Appendix C

Texas-Oklahoma Passenger Rail Study Route Alternatives Analysis

Final Route Alternatives Analysis Technical Memorandum

Texas-Oklahoma Passenger Rail Study

June 23, 2014

Prepared by CH2M HILL

in coordination with Oklahoma DOT

Texas Department of Transportation

Contents

Acronyms and Abbreviations

DGNO	Dallas Garland and Northeastern Railroad
DUS	Dallas Union Station
EIS	environmental impact statement
FRA	Federal Railroad Administration
GIS	Geographic Information Systems
IH	Interstate Highway
ITC	Intermodal Transportation Center
KCS	Kansas Southern Railway
LCSB	Laredo-Columbia Solidarity Bridge
NLCD	National Land Cover Database
mph	miles per hour
MSA	Metropolitan Statistical Area
N/A	not applicable
NEPA	National Environmental Policy Act
O-D	origin-destination
SAT	San Antonio International Airport
SCT	Secretaría de Comunicaciones y Transportes
Study	Texas-Oklahoma Passenger Rail Study
TOPRS	Texas-Oklahoma Passenger Rail Study
TRE	Trinity Railway Express
TxDOT	Texas Department of Transportation
USGS	U.S. Geological Survey

TECHNICAL MEMORANDUM

Texas-Oklahoma Passenger Rail Study Draft Route Alternatives Analysis

TO: Texas Department of Transportation

FROM: CH2M HILL

DATE: May 16, 2014

1.0 Introduction

This memorandum provides an overview of the Route Alternatives Analysis conducted to establish the set of route alternatives, including routes and rail service-level alternatives, to be carried forward into the service-level environmental impact statement (EIS) for the Texas-Oklahoma Passenger Rail Study (TOPRS). The memorandum includes an overview of the initial range of alternatives and feasibility screening, the alternatives carried forward into the Route Alternatives Analysis, the Route Alternatives Analysis criteria, and the key findings and results of the Route Alternatives Analysis. This memorandum concludes with recommendations of route alternatives to be carried forward and not to be carried forward into the EIS, as well as an explanation of next steps. The information in this memorandum will ultimately be described in the full Alternatives Analysis Report, which will provide a detailed description of the route and station location alternatives, alternatives analysis methodology, service-level descriptions, performance and cost modeling, and results from each type of analysis. The results of the Alternatives Analysis Report will be summarized in the EIS.

2.0 Development of Initial Range of Alternatives

2.1 Initial Fatal Flaw Analysis

After the completion of the NEPA Service-level EIS scoping process during March and April 2013, the TOPRS team developed 12 initial route alternatives (four in each of the three geographic segments) to provide additional or new passenger rail service between Oklahoma City and south Texas, as described in the Initial Development of Alternatives Technical Memorandum (CH2M HILL 2013). Each initial alternative included both a proposed route, some with minor route options, and two of three possible service-level operating features: conventional (emerging), higher speed rail (regional), or high-speed rail (core express) service. The geographic segments, which have significantly different population and travel characteristics, were delimited as follows:

- Northern Section: Oklahoma City to Dallas and Fort Worth
- Central Section: Dallas and Fort Worth to San Antonio
- Southern Section: San Antonio to south Texas.

In addition, the Northern Section of the Program Corridor was extended north of Oklahoma City to Edmond, Okla., based on preliminary ridership information and stakeholder input. In the Southern Section, based on stakeholder input at Laredo and Harlingen, an option was added to extend the southern end of the Program Corridor across the U.S.-Mexico border to Monterrey, Mexico, to capture significant ridership generators. In the case of service to Monterrey, the Study is considering the effect of ridership generated by potential extensions to Monterrey but not the route impact, which is the subject of a separate approval by the Secretaría de Comunicaciones y Transportes (SCT) in Mexico.

In the Initial Development of Alternatives Technical Memorandum, routes were initially screened to determine overall feasibility by considering the following:

- Findings from the Oklahoma City to South Texas Infrastructure Analysis (Texas Department of Transportation [TxDOT] 2013a)
- Concurrence from the railroads that the use of existing railroad rights-of-way would be suitable for joint freight and passenger rail operations

The Oklahoma City to South Texas Infrastructure Analysis is a 2013 study of the possibility of operating high-speed or higher speed rail in the rights-of-ways of interstate highways within the Study area. The findings in this report established that interstate highways are designed with curve radii that are too small for high- or higher speed railroad operation, that railroad vertical clearance needs are often higher than highway clearances at existing overpasses, and that many operational limitations of both highways and railroads make shared rights-of-way problematic for all but short stretches of a new rail alignment.

Figure 2-1, which is from the Initial Development of Alternatives Technical Memorandum, shows the alternative routes that were considered in the initial fatal flaw analysis. The following routes (described in the Initial Development of Alternatives Technical Memorandum) were eliminated from further consideration because either they use a railroad right-of-way, which led the railroad to request their removal from further study, or they use a shared highway right-of-way for most of their length.

- N3 (uses Interstate Highway [IH]-35)
- C3 (uses IH-35)
- S1 (uses IH-35)
- S3 (uses IH-37)

A segment option between Dallas and Fort Worth included the possible use of Union Pacific Railroad (UPRR) track. During subsequent stakeholder meetings, UPRR advised TxDOT that they would not consider adding new intercity passenger trains to this corridor and so that segment option was removed from the study.

The routes alternatives eliminated from further consideration are shown in grey on Figure 1. A segment option for high-speed service over IH-30 between Dallas and Fort Worth was retained because the Study team was advised by the North Central Texas Council of Governments that they have reserved space on the highway for an elevated high-speed railway alignment (CH2M HILL, 2012) and requested that it be included in the study.

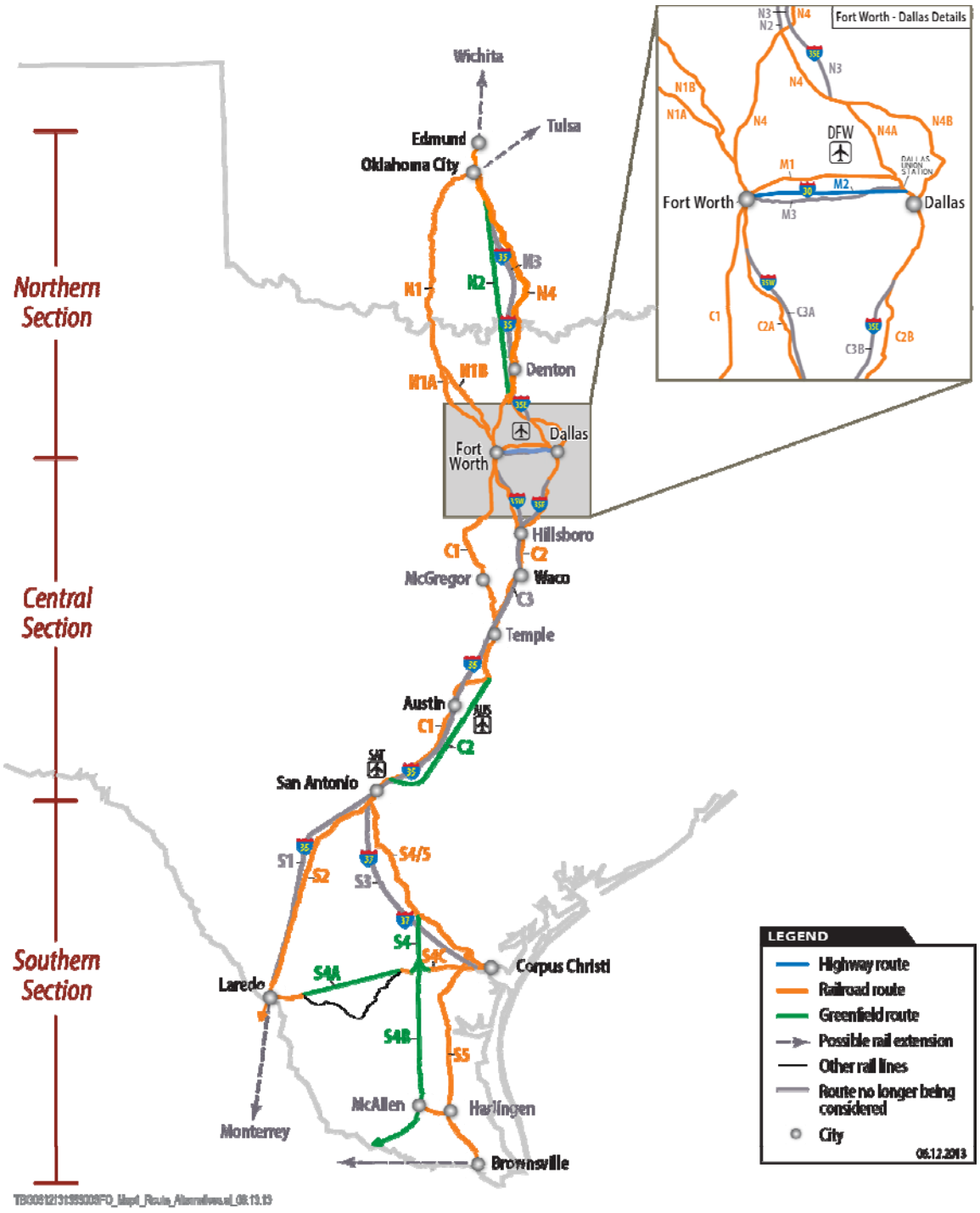


Figure 2-1: Screened Route Alternatives

2.2 Route Alternatives Carried Forward into Route Alternatives Analysis

The route alternatives carried forward into the Route Alternatives Analysis are shown on Figure 2-2 and described below. Each route alternative includes two of three of the following service-level alternatives:

- Conventional Service (referred to as emerging corridors by the Federal Railroad Administration [FRA]) would be operated at speeds up to 79 to 90 miles per hour (mph). This service-level alternative is associated with route alternatives that would use existing railroad rights-of-way. It is not an option on greenfield[1] corridors because it would not be cost-effective to construct a new alignment for a low level of service.
- Higher Speed Service (referred to as regional corridors by FRA) would be operated at speeds up to 110 to 125 mph. This service-level alternative is associated with all route alternatives. Where used on an existing railroad right-of-way, it indicates construction of a shared right-of-way with separate tracks for freight and passenger service. Where used on a greenfield corridor, it indicates a new alignment built for future high-speed rail service but without electrification, without full double track, and with some grade crossings remaining.
- High-Speed Service (referred to as core express by FRA) would be operated at speeds up to 220 to 250 mph. The entire right-of-way would be fenced and fully grade separated. The entire alignment would be electrified and double tracked. This service-level alternative is associated only with greenfield corridors because existing railroad alignments are neither compatible with the speeds required nor do they have the required room for separation of freight and high speed passenger services.

Figure 2-2 is a map of the route alternatives that were carried into the Route Alternatives Analysis screening, while Figures 2-3 though 2-5 focus on each geographic section. Section 2.2.1 through Section 2.2.3 provide descriptions of the route alternatives for each geographic section. Tables 2-1, 2-2, and 2-3 identify the service levels for each route alternative in the three geographic sections, respectively.

