Appendix C. Technical Documents in Support of NLX Service Plan

- Preliminary Economic Impact Analysis, December 3, 2015
- Preliminary Benefit Cost Analysis, December 3, 2015
- Ridership and Revenue Forecast, October 2015
- Capital Cost Report, January 2017
- Operating and Maintenance Costs and Capital Replacement Forecast, January 2017

Preliminary Economic Impact Analysis

NORTHERN LIGHTS EXPRESS

QUANDEL CONSULTANTS, LLC
161 N. Clark St., Suite 2060
Chicago, IL 60601
Main 312.634.6200 | **Direct** 312.634.6201
cquandel@quandel.com
quandelconsultants.com

Northern Lights Express

Technical Memorandum #24

To:	**Francis Loetterle, Project Manager**
	Minnesota Department of Transportation (MnDOT)
Subject:	**Preliminary Economic Impact Analysis**
Prepared By:	**Quandel Consultants, LLC**
Date:	**December 3, 2015**

1. Purpose of Technical Memorandum

An Economic Impact Analysis (EIA) was undertaken by PMO subconsultant AECOM in order to provide quantifiable employment, earning, tourism, and tax impacts that result from the construction and operation of the NLX service. The results of the EIA were provided to the project team in December 2015 to support the creation of the NLX Brochure.

The purpose of this memorandum is to document the methodology used to conduct the EIA and summarize the results of the EIA. The data and text presented in this memorandum were provided by AECOM in several documents; this memorandum combines the EIA into one summary document to provide one source for economic impacts.

The economic impacts were computed using train schedules, capital and operating cost data, and ridership and revenue forecasts that were current as of September 2015. The results of the EIA included herein are based on September 2015 data. The EIA will be updated for final train schedules, capital and operating costs dated January 2017 for Scenario C-1. EIA results will be presented in a future Final Economic Impact Analysis Technical Memorandum.

2. Introduction

Implementation of the NLX service between Minneapolis, MN and Duluth, MN would provide a new transportation alternative for business travelers, commuters, tourists, and other corridor users. The benefits resulting from the implementation of NLX service would be shared by those who use the rail system and those who remain on the corridor's road system. The availability of rail would allow current auto travelers to shift from cars, thereby reducing the harmful impacts of emissions, the injuries and fatalities associated with crashes, vehicle operating costs, and pavement maintenance. Rail passengers may experience productivity increases as a result of using the train instead of driving for business trips. In addition, the project would improve freight operations on the shared corridor by upgrading sidings and track, which saves BNSF and their customers' time and money.

Travelers who remain on the corridor's roads would also benefit through a reduction in congestion in the MN 65 and I-35 corridors and through greater safety and reduced delays at grade crossings. New station accessibility would result in properties within a ½-mile radius becoming more valuable, and the upgrade of existing at-grade crossings would result in fewer train-vehicle conflicts. Together, these benefits demonstrate that the project would have long-term quantifiable value to the region's residents, tourists, users, and non-users.

The analysis described in this memorandum presents the quantifiable economic impacts of the NLX Scenario C-1 and the employment and earnings impacts that result from construction and operation of the service.

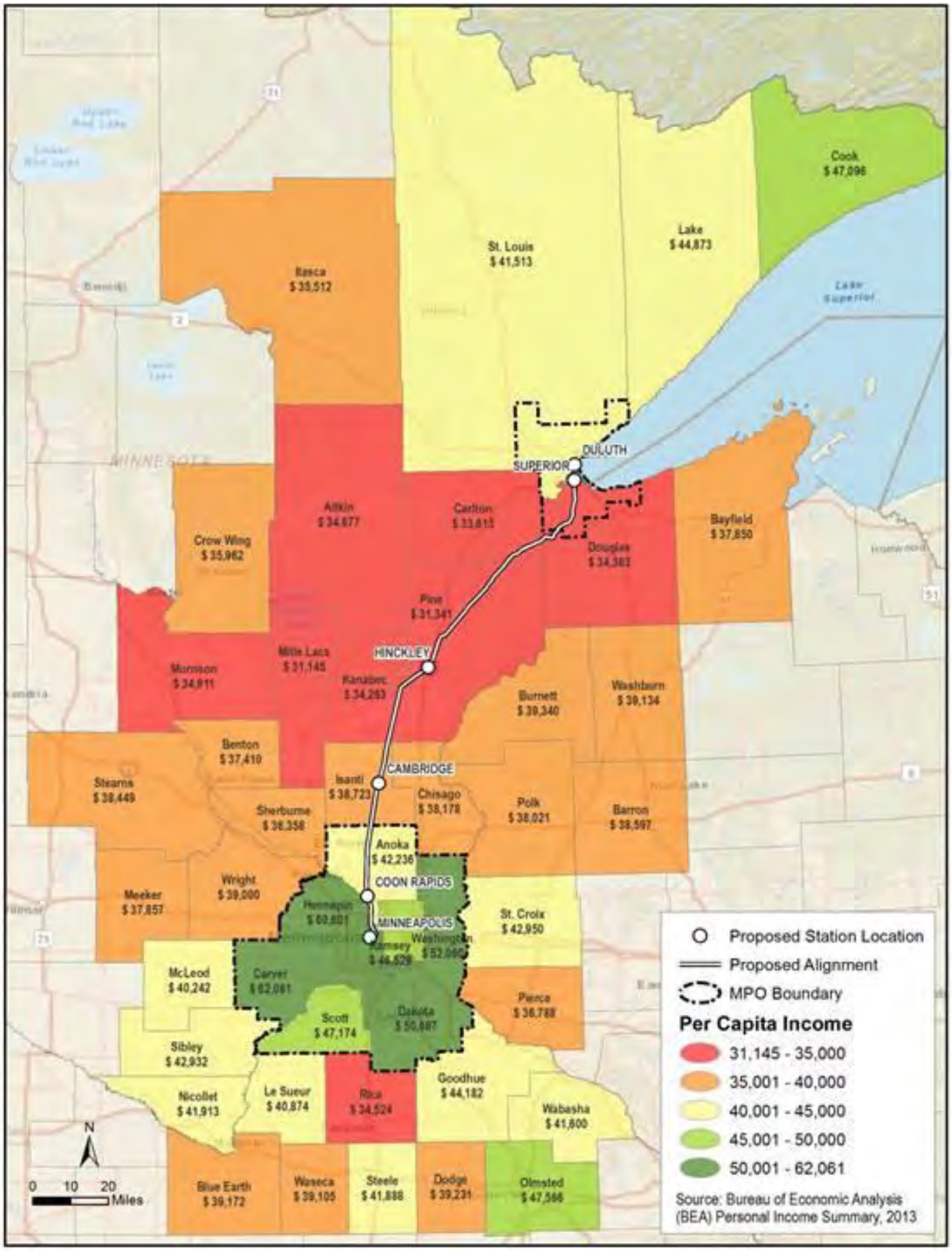
3. Economic Impact Analysis

While there are common factors between a Benefit Cost Analysis (BCA) and an EIA, some types of economic impact metrics, such as construction jobs created and sustained, operations and maintenance jobs created and sustained, are not included in a BCA. This is because the two analyses have different purposes. Impacts estimated as part of the EIA include jobs and earnings. Because jobs represent both a cost to the employer (paying a wage), and a benefit to the employee (receiving a wage), it is a transfer payment rather than a net benefit and therefore is not included in a BCA. This EIA examines the impact to jobs and earnings because of a project's construction and implementation and the recipient of these impacts regardless of whether the "pie is expanded."

3.1. Economic Impact Study Area

The economic impact study area includes counties in central Minnesota and northwest Wisconsin through which the NLX service is planned to operate. The system will terminate at Target Field Station in Minneapolis and at the Union Depot in Duluth. The NLX service proposes mid-route stations in Coon Rapids, Cambridge, Hinckley, and Superior, WI. A maintenance facility would be located in either Sandstone or Duluth and a layover facility would be located in Duluth. The Minnesota counties included in the study area are: Aitkin, Anoka, Benton, Blue Earth, Carlton, Carver, Chisago, Cook, Crow Wing, Dakota, Dodge, Goodhue, Hennepin, Isanti, Itasca, Kanabec, Lake, Le Sueur, McLeod, Meeker, Mille Lacs, Morrison, Nicollet, Olmsted, Pine, Ramsey, Rice, St. Louis, Scott, Sherburne, Sibley, Steams, Steele, Wabasha, Waseca, Washington, and Wright. The Wisconsin counties include: Barron, Bayfield, Burnett, Douglas, Pierce, Polk, St. Croix, and Washburn. Figure 3-1 shows the counties that constitute NLX the study area.

Figure 3-1: Counties within NLX Study Area



The Bureau of Economic Analysis' (BEA) Regional Input-Output Modeling System (RIMS II) multipliers were used to estimate employment and earnings impacts for the above-listed counties comprising the NLX study area. RIMS II is a regional modeling system that is used to estimate the economic impact of an event, construction project, or other change in a local economy. RIMS II provides regional input-output multipliers that consider interindustry economic relationships within regions and estimate how regional economies are likely to respond to project-related changes.[1]

3.2. Economic Effects

Implementation of the NLX service would support the regional economy through its construction and its operation. This section estimates the anticipated construction and operation effects of implementing NLX Scenario C-1. Construction and operating impacts were assessed in terms of jobs and earnings.

3.2.1. Construction Effects

The capital costs are applied over a 36-month construction period estimated to begin in June 2017 and end in December 2019. Construction costs are spent as follows: 20% in 2017, 50% in 2018, and 30% in 2019. The costs for Scenario C-1 are shown in Table 3-1 below.

Table 3-1: Capital Costs Scenario C-1, in $2014M

	Total	Discounted at 7%	Discounted at 3%
Scenario C-1	$561.57	$455.83	$512.51

Table Source: AECOM

Construction Jobs

Construction of the infrastructure investments needed to accommodate NLX service represents significant capital investment in the study area economy. Construction spending would increase employment in the study area for the duration of the construction period.

[1] Bureau of Economic Analysis

Table 3- shows the employment multipliers used in the analysis to estimate the impact on employment in the study area. The Construction and the Professional/scientific/technical services industries are anticipated to be the two industries that would be impacted by implementation of the NLX service.

Table 3-2: Study Area Employment Multipliers

	Final Demand Employment Multiplier	Direct Effect Employment Multiplier
Construction	19.7397	2.0787
Professional, scientific, and technical services	18.4883	2.1372

Table Source: BEA

The Final Demand Employment Multiplier represents the total change in number of jobs that occurs in all industries for each $1 million of output (in 2010 dollars) resulting from the implementation of the NLX service by the construction industry. Based on the multipliers in

Table 3-, every $1 million in construction goods and services spent to implement the NLX in the study area (in 2010 dollars) yields 19.7397 jobs in all industries for the study area.

The Direct Effect Employment Multiplier represents the total change in number of jobs in all industries for each additional job in the construction industry as a result of implementing the NLX service. Based on the multipliers in

Table 3-, every study area job in the construction industry generates 2.0787 jobs in all industries for the study area.

Applying the Final Demand Employment Multipliers for the construction industry to the construction capital expenditures deflated to 2010 dollars provides estimates of the net total employment and earnings impacts generated by implementation of the NLX service in the study area. To estimate the direct employment impacts, the ratio of the Final Demand Employment Multiplier to the Direct Effect Employment Multiplier is applied to the construction capital expenditures deflated to 2010 dollars.

In order to isolate the potential economic effects of the NLX service to the study area's regional economy, it is necessary to distinguish those resources that are new to the economy and that would not be invested in study area counties but for the project. Only those impacts from new funding sources would create new employment in the study area. Federal and state funding is anticipated.

The results are summarized for Scenario C-1 in

Table . The employment effects are expressed in job-years, which is defined as one full-time job for one person for one year. For example, three job-years are equal to three people doing a job for one year, or one person doing a job for three years. Direct employment represents the number of job-years created directly by the construction and professional services industries as a result of implementing the NLX service. Indirect employment represents the number of job-years that are created or supported in industries from construction employee spending in the region.

Table 3-3: Employment Impacts in Job-Years for Scenario C-1

	Direct Employment	Indirect Employment	Total Employment
Scenario C-1	4,453	4,834	9,287

Table Source: AECOM

To put these results into context, Scenario C-1 would result in an average of 3,096 total jobs per year assuming a 3-year construction period. Compared to the typical Walmart that employs 250 people, construction of Scenario C-1 is like hiring employees for more than 12 new Walmart locations in the study area every year.

3.2.1.1. Construction Earning

Construction spending would increase earnings in the study area for the duration of the construction period. This section describes the anticipated total earnings impacts based on the RIMS II multiplier analysis. Table shows the earnings multipliers used in the analysis to estimate the impact on earnings in the study area. The Construction and the Professional/scientific/technical services industries are anticipated to be the two industries that would be impacted by implementation of the NLX service.

The Final Demand Earnings Multiplier represents the total dollar change in earnings of households employed in all industries for each additional dollar of output resulting from the implementation of the NLX service by the construction industry. Based on the multipliers in

Table 3-, every $1 in construction goods and services spent to implement the NLX in the study area yields $0.7785 of earnings for households employed in all industries in the study area.

Table 3-4: Study Area Earnings Multipliers

	Final Demand Earnings Multiplier
Construction	0.7785
Professional, scientific, and technical services	0.8108

Table Source: BEA

The earnings for Scenario C-1 are shown in Table 3-5.

Table 3-5: Construction Earnings Impacts for Scenario C-1, in $2014M

	Total Earnings
Scenario C-1	$390.63

Table Source: AECOM

To put these results into context, Scenario C-1 would result in average earnings of $42,061 per total job-years for households employed in all industries in the study area.

3.2.2. Rail Sector Employment Effects

Operating and maintaining the NLX service would expand rail sector payrolls in each year that the project is operated. The operating and maintenance hiring associated with the project represents the direct effects of the project in the region. The earnings of these newly-hired rail sector employees would translate into a proportional increase in consumer demand as these workers purchase goods and services in the region. A further increase of new employment across a variety of industrial sectors and occupational categories is expected as employers hire to meet this increase in local consumer demand. The latter hiring represents the project's indirect and induced impact.

This section describes the anticipated operating and maintenance effects of the NLX project. The changes in operating and maintenance (O&M) costs would result in changes in jobs and associated earnings within the rail sector for each of the scenarios. The proposed services for each scenario would increase the expenditures for ongoing rail labor and non-labor O&M expenses in the region.

3.2.2.1. O&M Jobs

Annual O&M spending will increase the employment in the region as long as the NLX service is operated. Employment impacts are long-term annual impacts that would continue for the life of the service. This section describes the anticipated direct and total employment impacts resulting from the implementation of NLX service.

Table shows the employment multipliers used in the analysis to estimate the impact on earnings in the study area. The petroleum/coal products manufacturing and the transit/ground passenger transportation industries are anticipated to be the two industries that would be impacted by implementation of the NLX service.

Table 3-6: Study Area Employment Multipliers

	Final Demand Employment Multiplier	Direct Effect Employment Multiplier
Petroleum and coal products manufacturing	4.5837	2.5317
Transit and ground passenger transportation	28.3519	1.4148

Table Source: BEA

The Final Demand Employment Multiplier represents the total change in number of jobs that occurs in all industries for each $1 million of output (in 2010 dollars) resulting from the operation and maintenance of the NLX service. Based on the multipliers in

Table 3-, every $1 million in goods and services spent to operate and maintain the NLX in the study area (in 2010 dollars) yields 28.3519 jobs in all industries for the study area.

The Direct Effect Employment Multiplier represents the total change in number of jobs in all industries for each additional job in the petroleum/coal products manufacturing and transit/ground passenger transportation industries as a result of operating and maintaining the NLX service. Based on the multipliers in

Table 3-, every study area job in the petroleum/coal products manufacturing and transit/ground passenger transportation industries generates 1.4148 jobs in all industries for the study area.

The O&M costs were broken-down into line items that allowed the RIMS II multipliers to be more appropriately applied to specific industries. For most line items, Transit and Ground Passenger Transportation was the most appropriate industry category; however, fuel used the Petroleum and Coal Products Manufacturing industry multiplier.

The employment effects are expressed in job-years or one job for one person for one year. This analysis assumes that funding for O&M would be procured from federal and local government funds as well as project-generated funds. Although some of these expenses would originate from local sources, this represents spending that would not take place but for the implementation of the NLX service. The expansion of rail passenger service represents an expansion of economic activity in the study area and thus generates recurring net economic impacts (long-term).

The O&M employment impact for Scenario C-1 are shown in Table 3-7.

Table 3-7: Total O&M Employment in Job-Years

	Direct Employment	Indirect Employment	Total Employment
Scenario C-1	12,347	5,370	17,718

Table Source: AECOM

To put these results into context, Scenario C-1 would result in 17,718 total job-years over the 40-year analysis period, or an average of 443 jobs per year. Compared to the typical Walmart that employs 250 people, the operation and maintenance of the NLX service under Scenario C-1 is like hiring employees for nearly 2 new Walmart locations in the study area.

3.2.2.2. <u>O&M Earnings</u>

The annual operation and maintenance of the NLX service would increase employee earnings in the study area as long as the service is in operation. These impacts are long-term annual impacts that would continue for the life of the service. This section describes the anticipated total earnings impacts based on the RIMS II multiplier analysis.

Table shows the earnings multipliers used in the analysis to estimate the impact on earnings related to the operation and maintenance of the NLX service in the study area. The petroleum/coal products manufacturing and transit/ground passenger transportation industries are anticipated to be the two industries that would be impacted by operation and maintenance of the NLX service.

The Final Demand Earnings Multiplier represents the total dollar change in earnings of households employed in all industries for each additional dollar of output resulting from the operation and maintenance of the NLX service. Based on the multipliers in

Table 3-, every $1 in goods and services spent to operate and maintain the NLX in the study area yields $0.7826 of earnings for households employed in all industries in the study area.

Table 3-8: Study Area Earnings Multipliers

	Final Demand Earnings
Petroleum and coal products manufacturing	0.2595
Transit and ground passenger transportation	0.7826

Table Source: BEA

The earnings for Scenario C-1 are shown in Table 3-9.

Table 3-9: O&M Earnings Impacts for Scenario C-1, in $2014M

	Total Earnings
Scenario C-1	$541.53

Table Source: AECOM

3.2.3. Tourism Effects

Amtrak conducts surveys of its riders to better understand the rail travel market. As a result of these surveys, a State Economic Impact Brochure is produced for each state in which Amtrak operates. Amtrak reports the number of riders who would not have made the trip but for the availability of Amtrak's rail service. Assuming that rail travelers are indifferent to the operator of the train, this information combined with NLX's ridership data offers a means to identify those travelers who would not have traveled but for the availability of the service. Using spending multipliers for the tourism industry, the local economic impact of these visitors can be assessed. To the degree that these travelers are Minnesota residents, this is largely not a net new gain to the state. It does, however, describe an infusion of economic activity into the local host economies for these rail travelers.

The types of tourism impacts considered and their definition include:

- Sales revenues – estimated spending by travelers who would not have otherwise taken the trip, based on Amtrak tourism in the region, NLX ridership, and average spending per business and leisure traveler
- Sales taxes on revenues – based on state sales taxes
- Tourism employment – multiplier effect based on traveler spending
- Tourism earnings – multiplier effect based on traveler spending

Table 3-10 summarizes the tourism impacts over a 40 year period for Scenario C-1.

Table 3-10: Total Impacts from Tourism (40 years) for Scenario C-1

Scenario C-1	Total Tourism Impacts, Undiscounted $2014
Revenue (total)	$377.79 M
Earnings (total)	$232.72
Employment (total job-years)	10,635

3.2.4. Tax (Fiscal) Effects

The earnings and spending associated with construction and operation and maintenance of the NLX service, as well as the increase in property values in the station areas will increase income, retail sales, and property tax base in the study area. State tax rates for income and retail sales, combined with local property tax rates were applied to estimate the fiscal return to the state of economic activity associated with the NLX project.

The types of fiscal impacts considered and their definition include:

- Income taxes on earnings – using the effective tax rate of 5.89% based on 2012 income tax and total wages and salaries in Minnesota from the Department of Revenue (income tax yield) and Bureau of Economic Analysis (wages and salaries)
- Sales taxes on earnings – based on the Consumer Expenditure Survey share of spending in Minneapolis that is sales tax eligible and the state sales tax rate
- Sales taxes on construction goods – assumes 50% of construction purchases in categories 10, 20, 30, 40, 50, 50, and 90 are for goods in-state (MN); assumes the other 50% represents labor and out-of-state purchases
- Property taxes – local property taxes on the increased value of property due to the property premium effect

The total undiscounted tax impacts for Scenario C-1 over the 40-year analysis period are shown in Table 3-11 and the first year of undiscounted impacts are shown in Table 3-12.

Table 3-11: Total Tax Impacts (40 years), Undiscounted for Scenario C-1

Scenario C-1	Income Tax Impacts (40 Years), Undiscounted $2014	Sales Tax Impacts (40 Years), Undiscounted $2014	Property Tax Impacts (40 Years), Undiscounted $2014	Total Tax Impacts (40 Years), Undiscounted $2014
Construction Purchases (total)	N/A	$14.92	N/A	$14.92[1]
Construction Earnings (total)	$23.00	$6.81	N/A	$29.82[2]
O&M Earnings (total)	$31.89	$9.44	N/A	$41.33[3]
Property Premium (total)	N/A	N/A	$225.41	$225.41[4]
Tourism Revenues (total)	$13.70	$30.03	N/A	$43.74
Total Tax Impacts	**$68.60**	**$61.21**	**$225.41**	**$355.22**

(1) assumes 50% of purchases are taxable, only includes state sales tax

(2) effective tax rate based on 2012 state income tax and sales tax revenues

(3) effective tax rate based on 2012 state income tax and sales tax revenues

(4) assumes 40 years of constant premium and property taxes

Table 3-12: Tax Impacts in the First Year, Undiscounted for Scenario C-1

Scenario C-1	Income Tax Impacts (40 Years), Undiscounted $2014	Sales Tax Impacts (40 Years), Undiscounted $2014	Property Tax Impacts (40 Years), Undiscounted $2014	Total Tax Impacts (40 Years), Undiscounted $2014
Construction Purchases (2017)	N/A	$2.98	N/A	$2.98[1]
Construction Earnings (2017)	$4.60	$1.36	N/A	$5.96[2]
O&M Earnings (2020)	$0.64	$0.19	N/A	$0.82[3]
Property Premium (2020)	N/A	N/A	$5.64	$5.64[4]
Tourism Revenues (2020)	$0.26	$0.57	N/A	$0.83
Total Tax Impacts	**$5.49**	**$5.10**	**$5.64**	**$16.23**

(1) assumes 50% of purchases are taxable, only includes state sales tax

(2) effective tax rate based on 2012 state income tax and sales tax revenues

(3) effective tax rate based on 2012 state income tax and sales tax revenues

In total, the discounted tax impacts for NLX would cover 25% of the discounted capital costs of constructing the project at a 7% discount rate, or 39% at a 3% discount rate. Table 3-13 compares the tax impacts to the construction impacts.

Table 3-13: Summary of Tax Impacts Compared to Construction Costs for Scenario C-1

Scenario C-1	7% Discount Rate	3% Discount Rate
Total Discounted Tax Impacts	$113.45	$198.49
Total Discounted Construction Impacts	$455.83	$512.51
Share of Construction Covered by Tax Impacts	25%	39%

Preliminary Benefit Cost Analysis

QUANDEL CONSULTANTS, LLC
161 N. Clark St., Suite 2060
Chicago, IL 60601
Main 312.634.6200 | **Direct** 312.634.6201
cquandel@quandel.com
quandelconsultants.com

Northern Lights Express

Technical Memorandum #25

To:	**Francis Loetterle, Project Manager**
	Minnesota Department of Transportation (MnDOT)
Subject:	**Preliminary Benefit Cost Analysis**
Prepared By:	**Quandel Consultants, LLC**
Date:	**December 3, 2015**

Purpose of Technical Memorandum

As part of the analysis of Service Alternatives for the NLX project, a Benefit Cost Analysis (BCA) was undertaken by PMO subconsultant AECOM in order to provide quantifiable benefits and costs that result from the construction and operation of the NLX service. The purpose of the BCA was to evaluate five service alternatives considering capital and operating costs and benefits related to travel cost savings; safety improvements and emissions savings for automobile travelers; operating cost savings, emissions savings and inventory savings for freight rail; grade crossing improvements; and economic development.

The analysis was completed by AECOM in September 2015, and the results of the BCA were provided to MnDOT in order to aid in the identification of the Preferred Service Alternative. The purpose of this memorandum is to document the methodology used to conduct the BCA and summarize the results of the BCA. The BCA data and text presented in this memorandum were provided by AECOM in several documents; this memorandum combines the BCA into one summary document to provide one source for benefits and costs.

The benefits and costs were computed using train schedules, capital and operating cost data, and ridership and revenue forecasts that were current as of September 2015. The results of the BCA included herein are based on September 2015 data. The Benefit Cost Ratios (BCR) were computed for the five Service Alternatives. Scenario C-1 (4 round trips at 90 MPH maximum speed) had the highest BCR of all the Alternatives with a BCR of 1.65 discounted at 3% and 1.26 discounted at 7%.

Based on this analysis, MnDOT advanced Scenario C-1 into the Tier 2 Environmental Assessment for further analysis. The BCA for Scenario C-1 will be updated for final train schedules, capital costs, and operating costs. BCA results will be presented in a future Final Benefit Cost Analysis Technical Memorandum.

1. Introduction

The Northern Lights Express (NLX) project would re-introduce passenger rail service between the cities of Minneapolis and Duluth, MN. Amtrak's service in the corridor ended in 1985. The corridor is currently owned and operated by the BNSF Railway. Six stations are planned, including Target Field in Minneapolis, Coon Rapids, Cambridge, Hinckley, Superior (Wisconsin), and Union Depot in Duluth. A maintenance facility is planned for either Sandstone or Duluth. A map of the proposed alignment is shown in Figure 1-1.

MnDOT developed numerous Service Alternatives that included maximum operating speeds that varied from 79 mph to 110 mph, daily round trip frequencies from 2 to 8 round trips per day and operating strategies including express service and short turns. Five Service Alternatives were advanced to the Benefit-Cost Analysis after a screening process that included capital and operating cost estimates, ridership forecasts, revenue estimates and preliminary review of environmental impact. The five Service Alternatives are briefly defined in Table 1-1.

Table 1-1: Scenario Assumptions

	Round Trips per Day	Maximum Operating Speed (mph)
Scenario B-1	4	110
Scenario C-1	4	90
Scenario C-2	6	90
Scenario C-10	2	90
Scenario C-11	8	90

Source: Quandel Consultants

Figure 1-1: NLX Corridor Map

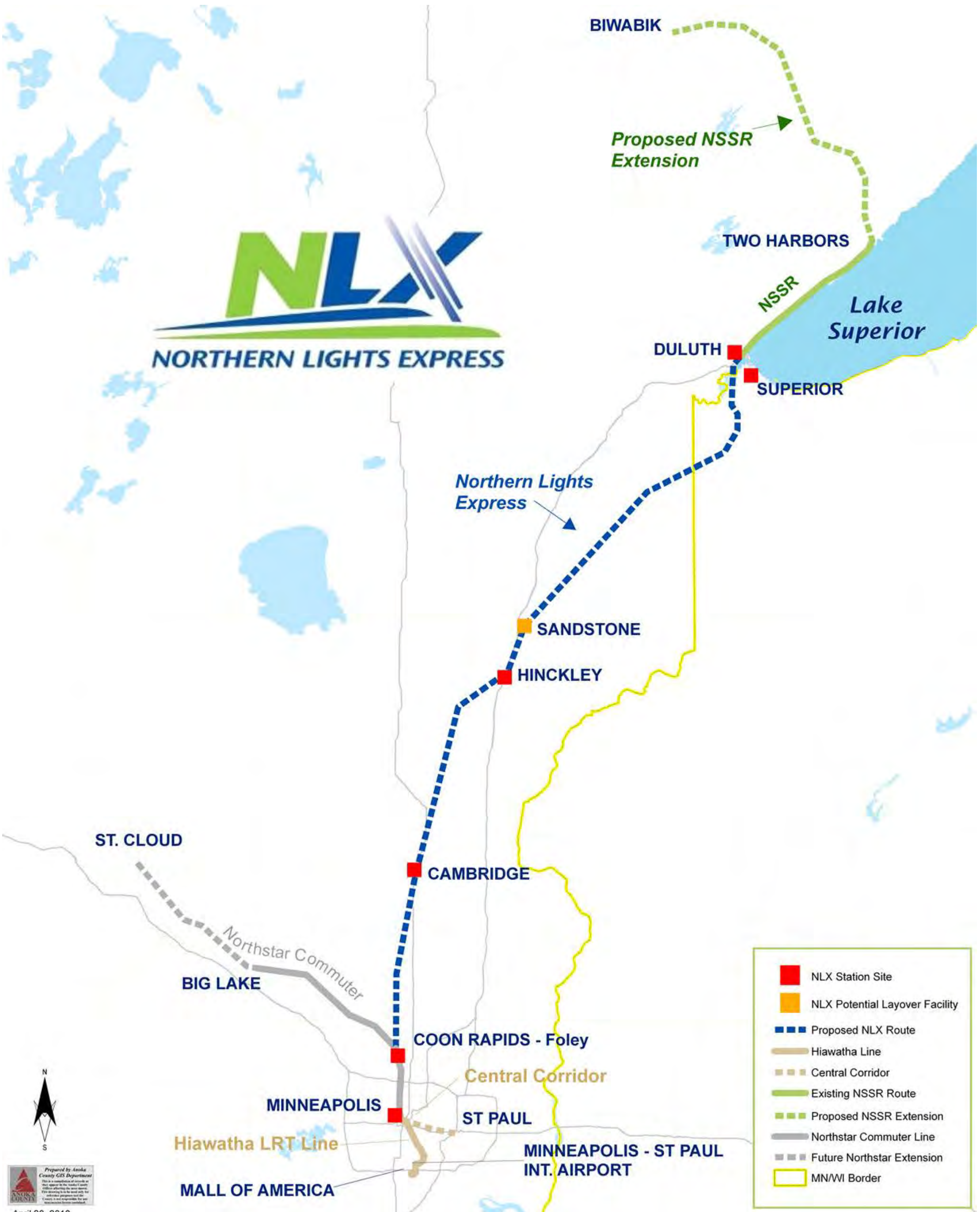


Figure Source: NorthernLightsExpress.org

Implementation of the NLX service between Minneapolis, MN and Duluth, MN would provide a new transportation alternative for business travelers, commuters, tourists, and other corridor users. The benefits resulting from the implementation of NLX service would be shared by those who use the rail system and those who remain on the corridor's road system. The availability of rail would allow current auto travelers to shift from cars, thereby reducing the harmful impacts of emissions, the injuries and fatalities associated with crashes, vehicle operating costs, and pavement maintenance. Rail passengers may experience productivity increases as a result of using the train instead of driving for business trips. In addition, the project would improve freight operations on the shared corridor by upgrading sidings and track, which saves BNSF and their customers' time and money.

Travelers who remain on the corridor's roads would also benefit through a reduction in congestion in the MN 65 and I-35 corridors and through greater safety and reduced delays at grade crossings. New station accessibility would result in properties within a ½-mile radius becoming more valuable, and the upgrade of existing at-grade crossings would result in fewer train-vehicle conflicts. Together, these benefits demonstrate that the project would have long-term quantifiable value to the region's residents, tourists, users, and non-users.

The analysis described in this memorandum results in the quantification of benefits and costs of implementing NLX service for the five Service Alternatives evaluated within this memorandum.

2. Benefit Cost Analysis

Impacts that "expand the pie" by increasing efficiency, avoiding costs, or enhancing productivity are net benefits that are included in the BCA. The BCA is used to determine whether a project yields a positive return on investment and thus focuses on the net changes attributable to the project. The results of the BCA provide MnDOT with information on how each scenario would affect rail operations and the overall system.

A BCA is a ratio that compares the sum of a project's benefits to the cost of constructing and operating the project. Typically, a BCA ratio of 1.0 says that the benefits and costs are equal over the analysis period, and a BCA ratio over 1.0 shows that there are more quantifiable benefits than costs for the project. Alternately, a BCA ratio of less than 1.0 may indicate that there are not enough benefits to outweigh the costs, or that all of the benefits are not quantifiable. The difference between a BCA of 0.99 and 1.01 does not amount to a meaningful difference and could amount to nothing more than rounding error in the long term. Given the risks associated with forecasting costs and benefits, a successful project or program generally has a BCA ratio well over 1.0. The greater the ratio is over 1.0, the more downside risk the project or program can absorb. Best practice dictates that qualitative benefits should also be considered when comparing project alternatives.

The BCA is used to estimate the ratio of an alternative's costs to the benefits associated with the improvements. The balance of this discussion describes the assumptions and methods used to develop the BCA and the long-term benefits generated by the scenarios. The stream of anticipated benefits and costs for the alternative capital investments have been estimated over a 40-year analysis horizon, starting the first full year each alternative is in operation (2020).

The benefit stream estimated as part of the BCA is converted to present values using real discount rates of 7% and 3% and is then compared to the similarly discounted project capital and operating costs.

Discounting is important because a dollar 10 years from now is not worth the same as a dollar today. The dollar today could be invested and return more than a dollar 10 years from now (excluding inflationary impacts). As a result, costs and benefits that are experienced today are more valuable than the costs and benefits expected in 10 years. Projects expecting to use federal funding are required to use a 7% discount rate (in real dollars, in this analysis 2014 dollars); however, given the interest rates of the last few years, the results are also shown with a 3% discount rate. All benefits are estimated in accordance with guidance provided by the US Department of Transportation (US DOT) for benefit cost analysis. If no US DOT guidance were available, the project team consulted industry research for the best practice and information on which to base the assumptions and methodology.

Each Service Alternative's benefits are summed and then divided by its associated costs to yield the BCA ratio.

2.1. Costs

The project has four elements that contribute to the cost side of the benefit cost equation: capital costs to construct the project, operating and maintenance costs (O&M) to run the services and maintain facilities, cyclic capital costs to annually support structural improvements on the track and platforms and purchase equipment, and the operating cost offset of fare revenues. The four elements are described in greater detail in the following sections.

2.1.1. Capital Costs

The capital costs are applied over a 30-month construction period estimated to begin in June 2017 and end in December 2019. Construction costs are spent as follows: 20% in 2017, 50% in 2018, and 30% in 2019. The costs for the Service Alternatives are shown in Table 2-1 below.

Table 2-1: Capital Costs, in $2014M

	Total	Discounted at 7%	Discounted at 3%
Scenario B-1	$648.58	$526.46	$591.92
Scenario C-1	$561.57	$455.83	$512.51
Scenario C-2	$632.67	$513.54	$577.40
Scenario C-10	$535.20	$434.42	$488.44
Scenario C-11	$880.50	$714.71	$803.58

Table Source: AECOM

2.1.2. O&M Costs

The NLX service requires annual and periodic O&M costs to keep the track, stations, and service operating efficiently. The discounted O&M costs of the Service Alternatives over the 40-year study period are shown in Table 2-2.

Table 2-2: O&M Costs over the 40-Year Study Period, in $2014M

	Total	Discounted at 7%	Discounted at 3%
Scenario B-1	$988.52	$237.96	$494.70
Scenario C-1	$779.99	$188.23	$390.89
Scenario C-2	$1,028.39	$245.74	$513.00
Scenario C-10	$479.64	$118.27	$242.80
Scenario C-11	$1,326.54	$314.73	$659.23

Table Source: AECOM

2.1.3. Cyclic Capital Costs

In addition to annual O&M costs, annual cyclic capital costs that are expended as part of the project maintenance. The cyclic capital costs include maintenance costs for rail replacement, tie renewal, surfacing, ballast replacement, and platform extension costs, as well as periodic equipment purchases. The cyclic capital costs are distributed annually, with equipment procurement occurring every five to 10 years, depending on the operating scenario. The cyclic capital costs for the Service Alternatives over the 40-year study period are shown in Table 2-3.

Table 2-3: Cyclic Capital Costs over the 40-Year Study Period, in $2014M

	Total	Discounted at 7%	Discounted at 3%
Scenario B-1	$183.00	$45.25	$93.02
Scenario C-1	$145.76	$37.36	$75.18
Scenario C-2	$184.36	$43.33	$91.62
Scenario C-10	$99.21	$25.13	$50.86
Scenario C-11	$208.23	$49.52	$104.25

Table Source: AECOM

2.1.4. Operating Cost Offset: Fare Revenue

The operation of the service will result in fare revenues,[1] and the revenue earned by the ticket sales is an offset to the capital and operating costs. The discounted revenues for the Service Alternatives are shown in Table 2-4 for the 40-year study period.

Table 2-4: Fare Revenues over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 7%	Discounted at 3%
Scenario B-1	$634.52	$144.76	$309.63
Scenario C-1	$584.17	$133.05	$284.84
Scenario C-2	$640.75	$145.94	$312.43
Scenario C-10	$327.66	$77.63	$162.72
Scenario C-11	$678.21	$154.36	$330.59

Table Source: AECOM

2.2. Benefits

The following sections outline the benefits assessed for the NLX Service Alternatives. The benefits are discussed according to Transportation Investment Generating Economic Recovery (TIGER) Grant benefit categories: Safety, State of Good Repair, Environmental Sustainability, Economic Competitiveness, and Quality of Life. In addition to the five TIGER benefit categories, the analysis used FRA's GradeDec tool to estimate the benefits to safety improvements at grade crossings. The GradeDec tool estimates four benefits that are included in TIGER categories (reduced crashes at grade crossings, and emissions, travel time, and vehicle cost impacts at grade crossings), but are discussed in a separate section as they are common to the GradeDec tool methodology.

2.2.1. Safety Benefits

Implementing NLX service would provide an opportunity for diversions from auto to rail, resulting in the reduced likelihood of being in a crash for those travelers choosing rail transportation over auto travel. In addition, the project would construct warning devices at rail grade crossings and improve safety for drivers at those intersections. The safety benefit for diverted drivers is discussed in the next section and the estimated safety benefit for at-grade crossings is discussed in the Grade Crossing Impacts section.

The analysis does not estimate the effects on safety for diversions from air because that mode would continue to provide service between the NLX termini even if some commuters divert to NLX from air. Therefore, that mode will continue to contribute to the number of crashes regardless of whether ridership

[1] Fare revenues include Ancillary Revenues

decreases. The analysis is unable to predict if there would be a reduction in the number of routes or the frequency for air travel if load factors were to fall below a certain criteria. As a result, changes to safety are estimated only for passengers who divert from auto to rail.

2.2.1.1. Reduced Highway Fatalities and Crashes

Passenger rail provides an alternative to using highway corridors parallel to the rail route and improves safety for travelers who divert from auto travel while increasing the accessibility for the region's populations to jobs, education, and recreational opportunities. Better access to rail would result in auto Vehicle Miles Traveled (VMT) saved with passenger rail users no longer using autos. This reduces the likelihood of crashes and associated deaths, injuries, and property damage as travelers continue to use the new and expanded passenger rail services.

The rates of crashes that result in fatalities, injuries, and property damage only are applied to the VMT diverted to derive the estimated crashes avoided from drivers switching from autos to rail service. To ensure consistency between the types of accidents, the crash rates for fatalities, injuries, and property damage only are the national average crash rates. These crash rates are shown in Table 2-5.

Table 2-5: Accidents by Type per 100,000,000 VMT

	Rate	
Fatalities	1.0949	per 100,000,000 VMT
Injured persons	77.3961	per 100,000,000 VMT
Crashes	190.2989	per 100,000,000 VMT

Table Source: 2013 BTS Motor Vehicle Safety Data Table 2-17, http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/index.html#chapter_2

These crash reduction factors were converted to the Maximum Abbreviated Injury Score (MAIS) accident types in order to apply US DOT Guidance on the value of avoiding an accident. The conversion is based on the National Highway Safety and Traffic Administration (NHTSA) KABCO-AIS Conversion Table (July 2011) provided on page 13 of the TIGER Benefit-Cost Analysis Resource Guide (USDOT 2015)[2], for Injury (severity unknown), and No Injury accidents. KABCO refers to the letters used to designate five levels of crash severity used by police at a crash scene; AIS refers to the Abbreviated Injury Scale used by hospitals. These factors provide the probability that an injury will range from critical to minor to more accurately capture the total number of different types of injuries associated with the diverted VMT. Estimating the distribution of expected injury types is important because each type of injury has a different associated economic cost.

[2] TIGER Benefit-Cost Analysis Resource Guide (updated April 2, 2015), http://www.dot.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf

The total annual value for accident severity is based on USDOT guidance and the National Highway Safety Council estimates for the value of avoiding an accident. These estimates are applied to the number of crashes avoided to estimate the total value of accidents avoided from auto VMT diverted to passenger rail. Table 2-6 provides the estimated cost of different types of crashes.

Table 2-6: Value of Accidents Avoided, in $2014M

	2014$ Millions
Value of Statistical Life, 2013	$9.27
MAIS 5 Critical (0.593) Fraction of VSL	$5.50
MAIS 4 Severe (0.266) Fraction of VSL	$2.47
MAIS 3 Serious (0.105) Fraction of VSL	$0.97
MAIS 2 Moderate (0.047) Fraction of VSL	$0.44
MAIS 1 Minor (0.003) Fraction of VSL	$0.03
No Injury, 2010	$0.004

Table Source: 2015 OST Guidance, see http://www.transportation.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf

Based on the above rates, which increase by 1.18% per year per guidance,[3] the value of safety incidents avoided due to a diversion of auto VMT to NLX rail service is estimated for the entire study area. Table 2-7 shows the total reduction in highway fatalities and crashes for each Service Alternative for the 40-year study period.

[3] Source: U.S. Department of Transportation. Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in U.S. Department of Transportation Analyses – 2014 Adjustment from https://www.transportation.gov/sites/dot.gov/files/docs/VSL_Guidance_2014.pdf

Table 2-7: Value of Reduced Highway Fatalities and Crashes over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 7%	Discounted at 3%
Scenario B-1	$381.86	$77.91	$176.95
Scenario C-1	$344.72	$70.23	$159.65
Scenario C-2	$375.62	$76.58	$174.01
Scenario C-10	$193.91	$40.50	$90.72
Scenario C-11	$393.52	$80.24	$182.31

Table Source: AECOM

2.2.1.2. Reduced Crashes at Grade Crossings

Please refer to Section 2.2.6 for information on how safety improves at rail grade crossings.

2.2.2. State of Good Repair

Implementing NLX service would provide the opportunity for infrastructure assets to be maintained in a better state of condition. The operation of NLX would attract drivers away from the highways, thereby reducing marginal pavement maintenance costs to the state. In addition, the construction of NLX would upgrade rail and highway facilities that the private rail operator BNSF will not have to construct themselves, and likewise highway infrastructure improvements that the state can avoid.

2.2.2.1 Pavement Savings

The reduction in VMT associated with the diversion of auto travelers to rail with the NLX service reduces the wear and tear on the pavement for regional urban interstates, and as such, reduces the marginal cost of maintaining the pavement. It is assumed that all diverted VMT are removed from I-35 and only reduce VMT for autos traveling on urban pavement.

The FHWA Cost Allocation Study, 2000 Addendum[4] estimates the marginal pavement costs per VMT to be $0.001 cents ($2000) or $0.001 cents ($2014) for autos on urban Interstates. Table 2-8 summarizes the discounted pavement savings associated with each Service Alternative for the 40-year study period.

[4] US DOT, Addendum to the 1997 Federal Highway Cost Allocation Study Final Report, May 2000, accessed at: http://www.fhwa.dot.gov/policy/hcas/addendum.cfm

Table 2-8: Pavement Savings over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 7%	Discounted at 3%
Scenario B-1	$0.14	$0.03	$0.07
Scenario C-1	$0.12	$0.03	$0.06
Scenario C-2	$0.13	$0.03	$0.06
Scenario C-10	$0.07	$0.02	$0.03
Scenario C-11	$0.14	$0.03	$0.07

Table Source: AECOM

2.2.2.2 Freight Costs Avoided

Since the NLX Service is proposed to operate on an existing freight rail corridor owned by BNSF, infrastructure improvements have been identified to accommodate the proposed NLX Service and avoid unduly impairing freight service. Because the improvements will be constructed as part of the NLX project, BNSF will avoid having to construct the improvements themselves. In benefit cost analysis, the elimination of a future cost anticipated under the status quo through implementation of the project being assessed is a valid benefit (a future savings). The analysis has to be reasonably certain that the future cost would be incurred—in this case that growth in freight traffic would require future capacity expansions elsewhere in the network. If the investments made for NLX open up capacity or operational flexibility that allow BNSF to avoid making capacity or performance investments elsewhere in the system and still serve the same projected level of shippers, this is a savings and can be counted as a benefit. The benefit comes through the way in which the freight traffic problem is solved.

However, expenditures on freight-related assets are not automatically costs avoided. For example, if NLX purchases a rail asset that BNSF would otherwise have needed to purchase, this is a transfer, but not a benefit. In this instance, the rail freight traffic problem is solved in the same way, it is just a difference in who pays.

The costs are assumed to be avoided over the three year construction period, between 2017 and 2019. The freight investments avoided by Service Alternative are shown in Table 2-9 for the 40-year study period.

Table 2-9: Freight Investments Avoided over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 7%	Discounted at 3%
Scenario B-1	$293.36	$239.83	$268.54
Scenario C-1	$248.60	$203.24	$227.57
Scenario C-2	$308.52	$252.23	$282.42
Scenario C-10	$239.05	$195.43	$218.82
Scenario C-11	$378.28	$309.26	$346.28

Table Source: AECOM

2.2.2.3 Highway Costs Avoided

NLX Service is proposed to operate at a maximum of either 90 MPH or 110 MPH in the existing freight corridor. Upgrades to approach slopes at humped rail grade crossings and grade crossing warning device upgrades are proposed to ensure the safe movement of trains, vehicles, and pedestrians at the grade crossings where NLX trains will travel at higher speeds than are currently in operation. Some upgrades will be made to the highway outside of the railroad right-of-way. The costs are assumed to be avoided equally over three years coinciding with the construction period, 2017-2019. The highway investments avoided by scenario are shown in Table 2-10 for the 40-year study period.

Table 2-10: Highway Investments Avoided over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 7%	Discounted at 3%
Scenario B-1	$31.15	$25.47	$28.52
Scenario C-1	$31.15	$25.47	$28.52
Scenario C-2	$31.15	$25.47	$28.52
Scenario C-10	$31.15	$25.47	$28.52
Scenario C-11	$31.15	$25.47	$28.52

Table Source: AECOM

2.2.3. Environmental Sustainability

Environmental sustainability measures the change in auto and train emissions due to the NLX Project. This analysis considers the reduction in emissions due to drivers diverting to rail, the reduction in emissions due to more efficient freight rail operations, and the increase in emissions due to new NLX trains in the corridor. In total, the project results in a net benefit to the public by reducing the total emissions in the region.

2.2.3.1 Auto Emissions Savings

The NLX would provide an opportunity for riders to divert current or future auto trips to rail thereby reducing auto VMT and emissions in the region. Auto emission rate outputs MOVES 2010a for carbon monoxide (CO), nitrogen oxide (NOx), particulate matter (PM), sulfur dioxide (SO2), volatile organic compounds (VOCs), and carbon dioxide (CO2), are applied to the annual auto VMT avoided to estimate the pollutant emissions avoided. Table 2-11 displays the auto emission rates applied. The 2015 factors were applied until 2025, 2025 rates were applied until 2035, and the 2035 rates were used through the end of the analysis period.

Table 2-11: Auto Emissions Factors (g/VMT)

Year	CO	NOX	PM2.5	PM10	SO2	VOC	CO2
2015	16.77	0.91	0.01	0.16	0.0057	0.6	532
2025	11.46	0.28	0.01	0.1	0.0055	0.27	434
2035	10.26	0.2	0.01	0.05	0.0053	0.21	397

Table Source: MOVES 2010a[5]

The emission rates in grams per mile are multiplied by the appropriate conversion factors to calculate short tons per mile for each pollutant type, except CO2 which is in metric tons per mile. The tons of emissions avoided per VMT are then multiplied by the annual VMT avoided. The resulting tons were multiplied by the economic value of the emissions damage cost from National Highway Safety Administration (NHTSA) guidance[6] as shown in Table 2-12.

