 Space mean speed in outer lanes,  $S = 68.0$  mph  
 0  
 Space mean speed for all vehicles,  $S = 61.8$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2989	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	830	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1555	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1555	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.6	mi/h
Number of lanes, N	3	
Density, D	22.3	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

2011 AM  
Alt 4

Northbound I-65

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	2605	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	724	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1356	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1356	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	19.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	1801	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	2		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	804	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane	0	ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	600	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	6300	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent	
Volume, V (vph)	1801	804	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	500	223	167	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2792	1014	930	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.450$  Using Equation 0  
 FD  
 $v = v + (v - v) P = 1814$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$	2792	7200	No
Fi F			
$v$	1814	4400	No
12			
$v = v - v$	1778	7200	No
FO F R			
$v$	1014	4400	No
R			

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 1.9$  pc/mi/ln  
 R 12 D

Level of service for ramp-freeway junction areas of influence A

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.259$   
 S  
 Space mean speed in ramp influence area,  $S = 62.7$  mph  
 R  
 Space mean speed in outer lanes,  $S = 76.8$  mph  
 0  
 Space mean speed for all vehicles,  $S = 67.0$  mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	1801	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	500	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	937	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	937	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	13.4	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	1801	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	428	vph	
Length of first accel/decel lane	850	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	1200	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	1801	428	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	500	119	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2792	540	221	pcph

---

Estimation of V12 Merge Areas

---

L = 1565.05 (Equation 25-2 or 25-3)  
 EQ  
 P = 0.578 Using Equation 2  
 FM  
 $v = v(P) = 1614 \text{ pc/h}$   
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	3332	7200	No
FO			
v	2154	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 16.7 \text{ pc/mi/ln}$   
 R R 12 A

Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

Intermediate speed variable, M = 0.261  
 S  
 Space mean speed in ramp influence area, S = 62.7 mph  
 R  
 Space mean speed in outer lanes, S = 67.6 mph  
 0  
 Space mean speed for all vehicles, S = 64.3 mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2229	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	619	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1160	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1160	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	16.6	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2229	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	233	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	428	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2229	233	428	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	619	65	119	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3455	294	663	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.660$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 2381$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	3455	7200	No
$v$ 12	2381	4400	No
$v = v - v$ FO F R	3161	7200	No
$v$ R	294	2100	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 6.7$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence A

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.324$   
 S  
 Space mean speed in ramp influence area,  $S = 60.9$  mph  
 R  
 Space mean speed in outer lanes,  $S = 76.5$  mph  
 0  
 Space mean speed for all vehicles,  $S = 65.0$  mph

---

Southbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	3150	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	875	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1639	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1639	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.2	mi/h
Number of lanes, N	3	
Density, D	23.7	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109/WELCOME CENTER Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2472	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	843	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	336	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	4500	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2472	843	336	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	687	234	93	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.866	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3832	1063	431	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)

EQ

$P = 0.615$  Using Equation 5

FD

$v = v + (v - v) P = 2767$  pc/h

12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	3832	7200	No
$v$ 12	2767	4400	No
$v = v - v$ FO F R	2769	7200	No
$v$ R	1063	2200	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 19.0$  pc/mi/ln

R 12 D

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

---

Intermediate speed variable,  $D = 0.264$

S

Space mean speed in ramp influence area,  $S = 62.6$  mph

R

Space mean speed in outer lanes,  $S = 76.5$  mph

0

Space mean speed for all vehicles,  $S = 66.0$  mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2472	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	687	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1286	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1286	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	18.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2472	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	336	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	135	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2472	336	135	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	687	93	38	v
Trucks and buses	25	9	5	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.930	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3832	424	161	pcph

---

Estimation of V12 Merge Areas

---

L = 743.31 (Equation 25-2 or 25-3)  
 EQ  
 P = 0.605 Using Equation 1  
 FM  
 $v = v(P) = 2320$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	4256	7200	No
FO			
v	2744	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 20.4$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable, M = 0.272  
 S  
 Space mean speed in ramp influence area, S = 62.4 mph  
 R  
 Space mean speed in outer lanes, S = 66.4 mph  
 0  
 Space mean speed for all vehicles, S = 63.7 mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2643	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	734	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1375	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1375	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	19.6	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

# 2011 PM Alt 4

Northbound I-65

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	3548	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	986	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1846	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1846	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	67.3	mi/h
Number of lanes, N	3	
Density, D	27.4	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2900	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	2		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	222	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane	0	ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	600	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	6300	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2900	222	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	806	62	167	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4495	280	757	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.450$  Using Equation 0  
 FD  
 $v = v + (v - v) P = 2177$  pc/h  
 12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	4495	7200	No
$v$ 12	2177	4400	No
$v = v - v$ FO F R	4215	7200	No
$v$ R	280	4400	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 5.0$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence A

Speed Estimation

---

Intermediate speed variable,  $D = 0.193$   
 S  
 Space mean speed in ramp influence area,  $S = 64.6$  mph  
 R  
 Space mean speed in outer lanes,  $S = 71.6$  mph  
 0  
 Space mean speed for all vehicles,  $S = 68.0$  mph

---

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	2900	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	806	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1509	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1509	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.8	mi/h
Number of lanes, N	3	
Density, D	21.6	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2900	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	648	vph	
Length of first accel/decel lane	1200	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	1200	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2900	648	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	806	180	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4495	817	221	pcph

---

Estimation of V12 Merge Areas

---

$L = 2144.17$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.552$  Using Equation 2  
 FM  
 $v = v(P) = 2479$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	5312	7200	No
FO			
v	3296	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 23.3$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.294$   
 S  
 Space mean speed in ramp influence area,  $S = 61.8$  mph  
 R  
 Space mean speed in outer lanes,  $S = 64.5$  mph  
 0  
 Space mean speed for all vehicles,  $S = 62.8$  mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3122	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	867	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1625	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1625	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.3	mi/h
Number of lanes, N	3	
Density, D	23.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3548	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	233	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	648	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3548	233	648	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	986	65	180	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	5499	294	1004	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)

EQ

$P = 0.609$  Using Equation 5

FD

$v = v + (v - v) P = 3464$  pc/h

12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	5499	7200	No
$v$ 12	3464	4400	No
$v = v - v$ FO F R	5205	7200	No
$v$ R	294	2100	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 16.0$  pc/mi/ln

R 12 D

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

---

Intermediate speed variable,  $D = 0.324$

S

Space mean speed in ramp influence area,  $S = 60.9$  mph

R

Space mean speed in outer lanes,  $S = 72.8$  mph

0

Space mean speed for all vehicles,  $S = 64.8$  mph

---

Southbound I-65

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E-mail: ssewell@palmernet.com

Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	2659	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	739	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1384	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1384	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	19.8	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109/WELCOME CENTER Off Ramp  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	3	
Free-flow speed on freeway	70.0	mph
Volume on freeway	2232	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	55.0	mph
Volume on ramp	592	vph
Length of first accel/decel lane	1000	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	992	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	4500	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2232	592	992	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	620	164	276	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.866	
Driver population factor, fP	1.00	1.00	1.00	



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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	2232	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	620	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1161	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1161	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	70.0	mi/h
Number of lanes, N	3	
Density, D	16.6	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	2232	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	922	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	369	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2232	922	369	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	620	256	103	v
Trucks and buses	25	9	0	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	1.000	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3460	1163	410	pcph

---

Estimation of V12 Merge Areas

---

L = 1892.89 (Equation 25-2 or 25-3)  
 EQ  
 P = 0.605 Using Equation 1  
 FM  
 $v = v(P) = 2095 \text{ pc/h}$   
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	4623	7200	No
FO			
v	3258	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 24.1 \text{ pc/mi/ln}$   
 R R 12 A

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable, M = 0.312  
 S  
 Space mean speed in ramp influence area, S = 61.3 mph  
 R  
 Space mean speed in outer lanes, S = 66.9 mph  
 0  
 Space mean speed for all vehicles, S = 62.8 mph

---

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2011  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	2989	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	830	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1555	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	1555	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.6	mi/h
Number of lanes, N	3	
Density, D	22.3	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

2031 AM  
Alt 1

Northbound I-65

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	6213	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1726	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	3233	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	3233	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	3	
Free-flow speed on freeway	70.0	mph
Volume on freeway	4608	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-Flow speed on ramp	55.0	mph
Volume on ramp	1605	vph
Length of first accel/decel lane	1000	ft
Length of second accel/decel lane	0	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	600	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	6300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	4608	1605	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1280	446	167	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	

Flow rate,  $v_p$                       7142      2024      930      pcph

---

Estimation of V12 Diverge Areas

---

L =            (Equation 25-8 or 25-9)  
EQ  
P = 0.450 Using Equation 0  
FD  
 $v = v + (v - v) P = 4327$  pc/h  
12 R    F R    FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	7142	7200	No
$v$ 12	4327	4400	No
$v = v - v$ FO F R	5118	7200	No
$v$ R	2024	4400	No

---

Level of Service Determination (if not F)

---

Density,                       $D = 4.252 + 0.0086 v - 0.009 L = 23.5$  pc/mi/ln  
R                              12                      D

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,                      D = 0.350  
S  
Space mean speed in ramp influence area,    S = 60.2 mph  
R  
Space mean speed in outer lanes,                S = 69.7 mph  
0  
Space mean speed for all vehicles,              S = 63.6 mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	4608	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1280	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2398	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2398	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	53.4	mi/h
Number of lanes, N	3	
Density, D	44.9	pc/mi/ln
Level of service, LOS	E	

Overall results are not computed when free-flow speed is less than 55 mph.

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	4608	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	969	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent	
Volume, V (vph)	4608	969	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1280	269	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	7142	1222	221	pcph

---

Estimation of V12 Merge Areas

---

L = 3152.50 (Equation 25-2 or 25-3)  
 EQ  
 P = 0.561 Using Equation 2  
 FM  
 $v = v(P) = 4005 \text{ pc/h}$   
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	8364	7200	Yes
FO			
v	5227	4600	Yes
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 33.1 \text{ pc/mi/ln}$   
 R R 12 A

Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.827$   
 S  
 Space mean speed in ramp influence area,  $S = 46.8 \text{ mph}$   
 R  
 Space mean speed in outer lanes,  $S = 58.4 \text{ mph}$   
 0  
 Space mean speed for all vehicles,  $S = 50.6 \text{ mph}$

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	5577	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1549	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2902	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2902	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	5577	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	305	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	969	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5577	305	969	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1549	85	269	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	8644	385	1502	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.526$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 4731$  pc/h  
 12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	8644	7200	Yes
$v$ 12	4731	4400	Yes
$v = v - v$ FO F R	8259	7200	Yes
$v$ R	385	2100	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 26.9$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence F

Speed Estimation

---

Intermediate speed variable,  $D = 0.333$   
 S  
 Space mean speed in ramp influence area,  $S = 60.7$  mph  
 R  
 Space mean speed in outer lanes,  $S = 65.4$  mph  
 0  
 Space mean speed for all vehicles,  $S = 62.7$  mph

---

Southbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	4664	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1296	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2427	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2427	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	3	
Free-flow speed on freeway	70.0	mph
Volume on freeway	3194	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	55.0	mph
Volume on ramp	1470	vph
Length of first accel/decel lane	1200	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent
Volume, V (vph)	3194	1470	vph
Peak-hour factor, PHF	0.90	0.90	
Peak 15-min volume, v15	887	408	v
Trucks and buses	25	9	%
Recreational vehicles	2	0	%
Terrain type:	Rolling	Rolling	
Grade	0.00 %	0.00 %	%
Length	0.00 mi	0.00 mi	mi
Trucks and buses PCE, ET	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	4951	1854	pcph

Estimation of V12 Diverge Areas

$$L = \text{(Equation 25-8 or 25-9)}$$

$$EQ$$

$$P = 0.551 \text{ Using Equation 5}$$

$$FD$$

$$v = v + (v - v) P = 3560 \text{ pc/h}$$

$$12 \quad R \quad F \quad R \quad FD$$

Capacity Checks

	Actual	Maximum	LOS F?
$v = v$	4951	7200	No
$Fi \quad F$			
$v$	3560	4400	No
12			
$v = v - v$	3097	7200	No
$FO \quad F \quad R$			
$v$	1854	2200	No
R			

Level of Service Determination (if not F)

$$\text{Density, } D = 4.252 + 0.0086 v - 0.009 L = 24.1 \text{ pc/mi/ln}$$

$$R \quad 12 \quad D$$

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,  $D = 0.335$

$$S$$

Space mean speed in ramp influence area,  $S = 60.6 \text{ mph}$

$$R$$

Space mean speed in outer lanes,  $S = 75.3 \text{ mph}$

$$0$$

Space mean speed for all vehicles,  $S = 64.1 \text{ mph}$

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3194	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	887	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1662	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1662	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.1	mi/h
Number of lanes, N	3	
Density, D	24.1	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3194	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	449	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	1500	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3194	449	1500	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	887	125	417	v
Trucks and buses	25	9	0	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	1.000	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4951	566	1667	pcph

---

Estimation of V12 Merge Areas

---

$L = 7696.21$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.695$  Using Equation 3  
 FM  
 $v = v(P) = 3440$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	5517	7200	No
FO			
v	4006	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 30.2$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence D

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.425$   
 S  
 Space mean speed in ramp influence area,  $S = 58.1$  mph  
 R  
 Space mean speed in outer lanes,  $S = 66.4$  mph  
 0  
 Space mean speed for all vehicles,  $S = 60.1$  mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3643	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1012	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1896	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1896	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	66.6	mi/h
Number of lanes, N	3	
Density, D	28.5	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

2031 PM  
Alt 1

Northbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	4469	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1241	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2326	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2326	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	56.1	mi/h
Number of lanes, N	3	
Density, D	41.5	pc/mi/ln
Level of service, LOS	E	

Overall results are not computed when free-flow speed is less than 55 mph.

