TEXAS CENTRAL PARTNERS
AMERICA'S BULLET TRAIN

Texas Central Partners, LLC
1601 Elm Street
Suite 4343
Dallas, TX 75201

Dear Stakeholder,

We are writing to inform you of an important milestone for Texas Central. Last week, the Federal Railroad Administration (FRA) published a technical report that concluded the Utility Corridor is preferred from an environmental perspective over the BNSF corridor because this Corridor is feasible with lesser environmental impacts. It is referred to as the Utility Corridor because potential alignments generally follow existing high-voltage electrical transmission lines.

The FRA published on its website its "Dallas to Houston High-Speed Rail Project Corridor Alternatives Analysis Technical Report." This report details the FRA's analysis of high-speed rail corridors considered and concludes that the Utility Corridor will be studied further.

In the FRA report, reference is made to the "Step 1 Screening of Corridor Alternatives Report," which was prepared by affiliates of Texas Central. The FRA used information in this report and additional information prepared by its independent environmental consultant to perform its own analysis of the potential corridors.

A detailed study of these technical reports is likely to generate questions. In anticipation, we generated a "Frequently Asked Questions" to provide responses to potential questions that you may have; it is attached herein.

It is our priority to maintain a transparent, open line of communication with all stakeholders throughout this process. Should you have any questions or require any additional information, please do not hesitate to contact me directly.

Sincerely,

Tim Keith
CEO

Enclosure: Step 1 Screening of Corridor Alternatives Report – Frequently Asked Questions

Step 1 Screening of Corridor Alternatives Report: Frequently Asked Questions

On August 10, the Federal Railroad Administration (FRA) published on its website the FRA's "Dallas to Houston High-Speed Rail Project Corridor Alternative Analysis Technical Report," (FRA Report) which narrows the focus of the ongoing EIS to potential alignments associated with the Utility Corridor. In the FRA Report, it cites a separate document prepared by us (the *Step I Screening of Corridor Alternatives Report*) that is our suitability analysis of the four potential high-speed rail corridors.

As background, during the development of the Environmental Impact Statement (EIS), we will prepare a number of technical reports and analyses for submittal to the FRA. Our submittals are a part of the overall administrative record of documents that the FRA will review. The FRA, in turn, will review these reports in addition to reports generated at the direction of the FRA by its environmental consultant to make its own independent conclusions.

Specifically, we provided our report that is cited by the FRA. The Report is our suitability analysis of the potential high-speed rail corridors. This is one of several documents that we, along with our professional environmental and engineering consultants, will develop to support the FRA-led EIS process. Again, the findings and conclusions of our Report is but one source of information for consideration by the FRA.

We understand that a detailed study of this technical report without the full context is likely to generate questions. As such, we are providing the below responses to questions that may arise from a reading of the "Step 1 Screening of Corridor Alternatives Report." We appreciate your interest and should you have additional questions, please contact us or the FRA.

Q: There are references to road closures in the Project Report. What is Texas Central's position on closing roads and has it changed?
A: Our position has not changed. It is our expectation that every existing public road will remain in service and the train will pass over or under each. Some existing roads may be realigned or redesigned as a result of the development of the project and we expect the function and utility of those roads would remain or be enhanced. Each road crossing will be examined to determine the best way to accommodate the needs of the traveling public and the project. Those decisions will be made by the entities empowered to do so; state, county and municipal agencies and governments. We also expect the project will bring transportation improvements to communities through improved access for emergency services and utilities. We are a transportation company and believe that easy movement of people and goods throughout the entire state is good for Texas and its citizens.

Q. The report references "private property access reconfigurations." Will the project cut off my access to my land?
A: We intend to maintain landowners' access to their property. As part of the EIS and project development processes, we and our representatives will be meeting with each landowner to discuss their needs – including necessary underpasses or overpasses to cross the track alignment. Our commitment is to work with each landowner in a fair and transparent manner. Care will also be taken to accommodate wildlife and livestock movement within the project alignment.

Q: The number of acres required by each corridor is shown as much higher than the 3,000 acres referred to by the Project in the past. What has changed?
A: There has been no change in our estimate of the amount of land required for the actual rail alignment. The numbers shown on page 107 of the report refer to an approximately 350 foot wide required *study area* that is being examined during the Step 1 analysis to evaluate potential direct and indirect environmental impacts. The total number of acres required for the project construction will be much smaller than the acreage that will be studied.

To reiterate our approach of working with landowners and other stakeholders, we want to make sure that we understand clearly the sound, vibration, wetland and other impacts on the area immediately adjacent to the land required for the infrastructure. As a result, a wider study area is used during the EIS process to ensure a full review.

Q: Putting the train down Interstate 45 looks like it would be the best option and save people's property. Why do you not use the I-45 corridor?
A: The I-45 corridor was designed to accommodate automobile and truck traffic traveling at speeds consistent for autos. For travel at the planned speed of the high-speed trains proposed by the project, the HSR alignment would need more gentle curves than strictly following the existing interstate highway would allow. This would mean that along curved segments of the highway, the HSR alignment would deviate from the highway and greatly impact adjoining properties and businesses. Given development along the highway, particularly with the densely developed Houston and Dallas markets, this would cause significant impacts on existing commercial and other community services. The trains must operate between Dallas and Houston at a speed sufficient to meet the demands of the market in order for the high-speed rail project to be viable as a private venture. As the report notes, though, the travel speed restriction was only one of several issues noted with the I-45 corridor, including impacts of the construction on I-45 itself.

However, in our work to identify potential alignments that will have a minimal impact on communities, we are continuing to study certain portions of the I-45 corridor as part of the Utility Corridor Alignment. Those portions of I-45 under consideration are in the mid-section of the alignment.

Q: What "construction costs" were considered and why is construction cost so important at this stage in the analysis?
A: The Report provided to the FRA refers to "construction complications” or "construction costs" because these factors influence and help determine the financial viability of the Project. During this corridor analysis, such cost considerations generally include additional land requirements, unique construction approaches, traffic impact mitigation, secondary projects and extended construction duration. We are trying to minimize impacts by designing the most efficiently deliverable project. As we minimize the Project's impact on surrounding communities, we also reduce the project¹s overall cost and ensure the Project's feasibility.

Per the FRA¹s Report, the "FRA is obligated to avoid and minimize impacts to the human and natural environment." Additionally, the FRA must carry forward potential corridor alternatives that meet the Project’s purpose and need, which includes the requirement that the project be "economically viable." As such, the various elements of the project¹s construction, including those directly impacting overall cost and the Project’s impact on the human and natural environment must be considered at this and future stages of the EIS.

Q: The Project frequently cites the need of approximately 100 feet for its right-of-way. Why does the report reference a range of 70-200 feet?
A: For the vast majority of the 240-mile project, the right of way (ROW) will be approximately 100 feet wide. In the places where improved access is provided for adjacent landowners, emergency response, or maintenance of way activities, or where ancillary facilities such as drainage swales, wildlife crossings, substations or signal huts are adjacent to the track, the ROW will be wider. We are working to consider all of the potential impacts in our fieldwork and studies.

Q: Where will the heavy maintenance facility and light maintenance facilities be located?
A: The locations of these facilities have not been determined at this time, but we anticipate that they will be located close to the passenger stations on either end of the line.

Q: What is an "RPA" and its relevance to the Project?
A: A Rule of Particular Applicability (RPA) is a set of regulations developed for the express purpose of regulating the Texas Central proposed high-speed rail system. The RPA process is a routine process used by federal agencies to address new or unique situations that current rules an regulations do not adequately address. For additional definitions or information regarding the RPA process, please contact the FRA.

Q: On page 10, this report references a large amount of electricity that will be needed to operate this system. Where will that electricity come from?
A: The power needs of the high-speed rail traction power system will require that the electrical utility connection be a transmission level voltage i.e. >69,000V. By utilizing a transmission level utility supply, Texas Central can help manage and balance power needs elsewhere in the state. Our preferred route is adjacent to or nearby existing utility lines, thus minimizing the need for additional electrical infrastructure. This high-speed passenger train system being deployed in Texas is based on one of the most energy efficient passenger rail systems in the world but will rely on the availability and redundancy of power supply.

Q: On page 11 of the report, it mentions a high number of trains in each direction per hour, but Texas Central's website states a different figure. Which is right?
A: While we initially plan on trains running every 30 minutes during peak periods, the system design will accommodate more frequent travel as demand increases over many decades. These future service considerations must be included now in the EIS process to accurately inform the project's overall design and ensure that the project's construction requirements and potential long-term environmental impacts are not underestimated.

Q: There is reference on page 20 to increased costs associated with noise mitigation measures. Will Texas Central incur those costs to help reduce sound? How loud will the train be?
A: We believe that this is the quietest system available in the world. It has a sound pattern that is much less frequent and quieter than traffic on many roads and highways and does not require the use of horns or whistles. We believe people will be pleasantly surprised with how quietly the train operates. To demonstrate this, we will be providing sound data in an upcoming report that will be publicly available.

To be clear, the Project will incur the costs associated with mitigating sound and vibration impacts. If any are identified, we will work with local communities and stakeholders to find common sense solutions to potential impacts.

Q: How is the Transportation Security Administration (TSA) involved in your project?
A: The TSA will be reviewing our security processes and procedures as they do currently for other passenger rail service. The Project will be required to develop and implement security measures and procedures that will be reviewed by the TSA.

Q. The report emphasizes your preference of the Utility Corridor due to its high percentage of farm/agriculture land. Does this mean you value urban land more than farm and agriculture land?
A: We prefer the Utility Corridor because it minimizes engineering and construction complexity and because it minimizes overall impacts. Costs for minimizing impacts to communities, construction, systems, and equipment far exceed property costs. The Utility Corridor offers the best potential for minimizing impact to the environment and to existing homes, facilities and businesses, while maximizing constructability and financial feasibility.

Q. On page 107, it appears that the amount of the route that will be elevated is less than what you have publicly stated. Why?
A: During our evaluation of the various corridors, we recognized that certain sections of the line have to be elevated (e.g.: entering urban areas or above wetlands). The table on page 107 describes the percentage of elevated sections required to mitigate wetland impacts and these values do not reflect the total elevated sections of the system. Other approaches such as local realignment will also be studied through the EIS to minimize these impacts. We are in the early stages of the planning and design phase and can expect these percentages to change as the final design develops. Nonetheless, we fully expect that viaducts will be used extensively in urban areas, in areas of significant elevation change and to accommodate existing road and freight rail facilities, and within flood plains and other environmentally sensitive areas.

Q: The environmental rankings on page 136 are hard to understand. What do they mean?
A: The table on page 136 ranks the various possible alignments (routes) within each potential corridor from an environmental perspective. The Utility Corridor was found by the Project to have the highest number of potentially viable and preferable routes than any of the other potential corridors.

Q: What is the relationship between TCR and TCP?
A: TCR and TCP are independent companies involved with the Project. TCR has led the feasibility phase of the project, which includes completion of the EIS. Texas Central Partners, LLC is the project developer and will use the EIS results and other selected information produced or provided by TCR, as well as information, designs, and engineering produced by TCP itself, to develop the high-speed rail system ("the Project"). TCP will be the ultimate builder and operator of the Project.

Texas Central High-Speed Railway

Step 1 Screening of Corridor Alternatives Report

Dallas-Houston, Texas, High-Speed Rail Project

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1 Executive Summary

Texas Central High-Speed Railway (TCR)[1], a private Texas-based entity, desires to bring a reliable, safe and profitable passenger rail transportation system between Houston and Dallas, Texas using proven Japanese high-speed rail (HSR) technology (hereafter the "Project"). Advancing the Project will require an assortment of regulatory approvals, including a favorable Record of Decision (ROD) resulting from an Environmental Impact Statement (EIS) as required under the National Environmental Policy Act (NEPA). One requirement of the EIS effort will be evaluation of all reasonable alternatives.

Nine Alignments considered in Four Corridors. TCR has invested significant effort over the last four years to screen four HSR corridors between Houston and Dallas and to identify potential alignments within those corridors that represent potentially reasonable alternatives. This report documents the environmental and engineering efforts completed to date to evaluate nine alternative alignments within the four HSR corridors, and to screen out those alignments found to be flawed from an engineering, environmental, safety, or financial viability perspective.

Table 1 – 4 Corridors and 9 Alignments

	Corridors	Alignments
1	BNSF	"BNSF Option 1" Alignment
2		"BNSF Option 2" Alignment
3		"BNSF Option 3" Alignment
4		"BNSF Option 4" Alignment
5	IH-45	"IH-45" Alignment
6		"IH-45 With Hardy" Alignment
7	Utility	"Utility Corridor" Alignment
8		"Utility Corridor with IH-45" Alignment
9	UPRR	"UPRR" Alignment

Recommended Corridor. One of the nine alignments was found to be preferable with respect to expected impacts and financial viability through the comparative analysis, namely the "Utility Corridor" alignment (hereafter referred to as "Utility Corridor" or "UC") following existing high-voltage electrical transmission lines. It is TCR's desire to advance the study of this alignment and other potentially reasonable alignments within the Utility Corridor through the NEPA EIS effort, and, in so doing, to identify a preferred alignment that can be advanced to design and construction.

Extensive Analysis. The development and evaluation of the nine alignments was initiated in 2009, and represents a progression in thinking informed by past Texas

[1] Texas Central High Speed Railway ("TCR") includes affiliates for the project to include construction and operation of the HSR.

HSR corridor planning, engineering and environmental evaluation, ridership modeling, and stakeholder coordination. This report also provides the general characteristics of the proposed HSR system, describes the corridors and alignments evaluated, outlines the key planning and design criteria used, documents the engineering and environmental analysis approach used, and presents the results of the analysis.

Initial Analysis of Three Corridors. TCR's initial corridor development sought to avoid and/or minimize property and environmental impacts between Houston and Dallas, by focusing on corridors that followed existing transportation routes. Three potential existing transportation corridors were studied: the Burlington Northern Santa Fe Railway (BNSF) Teague Line, the Union Pacific Railroad (UPRR) Hempstead Line, and the Interstate Highway 45 (IH-45) corridor. These three corridors were also evaluated in the Texas Rail Plan released in November of 2010; and, as such, this analysis is consistent with planning previously undertaken by the State of Texas.

Alignment "BNSF Option 1" Early Leader. Various alignment options were identified to address HSR design requirements, engineering and constructability challenges, and environmental constraints during TCR's study within these three transportation corridors. Through this initial effort, seven alignment alternatives were developed and evaluated, and the "BNSF Option 1" alignment was found to be preferable. The BNSF Option 1 alignment generally follows the BNSF Teague Line from Houston to Teague, then follows a greenfield alignment to bypass Corsicana to the west, and then follows the UPRR line into Dallas.

Potential Risks Identified. Throughout the screening efforts, TCR undertook significant engineering and environmental analyses and coordinated with various stakeholders within the corridors studied, including BNSF, UPRR, and the Texas Department of Transportation (TxDOT). Based upon this coordination and analyses, constructability, environmental impact, cost escalation, and risk concerns were identified with construction adjacent to IH-45 and the freight rail lines. It was found that closely following IH-45 and the freight railroads did not allow for the desired operating speeds and would result in significant impacts, engineering and safety challenges, and construction complications given existing development along these transportation corridors, particularly within urban areas. While the BNSF Option 1 alignment was initially found to be the early leader in the evaluation with respect to these issues, risk mitigation and indemnification requirements identified by the freight railroads later indicated that an alignment that closely follows the existing BNSF freight line over a significant length would prove unreasonable and financially unviable.

Utility Corridor Identified. For these reasons, TCR sought a less-developed corridor that would offer better potential alignment geometry, present fewer construction challenges, and generate less impacts, while avoiding environmentally sensitive undeveloped areas. This search identified the possibility of following existing high-voltage transmission line rights-of-way (ROW) between Houston and Dallas. As a result, a fourth corridor option, called the Utility Corridor, was identified and two additional alignments were developed resulting in a total of nine alignments evaluated in this report.

All Alignments Share Common Starting and Ending Points. Alternatives as discussed herein run south to north from Houston to Dallas. Starting in Houston, each of the HSR alignments begin near the existing Amtrak station in downtown Houston and end near the Reunion Arena site in downtown Dallas. The alignment options exit from Houston along significantly different routes, but generally converge north of the city of Teague, passing between the Richland Chambers Reservoir and Navarro Mills Lake near the city of Purdon. North of Waxahachie, all alignment options considered generally follow the IH-45 corridor. North of Ferris, all alignment options except one follow the same route along the UPRR Dallas corridor to reach the former Reunion Arena site.

Evaluation Criteria for Alignment Comparison. The analysis involved a comparative assessment of potential HSR alignments across a broad array of criteria ranging from economic viability, constructability considerations, and potential environmental impacts. The goal of the analysis was to select the most feasible alternative alignment for advancement to more detailed planning, engineering, and environmental reviews. The focus of this analysis was on the overall alignment linking potential Houston and Dallas terminal locations. While general station locations are presented, the discussion focuses on how general station locations might affect alignment comparisons. Subsequent analysis efforts will address potential alternative station locations, station approaches, and segments of alignments within the cities of Houston and Dallas (the “last mile”).

Results of Alignment Evaluation. Based on the engineering and constructability evaluation completed to date, the Utility Corridor alignment presents the fewest complications and environmental challenges. The Utility Corridor alignment stands out from the other alignments in terms of infrastructure crossings, freight railroad impacts, and construction within urban areas and local communities. Moreover, the Utility Corridor alignment follows a straighter alignment through more rural areas that would minimize construction requirements, make construction access easier, reduce the use of more advanced viaduct construction approaches, and minimize impacts to existing development and traffic.

Analysis of Maintenance and System Facilities. This report is focused on the evaluation of HSR corridors and alignments and, as such, it does not address facilities requirements in detail or the evaluation of potential maintenance and system facilities sites. Nonetheless, general facilities requirements are identified. Maintenance facilities requirements would be identical for all alignments considered, except that additional substations and maintenance-of-way (MOW) facilities would likely be required for the longer UPRR alignment alternative and siting of facilities would be more difficult along those corridors passing through more developed areas, such as the IH-45 alternatives.

Analysis of Station Sites. This report documents the evaluation of HSR corridors and alignments, but does not address evaluation of specific station sites. However, general station locations considered are presented with a focus on how the general station locations would impact the corridor evaluation effort. While both urban and suburban station locations are discussed herein, the evaluation of corridors and alignments assumed that all corridors and alignments begin and terminate in downtown Houston and downtown Dallas to ensure a consistent analysis of impacts and costs across competing alignments.

Conclusion. In conclusion, the preferred corridor resulting from the analyses to date as documented herein was found to be the "Utility Corridor". An alignment within the Utility Corridor would be more constructible, have less impact, and minimize risks, thereby allowing for accelerated project delivery, reduced project cost, and less environmental impacts. Subsequent reports will further detail the evaluation of additional alternative alignments, facilities, and stations locations for the Utility Corridor only.

2 Purpose and Need

The purpose of the privately proposed Project is to provide reliable, safe, and economically viable passenger rail transportation using proven high-speed rail technology between Houston and Dallas. The proposed action will provide a convenient alternative to automobile travel on IH-45 or air travel between the two major metropolitan areas and introduces rail capacity in the corridor. Furthermore, to achieve TCR’s economic viability and safety requirements, the Project must meet the following criteria:

- Economic: achieve a favorable return on investment when weighing expected ridership and revenue against estimated project capital investments, project delivery schedule, and long-term operations and maintenance expenses.
- Technological: bullet train vehicle and operating procedures based on the N700-I, the international version of the Tokaido Shinkansen.
- Operational: approximate 90 minute travel time between Dallas and Houston, with achievable speeds exceeding 200 mph in a fully sealed corridor.
- Environmental: minimal impacts to the natural and built environments through context sensitive design and adjacency to existing infrastructure right-of-way (ROW) as appropriate.

The functional project need is to address congestion-related issues in the IH-45 corridor. Existing and future issues that could be addressed by the proposed action include:

- There is no practical alternative to air and highway transportation between Houston and Dallas.
- Average automobile travel time between the two regions is projected to increase from 5 to 6.5 hours by 2035.
- Average automobile travel speeds are projected to decrease from 60 mph to 40 mph by 2035.
- Average travel time between the regions’ airports is approximately 65 minutes plus a minimum of one hour gate time.
- Air travel time and reliability is sensitive to delays resulting from land-side and airside congestion, incidents, and inclement weather, both inside and outside of Texas.
- While additional roadway capacity may be provided, additional capacity will not significantly reduce travel time and congestion.
- Existing and future congestion increases air pollution, wastes energy, and adds costs to the public through travel delays.
- Automobile accidents in the IH-45 corridor are frequent and cause additional congestion delay.

The regulatory project need includes embracing the Federal Railroad Administration’s (FRA’s) mission to “enable the safe, reliable, and efficient movement of people and goods for a strong America, now and in the future." FRA's responsibility includes conformance with this mission as a condition of approving the Applicant's proposed action. In order for the proposed action to conform to FRA's mission it must meet the following needs:

- Improve intercity mobility through a reliable and sustainable transportation option.
- Improve passenger accessibility and connectivity to regional transportation systems.
- Improve overall transportation system safety through the provision of a safe alternative mode of travel.

Current FRA regulations do not address equipment requirements for train speeds above 150 mph. For this Project, FRA's approval of TCR's high-speed rail technology through a Rule of Particular Applicability (regulations that apply to a specific railroad or a specific type of operation) constitutes the federal action.

3 System Description

The general infrastructure requirements and system characteristics of the proposed high-speed-railway (HSR) system and associated facilities are described in this section.

3.1 Service Characteristics

The preliminary operating schedule for service is planned to be 5:30am to 11:30pm with the peak periods occurring from 5:30am to 9:00am and from 4:00pm to 7:00pm.

A fleet of between eleven (11) and fifteen (15) 8-car trainsets will be required to support the preliminary operating plan. Each train set will seat approximately 400 passengers.

3.2 General Civil Infrastructure Configuration

This section describes the general infrastructure configuration of the proposed HSR system. Site specific design at the appropriate level of detail would be developed during more advanced planning in support of the EIS.

3.2.1 Trackway

The proposed HSR system will typically consist of a two-track ROW with additional tracks added at stations, maintenance of way (MOW) facilities, and maintenance yards. The conceptual design was configured to be raised slightly above the surrounding grade on an embankment, with elevated sections on viaducts as required to suit topography, to minimize environmental and property impacts, and to provide for grade separated rail and road crossings. During more detailed design, the use of embankments and viaducts along the alignment will be optimized to balance earthwork, to minimize environmental and property impacts, and to address constructability concerns and capital cost requirements.

Where the HSR exists independently of an existing transport corridor, the typical ROW required will range between approximately 70 ft (21 m) to 200 ft (61 m) in width. Where it exists alongside an existing freight rail corridor, the ROW width required to accommodate the new HSR tracks could potentially be reduced through shared ROW, but separation of the freight and HSR tracks by a barrier wall or by elevating the HSR system on structure will likely be required. It is expected that the entire ROW will be fenced except where elevated and that an access road would be provided along the HSR tracks to facilitate maintenance, inspection, and emergency access. The exact configuration to meet regulatory requirements and operating and maintenance needs will be developed through more detailed design, consideration of local conditions, close coordination with any adjoining freight railroad, or roadway authority, or utility owner, and would require agreement with the FRA regarding risk mitigation requirements.

3.2.2 Separation Distances

The proposed use of N700-I rolling stock technology would require a minimum track separation of 14 ft 9 in (4.5 m) between the two HSR track centers to avoid overlapping vehicle dynamic envelopes of passing HSR trains. To accommodate a yet unidentified variety of embankment slope and drainage requirements, the distances from the ROW line to the centerline of the nearest HSR track is projected to be no less than approximately 30 ft (9.2 m). This results in a minimum ROW width of approximately 76 ft (23.2 m).

Through coordination with the Burlington Northern Santa Fe Railway (BNSF) and review of other HSR studies within freight rail corridors it is estimated that the centerline of the nearest HSR track should be no closer than 50 ft (15.25 m) from the centerline of an adjacent freight track. However, it is expected that the separation distance could narrow to as low as 25 ft (7.62 m) between track centers if appropriate risk mitigations, such as barrier walls, are implemented between the two tracks. In addition, the typical minimum clearance requirement between a freight line and an adjacent structure is no less than 10 ft (3.05 m). Hence, even when separated by a barrier walls or vertically separated, following an existing freight line will require meeting minimum requirements that will dictate the alignment and ROW width.

Similar requirements would be identified by the Texas Department of Transportation (TxDOT) for alignments following a highway. In all cases, final alignment and structural design would require close coordination with affected stakeholders on a location-by-location basis.

3.2.3 Alignment Crossings

The analyzed HSR alignments cross a number of existing highways and roads, and in all cases the new HSR system will be fully grade separated from rail and roadway traffic. In some cases, it will be more cost-effective to carry the roadway over the HSR alignment rather than carry the railway over the roadway. In some cases raising the HSR alignment over the roadway will be the preferred option to minimize potential impacts. In general, it is assumed that the HSR tracks will cross over US Interstates, US Highways and State Highways, while Farm to Market (FM) Roads, County Roads, and local roads will cross over the HSR tracks. Where local roads cross over the HSR ROW, suitable safety features will be constructed in order to minimize the possibility of intrusion onto the ROW. Some smaller local roads may be closed and traffic rerouted to an adjacent roadway. Each roadway crossing would be evaluated on a case-by-case basis during more detailed design to minimize impacts.

Where the HSR alignment crosses existing freight lines, the freight lines would be fully grade separated from HSR operations. In some cases this may mean realignment of the freight line. It is expected that elevating roadways above HSR operations would also eliminate existing freight rail grade crossings in some locations, which would be a benefit to the affected community.

3.2.4 Structure Types

Many types of structures wiould be required, including HSR bridges, highway and roadway bridges, barrier walls, retaining walls, noise walls, and fences. The HSR bridges would primarily be viaducts to carry the high-speed trains over waterways, flood plains, freight railway crossings, and roadway crossings. Where the HSR alignment remains at-grade, road bridges would be used to carry streets and highways across the alignment in accordance with TxDOT standards.

The size and locations of noise walls, barrier walls, and retaining walls would be based on site constraints, design criteria, and impact mitigation requirements. Barrier walls or other risk mitigation measures would be required in locations where the distance between the HSR tracks and an adjacent freight track or highway lane is less than desired to minimize the risk of intrusion into the HSR ROW by a derailed freight train or roadway vehicle. Barrier walls would also be required in locations where the HSR tracks must pass close to existing structures due to site constraints in order to protect both the structure and the HSR train from the possibility of impact.

3.3 Rail Systems

All of the analyzed alignments would be constructed using the same system technology for traction power, communications, and signaling. As such, these system elements would not be a determining factor in comparative assessments of alignments, except that the costs for system elements would be higher for longer alignments.

3.4 Facilities Requirements

The HSR system would include various ancillary facilities to support operations and maintenance, including systems builings and infrastructure, train storage yards and maintenance facilities, and smaller facilities located along the ROW to support routine maintenance of the ROW and systems.

3.4.1 Heavy Maintenance Facility

A Heavy Maintenance Facility (HMF) would be required and serve as the primary maintenance facility for the cleaning and maintenance of the rolling stock. In addition, the primary storage yard for the trains would be at the HMF.

The HMF would provide for all periodic inspections and scheduled maintenance and is estimated to be approximately 2.2 M sqft (200,000 m^2) in size. A detailed program and schematic layout of the HMF and associated yard would be developed during the EIS process based on the refined operating plan to identify potential sites and to assess potential impacts.

3.4.2 Light Maintenance Facility

A separate Light Maintenance Facility (LMF) for light servicing and inspection of rolling stock would be located close to the opposite end of the alignment from the HMF. The LMF would be smaller than the HMF and is expected to be about 1.1 M sqft (100,000 m^2). Train maintenance and storage services could be split between the LMF and HMF facilities, for example, with cleaning of trains taking place at the LMF and servicing at the HMF. A detailed program and schematic layout of the HMF and associated yard would be developed during the EIS based on the refined operating plan to identify potential sites and to assess potential impacts.

3.4.3 Maintenance of Way Facilities

A rigorous inspection and maintenance program would be required to maintain tracks, ballast, bridges, overhead catenary poles, and other elements. The maintenance plan is commonly referred to as the MOW Program.

It is expected that the MOW Program will require facilities located approximately every 40 to 50 mi (65 to 80 km) along the alignment. Each MOW facility will be approximately 550,000 sqft (50,000 m^2).

3.4.4 Operations Control Center

An Operations Control Center (OCC) would be located either in a central maintenance facility, a terminal station facility, or a headquarters location. The area required by the OCC would be incorporated into the overall station or maintenance facility plan.

3.4.5 Traction Power Substations

The trains will be powered by electricity which would require up to 10 traction power substations distributed along the alignment at approximately 25 mi (40 km) spacing.

Each traction power substation will be comprised of a transmission level (> 69 kV) incoming utility service together with step-down transformers and 25 kV distribution switchgear. Each traction power substation will be approximately 110,000 sqft (10,000 m^2).

4 Planning Approach for Alternatives Development

This section outlines key assumptions and design considerations and the approach used in the conceptual development of alternatives and their respective alignments.

4.1 Assumptions

Several key service planning assumptions were established that guided the development of alignments analysis.

- **Train volumes/frequencies:** The HSR alignment should support a minimum unimpeded (no increase in travel time due to congestion) capacity of about 10 trains each direction per hour (6 minute headway). Terminals would be configured to match the line capacity with some additional spare capacity for staging of trains and to be capable of future expansion to support additional throughput or multimodal connectivity.
- **Travel time goal:** A travel time goal of 90 minutes from Houston to Dallas was set in close coordination with ridership analyses.
- **Alignment corridors:** The proposed HSR system would be configured as a dedicated, fully grade separated, two-track alignment as needed to meet safety, service planning, and travel time goals. The analysis of TCR HSR alignments was designed to encompass minimizing impacts and constructability concerns.
- **Station Locations and Configuration:** The two proposed TCR HSR terminal stations, one in Houston and one in Dallas, and a potential intermediate station, would serve intercity travel demand and commerce, provide for economic redevelopment, and provide connectivity with the region's major transit systems. Stations would be strategically located to minimize impacts and maximize multimodal connectivity. The stations would be configured to support near-term operating goals and allow for potential further extensions so that the proposed HSR system could serve as an extendable passenger rail network spine connecting with regional transportation services. A preliminary study of potential station locations was undertaken to complete ridership studies. A more detailed evaluation of station locations would be undertaken upon selection of the preferred HSR corridor as documented herein.

4.2 Alignment Objectives

Consistent with the purpose and need of this Project, alternative HSR alignments were developed to follow existing transportation and major utility corridors as much as possible to minimize impacts to development. The primary alignment objectives were:

- Minimize risks to safe HSR operations.
- Maximize co-location opportunities with transportation and utility corridors.

- Minimize relocation of any existing roadways or freight railroad tracks.
- Optimize the alignment to allow for the desired maximum operating speed and operational efficiency.
- Minimize the number of times the HSR tracks must cross existing freight tracks or major roadways.
- Minimize expected impacts of construction to traffic and freight operations.
- Minimize expected environmental impacts and constructability concerns.
- Minimize expected ROW and construction costs associated with heavy infrastructure requirements.
- Achieve both the travel time and economic objectives.

4.3 General Design Guidelines

In order to develop the conceptual alignments, general design guidelines were established based on engineering judgment and professional experience. The alignment design guidelines were largely limited to alignment curvature, profile gradient, and constructability considerations. The focus of the effort was to determine the least impact and least cost alignment possible along each particular corridor studied. Conservative design guidelines were used to ensure that the results of the engineering, constructability and environmental reviews, operational analyses, travel time predictions, and construction feasibility assessments would remain valid during the more detailed planning and design at the later stages of Project development.

The general design guidelines used in developing the alignments analyzed in this report were as follows:

- **Maximum Operating Speed:** A desired and conservative maximum operating speed of 205 mph (330 km/h) was chosen to be consistent with N700-I technology. The alignment was designed to provide for maximum operating speeds throughout to the extent practical, but in many locations alignment curvature to minimize property and environmental impacts would restrict speeds.
- **Separation from Existing Freight Rail Lines:** The proposed HSR system would not operate on any existing freight rail lines. It is expected that reconfiguration of existing freight lines in select locations will be required to support construction and operations of the HSR system. For preliminary alignment planning a minimum separation distance of 200 ft (60 m) from existing transportation corridors was assumed.
- **Alignment Curvature:** A desired minimum radius of 17,060 ft (5,200 m) was used for development of the preliminary alignments. This minimum radius curve would allow for operations at 205 mph (330 km/h) using the maximum permissible cant (actual superelevation) of 7 in (175 mm). Curves were generally set at values exceeding the desired minimum to allow for less than the maximimum permissible cant.

- **Maximum Grade:** The desired maximum grade was set at 1.5%.
- **Special Trackwork:** For the design of the trackwork at the approaches to stations, where all trains would stop, a conservative assumption of 31 mph (50 km/h) special trackwork components was used to establish the footprint of the station approach limits.
- **Mapping:** At this level of alignment, no development of topographic surveys or detailed site investigations was undertaken or utilized. Readily available data sources and mapping were used.
- **Recommended Minimum Offset between HSR and Utility ROW:** A 165 ft (50 m) offset was established as the minimum separation distance from the centerline of the electrical transmission line corridor to the centerline of the HSR corridor. This was determined by taking approximately half of the minimum assumed transmission line ROW width of 215 ft (65 m) for a electrical transmission line corridor and adding it to half of the assumed 100 ft (30 m) minimum HSR ROW width.

4.4 GIS Data Collection and Design Support

A wide range of geospatial data was collected and converted into useful electronic formats for environmental and engineering analyses. Information was collected in the following categories:

Base mapping was assembled using:

- BNSF track sheets
- FEMA Flood Insurance Rate Maps
- Ortho-photography

Figure 1 – Base Mapping Used for Study

GIS data was gathered to support the analysis and included information on the following:

- Topography
- Parks and community facilities
- Hydrology
- Geology
- Soils
- Oil and gas pipelines
- City and county boundaries
- Existing land uses
- Existing urban infrastructure such as roads, rail, and utilities
- Cultural/historic resources
- Population, employment, socioeconomics, and travel data

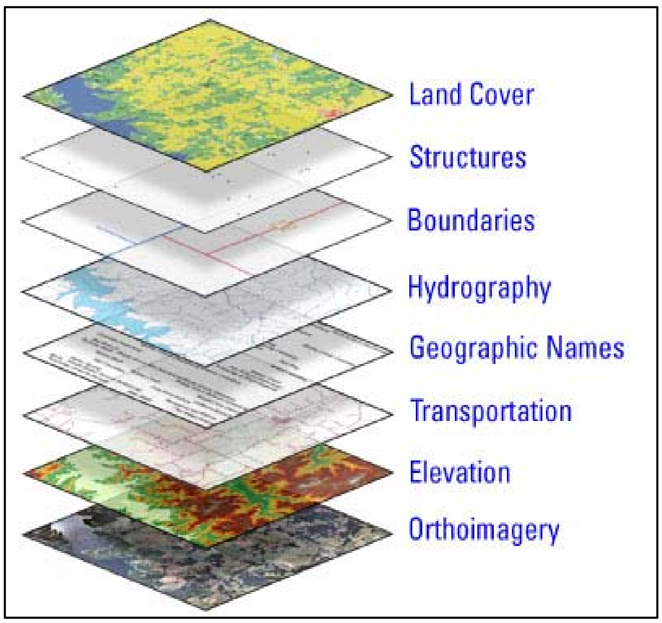

Figure 2 – Geographic Information Gathered

The key data sources used to collect this data included:

- US Geological Survey
- US Department of Agriculture/Natural Resources Conservation Service
- US Fish & Wildlife Service
- US Census Bureau
- Texas Commission on Environmental Quality
- Texas General Land Office
- Texas Parks and Wildlife Department
- Texas Historical Commission

- Environmental Sciences Research Institute
- National Pipeline Mapping System
- TxDOT

For the utility transmission lines, a preliminary review of typical transmission line ROW widths was undertaken through an internet-based search to establish the approximate limits of electrical utility ROWs within the corridor as follows:

- Minimum 50-foot wide of ROW for power line up to 69 kV.
- Minimum 100-foot wide of ROW for power line up to 115 kV.
- Minimum 100-foot wide of ROW for power line up to 138 kV.
- Minimum 130-foot wide of ROW for power line up to 230 kV.
- Minimum 165-foot wide of ROW for power line up to 345 kV.
- Minimum 215-foot wide of ROW for power line up to 500 kV.

5 Assessment Method and Criteria

A method was developed to evaluate the various alignments considered and to identify those alignments that should be advanced for further study because they meet the Project's purpose and need and those that should be discarded because they do not. The conceptual engineering and planning efforts were aimed at developing all alignments to a sufficient and consistent level of detail to enable this comparative assessment of competing alignments.

Meaningful evaluation criteria were selected that covered a broad range of engineering and environmental considerations as described in this section. Engineering judgment, corridor understanding, and prior experience with passenger rail and heavy infrastructure projects were used in assessing and rating these criteria.

5.1 Evaluation Method

A broad array of both quantitative and qualitative evaluation criteria were considered in the comparison of alignments. Alignments were compared across 23 separate categories of criteria covering engineering, economic, and environmental considerations. Based on the results of the analysis, a red, yellow, or green value was assigned to each alignment for each evaluation category to create a "stoplight chart". For each evaluation category, an assessment was made both in terms of the overall "value" of the category and its comparative "ranking". For example, all BNSF alignments had significant exposure to the risks associated with construction in areas with shrink-swell soils, so all BNSF alignments were assigned a red value. In other evaluation categories, such as major structures, all alignments would have major structures, but there were clear differences in number of major structures between alignments and green values were assigned to those alignments with the lowest number of anticipated major structures.

For some evaluation criteria a quantifiable measure could be made using GIS tools such as the number of impacted acres of wetlands. For other criteria a more qualitative assessment was required using professional judgment, such as expected risks.

An overall rating was then made for each alignment using professional judgment when considering the alignment's ranking across all evaluation categories relative to the other alignments. This allowed for consideration of those evaluation categories of criteria with the most significant impact on viability of the alignment, such as construction cost and environmental impacts.

The "stoplight chart" approach was used since it is not practical to perform an overall quantitative ranking of alignments for major transportation infrastructure alternatives such as this when the various criteria are not additive. Nonetheless, the evaluation categories were grouped and a simplified weighting approach applied to each group to reflect the fact that some considerations would heavily influence the overall economic viability of the Project while other considerations, albeit important, could be mitigated through site specific design and construction approaches at relatively insignificant costs relative to the overall scale of the Project.

The evaluation categories of criteria and grouping used in the comparative analysis are outlined in the following section.

5.2 Evaluation Criteria

The evaluation categories of criteria selected for comparative assessments are identified below. Key considerations used in the evaluation of each alignment and general guidelines for how the alignments were "scored" with respect to that category are also provided.

Group A: Financial and Project Delivery Considerations

This group contains those evaluation categories of criteria that represent the greatest impact on the economic viability of the overall Project. This would include estimated capital construction costs, property acquisition costs, and revenue potential. This group also includes criteria that would impact the design, regulatory approval, or construction schedule. Schedule impacts for a project of this magnitude would have significant impact on the overall Project financial viability.

Ridership/Revenue Potential: The number of anticipated fee paying riders and the corresponding amount of revenue that will be generated by their purchase of tickets. An increasing number of fee paying riders generate greater revenue to offset the railroad's costs. The evaluation category is rated red, yellow, or green depending on the variation from the average number of riders for all alignments.

Financial Viability Risk: Major factors and issues that could negatively impact the Project's finances either by increasing costs or decreasing revenue. The greater the number of factors and issues associated with an alignment and the greater the complexity of a factor or issue, the greater the risk of a negative impact. The evaluation category is rated red, yellow, or green depending on the identified risks unique to each alternative that are greater or more complex than anticipated risks for all alternatives and for this type of project.

ROW Acquisitions: General extent and type of real estate required for the alternative. Normally, the higher complex usage of the property and the surrounding area's density and valuations, the greater the cost of property acquisition. Rural property is normally less expensive than urban property. The evaluation category is rated red, yellow, or green depending on not only the type of real estate required, but its characteristics, such as being rural or urban. Alignments with the possibility of shared corridor that would limit real estate acquisition costs and schedules are rated more positively.

Construction Duration: The total time from beginning of construction to beginning of revenue service. The greater the duration, the greater the overall Project costs due to factors such as financing and insurance costs, inflation, and contractor administrative costs. The metric is duration in years. The category is rated red, yellow, or green depending on the variation from the average for all alternatives.

Schedule Risks: Those areas or items that are unique to the alignment that could negatively delay or change the timing and sequencing of work and thus negatively impact the schedule. Examples would include constructing within oil and gas fields with potential work stoppage or limitations on times for work activities. Another example would be working within dense existing transportation corridors where construction access, staging, or maintenance of traffic would create additional risks. The category is rated red, yellow, or green depending on the unique schedule risks for a given alignment relative to all alignments.

Capital Construction Cost: The estimated capital construction costs for the heavy infrastructure elements of the project. It does not include items that are of the same quantity and cost magnitude relative to all the alignments such as the vehicle fleet, maintenance facilities, and systems. The evaluation category is rated red, yellow, or green depending on the variation from the average capital cost for all alignments.

Stakeholder/ Regulatory Considerations: This category captures issues associated with gaining Project approval from various potential stakeholders and regulatory bodies. Meeting demands of Project stakeholders can significantly impact the Project's cost, construction duration, or constructability. Issues associated with stakeholder considerations include degree of cooperation, interpretation of stakeholder's design criteria and procedures, likely requirements for betterments to stakeholder properties, and stakeholder assignment of dedicated staff to assist on design and construction issues. The evaluation category is rated red, yellow, or green depending on the assessment of expected stakeholder and regulatory issues the alignment would be expected to confront relative to all alignments.

Group B: Engineering Considerations

This group contains those categories of criteria that constitute the major infrastructure elements of the Project or that directly affect the design or construction complexity of these elements. Increasing complexity or magnitude of infrastructure requirements will translate directly to extended delivery schedules and increased Project costs.

Constructability Issues: This category captures the expected degree of difficulty in constructing the Project; the greater the expected construction difficulty, the greater the risk of cost or schedule impacts. Alignments requiring special construction approaches (including types of equipment and construction skills) would be more costly to deliver and construction schedules would be extended. Typical constructability concerns include known conflicts with major utilities, construction in densely developed areas, construction adjacent to or crossing of heavily travelled highways, and construction adjacent to operating freight lines. While construction of any project of this magnitude that connects two major urban areas will involve specialized and complicated construction, the evaluation category is rated red, yellow, or green depending on the magnitude of potential complicated and risky construction required relative to those expected with all alignments.

Alignment: The total distance from the terminal station in Houston to the terminal station in Dallas. It is measured in miles (kilometers). Higher construction costs are normally associated with longer distances (with allowances made for special conditions such as structures). The metric for evaluation is the total distance in miles (kilometers). For this alignments analysis effort all alignments were designed to meet the desired operating speeds, except within the urban areas of Houston and Dallas; as such, the alignment length is the key differentiator.

General Infrastructure Requirements: Project elements of an alignment that represent substantial costs to the overall Projects. The evaluation metric would be identification of the element and a quantification of size, such as length in miles of viaducts. The category is rated red, yellow, or green depending on the expected infrastructure requirements for the alignment under consideration. Alignments with more significant infrastructure requirements, such as extended viaducts or numerous roadway reconfigurations would receive less a less favorable rating.

Major Structures: Large and/or complex structures for crossing major highways and interchanges, rivers, rail lines, reservoirs, and other major physical barriers. The greater the number, size, height and complexity of the major structures, the greater the costs and the greater the impact on construction duration and constructability. The evaluation category is rated red, yellow, or green depending on the expected number and scale of major structures relative to all alignments.

Crossings: The crossing of non-major highways or local roads that do not require a major structure but will require road closure or re-profiling of the road above the HSR line to separate roadway traffic from HSR operations. The greater the number of such crossings and closures, the greater the Project costs and time for construction and the worse that alignment's rating.

Shrink-Swell Soils: Soils that expand and contract considerably greater than the average soils located along an alignment. These soils result in greater costs because the soils either need to be removed and replaced with suitable soils or additional mitigation measures need to be incorporated into the geotechnical design and construction. The evaluation metric is area in acres.

Utilities: Major public and private utility lines including electrical transmission lines, oil and gas pipelines, waterlines, sanitary and storm sewers, and other utilities such as telecommunications. The greater the number of such crossings the greater the Project costs due to special construction approaches and equipment, approval and coordination issues, and longer construction durations. The evaluation metric is the number and categorization of utility crossings.

Group C: Environmental Considerations

This group contains those categories of that define and quantify those issues affecting the environment and community and must be mitigated. The greater complexity or size of impact, the greater Project costs. Significant environmental impacts would result in project delivery concerns reflected in Group A. Further discussion is provided in Section 10 with respect to environmental considerations. Best professional judgment was applied in assigning stoplight values based on the data presented in Section 10, and to ensure that factors were not unduly weighted in the overall assessment.

Prime Farmland: Land that is designated by the Natural Resources Conservation Service for its great agricultural productivity ability, if actively managed. Use of this land in the Project alignment would result in greater costs associated with mitigation studies and potential mitigation measures and higher property valuations. The evaluation metric is area in acres. The scoring reflects the fact that construction of any of the alignments will affect a significant acreage of prime farmland soils.

Socio-Economics: A quantification of the number of households that are either within the poverty threshold or that are constituted or defined ethnicity groups. Federal review requires that projects do not unduly affect impoverished or highly ethnic areas. Greater costs are sometimes incurred by a project to ensure these households are not negatively impacted. The evaluation metric is the number of such households impacted by an alignment.

Noise: The extent that noise impacts to residences exceed federal and state guidelines and regulations. Greater costs would be incurred by the Project for installation of noise mitigation measures. The evaluation metric is the number of sensitive properties that would be impacted with recognition that the impact would be less in areas where above-background noise is already present.

Land Use Considerations: This category captures compatibility of land uses impacted by the HSR line. Generally, the more urbanized or complex the usage of the property impacted, the greater the Project costs. Preference is also given to those alignments that minimize impacts to residential or largely undisturbed parcels. The evaluation metric is area in acres.

Hydrology and Wetlands: Areas and physical features along the route that encompass perennial waterbodies and wetlands that will impact the design and construction of the project. Included in this category are rivers, streams, lakes, water reservoirs, floodplains, and wetlands. Increased impacts to waterbodies and wetlands will increase the complexity of project permitting and also require greater mitigation to offset project impacts. Constructing through and over these areas would also result in greater project costs in that bridges, large diameter culverts, detention facilities, and other impact mitigation measures would be required. The greater the number and magnitude of such crossings the greater the costs to the Project. The evaluation metrics are number of crossings by type (e.g. rivers, streams) and length co-located within the alignment in miles (kilometers) and area in acres. The evaluation category is rated red, yellow, or green depending on the number and acreage of impacts relative to all alignments.

Threatened and Endangered Species: Those species of wildlife that have been designated by the United States Fish and Wildlife Service as rare or likely to become rare and in danger of becoming extinct in all or a portion of their range. Impacts to the individuals or the habitat of these species would require mitigation measures including potential localized alignment modifications resulting in greater costs, both from a permitting standpoint and from the need for greater mitigation to offset impacts. The evaluation category represents the likelihood of encountering these species members by reported element occurrence area measured in acres. Equally important, the category also considers lands specifically managed to create and promote habitat for a species. The evaluation metric for habitat areas is measured in acres. Alignments with lesser impacts are scored more favorably.

Parks and Forests: Areas designated by state and federal agencies for recreation and wildlife habitat (i.e. extremely limited development) are substantially forested, largely undisturbed, and highly utilized for recreational activities. Impacts to parks require substantial study and mitigation measures including potential localized alignment modifications. Impacts to forests may require off-site mitigation measures for loss of habitat and recreational use. These impacts result in greater costs to the Project and generally the greater the impact, the greater the cost impact. The evaluation metrics are the number of parks and the size in acres of areas impacted. Alignments with lesser impacts are scored more favorably.

Cultural Resources: Those properties and areas are designated by the National Historic Preservation Act and the Antiquities Code of Texas as having historical or archeological significance. Impacts to these properties and areas result in additional study and possible mitigation costs including potential localized alignment modifications. The greater the number of properties and areas potentially impacted the greater the costs. The evaluation metrics are the number and type of property or district area. Alignments with lesser impacts are scored more favorably.

Community Facilities: Properties and areas utilized by the local community at large. These facilities include schools, churches, and cemeteries. Impacts to these facilities require additional study, review, community input and approvals, and possible mitigation measures. The greater the number of reported properties the greater the resultant cost. The evaluation metrics are number and type of property. Alignments with lesser impacts are scored more favorably. It is recognized that significant coordination would be required for any of the selected alignments to develop site specific route deviations and/or mitigation measures to offset potential impacts to community facilities.

