San Juan County Four Corners Freight Rail Project

Task 4.4 Conceptual and Early Preliminary Engineering

Feasibility Study

San Juan County, New Mexico

October 4, 2024

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CONTENTS

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I. SUBTASK 4.4: CONCEPTUAL AND EARLY PRELIMINARY ENGINEERING

OVERVIEW

This Conceptual and Early Preliminary Engineering Memorandum is an overview of the process used to refine the five route options and several investment options initially identified and developed in Task 3. These refinements were implemented based on:

- Improving the physical feasibility and constructability of the routes, including improving earthwork balance between cuts and filles and route location in developed areas and locations with rugged terrain.
- Verifying that the routes would fulfill the operational objectives as established from the analysis performed as part of Task 4.2 (Operations Analysis) and implementing features such as sidings that were developed from that analysis.
- Performing refinements based on early environmental information to support a future detailed environmental study to be performed on the routes. For Task 4.4 this primarily focused on avoidance of residential areas and floodplains.

The naming convention for the options continues to be based on their connection point with the national rail network and a main feature (such as a parallel highway), if existing, along the route. The five design options carried forward in this analysis are named as follows, starting with the westernmost of the routes and ending with the easternmost of the routes and their connection point with the national rail network (also see the map in Figure 1):

- **Defiance via Highway 491**
- **Defiance via Indian Creek**
- **Defiance via Highway 371**
- **El Segundo**
- **Star Lake**

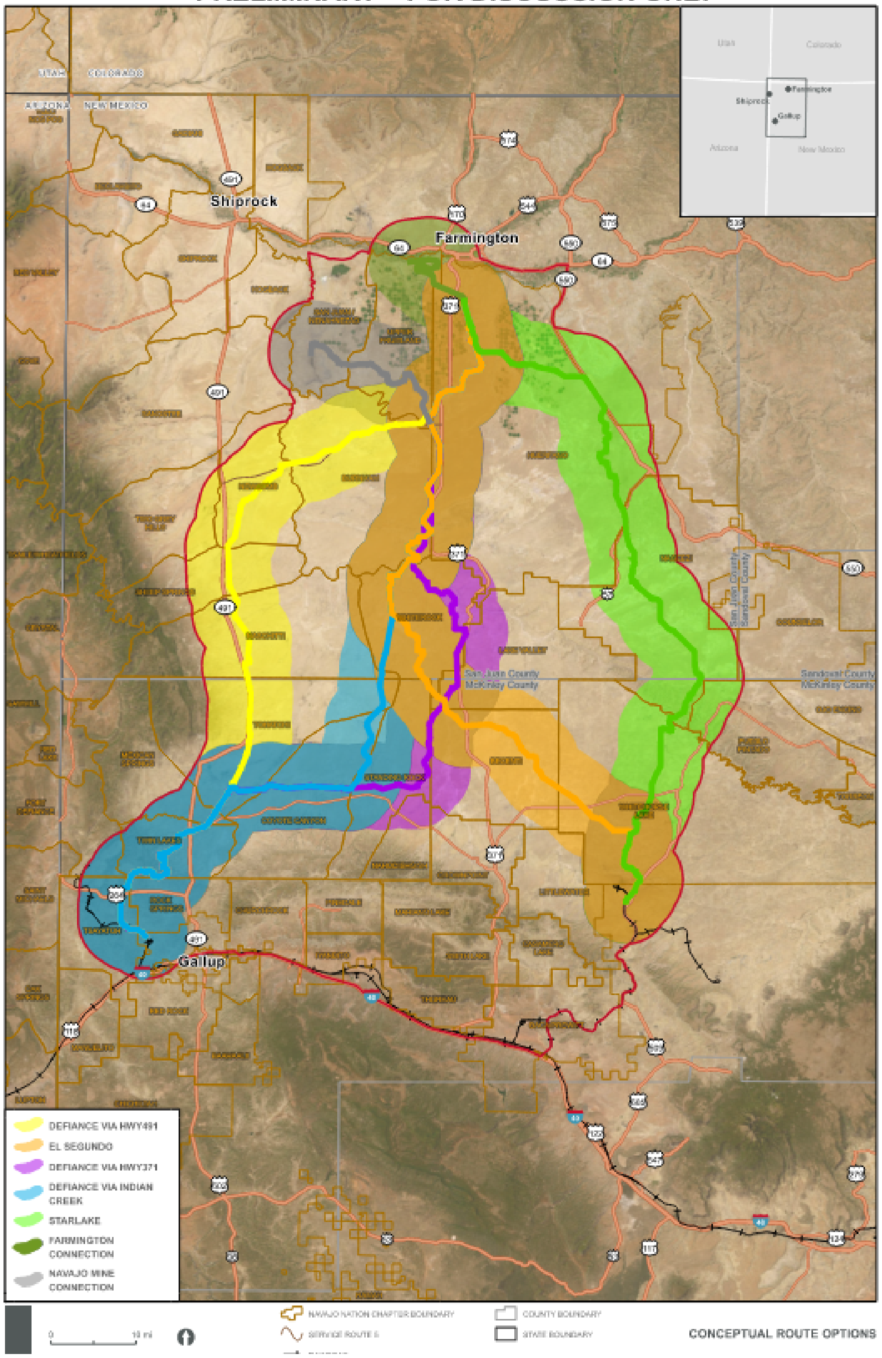
Additionally, several investment options are identified for consideration in this Subtask, including:

- The Farmington Connection extends each of the 5 routes into the San Juan River valley to provide closer access to Farmington, New Mexico.
- The Navajo Mine Connection provides a connection to the Navajo Mine operated by Navajo Transitional Energy Company (NTEC), which has an isolated mine railroad. This connection would provide NTEC access to the greater North American rail network for shipment of product and maintain the mine as an employment source for the Navajo Nation.

- The northern terminal at the Navajo Agricultural Products Industry (NAPI), which would be the location of the maintenance facility and transload facility serving Farmington.
- Sidings for trains traversing opposite directions to meet and set-out tracks (short sidings for use by maintenance equipment or crews or for temporary storage of railcars that are determined to need repair while en route), and road/rail grade separations, are included in the drawings for each route option.