[5] Source: MOVES 2010a Accessed at http://www.fta.dot.gov/documents/NS-SS_Final_PolicyGuidance_August_2013.pdf

[6] *NHTSA, Corporate Average Fuel Economy for MY2017-MY2025 Passenger Cars and Light Trucks (August 2012), http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/FRIA_2017-2025.pdf*

Table 2-1: Value of Emissions Avoided, in 2014 Dollars

	2014$	Unit
Carbon Monoxide	$0	$/short ton
Volatile Organic Compounds	$1,841	$/short ton
Nitrogen Oxides	$7,256	$/short ton
Particulate Matter	$331,910	$/short ton
Sulfur Dioxide	$42,883	$/short ton
Carbon Dioxide	*varies*	$/metric ton

Table Source: Sources: Corporate Average Fuel Economy for MY2017-MY2025 Passenger Cars and Light Trucks (August 2012) and Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (May 2013; revised November 2013)
Note: USDOT TIGER 2015 BCA Resource Guide escalated the values to 2013 dollars. Values were further escalated to 2014 dollars using the GDP Chained Price Index Deflator.

Table 2-13 summarizes the discounted emission savings associated with each Service Alternative for the 40-year study period.

Table 2-2: Auto Emissions Savings over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 7%	Discounted at 3%
Scenario B-1	$37.52	$11.09	$20.52
Scenario C-1	$33.84	$9.98	$18.50
Scenario C-2	$36.89	$10.89	$20.17
Scenario C-10	$19.36	$5.87	$10.72
Scenario C-11	$38.65	$11.41	$21.14

Table Source: AECOM

Table 2-14 shows the discounted CO2 benefits for the scenarios for the 40-year study period. Note that CO2 is discounted at 3% only.

Table 2-3: Auto CO2 Savings over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 3%
Scenario B-1	$36.00	$16.82
Scenario C-1	$32.50	$15.17
Scenario C-2	$35.42	$16.54
Scenario C-10	$18.30	$8.63
Scenario C-11	$37.10	$17.33

Table Source: AECOM

2.2.3.2 Train Emissions Savings (Freight Net of New Passenger Trains)

To estimate freight and grade crossing impacts, it was necessary to divide the corridor into segments. The six[7] segments more adequately account for the number of freight trains along the corridor and their associated speeds. The segments and train volumes are:

1. Target Field to Minneapolis Junction (W Island Ave to Harrison St)
2. Minneapolis Junction to 14th Ave NE (12th Ave NE to 14th Ave NE)
3. Osbourne to Coon Creek Junction (Osborne Rd NE to Foley Blvd)
4. Coon Creek Junction to Boylston (Egret Blvd to County Road C)
5. Boylston to Saunders (Schallermeier Rd to Ames Rd)
6. Saunders to Rice Point (69th St to 28th St)

To estimate the freight impacts, the average freight speeds per segment before NLX implementation and after NLX implementation were used to calculate the freight time savings. The average freight speeds were improved on Segments 2 (Minnesota Junction to 14th Avenue) and 3 (Osborne to Coon Creek). Freight speed data was not available for Segments 1 (Target Field to Minnesota Junction), 4 (Coon Creek to Boylston), 5 (Boylston to Saunders), and 6 (Saunders to Rice Point); as a result, no freight impacts were measured there. Because high volumes of freight trains travel over Segments 2 and 3, the freight trains would experience an overall improvement in travel times in those segments.

Segment lengths were used to calculate the freight time savings by dividing the segment lengths by the speed. Table 2-15 summarizes the segment lengths along the NLX corridor.

[7] Note that Quandel provided eight segments, but because there are no public at grade crossings on the last two, they were excluded from the analysis and are not listed here.

Table 2-4: Segment Lengths used in Analysis

	Length (miles)
Target-Minn. Jct.	0.96
Minn Jct - 14th Ave	0.45
Osborne - Coon Creek	10.26
Coon Creek - Boylston	124.75
Boylston - Saunders	2.8
Boylston - Saunders	3.56

Table Source: AECOM

The total freight time savings in hours for the Services Alternatives are shown in Table 2-16.

Table 2-5: Freight Time Savings per Train by Segment, in Hours

	Scenario B-1	Scenario C-1	Scenario C-2	Scenario C-10	Scenario C-11
Target-Minn. Jct.	NA	NA	NA	NA	NA
Minn Jct - 14th Ave	0.0018345	0.00094725	0.002481	0.0004883	0.0018345
Osborne - Coon Creek	0.0418266	0.0215973	0.0565668	0.0111321	0.0418266
Coon Creek - Boylston	NA	NA	NA	NA	NA
Boylston - Saunders	NA	NA	NA	NA	NA
Boylston - Saunders	NA	NA	NA	NA	NA

Table Source: AECOM

The positive values in Table 2-16 for Segments 2 and 3 (Minneapolis Junction-14th Ave and Osborne-Coon Creek) indicate that the average speed of freight trains increases with the implementation of NLX service in those segments and experience travel time savings with NLX.

Another factor contributing to the overall freight time savings is the number of trains in the segment, as shown Table 2-17.

Table 2-6: Number of Freight Trains per Day by Segment

	Scenario B-1	Scenario C-1	Scenario C-2	Scenario C-10	Scenario C-11
Target-Minn. Jct.	6	6	6	6	6
Minn Jct - 14th Ave	85	85	85	85	85
Osborne - Coon Creek	65	65	65	65	65
Coon Creek - Boylston	13	13	13	13	13
Boylston - Saunders	28	28	28	28	28
Boylston - Saunders	23	23	23	23	23

Table Source: AECOM

The passenger train trip times were estimated based on average running times for each Service Alternative. The trip times are shown in Table 2-18 for each Service Alternative.

Table 2-7: Passenger Train Trip Time, in Hours

	Scenario B-1	Scenario C-1	Scenario C-2	Scenario C-10	Scenario C-11
Trip Time (hours)	2.37	2.55	2.55	2.55	2.55

Table Source: Table 2.3, SDG NLX Ridership and Revenue Report - May 2015

The hours of delay per freight train avoided due to implementation of the NLX service results in decreases in the amount of CO, NOx, PM10, HC, and CO2 in the atmosphere. This improvement is netted with the negative impact of running new passenger trains in the corridor to result in the net train emissions savings (or costs).

The US Environmental Protection Agency's (EPA) Office of Transportation and Air Quality published long-haul rail engine emission rates (g/brake horsepower hour) for various Tiers based on the year the locomotive was built.[8] Tier 0 locomotives apply to most locomotives built prior to 2001, while higher Tiers apply to the locomotives manufactured most recently. Tier 2 was assumed to be an appropriate average emissions rate standard for freight trains operating in the corridor. Table 2-19 presents the freight emissions rates used in the analysis. The analysis also assumes that all freight trains utilize one locomotive per consist.

[8] FMCSA US EPA, Office of Transportation and Air Quality, Emissions Factors for Locomotives, EPA-420-F-09-025, April 2009, p.2, http://www.epa.gov/nonroad/locomotv/420f09025.pdf

Table 2-8: Freight Train Emission Rates (Grams per Brake Horsepower Hour)

	PM10	NOX	CO	HC	CO2 (g per gal of fuel)
Tier 2 Line-Haul Locomotive	0.18	4.95	1.28	0.26	10,150.00

Table Source: Note: Tier 2 locomotives used to account for locomotives being replaced/re-manufactured throughout the analysis period and adhering to higher emissions standards
Source: US EPA, Office of Transportation and Air Quality, Emissions Factors for Locomotives, EPA-420-F-09-025, April 2009, p.2, http://www.epa.gov/nonroad/locomotv/420f09025.pdf
**SOURCE: EPA Voluntary Reporting of Greenhouse Gases Program, http://www.eia.gov/oiaf/1605/coefficients.html*

Since the emission rates for PM10, NOX, CO, and HC are based on horsepower hours, the average horsepower associated with the locomotives (4,050)[9] was multiplied by the annual travel time savings (in hours), and the emissions factors yielding the annual grams of CO, NOx, PM10, and HC avoided.

To estimate the total tonnage of CO2 avoided, the diesel fuel consumption per hour (101 gallons)[10] multiplied by the grams per gallon was multiplied by the annual travel time savings. The grams were converted to short tons (metric tons for CO2).

To estimate the negative emissions impacts of the new passenger trains, the travel times for each scenario in hours as shown in Table 2-18 were multiplied by the number of passenger trains across the Service Alternatives and annualized to determine the annual hours of operation. The locomotives assumed to be used for NLX service are Tier 4-compliant. The emissions factors for passenger trains are shown in Table 2-20.

Table 2-20: Passenger Train Emission Rates (Grams per Brake Horsepower Hour)

	PM10	NOX	CO	HC	CO2 (g per gal of fuel)
Tier 4 Locomotive Emissions	0.015	0.04	1	1.28	10150

Table Source: EPA Emission Factors for Locomotives, April 2009, EPA-420-F-09-025
**Source: EPA Voluntary Reporting of Greenhouse Gases Program, http://www.eia.gov/oiaf/1605/coefficients.html*

Passenger train emissions are calculated by multiplying by the emission rate for PM10, HC, NOX, and CO, by the fuel consumption of 56 gallons per hour[11] and by a conversion factor for break horsepower hours

[9] Average of low and high used in the analysis. Source: http://www.4rail.net/reference_nam_bnsf_locos1.php
[10] Assumes C44-9 locomotive and averages all speed notches, from GATX Corporation Fuel Consumption chart, accessed at http://www.gatx.com/wps/wcm/connect/d6109c4a-a86a-4d37-a0b4-
[11] Based on engineering judgement and previous project experience and discussion with the California Air Resource Council. Tier 4 fuel consumption is 80% of Tier 0 (70 gallons/hr.)

per gallon (20.8) [12] and converting from grams to short tons.

To estimate the total tonnage of CO_2 incurred, the diesel fuel consumption per hour is multiplied by the grams per gallon and the annual hours of operation, then converted metric tons.

Netting the passenger train emissions with the freight emissions results in the total train emissions. The tons of pollutants were valued by applying the economic cost of air emissions as recommended in the US DOT 2015 TIGER BCA Resource Guide[13] as shown in Table 2-21. HC was valued using the default value in FRA's GradeDec.NET model for highway-rail grade crossing investment analysis.[14] Values were converted to 2014 dollars using the GDP deflator.

Table 2-21: Value of Emissions in 2014 Dollars

	2014$	Unit
Carbon Monoxide	$0	$/short ton
Volatile Organic Compounds	$1,841	$/short ton
Nitrogen Oxides	$7,256	$/short ton
Particulate Matter	$331,910	$/short ton
Sulfur Dioxide	$42,883	$/short ton
Carbon Dioxide	*varies*	$/metric ton
Hydrocarbons*	*$2,040*	$/short ton

Table Source: Corporate Average Fuel Economy for MY2017-MY2025 Passenger Cars and Light Trucks (August 2012), page 922, Table VIII-16, "Economic Values Used for Benefits Computations (2010 dollars)"
http://www.dot.gov/sites/dot.gov/files/docs/TIGER_BCARG_2014.pdf
**GradeDec default value*

The net values of emissions are shown for the Service Alternative in Table 2-22 for the 40-year study period. In all scenarios, CO_2 impacts are negative and are shown in Table 2-23.

[12] The Carl Moyer Memorial Air Quality Standards Attainment Program Guidelines, California Environmental Protection Agency Air Resources Board, September 30, 2003.
[13] TIGER Benefit-Cost Analysis Resource Guide (updated April 2, 2015), http://www.dot.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf
[14] HC valued at $2,040 per ton, assumed to be 2014 dollars.

Table 2-22: Net Train Emissions Savings (Costs) over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 7%	Discounted at 3%
Scenario B-1	$94.10	$23.93	$48.32
Scenario C-1	$93.77	$23.84	$48.14
Scenario C-2	$43.78	$11.13	$22.48
Scenario C-10	$130.83	$33.26	$67.17
Scenario C-11	$16.79	$4.27	$8.62

Table Source: AECOM

Table 2-9: Net Train CO2 Savings (Costs) over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 3%
Scenario B-1	($3.99)	($1.94)
Scenario C-1	($4.89)	($2.38)
Scenario C-2	($14.79)	($7.19)
Scenario C-10	$4.01	$1.95
Scenario C-11	($22.92)	($11.14)

Table Source: AECOM

2.2.3.3. Reduced Emissions at Grade Crossings

Please refer to Section 2.2.6. for information on how safety improves at rail grade crossings.

2.2.4. Economic Competitiveness

The NLX service would provide positive transportation market effects. The benefits to users and non-users would include reduced travel costs, increases in productive time on the train, reduced congestion on nearby highways, and improved freight operations. The effects associated with the Service Alternatives are expressed as net benefits or costs, with positive values showing benefits to the study area and negative values showing costs, over the 40-year analysis period. All values are reported in 2014 dollars.

2.2.4.1. Value of Time

For two of the economic competitiveness benefits, it is necessary to estimate the value of time (VOT) for users and non-users. Both the Productivity Savings and MN 65 Marginal Congestion Savings estimate benefits based on the value of user and non-user time. The VOT is estimated per US DOT guidance,[15] and depends on the trip purpose, whether it is for business travel or non-business travel. Personal trips and commute trips are considered non-business travel. For trips that are for business purposes, users value their time at the hourly local median wage. In this analysis, this value of time is found through the Minnesota 2014 Quarterly Census of Employment and Wages (QCEW) for the affected counties. In 2014, this comes to $28.30. Per guidance, the VOT increases by 1.2% per year to account for real wage growth as a result of increased productivity and is not related to inflation. As a result, the VOT is increased to $30.04 in 2020, and a further 1% per year for the remainder of the analysis period. For non-business trips such as commuters, the VOT is found by taking one half of the hourly median household income for the Minneapolis-St. Paul- Bloomington MSA. Per the 2013 American Community Survey 2013 5-year estimates, median income was $66,940 in 2013 dollars. Converting to 2014 dollars, dividing by 2,080 (hours per year), and escalating by 1% per year to 2020 results in $34.68 per hour; further applying the 50% reduction factor to account for personal travel time results in an hourly VOT of $17.34. Table 2-24 presents the hourly rates used in the analysis.

Table 2-10: Value of Time, in $2014

	Non-Business	Business
VOT 2014	$16.34	$28.30
VOT 2020	$17.34	$30.04

Source: Non-business: ACS 2013 5-year survey for Minneapolis-St. Paul-Bloomington MSA
Business: 2014 Minnesota QCEW for affected counties
VOT increases by 1.2% per year to account for real wage growth
Table Source: AECOM

2.2.4.2. Travel Cost Savings

The quantitative analysis focuses on the travel cost savings associated with air and auto diversions in the corridor based on VMT and trip purpose data. Travel cost savings considers the VMT avoided by auto diversions, which results in vehicle costs avoided, parking fees avoided, and airfare avoided, net of new rail fares incurred.

For auto diverted trips, avoided costs include vehicle operating and maintenance costs and parking. Costs for auto trips were calculated as the out-of-pocket operating costs, which includes gas, maintenance, tires, and half of depreciation for non-business and commuter trips (at $0.31 per mile) based on AAA Your Driving Costs in 2014.[16] Parking fees avoided were calculated through a weighted average of business travelers. Assuming that it would cost $10 per day to park at Target Field Station and would be free at

[15] USDOT, Office of the Secretary of Transportation, Memorandum on the Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis, 2015, accessed at: https://www.transportation.gov/sites/dot.gov/files/docs/Revised%20Departmental%20Guidance%20on%20Valuation%20of%20Travel%20Time%20in%20Economic%20Analysis.pdf
[16] Source: AAA, Your Driving Costs, 2014, accessed at: http://publicaffairsresources.aaa.biz/wp-content/uploads/2014/05/Your-Driving-Costs-2014.pdf

other stations, riders can expect a net savings of $4 per vehicle for parking fees. To estimate the number of riders who would save parking fees, auto occupancy rates and trip purposes were considered. Business travelers [17] are assumed to travel alone, while the average non-business trips would have an average auto occupancy rate of 1.6.[18] Using a weighted average of trip purposes and auto occupancy results in the number of autos avoiding parking fees.

The weighted average of airfare avoided for a trip between Duluth and Minneapolis was found to be $212.[19] The percentage of air diversions for each scenario range from 10% to 25% of trips in 2020 through 2040. After 2040, the number of riders diverted from air is assumed to grow at a conservative 1% per year.

The vehicle costs avoided, parking costs avoided, and airfare costs avoided were totaled to result in the total travel costs avoided. However, all diverted trips would incur a new rail fare, so the ticket revenues were subtracted from the travel costs avoided to result in the total travel cost savings. The resulting savings is a benefit across all Service Alternatives and are shown in Table 2-25 for the 40-year study period.

Table 2-11: Travel Cost Savings over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 7%	Discounted at 3%
Scenario B-1	$354.96	$72.84	$165.00
Scenario C-1	$342.45	$70.49	$159.42
Scenario C-2	$422.84	$87.57	$197.38
Scenario C-10	$162.42	$31.92	$74.02
Scenario C-11	$509.65	$105.57	$237.88

Table Source: AECOM

2.2.4.3. Productivity Savings

The diversion of auto travelers to rail due to the implementation of NLX service increases the productive time of some of the rail users. Riders who had driven for commute trips will be able to use that commute time more productively on the train than they could in the car. According to literature, it was found that 52.3% of business riders would spend time working on the train and would use 33.3% of their trip time to work[20]. In other words, it is assumed that all business riders would spend approximately 17% of their

[17] Averaged across the scenarios to be 55% and held constant throughout the analysis period.
[18] Minnesota average auto occupancy rate, accessed at: http://www.dot.state.mn.us/planning/program/benefitcost.html
[19] Source: FlightAware data, accessed at https://flightaware.com/insight/airline/KMSP/KDLH/DAL
[20] Lyons, G., Jain, J. and Holley, D. (n.d.) The use of travel time by rail passengers in Great Britain. Under revision for publication in Transportation Research A: Policy and Practice.;
Oxera, Review of the Government's case for a High Speed Rail programme, June 20th, 2011, accessed at: http://www.oxera.com/Oxera/media/Oxera/downloads/reports/Advice-on-the-government-s-high-speed-rail-programme.pdf?ext=.pdf;
Department for Transport, Productive Use of Rail Travel Time and the Valuation of Travel Time Savings for Rail Business Travellers, June 2009, accessed at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/4003/productive-use-of-travel-time.pdf;

train trip time being productive. Using Origin-Destination (O-D) ridership values and travel times between segments, the weighted average travel time across alternatives was found in hours for years 2020 and 2040. The productive time was interpolated straight-line between 2020 and 2040 and held constant after 2040.

The O-D ridership and travel times are shown for Scenario C-1 in Table 2-26 and Table 2-27, respectively.

Table 2-12: O-D Ridership Tables for Scenario C-1

2020	Minneapolis	Coon Rapids	Cambridge	Hinckley	Superior	Duluth	**Total**
Minneapolis	0	0	106,099	45,007	39,139	28,403	**218,648**
Coon Rapids	0	0	14,633	51,930	6,905	11,139	**84,607**
Cambridge	106,099	14,633	0	4,818	2,526	3,873	**131,949**
Hinckley	45,007	51,930	4,818	0	19,487	14,860	**136,102**
Superior	39,139	6,905	2,526	19,487	0	0	**68,057**
Duluth	28,403	11,139	3,873	14,860	0	0	**58,276**
Total	**218,648**	**84,607**	**131,949**	**136,102**	**68,057**	**58,276**	**697,639**

2040	Minneapolis	Coon Rapids	Cambridge	Hinckley	Superior	Duluth	**Total**
Minneapolis	0	0	152,871	57,013	51,997	34,591	**296,472**
Coon Rapids	0	0	18,859	65,166	8,665	13,829	**106,520**
Cambridge	152,871	18,859	0	6,093	3,646	5,497	**186,966**
Hinckley	57,013	65,166	6,093	0	23,801	17,527	**169,601**
Superior	51,997	8,665	3,646	23,801	0	0	**88,108**
Duluth	34,591	13,829	5,497	17,527	0	0	**71,445**
Total	**296,472**	**106,520**	**186,966**	**169,601**	**88,108**	**71,445**	**919,111**

Table Source: SDG Ridership and Revenue Report

Lyons, G., Jain, J., Susilo, Y., and Atkins, S., How do rail travelers use their time? A comparison of National (Rail) Passenger Survey findings between 2004 and 2010, University of the West of England, July 2011;
Fickling, R., Gunn, H., Kirby, H., Bradley, M., and Heywood, C., The Productive Use of Rail Travel Time and Value of Travel Time Savings for Travellers in the course of Work, Association for European Transport and contributors, 2008.

Table 2-13: Travel Time Matrix in Hours for Scenario C-1

	Minneapolis	Coon Creek	Cambridge	Hinckley	Superior	Duluth
Minneapolis	0.00	0.32	0.77	1.27	2.28	2.55
Coon Creek	0.32	0.00	0.45	0.95	1.97	2.23
Cambridge	0.77	0.45	0.00	0.50	1.52	1.78
Hinckley	1.27	0.95	0.50	0.00	1.02	1.28
Superior	2.28	1.97	1.52	1.02	0.00	0.27
Duluth	2.55	2.23	1.78	1.28	0.27	0.00

Table Source: SDG Ridership and Revenue Report

The VOT for business riders, as described in USDOT guidance,[21] is valued by the 2014 Quarterly Census of Employment and Wages in Minnesota at $28.30 in 2014 and $30.04 in 2020,[22] and grows by 1% per year throughout the analysis period. Applying this value of time to the share of productive business riders and their productive time results in the total value of additional productive time. Table 2-28 summarizes the productivity savings associated with each Service Alternative over the 40-year study period.

Table 2-14: Productivity Savings over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 7%	Discounted at 3%
Scenario B1	$167.63	$34.99	$78.54
Scenario C1	$167.19	$34.84	$78.28
Scenario C2	$182.95	$38.13	$85.67
Scenario C10	$95.08	$20.67	$45.39
Scenario C11	$193.69	$40.35	$90.68

Table Source: AECOM

[21] USDOT, Office of the Secretary of Transportation, Memorandum on the Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis, 2015, accessed at: https://www.transportation.gov/sites/dot.gov/files/docs/Revised%20Departmental%20Guidance%20on%20Valuation%20of%20Travel%20Time%20in%20Economic%20Analysis.pdf

[22] Minnesota 2014 QCEW for all ownerships in the affected counties, as found by through the database: https://apps.deed.state.mn.us/lmi/qcew/ResultsDisp.aspx

2.2.4.4. Congestion Savings

Because the NLX service would divert auto users from the region's urban highways, the remaining urban highway users would experience congestion relief, particularly in the peak periods. Using the Met Council travel demand model, traffic in the region on Minnesota State Highway 65 (MN 65) between Minneapolis and Cambridge was found to be high in the peak periods, as well as Friday evening rush hour on I-35 north of Minneapolis. Weekend congestion on I-35 was unable to be measured because the model only estimates average weekday traffic. As a result, congestion on MN 65 and I-35 was estimated using separate methodologies. The methodology used to estimate congestion savings on MN 65 uses the travel demand model to derive changes in average speed and thereby travel time savings that result from diverted autos. For I-35, the O-D pairs and distances between stations were used to estimate diverted VMT and congestion based on FHWA's Cost Allocation Study in cents per mile.

It is important to note that the Met Council model is a regional model and therefore traffic volumes were validated at a high level. Volumes may not be exactly representative of those observed on particular segments of Highway 65 in 2010. However, the model provides a reasonable estimate of the relative changes in volumes across scenarios with accuracy that is satisfactory to the purpose of our analysis.

MN 65 Marginal Congestion Savings

Congestion on MN 65 was found by reviewing the 2010 Met Council travel demand model volume to capacity ratios (V/C). The results showed that during peak periods, highway segments along the corridor between downtown Minneapolis and Cambridge are congested, as defined by a V/C ratio greater than or equal to 0.79. The peak periods are defined as 6:00-9:30 am and 3:30-7:00 pm. Travel times in congested segments were calculated using an equation implemented in the Met Council travel demand model. The equation calculates the time needed to traverse a particular segment factoring in traffic volume at a given time. Using a weighted sum of the automobile volumes and congested travel times along segments, total 2010 peak period travel times along the corridor were estimated for the baseline. The weighted sum was annualized using a factor of 250 to account for weekends and holidays. Met Council travel demand model data for 2040 was then obtained and total 2040 travel time along the corridor was then estimated using the same method as for 2010. In addition, 2020 and 2059 total travel times along the corridor were calculated. To obtain 2020 travel times, volumes were derived using a straight line interpolation between 2010 and 2040 volumes. To obtain 2059 travel times, volumes were grown at a rate of 2% per year from 2040 to 2059. These resultant travel times are used as the baseline travel times.

With implementation of the NLX service, riders who had previously driven autos would be diverted from the corridor. Automobile diversions for each Service Alternative were calculated for 2020, 2040, and 2059 for the Minneapolis to Cambridge segment. To obtain annual ridership for 2059, 2040 ridership was grown at a rate of 2% per year. The ridership was then converted to automobiles using an average auto occupancy rate of 1.22 in Minneapolis during peak periods, as found in the National Household Travel Survey. The ridership was then evenly distributed across 365 days of operation per year to obtain the daily ridership.

To coincide with the peak period congestion, users would be diverted from autos to the NLX service for peak trips; therefore train schedules were obtained to appropriately assign diversions. Diverted riders were assigned equally over the number of train round-trips per day per Service Alternative. Automobile diversions were then assigned to each congested segment along MN 65. It was assumed that diverted vehicles would have traveled the entire corridor. Depending on the direction of traffic on the segment, diversions were assigned to either the morning or evening peak period only (though a segment may experience congestion in both directions); southbound segments received diversions during the morning peak period when commuters travel from Cambridge to downtown Minneapolis and southbound traffic is heaviest, and northbound segments received diversions during the evening peak period when commuters are returning home to Cambridge and northbound traffic is heaviest. Within the peak period, diversions were assigned by time period based on the distribution of traffic volume within the peak period, meaning that the time period with the heaviest traffic was assigned the most diversions.

To derive new travel times for highway users that did not divert to NLX service in 2020, 2040, and 2059 under each Service Alternative, diversions for each time period within the peak period were reduced from each segment's baseline volumes and new congested travel times were calculated using the same method as for the baseline scenario. A weighted sum of volumes and congested travel times for each segment was summed across all congested segments to derive the total peak period travel time. This total travel time was then subtracted from the baseline for each corresponding year to derive the total travel time savings by segment for years 2020, 2040, and 2059. The savings were then interpolated using a straight-line interpolation to obtain the annual travel time savings for the analysis period. Vehicle hours saved were multiplied by the auto occupancy factor (1.22) to calculate person-hours saved. A value of time, estimated to be half of the hourly median household income in the Minneapolis-St. Paul-Bloomington MSA[23] ($17.34 in 2020) was then applied, growing at 1% per year during the analysis period per guidance. This methodology was repeated for each Service Alternative in the analysis.

The total congestion savings for the highway users on MN 65 who did not divert to NLX service is shown in Table 2-29 for each Service Alternative over the 40-year study period.

[23] American Community Survey 5-year estimates in 2013 dollars, escalated to 2014 dollars using the GDP deflator and divided by 2080 hours.

Table 2-15: MN 65 Marginal Congestion Savings over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 7%	Discounted at 3%
Scenario B-1	$457.04	$71.00	$188.33
Scenario C-1	$444.68	$69.09	$183.24
Scenario C-2	$324.22	$50.41	$133.65
Scenario C-10	$227.05	$36.53	$94.75
Scenario C-11	$255.53	$39.75	$105.36

Table Source: AECOM

I-35 Marginal Congestion Savings

The congestion on I-35 was calculated differently than the MN 65 congestion due to the Met Council travel demand model's inability to measure weekend traffic and because the model does not cover the entire I-35 corridor.

The Met Council travel demand model was used to confirm that there is congestion on I-35 in the peak period on weekdays. Using the O-D tables for 2020 and 2040, the number of riders (excluding air) between Duluth and Cambridge were divided by the vehicle occupancy factor of 1.6[24] to compute the number of auto diversions resulting from the implementation of NLX service. The trips between Cambridge and Minneapolis, Minneapolis and Coon Rapids, and Coon Rapids and Cambridge were excluded because they are attributing to the congestion on MN 65, and are addressed within the MN 65 congestion savings methodology above. The number of trips were interpolated straight-line between 2020 and 2040, and increased by 2% thereafter. Multiplying the number of diverted autos between an O-D pair by the distance as found by Google Maps between the endpoints of I-35 results in the total VMT avoided. The FHWA Cost Allocation Study, 2000 Addendum[25] estimates the marginal congestion costs per VMT to be 0.78 cents (2000$) or 1.035 cents (2014$) for autos on rural Interstates and 7.70 cents (2000$) or 10.215 cents (2014$) for urban Interstates. Applying these marginal congestion costs to the annual reduction in urban and rural auto VMT, and sharing down the costs to account for the Friday and weekend traffic (assumed to be a factor of 2.5/7) yields the marginal congestion savings for I-35. Table 2-30 summarizes the congestion savings on I-35 associated with each Service Alternative over the 40-year study period.

[24] Because we are taking congestion benefits for Friday evenings and weekends, the commuting vehicle occupancy rate of 1.22 is not appropriate. The 1.6 factor is consistent with factor used in the Travel Cost Savings methodology, which is for all urban and rural trips in Minnesota.

[25] US DOT, Addendum to the 1997 Federal Highway Cost Allocation Study Final Report, May 2000, accessed at: http://www.fhwa.dot.gov/policy/hcas/addendum.cfm

Table 2-30: I-35 Marginal Congestion Savings over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 7%	Discounted at 3%
Scenario B-1	$10.93	$2.45	$5.28
Scenario C-1	$9.87	$2.21	$4.77
Scenario C-2	$10.86	$2.43	$5.25
Scenario C-10	$5.77	$1.31	$2.81
Scenario C-11	$11.54	$2.58	$5.57

Table Source: AECOM

2.2.4.5. Travel Time Savings at Grade Crossings

Please refer to Section 2.2.6 for information on how travel times for drivers are impacted by improved rail grade crossings.

2.2.4.6. Vehicle Operating Cost Savings at Grade Crossings

Please refer to Section 2.2.6 for information on how vehicle operating costs are impacted by improved rail grade crossings.

2.2.4.7. Freight Effects

The construction of infrastructure improvements to support NLX service also benefits the owner of the right-of-way over which the NLX service would operate, BNSF. Track improvements result in freight trains overall experiencing faster average speeds across the corridor, which yield operating and inventory savings.

Operating Cost Savings

Operating savings result from BNSF more efficiently using their network and avoiding delays at crossings and through the added capacity afforded by track construction that accommodates both freight and the NLX service. To value the hourly savings of trains, the total freight operating expenses and the total train hours in road service were obtained from the BNSF 2014 R-1.[26] Dividing the expenses by the total train hours results in an average operating expense per train hour ($683 in 2014).

Multiplying the time savings in hours as shown in Table 2-16 (in Section 2.2.3.2) by the appropriate number of trains per segment per day as shown in Table 2-17 (in Section 2.2.3.2), and summing across segments results in the total hours of time savings by scenario. Multiplying the hours per day by an annualization factor of 365 results in the annual time savings. Each additional locomotive per train results in an incremental increase in operating costs for the portion of BNSF hourly operating costs attributable

[26] Source: BNSF 2014 R-1, accessed at http://www.bnsf.com/about-bnsf/financial-information/surface-transportation-board-reports/pdf/14R1.pdf

to a locomotive and not labor.[27] Multiplying the annual time by the BNSF hourly operating cost results in freight operating savings. The freight operating impacts by Service Alternative are shown in Table 2-31 over the 40-year study period.

Table 2-16: Freight Operating Savings over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 7%	Discounted at 3%
Scenario B-1	$74.10	$16.65	$35.90
Scenario C-1	$38.26	$8.60	$18.54
Scenario C-2	$74.10	$16.65	$35.90
Scenario C-10	$100.22	$22.51	$48.56
Scenario C-11	$19.72	$4.43	$9.56

Table Source: AECOM

Inventory Savings

Moving freight faster through the same corridor also results in inventory savings for shippers. The inventory cost associated with the annual carloads and annual hours of delay is based on the commercial discount rate, or the opportunity cost associated with holding assets in inventory rather than using them for another purpose. The analysis assumes a commercial discount rate of 4.0%. Assuming 8,760 hours in a year (365 days * 24 hours), this yields an hourly discount rate of 0.00046%. Multiplying the annual number of trains by the time savings or loss per train,[28] the average tonnage per train by segment (see Table 2-32), the Minnesota rail value per ton ($791.26)[29], and the hourly commercial discount rate (4.0%) results in the total inventory savings. The inventory savings by Service Alternative are shown in Table 2-33 for the 40-year study period.

[27] Using the R-1, the share of hourly operating costs attributable to labor was found to be 35%; as a result, each extra locomotive over 1 incurs in an additional increment of 65% of the hourly operating costs.

[28] As found in the freight operating savings analysis.

[29] Using the Minnesota Statewide Rail Plan, the value of all Minnesota rail freight in 2012 was $191.5 billion and the rail tons were 250 million, resulting an average of $766.08 (2012$) per rail ton in Minnesota. Converted to 2014$ using GDP deflator. Source: http://www.dot.state.mn.us/planning/railplan/2015report/DraftMNStateRailPlan.pdf

Table 2-17: Average Tonnage per Train by Segment

	Tons per Train
Target-Minn. Jct.	9664
Minn Jct - 14th Ave	8190
Osborne - Coon Creek	8190
Coon Creek - Boylston	8571
Boylston - Saunders	3606
Saunders - Rice Point	3606

Table Source: Quandel Consultants

Table 2-18: Freight Inventory Savings over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 7%	Discounted at 3%
Scenario B-1	$0.55	$0.14	$0.28
Scenario C-1	$0.55	$0.14	$0.28
Scenario C-2	$0.28	$0.07	$0.14
Scenario C-10	$0.74	$0.19	$0.38
Scenario C-11	$0.15	$0.04	$0.07

Table Source: AECOM

2.2.5. Quality of Life and Other Effects

The construction and operation of the NLX service will afford residents and businesses another modal opportunity for access to work, home, recreational activities, and labor pools across the region as well as a higher quality of life. As such, properties with greater accessibility to the NLX service would experience an increase in value. In addition, investments in infrastructure will have a useful life longer than the analysis period, resulting in a residual value benefit.

2.2.5.1. Land Premium

Once the NLX system begins operation, parcels located within station areas will enjoy greater access to the broader regional economy.

The assessed value of parcels within a ½-mile radius of a station amounted to a value of over $2.4 billion (based on 2014 assessed values), as shown in Table 2-34 below. The impacted properties were identified by buffering ¼-mile and ½-mile radii around station locations. The assessed values, sometimes called "market value" depending on the jurisdiction, were collected for 2014 for all station areas. The values were obtained from county assessor records.

Table 2-19: Total Assessed Value by Station Area, in $2014M

Station	1/4 Mile Assessed Value	1/4-1/2 Mile Assessed Value	Total
Target Field*	$938.51	$439.99	$1,378.49
Coon Rapids	$62.14	$126.67	$188.81
Cambridge	$84.84	$98.21	$183.05
Hinckley	$39.37	$33.70	$73.07
Superior	$38.77	$125.80	$164.58
Duluth	$266.09	$228.28	$494.37

Table Source: County Assessor's Records, 2014
**Target Field ¼- ½ mile buffer is the North Loop area*

The Target Field station was a special case because it is in downtown Minneapolis, and as such, much of the parcels are already built-up and of high value, and rail service already exists at the Target Field Station. However, the area known as the North Loop is redeveloping, and the team felt that this area was likely to experience the property premium instead of the properties within the ½-mile radius. As a result, the ½-mile "buffer" for Target Field Station was substituted with a customized polygon to fit with the North Loop boundaries, as seen in Figure 2-1, which is based on the map found at the North Loop Neighborhood Association's website[30]. The ¼-mile buffer was obtained consistently with the other stations.

[30] http://northloop.org/

Figure 2-1: Target Field Station North Loop Polygon

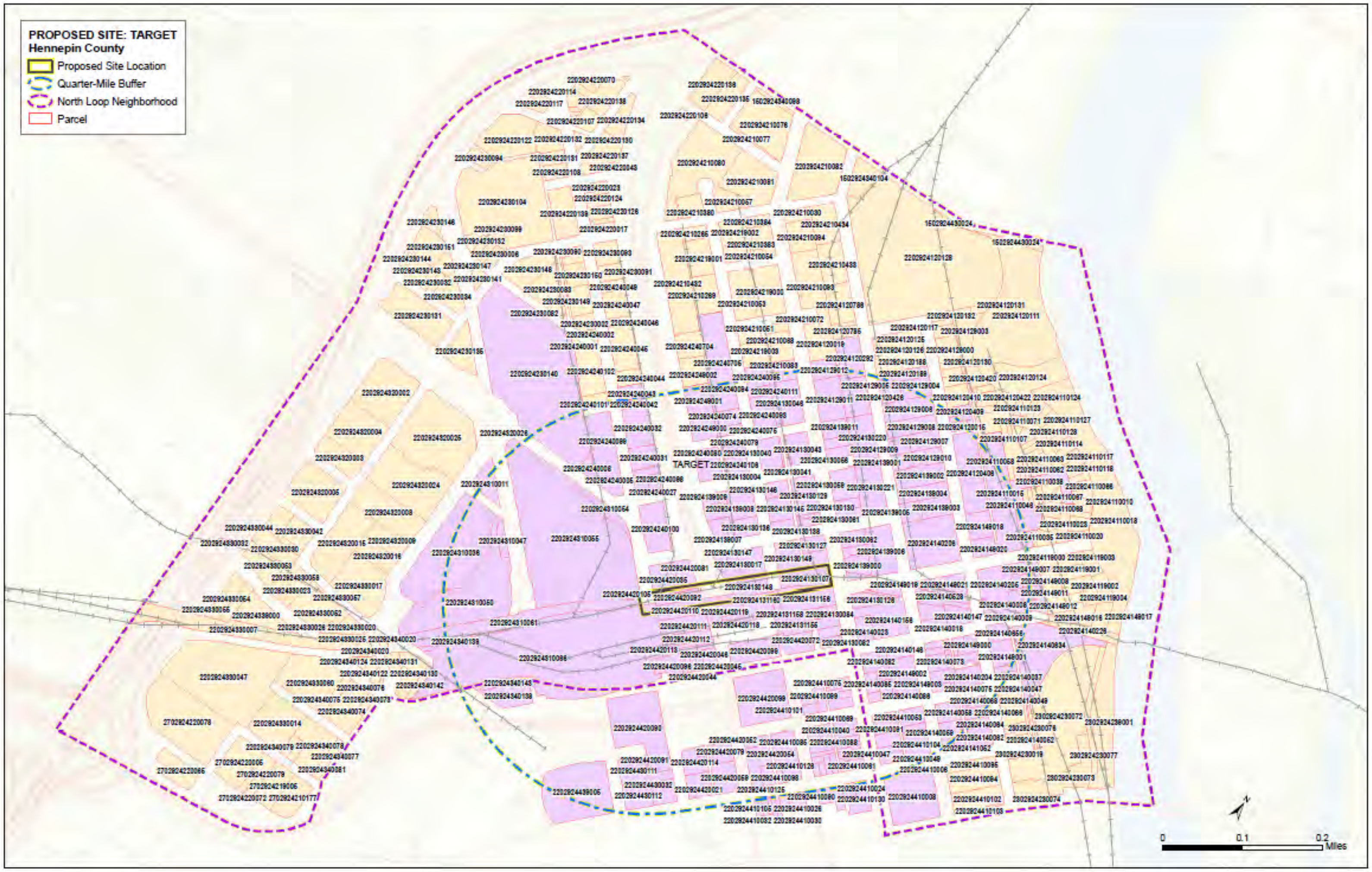


Table Source: County Assessor's Records, 2014

The TIGER BCA Resource Guide (p. 17 of 21) specifically addresses the question of property value impacts, recognizing them as a legitimate potential benefit. The TIGER BCA Resource Guide is the best resource on USDOT's current approach to benefit cost analysis of transportation investments. This type of benefit is also discussed in TCRP Report 78: Estimating the Benefits and Costs of Public Transit Projects: A Guidebook for Practitioners. The key consideration raised is the question of double counting (recognizing that land values capitalize the transportation benefits) and the care that must be taken in selecting a peer location of results of other studies are applied.

The question of double counting does not arise in the context of NLX benefits as the analysis does not estimate travel time savings from each of the station areas. Second, in terms of peer benefits, the analysis is conservative both in terms of the amount of surrounding area affected and in the rate applied.

Residents and commercial enterprises would be willing to pay a premium for the locations where access is improved relative to the baseline. This premium is applied only to the value of existing properties at all stations; it is assumed that existing stations will also experience the premium effect due to the availability of the new service, but to a lesser degree. Studies[31] have shown that an increase in property values near transit lines can range from 2% to over 167%, depending on the property type, transit mode, and proximity; a modest 8.5% increase in the property values is applied in this analysis for all properties within the ¼-mile buffer because of the new availability of intercity rail[32]. For properties outside of the ¼-mile but within the ½-mile buffer, a lower premium of 4% was applied.[33] Due to the North Loop's higher potential for redevelopment, the 8.5% premium was applied to those properties. Further, it is assumed that these land gains are realized over a two year period between 2019 (in anticipation of opening) and 2020 as the system comes into operation and the market responds to its availability; the net gains are then discounted at 3% and 7%.[34] The land premium benefits, which do not vary by operating scenario, are shown in Table 2-35.

Table 2-20: Land Premium Benefits, in $2014M

	Total	Discounted at 7%	Discounted at 3%
Target Field to Duluth	$183.43	$135.36	$160.60

Table Source: AECOM

2.2.5.2. Residual Value

Construction of infrastructure and station area improvements will have residual value after the end of the 40-year analysis period, because the useful life of these elements is longer than 40 years. The useful life

[31] Center for Transit Oriented Development's November 2008 report titled Capturing the Value of Transit (Capturing the Value of Transit, 2008, p.10)

[32] The Southern High-Speed Rail Commission, Baton Rouge-New Orleans Intercity Passenger Rail Volume 1 Summary Report, p. 8.27, December 2010, accessed at: http://www.norpc.org/assets/pdf-documents/studies-and-plans/BR-NO_Pass_Rail-Vol-1_2010.pdf

[33] Ibid.

[34] In studies with travel time savings, the travel time savings would be subtracted from the property premium impacts because a portion of the land premium is associated with the recapitalization of the time savings; however, because no travel time savings are included as part of this analysis, there is no double counting.

of the rail structural improvements and support facilities is 54 years. Therefore, the value of these improvements is depreciated straight-line over 54 years. Offsetting the depreciation, the cyclic rail structural improvements for platform, track, and rolling stock result in extending the useful life of those assets by reducing the annual rate of depreciation. Track depreciates over 38 years, and rolling stock purchases depreciate over 50 years[35] and depending on the operating scenario, some sets are purchased during the analysis period. All assets are depreciated straight-line. Right of way does not depreciate, and is included in the residual value benefit. The first 40 years of depreciation are excluded from the residual estimation, as they are the basis of the benefits estimated elsewhere in the analysis; while, the remaining years are discounted at 7% and 3%.

The remaining discounted value is summed and discounted in 2060, the first year after the analysis period ends. The values of the remaining useful life are shown in Table 2-36 for the 40-year study period.

Table 2-21: Residual Value over the 40-Year Study Period, in $2014M

	Total (2020-2059)	Discounted at 7%	Discounted at 3%
Scenario B-1	$111.65	$5.32	$29.52
Scenario C-1	$125.47	$5.97	$33.18
Scenario C-2	$155.75	$7.42	$41.19
Scenario C-10	$71.63	$3.41	$18.94
Scenario C-11	$175.76	$8.37	$46.48

Table Source: AECOM

2.2.6. Grade Crossing Impacts

Rail grade crossings generate negative community impacts through two primary highway-rail interactions: crashes and highway delays while crossings are blocked by trains. Highway delays at grade crossings increase travel times, vehicle operating costs, and emissions while vehicles idle at blocked grade crossings. These interactions are a safety concern for the community as well as a drain on its economic competitiveness as productivity and access are negatively impacted.

The proposed near-term grade crossing improvements would improve safety at existing grade crossings, thereby reducing the potential for vehicle, pedestrian, and train conflicts and wait times at crossings. There are 126 public crossings on the corridor over six segments. The crossings would all be upgraded to a minimum of dual gates.

[35] Title 49, Subtitle B, Chapter II, Part 215, §215.203 Restricted cars, accessed at: http://www.ecfr.gov/cgi-bin/text-idx?SID=f019a981d484d703d2ed2ccc3096041f&mc=true&node=pt49.4.215&rgn=div5#se49.4.215_1203

The grade crossing analysis requires a number of assumptions regarding train and vehicle traffic. The assumptions that were constant across projects are listed below. By 2020, all grade crossing upgrades are assumed to be completed and the NLX service fully operational. Other assumptions that were consistent across the projects included:

- Train cars for passenger: 7
- Train cars for freight: 100
- Average length of freight rail car: 50 feet
- Average length of passenger car: 85 feet
- AADT growth: 1%
- Truck growth: 1.5%
- Rail growth: 1.5%
- Annualization factor: 280

The community benefits associated with improving grade crossings include:

- Safety
- Travel time savings
- Vehicle operating cost savings
- Vehicle emissions reductions

The maximum timetable speeds for each Service Alternative and segment are shown in Table 2-37. These values were used in GradeDec.NET.

Table 2-22: Maximum Timetable Speeds

	110 mph Scenarios	90 mph Scenarios
Target-Minn. Jct.	40	40
Minn Jct - 14th Ave	79	79
Osborne - Coon Creek	79	79
Coon Creek - Boylston	110	90
Boylston - Saunders	110	90
Saunders – Rice Point	110	90

Table Source: Quandel Consultants

The benefits, which consider the existing and future freight, as well as future NLX trains, were estimated using FRA's GradeDec.NET model. The use of GradeDec.NET estimates the net safety, travel time, vehicle operating cost, and emissions savings associated with proposed improvements to corridor grade crossings (i.e. improvement of device) net of the additional risk of exposure from new passenger trains.[36] The GradeDec.NET methodology is described below.

After consultation with the FRA, it was determined that this estimation required netting two scenarios, denoted as A and B, to adequately capture the impacts of both the improved rail crossing safety devices, as well as the change in operations from the baseline (freight trains only) to the build (freight and passenger trains and grade crossing improvements).

Scenario A estimates the costs of current freight traffic considering the existing grade crossing types by considering the Base Case as current freight conditions and existing crossings, and changing all crossing devices in the Alternate Case to grade separations.

Scenario B estimates the future cost or benefit of the new passenger rail traffic while still considering the freight traffic and improved grade crossing devices. To measure that, the Base Case devices and supplemental safety measures are the grade crossing improvements that will be made as part of the project (listed in Appendix A), while the crossing devices are again grade separated in the Alternate Case. Per GradeDec.NET (FRA) and the Volpe Center, the supplemental devices range in effectiveness with four-quadrant gates with presence detection having an effectiveness of 0.77, up to four quadrant gates with 60' medians having an effectiveness of 0.92. These can be seen in Table 2-38. Of particular note is that the presence detection (or trap vehicle detection) has a lower effectiveness rate than no presence detection, which appears to be counterintuitive, because the purpose of the detection device is to raise the arm to let a vehicle out that is trapped on the tracks by the crossing arms. However, as reported by FRA, this is due to the learned behavior of motorists at grade crossings with trap detection devices. Over time, motorists observe that the lowering of exit gates may be delayed by vehicles driving over the grade crossing. Presence detectors keep the exit gates raised, and motorists then learn that by driving around the lowered gates they can keep them up longer, but those motorists also increase their risk of a collision with an oncoming train, resulting in the lower effectiveness rate.

Table 2-23: Four Quadrant Gate Effectiveness Rates

	Effectiveness Rate
Four Quad Gates No Detection	0.82
Four Quad Gates with Detection	0.77
Four Quad Gates with 60' Median	0.92
Barrier Curbs	0.80

Table Source: FRA Federal Register49 CFR Parts 222 and 229: Use of Locomotive Horns at Highway-Rail Grade Crossings; Final Rule, August 17, 2006; and USDOT Volpe National Transportation Systems Center, North Carolina "Sealed Corridor" Phase I, II, and III Assessment, October 2009.

[36] Network and Induced benefits are also included in Net Benefits. They are distributed among the main four benefits reported in the analysis.