5.2.1 Evaluation Criteria Weighting

Weighting for the various evaluation criteria was determined through professional judgment regarding the effect that each specific group of evaluation categories of criteria would have on the relative financial feasibility of the Project. In each Evaluation Group, a tally of the number of red, yellow, and green values was made to arrive at an overall total for the Evaluation Group for each alignment with stoplight colors assigned the following values: Red = 1, Yellow = 2, Green = 3. This total value was then "normalized" by dividing the total tally by the number of evaluation categories in each specific group (and rounded to the nearest tenth).

Evaluation Group totals were then multiplied by the following group weightings as follows:

Group A: Financial and Project Delivery Considerations = 2

Group B: Engineering Considerations = 1

Group C: Environmental Considerations = 1

Group totals were then tallied to arrive at an overall score for each alignment.

The weighting selected reflects the critical importance of financial viability for the Project. While engineering and environmental issues are, of course, critically important, the concerns raised in either area can be addressed through design and impact mitigation. Hence, these groups are weighted equally, but the effect construction difficulties, environmental impacts, and stakeholder challenges within these two areas would have on overall project delivery and financial viability is double weighted in Group A.

6 Alignments Considered

The development of the HSR alignments between Houston and Dallas involved the study of various constraints, including existing development, environmentally sensitive areas, and topography. The alignments were generally located along existing infrastructure (road, rail, or high-voltage transmission) corridors in an effort to minimize adverse social and environmental impacts. Additionally, following existing corridors takes advantage of prior knowledge of constraints utilized in development of those networks. Through conceptual analysis, and through review of previous studies, four primary corridors were selected for further analysis. Three of the corridors were identified in the Texas Rail Plan as shown in Figure 3.

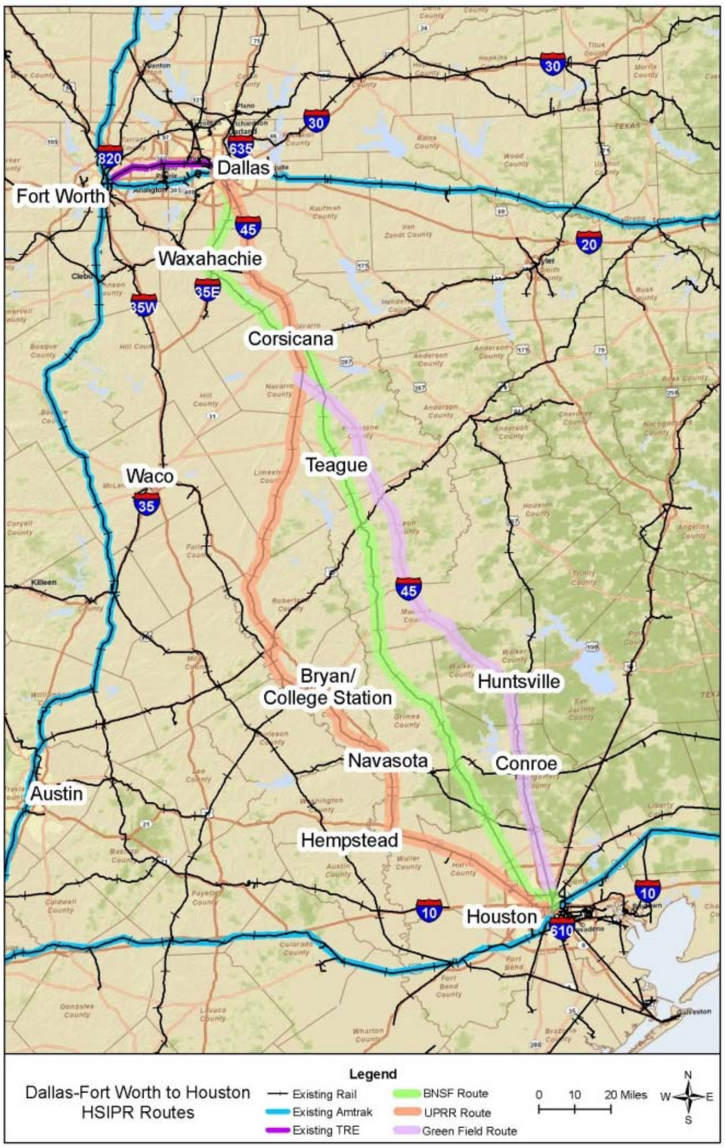

Figure 3 – Corridors Identified in Texas Rail Plan

The fourth corridor resulted from further development and follows high-voltage transmission line corridors which exist between the BNSF and UPRR freight lines. These four corridors are shown in Figure 4.

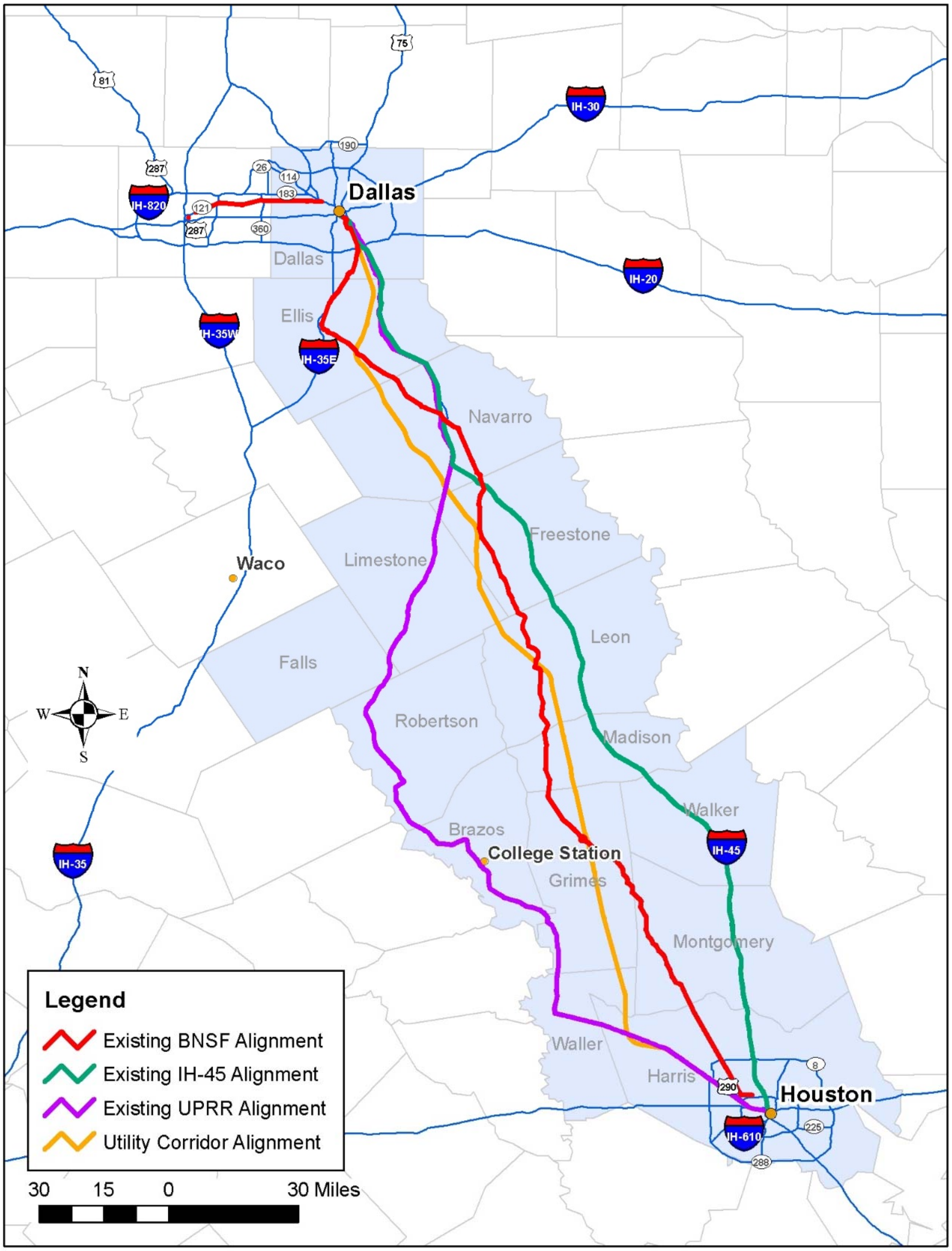

Figure 4 – Four Alignment Corridors

Nine alignments were identified along these four corridors that appeared suitable to meet the Project purpose and need. A brief overview of these alignments is as follows. The nine alignments are shown in Figure 5.

BNSF Teague Line Corridor – Four Alignments: BNSF w/ Options 1-4

All four BNSF alignments share a common segment that generally follows the existing BNSF freight corridor from Houston north to the City of Teague, approximately 70 percent of the alignment distance. North of Teague, four alignments were studied.

IH-45 Corridor – Two Alignments: IH-45 and IH-45 w/ Hardy Line

Both IH-45 alignments generally follow IH-45 and its related corridor from Houston to Dallas. One IH-45 alignment follows IH-45 into downtown Houston. The second IH-45 option follows the UPRR Hardy line from Houston to Conroe.

UPRR Hempstead Line Corridor – One Alignment: UPRR

The sole UPRR Hempstead alignment generally follows the existing UPRR Hempstead line from Houston to Dallas passing through Bryan/College Station about mid-way along the route.

Utility Corridor – Two Alignments: UC and UC w/ IH-45

The Utility Corridor (UC) generally follows the UPRR Hempstead Line from Houston to Hockley (about 10 percent of the alignment distance) and then follows the CenterPoint Energy and Oncor Electric Delivery major electrical transmission lines (345kV to 500kV, nominal). Two alignment options were studied: one largely follows existing utility lines to Dallas with some greenfield (or undeveloped) segments to avoid impacts to large electrical facilities, and one follows the existing utility lines except for following a segment of IH-45 between Madisonville and Fairfield, where it rejoins the UC. The alignment is co-located with IH-45 over approximately 30 percent of the route length.

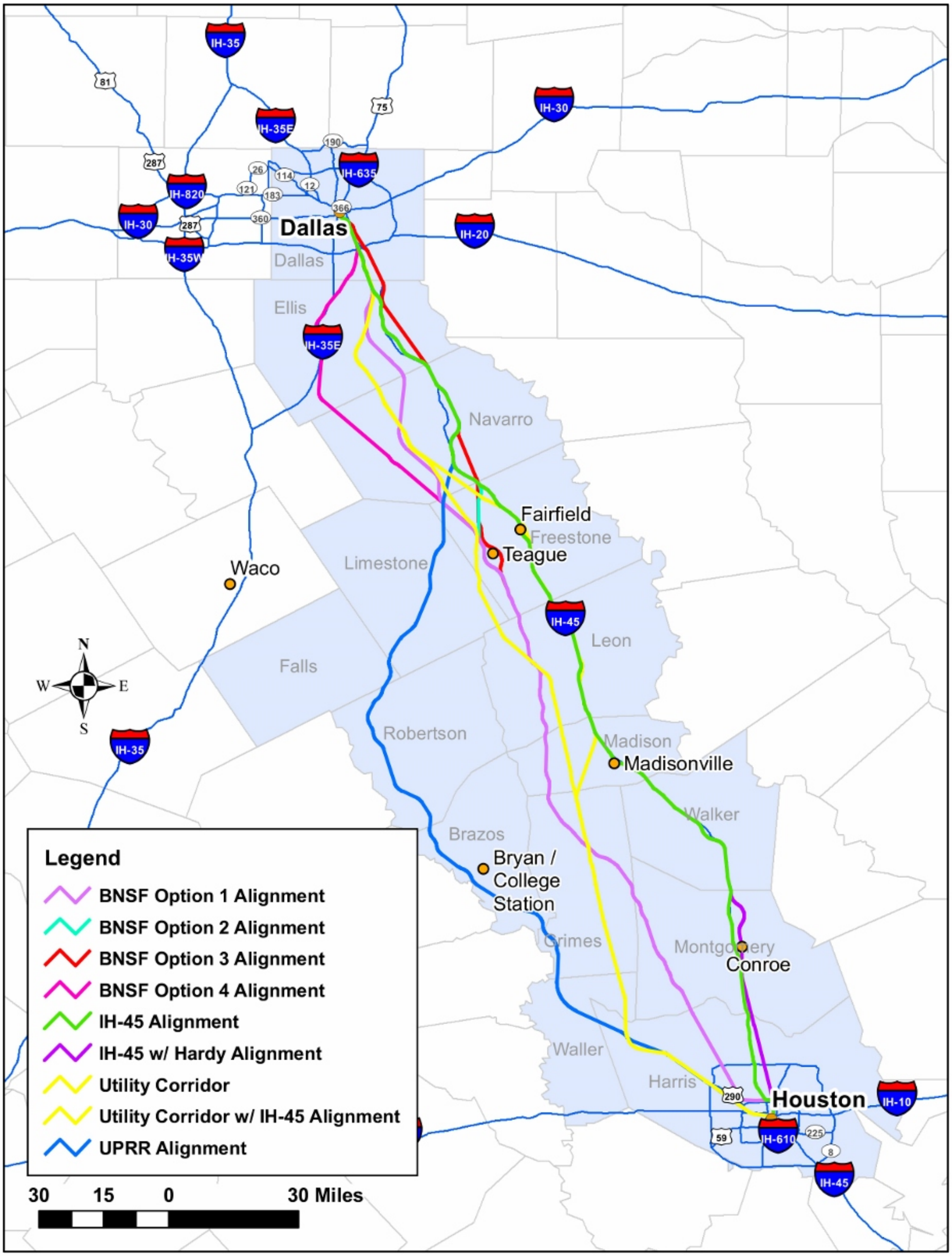

Figure 5 – Nine Alignments Considered in the Four Corridors

Each of the corridor alignments chosen can generally be described as "urban – rural – urban" in the Houston to Dallas corridor, i.e. two densely developed urban zones separated by a rural section.

The densely developed areas are of particular concern with respect to construction and impact mitigation requirements. These urban areas contain concentrated populations that could be adversely impacted both during construction and during operations without appropriate impact mitigation measures. Following existing transportation corridors would help to mitigate the long term impacts from operation of the HSR system, but would result in greater impacts during construction given that development in the more urban areas of Houston and Dallas lies along the freight lines and the highway frontage roads.

Through the rural sections, attempts were made to keep the alignments away from towns and cities wherever practicable and on low embankments within the landscape to screen its visibility and reduce noise impacts. This established a balance between avoiding impacts and maintaining an effective high-speed railway. Where wetlands and floodplains were encountered, the HSR alignments would be elevated on viaduct structures to mitigate the temporary construction and permanent impacts associated with construction in such environmentally sensitive areas.

The results of the financial viability, engineering, constructability, and environmental-related analyses for each alignment are discussed herein and summarized in the "Stop Light Chart" provided in the conclusion of the report.

6.1 BNSF Alignments

The basis of four BNSF alternative alignments is the BNSF Corridor that parallels much of the BNSF Teague Line. The existing freight railroad is shown in Figure 6.

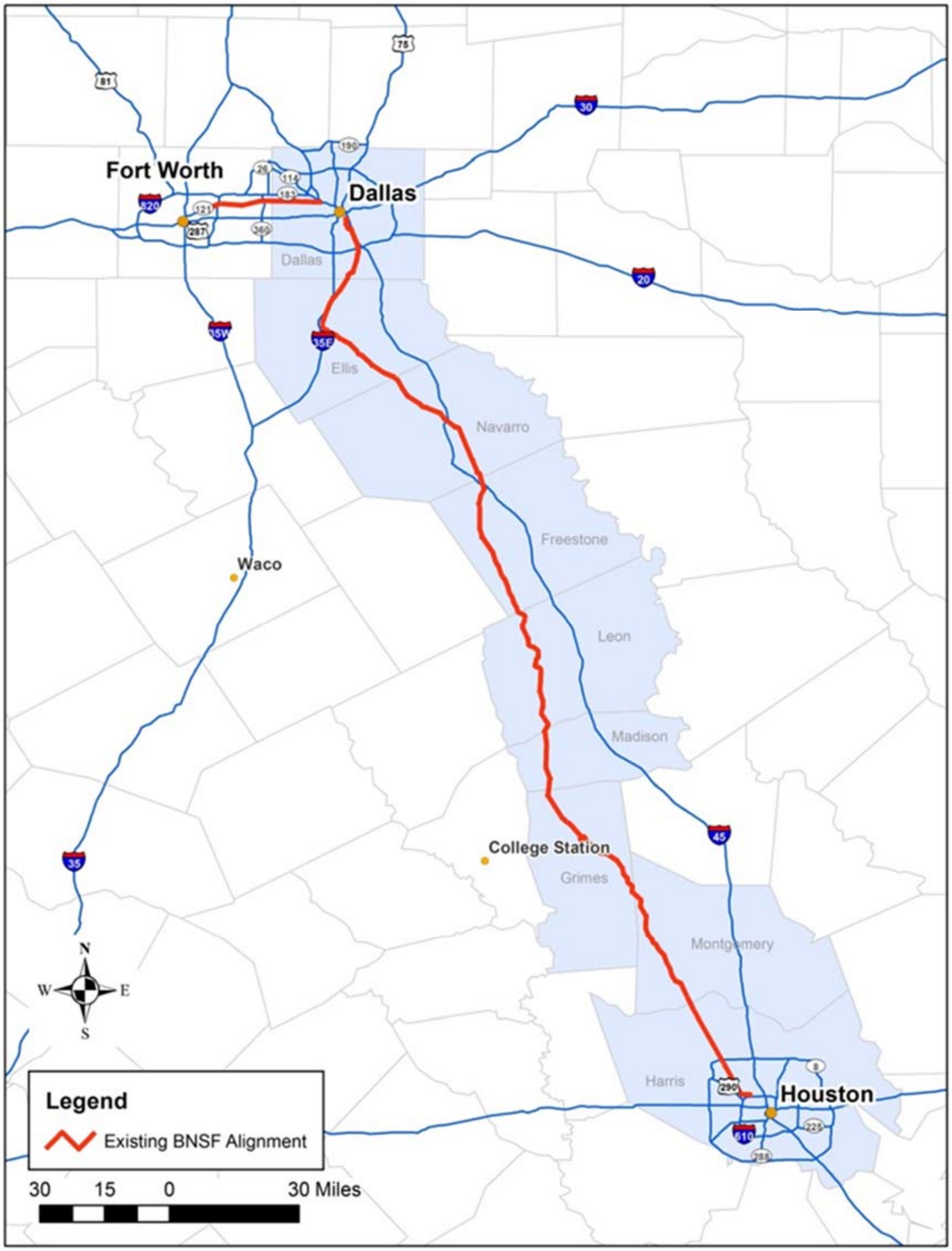

Figure 6 – Existing BNSF Teague Line Freight Railroad

The four BNSF alignments consist of:

- Common segment from the terminal station in Houston to south of Teague.
- Four alignments from south of Teague to IH-20.
- Two alignments from IH-20 to the terminal station in Dallas.

The four options are shown in Figure 7.

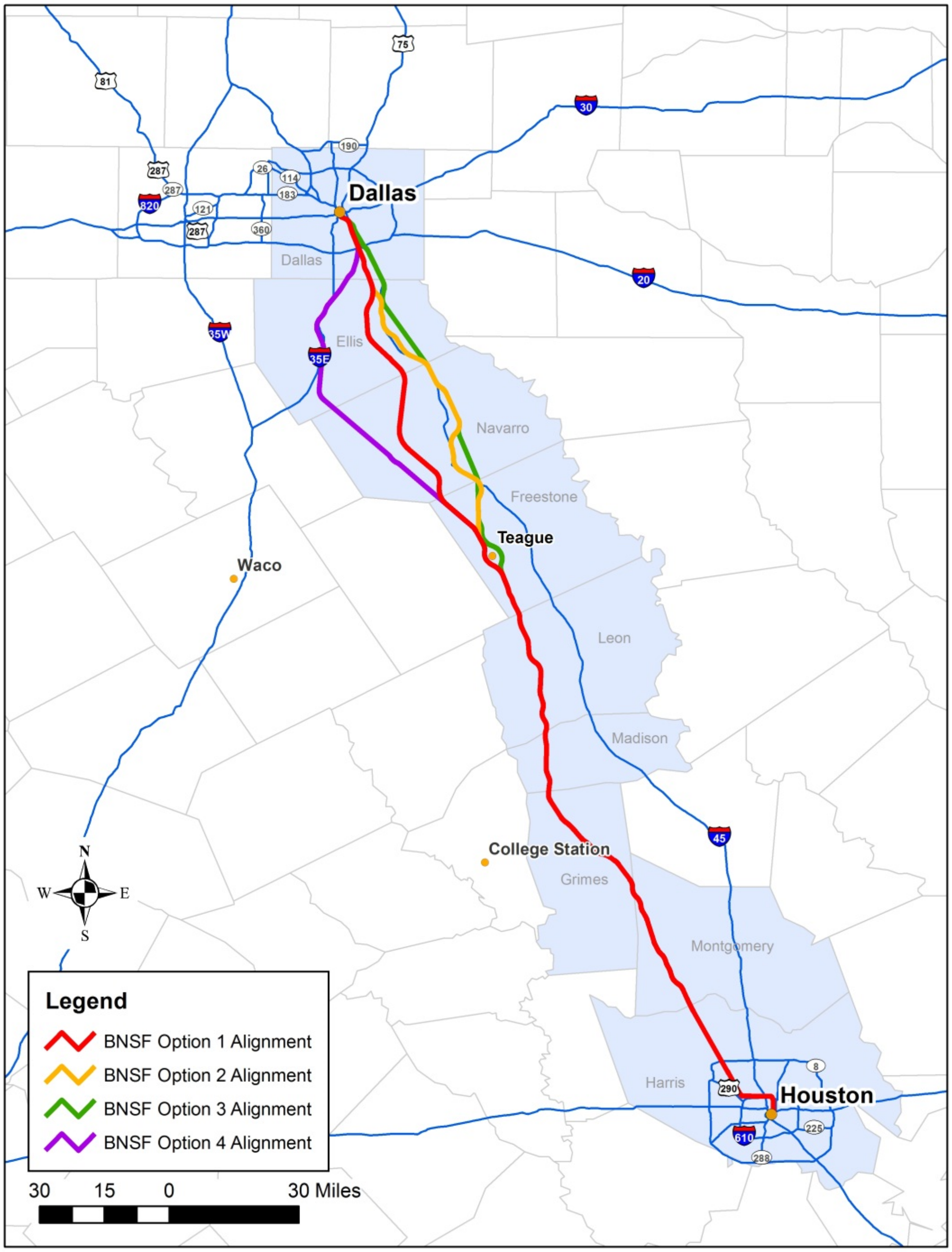

Figure 7 – BNSF Alignment Options North of Teague

6.1.1 Houston to Teague – Common Segment

The four BNSF alignments begin with a common alignment starting at the terminal station in Houston, which was assumed to be at the Amtrak Station/Post Office location in downtown Houston. The four BNSF alignments follow a north-east trajectory across the junction of White Oak and Buffalo Bayous and generally follow the existing Houston Belt and Terminal (HB&T) railroad corridor east and north towards IH-610. The four BNSF alignments are east of, and run parallel to, Elysian Street until the alignments cross the North Loop (IH-610).

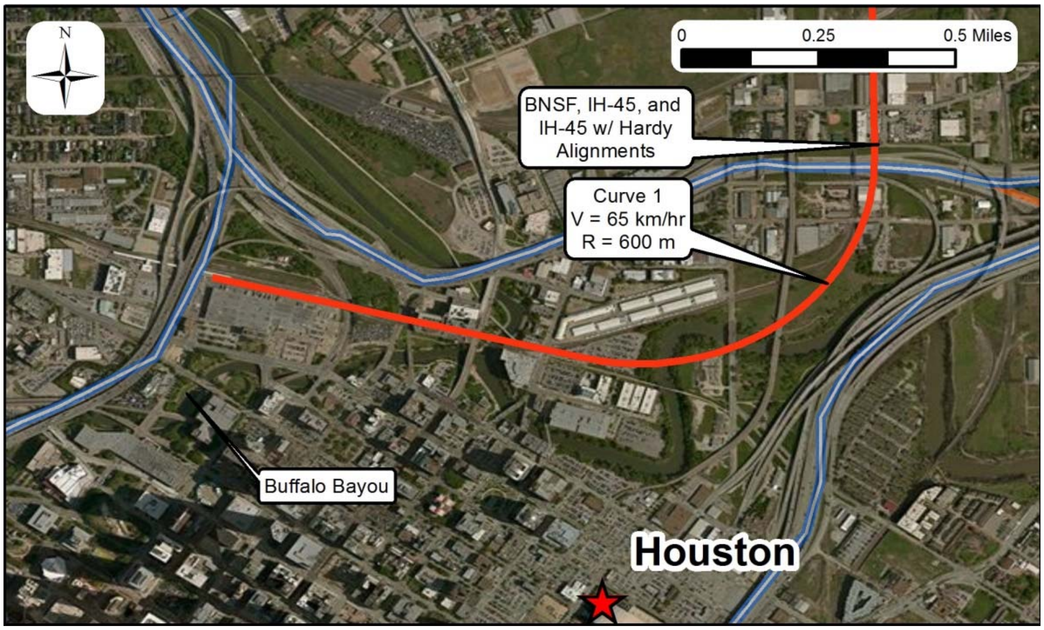

Figure 8 – Houston Terminal to BNSF

Due to the highly developed nature of downtown Houston, significant environmental and community impacts during construction would be expected. Moreover, the BNSF alignments must follow the constrained geometry shown in Figure 8, which will significantly reduce allowable operating speeds. The first curve after crossing the Buffalo Bayou has a radius of 1,968 ft (600 m) which restricts the train to travel at a maximum speed of about 40 mph (65 km/hr). However, this is not a major concern given that trains entering and leaving the terminal will not be traveling at maximum speeds. The more significant alignment concerns are the next two curves located farther north near IH-610 and White Oak Bayou, which are also less than the minimum desired curve radius. These two curves would restricts allowable operating speeds to 45 mph (70 km/hr) on the main alignment, as shown in Figure 9. This alignment geometry constraint distant from the terminal would be a a significant speed restriction that will impact operations and increase maintenance requirements.

Once across IH-610, the BNSF alignments turn west across the Hardy Toll Road to follow the BNSF Teague line. This crossing will involve a tall bridge structure over the multi-level interchange of IH-610 and the Hardy Toll Road. Elevating the alignments to pass above this interchange will require an extended tall viaduct of several kilometers in length. As the BNSF alignments turn to the west, the

BNSF alignments would be co-located in the BNSF ROW on an elevated viaduct from this point to Pinehurst, approximately 31 mi (50 km) to the northwest. It would be elevated above local roadways to minimize impacts that would result from re-profiling the many intersections to achieve full grade separation. Additionally, elevating the HSR line minimizes certain risks associated with HSR operations in a freight corridor. After passing over White Oak Bayou as shown in Figure 9, the existing freight alignment is straight and the four BNSF alignments parallel the BNSF track for approximately 28 mi (45 km) to Pinehurst.

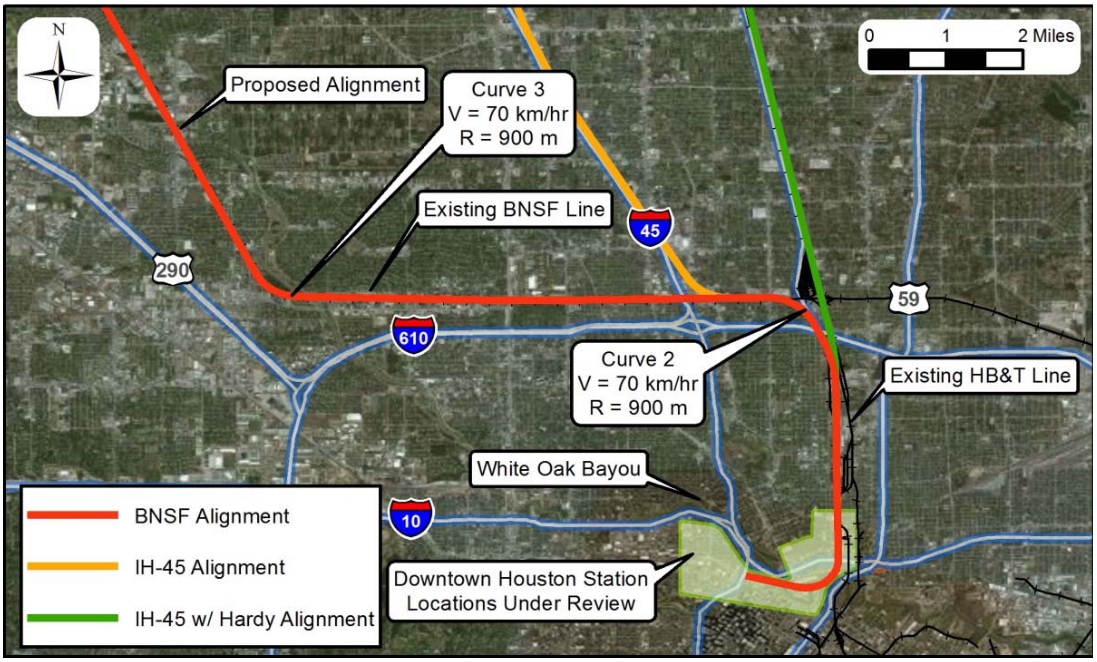

Figure 9 – BNSF Alignment in Houston

Once north of Pinehurst, the BNSF alignments follow the BNSF Corridor for approximately 34 mi (55 km) to a potential intermediate station near State Highway 30 that could serve to provide connectivity to Bryan/College Station. The BNSF alignments then continue to follow the BNSF line approximately 71 mi (115 km) to a point midway between Donnie and Teague where the four alignments diverge as they head towards Dallas (see Figure 10).

Local deviations from the BNSF ROW occur between Pinehurst and Teague to bypass communities and avoid impacts at Dobbin, Richards, Iola, North Zulch, Normangee, Jewett, and Donnie.

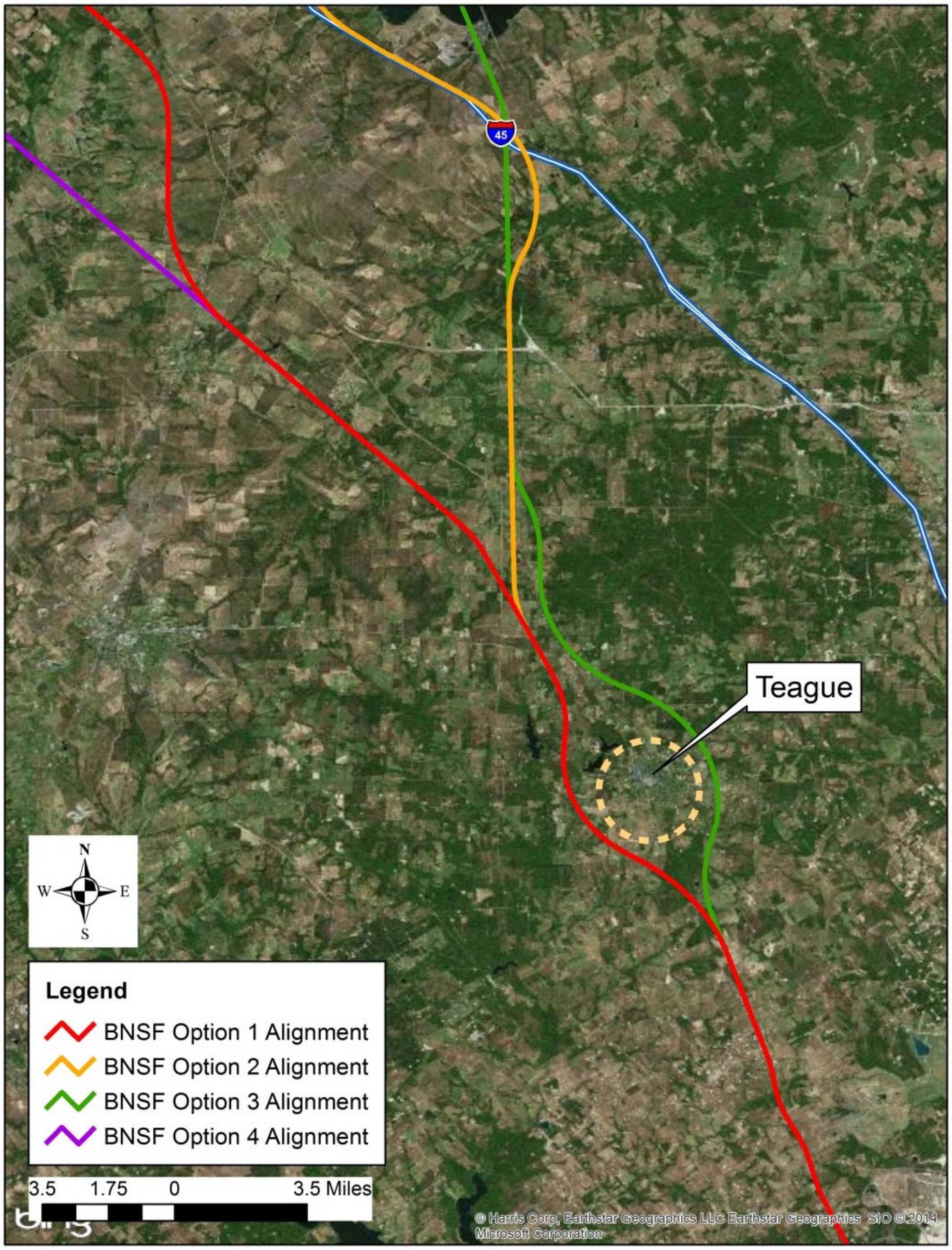

Figure 10 – Common Point at Teague Where the Alignments Separate

Given the largely rural nature along the Teague Line, and given that the line is generally straight along a good portion of its length, it was estimated that the HSR alignment could be configured as a shared ROW corridor over much of the length from Houston to Teague. The final track spacing between the freight track and HSR tracks would be determined through close coordination with BNSF and the FRA. Where shared ROW was assumed, the cost estimates included either a barrier walls or elevated viaduct to address risk mitigation requirements.

6.1.2 Oil Wells Between Jewett and Teague

Each of the BNSF, UC, and IH-45 alignments encounter numerous gas wells and mining operations in the 20 mi (32 km) segment between Jewett and Teague as shown in Figure 11.

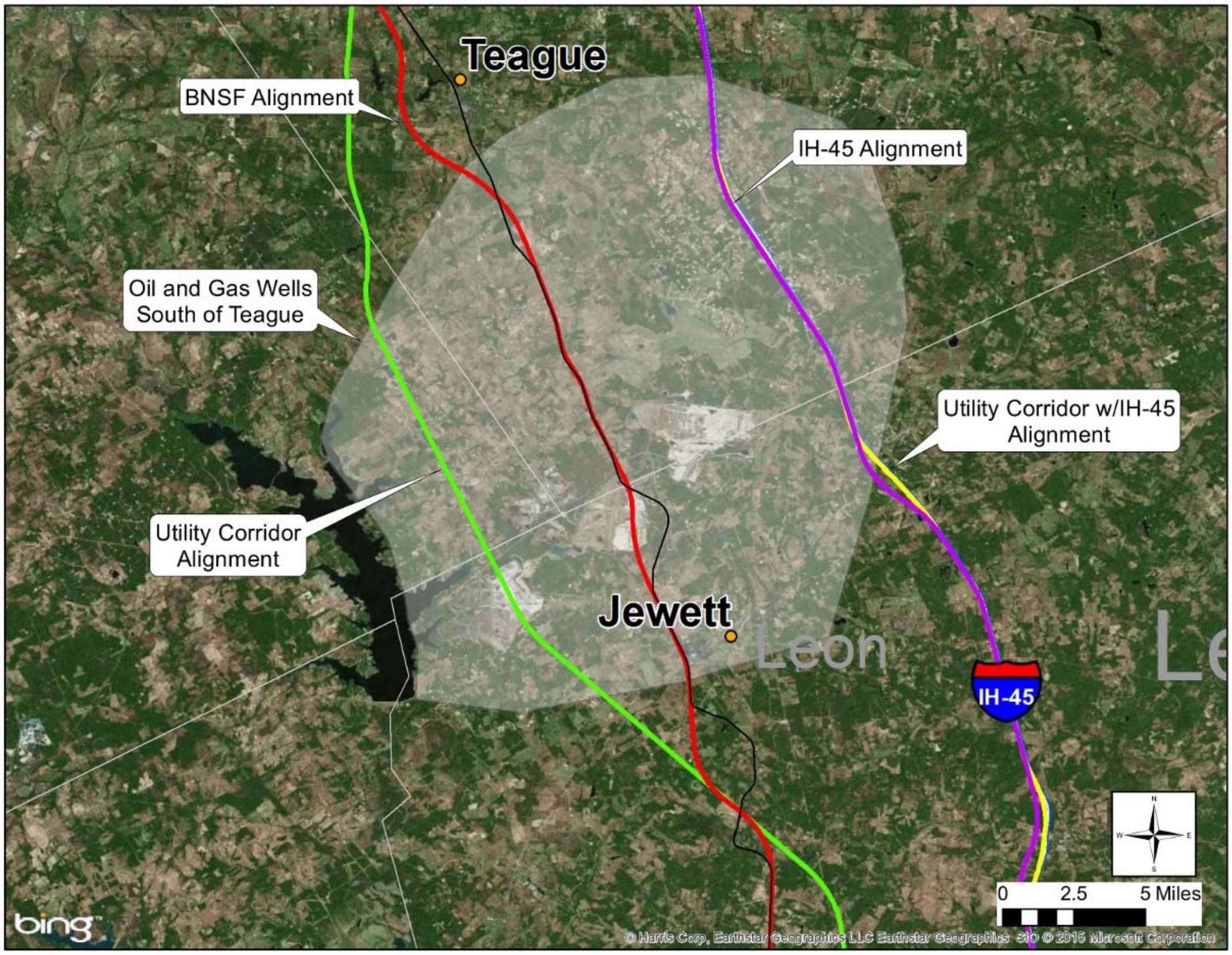

Figure 11 – Oil Fields between Jewett and Teague

The density of oil wells and mining operations over this segment would require careful development of HSR alignments during more detailed design to minimize the impacts.

6.1.3 Teague to Dallas – Four Options

From the common point 6 mi (10 km) to the south of Teague, four BNSF alternative alignments were developed to connect to Dallas. These four BNSF alignments are shown in Figure 12.

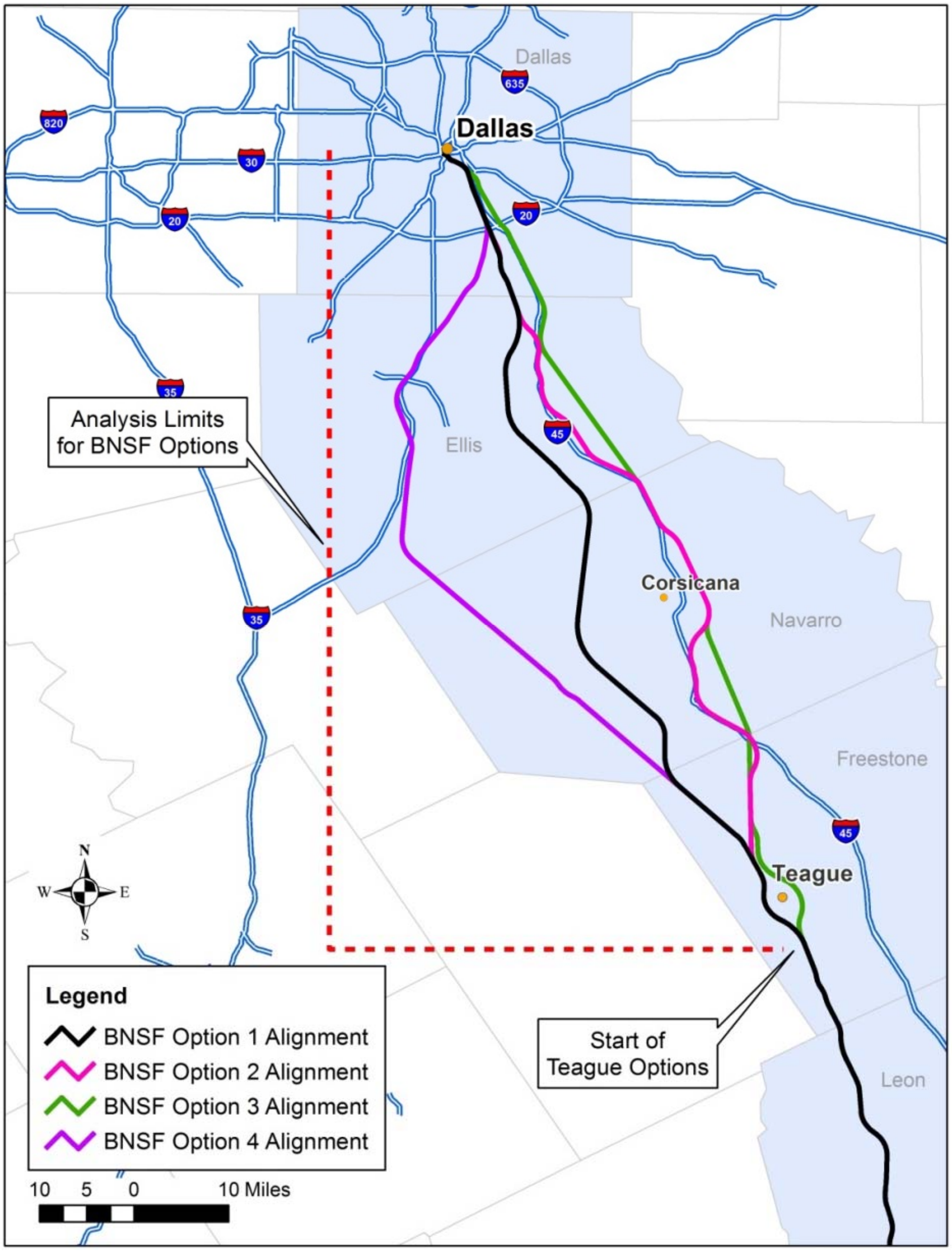

Figure 12 – BNSF Options from Teague to Dallas

Two of these four BNSF alignments can be considered "greenfield" options while the other two generally follow transportation corridors. BNSF Options 1, 2, and 4 merge together south of IH-20 in Dallas and follow the same alignment into a terminal station in downtown Dallas while BNSF Option 3 has an alternate alignment.

6.1.3.1 BNSF Option 1

The "BNSF Option 1" alignment represents the "base" BNSF alignment. BNSF Option 1 begins south of Teague where the alignment separates from the existing BNSF line just north of Donnie, to bypass Teague to the west as shown in Figure 13.

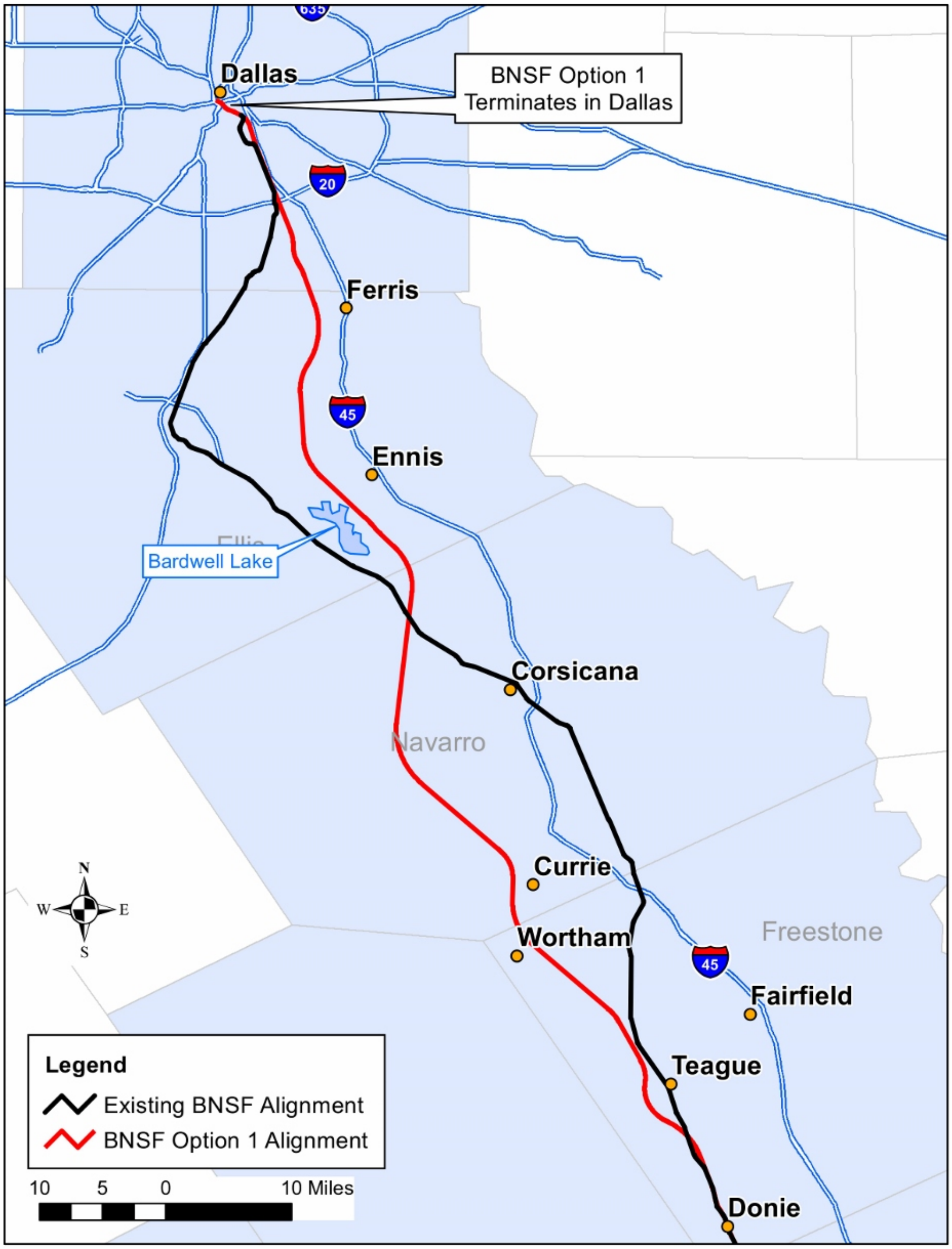

Figure 13 – BNSF Option 1

The existing BNSF Teague Line passes through Teague and then continues north to pass through Corsicana; following this segment of the line would result in extensive development impacts. After bypassing Teague, the BNSF Option 1 alignment continues in a northwest direction to pass east of Wortham and west of Currie. The route continues in a north to north-westerly direction to pass between Lake Bardwell and Ennis. After passing to the west of Ferris, where the UPRR line intersects with the BNSF line, the alignment rejoins the existing BNSF Teague alignment at IH-20 to the south of Dallas. The BNSF Option 1 alignment then runs parallel to IH-45 and the Teague line to enter Dallas. After crossing the Trinity River, the BNSF Option 1 alignment turns to the northwest to run parallel with the UPRR line and terminates at a station site assumed to be near the Reunion Arena.

6.1.3.2 BNSF Option 2

The "BNSF Option 2" alignment starts at the common point south of Teague and follows the same bypass alignment of Teague as BNSF Option 1. North of Teague it realigns with the existing BNSF alignment, paralleling FM-80. BNSF Option 2 passes to the west of Kirvin before joining the IH-45 alignment just north of Streetman, which it follows the rest of the way to Dallas. At Richland, BNSF Option 2 alignment turns north across the western edge of the Richland Chambers Reservoir, following IH-45 to just south of Angus, where it takes an easterly route around Corsicana before rejoining IH-45 and following the interstate very closely, bypassing Rice, Alma, Ennis and Palmer to the east, until just south of Ferris. At this point, BNSF Option 2 crosses IH-45 and UPRR to converge with the BNSF Option 1 alignment, passing to the west of Ferris and then heading north to Dallas along the UPRR Dallas Line. This complete alignment is as shown in Figure 14.