[1] A greenfield corridor in this context refers to a possible new railroad alignment built on a new right-of-way acquired for that purpose. In this memorandum, a greenfield corridor designation is used to represent a typical new alignment, not a specific alignment (which would be identified at a later project-level EIS).

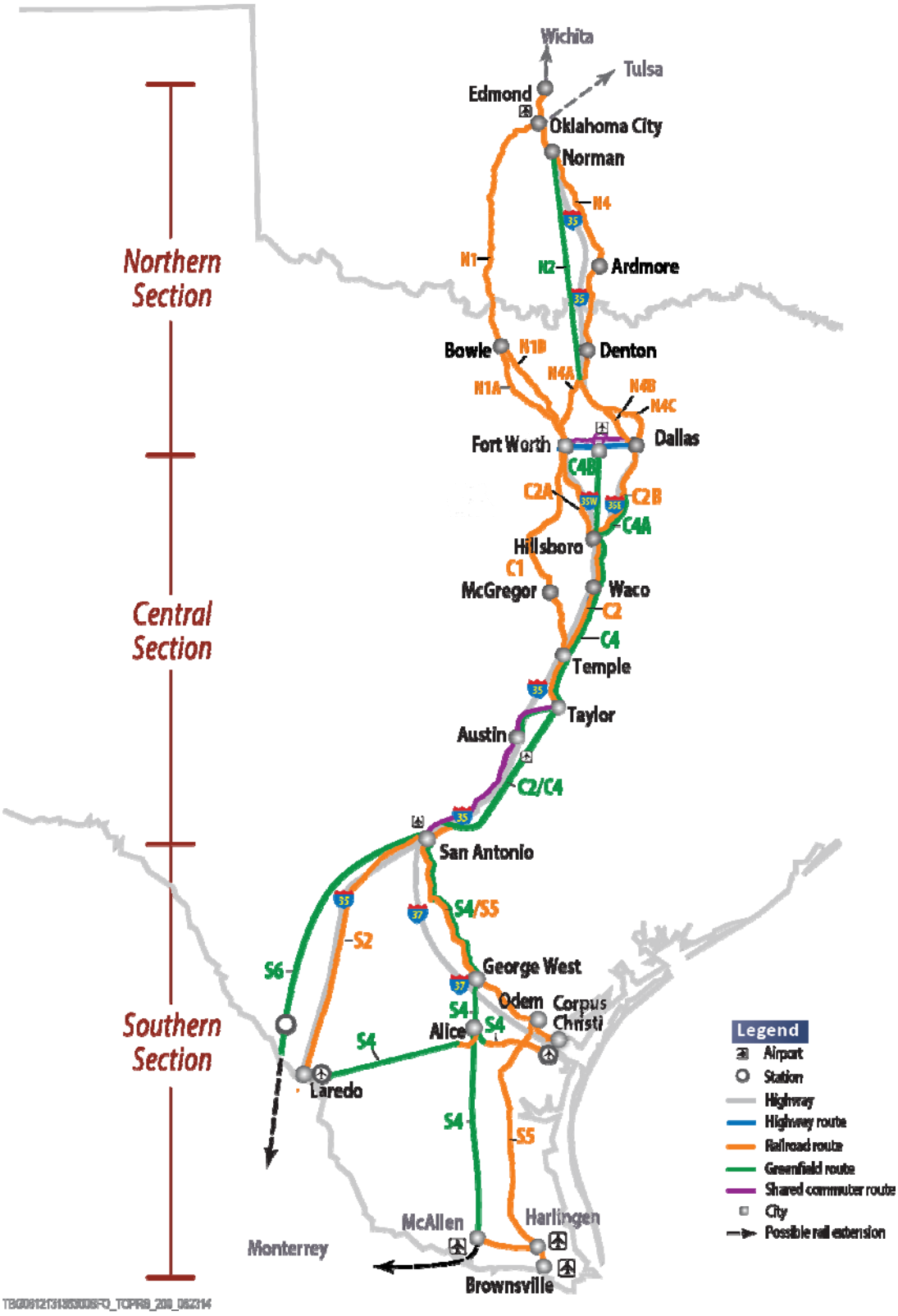
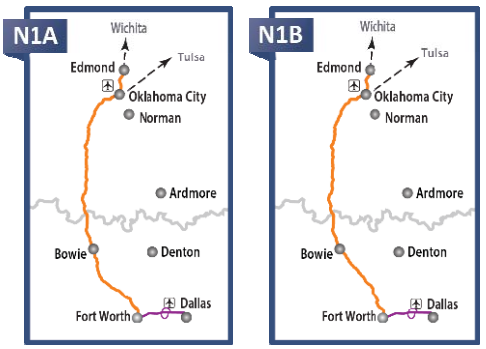


Figure 2-2: Route Alternatives Carried Forward into the Route Alternative Analysis

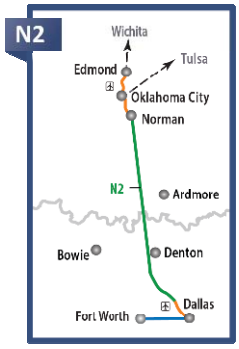
2.2.1 Northern Section Route Alternatives

Figure 2-3: Northern Section Overview

N1 This alternative would begin at Edmond, Okla., and follow the BNSF south to a connection with a regional railroad to Chickasha, Okla. It would then follow the UPRR to Bowie, Okla., where the route can either (Option N1A) continue on UPRR track to Fort Worth or (Option N1B) transition back to the BNSF for entry into Fort Worth at the Intermodal Transportation Center (ITC). It would then continue to Dallas Union Station (DUS) via the Trinity Railway Express (TRE).



N2 This alternative would begin at Edmond, Okla., and follow the BNSF south to Norman, Okla., where the route would transition into a new greenfield alignment. It would follow this alignment to a point near Krum, Texas, where it would transition onto the Kansas Southern Railway (KCS) and the Dallas Garland and Northeastern Railroad (DGNO) to DUS, entering from the west, and then continue to the Fort Worth ITC on a new high-speed alignment built over IH-30.



N4 This alternative would begin at Edmond, Okla., and follow the BNSF south to Metro Junction, just north of Krum, Texas. Option N4A would continue to the Fort Worth ITC on the BNSF (as does the existing Amtrak Heartland Flyer) and then continue to DUS via the TRE. Option N4B would continue to DUS over the KCS/DGNO and then reverse direction to Fort Worth over the TRE. Option N4C would continue to DUS over the KCS and then continue to Fort Worth over the TRE.

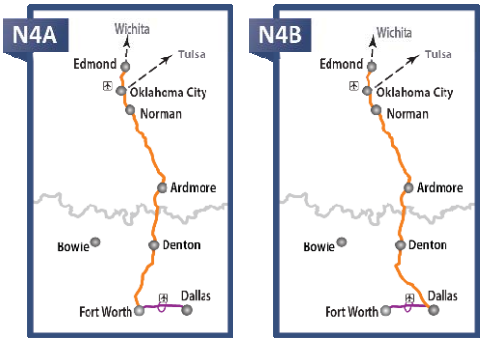


TABLE 2-1
Northern Section Route Alternatives and Service Levels

Alternative/ Option	Conventional (Emerging)	Higher Speed (Regional)	High Speed (Core Express)
N1 (A and B)	Yes	Yes	No
N2	No	Yes	Yes
N4 (A, B, C)	Yes	Yes	No

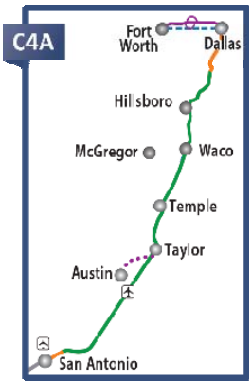
2.2.2 Central Section Route Alternatives

Figure 2-4: Central Section Overview

C1 This alternative would begin at DUS and follow the TRE to the Fort Worth ITC. From there C1 would run on the existing BNSF line south to Temple (the same route as Amtrak's Texas Eagle), where it would use an existing connection to continue on to the UPRR track to Taylor. At Taylor, this alternative would continue to operate over the UPRR to Austin and San Antonio, coordinating schedules with Lone Star Rail District trains which are planned to operate along this line.

C2 Option C2A would begin at DUS and follow the TRE to the Fort Worth ITC and then run on the UPRR south to Hillsboro. Option C2B would begin at the Fort Worth ITC and follow the TRE to DUS. It would then run on the BNSF south to Waxahachie, where it would enter a rebuilt abandoned railroad corridor to Hillsboro. These options can be combined to provide a "loop" service where trains travel to and from Dallas and Fort Worth before returning south. All of these options would then continue south from Hillsboro through Waco to Taylor. At Taylor conventional service trains would follow the UPRR through Austin and San Antonio, coordinating schedules with the proposed Lone Star regional rail service. Higher speed service would enter a new greenfield right-of-way through the Austin-Bergstrom International Airport and south to just north of the San Antonio International Airport (SAT). After looping through SAT, service would then continue over the UPRR, ending at the former San Antonio Missouri Pacific station (now the VIA Transit Center), just west of downtown San Antonio. For the higher speed service, downtown Austin would be served either by a connection to the planned extension of Austin's urban rail (which is not a part of this study) to Austin-Bergstrom International Airport from downtown or by having some trains follow the UPRR from Taylor to the Austin Amtrak station (partial C1 alternative), coordinating schedules with the Lone Star Rail District trains planned to operate along this line (which are part of this study).

C4 Option C4A would begin at the Fort Worth ITC and follow the TRE to DUS, where it would then follow the BNSF south toward Waxahatchi and enter a high-speed greenfield corridor to travel south to Hillsboro and Taylor. Option C4B would begin at both the Fort Worth ITC and DUS, with trains following a high-speed alignment above IH-30 to Arlington, where the lines would merge and turn south to Hillsboro on a high-speed greenfield alignment to Taylor and south, following the same alignment as the C2 higher-speed alternative. Alternative C4 also has an option of direct service to downtown Austin via connections with trains operating over the UPRR from Taylor to Austin, which would coordinate schedules with the proposed Lone Star Rail District.