Figure 1: Map of Design Options

PRELIMINARY – FOR DISCUSSION ONLY



DATA FROM OTHER SUBTASKS AND SOURCES

The team reviewed data acquired from outside sources, as well as data developed from other Tasks and Subtasks to support this Subtask 4.4, including:

- High-level land ownership information from the two counties traversed by the various route options, San Juan County and McKinley County. This information was high-level in the sense that it identifies major land ownership types, but not individual landowners. For example, this information identifies the locations of Navajo Reservation land, Tribal land outside the Navajo Reservation, Tribal trust lands, allotment land, private land, state land, federal land.
- Preliminary flood hazard mapping from the Federal Emergency Management Agency (FEMA). It should be noted that FEMA does not have mapping for Navajo Reservation lands, which most of the routes traverse.
- Locations of developed areas, specifically residences and commercial developments. These were identified primarily via desktop analysis of aerial imagery and information received from GIS showing emergency services data for home locations. This GIS data was incomplete on Navajo Reservation lands, thus the supplementation with desktop analysis.
- Information from Subtask 3.2 Investment Options Analysis and Subtask 3.3, Design Options Analysis. The five route options and investment options identified in Subtask 3.3 were the basis for the current Subtask 4.4 Conceptual and Early Preliminary Engineering. The Investment Options and Design Options were analyzed and further refined in conjunction with the aforementioned data.
- Subtask 4.2 (Operations Analysis) was used to determine interchange track, siding track, and setout track locations, as well as updated operating speeds for the routes.
- Digital terrain model and accompanying orthorectified and geolocated aerial imagery employed for previous Tasks, acquired from the United State Geological Service (USGS), remain the same for this current Subtask 4.4 Conceptual and Early Preliminary Engineering analysis.

DESIGN OPTION CHARACTERISTICS

As outlined in the Subtask 4.4 Conceptual and Early Preliminary Engineering Methodology, the following criteria have been addressed:

- The physical feasibility of the design
- The ability of the proposed design to fulfill the operational objectives and functional requirements of the specific component investments
- The general constructability of the design, including consideration of potential construction phasing to allow for the continuation of operations during the construction period
- The adequacy of the design to support a future detailed site-specific environmental analysis of the component investment
- Scale drawings of proposed track designs, showing track configuration, turnout sizes and type (powered, hand thrown, etc.), proposed rolling stock equipment wayside detector locations, distance between detectors, limits of curves and curve geometry, gradients and proposed speeds. The Subtask 4.4 methodology indicated a “comparison of proposed and

existing conditions through parallel drawings" would be included. Since this is an entirely new railroad, there are no areas in which to compare the proposed design to existing conditions, so such parallel drawings are not included.

Physical Feasibility of the Design

All design options engineered in this Subtask are physically feasible.

The routes illustrated in the design options (Figure 1) are constructible and incorporate geometrics similar to other heavy-haul railways, implying that they can be operated effectively, as evidenced in Subtask 4.2, Operations Analysis. There are no insurmountable physical obstacles, such as wide canyons or impenetrable mountain ranges, that would prevent any of the routes from being constructed.

Right of way for all design options appears possible to obtain. Each route traverses a mixture of private, public agency (State and National), and Navajo Reservation and Trust lands. Four of the routes also traverse allotment land[1]. Impacts to allotment lands were sought to be minimized due to expected difficulties in the process of obtaining right of way through them.

Physical feasibility of the design is also supported by the key geometric parameters noted below for the main line for the five design options analyzed in this report:

- Curvature
    - Typical maximum curvature: 5 degrees or less
    - Sharpest curvature: 7.5 degrees.
- Grades
    - Typical steepest grade: 2.0% compensated for effects of curvature

The railroad geometry was based on recommended practices contained in the American Railway Engineering and Maintenance of Way Association (AREMA) Manual for Railway Engineering (MRE) and is consistent with the route design recommendations of the International Heavy Haul Association. Curvature is limited to approximately 2 degrees in open areas, and 5 degrees in more constrained areas. Applying up to 4.5 inches of total elevation (e.g., 2.5 inches of superelevation and 2 inches of underbalance) to the curves would allow for speeds of 45mph, in open areas, and 35mph in constrained areas. This is consistent with mountainous railroads in other areas of North America. As part of Task 4.2,

[1] Allotment lands are located outside the Navajo Reservation and were historically "allotted" to tribal members, often in a checkerboard pattern of generally square cadastral sections of allotment lands interspersed among sections of other land ownership types (a cadastral section generally being 1 mile on each side). However, ownership of these lands is restricted to tribal members from the same family and is passed down from one generation to the next. As a result, land that was allotted to a single family (say, consisting of parents and their children) has, over successive generations, come to be controlled by many more members of the same family. In general, decisions over land use for allotment lands must be agreed-to by all surviving descendants of the initial allotee(s). As a result, in some extreme cases, a single allotment section may be controlled by over 400 allotees, though many are controlled by smaller number of allotees. Thus, obtaining a right-of-way for a railroad over allotment lands can be a relatively complex issue, with many individual allotees all needing to agree in order for the right-of-way to traverse an allotment section. Therefore, reducing the number of individual allotments traversed will also reduce the complexity of eventual right-of-way acquisition for a given route option.

speeds have been adjusted below the previous mentioned theoretical maximums based on expected train performance on the grades in the area of a particular curve.

The grades have been refined and reduced somewhat compared to those presented in the initial profiles as part of Subtask 3.3 Design Options Analysis; the maximum grades in Subtask 3.3 were 2.1% compensated. There has been a slight reduction in grade, sometimes as little as 0.1%, during the refinement process in this Subtask 4.4, for a maximum of 2.0% compensated. Undulating grades were also reduced to aid in train handling. When undulations were unavoidable (e.g., in hilly territory), where possible the profile was adjusted to provide at least an entire train length before a change in grade.

Further refinements were made to address the construction cost efficiency of the alignments by reducing earthwork. However, there are certain locations where the nature of the alignments may require wasting excess material or acquiring borrow. Locations of significant cut and fill that were present on the routes at the completion of Subtask 3.3 were studied to assess whether they could be reduced. In some cases, the profile was altered to aid in earthwork balance, while in other cases the route was realigned in order to reduce the amount of earthwork or to avoid a topographic obstruction (such as a hill) by more closely following the contours of the terrain.

The maximum excavation depth has been assumed to be approximately 100 feet. If an excavation were deeper than 100 feet and extended for a relatively long distance, it would be evaluated for a tunnel. Conversely, short lengths of deeper cuts are assumed to be acceptable (in order to avoid the relatively high cost of a short tunnel and two associated portals). At this time, only the Star Lake route appears to require a tunnel, which is estimated to be approximately 3/4 mile long.

The maximum height of fill for relatively long embankments was assumed to be approximately 100 feet before a bridge would be required. However, as further engineering progresses on the routes, high fills may be changed to bridges based on engineering judgement, required needs for drainage, and local access through the embankment.