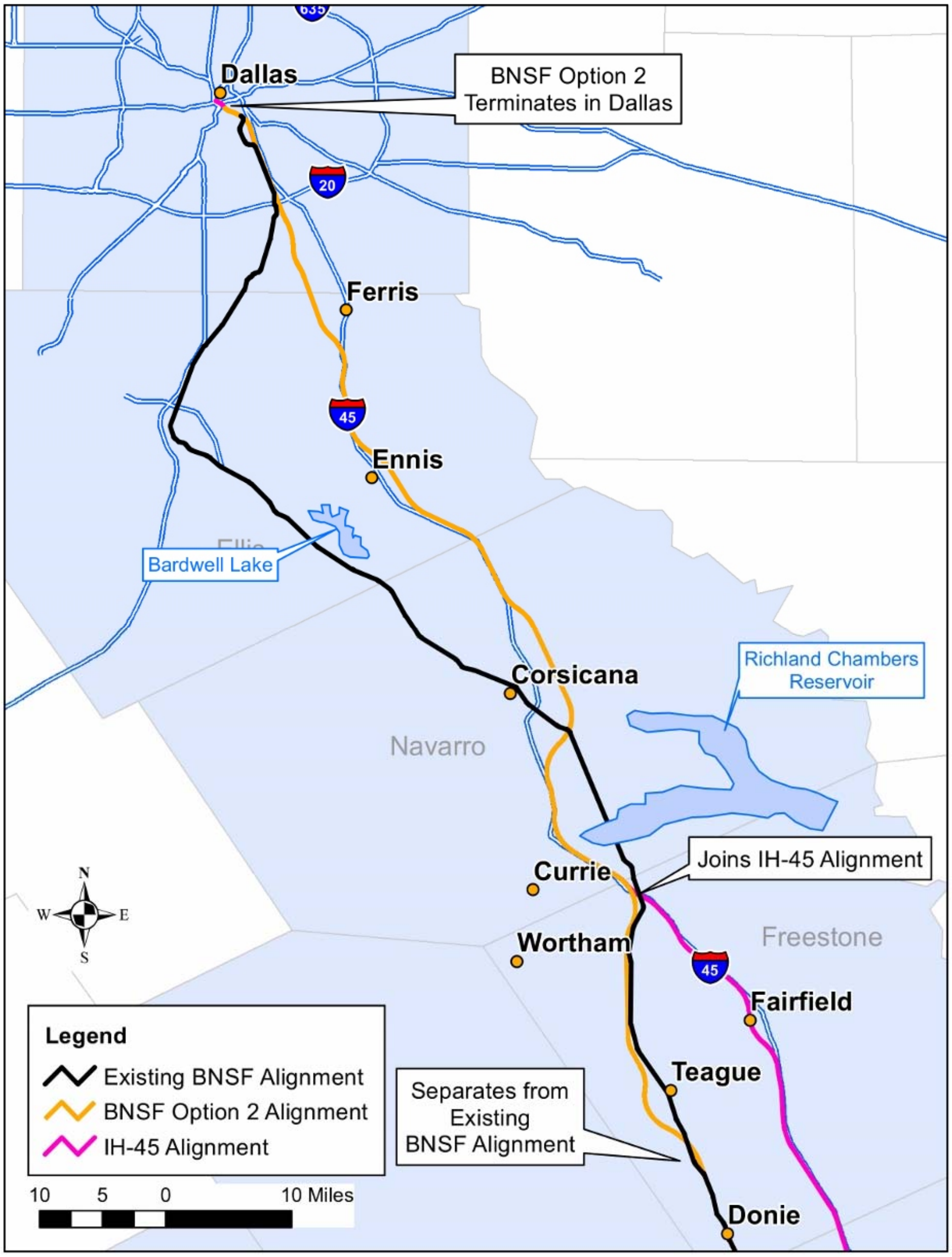

Figure 14 – BNSF Option 2

6.1.3.3 BNSF Option 3

The "BNSF Option 3" alignment leaves the BNSF alignment south of Teague and passes to the east of the city. BNSF Option 3 crosses the existing BNSF alignment south of Kirvin and continues north to pass west of the towns of Kirvin and Streetman before crossing the Richland Chambers Reservoir near the existing BNSF crossing as shown in Figure 15. BNSF Option 3 follows along IH-45 to pass east of Corsicana and Rice. Just to the north of Rice, it straightens to bypass approximately 3 mi (5 km) to the east of Ennis. The BNSF Option 3 alignment joins with the IH-45/UPRR corridors just south of Ferris as shown in Figure 16.

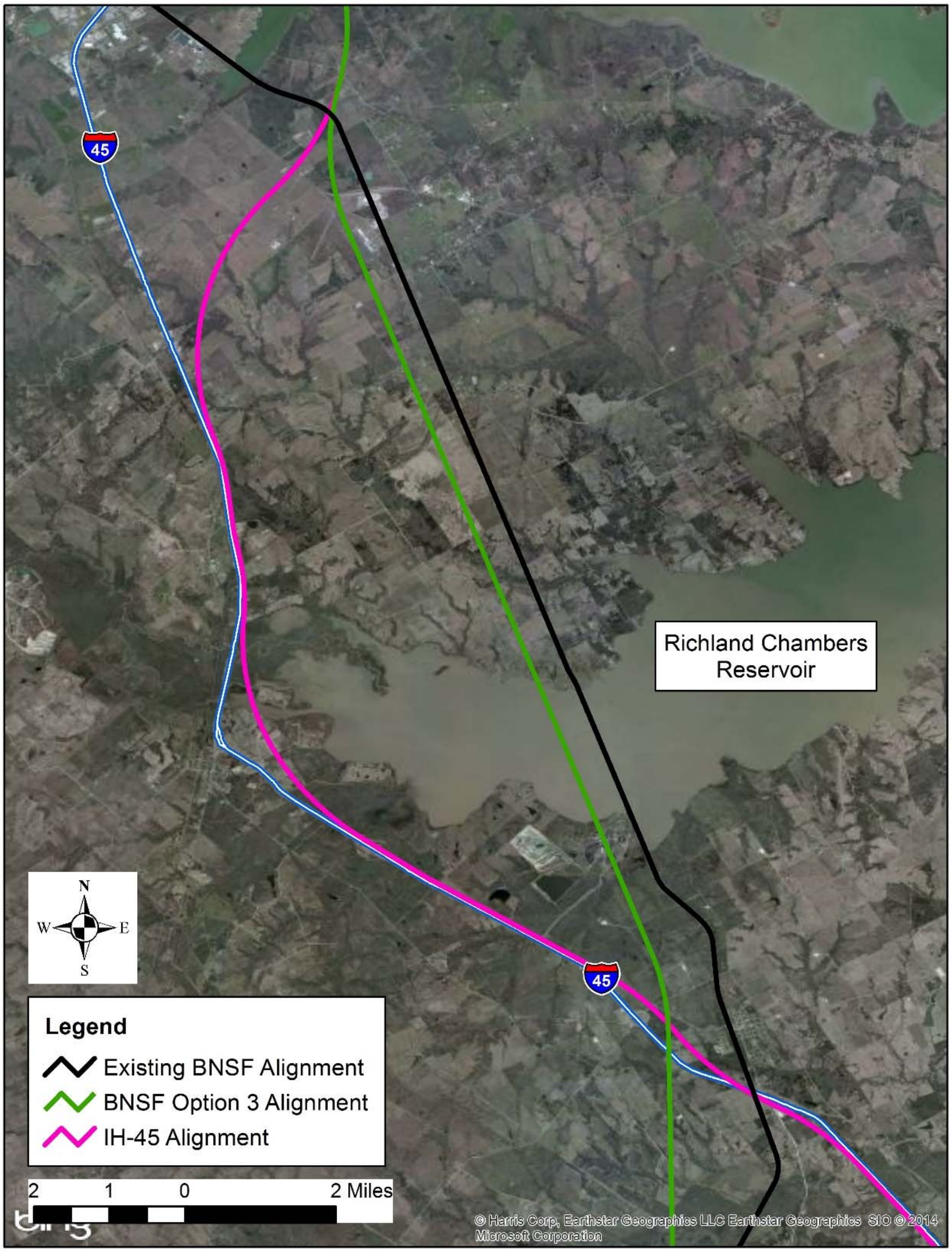

Figure 15 – BNSF Option 3 Crossing Richland Chambers Reservoir

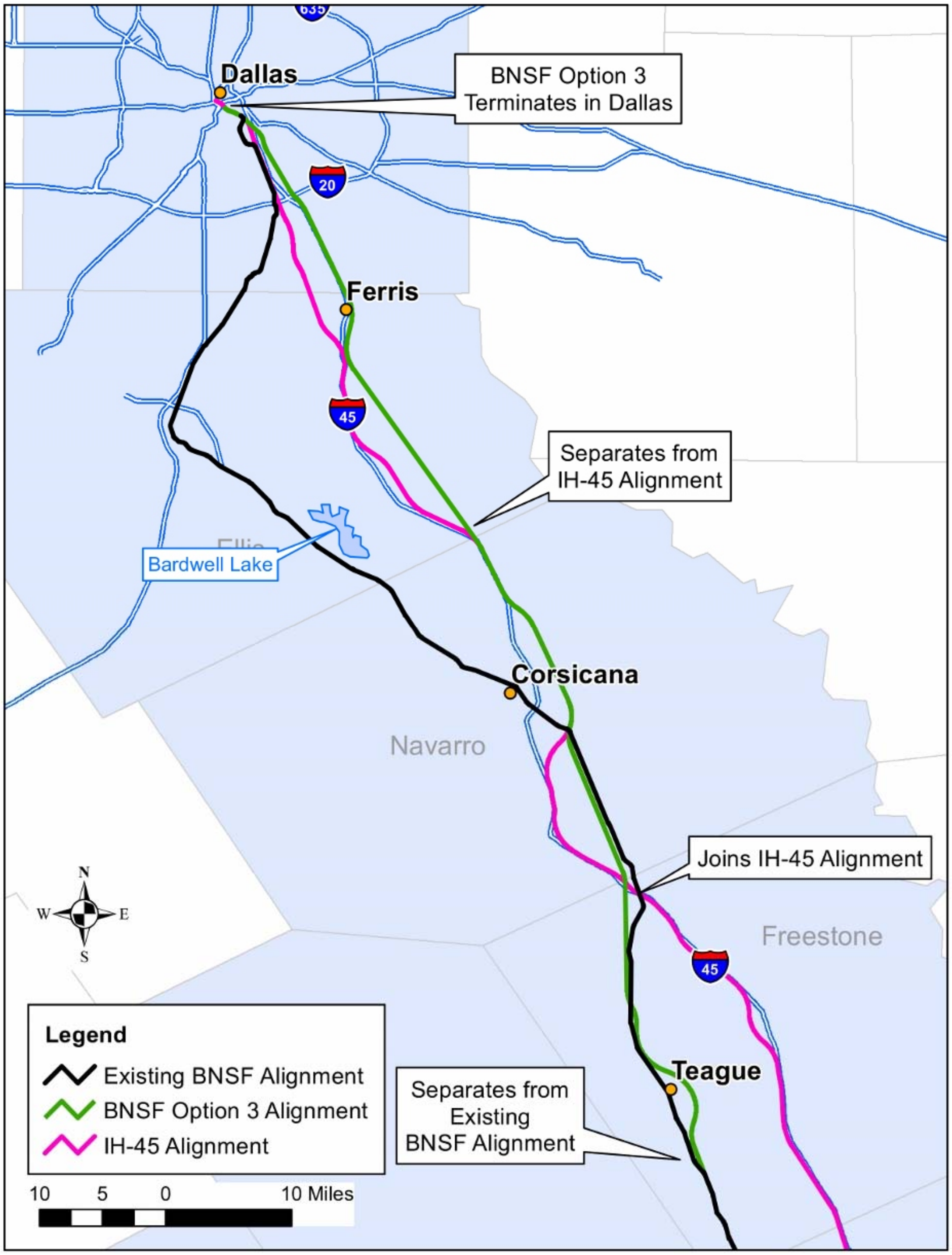

Figure 16 – BNSF Option 3

BNSF Option 3 is the only alignment alternative that stays on the east of IH-45 north of Ferris and follows the IH-45 & UPRR corridor closely until it crosses the Trinity River. Once across the Trinity River, BNSF Option 3 turns northwest to follow the UPRR ROW into Reunion Arena along the BNSF Option 1 alignment as shown in Figure 17.

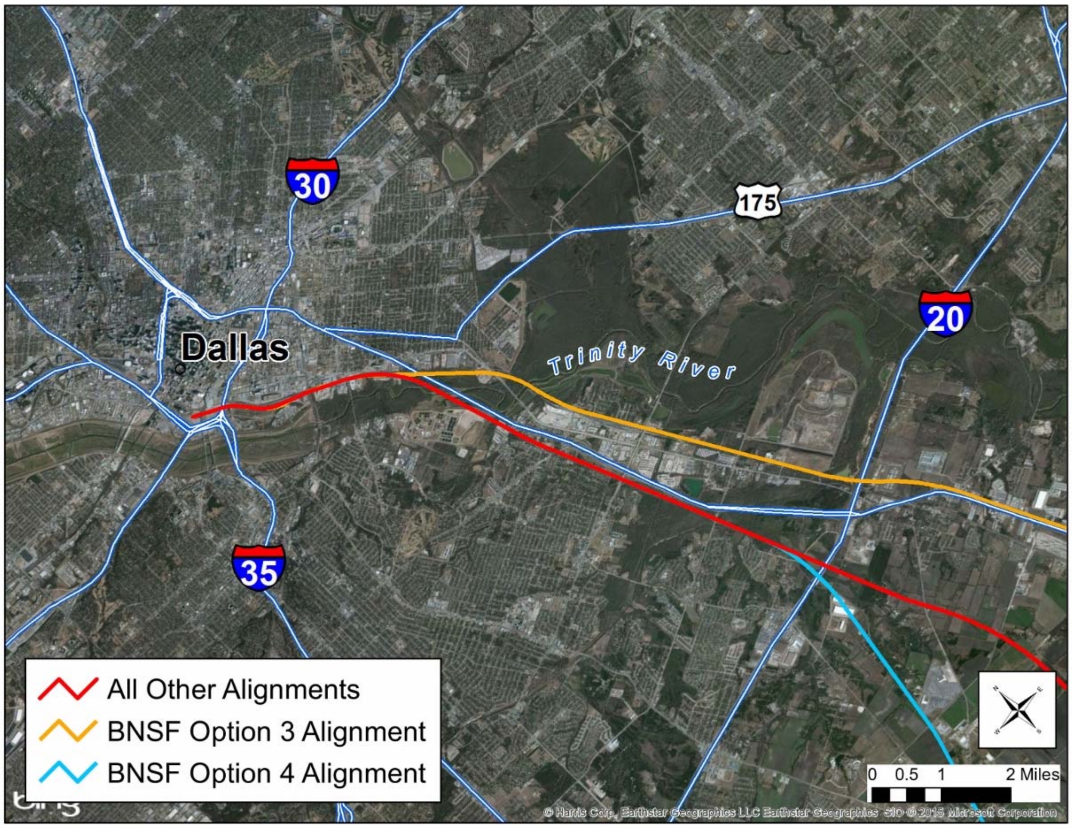

Figure 17 – Option 3 East of IH-45 Entrance to Dallas

6.1.3.4 BNSF Option 4

The "BNSF Option 4" alignment follows the BNSF Option 1 alignment as far north as Wortham where it separates from BNSF Option 1 and continues in a northwesterly direction along a greenfield alignment, bypassing Purdon, Silver City, and Frost as shown in Figure 18.

Figure 18 – BNSF Option 4

The BNSF Option 4 alignment then turns to the north just west of Italy and follows an abandoned railway line parallel to IH-35E and SH 77. BNSF Option 4 crosses IH-35E and SH 77 to the west of Lake Waxahachie and then continues north, bypassing Waxahachie to the west as shown in Figure 19. North of Waxahachie, the BNSF Option 4 alignment again crosses IH-35E and SH 77 to rejoin the BNSF Teague alignment south of Red Oak. BNSF Option 4 follows the BNSF alignment from just north of the IH-20 and IH-45 Interchange near Hutchins and continues on to Dallas.

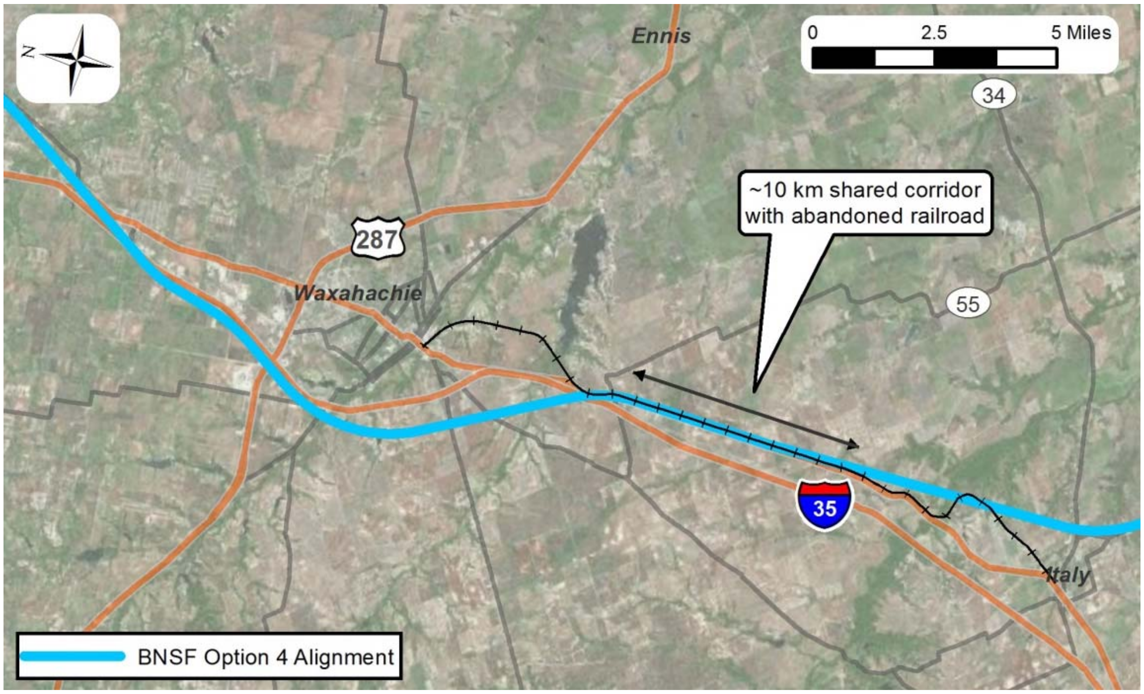

Figure 19 – Bypass of Waxahachie and Use of Abandoned Rail ROW

6.2 IH-45 Corridor

The basis of the two IH-45 Corridor alternatives is the existing alignment of the interstate highway as shown on Figure 20.

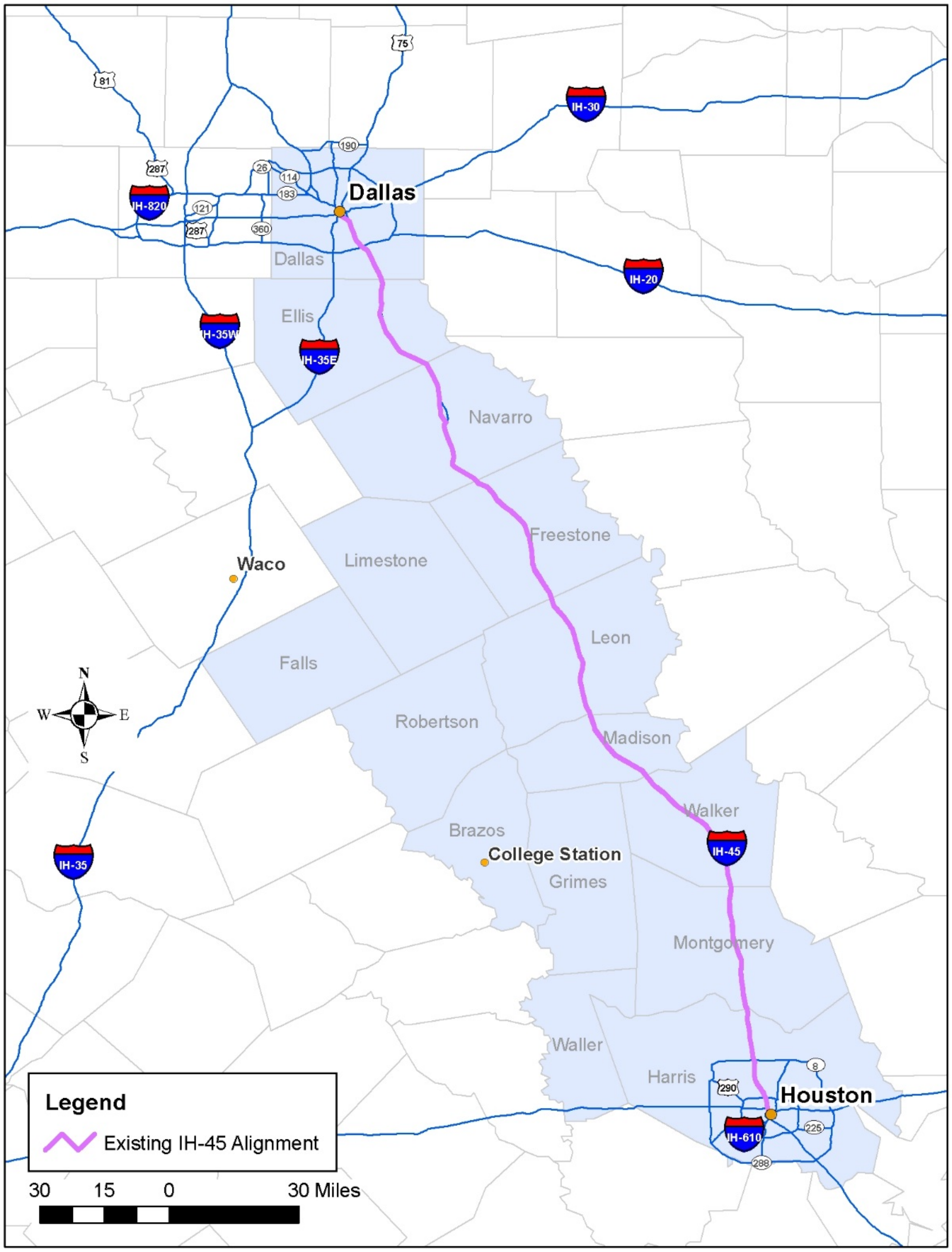

Figure 20 – Existing IH-45 Roadway

The "IH-45 Alignment" closely follows the IH-45 interstate highway from downtown Houston to downtown Dallas as closely as the design criteria of the HSR permits as shown in Figure 21.

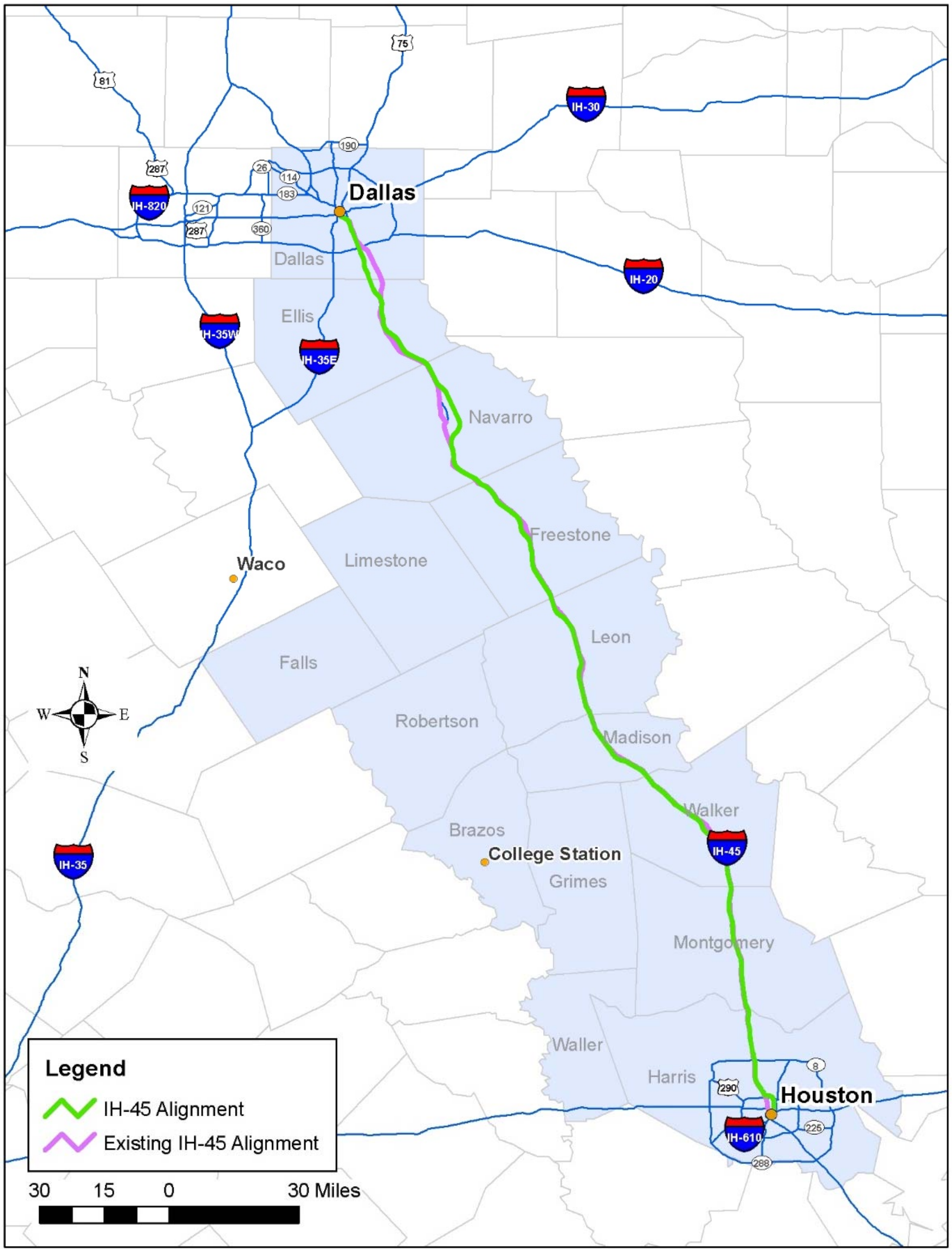

Figure 21 – IH-45 Alignment

Starting at the Post Office location in downtown Houston, the IH-45 alignment crosses the UPRR yard to the east of the Amtrak station and heads north out of Houston across the IH-10/IH-45 junction. The IH-45 alignment follows the IH-45 Corridor to the extent practical within the constraints of the significant development along the Corridor between Houston and Conroe as shown in Figure 22.

Figure 22 – IH-45 Alignment out of Houston

The roadway alignment of the IH-45 Corridor was designed for automobile curvature and speed characteristics so the IH-45 HSR alignment deviates from IH-45 frequently to meet operating speed goals. In addition to the curvature constraints derived from the road design criteria, there are frequent connections from the interstate to the local roadway network through interchanges and ramps to feeder roads. These frequent interchange and the dense commercial and residential development alongside the interstate would mean that the HSR is on an elevated structure throughout the Corridor from Houston to Conroe, approximately 45 mi (70 km), minimizing but causing significant disruption to existing development and access points along the highway. The elevated alignment, dense development and lack of construction lay down space would bring significant impacts to the Corridor, and close coordination with TxDOT, local roadway authorities, utility companies, and property owners would be required. The result of these many constraints would be extended construction periods for this section of the alignment.

From downtown Houston to Willis the “IH-45 with Hardy” alignment follows the UPRR Hardy Line. The IH-45 with Hardy alignment is identical to the other IH-45 alignment from Willis to Dallas. Both of these IH-45 alignments are shown in Figure 23.

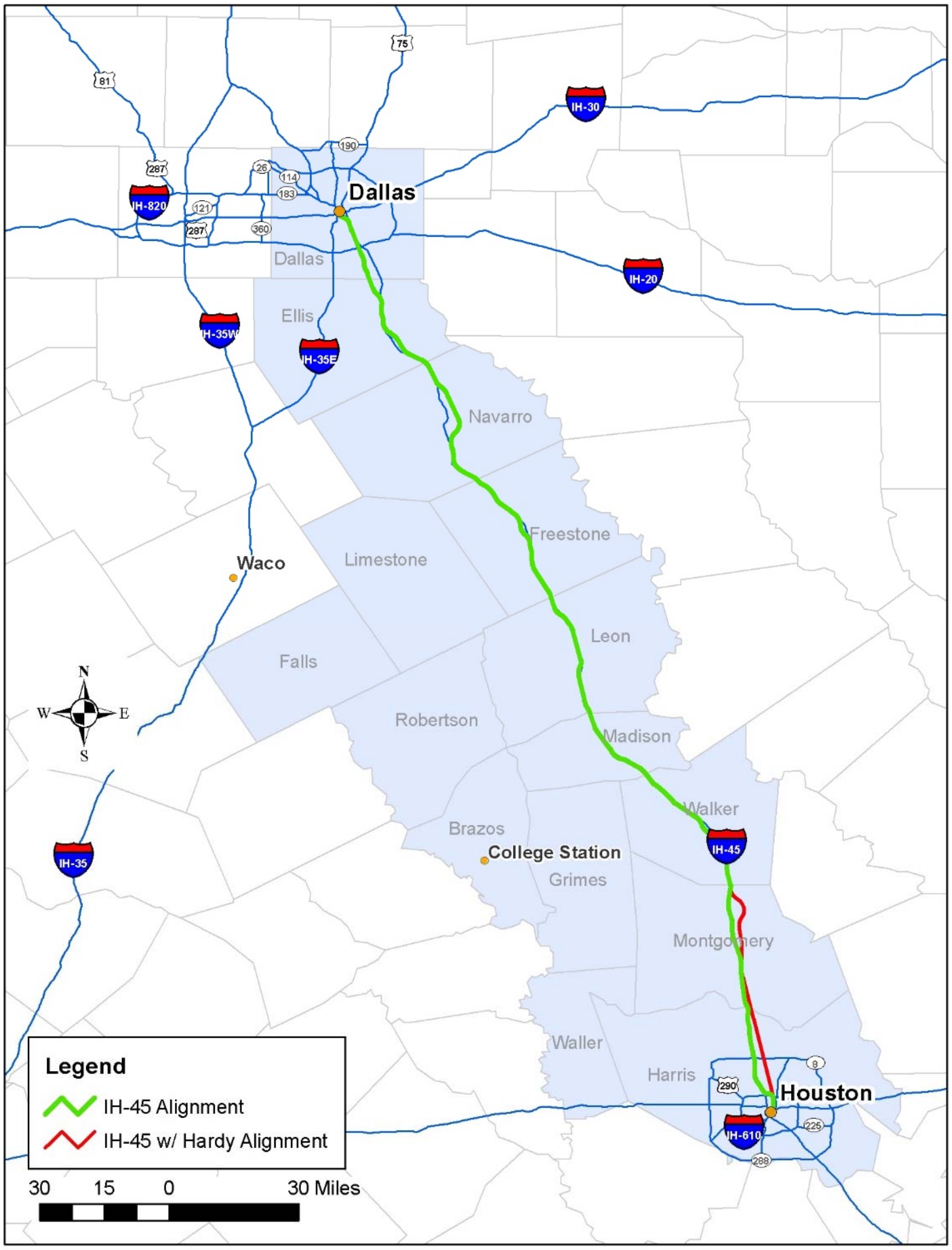

Figure 23 – IH-45 and IH-45 with Hardy Alignments

6.2.1 Considerations Regarding Shared-Use of the IH-45 Corridor Outside of the Houston Metropolitan Area

Locating an HSR alignment adjacent to an interstate highway is not without its challenges. The challenges include design speed curvature differences, development adjacent to the highway, and the numerous connecting roads that meet the highway as interchanges, underpasses, or overpasses.

In order to develop the geometrical relationship between HSR and the interstate, aerial photography was used to estimate the space available within medians between the main highway and frontage roads to develop approximate ROW boundaries as shown in Figure 24. The highway is generally at-grade but has several local streets that cross IH-45 both overhead and under grade.

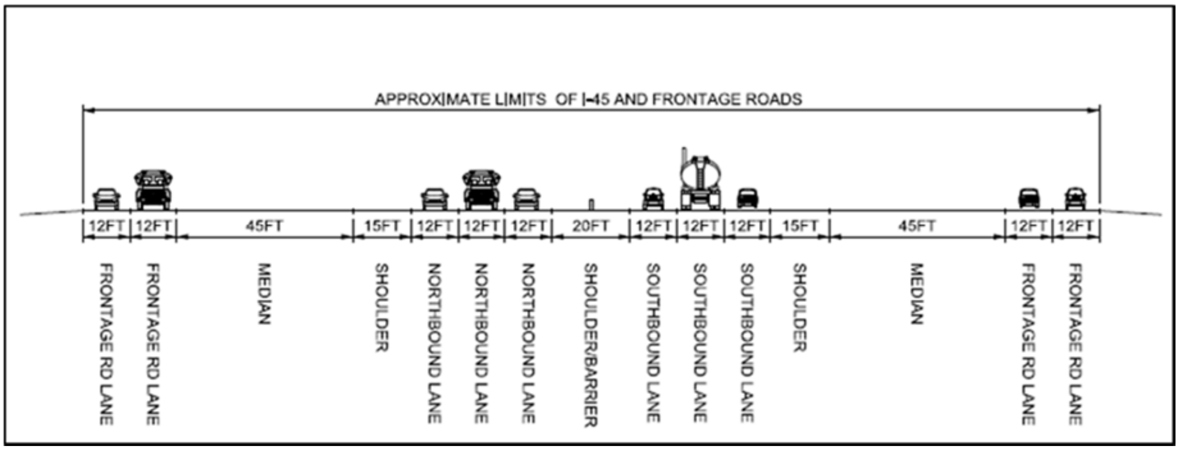

Figure 24 – Typical Schematic Section of IH-45

Detailed surveys and property mapping was not carried for this conceptual design.

The conceptual IH-45 alignment developed generally locates the HSR infrastructure between the existing IH-45 frontage road and southbound highway lanes as shown in Figure 25. Based on available aerial photography, this area would provide enough space for a viaduct structure; however, more detailed study would be required to assess roadway reconfiguration requirements and potential impacts. It is likely that all existing roadways crossing above IH-45 would be impacted. Use of an at-grade embankment could be investigated, but significantly greater reconfiguration of existing roadways would be expected and barrier separation would be required along both sides of the HSR tracks. The at-grade approach would likely require reconfiguration of highway ramps.

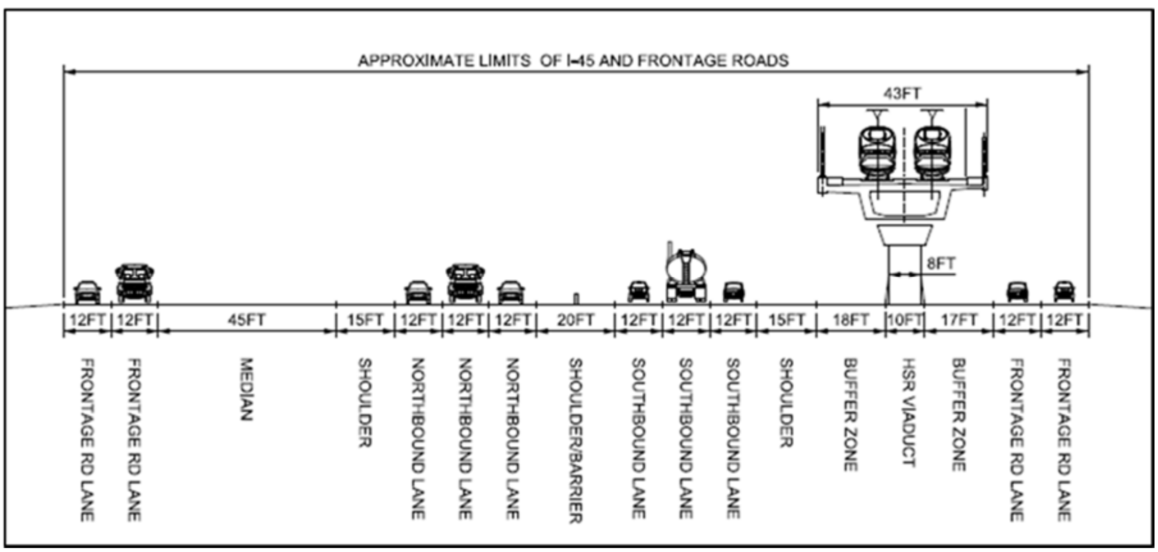

Figure 25 – Proposed HSR Typical Section along IH-45 Looking South

Locating the HSR infrastructure within the space between the frontage road and highway lanes rather than adjacent to the frontage road would reduce impacts to adjacent properties that have developed near the IH-45 highway and have access to the frontage road as shown in Figure 26. However, this median space between the frontage road and the highway lanes is also used for on and off ramps and viaduct design would need to span each of these ramps.

Figure 26 – Proposed HSR Location between Highway Lanes and Frontage Road

While the existing roadway configuration generally provides space for the desired HSR infrastructure, following the IH-45 ROW presents some challenges, namely existing development along the highway, the slower speed highway alignment geometry, and highway overpasses.

Development of an alignment that closely follows the median between the IH-45 frontage road and highway lanes would be possible, but following the relatively tight curvature of the existing highway would require significant speed restrictions along the alignment. As illustrated by Figure 27, the curves shown in red illustrate the smaller radius curves needed to follow the existing IH-45 ROW, which would require speed restrictions as low as 115 mph (186 km/h) in the area of Palmer. This is because the highway was designed for automobile operating speeds, which are significantly less than the desired 205 mph (330 km/h) operating speed for the HSR.

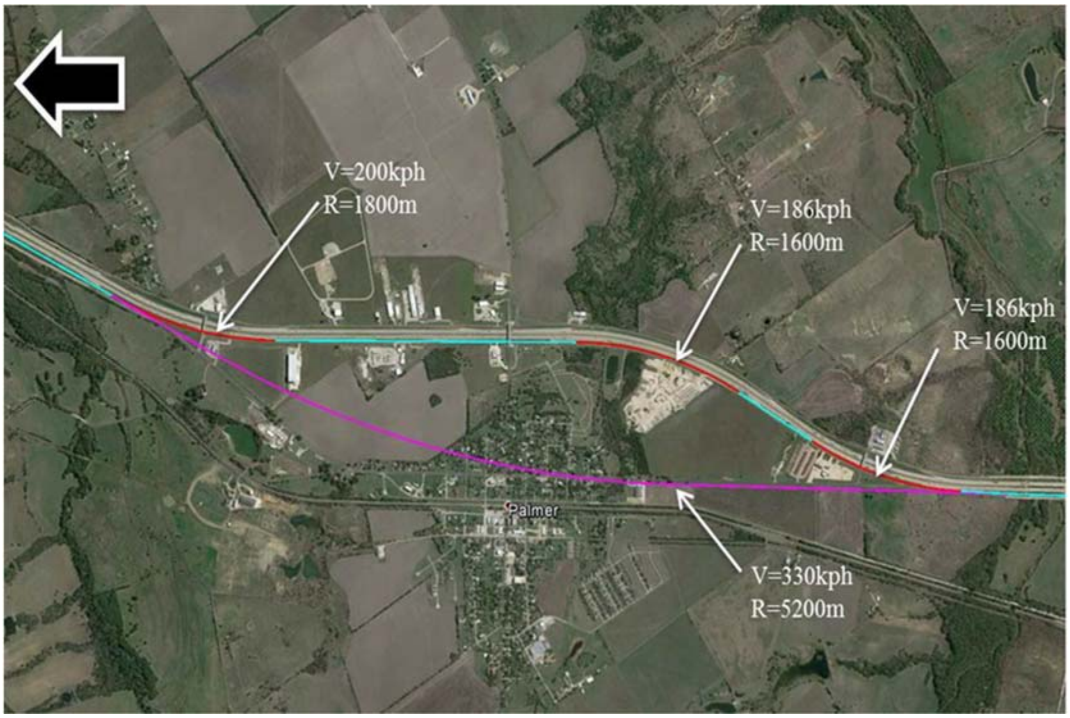

Figure 27 – Proposed HSR Options (Town of Palmer)

In order to support the desired operating speed of 205 mph (330 km/h), the HSR curves would need to have a minimum radius of 17,060 ft (5,200 m), assuming that the maximum amount of track superelevation is used. Using this high radius curve would not allow the HSR alignment to stay within the IH-45 ROW. As shown in Figure 27, the magenta curve illustrates that the use of the minimum allowable radius curve of 17,060 ft (5,200 m) would force the HSR alignment away from the IH-45 ROW and through the center of Palmer which would cause unacceptable impacts. Hence, to avoid impacts to communities along the highway, significant lengths of greenfield alignment deviating from IH-45 would be required that would allow the HSR alignment to meet operating speed requirements while also bypassing the communities of Palmer, Ennis, Corsicana and Madisonville.

Depending on the IH-45 curve direction, another conflict that would result from using the desired minimum 17,060 ft (5,200 m) radius curve for HSR when following the IH-45 ROW would be the need to cross back and forth over the existing highway. As shown in Figure 28, the red curve shows the reduced curve radius that allows the HSR to follow the IH-45 alignment, but that causes a speed restriction of 112 mph (180 km/h). When the curve radius is brought up to the desired minimum 17,060 ft (5,200 m) radius shown in magenta, the curve would be so wide that it would cross the existing highway at two different locations. This would cause significant viaduct design issues given the long spans required to cross the highway lanes on a skew, and significant constructability concerns to construct these viaduct sections over the active highway.

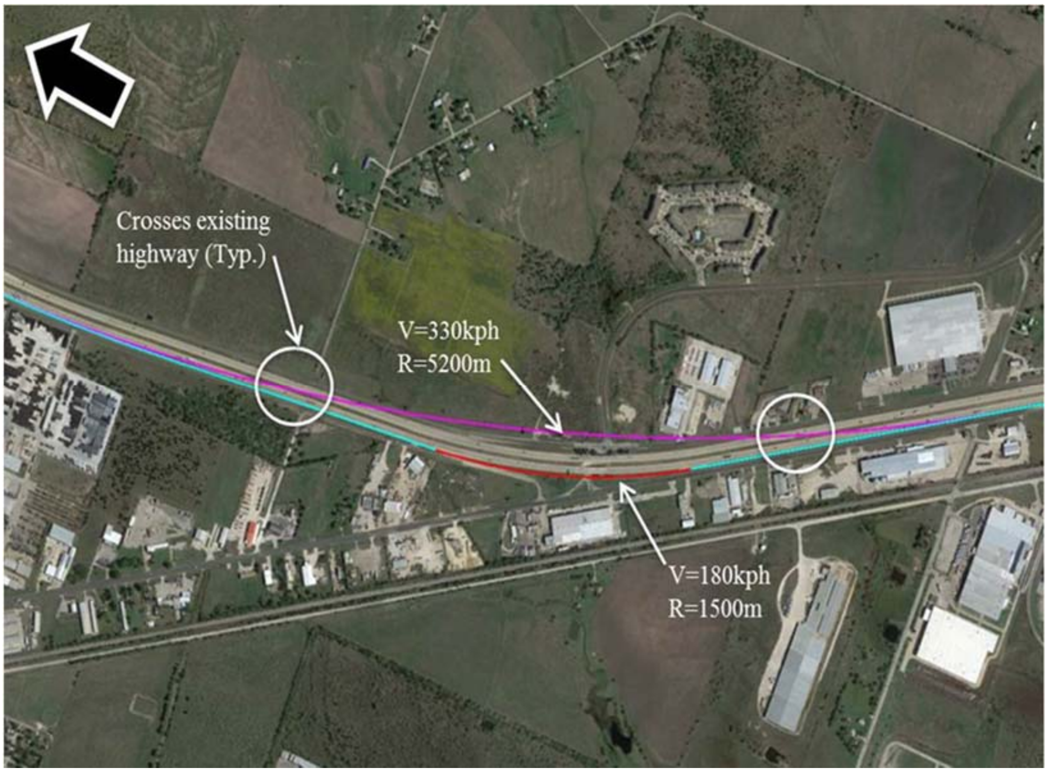

Figure 28 – Proposed HSR Options (South of Ennis)

Along the middle of the corridor, as shown in Figure 29, the required 17,060 ft (5,200 m) minimum radius curve could be accommodated without major impacts to the existing IH-45 highway in many locations, but some localized realignment of the IH-45 frontage road or crossing of the frontage road by the HSR viaduct would be required.

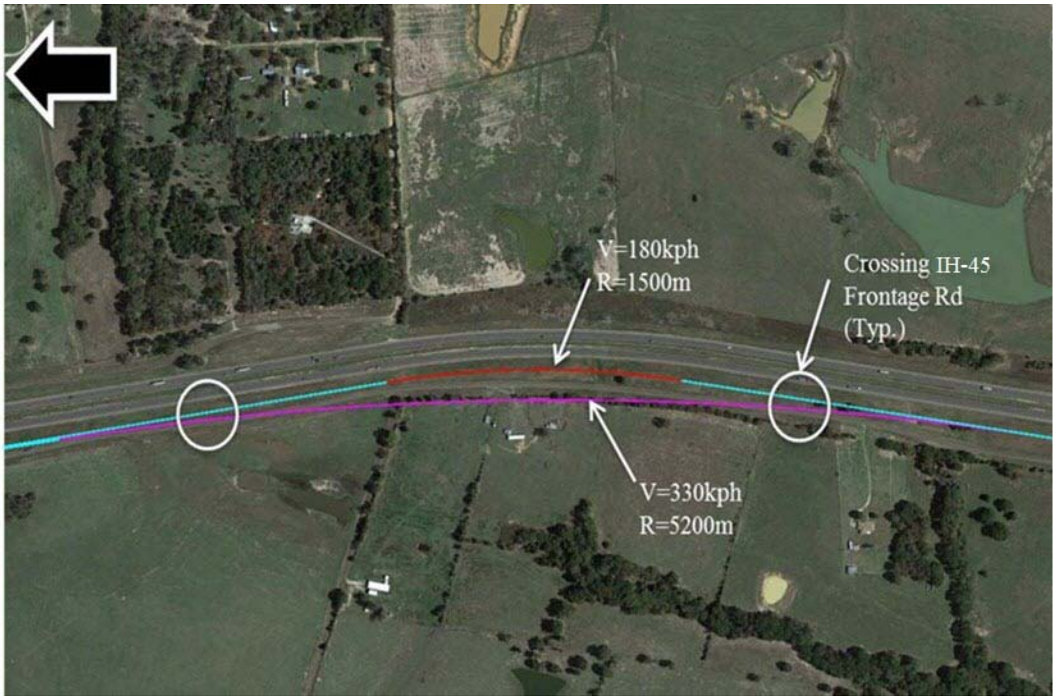

Figure 29 – Proposed HSR Options (South of Buffalo)

These considerations were taken into account in development of the proposed UC with IH-45 alignment. For the segment of the alignment utilizing the ROW of IH-45 with that alignment, the proposed HSR infrastructure would be located within the existing median between the main IH-45 highway lanes and the frontage road. It is expected that the HSR system would be constructed on an elevated viaduct to minimize impacts to the existing ramps between the highway lanes and the frontage road. Localized realignment of certain segments of the highway and frontage road would be required. Impacts to roadways crossing above IH-45 would need to be studied in further detail, but it is expected that the HSR viaduct could be elevated above most of these roadways.

Following the IH-45 alignment would, however, require that the HSR alignment use the minimum desirable curvature and maximum permissible superelevation to achieve the desired operating speed to achieve the minimum impacts to IH-45 and the connecting roadways. Hence, the alignment would not be as desirable as the UC alignment from an operations and maintenance perspective. Moreover, construction within the ROW of IH-45 would entail careful staging of work and close coordination with TxDOT to ensure that impacts to traffic are appropriately mitigated.

6.2.2 IH-45 Alignment Option

The following analysis relates specifically to the "IH-45 Alignment" option, one of two alignments in the IH-45 Corridor.

To the north of Conroe, the IH-45 Alignment becomes more rural with development generally limited to townships adjacent to IH-45. North of Willis the IH-45 Alignment follows IH-45 closely through the Sam Houston National Forest before bypassing Huntsville to the west. After bypassing Huntsville, the IH-45 Alignment rejoins IH-45 and closely follows it to Richland with minor deviations at Madisonville, Centerville, Buffalo, Fairfield, and Streetman. A typical bypass of these townships is shown in Figure 30.