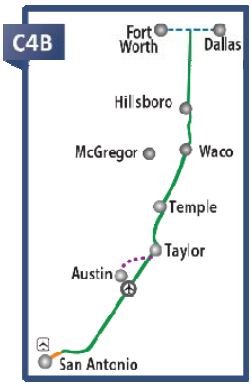


TABLE 2-2
Central Section Route Alternatives and Service Levels

Alternatives	Conventional	Higher Speed	High Speed
C1	Yes	Yes	No
C2 (A and B)	Yes	Yes	No
C4 (A and B)	No	Yes	Yes

2.2.3 Southern Section Alternatives

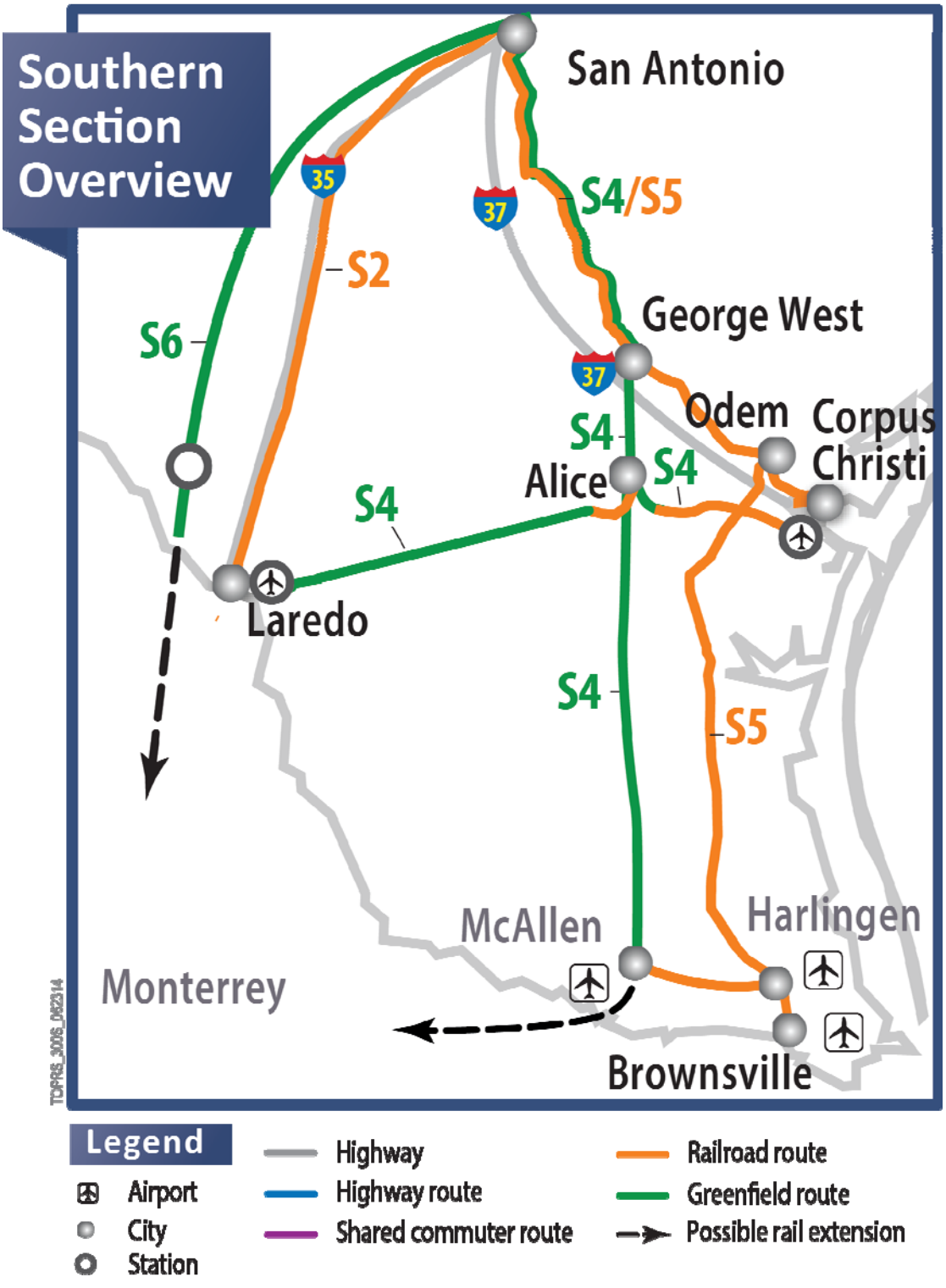
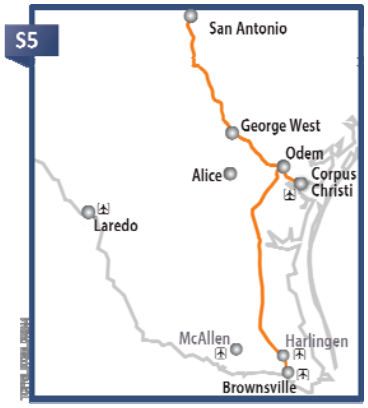


Figure 2-5: Southern Section Overview

S2 This alternative would begin at the San Antonio VIA Transit Center station and continue southwest on the UPRR, ending at Laredo. While there is a freight railroad connection to the KCS de Mexico at that point, it is too congested by existing freight operations to consider for extended passenger rail service to Monterrey.

S4 This alternative would begin at the San Antonio VIA Transit Center station and continue southeast on the UPRR to George West, where the line would enter a greenfield right-of-way to Alice. At Alice, there would be a stop where this alternative would divide into three legs, each of which could have direct service to San Antonio or shuttle service to Alice. The first leg would travel west along the KCS Railway to San Diego, Texas, where it would enter a greenfield right-of-way to Pescadito and then rejoin the KCS Railway to end at the Laredo International Airport. While there is a freight railroad connection to the KCS de Mexico from that line, it is too congested by existing freight operations to consider for extended passenger rail service to Monterrey. The second leg would travel south along rebuilt abandoned track to McAllen, where a connection could be made to Harlingen and Brownsville over a proposed commuter rail service (which is not part of this study). This leg could also be extended into Mexico over a greenfield border crossing and then follow another route of the KCS de Mexico to Monterrey. The third leg would travel east along the KCS Railway to Corpus Christi to a new station facility at Corpus Christi International Airport.

S5 This alternative would begin at the San Antonio VIA Transit Center station and continue southeast on the UPRR to Odem, where a shuttle train or bus would provide service from Odem to Corpus Christi. The type of service (train or bus) from Odem to Corpus Christi will be determined during the EIS analysis when specific ridership data is available. This route alternative would continue south from Odem along the UPRR to Brownsville, stopping at a new station near the Brownsville Transit Center. A proposed commuter rail service (which is not a part of this study) could connect to Harlingen and McAllen.



S6 This alternative was added as a result of stakeholder meetings in Laredo, at which attendees expressed a desire for direct service from San Antonio to Monterrey, Mexico, with a new stop northwest of Laredo near the Laredo-Columbia Solidarity Bridge (LCSB). This alternative would begin at the San Antonio VIA Transit Center station and continue on a direct line to the station at the LCSB. It would then cross on a new railway bridge to join a new line that has been approved for construction in Mexico, which would continue to Monterrey, Mexico. This study only examines the U.S. component of this new line, but it does consider the ridership impact of such a connection.

TABLE 2-3
Southern Section Route Alternatives and Service Levels

Alternatives	Conventional	Higher Speed	High Speed
S2	Yes	Yes	No
S4	No	Yes	Yes
S5	Yes	Yes	No
S6	No	Yes	Yes

3.0 Route Alternatives Analysis Criteria and Methodology

3.1 Criteria Development Process

Screening criteria for the Route Alternatives Analysis were developed based on a number of considerations. First, criteria were included that evaluate whether routes are aligned with the project Purpose and Need, which are identified in Table 3-1. As a result, analyses completed in other technical memoranda for this study (such as ridership, travel time, and cost) are included. In addition, the criteria were designed to compare consistency of the route alternatives with local and regional goals, as well as the level of community and agency support for each alternative. The final criteria reflect stakeholder comments and input received during individual stakeholder meetings and during the scoping process. A record of comments received during the scoping process is included in the *Texas-Oklahoma Passenger Rail Program Scoping Report,* which was completed in November 2013 (TxDOT 2013b). Finally, criteria were developed to evaluate potential effects of routes on environmental resources. This criteria development process and the methodologies used to evaluate each criterion are described below.

The Route Alternatives Analysis criteria development process included identification of an initial list of criteria and metrics, and determination of criteria alignment with the project Purpose and Need elements. Additionally, throughout the development process, the criteria were reviewed and evaluated to verify they meet the following additional overall goals:

1. Tie directly to the project goals and objectives
2. Are measureable (quantitatively or qualitatively)
3. Identify thresholds over or under which alternatives could potentially be rejected
4. Are based on data available through this Study
5. Differentiate among alternatives

3.2 Final Criteria

Table 3-2 lists the final criteria that were used to screen alternatives for the Route Alternatives Analysis. The criteria are grouped into four categories: alignment attributes, operational criteria, infrastructure criteria, and environmental criteria, according to the topics they address. The measure used to evaluate each criterion is shown in Table 3-2, along with threshold values, when applicable. In addition, the source of data used to evaluate each criterion is included, as well as the elements of the project Purpose and Need related to each, as identified and numbered in Table 3-1. Section 3-3 describes the methodology used to evaluate each criterion3.

TABLE 3-1
Summary of Overall Program Purpose and Need

No.	Elements of Purpose and Need
Purpose	
Overall	To enhance intercity mobility by providing new, improved, and, where feasible, high-speed passenger rail service as a transportation alternative that is competitive with automobile, bus, and/or air travel.
P1	Provide infrastructure for a high-quality intercity rail service that will reduce travel times, increase schedule reliability, and increase traveler comfort.
P2	Encourage more efficient and environmentally sensitive modes of intercity travel.
P3	Provide an equitable and affordable intercity travel alternative to automobile, bus, and air service.
P4	Enhance interconnectivity between intercity rail services, regional transit services, and major regional airports.
P5	Enhance environmental sustainability by facilitating regional land use and transit-oriented development plans within the Program corridor.
P6	Enhance interregional access to employment, entertainment, recreation, health, and shopping opportunities for existing and future residents in the Program corridor.
P7	Coordinate with and do not negatively affect freight rail operations or facilities.
P8	Be a cost-efficient investment where the projected train service revenue meets or exceeds operations and maintenance costs, based on service level.
Need	
N1	Population and economic growth will increase travel demand, generate additional congestion, and reduce automobile and transit reliability and thereby require regional mobility alternatives.
N2	Limited intercity passenger rail service and capacity restrict both mobility and economic development.
N3	Declining air quality resulting from increased travel demand and congestion requires more environmentally sustainable modes of travel.
N4	Growth in truck and rail freight has negative impacts on the safety of the transportation system.