Ability of the Proposed Options' Design to Fulfill the Operational Objectives and Functional Requirements

Operational objectives for the rail line, identified in Subtask 2.3, the Freight Demand Forecast, are summarized below:

- Much of the traffic on the proposed railway is anticipated to consist of bulk traffic handled in unit trains or carload traffic handled in manifest trains,
- No intermodal, automotive, or passenger trains are anticipated,
- The high range estimate of traffic is approximately 10,000,000 tons net per year (approximately 12 – 13 million gross tons, or MGT per year), equating to approximately 29,000 daily net tons,
  - 2 or 3 loaded trains per day (assuming net weights of 115 tons in 125 car bulk trains or 85 car manifest trains),
  - An equal number of empty trains traversing the opposite direction,

    - The route is predicted to support 3 geographically northbound trains and 3 geographically southbound trains per day.
- Operating effectiveness is addressed by:
    - Establishing design criteria limiting grades and curvature and appropriate speed limits
    - Providing sidings with set-out tracks for defective rolling stock
    - Providing periodic MOW set-out tracks to minimize time spent clearing track for trains by maintenance crews allowing more effective track maintenance
    - Providing rolling stock way-side detectors consisting of a warning signal and radio detection messaging for Hot Box Detectors, HBD (hot wheel detection), Wheel Impact Load Detection, WILD, Dragging Equipment Detectors, DED, and High/Wide Load Detectors, HWD. Detection equipment is placed enough distance from sidings to allow trains to use the siding to set-out the identified car.

Subtask 4.2 established siding locations and interchange locations with BNSF. These were established in desirable locations, and some profile refinement was undertaken to make the siding locations more suitable for train handling for starting and stopping trains for meets.

As outlined in the Subtask 4.2 Operations Analysis memo, the routes fulfill the operational objectives and functional requirements associated with the Freight Demand Forecast, and do so in conjunction with the specific component investments identified in Subtask 3.2, Investment Options Analysis, particularly the northern terminal, which was located close to one major traffic generator and was located in an area tentatively agreed-to by the landowner (NAPI), which would originate or receive bulk agricultural commodities and host transload facilities for carload freight. Refinements were made to connect the routes to the northern terminal at NAPI, which was further developed as part of Subtask 4.3, Support Facilities and Access Analysis. The other major traffic generator, the proposed investment option connection to NTEC's Navajo Mine Railroad, is also operationally feasible in conjunction with the design options provided in this Subtask 4.4, which build upon the initial design options developed in Subtask 3.3.

As a check for reasonability, there are many single-track railroads in the United States and Canada[2] that feature grades steeper than 2.0% and curves sharper than 7.5 degrees that have operational capacity in excess of six trains per day.

The options as proposed in this Subtask 4.4 (which are further evolutions of the concepts presented in Subtask 3.3, Design Options) were adjusted to a maximum of 2% vertical grade, compensated for curvature, and maintained a maximum horizontal curvature of 7.5 degrees. The five alignment alternatives and the proposed investment options, given the conceptual comparative analysis above, fulfil the operational objectives and functional requirements identified for the project.

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[2] Examples abound, such as Canadian Pacific's Rogers Pass, BNSF Railway's Stevens Pass, BNSF Railway's Stampede Pass, Union Pacific's Oregon Short Line, comprising two mountain passes, Union Pacific's former D&RGW route, comprising multiple mountain passes.

General Constructability of the Design

All design options appear constructable given typical greenfield railroad construction means and methods. While constructability would be a consideration in a constrained urban area or in a busy rail terminal, where complex phasing and temporary alignments might be required, the five design options connecting the Four Corners region to the national railway network present no such challenges since the country is largely open and there are no conflicting rail lines and only minimal existing infrastructure.

The five routes generally pass through open lands with lightly rolling hills for the majority of their alignments. However, each route has areas of more rugged terrain requiring large cuts and fills for the roadbed and in some places bridges exceeding 300’ of length or 50’ of height. The most challenging segment of construction is expected to be on the Star Lake route between mileposts 27 and 31, where the route bores through a ridge via a tunnel, and then follows a rugged canyon with no current roadway access.

For example, grade separated crossings of major highways could readily be constructed with temporary roadway detours (as found on many highway construction projects), if needed. Connections to the BNSF Railway are made at existing spurs (on the BNSF Defiance and Lee Ranch Subdivisions) with infrequent train operations, again presenting no construction challenges to installation of an additional turnout to connect to any of the proposed options; the current sporadic operations on these branch lines could continue uninterrupted outside of the brief time (approximately 12 hours) required to install a new turnout.

The need for, and how, construction facilities are provided for personnel, project management, equipment maintenance and consumables, material handling, and emergency safety response will be developed in future phases of the project.

Adequacy of the Design to Support a Future Site-Specific Environmental Analysis

The design options are capable of supporting a site-specific environmental analysis. The five design options avoid the major cultural resource, the Chaco Culture National Historic Park. Very preliminary discussions with stakeholders, such as Tribal members, were held (note that these Tribal members were speaking as individuals, not as representatives of the Tribe or specific Chapters) as part of the initial stakeholder outreach process. In addition, two public meetings (one in Newcomb and one in Crown Point) were conducted in August 2024. Key resources identified by these stakeholders were the existence of properties and grazing rights within the Navajo Nation that could be affected. However, no electronic record of these properties grazing rights has yet been found. Thus, these properties and grazing rights will need to be identified and addressed at a later time during a full assessment performed as part of a NEPA process with the current design options developed as alternatives to be included in the environmental analysis.

This design options analysis includes development of scale drawings of the design options, including "footprints" to show the extents of grading, which could be used to establish a preliminary Area of Potential Effect. Using Geographic Information System (GIS) tools, a buffer can be placed around each design option or footprint to provide additional conservatism in establishing a preliminary Area of Potential Effect.

In terms of data format to support environmental analysis, all route options presented in the accompanying appendix have been developed on geo-located aerial imagery and digital terrain models (DTM) which can be exchanged with GIS data formats. Much recorded environmental data is maintained in GIS format (such as the national wetland inventory, and inventories of known cultural and historic resources). Environmental data acquired from other, non-GIS sources can also readily be mapped onto the design options via various coordinate systems or by reference to known landmarks visible in aerial imagery.

Although at a preliminary stage, to address potential concerns, the design options have endeavored to avoid homesites visible in the aerial imagery by at least 1000 feet where practical. Clusters of homes and developments were given a wider berth, up to 1 mile separation where practical. Although no formal environmental studies, such as noise, vibration and viewshed studies, nor outreach to the residents or owners of land being crossed, have yet been conducted, a Preliminary Environmental Analysis is being conducted in Task 5. As part of the National Environmental Policy Act process, the routes may require further refinement.