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3894	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	2		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	575	vph	
Length of first accel/ ecal lane	1000	ft	
Length of second accel/ ecal lane	0	ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	600	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	6300	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3894	575	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1082	160	167	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	6036	725	757	pcph

Estimation of V12 Diverge Areas

$$L = \text{(Equation 25-8 or 25-9)}$$

$$EQ$$

$$P = 0.450 \text{ Using Equation 0}$$

$$FD$$

$$v = v + (v - v) P = 3115 \text{ pc/h}$$

$$12 \quad R \quad F \quad R \quad FD$$

Capacity Checks

	Actual	Maximum	LOS F?
$v = v$ Fi F	6036	7200	No
$v$ 12	3115	4400	No
$v = v - v$ FO F R	5311	7200	No
$v$ R	725	4400	No

Level of Service Determination (if not F)

$$\text{Density, } D = 4.252 + 0.0086 v - 0.009 L = 13.0 \text{ pc/mi/ln}$$

$$R \quad 12 \quad D$$

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable,  $D = 0.233$   
S

Space mean speed in ramp influence area,  $S = 63.5 \text{ mph}$   
R

Space mean speed in outer lanes,  $S = 69.3 \text{ mph}$   
0

Space mean speed for all vehicles,  $S = 66.2 \text{ mph}$

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3894	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1082	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2026	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2026	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	64.3	mi/h
Number of lanes, N	3	
Density, D	31.5	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3894	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	1405	vph	
Length of first accel/ decel lane	1200	ft	
Length of second accel/ decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	1200	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3894	1405	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1082	390	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	6036	1772	221	pcph

Estimation of V12 Merge Areas

---

$L = 2678.31$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.518$  Using Equation 2  
 FM  
 $v = v(P) = 3126$  pc/h  
 12 F FM

Capacity Checks

---

	Actual	Maximum	LOS F?
v	7808	7200	Yes
FO			
v	4898	4600	Yes
R12			

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 35.3$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence F

Speed Estimation

---

Intermediate speed variable,  $M = 0.712$   
 S  
 Space mean speed in ramp influence area,  $S = 50.1$  mph  
 R  
 Space mean speed in outer lanes,  $S = 59.8$  mph  
 0  
 Space mean speed for all vehicles,  $S = 53.3$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	5299	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1472	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2757	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2757	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	5299	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	305	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	1405	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5299	305	1405	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1472	85	390	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	8213	385	2178	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.537$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 4588$  pc/h  
 12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	8213	7200	Yes
$v$ 12	4588	4400	Yes
$v = v - v$ FO F R	7828	7200	Yes
$v$ R	385	2100	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 25.7$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence F

Speed Estimation

---

Intermediate speed variable,  $D = 0.333$   
 S  
 Space mean speed in ramp influence area,  $S = 60.7$  mph  
 R  
 Space mean speed in outer lanes,  $S = 66.6$  mph  
 0  
 Space mean speed for all vehicles,  $S = 63.1$  mph

---

Southbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	5067	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1408	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2637	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2637	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	3	
Free-flow speed on freeway	70.0	mph
Volume on freeway	4109	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	55.0	mph
Volume on ramp	958	vph
Length of first accel/decel lane	1200	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent
Volume, V (vph)	4109	958	vph
Peak-hour factor, PHF	0.90	0.90	
Peak 15-min volume, v15	1141	266	v
Trucks and buses	25	9	%
Recreational vehicles	2	0	%
Terrain type:	Rolling	Rolling	
Grade	0.00 %	0.00 %	%
Length	0.00 mi	0.00 mi	mi
Trucks and buses PCE, ET	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	6369	1208	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.545$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 4022$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	6369	7200	No
$v$ 12	4022	4400	No
$v = v - v$ FO F R	5161	7200	No
$v$ R	1208	2200	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 28.0+$  pc/mi/ln  
 R 12 D

Level of service for ramp-freeway junction areas of influence D

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.277$   
 S  
 Space mean speed in ramp influence area,  $S = 62.3$  mph  
 R  
 Space mean speed in outer lanes,  $S = 71.5$  mph  
 0  
 Space mean speed for all vehicles,  $S = 65.4$  mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	4109	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1141	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2138	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2138	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	61.8	mi/h
Number of lanes, N	3	
Density, D	34.6	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	4109	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	1575	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	1500	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	4109	1575	1500	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1141	438	417	v
Trucks and buses	25	9	0	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	1.000	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	6369	1986	1667	pcph

---

Estimation of V12 Merge Areas

---

L = 7696.21 (Equation 25-2 or 25-3)  
 EQ  
 P = 0.695 Using Equation 3  
 FM  
 $v = v(P) = 4425$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v FO	8355	7200	Yes
v R12	6411	4600	Yes

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 48.3$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

Intermediate speed variable, M = 2.584  
 S  
 Space mean speed in ramp influence area, S = -2.4 mph  
 R  
 Space mean speed in outer lanes, S = 64.8 mph  
 0  
 Space mean speed for all vehicles, S = mph

---

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	5684	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1579	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2958	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2958	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

2031 AM  
Alt 2

Northbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	6213	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1726	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	3233	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	3233	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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\_\_\_\_\_ Diverge Analysis \_\_\_\_\_

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

\_\_\_\_\_ Freeway Data \_\_\_\_\_

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	4608	vph	

\_\_\_\_\_ Off Ramp Data \_\_\_\_\_

Side of freeway	Right		
Number of lanes in ramp	2		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	1605	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane	0	ft	

\_\_\_\_\_ Adjacent Ramp Data (if one exists) \_\_\_\_\_

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	600	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	6300	ft	

\_\_\_\_\_ Conversion to pc/h Under Base Conditions \_\_\_\_\_

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	4608	1605	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1280	446	167	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	7142	2024	930	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.450$  Using Equation 0  
 FD  
 $v = v + (v - v) P = 4327$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	7142	7200	No
$v$ 12	4327	4400	No
$v = v - v$ FO F R	5118	7200	No
$v$ R	2024	4400	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 23.5$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.350$   
 S  
 Space mean speed in ramp influence area,  $S = 60.2$  mph  
 R  
 Space mean speed in outer lanes,  $S = 69.7$  mph  
 0  
 Space mean speed for all vehicles,  $S = 63.6$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	4608	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1280	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2398	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2398	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	53.4	mi/h
Number of lanes, N	3	
Density, D	44.9	pc/mi/ln
Level of service, LOS	E	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	4608	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	969	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	4608	969	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1280	269	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	7142	1222	221	pcph

---

Estimation of V12 Merge Areas

---

L = 3152.50 (Equation 25-2 or 25-3)  
 EQ  
 P = 0.561 Using Equation 2  
 FM  
 $v = v(P) = 4005 \text{ pc/h}$   
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	8364	7200	Yes
FO			
v	5227	4600	Yes
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 33.1 \text{ pc/mi/ln}$   
 R R 12 A

Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.827$   
 S  
 Space mean speed in ramp influence area,  $S = 46.8 \text{ mph}$   
 R  
 Space mean speed in outer lanes,  $S = 58.4 \text{ mph}$   
 0  
 Space mean speed for all vehicles,  $S = 50.6 \text{ mph}$

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	5577	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1549	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2902	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2902	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	5577	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	305	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	969	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5577	305	969	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1549	85	269	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	8644	385	1502	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.526$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 4731$  pc/h  
 12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	8644	7200	Yes
$v$ 12	4731	4400	Yes
$v = v - v$ FO F R	8259	7200	Yes
$v$ R	385	2100	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 26.9$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence F

Speed Estimation

---

Intermediate speed variable,  $D = 0.333$   
 S  
 Space mean speed in ramp influence area,  $S = 60.7$  mph  
 R  
 Space mean speed in outer lanes,  $S = 65.4$  mph  
 0  
 Space mean speed for all vehicles,  $S = 62.7$  mph

---

Southbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	4664	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1296	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2427	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2427	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Freeway Weaving Release 5.2

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Operational Analysis

Analyst: STEPHEN SEWELL  
Agency/Co.: PALMER ENGINEERING  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Dir of Travel: I-65 SB  
Weaving Location: REST AREA AND SB OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Inputs

Freeway free-flow speed, SFF 70 mph  
Weaving number of lanes, N 4  
Weaving segment length, L 1200 ft  
Terrain type Rolling  
Grade %  
Length mi  
Weaving type A  
Volume ratio, VR 0.31  
Weaving ratio, R 0.10

Conversion to pc/h Under Base Conditions

	Non-Weaving		Weaving		
	V	V	V	V	
	A-C	B-D	A-D	B-C	
Volume, V	3029	0	1470	165	veh/h
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	
Peak 15-min volume, v15	841	0	408	46	v
Trucks and buses	25	0	10	10	%
Recreational vehicles	0	0	0	0	%
Trucks and buses PCE, ET	2.5	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.727	1.000	0.870	0.870	
Driver population adjustment, fP	1.00	1.00	1.00	1.00	
Flow rate, v	4627	0	1878	210	pc/h

Weaving and Non-Weaving Speeds

	Weaving	Non-Weaving
a (Exhibit 24-6)	0.15	0.00
b (Exhibit 24-6)	2.20	4.00
c (Exhibit 24-6)	0.97	1.30
d (Exhibit 24-6)	0.80	0.75
Weaving intensity factor, Wi	2.94	0.45
Weaving and non-weaving speeds, Si	30.25	56.34
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)	1.56	
Maximum number of lanes, Nw (max) (Exhibit 24-7)	1.40	
Type of operation is	Constrained	

\_\_\_\_\_Weaving Segment Speed, Density, Level of Service and Capacity\_\_\_\_\_

Weaving segment speed, S            44.42 mph  
 Weaving segment density, D        37.79 pc/mi/ln  
 Level of service, LOS                E  
 Capacity of base condition, cb      7377 pc/h  
 Capacity as a 15-minute flow rate, c 5365 pc/h  
 Capacity as a full-hour volume, ch 4828 pc/h

\_\_\_\_\_Limitations on Weaving Segments\_\_\_\_\_

	If Max Exceeded See Note		
	Analyzed	Maximum	Note
Weaving flow rate, Vw	2088	2800	a
Average flow rate (pcphpl)	1678	2400	b
Volume ratio, VR	0.31	0.35	c
Weaving ratio, R	0.10	N/A	d
Weaving length (ft)	1200	2500	e

Notes:

- a. Weaving segments longer than 2500 ft. are treated as isolated merge and diverge areas using the procedures of Chapter 25, "Ramps and Ramp Junctions".
- b. Capacity constrained by basic freeway capacity.
- c. Capacity occurs under constrained operating conditions.
- d. Three-lane Type A segments do not operate well at volume ratios greater than 0.45. Poor operations and some local queuing are expected in such cases.
- e. Four-lane Type A segments do not operate well at volume ratios greater than 0.35. Poor operations and some local queuing are expected in such cases.
- f. Capacity constrained by maximum allowable weaving flow rate: 2,800 pc/h (Type A), 4,000 (Type B), 3,500 (Type C).
- g. Five-lane Type A segments do not operate well at volume ratios greater than 0.20. Poor operations and some local queuing are expected in such cases.
- h. Type B weaving segments do not operate well at volume ratios greater than 0.80. Poor operations and some local queuing are expected in such cases.
- i. Type C weaving segments do not operate well at volume ratios greater than 0.50. Poor operations and some local queuing are expected in such cases.

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3194	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	887	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1662	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1662	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.1	mi/h
Number of lanes, N	3	
Density, D	24.1	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3194	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	449	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	1500	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3194	449	1500	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	887	125	417	v
Trucks and buses	25	9	0	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	1.000	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4951	566	1667	pcph

Estimation of V12 Merge Areas

---

$L = 7696.21$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.695$  Using Equation 3  
 FM  
 $v = v(P) = 3440$  pc/h  
 12 F FM

Capacity Checks

---

	Actual	Maximum	LOS F?
v	5517	7200	No
FO			
v	4006	4600	No
R12			

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 30.2$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

---

Intermediate speed variable,  $M = 0.425$   
 S  
 Space mean speed in ramp influence area,  $S = 58.1$  mph  
 R  
 Space mean speed in outer lanes,  $S = 66.4$  mph  
 0  
 Space mean speed for all vehicles,  $S = 60.1$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3643	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1012	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1896	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1896	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	66.6	mi/h
Number of lanes, N	3	
Density, D	28.5	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

2031 PM  
Alt 2

Northbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	4469	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1241	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2326	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2326	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	56.1	mi/h
Number of lanes, N	3	
Density, D	41.5	pc/mi/ln
Level of service, LOS	E	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	3	
Free-flow speed on freeway	70.0	mph
Volume on freeway	3894	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-Flow speed on ramp	55.0	mph
Volume on ramp	575	vph
Length of first accel/decel lane	1000	ft
Length of second accel/decel lane	0	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	600	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	6300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent	
Volume, V (vph)	3894	575	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1082	160	167	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	6036	725	757	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.450$  Using Equation 0  
 FD  
 $v = v + (v - v) P = 3115$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	6036	7200	No
$v$ 12	3115	4400	No
$v = v - v$ FO F R	5311	7200	No
$v$ R	725	4400	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 13.0$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.233$   
 S  
 Space mean speed in ramp influence area,  $S = 63.5$  mph  
 R  
 Space mean speed in outer lanes,  $S = 69.3$  mph  
 0  
 Space mean speed for all vehicles,  $S = 66.2$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	3894	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1082	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2026	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2026	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	64.3	mi/h
Number of lanes, N	3	
Density, D	31.5	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3894	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	1405	vph	
Length of first accel/decel lane	1200	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	1200	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3894	1405	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1082	390	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	6036	1772	221	pcph

---

Estimation of V12 Merge Areas

---

$L = 2678.31$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.518$  Using Equation 2  
 FM  
 $v = v(P) = 3126$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	7808	7200	Yes
FO			
v	4898	4600	Yes
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 35.3$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.712$   
 S  
 Space mean speed in ramp influence area,  $S = 50.1$  mph  
 R  
 Space mean speed in outer lanes,  $S = 59.8$  mph  
 0  
 Space mean speed for all vehicles,  $S = 53.3$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	5299	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1472	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2757	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2757	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	5299	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	305	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	1405	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5299	305	1405	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1472	85	390	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	8213	385	2178	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.537$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 4588$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	8213	7200	Yes
$v$ 12	4588	4400	Yes
$v = v - v$ FO F R	7828	7200	Yes
$v$ R	385	2100	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 25.7$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.333$   
 S  
 Space mean speed in ramp influence area,  $S = 60.7$  mph  
 R  
 Space mean speed in outer lanes,  $S = 66.6$  mph  
 0  
 Space mean speed for all vehicles,  $S = 63.1$  mph

---

Southbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	5067	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1408	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2637	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2637	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Freeway Weaving Release 5.2

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Operational Analysis

Analyst: STEPHEN SEWELL  
Agency/Co.: PALMER ENGINEERING  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Dir of Travel: I-65 SB  
Weaving Location: REST AREA AND SB OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Inputs

Freeway free-flow speed, SFF 70 mph  
Weaving number of lanes, N 4  
Weaving segment length, L 1200 ft  
Terrain type Rolling  
Grade %  
Length mi  
Weaving type A  
Volume ratio, VR 0.19  
Weaving ratio, R 0.15

Conversion to pc/h Under Base Conditions

	Non-Weaving		Weaving		
	V	V	V	V	
	A-C	B-D	A-D	B-C	
Volume, V	3944	0	958	165	veh/h
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	
Peak 15-min volume, v15		1096	0	266	46 v
Trucks and buses	25	0	10	10	%
Recreational vehicles	0	0	0	0	%
Trucks and buses PCE, ET	2.5	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.727	1.000	0.870	0.870	
Driver population adjustment, fP	1.00	1.00	1.00	1.00	
Flow rate, v	6025	0	1224	210	pc/h

Weaving and Non-Weaving Speeds

	Weaving	Non-Weaving
a (Exhibit 24-6)	0.15	0.00
b (Exhibit 24-6)	2.20	4.00
c (Exhibit 24-6)	0.97	1.30
d (Exhibit 24-6)	0.80	0.75
Weaving intensity factor, Wi	1.13	0.62
Weaving and non-weaving speeds, Si	43.16	52.05
Number of lanes required for unconstrained operation, Nw (Exhibit 24-7)	1.17	
Maximum number of lanes, Nw (max) (Exhibit 24-7)	1.40	
Type of operation is	Unconstrained	

\_\_\_\_\_Weaving Segment Speed, Density, Level of Service and Capacity\_\_\_\_\_

Weaving segment speed, S            50.07 mph  
 Weaving segment density, D        37.24 pc/mi/ln  
 Level of service, LOS                E  
 Capacity of base condition, cb      8258 pc/h  
 Capacity as a 15-minute flow rate, c 6006 pc/h  
 Capacity as a full-hour volume, ch 5405 pc/h

\_\_\_\_\_Limitations on Weaving Segments\_\_\_\_\_

	If Max Exceeded See Note		
	Analyzed	Maximum	Note
Weaving flow rate, Vw	1434	2800	a
Average flow rate (pcphpl)	1864	2400	b
Volume ratio, VR	0.19	0.35	c
Weaving ratio, R	0.15	N/A	d
Weaving length (ft)	1200	2500	e

Notes:

- a. Weaving segments longer than 2500 ft. are treated as isolated merge and diverge areas using the procedures of Chapter 25, "Ramps and Ramp Junctions".
- b. Capacity constrained by basic freeway capacity.
- c. Capacity occurs under constrained operating conditions.
- d. Three-lane Type A segments do not operate well at volume ratios greater than 0.45. Poor operations and some local queuing are expected in such cases.
- e. Four-lane Type A segments do not operate well at volume ratios greater than 0.35. Poor operations and some local queuing are expected in such cases.
- f. Capacity constrained by maximum allowable weaving flow rate: 2,800 pc/h (Type A), 4,000 (Type B), 3,500 (Type C).
- g. Five-lane Type A segments do not operate well at volume ratios greater than 0.20. Poor operations and some local queuing are expected in such cases.
- h. Type B weaving segments do not operate well at volume ratios greater than 0.80. Poor operations and some local queuing are expected in such cases.
- i. Type C weaving segments do not operate well at volume ratios greater than 0.50. Poor operations and some local queuing are expected in such cases.