TABLE 3-2
Route Alternatives Analysis Criteria

Criterion No.	Criterion	Measure	Threshold	Data Source[a]	Related Purpose & Need Elements[b]
Alternative Attributes					
1a	Access to Stations	Total population of cities served by stations	N/A	U.S. Census (2010)	P3, P4
1b	Access to Stations with endpoint cities removed	Total population of cities served by stations with endpoint cities removed	N/A	U.S. Census (2010)	P3, P4
2	Ridership for each Alternative	Ridership (annual trips)	N/A	CONNECT model	P3, P6, N1, N2
3	Length of Route	Length of route in miles	N/A	Route design files	N/A
4	Cost to Construct Alternative	Total Capital Cost for Alternative ($)	N/A	CONNECT model with local data	P8
Operational Criteria					
5	Revenue/ Operating Cost Ratio	Revenue/ Operating Cost (%)	Conventional: 50% cost recovery; higher-speed: 75% cost recovery; high-speed: 100% cost recovery	CONNECT model	P8
6	Reduce Travel Times	Time reduction vs. Automobile	N/A	CONNECT model	P1, P6
7	Enhance Mode Share on Rail	Rail mode share (%)	N/A	CONNECT model	P6, N1
Infrastructure Criteria					
8	Capital Cost per Passenger Mile	Capital Cost per Passenger Mile ($)	N/A	CONNECT model and local cost enhance-ments	P8
9	Minimize Right-of-Way/ Real Estate Impacts	Acres of non-transportation right-of-way within study area	N/A	Study route right-of-way	P2
10	Provides Additional Improvements to National Railroad Network	Professional judgment (value of improvements and risk reduction evaluation)	N/A	Analysis of railroad infrastruc-ture and operations	P5, P7, N4

Criterion No.	Criterion	Measure	Threshold	Data Source[a]	Related Purpose & Need Elements[b]
Environmental Criteria [c]					
Minimize Impacts on Natural Resources					
11a	Wetlands	Acres within study area	N/A	National Land Cover Data Base	P2
11b	Critical Habitat	Acres within study area	N/A	U.S. Fish and Wildlife Service Data	P2
Minimize Impacts on Cultural/Recreational Resources					
12a	National and State Historic Places	Number of Historic Sites	N/A	National Register of Historic Places, State Historic Data	P2
12b	River and Stream Crossings	Number of river and stream crossings	N/A	Number of river and stream crossings	P2
12c	Parks and Open Space	Acres within study area	N/A	ESRI parks data and Texas Parks & Wildlife data	P2
Minimize Impacts on Social Resources					
13a	Prime Farmland	Acres within study area	N/A	Natural Resources Conserva-tion Service, U.S. Dept. of Agriculture	P2
13b	Sensitive Receptors	Number of schools, places of worship, and hospitals within study area	N/A	USGS, ESRI, and Texas Education Agency data	P2, N3

Criterion No.	Criterion	Measure	Threshold	Data Source[a]	Related Purpose & Need Elements[b]
13c	Environmental Justice	Number of census blocks with % minority greater than state	N/A	US Census (2010)	P2

Notes:

N/A = not applicable

USGS = U.S. Geological Survey

[a] FRA's CONNECT rail planning model is described in Section 3.3.1.1 of this memorandum.

[b] Purpose and Need statement numbers are listed in Table 3-1.

[c] The study area for environmental impacts equals 250 feet on either side of centerline, unless alternative uses existing infrastructure.

3.3 Criteria Analysis Methodology

A summary of the methodology used to determine values for each screening criterion is included below. The criteria are grouped into the following related sets:

- Alternative attributes
- Operational criteria
- Infrastructure criteria
- Environmental criteria

As explained in Section 3.3.1 below, alternative attributes were not used independently to compare alternatives; however, the criteria listed under operational, infrastructure, and environmental were used for comparison of alternatives and screening. Within each of these three groups, criteria are listed in order of priority, placing those with established thresholds first. Because no environmental fatal flaws were identified, potential environmental impacts were not used to screen out alternatives but, when appropriate, were used to support screening decisions.

3.3.1 Alternative Attributes

Criteria numbers 1 through 4 (see Table 3-2) describe attributes of each route alternative that are not used independently to compare alternatives but that instead help explain differences between route alternatives that are identified using the operational, infrastructure, and environmental criteria. For example, criterion number 3, Length of Route, is useful for understanding why some routes have greater potential to affect environmental resources; a longer route is likely to affect more acres of resources than a shorter one.

Other alternative attributes, such as the Ridership subcriteria and Cost to Construct Alternative criterion, were used to calculate operational and infrastructure criteria (for example, criterion number 5, Revenue/Operating Cost Ratio, and number 8, Capital Cost per Passenger Mile).

Section ridership (listed as "Ridership" in the tables below) is the ridership within a section assuming the other two sections also implement an assumed level of passenger rail improvements. An assumed set of routes and service levels were used in the ridership forecasts developed in FRA's CONNECT model (further described below) to represent the sections outside of the section alternatives being immediately analyzed (for example, when evaluating ridership for each Northern section alternative, an assumed route and service level was used for each of the Central and Southern sections to represent the entire system). The assumed routes and service levels used in the CONNECT modeling were based on the initial alternatives described in Section 2.1 and include:

- Northern: N4 route. Conventional service, 4 daily roundtrips
- Central: C3A/C3B route. High speed rail. 16 daily roundtrips
- Southern: S2 route. Conventional service. 4 daily roundtrips + S5 route. Conventional service. 4 daily roundtrips

Because these ridership forecasts from CONNECT were estimated prior to the evaluation of route alternatives (and prior to the recommendations in this report to eliminate routes from further consideration) they include assumed routes and service levels that in some cases are not carried forward for further consideration. As a result, these ridership forecasts should be used as relative measures to compare alternatives within a section and not as a refined estimate of ridership across the system. Refined ridership estimates will be developed for each alternative carried forward to the EIS.

3.3.2 Operational Criteria

3.3.2.1 Background/Overview of the CONNECT Model

Many of the operational screening criteria values were estimated using FRA's CONNECT model. CONNECT is a tool that enables sketch-level, regional, high-speed/intercity passenger rail planning in the context of a user-defined network. The tool is intended for use at the outset of the planning process, before alignment and operational plans are developed. CONNECT can support the analysis of multiple network configurations and compare the relative operational and financial performance of varying network configuration and service plan scenarios. CONNECT is not a substitute for detailed corridor and network planning; however, used in the early stages of the planning process, it can help narrow a wide range of potential scenarios and help in selecting only the most compelling to carry into more detailed analysis.

CONNECT's approach to forecasting the potential ridership of a proposed rail service comprises three broad stages. In the first stage, the total divertible intercity travel market is estimated for each existing mode. In the second stage, CONNECT estimates the number of trips that would be diverted to rail from each of the existing modes. Most results are reported at the origin-destination (O-D) level, with some outputs aggregated further to the Metropolitan Statistical Area (MSA), corridor, and network levels. All outputs are reported by CONNECT in ranges, to avoid implying more precision than is appropriate. For purposes of this analysis, the median ridership value is presented in the tables below.

CONNECT calculates capital costs using a simplified costing model driven by the infrastructure and operating characteristics defined by the user. This model relies on unit costs derived from domestic and international averages, which may not reflect local conditions. In this study, some local conditions were accounted for in the cost section but not the ridership section (which uses comparable data valid across the U.S.). The next phase of this work will use local ridership data to augment the CONNECT data. Operating and maintenance costs are estimated based on a simplified service plan consisting of daily frequencies and average speeds.[2]

3.3.2.1.1 Criterion 5: Revenue/Operating Cost Ratio

This criterion assesses the ratio of fare revenue to operating costs for the CONNECT scenario that most closely represents the proposed alignment. For example, an alternative with a score of 0% would have none of its operating costs covered by fare revenues, whereas an alternative with a score of 100% would have all of its operating costs covered by fare revenues. Both fare revenue and total operating cost are direct outputs of CONNECT.

3.3.2.1.2 Criterion 6: Reduce Travel Times

This criterion compares rail travel time to automobile travel time for the CONNECT scenario that most closely represents the proposed alignment. This helps to identify the alternatives that would provide travel time savings compared to automobile travel. Rail travel times were not compared to air travel times because generally rail alternatives would not have a shorter city to city travel time than air travel (train station to train station versus airport to airport). If total journey time (door to door) and frequency of service were considered, rail travel times could be competitive with air travel. However this level of detailed analysis exceeds the scope of this study. At a later stage in the study, analysis will be done to consider the feasibility of making rail options cost competitive with air travel. Both rail and automobile

[2] In the context of this Route Alternatives Analysis, CONNECT results are used for comparative purposes only. CONNECT is designed to predict passenger rail demand between MSA pairs and so has limited ability to distinguish between different alternatives that serve a given MSA pair. Route Alternatives Analysis results are not intended to be forecasts of anticipated ridership or cost.

travel times are direct outputs of CONNECT. Note that CONNECT auto travel times do not anticipate change with the introduction of rail service.

3.3.2.1.3 Criterion 7: Enhance Mode Share on Rail

This criterion assesses the rail mode share for the CONNECT scenario that most closely represents the proposed alignment. Rail mode share is a direct output of CONNECT.

3.3.3 Infrastructure Criteria

3.3.3.1 Criterion 8: Capital Cost per Passenger Mile

This criterion assesses the ratio of capital cost to passenger miles for the CONNECT scenario that most closely represents the proposed alignment. Both capital cost and passenger miles are direct outputs of CONNECT.

3.3.3.2 Criterion 9: Minimize Right-of-Way/Real Estate Impacts

Potential impacts on right-of-way were estimated for each route alternative and service-level option by calculating the total right-of-way required for each, then subtracting the area representing transportation land use (highways and rail) from the total.

3.3.3.3 Criterion 10: Provide Additional Improvements to National Railroad Network

Benefits to the national railroad network were determined for each route alternative and service-level option by considering factors such as existing freight or local commuter rail service on alignments, proposed capacity improvements for the host railroad, improvements in rail safety and speed (including grade separations), and mitigation measures that would enhance the national rail network.

3.3.4 Environmental Criteria

Potential effects of route alternatives on environmental resources were estimated using a study area of 250 feet on each side of the route alternative centerline. Environmental criteria are grouped according to the type of resource they address into impacts on natural resources, cultural/recreational resources, and social resources. Geographic Information Systems (GIS) was used to calculate acreages and counts of potentially affected resources, as described below.

3.3.4.1 Criterion 11a: Wetlands

This criterion assesses the acres of wetlands potentially affected by each route alternative. Calculations were completed using National Land Cover Database (NLCD) data and included the following categories: open water, woody wetlands, and emergent herbaceous wetlands. National Wetlands Inventory data were also evaluated, but complete coverage of the study area was not available; therefore, the values were not included in the screening comparison.

3.3.4.2 Criterion 11b: Critical Habitat

This criterion assesses the acres of critical habitat of federally endangered species potentially affected by each route alternative. The calculations were completed using U.S. Fish and Wildlife Service data.

3.3.4.3 Criterion 12a: National and State Historic Places

This criterion assesses the potential effects of each route alternative on national and state historic places. Potential effects were estimated by counting the number of national and state historic sites and districts within 250 feet of each side of the route alternative centerline. National and state historic places data were obtained from the U.S. National Park Service National Register of Historic Places, the Texas Historical Commission, Oklahoma Department of Transportation, and the "Exploring Oklahoma History" website.

3.3.4.4 Criterion 12b: River and Stream Crossings

This criterion assesses the potential effects of each alternative on rivers and streams. Using the USGS National Hydrography Dataset, potential effects were estimated by counting the number of times the centerline of each route alternative would cross a river or stream. In addition, because archaeological resources are often found along waterways, this criterion is considered a proxy for likelihood of finding cultural resources along an alternative.