Scale Drawings of Proposed Track Designs

Please see the scale drawings for each of the five design options in the accompanying Appendix 1. Following is a brief description of each route and the changes from the design options previously developed in Task 3.3. Note that these scale drawings show the current design options, and the two alignments identified as investment options (also noted as sub-options) from Task 3.2 to illustrate the progress of the design. They also show the footprint of the northern terminal at NAPI, developed as part of Task 4.3.

Description Of Routes

Defiance Routes – Common Segment

Three routes start from the Defiance, New Mexico, area, and share a common route from their start at milepost 0.0 to approximately milepost 28. The start point for these routes is located near the beginning of the existing BNSF Defiance Subdivision. Currently, the three Defiance routes diverge from the BNSF at approximately BNSF milepost 7.8 of the Defiance Subdivision. The prior BNSF connection used in previous phases, located near milepost 3.0 of the Defiance Subdivision, would have impacted more than 1 allotment parcel. This revised location, near milepost 7.8, was chosen due to the fact that routes from this location are only required to traverse a single parcel of allotment land to attain the Navajo Reservation Boundary. The common segment turns north to parallel the east side of Defiance Draw Road. The BNSF interchange sidings will be placed along this section, and the single allotment parcel is also encountered on this section. The common segment crosses NM Highway 264 with a grade separation taking the highway over the railroad. The route continues north, ascending onto the plateau and crossing into the Navajo Reservation Lands. The routes turn east, following the summit of the plateau, to milepost 12 where the route descends the face of the plateau. The plateau, which in places stands up to 300 feet higher than the valley below, is most favorable to descend in this location due to a smaller elevation differential between the plateau and valley and availability of rolling foothills to work the routes into the terrain more easily. The routes descend the face of the plateau with numerous large cuts and fills, a 2.0% compensated grade, and curves up to 7.5 degrees dictated by the contours of the land. By milepost 15, the worst of the terrain has been negotiated and the routes head generally eastward, passing north of the community of Twin Lakes until the Navajo-Gallup waterline is met, at which point the common segment turns to parallel the west side of this utility to approximately milepost 28. The area between mileposts 15 and 20 has numerous residential sites that have been identified, and the density and location of these is such that it is not practical to give them a wide buffer without rerouting far to the west and north, which would require highly technical construction and very possibly tunnels. Therefore, the route was threaded through a less dense area of development with as much residential buffer provided as was practical.

Defiance Routes – Defiance Via Highway 491

Continuing from milepost 28, the Defiance Via Highway 491 route diverges from the Defiance Via Highway 371 and Defiance Via Indian Creek routes to follow the Navajo-Gallup waterline on the west side. Near milepost 34, the route crosses to the east side of the waterline. At milepost 42, the route deviates to the east approximately 1.5 miles due to significant residential development near the waterline. Refinements were made to realign the route even further to the east between milepost 43 and 59 since the original alignment was located between the highway and several residences. By shifting the alignment to the east, the alignment is no longer between the residences and the highway.

Between mileposts 61 and 68 the route was refined to avoid the floodplain of Captain Tom Wash as well as to provide additional buffer from some residences noted east of the community of Newcomb. Near milepost 63.6, the route passes under Indian Service Rte 5 via an underpass beneath the roadway, and then turns east to generally follow this road to the north. A major bridge will need to be constructed for the crossing of Chaco Wash at milepost 71. Several refinements were made between milepost 71 and milepost 86, primarily to improve earthwork. The corridor the route shares with the highway is on a bench in the terrain which is narrow in some places, there are also a handful of residences which are encountered in this area.

Another refinement was made between milepost 86 and milepost 100 to avoid a pair of mountainous areas and a crossing of NM Highway 371 that was in a geometrically challenging location if impacts to agricultural lands were to be avoided. The revised route swings along the north side of the large hill between mileposts 86 and 88, which previously required a cut in excess of 100' depth. The route then continues east, crossing Highway 371 via a grade separation where the road is taken over the railroad. After descending into the valley, the route turns north to the northern terminal at NAPI. The revised route requires significantly less earthwork and reduces impacts while being approximately the same length as the prior route from previous Task 3.3.

Defiance Routes – Defiance Via Highway 371 and Defiance Via Indian Creek Common Segment

From the divergence point with the Defiance via Highway 491 route at milepost 28, the Defiance Via Highway 371 and Defiance Via Indian Creek routes share a common segment up to approximately milepost 45. This entire distance has been refined from the Task 3.3 routes due to the prior route cutting through communities between Twin Lakes and Standing Rock. The revised route skirts the base of the hills to the north, increasing the distance between the proposed rail line and these communities, without any notable degradation to the quality of the route in terms of grades and curvature.

Defiance Routes – Defiance Via Highway 371

From the divergence point at approximately milepost 45, the Defiance Via Highway 371 route continues east from the Defiance via Indian Creek Route, passing north of the community of Standing Rock. The refined alignment rejoins the previous Task 3.3 alignment at milepost 56 and exits the Navajo Reservation Lands as it heads northeast to join the Highway 371 corridor. Note that in areas where locating the route next to the highway is practical, the assumption was made that, since the highway was able to be located through those parcels, a railroad would be as well.

At milepost 68, the highway heads into terrain unfavorable for a railroad, and the Defiance Via Highway 371 route diverts onto an independent routing generally following the Chaco Wash valley. Through this valley the route has been refined to skirt the hills, avoiding allotment parcels and providing as much buffer from the existing residences and the proposed railroad as is practical. Near milepost 81 the route crosses Chaco and De-nah-zin Washes and crosses the ridge to the adjacent valley containing Hunter Wash, which is crossed near milepost 85. The route ascends the plateau to the north, rejoining Highway 371 at milepost 87.

Similar to Defiance Via Highway 491, a major refinement was undertaken to relocate the crossing of Highway 371 and provide an improved route in the process. This refinement is between milepost 92 and milepost 107 and features the alignment crossing under a grade separated Highway 371 and descending into the valley to the east before turning north to the norther terminal location at NAPI.

Defiance Routes – Defiance Via Indian Creek

From milepost 45, the Defiance Via Indian Creek route turns north through generally open country with few developed areas, following a utility corridor that is observable on aerial photography. At milepost 64 the route enters the Indian Creek valley, where refinements have been made to avoid the floodplain. At milepost 70 the route turns east for 3 miles, following Chaco Wash to where it is crossed at milepost 73.