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	4109	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1141	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2138	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2138	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	61.8	mi/h
Number of lanes, N	3	
Density, D	34.6	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	4109	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	1575	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	1500	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	4109	1575	1500	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1141	438	417	v
Trucks and buses	25	9	0	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	1.000	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	6369	1986	1667	pcph

Estimation of V12 Merge Areas

---

$L = 7696.21$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.695$  Using Equation 3  
 FM  
 $v = v(P) = 4425$  pc/h  
 12 F FM

Capacity Checks

---

	Actual	Maximum	LOS F?
v FO	8355	7200	Yes
v R12	6411	4600	Yes

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 48.3$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence F

Speed Estimation

---

Intermediate speed variable,  $M = 2.584$   
 S  
 Space mean speed in ramp influence area,  $S = -2.4$  mph  
 R  
 Space mean speed in outer lanes,  $S = 64.8$  mph  
 0  
 Space mean speed for all vehicles,  $S =$  mph

---

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	5684	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1579	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2958	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2958	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

2031 AM  
Alt 3

Northbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	6213	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1726	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	3233	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	3233	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	4608	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	2		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	1605	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane	0	ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	600	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	6300	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent	
	Ramp			
Volume, V (vph)	4608	1605	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1280	446	167	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	7142	2024	930	pcph

---

Estimation of V12 Diverge Areas

---

L = (Equation 25-8 or 25-9)  
 EQ  
 P = 0.450 Using Equation 0  
 FD  
 $v = v + (v - v) P = 4327$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	7142	7200	No
$v$ 12	4327	4400	No
$v = v - v$ FO F R	5118	7200	No
$v$ R	2024	4400	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 23.5$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.350$   
 S  
 Space mean speed in ramp influence area,  $S = 60.2$  mph  
 R  
 Space mean speed in outer lanes,  $S = 69.7$  mph  
 0  
 Space mean speed for all vehicles,  $S = 63.6$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	4608	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1280	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2398	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2398	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	53.4	mi/h
Number of lanes, N	3	
Density, D	44.9	pc/mi/ln
Level of service, LOS	E	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	4608	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	969	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	4608	969	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1280	269	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	7142	1222	221	pcph

---

Estimation of V12 Merge Areas

---

L = 3152.50 (Equation 25-2 or 25-3)  
 EQ  
 P = 0.561 Using Equation 2  
 FM  
 $v = v(P) = 4005 \text{ pc/h}$   
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	8364	7200	Yes
FO			
v	5227	4600	Yes
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 33.1 \text{ pc/mi/ln}$   
 R R 12 A

Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.827$   
 S  
 Space mean speed in ramp influence area,  $S = 46.8 \text{ mph}$   
 R  
 Space mean speed in outer lanes,  $S = 58.4 \text{ mph}$   
 0  
 Space mean speed for all vehicles,  $S = 50.6 \text{ mph}$

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	5577	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1549	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2902	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2902	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	5577	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	305	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	969	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5577	305	969	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1549	85	269	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	8644	385	1502	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.526$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 4731$  pc/h  
 12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	8644	7200	Yes
$v$ 12	4731	4400	Yes
$v = v - v$ FO F R	8259	7200	Yes
$v$ R	385	2100	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 26.9$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence F

Speed Estimation

---

Intermediate speed variable,  $D = 0.333$   
 S  
 Space mean speed in ramp influence area,  $S = 60.7$  mph  
 R  
 Space mean speed in outer lanes,  $S = 65.4$  mph  
 0  
 Space mean speed for all vehicles,  $S = 62.7$  mph

---

Southbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	4664	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1296	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2427	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2427	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	3	
Free-flow speed on freeway	70.0	mph
Volume on freeway	3029	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	55.0	mph
Volume on ramp	1635	vph
Length of first accel/decel lane	1200	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent
	Ramp		
Volume, V (vph)	3029	1635	vph
Peak-hour factor, PHF	0.90	0.90	
Peak 15-min volume, v15	841	454	v
Trucks and buses	25	9	%
Recreational vehicles	2	0	%
Terrain type:	Rolling	Rolling	
Grade	0.00 %	0.00 %	%
Length	0.00 mi	0.00 mi	mi
Trucks and buses PCE, ET	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	4695	2062	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.548$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 3504$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	4695	7200	No
$v$ 12	3504	4400	No
$v = v - v$ FO F R	2633	7200	No
$v$ R	2062	2200	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 23.6$  pc/mi/ln  
 R 12 D

Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.354$   
 S  
 Space mean speed in ramp influence area,  $S = 60.1$  mph  
 R  
 Space mean speed in outer lanes,  $S = 76.0$  mph  
 0  
 Space mean speed for all vehicles,  $S = 63.5$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3194	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	887	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1662	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1662	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.1	mi/h
Number of lanes, N	3	
Density, D	24.1	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3029	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	614	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	1500	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3029	614	1500	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	841	171	417	v
Trucks and buses	25	9	0	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	1.000	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4695	774	1667	pcph

---

Estimation of V12 Merge Areas

---

$L = 7696.21$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.695$  Using Equation 3  
 FM  
 $v = v(P) = 3262$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	5469	7200	No
FO			
v	4036	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 30.3$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence D

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.432$   
 S  
 Space mean speed in ramp influence area,  $S = 57.9$  mph  
 R  
 Space mean speed in outer lanes,  $S = 66.6$  mph  
 0  
 Space mean speed for all vehicles,  $S = 60.0$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3643	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1012	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1896	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1896	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	66.6	mi/h
Number of lanes, N	3	
Density, D	28.5	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

2031 PM  
Alt 3

Northbound I-65

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	4469	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1241	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2326	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2326	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	56.1	mi/h
Number of lanes, N	3	
Density, D	41.5	pc/mi/ln
Level of service, LOS	E	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3894	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	2		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	575	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane	0	ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	600	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	6300	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent	
Volume, V (vph)	3894	575	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1082	160	167	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	6036	725	757	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.450$  Using Equation 0  
 FD  
 $v = v + (v - v) P = 3115$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	6036	7200	No
$v$ 12	3115	4400	No
$v = v - v$ FO F R	5311	7200	No
$v$ R	725	4400	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 13.0$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.233$   
 S  
 Space mean speed in ramp influence area,  $S = 63.5$  mph  
 R  
 Space mean speed in outer lanes,  $S = 69.3$  mph  
 0  
 Space mean speed for all vehicles,  $S = 66.2$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3894	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1082	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2026	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2026	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	64.3	mi/h
Number of lanes, N	3	
Density, D	31.5	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3894	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	1405	vph	
Length of first accel/decel lane	1200	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	1200	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3894	1405	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1082	390	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	6036	1772	221	pcph

---

Estimation of V12 Merge Areas

---

$L = 2678.31$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.518$  Using Equation 2  
 FM  
 $v = v(P) = 3126$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	7808	7200	Yes
FO			
v	4898	4600	Yes
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 35.3$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.712$   
 S  
 Space mean speed in ramp influence area,  $S = 50.1$  mph  
 R  
 Space mean speed in outer lanes,  $S = 59.8$  mph  
 0  
 Space mean speed for all vehicles,  $S = 53.3$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	5299	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1472	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2757	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2757	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	5299	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	305	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	1405	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5299	305	1405	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1472	85	390	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	8213	385	2178	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.537$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 4588$  pc/h  
 12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	8213	7200	Yes
$v$ 12	4588	4400	Yes
$v = v - v$ FO F R	7828	7200	Yes
$v$ R	385	2100	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 25.7$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence F

Speed Estimation

---

Intermediate speed variable,  $D = 0.333$   
 S  
 Space mean speed in ramp influence area,  $S = 60.7$  mph  
 R  
 Space mean speed in outer lanes,  $S = 66.6$  mph  
 0  
 Space mean speed for all vehicles,  $S = 63.1$  mph

---

Southbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	5067	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1408	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2637	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2637	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	3	
Free-flow speed on freeway	70.0	mph
Volume on freeway	3944	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	55.0	mph
Volume on ramp	1123	vph
Length of first accel/decel lane	1200	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent
	Ramp		
Volume, V (vph)	3944	1123	vph
Peak-hour factor, PHF	0.90	0.90	
Peak 15-min volume, v15	1096	312	v
Trucks and buses	25	9	%
Recreational vehicles	2	0	%
Terrain type:	Rolling	Rolling	
Grade	0.00 %	0.00 %	%
Length	0.00 mi	0.00 mi	mi
Trucks and buses PCE, ET	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	6113	1416	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.542$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 3962$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	6113	7200	No
$v$ 12	3962	4400	No
$v = v - v$ FO F R	4697	7200	No
$v$ R	1416	2200	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 27.5$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.295$   
 S  
 Space mean speed in ramp influence area,  $S = 61.7$  mph  
 R  
 Space mean speed in outer lanes,  $S = 72.3$  mph  
 0  
 Space mean speed for all vehicles,  $S = 65.1$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	4109	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1141	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2138	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2138	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	61.8	mi/h
Number of lanes, N	3	
Density, D	34.6	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3944	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	1740	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	1500	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3944	1740	1500	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1096	483	417	v
Trucks and buses	25	9	0	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	1.000	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	6113	2194	1667	pcph

Estimation of V12 Merge Areas

---

$L = 7696.21$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.695$  Using Equation 3  
 FM  
 $v = v(P) = 4247$  pc/h  
 12 F FM

Capacity Checks

---

	Actual	Maximum	LOS F?
v	8307	7200	Yes
FO			
v	6441	4600	Yes
R12			

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 48.4$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence F

Speed Estimation

---

Intermediate speed variable,  $M = 2.656$   
 S  
 Space mean speed in ramp influence area,  $S = -4.4$  mph  
 R  
 Space mean speed in outer lanes,  $S = 65.1$  mph  
 0  
 Space mean speed for all vehicles,  $S =$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	5684	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1579	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2958	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2958	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

2031 AM  
Alt 4

Northbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	6213	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1726	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	3233	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	3233	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	3	
Free-flow speed on freeway	70.0	mph
Volume on freeway	4608	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-Flow speed on ramp	55.0	mph
Volume on ramp	1605	vph
Length of first accel/decel lane	1000	ft
Length of second accel/decel lane	0	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	600	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	6300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	4608	1605	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1280	446	167	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	7142	2024	930	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.450$  Using Equation 0  
 FD  
 $v = v + (v - v) P = 4327$  pc/h  
 12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	7142	7200	No
$v$ 12	4327	4400	No
$v = v - v$ FO F R	5118	7200	No
$v$ R	2024	4400	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 23.5$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence C

Speed Estimation

---

Intermediate speed variable,  $D = 0.350$   
 S  
 Space mean speed in ramp influence area,  $S = 60.2$  mph  
 R  
 Space mean speed in outer lanes,  $S = 69.7$  mph  
 0  
 Space mean speed for all vehicles,  $S = 63.6$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	4608	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1280	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2398	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2398	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	53.4	mi/h
Number of lanes, N	3	
Density, D	44.9	pc/mi/ln
Level of service, LOS	E	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	4608	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	969	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	4608	969	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1280	269	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	7142	1222	221	pcph

---

Estimation of V12 Merge Areas

---

$L = 3152.50$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.561$  Using Equation 2  
 FM  
 $v = v(P) = 4005$  pc/h  
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	8364	7200	Yes
FO			
v	5227	4600	Yes
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 33.1$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

Intermediate speed variable,  $M = 0.827$   
 S  
 Space mean speed in ramp influence area,  $S = 46.8$  mph  
 R  
 Space mean speed in outer lanes,  $S = 58.4$  mph  
 0  
 Space mean speed for all vehicles,  $S = 50.6$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	5577	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1549	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2902	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2902	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	5577	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	305	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	969	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5577	305	969	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1549	85	269	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	8644	385	1502	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.526$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 4731$  pc/h  
 12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	8644	7200	Yes
$v$ 12	4731	4400	Yes
$v = v - v$ FO F R	8259	7200	Yes
$v$ R	385	2100	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 26.9$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence F

Speed Estimation

---

Intermediate speed variable,  $D = 0.333$   
 S  
 Space mean speed in ramp influence area,  $S = 60.7$  mph  
 R  
 Space mean speed in outer lanes,  $S = 65.4$  mph  
 0  
 Space mean speed for all vehicles,  $S = 62.7$  mph

---

Southbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	4664	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1296	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2427	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2427	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109/WELCOME CENTER Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3194	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	1661	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	640	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	4500	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent	
	Ramp			
Volume, V (vph)	3194	1661	640	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	887	461	178	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.866	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4951	2095	821	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.540$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 3637$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	4951	7200	No
$v$ 12	3637	4400	No
$v = v - v$ FO F R	2856	7200	No
$v$ R	2095	2200	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 26.5$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence C

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.357$   
 S  
 Space mean speed in ramp influence area,  $S = 60.0$  mph  
 R  
 Space mean speed in outer lanes,  $S = 75.6$  mph  
 0  
 Space mean speed for all vehicles,  $S = 63.5$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3194	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	887	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1662	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1662	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	69.1	mi/h
Number of lanes, N	3	
Density, D	24.1	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: AM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3194	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	640	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	1661	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3194	640	1661	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	887	178	461	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	

Flow rate, vp                    4951    807    2095    pcph

---

Estimation of V12 Merge Areas

---

L = 9672.21 (Equation 25-2 or 25-3)

EQ

P = 0.732 Using Equation 3

FM

$v = v(P) = 3625$  pc/h

12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	5758	7200	No
FO			
v	4432	4600	No
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 33.4$  pc/mi/ln

R                    R                    12                    A

Level of service for ramp-freeway junction areas of influence D

---

Speed Estimation

---

Intermediate speed variable,                    M = 0.539

S

Space mean speed in ramp influence area,    S = 54.9 mph

R

Space mean speed in outer lanes,            S = 67.0 mph

0

Space mean speed for all vehicles,           S = 57.3 mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: AM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3643	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1012	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	1896	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	1896	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	66.6	mi/h
Number of lanes, N	3	
Density, D	28.5	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

2031 PM  
Alt 4

Northbound I-65

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	4469	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1241	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2326	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2326	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	56.1	mi/h
Number of lanes, N	3	
Density, D	41.5	pc/mi/ln
Level of service, LOS	E	

Overall results are not computed when free-flow speed is less than 55 mph.