3.3.4.5 Criterion 12c: Parks and Open Space

This criterion assesses the acres of parks and open space potentially affected by each route alternative. The calculations were completed using data obtained from ESRI and the Texas Parks and Wildlife Department.

3.3.4.6 Criterion 13a: Prime Farmland

This criterion assesses the acres of prime farmland potentially affected by each route alternative. The calculations were completed using U.S. Department of Agriculture Natural Resources Conservation data.

3.3.4.7 Criterion 13b: Sensitive Receptors

This criterion assesses the number of sensitive receptors potentially affected by each route alternative. Potential effects were estimated by counting the number of schools, places of worship, and hospitals within 250 feet of each side of the route alternative centerline. This criterion captures potential noise, vibration, and air quality at the appropriate level of analysis for this study.

3.3.4.8 Criterion 13c: Environmental Justice

This criterion assesses potential disproportionate effects of each route alternative on environmental justice populations. Potential effects were estimated by counting the number

of U.S. Census blocks along route alternatives with a higher percentage of minority residents than that of the state in which they are located. Data from the U.S. Census Bureau 2011 5-year American Community Survey were used.

4.0 Route Alternatives Analysis Results

The Route Alternatives Analysis compared study route alternatives and service-level options by geographic section (Northern, Central, and Southern), with the objective of screening out alternatives that are fatally flawed or that performed considerably less well than other alternatives within the same geographic section. The sections of this memorandum below discuss the values for each screening criterion by geographic section and whether any route alternatives or service-level options are recommended not to be carried forward into the EIS. In the case where no route alternative meets the threshold criteria, the best performing one from that section will be carried into the EIS.

The data tables in this section present values for each screening criterion for each of the geographic sections of the Study. The values in these tables are shaded using green, yellow or red to indicate each alternative's performance relative to the other alternatives or, in some cases, relative to a threshold. The performance level associated with each of these colors is provided in Table 4-1, but in general, green indicates the best performance among the alternatives and red indicates the poorest performance among the alternatives. The results of each assessment are included in Tables 4-2 through 4-4, respectively, for the Northern, Central, and Southern Section route alternatives.

TABLE 4-1
Criteria Key and Definitions

Criterion		Green	Yellow	Red
Revenue/Operating Cost Ratio [a]	CONV	over 50%	25-50%	0–25%
	HrSR	over 75%	50-75%	0–50%
	HSR	over 100%	50–100%	0–50%
Reduce Travel Times		Savings in travel time of more than 50% compared to auto	Savings in travel time of 25 to 50% compared to auto	Savings in travel time of 25% or less compared to auto
Enhance Mode Share on Rail		Over 20% rail mode share	10%–20% rail mode share	0–10% rail mode share
Capital cost		Under $16 (capital cost per annual passenger mile)	$16 - $100 (capital cost per annual passenger mile)	Over $100 (capital cost per annual passenger mile)
Minimize Right-of-Way/Real Estate Impacts		Lowest impact of all alternatives	Intermediate impact	Highest impact of all alternatives

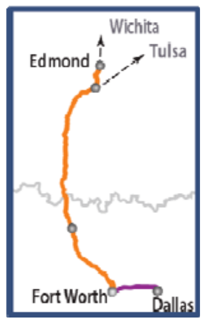
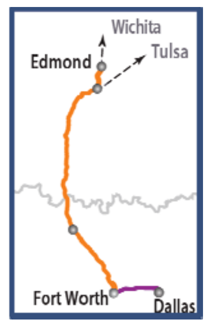
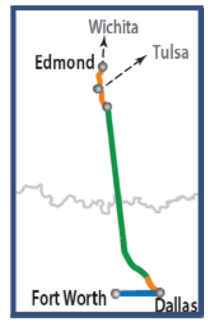
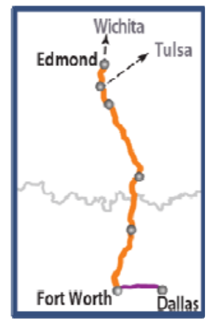
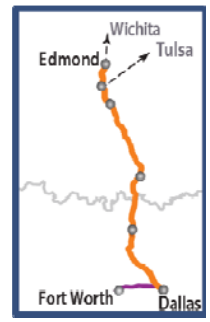
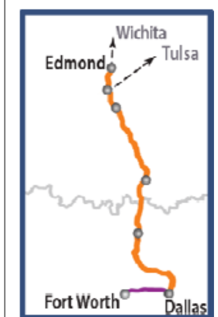
Criterion	Green	Yellow	Red
Provide Additional Improvements to National Railroad Network	The alternative provides new and substantial benefits to the existing rail network	The alternative provides some important benefits to the existing rail network	The alternative provides only limited benefits to the existing rail network
Environmental Criteria (Criteria 11 to 13)	Low area of potential impact compared to other alternatives	Area of potential impact similar to other alternatives	High area of potential impact compared to other alternatives

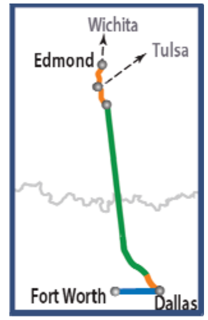
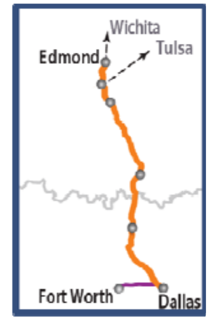
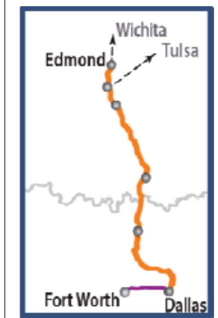
[a] Revenue/Operating Cost Ratio criterion is analyzed by service-level option:
CONV= conventional rail
HrSR = higher speed rail
HSR = high-speed rail

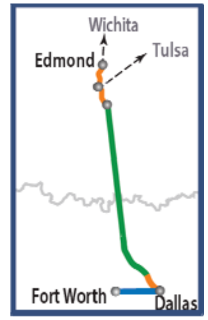
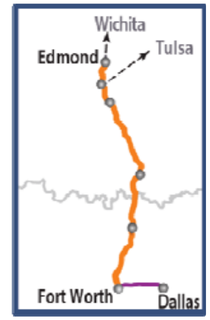
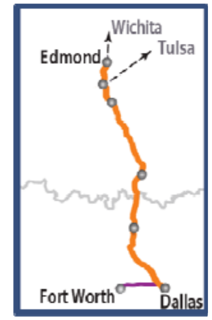
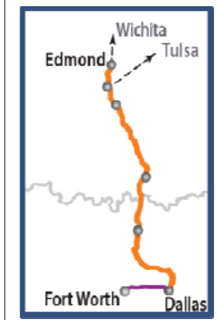
4.1 Northern Section

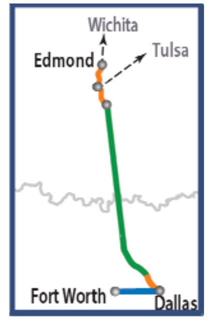
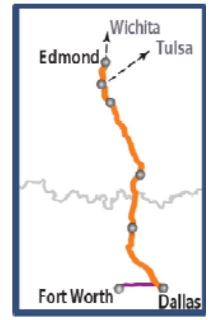
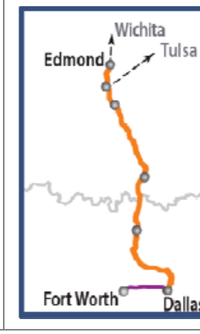
Table 4-2 presents values for each screening criterion in the Northern Section, including Alternatives N1 (A and B), N2, and N4 (A and B). Green, yellow, and red shading in the table indicate the relative performance of routes for each criterion; cells shaded gray indicate that the service-level does not apply to a given route alternative. Keys describing the range of values represented by each color can be found in Table 4-1.

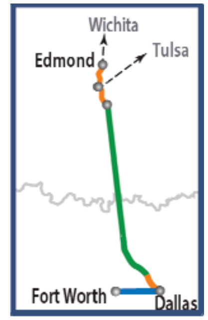
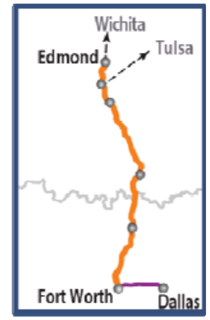
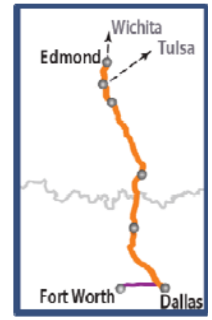
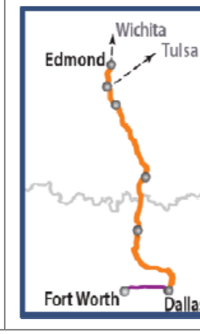
TABLE 4-2
Northern Section[a]

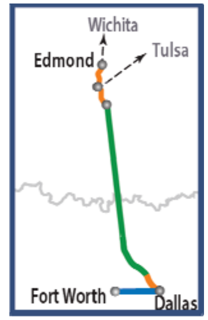
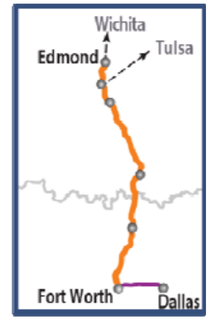
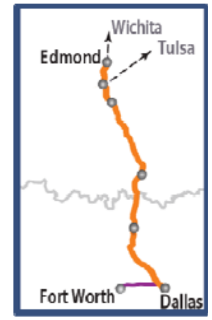
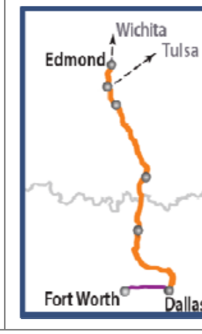
Crit. No.	Alternatives Analysis Criteria	Service Level [b]	N1/N1A	N1/N1B	N2	N4/N4A	N4/N4B	N4/N4C
								
Alternative Attributes								
1a	Access to Stations (total population of cities along route)	*	8,120,000	8,120,000	8,190,000	8,240,000	8,240,000	8,240,000
1b	Access to Stations with Endpoint Cities Removed (total population of cities along route)	*	121,000	121,000	192,000	239,000	239,000	239,000
2	Ridership (millions of passengers per year)	CONV	0.26	0.26		0.30	0.30	0.30
		HrSR	0.39	0.39	0.42	0.42	0.42	0.42
		HSR			0.46			

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	N1/N1A	N1/N1B	N2	N4/N4A	N4/N4B	N4/N4C
								
3	Length of Route (miles)	*	273	272	250	260	260	260
4	Cost to Construct Alternative ($)	CONV	$0.66 billion	$0.66 billion		$0.65 billion	$2.94 billion	$.71 billion
		HrSR	$4.35 billion	$4.34 billion	$1.69 billion	$4.60 billion	$6.10 billion	$5.08 billion
		HSR			$5.24 billion			
Operational Criteria								
5	Revenue/ Operating Cost Ratio (100% covers operating cost with revenue – above 100% indicates surplus available for capital cost)	CONV	20%	19%		27%	31%	31%
		HrSR	23%	23%	25%	24%	26%	26%
		HSR			29%			
6	Reduce Travel Time (percent time savings compared to auto)	CONV	9%	9%		14%	14%	14%
		HrSR	30%	30%	33%	33%	33%	33%
		HSR			68%			