An additional Scenario C was estimated to adequately account for the improved safety devices at crossings for the existing freight traffic (without NLX service) by using the current freight conditions and existing crossings as the Base Case and the improved grade crossing devices in the Alternate Case.

Subtracting Scenario B from A [A-B] and adding Scenario C results in the savings or costs that result from running the new passenger trains, continuing to run freight trains, and upgrading grade crossing devices. The results can be positive savings or a cost. Savings means that, although in the future there are more trains running along the corridor and thus increasing the exposure of autos to train collisions at crossings, the safety improvements at crossings are enough to counterbalance that exposure and the incremental increase in delay for vehicles waiting at crossings.

Scenarios A, B, and C were estimated for each of the six segments for each of the five Service Alternatives at two discount rates (3% and 7%).

2.2.6.1. Safety Savings

The exposure of vehicles associated with grade crossings results in a greater likelihood of safety incidents as trains travel through the crossings. However, constructing grade crossing improvements prohibit traffic from crossing the at-grade rail alignment, thereby preventing injury through normal operations and proper use of the grade crossing devices. The safety analysis calculates the benefits of reduced vehicle-rail crashes due to the grade separation or crossing improvement compared to the likelihood for highway-rail crashes at the existing at-grade crossings.

GradeDec.NET accounts for the time-of-day correlation factors between rail and highway traffic, which are used to predict the number of crashes by severity that would occur at the crossings. The safety analysis methodology for grade crossings predicts the number of crashes each year based on the number of daily trains, AADT, time-of-day exposure correlation factor, number of tracks, and number of highway lanes crossing the tracks.

The predicted crashes are then used to estimate the number of crashes by severity (fatal, injury, and property damage only) that would occur. The estimated crashes by severity are based on the maximum speed; Accident Prediction and Severity (APS) model factors for fatal crashes and casualty crashes for grade crossings with gates and lights; number of through, passenger, and/or switch trains; and number of tracks. The number of crashes is multiplied by the monetary value of the respective type of injury as described in the Safety Benefits section. As shown in Table 2-39, the safety benefit is positive across all scenarios.

Table 2-24: GradeDec Safety Savings, in $2014M

	Discounted at 7%	Discounted at 3%
Scenario B-1	$36.79	$60.66
Scenario C-1	$94.65	$176.30
Scenario C-2	$37.36	$61.64
Scenario C-10	$38.53	$63.45
Scenario C-11	$36.85	$60.86

Table Source: AECOM

2.2.6.2. Auto Emissions Savings

Highway delays associated with grade crossings result in greater vehicle emissions due to increased idling times at grade crossings while vehicles wait for trains to travel through the crossings. GradeDec.NET uses the monetized values of emissions of hydrocarbons, nitrogen oxides, and carbon monoxide to calculate the economic value of emissions reduced from keeping vehicles from waiting idly at grade crossings. The costs of hydrocarbon, nitrogen oxides, and carbon dioxide applied in the analysis were $2,040 per ton, $7,256 per ton, and $0 per ton respectively. The emissions rate by vehicle type was multiplied by the time spent by each vehicle type at the grade crossing. As shown in Table 2-40, the emissions savings at grade crossings are negligible.

Table 2-25: GradeDec Emissions Savings, in $2014M

	Discounted at 7%	Discounted at 3%
Scenario B-1	$0.00	$0.00
Scenario C-1	$0.00	$0.00
Scenario C-2	$0.00	$0.00
Scenario C-10	$0.00	$0.00
Scenario C-11	$0.00	$0.00

Table Source: AECOM

2.2.6.3. Travel Time Savings

Vehicles can experience travel time savings at grade crossings associated with the construction of rail/highway grade separations. When rail grade crossings are eliminated, existing vehicular queuing at these crossings would be eliminated. GradeDec.NET calculates the time travel savings for proposed grade separations based on:

- Trains per day
- Train time of day distribution assumed to be day flat
- Train length
- Average speeds at crossings
- AADT[37] was uniformly distributed throughout the day
- Number of highway lanes at crossings
- Highway traffic volumes
- Vehicle dispersal rates per lane when closure ends

No rail grade separations are planned as part of the NLX project.

Travel time impacts at rail grade crossings due to the implementation of NLX service are determined by calculating the average delay each highway vehicle experiences. This was accomplished by multiplying the probability that a highway vehicle would be blocked by a grade crossing and the minutes per delay. This value was further multiplied by the number of highway vehicles that arrive at the blocked gate to derive the total vehicle hours of delay. This total value was distributed by the percentage of trucks assumed for each crossing. Additionally, the number of people traveling in the vehicle was factored into the value of the travel time delay, because passengers also would be negatively impacted by the delay. The average auto occupancy used in the GradeDec.Net analysis was 1.6. All auto trip delays were multiplied by the average auto occupancy factors to account for all passengers in the vehicle. The analysis assumed an annualization factor of 280 days per year, which accounts for reduced levels of traffic on non-weekdays.

The trip purpose is important to the monetization of the impacts because people value their time differently for different types of trips. The average hourly wage for auto and truck drivers was based on national values as found in USDOT guidance.[38] The value of time for local auto travel, all purposes, is $13.38 ($2014). The average hourly wage for truck drivers is $26.55 ($2014). The national hourly rate was used for truck drivers because truck trips made locally could be made by any truck driver in the US, not just those drivers who reside in the study area. As shown in Table 2-41, the travel times are negative across the Service Alternatives. These negative values indicate that vehicles incur longer wait times due to the new passenger trains, even though freight trains move through crossings faster.

[37] AADT were provided by Quandel and used in GradeDec.NET tool
[38] TIGER Benefit-Cost Analysis Resource Guide (updated April 2, 2015), http://www.dot.gov/sites/dot.gov/files/docs/Tiger_Benefit-Cost_Analysis_%28BCA%29_Resource_Guide_1.pdf

Table 2-26: GradeDec Travel Time Savings (Costs), in $2014M

	Discounted at 7%	Discounted at 3%
Scenario B-1	($0.32)	($0.54)
Scenario C-1	($0.37)	($0.72)
Scenario C-2	($0.48)	($0.81)
Scenario C-10	($0.16)	($0.27)
Scenario C-11	($0.64)	($1.08)

Table Source: AECOM

2.2.6.4. Vehicle Operating Cost Savings

Highway delays at grade crossings result in greater vehicle operating costs associated with the increased idling times at grade crossings while vehicles wait for trains to travel through the crossings. Vehicle operating cost savings are created from the reduction in delay in waiting time, which leads to a decrease in fuel and oil consumption. GradeDec.NET calculated vehicle consumption of fuel and oil for both autos and trucks, as the time delay for each vehicle is multiplied by the consumption rate while waiting at a crossing. The reduction in consumption from the construction of a grade separation was multiplied by their respective costs to derive the vehicle operating cost savings. The gasoline and diesel prices per gallon were assumed to be $3.55 ($2014) and $3.96 ($2014), respectively, based on the Department of Energy's fuel prices. The price of motor oil per quart was assumed to be $4.00 ($2014) based on the price of motor oil available for sale. The negative values in Table 2-42 indicate that vehicles incur longer wait times and therefore higher operating costs due to the new passenger trains, even though freight trains move through crossings faster.

Table 2-27: GradeDec Vehicle Operating Cost Savings, in $2014M

	Discounted at 7%	Discounted at 3%
Scenario B-1	($0.04)	($0.07)
Scenario C-1	($0.04)	($0.09)
Scenario C-2	($0.06)	($0.10)
Scenario C-10	($0.02)	($0.03)
Scenario C-11	($0.08)	($0.13)

Table Source: AECOM

2.2.6.5. Grade Crossing Impact Summary

In total, all Service Alternatives result in positive grade crossing benefits. These results indicate that the safety improvement devices that are upgraded at crossings are a far greater benefit than the disbenefits of the incremental increase in delays and exposure at crossings due to the new passenger trains. The total grade crossing benefits are shown in Table 2-43.

Table 2-28: Grade Crossing Benefits by Scenario, in $2014M

	Discounted at 7%	Discounted at 3%
Scenario B-1	$36.42	$60.05
Scenario C-1	$94.23	$175.49
Scenario C-2	$36.82	$60.73
Scenario C-10	$38.35	$63.14
Scenario C-11	$36.13	$59.64

Table Source: AECOM and GradeDec.NET analysis

3. Results of Benefit Cost Analysis

The following section summarizes and displays the BCA results of the five Service Alternatives at both a 3% and 7% discount rate and presents the BCR of each Alternative. The benefits and costs are grouped in common categories. The costs include capital costs, O&M costs, and cyclic capital costs; the total of these costs is offset by the fare revenues. The benefits are divided into the five TIGER categories of Safety, State of Good Repair, Environmental Sustainability, Economic Competitiveness, and Quality of Life. For this analysis, Other Effects were added to Quality of Life for any remaining benefits that did not fall easily in the other four categories. The categories and their benefits are briefly described here:

- Safety: the project diverts riders from their automobiles, reducing the likelihood of crashes on regional roads. In addition, improved safety features at grade crossings reduce the exposure of vehicle-train collisions at grade crossings.
- State of Good Repair: the project upgrades and maintains track and highway infrastructure, and also reduces pavement wear and tear by diverting auto users to rail.
- Environmental Sustainability: the reduction in auto VMT reduces emissions and CO2 pollution, and freight trains that go faster in the corridor reduce emissions as well. However, the new passenger trains produce new emissions, which are netted against the freight and auto emissions savings. In addition, there is a negligible change in emissions associated with vehicles idling at grade crossings.
- Economic Competitiveness: a number of benefits fall into economic competitiveness because they accrue to passengers, non-passengers, and to the freight industry. Passengers experience

travel cost savings by diverting from their automobiles, and business riders get productivity savings by being able to work some of the time on the train when they could not have in their car. Non-passengers experience reduced congestion on MN 65 in the peak period and on I-35 on weekends, and drivers at grade crossings experience a slightly longer wait time and vehicle operating costs due to the additional new trains. Because of improved tracks and sidings, the freight operator in the region will have operating cost savings and inventory cost savings.

- Quality of Life and Other Effects: because properties nearby to the stations will experience an increased accessibility to the region, households and businesses experience a property premium benefit that increases their property values. In addition, the infrastructure investments will have a useful life longer than the analysis period, as reflected in the residual value benefit.

Scenario C-1 has the highest BCR of all Service Alternatives; 1.65 discounted at 3% and 1.26 discounted at 7%.

3.1. Scenario B-1

Scenario B-1, which would operate four round trips per day at 110 mph, results in a BCR of 1.12 at a 7% discount rate. The BCR rises to 1.41 at 3%.

The results in Table 3-1 show that the largest benefits include freight costs avoided, property premium, reduced highway fatalities and crashes, travel cost savings, and congestion benefits from MN 65. These benefits fall into both user benefits – those that accrue for the riders who switch from auto to train– and non-user benefits, such as the remaining drivers that experience less congestion on regional roads, the freight operator who saves on infrastructure investment, and property owners near stations whose value increases.

Table 3-1 BCA Results for Scenario B-1, in $2014M

	Target Field to Duluth	
	Scenario B-1: 4 round trips at 110mph	
	40 Year Analysis Period (2020 -2059)	
	Values stated in 2014 $M	
	Discounted at 7%	Discounted at 3%
Costs		
Capital Costs	$526.46	$591.92
O&M	$237.96	$494.70
Cyclic Capital	$38.86	$86.83
Fare Revenue (Cost offset)	$144.76	$309.63
Total Costs	***$658.51***	***$863.82***

Benefits		
Safety Benefits		
NLX Passenger Effects:		
Reduced Highway Fatalities and Crashes	$77.91	$176.95
Non-Passenger Effects:		
Reduced Crashes at Grade Crossings	$36.79	$60.66
Sub-Total Safety Benefits	***$114.70***	***$237.61***
State of Good Repair		
Non-Passenger Effects:		
Pavement Savings	$0.03	$0.07
Freight Costs Avoided	$239.83	$268.54
Highway Costs Avoided	$25.47	$28.52
Sub-Total State of Good Repair	***$265.33***	***$297.13***
Environmental Sustainability		
Non-Passenger Effects:		
Emissions Savings (auto)	$11.09	$20.52
CO2 Reductions (auto)*	$16.82	$16.82
Emissions Savings (Freight net of new Passenger Trains)	$3.47	$7.01
CO2 Reductions (Freight net of new Passenger Trains)*	-$4.09	-$4.09
Reduced Emissions at Grade Crossings	$0.00	$0.00
Sub-Total Environmental Sustainability	***$27.29***	***$40.26***
Economic Competitiveness		
NLX Passenger Effects:		

	Target Field to Duluth	
	Scenario B-1: 4 round trips at 110mph	
	40 Year Analysis Period (2020 -2059)	
	Values stated in 2014 $M	
	Discounted at 7%	Discounted at 3%
Travel Cost Savings	$72.84	$165.00
Productivity Savings	$34.99	$78.54
Non-Passenger Effects:		
Hwy 65 Marginal Congestion Savings	$71.00	$188.33
I-35 Marginal Congestion & Crash Benefit	$2.45	$5.28
Travel Time Savings at Grade Crossings	-$0.32	-$0.54
Vehicle Operating Cost Savings at Grade Crossings	-$0.04	-$0.07
Freight Effects:		
Operating Costs Savings (Train)	$7.29	$14.72
Inventory Savings	$0.14	$0.28
Sub-Total Economic Competitiveness Effects	***$188.35***	***$451.55***
Quality of Life and Other Effects		
Non-Passenger Effects:		
Property Premium	$135.36	$160.60
Residual Value	$5.32	$29.52
Sub-Total Quality of Life and Other Effects	***$140.68***	***$190.13***
Total Benefits	***$736.35***	***$1,216.68***
BC Ratio	**1.12**	**1.41**

*Climate Change (CO2) benefits are only discounted at 3% per Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon, Feb 2010

Table Source: AECOM

3.2. Scenario C-1

Scenario C-1, which would operate four round trips per day at 90 mph, results in a BCR of 1.26 at a 7% discount rate. The BCR rises to 1.65 at 3%.

The results in Table 3-2 show that the largest benefits include freight costs avoided, property premium, travel cost savings, reduced highway fatalities and crashes, and congestion benefits from MN 65. These benefits fall into both user benefits – those that accrue for the riders who switch from auto to train– and non-user benefits, such as the remaining drivers that experience less congestion on regional roads, the freight operator who saves on infrastructure investment, and property owners near stations whose value increases.

Table 3-1: BCA Results for Scenario C-1, in $2014M

	Target Field to Duluth	
	Scenario C-1: 4 round trips at 90mph	
	40 Year Analysis Period (2020 -2059)	
	Values stated in 2014 $M	
	Discounted at 7%	Discounted at 3%
Costs		
Capital Costs	$455.83	$512.51
O&M	$188.23	$390.89
Cyclic Capital	$32.83	$71.29
Fare Revenue (Cost offset)	$133.05	$284.84
Total Costs	***$543.84***	***$689.85***

Benefits		
Safety Benefits		
NLX Passenger Effects:		
Reduced Highway Fatalities and Crashes	$70.23	$159.65
Non-Passenger Effects:		
Reduced Crashes at Grade Crossings	$37.92	$62.50
Sub-Total Safety Benefits	***$108.15***	***$222.15***
State of Good Repair		
Non-Passenger Effects:		
Pavement Savings	$0.03	$0.06
Freight Costs Avoided	$203.24	$227.57
Highway Costs Avoided	$25.47	$28.52
Sub-Total State of Good Repair	***$228.74***	***$256.15***
Environmental Sustainability		
Non-Passenger Effects:		
Emissions Savings (auto)	$9.98	$18.50
CO2 Reductions (auto)*	$15.17	$15.17
Emissions Savings (Freight net of new Passenger Trains)	$3.39	$6.84
CO2 Reductions (Freight net of new Passenger Trains)*	-$4.52	-$4.52
Reduced Emissions at Grade Crossings	$0.00	$0.00
Sub-Total Environmental Sustainability	***$24.02***	***$35.98***
Economic Competitiveness		
NLX Passenger Effects:		

	Target Field to Duluth	
	Scenario C-1: 4 round trips at 90mph	
	40 Year Analysis Period (2020 -2059)	
	Values stated in 2014 $M	
	Discounted at 7%	Discounted at 3%
Travel Cost Savings	$70.49	$159.42
Productivity Savings	$34.84	$78.28
Non-Passenger Effects:		
Hwy 65 Marginal Congestion Savings	$69.09	$183.24
I-35 Marginal Congestion & Crash Benefit	$2.21	$4.77
Travel Time Savings at Grade Crossings	-$0.32	-$0.54
Vehicle Operating Cost Savings at Grade Crossings	-$0.04	-$0.07
Freight Effects:		
Operating Costs Savings (Train)	$7.29	$14.72
Inventory Savings	$0.14	$0.28
Sub-Total Economic Competitiveness Effects	***$183.70***	***$440.11***
Quality of Life and Other Effects		
Non-Passenger Effects:		
Property Premium	$135.36	$160.60
Residual Value	$4.73	$26.29
Sub-Total Quality of Life and Other Effects	***$140.10***	***$186.89***
Total Benefits	***$684.71***	***$1,141.29***
BC Ratio	**1.26**	**1.65**

*Climate Change (CO2) benefits are only discounted at 3% per Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon, Feb 2010

Table Source: AECOM

3.3. Scenario C-2

Scenario C-2, which would operate six round trips per day at 90 mph, results in a BCR of 1.13 at a 7% discount rate. The BCR rises to 1.39 at 3%.

The results in Table 5-3 show that the largest benefits include freight costs avoided, property premium, travel cost savings, reduced highway fatalities and crashes, and congestion benefits from MN 65. These benefits fall into both user benefits – those that accrue for the riders who switch from auto to train– and non-user benefits, such as the remaining drivers that experience less congestion on regional roads, the freight operator who saves on infrastructure investment, and property owners near stations whose value increases.

Table 3-1: BCA Results for Scenario C-2, in $2014M

	Target Field to Duluth Scenario C-2: 6 round trips at 90mph 40 Year Analysis Period (2020 -2059) Values stated in 2014 $M	
	Discounted at 7%	Discounted at 3%
Costs		
Capital Costs	$513.54	$577.40
O&M	$245.74	$513.00
Cyclic Capital	$37.86	$86.50
Fare Revenue (Cost offset)	$145.94	$312.43
Total Costs	***$651.20***	***$864.46***

Benefits		
Safety Benefits		
NLX Passenger Effects:		
Reduced Highway Fatalities and Crashes	$76.58	$174.01
Non-Passenger Effects:		
Reduced Crashes at Grade Crossings	$37.36	$61.64
Sub-Total Safety Benefits	***$113.95***	***$235.66***
State of Good Repair		
Non-Passenger Effects:		
Pavement Savings	$0.03	$0.06
Freight Costs Avoided	$252.23	$282.42
Highway Costs Avoided	$25.47	$28.52
Sub-Total State of Good Repair	***$277.73***	***$311.00***
Environmental Sustainability		
Non-Passenger Effects:		
Emissions Savings (auto)	$10.89	$20.17
CO2 Reductions (auto)*	$16.54	$16.54
Emissions Savings (Freight net of new Passenger Trains)	$0.57	$1.15
CO2 Reductions (Freight net of new Passenger Trains)*	-$8.29	-$8.29
Reduced Emissions at Grade Crossings	$0.00	$0.00
Sub-Total Environmental Sustainability	***$19.70***	***$29.56***
Economic Competitiveness		
NLX Passenger Effects:		

	Target Field to Duluth Scenario C-2: 6 round trips at 90mph 40 Year Analysis Period (2020 -2059) Values stated in 2014 $M	
	Discounted at 7%	Discounted at 3%
Travel Cost Savings	$87.57	$197.38
Productivity Savings	$38.13	$85.67
Non-Passenger Effects:		
Hwy 65 Marginal Congestion Savings	$50.41	$133.65
I-35 Marginal Congestion & Crash Benefit	$2.43	$5.25
Travel Time Savings at Grade Crossings	-$0.48	-$0.81
Vehicle Operating Cost Savings at Grade Crossings	-$0.06	-$0.10
Freight Effects:		
Operating Costs Savings (Train)	$3.77	$7.60
Inventory Savings	$0.07	$0.14
Sub-Total Economic Competitiveness Effects	***$181.84***	***$428.78***
Quality of Life and Other Effects		
Non-Passenger Effects:		
Property Premium	$135.36	$160.60
Residual Value	$5.97	$33.18
Sub-Total Quality of Life and Other Effects	***$141.34***	***$193.78***
Total Benefits	***$734.55***	***$1,198.79***
BC Ratio	**1.13**	**1.39**

*Climate Change (CO2) benefits are only discounted at 3% per Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon, Feb 2010

Table Source: AECOM

3.4. Scenario C-10

Scenario C-10, which would operate two round trips per day at 90 mph, results in a BCR of 1.12 at a 7% discount rate. The BCR rises to 1.38 at 3%.

The results in Table 3-4 show that the largest benefits include freight costs avoided, property premium, reduced highway fatalities and crashes, reduced crashes at grade crossings, and congestion benefits from MN 65. These benefits fall into both user benefits – those that accrue for the riders who switch from auto to train– and non-user benefits, such as the remaining drivers that experience less congestion on regional roads, the freight operator who saves on infrastructure investment, and property owners near stations whose value increases.

Table 3-1: BCA Results for Scenario C-10, in $2014M

	Target Field to Duluth	
	Scenario C-10: 2 round trips at 90mph	
	40 Year Analysis Period (2020 -2059)	
	Values stated in 2014 $M	
	Discounted at 7%	Discounted at 3%
Costs		
Capital Costs	$434.42	$488.44
O&M	$118.27	$242.80
Cyclic Capital	$21.27	$47.19
Fare Revenue (Cost offset)	$77.63	$162.72
Total Costs	***$496.34***	***$615.71***

Benefits		
Safety Benefits		
NLX Passenger Effects:		
Reduced Highway Fatalities and Crashes	$40.50	$90.72
Non-Passenger Effects:		
Reduced Crashes at Grade Crossings	$38.53	$63.45
Sub-Total Safety Benefits	***$79.03***	***$154.16***
State of Good Repair		
Non-Passenger Effects:		
Pavement Savings	$0.02	$0.03
Freight Costs Avoided	$195.43	$218.82
Highway Costs Avoided	$25.47	$28.52
Sub-Total State of Good Repair	***$220.92***	***$247.38***
Environmental Sustainability		
Non-Passenger Effects:		
Emissions Savings (auto)	$5.87	$10.72
CO2 Reductions (auto)*	$8.63	$8.63
Emissions Savings (Freight net of new Passenger Trains)	$5.60	$11.31
CO2 Reductions (Freight net of new Passenger Trains)*	-$0.95	-$0.95
Reduced Emissions at Grade Crossings	$0.00	$0.00
Sub-Total Environmental Sustainability	***$19.14***	***$29.70***
Economic Competitiveness		
NLX Passenger Effects:		

	Target Field to Duluth	
	Scenario C-10: 2 round trips at 90mph	
	40 Year Analysis Period (2020 -2059)	
	Values stated in 2014 $M	
	Discounted at 7%	Discounted at 3%
Travel Cost Savings	$31.92	$74.02
Productivity Savings	$20.67	$45.39
Non-Passenger Effects:		
Hwy 65 Marginal Congestion Savings	$36.53	$94.75
I-35 Marginal Congestion & Crash Benefit	$1.31	$2.81
Travel Time Savings at Grade Crossings	-$0.16	-$0.27
Vehicle Operating Cost Savings at Grade Crossings	-$0.02	-$0.03
Freight Effects:		
Operating Costs Savings (Train)	$9.86	$19.91
Inventory Savings	$0.19	$0.38
Sub-Total Economic Competitiveness Effects	***$100.31***	***$236.96***
Quality of Life and Other Effects		
Non-Passenger Effects:		
Property Premium	$135.36	$160.60
Residual Value	$3.41	$18.94
Sub-Total Quality of Life and Other Effects	***$138.77***	***$179.54***
Total Benefits	***$558.17***	***$847.74***
BC Ratio	**1.12**	**1.38**

*Climate Change (CO2) benefits are only discounted at 3% per Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon, Feb 2010

Table Source: AECOM

3.5. Scenario C-11

Scenario C-11, which would operate eight round trips per day at 90 mph, results in a BCR of 0.83 at a 7% discount rate. The BCR rises to 1.00 at 3%.

The results in Table 3-5 show that the largest benefits include freight costs avoided, property premium, travel cost savings, reduced highway fatalities and crashes, productivity savings, and congestion benefits from MN 65. These benefits fall into both user benefits – those that accrue for the riders who switch from auto to train– and non-user benefits, such as the remaining drivers that experience less congestion on regional roads, the freight operator who saves on infrastructure investment, and property owners near stations whose value increases.

Table 3-1: BCA Results for Scenario C-11, in $2014M

	Target Field to Duluth	
	Scenario C-11: 8 round trips at 90mph	
	40 Year Analysis Period (2020 -2059)	
	Values stated in 2014 $M	
	Discounted at 7%	Discounted at 3%
Costs		
Capital Costs	$744.98	$837.61
O&M	$314.73	$659.23
Cyclic Capital	$56.08	$128.24
Fare Revenue (Cost offset)	$154.36	$330.59
Total Costs	***$961.43***	***$1,294.50***

Benefits		
Safety Benefits		
NLX Passenger Effects:		
Reduced Highway Fatalities and Crashes	$80.24	$182.31
Non-Passenger Effects:		
Reduced Crashes at Grade Crossings	$36.85	$60.86
Sub-Total Safety Benefits	***$117.10***	***$243.17***
State of Good Repair		
Non-Passenger Effects:		
Pavement Savings	$0.03	$0.07
Freight Costs Avoided	$309.26	$346.28
Highway Costs Avoided	$25.47	$28.52
Sub-Total State of Good Repair	***$334.76***	***$374.87***
Environmental Sustainability		
Non-Passenger Effects:		
Emissions Savings (auto)	$11.41	$21.14
CO2 Reductions (auto)*	$17.33	$17.33
Emissions Savings (Freight net of new Passenger Trains)	-$1.18	-$2.37
CO2 Reductions (Freight net of new Passenger Trains)*	-$11.71	-$11.71
Reduced Emissions at Grade Crossings	$0.00	$0.00
Sub-Total Environmental Sustainability	***$15.85***	***$24.38***
Economic Competitiveness		
NLX Passenger Effects:		

	Target Field to Duluth	
	Scenario C-11: 8 round trips at 90mph	
	40 Year Analysis Period (2020 -2059)	
	Values stated in 2014 $M	
	Discounted at 7%	Discounted at 3%
Travel Cost Savings	$105.57	$237.88
Productivity Savings	$40.35	$90.68
Non-Passenger Effects:		
Hwy 65 Marginal Congestion Savings	$39.75	$105.36
I-35 Marginal Congestion & Crash Benefit	$2.58	$5.57
Travel Time Savings at Grade Crossings	-$0.64	-$1.08
Vehicle Operating Cost Savings at Grade Crossings	-$0.08	-$0.13
Freight Effects:		
Operating Costs Savings (Train)	$1.94	$3.92
Inventory Savings	$0.04	$0.07
Sub-Total Economic Competitiveness Effects	***$189.51***	***$442.28***
Quality of Life and Other Effects		
Non-Passenger Effects:		
Property Premium	$135.36	$160.60
Residual Value	$8.37	$46.48
Sub-Total Quality of Life and Other Effects	***$143.73***	***$207.08***

Total Benefits	***$800.96***	***$1,291.77***

BC Ratio	**0.83**	**1.00**

*Climate Change (CO2) benefits are only discounted at 3% per Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon, Feb 2010

Table Source: AECOM

Ridership and Revenue Forecast

NORTHERN LIGHTS EXPRESS

NORTHERN LIGHTS EXPRESS

TECHNICAL DOCUMENT IN SUPPORT OF THE NLX SERVICE DEVELOPMENT PLAN

Ridership and Revenue Forecast

October 2015

Prepared by:

QUANDEL CONSULTANTS

161 N. Clark Street, Suite 2060
Chicago, IL 60601

161 St. Anthony Avenue, Suite 940
St. Paul, MN 55103

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TABLES

1. INTRODUCTION

The Northern Lights Express is a proposed high speed intercity passenger rail project that would provide passenger rail service between Minneapolis and Duluth, operating on 152 miles of track owned by the BNSF Railway. The NLX Project is being managed by the Minnesota Department of Transportation through the Passenger Rail Office, in consultation with the Federal Railroad Administration and the cooperation of the Minneapolis-Duluth/Superior Passenger Rail Alliance, with the objective of completing environmental review and preliminary engineering to position the project for advancement to final design, construction and operation. A critical step in achieving this objective is the preparation of ridership forecasts, revenue projections and estimates of public benefits. This memo summarizes the process followed to prepare the ridership forecasts and revenue projections.

2. RIDERSHIP AND REVENUE FORECAST

In September 2013, MnDOT entered into a contract with Steer Davies Gleave (SDG) to provide ridership forecasts and revenue projections for the NLX Project. In compliance with the contract requirements, SDG delivered the Northern Lights Express Ridership and Revenue Forecast Report in May 2015, which is included as Attachment A to this report. A summary of the forecasted annual ridership and revenue for the base operating plan and sixteen NLX alternatives is detailed in Table 3.4 of the May 2015 report.

During the preparation of the ridership forecasts and after the submittal of the May 2015 report, MnDOT convened a Peer Review Panel to review the assumptions, methodology, and results presented by SDG. In addition to this Peer Review, and after a detailed review of the SDG May 2015 Ridership and Revenue Forecast Report, MnDOT requested that Quandel Consultants conduct an independent review of the SDG forecasts. Quandel contracted with the Whitehouse Group (WGI) to undertake this independent assessment. The findings of this review were summarized to MnDOT and SDG during an in person meeting on July 21, 2015 and in a presentation to MnDOT, NLX Alliance, the Peer Panel, and FRA on August 13, 2015. WGI conclusions were as follows:

1. The forecasting approach taken by SDG is practical given the lack of existing intercity rail service in the corridor

2. The magnitude and impact of asserted constants, taken together with resulting effective fare, plays an important role in the ridership/revenue forecast

3. A different mix of constants and fares could result in comparable ridership patterns but a fare policy more in line with expectations for end-to end trips

WGI recommended that MnDOT should reexamine the proposed fare matrix and modal constant relationship to see if adjustments were warranted given the character of the corridor, current pricing for intercity bus, confidence in the stated preference data, and results of other studies. The WGI presentation is included as Attachment B.

MnDOT, with the concurrence of FRA and the Peer Panel, asked SDG to conduct additional ridership and revenue projections and to modify modal constants to be responsive to the independent review conducted by WGI. Interim results were presented at the August 13, 2015 meeting.

Following the SDG August 13, 2015 presentation, SDG was asked to conduct a revenue maximization exercise with the modified modal constant values. For this exercise, SDG studied several plausible fare plans that met the desired fare structure for the corridor. The final results were presented in a Supplement to May 2015 Ridership and Revenue Report dated September 1, 2015, which is included as Attachment C.

After reviewing all of the information provided by SDG and Whitehouse Group, MnDOT determined that the ridership forecasts and revenue projections would be presented as a range as shown in Table 2-1, using the following criteria:

- Low end of the range
  - Fare - $5 + 13 cents per mile
  - Initial modal constant representing a reasonable comparison to existing Amtrak service;
- High end of the range
  - Fare - $5 + 16 cents per mile
  - Adjusted modal constant representing a reasonable comparison to higher speed reliable service provided with modern Next Gen equipment.

Table 2-1: Range of Ridership and Revenue

	Low	High	Low	High
	2020		2040	
Ridership (000)	698	766	919	1011
Revenue ($M)	10.74	13.62	14.01	17.77

MnDOT presented this range of ridership forecasts and revenue projections to the NLX Peer Panel on September 30, 2015. The presentation is included as Attachment D. There was general consensus within the Peer Panel for supporting the use of a low and high range of ridership and revenue as presented.

MnDOT presented this range of ridership forecasts and revenue projections to FRA on October 1, 2015. The presentation is included as Attachment E. FRA approved the use of a low and high range of ridership as presented.

Attachment A: Northern Lights Express Ridership and Revenue Forecast Report, May 2015

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Northern Lights Express Ridership and Revenue Forecasting

Report
May 2015

Minnesota Department of Transportation

Our ref: 22602101
Client ref: MnDOT Contract No. 03322

Northern Lights Express Ridership and Revenue Forecasting

Minnesota Department of Transportation

Report
May 2015

Our ref: 22602101
Client ref: MnDOT Contract No. 03322

Prepared by:

Steer Davies Gleave
883 Boylston Street, 3rd Floor
Boston, MA 02116

+1 (617) 391 2300
na.steerdaviesgleave.com

Prepared for:

Minnesota Department of Transportation
395 John Ireland Blvd
St. Paul, MN 55155

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Appendices

1 Introduction

This report provides the ridership and revenue forecasts obtained from Steer Davies Gleave (SDG)'s intercity rail models for the proposed Minneapolis-Duluth Northern Lights Express (NLX) train service. The work documented in this report corresponds to Tasks 1-3 and 5-6 of the original September 2013 contract between Steer Davies Gleave, Quandel Consultants and MnDOT, and Task 10 in the December 2014 amendment to analyze two additional service options. Task 4, the Public Benefits Analysis, and Task 11, analysis of the proposed St. Paul extension, will be documented in separate memos.

Tasks 1-3, covering development of the components of the intercity rail model, including the no-build travel demand, intercity network, stated preference survey, mode choice model, and forecasting tools, took place in late 2013 and early 2014. Ridership and Revenue forecasts were first developed in the spring of 2014 with the service parameters of the Base Operating Plan, described in section 2.3. These parameters are equivalent to those in the 2013 Service Development Plan[1] (SDP) and the Technical Report[2] which provided the forecasts referenced in the SDP. This represents Task 5 of the project.

The forecasts obtained from Task 5 were presented to the project's Peer Panel in July of 2014, and were approved in August 2014 after comments, and minor revisions were suggested to the modeling methodology. These revisions produced forecasts for the Base Operating Plan which

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[1] *Northern Lights Express Service Development Plan,* Quandel Consultants, LLC, in association with SRF Consulting Group, Inc.

[2] *Northern Lights Express Technical Report: Preferred Alternative – Route 9 Option 2 (Level 3 Analysis)*, Transportation Economics & Management Systems, Inc., March 2012.

were slightly but not significantly different from those presented to the Peer Panel (578,000 vs. 573,000 annual riders forecast for year 2020).[3]

Task 6, Development of Optimal Operating Plan, began in October 2014 after the baseline forecasts were finalized. The first phase of this Task was to decide on an optimal fare structure. Based on the results of the fare optimization analysis, MnDOT chose to revise the proposed fare structure from a flat 29 cents per mile (as was assumed in the Base Operating Plan) to a $5 boarding fee + 13 cents per mile. The significant fare reductions were predicted to increase ridership substantially without a major loss to ticket revenue. In addition, although the quantitative results are not discussed in this report, the lower fares would provide higher levels of public benefits and a favorable impact on the results of a cost-benefit analysis.

The second phase of Task 6 was to forecast NLX ridership and ticket revenue for a wide variety of possible service options, given the optimal fare structure. The results of these forecasts will be used to determine one or two preferred alternatives. Once those are chosen, they will be analyzed in more detail in the summer of 2015, including public benefits and economic impacts such as employment and tax revenue.

The Task 6 forecasts were originally presented in the Ridership and Revenue Report dated February 2015. Upon review of that report, MnDOT asked SDG to investigate further as to how the accuracy of the NLX ridership can be improved, especially in relation to the potential trip making to the Grand Casino in Hinckley, given that additional data from the Grand Casino were made available to SDG since the initial forecasts were produced. This led to two changes in SDG's forecasting approach/model compared to what was reported in the February SDG Draft NLX Ridership and Revenue Report. These changes were documented in the Supplement to the February Ridership and Revenue Report, dated March 31st, 2015.

This report is the final and complete Ridership and Revenue Report, updating the February draft version with the results in the March supplement, integrating four new potential service options, and incorporating comments received about the forecasts in the April 2015 Peer Panel Meeting.

This report integrates several earlier deliverables, including

- Modeling Methodology Memo (Task 1)
- No-Build Travel Demand Memo (Task 2)
- Modeling Methodology Report (Task 2)
- Mode Choice Models Memo (Task 2)
- Revenue Projection Methodology Memo (Task 3)
- Base Operating Plan Ridership and Revenue Report (Task 5)
- Draft Ridership and Revenue Report (Task 6 - February)
- Supplement to Draft Ridership and Revenue Report (Task 6 - March)

In addition, this report documents additional Task 6 efforts described above.

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[3] The Base Operating Plan results in this report differ slightly from those in the August reports, due to these minor revisions.

1.1 Context

This study will be used to update the SDP with a service and operating plan that provides the optimal combination of ridership, revenue and public benefits. The ridership, revenue and some components of the public benefits forecasts developed by SDG will be supplemented by a financial planning study by Parsons Brinckerhoff and additional public benefits studies by MnDOT.

Ultimately, the goal of this study, when combined with environmental assessments of the project and individual stations, along with engineering studies of the railroad infrastructure, will be to provide sufficient documentation to make an informed decision on the next phase of the proposed NLX service.

1.2 Report Sections

Chapter 2 of this report provides definitions of the project study area and travel markets considered in the forecasts, and describes both the base operating plan and the service options tested as part of Task 6 (Development of Optimum Operating Plan). Chapter 3 provides detailed model outputs of ridership and revenue by travel market and geographical market. Additional information is provided in the form of sensitivity tests and sample zone pair inputs and outputs.

Although it is not possible to validate the model outputs against any existing data, Chapter 4 discusses several ways the results can be checked with external data for reasonableness, including ridership on similar existing train services, other forecasts on proposed services, and census data to check on the magnitude of the travel market between the key station pair of Target Field and Cambridge.

Chapter 5 outlines the model inputs for all travel modes (auto, bus, air and NLX) and their sources, and discusses the rules used to define "in-scope" travel demand. Chapter 6 provides a general discussion of the models and how their components fit together. Finally, Chapter 7 briefly discusses the subsequent steps of the project. Greater technical detail on all the models is included in earlier project memos, which are included as Appendices to this report.

The appendices to this report include a series of technical memorandums that were prepared, submitted and subsequently approved by MnDOT and the Peer Review Panel. These technical memos provide detailed and in-depth description on the ridership and revenue forecasting modeling methodology for this study (Appendix A), no-build travel demand on the study corridor (Appendix B), the mode choice models developed/estimated as part of this study (Appendix C), the revenue projection methodology (Appendix D) and the schedules for the service options that were analyzed (Appendix E).

2 Project Definitions

2.1 Study Area Definition

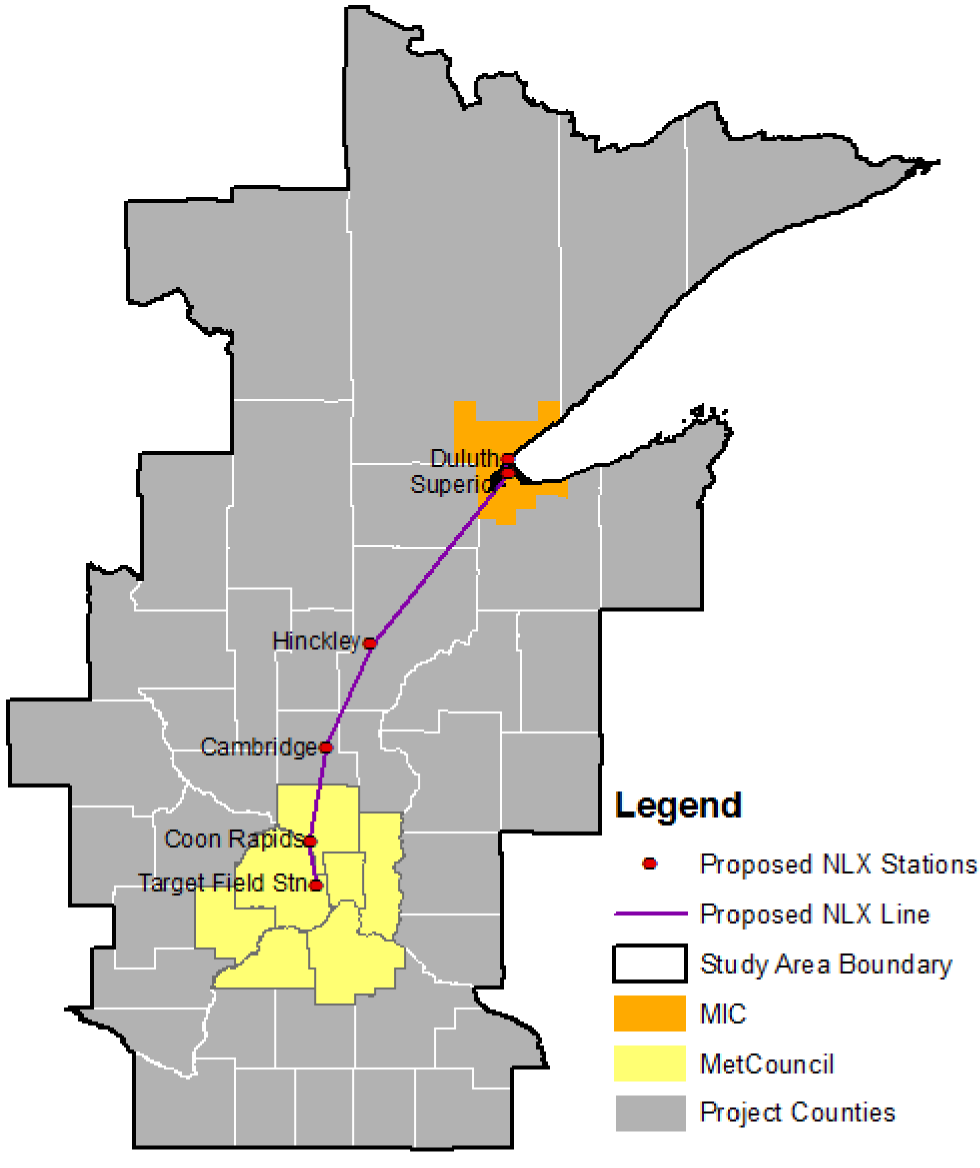
As seen in Figure 2.1, the project will provide passenger rail service to the 155-mile corridor between Minneapolis and Duluth, with proposed intermediate stops in Coon Rapids, Cambridge, Hinckley, and Superior, WI. The study area consists of 45 counties in Minnesota and Wisconsin, representing an area of 50-100 miles around the proposed train service. Trips within this region are potential candidates for diversion to the proposed NLX train service. The 45 counties were further divided into 378 zones for the purpose of detailed modeling, with greater resolution in the urban areas and at proposed rail stations and airports. Zones within metropolitan areas were developed from the MPO zone structures, and zones outside metro areas were developed from Census tracts.

Table 2.1: Summary of SDG Zone System

Geographic Area	Number of Counties	Number of SDG Zones
Metropolitan Council (Twin Cities)*	7	234
Duluth-Superior Metropolitan Interstate Council	2 (partial)	80
Hinckley	1 (partial)	2 (Downtown and Casino)
Other regions	35 + 3 partial	62
Total	45	378

** Tabulated using the core 7-county Transportation Analysis Zones (excludes the External Counties), which is consistent with the zone structure within the MetCouncil Travel Demand Model.*

Figure 2.1: Project Boundary



2.2 Markets

As with any new transportation system, potential passengers include both diverted demand (existing trips within the corridor that are diverted to the new system from automobile, bus or air modes) and induced demand (trips that are currently not made, but will take place as a result of the improved service provided by the new system).

2.2.1 Current Intercity Auto Travelers

The overwhelming majority of intercity travel in the Twin Cities-Duluth corridor is by automobile. It is therefore critical to understand the origin-destination patterns of the auto trips in order to determine the number of trips that will divert to NLX. Two months of anonymous cellphone movement data were purchased from AirSage, a firm that specializes in analyzing the movements of mobile devices to provide origin-destination patterns without compromising the anonymity of the traveler. The cellphone travel patterns were calibrated using data from MnDOT continuous count stations and the 2010 Twin Cities Household Travel Survey, annualized, and disaggregated to derive an auto trip table for the 378x378 zone pairs in the study area.

2.2.2 Current Intercity Bus Travelers

Currently, Jefferson Lines and Skyline Shuttle are the primary operators of intercity bus service between the Twin Cities, Hinckley, and Duluth. Existing corridor bus ridership was estimated by factoring the ridership data provided in the 2010 *Minnesota Intercity Bus Network Study* with current service levels, and distributed among study area zone pairs based on defined catchment areas.

2.2.3 Current Air Travelers

There are very few air trips made entirely within the study area (i.e. between Minneapolis-St. Paul International Airport, MSP and Duluth International Airport, DLH), but a larger amount of travelers starting at DLH connect through MSP or at another airport to reach their final destination (or the reverse, if the final destination is DLH). Even though the Target Field NLX Station is not at MSP, some air travelers may divert to NLX, take transit (e.g. ride the light rail blue line to MSP), and fly from MSP to their destination. Data were collected for connecting travel that originated in Duluth in order to quantify this existing air traveler market.

Detailed descriptions of the existing auto, bus, and air travel markets are available in the "NLX No-Build Travel Demand Memo", included as Appendix B to this report.

2.2.4 Induced Travelers

The introduction of a new transportation option such as NLX improves the overall transportation system in the corridor; this may lead to additional trips which would not have been made otherwise. Stated Preference (SP) survey responses were used to gauge the additional trips that travelers in the corridor would make with the introduction of NLX; the responses, along with the differences in travel times and costs that NLX would provide, were then used to estimate the volume of travel that would be induced by NLX. Induced demand was assumed to apply to non-business trips only, and the model output was benchmarked to several external studies, shown in section 4.4, to ensure that the overall percentage of demand which is induced was realistic.

More information on the estimation of induced travel is available in the "NLX Mode Choice Models Memo", included as Appendix C to this report.

2.3 Description of Base Operating Plan

The 2013 NLX Service Development Plan (SDP)[4] included a Base Operating Plan with proposed schedules, fares, and service locations. The base model output was developed using these parameters in order to maintain consistency between the two sets of forecasts. Table 2.2 illustrates the base operating plan.

Table 2.2: Description of the Base Operating Plan

Station	Frequency	Cumulative Distance*	Cumulative Travel Time*	Fare ($)**	Maximum Speed (mph)***
Target Field	8 round trips/day	0	0	0	79
Coon Rapids		13	15	4	90
Cambridge		43	41	12	110
Hinckley****		78	67	23	90
Superior		147	126	43	90
Duluth		152	139	44	n/a

** Represent distance and travel time from Target Field Station*

*** Fare from Target Field Station, based on an assumption of $0.29/mile, rounded to the nearest dollar.*

**** Represents maximum speed on the segment beginning at the station in the northbound direction. For example, the 110 MPH maximum speed for Cambridge represents the maximum speed on the segment between Cambridge and Hinckley.*

***** Hinckley station is assumed to be located in downtown Hinckley*

2.4 Fare Optimization

After the modeling methodology and base operating plan forecasts were approved by the Peer Panel, the fare optimization was performed. Ridership and revenue levels were forecast for fare structures varying between 10 and 30 cents per mile, with $0, $5 and $10 boarding fees. Figure 2.2 plots the estimated 2020 annual NLX ticket revenue (for the base operating plan) as a function of varying per mile fare levels. Separate lines are plotted for $0, $5 and $10 boarding fees.