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3894	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	2		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	575	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane	0	ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	600	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	6300	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent	
	Ramp			
Volume, V (vph)	3894	575	600	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1082	160	167	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	6036	725	757	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.450$  Using Equation 0  
 FD  
 $v = v + (v - v) P = 3115$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	6036	7200	No
$v$ 12	3115	4400	No
$v = v - v$ FO F R	5311	7200	No
$v$ R	725	4400	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 13.0$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence B

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.233$   
 S  
 Space mean speed in ramp influence area,  $S = 63.5$  mph  
 R  
 Space mean speed in outer lanes,  $S = 69.3$  mph  
 0  
 Space mean speed for all vehicles,  $S = 66.2$  mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	3894	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1082	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2026	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2026	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	64.3	mi/h
Number of lanes, N	3	
Density, D	31.5	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	3894	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	1405	vph	
Length of first accel/decel lane	1200	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	175	vph	
Position of adjacent Ramp	Upstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	1200	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3894	1405	175	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1082	390	49	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.881	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	6036	1772	221	pcph

Estimation of V12 Merge Areas

---

$L = 2678.31$  (Equation 25-2 or 25-3)  
 EQ  
 $P = 0.518$  Using Equation 2  
 FM  
 $v = v(P) = 3126$  pc/h  
 12 F FM

Capacity Checks

---

	Actual	Maximum	LOS F?
v	7808	7200	Yes
FO			
v	4898	4600	Yes
R12			

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 35.3$  pc/mi/ln  
 R R 12 A

Level of service for ramp-freeway junction areas of influence F

Speed Estimation

---

Intermediate speed variable,  $M = 0.712$   
 S  
 Space mean speed in ramp influence area,  $S = 50.1$  mph  
 R  
 Space mean speed in outer lanes,  $S = 59.8$  mph  
 0  
 Space mean speed for all vehicles,  $S = 53.3$  mph

---

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 NB  
From/To: NORTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	5299	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1472	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2757	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2757	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 NB  
Junction: Rest Area Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	5299	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	45.0	mph	
Volume on ramp	305	vph	
Length of first accel/decel lane	2000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	1405	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	2000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5299	305	1405	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1472	85	390	v
Trucks and buses	25	9	25	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.717	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	8213	385	2178	pcph

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)

EQ

$P = 0.537$  Using Equation 5

FD

$v = v + (v - v) P = 4588$  pc/h

12 R F R FD

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	8213	7200	Yes
$v$ 12	4588	4400	Yes
$v = v - v$ FO F R	7828	7200	Yes
$v$ R	385	2100	No

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 25.7$  pc/mi/ln

R 12 D

Level of service for ramp-freeway junction areas of influence F

Speed Estimation

---

Intermediate speed variable,  $D = 0.333$

S

Space mean speed in ramp influence area,  $S = 60.7$  mph

R

Space mean speed in outer lanes,  $S = 66.6$  mph

0

Space mean speed for all vehicles,  $S = 63.1$  mph

---

Southbound I-65

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: NORTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

Volume, V	5067	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1408	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2637	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

Flow rate, vp	2637	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Diverge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109/WELCOME CENTER Off Ramp  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Diverge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	4109	vph	

Off Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-Flow speed on ramp	55.0	mph	
Volume on ramp	1149	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent ramp	1766	vph	
Position of adjacent ramp	Downstream		
Type of adjacent ramp	On		
Distance to adjacent ramp	4500	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent	
	Ramp			
Volume, V (vph)	4109	1149	1766	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1141	319	491	v
Trucks and buses	25	9	9	%
Recreational vehicles	2	0	2	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	0.00 %	0.00 %	0.00 %	
Length	0.00 mi	0.00 mi	0.00 mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	0.866	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	6369	1449	2266	pcph

---

Estimation of V12 Diverge Areas

---

$L =$  (Equation 25-8 or 25-9)  
 EQ  
 $P = 0.534$  Using Equation 5  
 FD  
 $v = v + (v - v) P = 4077$  pc/h  
 12 R F R FD

---

Capacity Checks

---

	Actual	Maximum	LOS F?
$v = v$ Fi F	6369	7200	No
$v$ 12	4077	4400	No
$v = v - v$ FO F R	4920	7200	No
$v$ R	1449	2200	No

---

Level of Service Determination (if not F)

---

Density,  $D = 4.252 + 0.0086 v - 0.009 L = 30.3$  pc/mi/ln  
 R 12 D  
 Level of service for ramp-freeway junction areas of influence D

---

Speed Estimation

---

Intermediate speed variable,  $D = 0.298$   
 S  
 Space mean speed in ramp influence area,  $S = 61.6$  mph  
 R  
 Space mean speed in outer lanes,  $S = 71.8$  mph  
 0  
 Space mean speed for all vehicles,  $S = 64.9$  mph

---

HCS+: Basic Freeway Segments Release 5.2

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Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 OFF RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	4109	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1141	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2138	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2138	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S	61.8	mi/h
Number of lanes, N	3	
Density, D	34.6	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Ramps and Ramp Junctions Release 5.2

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Palmer Engineering  
400 Shoppers Drive  
PO Box 747  
Winchester, Ky 40392  
Phone: 859-744-1218 Fax: 859-744-1266  
E-mail: ssewell@palmernet.com

Merge Analysis

Analyst: Stephen Sewell  
Agency/Co.: Palmer Engineering  
Date performed: 9-13-2006  
Analysis time period: PM  
Freeway/Dir of Travel: I-65 SB  
Junction: SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Freeway Data

Type of analysis	Merge		
Number of lanes in freeway	3		
Free-flow speed on freeway	70.0	mph	
Volume on freeway	4109	vph	

On Ramp Data

Side of freeway	Right		
Number of lanes in ramp	1		
Free-flow speed on ramp	55.0	mph	
Volume on ramp	1766	vph	
Length of first accel/decel lane	1000	ft	
Length of second accel/decel lane		ft	

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes		
Volume on adjacent Ramp	572	vph	
Position of adjacent Ramp	Downstream		
Type of adjacent Ramp	Off		
Distance to adjacent Ramp	3000	ft	

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent	
	Ramp			
Volume, V (vph)	4109	1766	572	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1141	491	159	v
Trucks and buses	25	9	0	%
Recreational vehicles	2	0	0	%
Terrain type:	Rolling	Rolling	Rolling	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	2.5	2.5	
Recreational vehicle PCE, ER	2.0	2.0	2.0	
Heavy vehicle adjustment, fHV	0.717	0.881	1.000	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	6369	2227	636	pcph

---

Estimation of V12 Merge Areas

---

L = 2936.29 (Equation 25-2 or 25-3)  
 EQ  
 P = 0.605 Using Equation 1  
 FM  
 $v = v(P) = 3856 \text{ pc/h}$   
 12 F FM

---

Capacity Checks

---

	Actual	Maximum	LOS F?
v	8596	7200	Yes
FO			
v	6083	4600	Yes
R12			

---

Level of Service Determination (if not F)

---

Density,  $D = 5.475 + 0.00734 v + 0.0078 v - 0.00627 L = 45.6 \text{ pc/mi/ln}$   
 R R 12 A

Level of service for ramp-freeway junction areas of influence F

---

Speed Estimation

---

Intermediate speed variable, M = 1.921  
 S  
 Space mean speed in ramp influence area, S = 16.2 mph  
 R  
 Space mean speed in outer lanes, S = 62.2 mph  
 0  
 Space mean speed for all vehicles, S = 20.7 mph

---

HCS+: Basic Freeway Segments Release 5.2

Stephen Sewell  
Palmer Engineering  
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Phone: 859-744-1218 Fax: 859-744-1266  
E-mail: ssewell@palmernet.com

Operational Analysis

---

Analyst: Stephen Sewell  
Agency or Company: Palmer Engineering  
Date Performed: 9-13-2006  
Analysis Time Period: PM  
Freeway/Direction: I-65 SB  
From/To: SOUTH OF SR 109 ON RAMP  
Jurisdiction:  
Analysis Year: 2031  
Description: ROBERTSON COUNTY I-65 @ SR 109

Flow Inputs and Adjustments

---

Volume, V	5684	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1579	v
Trucks and buses	25	%
Recreational vehicles	2	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.5*	
Heavy vehicle adjustment, fHV	0.712	
Driver population factor, fp	1.00	
Flow rate, vp	2958	pc/h/ln

Speed Inputs and Adjustments

---

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	0.0	mi/h
Free-flow speed, FFS	70.0	mi/h

Rural Freeway

LOS and Performance Measures

---

Flow rate, vp	2958	pc/h/ln
Free-flow speed, FFS	70.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph.

# **APPENDIX E**

## **PROJECT PHOTOGRAPHS**



Industrial Park west of I-65



Industrial Park west of I-65



Industrial Park west of I-65



Industrial Park west of I-65



Industrial Park west of I-65 (Looking West)



SR 109 / 31W east of I-65 (Looking East)

# **APPENDIX F**

## **ALTERNATE INTERCHANGES CONSIDERED**

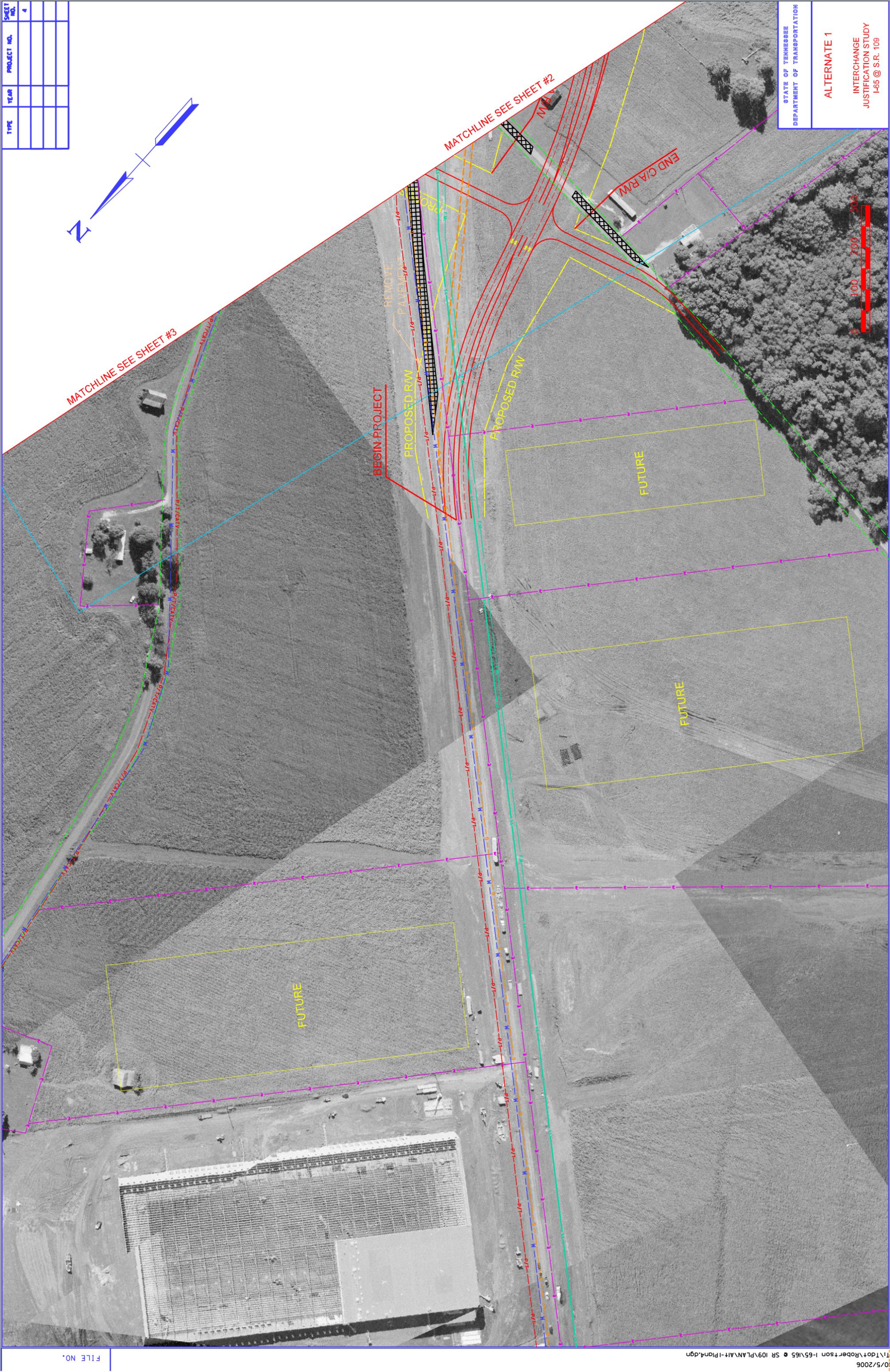
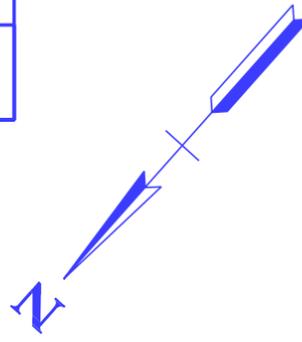








TYPE	YEAR	PROJECT NO.	SHEET NO.
			4



STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

**ALTERNATE 1**

INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109

MATCHLINE SEE SHEET #3

MATCHLINE SEE SHEET #2

BEGIN PROJECT

REMOVE PAVEMENT

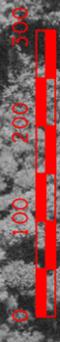
PROPOSED RAW

EXISTING RAW

FUTURE

FUTURE

FUTURE



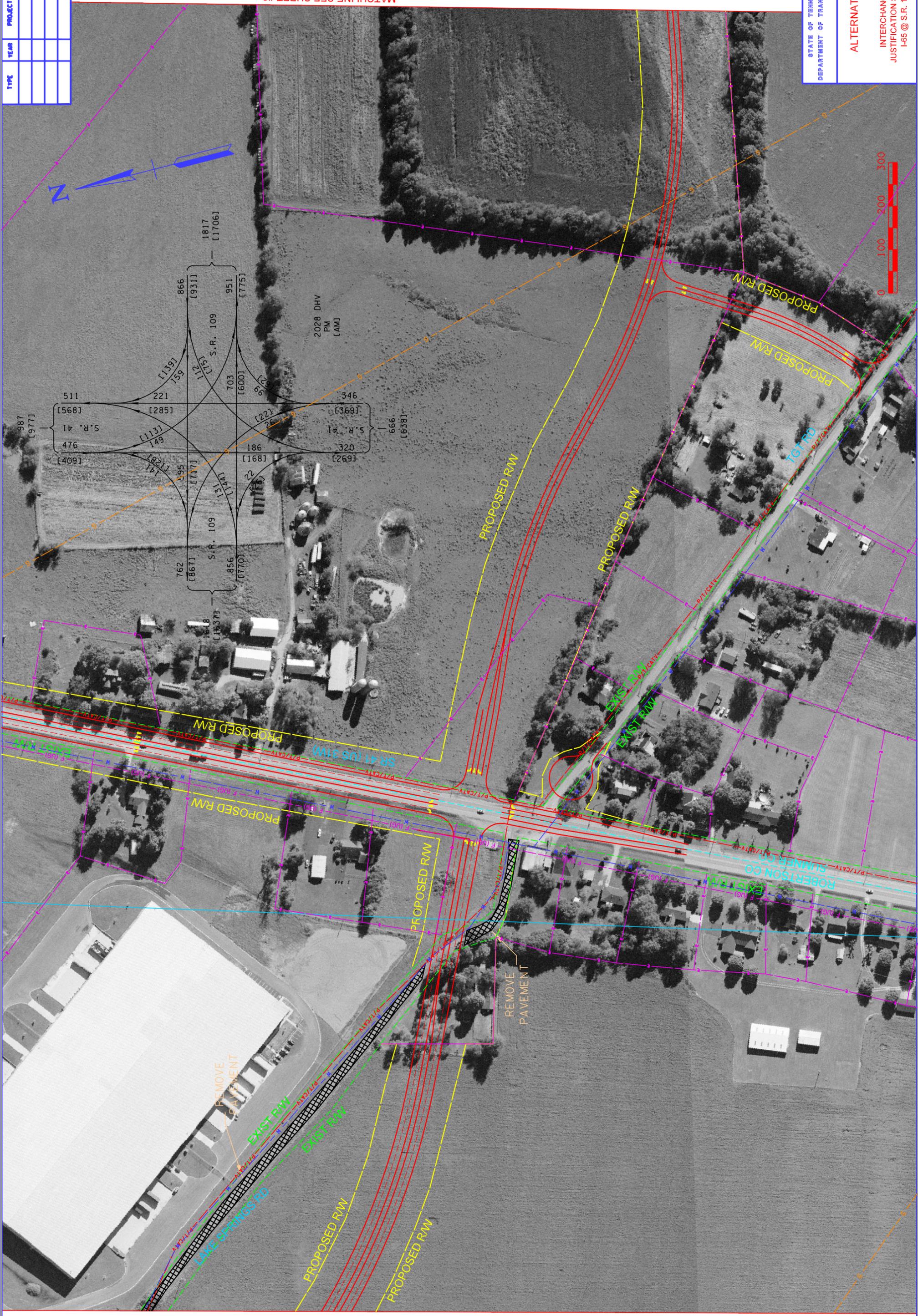
TYPE	YEAR	PROJECT NO.	SHEET NO.
			5

MATCHLINE SEE SHEET #6

STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

**ALTERNATE 1**

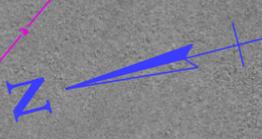
INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109