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	N1/N1A	N1/N1B	N2	N4/N4A	N4/N4B	N4/N4C
								
7	Enhance Mode Share on Rail (% rail mode share)	CONV	12%	12%		12%	12%	12%
		HrSR	17%	17%	17%	17%	17%	17%
		HSR			21%			
Infrastructure Criteria								
8	Capital Cost per Passenger Mile	CONV	$10.60	$10.60		$10.50	$47.50	$11.50
		HrSR	$46.20	$46.20	$19.10	$52.00	$69.00	$57.50
		HSR			$52.80			
9	Minimize Right-of-Way/Real Estate Impacts (acres) *N2 is higher because it is a greenfield route that is not adjacent to an existing transportation corridor.*	CONV[c]						
		HrSR	680	730	2,680	1,270	1,260	1,170
		HSR			2,680			
10	Provide Additional Improvements to National Railroad Network	CONV						
		HrSR			N/A			
		HSR			N/A			

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	N1/N1A	N1/N1B	N2	N4/N4A	N4/N4B	N4/N4C
								
Environmental Criteria								
Minimize Impacts on Natural Resources								
11a	Wetlands (acres; NLCD) *N4/N4C (HrSR) is highest due to proximity to White Rock Creek and Trinity River (and their associated wetlands) west of Dallas.*	CONV[c]						
		HrSR	20	10	30	10	20	80
		HSR			30			
11b	Critical Habitat (acres) *Critical habitat in the Northern Section is a reflection of the number of acres of the Canadian River and its floodplain within the buffer area (critical habitat for the Arkansas River shiner).*	CONV[c]						
		HrSR	5	5	50	34	34	34
		HSR			50			

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	N1/N1A	N1/N1B	N2	N4/N4A	N4/N4B	N4/N4C
								
Minimize Impacts on Cultural/Recreational Resources								
12a	National and State Historic Places (count) *The number of historic sites is generally a reflection of the number of cities/towns the route alternative passes through.*	CONV[c]						
		HrSR	10	11	5	20	17	21
		HSR			5			
12b	River and Stream Crossings (count)	CONV[c]						
		HrSR	260	230	320	300	300	310
		HSR			280			
12c	Parks and Open Space (acres state and local parks) *N4/N4C (HrSR) is higher because it passes through the open space south of Lake Louisville for about 4.5 miles.*	CONV[c]						
		HrSR	130	140	150	110	210	460
		HSR			130			

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	N1/N1A	N1/N1B	N2	N4/N4A	N4/N4B	N4/N4C
								
Minimize Impacts on Social Resources								
13a	Prime Farmland (acres)	CONV[c]						
		HrSR	7,880	7,660	4,720	6,250	5,530	5,930
		HSR			4,570			
13b	Sensitive Receptors (count) *The number of sensitive receptors is generally a reflection of the number of cities/towns the route alternative passes through.*	CONV	5	6		12	13	12
		HrSR	5	6	11	12	13	12
		HSR			14			
13c	Environmental Justice (census blocks with % minority greater than state)	CONV	90	90		100	120	140
		HrSR	90	90	110	100	120	140
		HSR			110			

[a] Cells shaded gray indicate that the service level does not apply to this route.
[b] Service-Level Option: CONV= conventional rail; HrSR = higher speed rail; HSR = high-speed rail
[c] Acreage impacts for conventional rail alternatives are considered to have minimal impact for right-of-way and most environmental resources because they would use existing rail infrastructure.
* This criterion does not distinguish between service levels.

Based on the relative performance of routes for the different criteria shown in Table 4-2, the following route alternatives in the Northern Section are recommended **not to be carried forward** into the EIS:

- **N1** (including sub-alternatives N1A and N1B and both conventional and higher speed service levels) – The revenue to operating cost ratio does not meet the required threshold for this alternative. The anticipated ridership and population access to the proposed station are very low. The significant investment in infrastructure required for this alternative would not produce a commensurate increase in ridership. The environmental benefits of this route are similar to other higher ranked alternatives, which provides no compelling reason to further study this alternative.
- **N2** (including both higher speed and high speed service levels) – The revenue to operating cost ratio does not meet the criterion threshold. This alternative would have the highest potential impact on non-transportation right-of-way, and potential environmental effects would be similar to N4A, which performs much better in terms of operational criteria. The significant investment in infrastructure required for this alternative would not produce a commensurate increase in ridership. Removing this alternative would avoid potential issues with farming stakeholders without sacrificing improvements to mobility.
- **N4A** (higher-speed service level) – The capital cost per passenger mile is excessive for this option at six times other alternatives and providing a lower revenue to operating cost ratio than the conventional service indicating that the market is saturated at the conventional speed service option.
- **N4B** (conventional and higher speed service level) – This alternative has a much higher capital cost per passenger-mile than similar alternatives N4A and N4C and would also enter the TRE at a location that would be difficult to handle the additional trains as well as requiring reversing the trains in DUS that the other alternatives would not need.
- **N4C** (conventional and higher speed service level) – This alternative would perform the most poorly from an environmental perspective including the greatest potential effects on wetlands as well as parks and open space. It traverses a long looping arc through suburban Dallas subject to many grade crossing issues and potential delays at a KCS yard along the route. Alternative N4A at the conventional service level has the same benefits without the negative effects.

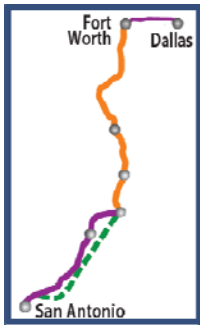
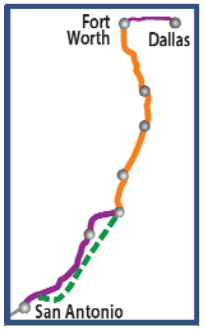
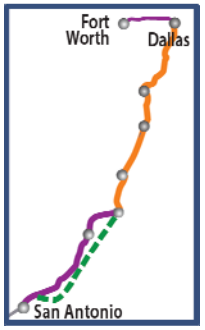
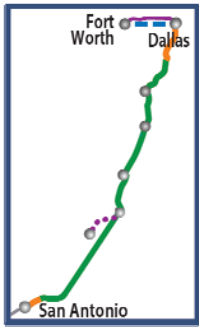
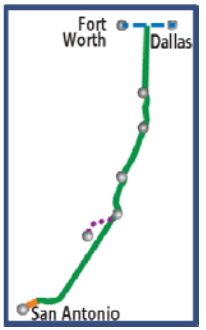
Based on the relative performance of routes for the criteria shown in Table 4-2, the following route alternative in the Northern Section are recommended **to be carried forward** into the EIS:

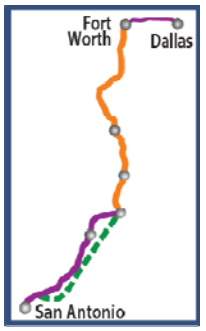
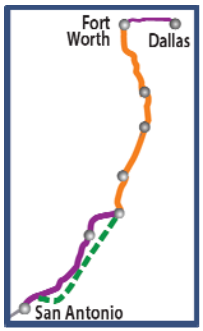
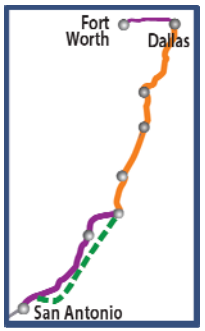
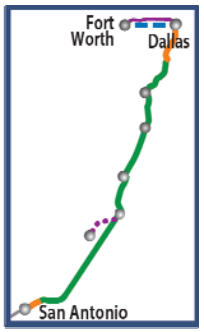
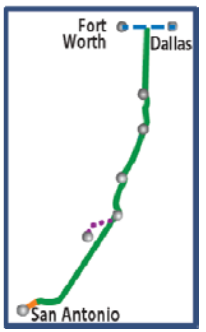
- **N4A** (conventional speed level) – This route alternative covers most of the same line that has been upgraded by the TxDOT and ODOT as part of an on-going rail passenger improvement program and therefore represents a good use of resources that can be further built-upon. While Route alternative N4A does not meet the revenue to operating cost threshold it has the lowest capital cost per passenger mile for the Northern Section alternatives and will therefore be carried forward to represent the Northern Section in the EIS.

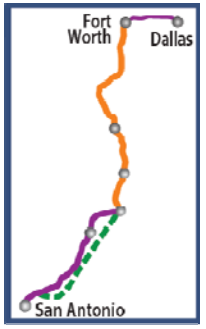
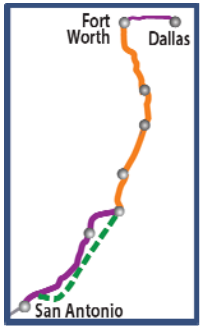
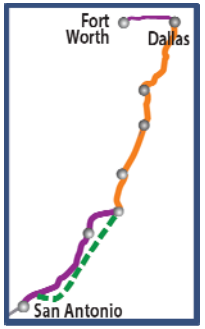
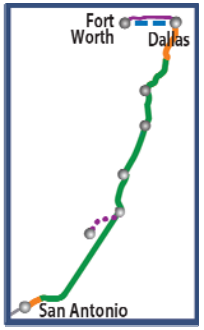
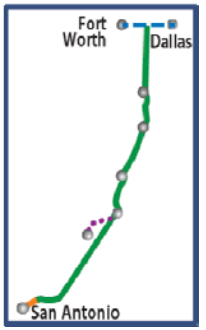
4.2 Central Section

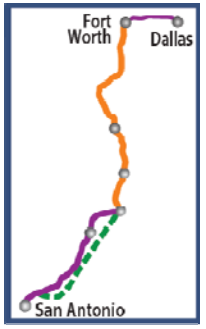
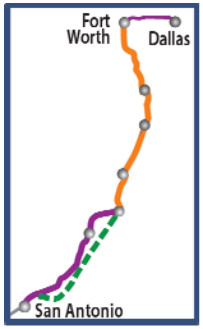
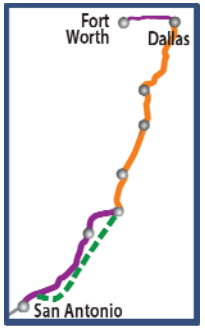
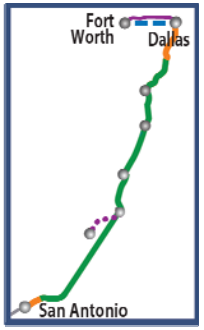
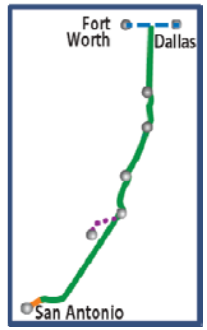
Table 4-3 presents values for each screening criterion in the Central Section, including routes C1, C2 (A and B), and C4 (A and B). Green, yellow, and red shading in the table indicates the relative performance of routes for each criterion; cells shaded gray indicate that the service-level does not apply to a given route alternative. Keys describing the range of values represented by each color can be found in Table 4-1.