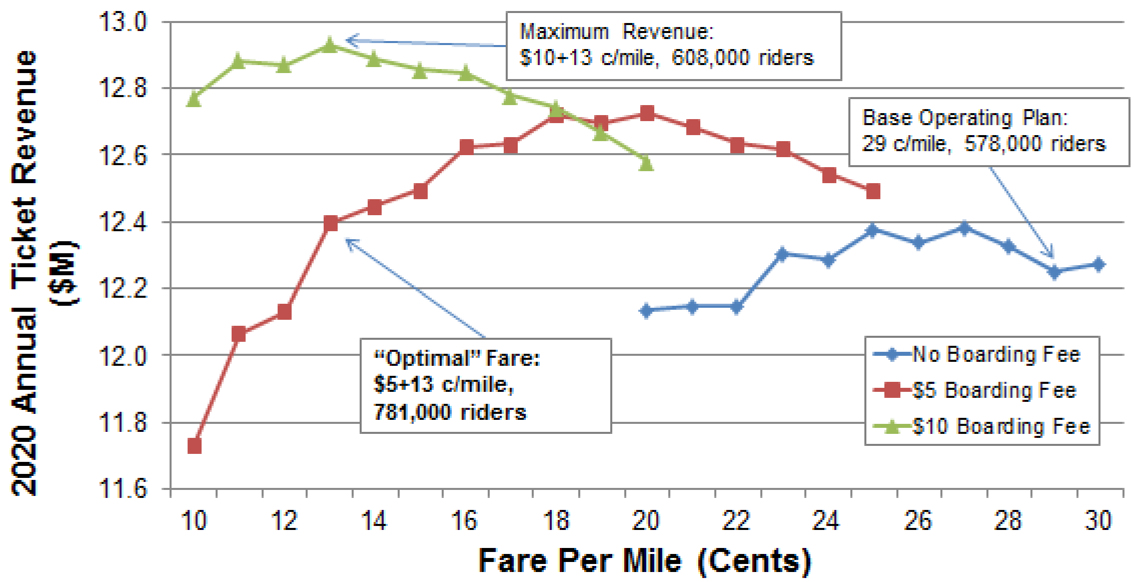
As Figure 2.2 shows, it was possible to achieve significantly higher ridership than the Base Operating Plan forecast[5] by changing the fare structure keeping the ticket revenue level almost the same, because the higher ridership offset the reduced ticket revenue per rider. Although optimal revenue could be achieved with a fare of $10 + 13 cents per mile, that structure did not provide significantly more riders than the Base Operating Plan structure ($0 + 29 cents per mile). Therefore, with MnDOT's approval it was decided to use $5 + 13 cents per mile fare structure,

[4] *Northern Lights Express Service Development Plan*, Quandel Consultants, LLC in association with SRF Consulting Group, Inc., March 2013.

[5] The 578,000 riders shown for the base operating plan in Figure 2.2, as well as the other ridership and revenue results for the other fare amounts, were the forecasts prior to the March model revisions discussed in the introduction. There was no need to redo this analysis, because it illustrates relative ridership between scenarios, which would not change significantly based on the model revisions that were made. In addition, this fare optimization will also be redone and finalized after the preferred alternative is selected.

which increased the 2020 annual ridership forecast by about 35% (781,000 vs. 578,000) and consequently resulted in higher public benefits in addition. All service option forecasts presented in this report other than the Base Operating Plan used this $5 + 13 cents per mile structure.

Figure 2.2: Fare Optimization Model Output



2.5 Service Options Tested in Developing the Optimum Operating Plan

SDG tested 17 possible service options with the optimal fare of $5 + 13 cents per mile, including the Base Operating Plan. The options were provided by Quandel Consultants between November 2014 and April 2015. The train schedules for each service option are provided in Appendix E to this report. The train schedules, which incorporate travel times between all station pairs, maximum speed, train frequency and stopping pattern (Express vs. Local), were all that varied between the service options.

Table 2.3 provides a summary of all the service options tested. Note the nomenclature of each option with the first letter representing the maximum speed and the second letter (the numerical portion) representing different frequency characteristics. All options named with first letter "B" correspond to a maximum train speed of 110 MPH, all options with a first letter "C" have a maximum of speed of 90 MPH, and the "D" options have a maximum speed of 79 MPH. Option A represents the Base Operating Plan with the optimal fare structure.

Table 2.3: Summary of Service Options Tested in Development of Optimum Operating Plan

Option Name	Maximum Train Speed (MPH)	End-to-end Travel Time (min)	Number of Trains / Day			
			Local	Express*	Short**	Total
A	110	139	8			8
B1	110	142-147	4			4
B2	110	142-152	6			6
B3	110	134-147	1	2	1	4
B4	110	133-152	6	2		8
B5	110	133-154	3	1	1	5
B10	110	142	2			2
B11	110	142-152	8			8
C1	90	153-158	4			4
C2	90	153-158	6			6
C3	90	146-158	1	2	1	4
C4	90	142-158	6	2		8
C5	90	142-164	3	1	1	5
C10	90	153	2			2
C11	90	153-158	8			8
D1	79	163-168	4			4
D3	79	157-168	1	2	1	4

** Express trains in options B3, C3 and D3 stop only at Target Field, Coon Creek, Superior and Duluth. Express trains in options B4, B5, C4 and C5 stop only at Target Field, Superior and Duluth.*

*** "Short" trains run and make all stops between Target Field and Hinckley.*

3 Travel Demand Model Outputs

The travel demand model was applied for an assumed project opening year of 2020 and a horizon year of 2040, to produce forecasts of ridership and revenue for both years. Forecasts for other years were calculated by interpolation or extrapolation from the 2020 and 2040 outputs.

The travel demand model produced ridership forecasts for each station pair, and for business/commute and non-business travel purposes. Results of the model output are reported in the remainder of this chapter. All forecasts are annual totals or averages, and **all monetary amounts are in constant 2013$**.

3.1 Annual In-Scope Demand

Detailed descriptions of the existing auto, bus, and air travel market demands are available in the "NLX No-Build Travel Demand Memo", included as Appendix B to this report. However, this section presents a summary of the annual in-scope demand used in the travel demand models to produce the NLX ridership and revenue figures.

Based on calibrated AirSage data, the 2020 'gross' travel demand was estimated to be 3.57 billion trips, representing all travel within the study area. In-scope demand was then computed by ruling out origin-destination pairs that are highly unlikely to use the proposed NLX service using the set of criteria (filters) described in section 5.5.1.

After applying these filters to the gross demand, the demand from the airport choice market (not included in the AirSage data and not subject to the filters described above) was added and split equally between Target Field to Duluth and Duluth to Target Field. The resulting total in-scope demand was 26.1 million trips for year 2020 and 30.3 million trips for year 2040. Table 3.1 shows the 2020 and 2040 in-scope demand broken out by current travel market. Table 3.2 and Table 3.3 show the total in-scope demand by station pair for 2020 and 2040, respectively. The demand from current air travelers was determined separately, as described in Appendix B.

Table 3.1: Annual In-Scope Demand by Travel Market

Market	2020	2040
Current Auto Travelers	25,852,400	30,022,600
Current Intercity Bus Travelers	46,600	51,500
Current Air Travelers	179,300	267,300
Total	26,078,300	30,341,400

Table 3.2: 2020 Annual In-Scope Demand by Station Pair

	Target Field	Coon Rapids	Cambridge	Hinckley	Superior	Duluth	Total
Target Field			2.77 M	2.06 M	1.35 M	1.78 M	**7.96 M**
Coon Rapids			0.17 M	1.79 M	0.51 M	0.76 M	**3.24 M**
Cambridge	2.74 M	0.17 M		0.06 M	0.21 M	0.25 M	**3.43 M**
Hinckley	2.09 M	1.98 M	0.06 M		0.87 M	0.45 M	**5.45 M**
Superior	1.33 M	0.48 M	0.20 M	0.86 M			**2.87 M**
Duluth	1.75 M	0.71 M	0.24 M	0.43 M			**3.13 M**
Total	**7.90 M**	**3.35 M**	**3.45 M**	**5.20 M**	**2.94 M**	**3.24 M**	**26.08 M**

Table 3.3: 2040 Annual In-Scope Demand by Station Pair

	Target Field	Coon Rapids	Cambridge	Hinckley	Superior	Duluth	Total
Target Field			3.47 M	2.23 M	1.51 M	1.93 M	**9.14 M**
Coon Rapids			0.22 M	2.07 M	0.58 M	0.85 M	**3.72 M**
Cambridge	3.55 M	0.22 M		0.08 M	0.26 M	0.31 M	**4.42 M**
Hinckley	2.30 M	2.31 M	0.08 M		1.03 M	0.51 M	**6.24 M**
Superior	1.49 M	0.55 M	0.25 M	1.03 M			**3.32 M**
Duluth	1.91 M	0.81 M	0.30 M	0.49 M			**3.50 M**
Total	**9.24 M**	**3.90 M**	**4.32 M**	**5.89 M**	**3.38 M**	**3.60 M**	**30.34 M**

Note that the in-scope demand applies to all service options.

3.2 Annual Ridership and Revenue

The probabilities of diversion from the current travel mode to NLX are computed with the mode choice models described in chapter 6 and in the various appendices to this report (especially in Appendix C). Induced demand, where applicable, is added to determine the overall ridership forecasts. Finally, the NLX fare is multiplied by the ridership for each station pair; adding all the station pairs together gives the NLX ticket revenue forecast.

Across the base operating plan and the 17 service options run with the optimal fare structure, the travel demand models forecast total NLX ridership to vary between 431,000 and 900,000 for the year 2020 and between 511,000 and 1,181,000 for the year 2040. Ticket revenue varied between $6.65 and $14.09 million for 2020 and between $7.89 million and $18.30 million for 2040. Table 3.4 presents a summary of total annual ridership and revenue forecasts for 2020 and 2040 for the Base Operating Plan and each of the service options.

Table 3.4: Summary of Annual Ridership and Revenue for NLX Service Options

Option Name	Max. Speed (MPH)	Trains Per Day	Ridership 2020 ('000)	Ticket Revenue 2020 ($million)	Ridership 2040 ('000)	Ticket Revenue 2040 ($million)
Base Operating Plan*	110	8	653	13.66	875	18.12
A	110	8	900	14.09	1,181	18.30
B1	110	4	753	11.72	988	15.22
B2	110	6	819	12.76	1,076	16.58
B3	110	4**	615	9.68	809	12.57
B4	110	8**	832	13.10	1,093	17.04
B5	110	5**	717	11.17	943	14.55
B10	110	2	465	7.25	551	8.60
B11	110	8	857	13.36	1,126	17.39
C1	90	4	698	10.74	919	14.01
C2	90	6	764	11.78	1,005	15.37
C3	90	4**	568	8.85	751	11.55
C4	90	8**	780	12.20	1,028	15.92
C5	90	5**	675	10.43	889	13.60
C10	90	2	431	6.65	511	7.89
C11	90	8	804	12.45	1,060	16.26
D1	79	4	648	9.91	856	12.96
D3	79	4**	526	8.13	698	10.65

** The base operating plan had a fare structure of $0 + 29 cents per mile. All other options had a fare structure of $5 + 13 cents per mile.*

*** Options ending in "3" or "4" include2 express trains per day. Additionally, options ending in "3" include one short train per day operating only between Target Field and Hinckley. Options "5" include one express train and one short train.*

3.3 Detailed Ridership Data for Service Option B2

The remainder of this chapter presents in more detail the ridership forecasts for service option B2, including ridership by market, trip purpose, and origin-destination pair, diversion percentages, and access / egress splits. These ridership breakdowns, in relation to the total ridership forecast, do not vary significantly between service options, so this section is limited to a single option in this report; analogous details for other options are available if needed.

Option B2 (with a maximum speed of 110 MPH, and 6 local trips per day) results are presented in more detail as it is a strong contender for the preferred alternative, offering one of the best trade-offs between ridership and operating costs. Similar detailed results were reported for the Base Operating Plan in July 2014.

3.3.1 Ridership By Market

Table 3.5 shows the ridership forecasts and diversion percentages for 2020 and 2040, broken out by current travel mode. The diversion percentages illustrate that although NLX will divert a small percentage of current auto travelers, it is very competitive when compared to current intercity bus service, and will divert a significant portion of current air travelers as well.

Table 3.5: NLX Ridership Forecasts By Market – Service Option B2

Current Travel Mode	2020			2040		
	In-Scope Demand	Ridership	Pct. Diverted	In-Scope Demand	Ridership	Pct. Diverted
Auto	25,852,400	673,300	2.6%	30,022,600	890,200	3.0%
Bus	46,600	43,300	92.9%	51,500	47,800	92.8%
Air	179,300	46,100	25.7%	267,300	68,800	25.7%
Induced	n/a	56,500	n/a	n/a	68,800	n/a
Total	26,078,300	819,300	3.1%	30,341,400	1,075,600	3.5%

3.3.2 By Trip Purpose

Table 3.6 shows the ridership forecasts and diversion percentages for 2020 and 2040, broken out by trip purpose. Note that induced demand is assumed to be entirely non-business, and there is no distinction made between air travel trip purposes in the airport choice model, so that is reported on a separate line.

Table 3.6: NLX Ridership Forecasts By Trip Purpose – Service Option B2

Trip Purpose	2020			2040		
	In-Scope Demand	Ridership	Pct. Diverted	In-Scope Demand	Ridership	Pct. Diverted
Business/Commute	7,102,500	418,400	5.9%	8,632,200	547,300	6.3%
Non-Business	18,796,500	354,700	1.9%	21,442,000	459,500	2.1%
Total Air	179,300	46,100	25.7%	267,300	68,800	25.7&
Total	26,078,300	819,300	3.1%	30,341,400	1,075,600	3.5%

NLX is predicted to divert higher percentages of current business/commute travelers than non-business travelers, for the following major reasons:

- Higher auto operating costs are assumed for business/commute trips;
- A higher percentage of business/commute trips occur during periods of highway congestion; and
- Business/commute travelers are more willing in general to use the rail mode for their travel, due to the lower variability in travel time, their ability to use the time on the train more productively and their lower sensitivity to costs.

3.3.3 By O-D Pair

Table 3.7 and Table 3.8 show the forecast 2020 annual ridership and revenue, respectively at a station pair level. Note that trips within MPO areas (between Target Field and Coon Rapids or between Superior and Duluth) are not part of the in-scope demand.

Table 3.7: 2020 Annual Ridership by Station Pair – Service Option B2

	Target Field	Coon Rapids	Cambridge	Hinckley	Superior	Duluth	Total
Target Field			118,600	53,600	48,000	34,400	**254,600**
Coon Rapids			16,300	62,500	8,800	14,000	**101,600**
Cambridge	118,600	16,300		5,600	3,200	4,800	**148,500**
Hinckley	53,600	62,500	5,600		22,700	17,200	**161,600**
Superior	48,000	8,800	3,200	22,700			**82,700**
Duluth	34,400	14,000	4,800	17,200			**70,400**
Total	**254,600**	**101,600**	**148,500**	**161,600**	**82,700**	**70,400**	**819,300**

Table 3.8: 2020 Annual Revenue by Station Pair (Million $) – Service Option B2

	Target Field	Coon Rapids	Cambridge	Hinckley	Superior	Duluth	Total
Target Field			$ 1.30	$ 0.80	$ 1.15	$ 0.86	**$ 4.12**
Coon Rapids			$ 0.15	$ 0.81	$ 0.19	$ 0.32	**$ 1.47**
Cambridge	$ 1.30	$ 0.15		$ 0.06	$ 0.06	$ 0.09	**$ 1.66**
Hinckley	$ 0.80	$ 0.81	$ 0.06		$ 0.32	$ 0.26	**$ 2.25**
Superior	$ 1.15	$ 0.19	$ 0.06	$ 0.32			**$ 1.72**
Duluth	$ 0.86	$ 0.32	$ 0.09	$ 0.26			**$ 1.53**
Total	**$ 4.12**	**$ 1.47**	**$ 1.66**	**$ 2.25**	**$ 1.72**	**$ 1.53**	**$ 12.76**

Table 3.9 and Table 3.10 show the forecast 2040 annual ridership and revenue at a station pair level.

Table 3.9: 2040 Annual Ridership by Station Pair – Service Option B2

	Target Field	Coon Rapids	Cambridge	Hinckley	Superior	Duluth	Total
Target Field			170,600	67,600	63,800	41,800	**343,800**
Coon Rapids			21,000	78,300	10,900	17,400	**127,600**
Cambridge	170,600	21,000		7,000	4,500	6,800	**209,900**
Hinckley	67,600	78,300	7,000		27,800	20,200	**200,900**
Superior	63,800	10,900	4,500	27,800			**107,000**
Duluth	41,800	17,400	6,800	20,200			**86,200**
Total	**343,800**	**127,600**	**209,900**	**200,900**	**107,000**	**86,200**	**1,075,600**

Table 3.10: 2040 Annual Revenue by Station Pair (Million $) – Service Option B2

	Target Field	Coon Rapids	Cambridge	Hinckley	Superior	Duluth	Total
Target Field			$ 1.88	$ 1.01	$ 1.53	$ 1.04	**$ 5.47**
Coon Rapids			$ 0.19	$ 1.02	$ 0.24	$ 0.40	**$ 1.85**
Cambridge	$ 1.88	$ 0.19		$ 0.07	$ 0.09	$ 0.13	**$ 2.35**
Hinckley	$ 1.01	$ 1.02	$ 0.07		$ 0.39	$ 0.30	**$ 2.80**
Superior	$ 1.53	$ 0.24	$ 0.09	$ 0.39			**$ 2.25**
Duluth	$ 1.04	$ 0.40	$ 0.13	$ 0.30			**$ 1.88**
Total	**$ 5.47**	**$ 1.85**	**$ 2.35**	**$ 2.80**	**$ 2.25**	**$ 1.88**	**$ 16.58**

3.3.4 Diversion Percentages

Table 3.11 shows the modeled diversion percentages for service option B2 in year 2020 at a station-pair level. Note that all the demand on the NLX service for travel between Coon Rapids and Cambridge and between Cambridge and Hinckley are generated from around the vicinity of these stations due to the narrowly defined catchment areas for those two particular station pairs. As a result, the diversion percentages to NLX from the existing auto mode are high for these station pairs. This is further discussed in section 5.5.1. Other than those special cases, the highest diversion is between Target Field Station and Cambridge. There are several reasons for this:

- About 45% of in-scope trips between Target Field and Cambridge are business/commute trips, compared to 30% of in-scope trips overall; and
- Roadway congestion between these two stations is higher as a percent of the entire trip than between any other pair of non-adjacent stations on the proposed service.

In addition to the above factors, a discussion on the level of ridership between Target Field and Cambridge is provided in section 4.3.

Table 3.11: 2020 NLX Diversion Percentages by Station Pair – Service Option B2

	Target Field	Coon Rapids	Cambridge	Hinckley	Superior	Duluth	Total
Target Field			4.3%	2.6%	3.6%	1.9%	**3.2%**
Coon Rapids			9.1%*	3.5%	1.7%	1.9%	**3.1%**
Cambridge	4.3%	9.3%*		9.7%*	1.6%	1.9%	**4.3%**
Hinckley	2.6%	3.2%	8.9%*		2.6%	3.8%	**3.0%**
Superior	3.6%	1.8%	1.6%	2.6%			**2.9%**
Duluth	2.0%	2.0%	2.0%	4.0%			**2.3%**
Total	**3.2%**	**3.0%**	**4.3%**	**3.1%**	**2.8%**	**2.2%**	**3.1%**

* Special cases, due to narrower definition of catchment area

The diversion percentages are also reasonable given the base operating plan service characteristics of NLX. These are similar to other intercity passenger rail studies. For example, in the Atlanta-Charlotte corridor High-Speed and Intercity Passenger Rail Study, diversion percentages close to 2% were estimated for 79 mph and 110 mph maximum speed on existing Amtrak alignment. For a Core Express type of service (220 mph or higher maximum speed) for this corridor, the diversion percentage was significantly higher at more than 8%. Similarly, for Amtrak's proposed NextGen High-Speed Rail Service (also Core Express type of rail service as defined by the FRA) in the Northeast Corridor, high single digit diversion percentages were observed.

3.3.5 Access/Egress Splits

One component of the travel demand model is an access/egress model which estimates the probability of accessing or egressing the NLX service by each of six different access/egress modes: drive and park, drop-off or pick-up, walk, rental, taxi and transit. This model is described in detail in the "NLX Mode Choice Models Memo", included as Appendix C to this report.

Table 3.12: Station Level NLX Access/Egress Probabilities

Station	Rail Access Probability						Rail Egress Probability					
	Drive/ Park	Walk	Drop-off	Rent car	Taxi	Transit	Drive/ Park	Walk	Pick-up	Rent car	Taxi	Transit
Target Field	34%	0.4%	44%	2.6%	2.7%	16%	0%	0.8%	68%	5.9%	4.4%	21%
Coon Rapids	41%	0.2%	40%	3.1%	2.0%	14%	0%	0.2%	79%	7.0%	3.6%	10%
Cambridge	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
Hinckley	81%	0%	0%	0%	0%	19%	0%	0%	81%	0%	0%	19%
Superior	71%	0.5%	25%	1.8%	2.0%	0%	0%	1.1%	91%	3.8%	3.6%	0%
Duluth	46%	1.8%	45%	2.9%	3.9%	0%	0%	3.6%	83%	6.2%	6.9%	0%
Total	71%	0.3%	20%	1.3%	1.4%	6%	0%	0.7%	82%	3.8%	3.0%	10%

Table 3.12 shows the modeled access and egress splits aggregated to an NLX station level. A few things should be noted about the results above:

- The airport choice market is not included in the above figures (we can assume similar access/egress modal percentages for MSP and DLH for the airport choice market as was calculated for Target Field and Duluth, respectively).
- Access and egress choice were not modeled for the two stations outside of the major MPOs.
  - For the Cambridge station, all access and egress was assumed to be by auto mode. It is displayed in the table as drive and park access and pick-up egress. In reality, the access would likely be split between drive and park and drop-off/pick-up (we will use estimates from the SP survey to calculate the access splits between drive/park and drop off for these two stations).
  - For the Hinckley station, the 19% transit share was estimated using the percentage of trips to or from Hinckley station with origins or destinations in the Grand Casino Hinckley zone, assuming these passengers will use a shuttle between the NLX station and the casino. The remainder of access and egress was treated similar to Cambridge.
- Although some local bus transit serves the Duluth area, the Duluth MPO model does not include this mode, so it was not possible to model it in the same way as it was modeled for the Twin Cities region stations.
- Walk mode access and egress is highest for Duluth, due to the station's downtown location.
- The access splits between drive and park and drop-off are very sensitive to the assumed station parking cost; SDG currently is assuming that parking will cost $10 / day at Target Field Station, and will be free at other stations.

4 Reasonableness Checking

Any forecast of ridership and revenue on a transportation service that does not yet exist is inherently uncertain as there has been no track record of the performance of such “Greenfield” transportation service. Any modeling for such service like NLX has to be based on “hypothetical” Stated Preference (SP) data as “actual” Revealed Preference (RP) data on the patronage of the service is not available. If NLX had already been built, the general level of ridership would be known, and any estimates of future ridership would have a far higher level of confidence.

However, since intercity rail between Minneapolis and Duluth has not existed in nearly 30 years, there is no RP data available; the only sources of data against which to check the reasonableness of the model output are external. In this section, we present a few of these sources and compare the ridership and revenue outputs of the base operating plan against these to gauge the reasonableness of the forecasts for the NLX service. These sources include:

- Ridership on several existing Amtrak routes similar to NLX;
- Other recent intercity rail project forecasts performed by SDG;
- Census journey to work and LEHD data to validate the level of modeled ridership between Target Field and Cambridge; and
- Industry induced demand data and forecasts to validate the level of modeled induced demand.

It is also possible to check the reasonableness of model results internally. Two ways of doing this are:

- Sensitivity analysis, where one variable is changed at a time to check the model’s reasonableness, adequacy, functionality of components, and, most importantly, the results.
- Reviewing output at a more detailed “sample cell” level.

Both of these analyses were performed in conjunction with the Base Operating Plan ridership forecasts in the spring of 2014 as part of the model development, and the results are included below in sections 4.5 and 4.6.

Note that the comparisons in this chapter are done with the NLX Base Operating Plan ridership forecasts, but are equally valid with any of the 15 other scenarios tested with optimal fare, because the ridership forecasts are all within the same order of magnitude.

4.1 Comparison to Similar Existing Amtrak Service

4.1.1 Ridership

The most valuable revealed preference data that is possibly available is the actual ridership on existing Amtrak routes. It is not common to have a proposed passenger rail service like NLX that has similarities to a few existing Amtrak routes against which it can be compared. Although there is no one Amtrak line which replicates NLX service characteristics and the cities/communities it serves precisely, there are several routes which share one or more characteristics, including serving corridors with similar populations, similar distances, speeds, and/or frequencies. Furthermore, by comparing several different routes' ridership and seeing how NLX's characteristics compare to these routes, one can get a sense of the reasonableness of the ridership estimates being forecast for NLX as part of this study. Table 4.1 shows several routes' key characteristics along with the ridership on these routes in FY13, with a row for the year NLX 2020 forecasts at the bottom. Figure 4.1 plots ridership and the combined population of the two major markets for each route.

Table 4.1: Comparison of NLX to Similar Amtrak Routes

Route	Cities Served	Total Population of Origin and Destination Cities (million)	Frequency (Trains / Day)	End to End Distance (miles)	End to End Travel Time	Average Speed (MPH)	FY13 Annual Ridership (thousands)
Downeaster	Boston – Portland	5.2	5	116	2 h 30 m	46	560
Hiawatha	Chicago – Milwaukee	11.1	7	86	1 h 29 m	58	821
Empire	New York – Albany	15.1	9	141	2 h 30 m	56	1081
Wolverine	Chicago – Detroit	9.6	3	304	7 h 43 m	39	509
Lincoln Service	Chicago – St. Louis	12.3	4	284	5 h 20 m	53	655
MO River Runner	St. Louis – Kansas City	4.9	2	283	5 h 40 m	50	199
Piedmont	Raleigh – Charlotte	3.5	2	173	3 h 10 m	55	170
NLX*	Minneapolis - Duluth	3.7	8	152	2 h 19 m	66	653

* Year 2020 Base Operating Plan Forecast with $0 + 29 cents per mile fare structure

Figure 4.1: NLX and Similar Amtrak Routes: Ridership vs. Key City Populations

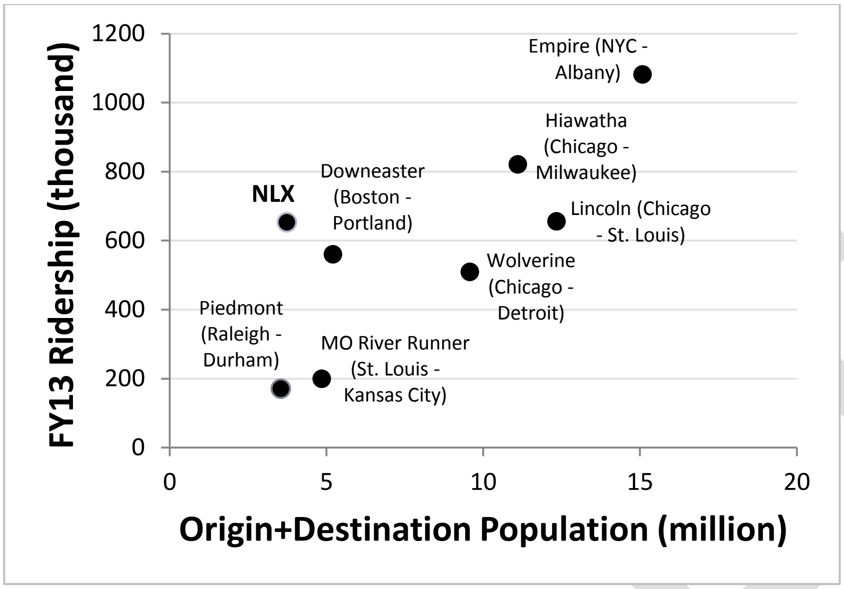


Table 4.1 and Figure 4.1 suggest that the year 2020 forecast of 653,000 is in line with the general trends suggested by the recent ridership figures on existing state-supported (shorter distance) Amtrak routes. Some key observations are:

- Downeaster's ridership was similar in FY13 (560,000) in spite of serving a higher population at its endpoint cities (5.2 million vs. 3.7 million for NLX), but as Table 4.1 shows, NLX would run faster on average and more frequently, so it seems reasonable to expect the two to have comparable ridership levels.
- Empire is the route with the closest daily frequency to that of NLX (as assumed in the base operating plan), but it serves more than 4 times as many people including New York City where many residents do not own automobiles. This can easily explain why it would experience nearly double the ridership of NLX.
- The Wolverine and Lincoln routes have similar ridership levels to the NLX forecast, in spite of serving 2-3 times as many people at their major cities; however, they run less frequently and slower on average, and unlike most of these routes, the Wolverine travel time is long enough to make air travel a more attractive option.
- The Piedmont and MO River Runner routes are the ones which serve the closest level of population to that of NLX, but both routes only run twice per day, which is a reasonable explanation for the far lower ridership on these routes.

We believe the overall comparison provides several valuable data points that suggest that the base operating plan ridership (653,000), as forecasted by the SDG travel demand model system developed as part of this study, is a realistic expectation for NLX annual ridership in 2020.

4.1.2 Trip Purpose Splits

According to the AirSage cell phone data, about 29% of the travel in the NLX corridor is home-based work travel, i.e. travel for business or commute purposes. Since the methodology AirSage uses for determining trip purpose is based on how frequently and at what times people make trips, it can be assumed that most of the travel of this type is commuting. However, the forecasts from SDG's models predict that roughly 55% of NLX travel will be for business or commuting. This is higher than most current Amtrak routes, according to recent survey data, but in line with existing Amtrak routes that are primarily designed for commuting, such as Hiawatha (Chicago-Milwaukee) or Keystone (Harrisburg-Philadelphia). The primary reason for this is that the portion of the corridor on which NLX travel times and costs are most competitive with automobile travel is between Minneapolis and Cambridge. Most of the traffic congestion on the corridor occurs between Minneapolis and Cambridge, and the high cost of parking in downtown Minneapolis makes trips destined for Minneapolis more likely to consider train travel as well.

It should also be noted that two of the model's parameters, the auto operating cost per mile and the modal constants in the mode choice model, are both more favourable towards business/commute travel purpose and hence are also key contributors to the predicted trip purpose splits mentioned above.

4.1.3 Average Trip Length as a Percentage of Corridor Length

The average trip length (in train miles) in SDG's forecasts varies between 79 and 82 miles, or between 52% and 54% of NLX's 152 mile track length.[6] Other Midwestern Amtrak routes vary considerably, between 58% (Chicago-Carbondale) and 93% (Chicago-Milwaukee). We believe it is reasonable for NLX to be at or below the low end of this range, because:

- In contrast to most Amtrak routes which have a large city at either end, the majority of the population of the NLX region is concentrated at one end of the corridor;
- The congestion on parallel highways is also concentrated at one of the corridor; and
- There is a major trip attractor – the Grand Casino Hinckley – halfway across the corridor

4.2 Other Intercity Rail Project Forecasts

Some examples of recent intercity rail forecasts performed by SDG, using the same methodology that was used in preparing the NLX forecasts for this study, are:

- Improvements to Lincoln Service (Chicago-St. Louis);
- Colorado Inter-regional Connectivity Study (ICS);
- Atlanta-Charlotte Intercity Passenger Rail Tier 1 EIS Study; and
- ZipRail (Twin Cities-Rochester).

The details of the mode choice model coefficients, operating plans and ridership and revenue forecasts for these projects are proprietary, but Table 4.2 shows that the components of the models were very similar.

Nearly every project in Table 4.2 used AirSage cell phone data successfully. And although budgetary constraints prevented two of the projects from conducting original SP surveys, the structural form of the mode choice model was the same as for the projects which did use surveys, and they used the same input variables as well. Every one of these projects used the basic process

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[6] The lone exception to this is the original SDP, where it Is 73 miles. The SDP assumes fares of 29 cents / mile, without a boarding fee, which favors shorter trips compared to all other scenarios which assume a fare of $5 + 13 cents/mile.

flowchart shown in Figure 6.1, with only minor differences (such as only including intercity air or bus in cases where it was applicable).

Table 4.2: Components of Intercity Rail Mode Choice Model for Other SDG Ridership Forecasting Studies

Study Name	Auto Trip Table Source	Stated Preference Survey?	Form of Mode Choice Model	Input Variables for Mode Choice Model				
				In-Vehicle Time	Cost	Train Wait Time	Train Access Time	Train Frequency
Lincoln Service (Chicago-St. Louis)	AirSage cell phone data	Yes	Binary logit	X	X	X	X	X
Colorado ICS	AirSage cell phone data	Yes	Binary Logit	X	X	X	X	
Atlanta-Charlotte	AirSage cell phone data	No	Binary logit	X	X	X	X	X
ZipRail (Twin Cities-Rochester)	HH Surveys, Traffic Counts	No	Binary logit	X	X	X	X	X
NLX	AirSage cell phone data	Yes	Binary logit	X	X	X	X	X

Furthermore, with one of these studies, the Lincoln Service improvements, there was revealed preference data, (i.e. actual Amtrak ridership data from FY13) to validate the model's results. The binary logit mode choice (diversion) models (existing auto vs. rail and existing bus vs. rail) used for the Lincoln Service improvements study had the exact same structural forms as the ones being used for the NLX study. Moreover, those models were developed from SP survey data, and only minor modifications were required to calibrate it to actual ridership data. After the modifications, the model produced ridership estimates which were within 20% of actual ridership for all four of the major stations on the corridor (Chicago, Bloomington-Normal, Springfield and St. Louis), within 10% of actual ridership for the route as a whole, and which approximated travel patterns closely enough that no adjustments were necessary to produce reasonable-looking forecasts. This gives considerable additional confidence in the methodology and model structures used for this study and consequently the resulting NLX ridership and revenue forecasts.

4.3 Validating Cambridge to Target Field Market

The Target Field/Cambridge origin-destination pair has several outputs which are the highest of any station pair, including[7] (for 2020):

- In-scope demand of 3.4 million trips each way;
- 149,000 riders in each direction annually; and
- Diversion probability of 4.3%.

Several reasons were cited earlier in this report for the high diversion probability of 4.3%, including congestion, a higher percent of business/commute trips, and the flat fare structure.

[7] These figures correspond to the base operating plan.

Nevertheless, we believe the validity of these outputs ought to be checked with some external sources, to ensure their reasonableness.

One potential source is the US Census Transportation Planning Package (CTPP) Journey to Work Data. The most recent data available, based on the five year 2006-10 American Community Survey (ACS), estimate that about 6,000 people commute from either Isanti or Chisago County (which would likely be the general catchment area of the Cambridge NLX station) to Hennepin County. Multiplying the 6,000 by 235 commuting weekdays per year results in approximately 1.4 million commute trips annually. This would be about 41% of the total in-scope demand of 3.4 million trips each way, which is very close to the 45% implied in the AirSage anonymous cell phone data (discussed in section 3.3.4). Furthermore, although commute trips are typically 30-35% of all trips on average in most metropolitan regions, the relationship between these counties (Hennepin County being the employment center of the region, and Isanti and Chisago Counties being far enough away that non-work trips would often have closer options) is such that one would expect the percentage to be higher in this case.

Additional support for the ridership forecast can be found by looking at the Census Longitudinal Employer Household Dynamics (LEHD) data, which although slightly less accurate than survey data, has the added precision of tract-to-tract resident-workplace flows. Because of the large size of Hennepin County, much of it is too far from Target Field station to make commuting by NLX a feasible option. Using the LEHD data, one can estimate flows from residents of Isanti or Chisago Counties to the downtown area of Minneapolis bound by I-94, I-35W, and the Mississippi River. The data estimate that about 3,200 commuters fall into this category. Using an annualization factor of 235 again, this suggests about 750,000 trips per year. The intercity NLX rail ridership model forecasts that 99,900 of 148,500 round trips between these stations are business/commute trips, implying a commute share of about 13 percent (99,900 divided by 750,000), a very realistic figure in a corridor with significant peak highway congestion.

Finally, we can compare the model output to actual ridership on the North Star commuter rail service, which operates between Target Field and a corridor to the west of Cambridge. The line as a whole has nearly 800,000 riders in 2013, and Big Lake station, the terminus of the North Star line (and only slightly closer to Target Field than Cambridge), currently is on a pace to serve over 110,000 riders per year. The immediate area around Cambridge station (including Cambridge, Isanti and North Brach) has a slightly smaller population than the area around Big Lake station (including Big Lake and Monticello). But unlike Big Lake, the Cambridge NLX station would not have any other nearby stations to the south limiting the size of its service area in that direction. Furthermore, Woods & Poole socioeconomic data project that Isanti and Chisago counties will grow about 14% between 2013 and 2020, as compared to 7% for the region as a whole, so the forecast of 99,900 commute trips on NLX from Cambridge to Target Field in 2020 seems realistic.

4.4 Induced Demand Examples

As discussed in more detail in Appendix B, the level of induced demand is determined by a statistical model estimated using the stated preference (SP) survey data. However, it largely depends on a single survey question that asks respondents how many more trips they may be likely to make on the corridor if NLX were to be built. Due to the inherent uncertainty of SP data, it is therefore prudent to compare the output of the induced demand model to other studies as well as actual experience on intercity passenger rail services in the US and elsewhere where possible.

Table 4.3: Induced Demand Experience on Other Rail Lines

Project	Type	Year	City Pair	Dist (mi)	Initial Travel Time	Improved Travel Time	Induced Demand (%)
New Lines	Forecast	2030	London - Birmingham	110	82 mins	46 mins	18%
LGV	Observed	1985	Paris – Lyon	290	180 mins	115 mins	15%
Brazil TAV (Halcrow)	Forecast	2014	São Paulo – Rio de Janeiro	250	N/A	93 mins	13%
Brazil TAV (SDG)	Forecast	2016	São Paulo – Rio de Janeiro	250	N/A	93 mins	14%
Eurostar HS1	Observed	2008	London - Paris	250	155 mins	135 mins	6%
Amtrak NextGen	Forecast	2012	Washington DC - Boston	420	380 mins	185 mins	11%
NLX	Forecast	2014	Minneapolis - Duluth	150	N/A	139 mins	5%

Table 4.3 shows several examples of induced demand for intercity rail travel as a percentage of total rail demand, with a row for the year 2020 NLX output at the bottom. In three of the cases above (London-Birmingham, Paris-Lyon and Washington DC-Boston), the improvements being made represented 40-50% reductions in travel time on existing rail systems. In the two Brazil cases, the new line constructed was a high speed service, traveling 250 miles in 93 minutes. Therefore, it is not surprising that the induced demand (either observed or forecast) was considerably higher (between 11% and 18% of total ridership) than what is being forecast for NLX.. The one above example with a percentage close to NLX, London-Paris, represented a more modest 13% reduction in travel time. This is comparable to NLX's travel time reduction between Minneapolis and Duluth, so we believe that 5% is an appropriate level of induced demand for NLX's base operating plan.

It should be noted that induced demand is inherently a difficult phenomenon to estimate, even with revealed data, because it represents comparisons to an alternate scenario which never occurred. It is well recognized that survey responses pertaining to what people would do differently in hypothetical environments, particularly those which the respondents have never experienced (such as a new train line causing people to travel more often), have a large margin of uncertainty.

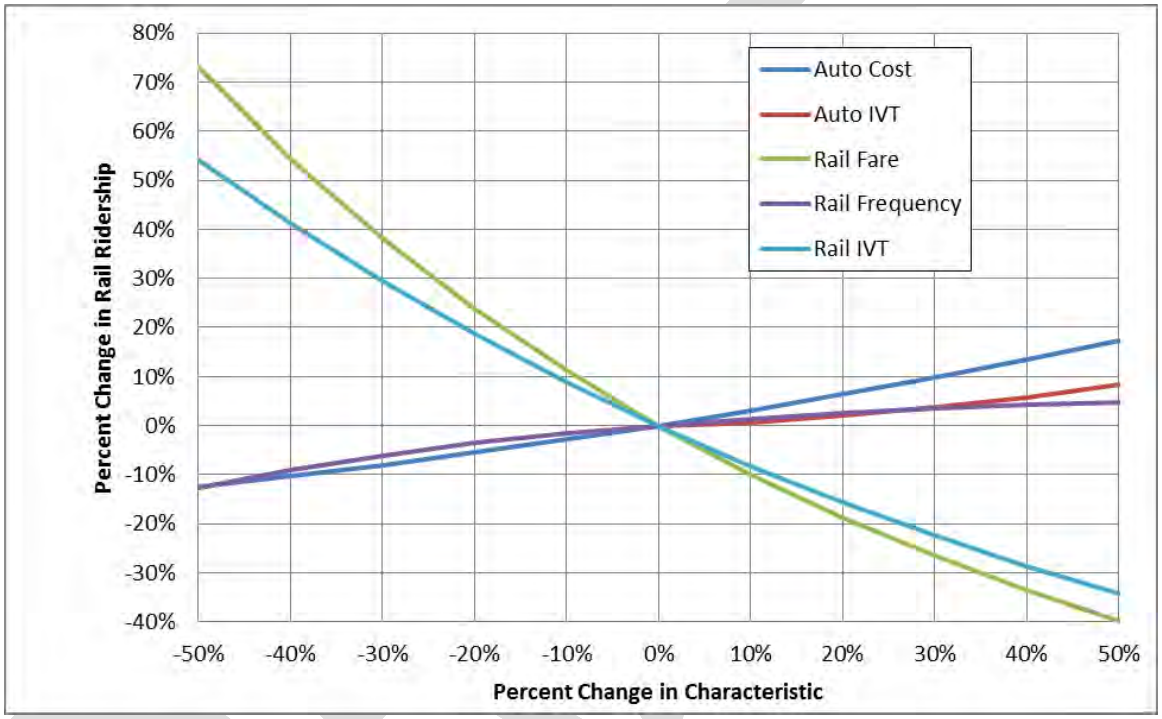
4.5 Sensitivity Analysis

A detailed sensitivity analysis was also performed on the Base Operating Plan forecasts, to test the sensitivity of NLX ridership with respect to key Level of Service (LOS) variables, including train fare, train in-vehicle time, train frequency, auto in-vehicle time, and auto operating cost. Note that the auto operating cost and auto IVT were only *increased* in the sensitivity analyses as it is not realistic to assume that auto travel on the corridor could become significantly faster or cheaper than its current level.

The base operating plan was used as the base case for the sensitivity analyses. However, although the train service characteristics vary from option to option the models and the modeling methodology remain the same. This means that the results of the sensitivity analysis remain valid for all the other service plans that have been already analyzed and the subsequent analyses that will be performed as part of the optimization process.

The sensitivity analysis results are shown in Figure 4.2. For each set of sensitivity analyses, the corresponding variable was varied from at 10% increments from its base level.

Figure 4.2: Sensitivity Analysis



Recognizing that there are many LOS variables other than the variable in question that impact train ridership, the impact of changes in a single variable is isolated by holding all other LOS variables constant at their base values. However, the ridership sensitivity has significant dependence on the values of these other variables in absolute terms as well as in relative terms to the value of the LOS variable in question and may exhibit different sensitivity depending on these. Consequently, NLX ridership sensitivity can be quite different for different values of the LOS variable (whose sensitivity is being tested) along the sensitivity curve on both sides of its base value.

All the sensitivity analyses were performed for the year 2020; correspondingly, all LOS variables and other input data used were for the year 2020.

The results of this analysis conform to expectations. Figure 4.2 shows that NLX ridership is slightly more sensitive to rail fares when fares are below the base levels than when fares are above the base levels. This can be explained by comparing NLX fares with auto costs. As even the base NLX fares calculated at $0.29 per mile are significantly higher than the base non-business auto operating cost of $0.16 per mile, ridership sensitivity is relatively lower at higher-than-base NLX fares. When NLX fares are significantly lower than the base levels, NLX starts to compete more effectively on cost with auto, which results in higher ridership sensitivity.

Similar to rail fares, NLX ridership is more sensitive to rail in-vehicle time with times below the base levels than above. Ridership sensitivity to rail in-vehicle times is lower compared to that of rail fares. As non-business travelers make up more than 70% of the traveling population, the higher sensitivity to cost is understandable. Moreover, it is more pronounced as the travel party size of non-business travelers is higher, which increases their sensitivity to rail fare.

Figure 4.2 shows that NLX ridership is quite insensitive to headway variation, especially at frequency levels at or higher than the base level of 8 round trips per day. This indicates that given the other service characteristics of the base operating plan, the base case has frequent service already in place. As a result, any further increases in frequency are not accompanied by proportional increases in ridership. However, the sensitivity curve becomes more steep near the 50% reduction in base frequency, when the service becomes quite infrequent.

The auto in-vehicle time sensitivity curve is less steep than the rail in-vehicle time sensitivity curve. As Table 3.12 shows, most NLX trips use some of form of auto access, so any changes in auto in-vehicle time have two opposite impacts on NLX ridership. Increases in auto in-vehicle times make NLX more attractive as it competes with auto for mode share. At the same time, it also increases the access/egress times to/from the NLX stations, which impacts it negatively. The combined effects of these two opposite impacts dictate the low sensitivity of NLX ridership to changes in auto in-vehicle time.

It is observed from Figure 4.2 that NLX ridership is also sensitive to auto operating cost changes than it is to rail fare changes. This is analogous to the reason why ridership is less sensitive to auto in-vehicle time than to rail in-vehicle time, as discussed in the above paragraph.

In addition to the sensitivity analysis described above, an unconstrained revenue maximizing analysis was performed for the base operating plan. This analysis was not meant to be conclusive about the revenue maximizing or optimal fare level but rather to emphasize the importance of optimization. The revenue-maximizing analysis determined the per-mile fare that maximizes the intercity revenue for the proposed NLX service.

To identify the revenue-maximizing fare, per-mile NLX fares were varied in +/-10% increments to +/-90% from the vase operating plan (and SDP) fare of $0.29/mile.

Figure 4.3 graphically presents the results of the revenue-maximizing analysis for the intercity travel markets.[8] As expected, with the increase/decrease in NLX fare, intercity rail ridership increases/decreases monotonically. As fare decreases, the slope of the ridership curve steepens, representing greater increases in ridership per fare unit. The ticket revenue curve is quite flat around the revenue-maximizing fare levels (i.e. at higher or lower fares in the vicinity of the revenue-maximizing fares), meaning that corresponding ticket revenue losses are quite minimal.

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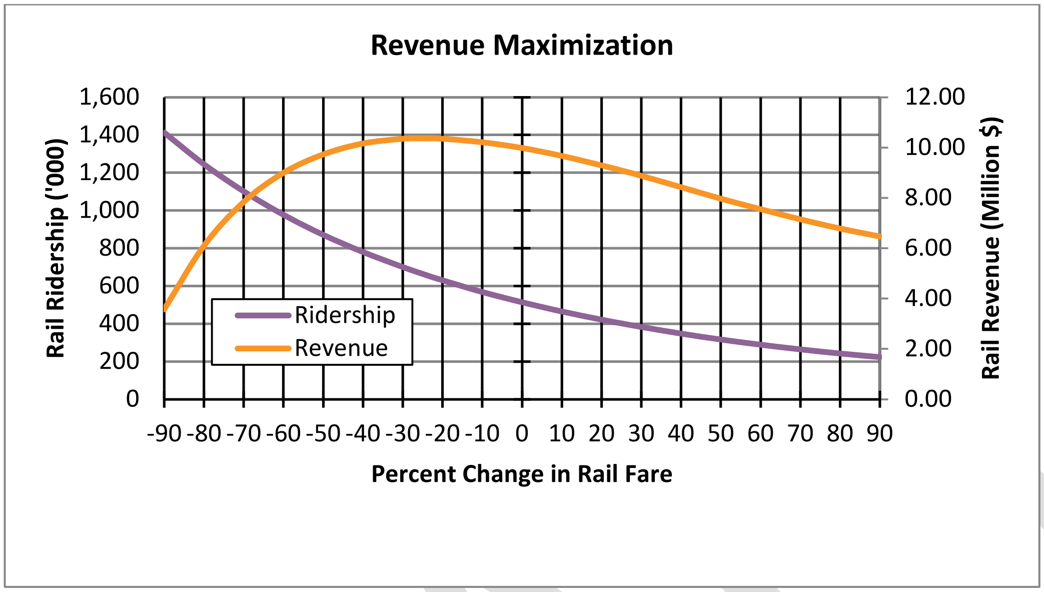
[8] As in Figure 2.2, the ridership numbers correspond to forecasts performed prior to March 2015 model revisions. However, as relative ridership and revenue between scenarios would not change significantly as a result of the revisions that were made, it was not necessary to revise this figure.

This follows the same trend that has been observed in many other HSIPR studies around the country and abroad.

Figure 4.3: Unconstrained Revenue Maximization Analysis



Indeed, Figure 4.3 shows that the NLX fare can be decreased by up to 40% of its base level of $0.29/mile without significant revenue losses. Maximum ticket revenue (about a 4% revenue increase from the base level) can be achieved at about a 25% fare reduction ($0.22/mile); however, even a 40% decrease in NLX fare to $0.17/mile results in a 51% ridership gain and a 2% revenue gain from the base level. As increased rail ridership also directly translates to higher levels of public benefits, such fare levels will be good starting points for the subsequent optimization process, while also acknowledging the possible negative implications of higher costs associated with higher ridership figures. Indeed, the optimum fare level for the NLX service was determined based on this principle while performing the fare optimization as was discussed earlier in this report under Section 2.4.