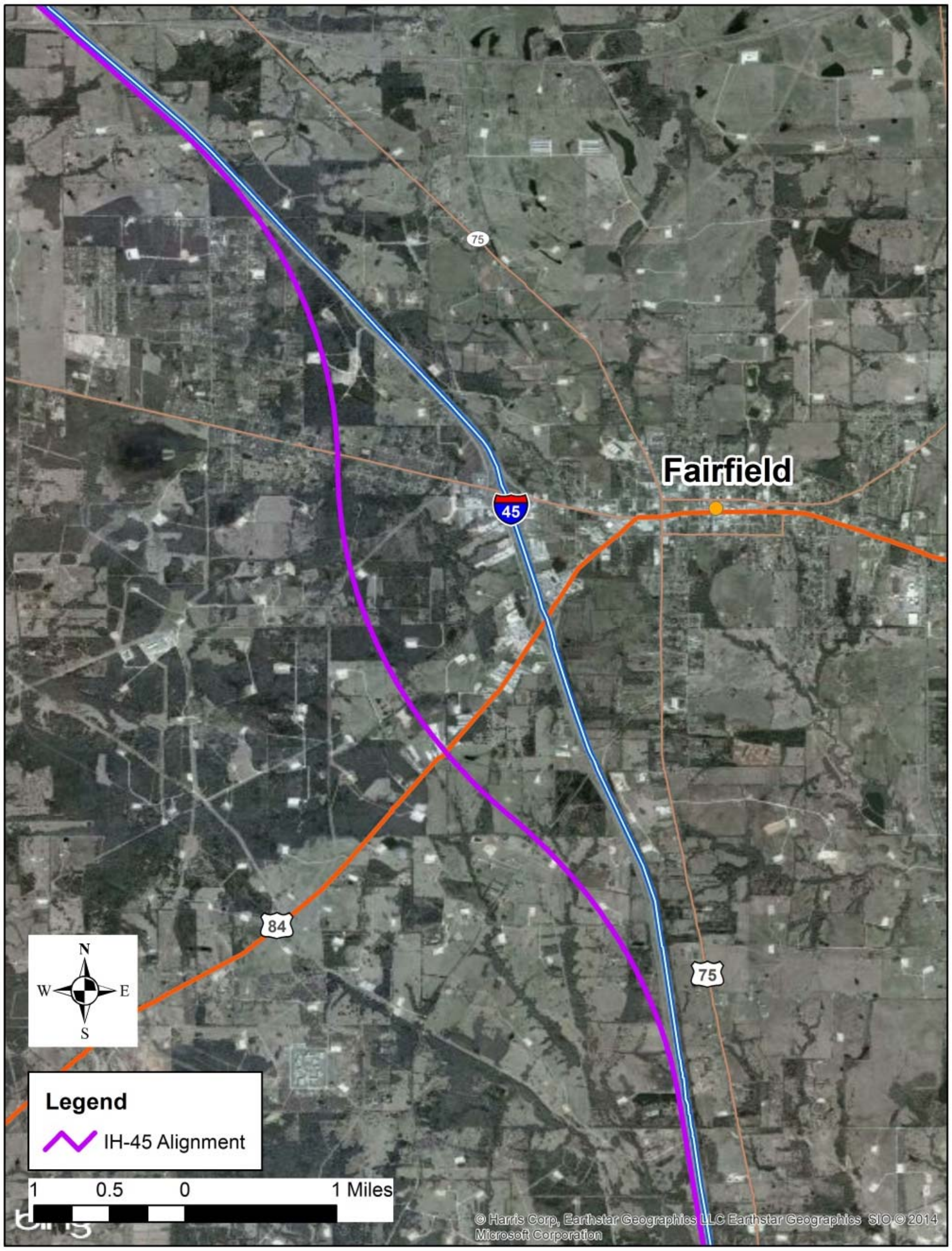

Figure 30 – Typical Deviation of IH-45 Alignment to Bypass Local Township

A typical cross-section of the IH-45 Alignment in the rural area of IH-45 is shown in Figure 31.

Figure 31 – Typical HSR Configuration along Rural IH-45 Segment

At Richland, the IH-45 Alignment turns north across the western edge of the Richland Chambers Reservoir, following IH-45 to just south of Angus, as shown in Figure 32.

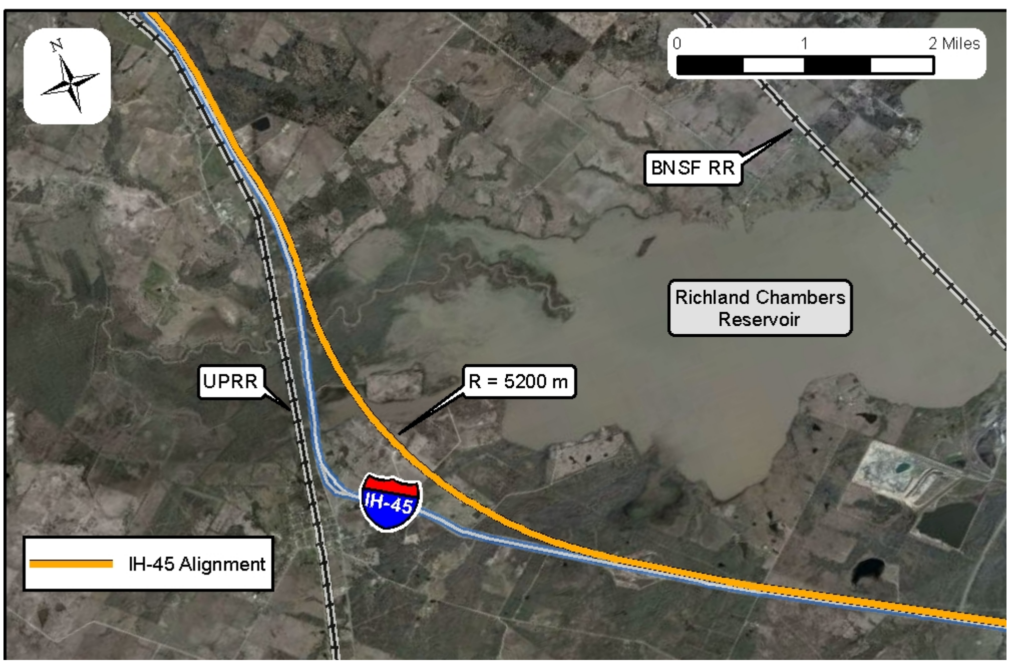

Figure 32 – IH-45 Alignment at Richland Chambers Reservoir

Once around the reservoir, the IH-45 Alignment takes an easterly route around Corsicana before rejoining IH-45 and following the interstate very closely, bypassing Rice, Alma, Ennis, and Palmer to the east, until just south of Ferris. At this point, the IH-45 Alignment crosses IH-45 and UPRR to converge with the

BNSF Teague alignment just south of IH-20, passing to the west of Ferris and then heading north to Dallas along the BNSF alignment as shown in Figure 33.

Figure 33 – Common Alignments Approaching Dallas

6.2.3 IH-45 with UPRR Hardy Line Option

The following analysis relates specifically to the "IH-45 with Hardy" alignment, one of two alignments alternatives in the IH-45 Corridor.

This IH-45 with Hardy option utilizes a portion of the UPRR Hardy subdivision line to the east of IH-45, as an alternative way to travel north out of Houston as shown in Figure 34.

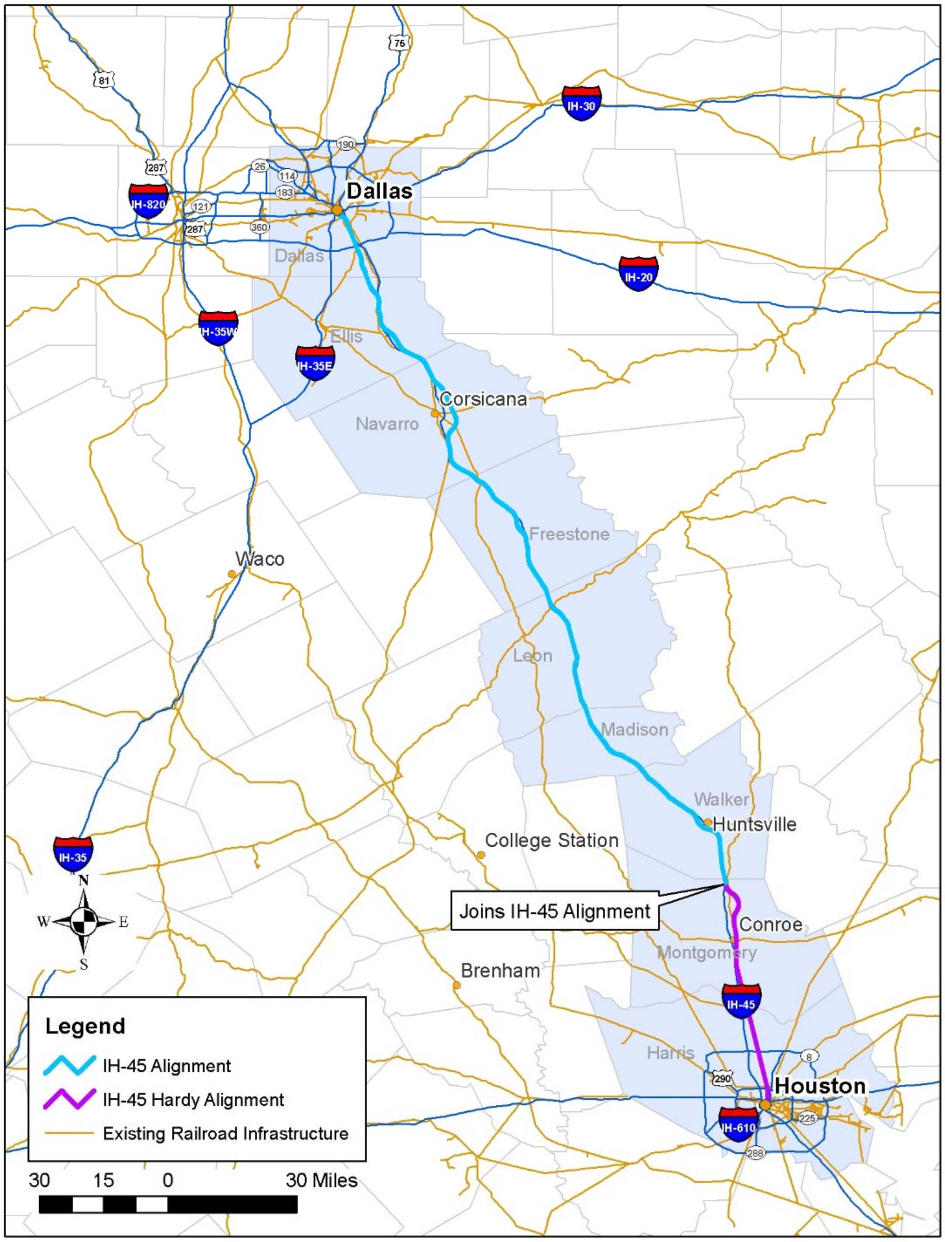

Figure 34 – IH-45 with UPRR Hardy Line Option

Starting at the terminal station in downtown Houston, the IH-45 with Hardy alignment option follows the UPRR Hardy Subdivision across IH-10, through the UPRR rail yards, and across IH-610 to the north, as shown in Figure 35, and continues north passing through Spring and Conroe.

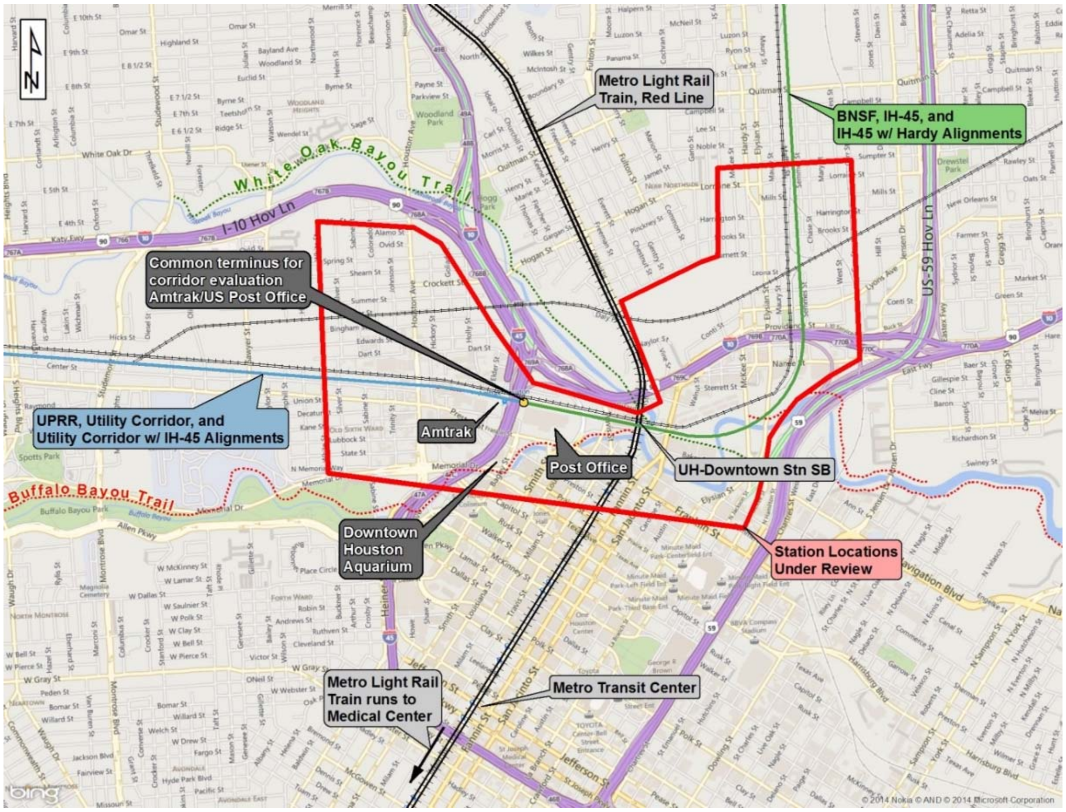

Figure 35 – IH-45 Hardy Alignment Departure from Houston

Like the IH-45 Alignment described above, this IH-45 with Hardy alignment consists of dense urban/suburban development with a mixture of residential, commercial, and industrial development along this route. However, as a railroad corridor alignment, the IH-45 with Hardy Alignment is generally straighter than the IH-45 Alignment and has more industrial and commercial properties along its length. Nonetheless, to minimize disruption to access and current freight operations, significant sections of this part of the IH-45 with Hardy alignment are assumed to be elevated. Figure 36 shows the differences between IH-45 and IH-45 with Hardy in the greater Houston area.

Figure 36 – IH-45 and IH-45 with Hardy in Houston

North of Conroe, the IH-45 with Hardy alignment separates from the UPRR Hardy alignment to pass east of Willis before crossing back over the UPRR alignment and IH-45 south of New Waverly. The IH-45 with Hardy then joins with the IH-45 alignment and continues along that route to Dallas as shown in Figure 37.

Figure 37 – IH-45 with Hardy Alignment Joining the IH-45 Alignment at Willis

6.3 UPRR Hempstead Alignment Option

The "UPRR Alignment" follows the existing UPRR Hempstead line from Houston to Dallas, which runs through Hockley, Navasota, and College Station, before crossing the BNSF line at Teague to enter Dallas. The overall existing alignment of the UPRR Hempstead line is shown in Figure 38.

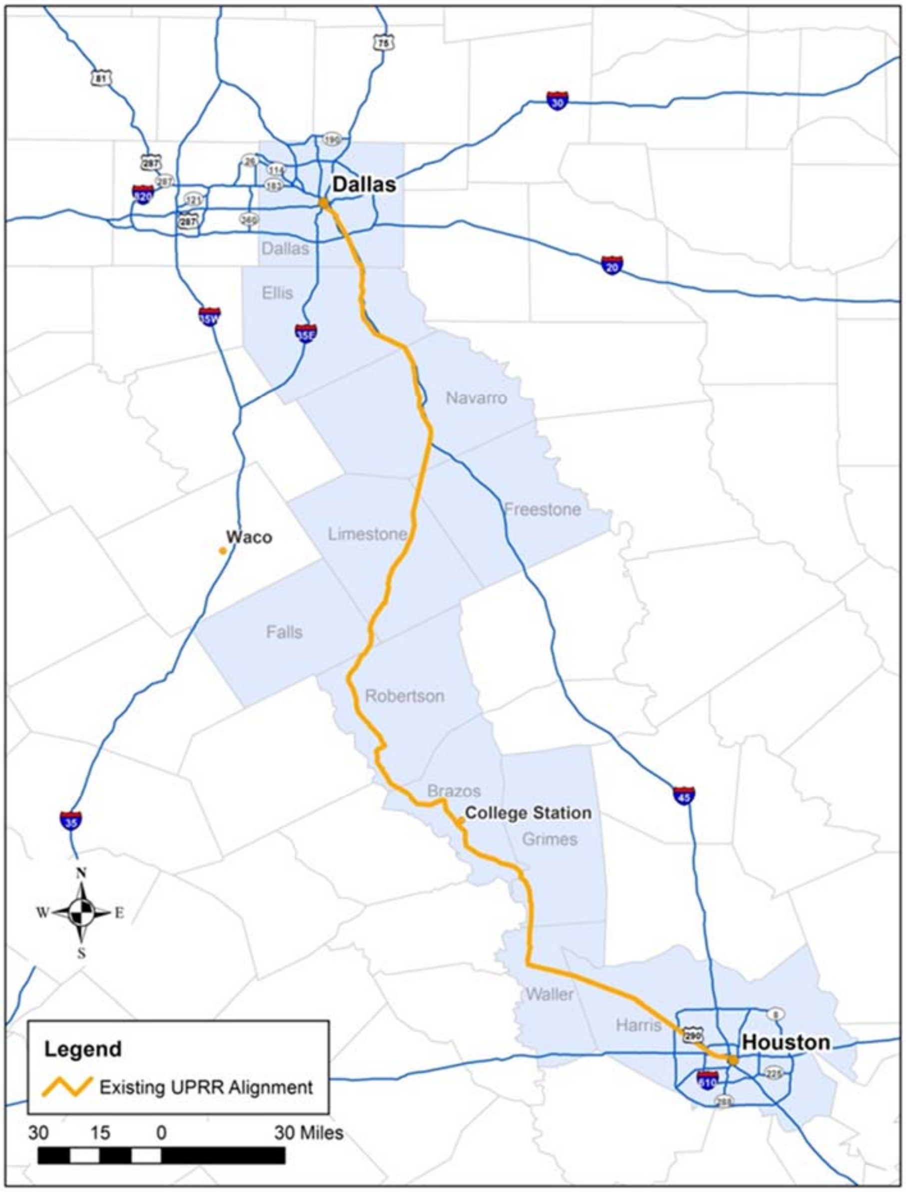

Figure 38 – Existing UPRR Railroad

The HSR "UPRR Alignment" alternative follows the existing freight alignment as shown in Figure 39. However, the existing UPRR Hempstead freight line is more highly curved than the existing BNSF Teague line. As such, the estimated length of shared ROW corridor is significantly less.

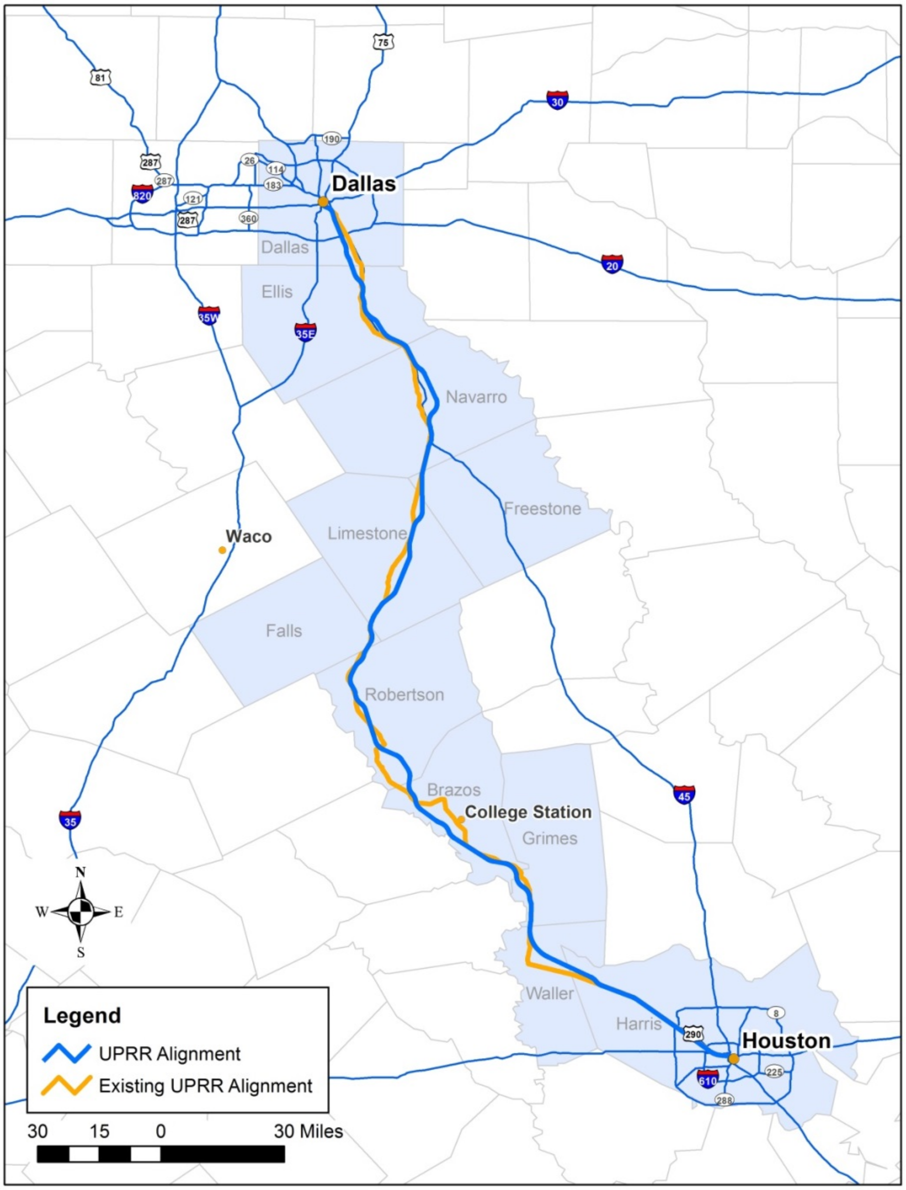

Figure 39 – UPRR Option

Starting at the downtown Houston terminal station, the HSR UPRR Alignment follows the UPRR Hempstead line westward out of Houston generally along the UPRR Corridor and Hempstead Road as shown in Figure 40.

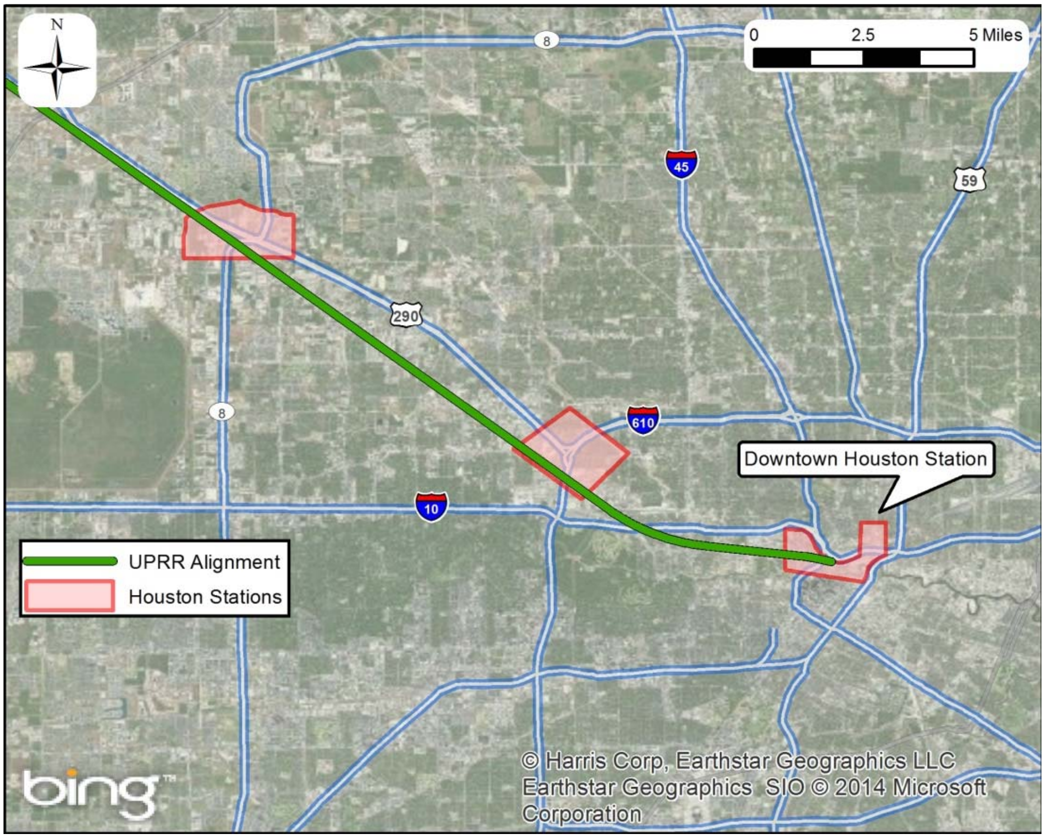

Figure 40 – UPRR Alignment Along UPRR/Hempstead Road

Along the Hempstead road there are significant engineering and constructability concerns with the introduction of the HSR to the corridor. These are further discussed in section 6.3.1.

The HSR UPRR Alignment exits the Houston metropolitan area to the northwest, generally parallel to US 290. Near to Hockley, the HSR UPRR Alignment crosses US 290 and UPRR, and diverges significantly from the UPRR to the east of Hempstead, where the UPRR line makes a sharp turn to the north to Navasota as shown in Figure 41.

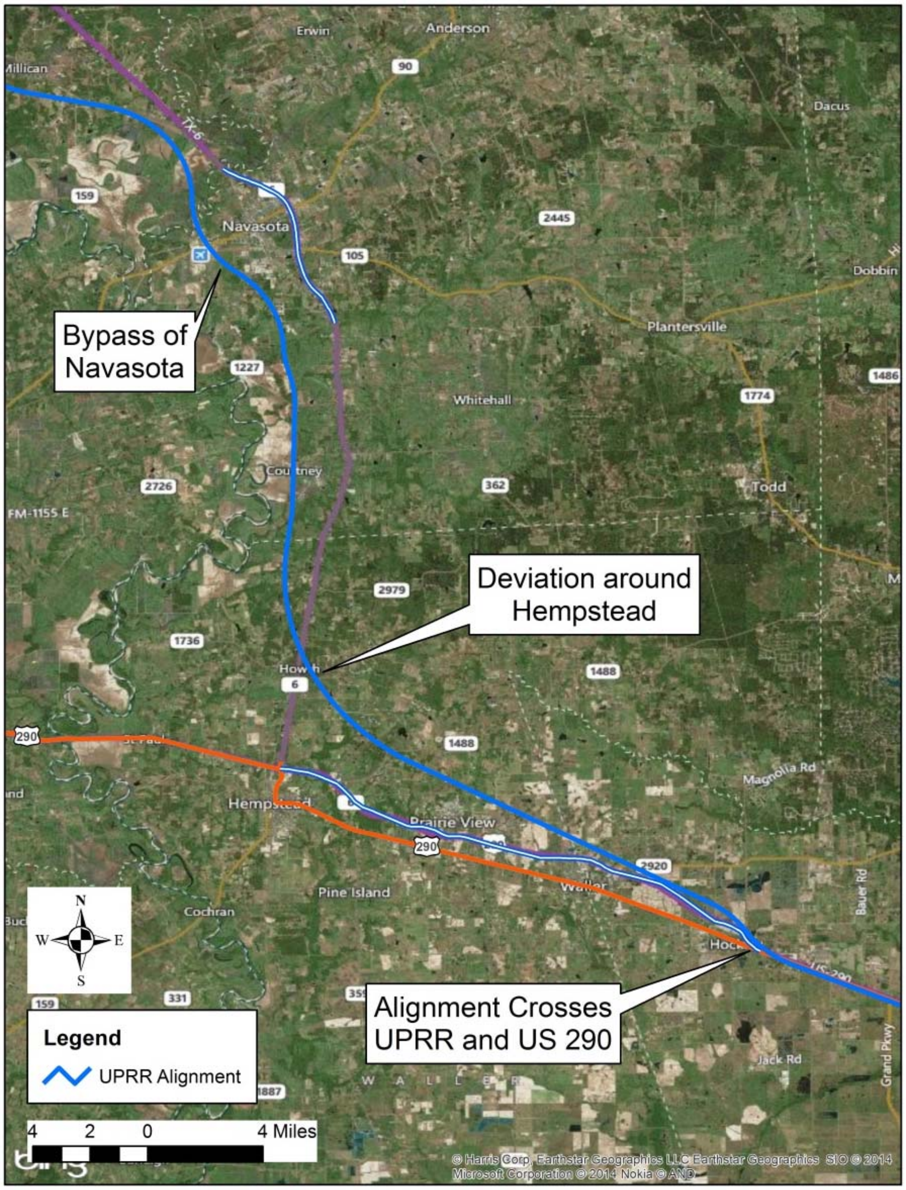

Figure 41 – UPRR Alignment Turning to North near Hempstead

The HSR UPRR Alignment bypasses Bryan/College Station to the west as shown in Figure 42. This bypass follows along the west side of SH 47. This area to the north of Easterbrook airport has been designated as “Bioresearch Valley” by Texas A&M University. See section 7.3.2 for further details of the area available for a station.

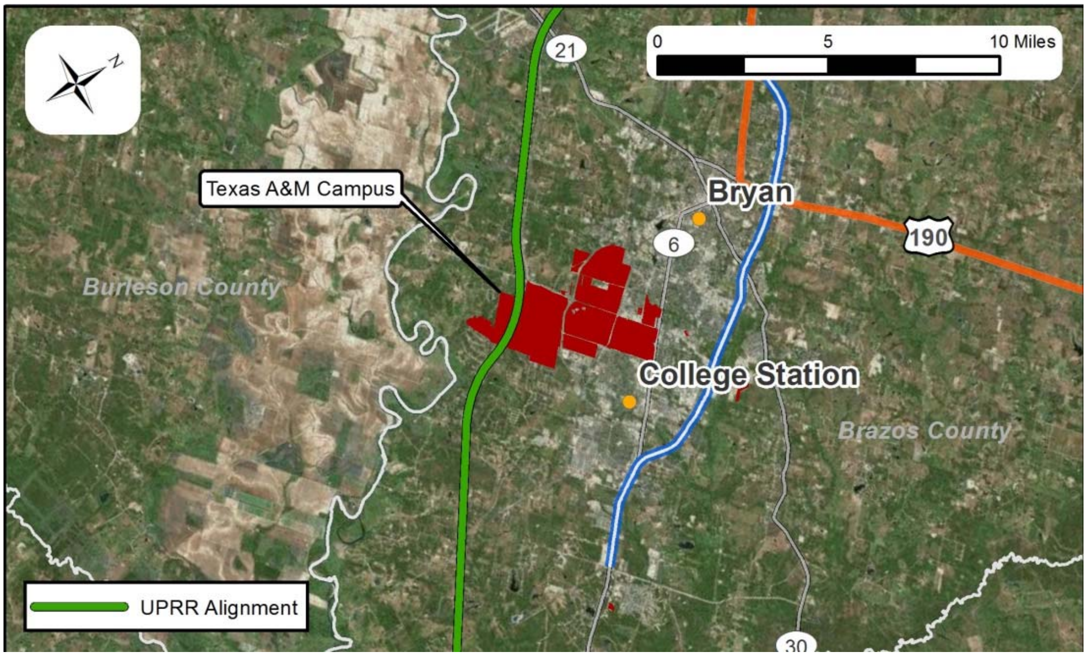

Figure 42 – UPRR Alignment bypassing Bryan/College Station

From Bryan, the HSR UPRR Alignment continues to follow the existing UPRR freight ROW north and north east past Hearne, Bremondm and Mexia until it reaches Richland as shown in Figure 43.

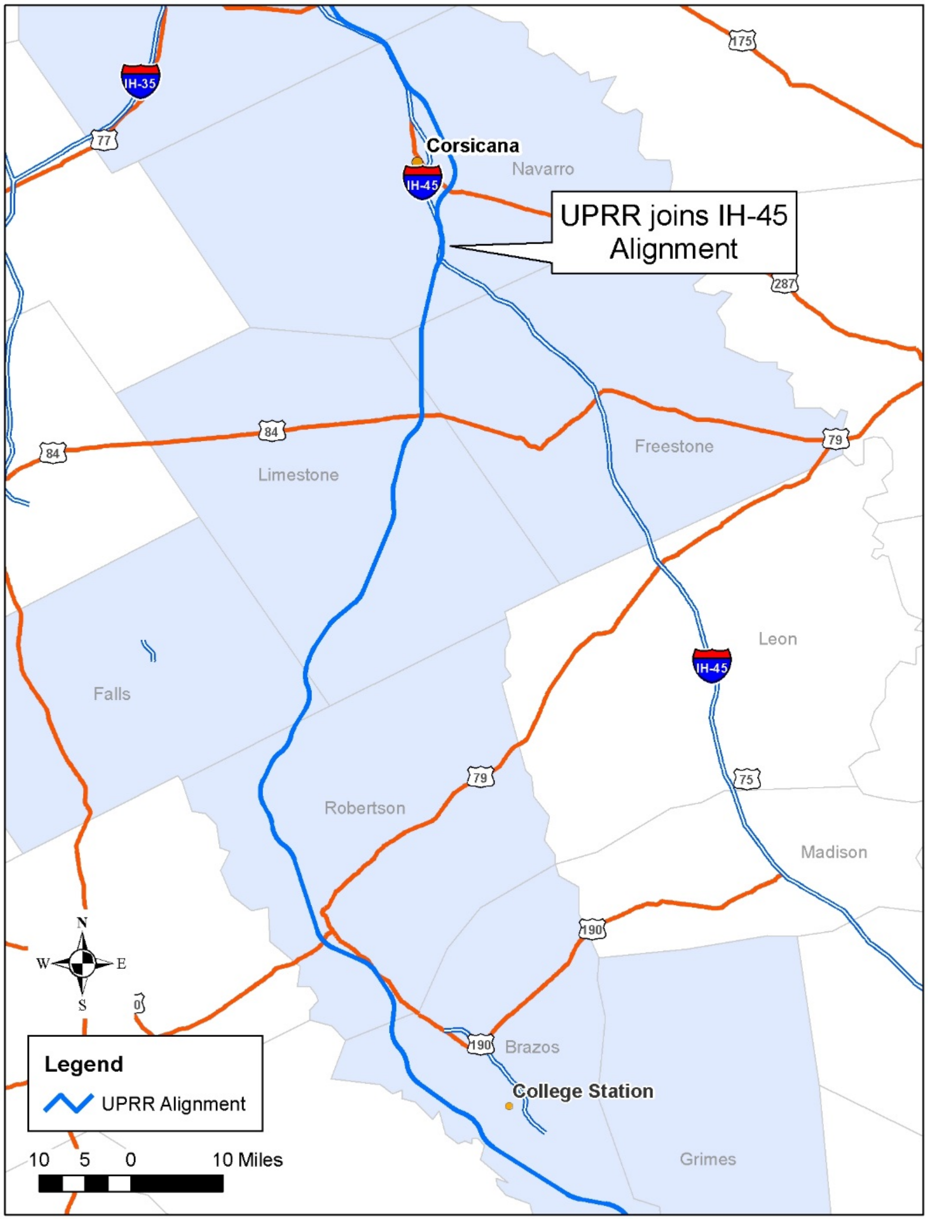

Figure 43 – UPRR Alignment North of Bryan/College Station

The HSR UPRR Alignment converges with the IH-45 Alignment just to the north of Richland, as both alignments pass the western edge of the Richland Chambers Reservoir. The remainder of the HSR UPRR Alignment is the same as the description of the IH-45 Alignment in section 6.2.2.

6.3.1 Conceptual Space Reallocation of Hempstead Road

For both the UPRR Corridor and the Utility Corridor, a conceptual space reallocation of Hempstead Road was developed to evaluate the spatial feasibility of constructing an elevated HSR viaduct within the ROW of Hempstead Road. Based upon this analysis, it appears feasible to allocate the existing 100-foot wide ROW in a way that could provide the same amount of roadway space to vehicular traffic, although care would be required to configure center turn pocket lanes at intersections and to coordinate the lengths available for queue space given heavy truck traffic.

Two alternatives were considered in this preliminary analysis as outlined below.

Hempstead Road Configuration 1: The travel lanes of Hempstead Road would be reconfigured to lie along the north side of the ROW to make space for a new HSR viaduct between the reconfigured roadway and the UPRR ROW as shown in Figure 44.

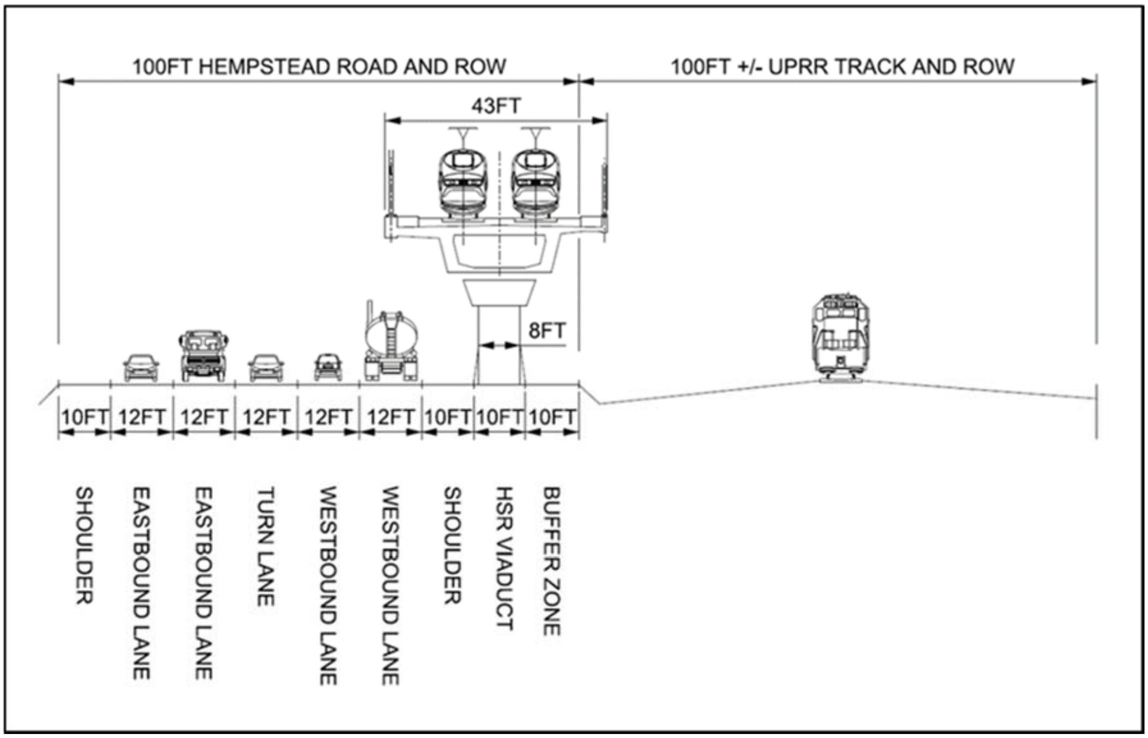

Figure 44 – Hempstead Road Configuration 1 – HSR Viaduct Adjacent to UPRR ROW

As shown in the conceptual cross section for Hempstead Road Configuration 1, the 100-foot wide ROW provides sufficient space for the development of a HSR viaduct without construction within the ROW of UPRR. Similar to existing conditions, the reconfigured roadway would include two travel lanes in each direction with a continuous center turn lane.

As shown in Figure 44, a 10 ft (3 m) wide buffer zone is provided between the viaduct supporting columns and the UPRR ROW. Given the expected viaduct deck width of approximately 43 ft (13 m), the viaduct would extend over the UPRR ROW by approximately 7 ft (2m) and require an aerial easement. During more detailed design, it may be deemed necessary to provide space along the north side of the roadway to accommodate drainage and utilities, or to ease property access reconfigurations. Additionally, a continuous barrier wall may be required along the edge of the UPRR ROW to minimize liability concerns. While these needs could be accommodated given the 10-foot wide buffer provided in the conceptual configuration shown, these measures would increase the viaduct overhang of the UPRR ROW.

Hempstead Road Configuration 2: The travel lanes of Hempstead Road would be reconfigured to make space for a new HSR viaduct between the eastbound and westbound travel lanes. See Figure 45.

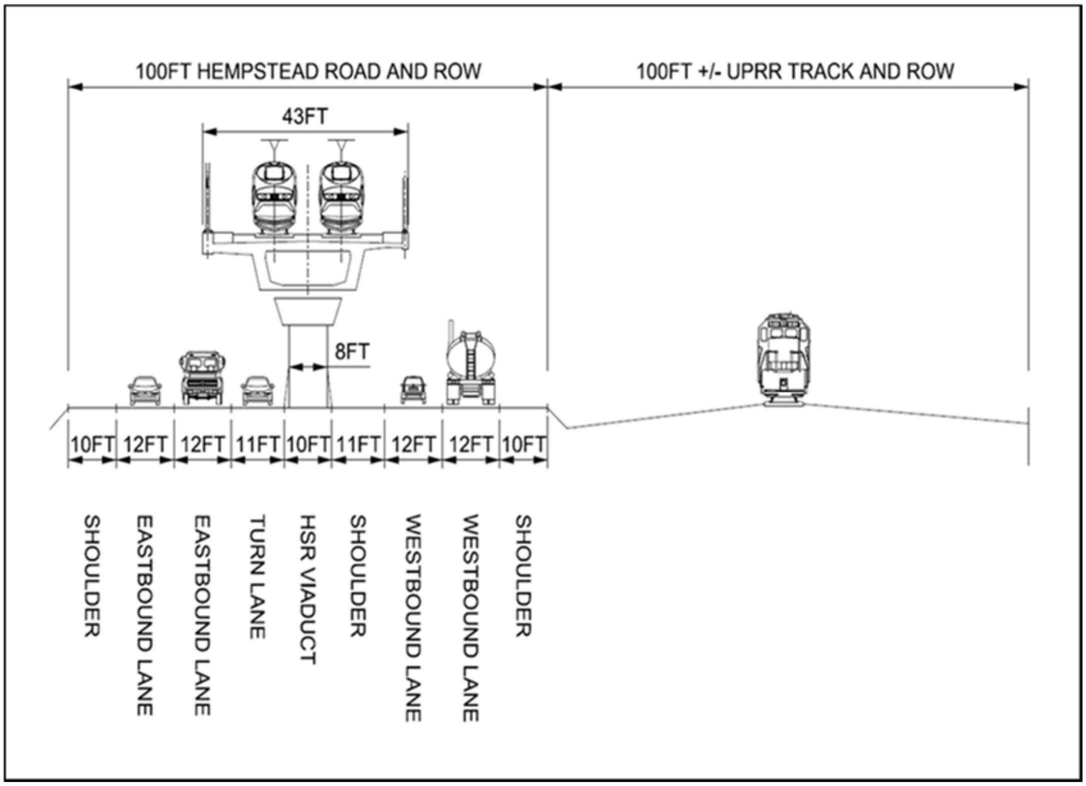

Figure 45 – Hempstead Road Configuration 2 – HSR Viaduct in Center of Road

As shown in the conceptual cross section for Hempstead Road Configuration 2, the 100 ft (30 m) wide ROW provides sufficient space for an elevated HSR viaduct constructed between the eastbound and westbound travel lanes. However, while it appears feasible to allocate the existing 100 ft (30 m) wide ROW in a way that could provide the same amount of roadway space to vehicular traffic, this configuration is much more constrained given the need to provide space for turn lanes on either side of the raised barrier supporting the viaduct. Further, there is no allowance for drainage or utility space within this configuration.

With Hempstead Road Configuration 2, these issues could be addressed by limiting the turn lanes to pockets at each side of major intersections and limiting turning movements to only the more significant cross streets. Between intersections where no pocket lanes are provided, the 100 ft (30 m) ROW width would provide a reasonable roadway configuration with a generous median space of 32 ft (10 m) in width. Two 12 ft (3.6 m) wide travel lanes and a 10-foot wide shoulder could be accommodated in each direction as shown in Figure 46.

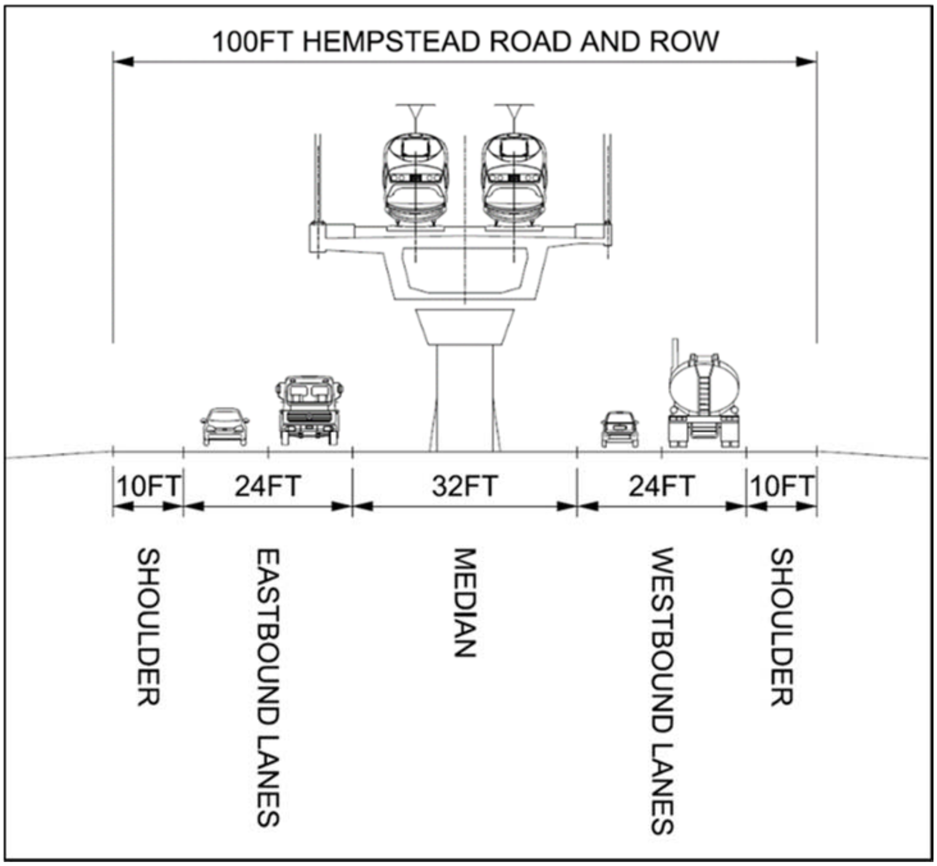

Figure 46 – Hempstead Road Configuration 2 – Viaduct Location between Intersections

With Hempstead Road Configuration 2, a continuous barrier approximately 10 ft (3 m) in width would be provided below the viaduct, with columns supporting the viaduct approximately 8 ft (2.5 m) in width projecting out of the top of this raised barrier. A grassed median or shoulder of 11 ft (3.3 m) in width could be provided between the nearest travel lane and this raised barrier between intersections. Given the expected viaduct deck width of approximately 43 ft (13 m), the viaduct would extend over the adjacent travel lane approximately 5 ft (1.8 m). At turn lanes, the median space adjacent to the raised barrier would be used to provide the turn lane pocket. A preliminary intersection plan has also been developed for the intersection with Kempwood Drive/W. 34th Street and is shown in Figure 48.

The 11-foot width available for designated turn lanes in Hempstead Road Configuration 2 is less than desired, but appears to be feasible. The location of viaduct supporting columns and termination of the raised median would have to be carefully considered at intersections to ensure proper sightlines for vehicular safety. The standard column spacing for the viaduct would be on the order of 110 ft (33.5 m); however, at intersections spans of approximately 150 ft (45 m) or more may be required to ensure columns do not interfere with visibility.

The renderings on the following pages conceptually illustrate the proposed space allocation and elevated viaduct structure within the ROW of Hempstead Road for each alternative studied.