The route then crosses the ridge to the north via an alignment that seeks to reduce gradient and earthwork, and crosses Hunter Wash near milepost 79. From Hunter Wash, the route ascends the plateau, but has been refined to be closer to Highway 371 to reduce the potential for impacts to several identified residences. Near milepost 85, the route once again becomes common with the Defiance Via Highway 371 route and includes the same refinement that was made to improve the Highway 371 crossing location and reduce earthwork.

El Segundo and Star Lake Common Segment

The El Segundo and Star Lake routes are in common for the first 8 miles of the routes. The start point for the routes is approximately milepost 32 of BNSF's Lee Ranch Subdivision. From this point, the routes head northeast towards NM Highway 509, crossing a haul road to the El Segundo coal mine near milepost 1.5 via a rail over road grade separation. At milepost 3, the routes turn generally north and west. At milepost 3.5 the BNSF interchange sidings are located where a favorable profile for these tracks can be obtained. Beyond these sidings is open country to the end of the common segment.

El Segundo Route

From milepost 8, the El Segundo Route continues north to milepost 10, then west through open country. Between mileposts 15 and 24, several refinements were made to reduce earthwork and follow the terrain more closely. Although this introduces more curves, it avoids an undulating profile as the method to reduce earthwork. At milepost 24 the route begins following the Kim-me-ni-oli wash northwestward. A group of allotment lands are also encountered. The route avoids allotment parcels where practical, but it appears approximately 5 allotment parcels are impacted. Refinements to reduce the impacted parcels below this number brought the alignment in close proximity to Chaco Culture National Historic Park and, based on stakeholder feedback at public meetings and informal discussions with tribal representatives, were deemed too unfavorable due to the close proximity.

Leaving the allotment lands, the route crosses NM Highway 371 via a road over rail grade separation, before descending into the valley of Indian Creek, which is followed between milepost 42 to milepost 57. Refinements were made in this stretch to pull the route away from the floodplain, reduce curvature and reduce earthwork. Between mileposts 57 and 60, the route follows Chaco Wash, which is crossed at milepost 60. The route then crosses the ridge to the north via an alignment that seeks to reduce gradient and earthwork, and crosses Hunter Wash near milepost 67. From Hunter Wash, the route ascends the plateau to the north, joining the west side of Highway 371 at milepost 71. Near milepost 72, the route once again becomes common with the Defiance Via Highway 371 route and Defiance Via Indian Creek routes the remainder of the way to the northern terminal at NAPI and includes the same refinement that was made to improve the Highway 371 crossing location and reduce earthwork.

Star Lake Route

From milepost 8, the Star Lake route continues northward through open lands. Between mileposts 19 and 23, the route skirts the west side of a large block of allotment lands. From milepost 24 to 27, the route ascends, winding along the face of a large plateau which is tunneled through with an approximately 3,760’ long tunnel. East of the tunnel the route hugs the face of the rugged canyon walls as it descends to a crossing of the Chaco Wash near milepost 32. Past Chaco Wash, the route travels northwestward. A series of drainages which drain the hills to the east into Chaco Wash must be negotiated between mileposts 40 and 51. In order to keep a buffer from Chaco Culture Historic Park, and due to the location of some allotment parcels in this area, the sawtooth nature of the land is encountered head on, resulting in an undulating profile. Significant earthwork is used to keep the profile grades within desired tolerances, as opposed to hugging the hilly terrain and venturing into allotment parcels. The alignment was also refined between mileposts 44 and 50 to avoid a steep, short ridge to reduce train handling challenges. The realigned route skirts this ridge to the west, and although 2 miles longer, has significantly lower grades than the prior routing, and offers an improved site for a passing siding.

Beyond milepost 51, the terrain is more straightforward, and the route ascends onto a plateau at milepost 55, continuing through open country in a northward direction. Between mileposts 74 and 74, the route travels on the west side of US Highway 550. Turning west, the route skirts agricultural lands as it descends to a crossing of Gallegos Wash near milepost 89. From this point, the route heads west to Road 7100, then north to the northern terminal at NAPI, ascending the entire distance.

To join with the Navajo Mine Connection investment option, the Star Lake route option would need to include an approximately 17 mile long section of any of the three “Defiance Via…” design options between the northern terminal at NAPI and the Navajo Mine Connection.

The Star Lake route does not impact any allotment parcels.

<u>Additional Notes on Routes</u>

North of the county line dividing San Juan and McKinley Counties, three of the routes, Defiance via Indian Creek, Defiance via Highway 371, and El Segundo, are relatively close to each other. If, during a future phase of study, a portion of one route emerges as preferable to the others north of the county line, it would be possible to link the other portions of the routes to use this more preferable portion.

The typical sections, which FRA approved as part of Subtask 3.2, have been included in the Appendices to accompany the scale drawings of the design options. The grading footprint shown on the scale drawings is based on the embankment slopes shown in these typical sections. The typical sections include embankment slopes (supporting railroad track) at 3 Horizontal: 1 Vertical (referred to as “3:1” or “3H:1V”) and excavation slopes (not supporting track) at 2H:1V. The steepness of the side slopes will be refined in later design efforts as geotechnical investigations are performed.

The train frequency is relatively low and could be supported by Track Warrant Control or a similar system, with no need for a centralized traffic control system or other wayside signals. Due to the low train frequency, the sidings were located at approximately the quarters points of each route in Task 4.2, dependent on a suitable location for a passing siding with flatter grades and gentle terrain. Wayside detectors (which for reasons of economy typically incorporate dragging equipment detectors and hot bearing detectors into a single signal location) would be located in approach of each end of each siding, in order to identify defective equipment prior to it reaching the turnouts at the ends of the sidings.

Bridges

Drainages have been identified as blue lines on the scale drawings of the design options. The size of the crossings and conceptual bridge types for bridges more than 300’ long or 50’ tall have been identified for each of the alternative routes. Structure types, typical of freight railroad industry design for crossings of the anticipated length and height, have been developed as an aid in presenting a typical structure type and use in developing the order of magnitude opinion of probable conceptual project cost. A brief description of the structure types is provided, below. Typical cross sections of each main span type, used to also define the anticipated structure type are shown as well. The anticipated substructure type is based on similar railroad projects with similar bridges. Additional design work as the project progresses in future phases, including geotechnical investigations, will refine the required hydraulic capacity, the superstructure and substructure for the bridges.