Sensitivity to Air Travel Growth Rate

The FAA's Terminal Area Forecast estimates the volume of air travelers in Minneapolis and Duluth to grow at a significantly higher rate than that estimated for automobile travel within the corridor. Since the number of NLX riders that can be diverted from air travel is based on the actual demand for air travel within the corridor, sensitivity tests were performed to analyse the impact of the air market growth rate on the NLX system-wide forecasts.

Table 4.4 shows the impact if the demand for air travel is assumed to grow at the same rate as automobile travel. The 2020 and 2040 passenger volume forecasts decrease by 2% or less with the lower growth rate. This highlights the small share of NLX ridership that is expected to be drawn from air passengers, and the relatively smaller influence of air growth rate assumptions on NLX system-wide forecasts.

Table 4.4: Estimated Total Corridor Ridership For Different Air Market Growth Rates

Year	Using FAA TAF Growth		Using Project Area Auto Travel Growth		Pct. Difference in Ridership
	Avg. Growth Rate	Total NLX Ridership	Avg. Growth Rate	Total NLX Ridership	
2020	1.9%	653,300	0.9%	649,800	0.5%
2040	2.0%	875,200	1.0%	857,900	2.0%

4.6 Sample Zone Pair Level Calculations

In the tables below, we present the key model inputs and outputs for a series of representative "cells" in the intercity mode choice model. The outputs come from the Base Operating Plan model runs in the spring of 2014.

Table 4.5: Sample Zone Pair Model Inputs in Off-Peak Period

Cell #	Origin	Destination	Trip Purpose	Existing Mode	NLX	
					Access Mode	Egress Mode
1	Downtown Minneapolis	Downtown Duluth	Business/Commute	Bus	Walk	Walk
2	Bloomington		Non-Business	Auto	Transit	Drop off
3	Minnetonka		Non-Business	Auto	Auto	Auto
4	Champlin		Non-Business	Auto	Rental car	Taxi
5	UMD (Duluth)	Downtown Minneapolis	Non-Business	Bus	Drop off	Transit
6	Saginaw		Business/Commute	Auto	Auto	Taxi
7	Superior		Non-Business	Auto	Auto	Drop off
8	Cambridge		Business/Commute	Auto	Auto	Auto
9	Downtown Minneapolis	Hinckley – City	Business/Commute	Auto	Drop off	Auto
10	White Bear Lake	Hinckley – Casino	Non-Business	Auto	Transit	Auto

Table 4.6: Annual Sample Zone Pair Model Outputs

Cell #	Sample Existing Mode				Rail						Diversion Probability
	IVT*	Out-of-Vehicle Time**	Total Time	Total Cost***	IVT	Access Time	Egress Time	Rail Fare	Total Time	Total Cost#	
1	2:50	0:04	**2:54**	**$31**	2:19	0:04	0:02	$44	**2:25**	**$44**	**4%**
2	2:44		**2:59**	**$31**	2:19	1:10	0:00	$44	**3:29**	**$45**	**3%**
3	2:49	0:15	**3:04**	**$32**	2:19	0:22	0:00	$44	**2:42**	**$54**	**2%**
4	2:25		**2:40**	**$29**	2:19	0:52	0:10	$44	**3:22**	**$68**	**3%**
5	2:50	0:09	**2:59**	**$31**	2:20	0:07	0:23	$44	**2:50**	**$46**	**5%**
6	2:43	0:15	**2:58**	**$64**	2:20	1:01	0:18	$44	**3:39**	**$67**	**1%**
7	2:27		**2:42**	**$34**	2:05	0:07	0:08	$43	**2:20**	**$48**	**4%**
8	1:07		**1:07**	**$29**	0:39	0:06	0:08	$12	**0:53**	**$13**	**23%**
9	1:33	0:00	**1:33**	**$27**	1:07	0:04	0:06	$23	**1:17**	**$24**	**7%**
10	1:07		**1:07**	**$10**	1:07	1:38	0:15	$23	**3:00**	**$24**	**0.5%**

* For bus travelers (cells 1 and 5), this represents the time spent on the bus. For auto travelers (all others), this represents the driving time and does not include the 15-minute rest stop assumption allocated to trips that exceed two hours' driving time.

** For bus travelers (cells 1 and 5), this represents the access/egress time to and from the bus station. For auto travelers (all others), this represents a 15-minute rest stop time assumed for trips that exceed two hours' driving time.

*** For bus travelers (cells 1 and 5), this is primarily the bus fare. For auto travelers (all others), this includes the auto operating cost and the parking cost.

This includes the access/egress cost for the modes outlined in Table 4.5.

4.6.1 Sample Diversion Percentages

Table 4.5 shows, for our representative cells, the origin and destination locations, trip purpose, existing travel mode, access mode to NLX and egress mode from NLX. The outputs, presented in Table 4.6, include the various travel times and costs of both the existing mode and the alternative trip made on NLX, and the estimated probability of diversion to NLX. Note that zones are smaller in urban cores; for example, the 'Downtown Minneapolis' zone presented below is only one of many zones in the core bound by I-94 and the Mississippi River, and is not meant to represent the entire city of Minneapolis. Two of the notable observations which can be made on the above two tables are:

- Cells 8 and 9 are the only ones where the total trip cost on the NLX alternative is less than the existing mode's total trip cost. Cell 8 in particular, a trip from Cambridge to Minneapolis, is a business/commute trip, and the existing mode involves parking in Downtown Minneapolis. The NLX alternative is slightly faster and costs considerably less. This is useful in understanding the high Cambridge – Target Field Station ridership presented in Table 3.7, and the higher diversion probability of this zone pair presented in Table 3.11.
- In many cells, such as 2, 4, 6 and 10, the access time is significant enough to offset the in-vehicle time savings that NLX provides compared to auto mode. This is useful in understanding

that the portion of the study area for which NLX is a more attractive travel option than auto may be limited to areas with easy access to the NLX stations.

4.6.2 Sample Access/Egress Splits

Table 4.7 and Table 4.8 display, for the same cells, the rail access and egress probabilities across all modes in the off-peak period - note that there are no time period differences in the Duluth Area MPO model or the non-MPO zones.

Table 4.7: Off-Peak Rail Access Probabilities

Cell #	Origin	Destination	Rail Access Probability					
			Drive /Park	Walk	Drop -off	Rent car	Taxi	Transit
1	Downtown Minneapolis	Downtown Duluth	27%	0%	48%	3%	4%	17%
2	Bloomington		31%	0%	51%	4%	0%	13%
3	Minnetonka		32%	0%	48%	4%	0%	16%
4	Champlin		37%	0%	44%	5%	0%	14%
5	UMD (Duluth)	Downtown Minneapolis	40%	0%	54%	4%	2%	0%
6	Saginaw		100%	0%	0%	0%	0%	0%
7	Superior		38%	0%	54%	4%	4%	0%
8	Cambridge	Downtown Minneapolis	100%	0%	0%	0%	0%	0%
9	Downtown Minneapolis	Hinckley - Town	27%	0%	48%	3%	4%	17%
10	White Bear Lake	Hinckley – Casino	39%	0%	46%	5%	0%	10%

Table 4.8: Off-Peak Rail Egress Probabilities

Cell #	Origin	Destination	Rail Egress Probability					
			Drive /Park	Walk	Pick-up	Rent car	Taxi	Transit
1	Downtown Minneapolis	Downtown Duluth	0%	17%	72%	5%	7%	0%
2	Bloomington		0%	17%	72%	5%	7%	0%
3	Minnetonka		0%	17%	72%	5%	7%	0%
4	Champlin		0%	17%	72%	5%	7%	0%
5	UMD (Duluth)	Downtown Minneapolis	0%	0%	64%	8%	5%	23%
6	Saginaw		0%	0%	64%	8%	5%	23%
7	Superior		0%	0%	64%	8%	5%	23%
8	Cambridge	Downtown Minneapolis	0%	0%	64%	8%	5%	23%
9	Downtown Minneapolis	Hinckley - Town	100%	0%	0%	0%	0%	0%
10	White Bear Lake	Hinckley – Casino	100%	0%	0%	0%	0%	0%

A few notable observations are:

- The lower use of automobiles as an access mode in downtown Minneapolis, compared to the surrounding counties.
- Walk mode is only significant for egress into downtown Duluth, because Target Field station is not walking distance to the downtown Minneapolis zone that was selected.
- The transit egress mode is significant for egress into downtown Minneapolis, due to the ability to transfer to the light rail at Target Field.
- Access/egress mode choice was not modeled outside the two major MPOs in the corridor – hence, the Cambridge and Hinckley probabilities are kept at 100% drive and park mode. In reality, the access would likely be split between drive and park and drop-off/pick-up (we will use estimates from the SP survey to calculate the splits for these two stations).

5 Model Input Data

This section describes the input data used in the travel demand model system developed by SDG for this study to produce the model output presented in the preceding sections It discusses the development of the no-build trip tables, level of service (LOS) characteristics for each mode considered, and special assumptions for travel to and from the Grand Casino Hinckley, a major trip generator in the corridor.

5.1 Travel By Train (NLX)

Each of the 378 study area zones are assigned to the nearest NLX station, and all travelers beginning or ending their trips in a particular zone are assumed to use the assigned station for their travel on the proposed NLX service.

The estimated travel time, ticket cost, and service frequency for NLX are taken from the Service Development Plan, described in Section 2.3.

For the potential NLX passengers, the train ride is only one component of their total journey. NLX users need to access the departure station from their point of origin, and travel from the arrival station to reach their final destination.

Where the NLX station is within a MPO's boundaries, we calculate the distance, time, and cost of the access/egress portion of the trip using the MetCouncil or MIC travel demand models. In the MetCouncil model, this information is further available for three time periods (morning peak, evening peak, and off-peak); the MIC model does not have splits by time of day.

Where the NLX station is not in an urban area, we assume that all access/egress to the station is by automobile and there would be no delays due to roadway congestion. Distance and free-flow speed (and in turn, travel time) were estimated based on road classifications from the National Highway Planning Network and speed limits from the Minnesota and Wisconsin Departments of Transportation. The access/egress cost was then calculated based on the distance and the estimated auto operating cost per mile corresponding to the traveler's trip purpose.

5.2 Travel By Private Automobile

5.2.1 Existing Trip Table

Almost all travel in the corridor is done by private automobile. Thus, it is particularly important to understand auto users' travel patterns in the NLX corridor, as this is a critical input to mode choice or induced demand modeling and strongly influences the accuracy of the forecasts.

There is relatively little data on intercity automobile travel within the corridor that is sufficiently detailed for forecasting. The MetCouncil Travel Behavior Inventory primarily focuses on the travel patterns of Twin Cities residents, whereas traffic count stations provide information on volume but not origin or destination patterns.

Under the circumstances, anonymous cellphone data is the most efficient way to understand the origins and destinations of auto travelers in the corridor. AirSage, a firm specializing in the analysis of anonymous cellphone data to provide origin-destination patterns, was engaged for this purpose. Since the cost of AirSage data is directly related to the number of zones and months of data collected, it was decided to purchase two months' worth of data for a 100x100 zone structure. The trip data was annualized based on the seasonal distribution of traffic observed at MnDOT continuous count station #191, located about 40 miles north of Minneapolis in Wyoming, MN. Data from the 100 AirSage zones were then disaggregated into the 378 SDG zones based on trip generation (if within MPO boundaries) or demographics (if outside MPO boundaries).

AirSage data was then calibrated against the continuous count station:

- Dividing the AirSage counts by auto occupancy rates (derived from survey responses) to obtain AirSage auto volumes; and
- Applying a uniform calibration factor to account for technological limitations, such as limited market penetration of the cell phone carrier (AirSage used data from Verizon for this study), poor reception, or cell phones that are switched off.

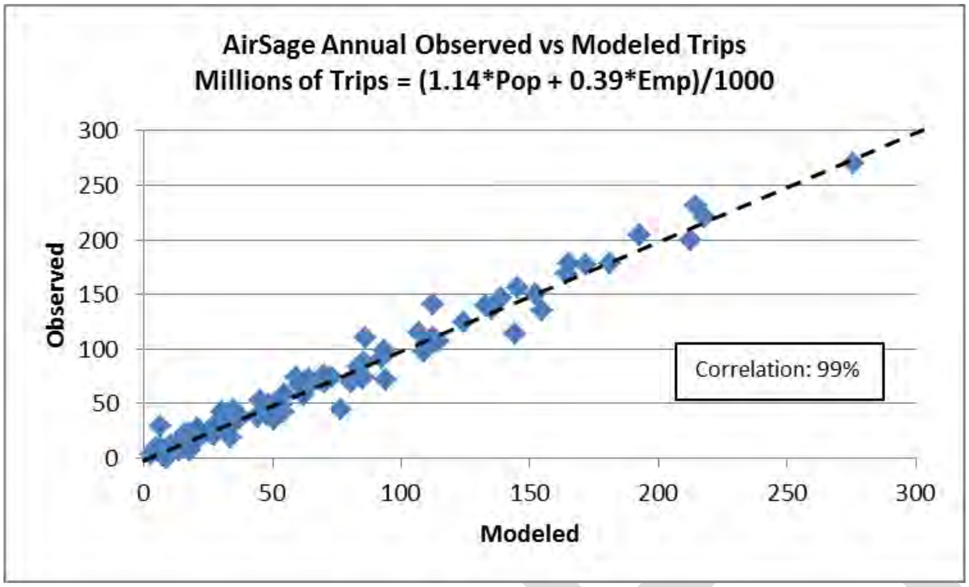
After calibration, the trip table developed based on AirSage data was quite reasonable when validated against the Twin Cities Household Survey and with local socioeconomic activity.

Detailed information on the development of the no-build auto trip table and the validation exercise and results can be found in the "NLX No-Build Travel Demand Memo", included as Appendix B to this report.

5.2.2 Market Growth Rate

Since AirSage data are available only for 2013 but the forecast milestone years are 2020 and 2040, the trip table needed to be adjusted to represent trip making behavior in those years. A linear regression model correlating trip volumes with zonal population and employment was developed. The model produced good results, as shown in Figure 5.1.

Figure 5.1: Regression of AirSage Trips on Zonal Population and Employment



Projections of 2020 and 2040 population and employment levels were obtained for each of the 100 ‘AirSage zones’ using growth rates implied by county-level population and employment forecasts from Woods & Poole, a reputable economic forecasting firm. The linear regression model was then applied to these projections to model trip volumes to or from each zone in 2013, 2020, and 2040. The modelled growth rates in trip making was then used to extrapolate the 2013 trip table to 2020 and 2040 using an “incremental approach”.

The development of zonal trip forecasts is further discussed in the “NLX No-Build Travel Demand Memo”, included as Appendix B to this report.

5.2.3 Service Characteristics

An intercity highway network was created by merging GIS data from the two local MPO travel demand models with the National Highway Planning Network data outside the two model coverage areas. This exercise included every major road in the 45-county study region.

Within the MPO zones, distance, speed, and congested travel times were calculated from the MPO models. In the MetCouncil model, as mentioned above, this data is available by three time periods – morning peak, afternoon peak, and off-peak.

Outside the MPO boundaries, the network was based on the National Highway Planning Network. We assumed little congestion in these areas and estimated travel time based on posted speed limits from the Minnesota and Wisconsin Departments of Transportation.

Once the entire intercity highway network was created, and travel times were determined for each facility, the network was “skimmed” to determine the total auto travel distance and time between each zone pair. The auto travel cost was then derived by using the auto distance and auto operating cost assumptions of 32 cents per mile for business/commute trips and 16 cents per mile for non-business trips.

5.3 Travel By Intercity Bus

5.3.1 Existing Trip Table

Jefferson Lines and Skyline Shuttle are the main operators of long-distance bus service in the project corridor. Commercial bus operators are generally reluctant to release ridership figures due to their proprietary nature. The most recent publicly available ridership information is from the 2010 Minnesota Intercity Bus Study, which reports ridership and revenue for Minneapolis-Duluth buses in 2007 and 2008.[9] This study did not include Skyline Shuttle, which uses smaller vans, nor did it report ridership to Hinckley.

A bus load factor of 55% was estimated based on the 2007/08 ridership, an annual multiplier of 330 (to account for lower loads on weekends), and an assumed 50-seat bus capacity. This was applied to the 2013 bus service levels. Jefferson Lines' annual ridership was split between Minneapolis-Duluth trips and trips with one end at Hinckley based on the relative service frequencies on Jefferson Lines. Between Minneapolis-Hinckley and Duluth-Hinckley, they were split based on the relative populations of Minneapolis and Duluth. The resulting bus ridership estimates are presented below:

Table 5.1: Estimated 2013 NLX Corridor Intercity Bus Ridership

	Jefferson Lines	Skyline Shuttle	Total
Minneapolis – Duluth	24,596	14,055	38,651
Minneapolis – Hinckley	6,486	3,706	10,192
Duluth – Hinckley	542	310	852
Corridor Total	**31,624**	**18,071**	**49,695**

For each bus stop, a set of 'catchment' zones from the study's 378-zone system was selected as the most probable source of bus riders based on geographic proximity to existing bus stops. The ridership in Table 5.1 was disaggregated to each of the catchment zones based on their 2013 automobile trip volumes as measured through the AirSage data.

5.3.2 Market Growth Rate

2020 and 2040 bus volumes were estimated using the forecast growth rates in automobile trips.

Table 5.2: Projected NLX corridor "No-Build" Bus Ridership

	2013 Ridership	2020 Ridership	2040 Ridership
Minneapolis – Duluth	38,651	40,066	44,346
Minneapolis – Hinckley	10,192	10,565	11,694
Duluth – Hinckley	852	883	978
Corridor Total	**49,695**	**51,514**	**57,018**

[9] *Minnesota Intercity Bus Network Study Final Report*, March 2010. Prepared by KFH Group, Inc. and SRF Consulting Group, Inc. for the Minnesota Department of Transportation.

5.3.3 Service Characteristics

SDG estimated current bus service levels based on publicly available information on the Greyhound and Skyline Shuttle websites.[10] In developing future year trip tables, it was assumed that bus service levels, travel conditions, and user preferences remain unchanged.

Operator	Capacity/vehicle	Frequency	Service description
Greyhound/Jefferson Lines	50	3-4x/day	2 direct + 1 local/day; +1 RT/day on Fridays
Skyline Shuttle	10 (large van)	10x/day	10x/day MSP Airport – Hinckley - Duluth

More information on the estimates of intercity bus travel can be found in the No-Build Travel Demand Memo, included as Appendix B to this report.

5.4 Travel By Air

5.4.1 Market Size

The study area is served by two international airports, Minneapolis-St. Paul International Airport (MSP) and Duluth International Airport (DLH). Due to the relatively shorter distance, very few Minneapolis-Duluth travelers choose a direct flight. However, there are many air trips connecting to/from locations outside the NLX corridor, where the first or last leg is a MSP-DLH flight. These 'connect air' trips could potentially divert their MSP-DLH leg to a Duluth-Target Field (via NLX) – MSP Airport (via light rail) journey. Air passengers whose connection is not on the corridor (e.g. DLH-Chicago-Another City), may also switch to a NLX-MSP-Another City connection if the rail connection is found to be favorable as a result of lower total cost or better air connections at MSP.

The Bureau of Transportation Statistics (BTS) report passenger ticketing and airline service data in its DB1B and T-100 databases respectively. As shown in Table 5.3, an analysis of 2013 BTS data found that there were over 156,000 trips on the corridor that are candidates for diversion to NLX.

Table 5.3: Annual In-Scope Connect Air Trips for 2013

Connect Air Trip	Number of Passengers
Connections on the Corridor	88,420
Connections not on the Corridor	42,580
Non-stop with one end not on the corridor	25,640
Total	**156,640**

Source: SDG analysis of USDOT DB1B 2013 data

5.4.2 Market Growth Rate

The Federal Aviation Administration (FAA) Terminal Area Forecast provide annual enplanement forecasts for each US airport through year 2040. These forecasts were used to estimate the DLH

[10] While Greyhound no longer operates buses on the corridor, it sells Jefferson Lines-operated buses on its website.

and MSP enplanement volumes in 2020 and 2040, using FAA data from a base year of 2013. The volumes were estimated to be 179,300 for year 2020 and 267,300 for year 2040. These correspond to the in-scope air travel demand shown in Table 3.1.

Diversion of air to NLX is highly dependent on the competitive response of air carriers to the presence of new rail service between downtowns. For example, carriers may pursue code-sharing agreements with NLX, add direct flights to and from DLH, or adjust air fares.

In estimating future year connect air markets, we have assumed no response from air carriers. As shown by Table 3.5, NLX riders diverted from air represent relatively small percentage of total forecast NLX ridership, so alternate market growth assumptions will not likely cause significant changes to the results.

5.4.3 Service Characteristics

Duluth International Airport (DLH) is the third-busiest airport in Minnesota, and mainly served by feeder flights to MSP, Chicago, and Detroit by Delta Airlines and United Airlines.[11] This means passengers traveling to other destinations are making connections at these hubs. There is very limited public transit between downtown Duluth and DLH; it is most accessible by automobile.

Minneapolis-St. Paul Airport (MSP) is located in-between Twin Cities. It is the 11th busiest airport in the US, and a major hub for Delta Airlines, low-cost carrier Sun Country Airlines, and commuter carrier Great Lakes Airlines, thus offering many connections to domestic and international locations. MSP is connected to the Twin Cities via the Blue Line and various buses. As a larger airport, MSP offers more flight options and possibly lower fares, but may also have longer security wait times or higher parking costs.

More information on the estimate of air travel can be found in Section 3 of the “NLX No-Build Travel Demand Memo”, included as Appendix B to this report.

5.5 Other Assumptions

5.5.1 In-Scope Filters

As discussed in section 3.1, the trip table obtained from AirSage includes all travel in the region, and much of it is unlikely to be divertible to the proposed NLX service. Before applying the mode choice models, a set of predetermined rules i.e. “filters”[12] was applied to the trip matrix to create “in-scope” demand, by removing the “non-divertible” trips. As the mode choice modeling process, by definition and construction, is a probabilistic approach, this filtering process is an important and even essential process in screening out trips that are not realistic candidates for diversion to the proposed NLX service. The filtering process removed following types of trips:

- Heavy commercial traffic (assumed to be 5.5% of all traffic, based on MnDOT count stations);

[11] http://www.duluthairport.com/flight-airlines.php

[12] These filters were initially designed based on experience from other similar intercity passenger rail studies and professional judgment. However, they were further revised and refined based on inputs from the peer review panel.

- Trips whose closest NLX station to the origin was the same as the closest NLX station to the destination;
- "En-Route Captive" trips: auto traveler makes stops along the way other than for gas and/or rest stops (except for Grand Casino, Hinckley non-business travelers);
- Trips within the MPO boundaries (between Target Field and Coon Rapids or between Duluth and Superior); and
- Trips whose train distance was shorter than the combined access distance and egress distance.

In addition, for travel between two other pairs of adjacent stations, the definition of in-scope trips was revised (by selecting narrower catchment areas) as follows:

- For travel between Coon Rapids and Cambridge, in-scope trips were those traveling between the neighborhoods in the immediate vicinities of the proposed NLX stations, roughly corresponding to the Towns of Coon Rapids and Cambridge; and
- For travel between Cambridge and Hinckley, in-scope trips were those traveling between the Town of Cambridge and the Grand Casino Hinckley.

5.5.2 Captive Percentages

From the Stated Preference Survey, 23% of Non-Business auto travelers and 18% of Business/commute travelers reported that they needed their automobile to make stops during their journey along the corridor. Since these travelers are extremely unlikely to divert to NLX due the high need for flexibility through auto access, the in-scope demand was reduced accordingly (except for Grand Casino, Hinckley non-business travelers).

A further 53% of Non-Business auto travelers and 56% of Business/commute auto travelers reported being 'destination captive', meaning they needed their automobiles at their destination. Since alternatives such as rental cars or taxis will presumably be available at their destination, these passengers were not ruled out completely from diverting to NLX. However, an additional penalty was estimated and added to the mode choice model (except for Grand Casino, Hinckley travelers), reflecting a higher disutility of travel on NLX and hence a lower likelihood of switching from automobile to rail for this group of travelers.

More information on the development of modal constants to account for these different travel situations is available in the "NLX Mode Choice Models Memo", included as Appendix C to this report.

5.5.3 Special Assumptions For Grand Casino Hinckley

The Grand Casino Hinckley is a major trip generator on the Twin Cities-Duluth corridor. Therefore, several adjustments to the models were made to account for trips to and from Hinckley.

Visitor Volume

A 2010 report from the Minnesota Office of Tourism estimated that the Grand Casino Hinckley received over 2.85 million visitors that year.[13] Accordingly, the non-business trips from the AirSage

[13] http://www.exploreminnesota.com/industry-minnesota/research-reports/researchdetails/?nid=141

trip table were factored to match the visitor volume to Hinckley. The volume was grown at 1% per year for the 2020 and 2040 forecasts.

Geographical Distribution of Home Origins of Casino Visitors

The Grand Casino Hinckley circulated the SDG-designed survey to a randomly selected sample of its patrons. The vast majority of survey respondents resided within the 45-county study boundary. This provided additional information on demographics, trip-making patterns, auto occupancy rates, and user travel preferences.

Upon review of this data from Grand Casino, it was decided that it would be reasonable to use the Grand Casino patron data as much as possible for trips to and from the Grand Casino. Hence, for casino trips only, the cell phone travel data from AirSage was replaced with information from the patron data to determine the regions from which the casino's patrons travel. Although the AirSage data is accurate at a zonal level, and all efforts were made to draw the zone system such that the casino was located in a zone with very little else in it, it can't be expected to provide the same level of accuracy as the patron data, which by definition captures their travel pattern to and from the casino.

Even though the sample size of the patron data was not sufficient to distinguish casino travel among the 378 zones in our model, it was possible to aggregate the data into the NLX station service areas. By shifting the distribution of casino travelers to the patron data, far more of the casino trips were assumed to be from the Twin Cities area, and fewer were local. Relative numbers of trips within the zones in each service area, as predicted by the AirSage data, were maintained.

Captive Percentages for Casino Patrons

All non-business trips to and from the casino zone were assumed to be "choosers," i.e. travelers who do not need their car at their destinations, and who do not make stops en-route to their destinations other than for food and/or refueling. These travelers, by design, are more likely to see NLX as an attractive alternative to driving.

5.5.4 Reassignment of Service Areas Between Downtown and Suburban MPO Stations

Originally, potential NLX riders in the Twin Cities area were assumed to access whichever of Target Field or Coon Rapids station is closer geographically based on an automated process. Similarly, potential NLX riders in the Duluth / Superior area were assumed to access whichever of Duluth or Superior station is closer. For many people in both cases, this will be true; however, there would be some areas between the two stations for which downtown station is closer, but the suburban station would be the optimal station to access. There could be potentially several reasons for this:

- Coon Rapids and Superior are assumed to have free parking, whereas Target Field would be $10/day and Duluth would be $5/day;
- Traffic congestion would be less; and
- The travel time on NLX to the passengers' destinations would be 13-15 minutes less.

Therefore, some areas were reassigned from Target Field and Duluth to Coon Rapids and Superior. For these areas, travel on NLX became more attractive than before.

6 Model Description

This section will briefly describe the travel demand forecasting process, and the travel demand models used to produce ridership and revenue forecasts for the inter-urban (long distance intercity) travel market. The components of the models will be described at a high level; specific details of each component can be found in the various appendices to this report – especially in the "Modeling Methodology Memo" included as Appendix A and "NLX Mode Choice Models Memo" included as Appendix C . These appendices represent memos delivered earlier in the project, but subsequently revised to address peer panel comments.

6.1 The Forecasting Process

The travel demand model implements a well-established three-stage process (Figure 6.1) for forecasting inter-urban NLX ridership and revenue for 2020 and 2040, the analysis years chosen for this study. In the first step, the growths of the travel markets to 2020 and 2040 are estimated. In the second step, the number of trips diverted to the proposed NLX service from the existing modes are calculated using mode choice models developed as part of this study. In the final step, the induced ridership is estimated, and this is added to the forecast of diverted NLX trips to produce the total ridership forecast.

Stage 1 estimates the 2020 and 2040 origin-destination (OD) travel volume of all relevant inter-urban modes by growing base year (2013) OD volumes to 2020 and 2040. The base year auto intercity trip table[14] is grown to both 2020 and 2040 using growth rates obtained from direct demand models estimated for this study (described more in detail in the "NLX No-Build Travel Demand Memo" in Appendix B). The base year intercity bus trip table is grown at the same rates estimated by the direct demand models for the auto trip table. The air travel market which represents potential diverters to NLX and air travel from MSP is grown using FAA forecasts for air

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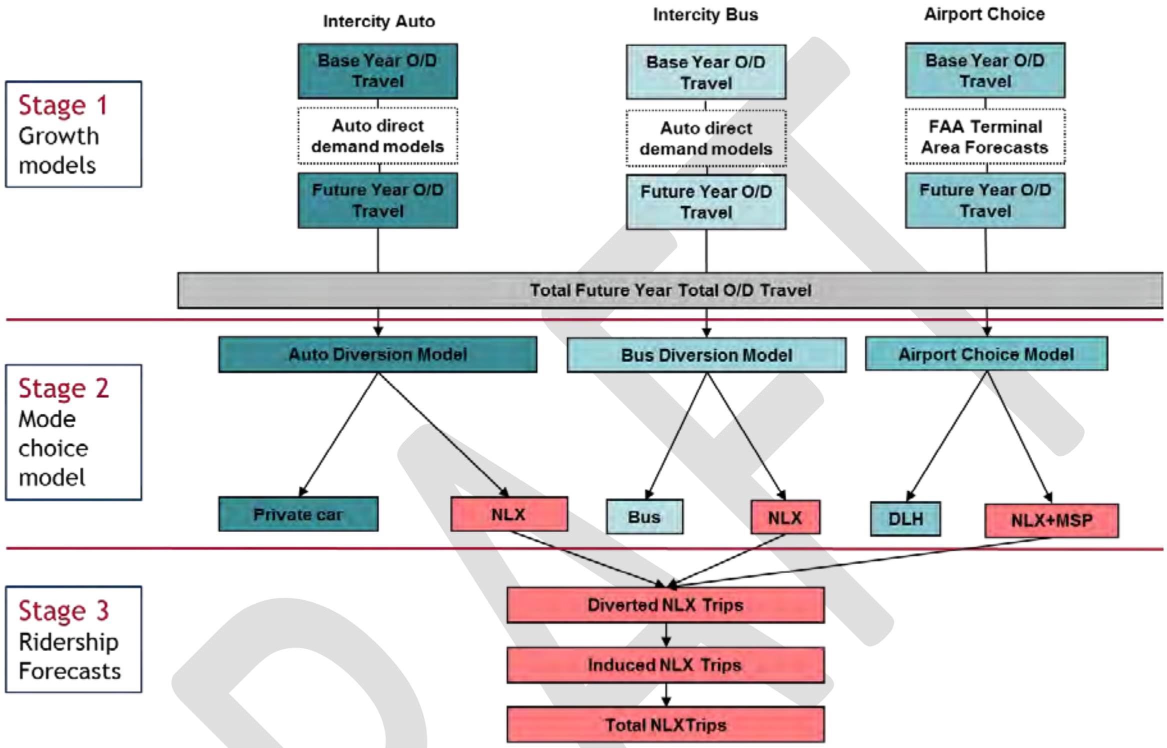
[14] Obtained from anonymous cell phone movement data in the study area and described in detail later in the "NLX No-Build Travel Demand Memo", included as Appendix B to this report.

passenger data to and from DLH. The various mode-specific trip tables developed in this way produce the total travel volumes for 2020 and 2040. Finally, a set of predetermined rules (i.e. filters, discussed in section 5.5.1) were applied to screen out travelers who are unlikely to be divertible to NLX from their current travel mode to create the “in-scope” travel demand tables.

Figure 6.1: Ridership and Revenue Forecasting Process



Stage 2 applies mode choice models (described in detail in “NLX Mode Choice Models Memo” in Appendix C) to predict the share of each considered mode in the future year, considering their respective Level of Service (LOS) characteristics. Market-specific mode choice models, each with a binary logit form, are applied to predict, for 2020 and 2040 and for each OD pair, the share of travelers who will use NLX; separate models are applied for different current travel purposes. For example, the auto intercity mode choice models compute the probability that a traveler currently making a trip by auto will instead choose NLX given the trip purpose, the need for a car (or lack thereof) at the destination end of the trip, the origin and destination of the trip, and the auto and NLX modes’ LOS in 2020 or 2040. The logit model structure is shown and described in Appendix C. These mode choice models are developed, whenever possible, from statistical analysis of Stated Preference (SP) survey[15] data in which travelers express their choices in hypothetical situations presented to them as well as information pertaining to their travel characteristics in actual travel situations for reference trips. These sources are supplemented by results from other high-speed and inter-urban passenger rail studies in the US and elsewhere.

[15] A SP survey was undertaken specifically as part of this study; its details are described in a survey methodology memo, delivered in November 2013.

Stage 3 calculates actual volumes on each intercity travel mode by relating the mode shares to the in-scope travel demand; it also estimates the volume of new trips that result from travel condition improvements (induced travel). The NLX mode shares computed in Stage 2 are applied to the modal trips estimated in Stage 1 to obtain the corresponding NLX ridership; this computation is carried out for each OD pair and separately for each market. Induced travel volumes are also calculated in this stage; elasticity-based induced demand models, which relate a percentage change in demand to a corresponding percentage change in composite generalized cost, are developed and applied for this purpose. The composite generalized costs used in the induced demand models are calculated from the mode choice models used in Stage 2. For each OD pair and travel purpose, the combined results of the mode choice and induced travel models for each year provide the NLX ridership forecasts for that year. These OD level ridership forecasts are then multiplied by the corresponding fares (for each OD pair) to calculate the ticket revenue. The calculation of ticket revenue and revenue from ancillary sources are described in more detail in Appendix D as part of the "NLX Revenue Projection Methodology Memo". Forecasts for individual OD pairs are then aggregated to the NLX stations, based on predefined station service areas.

6.2 Intercity Mode Choice Model

The intercity travel demand model uses a series of mode choice models, each of which predicts the probability that an existing traveler will choose NLX as his or her travel mode instead of the current mode. The models are all 'binary', meaning they include only two travel mode choices: the current mode (either auto or intercity bus; current air travelers are modeled slightly differently, as discussed in section 6.4) and NLX. This corresponds to the intercity mode choice model piece of Stage 2 in the process shown in Figure 6.1.

The models all exhibit similar structures, with a series of input variables and coefficients, which are estimated statistically using data from the stated preference survey responses or asserted based on professional judgement and experience from other intercity rail studies . For a given origin and destination zone, the probability predicted by the models depends on the following input variables:

- Travel costs for the current mode;
  - For auto trips, this includes fuel costs and parking at the destination if applicable; and
  - For bus trips, this includes cost to access/egress the bus stations and the bus fare.
- Travel times for the current mode;
- Travel costs for NLX (including cost to access/egress the train stations and the NLX fare);
- Travel time for NLX (including time to access/egress the train stations);
- Frequency of the NLX service; and
- An NLX "modal constant" reflecting travelers' inherent preferences for one mode over another, outside of comparative modal level of service characteristics (e.g. times and costs etc.) included explicitly in the model.

The coefficients for a given input variable depend on the following:

- The current travel mode;
- The trip purpose (business/commute or non-business);
- For current auto trips, a distinction between "destination captive" trips (where a car is needed at the destination) or "non-captive" trips (where no car is needed). Note that "en-route

captive" trips (where a car is needed en-route) are removed from the model; these trips are considered non-divertible (except for Grand Casino, Hinckley non-business travelers).

And finally, if a trip has an origin and/or destination zone in either the Minneapolis or Duluth MPO, the access and egress costs and times for NLX are split further into probabilities of each of six possible access or egress modes, using a multinomial logit model, also developed from the SP survey responses. The in-scope demand for the origin-destination pair, trip purpose, and current travel mode is weighted further by the probability of each particular access/egress mode combination before applying the probability of diversion to NLX, and then the diverted NLX ridership is aggregated over all combinations.

Technical details of the models' coefficients and how they were derived are provided in the "NLX Mode Choice Models Methodology Memo", included as Appendix C to this report.

6.3 Induced Demand Model

The induced demand is based on the change in composite generalized cost (CGC) resulting from the construction of NLX. The more the additional travel option of NLX improves the travel conditions (e.g. travel time and/or cost) between a given pair of origin and destination zones, the greater the induced demand will be. Like the main intercity mode choice model, the model that creates a quantitative relationship between the improvement in CGC and the level of induced demand was developed from the stated preference survey responses. The technical details of this model are also described in the "NLX Mode Choice Models Methodology Memo", included as Appendix C to this report.

6.4 Airport Choice Model

As noted in section 2.2.3, the current market for air travel strictly between Minneapolis and Duluth is extremely small, due to the relatively close proximity of the two cities. However, there is a potential market for NLX from current air travelers who begin or end their trip at Duluth International Airport (DLH) and have the option of using Minneapolis St. Paul International Airport (MSP) instead as the origin or destination airport for their trips with possible NLX connections to their ultimate origin or destination depending on the directionality of their trips. MSP serves a significantly larger number of destinations, and in many cases offers more flexible travel times, faster and/or cheaper flights. Thus, it may be advantageous to ride NLX from Duluth to Target Field, and then ride the Metro Light Rail Blue Line from Target Field to MSP (or the reverse trip if DLH is the destination), in spite of the multiple transfers required.

The model developed for this purpose is an "itinerary choice" model, in the sense that it does not model diversion from air to NLX, but rather from an air-only trip to a combination rail and air trip. The structure of the model is otherwise very similar to the intercity mode choice models, with variables for the total trip fare, travel time, frequency, and a positive constant for the travel advantages that using a hub airport such as MSP provides over DLH.

The technical details of this model are also described in the "NLX Mode Choice Models Methodology Memo", included as Appendix C to this report.

7 Next Steps

Detailed ridership and revenue forecasts for all the candidate service options have been produced and presented in this report. In addition, detailed input data for the public benefits analysis and economic impact analysis have also been produced and prepared. The next steps of SDG's involvement in this project include the following.

7.1 Public Benefits Output

SDG submitted the "NLX Public Benefits Methodology Memo" in July of 2014. This memo includes SDG's methodology for estimating the benefits of consumer surplus (the difference between potential passengers' willingness to pay for NLX and the actual price, in generalized cost terms including the effects of time as well as cost), reduced auto accidents, reduced emissions, and reduced auto congestion, as a result of NLX. SDG will update this memo and report this analysis for the service options chosen as the preferred alternatives. SDG's analysis will also include economic benefits estimated from the IMPLAN software, such as new jobs and tax revenue impacts. At MnDOT's request, benefits from reduced auto accidents and reduced emissions will be presented in units of vehicle miles traveled (VMT) saved, and will not be monetized.

SDG's analysis will be supplemented by calculations of other potential benefits from studies by MnDOT, and ultimately the combined analyses will be fed into a cost-benefit analysis (CBA) by MnDOT to determine the feasibility of the project.

7.2 Financial Analysis

This analysis will be performed later in the project by Parsons Brinckerhoff (PB). PB will develop both a capital and operational financial plan element, exploring funding sources and financing structures, risk management plans, and forecasting operating and maintenance and capital replacement costs.

Appendices

A Modeling Methodology Memo

Ridership and Revenue Plan

Northern Lights Express Ridership and Revenue Forecasting

Report

January 2014

Prepared for:
Minnesota Department of Transportation
395 John Ireland Boulevard
St. Paul, MN 55155-1800

Prepared by:
Steer Davies Gleave
883 Boylston Street, 3rd Floor
Boston, MA 02116
USA

+1 (617) 391 2300
www.steerdaviesgleave.com

CONTENTS

1 Introduction

This document is the Ridership and Revenue Plan provided for in Task 2 of the Northern Lights Express Ridership and Revenue Forecasting Study (NLX). The purpose of the Ridership and Revenue Plan is to review the context of the NLX travel demand modeling activity, and from this review to propose a methodology for developing ridership and revenue forecasts that meets the needs of the NLX study, is acceptable to MnDOT and FRA, and exemplifies national and international best practice. The context of the NLX demand modeling activity includes:

- The overall NLX project objectives;
- Particular project issues or decisions that the travel demand modeling effort is expected to help analyze and clarify;
- Background information about transport in the study area, including relevant prior studies;
- Data sources that are currently available for use by the NLX study; and
- Potential sources of original data that could be collected and used.

This Plan has several purposes. It documents, at a high level, the results of the team's initial investigation into available and relevant travel demand forecasting model systems and data, which are some of the resources from which the ridership forecasting model for the project will be constructed. Familiarity with recent studies and available relevant data is necessary to orient the modeling methodology at the beginning of the modeling process, and for informed and efficient decision-making during the model development. The Plan also highlights the key travel demand modeling issues that have been identified and that will need to be addressed during the modeling work. Lastly and most importantly, the Plan outlines the team's intended approach for developing a ridership forecasting model system for this study.

It must be remembered that the development of a forecasting model is an inherently exploratory process. Hence, it is not possible at this stage of the NLX study and its modeling activity to define in complete detail the demand forecasting methodology that will be developed based on the above factors: many details of the methodology will be best worked out during the model development itself, based on experience gained and lessons learned during the process. Rather, the intent here is to motivate and describe at a high level the general approach that is proposed for the NLX demand model development, in sufficient detail to allow readers to understand the overall model architecture and its key methodological features. In addition, this Plan discusses new travel data collection activities that the NLX study is undertaking to enhance the empirical basis of its travel modeling.

The travel demand forecasting element of the NLX study is being carried out by Steer Davies Gleave, working under contract to the Minnesota Department of Transportation.

This chapter provides an overview of the team's approach and the results of earlier demand forecasting studies, through the following sections:

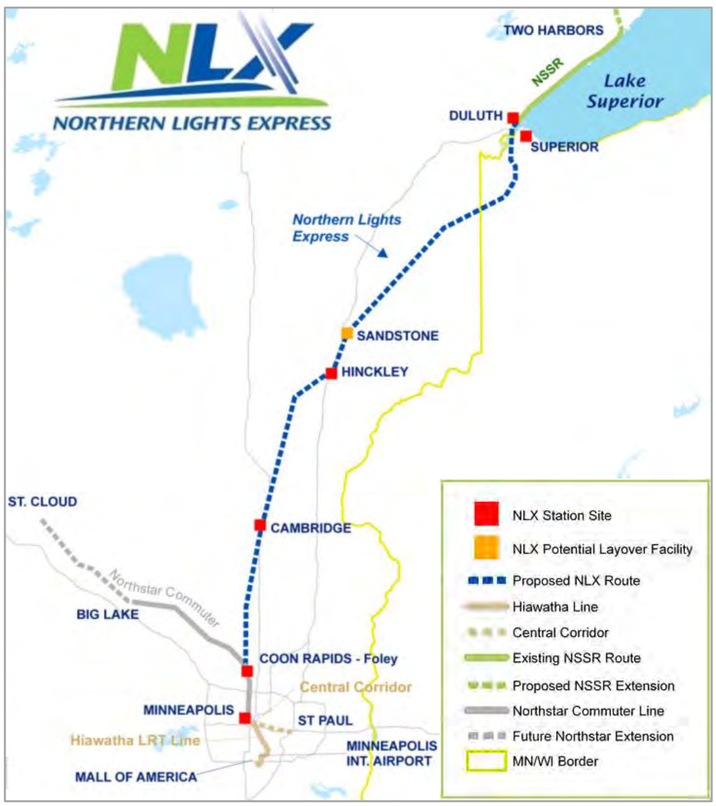
- The project characteristics and study scope;
- The key potential markets;

- Our general modeling approach; and
- Ridership and revenue results from earlier studies.

1.1 Project Characteristics and Study Scope

As seen in Figure 1-1, the project will provide passenger rail service to the 155-mile corridor between Minneapolis and Duluth, the first and fourth largest cities in Minnesota, with proposed intermediate station stops at Coon Rapids, Cambridge, Hinckley, and Superior, WI. Project options without a station stop in Superior and with a loop serving the Grand Casino Hinckley are also under consideration.

FIGURE 1-1 NLX CORRIDOR



1.2 Key Potential Markets

A useful way of thinking about the development of a travel demand model for this study is in terms of the issues the model will have to address. These issues can be characterized as follows:

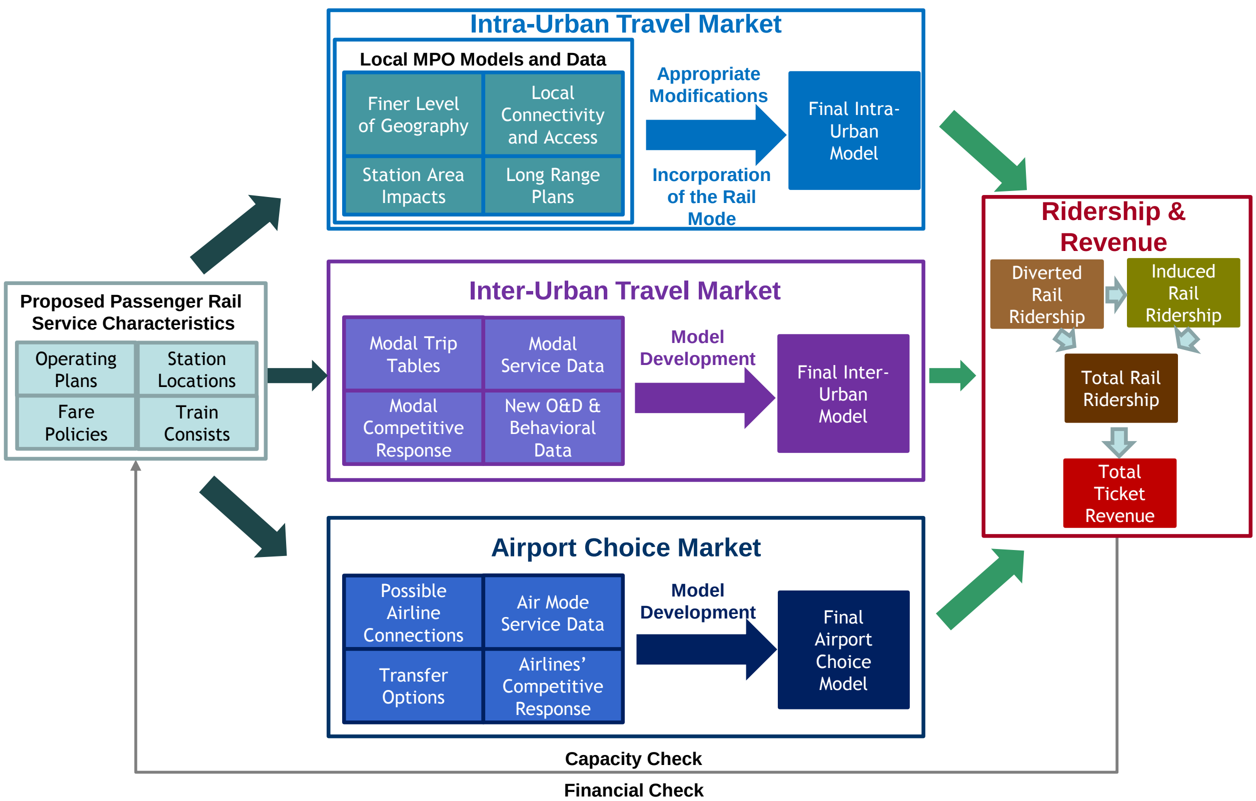
- Competition between the proposed NLX rail service and other modes (including auto, air, bus and other shuttle services) for intercity travel;
- Competition between the rail service and other modes (including auto and public transit) for intra-urban travel in the Minneapolis and St Paul metropolitan areas; and

- Passenger airport choice as it may be affected by the rail service. This air market include air trips to/from Duluth International Airport (DLH) with an ultimate origin or a destination that is not within the corridor (i.e., that is not at MSP).

Based on these competition issues, we identified three markets for the proposed NLX High-Speed and Intercity Passenger Rail (HSIPR) service. These markets are based on whether they are intercity (trips between the Duluth, other intermediate points and the Twin Cities), intra-urban (within the Twin Cities metropolitan area), or air trips with an ultimate origin or destination out of the corridor (Airport Choice).