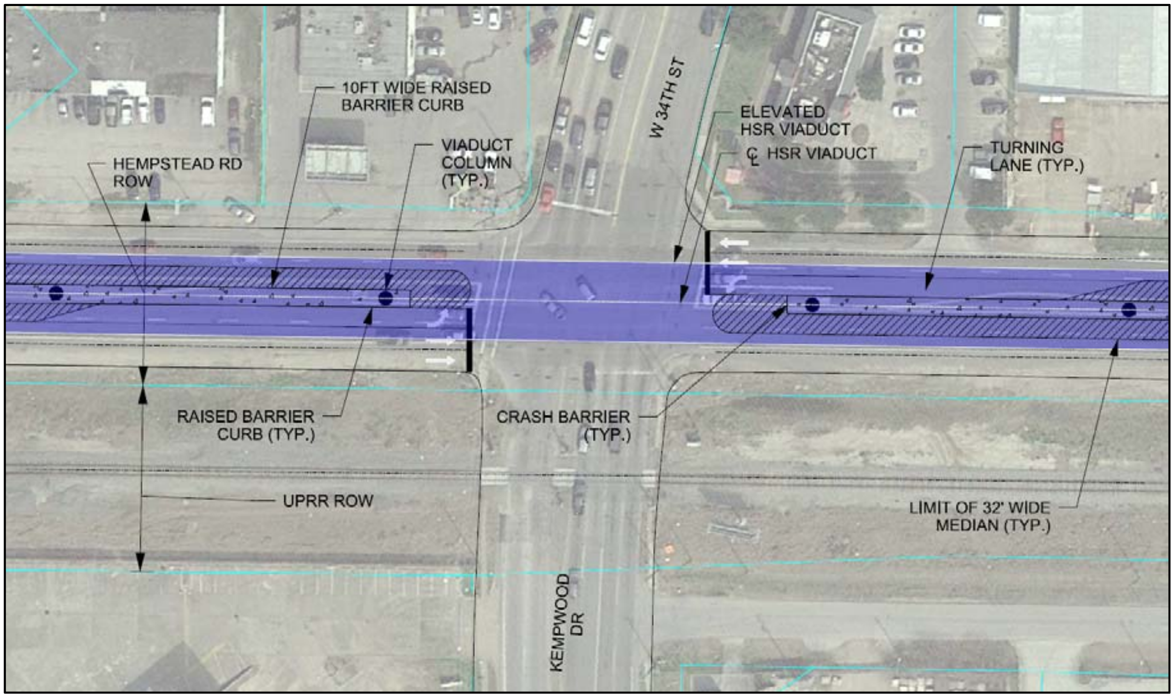

Figure 47 – Conceptual Roadway Configuration Plan at Intersection of Hempstead Road and Kempwood Drive/W. 34th Street

Figure 48 – Conceptual Rendering of Hempstead Road HSR Viaduct Configuration 1 Looking East

Figure 49 – Conceptual Rendering of Hempstead Road HSR Viaduct Configuration 1 from Above

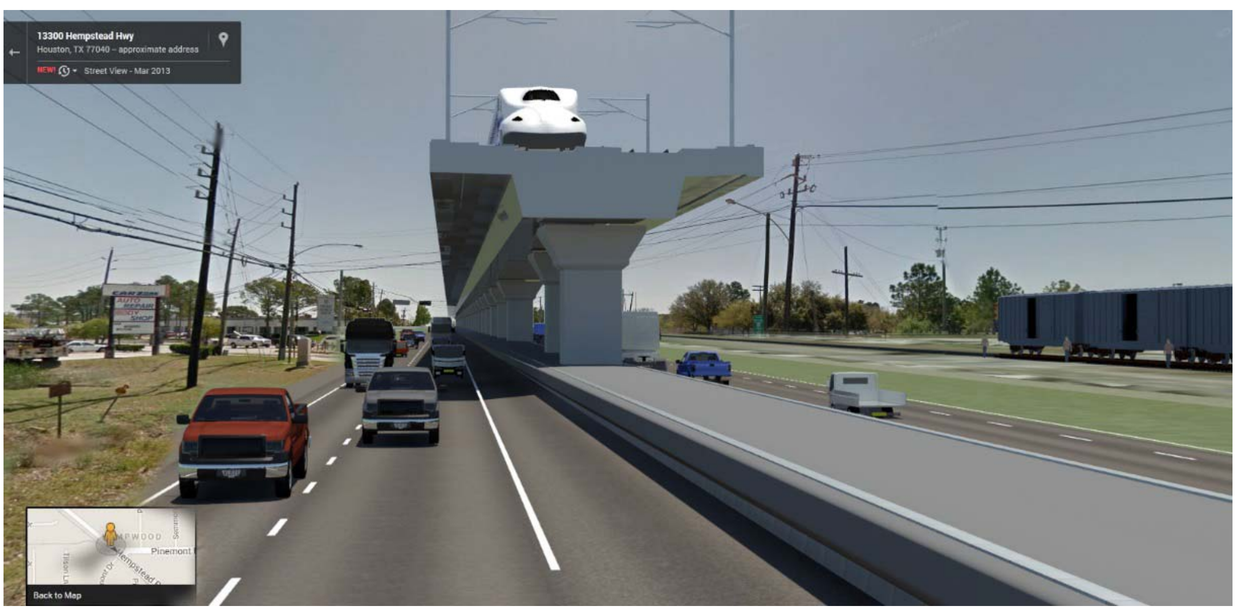

Figure 50 – Conceptual Rendering of Hempstead Road HSR Viaduct Configuration 2 Looking East

Figure 51 – Conceptual Rendering of Hempstead Road HSR Viaduct Configuration 2 from Above

6.4 Utility Corridor

The Utility Corridor was introduced to assess alternative HSR alignments between Houston and Dallas that generally follow a high-voltage electrical utility corridor, minimizing impacts to development and the environment primarily due to the location of the utility ROW, which, unlike the road and rail ROW that have been previously discussed, does not have to follow the constraints of existing topography.

Development of HSR alignments that follow high-voltage electrical utility corridors was considered since electrical transmission line facilities:

- Are generally located in more remote areas because high-voltage transmission lines are not typically constructed near to established communities and development generally avoids locations near existing transmission lines.
- Generally follow relatively straight alignments since tower heights can be adjusted to account for topography.
- Are generally in less environmentally sensitive areas since they were developed more recently.
- Have less activity within the ROW that third parties must be protected from, such as movement of freight trains along a rail corridor.

Upon initial review it became apparent that high-voltage electrical transmission utility lines could be followed to develop alignments that generally followed the BNSF Corridor as shown in Figure 52.

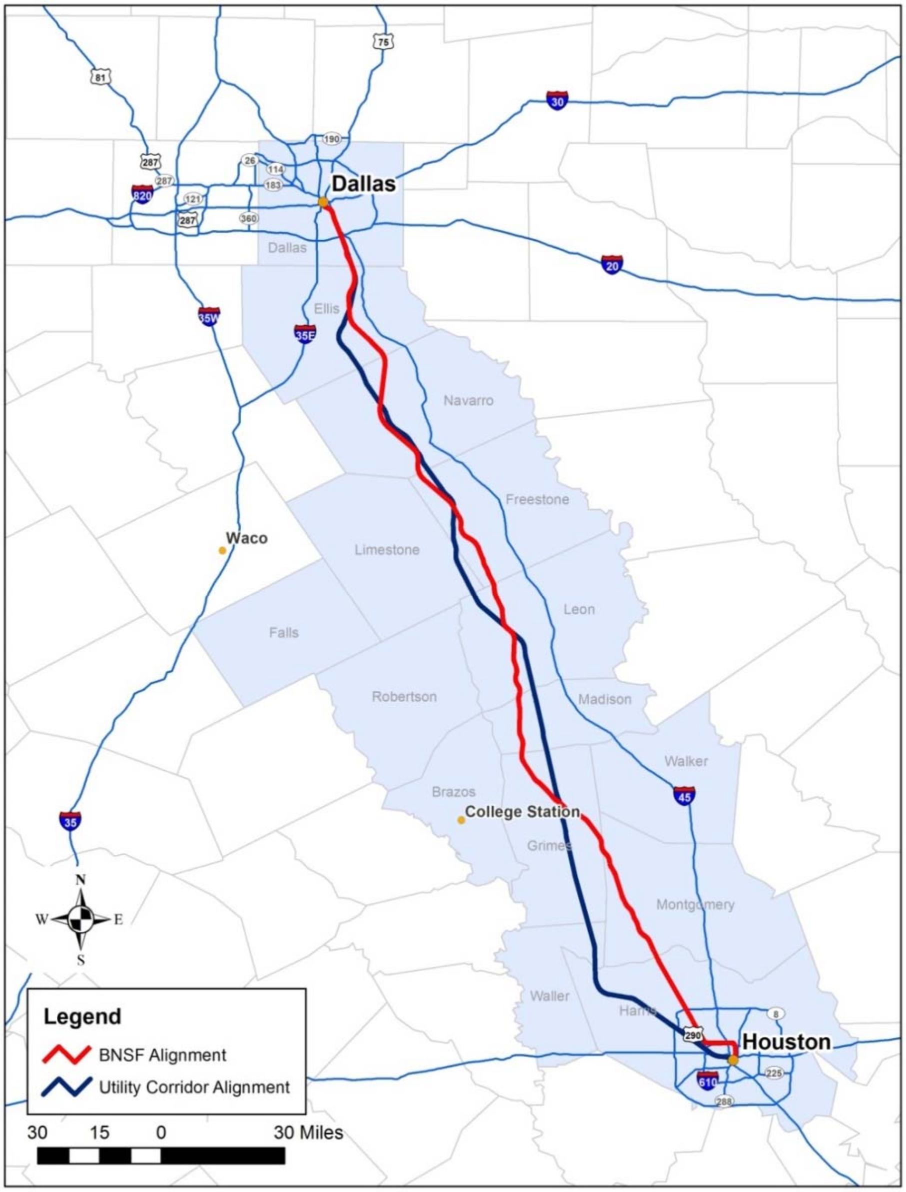

Figure 52 – BNSF Corridor and Utility Corridor

However, it also became apparent that no electrical transmission lines run along the BNSF Corridor into the northwest of Houston that would yield reduced impacts relative to the BNSF alignment alternatives. To the contrary, the existing CenterPoint Energy electrical transmission line intersects with the previously discussed UPRR Alignment alternative near Hockley, and HSR could utilize the UPRR Alignment's approach into Houston along the UPRR Hempstead line. Hence, to develop an alignment that maximizes the length following a transmission line, a general alignment routing was developed to follow the UPRR Hempstead line ROW to a terminal in downtown Houston.

Through the review and analysis of multiple electrical transmission utility corridors, a preferred Utility Corridor was identified, as shown in Figure 53, with one optional deviation that follows a segment of IH-45 where the Utility Corridor comes close to the existing highway between Madisonville and Palmer. This resulted in two alignments as discussed herein:

- "Utility Corridor Alignment"
- "Utility Corridor with IH-45 Alignment"

These two alignments are identical on the Houston end from downtown Houston to Bedias, and on the Dallas end from Purdon to Dallas.

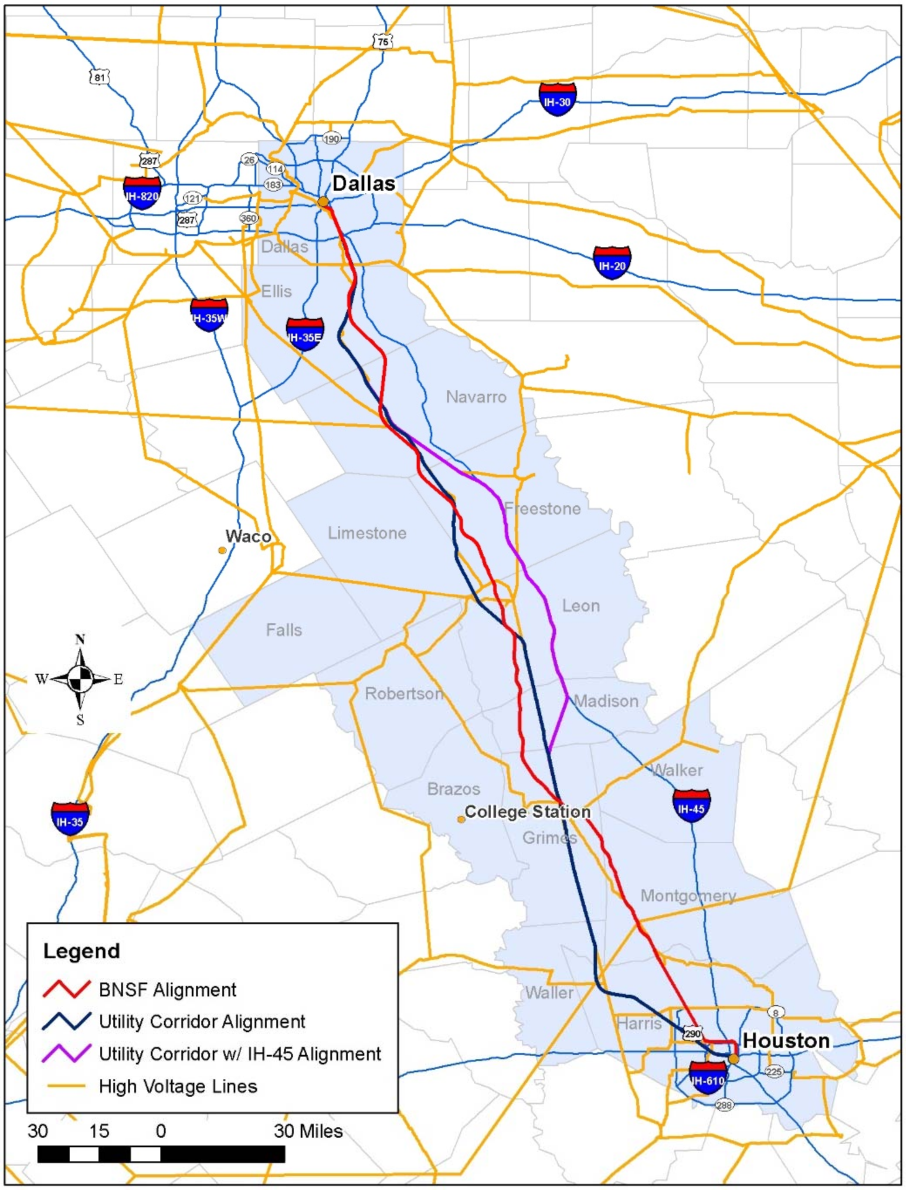

Figure 53 – BNSF and UC Alignments

6.4.1 Utility Corridor Alignments

As mentioned, all alternative alignments assume a station location adjacent to the US Post Office in downtown Houston. Further, based on review of existing electrical transmission lines in the corridor it was found that the electrical transmission line corridor that comes closest to downtown Houston and could connect to a feasible routing into downtown Houston is the CenterPoint Energy line. Hence, it is assumed that any Utility Corridor alignment alternative will require a route into downtown Houston from near the town of Hockley at US 290. The most feasible route appears to be one that generally follows the UPRR Eureka subdivision that runs parallel to US 290 as shown in Figure 54.

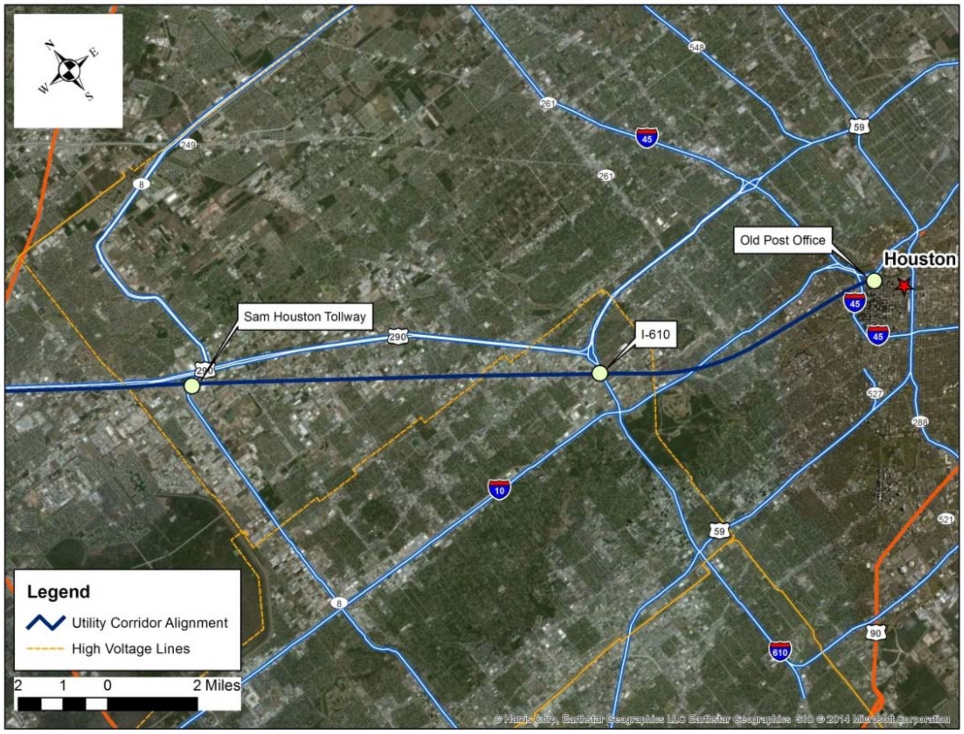

Figure 54 – UC Alternatives – Approach to Houston Metropolitan Area

Many concerns have been identified with constructing a HSR system along Hempstead Road and are discussed in section 6.3.1. Further, studies are currently underway to investigate commuter rail alternatives to serve the Houston metropolitan area, and one of the concepts under consideration involves development of a commuter rail corridor adjacent to or within the UPRR ROW. As such, alternatives to being located with the UPRR ROW were considered along this segment. Through this review, it is proposed that the HSR alignment for the Utility Corridor alternatives would be within the ROW of Hempstead Road ROW along this segment to minimize impacts to the UPRR between Beltway 8 and IH-610, a distance of approximately 8.5 mi (14 km).

Property limits along Hempstead Road were secured through publically available sources and identified that the existing ROW of Hempstead Road is approximately 100 ft (30 m) wide. Hempstead Road between Beltway 8 and IH-610 is generally configured as a four lane roadway with intermittent center turn lanes. The road runs through a largely industrial area that is a primary bypass route for US 290 and a route used by truck traffic. Intersecting streets are generally at-grade, as are grade crossings of the UPRR track.

The UPRR ROW is also approximately 100 ft (30 m) wide through this area and lies on the south side of the Hempstead Road ROW. UPRR has a single track that lies in the middle of the ROW, approximately 50 ft (15 m) offset from the shoulder of Hempstead Road (see Figure 55 and Figure 56). There are various industrial sidings that lie along the south side of the UPRR track. There are no track connections or industrial sidings that cross Hempstead Road.

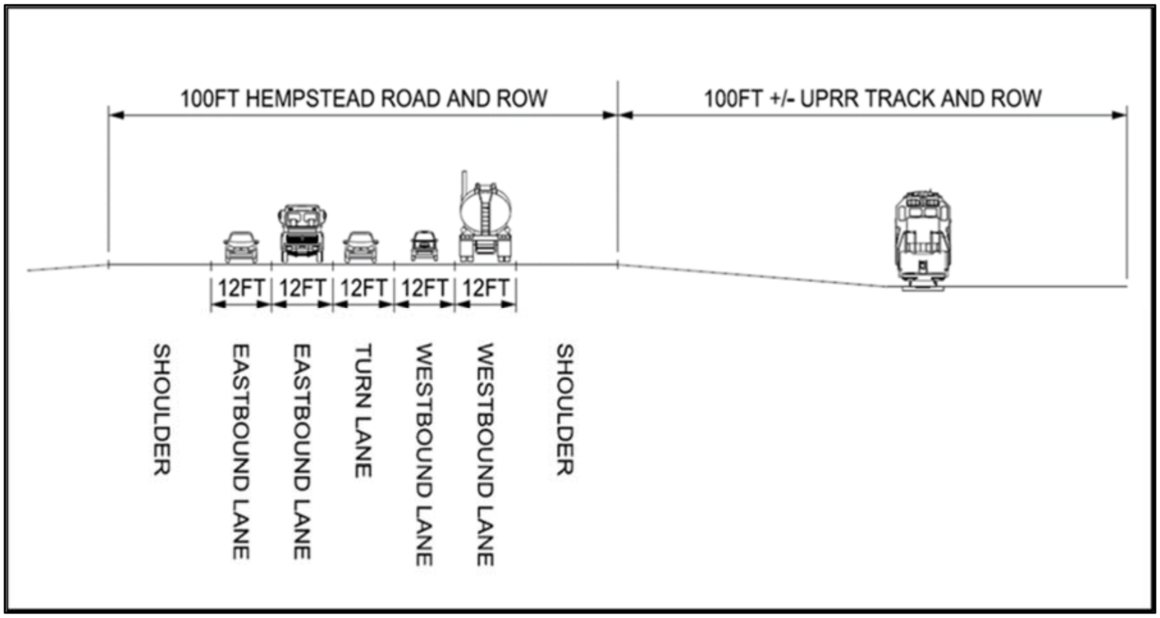

Figure 55 – Existing Configuration of Hempstead Road ROW at Intersections

Figure 56 – Existing Configuration of Hempstead Road ROW at W. 34th Street/Kempwood Drive

Once past the crossing of the Sam Houston Parkway, the original Hempstead Road ROW is no longer available as US 290 follows the former Hempstead Road ROW. To avoid conflict with the UPRR, both of the proposed HSR alignments for the Utility Corridor cross over the UPRR ROW to follow closely along its south side through the highly developed northwest suburbs of Houston. Just west of Cypress the Utility Corridor HSR alignments sweep south before turning north through a large radius curve suitable for high-speed operations to cross US 290 just east of the town of Hockley. The Utility Corridor alignments head north following Hegar Road to minimize impacts to local development until they align with the CenterPoint transmission line between the towns of Hempstead and Magnolia as shown in Figure 57.

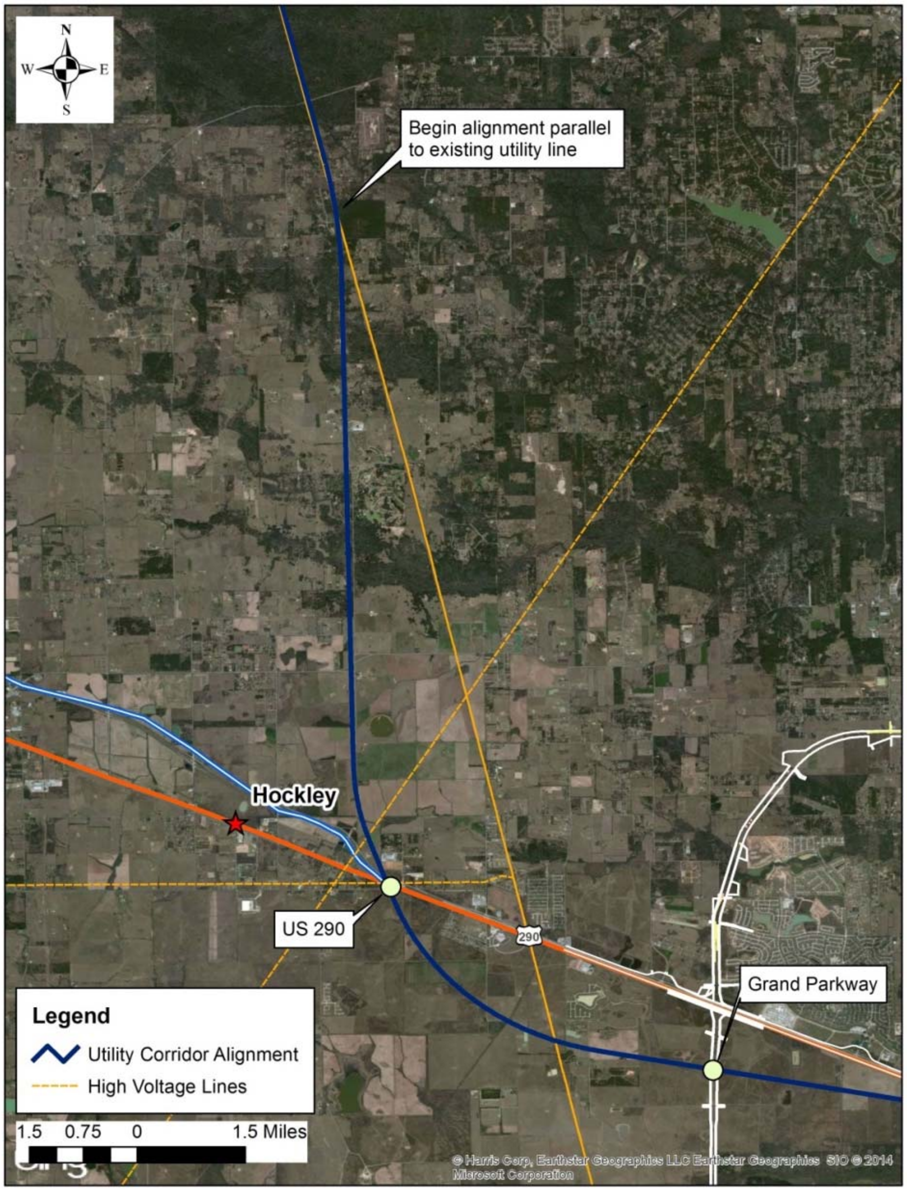

Figure 57 – Utility Corridor at Crossing of US 290

From this point, the Utility Corridor alignments parallel the CenterPoint line for approximately 75 mi (120 km). As the Utility Corridor alignments approach Jewett, it was necessary to break away from the utility line to mitigate potential impacts and construction difficulties given the convergence of several major transmission lines as shown in Figure 58.

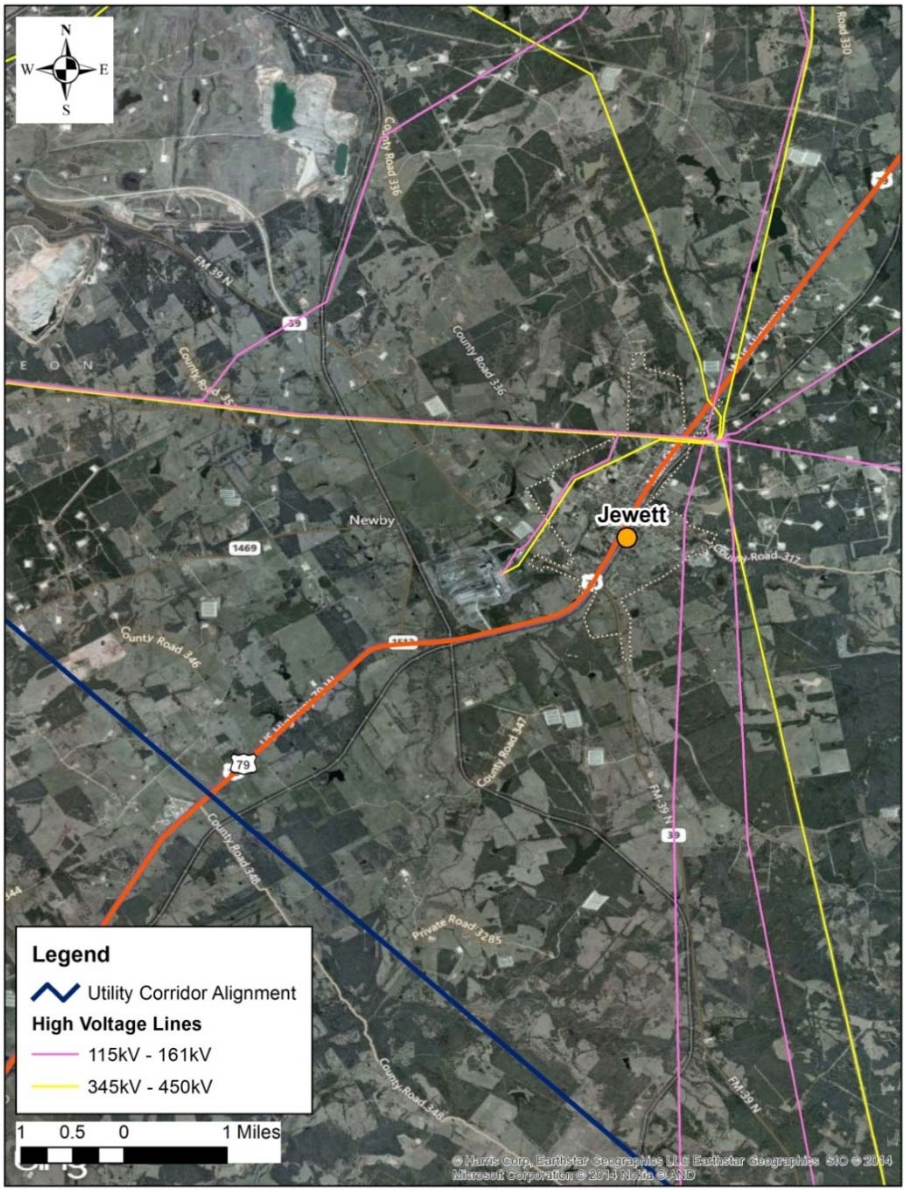

Figure 58 – Convergence of Electrical Transmission Lines near Jewett

To avoid this confluence of transmission lines, the HSR Utility Corridor alignments turn west near Concord to follow a greenfield route. This greenfield routing also allows the alignment to avoid a major mining operation. The Utility Corridor alignments then become greenfield again in order to avoid major mining operations and oil wells between Jewett and Teague as discussed in section 6.1.2.

North of Personville, the Utility Corridor alignments again follow the Oncor Electric Delivery Company transmission line from Personville to Palmer over a length of approximately 69 mi (111.5 km).

Between Palmer and the crossing of IH-20 south of Dallas, the Oncor transmission line deviates back and forth and it was not possible to follow the line and maintain HSR alignment characteristics. Hence, over this segment, both of the Utility Corridor alignments follow a greenfield route to the crossing of IH-20 near Hutchins as shown in Figure 59.

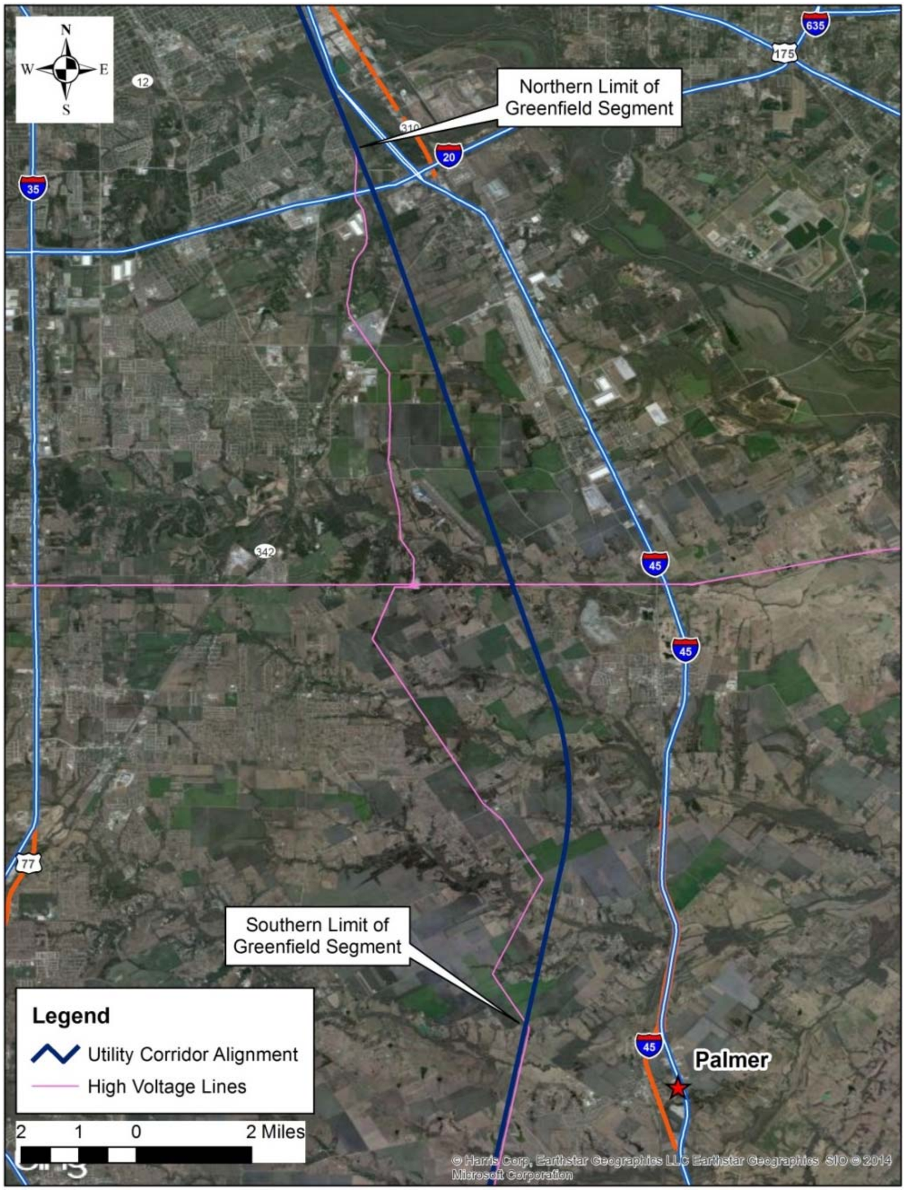

Figure 59 – Greenfield Alignment Segment near Hutchins

Once the Utility Corridor alignments reach IH-20, the alignments again follow an electric transmission line for approximately another 4.3 mi (7 km) before crossing the Trinity River and following the UPRR ROW into downtown Dallas as shown in Figure 60. The alignment as shown does not preclude a future potential extension to Fort Worth.

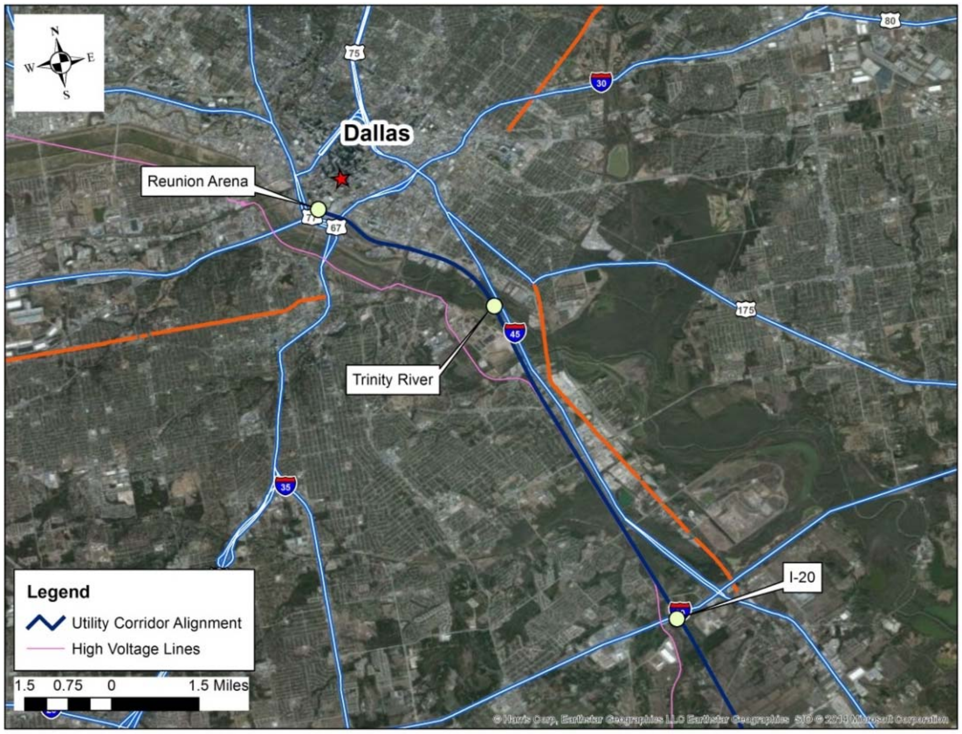

Figure 60 – Approach to Downtown Dallas along UPRR ROW

6.4.2 Utility Corridor with IH-45

The "Utility Corridor with IH-45" alignment follows the same high-voltage transmission line corridor used in the "Utility Corridor" alignment described above except that it uses a segment of the IH-45 ROW from approximately Madisonville to Fairfield, as shown in Figure 61. This Utility Corridor with IH-45 alignment was developed to determine if the HSR infrastructure could be accommodated within the IH-45 ROW over that segment of the corridor that was along a greenfield alignment between Concord and Personville.

Through ongoing Project discussions and coordination with TxDOT, it was determined that while the overall IH-45 alignment alternative from Houston to Dallas was found infeasible, there may be opportunities to develop more limited segments of shared corridor along IH-45 between Houston and Dallas. Further, whereas the Utility Corridor alignment does not follow any major public ROW, the Project would need to secure the necessary land for the alignment from private property owners. Hence, the Utility Corridor alignment was reviewed to determine if there were segments along the Utility Corridor where the HSR alignment could be realigned to be within the IH-45 ROW to minimize property and environmental impacts.

In response, the alignment of the existing IH-45 highway was reviewed in relationship to the proposed Utility Corridor alignment as shown in Figure 61. North of Richland, the IH-45 alignment has many curves to avoid environmentally sensitive areas such as the Richland Chambers Reservoir and passes through the more developed towns of Corsicana and Ennis. South of

Madisonville, the IH-45 alignment shifts to the east to serve Huntsville and passes through the Sam Houston National Forest. Hence, if the alignment follows IH-45 south of Madisonville there is no real opportunity to then rejoin the Utility Corridor alignment to access Houston along US 290. Between Richland and Madisonville, IH-45 passes through more rural areas and its alignment has longer tangents and larger curve radii. Based on these limitations, the segment of the IH-45 alignment between Palmer and Fairfield was studied in further detail to determine its suitability for HSR in relation to the Utility Corridor alignment.

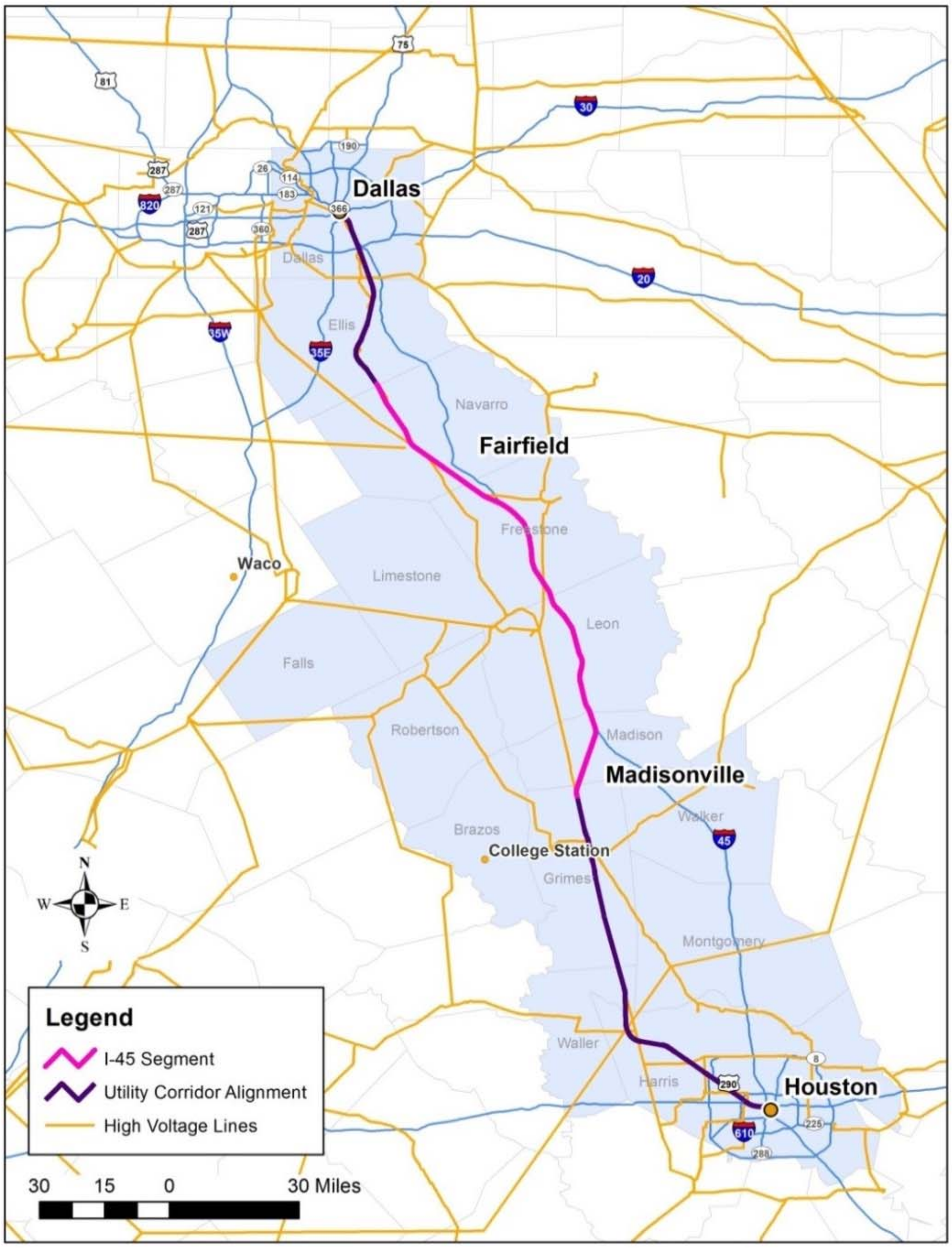

Figure 61 – IH-45 Segment along UC Alignment

6.4.2.1 Utility Corridor with IH-45 Alignment Description

Based on the review of the IH-45 corridor, the conceptual shared-use segment IH-45 alignment developed was limited to the segment between Palmer and Madisonville. These two towns are located close to the Utility Corridor alignment and minimal impacts would be expected when connecting the IH-45 alignment back to the Utility Corridor alignment with short segments of greenfield alignment.

On the south end, the "Utility Corridor with IH-45" alignment is identical to the Utility Corridor alignment from downtown Houston to Bedias. Once past Bedias, the Utility Corridor with IH-45 alignment turns northeast and follows a greenfield alignment towards Madisonville, as shown in Figure 62.

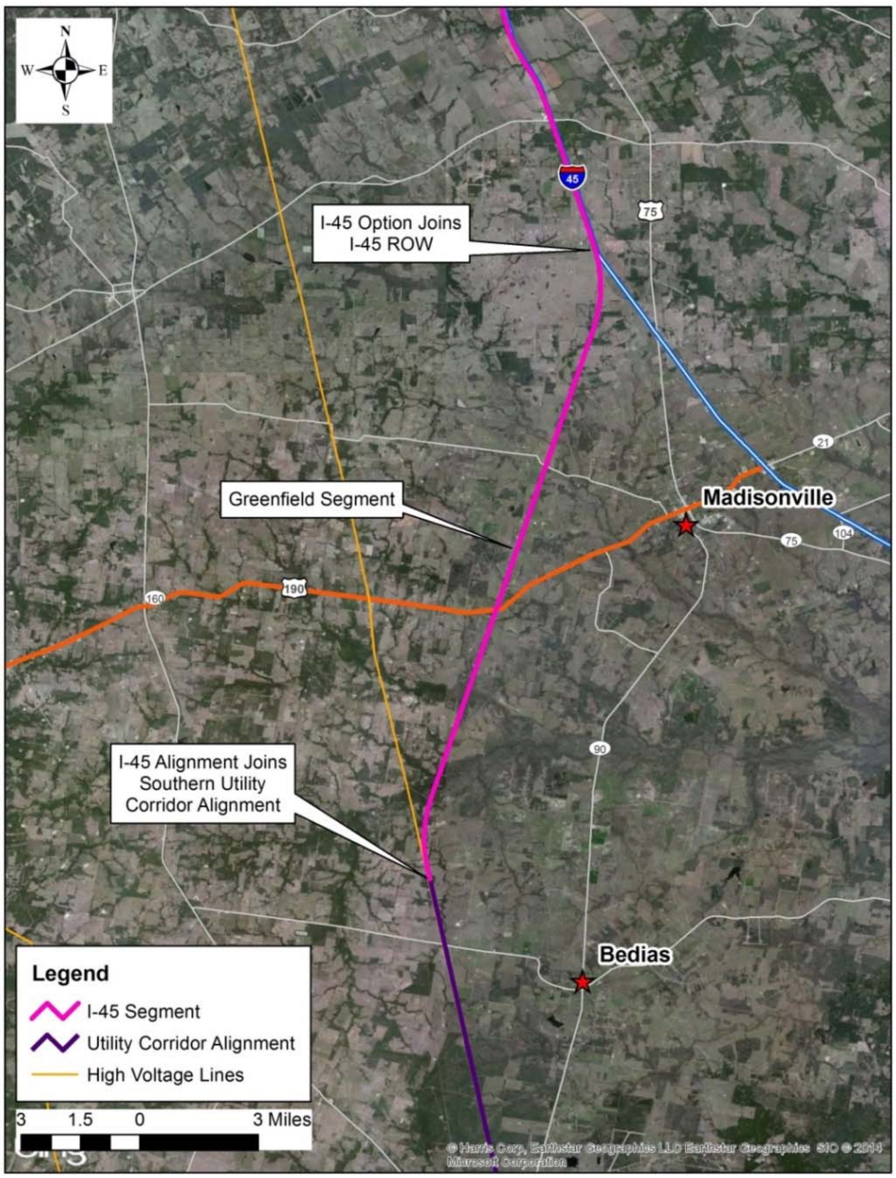

Figure 62 – Greenfield Alignment Connecting UC to IH-45 ROW – Bedias to Madisonville

The Utility Corridor with IH-45 alignment crosses over the IH-45 frontage road and generally runs between the IH-45 main lanes and frontage road north for approximately 56 mi (90.5 km), as shown in Figure 63.

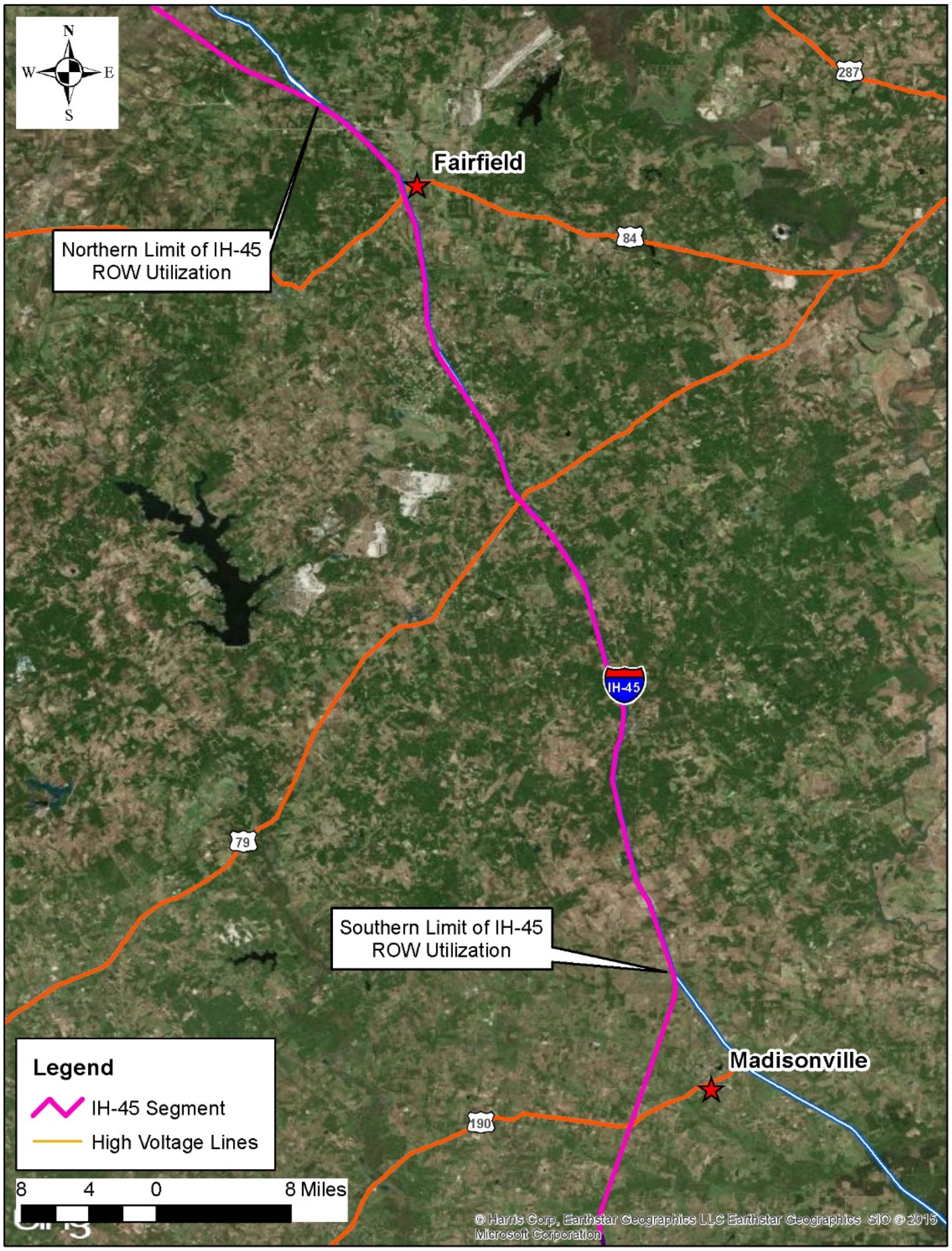

Figure 63 – Limits of IH-45 Segment used in UC with IH-45

Design criteria constraints of the HSR will move the alignment outside the existing IH-45 ROW at several locations. Once the alignment passes north of Fairfield, the Utility Corridor with IH-45 alignment again follows a greenfield alignment to rejoin the Utility Corridor alignment near Rankin as shown in Figure 64.