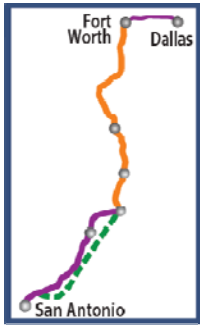
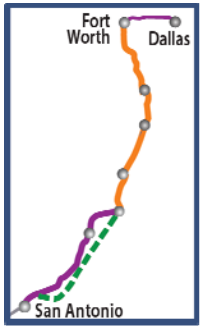
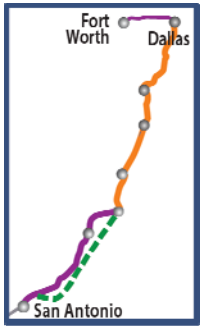
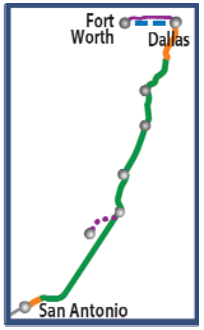
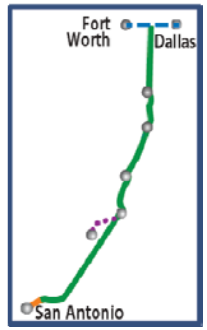
TABLE 4-3
Central Section[a]

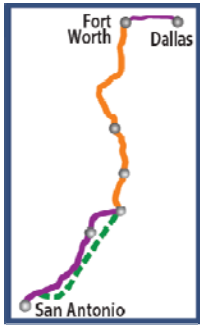
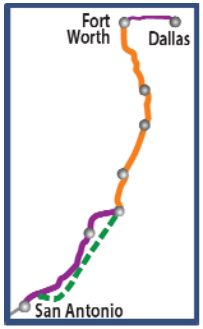
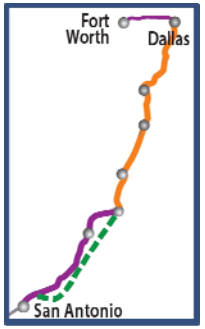
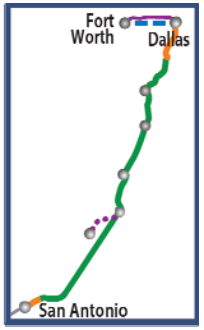
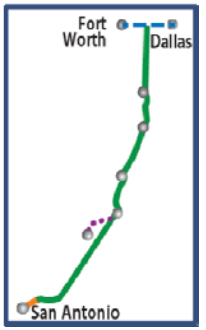
Crit. No.	Alternatives Analysis Criteria	Service Level [b]	C1	C2/C2A	C2/C2B	C4/C4A	C4/C4B
							
Alignment Attributes							
1a	Access to Stations (total population of cities along route)	*	10,890,000	11,020,000	11,020,000	11,020,000	11,020,000
1b	Access to Stations with Endpoint Cities Removed (total population of cities along route)	*	1,960,490	2,080,000	2,080,000	2,080,000	2,080,000
2	Ridership (millions of passengers per year)	CONV	1.2	1.7	1.7		
		HrSR	2.4	2.5	2.5	2.5	2.5
		HSR				2.7	2.7
3	Length of Route (miles)	*	230	320	320	330	310

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	C1	C2/C2A	C2/C2B	C4/C4A	C4/C4B
							
4	Cost to Construct Alternative ($)	CONV	$1.38 billion	$1.51 billion	$1.54 billion		
		HrSR	$4.22 billion	$6.58 billion	$5.19 billion	$4.22 billion	$4.65 billion
		HSR				$5.65 billion	$5.36 billion
Operational Criteria							
5	Revenue/ Operating Cost Ratio (100% covers operating cost with revenue – above 100% indicates surplus available for capital cost)	CONV	60%	89%	87%		
		HrSR	82%	87%	89%	89%	89%
		HSR				114%	114%
6	Reduce Travel Time (percent time savings compared to auto)	CONV	16%	21%	21%		
		HrSR	35%	37%	37%	37%	37%
		HSR				67%	67%

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	C1	C2/C2A	C2/C2B	C4/C4A	C4/C4B
							
7	Enhance Mode Share on Rail (% rail mode share)	CONV	11%	16%	16%		
		HrSR	23%	23%	23%	23%	23%
		HSR				27%	27%
Infrastructure Criteria							
8	Capital Cost per Passenger Mile	CONV	$7.90	$5.40	$5.50		
		HrSR	$6.80	$10.80	$8.50	$6.90	$7.60
		HSR				$8.00	$7.50
9	Minimize Right-of Way/Real Estate Impacts (acres)	CONV[c]					
		HrSR	1,200	1,750	1,780	3,740	3,700
		HSR				3,720	3,700
10	Provide Additional Improvements to National Railroad Network	CONV					
		HrSR					N/A
		HSR					N/A

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	C1	C2/C2A	C2/C2B	C4/C4A	C4/C4B
							
Environmental Criteria							
Minimize Impacts on Natural Resources							
11a	Wetlands (acres; NLCD) *The higher value for C1 is a result of its proximity to the Brazos River, the North Bosque River, and their tributaries.*	CONV[c]					
		HrSR	510	390	430	430	380
		HSR				420	380
11b	Critical Habitat (acres)	CONV[c]					
		HrSR	0	0	0	0	0
		HSR				0	0
Minimize Impacts on Cultural/Recreational Resources							
12a	National and State Historic Places (count)	CONV[c]					
		HrSR	3	4	10	10	1
		HSR				8	1

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	C1	C2/C2A	C2/C2B	C4/C4A	C4/C4B
							
12b	River and Stream Crossings (count)	CONV[c]					
		HrSR	360	360	370	370	350
		HSR				330	350
12c	Parks and Open Space (acres state and local parks)	CONV[c]					
		HrSR	450	260	300	300	230
		HSR				280	230
Minimize Impacts on Social Resources							
13a	Prime Farmland (acres)	CONV[c]					
		HrSR	10,800	10,290	10,400	10,400	9,790
		HSR				10,250	9,790
13b	Sensitive Receptors (count)	CONV	14	14	16		
		HrSR	13	13	15	15	15
		HSR				18	15

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	C1	C2/C2A	C2/C2B	C4/C4A	C4/C4B
							
13c	Environmental Justice (census blocks with % minority greater than state)	CONV	150	150	150		
		HrSR	140	140	140	140	140
		HSR				140	140

[a] Cells shaded gray indicate that the service level does not apply to this route.
[b] Service-Level Option: CONV= conventional rail; HrSR = higher speed rail; HSR = high-speed rail
[c] Acreage impacts for conventional rail alternatives are considered to have minimal impact for right-of-way and most environmental resources because they would use existing rail infrastructure.
* This criterion does not distinguish between service levels.

Based on the relative performance of routes for the different criteria shown in Table 4-3, the following route alternative in the Central Section is recommended **not to be carried forward** into the EIS:

- **C1** (conventional and higher speed service levels) – This alternative shows the least benefit in terms of travel time, would have the lowest potential ridership of all alternatives, has the lowest Revenue/Operating Cost Ratio and the highest cost per passenger-mile as well as significant environmental concerns.
- **C2A** (conventional service level) – This alternative is comparable to C2B in operating performance and environmental issues but requires trains to cross the already highly congested Tower 55 in Ft. Worth. It is unlikely that consistent operating slots can be

obtained for this crossing which will severely limit service options. Since C2B provides a better alignment without freight train interference, it is recommended that C2A be dropped in favor of continuing C2B.

- **C2 (A and B)** (higher-speed service level) - These alternatives have significantly higher costs per passenger mile but the same revenue to operating cost ratio when compared the C4 higher speed options. They also carry significant capital cost risk in coordinating a joint right-of-way with the UPRR.

Based on the relative performance of routes for the criteria shown in Table 4-3, the following route alternatives in the Central Section are recommended **to be carried forward** into the EIS:

- **C2B** (conventional service level). C2B has the lowest capital cost of the central section route alternatives and among the highest revenue/operating cost ratios. Unlike C2A, it avoids crossing the highly congested Tower 55 in Ft. Worth. Therefore it is recommended to be carried forward into the EIS.
- **C4 (A and B)** (higher-speed and high speed service levels). C4 (A and B) have the highest revenue/operating cost ratio, the biggest travel time savings compared to auto travel, and are comparable with other route options in the central section in terms of potential environmental effects. Therefore they are recommended to be carried forward into the EIS.

4.3 Southern Section

Table 4-4 presents values for each screening criterion in the Southern Section, including routes S2, S4, S5, and S6. Green, yellow, and red shading in the table indicate the relative performance of routes for each criterion; cells shaded gray indicate that the service-level does not apply to a given route alternative. Keys describing the range of values represented by each color can be found in Table 4-1.

In the Southern Section, several criteria were evaluated using an additional scenario where trains continue south to Monterrey, Mexico. For each criterion that included this analysis scenario, the results “if Monterrey is included” are included in the table directly below the original criterion (that includes trains stopping in south Texas). These additional values are identified with a criterion number that ends in “- M.”

TABLE 4-4
Southern Section [a]

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	S2	S4	S5	S6
						
Alternative Attributes						
1a	Access to Stations (total population of cities along route)	*	2,470,000	3,100,000	2,840,000	2,470,000
1b	Access to Stations with Endpoint Cities Removed (total population of cities along route)	*	236,000	865,000	610,000	236,000
2	Ridership (millions of passengers per year)	CONV	0.058		0.35	
		HrSR	0.069	0.32	0.39	0.069
		HSR		0.33		0.083
2 - M	Ridership if Monterrey is included (millions of passengers per year)	CONV				
		HrSR		0.68		0.59
		HSR		0.77		0.72
3	Length of Route (miles)	*	155	420	280	140
4	Cost to Construct Alternative ($)	CONV	$0.17 billion		$0.31 billion	
		HrSR	$2.37 billion	$2.46 billion	$4.29 billion	$0.84 billion
		HSR		$3.59 billion		$1.23 billion

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	S2	S4	S5	S6
						
4-M	Cost to Construct Alternative if Monterrey is included - cost to build in Mexico included ($)	CONV				
		HrSR		$2.98 billion		$1.43 billion
		HSR		$4.86 billion		$2.67 billion
Operational Criteria						
5	Revenue/Operating Cost Ratio (100% covers operating cost with revenue – above 100% indicates surplus available for capital cost)	CONV	7%		24%	
		HrSR	7%	20%	26%	7%
		HSR		12%		5%
5 - Ma	Revenue/Operating Cost Ratio if Monterrey is included – operating and maintenance cost in Mexico not included	CONV				
		HrSR		61%		96%
		HSR		31%		73%
5 - Mb	Revenue/Operating Cost Ratio if Monterrey is included (100% covers operating cost with revenue – above 100% indicates surplus available for capital cost)[c]	CONV				
		HrSR		45%		58%
		HSR		30%		37%