Figure 1-2 shows a demand forecasting methodology framework that SDG has developed to address these key travel markets separately and specifically. More detailed descriptions of the modeling steps for each of these markets are provided later in Chapter 4.

FIGURE 1-2 SDG RIDERSHIP AND REVENUE FORECASTING MODELING FRAMEWORK



For the intercity market, travel between the two cities can be made by three main travel modes:

- Intercity travel by auto: current auto trips made between Duluth, other intermediate points and the Twin Cities metro areas on the corridor;
- Intercity travel by air: current air trips between DLH and MSP (direct flights starting and ending within the corridor); and

- Intercity travel by bus: current bus/van/shuttle trips between Duluth, other intermediate points and the Twin Cities metro areas on the corridor.

For the intercity market the team proposes to use an approach that is outlined below and described in detail later in Chapter 4.

For the intra-urban market, as the proposed alignment includes multiple stations (Target Field station, Coon Rapids - Foley) in the Twin Cities metro area, the team proposes to use modified versions of the Metropolitan Council travel demand model (the Twin Cities MPO model) to forecast demand for the local rail travel market, which will be overlaid on the intercity forecasts.[1] Modifications to the Twin Cities model will, at a minimum, involve the addition of the new NLX rail mode. However, allowing such short-distance, low-revenue passengers on the train may lead to the loss of more desirable longer-distance, higher-revenue trips due to limited capacity issues. Hence, restricting travel between Target Field and Foley at the Twin Cities end and Duluth and Superior at the Duluth end should be seriously considered – a practice that is quite common in several existing Amtrak routes (e.g. Hiawatha service, Lincoln service). This will mean no separate detailed modeling effort would be required for the local short-distance travel on the proposed NLX service.[2]

Similarly, with respect to airport choice modeling, the team recognizes that air passengers typically choose the airport they will use to start (or end) a long-distance trip based on factors that include, for each: access distance and travel time; the range of destinations offered; and flight frequencies, times, and fares. Hub airports offer materially more choices to passengers and are therefore particularly attractive. Minneapolis St. Paul International Airport (MSP) is a major hub airport and, with improved rail access, passengers currently flying to them from a feeder airport like Duluth International Airport (DLH) might divert from feeder air to rail. However, the proposed NLX service does not have a station at MSP. The currently proposed station at the Minneapolis end for the NLX service is at the Target Field station. Significant additional time will be required to transfer between the Target Field station and MSP. Given these considerations, we propose not to include the connect air modeling as part of this modeling effort.

Our general modeling approach for each of the three main markets is outlined below.

1.3 General Modeling Approach

1.3.1 Intercity Model Overview

The team's proposed approach to forecasting the potential ridership and revenue of the proposed NLX rail services for the intercity markets entails six broad steps:

[1] Interactions and competition of the proposed NLX service with the existing transit service in the Duluth-Superior metro areas are not significant enough to warrant separate modeling of the possible intra-urban travel on the NLX service at this end of the corridor.

[2] Indeed, based on inputs from MnDOT and the Peer Review Panel, it has since been decided not to consider the proposed NLX service as an intra-urban mode within the Twin Cities and Duluth-Superior metro areas. Hence, no further modeling of the intra-urban market involving NLX was undertaken. The main body of the NLX ridership and Revenue Report also reflects that.

- Step 1: Estimate the current market of potentially divertible trips (including trips by air, bus/shuttle, and automobile). These estimates are developed on a zone-to-zone basis as outlined below in the "Geographic Scope and Zoning Structure" section. They are also disaggregated by trip purpose. The "base year", i.e. the year NLX would first provide service, will be 2020.
- Step 2: Estimate how this market will grow in the future, to a forecast year of 2040. These estimates will reflect forecast socio-economic trends (such as changes in population and employment) and assumptions regarding the sensitivity of changes in trip making behavior to these trends.
- Step 3: Estimate the Level of Service (LOS) characteristics for each mode and each zone pair. For a trip by common carrier (including the proposed NLX service), this takes into account the in-vehicle time, frequency of service, fare, and time/cost needed to access and egress the mode's station from the trip's actual origin and destination respectively (i.e., the traveler's home, place of work, or leisure destination). For a trip by automobile, this takes into account the origin-destination travel time (including any delays due to road congestion) and vehicle operating costs (largely fuel cost).
- Step 4: Estimate the potential market share that the new service will capture (i.e. the ridership). This is estimated using the LOS characteristics calculated in the previous step and the established mode choice models and modeling methodology. This process is explained in detail in Chapter 4.
- Step 5: Estimate the level of induced demand. These are new intercity trips not made in the no-project situation, but occur as a result of the improved service provided by the proposed project.
- Step 6: Estimate the rail farebox revenue. This is calculated using the ridership calculated in the previous two steps and the fare assumptions used for the new rail service from Step 3 above. Note that the level of ridership is sensitive to fares.

These forecasting steps include the following additional tasks: gathering and analyzing available existing data; preparing input assumptions and tables; specifying, building and testing the forecasting model; producing and reviewing forecasts; and running sensitivity tests.

1.3.2 Airport Choice Model Overview

As discussed above, the proposed NLX service will not have a station at the MSP airport. Hence, this market is not a relevant market for this study and will not be included in this modeling effort. This is discussed in detail again in Chapter 4.

1.3.3 Intra-Urban Model Overview

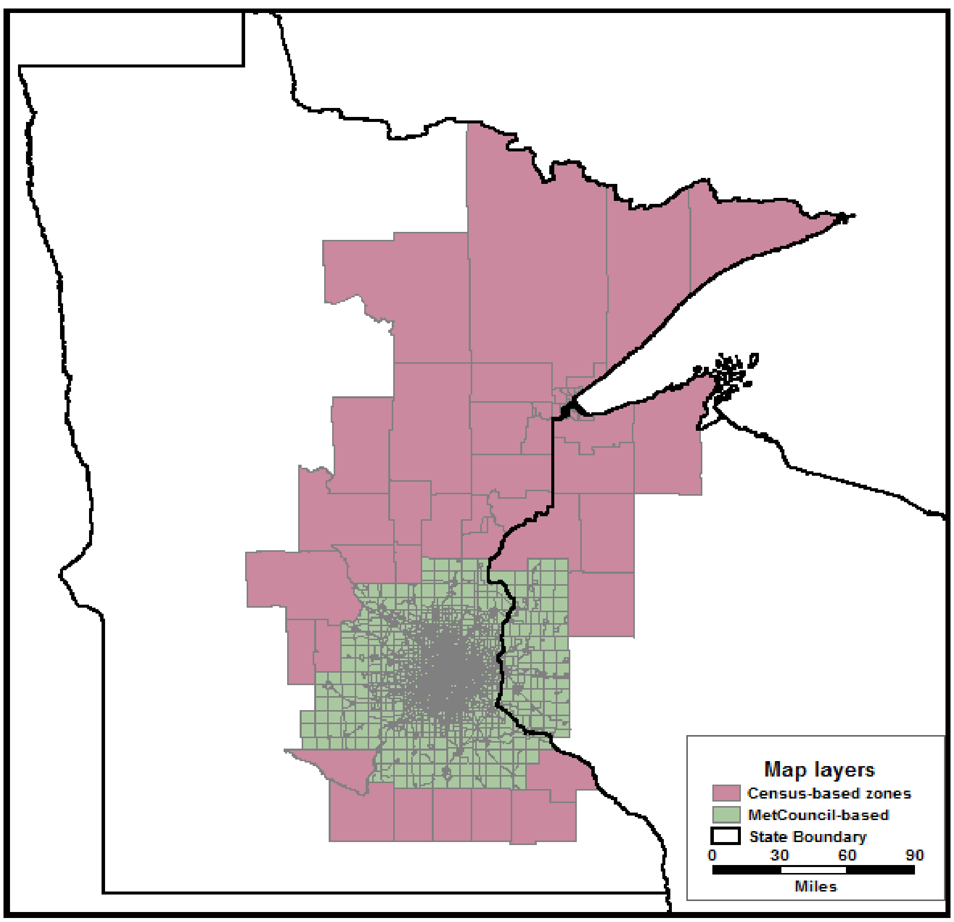
The Met Council Regional Travel Demand Forecast Model (RTDFM) system for the Twin Cities will be used for intra-urban (local) travel in the Twin Cities metro areas in the event it is decided to allow local travel on the NLX service between Target Field and Foley. This is discussed in detail in Chapter 4.

1.3.4 Geographic Scope and Zoning Structure

The intercity model will cover a geographic area (as shown in Figure 1-3) that generally follows the 155-mile corridor between the Twin Cities and Duluth and extends approximately 50 miles on each side of the proposed route alternatives. This is a typical planning assumption for access catchment for HSIPR services. However, the 50-mile distance is indicative rather than absolute, and has been adjusted as appropriate to include some areas beyond the 50-mile buffer in which the residents have the potential to use the proposed NLX service.

The geographic area described above has been split into a number of zones. The team has based the zoning structure on aggregations of traffic analysis zones (TAZs) for the areas covered by either the Twin Cities or Duluth-Superior MPO travel demand model regions, and on aggregations of Census tracts and/or county boundaries for the area outside the two models. In addition, special travel generators (e.g. MSP airport, Duluth airport, Grand Casino etc.) have their own zones and travel to/from these generators will explicitly be represented in the modeling effort. The total model coverage area includes approximately 380 zones; this strikes a good balance between having sufficient granularity to reflect the differences in LOS characteristics for residents of adjacent areas, and the need to model a large area for a study in its initial phase. This also provides a more detailed representation of the urban areas, while maintaining a manageable number of zones. Figure 1-3 shows the zone boundaries that the team is proposing for this study.

FIGURE 1-3 STUDY AREA BOUNDARY AND THE ZONE SYSTEM



There are two common approaches to estimating travel times employed in travel forecasting. The first is to prepare a representation of the network using network modeling software and then use this to estimate travel times. The second is to estimate the times using actual travel time data sources, for example commercial trip planning software (MapQuest and Google Maps) supplemented with real time travel alert websites (www.sigalert.com, or www.beatthetraffic.com). These can then be combined with other assumptions (regarding vehicle operating costs, fares or service frequencies) to estimate LOS characteristics between all relevant zone pairs.

Irrespective of the method used to calculate the LOS characteristics, network modeling software will be used for developing forecasts for this study, as it offers the capability to hold and manipulate the large volumes of data created in preparing demand forecasts. In addition, travel times calculated from network modeling software can be used to check the travel times obtained through other processes.

1.3.5 Modeling Alternatives

Our demand modeling methodology will be flexible and able to model a range of project alternatives. The model will be able to produce detailed ridership forecasts and revenue projections for:

- Multiple alignments within the study area;
- Multiple train technologies (variations of top and average speeds, which will deliver different station-to-station travel times); and
- Multiple service patterns (including the frequency of service, and the fare levels).

More specifically, the forecasting methodology will allow us to model and analyze in detail:

- The Base Operating Plan as identified in Section 7.3 of the NLX Service Development Plan (NLX SDP);
- A Modified Base Operating Plan that assumes six round trips per day between Minneapolis and Duluth and an additional three round trips per day between Minneapolis and Hinckley;
- An operating plan that optimizes ridership, revenue and operations to achieve the most favorable financial performance. As part of this, we will systematically vary the proposed NLX service characteristics from the Base and Modified Base operating plans with the objective of maximizing ridership, revenue and public benefits;
- An operating plan option consistent with the optimum operating plan that does not include a station stop in Superior, WI;
- An operating plan option consistent with the optimum operating plan that includes the Hinckley loop option; and
- Possible other variations of the operating plans described above, if deemed appropriate by MnDOT.

Note that there are limits to this flexibility. For example, alternatives with more than one station within the same zone cannot be easily modeled via the approach proposed here, and in some cases situations involving multiple characteristics will be represented in terms of an average rather than individually. In addition, the approach will not be able to distinguish alternative alignments where the only difference between the two is a different location of a station within the same zone.

Ridership and revenue forecasts will be produced for base (2020) and future forecast year (2040). Initially, a per-mile fare level for the NLX service will be used based on fare levels used in earlier studies, fare levels for similar Amtrak services elsewhere in the country and finally consultation with the PMT, TAC and the FRA. Later on revenue maximizing fare levels will be determined (discussed later) and used for subsequent analyses. All revenue numbers for the base and horizon years will be reported in common year constant dollar values (2013$). Ridership and revenue forecasts for all years between base and future forecast years can be produced by interpolation.

1.3.6 Sensitivity Analyses

In addition to being able to model project alternatives, the proposed modeling methodology will be specified to carry out a range of sensitivity analyses to determine the effects of the changes in the values of key endogenous (fare and level of service attributes of the rail mode, competitive factors with other modes) and exogenous (socio-economic characteristics, gas price) variables on ridership and revenue and consequently on project finances and other project impacts. This capability also provides a useful tool for checking the model's reasonableness and robustness.

We will also investigate alternate NLX rail fare policies in order to identify those that maximize revenues in the absence of capacity or other constraints. We have successfully conducted such analyses to determine revenue maximizing fares; key to these analyses is a detailed understanding of the relationship between ridership and fare levels.

1.4 Ridership and Revenue Results from Earlier Studies

Past studies that analyzed ridership and revenue potential for various intercity travel options in the study area include the TEMS Feasilibity Study[3]; the Minnesota Comprehensive Statewide Freight and Passenger Rail Plan Tech Memo[4] and Final Report[5]; and the Service Development Plan (NLX SDP) supporting the Tier 1 Service Level Environmental Assessment (NLX EA) [6]. It is not easy to compare the results of these different studies because the projects that they evaluated were not necessarily comparable, and because they often did not produce results for the same forecasting or financial reference years.

With these caveats, Table 1-1 attempts to summarize and compare the ridership, revenue, O&M costs and operating ratio figures found by these different studies. Note that the specific forecast variables as well as the level of detail presented in the study reports vary widely. Any

[3] Minneapolis – Duluth/Superior Restoration of Intercity Passenger Rail Service Comprehensive Feasibility Study and Business Plan, Transportation Economics & Management Systems, Inc. (TEMS), December 2007

[4] Minnesota Comprehensive Statewide Freight and Passenger Rail Plan Technical Memorandum #3, Cambridge Systematics, Kimley-Horn and TDKA, July 2009

[5] Minnesota Comprehensive Statewide Freight and Passenger Rail Plan, February 2010

[6] Northern Lights Express Technical Report: Preferred Alternative, TEMS, March 2012

empty cells in Table 1-1 indicate missing information in the study reports. In some cases (e.g. the TEMS study), only a subset of the study outputs (e.g. selected year and selected modes/technologies) is presented here to facilitate the comparison.

Table 1-1 shows a wide range of variations in the ridership and revenue figures among these studies (even recognizing that different studies produced forecasts for different years). Of the four studies of the NLX corridor, the TEMS study had the highest ridership, revenue and operating ratio figures; and the Statewide Freight and Passenger Rail Plan forecasting tech memo, performed by Cambridge Systematics, had the lowest.

TABLE 1-1 RIDERSHIP AND REVENUE RESULTS FROM PAST STUDIES

2007 Feasibility Study, Transportation Economics & Management Systems, Inc., assuming of full operations begin in 2010 but "steady state" financial performance begins in 2012					
Operating Scenario (Speed/ Frequency/Fare in cents per mile)	2010 Ridership ('000s)		2012 Revenue (millions)	2012 Operating and Maintenance Cost (millions)	2012 Operating Ratio
	Shuttle Bus to Casino	Direct Casino Connection			
79/2/22	229	n/a	4.4	8.6	0.51
79/4/22	360	n/a	7.2	13.2	0.55
110/4/35	595	982	18.3	17.1	1.07
110/8/35	889	1,363	30.7	26.0	1.18
125/4/35	628	1,021	19.8	19.1	1.03
125/8/35	937	1,419	32.9	27.7	1.19

Source: TEMS 2007 Restoration of Intercity Passenger Rail Service Comprehensive Feasibility Study and Business Plan

2009 Tech Memo Minnesota Comprehensive Statewide Freight and Passenger Rail Plan		
Operating Scenario (Speed/ Frequency/Fare in cents per mile)	2030 Ridership ('000)	2030 Revenue (millions, 2009$)#
79/1/20	113*	
79/4/20	290*	5.62
79/8/20	384*	7.64

*Minneapolis-Hinckley and Minneapolis-Duluth trips; does not include Duluth-Hinckley trips which were estimated at between 150,000-200,000 per year.
Calculated based on a fare of $0.20/mile, 155 miles between Minneapolis – Duluth and 80 miles between Minneapolis – Hinckley.

Source: Cambridge Systematics, Kimley-Horn and Associates, and TKDA 2009 Minnesota Comprehensive Statewide Freight and Passenger Rail Plan Technical Memorandum #3

2010 Minnesota Comprehensive Statewide Freight and Passenger Rail Plan				
Operating Scenario (Speed/ Frequency)	2030 Ridership ('000)	2030 Revenue (millions, 2009$)	Operating & Maintenance Cost (millions)	Operating Ratio
110/8/20	430	9.6	45.7	0.21
110/8/20*	650	12	35.9	0.34

*"Best Case" scenario with $4 / gallon gas (instead of $2)

Source: Minnesota Comprehensive Statewide Freight and Passenger Rail Plan Final Report, February 2010

TEMS Level 3 Analysis of Preferred Alternative, via 2013 NLX Service Development Plan				
Operating Scenario (Speed/ Frequency/Fare in cents per mile)	Ridership ('000)	2030 Revenue (millions, 2010$)	Operating & Maintenance Cost (millions)	Operating Ratio
110/8/29	1,164	36.8*	34.9	1.05

* Including on-board service and ancillary revenue; $33.7 ticket revenue.

Source: NLX Technical Report: Preferred Alternative – Route 9 Option 2 Level 3 Analysis (part of High Speed Rail Environmental Assessment), TEMS, March 2012

1.5 Structure of the Plan

The remainder of this plan is structured as follows:

- Chapter 2 discusses the key travel markets and their characteristics;
- Chapter 3 discusses the main data sources available;
- Chapter 4 reviews the principal issues regarding the study modeling methodology, and discusses their resolution using the data sources discussed previously; and
- Chapter 5 summarizes the contents of this report, and outlines the next steps to be taken in the modeling effort.

2 Current Key Travel Markets

The NLX rail projects address three principal travel markets:

- Inter-urban (intercity) travel market;
- Intra-urban travel market; and
- Airport choice market.

These are discussed in turn below.

2.1 Inter-Urban Market

For the purposes of this discussion, the inter-urban market includes travel between the urbanized areas located on the NLX corridor. Such trips currently use any of three available modes:

- Automobile;
- Bus service; and
- Air service.

2.1.1 Automobile

Automobile is the predominant travel mode in the corridor. Diversions from auto to rail are frequently the principal source of ridership on new rail services in medium-distance corridors such as the one considered here. Accordingly, it is important for the travel forecasting effort to have a good understanding of automobile travel patterns and levels in the study corridors.

Some information exists on specific aspects of intercity travel - Travel Survey Inventory External Survey done by the Metropolitan Council MPO (Metropolitan TBI External survey), journey-to-work data available from the year 2000 Census Transportation Planning Package (CTPP) and 2006-2008 American Community Survey (ACS). MnDOT's traffic counting program collects data on traffic volumes on I-35, the major inter-urban highway connecting the Twin Cities to Duluth. MnDOT has two continuous count stations in the cities of Duluth and Wyoming, in addition to point counts performed at additional locations along this route. These counts do not identify trip purposes. In addition, there is no readily available data on the composition of this traffic in terms of travel between specific origin-destination (OD) pairs in the corridor. It will therefore be necessary to estimate inter-urban automobile travel demand characteristics from other sources.

Table 2-1 and Table 2-2 present a selection of recent relevant traffic count data on I-35. Average Annual Daily Counts (AADT) and Heavy Commercial AADT (HCAADT) estimates reflect traffic and truck volumes across the corridor, while data from Automatic Traffic Recorders (ATR) demonstrate vehicle classifications, monthly seasonality and time-of-day travel patterns. The ATR station (Station # 191) in Wyoming MN is 30-40 miles north of the Twin Cities metropolitan area, and can be considered representative of travel outside the urban region.

TABLE 2-1 SELECTED TRAFFIC COUNTS ON I-35

Location	AADT	HCAADT	% Heavy Commercial Vehicles	Year*	County
Minneapolis (I-35W)	156,000	8,300	5.3	2010	Hennepin
Wyoming	41,000	2,150	5.2	2010	Chisago
Pine City	21,400	1,450	6.8	2010	Pine
Hinckley	20,700	Not available	N/A	2010	Pine
Duluth	41,500	2,450	5.9	2011#	St. Louis

* More recent (2013) AADT counts are available for some locations; however, AADT and HCAADT of the same year are presented here to facilitate comparison

No 2010 counts are available for Duluth

Source: MnDOT Traffic Forecasting and Analysis Unit, Traffic Volume (AADT/HCAADT) Table & AADT County maps

TABLE 2-2 SELECTED 2013 TRAFFIC COUNTS FROM ATR STATION #191

Month	MADT	% Heavy Commercial Vehicles#
January	33,769	5.2 (2011)
February	35,348	5.1 (2011)
March	36,735	5.1 (2011)
April	36,025	5.1 (2011)
May	43,139	5.9 (2011)
June	47,069	5.6
July	48,958	5.2
August	50,684	5.6
September	45,992	6.1
October	43,761	Not available
November	40,489	Not available
December	35,095	Not available

Unavailable due to station and/or piezoelectric sensor issues in June 2011 – May 2012, and after October 2012

Sources: MnDOT Traffic Forecasting and Analysis Unit, 2013 Continuous Traffic Recorder Report & ATR Monthly Vehicle Classification Reports

A total of 734 respondents intercepted on I-35 were interviewed as part of the 2011 Metropolitan TBI External survey. Among other things, information on the origins and destinations of their trips were obtained which will be valuable in the auto trip table development for this study. Table 2-3 shows the number of responses by day of week.

TABLE 2-3 CROSS-TABULATION OF EXTERNAL SURVEY RESPONSES BY DAY

Roadway	Monday	Tuesday	Wednesday	Thursday	Friday	Total
I-35	152	130	135	167	150	734

Source: Metropolitan Council TBI External Survey 2011

Table 2-4 shows automobile travel distances and times between the major destinations in the study area. The data are obtained from Google Maps and reflect speed limits and representative congestion levels on each route. This shows that the destinations are separated by distances and travel times that are potentially addressable by a short- to medium-distance intercity rail service.

TABLE 2-4 AUTOMOBILE TRAVEL TIMES AND DISTANCES BETWEEN CORRIDOR CITIES

Route	Distance (miles)	Time (minutes)
Minneapolis – Duluth	155	150
Minneapolis – Hinckley	80	80
Duluth – Hinckley	75	70
Minneapolis – Cambridge	45	50
Minneapolis – Coon Rapids	15	25

Source: maps.google.com

2.1.2 Bus service

Table 2-5 presents a summary of the regularly-scheduled bus services operating in the study area. Charter bus operations, such as those between the Grand Casino Hinckley and the Twin Cities, are not listed here. The table also does not include the MetroTransit express bus between Minneapolis and Coon Rapids. Note that while Greyhound's website sells tickets for this corridor, the buses are operated by Jefferson Lines.

TABLE 2-5 BUS SERVICES SUMMARY

City Pair	Operator	Travel time (minutes)	Frequency	Fare per seat mile	Full fare for one-way trip
Minneapolis – Duluth	Jefferson Lines	140 – 210	3x-4x/day	$0.19	$30
	Skyline Shuttle	170	10x/day	$0.27	$42
Minneapolis - Hinckley	Jefferson Lines	125	1x/day	$0.48	$38
	Skyline Shuttle	100	10x/day	$0.38	$30
Duluth-Hinckley	Jefferson Lines	85	1x/day	$0.39	$29
	Skyline Shuttle	75	10x/day	$0.41	$30

Locations of the main bus stations, and their proximity to downtown areas of the major cities, are set out in Table 2-6 for context. As can be seen, the locations (and related access/egress convenience) of these stations vary considerably among the cities in the study area.

TABLE 2-6 BUS AND TRAIN STATION LOCATIONS

City	Service	Description of Station Location/Pick-up Points
Minneapolis	Jefferson Lines	Central location; close to transit stops
	Skyline Shuttle	MSP Airport
Duluth	Jefferson Lines	4 miles SW of downtown Duluth, between Duluth and West Duluth
	Skyline Shuttle	Downtown Duluth
Hinckley	Jefferson Lines	Tobie's Station, just SE of I-35/Highway 48 junction
	Skyline Shuttle	Same as Jefferson Lines (also drops off at area hotels, including Grand Casino, on request)

Sources: Bus company websites; www.greyhound.com, www.jeffersonlines.com, www.skylineshuttle.com

Commercial bus operators are generally reluctant to release ridership numbers. In the absence of any such information from the operators, approximate ridership estimates based on bus capacity and load factors will be prepared.

2.1.3 Air service

The study area is served by a large hub airport, the Minneapolis-St. Paul International Airport (MSP), and a regional airport in Duluth (DLH). Table 2-7 sets out a number of key characteristics of each of these airports, including its ranking among US airports in terms of 2012 domestic passenger enplanements, scheduled departures, passenger carriers operating at the airport, and enplanements per departure.

Minneapolis-St. Paul International Airport (MSP) is located in-between the Twin Cities. It is the 11th busiest airport in the US, and a major hub for Delta Airlines, low-cost carrier Sun Country Airlines, and commuter carrier Great Lakes Airlines. The airport is a destination for domestic and international flights, and a regional connecting point for longer-distance flights. Duluth International Airport is the third busiest airport in Minnesota, and is mainly served by feeder flights to MSP and other hubs; this means passengers traveling to other destinations are making connections at these hubs.

TABLE 2-7 AIRPORT CHARACTERISTICS

Code	Airport	US Airport Rank	2012 Passenger Enplanements	2012 Scheduled Departures	2011 Passenger Carriers	Enplanements per Departure
MSP	Minneapolis-St. Paul International	11	14,971,000	185,128	28	81
DLH	Duluth International	191	157,000	4,044	8	39

Source: Airport snapshots from www.bts.gov

Table 2-8 shows the total number of true Origin-Destination (i.e. not connecting) trips between the two airports by direction, with outbound passenger volumes shown to the left of the diagonal and inbound passenger volumes shown to the right of the diagonal. The data shown here are as reported in the DB1B airline ticket sample database, without additional processing.

TABLE 2-8 ORIGIN-DESTINATION AIR TRIPS BY DIRECTION, 2012

	Destination (To)	
Origin (From)	Minneapolis-St. Paul (MSP)	Duluth (DLH)
MSP		143
DLH	104	

Source: DB1B Market data for number of passengers between airport pairs for 2012Q1 to 2012Q4, extracted from www.transtats.bts.gov

2.2 Intra-Urban (Local) Market

Interactions between the proposed NLX service and the Twin Cities metropolitan transportation system (MetroTransit) can be a possibility. Under that circumstance, Twin Cities-area residents will use MetroTransit services for the access and egress legs of longer rail trips, and conversely the level of service experienced on the access/egress legs affects the attractiveness of rail for longer distance trips.

While there is only one proposed station in the Twin Cities metropolitan area, the proposed station at Foley in Coon Rapids means that the rail system can potentially be a suburban travel mode that may complement and compete with the other modes serving this corridor, such as the Northstar Commuter Rail and MetroTransit's Route 850 and 852 Express Buses.

The Northstar Commuter Rail makes six scheduled trips between Big Lake, Elk River, Anoka, Coon Rapids and Fridley to downtown Minneapolis during the morning rush hour, return service during the evening rush hour, and limited service during special events such as Twins baseball games.

Route 850 makes 29 trips from Foley Station to downtown Minneapolis during the weekday AM peak period, approximately 5:30 to 9:00 AM, and 28 reverse trips in the PM peak period, between approximately 3:00 and 7:00 PM. Route 852 makes 18 trips at hourly intervals between Foley Station and downtown Minneapolis on weekdays from early morning to late evening, and 8 trips at 90-minute intervals on Saturdays. Both routes operate some buses further north into Coon Rapids and Anoka County, and some buses which terminate at Foley Station.

As discussed earlier, Minneapolis/Coon Rapids-area trips may be modeled using an adapted version of the existing MetCouncil travel demand model, which includes Anoka County. The resulting forecasts will then be overlaid onto the forecasts of trips between this station pair. However, based on discussion with and feedback from MnDOT and the Peer Panel, it has since been decided not to consider the proposed NLX mode as a potential intra-urban mode competing with local transit services within the Twin Cities and Duluth-Superior metro areas.

Table 2-9 below lists the main transit options available in the main cities in the corridor and describes some of the key service characteristics.

TABLE 2-9 TRANSIT SERVICES IN THE STUDY AREA

City	Type of Services	Coverage in City	Coverage in corridor	Typical Fares
Minneapolis	MetroTransit - bus, light rail	Bus lines run throughout the Twin Cities; bus lines extend to Anoka and Washington counties. One light rail line between downtown Minneapolis and the Mall of America.	Bus and commuter rail to Coon Rapids	Local $1.75-$2.25 (peak), Express $2.25-$3 (peak), Northstar Line $3-$6
Duluth	Duluth Transit Authority - bus	Bus lines in downtown Duluth; Duluth airport; Proctor, MN; Superior, WI	N/A	$0.75-$1.50(peak)

Sources: Local transit agency websites

2.3 Airport Choice Market

The introduction of rail service with a station at a hub airport may cause some air passengers – those whose trips begin at smaller regional airports and involve a change at the hub – to access the hub airport by rail rather than by air. Data on the total number of passengers traveling between the key airport pairs was examined to establish the potential size of this airport choice market. This differs from the data shown above in Table 2-8, which shows only the passengers traveling between each point, and does not include those making *connecting* flights to other national and international destinations.

Table 2-10 shows segment-level traffic information for travel between MSP and DLH. The table includes total passengers, scheduled seats, scheduled departures, average daily frequency, average seats per flight, and average passengers per flight for 2012.

Comparing airport pair passenger volumes with the corresponding true Origin-Destination traffic in Table 2-8, it can be seen that nearly all of corridor air passengers are currently connecting in MSP.

TABLE 2-10 MSP-DLH CORRIDOR AIR SERVICES SUMMARY, 2012

Passengers	Seats	Scheduled Departures	Flights/Day	Seats/Flight	Pax/Flight
132,942	185,634	4,152	11.4	44.7	32.0

Source: T-100 Segment data for scheduled passengers in corridor for 2012Q1 – 2012Q4, extracted from www.bts.gov

As described above, given that the proposed NLX service will not serve the MSP airport directly we propose not to include the connect air modeling as part of this modeling effort.

3 Available Data Sources

3.1 Introduction

This study will conduct detailed original new data collection – cell phone movement based data for automobile trip table development and Stated Preference (SP) survey data for mode choice model development. Both of these data collection efforts are described in more detail later in Chapter 4. This chapter sets out the already available other primary sources of data for the highway, air and other transportation markets. In addition to these data sources, the team will explore potential secondary data sources that could be useful as supplementary sources.

3.2 Highway and Socio-Economic Data

This section will highlight various sources of data on the highway network and travel patterns in the corridor the project team intends to use as part of this study. The main sources are:

- Travel Behavior Inventory (TBI) surveys conducted by the Twin Cities MPO;
- MnDOT's traffic count data;
- Socio-economic data from existing MPO travel demand models;
- Other socio-economic data (e.g., population, employment, income, etc.); and
- Journey planning software.

3.2.1 Travel Behavior Inventory (TBI) surveys conducted by the Twin Cities MPO

Conducted roughly every 10 years since 1949, the TBI is the most comprehensive source of travel data in the Twin Cities region. The Metropolitan Council conducted its seventh TBI starting in the fall of 2010 and continuing into the spring of 2012. The TBI is a series of surveys that examine where people travel, as well as when, why and how. The TBI survey will provide useful information for our project and include:

- *The Household Interview Survey* - Approximately 13,000 households in the greater Twin Cities region (the seven-county area plus the twelve adjacent counties) were asked to keep a travel diary, recording all of their trips for a selected day or days. Household demographic information is collected to allow the survey data to be expanded to the entire population. A sub-sample of 250 households was issued a portable GPS unit to record all of their trips for a week. This survey was conducted in the fall of 2010 through March 2012.
- *The Transit On-Board Survey* – A random sample of transit system riders (bus, LRT, and commuter rail) was given surveys to fill out describing their trip. This was conducted to gather more detailed information about the travel patterns of transit users. This survey was completed in November 2010. Preliminary data is now available.
- *Airport Survey* - Departing passengers at MSP airport were given a survey describing how they got to the airport and where they started their trip. This survey was completed in June 2011. The data and report is now available.

- *External Survey* – Surveys were mailed to residents outside the Twin Cities region asking about their last trip into and out of the region. This survey occurred in the spring of 2012.
- *Special Generator Surveys* – At the University of Minnesota and the Mall of America, special surveys help the region better understand the unique travel patterns of visitors and students.
  - The Mall of America survey occurred in September 2011. Survey crews were at selected entrances to the mall, interviewing visitors about how they arrived, what part of the region they came from, by what transportation mode, and the number of people in their group. Data from this survey are incorporated into the regional models for forecasting future travel and are critical to understanding the role of this unique attraction to the region's transportation system.
  - The University of Minnesota survey occurred throughout 2011 as part of the larger Household Interview Survey.

3.2.2 MnDOT Traffic Count Data

MnDOT maintains GIS-based applications that present traffic count data. These applications provide a web-based interface displaying traffic counts derived from permanent traffic count stations and portable traffic count locations on major roads. The type of counts and the robustness of each source will vary from count site to count site. This available data (described in detail in Section 2.1.1) will primarily be used to validate the trip tables to be developed.

3.2.3 Socio-Economic Data from Existing MPO Travel Demand Models

One of the primary sources of socio-economic data for the Twin Cities and Duluth areas will be the existing MPO travel demand models: the Metropolitan Council Travel Demand Model and the Duluth-Superior Metropolitan Interstate Council (MIC) model. Both models contain socio-economic data, including estimates of population, households, and employment at the traffic analysis zone level for each model year, along with other potentially useful attributes, such as median income. We propose to use the socio-economic data from the two MPO models in both the intercity and intra-urban modeling phases, supplemented by census and Woods & Poole data (described below) as needed.

3.2.4 Other Socio-Economic Data

County Business Patterns Data

County business patterns data[7] is an annual series developed by the U.S. Census Bureau that provides disaggregate economic employment information: employment by county by industry and business size. The data has been collected continuously since 1964 and the most recently published data is for 2008. The aggregated nature of the data helps to maintain confidentiality, but in some instances, data is suppressed to meet this requirement. The series also excludes some categories of employed persons (i.e. self-employed individuals, employees of private households, railroad employees, agricultural production employees, and most government employees).

[7] www.census.gov//econ/cbp//index.html

Woods and Poole Data

This commercially-prepared source[8] contains data for population, households, employment and income by county. The data includes historical data since 1970 and forecasts to 2040. The data is disaggregated by many factors; for example, population is disaggregated by age and race, employment by industry, earnings of employees by industry, personal income by source, and households by income bracket. This data, supplemented with growth elasticities from previous studies[9], can be used to estimate future year trip tables.

Each of the major MPOs in the corridor prepares population and employment forecasts. Given the resource and timing constraints for this project, and the need to ensure consistency of assumptions, Woods and Poole data is likely to be the best single source of comprehensive socio-economic data (both historical as well as future forecasts) for the entire study area. However, it will be important to understand the differences between the locally developed MPO forecasts and those used in the model. These differences can potentially be used to define sensitivity tests.

3.2.5 Trip Planning Software

A variety of commercial journey planning software can be used to estimate point-to-point travel times, including Mapquest and Google Maps. These can be used to estimate both county-to-county automobile drive times and county-to-common carrier access point (i.e. airports and stations) drive times. County seats will be used as the center of each zone, unless better information about the actual county population center becomes available. This data will be supplemented with data from real time travel alert websites (e.g. www.sigalert.com, www.beatthetraffic.com), which can furnish more representative estimates of congestion and delay on specific links. Network modeling software (e.g. CUBE Voyager, TransCAD) can also be used to check the travel times derived from these sources.

3.3 Air Data

This section will highlight various sources of data on corridor airports and air travel patterns that the project team intends to use as part of this study. The sources are:

- Airline Origin and Destination Survey (DB1B) data;
- Form 41 T-100 air travel data; and
- Airline schedules/websites and data directly available from MSP and DLH.

3.3.1 DB1B Data

The Bureau of Transportation Statistics' (BTS) DB1B database contains a 10% sample of airline tickets from reporting carriers (where reporting carriers are those above a certain size threshold). Data includes origin, destination and other itinerary details of passengers transported for both domestic and international trips (only the domestic data is required for this study). This database is used to determine air travel patterns, air carrier market shares, and passenger flows. Data is available for individual travel segments (i.e. each leg of a

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[8] www.woodsandpoole.com/main.php?cat=country

[9] For example, previous studies considering trip patterns in the study corridor, or the Interim Traveler Response to Transportation System Changes handbook, http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_webdoc_12.pdf

passenger's air trip) as well as for markets (i.e. the entire air component of a passenger's trip). Data for non-reporting carriers can be estimated from other data sources (e.g. the T-100 discussed below) and appended.

3.3.2 T-100 Data

The BTS' Air Carrier Statistics database, also known as the T-100 data bank, contains domestic and international airline market and segment data. Certificated U.S. air carriers report monthly travel information using Form T-100. This data contains fewer variables than DB1B, but includes all relevant air carriers and thus can be used to in-fill for data missing in DB1B.

3.3.3 Airline Schedules/Websites

Airline websites contain information on their services, including scheduled flight times, frequency of services and fares. Note that these will typically be based on the available fares and current schedules the airline is operating. Historic pricing information and some service information is available in the BTS databases described above. Assumptions will be made based on historic trends regarding future airline pricing and service levels.

3.3.4 Airports data

We will also contact the MSP and DLH airports directly to collect any additional flight schedule and volumes data as well as airport access surveys if available.

4 Travel Demand Forecasting Methodology

4.1 Introduction

As noted in Chapter 1, development of a ridership forecasting model system suitable for predicting HSIPR ridership volumes in the study corridor will require the resolution of a number of modeling issues. The following sections summarize key issues and indicate the proposed methodology for addressing them.

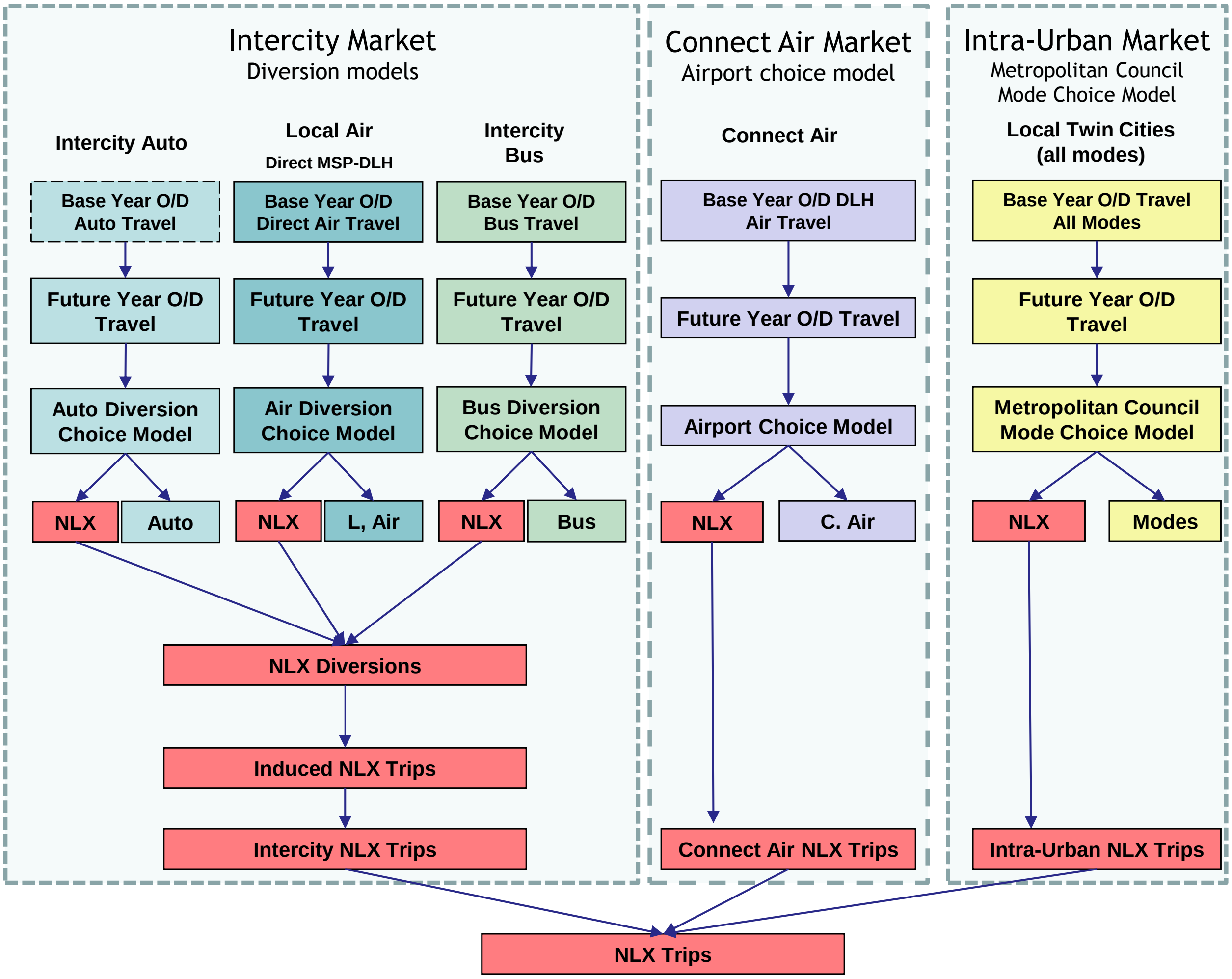
As noted earlier, model development is an inherently exploratory process. While the modeling methodology will follow the general direction indicated here, it is expected that adjustments and modifications will be required as the model is developed and tested.

We identified three separate markets for the proposed NLX service.

- Intercity Markets:
  - Intercity travel by auto: current auto trips between Duluth, other intermediate points and the Twin Cities in the corridor;
  - Intercity travel by air: current air trips between DLH and MSP airports (direct flights starting and ending within the corridor); and
  - Intercity travel by bus/Shuttle/Van: current bus, shuttle or van trips between Duluth, other intermediate points and the Twin Cities in the corridor.
- Airport choice connect air market (*not applicable for this study*): current air travel to/from DLH traveling from an origin to a destination that is not within the corridor; and
- Intra-urban markets (*may or may not be applicable for this study depending on the possibility of selling tickets for local travel on the NLX service)* : current travelers within the Twin Cities metropolitan area (all modes).

We propose to forecast the diversion to the proposed NLX service from the existing intercity modes (auto, bus/shuttle/van, air) using a set of diversion models (described in detail below under “Modeling Inter-Urban Travel” section). The airport choice market, where applicable, is usually modeled using an air route choice model, while the local intra-urban market will be modeled using a modified version of the existing Metropolitan Council travel demand model for the Twin Cities. The markets and the proposed modeling approaches are summarized graphically in Figure 4-1.

FIGURE 4-1 MARKETS AND PROPOSED MODELS



4.2 Modeling Inter-Urban Travel

The proposed approach to forecasting the potential ridership and revenue of the proposed NLX rail services for the inter-urban (long distance intercity) market entails five broad steps:

1. establish the study area geographic scope and its zone structure;
2. define and establish all required input data including service characteristics for each mode and each zone pair;
3. estimate the current in-scope travel market;
4. estimate how this market will grow in the future; and
5. estimate the potential market share that the new rail service will capture (i.e. the ridership).

4.2.1 Establish the study area geographic scope and its zone structure

As described before, the intercity model will cover a geographic area that generally follows the NLX corridor and extends approximately 50 miles on each side of the proposed alignments (Figure 1-3), which is a typical planning assumption for the catchment area of HSIPR services.

However, the 50- mile distance is indicative rather than absolute, and has been adjusted as appropriate in specific instances. The study area is further split into a total of approximately 380 Transportation Analysis Zones (TAZ) as seen in Figure 1-3. In the Twin Cities Metropolitan Council Regional Travel Demand Forecasting Model (RTDFM) and the Duluth-Superior Metropolitan Interstate Council (MIC) model areas, the TAZs will be based on the MPO model TAZs or some aggregation of them; in more rural areas they will be based on county boundaries or some disaggregation of them by census tract. Proper care has been taken to have some of the major transportation attractions or travel generators (e.g. the MSP airport, the Target Field station, the Grand Casino, the CBDs in Minneapolis, St. Paul and Duluth, etc.) to be represented by their own TAZs.

This strikes a good balance between the need to consider a large study area while having sufficient detail to reflect important geographic differences in modal service characteristics. This also provides a more detailed representation of the urban areas, while maintaining a manageable number of zones.

4.2.2 Prepare input data

We will first establish the demand modeling base year and the 20-year planning horizon based on input from MnDOT and other project proponents, and then collect or develop modeling input data for these years. These will include the study area network, historic and future socio-economic and exogenous variables (employment, population, income, general economic conditions, information on visitors, patients, students, commuters etc.), travel market segments (e.g. resident work, resident non-work, visitor business, visitor leisure, special generators like the Grand Casino at Hinckley), information about the service characteristics[10] of existing and future travel modes and about patterns and levels of trip making on these modes. This information will be collected from the MPO models, existing studies and other sources as applicable.

Accurate establishment of modal travel times is particularly important, and two approaches are commonly used to estimate these in travel forecasting. The first is to prepare a representation of the network using network modeling software and then use this to estimate travel times. The second is to estimate the times using empirical sources, for example commercial trip planning software (MapQuest and Google Maps) supplemented with real time travel alert websites (e.g. www.sigalert.com, www.beatthetraffic.com and www.cotrip.org). These data can then be combined with other assumptions (regarding vehicle operating costs, fares or service frequencies) to estimate modal service characteristics between individual zone pairs.

Irrespective of the method used to calculate the modal service characteristics, network modeling software can be useful for developing our forecasts, as it offers the capability to hold and manipulate the large volumes of data created in preparing demand forecasts. In addition, travel times calculated from network modeling software can be used to check those obtained through other processes.

[10] For a trip by common carrier mode (including the NLX rail service), this takes into account the in-vehicle time, frequency of service, fare, and time/cost needed to access and egress the mode’s station from the trip’s actual origin and destination. For a trip by automobile, this takes into account the OD travel time (including any delays due to road congestion) and vehicle operating costs (largely fuel cost).

4.2.3 Estimate the base year (2020) in-scope no-build travel demand

The inter-urban travel market includes trips by air, bus, train and private automobile, and for different travel purposes. Chapter 2 of this report has reviewed at a high level the salient characteristics of these travel markets. For the purposes of forecasting model development and application, data on these markets will need to be developed on a much more detailed zone-to-zone basis, as outlined below.

4.2.3.1 Air

Current true origin-destination (OD) volumes and patterns of corridor travel by air (local air trips) can be determined by reference to standard sources such as the DB1B and T-100 databases from the Bureau of Transportation Statistics (BTS). These local airport-to-airport volumes can be allocated to OD zones, and their trip purpose (e.g. business/commute vs. non-business) distribution can be estimated using data from the Census, County Business Patterns, and Woods and Poole.

Similarly, air passengers who are connecting between the study area airports during the first or final legs of their trips can be quantified from segment level data of the T-100 databases.

4.2.3.2 Intercity bus and transit

Intercity bus travel (with Greyhound / Jefferson Line, Skyline Shuttle and others running 15-20 round trips per day between Minneapolis and Duluth) is rapidly gaining popularity in the NLX corridor. However, as mentioned before, bus ridership data tends to be treated as commercially sensitive by the bus operators and information on this travel market is difficult to obtain. As a result, bus OD trip tables will be estimated using supply side data on current service frequencies and appropriate load factor assumptions.

4.2.3.3 Auto

In forecasting intercity passenger rail ridership and revenue, the accuracy of the auto trip tables strongly influences the overall accuracy of the forecasts. However, in contrast to the air mode, relatively little data on intercity automobile travel is collected at the national level, and in the US there currently is no standard up-to-date source of information about intercity auto trip making that is sufficiently detailed to be used in project-level forecasting.