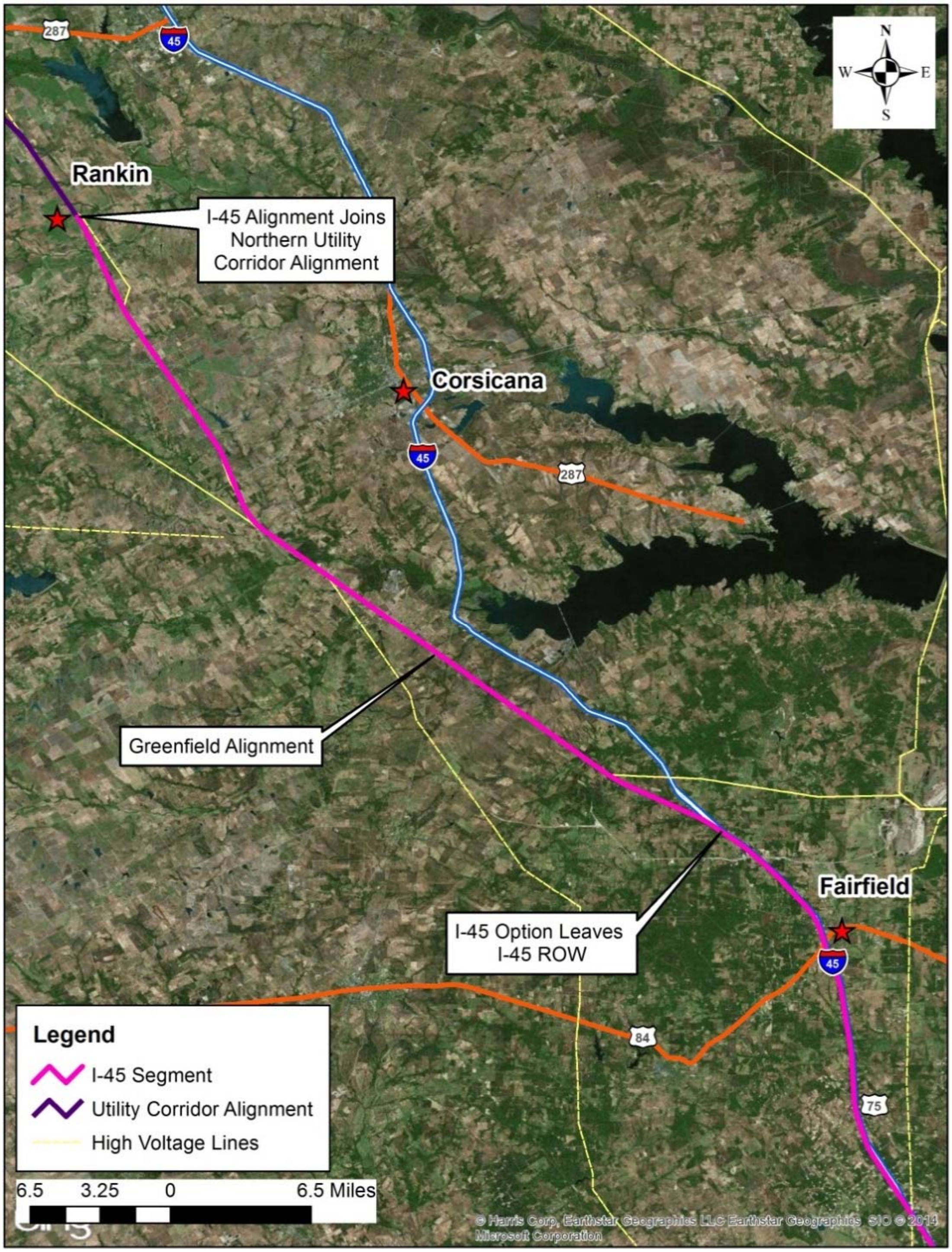

Figure 64 – Greenfield Alignment Connecting IH-45 Segment back to UC – Fairfield to Rankin

7 Station Alternatives Assessed

As noted, this evaluation is focused on a comparative assessment of alternative HSR alignments linking Houston and Dallas. To ensure a fair comparison of competing alternatives, all alignment evaluations were completed assuming one terminus station located in both Dallas and Houston. Nonetheless, this section discusses both suburban and downtown station location options with a focus on how alternative general station locations would impact the corridor evaluation effort. An additional mid-line station will be included in subsequent analyses, located approximately 75 mi (120 km) north of Houston to serve the College Station area.

It is recognized that development of the "Last Mile" into heavily urbanized and developed areas may generate additional ridership demand, particularly with respect to trip destinations. However, reaching the downtown station locations would require significant construction costs and result in additional impacts that would likely not be offset by the additional revenue gained from the ridership increase. Moreover, from the perspective of trip originations, there has been some evidence on HSR systems worldwide that suburban stations are more attractive since users of the system would not need to make their way into the urban core to begin their trip to a distant city. The identification of the preferred station locations has been the subject of significant ridership and engineering studies and will be documented separately from this report.

7.1 Station Requirements

The purpose and function of the Project is to provide a convenient alternative to inter-urban travel between the Dallas and Houston metropolitan areas, and address mobility- and congestion-related issues in the IH-45 corridor. It is understood that the riding public requires a station location that is accessible by automobile and public transportation. As a privately developed project, the station location must also generate ridership and revenue. Therefore, the station location must be accessible to the traveling public so that they will use it.

The two proposed terminus HSR stations will serve intercity travel demand and commerce, provide for economic redevelopment, and provide connectivity with the region's major transit and roadway systems. Stations will be strategically located to minimize impacts, maximize multi-modal connectivity, optimize ridership with respect to revenue, and optimize adjacent land-uses to provide long-term local development opportunities.

Station locations should account for:

- At-grade or elevated station
- Ticketing and passenger waiting area
- 8-car trainsets
- Platforms at 705 ft (215 m) long by 30 ft (9 m) wide (5 m wide for side platforms)

- Initial configuration – four tracks with two island platforms
- Future build out – two additional tracks with two side platforms
- Approximately 75% of passengers arrive by cars – 430,550 sf (40,000 m^2) parking site
- Station building footprint size of approximately 53,820 sf (5,000 m^2)
- Allowances for rental cars, drop off and multi-modal connections

While the HSR Project is being developed on the merits of its standalone characteristics and independent utility, the stations should be configured to support near-term operating goals, and allow for future expansions and extensions (stations as well as tracks) so that the proposed HSR system can serve as an extendable passenger rail network spine, connecting with regional transportation services.

The initial screening study of alternative station locations considers general terminus areas rather than specific land parcels. As the alignment study is advanced and finalized, evaluation of alternative station locations will focus on specific parcels and will consider ridership, economic viability, engineering and environmental considerations, and development potential. Evaluation of station sites will be advanced through the EIS effort.

Both Dallas and Houston have multiple commercial and economic centers spread across their respective metropolitan areas, including each having a downtown central business district. These many business districts are served by highly developed highway and roadway networks. Consequently, it is appropriate to consider opportunities for “Downtown” and “Suburban” locations.

Key criteria used in this evaluation are:

- Availability of property
- Access to the rail alignment corridors being studied
- Access to the public transportation network
- Access to the highway and roadway network
- Annual ridership and revenue potential
- Relative “last mile” costs
- Station area development potential

7.2 Stations in Houston

Seven potential station locations for Houston were identified. These locations are:

- Greenspoint Area
- Downtown – Post Office site
- Downtown – Hardy Yards
- South of Exxon Mobil Campus

- Intersection of US 290/IH-610
- Intersection of US 290/Beltway 8
- Intersection of SH 249/Beltway 8

The ability to serve each of these locations from each alignment alternative is identified in Table 2.

Table 2 – Station Locations Served by Alternative Alignments In Houston

Station Location	IH-45 & IH-45 with Hardy	BNSF (Options 1-4)	UPRR	Utility Corridor & Utility Corridor with IH-45
Greenspoint Area	X	X		
Downtown Houston – Post Office Site	X	X	X	X
Downtown Houston – Hardy Yards	X	X		
South of Exxon Mobil Campus	X			
Intersection of US 290/IH-610		X	X	X
Intersection of SH 249/Beltway 8		X		
Intersection of US 290/Beltway 8			X	X

As shown in Table 2, all nine alignments studied can access the downtown station locations in both Dallas and Houston. For station locations northwest of downtown Houston, the alignments of the UPRR and BNSF corridors can serve stations at US 290/IH-610, but must diverge from their direct route to Dallas. Only the four alignments of the BNSF corridor can efficiently serve the SH 249/BW-8 and SH 249 sites near the Woodlands. The UPRR Alignment could serve a station at US 290/BW-8 as an alternative to the SH 249/BW-8. Along the UPRR Corridor, a station location at US 290/BW-8 would be expected to capture significant ridership given the location's good connectivity to the roadway network. Serving station locations further within the Houston urban area along the UPRR Alignment, such as at IH-610 or at either of the downtown station sites, would come with significantly greater impacts given that development is much more crowded on the existing freight line east of BW-8. North of downtown Houston, both the IH-45 alignment and the IH-45 with Hardy alignment can readily serve potential stations at the Exxon Mobil Campus and Greenspoint.

7.2.1 Greenspoint Area

The Greenspoint Area encompasses the developed area centered on the IH-45 and Beltway 8 interchange in north Houston. This intersection forms the centroid of the Greenspoint Business District. This is a key roadway intersection in the north Houston area providing access to a highly developed urban neighborhood. There are station options in three of four quadrants of the intersection with open parcels of land on the western side. On the eastern side, the existing Greenspoint Mall site would offer a potential station side. The area considered is shown in Figure 65.

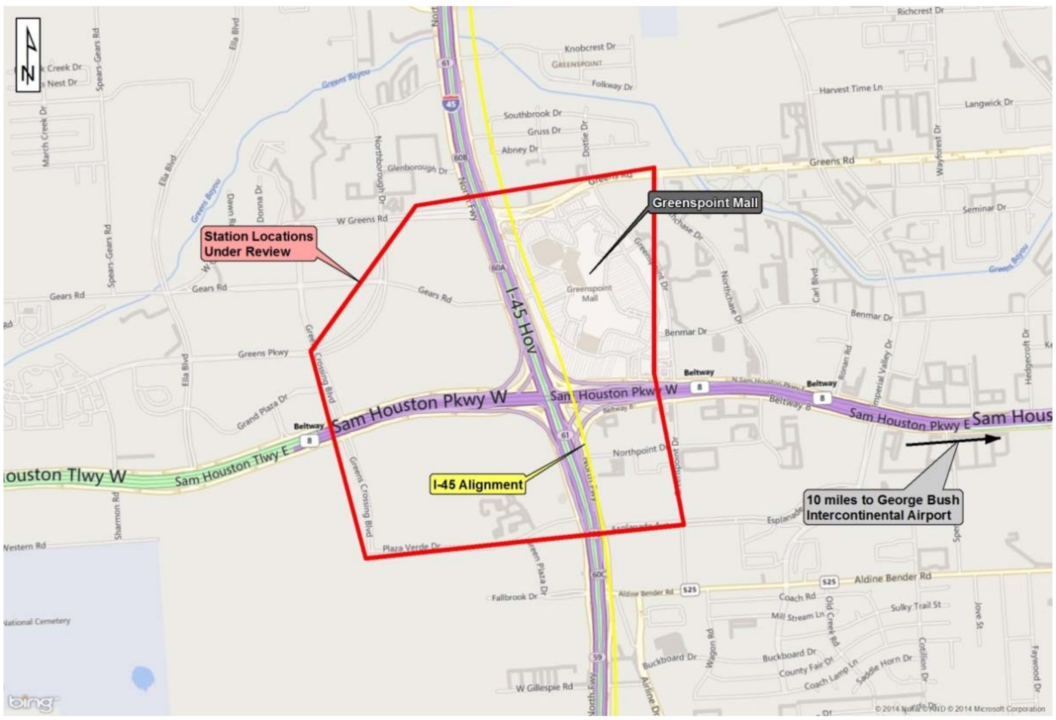

Figure 65 – Greenspoint Area Station

Key Issues

- Convenient highway access from IH-45 and Beltway 8
- Development potential for the station area
- Proximity to key employment centers
- Proximity to Houston-Dallas corridor
- Proximity to IH-45 and IH-45 with Hardy alignment options
- Distance from BNSF, Utility Corridor, and UPRR corridor alignment options
- Heavy urban congestion inside Beltway 8 with higher station location impacts

7.2.2 Downtown Houston

For this study, Downtown Houston is defined as the area approximately bounded by IH-10 to the north, IH-45 to the west, and US 59 to the east. It remains a key employment center for the Houston region and has direct light rail access to the Texas Medical Center (TMC), one of the other major employment centers of Houston. Because of dense urban development, the options for access to and property for station locations in the downtown area are limited. The limits of the downtown area are shown in Figure 66.

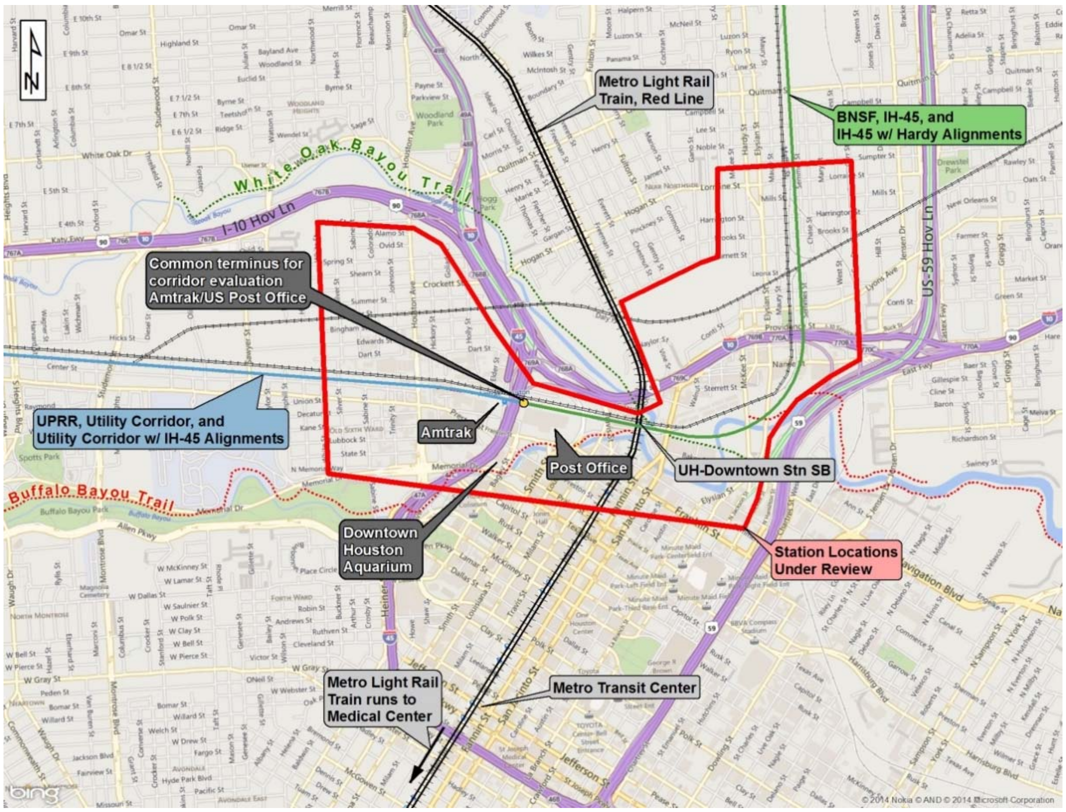

Figure 66 – Houston Downtown Station Area

Key Issues

- Access to existing METRO light rail and bus transit center
- Access to Amtrak passenger railway services
- Limited property availability
- Development potential for the station area
- Access to IH-10, IH-45, IH-610, SH 288, and US 59
- Proximity to TMC
- Alignment construction costs inside Beltway 8
- Congestion in existing rail corridors and right-of-way availability
- Heavy traffic congestion during peak hours

- Distance from most key employment centers other than Downtown and TMC

7.2.3 South of Exxon Mobil Campus

This location is north Harris County, just west of the IH-45 and runs along the Grand Parkway (SH 99) and is immediately south of the new Exxon Mobil headquarters. This area in Harris County is seeing significant growth as the area anticipates the opening of the new Exxon Mobil headquarters in 2015. This station location would have good access around the region via IH-45 to Houston and via SH 99 to the east and west. The limits of the area under consideration are shown in Figure 67.

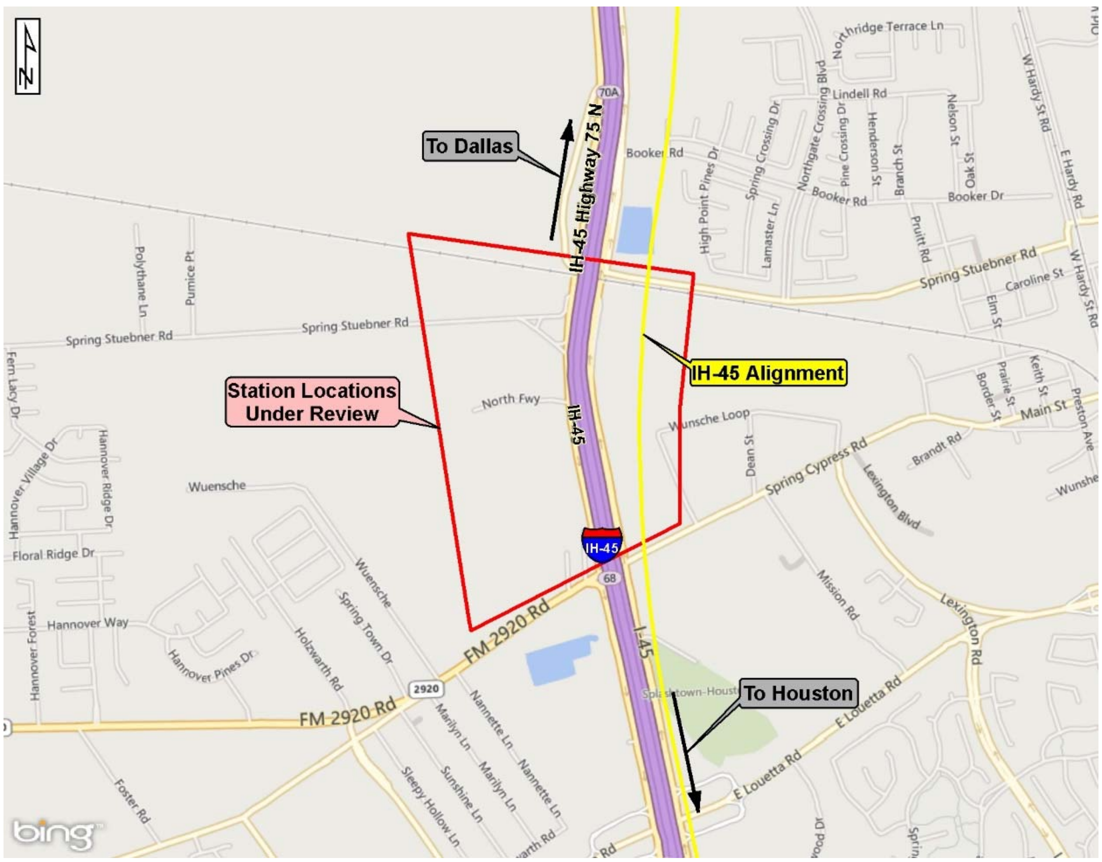

Figure 67 – South of Exxon Mobil Headquarters

Key Issues

- Convenient highway access from SH 99 and IH-45
- Development potential for the station area
- Proximity to key employment centers
- Proximity to Houston-Dallas corridor
- Proximity to IH-45 alignment options
- Distance from BNSF, Utility Corridor and UPRR corridor alignment options

7.2.4 Intersection of US 290/IH-610

The intersection of US 290 and IH-610 is a key roadway connection in central-northwest Houston. The area surrounding this intersection is heavily developed and congested. Despite heavy urban development, there are some potential station locations that could be developed. The location is at the southerly end of the US 290 corridor and provides direct access to both the growing development in the northwest of Houston and central Houston. The UPRR alignment alternative parallels US 290 up to approximately Hempstead. The limits of the area under consideration are shown in Figure 68.

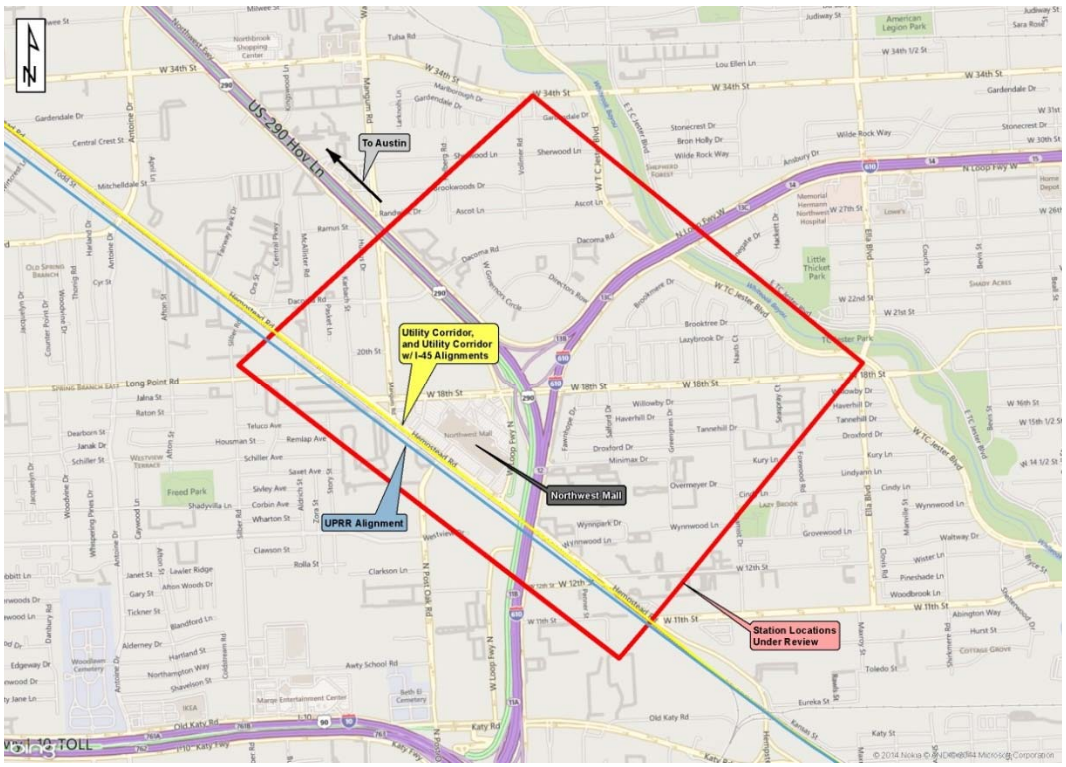

Figure 68 – US 290 and IH-610 Station Area

Key Issues

- Convenient highway access from US 290 and IH-610
- Development potential for the station area
- Proximity to key employment centers
- Proximity to central and downtown Houston
- Transit connectivity to downtown and the METRO LRT network via Northwest Transit Center (future planned)
- Access to BNSF, UPRR, and UC alignment options
- Heavy urban congestion
- Distance from IH-45 alignment option

7.2.5 Intersection of SH 249/Beltway 8

The intersection of SH 249 and Beltway 8 is a key roadway connection in northwest Houston, and provides access to this continually growing area. Due to urban development and congestion, station locations are potentially more available outside Beltway 8 rather than inside. SH 249 is a key corridor to growing development in northwest Houston. SH 249 runs approximately parallel to the BNSF corridor alignment options through Tomball and to Pinehurst, where SH 249 ends. The limits of the area under consideration are shown in Figure 69.

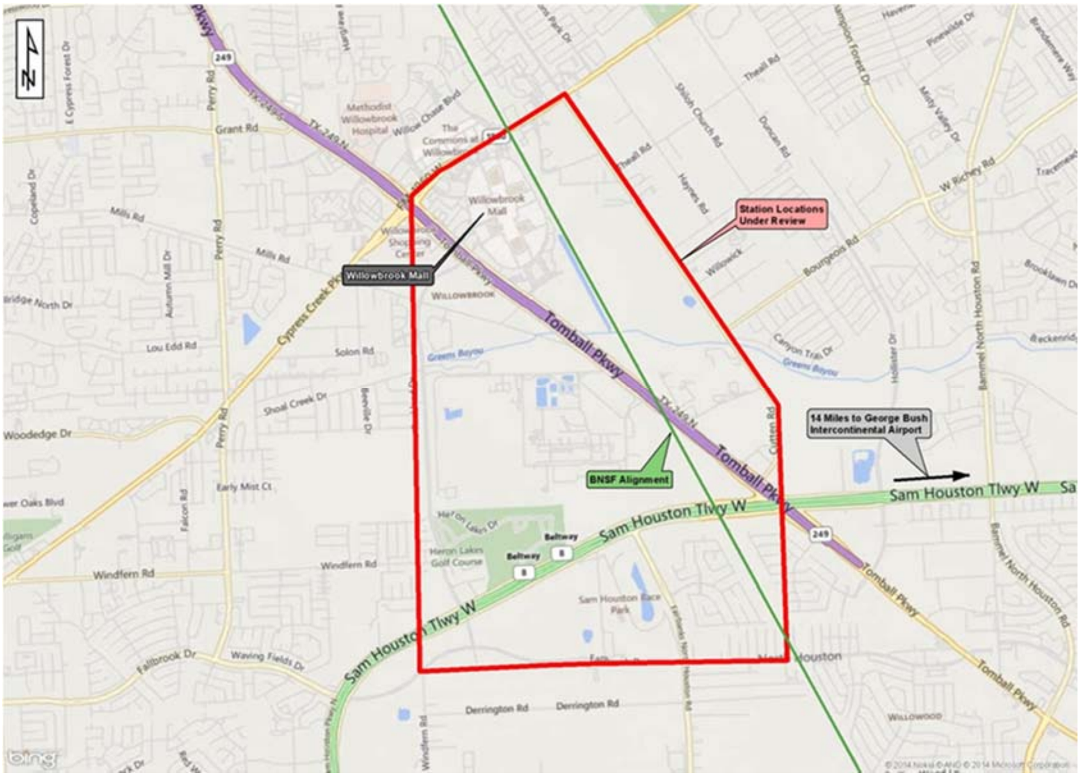

Figure 69 – SH 249/Beltway 8 Station Area

Key Issues

- Convenient highway access from SH 249 and Beltway 8
- Development potential for the station area
- Proximity to key employment centers
- Proximity to George Bush Intercontinental Airport
- Proximity to BNSF, Utility Corridor, and UPRR corridor alignment options
- Heavy urban congestion inside Beltway 8 with higher station location impacts
- Distance from IH-45 corridor alignment options

7.2.6 Intersection of US 290/Beltway 8

The intersection of US 290 and Beltway 8 is a key roadway connection in northwest Houston, and provides access to this continually growing area. Due to urban development and congestion, station locations are potentially more available outside Beltway 8 rather than inside. US 290 is a key corridor to growing development in the northwest of Houston, and connects Houston to Hempstead, Prairie View, College Station, and Austin. The UPRR alignment alternative parallels US 290 up to approximately Hempstead. The limits of the area under consideration are shown in Figure 70.

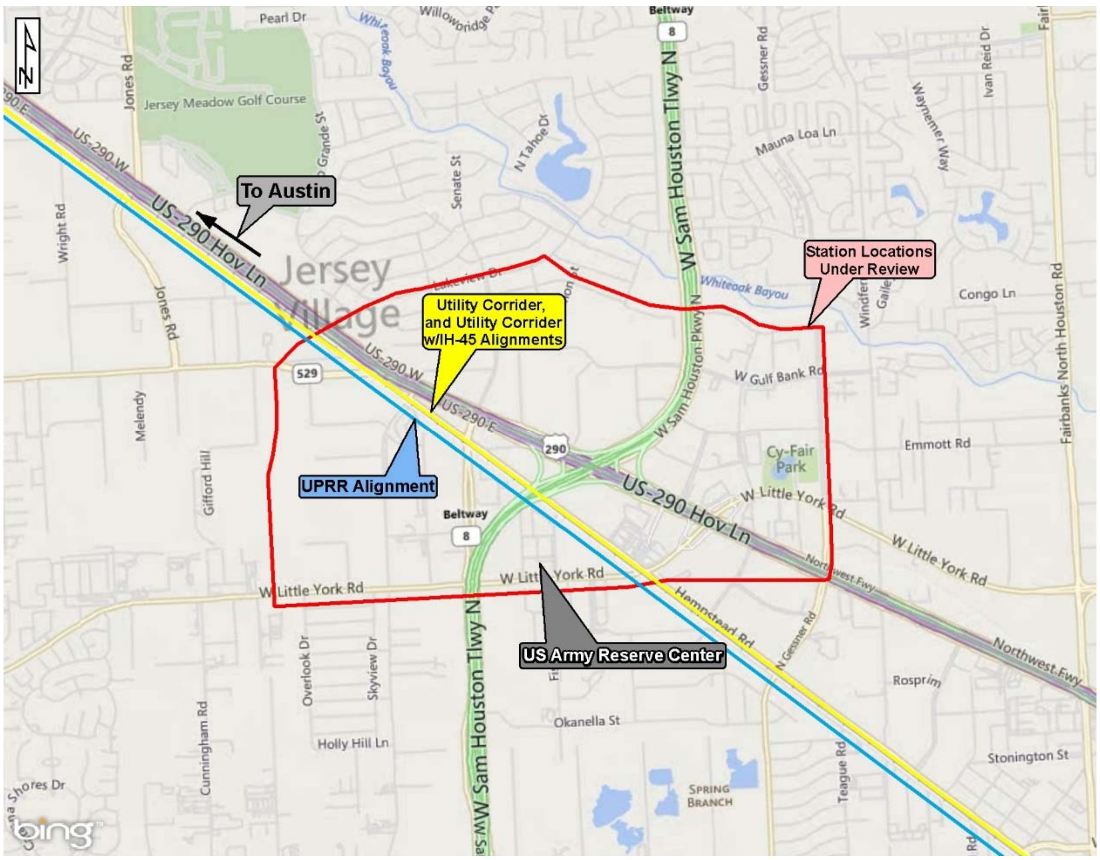

Figure 70 – US 290/Beltway 8 Station Area

Key Issues

- Convenient highway access from US 290 and Beltway 8
- Development potential for the station area
- Proximity to key employment centers
- Proximity to Houston-Austin corridor
- Proximity to BNSF, Utility Corridor, and UPRR corridor alignment options
- Heavy urban congestion inside Beltway 8 with higher station location impacts
- Distance from IH-45 corridor alignment options

7.3 Intermediate Station

An intermediate station has been considered to serve the Bryan-College Station (BCS) population. BCS has proximity to seven of the nine alignment options. Six of these alignments (each of the BNSF options and both of the UC options), pass to the east of BCS close to the intersection of State Highway 30 and State Highway 90 as shown in Figure 71. In contrast, the UPRR alignment bypasses BCS to the west as shown in Figure 72. A logical station location along the IH-45 corridor alignments would be near Huntsville, but was not considered given the approximately one hour drive time from Huntsville to College Station.

Table 3 – Intermediate Station Locations Served By Alignments

Station Location	IH-45 & IH-45 with Hardy	BNSF (Options 1-4)	UPRR	Utility Corridor & Utility Corridor with IH-45
State Highway 30/90		X		X
Bryan/College Station			X	

7.3.1 State Highway 30 and 90 Station

The State Highway 30 and 90 station location is around the intersection of SH 30 and SH 90, approximately 28 mi (45 km) east of BCS and 29 mi (47 km) west of Huntsville affording reasonable access as shown in Figure 71.

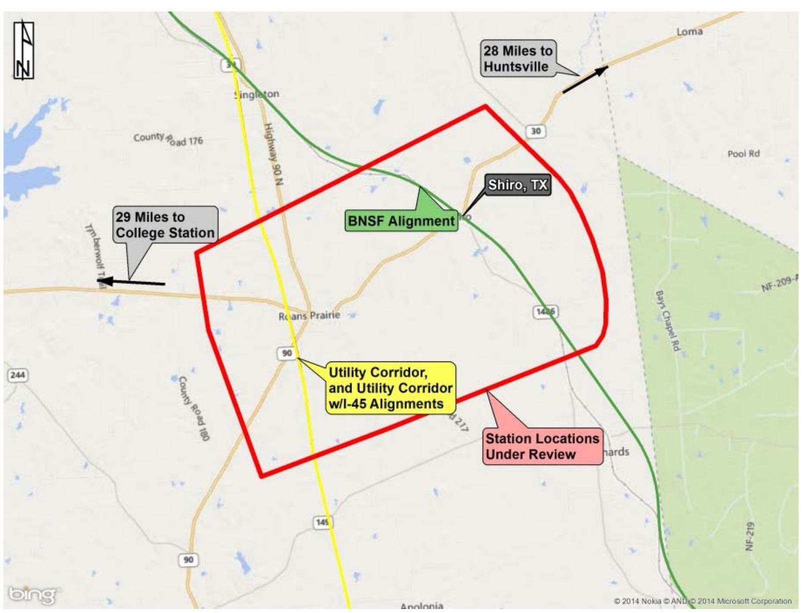

Figure 71 – SH30/SH90 Station

Key Issues

- Access to SH 90 and SH 30
- Access to railroad rights-of-way
- Availability of undeveloped land
- Distance from key employment centers
- Distance from regional public transportation network

7.3.2 Bryan-College Station Station

The UPRR alignment bypasses BCS to the west parallel to SH 47. The proposed BCS station location could be situated on SH 47 between the Easterwood Airport and Texas A&M Flight Test Station, an area where Texas A&M is currently planning to develop a research corridor. The potential BCS option is shown in Figure 72.

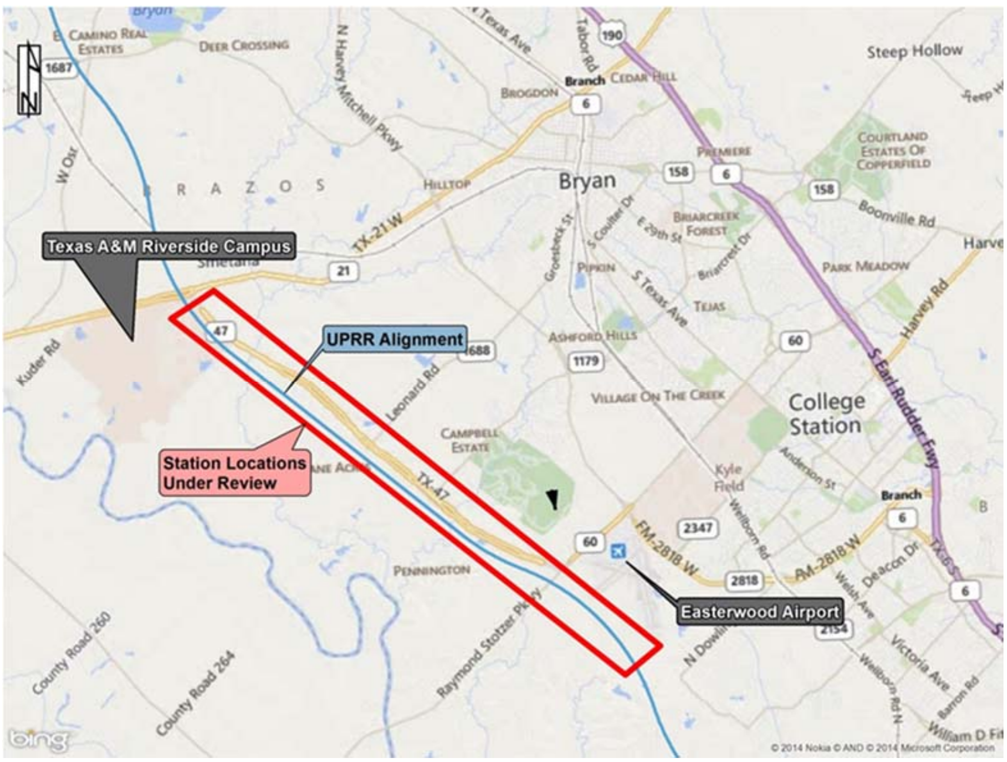

Figure 72 – Bryan-College Station Station

Key Issues

- Access to SH 47 and SH 30
- Intermodal connectivity with Easterwood Airport
- Availability of undeveloped land
- Transit oriented development opportunities
- Regional public transportation network

7.4 Stations in Dallas

The Dallas locations considered for all alignments are:

- Intersection of IH-45/IH-20
- Intersection of IH-45/Loop 12
- Downtown

Table 4 – Station Locations Served By Alternative Alignments In Dallas

Station Locations	IH-45 & IH-45 with Hardy	BNSF (Options 1-4)	UPRR	Utility Corridor & Utility Corridor with IH-45
Intersection of IH-45/ IH-20	X	X	X	X
Intersection of IH-45/ Loop 12	X	X	X	X
Downtown Dallas	X	X	X	X

7.4.1 Intersection of IH-45/IH-20

This study area is considered to be the quadrants formed by the intersection of IH-45/IH-20, approximately 10 mi (16 km) south of downtown Dallas. All nine alignment alternatives begin to converge south of this area, and both the UPRR and BNSF rights-of-way cross IH-20 as shown in Figure 73. All nine alignment alternatives run approximately parallel to IH-45 in this location. The area is predominately rural, with some light industrial and commercial development along with a correctional facility. The area is easily accessible to both rail right-of-way and highway corridors. Although open parcels of land are available for station location, the long distance from the employment and commercial centers of the Metroplex may diminish its attractiveness from a ridership and development perspective.

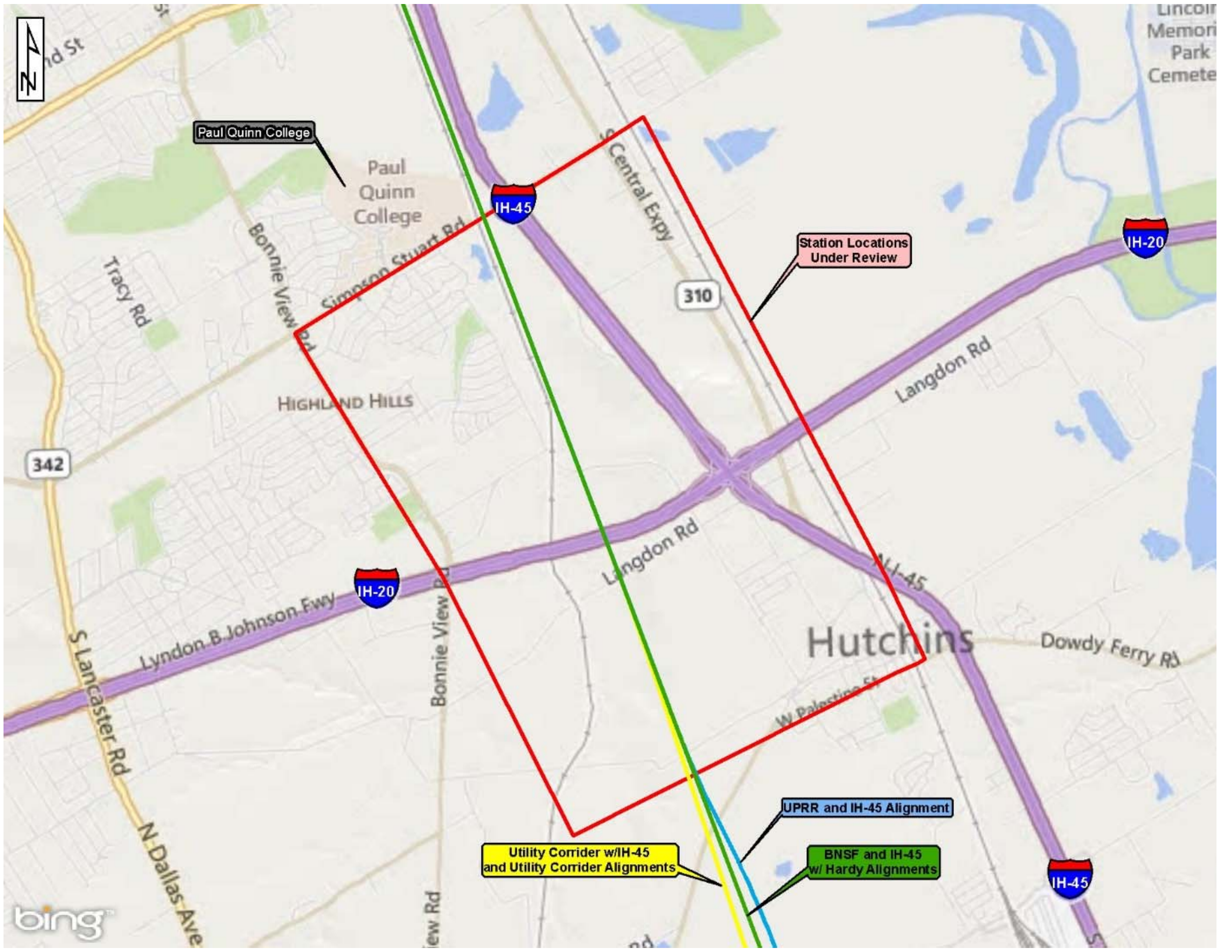

Figure 73 – IH-45/IH-20 Station Area

Key Issues:

- Access to IH-45/IH-20
- Access to railroad rights-of-way
- Availability of undeveloped land
- Distance from key employment centers
- Distance from regional public transportation network
- Lack of commercial development to enhance or support station area development opportunities

7.4.2 Intersection of IH-45/Loop 12

This study area is considered to be the quadrants formed by the intersection of IH-45/Loop 12, approximately 6 mi (10 km) south of downtown Dallas. All nine alignments begin to converge south of this area, and both the UPRR and BNSF rights-of-way cross Loop 12. All alignments run approximately parallel to IH-45 in this location as shown in Figure 74.

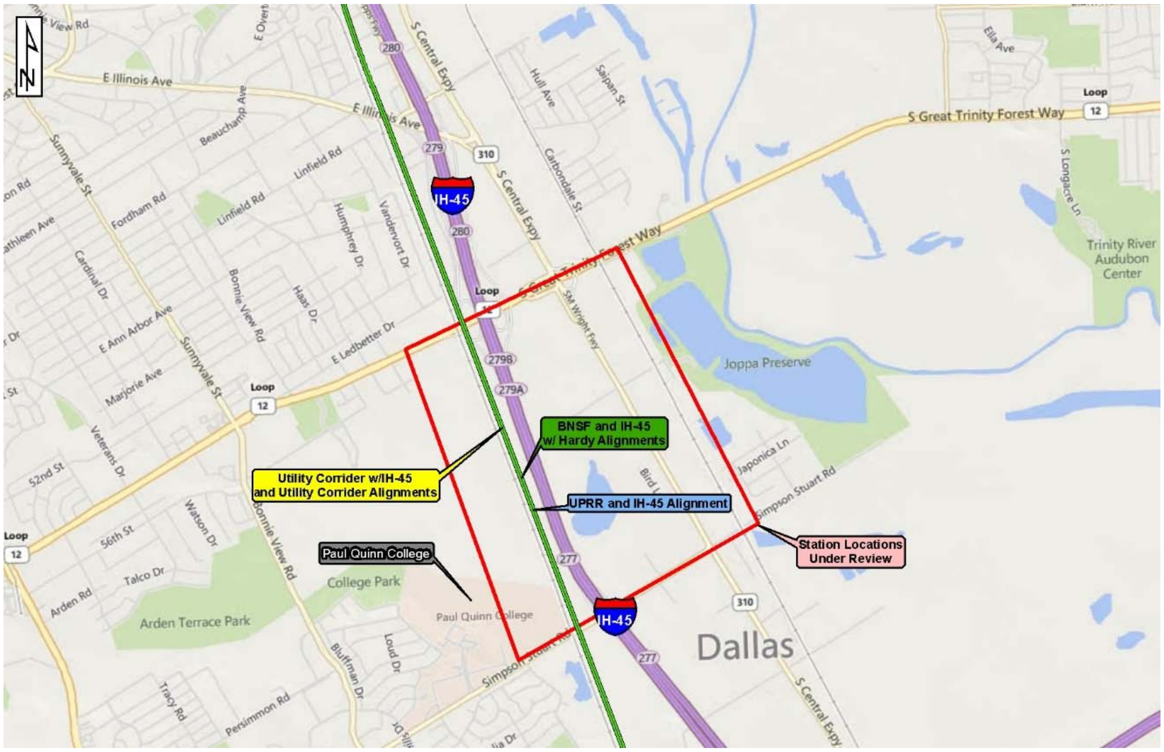

Figure 74 – IH-45/Loop 12 Station Area

The area is a mix of rural with some light industrial and commercial development. It is easily accessible to both rail right-of-way and highway corridors. Although open parcels of land are available for station location, the long distance from the employment and commercial centers of the Dallas-Fort Worth Metroplex may diminish its attractiveness from a ridership and development perspective.

Key Issues

- Access to IH-45/Loop 12
- Access to railroad rights-of-way
- Availability of undeveloped land
- Distance from key employment centers
- Distance from regional public transportation network
- Lack of commercial development to enhance or support station area development opportunities

7.4.3 Dallas Downtown

The Dallas Downtown study area is considered to be the area approximately bounded by IH-35E to the southeast, Woodall-Rodgers Freeway to the north, the Trinity River to the west, and Corrinth Street to the southwest. All alignment alternatives having converged south of Dallas run through this study area as shown in Figure 75.

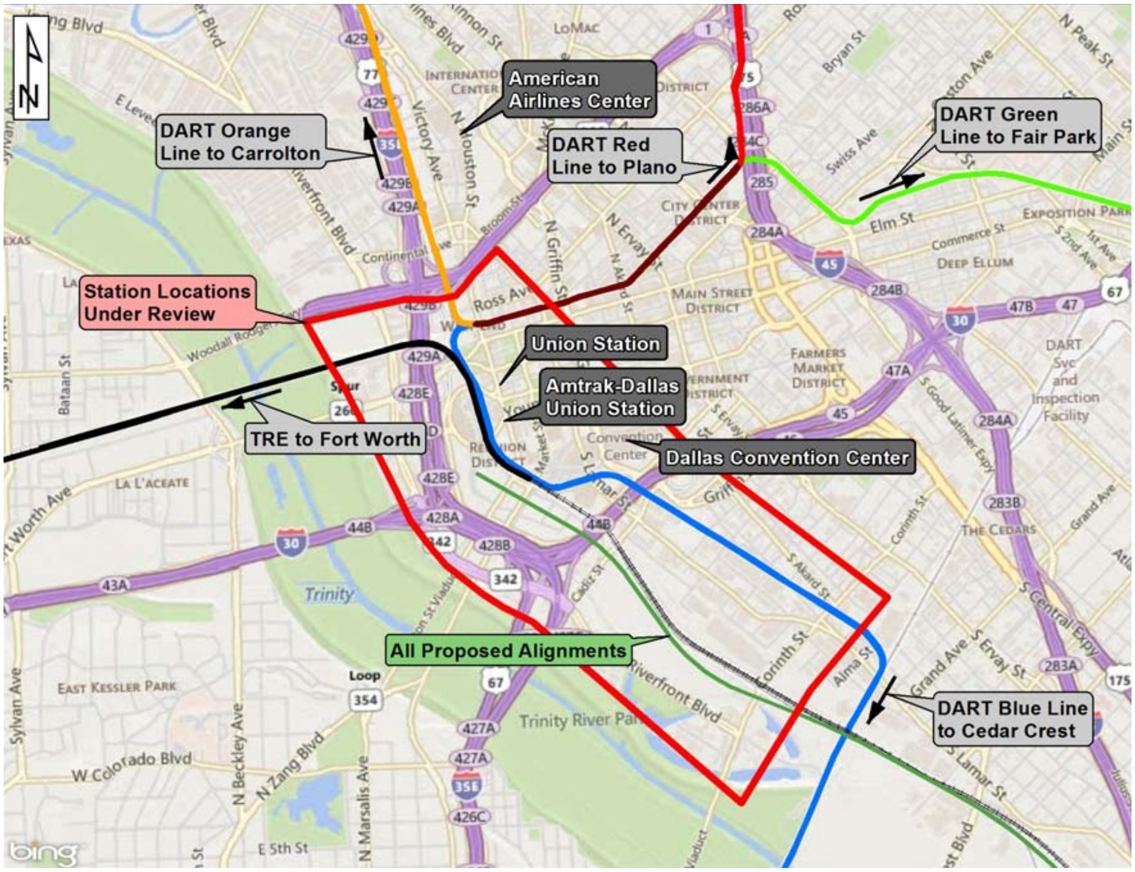

Figure 75 – Dallas Downtown Station Area

There are limited potential locations within this study area, in close proximity to the former Reunion Arena site and the Union Station area. The Reunion Arena and Union Station areas provide access to the existing public transportation network and Amtrak passenger rail services. The area is heavily urban with access to the roadway and highway network. The area can be accessed by all alignment alternatives entering the City of Dallas and the connection to Fort Worth (being considered under a separate study).

Key Issues

- Access to the existing public transportation network
- Access to Amtrak passenger railway services
- Property availability
- Development potential for the station area
- Access to the existing roadway and highway network
- Access to rail rights-of-way
- Proximity to Metroplex employment centers
- Heavy traffic congestion during peak hours

7.5 Station Locations Summary

The current Project definition considers one terminus station for each of Dallas and Houston and a mid-line station to serve the College Station area. This initial study of alternative station locations currently considers general termini areas rather than specific land parcels. Suburban and downtown locations are considered.

Based on the criteria evaluated, the preferred order of station locations from this initial assessment is as follows for each of the Houston and Dallas termini. These results are not weighted. The ultimate selection of a station will be dependent upon the preferred alignment, appropriate weightings based on key criteria, and information received from ongoing ridership studies.

Table 5 – Houston Station Locations Stop Light Chart

Houston Station Locations Stop Light Chart	Houston Station Alternatives			
	US-290/ BW-8	SH-249/ BW-8	US-290/ IH-610	Downtown
Availability of Property	3	3	3	2
Access to proposed rail alignment alternatives	3	3	3	3
Access to the public transportation network	1	1	2	3
Access to the highway and roadway network	3	3	3	3
Annual Ridership/Revenue Potential	2	2	3	2
"Last Mile" costs due to urban development constraints	3	3	2	1
Station area development opportunities	3	3	3	3
Overall Score	18.0	18.0	19.0	17.0

Table 6 – Dallas Station Locations Stop Light Chart

Dallas Station Locations Stop Light Chart	Dallas Station Alternatives		
	IH-45/ IH-20	IH-45/ Loop 12	Downtown
Availability of Property	3	3	3
Access to proposed rail alignmnet alternatives	3	3	3
Access to the public transportation network	1	1	3
Access to the highway and roadway network	3	3	3
Annual Ridership/Revenue Potential	1	1	3
"Last Mile" costs due to urban development constraints	3	2	1
Station area development opportunities	1	1	3
Overall Score	15.0	14.0	19.0

Based on this initial screening, the preferred station area for Houston is the location around the intersection of US 290 and IH-610. The preferred station area for Dallas is the downtown area.