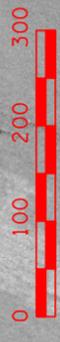
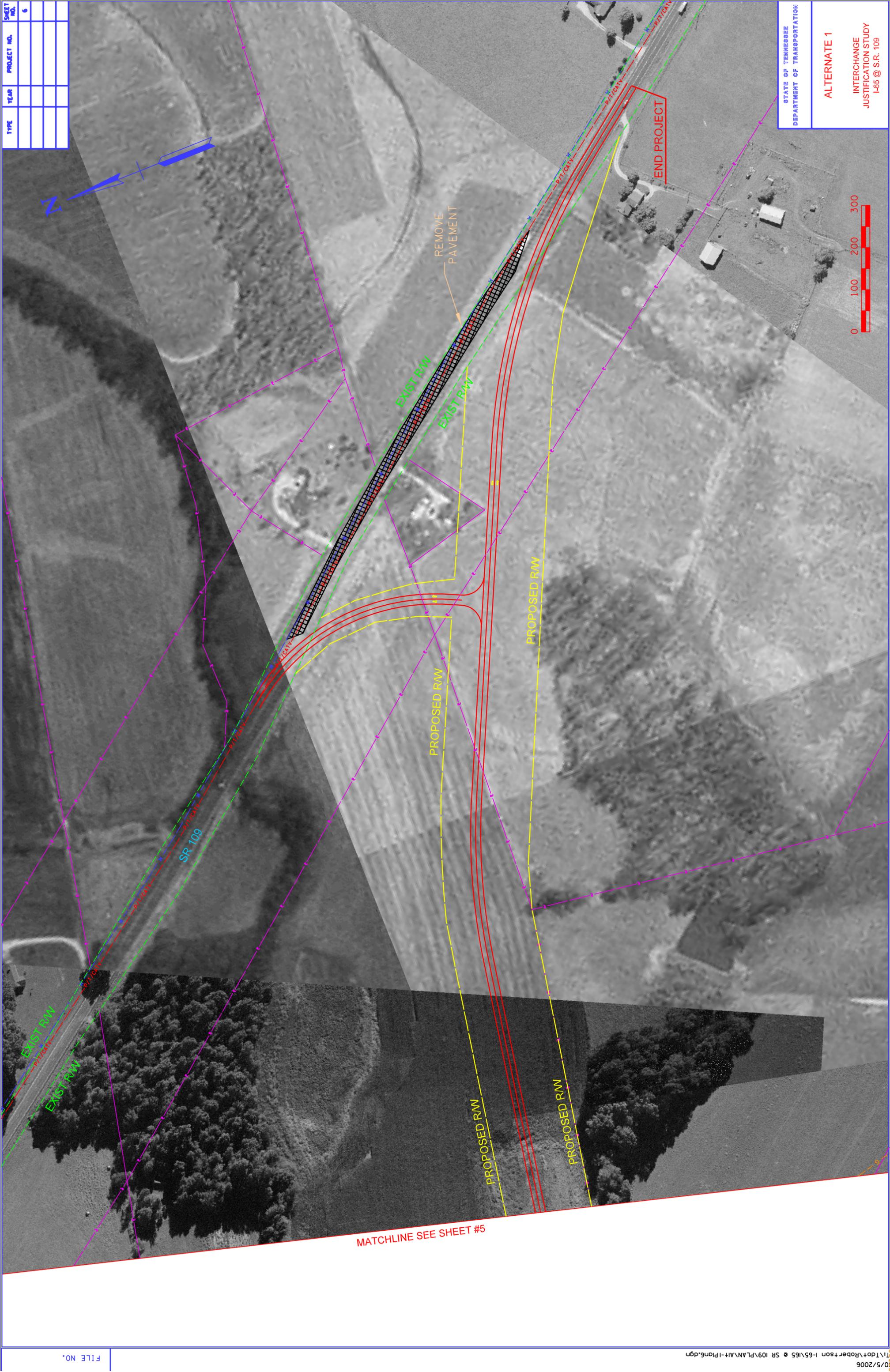
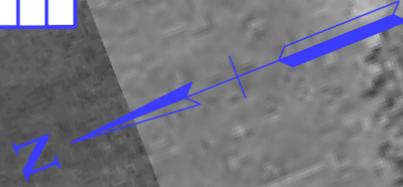
MATCHLINE SEE SHEET #2

FILE NO.

T:\1\dot\Robertson I-65\165 SR 109\PLAN\A1-Plans.dgn 5/2006



TYPE	YEAR	PROJECT NO.	SHEET NO.
			6



STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

**ALTERNATE 1**

INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109

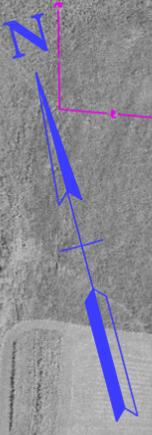
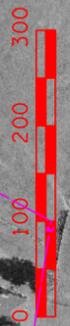
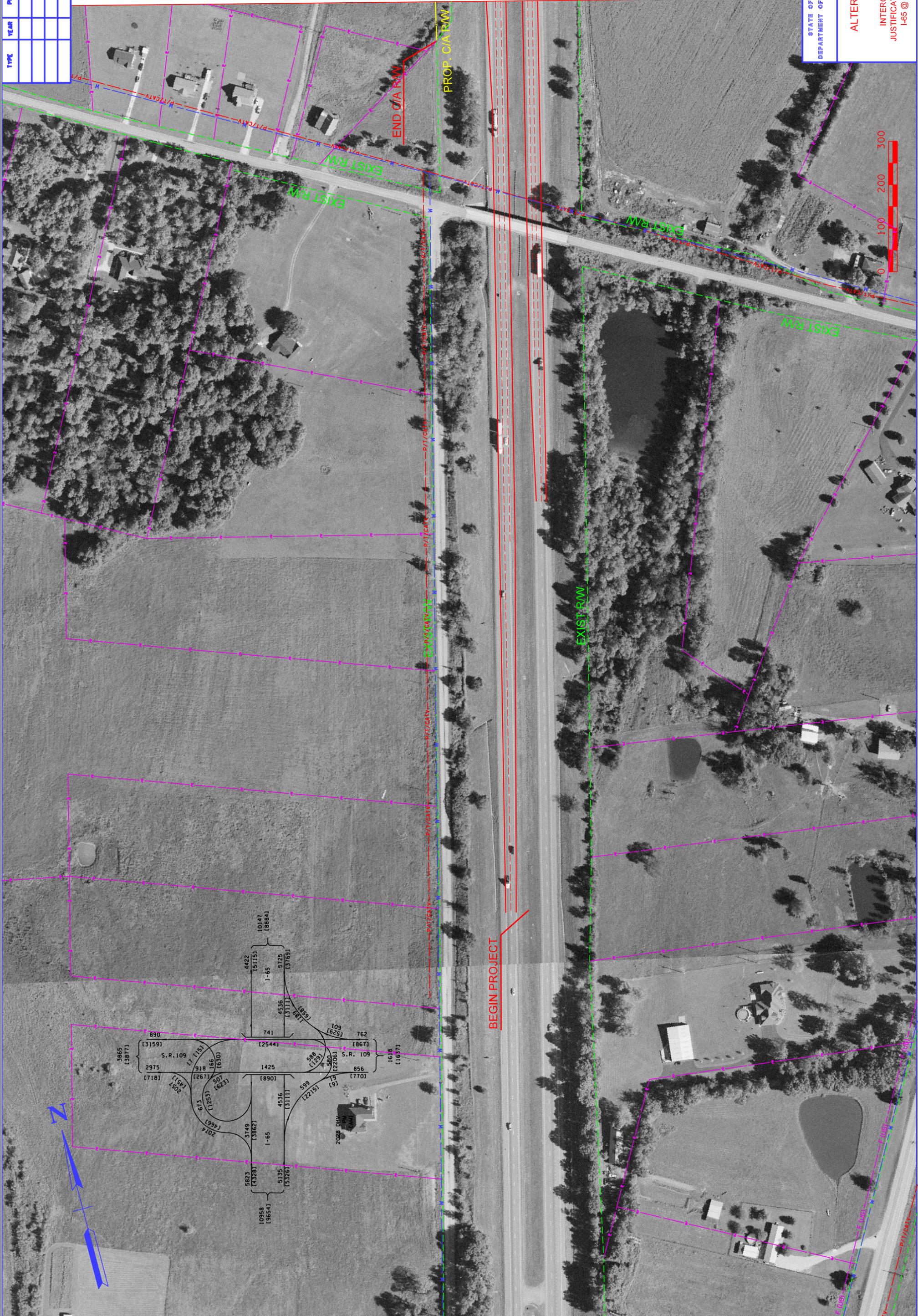
MATCHLINE SEE SHEET #5