Anonymous cell phone data is the most efficient way to understand the origins and destinations of auto travelers in the corridor. A firm called AirSage has been engaged for this purpose. AirSage has a contract with Verizon and Sprint to obtain the communications protocol data exchanged between mobile devices and communications towers; these data allow the movements of mobile devices to be analyzed in a way that preserves the anonymity of device owners and the privacy of their communications. Data are available starting from January 2010. This is a newly available and rich data source with great potential given the large sample size, wide geographic coverage, availability of prior years' data, and ongoing collection without intervention by users or network operations staff.

We have used AirSage data for a number of rail forecasting studies. The technology is still developing and we are familiar with its challenges and with robust approaches for extracting useful travel information from the data. This will be an efficient way of obtaining useful data on travel patterns in the study area. Key advantages for this study include:

- Ready availability of a large sample of several years of anonymous cell phone movement data;
- Ability to obtain current or retrospective information for multiple seasons – very useful to determine travel seasonality in the study area;
- Ability to aggregate data to different time periods (weekday/weekend; periods within the day); and
- Less expensive than most other OD data collection methods.

However, there are also some issues with this kind of data including:

- Limited applicability in the context of urban tripmaking. (Location accuracy is generally not adequate to provide useful geographic resolution in urban environments);
- Lack of direct information about trip or tripmaker characteristics other than origin and destination;
- It is based on an evolving technology that has not yet attained complete maturity.

It was necessary to identify representative time periods for which cell phone data are obtained and processed. Based on an examination of MnDOT data on the monthly distribution of traffic volumes at rural locations, it was found that there are only three continuous count stations between Minneapolis and Duluth, and only one *(count station 191)* that is directly in the proposed NLX corridor along I-35:

- Count station 222 is on Highway 65, a considerable distance away from I-35;
- Count station 103 on I-35 is very close to downtown Duluth, and does not have complete counts for each year between 2010-2012; and
- Counts station 191 on I-35 is in Wyoming, MN, 40 miles north of downtown Twin Cities.

Using station 191 counts as representative of NLX corridor traffic, it was found that the counts fluctuate seasonally, from a high of about 50,000 in August to a low of around 35,000 in January, with roughly linear trends in-between. Hence, it was decided to obtain AirSage cellphone data for these two months in 2013. Of the two selected months, January represents a typical winter month with low traffic volumes, and August a typical summer month with the highest traffic volumes. The annual trip table(s) will be inferred based on the traffic count distribution for the remaining 10 months. Traffic counts by the hour are also available, which will be used to validate the within day trip table distributions that will be provided by AirSage.

The trip table(s) developed in this way will also supplemented by and checked against data from the TBI surveys (Twin Cities 2010 household surveys and the 2011 external travel survey) that were conducted by Twin Cities Metropolitan Council as described in Chapters 2 and 3. In addition, the intercity automobile trip table developed from these sources will be validated against available traffic count data on I-35 at carefully selected rural locations and information (if available) from the Grand Casino on casino visitors. There are annual point (one-time) counts that are available at various locations along I-35 in the counties of Chisago, Pine and St. Louis. These will be used in the validation exercise.

4.2.4 Estimate the future year (2040) in-scope no-build travel demand

These estimates will reflect socio-economic trends (such as changes in population and employment) and assumptions regarding the sensitivity of changes in trip making behavior to these trends.

Separate mode-specific econometric models (also called direct demand models) will be used to estimate the volume of OD trips by zone pair in future analysis year(s) by auto and bus based on exogenous socio-economic characteristics and modal levels of service. These direct demand models capture exogenous demand growth and have the following general functional form:

$$T_{OD}^{m} = f(P_{OD}, E_{OD}, LOS_{OD})$$

where

T_{OD}^{m} = number of trips by mode m made between origin O and destination D;

P_{OD} = population estimates related to O and D;

E_{OD} = socio-economic and other exogenous variables related to O and D;

LOS_{OD} = level-of-service variables (including prices) for the existing modes between O and D.

Given the current data described earlier, the direct demand models allow us to develop projections of future year trip volumes by auto and bus based on changes in the relevant input variables. We then use survey data and other sources to estimate, for each mode, the shares of total trips that are made for business/commute and nonbusiness purposes.

Future year air trip tables will be prepared based on published FAA Terminal Area forecasts of total annual airport enplanements for each of the study area airports as these are a generally-accepted standard source.

4.2.5 Estimate the rail project market share

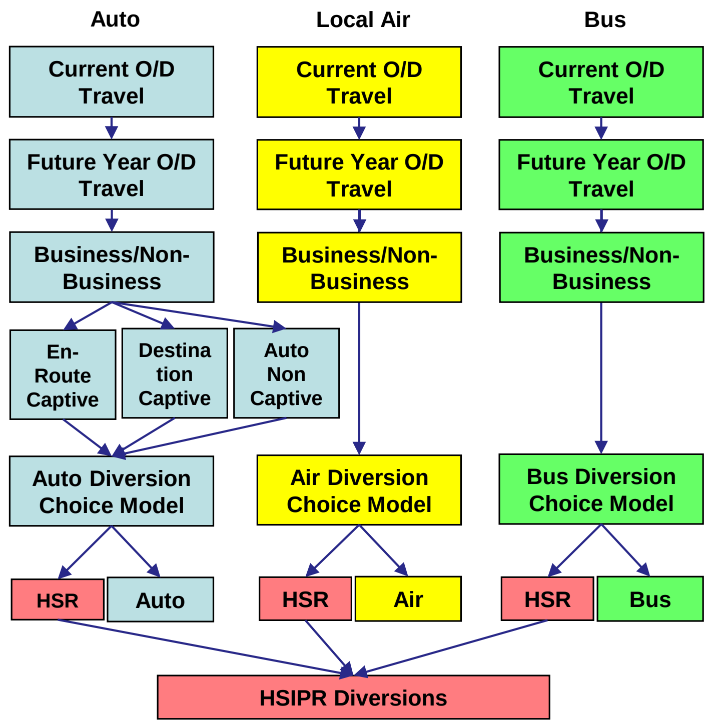
For the inter-urban market forecasts, we propose to apply a method that we have used on numerous FRA- and USDOT-funded studies. The key feature of this method is its use of separate binary (two mode) logit relationships to predict traveler diversions from each existing mode to the new NLX rail service. Binary logit models are one of the standard methods used to predict the market share of new or improved travel modes. Compared to other forecasting approaches, we have found these models to be transparent, readily explained and assessed, robust and practical. They reflect a theoretically satisfying choice structure, and generally avoid many of the issues that other approaches often encounter.

As noted, this approach is similar to that adopted in our other ongoing FRA funded demand forecasting projects for HSIPR services in the Zip Rail (Minneapolis-Rochester) corridor, Chicago-St. Louis corridor, Atlanta-Charlotte corridor, Oklahoma City-South Texas corridor and for a sketch-planning demand forecasting tool developed for the FRA's National Rail Planning Study. Forecasts produced using this methodology have been benchmarked to Amtrak's Acela Express and Northeast Direct ridership and revenue in the Northeast Corridor.

This forecasting approach is graphically shown in Figure 4-2. Travel market segments are carefully defined based on a combination of current mode, trip purpose and other traveler and trip characteristics. Market segments include:

- Local air travel;
- Inter-city auto travel; and
- Inter-city bus travel.

FIGURE 4-2 INTER-URBAN MODELING FRAMEWORK



This market segmentation approach to the NLX rail mode choice modeling is based on the recognition that people's current choice of intercity travel mode reveals a great deal about their preferences for the various features of these modes. For this reason, we expect that a market segmentation based in part on the current preferences of intercity travelers in the NLX study area for air, private vehicle and bus will also capture significant differences between the segments in their attitudes and preferences towards the NLX rail service. Incorporating trip purpose in the market segmentation further captures known behavioral differences between people traveling for different purposes.

For each combination of trip purpose and current mode, we calibrate relationships of the following form that express the fraction of travelers who would divert from the existing mode to the NLX rail service as a function of the respective modal service attributes. These relationships are then applied to predict the volume of travel on the modes that will divert to rail. Induced (new) travel on the rail mode is separately forecast using models based on changes in composite traveler utility. Total rail ridership is obtained by summing the predictions for the individual market segments and OD pairs.

$$S_{OD}^{m,HSR} = f(time_{OD}^{m,HSR}, cost_{OD}^{m,HSR}, freq_{OD}^{m,HSR}, QOS_{OD}^{m,HSR}, const_{OD}^{m,HSR})$$

where

$S_{OD}^{m,HSR}$	= share of existing mode m trips between O and D that will divert to NLX;
$time_{OD}^{m,HSR}$	= access, egress, line-haul, and processing time components for mode m and rail;
$cost_{OD}^{m,HSR}$	= access, egress, and line-haul travel cost components for mode m and rail;
$freq_{OD}^{m,HSR}$	= measures of the frequency for mode m and rail;
$QOS_{OD}^{m,HSR}$	= quality of service measures (comfort, reliability, etc.) for mode m and rail; and
$const_{OD}^{m,HSR}$	= effect of unquantified characteristics of rail relative to the existing mode.

As shown in Figure 4-2, we will use a set of binary logit models to predict diversions to the NLX service from each mode and for each trip purpose; each such model compares the attractiveness of rail against one existing mode (local air, auto, bus, as applicable) for one trip purpose.

The modal diversion process is further refined by distinguishing between three groups of auto travelers: (1) those who need a vehicle at their final destination ("destination-captive"), (2) those who do not ("non-captive"), and (3) those who need to make stops en route during their trip ("en route-captive"). Many analyses of intercity travel assume that intercity trip makers are not captive to a particular mode, but empirical work indicates that this is not the case, particularly for private vehicle travelers. The likelihood of selecting the NLX rail service for intercity travel will be very different for the three groups of auto travelers. For example, those who need a vehicle at their final destination (group 1) will have to arrange for other transportation, typically by paying for the additional cost of renting a vehicle for the duration of their stay and spending extra time renting and returning the vehicle. In addition, private vehicle travelers who need to make stops en route during their trip (group 3) are considered not to be "choosers"; that is, they are not eligible for diversion to rail.

Each diversion model computes the probability that a traveler would choose rail over the current travel mode, given the modes' respective service characteristics. Characteristics include time, cost, frequency, reliability, and quality of service, for rail and the current mode, with time and cost typically broken down into their access, egress, transfer, terminal and line haul components. Mode-specific constants account for the effects of other (not explicitly modeled) characteristics of rail relative to other modes.

Rail access/egress, transfer and terminal characteristics by different Metro Transit modes in the Twin Cities metropolitan area will be explicitly modeled. This will be done by estimating new access/egress mode choice models to/from the proposed NLX station at Target Field and Foley stations. These access/egress mode choice models will be estimated in addition to the main inter-urban long-distance mode choice models and will use data from the new Stated Preference (SP) survey (discussed in the next section) and data from the Met Council model.

Conversely, for trips within the Twin Cities area, the NLX service may be a potential urban mode for a couple of station pairs, and again the Metropolitan Council model will be used to analyze this competitive situation (as discussed later).

4.2.6 Stated Preference Survey

In order to assess the attractiveness of a proposed new mode relative to other existing modes, data are required about traveler responses to the new mode. These data are sometimes obtained from surveys called Stated Preference (SP) surveys. SP surveys are used to elicit traveler preferences and tradeoffs involving different modal attributes. Survey data can then be used to develop choice models involving the new mode, such as the binary models described above.

Ideally, forecasting efforts should be based to the extent feasible on recent locally-collected data. The advantages of this are that it reflects the travel decision logic of corridor residents, it provides the best possible empirical basis for accurate forecasts, it allows incorporation of conclusions and results from earlier efforts, and it guards against possible criticisms regarding lack of local relevance in mode choice modeling. Other useful characteristics of study area travel such as auto captivity, travel party size, travel purpose, etc. can also be obtained via a survey. Hence, it was decided to undertake a new SP survey for the NLX study and to develop new mode choice models based on this data.

The Stated Preference survey will be carried out through the use of an on-line survey questionnaire. The internet-based SP survey will be designed by Steer Davies Gleave and developed and conducted by the well-known travel survey firm TNS. This has the benefits of providing data in a readily available electronic format, being relatively quick and cost effective to set up, and potentially providing high volumes of responses for little incremental cost. This is a common approach which Steer Davies Gleave has used on many occasions both in the USA and overseas. Experience shows that with properly designed on-line questionnaires, a wide range of contextual, attitudinal and choice data, as well as the socioeconomic and demographic characteristics of the current travelers can be accurately and efficiently collected.

Prior to the main survey launch, careful pre-testing of the questionnaire will be carried out to ensure the interview is of the right length, that there is no ambiguity in questions or tasks, and that respondents remain engaged to the end. Earlier research – carried out directly by Steer Davies Gleave or by its survey sub-contractors – shows that surveys up to 15 minutes long can be successfully administered. Moreover, researches have shown that surveys that take respondents more than 15 minutes to complete lead to fatigue and reduction in the quality of responses. Hence, we will keep this time constraint in mind while designing the NLX survey.

This online panel-based survey can only focus on study area residents who were members of a market research survey panel. Approximately 700 complete survey responses will be obtained from the SP survey of study area residents that are on the panel of the survey firm. We propose a multi-pronged approach to recruiting participants, some of which would depend on permissions from MnDOT and the relevant authorities and the availability of data. This will ensure that a large enough sample is gathered, have some meaningful representation of corridor visitors in the survey responses and incorporate the ability to include Grand Casino visitors/patrons in the SP survey effort.

The primary approach that we propose for the SP survey will be an online survey of residents using panels maintained by the survey firm TNS. Given the importance of Grand Casino to the NLX project, we therefore also intend to carry out additional survey data collection activities specifically targeting Grand Casino patrons. In addition, we will ask the Grand Casino Authority for relevant information that they may already collect from their patrons and the guests at the hotel on-site. Moreover, if timely permission is granted, we will distribute post cards with the survey link or carry out in-person interviews at major attractions (e.g. bus stations, Target Field Station, Mall of America) in the study area. Posting the survey link on major local websites is another option we will explore. However, we would need to be careful and treat the responses from this approach separately as this has a greater risk for response bias.

The survey response data from various sources will be used to develop mode choice models (as described above) that will calculate traveler diversions from existing modes to the proposed new NLX rail mode. In addition, the SP survey will be designed in such a way so that responses about the possible access/egress mode choices of the prospective NLX service users in the Twin Cities metro area will also be collected and subsequently used to develop an access/egress mode choice model for the metro area. Model development will also incorporate relevant information from other sources (e.g. USDOT guidance on values of time for intercity travel), and professional judgment based on forecasting best practices as required.

4.3 Intra-Urban Travel

The NLX project may include a station at Coon Rapids. The project could provide local rail service between Coon Rapids and Target Field Station. However, allowing such short distance low revenue passengers on the train may lead to the loss of longer distance, higher revenue trips due to limited capacity, as well as create a direct competition between the proposed NLX service and the already existing express bus service (described earlier in Chapter 2) between those areas. Hence, restricting travel between Target Field and Foley at the Twin Cities end and Duluth and Superior at the Duluth end should be seriously considered – this is a practice that is prevalent in several existing Amtrak routes.[11] For example, Amtrak for its Hiawatha service between Chicago and Milwaukee does not sell tickets between Chicago Union Station and Glenview and between the downtown Milwaukee station and the Milwaukee Airport Station. Similarly, travel is also restricted between Chicago Union station and Joliet on Amtrak's Lincoln service.

4.4 Airport Choice

In general, the introduction of a HSIPR service with a station at a hub airport can produce changes in air demand levels and patterns. Air travelers who begin their trip at a regional airport and change planes at a hub airport may prefer to access the hub airport by rail, or indeed may in some cases change their choice of hub.

Because of the attractiveness of Minneapolis St. Paul International Airport (MSP) as a hub (due to the large number of destinations served, and the presence of major carriers there), the main

[11] Taking this into consideration, the subsequent demand forecasting analysis carried out as part of this study did not consider the proposed NLX mode as an intra-urban mode competing with local transit services within the Twin Cities and Duluth-Superior metro areas. Based on discussion with and feedback from MnDOT and the Peer Panel.

issue here is modeling the behavior of air travelers who begin their trip in the other relevant study area regional airport – Duluth International Airport (DLH) - and who have the option of taking a connecting flight at MSP to their destination. This connection at MSP may be obligatory (no other flight from DLH is viable) or optional (direct flights from DLH to the other airports or viable connecting flights via other hubs are available from DLH). When considering a connection at MSP, the choice then is whether to begin the trip at DLH, fly to MSP and connect there to the onward leg; or to access MSP via a surface mode (including possibly NLX rail) and begin the air leg there. Similar but reversed choices confront air travelers who end their trip at DLH.

We will conduct a preliminary analysis to determine if air travelers are likely to use the NLX service and an MSP connection as an alternative to DLH, looking at the most common destinations and comparing travel times and costs. If we believe it to be an attractive choice, we will use a 'connect air model' developed for a similar project to estimate travelers who will use NLX in lieu of a connecting flight. However, we believe it is unlikely that this market will constitute a large number of travelers diverting to the NLX service, for the following reasons:

- The proposed NLX service does not have a station at MSP. The currently proposed station at the Minneapolis end for the NLX service is at the Target Field station. Significant additional time will be required to transfer between the Target Field station and MSP (involving a ride on the light rail Blue Line – approximately a 30 minute ride in addition to the time required inside MSP or the Target Field station to and from the light rail and vice versa). In addition, luggage transfer and re-checking could possibly be another deterrent.
- The potential size of this air market is quite small. There are currently 66,000 travelers flying each way annually to and from DLH and connecting at MSP on the six round trips that Delta operates daily between them. Another 80,000 air travelers currently fly annually between DLH and major destinations (Chicago, Detroit, Las Vegas and Phoenix-Mesa) without using MSP.

4.5 Induced Demand

Induced travel refers to trips that were not made before a project opens, but which come to be made as a result of the mobility and accessibility improvement that the project brings about. Two different sources of induced travel can be distinguished:

- People decide to not make a trip when the disutility of travel is greater than the utility that they derive from making the trip. A transportation system improvement reduces the disutility of travel, so when people re-assess their former decision to not make a trip, some may find that the trip has now become worthwhile and decide to make it.
- Over time, the mobility and accessibility changes brought about by a transportation system improvement will produce changes in the type, intensity and location of land uses and economic activities in the improvement's impact area. The transportation improvement will affect the socio-economic system. Increased population and economic activity will lead to increased travel.

The first source above is travel induced as a result of movement along a demand curve, while the second is travel induced by a shifting of the demand curve itself.

The NLX travel demand modeling effort will consider the first source of induced travel. However, it is beyond the scope of this effort to predict the land use and economic changes that might result from the presence of the premium rail service in the corridor.

With this understanding, it is proposed to forecast the induced travel resulting from the introduction of the NLX rail service using a simple elasticity-based approach, where the elasticity is expressed as the percentage impact on travel volumes resulting from a percent change in accessibility. Accessibility, in turn, will be defined in terms of a generalized cost or logsum variable computed from the mode choice model. The SP survey questionnaire will include a couple of questions regarding the induced travel and we will estimate the elasticity value from the responses of those questions. Reasonable elasticity values (or a range of values for sensitivity testing) may also be proposed if the SP survey data results in unreasonable elasticity estimates.

4.6 Rail Ridership and Farebox Revenue

Rail ridership diverted from different existing modes for the three markets are combined to produce total diverted ridership to the NLX rail mode. The induced rail ridership is then added to the diverted ridership to calculate total rail ridership. As was seen above, our models directly estimate diversions from other modes to rail. Consequently, impacts such as ridership and revenue losses on competing modes can be directly calculated from model outputs.

All ridership forecasts will initially be produced at the rail station pair level. Ridership at this level will then be multiplied by the corresponding fares to obtain ticket revenue for the station pair. Detailed ridership and revenue forecasts will be produced including OD trip tables at zone- and station-pair levels; station boardings and alightings; and rail diversions by source mode. These outputs will be suitable as inputs for other elements of the planning and environmental assessment process.

Each of the NLX rail modeling alternatives developed by the study process will be appropriately represented. Demand impacts will be forecast for all components of the study area transportation system, including the non-rail modes. The stated preference survey will be used as a preliminary guide to the fare levels at which significant ridership can be expected. In addition, fare levels used in earlier studies, fare levels for similar Amtrak services elsewhere in the country and inputs from with the PMT, TAC and the FRA will be taken into consideration to determine the initial per-mile fare levels for the proposed NLX service. Finally, a revenue maximizing fare level for NLX will be determined through the revenue maximizing analyses mentioned before. Past experience has shown that higher levels of ridership can be achieved with fare levels that represent only modest revenue reductions compared to the revenue-maximizing fare.

4.7 Capacity and Financial Information Feedback

Our demand analysis will take into account train passenger capacity to avoid a potential mismatch between the forecast ridership and available passenger carrying capacity as specified by the service plans. In the event of a mismatch, we will work with the Project Management Oversight (PMO) consultants to revise the rail service characteristics discussed above and will reforecast. We will also evaluate various financial metrics (ticket revenue, operating ratio) which may warrant further revisions to the plans for the proposed rail service. In the event of such revisions, the demand forecasts will be redone as well.

5 Summary, Decisions and Next Steps

This Ridership and Revenue Plan has summarized the context in which the NLX travel demand forecasting activities will be conducted, highlighted the modeling methodology that will be followed, identified a number of options regarding data sources for the modeling effort and discussed a couple of new original data collection efforts. Because the demand modeling work is still at the very initial stage, many of the detailed methodological issues have not been finalized yet. However, these will need to be resolved during the model development and application; for this reason, the description of the methodology presented here is at a relatively high level, and some elements described may ultimately change.

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B No-Build Travel Demand Memo

No-Build Travel Demand Memo

Northern Lights Express Ridership and Revenue Forecasting

Technical Memorandum

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Prepared for:
MnDOT
395 John Ireland Boulevard, MS 480
St. Paul, MN 55155-1800

Prepared by:
Steer Davies Gleave
883 Boylston Street, 3rd Floor
Boston, MA 02116
USA

+1 (617) 391 2300
www.steerdaviesgleave.com

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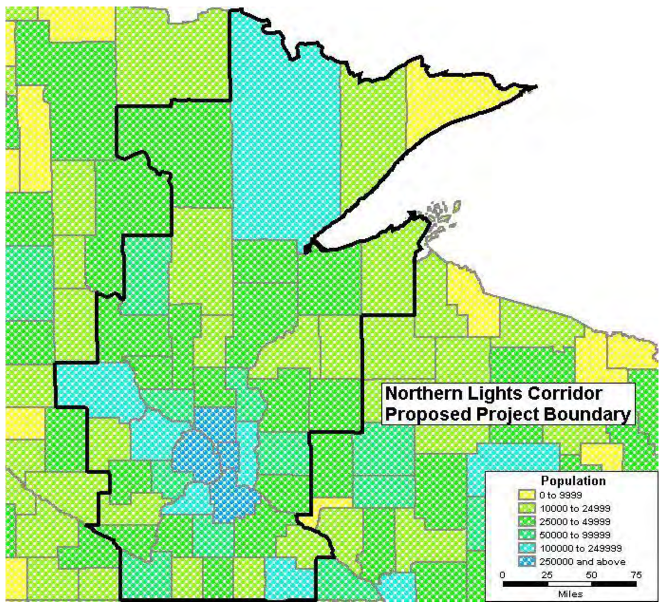
1 Introduction

This memorandum documents the creation of 'no-build' trip matrices for use in forecasting the ridership on the proposed Northern Lights Express (NLX) train service. These trip matrices will represent annual travel by the existing long-distance modes among all the possible origin-destination pairs (based on the geographic zone systems developed earlier as part of this study) in the project study area in no-build scenarios - scenarios where the NLX service is not built.

The NLX service is assumed to open in the year 2020. Additionally, forecasts will be prepared for one horizon year (2040). The project boundary consists of 45 counties in Minnesota and Wisconsin, representing an area of 50-100 miles around the proposed train service, as shown in Figure 4 below.

FIGURE 1 PROJECT BOUNDARY



The area has been divided further by SDG into 378 zones for the purpose of detailed modeling of travel movements and NLX ridership forecasts at a more disaggregate zone (OD) pair levels.

Trip matrices were created for various intercity (long distance) travel modes as follows:

- Current (2013) Auto Travel;
- Projected 2020 Auto Travel;
- Projected 2040 Auto Travel;
- Current (2013) Bus Travel;
- Projected 2020 Bus Travel; and
- Projected 2040 Bus Travel.

For Air Travel, there are very few trips made entirely within the project boundary (i.e. between Minneapolis-St. Paul International Airport, MSP and Duluth International Airport, DLH). However, since the potential exists for travelers from DLH using the proposed NLX service to access MSP for a cheaper and/or more direct flight itinerary, an 'AirConnect' model will be used to calculate the potential diversions of these existing connecting air travelers, as discussed in the section below. Data was collected for travel between Duluth DLH and all the destinations for travelers leaving from DLH, via connections both at Minneapolis-St Paul (MSP) and at other airports in order to quantify the no-build connect air market.

This memorandum is divided into three sections, representing the three major modes of existing intercity (long distance) travel (Auto, Bus and Air) from which travelers could divert to the proposed NLX service.

2 Development of No-Build Auto Trip Table

2.1 Introduction

As discussed in the Modeling Methodology Report submitted earlier, anonymous cell phone data is the most effective way to understand and estimate the origin-destination patterns of auto travelers in the Twin Cities-Duluth corridor. A firm called AirSage has been engaged for this purpose. AirSage has a contract with Verizon and Sprint to obtain the communications protocol data exchanged between mobile devices and communications towers; these data allow the movements of mobile devices to be analyzed in a way that preserves the anonymity of device owners and the privacy of their communications. This is a newly available and rich data source with good potential given the large sample size, wide geographic coverage, availability of historical data, and ongoing collection without any interventions whatsoever.

Since the cost of AirSage's data is directly related to the number of months of data collected, it is more cost-effective to obtain data for a smaller set of months and extrapolate to annual trips. To determine which month(s) to collect, we examined traffic count data at the two MnDOT count stations within the study corridor: station #191 on I-35 in Wyoming, MN (about 40 miles north of Minneapolis) and station #103, also on I-35, just outside of the Duluth city limits. It was found that traffic counts at these two stations fluctuate seasonally, from highs in August to lows in January and February, with roughly linear trends in-between. Hence, it was decided to obtain AirSage cellphone data for the most recent August and February months (i.e. August and February in 2013). The total annual trip table(s) will be inferred based on the seasonal distribution of traffic throughout 2013 using traffic count data for 2013 collected and maintained by MnDOT.

AirSage provides their data in the form of a zone to zone trip table for any system of zones specified. Because the cost of data collection is dependent on the number of zones, it was decided to submit the data request to AirSage with 100 zones, and then disaggregate the data into the study's 378 zones.

The steps required for preparing the project's opening year (2020) and horizon year (2040) auto trip tables are:

- Disaggregation: Expand from the 100 'AirSage' zones into the 378 'study' zones;
- Validation: Compare AirSage trip data to other existing data sources – traffic counts and household survey data - and make appropriate adjustments;
- Annualization: Convert the data from February and August into annual trips using seasonality factors obtained from traffic counts;
- Growth: Project the annual trips forward from 2013 to 2020 and 2040; and
- Filtering: Create 'in-scope' trip matrices by ruling out trips for origin-destination pairs highly unlikely to use the proposed NLX service.

The following sections describe each of these steps in more detail. It should be noted that no adjustments were made to the future auto trip table with respect to changing fuel prices. The reason for this is also discussed in this chapter in the final section.

2.2 Disaggregation

The 100x100 raw OD matrices produced and provided by AirSage were disaggregated into the study's 378 zone system based on the relative populations of the 'study' zones that lie within each 'AirSage' zone. Within the inner 7 counties of the Twin Cities region, the study zones were based on the MetCouncil MPO travel Demand Model for which employment data were also available for that level of disaggregation. As a result, for these zones only both population and employment was used to disaggregate (rather than just population) the trip tables from the AirSage zone pairs to the study zone pairs.

The purposes of expanding the raw AirSage trip matrices into the 'study' zones are:

- To represent the trip tables in finer levels of detail for better representation of the travel pattern within the study area;
- To create trip matrices that can be used in the assignment onto the study area (for the intercity portion) network, which is created with the study zone system, for the validation exercise against historical traffic counts (described below in section 1.3); and
- To have consistency between the trip matrices and the study zones which are also used in other modeling activities i.e. computing travel distances and times between each pair of 'study' zones and between each 'study' zone to/from its nearest proposed NLX station.

2.3 Validation

Traffic Counts

Of the two continuous traffic count locations on I-35 that may be suitable for the intercity (long distance) trip table validation purpose, much of the traffic at station #103 is likely to be local, because it is so close to Duluth. Therefore, we decided to use station #191 (near Wyoming, MN) exclusively in the validation of the data in comparison to relevant traffic counts.

SDG staff created an intercity network by merging GIS data from the two local MPO models (MetCouncil and MIC) with the National Highway Planning Network (NHPN) for the areas outside the two models (primarily in between the MetCouncil and MIC regions). This network has every major road within 50 miles of the proposed NLX service on either side, an area which includes over 40 counties as agreed upon by the project team. Each road in the network contains data on its length, speed limit, and congested travel time within the MPO boundaries (outside the MPO boundaries we assume little or no congestion).

As discussed above in step 1.2, disaggregate trip matrices were created for the four different sets of trip data received from AirSage: February weekdays, February weekends, August weekdays and August weekends. Those matrices were then 'assigned' to the intercity road network by minimizing 'generalized cost', a measure that combines travel time and cost into a single quantity, assuming travelers' perceived out-of-pocket cost of driving at 15 cents per mile and 'value of time' of $12/hour. This value of time assumption is based on survey results from similar projects, and may be revised after the survey results from this study are analyzed. We do not anticipate that revisions to this assumption would impact the results significantly, because of the limited route options for travel in this corridor. Trips from the AirSage data were tabulated for each of the 378x378 zone pairs for which the minimum generalized cost trip involves passing through station #191.

The trip tables produced by AirSage are *person trips*. However, since the MnDOT traffic count data are for vehicular trips, the AirSage trip tables were divided by a vehicle occupancy in order to make a valid comparison. The 2010 Minneapolis Household Travel Survey showed an average vehicle occupancy of 1.66 on weekdays for trips made by automobile (all trip purposes combined). There was no weekend data in the survey, so using professional judgment, we divided the weekend trips by 2.2 assuming higher party size for these trips. Table 1 compares the resultant AirSage trips to the vehicle counts at station #191 (I-35 in Wyoming, MN) for the four trip tables.

TABLE 1 UNCALIBRATED TRAFFIC COUNT COMPARISON

Month / Day Type	AirSage	MnDOT	Percent Diff.
February Weekday	49,893	36,238	38%
August Weekday	68,753	49,166	40%
February Weekend	47,902	33,120	45%
August Weekend	63,340	53,186	19%

Like any survey, AirSage's data do not represent a complete collection of person trips in the region. It relies on expansion factors to account for the fact that it samples data from a specific cell phone service provider (Verizon in this case), and to account for the probability that trips will be missed, due to poor reception, dead batteries on cell phones, or other reasons. Thus, it cannot be expected to replicate an empirical source of data such as traffic counts on its own; the hope is that if it varies from the empirical data, it does so in a consistent fashion. Table 1 illustrates that AirSage data consistently exceeds the traffic count in this region; applying a uniform "calibration factor" of 0.75 results in modified AirSage trip estimates that come much closer to the MnDOT counts, as shown in Table 2 below.

TABLE 2 CALIBRATED TRAFFIC COUNT COMPARISON

Month / Day Type	AirSage	MnDOT	Percent Diff.
February Weekday	37,420	36,238	3%
August Weekday	51,565	49,166	5%
February Weekend	35,926	33,120	8%
August Weekend	47,505	53,186	-11%

The evidence suggests that the AirSage data overestimates travel by about 25% in this region. Therefore, this factor of 0.75 will be applied universally to the forecasts of trips for the project analysis years (2020 and 2040), with the distribution of travel patterns preserved. Additional validation exercises discussed below will help build confidence that these travel patterns are indeed quite reasonable.

Twin Cities Household Survey

Other than cell phone data, the largest source of existing data capturing information about both the origin and destination of trips is usually household surveys, typically conducted by major MPOs. Metcouncil, the Twin Cities MPO has been conducting such household surveys that contain similar information for many years now and the most recent such data were collected in 2011-2012. Since those surveys only include trips made by residents of the MPO and immediately surrounding counties, they are not sufficient for complete trip-making patterns in a larger intercity region, such as the one being studied here. However, the AirSage data includes estimated breakdowns of trips between residents and visitors, and with some approximations, we can break those resident trips down further into trips made by residents of the Twin Cities MPO and compare them to the trips from the 2010 household survey.

The household survey included geographic coordinates (longitude and latitude) of the origin and destination of every trip taken. Those were geocoded, plotted on a map in GIS, and the 100 zone system from the AirSage data was overlaid on that map. Thus, we were able to determine numbers of trips made from the Twin Cities region to the cities and surrounding areas of Cambridge, Hinckley and Duluth/Superior. Those were compared to the AirSage data, with the following adjustments:

- The calibration factor of 0.75 was applied, to be consistent with the result from traffic count validation exercise as described above; and
- A 5.5% reduction was applied to account for heavy commercial traffic (which is not included in the survey data). The percentage was obtained from the MnDOT counts at station #191.

TABLE 3 COMPARISON OF AIRSAGE AND SURVEY TRIPS

Trips from Twin Cities to…	2010 HH Survey	AirSage	Pct. Difference
Cambridge	26,638	32,580	22%
Hinckley	2,779	3,891	40%
Duluth / Superior	1,698	11,979	605%
Elsewhere in Study Area	158,395	290,553	83%

As table 3 shows, the trips in the AirSage data were considerably higher than in the household survey. However, one would expect this to be the case, because the AirSage data includes all trips, whereas the household survey data includes only trips made by residents of the Twin Cities region. One would expect that the difference becomes greater as the area at the other end of the trip moves further away from the Twin Cities, and that is indeed the case.

Unfortunately, there is no empirical source of data available for us to be able to estimate how to adjust for this. Alternatively, we can determine what adjustments would be necessary in order for the two sets of trips to be consistent. Table 4 illustrates the 'implied' percentages of AirSage trips made by residents of the Twin Cities region in order to make the validation come out better.

TABLE 4 COMPARISON OF ADJUSTED AIRSAGE AND SURVEY TRIPS

Trips from Twin Cities to…	2010 HH Survey	Resident Adjustment Factor	Adjusted AirSage	Pct. Difference
Cambridge	26,638	80%	26,064	-2%
Hinckley	2,779	70%	2,724	-2%
Duluth / Superior	1,698	15%	1,797	6%
Elsewhere in Study Area	158,395	50%	145,277	-8%

For example, the implication is that about 80% of the trips made between the Twin Cities and Cambridge regions are made by Twin Cities region residents. That percentage is 70% for Hinckley, 15% for Duluth / Superior, and 50% for the rest of the study area as a whole.

The Duluth/Superior result may seem odd at first glance, given that there are about seven times as many people living in the Twin Cities region as there are in the Duluth / Superior region. On the other hand, the Twin Cities region is more of a 'destination' for residents of Duluth and Superior than the reverse, so one would expect a given resident of Duluth or Superior to make more trips to the Twin Cities than the other way around.

The single biggest reason for the inconsistency between Twin Cities to Duluth trips (and the reverse) reported in the two data sources is probably that long distance trips tend to be underreported in regional household surveys. These trips often occur over the course of several days, whereas the survey often takes place on a single day. Furthermore, people making these trips are busy preparing for or unpacking from the trip, and are less likely to participate in the survey. It is also quite possible that the household survey underestimates travel between the two regions, due to sampling error, reporting of intermediate stops, or a combination of the two.

Correlation with socioeconomic activity

Another important check to make with the AirSage data is whether the zones with the highest levels of "activity," i.e. population and/or jobs, are generating the most trips.

Since each AirSage zone is a collection of census tracts, tabulating the current populations of each was straightforward. However, numbers of jobs held in job locations within each tract is not part of household census data. To obtain estimates of numbers of jobs in each AirSage zone, the following steps were taken:

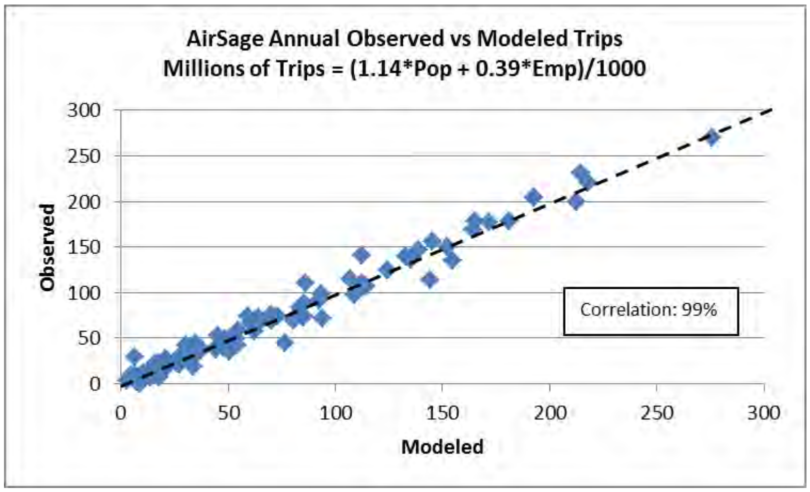
- Projected 2013 employment levels within each county in the study area were obtained from the 2011 Woods & Poole data[1];
- The US census Longitudinal Employer-Household Dynamics (LEHD) data was used to allocate jobs among census tracts within each county, using the more precise Woods & Poole data as county control totals;[2] and

[1] This is a private source of socioeconomic data, which Steer Davies Gleave has obtained for general usage.

- The allocated jobs within census tracts were added for the appropriate tracts to obtain jobs for each AirSage zone.

After the above steps, a simple linear regression was performed, using total trips made to or from each zone as the dependent variable, and population and employment as independent variables. Figure 2 shows a scatterplot of the best-fit regression (with the equation displayed on the plot). The dependent variable includes the calibration factor of 75 percent obtained from the traffic count validation.

FIGURE 2 REGRESSION OF AIRSAGE TRIPS ON ZONAL POPULATION AND EMPLOYMENT



With a correlation of 99%, we are confident that the areas with large amount of population and/or jobs are consistent with the areas which are generating more trips.

2.4 Annualization

Seasonality was accounted for by collecting Average Annual Daily Traffic (AADT) month by month for the two MnDOT count stations on I-35. Each month's AADT was compared to the AADT for the month for which AirSage data was collected, and then assigned a "factor" based on relative traffic levels. The 12 months were then added together to obtain a multiplier to convert one month of AirSage data to annual trips. For weekdays and weekends separately, this process was repeated for both traffic stations, and for February and August. The resulting annual traffic multipliers were averaged, and weighted 5/7 for weekdays and 2/7 for weekends to obtain annual traffic levels.

The AirSage data indicated that average number of trips made per day ranged from 9.9 million on August weekends to 13.1 million on February weekdays. Averaged over the whole year with seasonality taken into account, this resulted in about 12.0 million trips per day, or 4.37 billion per year. Applying the calibration factor of 75% to these totals resulted in 9.0 million trips per day and 3.27 billion trips per year among all the 378x378 zone pairs (approximately 143,000 zone/OD pairs) within the study area.

[2] The LEHD data is the result of a partnership between most states and the US census bureau. A variety of sources including unemployment insurance earnings data, quarterly census of employment and wages, and administrative data are used to synthesize employment data at the individual census block level.

2.5 Growth Forecasts

Projections of 2020 (Base Year) and 2040 (Horizon Year) population and employment levels were obtained for each of the 100 ‘AirSage Zones’. Projections were obtained by applying the growth rates implied by Woods & Poole county level data to the 2013 zonal population and employment figures calculated in step 1.3. Since Woods & Poole county totals were used as control totals for employment among all zones in each county in 2013, the projected employment levels for 2020 and 2040 were consistent with Woods & Poole projections across each county. The projected population levels were slightly different, to the extent that Woods & Poole and census populations differed for 2013.

The linear regression model from step 3 was then applied to these projections to obtain “modelled” trips made to or from each zone in 2020 and 2040. Finally, the growth rate in “modelled” trips between 2013 and 2020 was applied to 2013 actual trips to obtain forecasts for 2020, and a similar procedure was done for 2040. The projections were divided by 2 to obtain ‘target’ row and column totals for the future trip matrices, assuming that trips going in and out of each zone balance over the course of the year. A sample calculation for a single zone is shown in Table 5 below. Note that in rows b and f, the 2013 column shows observed trips from the AirSage data (after the 75% calibration factor is applied), whereas the 2020 and 2040 columns show forecasts that pivot from ratios in the 2013 column.

TABLE 5 SAMPLE ZONAL TRIP FORECAST CALCULATION

	2013	2020	2040
(a) Population (Woods & Poole)	45,699	47,545	53,132
(b) Actual or Forecast Population (a*[b/a for 2013])	45,058	46,878	52,387
(c) Employment (Woods & Poole)	24,575	26,308	32,011
(d) “Modelled” Trips (1.1368*b+0.3867*c)	60,722,972	63,462,098	71,929,270
(e) Actual or Forecast Trips (d*[e/d for 2013])	66,514,804	69,515,191	78,789,972
(f) Row and Column Totals (e/2)	33,257,402	34,757,596	39,394,986

Finally, the matrices of 2013 observed AirSage trips were projected forward to 2020 and 2040, using the forecast zone totals in a “fratar process.” This is an iterative procedure, frequently used in transportation planning for this purpose, in which the rows and columns of a matrix are repeatedly scaled to match “target” totals for its rows and columns which are different than the original totals. In this case, the “targets” are the forecasts of 2020 (or 2040) trips for each zone. This process preserves existing travel patterns to some extent, by starting with the 2013 trip matrix, but takes into account the fact that some zones are projected to grow faster than others. The fratar process repeats until the rows and columns match the targets as closely as possible, within certain convergence criteria.

A table of actual 2013 and forecast 2020 and 2040 trips by county is shown in Table 6 below. The 3.27 billion annual trips within the 45 county project area are estimated to grow to 3.54 billion by 2020, and 4.34 billion by 2040. This is a 1.1% compound annual growth rate (CAGR) from 2013 to 2020 and a 1.0% CAGR from 2020 to 2040.

TABLE 6 TRIP FORECASTS BY COUNTY

FIPS Code	Name	State	2013 Actual	2020 Forecast	2040 Forecast
27001	Aitkin	MN	12,070,365	12,749,333	14,753,524
27003	Anoka	MN	222,370,486	243,383,855	306,246,516
27009	Benton	MN	29,357,630	33,530,540	46,102,863
27013	Blue Earth	MN	49,219,427	52,907,595	64,199,459
27017	Carlton	MN	19,738,665	20,716,685	23,803,394
27019	Carver	MN	62,224,425	71,250,690	98,168,561
27025	Chisago	MN	38,318,762	43,734,677	59,827,463
27031	Cook	MN	3,599,934	3,856,789	4,675,041
27035	Crow Wing	MN	55,357,713	62,762,907	85,054,238
27037	Dakota	MN	274,017,465	315,268,589	438,579,644
27039	Dodge	MN	14,665,560	16,356,541	21,396,684
27049	Goodhue	MN	33,697,371	35,253,042	39,885,952
27053	Hennepin	MN	837,259,124	876,021,629	991,627,840
27059	Isanti	MN	22,253,072	25,794,599	36,606,805
27061	Itasca	MN	33,257,402	34,757,596	39,394,986
27065	Kanabec	MN	13,061,345	14,396,160	18,394,502
27075	Lake	MN	6,259,956	6,556,373	7,481,383
27079	Le Sueur	MN	18,409,672	19,694,330	23,499,133
27085	McLeod	MN	17,385,925	18,378,308	21,302,455
27093	Meeker	MN	12,183,352	12,722,973	14,417,393
27095	Mille Lacs	MN	22,457,198	23,801,604	27,797,911

FIPS Code	Name	State	2013 Actual	2020 Forecast	2040 Forecast
27097	Morrison	MN	26,703,746	27,748,866	30,926,000
27103	Nicollet	MN	19,100,256	19,819,657	21,931,899
27109	Olmsted	MN	100,027,135	112,944,069	151,597,291
27115	Pine	MN	26,639,797	27,870,875	31,501,821
27123	Ramsey	MN	344,244,633	352,105,074	375,405,018
27131	Rice	MN	36,869,072	38,502,827	43,426,269
27137	St. Louis	MN	122,185,832	124,155,785	130,776,042
27139	Scott	MN	88,801,627	103,128,899	145,958,000
27141	Sherburne	MN	53,295,646	61,700,973	86,475,437
27143	Sibley	MN	10,666,828	10,828,740	11,324,202
27145	Stearns	MN	115,867,347	126,080,896	156,672,453
27147	Steele	MN	25,882,149	28,020,880	34,590,199
27157	Wabasha	MN	15,088,179	15,222,054	15,624,278
27161	Waseca	MN	11,414,345	11,906,020	13,392,434
27163	Washington	MN	167,507,733	192,633,633	267,613,628
27171	Wright	MN	84,393,109	98,593,326	141,041,636
55005	Barron	WI	36,555,151	38,582,069	44,640,223
55007	Bayfield	WI	10,242,128	10,819,873	12,531,268
55013	Burnett	WI	13,644,083	14,412,275	16,668,696
55031	Douglas	WI	22,120,299	22,720,699	24,546,638
55093	Pierce	WI	24,855,618	26,727,102	32,234,688
55095	Polk	WI	36,919,122	39,137,761	45,720,546
55109	St. Croix	WI	70,185,431	79,485,886	106,904,839
55129	Washburn	WI	13,367,907	13,673,304	14,578,967
TOTAL PROJECT AREA			3,273,742,021	3,540,716,356	4,339,298,216

2.6 Filtering

The total number of trips made in the corridor (mentioned above) are a starting point, but the majority of them do not represent trips that would be candidates to divert to the proposed NLX service. The mode choice model developed from the SP survey will be the final step in determining the possibility of trips diverting to NLX, and with what probability they might do so. However, prior to even applying the mode choice model, we set some preliminary 'filters' that remove certain types of trips from the trip table and prevent them from even being considered in the ridership forecasting step. We call the resulting demand levels "in-scope" demand, as opposed to "gross" demand. This 'filtering' process is applied to prevent trips from diverting to the proposed NLX service in unrealistic situations.

Starting from the 3.27 billion annual trips from section 1.4, the following filters were applied:

- Heavy commercial traffic was assumed to be 5.5% of all trips based on MnDOT traffic count information;
- Trips where the combined access and egress distances to/from the most likely origin and destination NLX stations were greater than the auto travel distance were removed;
- Trips where the combined access and egress distances to/from the most likely origin and destination NLX stations were greater than the station to station (origin to destination) travel distance on NLX were removed;
- Trips which remained within either the seven county Twin Cities MPO core area or the Duluth-Superior MPO area were removed. These are intra-urban short distance trips in nature which will be analyzed separately with the MetCouncil travel demand model; and
- Trips less than 30 miles were removed. These are also short distance trips and hence are not candidate trips for the proposed intercity NLX service.

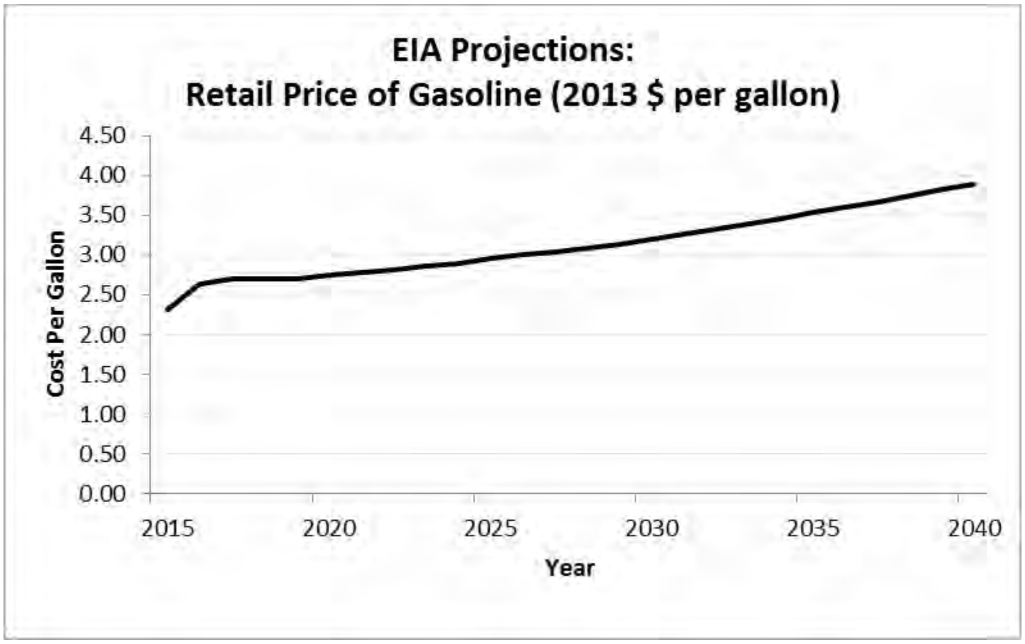
After applying all of the above filters simultaneously, about 98.7% of trips were removed, and the "in scope" demand for 2013 was reduced to about 39 million trips. Similar calculations resulted in about 42 million "in-scope" trips for 2020 and 51 million for 2040.