As planning efforts are advanced, a more rigorous analysis of potential station sites focusing on specific parcels will be advanced. Site specific costs and impacts will be assessed to identify the station sites that best suit the overall Project purpose and need and offer the best opportunity for success from a ridership and financial feasibility perspective.

8 Engineering and Constructability Evaluation

Design of any major project of the scale proposed will present both engineering and constructability challenges and impacts. Each alignment alternative will have unique construction requirements that will differentiate the alternatives and could significantly affect the financial viability of the Project. This section focuses only on the key elements of each alignment alternative, namely the extent of viaduct required, the number and types of various crossings, major structures, and other alternative specific engineering and constructability issues.

The overall Project will require numerous smaller structures to cross local roadways, freight railroads, culverts, retaining walls, and significant topographical features. However, consistent design approaches and efficient methods of construction can be developed to address these types of needs. Two important considerations in the comparison of the alignment alternatives are the number and types of crossings and the percentage of alignment on viaducts.

The use of elevated viaducts will be required to address local topographic changes, to minimize environmental impacts, and to separate HSR operations from existing development and transportation infrastructure. Viaduct structures have a significant cost and constructability consideration; however, typical approaches can reduce their negative impact on overall Project financial viability. Nonetheless, the overall viaduct length and the viaduct heights expected is a key differentiator between the alignment alternatives.

Major structures were designated as the structures required crossing significant topographic features, multi-level highway interchanges, or surface water features. In addition to the high-cost construction elements required with such structures, detailed site specific design, regulatory approvals, and construction approaches will be required for each of these structures. It is also likely that the contractor pool will be limited for some of the structures of the scale and type required. As such, each of these major structures can negatively affect the overall Project cost and schedule. Inside the city limits, at either end, all the alignments cross the same highway interchanges within the urban areas of Houston and Dallas

Special consideration will be required for the geotechnical and structural design of structures and their respective foundations due to the high performance requirements of the HSR operations and the shrink-swell soil characteristics in Houston.

All the alignments between Houston to Dallas will confront similar engineering challenges in the urban areas of Dallas and Houston. Outside of the urban areas, each alignment alternative will have its own unique set of engineering and constructability challenges.

8.1 Engineering Consideration

8.1.1 Crossings

At the proposed HSR operating speeds, it is necessary, and legally required, to have a fully grade separated system from the existing roadway and railroad infrastructure. Achieving this grade separation will result in roadway closures, roadway reconfigurations and realignments, and significant structures to carry either the roadways or the HSR system. This will translate to impacts during construction, including traffic congestion and temporary lane closures. These issues add to the complexity of the Project and result in constructability issues, increased construction time and cost, and thus could have a significant effect on the overall schedule and viability of the Project.

Within the urban areas, the decision to close roads will be taken on a case by case basis in close coordination with the local cities and municipalities to minimize and mitigate impacts to local traffic routes and emergency services. Within the rural areas, coordination with the local, county, and state organizations will be required to fully understand and mitigate any impacts on traffic, emergency services, school bus routes, and other considerations. In addition, consultation may be required with landowners whose properties are impacted by the project.

Each of the crossings will require site specific design approaches based on clear span, topography, constructability, implementation phasing, and expected impacts. For each alternative, the following types of crossings were quantified and classified as follows:

- Roadway Crossings: For major highway crossings, the HSR will often be raised over the highway given likely traffic impacts and costs of highway reconfiguration; for local roadways, it will often be less costly to raise the roadways above the HSR given that roadway profile grades can be greater than HSR profile grades. Crossings of major, multilevel highway interchanges will present significant challenges, especially in urban areas. During alignment development, efforts were taken to avoid crossing of these interchanges, but, in the complex urban environments of Houston and Dallas with their extensive highway networks, this was not possible. For the purposes of this alignments comparison, it was assumed that extended viaducts would be used to cross highways and interchanges, which translated into several kilometers of tall viaducts in certain locations. During more detailed design it may be possible for the HSR alignment to thread between the existing structures with some relocating of existing columns and carefully staged reconfiguration of certain highway elements. The preferred approach would be developed through a detailed review of construction and long-term impacts, expected costs and construction schedules, ROW requirements, and constructability issues.
- Freight Crossings: In most cases, it will be more cost-effective, and the preferred option, to carry the HSR alignment over existing freight lines given costs and impacts associated with reconfiguring an active freight

railroad operation, and the more gentle grades permissible for freight operations.

- Water Crossings: Efforts were taken during the alignment development to avoid major surface water features and other environmentally sensitive constraints. Where the alignments crossed water features, the assumed approach was to use elevated viaducts rather than embankment type construction.
- High-Voltage Transmission Line (HVTL) Crossings: For potential conflicts with the power transmission lines, the preferred design option would generally be to raise the height of the lines locally to accommodate the train infrastructure below. At each of the road, rail, and utility crossings coordination will be required with the owner of the infrastructure (TxDOT, CenterPoint, Oncore, UPRR, BNSF, etc.) to ensure that the design minimizes impact to existing infrastructure and is properly coordinated with other infrastructure improvement and development projects currently underway and planned.

Table 7 presents type and number of crossings for each alignment alternative and shows the percent difference between the infrastructure crossings for each alignment alternative in comparison to the corridor alternative with the least number of crossings, namely the Utility Corridor alignment.

Table 7 – Number and Type of Crossing for HSR Alignment Alternatives

Type of Crossing	BNSF w/ Option				IH-45	IH-45 w/ Hardy	UPRR	UC w/ IH-45	UC
	1	2	3	4					
Roads (Interstate Highways, State, County, and Municipal Roadways)	355	410	425	385	602	551	618	294	232
Rail (Passenger (DART), Freight (UPRR, BNSF, etc.))	48	48	48	50	17	25	25	25	17
Water (Rivers, Streams, Wetlands and Reservoirs)	60	59	60	71	72	74	69	24	25
HVTL (> 69 kV)	71	71	69	76	57	75	81	29	25
Total	534	588	602	582	748	725	793	372	299
Percentage Difference	179%	197%	201%	195%	250%	243%	265%	125%	100%

8.1.2 Utilities

Below grade utilities were not considered in the development or assessment of any alternatives at this stage. However, collection of underground and above ground utility data for major utilities will be required at the next stage of design development to avoid any potential conflicts that could result in unacceptable impacts, risks, costs, or schedule delays.

More detailed utility analysis would likely result in greater expected costs for the alignment alternatives that run parallel to the IH-45 ROW and the urban areas along the route given the expected density of utilities serving existing development. All the alignment alternatives except the UPRR alignment pass through the dense gas fields around Personville and Jewett.

8.1.3 Major Structure

Table 8 presents the list of major structures. The locations of structures common to all alignments and of structures encountered on an individual alignment are differentiated. Most of the alignment alternatives cross several major highways in the vicinity of Houston city limits. All the alignment alternatives cross several major highways while entering the city limits of Dallas.

Table 8 – Major Structures

Alignment Alternative	Major Structures (Specific to Each Alignment)	Major Structures (Common for All Alignments)
BNSF w/ Option 1	Buffalo Bayou SH 249	Houston Region: IH-10 IH-610 IH-45 Sam Houston Tollway/Beltway 8 SH 99 Dallas Region: IH-20 Loop 12 Trinity River Levees IH-30
BNSF w/ Option 2	Buffalo Bayou SH 249 IH-45 near Palmer IH-45 near Streetman	
BNSF w/ Option 3	Buffalo Bayou SH 249 Richland Chambers Reservoir IH-45 near Streetman IH-45 viaduct over Trinity River	
BNSF w/ Option 4	Buffalo Bayou SH 249 IH-35E (x2)	
IH-45 w/ Hardy Option	Hardy Toll Road Buffalo Bayou	
IH-45	Hardy Toll Road Buffalo Bayou	
UPRR	US 290 IH-45 near Richland	
UC w/ IH-45	US 290	
UC	US 290	

Construction of the major structures at interstates and interchanges will be very complex, especially in dense urban regions. Transport of the large structural members, excavated materials, and construction materials for the Project would have to be managed and scheduled to minimize transportation and environmental impacts. Traffic lanes would likely need to be temporarily closed or traffic will be diverted to safely transport equipment and material, and to perform construction operations. Work would require close coordination with TxDOT and other relevant parties within the corridor regarding not only existing operations, but also construction projects currently underway or planned. Adequate temporary construction access ways and staging areas would need to be developed to support construction of the Project. Specialized equipment and contractor skills would be necessary to install large foundations required to support the structures. At major water resource crossings, barges would likely be necessary for in water work.

Key issues relevant to each individual major structure are as follows:

- IH-45: The HSR system would be on viaduct to cross above the IH-45 interchange, which itself spans over the existing freight railroad tracks. This would be an extended viaduct approximately 70 to 80 ft (20-25 m) above grade.
- IH-10: HSR would be on an elevated viaduct before reaching this interchange and it would be more cost effective to keep the Utility Corridor alignment above ground to cross the IH-10 Interstate.
- IH-610: HSR would be on an elevated viaduct which spans over IH-610. The viaduct will also need to thread alongside of the existing freight railroad tracks. This viaduct would be approximately 70 to 80 ft (20-25 m) above grade which would present substantial engineering and constructability challenges including coordination with TxDOT and freight railroad, and would require substantial ROW acquisitions, traffic control, and temporary lane closures.
- Sam Houston Tollway/Beltway 8: Assuming that the HSR will be elevated as it approaches this interchange, it is envisioned that the HSR system would go over this intersection for most of the alignment alternatives except for the two Utility Corridor alignments. For the Utility Corridor alignments, it is envisioned that the HSR would be at ground level and pass between the existing columns of the Sam Houston Tollway. This approach appears feasible at this conceptual design stage, but would present challenges in terms of clearance distances (with the freight railroad and highway columns) and ROW widths.
- Grand Parkway (SH 99): A viaduct is assumed to cross over the Grand Parkway. The Grand Parkway would go through major reconstruction in the coming years and more traffic lanes may be added to its existing configuration. Considerable coordination would be required with TxDOT to fully understand long term improvement plans for this, and all other highways crossed.
- IH-20: A viaduct is assumed to span the IH-20 interchange.

- Loop 12: A viaduct is assumed to span the Loop 12 main lanes and the on and off ramps. The existing ramps at the interchange pass above the existing freight railroad and the HSR would thread alongside of these existing freight railroad tracks.

- Trinity River: A special long span structure would be required to cross the Trinity River, which would require close coordination with the Fort Worth District of the US Army Corps of Engineers with respect to environmental permitting. Environmentally sensitive design and construction approaches would be required, both from a groundwater and a surface water perspective.

- IH-30: For the downtown Dallas station options in Dallas using any of the alignment options, an HSR major rail viaduct would be required to span the IH-30 main lanes and the on and off ramps to and from IH-30. The ramps at the interchange are elevated and the HSR would thread alongside of the existing freight railroad tracks. This would be an extended length viaduct approximately 60 to 70 ft (18 to 22 m) tall which would present substantial engineering and constructability challenges.

- SH 249: HSR would stay on a viaduct to cross above the SH 249 and the SH 249 frontage road. The viaduct at this interchange would be approximately 60 to 70 ft (18 to 22 m) and would require temporary lane closures during construction.

- Richland Chambers Reservoir: Four HSR alignment options (BNSF Option 2, BNSF Option 3, and both UPRR alignments) would be raised on a viaduct to cross the Richland Chambers Reservoir. The elevation of the reservoir is 328 ft (100 m); however, natural ground elevations at the approaches to the viaduct that crosses the reservoir are at approximately 350 ft (107 m), resulting in a higher elevation for the viaduct.

- Buffalo Bayou: In all BNSF and IH-45 alignment options, the HSR crosses two sections of the Buffalo Bayou near the downtown post office in Houston. Each crossing would need to span 60 to 70 ft (18 to 22 m) in order to span the Bayou and the highways in close proximity. This crossing would require coordination with the US Army Corps of Engineers for environmental permitting.

- US 290: A viaduct is envisioned to cross over the US 290 interchange. The HSR would need to pass over both the existing freight rail and US 290 at this location. In addition, this intersection has two transmission lines that would need to be raised to pass over the elevated HSR tracks.

- Hardy Toll Road: As the HSR would already be elevated coming out of the Houston area, it is envisioned that a viaduct would be needed to cross over the Hardy Toll Road. This viaduct would need to be 60 to 70 ft (18 to 22 m) tall in order to crossover the already elevated ramp connecting IH-45 south bound lanes to the toll road.

- IH-35E: A viaduct would be needed to cross over the IH-35E in the BNSF w/ Option 4 alignment. This alignment crosses IH-35E in two sections the south of which would be a simple viaduct spanning all lanes of IH-35E and the nearby Hwy 77. The north crossing would be more robust with the need to pass over the Sterrett Road Bridge spanning IH-35E. Additionally, the transmission lines to the south of E Sterrett Road would need to be raised to stay above the HSR line.

- IH-45 near Palmer, Richland, and Streetman: A viaduct would be needed to cross all lanes of IH-45 at this point. At this intersection IH-45 is at-grade but the HSR crosses at an oblique angle requiring a longer section of viaduct to cross the major highway.

8.1.4 Viaducts

Where the ground is relatively flat and in rural areas where there is less interference with local roadways, the Project will generally construct tracks on embankments. For larger floodplains and select existing infrastructure along greenfield segments of the alignment, the Project will generally need to construct elevated viaducts because an at-grade configuration is not suitable. Structures over water bodies would be designed to be above the 100-year floodplain elevation with a suitable free board elevation. For this conceptual design effort, it was assumed that viaduct structures would be used to cross each floodplain above 100-year base flood elevation and that viaducts would be at a minimum elevation of 15 ft (5 m) above the ground elevation. During more detailed design, these viaduct locations will be further refined and embankment sections with appropriate culverts and/or lower elevation viaducts may be proposed.

The number, height, and length of the viaduct structures required for each alignment will present significant constructability challenges and will substantively add to the overall cost of the project. Thus the overall viaduct length and the percentage of the viaducts for each alignment alternative is a key differentiator between the alternatives.

In order to carry out a comparison of the alternatives, all the alignments were broken down into three segments:

- Houston Segment: Post Office location in Houston to SH 99
- Middle Segment: SH 99 to IH-20
- Dallas Segment: IH-20 to Reunion Arena in Dallas

For the conceptual level of analysis, the urban Houston Segment and Dallas Segment mentioned above are assumed to be on elevated viaducts due to the dense development and existing infrastructure.

For the Middle Segments of each alignment alternative, Federal Eemergency Management Agency (FEMA) Effective floodplain data, FEMA Q3 dataset, and the National Hydrography Dataset (NHD) flowline dataset sources were collectively used to gather the floodplain maps. This information was then used to determine the length of viaduct required to span floodplain areas for all the alignments.

Table 9 – Percentage of Viaducts Required by Floodplains for Middle Segments

Middle Segments	Viaduct Percentage required to Span Floodplain Areas
BNSF Option 1	31% Viaduct
BNSF Option 2	31% Viaduct
BNSF Option 3	32% Viaduct
BNSF Option 4	31% Viaduct
IH-45	35% Viaduct
IH-45 with Hardy	36% Viaduct
Utility Corridor	27% Viaduct
Utility Corridor with IH-45	31% Viaduct
UPRR	36% Viaduct

The percentages listed above do not include the additional viaduct within each Middle Segment required to minimize impacts through developed areas of existing infrastructure. For the IH-45 and IH-45 with Hardy alignments, extensive lengths of viaduct will be required due to spatial constraints and crossing on and off ramps because the alignment is located within the existing IH-45 ROW.

8.1.5 Shrink-Swell Soils – Geotechnical

A wide variety of soil conditions would be encountered for all the alignment alternatives from Houston to Dallas, making it necessary to acquire geotechnical data early on in the design to make ground improvement recommendations. An initial desk study has shown evidence of soft soils where the soils would need to be replaced and the presence of expansive soils that may need lime treatment or other mitigation measure during construction. These data collection and mitigation efforts would be necessary to refine infrastructure requirements and capital cost estimates. Enhanced geotechnical data is also critical to defining the expected construction approach and minimizing schedule and cost risks during construction due to unexpected soil conditions.

8.1.6 Other Structures

Retaining wall structures would be needed parallel to the proposed alignment alternatives where existing property lines, rights-of-way, and existing structures preclude the use of the desired 4:1 (horizontal to vertical) side slopes. In general, retaining walls would be required where site conditions preclude the use of embankment. Retaining walls would also be used at the start and end of viaduct sections and at highway and rail bridge approaches.

Noise walls would be required in more highly developed areas and other sensitive areas. Limits of noise walls would depend on regulatory requirements and stakeholder demands.

Barrier walls may be required at key locations along both alignments to minimize risks and meet regulatory and stakeholder requirements. For this conceptual level of design, it is assumed that barrier walls would be provided where the distance between the centerline of the BNSF track and the centerline of the nearest HSR track is less than 50 ft (15 m) to aid in the prevention of fouling the HSR track by a derailed freight train. Barrier walls may also be required where the HSR and IH-45 have an offset of less than 50 ft (15 m) in between.

8.2 Constructability Issues and Schedule Risks

This Project would involve significant earthwork, structures, and facilities construction. Location-specific construction activities would vary significantly for each alignment alternative from roadbed construction in rural areas to extensive utilities relocation, roadway realignment, and elevated railway viaduct structure construction in more developed or environmentally sensitive areas.

In addition to the specific risks outlined in the previous sections, the following are general risks associated with this Project:

- Land Acquisition: ROW/land acquisition process would be a significant effort for all corridor alternatives, but the various entities and property owners impacted would be unique to each alternative. Property acquisition requirements and difficulties could be reduced for those corridor alternatives following IH-45 or a freight railroad by minimizing the number of affected property owners. Following the Utility Corridor could provide some benefit since the abutting property owners are already bounded by the utility and there could be some Project joint benefit provided to the utility owner through provision of a corridor access road for construction and maintenance.
- Existing Freight: HSR alignment alternatives that parallel the existing freight railroad corridors will present the unique issue presented by the risk of freight derailments. These risks would be addressed through provision of barrier walls or through improvements to the existing freight line.
- Existing Development and Utilities: Corridor alternatives along IH-45 will confront significant challenges with commercial and urban development, extended above and underground utility networks, and maintenance and protection of traffic (MPT) issues. Safety during construction of the HSR system adjacent to high-voltage transmission lines would have to be carefully coordinated with the utility to ensure safety, especially for construction of elevated viaducts and overhead catenary structures.
- General: All alignments will have to carefully manage general construction risks that could significantly impact the financial feasibility of the Project.
    - Shortages of materials or skilled labor
    - Unforeseen utility and geological problems

- Construction of long viaducts
- Construction in urban areas and over interchanges where detailed MPT will be required along with close coordination with local and State public agencies.
- Long duration of weather interference
- Shortage of specialized construction equipment

8.3 Summary of Constructability Evaluation

All alignments for a project of this magnitude would involve significant construction challenges, but each alignment presents a different number of common challenges and unique particular infrastructure requirements. Table 10 provides a summary of the major issues and has been "colored" using the stoplight chart approach to help identify the variations amongst alignments.

Table 10 – Constructability Evaluation Summary

Alignments	Total Crossings	Specific Major Structures	Total % Viaduct*	Total % Barrier Wall	Key Issues
BNSF Option 1	534	2	30	20	• Crosses SH-249
BNSF Option 2	588	4	30	20	• Crosses SH-249 • Crosses IH-45 multiple times
BNSF Option 3	602	5	30	15	• Crosses SH-249 • Crosses IH-45 multiple times • Crosses Richland Chambers Reservoir
BNSF Option 4	582	4	30	20	• Crosses SH-249 • Crosses IH-35E multiple times
IH-45 Hardy	725	2	85	0	• Crosses Hardy Toll Road • High percentage of viaduct • High number of crossings
IH-45	748	2	85	0	• Crosses Hardy Toll Road • High percentage of viaduct • High number of crossings
UPRR	793	2	35	10	• Crosses US 290 • High number of crossings
UC IH-45	372	1	55	0	• Crosses US 290 • High percentage of viaduct
UC	299	1	35	0	• Crosses US 290

*Total percent viaduct is based on viaduct from both wetlands and development.

The connection into downtown Dallas will be the same for all the alignment alternatives. The connection to downtown Houston would vary for each alignment. Considering the highly developed area around the terminus location in Houston, the UPRR and Utility Corridor alignments will have the least impact, but will result in a slightly longer section. Since the alignment will be on viaduct for all the alternatives within Houston, the middle segment of the alignment becomes the primary differentiator regarding constructability between the alignment alternatives.

Based on the engineering and constructability evaluation completed to date, the Utility Corridor presents the fewest construction challenges. The Utility Corridor alignment also stands out from the other alignment alternatives in terms of infrastructure crossings, freight railroad impacts, and construction within urban areas and local communities. Moreover, the Utility Corridor alignment follows a straighter route through more rural areas that would ease construction requirements, facilitate improved construction access, reduce costly impacts to existing development, reduce impacts to traffic, and reduce the use of more advanced viaduct construction approaches.

9 Cost Estimate

Cost estimates were developed for the alternative alignments considered. These estimates are classified as Class 5 Rough Order of Magnitude (ROM) estimates in accordance with the Association for the Advancement of Cost Engineering International (AACE International) best practices.

9.1 Estimating Approach

The estimates were developed for each alignment to determine the relative cost difference between them. The estimates included the following key differentiators:

- Heavy civil infrastructure for the HSR alignment (at-grade, cut, and viaduct)
- Barrier walls
- Complexity factors for sections of the alignment within urban and suburban areas
- Roadway grade separations
- HSR trackwork
- Major structures
- Three HSR stations

Key assumptions used in the development of estimates included:

- Estimates were developed to evaluate the heavy infrastructure costs only to support the comparative assessment of competing alignments.
- Historical benchmark data was used from Arup's internal database of international HSR projects. Rates and costs were normalized for construction in the Texas market.
- The estimate assumes normal ground conditions. No allowances were made for ground decontamination or discovery of archaeological artifacts and their consequential effects on the Project.
- The estimate did not include impact mitigation costs for compensatory works or betterments to existing utilities, roadways, or developments.
- Unit rates used reflect the cost of direct construction and include labor, equipment, and materials.
- The quantities in the estimate are conceptual in nature and would be adjusted as more information becomes available and the design progresses.
- A construction contingency allowance was included, but did not address changes in alignment or scope.

9.2 Segments

Each alignment was estimated using a segmental buildup consisting of a unique middle segment that connects into two common end segments in the urban areas of Houston and Dallas.

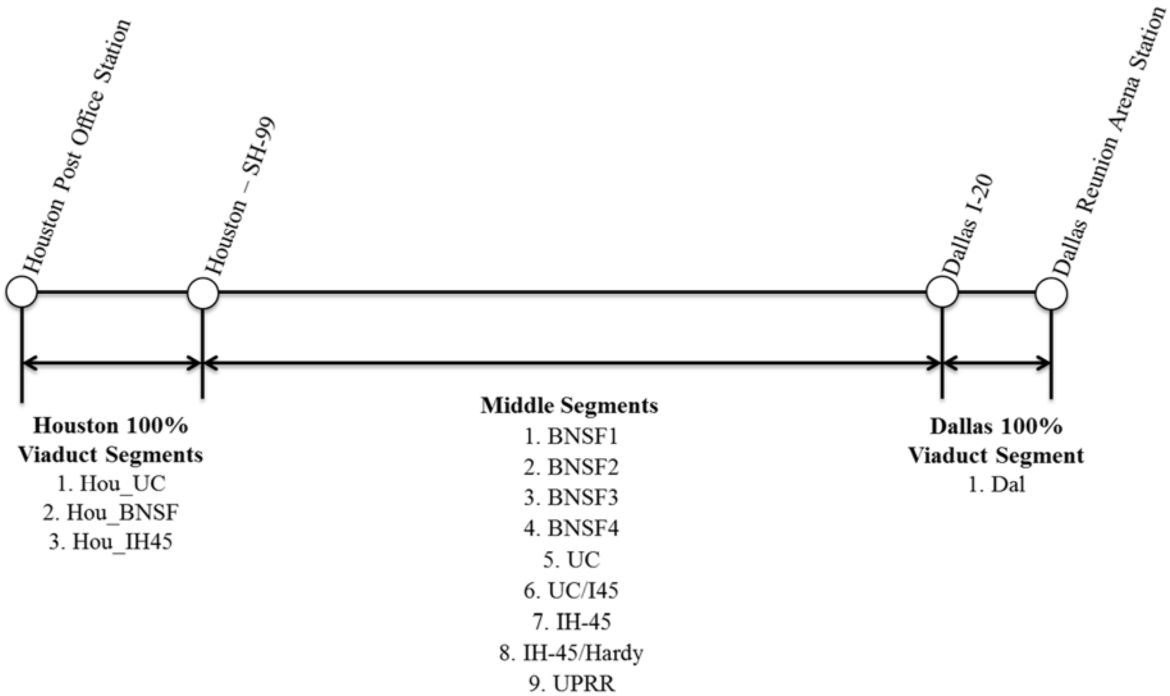

Figure 76 – Schematic Representation of Cost Estimate Segments Used to Produce Alignment Costs

Costs for each middle segment were estimated based on the following infrastructure categories:

- Heavy civil infrastructure
- Complexity factors
- Grade separations
- Major structures

9.3 Heavy Civil Infrastructure

The heavy civil infrastructure was broken down into the following 5 major section types:

1. Embankment
2. Embankment with barrier wall
3. Cut
4. Viaduct (due to development)
5. Viaduct (due to wetlands)

In order to determine the heavy civil infrastructure section types, a visual inspection using Google Earth was performed for all alignment middle segments to determine the length of alignment suitable for embankment/cut or viaduct due to interaction with existing infrastructure. Additionally, a preliminary flood plain analysis was performed by Freese and Nichols Inc. to determine the length of alignment requiring viaduct to pass over flood plain areas. Finally, a visual inspection was performed to determine the percentage of the embankment portions of the alignment within the existing freight railroad right-of-way that would require construction of a barrier wall.

Table 11 shows the percentages used to estimate each alignment mid-segment section type. It is important to note that due to the high levels of existing infrastructure and development already present in the urban areas, 100% of the Houston and Dallas segments were assumed to be on viaduct.

Table 11 – Section Type Percentages Used to Produce Alignment Costs

Section Type	Mid UC	Mid UCIH45	Mid BNSF1	Mid BNSF2	Mid BNSF3	Mid BNSF4	Mid UPRR	Mid IH45	Mid IH45H
Embankment	40%	25%	25%	20%	25%	25%	30%	10%	10%
Cut	25%	20%	25%	25%	25%	25%	25%	5%	5%
Viaduct (from development)	10%	30%	0%	5%	5%	0%	0%	50%	50%
Viaduct (from flood plains)	25%	25%	30%	30%	30%	30%	35%	35%	35%
Embankment w/ Crash Wall	0%	0%	20%	20%	15%	20%	10%	0%	0%
Total =	100%	100%	100%	100%	100%	100%	100%	100%	100%

9.4 Complexity Factor Percentages

The middle segments of the alignments were broken down into the following complexity factor categories based on visual inspections on the segments:

- Urban (20% cost premium)
- Developed (10% cost premium)
- Undeveloped (0% cost premium)

Table 12 shows the percentages used to estimate each alignment corridor mid-segment complexity factor. It is noted that 100% of the Houston and Dallas end segments were considered to have “urban” complexity factors.

Table 12 – Complexity Factor Percentages for Each Alignment Corridor Mid-Segment

Complexity Factor	Mid UC	Mid UCIH45	Mid BNSF1	Mid BNSF2	Mid BNSF3	Mid BNSF4	Mid UPRR	Mid IH45	Mid IH45H
Urban	0%	0%	0%	0%	0%	0%	0%	0%	0%
Developed	5%	5%	20%	30%	25%	30%	10%	45%	45%
Undeveloped	95%	95%	80%	70%	75%	70%	90%	55%	55%

9.5 Grade Separations

Cost allowances were made for grade separated roadway crossings required along at-grade portions of the alignment. For each alignment mid-segment, the total number of roads crossings were counted based on visual inspections using Google Earth. Table 13 shows the total number of roadway crossings for each alignment mid-segment.

Table 13 – Number of Roadway Crossings for Each Alignment Corridor Mid-Segment

	Mid UC	Mid UCIH45	Mid BNSF1	Mid BNSF2	Mid BNSF3	Mid BNSF4	Mid UPRR	Mid IH45	Mid IH45H
# of Roads Along Alignment	96	158	234	289	304	264	363	355	356
% of At-Grade Alignment	65%	45%	70%	65%	65%	70%	65%	15%	15%
# of Road Crossings Required	**60**	**70**	**160**	**190**	**200**	**180**	**240**	**50**	**50**

In order to accurately compute the number of grade separated road crossings required, the total road crossings were multiplied by the percentage of at-grade alignment length for each mid-segment (in order to exclude road crossings that would pass under viaduct sections of the alignment). For example, the IH-45 mid-segment has numerous road crossings, but also has a large percentage of viaduct resulting in a low number of roads requiring vertical realignment.

9.6 Major structures

As mentioned in Section 8 of this report, several major structures will be required through all segments. The following lists the major structures included in the cost estimate:

- SH 249/Beltway 8 Interchange
- Sam Houston Tollway/Beltway 8
- IH-45
- Hardy Toll Road/IH-610
- IH-610
- IH-10
- Buffalo Bayou
- Grand Parkway
- US 290
- IH-20
- Loop 12
- Trinity River 1

- IH-30
- Richland Reservoir
- IH-35E

9.7 Exclusions

The following items have not been included as part of this conceptual cost estimate comparison:

- ROW costs and/or demolition of existing structures
- All system costs (including):
  - signaling
  - catenary
  - traction power stations
  - communications
- Rolling stock
- Program/soft costs (including):
  - preliminary design
  - final design
  - project management for design and construction
  - construction administration and management
  - legal fees
  - permit costs, local planning obligations, agreements, and any fees associated with these
  - review fees
  - surveys
  - testing
  - inspections
  - insurance
  - contractors' bond
  - tax
  - owner's contingency
  - escalation/inflation/deflation beyond Q1 2012
- Owner's direct management costs, running and maintenance costs
- The costs or impacts of latent environmental issues that result in litigation or development delays
- Removal of any of the works at the end of their useful life — including allowance for any residual value
- Financing charges
- Credits for capital taxation allowances
- Compensatory costs to other interested parties
- Maintenance costs
- Hard rock excavations or the impact of encountering unfavorable soil conditions, hazardous materials, or poor working conditions during the construction process

9.8 Cost Estimate Results

Table 14 shows the normalized comparison of conceptual capital cost totals for each corridor resulting from the estimating methodology described.

Table 14 – Normalized Comparison of Conceptual Capital Cost Totals

Segment	Normalized Totals
UC	1.00
UC via IH-45	1.22
BNSF Option 1	1.04
BNSF Option 2	1.11
BNSF Option 3	1.12
BNSF Option 4	1.07
UPRR	1.18
IH-45	1.47
IH-45 w/ Hardy	1.48

10 Environmental Screening – Alignments and Stations

An environmental constraint analysis was made on nine alignments and seven terminal stations developed in the engineering review process for the HSR. An additional station (south of the Exxon Mobil Campus) identified in the engineering phase of the analysis was not fully vetted from an environmental standpoint due to the unviability of the IH-45 routes. Endpoint stations were chosen as a starting point and different alignments were identified. Other possible station locations were identified in the vicinity of the terminus stations and along the alignment.

The starting and endpoint of each alignment in this analysis was at the Post Office in downtown Houston (Figure 66) and the former Reunion Arena in Dallas (Figure 75). Additional station locations were identified, as discussed in section 7. General areas for these stations were selected based on the potential opportunities to locate a terminal station, but specific tracts for stations were not identified at this time. Individual station locations will be further vetted as the environmental permitting process proceeds.

For design purposes, intermediate stations would be located to provide service to the Bryan-College Station area. Similar to the metropolitan areas, a specific tract has not been identified but rather a general area has been identified on each alignment. Since only a single common station area has been identified for the Utility Corridor, BNSF and UPRR corridors, comparative environmental analyses have not been included as part of this Report.

Engineering of the HSR alignment ancillary facilities (control center, maintenance shops for trainsets and track, and electrical substations) was not done as part of this analysis because they would exist on any HSR alignment and their location along the HSR is less location constrained.

For the environmental assessment, commonly used features or constraints were selected and used to characterize the different alignment and station location options. The quantitative data for each feature was reviewed and an environmental rating assigned to each alignment. The alignments and station locations evaluated are presented in section 6 and section 7 of this report.

10.1 Methods

The objective of the screening environmental analysis was to identify and quantify, when possible and for comparative purposes only, features or constraints that would lead to the subsequent identification of one and potentially two environmentally preferred HSR alignments. The desktop analysis relied upon currently available public information and no ground verification of the data was performed. Each HSR alignment and station option was screened against the same dataset to allow comparison among alternatives. In some cases, specific features were not included in the analysis based on review of aerial imagery. For example, the existing National Wetland Inventory data for the terminal stations in

Houston do not reflect the degree of ongoing development that has occurred and as such present an inaccurate picture of current conditions. Reporting of data is not intended to be a complete inventory of a given feature in the screening buffer, rather data has been filtered in cases to allow for more useful comparison. For example, National Hydrographic Data for streams was filtered based on 1:100,000 scale data (medium resolution), rather than a finer 1:24,000 resolution. This provides a broader assessment of perennial streams that may be encountered versus countering less significant small or ephemeral drainages. While ultimately important for permitting, these smaller, ephemeral drainages will not affect design or drive the environmental impact assessment.

Utilizing the geoprocessing tools found in the ESRI ArcGIS suite, each feature or constraint was intersected with the screening buffer, and the results quantified as point counts, linear measures, or area measures depending on the geometry of the input features and the level of detail desired.

The HSR alignment alternative analysis considered a total of seven (7) different features, grouped into 18 categories that were screened for this analysis. The screening distance or buffer of 350 ft (107 m) or 175 ft (53 m) on either side of the centerline) was used with few exceptions. Select features, because of their unique characteristics, were reviewed with a wider buffer. For example, airports were screened at 0.5 mi (8 km) and noise sensitive receptor buffers were expanded by either 240 ft (73 m) or 380 ft (116 m) depending on existing noise background of the area.

The station alternative analysis considered a total of 29 different features grouped into nine categories. Because the station locations will ultimately fall within the polygons identified in section 7, the environmental analysis was limited to the identified polygons with no additional buffering. Also, because the station locations will comprise only a portion of the alternative polygons, a quantitative analysis was not considered an appropriate methodology to compare locations. Rather, for screening purposes the qualitative comparison of data was undertaken to identify potential constraints.

Table 15 is a summary of the data sources that were used in the characterization of the alternatives.

Table 15 – Environmental Data Sources

Resource Topic	Source
Threatened and Endangered (T&E) Species and Special Habitats	Texas Natural Diversity Database, T&E Species Element Occurrence Area and T&E Species Managed Habitat Areas, 2013, http://www.tpwd.state.tx.us/huntwild/wild/wildlife_diversity/txndd/ US Fish and Wildlife Service (USFWS), Critical Habitat, 2011, http://ecos.fws.gov/crithab/ Environmental Systems Research Institute, Parks and Refuges, 2010, http://www.esri.com/data/data-maps/data-and-maps-dvd
Soils (Shrink/Swell, Prime Farmland, Hydric Soils)	Natural Resources Conservation Service, Shrink/Swell and Prime farmland Soils, 2011,

Resource Topic	Source
	http://datagateway.nrcs.usda.gov/GDGOrder.aspx?order=QuickStat ewps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627
Hydrology	US Geological Survey National Hydrology Dataset (NHD), 2010, Water Bodies, Rivers and Streams, http://viewer.nationalmap.gov/viewer/ Texas Department of Environmental Quality (TCEQ), 2010, Reservoirs, https://www.tceq.texas.gov/assets/public/gis/metadata/segments_res_est.pdf
Wetlands	US Department of the Interior, Fish and Wildlife Service, 2010, Wetlands, http://www.fws.gov/wetlands/Data/Mapper.html Federal Emergency Management Agency (FEMA), Flood Zones, 2005, http://www.tnris.org/get-data#flood
Road Infrastructure	Texas Department of Transportation, Roads, 2012, http://www.tnris.org/get-data#transport
Transportation Terminal Opportunities	Texas Department of Transportation, Airports, 2012, http://www.tnris.org/get-data#transport Federal Transit Administration (FTA), Fixed-Guide way Transit Network, 2004. http://www.bts.gov/programs/geographic_information_services
Human Environment	Environmental Systems Research Institute, Landmarks, 2012, http://www.esri.com/data/data-maps/data-and-maps-dvd
Transmission Lines	United States Department of Transportation, National Pipelines, 2004, https://www.npms.phmsa.dot.gov/
Noise	US Geological Survey, National Land Cover Database, 2011, http://www.mrlc.gov/nlcd11_data.php
Lakes & Streams	US Geological Survey National Hydrology Dataset: http://nhd.usgs.gov/
Oil and Gas/Mineral Resources	General Land Office: http://www.glo.texas.gov/what-we-do/energy-and-minerals/oil_gas/permitting_and_leasing/index.html
Cultural and Historic Resources	Texas Historical Commission: ftp://ftp.thc.state.tx.us/GIS/ Texas Historic Commission, Cultural Locations of Interest, 2005-2012, http://atlas.thc.state.tx.us/shell-mrd.htm
Land Use/Land Cover	US Geological Survey National Land Cover Dataset: http://landcover.usgs.gov/natllandcover.php:
Environmental Justice	US Government Census http://www2.census.gov/census_2010/04-Summary_File_1/ http://www.census.gov/acs/www/
Ecological Regions	http://www.epa.gov/wed/pages/ecoregions/tx_eco.htm
Parks and Recreation Areas	Environmental Systems Research Institute, Parks, 2012, http://www.esri.com/data/data-maps/data-and-maps-dvd Texas Parts and Wildlife Department – Texas Natural Diversity Database: http://www.tpwd.state.tx.us/huntwild/wild/wildlife_diversity/txndd/

Resource Topic	Source
Cemeteries, Churches, Schools,	ESRI: http://www.esri.com/data/esri_data
Industrial Facilities & Impaired Waters	Environmental Protection Agency: http://www.epa.gov/enviro/geo_data.html and http://www.epa.gov/region6/region-6/tx/tx_303d.html

10.2 Environmental Features Assessed

This section presents the environmental features assessed and the results of the assessments for the nine HSR alignments and the multiple station areas in Dallas and Houston. As this is a screening level assessment evaluating alignments rather than defined Project workspaces, the potential impacts presented in Table 16 are over estimations of what can be expected with construction. As indicated previously, portions of the route will needed to be constructed on viaduct, and furthermore, construction impacts will be less than the identified study corridor width, and the Project will be further designed specifically to minimize potential impacts on some environmental resources. However, the tally of impacts, and comparison of impacts between the alternative corridors allows for a reasonable comparison in the identification of a preferred alignment.

10.2.1 Length

The values reported in Table 16 are for alignments of various lengths. The alignments, by design, are close in length with a difference of only 25 mi (41 km) between the longest alignment (the UPRR) and the shortest (the BNSF Option 3). Considering all other factors similar, environmental preference leans towards shorter alignments, which will result in the least disturbance.

10.2.2 Hydrology

The hydrology evaluation category considered streams, lakes and reservoirs within the screening buffer of the alignment. Environmental analysis will need to demonstrate that impacts to waterbodies are minimized either through aerial crossings or appropriate construction of culverted crossings to ensure flow patterns are not disrupted. As previously noted, for the purposes of this screening assessment, NHD data was filtered to present data at a scale of 1:100,000, thus reflecting the larger, perennial streams, and excluding smaller ephemeral drainages that are reflected at a scale of 1:24,000. For comparison purposes the NHD data analysis divides the alternatives into three groups: low, medium and high. The greater length of the UPRR alignment results in this alternative crossing the highest number of streams, and likely the greatest impact. The two Utility Corridor alignments, and BNSF Options 1, 2, and 3 cross the fewest streams. The remaining alternatives (BNSF Option 4 and the two IH-45 alignments) have stream crossing numbers that fall in between the high and low groups.

The HSR alignments have been selected to minimize crossing large water bodies. Richland Chambers and Lake Limestone are the largest reservoirs along the BNSF alternatives, though many smaller water bodies are present and may need to be crossed. The BNSF Option 3 is parallel to an existing freight rail bridge crossing the Richland Chambers Reservoir. While GIS data suggests a significant reservoir crossing for the Utility Corridor alignments, an aerial review at Lake Limestone shows the crossing is in the upper headwaters of one of the feeder streams and not in the open water of Lake Limestone.

10.2.3 Wetlands

Wetlands and flood areas make up this category of features. As part of the Project permitting, wetland impacts will need to be minimized and specific mitigation measures will be designed both during design and construction of the Project and as compensation of unavoidable impacts. Engineering considerations will be necessary where alignments pass through flood areas such that upstream areas are not adversely impacted due to construction and operation of the Project.

Based on National Wetlands Inventory (NWI) data, wetland acreages are lowest among those alternatives with the longer segments of highway colocation on the alignment. The IH-45 alignments followed by the Utility Corridor alignments have the lowest acreage impacted, and thus would have the least impact.

10.2.4 Sensitive Species Habitats/Natural Lands

The United States Fish and Wildlife Service and Texas Parks and Wildlife Department have identified the potential for threatened, endangered, and rare species and/or their associated habitats along all the alignments. TCR intends to conduct more rigorous field surveys to better define the potential for threatened, endangered, or rare species to occur as the environmental review process proceeds. No defined critical habitat are crossed by the various alignments. However, the Sam Houston National Forest is crossed by the IH-45 alignments, and portions of the Forest are specifically managed for threatened and endangered species habitat management. Further encroachment into the forest or the habitat management areas would make these alignments the least environmentally preferred for this feature, and would require significant coordination with both the US Forest Service and the US Fish and Wildlife Service to determine whether a viable route could be designed.

For the purposes of this analysis, the alternative with the lowest element occurrence area acreage (an area where a species report was made) is considered to have the lowest impact. The data reviewed indicate the Utility Corridor with IH-45 alignment has the smallest impact followed by the BNSF Option 1 and BNSF Option 4.

10.2.5 Soils

The impact of each alignment on prime farmland soils impacted by each alternative was identified as a screening measure. While the data considered also included shrink swell potential, this factor is more relevant to engineering design and is not a significant factor from an environmental perspective.

Prime farmland soils are assessed in order to conserve those lands with the potential for higher vegetative productivity. Typically, prime farmland soils are most frequently used for agricultural purposes and reflect the opportunity for agricultural practices for each of the corridors. TCR will undertake a more detailed evaluation of agricultural activities as the Project proceeds. The IH-45 alternatives reported the lowest acreages of prime farmland soils followed in general by the alignments of the BNSF and UPRR corridors. This is logical and reflects the amount of prior disturbance that has occurred. The two Utility Corridor alignments reported the highest acreages of prime farmland, and as such would have the greatest potential to impact the resource.

Table 16 – HSR Alignment Alternative Screening Results

Parameter	BNSF Option 1	BNSF Option 2	BNSF Option 3	BNSF Option 4	IH 45 with Hardy	IH45	UPRR	Utility Corridor with IH-45	Utility Corridor
Length Total (miles)	236.88	237.26	234.21	243.77	235.75	236.13	259.39	244.10	239.75
Hydrology									
Total Stream Crossings (count)	101	105	106	127	123	125	148	109	113
Stream Length within impact area (miles)	10.69	11.39	11.41	13.17	12.99	13.05	17.93	14.13	13.29
Reservoir Crossings (miles)	0.00	0.27	1.88	0.00	0.27	0.27	0.00	0.00	0.97
Waterbody Crossings (miles)	0.36	0.63	1.93	0.54	2.42	1.84	1.05	0.66	1.02
Wetlands (acres)									
NHD Flood Areas	23.60	0.00	0.00	15.33	0.00	0.00	0.00	0.00	0.00
Wetland Areas	396.35	400.88	445.99	399.19	229.47	202.89	368.44	338.29	379.72
Habitat/ Natural Lands (acres)									
T&E Species Element Occurrence Area	670.67	1146.48	1099.73	670.67	1048.09	1045.51	766.52	607.68	768.71
T&E Species Managed Habitat Areas	17.95	0.00	0.00	0.00	79.68	79.68	0.00	72.09	0.25
National Parks and Forests	0.00	0.00	0.00	0.00	347.46	347.46	0.00	0.00	0.00
USFWS Critical Habitat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soils (acres)									
Shrink Swell (moderate)	2517.83	2681.46	2510.86	2659.52	2427.71	2486.67	3251.92	1956.05	1927.33

Parameter	BNSF Option 1	BNSF Option 2	BNSF Option 3	BNSF Option 4	IH 45 with Hardy	IH45	UPRR	Utility Corridor with IH-45	Utility Corridor
Shrink Swell (high/very high)	5144.77	4902.60	4953.04	5241.36	3773.79	3764.95	4974.87	4056.82	4013.01
Prime Farmland	2565.02	2152.69	2093.76	2654.65	1689.12	1694.77	2995.51	3183.63	3298.36
Human Environment									
Cemeteries (acres)	0.04	0.04	0.04	3.99	5.00	12.17	0.25	0.19	0.31
Cemeteries (count)	3	2	2	2	3	4	2	2	3
Hospitals (count)	0	0	0	0	0	0	0	0	0
Churches (count)	4	4	5	5	6	6	2	1	2
Schools (count)	0	0	0	1	0	1	1	1	1
Energy Production Infrastructure									
Leases (acres)	12.65	12.65	14.51	12.65	0.67	0.67	75.09	0.93	11.25
Pooling Agreements (acres)	173.34	173.34	263.27	173.34	131.81	178.72	429.13	119.36	115.19
Surface Miles Crossed (miles)	4.58	4.58	4.58	4.58	3.52	3.52	0.00	3.52	3.17
Road Infrastructure (miles within impact area)									
Primary Roads and Motorways	2.66	13.67	5.80	4.59	100.46	106.11	12.14	98.59	3.96
Secondary Roads	5.57	5.75	5.56	6.03	2.63	3.04	1.65	1.52	1.43
Residential Roads	46.53	50.05	57.82	48.91	97.77	76.31	66.87	82.44	54.39
Other Road Impacts	11.59	24.21	18.23	13.89	37.21	65.18	14.32	10.94	4.42
Transportation Terminals Opportunities									

Parameter	BNSF Option 1	BNSF Option 2	BNSF Option 3	BNSF Option 4	IH 45 with Hardy	IH45	UPRR	Utility Corridor with IH-45	Utility Corridor
Airports (count within a half mile)	3	2	1	1	1	1	4	1	1
DART Line (miles within impact area)	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Recreation (acres)									
Park Areas	35.08	35.08	55.57	35.03	96.11	85.98	0.15	86.52	0.29
Historic Resources									
NRHP Sites (count)	0	0	0	0	0	0	0	0	0
NRHP Districts (acres)	0.00	0.00	0.00	15.75	0.00	0.00	17.42	1.90	1.90
State Historic Sites (acres)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
Archeological Sites (count)	1	2	2	3	5	5	3	7	7
Transmission Lines (miles within impact area)									
Less than 100kV	0.83	1.08	1.47	5.81	0.64	0.62	3.51	0.96	1.10
115 - 161 kv	43.90	43.53	43.75	43.71	8.51	5.28	2.79	3.05	3.16
220 - 315 kV	0.07	0.07	0.07	0.07	0.29	0.15	0.00	132.81	146.64
345 - 450 kV	24.90	22.23	14.44	22.58	8.61	8.60	9.51	0.09	0.09
735 - 765 kV	0.09	0.09	0.09	0.09	0.07	0.07	0.07	136.83	150.99
Crossings (total #)	76.00	76.00	75.00	81.00	71.00	58.00	80.00	82	90
Major Pipeline (length within impact area (miles))	25.70	26.14	34.14	25.90	6.41	4.08	10.46	10.43	33.86
Major Pipeline Crossings (total #)	33	35	34	34	40	35	33	35	37

Parameter	BNSF Option 1	BNSF Option 2	BNSF Option 3	BNSF Option 4	IH 45 with Hardy	IH45	UPRR	Utility Corridor with IH-45	Utility Corridor
Parallel Opportunities (acres)									
Railroad ROW used (BNSF)	472.40	472.19	490.29	489.57	20.39	20.39	19.90	5.2	63.81
Railroad ROW used (UPRR Temple)	16.22	16.32	28.00	16.11	280.58	15.60	115.56	1144.12	1145.04
Highway ROW used (IH-45)	2.77	117.18	21.95	2.77	844.62	1015.58	88.58	853.62	538.36
Noise									
Residences within noise screening (count)	1409	1441	1611	1432	1007	849	1123	1471	1526
Environmental Justice (%)									
Poverty Threshold Exceeded	57	56	52	53	61	60	51	53	41
Race Threshold Exceeded	21	19	19	19	18	15	17	5	7
Land Cover (acres)									
Barren Land (Rock/Sand/Clay)	329	250	238	239	28	25	19	16	126
Cultivated Crops	26	38	19	37	147	31	537	1003	934
Deciduous Forest	1154	895	899	858	1100	987	1337	394	547
Developed, High Intensity	96	385	141	152	310	319	576	392	389
Developed, Low Intensity	1098	1319	911	1638	915	1373	1058	1977	397
Developed, Medium Intensity	818	953	799	808	901	886	1134	975	459
Developed, Open Space	921	1082	1083	1068	1489	1584	1631	508	469
Emergent Herbaceous Wetland	42	52	58	43	68	55	125	35	34

Parameter	BNSF Option 1	BNSF Option 2	BNSF Option 3	BNSF Option 4	IH 45 with Hardy	IH45	UPRR	Utility Corridor with IH-45	Utility Corridor
Evergreen Forest	316	302	447	349	210	202	150	346	372
Grassland/Herbaceous	1122	1121	1123	1116	1443	1347	2165	1261	1527
Mixed Forest	755	665	792	809	433	349	109	219	502
Open Water	59	21	36	38	246	235	67	27	36
Pasture/Hay	1654	1488	1820	1605	1387	1218	1341	2514	3490
Shrub/Scrub	1270	1069	1084	1152	932	915	399	396	597
Woody Wetlands	389	426	487	430	394	493	356	311	294
Ecoregions (acres)									
Flatwoods	113	113	113	113	458	441	0	0	0
Floodplains and Low Terraces	82	82	128	82	82	82	756	82	82
Northern Blackland Prairie	3254	3067	2945	3545	3031	3031	3996	3152	3230
Northern Humid Gulf Coastal Prairies	1315	1315	1315	1315	896	961	1972	1769	1769
San Antonio Prairie	301	301	301	301	0	0	343	0	208
Southern Blackland/Fayette Prairie	434	434	434	434	0	0	231	661	661
Southern Post Oak Savanna	3514	3718	3663	3515	3484	3484	3706	4091	3604
Southern Tertiary Uplands	1038	1038	1038	1038	2050	2019	0	620	620

10.2.6 Human Community Environment

For the purposes of this analysis, the human environment feature reflects schools, churches, hospitals and cemeteries. This data was collected from publically available sources and will be field verified during the environmental review process. All alignments, as currently presented, have one or more churches, and cemeteries which will likely require minor shifts in the alignment to avoid the property. These shifts would occur during subsequent design phase of the preferred alignment. No hospitals were located within the screening buffer of any alignment. The IH-45 alignments had the most churches (a count of six) within their screening buffers. The number of cemeteries ranged from two to four among the alignments. The alignments will require site specific design during detailed engineering to avoid or mitigate these impacts.