SDPG, Steel Deck Plate Girder

This span type and length is typically used for heavy haul railroad applications for the anticipated overall bridge length (typically 180-feet) and height of structure. The combination of span length, type of substructure and height lends itself to economical construction costs. Typically, four steel girders are fabricated by welding flange plates to a web plate with additional steel for stiffeners, crossing bracing for diaphragms, and connection plates added. A cast-in-place concrete ballast deck is used to support the track structure and safety walkway across the bridge. Due to the span lengths and loads being transmitted to the substructure, cast-in-place concrete piers are used which are typically founded on drilled shaft concrete deep foundations.

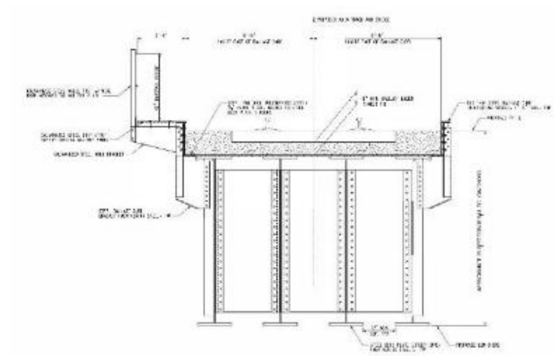

Figure 2, Steel Deck Plate Girder Section

SBM, Steel Beam Span

This span type and length is used for heavy haul railroad applications when the anticipated span lengths are not over 72-feet in length. This structure uses multiple rolled steel wide flange beams with diaphragms of steel plates or smaller size wide flange beams used to create a cross section supporting the cast-in-place ballast deck for the track structure. The longer span allows a single span to cross over most two or three lane roadways with modern shoulders. In road crossings, the multiple beam spans provide redundancy allowing trains to keep moving when moderate damage occurs from a high vehicle load strike. A cast-in-place concrete ballast deck is used to support the track structure and safety walkway across the bridge. The shorter anticipated bridge height and span length allows for the substructure to consist of precast-concrete caps supported by exposed driven H-pile deep foundations.

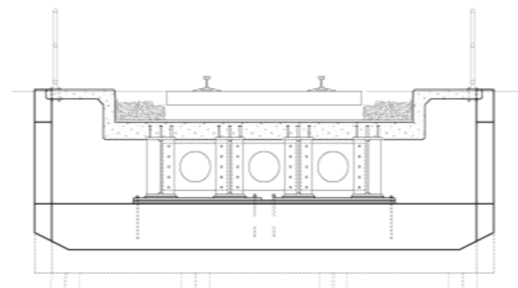

Figure 3, Steel Beam Span Section

30" & 42" BDDC, 30-inch or 42-inch Ballast Deck Double Cell Precast Concrete Span

This bridge type is the most common type used by heavy haul freight railroads in North America and elsewhere internationally where shorter height and span length structures can be used. It is the most economical span type, even taking into account the substructure. The entire structure can consist of precast concrete spans, which already have the ballast deck as part of the span, precast concrete caps and backwalls and walkways. The spans are lighter and easier to deliver to the project as well as erect. The precast concrete caps are erected, depending on span length, on 4 to 6 exposed driven deep foundation steel H-pile. 42-inch-deep spans are used up to approximately 50-feet span lengths and the 30-inch-deep spans are typically used up to 38-foot span lengths. These spans are also used as the initial "approach" spans at the start and ends of bridges to reduce the abutment construction costs and provide additional economics when long spans and tall height piers are used for the main part of the bridge.

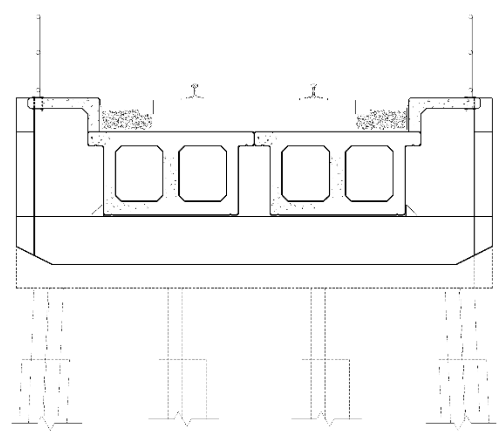

Figure 4, 30" & 42" Ballast Deck Double Cell Span Section

Each route's listing of major bridge, anticipated structure type for the main spans, estimated height and length are provided in the Table 1 below. The bridge type listed is based on the anticipated main longest single span type.

Table 1, Major Bridge Listing by Route

MP	Description	Opening Length	Est. Max Height, T/R To Invert	Est. Bridge Length	Bridge Type	Conceptual Foundation	Max. Single Span Length, FT.
Defiance Via Highway 491							
10.3	Wash	150	70	430	SDPG	supported on drilled shaft, CIP conc.	180'
13.9	Wash	150	72	440	SDPG	supported on drilled shaft, CIP conc.	180'
14.4	Wash	160	57	390	SDPG	supported on drilled shaft, CIP conc.	180'
17.0	Wash	350	74	650	SDPG	supported on drilled shaft, CIP conc.	180'
64.0	Captain Tom Wash	370	18	450	30" BDDC	H-pile	35'
71.0	Chaco Wash	1150	30	1270	SDPG	supported on drilled shaft, CIP conc.	180'
105.4	Road 7100	60	33	200	SBM	supported on H-pile, precast caps	72'
Defiance Via Highway 371							
10.2	Wash	150	70	430	SDPG	supported on drilled shaft, CIP conc.	180'
13.9	Wash	150	72	440	SDPG	supported on drilled shaft, CIP conc.	180'
14.4	Wash	160	57	390	SDPG	supported on drilled shaft, CIP conc.	180'
17.0	Wash	350	74	650	SDPG	supported on drilled shaft, CIP conc.	180'
34.5	Coyote Wash	240	10	280	30" BDDC	H-pile	35'
46.0	Standing Rock Wash	300	10	340	30" BDDC	H-pile	35'
58.7	Indian Creek	300	18	380	30" BDDC	H-pile	35'
74.5	Wash	300	45	480	SDPG	supported on drilled shaft, CIP conc.	180'
80.8	Chaco Wash	1975	54	2200	SDPG	supported on drilled shaft, CIP conc.	180'
85.5	Hunter Wash	260	28	380	42" BDDC	precast concrete on H-pile foundation	50'
112.6	Road 7100	60	33	200	SBM	supported on H-pile, precast caps	72'
Defiance Via Indian Creek							
10.3	Wash	150	70	430	SDPG	supported on drilled shaft, CIP conc.	180'