TYPE	YEAR	PROJECT NO.	SHEET NO.
			1

MATCHLINE SEE SHEET #2

STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

ALTERNATE 2  
INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109



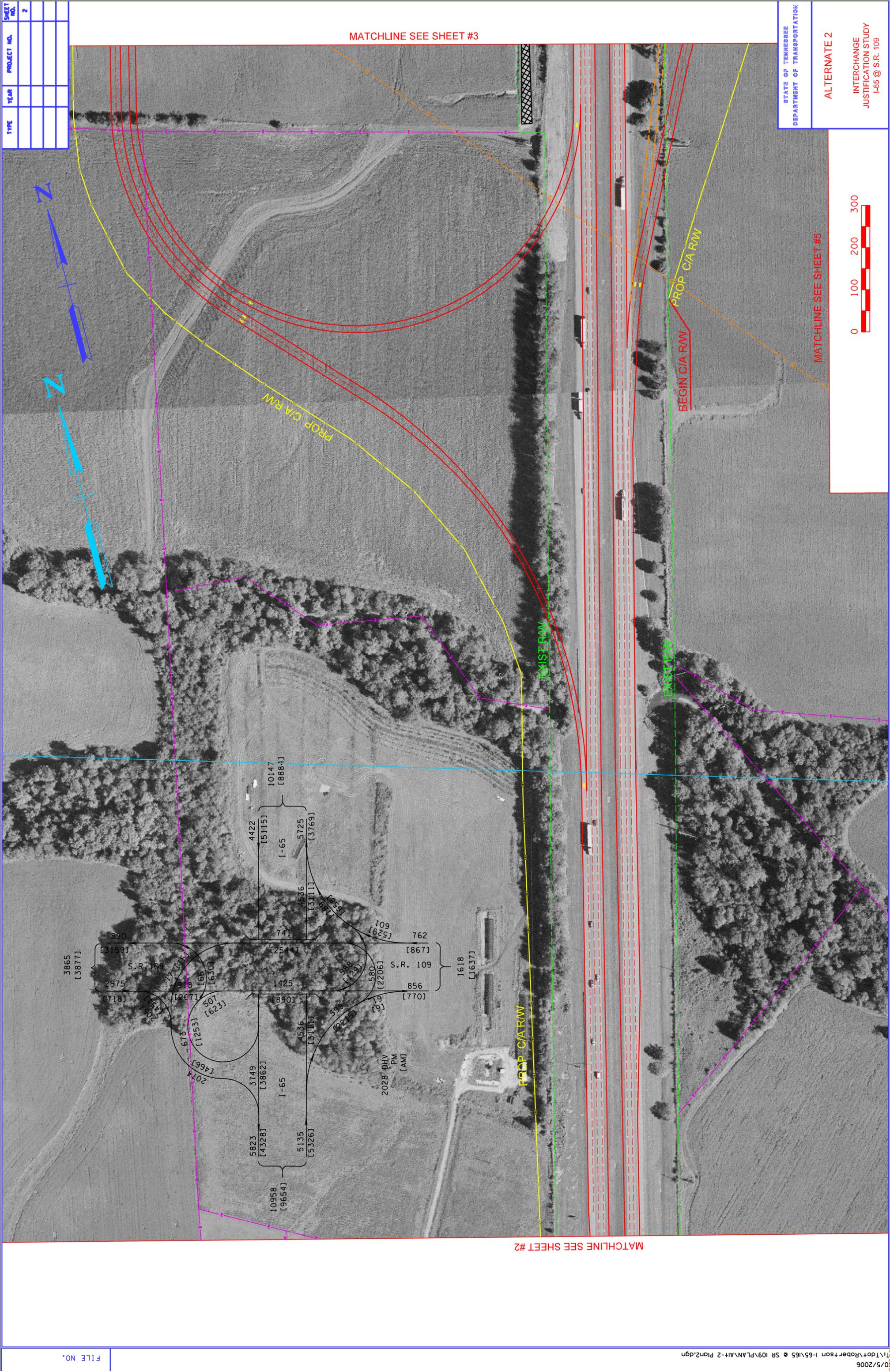
TYPE	YEAR	PROJECT NO.	SHEET NO.
			2

MATCHLINE SEE SHEET #3

STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

ALTERNATE 2

INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109



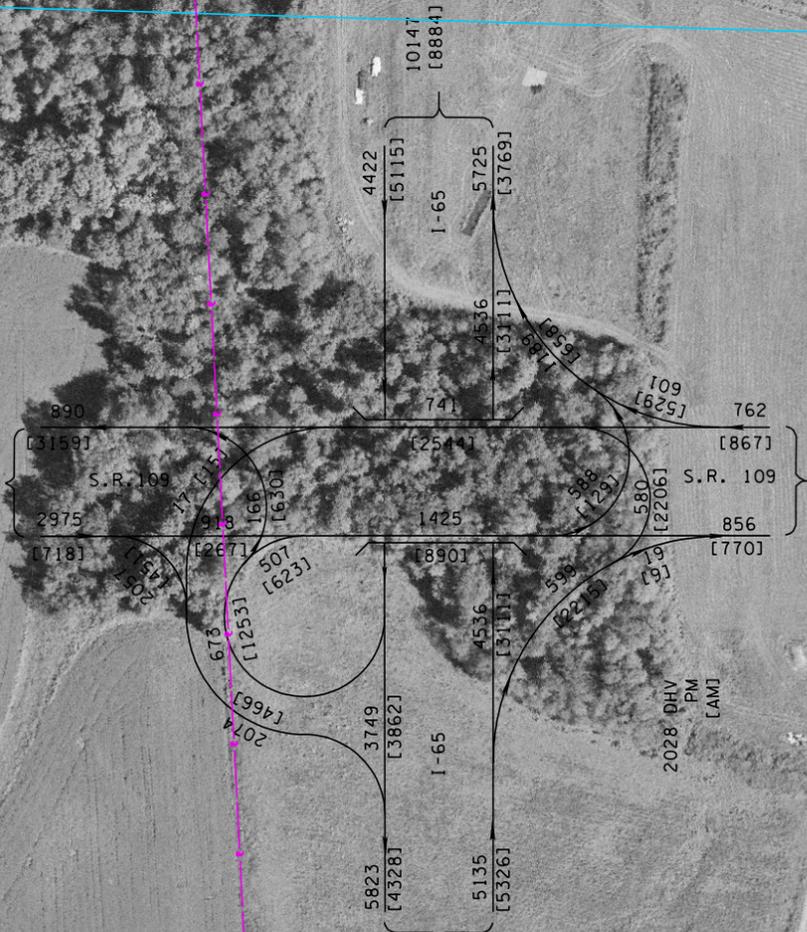
MATCHLINE SEE SHEET #5

PROP. CIA RW

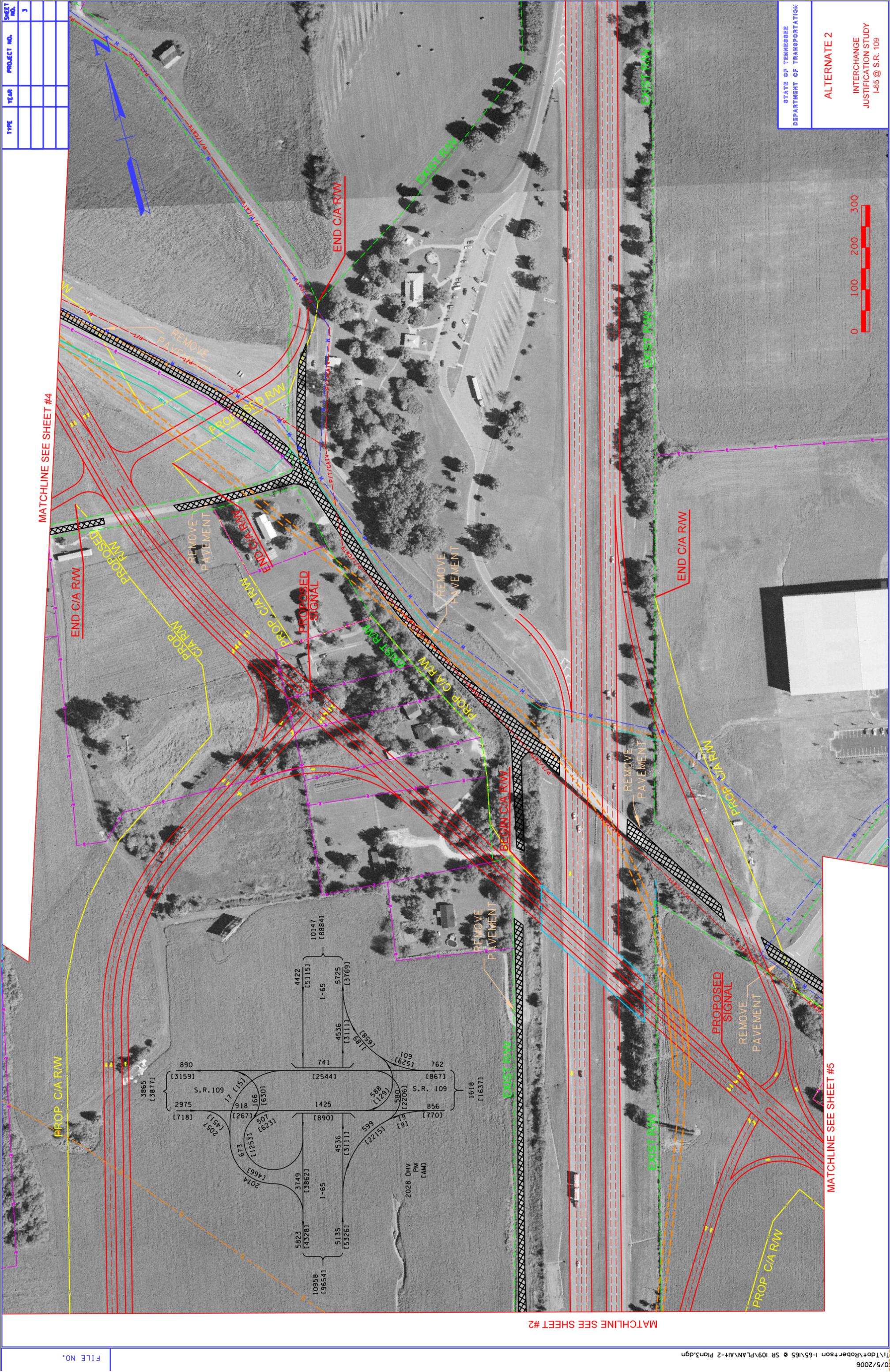
BEGIN CIA RW

PROP. CIA RW

MATCHLINE SEE SHEET #2



TYPE	YEAR	PROJECT NO.	SHEET NO.
			3



MATCHLINE SEE SHEET #4

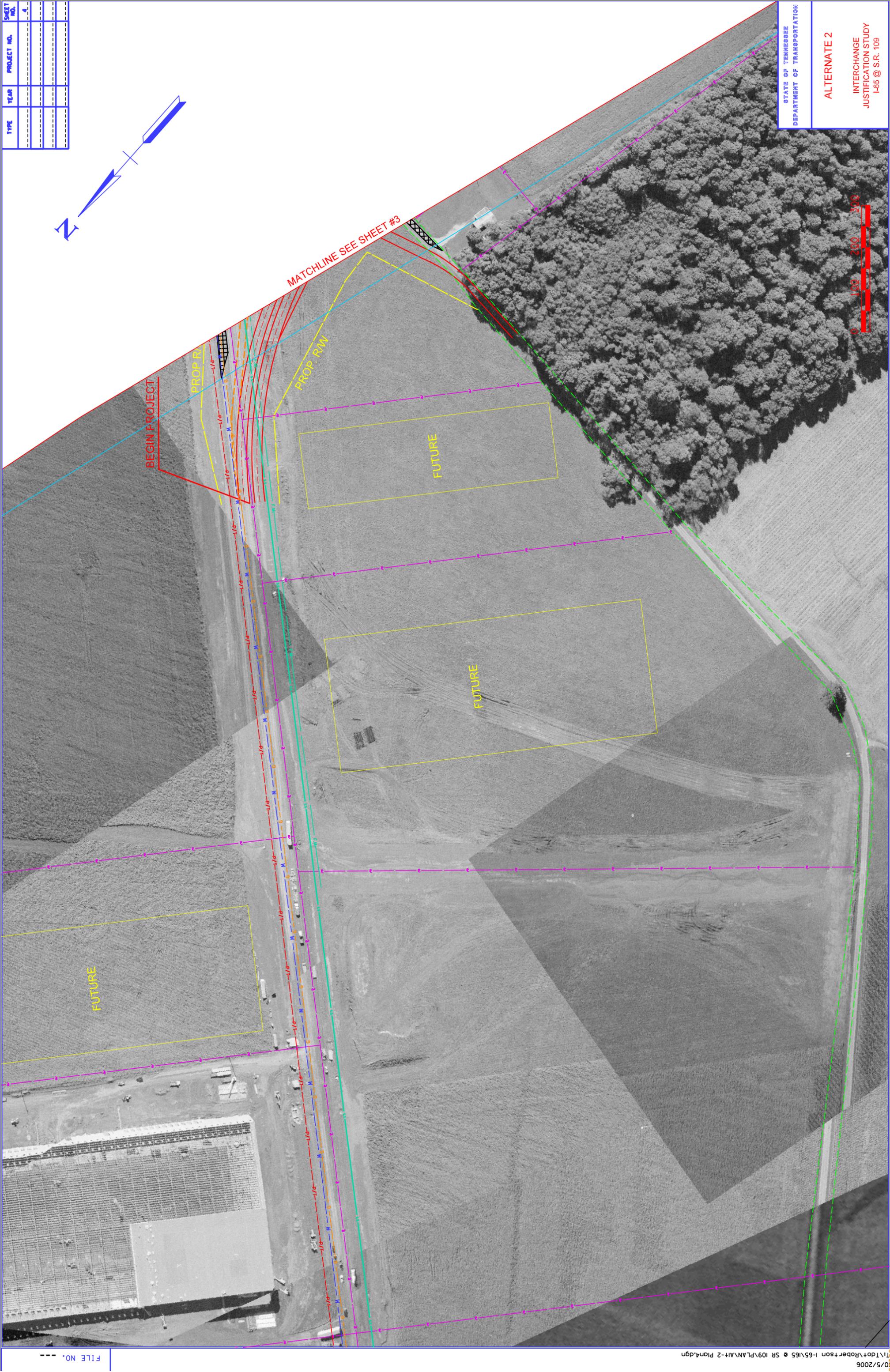
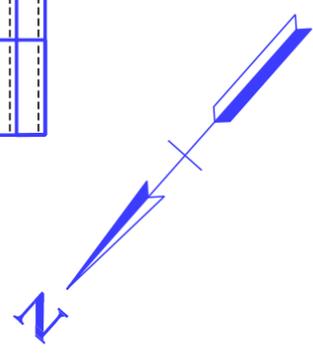
PROP. C/A RW

3865 [3877]	890 [3159]	2975 [718]	17 [15]	166 [630]	507 [623]	5823 [4328]	3749 [3862]	5135 [5326]	4536 [3111]	599 [2215]	580 [2206]	19 [9]	856 [770]	1618 [1637]
	S.R. 109						I-65						S.R. 109	
		918 [267]				1425 [890]		4422 [5115]	741 [2544]	4536 [3111]	189 [698]	109 [62]	762 [867]	
								10147 [8884]						
								5725 [3769]						

MATCHLINE SEE SHEET #2

MATCHLINE SEE SHEET #5

TYPE	YEAR	PROJECT NO.	SHEET NO.
			4



STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

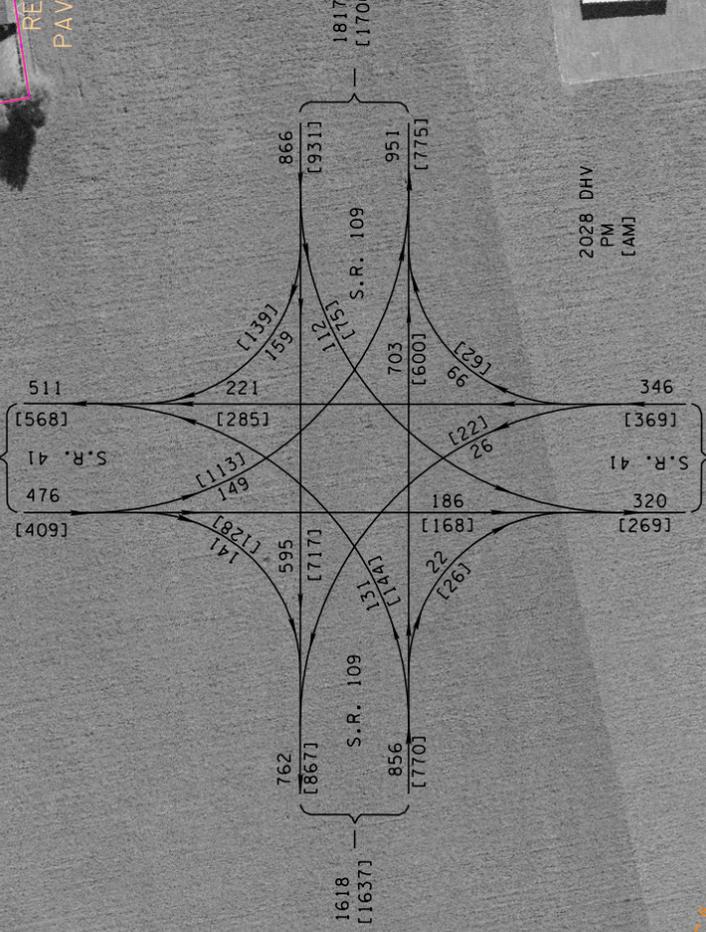
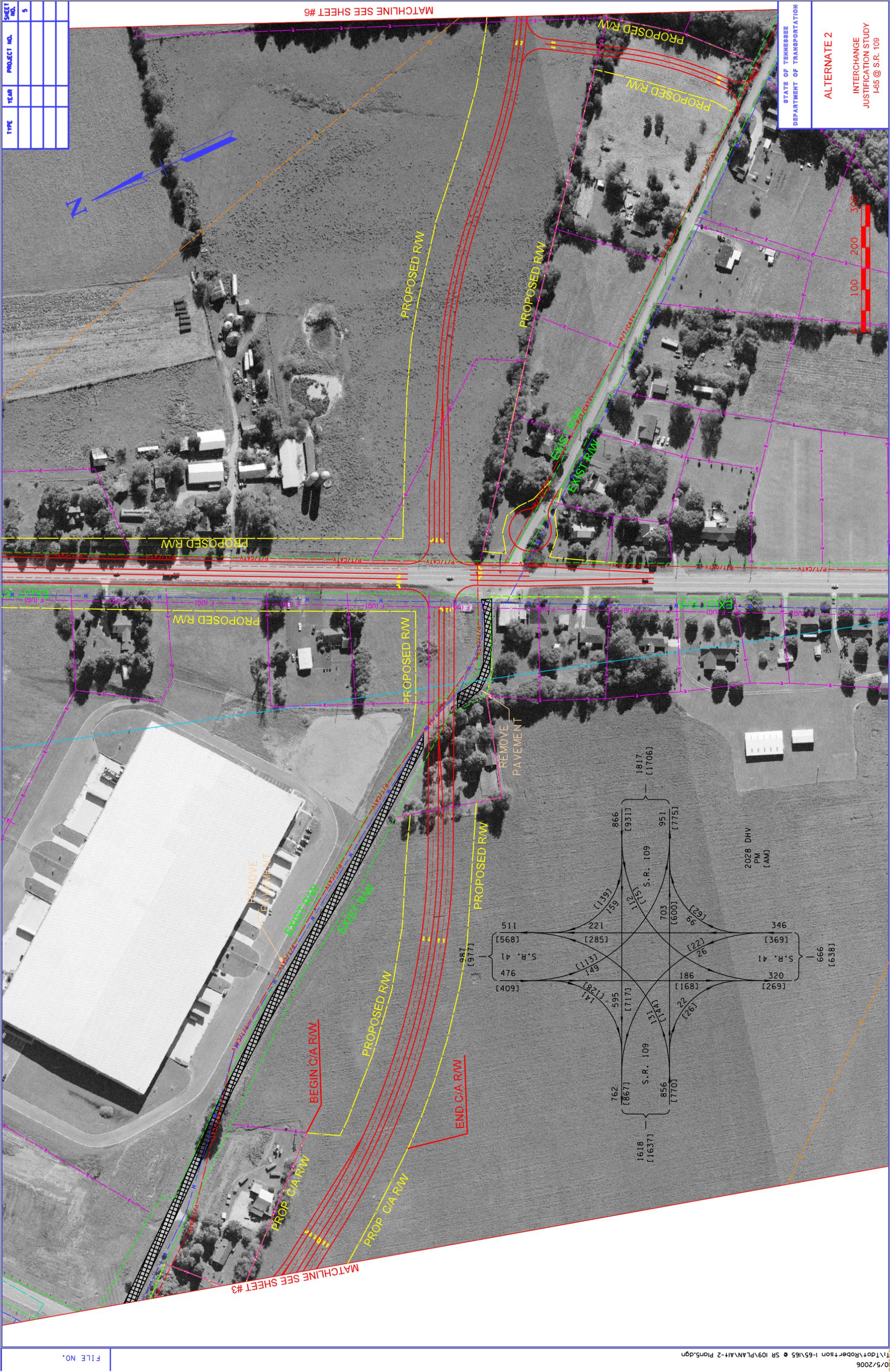
ALTERNATE 2  
INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109