The school reported on the Utility Corridor alternatives is within the IH-610 Loop in Houston where the alignment proposes to share or be immediately adjacent to the existing UPPR freight railroad. Due to the high density development in the area, impacts to the school, if not mitigated, would make the alignment in this area problematic.

10.2.7 Energy Production Infrastructure

Data on oil and gas lease and pooling agreements was obtained from the Texas General Land Office (GLO) and used to indicate the potential for conflicting land use and to minimize surface operations at the wellheads. The UPRR-Hempstead alignment crosses the greatest acreage by far, while the alignments collocated along IH-45 largely avoid impacts to oil and gas leases.

Data on surface lignite mines from the Texas Railroad Commission was used to indicate the potential for loss of resources. The Jewett Mine is crossed by all alternatives except the UPPR-Hempstead. The Utility Cooridor Alignment has the shortest length of crossing based upon the reported data.

Data on sand and gravel resources from the National Mineral Information Center of the US Geological Survey was reviewed to indicate the potential for conflicting land use and potential for loss of resources by impacting these surface pit mines. No surface pit mines were reported within the 350 ft (107 m) screening buffer along any alignment.

10.2.8 Road Infrastructure

The requirement to be fully grade separated will require all intersecting roadways to be raised above the HSR, bridged over by the HSR, or closed. The number of roads to be altered impacts the overall costs of each alternative and indirectly may increase the environmental impact due to the increased construction workspace needed where perpendicular infrastructure must be crossed. The Utility Corridor alignment has lowest number of roads crossed whereas most are associated with the IH-45 corridor alignments. For all alignments, residential roads are the most frequently intersected by the HSR.

Where roads are either closed or reconfigured to pass above the HSR line there will be secondary impacts associated with roadway and private property access reconfigurations that extend from the crossing several hundred feet or more. The secondary impacts of relocation or alterations will likely extend outside the current buffer boundary and were not specifically quantified. However, for the purposes of analysis, it was assumed that the greater the mileage of roads within the study corridor, the greater the environmental impact would be.

10.2.9 Mass Transportation Connectivity

An important environmental benefit expected from this Project will be relief of congestion, improved mobility with a new mode of travel, and intermodal connectivity at station locations.

10.2.10 Recreation Areas

As currently mapped, all alignment alternatives intersect portions of parks. Most alignments have cumulative crossing impacts greater than 35 acres. Detailed siting and design will need to specifically consider these features to reduce anticipated impact the UPPR Alignment and the Utility Corridor alignments have crossing impacts of less than 0.3 acres and would have less impact to parks than the other alternatives.

The IH-45 Alignment segment between Madisonville and Palmer impacts the most substantial amount (86 acres) of park area (the Fort Boggy State Park), resulting in the greatest impact.

10.2.11 Historic Resources

A search of publicly available records was made to identify National Register of Historic Places (NHRP) sites or districts. These records do not provide comprehensive data on the Project area and as such, TCR will undertake a more detailed archaeological investigation as the environmental process proceeds.

No identified state or national historic sites are impacted by any of the alignments. However, four of the nine alignments crossed a recognized NHRP district. The largest intersection with a district is the UPPR Alignment followed closely by the BNSF Option 4 alignment. The Utility Corridor alignments do cross historical districts, but to a lesser degree. The other alignments had no encroachment into a historic district. If the preferred alignment crosses a designated historic district, the Project will need to closely coordinate with the Texas State Historic Preservation Officer to develop adequate mitigation measures.

All alignments had recorded archaeological sites. The Utility Corridor alignments each reported seven sites compared to one site on the BNSF Option 1 alignment. While these numbers may be reflective of the potential for alternatives to encounter potential cultural resources, more detailed field surveys will be carried out as part of the environmental review process.

10.2.12 High-Voltage Transmission Lines

Transmission line features reviewed included both electrical lines and pipelines. The Utility Corridor alignments, by design, parallel the electric line to the greatest extent possible. The proposed HSR system would be electrically powered, with traction power substations spaced about every 25 mi (40 km), so close proximity to a large line (parallel or crossing) would reduce the secondary impacts associated with the length of feeder lines to the right-of-way from the transmission lines.

The two Utility Corridor alignments have the greatest opportunity to reduce the additional right-of-way impacts for the feeder lines. The remaining alignments have between 5% and 24% of the HSR collocated with an electrical transmission line. Crossings of powerlines are also viewed as a constraint since safe separation from these lines for construction or operations would likely require localized reconfiguration (and potentially greater environmental impact) of either the proposed Project or existing transmission lines.

Pipelines will require special construction activities to protect both the pipeline and HSR system. For the purposes of this analysis, it was assumed that additional construction workspace would be required around major pipelines that would increase the environmental impact. The total number of pipeline crossings is similar across all alignments (33 to 40), with the BNSF Option 1 and the UPRR alignments having fewer crossing than the other alternatives.

There is a significant difference between the alternatives when considering the number of miles of colocation with pipeline infrastructure. The IH-45 corridor alignments have the least length of colocation followed by the alignments of the BNFS and UPRR corridors. The BNSF Option 3 and the Utility Corridor Alignment have the greatest distance of colocation, respectively.

10.2.13 Rail and Highway Colocation

Colocation with linear railway and highway infrastructure would mitigate a portion of the environmental impact of a new HSR line due to the incremental impact to the local environment. The degree of impact reduction will largely be dependent on the final design of the Project. Construction immediately adjacent to existing rail line or construction within highway medians are elevated above roadways and would result in the least impact while lack of colocation or greater separation from IH-45 due to development would increase potential impact.

The Utility Corridor with IH-45 Alignment has the greatest acreage of total colocation and therefore would be considered very preferable if deemed feasible from an engineering standpoint.

10.2.14 Noise

Noise sensitive receptors have been identified as residences along the alignment. The Federal Railroad Administration guideline was used to define the screening buffer for noise. In the rural area it was set at 380 ft (116 m) and in urban areas set at 240 ft (73 m). In addition, residences already impacted by existing freight rail were not counted. The IH-45 Highway alignment which had the fewest sensitive receptors because of its colocation in or adjacent to the highway has the least negative impact specific to noise receptors.

10.2.15 Environmental Justice

The environmental justice factors considered to screen alternatives were the percentages of the route passing through census blocks exceeding the poverty and race thresholds. The IH-45 alternatives had the greatest percentage of blocks exceeding the poverty threshold. The alignments within the BNSF and UPRR corridors have similar poverty percentages. The Utility Corridor alignment crosses the lowest percentage of blocks that exceed the poverty threshold. With respect to percentage of blocks that exceed race thresholds, both of the Utility Corridor alignments are significantly lower than the other alternatives.

10.2.16 Land Cover

The land cover or land use data is divided into fifteen types. For ease of analysis, the fifteen types were placed within three groups representing the dominant groups of Agriculture, Development, and Undeveloped (Table 17). Development is the dominant land use across all alignments largely due to the overlap with existing linear infrastructure and the necessity for all of the alternatives to terminate in populated areas. Agriculture and Undeveloped follow with all acreages within about 10 percent of each other.

Table 17 – HSR Land Use Comparison (in acres)

Alignment	Agriculture	Developed	Undeveloped	Total Acres
BNSF Option 1	2,802	3,322	3,925	10,049
BNSF Option 2	2,647	4,011	3,409	10,066
BNSF Option 3	2,962	3,208	3,767	9,937
BNSF Option 4	2,758	3,943	3,641	10,342
IH-45 With Hardy	2,977	3,889	3,136	10,001
IH-45	2,596	4,422	3,000	10,018
UPRR	4,043	4,485	2,476	11,004
Utility Corridor	5,951	1,878	2,345	10,174
Utility Corridor with IH-45	4,778	3,895	1,701	10,375

Notes:

- Agriculture comprised of cultivated, grasslands, and pasture/hay types
- Developed comprised of all developed types, open space, barren land, and open water
- Undeveloped comprised of all forest types, and wetland types and shrub/scrub

From an environmental impact evaluation standpoint, the alternatives with less developed and undeveloped lands were considered preferred. The rationale is based on the desire to protect sensitive natural resources commonly associated with undeveloped lands and similarly reduce the impact to the existing developed lands, which in this analysis were associated with the Dallas and Houston metropolitan areas. The alignment with the most agricultural acreage in this analysis is the Utility Corridor Alignment and thus is the most favorable alignment based only on the land cover factor.

10.2.17 Ecological Regions

The ecological region data does not differentiate substantially among the alignments as the acreages within each region are about the same. The EPA defined ecoregions generally trend southwest/northeast and the alternatives generally run parallel to each other and perpendicular to the region.

10.3 Station Areas

10.3.1 Hydrology

The environmental screening analysis for hydrology considers streams, waterbodies, and wetlands within the buffer zone area of each alternative station. Portions of the Buffalo Bayou and White Oak Bayou cross the Houston Downtown station area. Portions of Greens Bayou cross the Greenspoint and SH 249/Beltway 8 station areas. The National Wetlands Inventory (NWI) database shows significant acres of wetlands areas within the Greenspoint and SH 249/Beltway 8 station areas in comparison to the other station alternative areas.

However, the NWI data is not reflective of ongoing development and does not represent current conditions. As such this analysis is based on review of current aerial imagery to provide a qualitative comparison. The SH 249/Beltway 8, Greenspoint, and US 290/Beltway 8 station areas include more freshwater forested and shrub wetlands, and therefore would not be a preferred alternative, unless siting was able to largely avoid these areas or adequate mitigation could be developed to offset impacts. No wetlands areas were identified within the US 290/IH-610 station alternative buffer area; this alternative is the most favorable for this factor.

Minimal areas of waterbodies or stream crossing were identified within the Dallas station locations. The NWI database shows more acres of wetlands areas within the IH-45/Loop 12 station area in comparison to the other station alternative areas. The Reunion Arena has the lowest acreage of wetlands impacted. As part of the Project permitting, wetland impacts will need to be minimized and specific mitigation measures will be designed both during design and construction of the Project and as compensation of unavoidable impacts.

10.3.2 Sensitive Species Habitats

The United States Fish and Wildlife Service and Texas Parks and Wildlife Department identify the potential for threatened, endangered, and rare species and/or their associated habitats. TCR intends to conduct more rigorous field surveys to better define the potential for threatened, endangered, or rare species to occur as the environmental review process proceeds. For the purposes of this analysis, the US 290/IH-610 station area is the only alternative within the Houston area with element occurrence area acreage (an area where a species report was made) and therefore is considered to have the highest impact.

10.3.3 Soils

Hydric soils, prime farmland, and soils with high shrink-swell potential require special mitigations when encountered during construction. While the data considered also included shrink-swell potential, this factor is more relevant to engineering design is not a significant factor from an environmental perspective. No prime farm lands were identified in Dallas's Reunion Arena or the IH-45/Loop 12 station alternative area, but prime farmlands were located within the IH-20/IH-45 area. The Reunion Arena and the IH-45/Loop 12 areas have the lowest impact to prime farmland, and therefore are the most favorable site for the Dallas terminus location. Given the urban development that has occurred in the area of potential station locations, prime farmland soils are not likely to be a significant criteria in the broader environmental analysis for the Project.

No prime farmland soils were identified within any of the station alternative areas in Houston.

10.3.4 Historic Resources

NRHP sites and districts and archeological sites were identified through public record and were used as the environmental screening analysis for historic resources. These records do not provide comprehensive data, and TCR will undertake a more detailed archeological investigation as the environmental process proceeds. The Houston Downtown station area has the greatest impact on historic resources, including archeological sites, NRHP sites, and NRHP districts, for the Houston alternatives. The Dallas Reunion Arena was the only location in the Dallas area encroaching upon historic resources, and therefore, for the purposes of this analysis was considered to have the most negative impact in terms of historic resources for the Dallas sites. TCR will need to coordinate with the Texas State Historic Preservation Officer to develop adequate mitigation measures for preferred alternatives that cross designated archeological sites, NRHP sites, and NRHP districts.

10.3.5 Human Community Environment

Human community environmental features in this analysis include schools, churches, and cemeteries. Data was collected from publically available sources and will be field verified during the environmental review process. In Houston, no schools were located within the Greenspoint and SH 249/Beltway 8 station areas. Churches were located within all station alternatives. Data indicates that Cemeteries are located within both the Downtown and Greenspoint station areas. The SH 249/Beltway 8 station area has the least impacts to human community resources, and the Houston Downtown station has the greatest impact.

No schools or cemeteries were identified within any of the Dallas station alternatives buffer areas. One church was identified within the IH-20/IH-45 station area.

10.3.6 Environmental Justice

The environmental justice features used to evaluate alternatives were the number and percentages of census tracts block groups with each station alternative's buffer zone area that exceeded the county's poverty threshold. In Houston, the Greenspoint station area has the greatest percentage of census block groups below the poverty threshold level. The SH 249/Beltway 8 station area alternative would have the least impact. In Dallas, the Reunion Arena alternative buffer area crosses fewer census tracts block groups exceeding the poverty thresholds, and therefore would be more favorably rated.

10.3.7 Transportation and Connectivity

An important environmental benefit expected from this Project will be relief of congestion, improved mobility with a new mode of travel, and intermodal connectivity at station locations. The Dallas Reunion Arena station alternative offers connectivity to the convention center, the Union Station, and the West End

Station, and therefore would be the most favorably rated location. The Houston alternatives are all located in proximity to major highways and Interstates. The Downtown station area also offers the greatest connectivity to highways in addition to the inner loop light rail system.

10.3.8 Transmission Lines

Transmission lines were evaluated based on power range and segment lengths with the alternative screening buffer areas. The SH 249/Beltway 8 station area is more favorably rated as the Houston terminus location because it has the best accessibility to transmission lines within the 115kV to 161kV range. Likewise, the IH-45/Loop 12 station area is the more favorably rated Dallas terminus location because of greater accessibility to 115kV to 161kV transmission lines. Proximity to existing transmission lines would reduce impacts associated with additional right-of-way for connecting feeder lines.

10.3.9 Recreational Areas

The number and location of local public parks within each station alternative were evaluated for recreational resources. Local parks were identified within the Houston Downtown, US 290/IH-610, US 290/Beltway 8, and IH-610/Shepherd station areas; therefore, these locations would have the largest impact. The Greenspoint and SH 249/Beltway 8 station alternative areas do not encroach on any designated recreational areas and are favorably rated as alternatives for the Houston terminus.

Local parks were only identified within the Dallas Reunion Arena station alternative area. The IH-20/IH-45 and IH-45/Loop 20 station areas do not cross any recreational areas and are favorably rated for this factor.

10.3.10 Land Uses

All station alternatives locations under consideration are developed or disturbed sites. Impacts to natural terrain would be minimal and displacement would not be a major factor. The environmentally favorable station alternative would have the least residential uses or public gathering uses due to potential short term construction activity and operating noise disturbances. Proximity to commercial/retail land use would result in temporary impacts during construction, but would be considered a benefit once the Project was in operation. The percent comparison of residential development (including single-family residential, multi-family residential, and other residential inventories) within each of the Houston station alternative areas was evaluated. Greenspoint, US 290/IH-610, and SH 249/Beltway 8 have a lower percent of residential development, and the Downtown and IH-610/Shepherd areas have a higher percent of residential development. Overall, the IH-610/Shepherd station area has the lowest percent of developed land. However, all proposed alternative station areas are surrounded by high to moderate density development, and a favorable location cannot be differentiated based on land use resources.

In the Dallas, Reunion Arena and IH-20/IH-45 station areas have more surrounding residential development. Overall, the Reunion Arena station area is surrounded by more high to moderate density development. Based on potential land use impacts, the IH-20/IH-45 areas would be the more preferred alternatives.

10.4 Environmental Analysis Summary

10.4.1 HSR Alignments

Differentiating alignments given the large number of factors to identify environmentally favorable alignments or stations was done by ranking. Three distinct tiers of ratings were selected: 1) first tier, which reflected environmental preference for a particular factor; 2) third tier, which reflected ratings that were least environmentally preferred; and 3) second tier, when factors fell between being obviously preferred or non-preferred. The alignments with the least environmental impact were rated 1. Alignments with the greatest impact for a given feature were rated as 3, and those alignments that fell in the middle were rated 2.

The most environmentally favorable HSR alignments were identified as those with the highest number of Number 1 ratings. Table 18 presents the ranking of the various alignments alternatives.

Table 18 – HSR Alignment Alternatives Environmental Ranking

Placement	BNSF Option 1	BNSF Option 2	BNSF Option 3	BNSF Option 4	IH-45 with Hardy	IH-45	UPRR	Utility Corridor with IH-45	Utility Corridor
First Tier	22	16	17	15	19	20	19	24	26
Second Tier	15	20	22	21	14	10	15	23	23
Third Tier	33	34	31	33	37	40	36	23	21

The environmental analysis of the nine alignments indicated that the Utility Corridor Alignment had the largest number of both Tier 1 and Tier 2 ratings, and would be considered the preferred alignment from a strictly environmental perspective. The Utility Corridor with IH-45 Alignment would be the second most preferred alignment from an environmental standpoint. The four BNSF alignments were closely grouped from an environmental perspective with BNSF – Option 1 having the most factors falling in Tier 1 rankings. The two IH-45 alternatives and the UPRR-Hempstead alignments would be the least preferred options, having the most factors that fell within the least preferred rating.

10.4.2 Station Areas

Differentiating station alternatives given the large number of factors to identify environmentally favorable station locations is based on ranking. Three distinct tiers of ratings were selected:

- first tier, which reflected environmental preference for a particular factor;
- third tier, which reflected ratings that were least environmentally preferred; and
- second tier, when factors fell between being obviously preferred or non-preferred.

The station areas with the least environmental impact were rated 1. Station areas with the greatest impact for a given feature were rated as 3, and station areas that fell in the middle were rated 2

The most environmentally favorable station locations were identified as those with the highest number of Tier 1 ratings. Table 19 presents the ranking of the various alignments alternatives.

From this analysis, the station study areas that receive the greatest number of both Tier 1 and Tier 2 ratings would be considered the preferred station areas from a strictly environmental perspective. In Houston, three station areas tied for the highest ranking (19 points): IH-610/Shepherd; US 290/Beltway 8; and US 290/IH-610. In Dallas, both the Downtown Dallas and IH-45/Loop 12 station areas each tied with the highest ranking of 17 points.

It should be noted however that the location of the station terminals will be critical to the economic viability and public acceptance of the Project. As such, the selection of the terminal locations are more likely to be selected on a full spectrum of criteria and not merely a qualitative analysis of environmental factors. Environmental factors and specific mitigation measures designed to avoid and/or minimize potential impacts for the Project stations will be more fully vetted during the environmental review process.

Table 19 – Station Alternatives Environmental Ranking

Placement	Houston						Dallas		
	Downtown Houston	Greenspoint	US 290 and IH-610	SH 249 and Beltway 8	US 290 and Beltway 8	IH-610 and Shepherd	Downtown Dallas	IH-45/ IH-20	IH-45 and Loop 12
First Tier	5	8	7	10	6	11	9	10	12
Second Tier	8	9	12	7	13	8	8	6	5
Third Tier	8	4	2	4	2	2	6	7	6

11 Alternatives Screening Results

The result of this analysis determined that the preferred alternative is the Utility Corridor alignment.

When analyzing the segment between Houston and Teague, the BNSF corridor alignments (Options 1-4) were found to be preferable to either of the IH-45 corridor alignments in terms of constructability, cost, and risk. The use of the IH-45 corridor from Houston and through its suburbs was found to have multiple constraints that would require complex engineering approaches and which would result in significant property impacts, construction difficulties, schedule risks, and increased costs.

The UPRR alignment, while advantageous in some respects, was not found preferable to the BNSF corridor alignments given increased route length, impacts, costs, and travel time. Of the four potential BNSF corridor alignment options between Teague and Dallas, BNSF Option 1 was found to be the preferred route based upon lower expected impacts.

Both Utility Corridor alignments followed the UPRR Hempstead Line Eureka subdivision that runs parallel to US-290 out of Houston and the UPRR Dallas Subdivision into Dallas that runs parallel to the Trinity River. The Utility Corridor with IH-45 alignment using the segment of IH-45 between Madisonville and Palmer was found to be the more costly of the two Utility Corridor alignments considered.

Based on the engineering and constructability evaluation completed to date, the Utility Corridor alignment presents the fewest construction challenges and greatest financial viability. The Utility Corridor alignment stands out from the other alignment alternatives in terms of infrastructure crossings, freight railroad impacts, construction within urban areas and local communities. Moreover, the Utility Corridor alignment follows a straighter alignment through more rural areas that would ease construction requirements, improve construction access, reduce costly impacts to existing development, reduce impacts to traffic, and minimize use of more advanced viaduct construction approaches.

The preferred alignment resulting from the analyses to date was found to be the the Utility Corridor alignment following high-voltage electrical transmission lines. Further coordination with the utility owners is underway and the results of those discussions will clarify requirements for construction adjacent to and within their ROW. This comparative assessment of competing alignments clearly demonstrates that any alternative following the BSNF corridor, IH-45 corridor, or the UPRR corridor should not be advanced further.

The results of the analysis are summarized in the stoplight chart presented in Table 20 and the sections below. Additionally, details summarizing the metrics used in the stoplight chart are presented in Table 21, Table 22, and Table 23.

Table 20 – Corridor Evaluation Stoplight Chart

Corridor Evaluation Stoplight Chart		Corridor Alternative								
		BNSF w/ Option 1	BNSF w/ Option 2	BNSF w/ Option 3	BNSF w/ Option 4	I-45 w/ Hardy Option	I-45	UPRR	Utility Corridor w/ I-45	Utility Corridor
GROUP A Financial and Project Delivery Considerations	Tally	15	13	14	15	9	9	15	15	20
	Normalized Tally	2.1	1.9	2.0	2.1	1.3	1.3	2.1	2.1	2.9
	Ridership/Revenue Potential	3	3	3	3	3	3	2	3	3
	Financial Viability Risk	1	1	1	1	1	1	3	2	3
	ROW Acquisitions	3	2	2	3	1	1	2	2	3
	Construction Duration	3	2	3	3	1	1	3	2	3
	Schedule Risks	1	1	1	1	1	1	2	2	2
	Capital Construction Cost	3	3	3	3	1	1	2	2	3
	Stakeholder / Regulatory Considerations	1	1	1	1	1	1	1	2	3
GROUP B Engineering Considerations	Tally	13	12	12	11	12	12	11	15	17
	Normalized Tally	1.9	1.7	1.7	1.6	1.7	1.7	1.6	2.1	2.4
	Constructability Issues	1	1	1	1	1	1	2	2	2
	Alignment	3	3	3	3	3	3	2	3	3
	General Infrastructure Requirements	2	2	2	2	1	1	2	2	3
	Major Structures	2	1	1	1	2	2	2	3	3
	Crossings	2	2	2	2	1	1	1	2	3
	Shrink Swell Soils	1	1	1	1	2	2	1	1	1
	Utilities	2	2	2	1	2	2	1	2	2
GROUP C Environmental Considerations	Tally	16	16	16	16	16	16	18	16	19
	Normalized Tally	1.8	1.8	1.8	1.8	1.8	1.8	2.0	1.8	2.1
	Prime Farmland	1	1	1	1	2	2	1	1	1
	Socio-Economics	2	2	2	2	2	2	2	2	3
	Noise	2	2	2	2	3	3	3	2	2
	Land Use Considerations	2	2	2	2	1	1	2	2	3
	Hydrology and Wetlands	2	2	2	2	3	3	2	2	2
	Threatened & Endangered Species	2	2	2	3	1	1	2	2	2
	Parks and Forests	2	2	2	2	1	1	3	1	3
	Cultural Resources	2	2	2	1	2	2	1	2	2
	Community Facilities	1	1	1	1	1	1	2	2	1

Weighting	Group	Results Summary								
2	Financial Considerations	4.3	3.7	4.0	4.3	2.6	2.6	4.3	4.3	5.7
1	Engineering Considerations	1.9	1.7	1.7	1.6	1.7	1.7	1.6	2.1	2.4
1	Environmental Considerations	1.8	1.8	1.8	1.8	1.8	1.8	2.0	1.8	2.1
FINAL Alternative Score		7.9	7.2	7.5	7.6	6.1	6.1	7.9	8.2	10.3

Table 21 – Quantitative Metrics used in the Corridor Evaluation Stoplight Chart (Group A)

Stoplight Chart Evaluation Metrics		Step 1 Screening Report Section References	Quantitative Evaluation Metrics	Table/Figure References	Data Sources Used	Comments
GROUP A Financial and Project Delivery Considerations	Ridership/Revenue Potential	Section 6	Length/Curvature of Alignment	N/A	Concept Alg, LBG Ridership Studies	Trip time (determined by alg length and curvature) effects Ridership/Revenue
	Financial Viability Risk	Section 6	Length/Curvature of Alignment	N/A	Concept Alg, LBG Ridership Studies	Trip time (determined by alg length and curvature) effects Ridership/Revenue
		Section 8	# of Major Structures	Table 7	Google Earth/Concept Alg	Major Structures have the potential to greatly increase capital cost requirements
		Section 9	Conceptual Estimated Capital Cost	Table 13	Conceptual Capital Cost Estimate	
		Section 10	Acres within Railroad ROW Impact Area	Table 14 & 15	GIS Database, Concept Alg	Areas of interaction with exiting rail and third parties may require high insurance/liability costs
		Section 10	Acres within Highway Impact Area	Table 14 & 15	GIS Database, Concept Alg	Areas of interaction with exiting highways and third parties may require high insurance/liability costs
	ROW Acquisitions	Section 10	Acres within Railroad ROW Impact Area	Table 14 & 15	GIS Database, Concept Alg	Alternatives with the possibility of shared corridor that would limit real estate acquisition costs and schedules are rated more positively.
		Section 10	Acres within Highway Impact Area	Table 14 & 15	GIS Database, Concept Alg	Alternatives with the possibility of shared corridor that would limit real estate acquisition costs and schedules are rated more positively.
		Section 10	Land Use Area (High, Medium, Low Development Intensity)	Table 14 & 15	U. S. Geological Survey National Land Cover Dataset (http://landcover.usgs.gov/natllandcover.php:)	Normally, the higher complex usage of the property and the surrounding area's density and valuations, the greater the cost of property acquisition.
	Construction Duration	Section 9	Percentage of section types (embankment, cut, viaduct)	Table 10	Concept Alg, Cost Estimate	
		Section 8	# of Major Structures	Table 7	Google Earth/Concept Alg	
		Section 8	# of Roadway/Rail Crossings	Table 6	Google Earth/Concept Alg	
		Section 9	% of Complexity Factors	Table 11	Google Earth/Concept Alg	
		Section 6	Length of Alignment	Figure 5	Concept Alg	
		Section 9	# of Grade Seperations	Table 12	Google Earth/Concept Alg	
	Schedule Risks	Section 10	Major Pipeline (length of impact & total crossings)	Table 14 & 15	United States Department of Transportation, National Pipelines, 2004 (https://www.npms.phmsa.dot.gov/)	Examples would include constructing within oil and gas fields with potential work stoppage or limitations on times for work activities.
		Section 10	Acres within Railroad ROW Impact Area	Table 14 & 15	GIS Database, Concept Alg	Examples would be working within dense existing transportation corridors where construction access, staging, or maintenance of traffic would create additional risks.
		Section 10	Acres within Highway Impact Area	Table 14 & 15	GIS Database, Concept Alg	Examples would be working within dense existing transportation corridors where construction access, staging, or maintenance of traffic would create additional risks.
		Section 10	Land Use Area (High, Medium, Low Development Intensity)	Table 14 & 15	U. S. Geological Survey National Land Cover Dataset (http://landcover.usgs.gov/natllandcover.php:)	Examples would be working within dense existing transportation corridors where construction access, staging, or maintenance of traffic would create additional risks.
	Capital Construction Cost	Section 9	Conceptual Estimated Capital Cost	Table 13	Conceptual Capital Cost Estimate (See Section 9 for Inputs/Methodology)	Based on Normalized Capital Cost Comparison
	Stakeholder/Regulatory Considerations	Section 9	% of Complexity Factors	Table 11	Google Earth/Concept Alg	Areas with higher levels of complexity factors have higher existing levels of development and higher potential levels of stakeholder coordination
		Section 10	# of Cemeteries, Hospitals, Churches, and Schools Impacted	Table 14 & 15	ESRI: http://www.esri.com/data/esri_data	
		Section 10	Poverty and Race Threshold Exceeded	Table 14 & 15	U.S Government Census http://www2.census.gov/census_2010/04-Summary_File_1/ http://www.census.gov/acs/www/	

Table 22 – Quantitative Metrics used in the Corridor Evaluation Stoplight Chart (Group B)

Stoplight Chart Evaluation Metrics		Step 1 Screening Report Section References	Quantitative Evaluation Metrics	Table/Figure References	Data Sources Used	Comments
GROUP B Engineering Considerations	Constructability Issues	Section 9	% of Complexity Factors	Table 11	Google Earth/Concept Alg	
		Section 8	# of Major Structures	Table 7	Google Earth/Concept Alg	
		Section 8	# of Roadway/Rail Crossings	Table 6	Google Earth/Concept Alg	
		Section 9	# of Grade Seperations	Table 12	Google Earth/Concept Alg	
	Alignment	Section 6	Length of Alignment	Figure 5	Concept Alg	
	General Infrastructure Requirements	Section 8	Length of Viaduct - Flood Plains	Table 8	Google Earth/Flood Plain Data	
		Section 9	Percentage of Section Types	Table 10	Google Earth/Concept Alg	
		Section 10	Miles within impact area of Roadways	Table 14 & 15	TXDOT, 2012 (http://www.tnris.org/get-data#transport)	
		Section 10	Length of Crashwall Required (Acres within Railroad ROW Impact Area)	Table 14 & 15	GIS Database	
	Major Structures	Section 8	# of Major Structures	Table 7	Google Earth/Concept Alg	
	Crossings	Section 8	# of Roadway/Rail Crossings	Table 6	Google Earth/Concept Alg	
		Section 10	Miles within impact area of Roadways	Table 14 & 15	TXDOT, 2012 (http://www.tnris.org/get-data#transport)	
	Shrink Swell Soils	Section 10	Area of Moderate, High, V. High Shrink Swell Soil	Table 14 & 15	Natural Resources Conservation Service, Shrink/Swell and Prime farmland Soils, 2011 (http://datagateway.nrcs.usda.gov/GDGOrder.aspx?order=QuickStatewps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627)	
	Utilities	Section 10	Major Pipeline (length of impact & total crossings)	Table 14 & 15	United States Department of Transportation, National Pipelines, 2004 (https://www.npms.phmsa.dot.gov/)	
		Section 10	Transmission Lines (length of impact & total crossings)	Table 14 & 15	United States Department of Transportation, National Pipelines, 2004 (https://www.npms.phmsa.dot.gov/)	Categories including: Less than 100kV, 115-161kV, 220-315kV, 345-450kV, 735-765kV)
		Section 8	Number of HVTL (> 69kV) Crossings	Table 6	Google Earth Pro	

Table 23 – Quantitative Metrics used in the Corridor Evaluation Stoplight Chart (Group C)

Stoplight Chart Evaluation Metrics		Step 1 Screening Report Section References	Quantitative Evaluation Metrics	Table/Figure References	Data Sources Used	Comments
GROUP C Environmental Considerations	Prime Farmland	Section 10	Area of Prime Farm Land Impacted	Table 14 & 15	Natural Resources Conservation Service, Shrink/Swell and Prime farmland Soils, 2011 (http://datagateway.nrcs.usda.gov/GDGOrder.aspx?order=QuickStatewps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627)	
	Socio-Economics	Section 10	Poverty Threshold Exceeded	Table 14 & 15	U.S Government Census (http://www2.census.gov/census_2010/04-Summary_File_1/)	
		Section 10	Race Threshold Exceeded	Table 14 & 15	U.S Government Census (http://www2.census.gov/census_2010/04-Summary_File_1/)	
	Noise	Section 10	Residences within noise screening (Count)	Table 14 & 15	United States Geological Survey, National Land Cover Database, 2011 (http://www.mrlc.gov/nlcd11_data.php)	
	Land Use Considerations	Section 10	Area of Land Cover Type	Table 14 & 15	U. S. Geological Survey National Land Cover Dataset: (http://landcover.usgs.gov/natllandcover.php)	Land Cover Types Including: Barren Land (Rock/Sand/Clay), Cultivated Crops, Deciduous Forest, Developed (High Intensity), Developed (Low Intensity), Developed (Medium Intensity), Developed (Open Space), Emergent Herbaceous Wetland, Evergreen Forest, Grassland/Herbaceous, Mixed Forest, Open Water, Pasture/Hay, Shrub/Scrub, Woody Wetlands, Flatwoods, Floodplains and Low Terraces, Northern Blackland Prairie, Northern Humid Gulf Coastal Prairies, San Antonio Prairie, Southern Blackland/Fayette Prairie, Southern Post Oak Savanna, Southern Tertiary Uplands
		Section 10	Energy Production Area and Surface Miles Crossed	Table 14 & 15	General Land Office: http://www.glo.texas.gov/what-wedo/energy-and-minerals/oil_gas/permitting_and_leasing/index.html	
	Hydrology and Wetlands	Section 10	Total Stream Crossings (count)	Table 14 & 15	United States Geological Survey National Hydrology Dataset (NHD), 2010, Water Bodies, Rivers and Streams (http://viewer.nationalmap.gov/viewer/) Texas Department of Environmental Quality (TCEQ), 2010, Reservoirs (https://www.tceq.texas.gov/assets/public/gis/metadata/segments_res_est.pdf)	
		Section 10	Stream Length within impact area (miles)	Table 14 & 15		
		Section 10	Reservoir Crossings (miles)	Table 14 & 15		
		Section 10	Waterbody Crossings (miles)	Table 14 & 15		
		Section 10	NHD Flood Areas	Table 14 & 15	U.S. Department of the Interior, Fish and Wildlife Service, 2010, Wetlands, http://www.fws.gov/wetlands/Data/Mapper.html Federal Emergency Management Agency (FEMA), Flood Zones, 2005, http://www.tnris.org/get-data#flood	
		Section 10	Wetland Areas	Table 14 & 15		
	Threatened & Endangered Species	Section 10	T&E Species Element Occurrence Area	Table 14 & 15	Texas Natural Diversity Database, T&E Species Element Occurrence Area and T&E Species Managed Habitat Areas, 2013, (http://www.tpwd.state.tx.us/huntwild/wild/wildlife_diversity/txndd/) US Fish and Wildlife Service (USFWS), Critical Habitat, 2011 (http://ecos.fws.gov/crithab/) Environmental Systems Research Institute, Parks and Refuges, 2010 (http://www.esri.com/data/data-maps/data-and-maps-dvd)	
		Section 10	T&E Species Managed Habitat Areas	Table 14 & 15		
		Section 10	National Parks and Forests	Table 14 & 15		
		Section 10	USFWS Critical Habitat	Table 14 & 15		
	Parks and Forests	Section 10	Area of National Parks and Forests	Table 14 & 15	Texas Parts and Wildlife Department – Texas Natural Diversity Database: (http://www.tpwd.state.tx.us/huntwild/wild/wildlife_diversity/txndd/)	
		Section 10	Area of Recreational Parks	Table 14 & 15	Environmental Systems Research Institute, Parks, 2012, (http://www.esri.com/data/data-maps/data-and-maps-dvd)	
	Cultural Resources	Section 10	NRHP Sites (count)	Table 14 & 15	Texas Historical Commission: ftp://ftp.thc.state.tx.us/GIS/ Texas Historic Commission, Cultural Locations of Interest, 2005-2012, http://atlas.thc.state.tx.us/shell-mrd.htm	
		Section 10	NRHP Districts (acres)	Table 14 & 15		
		Section 10	State Historic Sites (acres)	Table 14 & 15		
		Section 10	Archeological Sites (count)	Table 14 & 15		
	Community Facilities	Section 10	# of Cemeteries, Hospitals, Churches, and Schools Impacted	Table 14 & 15	ESRI: http://www.esri.com/data/esri_data	
		Section 10	DART Line (miles with impact area)	Table 14 & 15	Federal Transit Administration (FTA), Fixed-Guide way Transit Network, 2004. (http://www.bts.gov/programs/geographic_information_services)	
		Section 10	Ariports (count within a half mile)	Table 14 & 15	Texas Department of Transportation, Airports, 2012, (http://www.tnris.org/get-data#transport)	

11.1 Alternatives Summary

The Step 1 Screening of Corridor Alternatives analysis evaluated nine alignments for the Houston to Dallas HSR Project. As described below, eight of these alignments are not recommended for further consideration.

11.1.1 IH-45 Alignments: IH-45 & IH-45 with Hardy Line

Both of the IH-45 alignments were eliminated due to constructability issues, cost, and potential risk. It is expected that use of this corridor would result in significant property impacts, construction difficulties, schedule risks, and increased costs. These alignments ranked the lowest of all alternatives considered. The following highlights the key issues identified through the analyses:

- Existing development and infrastructure along the IH-45 corridor from downtown Houston through its suburbs, in particular, was found to present multiple constraints that would require complex engineering approaches.
- Number of roadway crossings through more developed areas along IH-45 would require extensive use of more costly viaducts to minimize transportation impacts.
- Transportation impacts and difficult construction operations associated with work along heavily used interstate highway.
- Outside of the urbanized Houston area, two environmentally sensitive areas could be impacted: Sam Houston National Forest and the Richland Chambers Reservoir.

11.1.2 UPRR Hempstead Alignment

While the UPRR Hempstead alignment scores well in environmental considerations relative to other options (due to the fact that it parallels an existing rail ROW), it scores lowest in terms of engineering considerations. The following highlights the key issues identified through the analyses:

- Longer overall alignment through more difficult terrain with highest number of roadway crossings.
- Existing UPRR alignment geometry does not provide much opportunity for shared corridor meeting HSR alignment criteria and requires numerous crossings of freight line.
- Increased complexity or magnitude of infrastructure requirements would translate directly to an extended delivery schedule and increased Project costs.
- Increased regulatory coordination for this alternative due to alignment near Richland Chambers Reservoir, route through College Station and Corsicana, and coordination requirements with UPRR.

11.1.3 BNSF Option 1 Alignment

Of the four potential BNSF alignment options between Teague and Dallas, the Option 1 alignment scored higher based upon lower expected impacts relative to the other BNSF Options. The BNSF with Option 1 alignment initially appeared promising; however, the numerous analyses and coordination efforts have revealed that potential HSR alignments within the BNSF Teague Line Corridor are unreasonable, infeasible and will not meet TCR's purpose to provide reliable, safe and economically viable high-speed passenger transportation using the N700-I Bullet System technology for the following reasons.

- Following the existing BNSF Teague Line closely would not allow service operations to achieve the desired operating speeds due to the existing curvature of the freight line.
- There is significant development along the BNSF Line given that the freight alignment was developed to connect existing urban centers, industries, and ports. This freight route then spurred additional development along the line as industries and communities took advantage of the means of transporting goods.
- The BNSF Line passes through numerous environmentally sensitive areas given its development prior to current practices to avoid environmental impacts during infrastructure design and construction. As such, the technical analyses have shown it to not be the least environmentally impacting solution.
- Following the BNSF Line closely would result in significant safety concerns related to possible derailment of a freight train and dispersion of freight rail vehicles onto the HSR line. Mitigating this risk would require both significant system and track improvements to the existing BNSF Line to reduce the likelihood a freight rail derailment and significant infrastructure to erect barriers or provide safe separation between freight and HSR operations. Furthermore, meeting BNSF indemnification and liability insurance requirements resulting from these risks would not be financially feasible.
- Following the BNSF Line raises concerns regarding possible impacts during construction and operations, potential interference to signaling and communications systems, and other issues similar to those identified on the California HSR project that would require resolution.
- Following the BNSF Line would create significant impacts to existing freight operations and BNSF customer impacts that would be costly to mitigate. The construction of the new HSR line would also limit future BNSF customer connections.
- The capital construction costs, right-of-way acquisitions, construction duration, and expected schedule to resolve risk mitigation issues make usage of the BNSF Line economically unviable.

These concerns have been reflected directly in the Stoplight chart in the following categories with "1" ratings:

- **Financial Viability Risk:** As stated above, concerns such as "impacts to freight operations that would be costly to mitigate", "safety concerns that would be costly to mitigate", and "BNSF indemnification and liability insurance requirements" are considered to have a substantial negative effect on the financial viability risk of the project. While these costs are not directly represented in the Capital Construction Cost Estimate, these external cost drivers make use of the BNSF Corridor alignments infeasible.
- **Schedule Risks:** As stated above, potential HSR alignments within the BNSF Teague Line Corridor present substantial schedule risks due to construction coordination and safety requirements adjacent to the active freight operations and through significant development along the corridor. Mitigating these risks and meeting the project delivery requirements to ensure financial viability of the project is not feasible.
- **Stakeholder/Regulatory Considerations:** As stated above, potential HSR alignments within the BNSF Teague Line Corridor over a significant length of the corridor will require substantial coordination efforts and extensive engagement with BNSF that will significantly affect project schedule. By operating for significant lengths within a shared freight corridor, numerous stakeholder and regulatory issues yet to be resolved would need to be substantially addressed before project financial feasibility could be confirmed.

11.1.4 BNSF Option 2 Alignment

The BNSF Option 2 alignment is identical to BNSF with Option 1 south of Teague. North of Teague, this alignment follows the IH-45 alignment between Streetman and Ferris. This alternative was ranked lowest of the BNSF options and was eliminated due to constructability issues, cost, and potential risk. It is expected that use of this alignment would result in significant property impacts, construction difficulties, schedule risks, and increased costs relative to other BNSF alignments. The following highlights the key issues identified through the analyses:

- Existing development and infrastructure along the IH-45 segment would present multiple constraints that would require complex engineering approaches.
- Number of roadway crossings increased along IH-45 would require use of more costly viaducts to minimize transportation impacts. Multiple crossings of IH-45.
- Transportation impacts and difficult construction operations associated with work along heavily used interstate highway.

- Additional stakeholder and regulatory coordination associated with work along IH-45 and bypass of Corsicana near sensitive Richland Chambers Reservoir.

11.1.5 BNSF Option 3 Alignment

The BNSF Option 3 alignment is identical to Option 1 South of Teague. North of Teague this alignment more closely follows the BNSF Teague Line into Dallas. This alternative was eliminated due to the increased number of major structures, particularly the crossing of the Richland Chambers Reservoir. The following highlights the key issues identified through the analyses:

- Additional construction complexity, regulatory issues, and potential environmental impacts associated with crossing of Richland Chambers Reservoir. Crossing would likely be fatally flawed from regulatory approval process given feasible alternatives.
- Additional construction complexity associated with the alternative route into Dallas from all other alternatives considered that involves following IH-45 north of Ferris and existing freight lines east of IH-45.
- Highest number of crossings and longest length of freight line followed would require use of more costly viaducts and barrier walls to minimize transportation impacts during construction and risks during operation.
- Transportation impacts and difficult construction operations associated with work along heavily used interstate highway.
- Additional stakeholder and regulatory coordination associated with work along IH-45, BNSF, and UPRR.

11.1.6 BNSF Option 4 Alignment

The BNSF Option 4 alignment does score better than Options 2 and 3, but not as well as Option 1. Option 4 does have an advantage of potentially impacting less environmentally sensitive habitats, but would require more major structures and potentially experience regulatory and stakeholder coordination requirements. The following highlights the key issues identified through the analyses:

- Longest alignment of the BNSF Options.
- Multiple crossings of IH-35E and existing freight lines would increase construction complexity and costs.
- Increased complexity or magnitude of infrastructure requirements would translate directly to an extended delivery schedule and increased Project costs.
- Increased regulatory and stakeholder coordination for this alternative due to work along IH-35E and freight lines, and bypass of Waxahachie.
- Increased potential impacts to development and utility conflicts due to route through more developed area than Option 1.

11.1.7 Utility Alignment with IH-45

While this alignment scores well relative to other alignments, it does not score as well as the base Utility Alignment. As such, this alignment was eliminated from further consideration. The following highlights the key issues identified through the analyses:

- Increased crossings, construction complexity, risk, and cost associated with viaduct construction following IH-45 over approximately 56 mi (90km) between Madisonville and Fairfield.
- Existing development and infrastructure along the IH-45 segment would present multiple constraints that would require complex engineering approaches.
- Increased number of roadway crossings along the IH-45 segment would require use of more costly viaducts to minimize transportation impacts. Multiple crossings of IH-45.
- Transportation impacts and difficult construction operations associated with work along heavily used interstate highway.
- Additional stakeholder and regulatory coordination associated with work along IH-45.

11.2 Alternatives for Detailed Evaluation

At this stage of Project planning, the preferred alternative would be the Utility Corridor Alternative. Further coordination with the utility owners would be required and the results of those discussions would clarify requirements for construction adjacent to and within their ROW. It should be noted that further investigations during the Project planning and development phase may warrant the need to revisit the alignment design and infrastructure requirements and may influence their financial viability.

11.2.1 Utility Corridor Alignment

Based on the engineering and constructability evaluation completed to date, the Utility Corridor Alignment would present the fewest construction challenges and the least risk to financial viability given expected decreased costs and risks. The following highlights the key issues identified through the analyses:

- The Utility Corridor Alignment stands out from the other alignment alternatives in terms of infrastructure crossings, freight railroad impacts, construction within urban areas and local communities.
- The Utility Corridor Alignment has the lowest number of crossings and major structures and the least environmental impact, particularly in terms of impacts to development.
- The Utility Corridor Alignment would provide a more direct alignment through the rural areas. This would ease construction requirements, make construction access easier, reduce costly impacts to existing development,

reduce impacts to traffic, ease use of more advanced viaduct construction approaches, and allow for an accelerated construction schedule, which is critical for a privately funded project that will need to provide a reasonable return on investment for Project shareholders.

TCR recommends that further detailed study of alignment alternatives along the Utility Corridor be advanced through the NEPA process. The alignment used to define the Utility Corridor as analyzed herein would serve as a base alignment and be evaluated along with other reasonable alignments alternatives. These alternatives within the Utility Corridor would be developed to avoid or mitigate impacts or constructability concerns identified along this base alignment through the Step 1 Screening analysis.