MP	Description	Opening Length	Est. Max Height, T/R To Invert	Est. Bridge Length	Bridge Type	Conceptual Foundation	Max. Single Span Length, FT.
13.9	Wash	150	72	440	SDPG	supported on drilled shaft, CIP conc.	180'
14.4	Wash	160	57	390	SDPG	supported on drilled shaft, CIP conc.	180'
17.0	Wash	350	74	650	SDPG	supported on drilled shaft, CIP conc.	180'
34.5	Coyote Wash	240	10	280	30" BDDC	H-pile	35'
48.0	Standing Rock Wash	300	13	360	30" BDDC	H-pile	35'
64.1	Indian Creek	300	25	400	30" BDDC	H-pile	35'
73.0	Chaco Wash	700	37	850	42" BDDC	precast concrete on h-pile foundation	50'
79.2	Hunter Wash	250	57	480	SDPG	supported on drilled shaft, CIP conc.	180'
106.3	Road 7100	60	33	200	SBM	supported on H-pile, precast caps	72'
El Segundo							
1.6	Mine Haul & Hdqtrs Access Rd	200	40	360	SDPG	supported on drilled shaft, CIP conc.	180'
31.5	Kim-me-ni-oli Wash	120	28	240	42" BDDC	precast concrete on h-pile foundation	50'
60.2	Chaco Wash	700	37	850	SDPG	supported on drilled shaft, CIP conc.	180'
68.0	Hunter Wash	300	28	420	42" BDDC	precast concrete on h-pile foundation	50'
95.1	Road 7100	60	33	200	42" BDDC	precast concrete on h-pile foundation	50'
Star Lake							
1.6	Mine Haul & Hdqtrs. Access Rd	200	40	360	SDPG	supported on drilled shaft, CIP conc.	180'
28.2	Wash	100	102	510	SDPG	Steel Deck Plate Girder Primary Span	180'
32.2	Chaco Wash	300	21	390	42" BDDC	precast concrete on h-pile foundation	50'
40.9	Escavada Wash	320	29	440	42" BDDC	precast concrete on h-pile foundation	50'
47.2	Betonnie-Tsosie Wash	410	24	510	42" BDDC	precast concrete on h-pile foundation	50'
50.3	Kimbeta Wash	420	42	590	SDPG	supported on drilled shaft, CIP conc.	180'

MP	Description	Opening Length	Est. Max Height, T/R To Invert	Est. Bridge Length	Bridge Type	Conceptual Foundation	Max. Single Span Length, FT.
59.6	Wash/Road	200	56	430	SDPG	supported on drilled shaft, CIP conc.	180'
67.6	Gallegos Wash (1)	300	36	450	42" BDDC	precast concrete on h-pile foundation	50'
88.6	Gallegos Wash (2)	1280	40	1440	SDPG	supported on drilled shaft, CIP conc.	180'

Numerous minor structures will be required for each route. These consist of smaller height, shorter length bridges, primarily using the 30-inch ballast deck double cell spans. Other drainage structures and potential livestock undercrossing structures will consist of precast concrete reinforced concrete box culverts or corrugated metal pipe. Corrugated metal pipes are assumed to be aluminized coated for corrosion protection. All structures supporting railroad loading will meet AREMA Manual of Railroad Engineering design standards with those supporting highway loading designed in accordance with New Mexico DOT requirements.

EVALUATION PROCESS

Assessment of the design options is based on the screening criteria, listed below. The results are included in Table 1, along with how each option meets the criteria for each category (Geometry and Operations; Feasibility and Constructability, and Environmental Constraints).

Note that the design options meet the Preliminary Purpose and Need goals by connecting the Four Corners region to the national rail network in order to provide improved economic opportunities that would accompany improved logistics options (i.e., a rail link). Thus, whether a design option meets the Preliminary Purpose and Need is not a distinguishing criterion.

It is assumed that the investment option for a northern terminal is required (since trains must have a place to terminate in order to meet the Preliminary Purpose and Need), and, since it is located at the same place (NAPI) and the same configuration, this is not a distinguishing feature.

The two other major investment options, the Farmington and Navajo Mine connections are also evaluated in the table.

- **Geometry and Operations:**
  - **Ruling Grade**: the steepest average grade on which an entire train may find itself stopped and be required to restart; for this effort an approximate 1-mile train length has been assumed.
  - **Curvature:** sharper curves are less favorable.
  - **Undulation:** Addresses how many crests or sags occur within close proximity to each other. As a baseline, we are assuming significant crests and sags within 1 train length (approximately 5000’) of each other could be problematic.

- **Feasibility & Constructability:**
    - o **Potentially High Cost Constraints:** such as grade separations, extremely high and long bridges, tunnels, etc., (we assume cuts and fills up to 100' are acceptable at this stage), and extensive lengths of private land where a right-of-way would be required. It is assumed that Tribal land or public land would be available.
    - o **Conflicts with Existing Infrastructure:** such as identified utilities and roadways.
    - o **Allotments Traversed:** number of full sections identified as allotment areas.
- **Environmental Constraints:** Communities, homesites, grazing permit areas, cultural resources (at this stage, Chaco Canyon is the major cultural resource), known archeological resources, and habitat. At this stage, it is believed that all routes pass through or near grazing permit areas. Additional information will be identified as part of Task 5.

The following table identifies how each design option compares to the criteria above.

Table 2: Comparison of Design Options

Route	Defiance via Hwy 491	Defiance via Indian Creek	Defiance via Hwy 371	El Segundo	Star Lake	Farmington Connection	Navajo Mine Connection
Geometry & Operations: Grade (uncompensated)	2.0% NB 2.0% SB	1.9% NB 2.0% SB	2.0% NB 2.0% SB	1.8% NB 1.9% SB	2.0% NB 1.9% SB	0.2% NB 2.0% SB	1.5% NB 1.5% SB
Geometry & Operations: Max. Curvature	5.0° (typical) 7.5° (max, 1)	5.0° (typical) 7.5° (max, 1)	5.0° (typical) 7.5° (max, 1)	4.0°	5.0° (typical) 7.5° (max, 2)	6.0°	3.0°
Geometry & Operations: Undulation	Minimal undulation	Minimal undulation	Minimal undulation	Minimal undulation	Relatively significant undulation	Minimal undulation, but long, steep continuous 2% grade	Minimal undulation
Geometry and Operations: **Meets Objectives**	Yes, Route meets Task 4.4 objectives	Yes, Route meets Task 4.4 objectives	Yes, Route meets Task 4.4 objectives	Yes, Route meets Task 4.4 objectives	Yes, Route meets Task 4.4 objectives	Yes, Investment Option meets Task 4.4 objectives	Yes, Investment Option meets Task 4.4 objectives
Feasibility and Constructability: Potentially High Cost Constraints	~1 mile private R/W	~1 mile private R/W	~1 mile private R/W	16 miles private R/W	18 miles private R/W, ~1 mile tunnel, undulation	~.5 mile private R/W	Primarily on reservation and tribal controlled lands.
Feasibility and Constructability: Conflicts with Existing Infrastructure	Parallels water line; Hwy 264, 491, 371 crossings	Parallels water line and gas lines; Hwy 264, 491, 371 crossings	Parallels water line; Hwy 264, 491, 371 crossings	Hwy 57, 371 (2) crossings	No identified conflicts with major infrastructure	No identified conflicts with major infrastructure	No identified conflicts with major infrastructure