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	S2	S4	S5	S6
						
6	Reduce Travel Time (percent time savings compared to auto)	CONV	22%		12%	
		HrSR	46%	25%	34%	46%
		HSR		56%		69%
6 - M	Reduce Travel Time if Monterrey is included (percent time savings compared to auto)	CONV				
		HrSR		40%		48%
		HSR		59%		67%
7	Enhance Mode Share on Rail (% rail mode share)	CONV	6%		15%	
		HrSR	7%	11%	17%	7%
		HSR		13%		10%
7 - M	Enhance Mode Share on Rail if Monterrey is included (% rail mode share)	CONV				
		HrSR		15%		9%
		HSR		18%		12%
Infrastructure Criteria						
8	Capital Cost (capital cost per passenger mile)	CONV	$19.30		$3.40	
		HrSR	$225.10	$42.20	$40.70	$79.90
		HSR		$51.60		$103.40

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	S2	S4	S5	S6
						
8 - Ma	Capital Cost if Monterrey is included – cost to build in Mexico not included (capital cost per passenger mile)	CONV				
		HrSR		$10.40		$5.30
		HSR		$13.60		$6.60
8 - Mb	Capital Cost if Monterrey is included – cost to build in Mexico included (capital cost per passenger mile)	CONV				
		HrSR		$12.60		$9.10
		HSR		$18.40		$14.30
9	Minimize Right-of-Way/Real Estate Impacts (acres) *S2 is the shortest route and is located on or adjacent to an existing transportation corridor.*	CONV[d]				
		HrSR	750	4,640	1,350	1,690
		HSR		4,640		1,690
10	Provide Additional Improvements to National Railroad Network	CONV				
		HrSR		N/A		N/A
		HSR		N/A		N/A

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	S2	S4	S5	S6
						
Environmental Criteria						
Minimize Impacts on Natural Resources						
11a	Wetlands (acres; NLCD) *S5 (HrSR) is higher because it travels through a coastal wetlands area.*	CONV[d]				
		HrSR	160	370	640	200
		HSR		370		200
11b	Critical Habitat (acres)	CONV[d]				
		HrSR	0	0	0	0
		HSR		0		0
Minimize Impacts on Cultural/Recreational Resources						
12a	National and State Historic Places (count)	CONV[d]				
		HrSR	1	4	1	1
		HSR		4		1
12b	River and Stream Crossings (count) *S4 is longer because of the multiple legs included in this route – the higher number of stream crossings reflects this.*	CONV[d]				
		HrSR	140	320	190	150
		HSR		320		150

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	S2	S4	S5	S6
						
12c	Parks and Open Space (acres state and local parks) *S4 is longer because of the multiple legs included in this route – the higher value for acres of parks potentially affected reflects this.*	CONV[d]				
		HrSR	6	250	110	3
		HSR		250		3
Minimize Impacts on Social Resources						
13a	Prime Farmland (acres) *S4 is longer because of the multiple legs included in this route – the higher value for acres of prime farmland potentially affected reflects this.*	CONV[d]				
		HrSR	5,920	11,500	9,030	5,590
		HSR		11,500		5,590
13c	Sensitive Receptors (count)	CONV	1		5	
		HrSR	1	20	5	1
		HSR		20		1

Crit. No.	Alternatives Analysis Criteria	Service Level [b]	S2	S4	S5	S6
						
13b	Environmental Justice (census blocks with % minority greater than state)	CONV	50		120	
		HrSR	50	220	120	30
		HSR		220		30

[a] Cells shaded gray indicate that the service level does not apply to this route.
[b] Service-Level Option: CONV= conventional rail; HrSR = higher speed rail; HSR = high-speed rail
[c] Mexico operating and maintenance costs are assumed to be 35% less than US operating and maintenance costs on a per-unit basis
[d] Acreage impacts for conventional rail alternatives are considered to have minimal impact for right-of-way and most environmental resources because they would use existing rail infrastructure.
* This criterion does not distinguish between service levels.

Based on the relative performance of routes for the different criteria shown in Table 4-4, the following alternatives from the Southern Section are recommended **not to be carried forward** into the EIS:

- **S2** (conventional and higher speed service levels) – This alternative would have the lowest revenue to operating cost ratio of all the conventional and higher-speed alternatives. It also has a cost per passenger-mile three times higher than any of the other alternatives.
- **S4** (high speed service level) – This alterative would have significantly higher capital cost per passenger-mile and a lower revenue to operating cost ratio than the higher speed option indicating that we would have exhausted the market at this service level.
- **S5** (higher speed service level) – This alterative would have a significantly higher capital cost per passenger-mile with a similar revenue to operating cost ratio compared to the conventional speed option. The S4 higher speed service level is one fourth the

cost per passenger mile than the S5 higher speed option indicating that there is no advantage in pursuing a S5 higher speed option. In addition, this alternative has the highest area of potential wetlands effects, and the S5 conventional speed alternative (operating the train within the existing rail ROW with limited rail improvements) would avoid most effects on wetlands.

- S6 (high speed service level) – This alterative has significantly higher capital cost per passenger-mile and a lower revenue to operating cost ratio than the higher speed option indicating that we would have exhausted the market at this service level.

Based on the relative performance of routes for the criteria shown in Table 4-4, the following route alternatives in the Southern Section are recommended **to be carried forward** into the EIS:

- S4 (higher-speed service level). While S4 has the greatest potential effect parks and open space, it is the longest alternative by a factor of 2 or 3, to serve the population centers which contribute to operational performance. So while the environmental criterion is highest for this alternative, this is a condition that could be avoided with project level refinement of the route and would not be expected to be a fatal flaw.
- S5 (conventional speed service level). This alternative avoids the potential effects on wetlands seen for the S5 higher speed alternative.
- S6 (higher-speed service level)

Route alternatives S4 and S6 both allow extension to Monterrey, Mexico. Without that extension these alternatives would not be recommended to be carried forward because they do not meet the revenue to operating cost ratio threshold. Route alternative S5 also does not meet the revenue to operating cost threshold but it has the highest ratio and the lowest capital cost per passenger mile for the Southern Section alternatives and will therefore be carried forward to represent the Southern Section in the EIS.

5.0 Conclusions and Next Steps

Based on the analysis performed as part of the Route Alternatives Analysis, it is recommended that the following route alternatives **be carried forward** into the EIS:

- N4A – Conventional Speed Service
- C2B – Conventional Speed Service
- C4A/B – Higher Speed and High Speed Service
- S4 – Higher Speed Service with future Monterrey Extension
- S5 – Conventional Speed Service
- S6 – Higher Speed Service with future Monterrey Extension

Figure 5-1 shows the route alternatives and options that are recommended **to be carried forward** for evaluation in the EIS. Once TxDOT reviews and approves the range of alternatives to be carried forward into the EIS, they will be provided to FRA for concurrence. The range of alternatives will then be presented to stakeholders and the public for their comments. Once the range of alternatives has been finalized, specific analysis of the route alternatives will begin as part of the EIS.

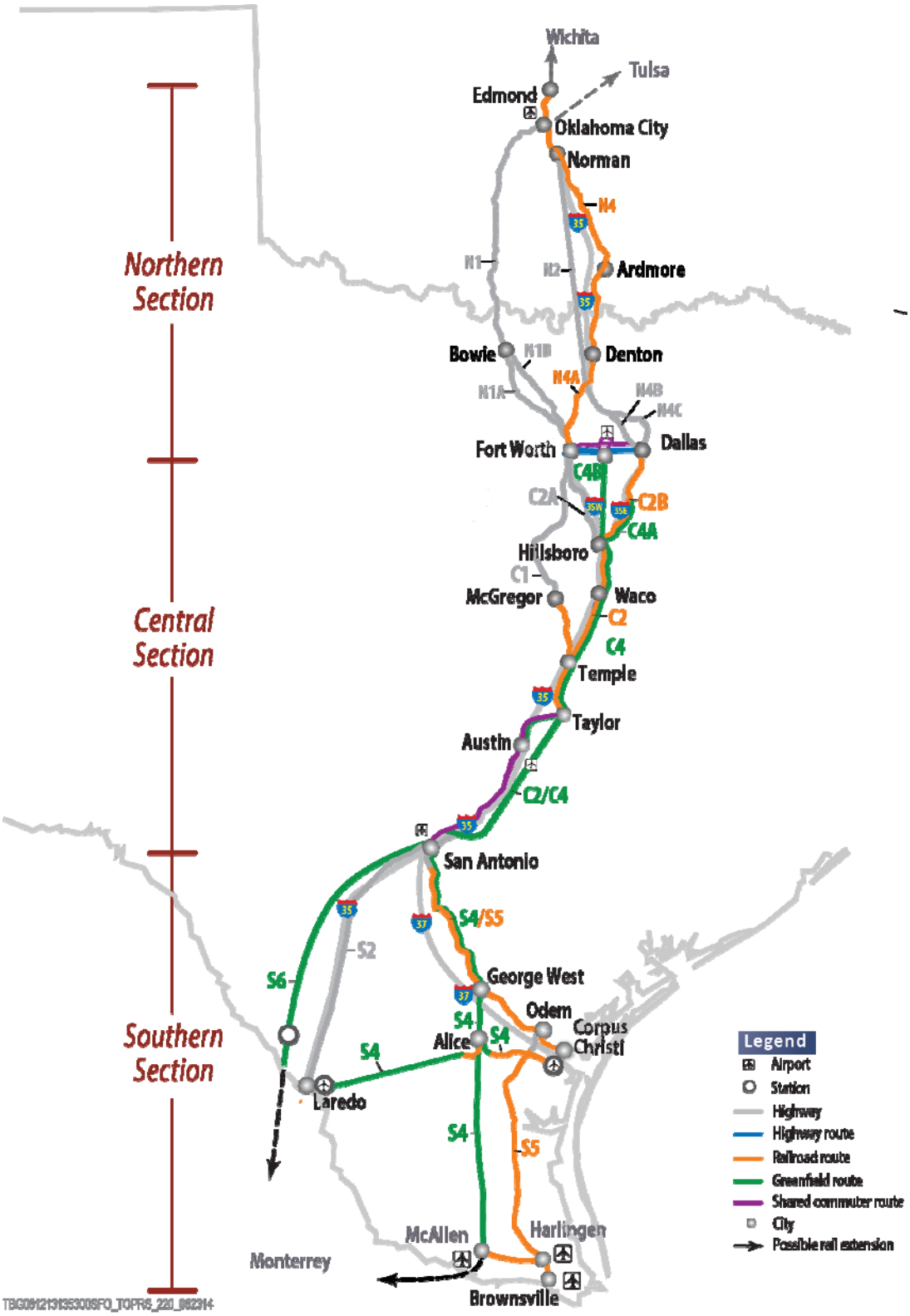


Figure 5-1: Route Alternatives and Options Recommended for Evaluation in the EIS

6.0 References

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