TYPE	YEAR	PROJECT NO.	SHEET NO.
			5

STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

ALTERNATE 2  
INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109

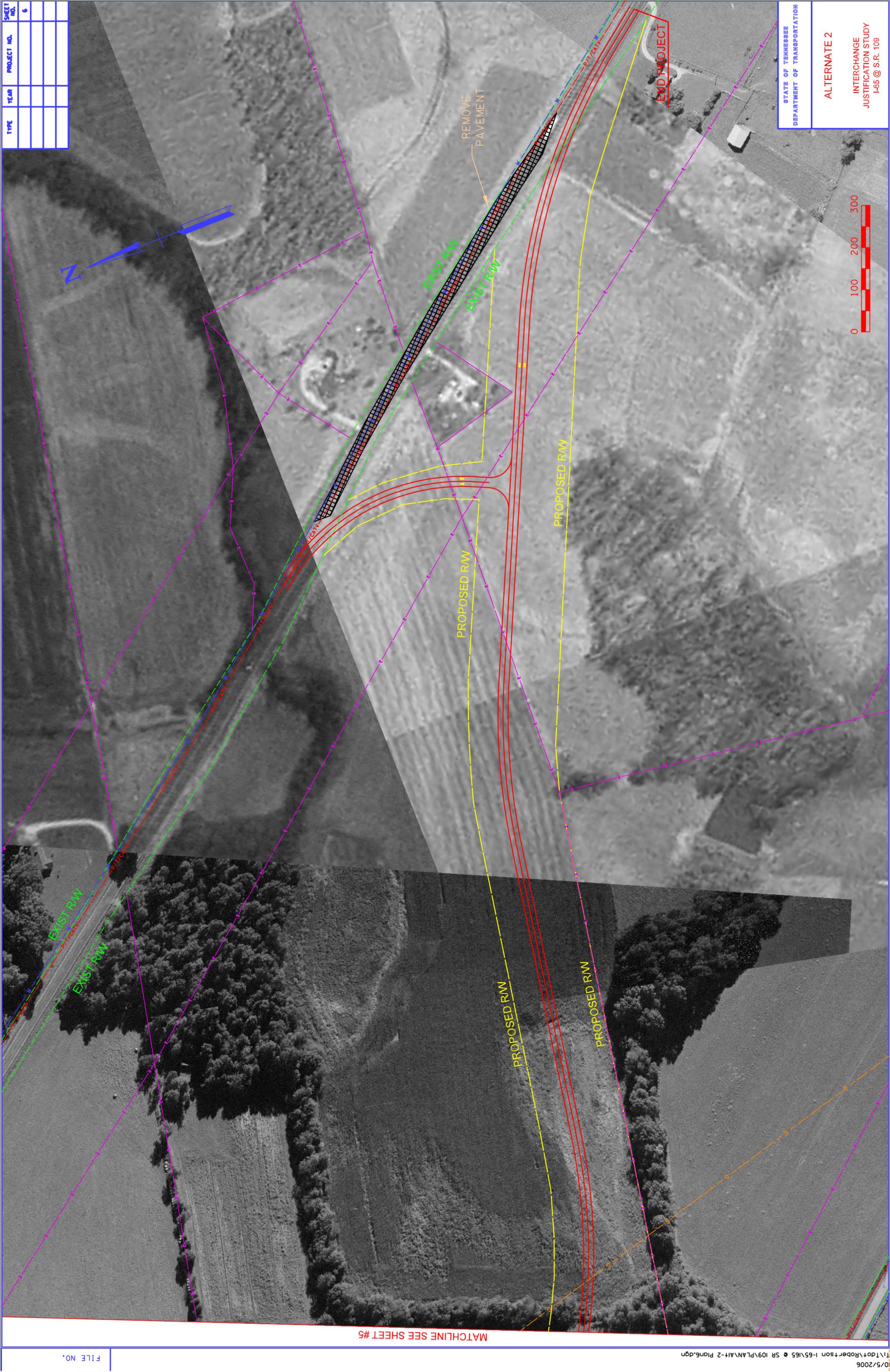


2028 DHV  
PM  
[AM]

MATCHLINE SEE SHEET #3

MATCHLINE SEE SHEET #6

TYPE	YEAR	PROJECT NO.	SHEET NO.
			6



STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

**ALTERNATE 2**  
INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109

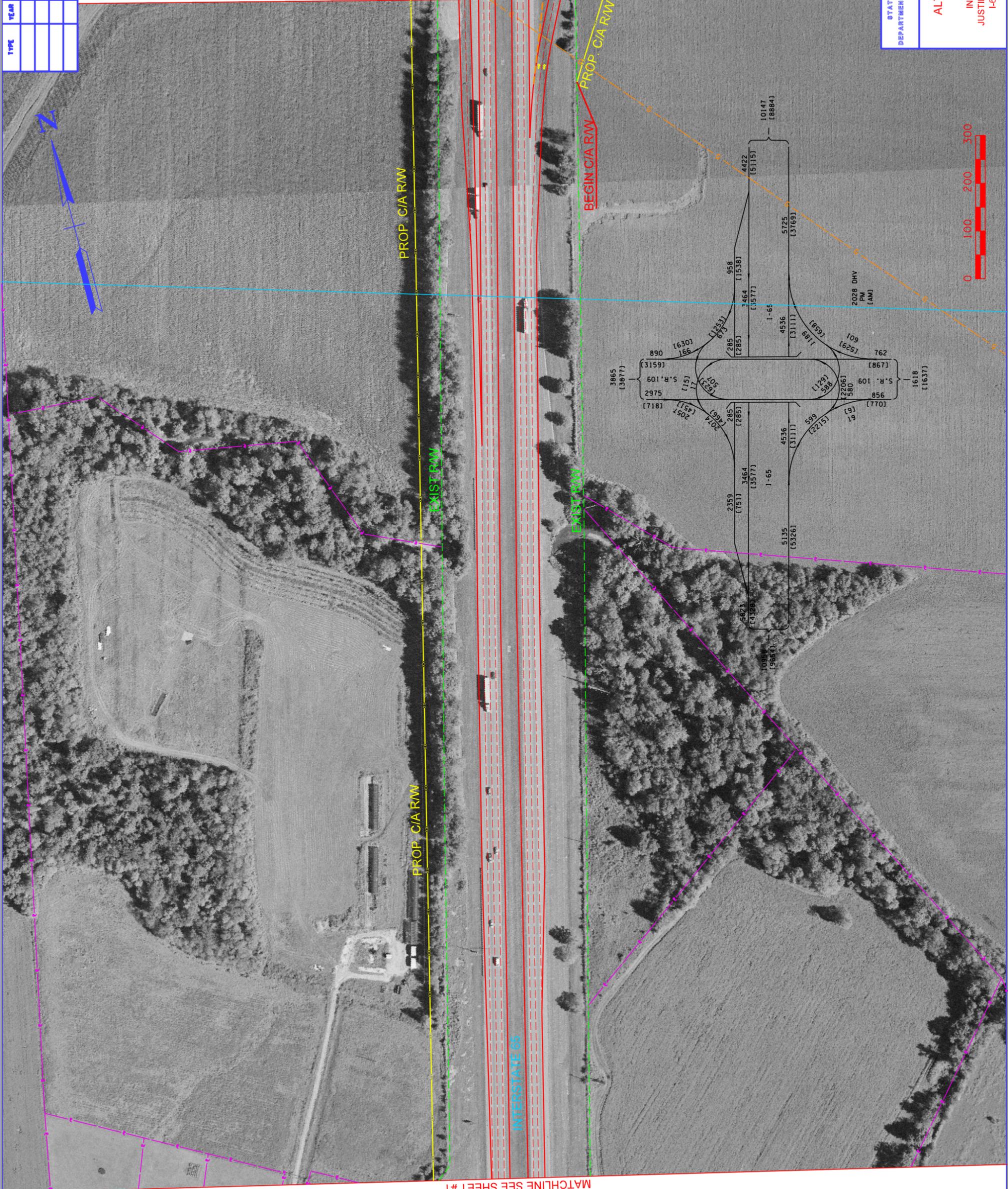
MATCHLINE SEE SHEET #5

FILE NO.

T:\105\2006\105\Tdot\Robertson I-65\165 SR 109\PLAN\AIT-2 Plan6.dgn



TYPE	YEAR	PROJECT NO.	SHEET NO.
			8



MATCHLINE SEE SHEET #2

MATCHLINE SEE SHEET #1

STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

ALTERNATE 3

INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109

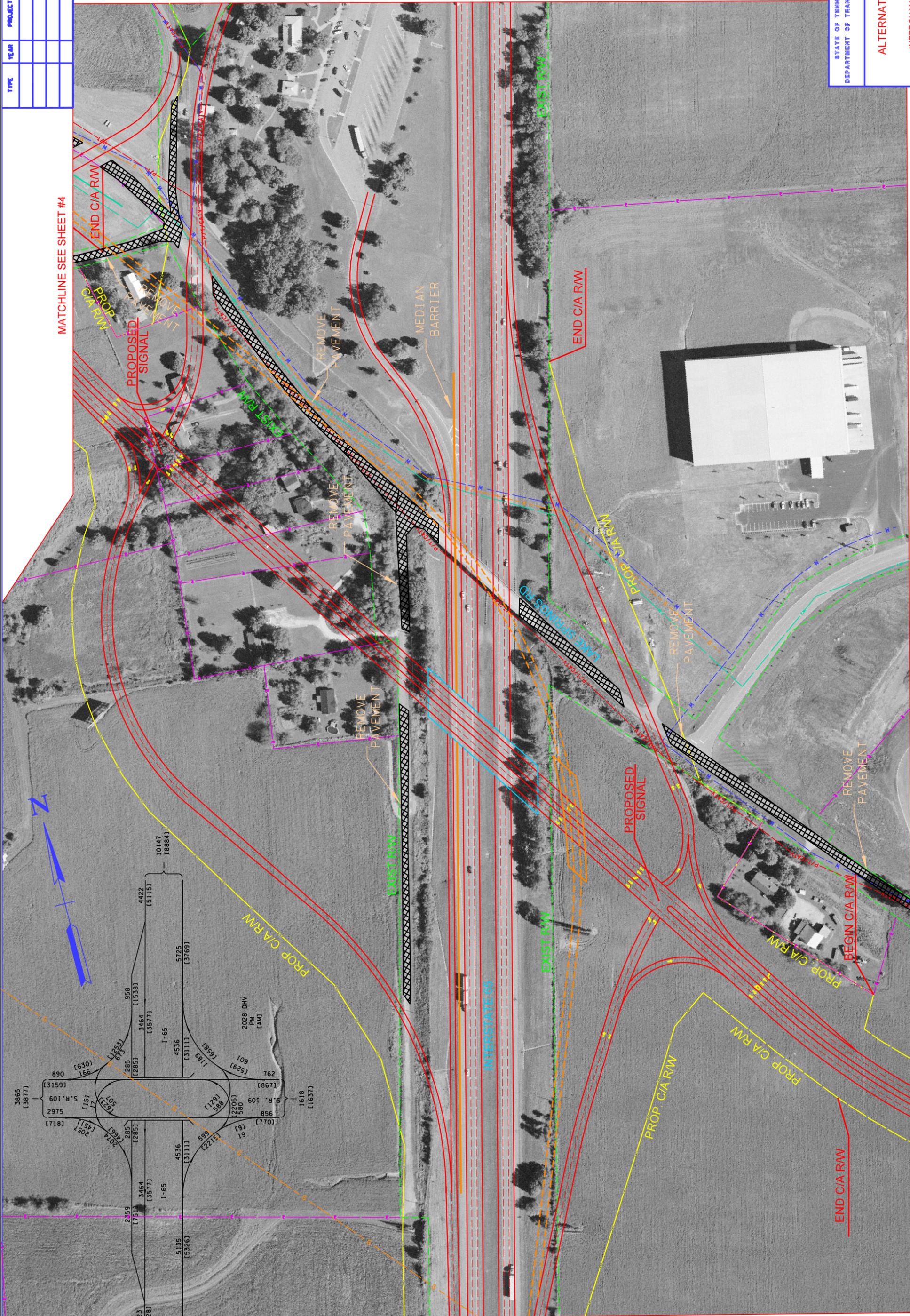


TYPE	YEAR	PROJECT NO.	SHEET NO.
			2

MATCHLINE SEE SHEET #3

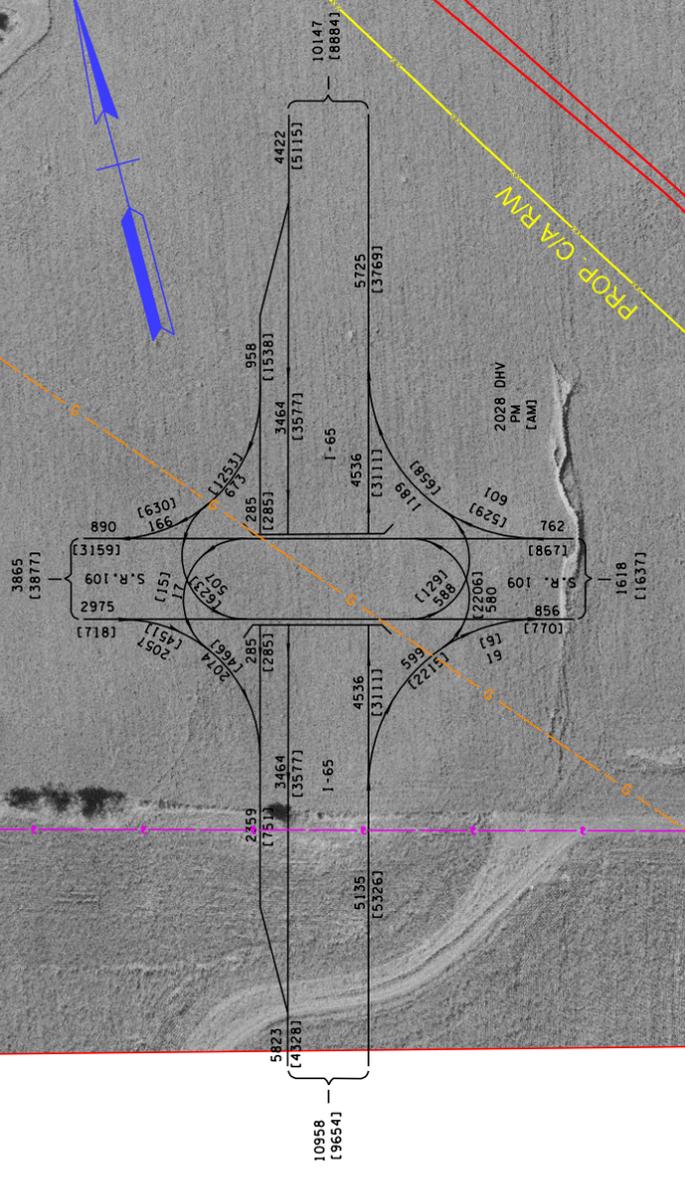
STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION  
**ALTERNATE 3**  
INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109