Route	Defiance via Hwy 491	Defiance via Indian Creek	Defiance via Hwy 371	El Segundo	Star Lake	Farmington Connection	Navajo Mine Connection
Feasibility and Constructability: Allotments Traversed	1	1	2 (these two allotments are already traversed by Highway 371)	5	None	None	None
Feasibility and Constructability: **Meets Objectives**	Yes, Route meets Task 4.4 objectives	Yes, Route meets Task 4.4 objectives	Yes, Route meets Task 4.4 objectives	Yes, Route meets Task 4.4 objectives	Yes, Route meets Task 4.4 objectives	No, the Farmington Connection Investment Option has been deemed to not provide enough benefit to study further at this time.	Yes, Investment Option meets Task 4.4 objectives
Environmental Constraints **(As they are known based on preliminary information from Task 5)**	To Be Determined (TBD) in Task 5 (Near existing Hwy 491 and water line corridor, already cleared; ~1 mile or less from Twin Lakes, Naschitti, and Sheep Springs, and homesites near Hwy 264; near grazing permit areas)	TBD in Task 5 (~1 miles to Twin Lakes and homesites near Hwy 264; near grazing permit areas)	TBD in Task 5 (Close to several homesites near Hwy 264 and ~1 mile from Twin Lakes, Standing Rock and White Rock; avoids Chaco Canyon by ~3.5 miles; near grazing permit areas)	TBD in Task 5 (avoids Chaco Canyon by ~3 miles; near grazing permit areas)	TBD in Task 5 (near grazing permit areas)	North end of Farmington Connection would be in or near a floodplain. Recommend that this option not be pursued.	TBD in Task 5

SUMMARY & EVALUATION RESULTS

Design Options

At this time, the five routes appear feasible and constructable. They meet the preliminary purpose and need. The five design options are recommended for further study as part of Task 5, environmental study. The results from the Task 4.5 Capital Cost Estimation, Task 5 Preliminary Environmental Analysis, and input from stakeholders will help determine which of the 5 routes are the preferred design options.

Investment Options

Two major investment option routes were considered, the Farmington option and the Navajo Mine connection. In addition, the northern terminal at NAPI was considered to be an investment option.

Navajo Mine Connection

The Navajo Mine connection links the Navajo Mine with the national rail network and is one of the major sources of traffic, as identified in the Freight Demand Forecast. The Navajo Mine Connection does not appear to have significant engineering challenges. It is recommended that this investment option be carried forward into the next stages of the study.

Farmington Connection

It is recommended that the Farmington connection be eliminated from further consideration. The Farmington connection would require approximately 14 miles of additional railroad descending on a 2.0% grade, with no un-developed land for a yard at the bottom of the San Juan River valley, where the towns of Farmington Fruitland, Kirtland, and Bloomfield are located. Nearly all the land in this valley is already being used for agricultural operations, light industry, or residential purposes, or is in the flood plain of the San Juan River. Moreover, the potential users of a rail in the San Juan River valley line, generally truck terminals and light industry, are widely dispersed throughout the San Juan River valley, meaning that it would be impossible to route spur lines to directly serve each of these potential shippers. As a result, shipments originating in the San Juan River valley would need to be trucked to a transload terminal.

For example, using the intersection of Highway 371 and Highway 64 in Farmington as a starting point, it would be the same trucking distance (approximately 5 miles) to a potential transload terminal at the end of the Farmington Connection spur line (which, due to the grades and earthwork required, would be located between Farmington and Kirtland) as it would be to the proposed transload terminal at the northern terminal at NAPI (NAPI), on the bluff above Farmington, accessed by Highway 371. Although trucks would have to ascend the bluff to reach a transload facility at NAPI, trucks regularly do this today when they use Highway 371 to access Interstate 40, approximately 95 miles south of Farmington.

As discussed in Subtask 4.3, Support Facilities and Access Analysis (approved by FRA on September 24, 2024), a transload facility can be located at NAPI, on relatively flat ground, with minimal additional grading, and in an area where NAPI has indicated (although not formally committed) a terminal would be acceptable. As a result, it would make little sense to add the high cost of a steeply-graded, 14-mile spur and second transload terminal, with the potential for associated environmental impacts, in the San Juan River valley while not reducing the trucking distance.

It is recommended that the Farmington Connection be eliminated from further consideration.

Northern Terminal at NAPI

The northern terminal at NAPI was included as an investment option. It is common to all design options, since each design option needs a northern terminal, and the site at NAPI has both sufficient space and NAPI is willing to discuss the possibility of a rail terminal and transload at this location. It is recommended that the northern terminal at NAPI be advanced with the design options for the various routes.

APPENDICES

Appendix 1: Design Options Scale Drawings: Plan and Profile drawings of 5 design options: These drawings illustrate the following five Route Options. All plan and profile drawings indicate curvature, design speeds, and grades, as well as gray shading indicating the approximate grading footprint. Investment Options (e.g., spur tracks to the Navajo Mine Railroad and Farmington) are also shown. All options share a common northern terminal location at NAPI (investment option) and access to the existing Navajo Mine Railroad (approved as part of Task 3.2). All options share common typical sections which were approved as part of Task 3.2, Investment Options.

- **Defiance via Hwy 491 Design Option**
- **Defiance via Indian Creek Design Option**
- **Defiance via Hwy 371 Design Option**
- **El Segundo Design Option**
- **Star Lake Design Option**

Appendix 2: Typical Sections

- Typical sections for main line track (1 page)

Appendix 3: Schematic Drawings of the 5 design options

Appendix 4: Investment Options Scale Drawings: These include plans for the spur connection to the Navajo Mine Railroad, the spur connection to Farmington, and the NAPI Terminal trackage. They have been updated as needed for the refinements made in Task 4.4.