MATCHLINE SEE SHEET #4



MATCHLINE SEE SHEET #5

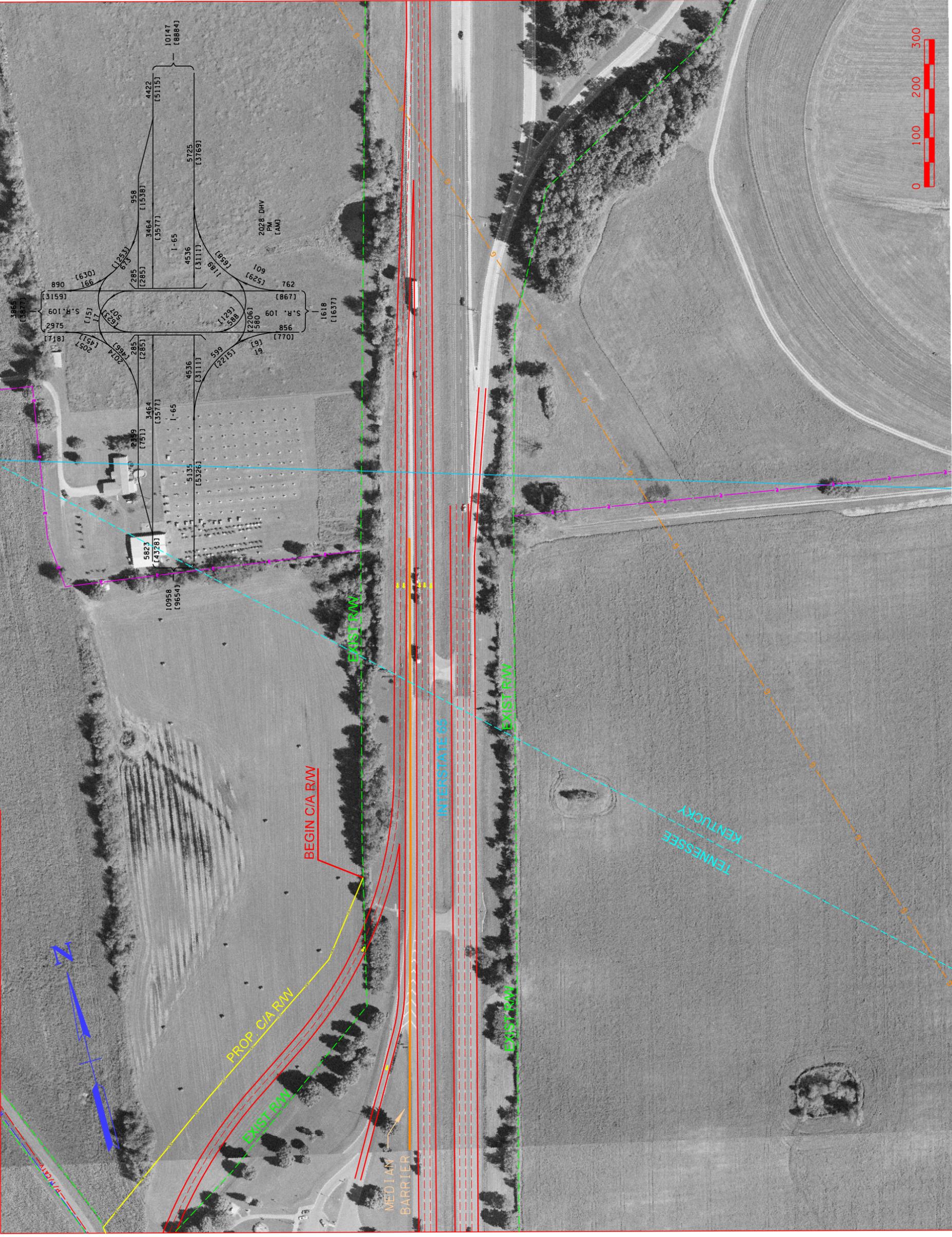
MATCHLINE SEE SHEET #1B



FILE NO.

T:\dot\Robertson I-65\65 SR 109\PLAN\AIT-3 Plan2.dgn 5/2006

TYPE	YEAR	PROJECT NO.	SHEET NO.
			3



MATCHLINE SEE SHEET #3B

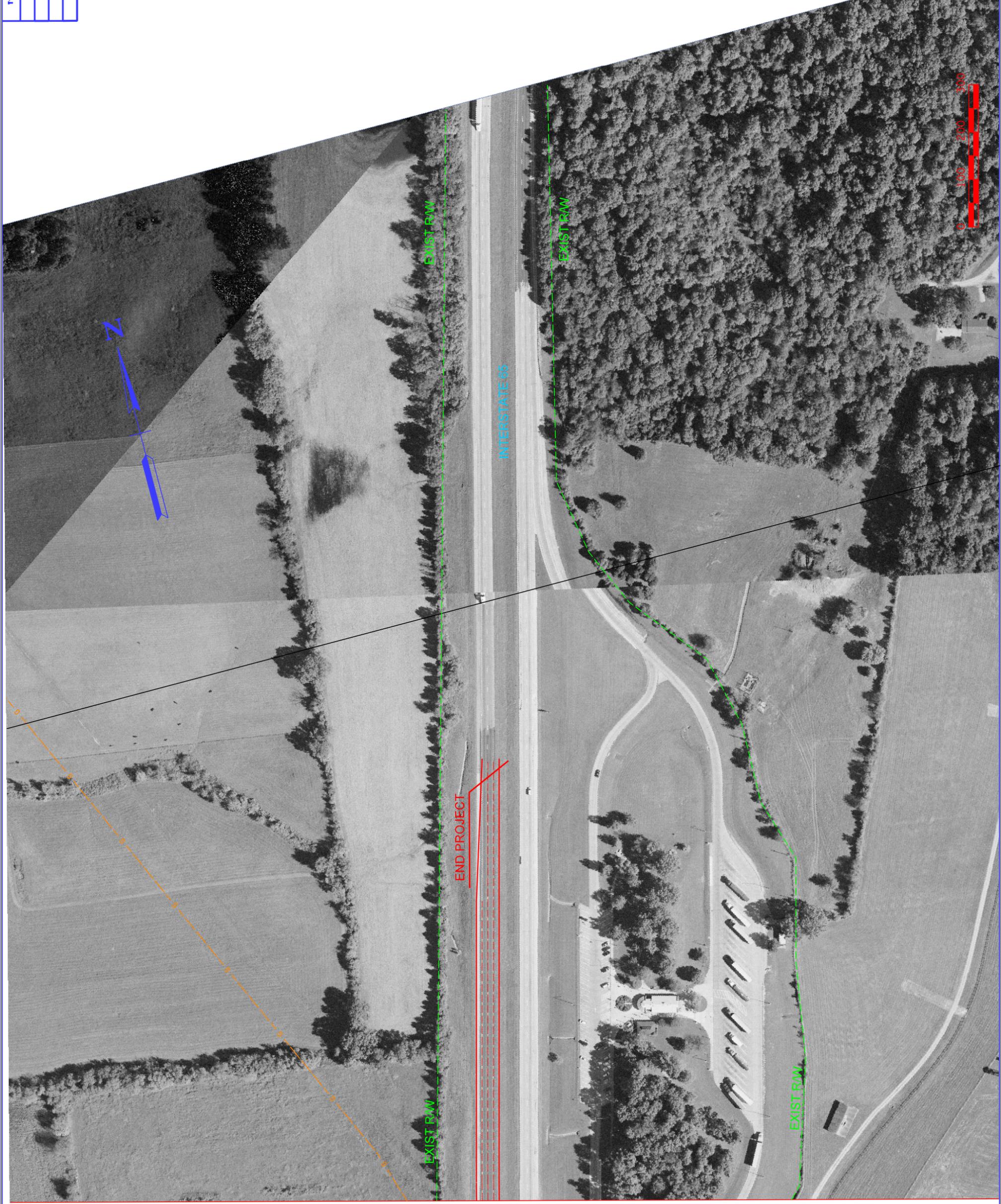
MATCHLINE SEE SHEET #2

MATCHLINE SEE SHEET #4

TYPE	YEAR	PROJECT NO.	SHEET NO.
			38

STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

ALTERNATE 3  
INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109



MATCHLINE SEE SHEET #3

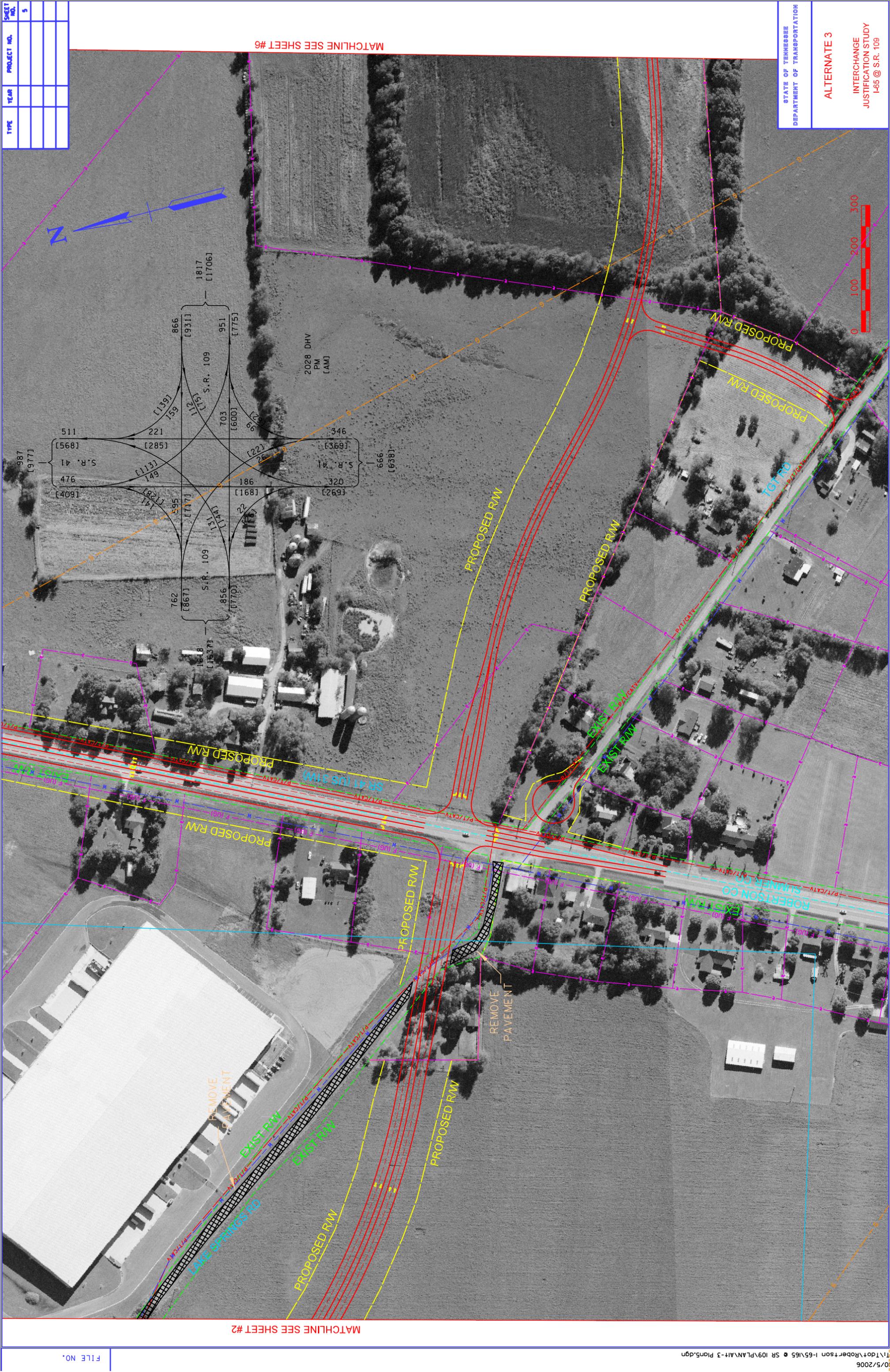


TYPE	YEAR	PROJECT NO.	SHEET NO.
			5

MATCHLINE SEE SHEET #6

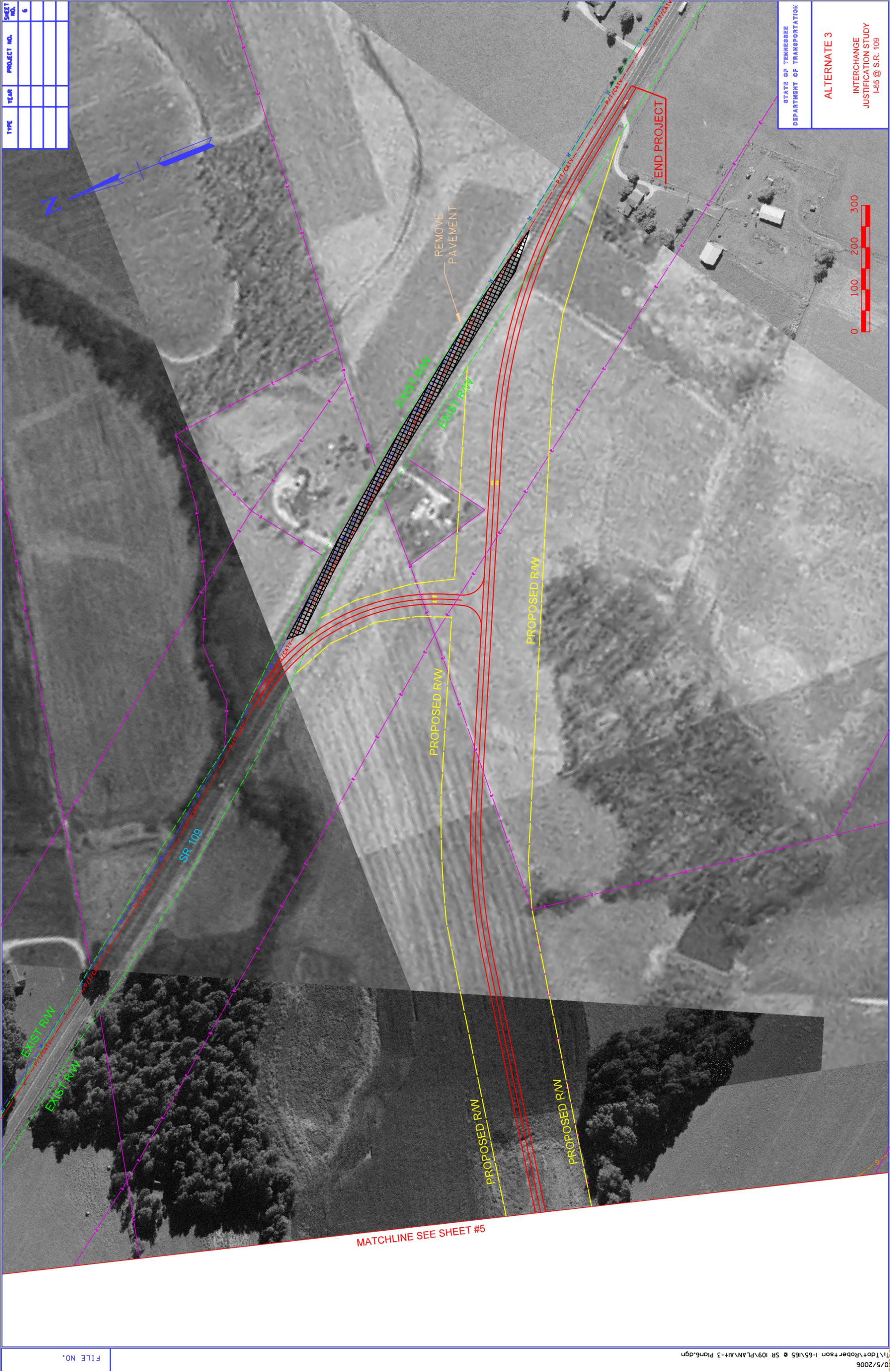
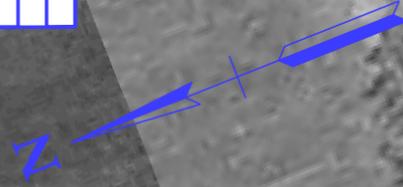
STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

ALTERNATE 3  
INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109

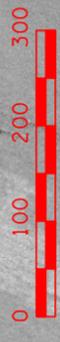


MATCHLINE SEE SHEET #2

TYPE	YEAR	PROJECT NO.	SHEET NO.
			6



MATCHLINE SEE SHEET #5



STATE OF TENNESSEE  
DEPARTMENT OF TRANSPORTATION

ALTERNATE 3

INTERCHANGE  
JUSTIFICATION STUDY  
I-65 @ S.R. 109