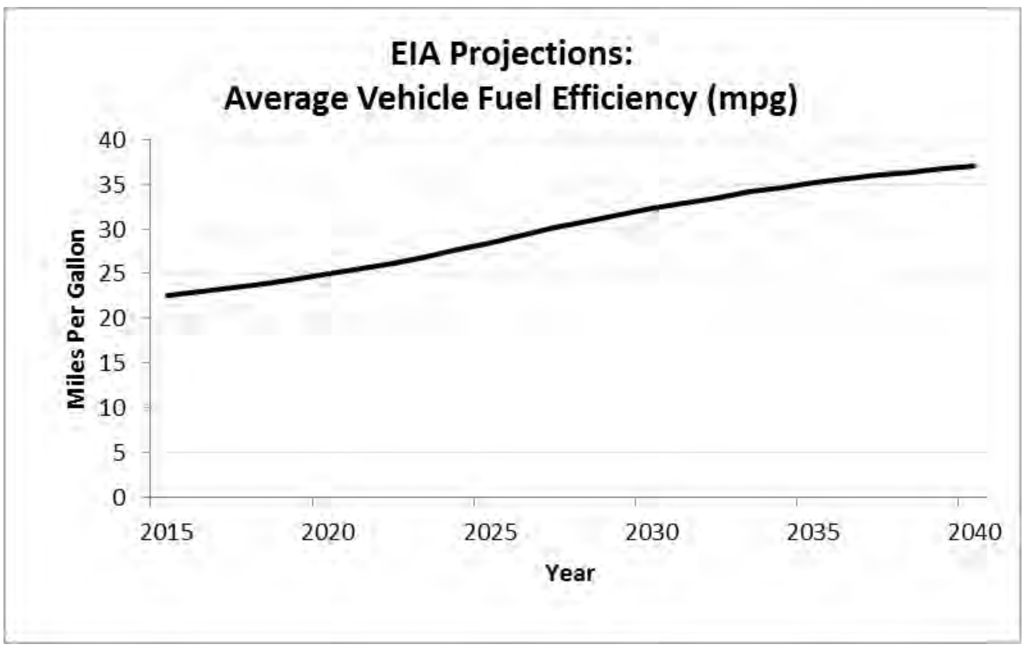
2.7 Fuel Prices

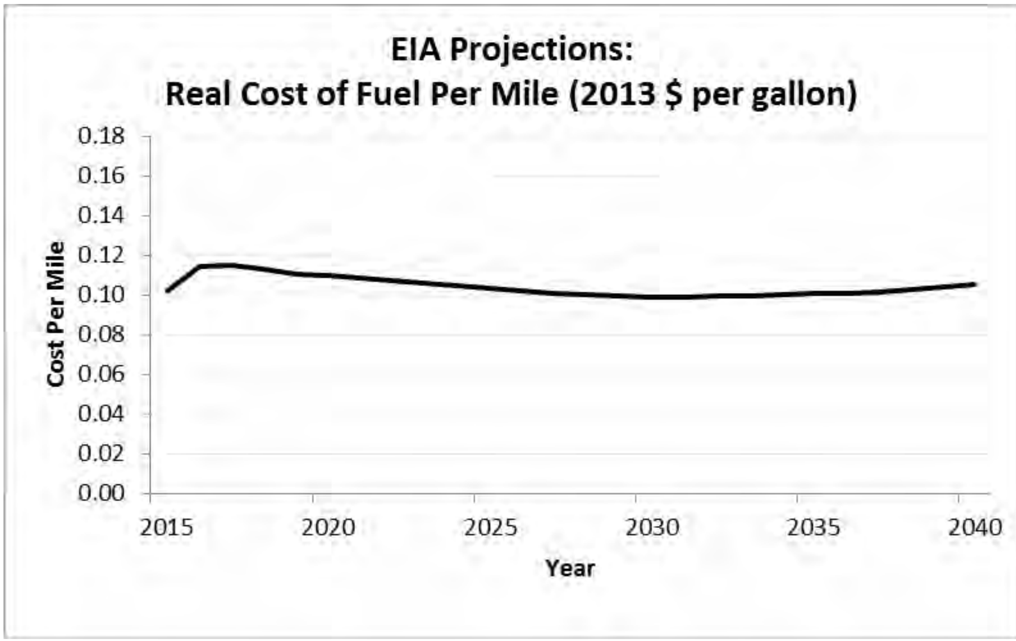
As noted above, there were no adjustments made in either direction for changing fuel prices. Although general opinion is that the retail price of gasoline will continue to increase into the future, predicting precisely how much it will increase, and how elastic travelers will be to the increase, is extremely challenging.

Furthermore, after adjusting for both inflation and the average vehicle's fuel efficiency, the actual fuel-related cost of operating a private automobile is projected to be relatively flat over the next 25 years. Figure 3 shows the current EIA Energy Outlook projections of the national average retail gasoline price (in 2013 dollars per gallon), the average on-road car and light truck vehicle fuel efficiency (in miles per gallon), and the cost of fuel per mile for 2015 to 2040. The cost of fuel per mile was obtained by dividing the retail gasoline price by the fuel efficiency. Although real fuel prices are expected to increase by more than 50% between 2015 and 2040, fuel economy is expected to keep pace, making the cost of fuel per mile essentially constant.

FIGURE 3 CURRENT EIA ENERGY OUTLOOK PROJECTIONS







Source: EIA Annual Energy Outlook, 2015.

3 Development of No-Build Bus Trip Table

3.1 Introduction

Jefferson Lines and Skyline Shuttle are currently the primary operators of long distance bus service on the project corridor. Commercial bus operators are generally reluctant to release ridership figures due to their proprietary nature. However, the 2010 Minnesota Intercity Bus Study[3] provides ridership and revenue data for bus service between Minneapolis and Duluth in 2007 and 2008. This is the most recent information available.

Jefferson Lines has increased its service frequency since the time of the study; Greyhound left the market in 2011 but continues to sell Jefferson Lines' tickets on its website.[4] Skyline Shuttle, which uses smaller vans, was not included in the 2010 study.

To approximate current and comprehensive bus ridership levels, the load factors from the 2010 report were applied to 2013 service levels. The average daily trip tables were then inferred based on local population and proximity to bus pick-up locations.

3.2 Corridor Bus Ridership

The 2010 Intercity Bus Study provided the following data about Jefferson Lines and Greyhound's service along the NLX corridor:

TABLE 7 MINNEAPOLIS-DULUTH GREYHOUND/JEFFERSON LINES SERVICE STATISTICS

Year	Annual ridership	Frequency	Service description
2007	15,812	2-3x/day	1 direct + 1 local round trip (RT)/day; +2 RTs/week during school year
2008	22,588		

A load factor of 55% was estimated using the ridership numbers above, a ratio of 330 annual/daily riders (to account for lower loads on weekends), and a capacity of 50 passengers per bus. While more recent ridership information is not available, it is reasonable to assume a load factor similar to that of 2008. Table 8 describes the current bus service levels.

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[3] *Minnesota Intercity Bus Network Study* Final Report, March 2010. Prepared by KFH Group, Inc. and SRF Consulting Group, Inc. for the Minnesota Department of Transportation.

[4] *Jefferson to take over Greyhound's Duluth bus operations.* May 13, 2011. John Myers for the Duluth News Tribune. http://www.duluthnewstribune.com/event/article/id/198976

TABLE 8 NLX CORRIDOR BUS SERVICE IN 2013

Operator	Capacity/vehicle	Frequency	Service description
Greyhound/ Jefferson Lines	50	3-4x/day	2 direct + 1 local RT/day, +1RT/day on Fridays
Skyline Shuttle	10 (large van)	10x/day	10x/day MSP Airport – Hinckley – Duluth

The 2008 load factor of 55% and the annual multiplier of 330 were applied to these numbers. Jefferson Lines' annual ridership was split between Minneapolis-Duluth trips and trips with one end at Hinckley based on their relative frequencies of 3.5 round trips/day and 1 round trip/day respectively. Between Minneapolis-Hinckley and Duluth-Hinckley, they were split based on the relative population between Minneapolis and Duluth. The resulting splits between Minneapolis-Duluth, Minneapolis-Hinckley and Duluth-Hinckley trips were applied to the total estimated Skyline Shuttle ridership.

The bus ridership thus estimated is as follows:

TABLE 9 ESTIMATED 2013 NLX CORRIDOR BUS RIDERSHIP

	Jefferson Lines	Skyline Shuttle	Total
Minneapolis-Duluth	24,596	14,055	38,651
Minneapolis-Hinckley	6,486	3,706	10,192
Duluth-Hinckley	542	310	852
Total	**31,624**	**18,071**	**49,695**

3.3 Disaggregation

For each bus stop, a set of "catchment" zones from the study's 378-zone system was selected as the most probable source of bus riders based on proximity to existing bus stops. In the Twin Cities, this was the area bound by the I-494/I-694 beltway, and the Mall of America and MSP area bound by I-35W and the Minnesota River. In Duluth-Superior, this was the Metropolitan Interstate Council (MIC) model region.

Within the Twin Cities, the main Greyhound boarding location is at the Hawthorne Transportation Center in downtown Minneapolis, whereas Skyline Shuttle boards passengers at MSP. The economy lot parking costs are comparable, and so the catchment zones of each operating company were determined based on geographic convenience. In Duluth, a combination of abundant free parking, limited public transportation options, and the proximity of the two companies' pick-up points – fewer than four miles apart – imply that access times are similar and does not factor into the selection of bus operator.

The ridership in Table 9 was then disaggregated to each of the catchment zones based on their 2013 automobile trip volumes as measured through AirSage data (discussed earlier).

3.4 Extrapolation to 2020 and 2040

2020 and 2040 bus ridership in Minneapolis-St. Paul and Duluth were estimated using the forecast growth in automobile trips as discussed earlier. Table 10 lists the estimated change in bus ridership demand between 2013, 2020 and 2040, assuming no changes to user preferences and travel conditions.

TABLE 10 PROJECTED NLX CORRIDOR "NO-BUILD" BUS RIDERSHIP

	2013 Ridership	2020 Ridership	2040 Ridership
Minneapolis-Duluth	38,651	40,066	44,346
Minneapolis-Hinckley	10,192	10,565	11,694
Duluth-Hinckley	852	883	978
Corridor Total	**49,695**	**51,514**	**57,018**

Creation of the 2020 and 2040 zonal trip tables for no-build bus demand was done using the same "frataring" methodology that was used for the auto trip tables. A preliminary step (not required in the auto trip table creation process) involved creating the table for 2013 based on the disaggregation discussed in section 2.3 above.

4 Connect Air Trips

4.1 Introduction

The study area is served by two international airports, Minneapolis-St. Paul International Airport (MSP) and Duluth International Airport (DLH). Though there are few air trips made entirely within the project corridor (with both origin and destination of those trips are either MSP or DLH airports), there are many air trips connecting to/from locations outside of the NLX corridor that include their first or last leg between MSP and DLH. These trips are referred to as connect air trips for the NLX corridor.

With the new NLX service, travelers between Duluth and an external location may choose to switch to NLX for one leg of their trip and a flight between MSP and the external location for the other leg of their trip. This includes travelers who are currently making an air connection at MSP and travelers who are currently making a connection elsewhere. It also includes travelers flying directly between DLH and an external location, since direct flights between MSP and that location may be substantially cheaper or offer a more favorable schedule. Trips with connections at DLH are negligible.

This section details the data sources and methodology used to define the connect air trips eligible for diverting to the proposed NLX service. Unlike the auto and the bus modes, it is not necessary to develop a demand matrix at the study zone pair level because there are very few (negligible) air trips made entirely between MSP and DLH without any connections. Instead, the connect air analysis will estimate diversion to NLX separately and directly at the station pair level, using the demand base discussed in the sections below.

4.2 Air Data

In order to determine the in-scope connect air trips and corresponding itineraries, data was collected and analyzed from the following sources:

- Airline Origin and Destination Survey (DB1B) data; and
- Form 41 T-100 air travel data.

DB1B Data

The Bureau of Transportation Statistics' (BTS) DB1B database contains a 10% sample of airline tickets from reporting carriers above a certain size. Data includes origin, destination and other passenger details for both domestic and international trips. This database is used to determine air travel patterns, air carrier market shares, fares, and passenger volumes.

Data is available for individual travel segments (i.e. each leg of a passenger's air trip) as well as for markets (i.e. the entire air component of a passenger's trip).

T-100 Data

The BTS Air Carrier Statistics database, also known as the T-100 data bank, contains domestic and international airline market and segment data. Certificated U.S. air carriers report monthly travel information using Form T-100. This data contains information on arrival and departure times for every flight, which is used in combination with the DB1B data to prepare an itinerary of possible connect air options.

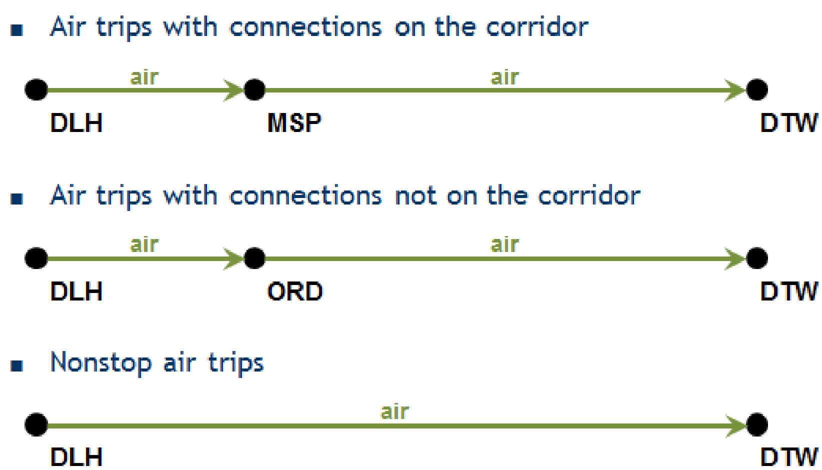
4.3 In-Scope Connect Air Trips

Connect air trips require a rail station at or near the connecting airports. Types of connect air trips eligible for diverting to the proposed rail include:

- Air trips with connections on the corridor (e.g., DLH-MSP-Detroit Metropolitan Airport, DTW);
- Air trips with connections not on the corridor (e.g., DLH–Chicago O'Hare Airport, ORD–DTW)l and
- Direct air trips between Duluth and an external airport (e.g. DLH-DTW).

These types of connect air trips are illustrated in Figure 4 using DTW as an example of an airport outside the project corridor.

FIGURE 4 TYPES OF CONNECT AIR TRIPS: DLH-DTW EXAMPLE



Air trips with connections on the corridor

One type of connect air trip includes travelers that connect to an airport in the corridor. MSP is an international hub for air carriers, and serves as a connecting option for travelers flying to or from Duluth. Passengers currently flying between DLH-MSP on one leg of their connecting trip may choose to switch to rail for this segment should the new service be introduced.

Air trips with connections not on the corridor

Rail access to MSP may also affect trips from corridor airports that have other air travel options. With NLX service, passengers currently connecting to an airport outside of the corridor to travel to or from Duluth have the option of taking rail between DLH and MSP for the first leg of their trip, and flying nonstop to their destination outside the study area for the second leg of their trip.

Nonstop air trips between DLH and an external airport

The addition of rail service to MSP may also impact nonstop air trips from DLH to airports outside of the corridor. Since MSP offers more flights and often cheaper fares than DLH, travelers may choose to switch to NLX to travel to MSP, and fly from MSP to their origin or destination airport.

Market response of air carriers

Diversion of air to NLX is highly dependent on the competitive response of the air carriers resulting from the presence of new rail service between airports. For example, the addition of NLX service may cause air carriers to pursue code sharing agreements with NLX, or replace current connecting service with more direct flights to and from DLH.

4.4 Development of In-Scope Connect Air Trips

Data extracted from the DB1B and T100 tables (i.e. origins, destinations, arrival times, and departure times), is manipulated to create all possible connect air combinations, or itineraries, for three types of connecting trips as described in subsection 3.3. The creation of itineraries is based on schedules from a random weekday in 2013.

The sum of the passenger flows for each type of connect air trip in all potential flight combinations is shown in Table 11.

TABLE 11 ANNUAL IN-SCOPE CONNECT AIR TRIPS

Connect Air Trip	Number of Passengers
Connections on the corridor	88,420
Connections not on the corridor	42,580
Nonstop with end not on corridor	25,640
Total	156,640

Source: SDG analysis of USDOT DB1B 2013 data

4.5 Development of 2020 and 2040 Connect Air Trips

Base (2013) connect air trips are grown to the model forecast years 2020 and 2040. These growth rates are determined using rates calculated from the FAA Terminal Forecasts, which provide enplanement forecasts by airport through year 2040. Annual enplanement forecasts for DLH and MSP and compound annual growth rates are detailed in Table 12.

TABLE 12 FAA ENPLANEMENT FORECASTS AND CAGRS

Year	DLH	MSP
2013	155,820	15,677,914
2020	178,288	18,399,100
2040	265,715	26,901,811
CAGR 2013-2020	**1.943%**	**2.313%**
CAGR 2013-2040	**2.015%**	**1.918%**

Source: SDG analysis of FAA Terminal Forecast 2012 data

Table 13 applies the growth rates for DLH from table 11 to the 2013 connect air trips to obtain forecasts, as shown below.

TABLE 13 ANNUAL IN-SCOPE CONNECT AIR TRIPS INCLUDING FORECASTS

Connect Air Trip	Number of Passengers		
	2013 Actual	**2020 Forecast**	**2040 Forecast**
Connections on the corridor	88,400	101,200	150,900
Connections not on the corridor	42,600	48,700	72,600
Nonstop with end not on corridor	25,600	29,300	43,700
Total	156,600	179,300	267,300

Variables for each itinerary also include number of passengers, fare, date, layover airport (if applicable), in-vehicle travel time, layover time, daily frequency, and distances. Rail service between DLH and MSP is added to the list of possible connect air itineraries and includes characteristics such as frequency, travel time, and wait time. The itinerary table serves as a key input into the connect air model, which predicts the share of travelers choosing an itinerary based on level of service characteristics such as fare, time, and cost. These shares (or probabilities) are multiplied by the original connect air volumes for each forecast year to determine trips diverting to NLX for that year.

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Client:	MnDOT
Steer Davies Gleave:	

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Technical Memorandum

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Prepared for:
MnDOT
395 John Ireland Boulevard, MS 480
St. Paul, MN 55155-1800

Prepared by:
Steer Davies Gleave
883 Boylston Street, 3rd Floor
Boston, MA 02116
USA

+1 (617) 391 2300
www.steerdaviesgleave.com

CONTENTS

Introduction

The Steer Davies Gleave (SDG) travel demand model for forecasting inter-urban NLX ridership and revenue implements a well-established three-stage process. In the first step, the growth of the travel markets to the year of analysis (2020 for the opening year, 2040 for the horizon year) is estimated. In the second step, the mode shares for all of the inter-urban travel modes, including NLX, are calculated using mode choice models developed as part of this study. The mode shares are applied to the travel market demand to obtain an estimate of the number of trips diverted to NLX. In the final step, the volume of induced ridership is estimated, and this is added to the forecast of diverted NLX trips to produce the total ridership forecast.

This memorandum describes the mode choice models used in Step 2 to calculate the NLX mode shares.

Mode Choice Models

To predict shares for a new mode, where observations of travelers' actual choices are not available, mode choice models can be developed from statistical analysis of stated preference (SP) data in which travelers express their choices in hypothetical situations presented to them in a survey.

The mode choice models presented below were developed from a statistical analysis of the 3,300 responses obtained from an online NLX Stated Preference survey that was designed and conducted by SDG in February and March 2014. This data was supplemented by results from other intercity passenger rail studies in the US and elsewhere.

Detailed information about the statistical analysis and estimated models is presented below. While the results obtained are felt to be reasonable and consistent with transportation modeling best practices, they will need to be tested and validated through application to realistic NLX service scenarios. It is frequently the case in modeling that such testing leads to minor adjustments to estimated values; accordingly, the results reported here should be considered as provisional until the application testing and possible adjustments are complete.

Modeling Framework: The Random Utility Model

Transportation modelers often use discrete choice models called random utility maximization (RUM) models to forecast mode shares. These models follow the microeconomic postulate that an individual's choice among a set of options can be represented as if each option provides a certain level of utility, and the individual chooses the option with the highest level. The distinguishing feature of RUM models is that an option's utility is assumed to have both a systematic (or deterministic) component as well as a random (or stochastic) component that reflects, among other things, modelers' inability to fully account for all the factors that influence a choice decision. Because of the stochastic component, these models predict the probability of choosing each of the available options rather than the actual choice made.

In a mode choice context, the general specification of the utility for a mode *i* is as follows:

$$U_i = V_i + \varepsilon_i$$

where U_i is the utility of mode *i*;
V_i is the systematic (or deterministic) part of the utility; and
ε_i is the stochastic error term.

The travel utility experienced by users of a mode is related to the mode's price and service levels, as well as to trip and user characteristics. It is common to use a linear specification for the systematic utility term, in which case the modal utility can be further decomposed as follows:

$$V_i = \alpha_i + \sum_{n=1}^{N} \beta_{in} X_{in}$$

where α_i is the modal constant of mode i. Modal constants are terms included in modal utility functions to reflect the inherent attractiveness of a mode after its explicitly-modeled attributes have been accounted for. These constants represent the average contribution to a mode's utility of non-modeled attributes.
$\beta_{i1}, \beta_{i2}, \ldots, \beta_{iN}$ are mode-specific coefficients for *N* level of service variables (such as in-vehicle time, access time, costs, frequency, on time performance) or socio-economic characteristics (such as income, large cities) for mode i; and
$X_{i1}, X_{i2}, \ldots, X_{iN}$ are values of the *N* level of service variables and socio-economic characteristics.

A multinomial logit RUM model assumes that the stochastic error terms of the different modes are independent and identically distributed with a Weibull distribution. This allows a particularly simple expression for the choice probabilities. For example, in a binary situation involving a choice between NLX and auto, the multinomial logit model expresses the probability of choosing the NLX mode (or equivalently the NLX mode share) as follows:

$$Mode\ Share_{NLX} = \frac{e^{V_{NLX}}}{e^{V_{auto}} + e^{V_{NLX}}}$$

When estimating the mode choice models, a variety of explanatory variables is tested, including separate line-haul (in-vehicle) time, access and egress time, wait time, frequency, travel cost (including vehicle operating cost, parking, tolls and fare), and transfer time at terminals. Combinations of variables are examined, and various interactions between income and the cost variable are tested. Multiple possible travel time specifications are also tested, including different definitions of travel time as combinations of line-haul, access/egress, and wait time. Several market segmentations are also tested. The most satisfactory model specifications are presented next; these are the models that will be tested for application in the forecasting.

Two types of mode choice models were estimated:

- Main mode choice models, assessing travelers' preferences for their existing mode of transport (auto or inter-urban bus) compared to the NLX mode; and
- Access and egress mode choice models, assessing travelers' preferences among six access and egress modes to (access) and from (egress) the NLX train station.

These are described next.

The Main Mode Choice Models

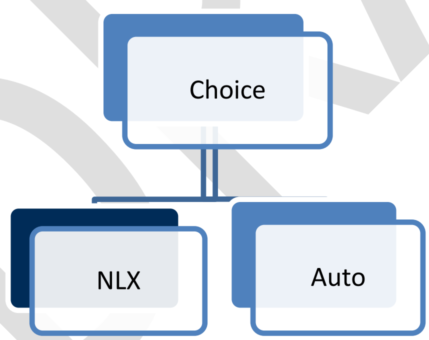
Travel within the corridor is primarily made by auto, and the focus of our work has been in estimating the behavioral parameters affecting the diversion of auto travelers to the NLX mode using a binary logit model of travelers' choices between auto and NLX. In a case such as this, where a new mode is introduced to compete against a dominant existing mode, the probability of diversion to the new mode is directly given by the probability of choosing the NLX option, as provided by the binary logit model.

Another growing market along the corridor is the inter-urban bus market, and a bus binary logit mode choice model was also estimated to cover this market. These two models are discussed below in turn.

The inter-urban auto binary logit mode choice model

Auto is the dominant mode of travel in the corridor. **FIGURE 2** shows the logit model structure used in the inter-urban auto mode choice models to forecast modal shares.

FIGURE 1. BINARY LOGIT STRUCTURE USED FOR THE INTER-URBAN AUTO MODE CHOICE MODELS



Auto mode choice models were estimated for application to two market segments, defined in terms of the purpose for which a trip is made:

- Non-business; and
- Business (which includes work and commute)

Several auto mode choice models were specified, estimated and tested using the SP survey data. The attributes tested and included in our final model include total travel cost (comprising access and egress costs, fares, gas cost and parking cost), in-vehicle time, access and egress time, wait time, service frequency (in trains per day), and modal constants (these are described in greater detail below).

The non-business model coefficients shown in **Table 1** were directly estimated from the newly collected SP survey data and did not need to be constrained or otherwise forced to reasonable values. The estimated coefficients are consistent with results that have been found in SDG's previous rail projects and other rail studies conducted in the US.

Table 1. Auto Non Business Logit Model Coefficients

Auto Non Business		Alternatives		Coefficient		
Coefficients	**Units**	**Auto**	**NLX**	**Value**	**Std. Error**	**T-test**
Time - In Vehicle	Minutes	X	X	-0.01498	0.0086082	-1.74
Time – Wait	Minutes			-0.05265	0.0244757	-2.15
Time – Access	Minutes			-0.03362	0.0183532	-1.83
Cost	Dollars (1)	X	X	-0.07264	0.0204359	-3.55
Frequency Damping Factor	See (2)	X	X	0.37291	0.2620727	1.42
Non Captive Constant	(0,1)(3)		X	-0.85000	0.5606863	1.85
Destination Captive Constant	(0,1)(3)		X	*-1.70000* (4)		

(1) Monetary values in 2013$
(2) Frequency Damping Factor takes the form log (1 – exp[-0.2 * freq in trains or buses per day])
(3) Dummy variables, taking the value 0 or 1.
(4) Destination captive coefficient asserted as explained below
Source: SDG analysis of SP survey data

The data did not allow us to estimate a satisfactory model for the business/commute traveler market. Because it was not possible to estimate a separate model for this market segment, the business/commute model coefficients shown in **Table 2** were asserted based on the non-business model (**Table 1**) and SDG professional judgment concerning the differences between business/commute and non-business travelers: Business/commute travelers usually have a higher value of time than non-business travelers, and they typically have a higher propensity to use non-auto modes than non-business travelers.

As used in travel demand modeling, the value of time (VOT) represents the amount that a traveler would be willing to pay in order to save a unit of time. The value of travel time can be estimated from the logit model utility function, as it is the marginal rate of substitution between time and cost. In a linear utility function, this is the ratio of the time and cost coefficients. Separately, the value of travel time for business/commute trips (time spent traveling in the course of work) can be related to prevailing wage rates.

Hence, **Table 2** for business/commute travelers was derived from **Table 1** for non-business by adjusting the cost coefficient to increase the implied value of time to the local wage rate in the region, and by reducing the modal constant penalties of business/commute travelers compared with their non-business counterparts. The adjusted parameters are highlighted in italic blue, while the remaining parameters are from the estimated non-business model.

TABLE 2. AUTO BUSINESS/COMMUTE LOGIT MODEL COEFFICIENTS

Auto Business		Alternatives		Coefficient
Coefficients	**Units**	**Auto**	**NLX**	**Value**
Time - In Vehicle	Minutes	X	X	-0.01498
Time – Wait	Minutes			-0.05265
Time – Access	Minutes			-0.03362
Cost	Dollars (1)	X	X	*-0.04376*
Frequency Damping Factor	See (2)	X	X	0.37291
Non Captive	(0,1) (3)		X	*-0.42500*
Destination Captive	(0,1) (3)		X	*-0.85000*

(1) Monetary values in 2013$
(2) Frequency Damping Factor takes the form log (1 – exp[-0.2 * freq in trains or buses per day])
(3) Dummy variables, taking the value 0 or 1.
Source: SDG analysis

Mode choice model coefficients are more readily interpreted when converted into time and monetary values. **TABLE 3** shows the corresponding non-business and business/commute VOTs as calculated from the mode choice models. It also includes the values of the modal constants both in time and monetary equivalents.

TABLE 3. AUTO VALUE OF TIME AND VALUE OF MODAL CONSTANT

Value of Time (VOT) and modal constants	Non-Business	Business/commute
In-vehicle time VOT ($/hr)	$12.38	$20.55
Wait time VOT ($/hr)	$43.49	$72.20
Access time VOT ($/hr)	$27.77	$46.10
Non Captive penalty	60min	30min
Destination Captive penalty	1hr50min	1hr

Note: All monetary values in 2013$
Source: SDG analysis

The non-business in-vehicle VOT ($12.38/hr) was estimated from the survey data (as mentioned earlier, it corresponds to the time coefficient divided by the cost coefficient, multiplied by 60 to convert minutes into hours). The business/commute VOT ($20.55/hr) was asserted to be aligned with the local wage rate plus benefits. These values of time are within the ranges recommended by the 2011 USDOT guidance[1].

[1] "Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis", US Department of Transportation, Office of the Secretary of Transportation, September 28, 2011. The USDOT publishes guidance on travel time valuation in the economic analysis of transportation projects. The latest memorandum, dated November 2011, recommends an array of values of time for different categories of travel, according to income, trip purpose, mode and distance. For surface modes, the guidance recommends VOTs for non-business inter-urban travel in a range from 60% to 90% of personal hourly income (annual household income divided by 2080).

These values of time are also aligned with SDG's previous rail projects and with other rail studies conducted in the US.

Out-of-vehicle time (including both access and wait time) coefficients were fully estimated for the non-business travel markets. Access time is found to be 2.2 times more onerous than in-vehicle time for non-business trips (value of access time $27.77/hr); while wait time is found to be 3.5 times more onerous than in-vehicle time for non-business trips (value of wait time $43.49/hr). These ratios were retained for the business/commute model.

A number of different functional forms were tested to represent the contribution of service frequency to utility, ranging from a linear specification, to inverse frequency (average headway), to a "damped" frequency. In intercity market models, the damped frequency specification has frequently been preferred as it captures well the diminishing effect of increasing service frequency.

Some private vehicle travelers are harder to divert than others, and some are essentially impossible to divert. The auto surveys provided us with information to divide auto travelers into three additional categories:

- Those driving vehicles who do not need to stop along the way, and do not need to use their vehicles at their final destination ("non-captive" auto travelers);
- Those driving private vehicles who do not need to stop along the way, but who do need a vehicle at their final destination ("destination captive" auto travelers); and
- Those driving vehicles who need their vehicles to make stops along the way ("en route captive" auto travelers).

NLX is a viable alternative for the first group of auto travelers. It may also be a viable alternative for the second group, but they will need to rent vehicles when they get to their final destination. For the third "en route captive" group of travelers, NLX is assumed not to be a viable alternative.

A set of modal constants was developed to account for these different travel situations. The modal constants are added to the NLX utility value determined from time, cost and frequency; they represent the relative attractiveness of NLX to these different types of travelers beyond the effects of the conventional level of service variables. Auto is taken as the reference mode with an implicit modal constant of 0.

The NLX modal constant value for non-business non-captive trips was developed from the SP survey results. It was estimated to be equivalent to a 60 min line-haul time compared to the reference auto option (TABLE 3), suggesting that auto attributes such as privacy and flexibility are highly valued relative to unrepresented NLX attributes. This is consistent with findings in SDG's previous studies and existing literature.

For business/commute non captive trips, the NLX penalty was asserted to be equivalent to a 30 min line-haul time penalty. This is supported by previous work and reflects the higher attractiveness of NLX for business/commute travelers than for leisure travelers (NLX allows productive work to be done during a trip).

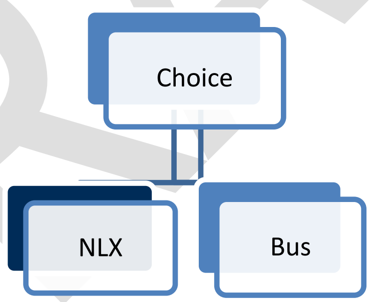
The destination captive modal constants were also asserted based on previous work. They translate into an additional 50 minutes penalty for the non-business destination captive segment (for a total penalty of 110 minutes), and an additional 30 minutes penalty for the business/commute destination captive segment (for a total penalty of 60 minutes), as shown in **TABLE 3.**

The auto binary logit models developed as described above will be applied to predict the share of inter-urban auto travelers who will switch to the NLX mode, considering the trip purpose, the type of traveler (captive or not) and the two modes' respective level of services characteristics.

The inter-urban bus binary logit mode choice model

The inter-urban bus demand forecasting approach is similar to the inter-urban auto demand forecasting approach described above. Market-specific mode choice models are applied to predict, for each OD pair, the fraction of existing bus travelers who would prefer the NLX mode. The bus inter-urban mode choice models use a binary logit form and compute the probability that an inter-urban bus traveler making a particular trip will choose NLX given the LOS characteristics for each mode. **FIGURE 2** shows the binary logit model structure used to predict the number of NLX trips that will divert from the existing bus mode; it shows bus as the existing mode and NLX as the new mode.

FIGURE 2. BINARY LOGIT MODEL STRUCTURE USED FOR THE INTER-URBAN BUS MODE CHOICE MODELS



Modal coefficients and modal constants were fully estimated using the SP data and are consistent with SDG's previous U.S. rail studies. The inter-urban bus mode choice models were also estimated for two market segments:

- Non-business; and
- Business (includes work and commute)

TABLE 4 shows the model coefficients and modal constants estimated for the bus binary logit model. Due to the low numbers of bus business/commute travelers, data for business/commute and non-business travelers were pooled together for estimation, but a separate modal constant was estimated for each to reflect the differences in the preferences of these two groups. The attributes tested and included in our final bus mode choice model are total travel cost (comprising fares, gas cost, access and egress costs and parking cost), total travel time (comprising access and egress time, in-vehicle time and wait time), service frequency (in trains or bus per day) and the modal constants.

TABLE 4. INTER-URBAN BUS BUSINESS/COMMUTE AND NON BUSINESS LOGIT MODEL COEFFICIENTS

Non Business and Business/commute		Alternatives		Coefficient			Values	
Coefficients	**Units**	**Bus**	**NLX**	**Value**	**Std. Error**	**T-test**	**Dollars**	**Minutes**
Time	Minutes	X	X	-0.02650	0.0041112	-6.45		
Cost	Dollars (1)	X	X	-0.14031	0.014528	-9.66		
Frequency Damping Factor	See (2)	X	X	0.61529	0.1881674	3.27		
NLX Constant Non Business	(0,1) (3)		X	1.56117	0.3036673	5.14	$ (11)	-1hr
NLX Constant Business/commute	(0,1) (3)		X	2.27883	0.5978325	1.2	$ (16)	-1hr30min

(1) Monetary values in 2013$
(2) Frequency Damping Factor takes the form log (1 – exp[-0.2 * freq in trains or buses per day])
(3) Dummy variables, taking the value 0 or 1.
Source: SDG analysis of SP survey data

The bus option is assigned a reference modal constant value of 0. A positive modal constant for the NLX mode implies that, all else equal, travelers prefer the NLX option to bus. A NLX modal constant equivalent to a 60 minute advantage was estimated for non-business trips and a modal constant equivalent to a 90 minute advantage was estimated for business/commute trips. Inter-urban bus is perceived as less attractive than rail, and business/commute travelers are more likely to prefer rail over bus than their non-business counterparts. These are intuitive results.

The corresponding value of time (VOT) of inter-urban bus travelers is $11.33/hr. Inter-urban bus VOTs are generally lower than auto VOTs, and our estimated VOTs for bus and auto follow this trend. Unlike in the auto models, wait and access times were found to be no more onerous than in-vehicle time. It was estimated that current auto travelers in this corridor weight access and wait time 2.2 and 3.5 times more than in-vehicle time respectively, while bus travelers weight these time components the same as in-vehicle time. This may reflect the fact that inter-urban bus travelers have already made the choice to use a mode requiring access, egress and wait times, and are therefore less sensitive to them than auto travelers.

The bus binary logit model will be applied to predict the share of inter-urban bus travelers who will switch to the NLX mode, considering the trip purpose and the two modes' respective LOS characteristics.

The Access And Egress Mode Choice Models

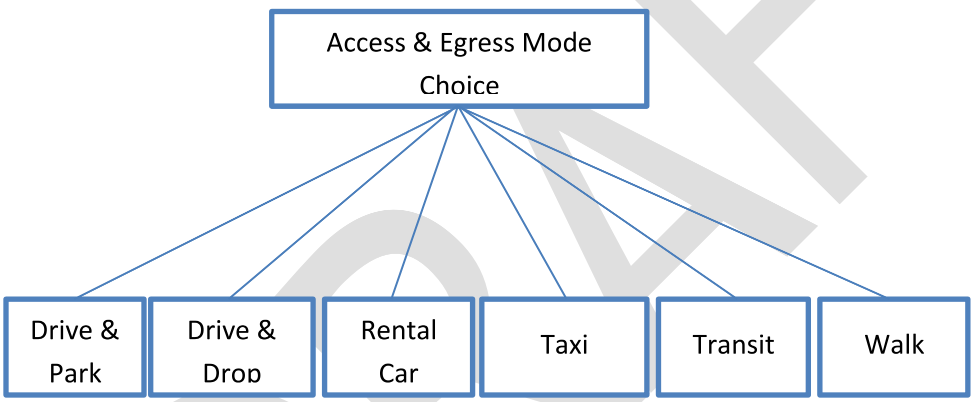
SP survey respondents were asked to choose an access mode and an egress mode based on hypothetical travel times and travel costs presented for each option. Six access and egress modes were considered:

1. Drive and park

2. Drive and dropped-off
3. Transit
4. Taxi
5. Rental car
6. Walk

This allowed the estimation of an access and egress mode choice. Several access and egress mode choice models were specified, estimated and tested using the SP survey data. Various model forms were examined, including multinomial logit choice and nested logit choice models; for the latter, alternative nesting structures were also examined. Based on an assessment of the model estimation results for the different model forms and specifications, the multinomial logit model structure shown in **Figure 3** was retained.

Figure 3. The Access and Egress Mode Choice Model Structure



While a nested structure is sometimes preferred for such models, the statistical estimation results of the various nested models that we tested were not satisfactory.

Table 5 and **Table 6** show the non-business and business/commute access and egress mode choice models estimated from the survey data. The attributes tested and included in our final access mode choice models include access cost (including fares, gas cost and parking cost) divided by the log of income, access time, and the modal constants.

For a median household income of $55,000[2], the value of access time was estimated at $10.87/hr for non-business travelers and $21.61/hr for business/commute travelers. For a household income of $75,000, the value of access time increases to $11.72/hr for non-business travelers and $23.28/hr for business/commute travelers.

[2] 2012 Median Household Income in the Past 12 Months (in 2012 inflation-adjusted dollars) was $58,906 in Minnesota and $51,059 in Wisconsin; as reported in U.S. Census Bureau, Median Household Income by State.

Wait time was not included in the access and egress mode survey questions, to reduce the burden on the respondents (the focus of the survey was the main mode choice exercise). Therefore, for application, SDG proposes to use the same coefficient for wait and access time, an approach that is supported by the literature.

Table 5. Access and Egress Non-Business Mode Choice Model Coefficients

Non-Business Access and Egress Mode Choice		**Coefficient Values**			**Values**	
Coefficients	**Units**	**Value**	**Std. Error**	**T-test**	**Dollars (3)**	**Minutes**
Access Time	Minutes	-0.0118502	0.0029487	-4.02		
Access Cost	Dollars (1) / log(income / 1000)	-0.1137964	0.0061783	-18.42		
Wait time	Minutes	-0.0118502	--asserted--			
Alternative Specific Constants						
Drive & Park Constant	(0,1) (2)	0	--base--		0	0
Drive & Drop Constant	(0,1) (2)	0	--base--		0	0
Rental Car Constant	(0,1) (2)	-0.7947942	0.1317762	-6.03	$12	67
Taxi Constant	(0,1) (2)	-1.893468	0.0988304	-19.16	$29	160
Transit Constant	(0,1) (2)	-0.7528466	0.0428542	-17.57	$12	64
Walk Constant	(0,1) (2)	-1.444305	0.0605783	-23.84	$22	122

(1) Monetary values in 2013$
(2) Dummy variables, taking the value 0 or 1
(3) For a median household income of $55,000
Source: SDG analysis of SP survey data

Table 6. Access and Egress Business/commute Mode Choice Model Coefficients

Business/commute Access and Egress Mode Choice		**Coefficient Values**			**Values**	
Coefficients	**Units**	**Value**	**Std. Error**	**T-test**	**Dollars (3)**	**Minutes**
Access Time	Minutes	-0.0078812	0.0089028	-0.89		
Access Cost	Dollars (1) / log(income / 1000)	-0.0380869	0.0208699	-1.82		
Wait time	Minutes	-0.0078812	--asserted--			
Alternative Specific Constants						
Drive & Park Constant	(0,1) (2)	0	--base--		0	0
Drive & Drop Constant	(0,1) (2)	0	--base--		0	0
Rental Car Constant	(0,1) (2)	-2.000168	0.405821	-4.93	$ 91	254
Taxi Constant	(0,1) (2)	-1.683481	0.2460991	-6.84	$ 77	214
Transit Constant	(0,1) (2)	-0.5805364	0.1259711	-4.61	$ 27	74
Walk Constant	(0,1) (2)	-0.7977004	0.1696368	-4.7	$ 36	101

(1) Monetary values in 2013$
(2) Dummy variables, taking the value 0 or 1
(3) For a median household income of $55,000
Source: SDG analysis of SP survey data

As mentioned earlier, modal constants are terms included in modal utility functions to reflect the inherent attractiveness of an access mode after its explicitly-modeled attributes have been accounted for. These constants represent the average contribution to an access mode's utility of non-modeled attributes, and can be expressed as an equivalent modal travel time penalty or bonus. The private auto access options (Drive & Park and Drive & Drop) are assigned a reference modal constant value of 0. The negative modal constants for the other access modes imply that, all else equal, travelers prefer the private auto access options to other modes.

The access and egress mode choice models will be applied to predict the mode shares to access and egress the NLX, considering the trip purpose, the average household income and the six modes' respective level of service characteristics.

Induced Demand Model

The introduction of a new transportation facility will improve the overall level of service for intercity travel within this corridor. The introduction of NLX may result in trips being made that were not made before. These are called induced trips.

The final step in the inter-urban NLX ridership forecasting process is therefore to forecast the volume of these induced trips brought about by NLX. Induced demand is calculated based on the impact of the introduction of NLX on the transportation system as a whole.

The travel induced by NLX can be expressed as the difference in travel pre- and post- NLX:

$$Induced\ travel = T_{with\ NLX} - T_{without\ NLX}$$

where

$T_{with\ NLX}$ is the total travel with the NLX service in place, and $T_{without\ NLX}$ is the total travel without NLX in place.

To estimate the volume of induced travel, we first relate total travel on all modes to a composite generalized cost (computed over all of the modes), as shown in the following equation. Total travel on all modes can be related to a composite generalized cost, as follows:

$$T_{OD} = SE_{OD}^{\alpha} * CGC_{OD}^{q}$$

where

T_{OD} is the total travel volume between a particular origin and destination on all modes;

SE_{OD} are socio-economic characteristics of the origin and destination;

CGC is the composite generalized cost of travel between the origin and destination; and

α and q are model coefficients or elasticity values.

For a multinomial logit model, the composite generalized cost can be shown to be given by

$CGC = ln(e^{V_{auto}} + e^{V_{rail}} + e^{V_{bus}})$.

Consequently, it can be written:

$$T_{without\ NLX} = SE^{\alpha} * CGC_{without\ NLX}{}^{q}$$

$$T_{with\ NLX} = SE^{\alpha} * CGC_{with\ NLX}{}^{q}$$

When applied to a given year, the socio-economic variables without and with the NLX are the same and cancel each other so that the growth in total travel becomes:

$$Growth\ in\ travel = \frac{T_{with\ NLX}}{T_{without\ NLX}} = \left(\frac{CGC_{with\ NLX}}{CGC_{without\ NLX}}\right)^{q} \qquad (1)$$

In the SP survey, respondents were asked if they would travel more often if NLX service was available, and if so, how much more. (Overall, 66% of the respondents said that if a rail service like the one described in the survey was available, they would make more trips along the corridor than they currently do.) It is therefore possible to estimate quantitatively the value of the induced demand coefficient q based on survey data.

From equation (1) a linear model can be estimated:

$$ln\left(\frac{T_{with\ NLX}}{T_{without\ NLX}}\right) = q * [\ln(GC_{with\ NLX}) - \ln(GC_{without\ NLX})] \qquad (2)$$

Based on the survey data, the following induced demand coefficient estimation results were estimated:

TABLE 7. INDUCED DEMAND MODEL COEFFICIENTS

Purpose	Coefficient Value	Std. Error	T-test
Business/commute	0.32	0.016	19.65
Non Business	0.38	0.006	63.45

For each inter-urban zone pair and trip purpose, the composite generalized cost per trip (including all travel modes) is calculated before and after the introduction of NLX. Differences in composite generalized costs pre- and post-NLX are used to calculate the percent increase in total travel for each inter-urban OD pair and each trip purpose, and this percent increase is then applied to the corresponding total volume of travel to obtain the volume of travel induced by NLX.

Total NLX trips for the inter-urban market are then the sum of the NLX trips forecasted by the mode choice models and the new trips induced by the NLX project.

CONTROL SHEET

Project/Proposal Name	NLX Mode Choice Models Memo
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Other Contributors	Mark Feldman, Jon Bottom, Masroor Hasan
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Steer Davies Gleave:	

D Revenue Projection Methodology Memo

Revenue Projection Methodology Development Memo

Northern Lights Express Ridership and Revenue Forecasting

Technical Memorandum

April 2014

Prepared for:
MnDOT
395 John Ireland Boulevard, MS 480
St. Paul, MN 55155-1800

Prepared by:
Steer Davies Gleave
883 Boylston Street, 3rd Floor
Boston, MA 02116
USA

+1 (617) 391 2300
www.steerdaviesgleave.com

CONTENTS

Introduction

This memorandum details Steer Davies Gleave (SDG)'s proposed methodology for projecting revenue for the proposed Northern Lights Express (NLX) train service. The methods proposed in this memo will apply to the base operating plan forecasts developed in June of 2014 as well as all scenarios for the train service analyzed in the summer and fall of 2014 to determine the optimum operating plan. Revenue projections will be produced for both the opening (2020) and forecast (2040) years, and intermediate years will be produced by interpolation.

In addition to the revenue from ticket sales, the introduction of the NLX service may also provide ancillary revenue-generating opportunities. The revenue stream will include revenue from both these sources.

Revenue from Ticket Sales

The predominant component of revenue is from ticket sales, which are determined by ridership forecasts. The methodology for forecasting ridership has been documented in other project deliverables, including SDG's project proposal, the *No-Build Travel Demand Memo*, and the *Mode Choice Model Development Memo*. Therefore, this memo will start from the point at which ridership has been forecast, and document the process by which we will calculate revenue from a given amount of ridership.

Calculating revenue from ticket sales is a straightforward exercise once the levels of ridership have been determined. The discrete choice model used to forecast individual rail trips is applied at a zone-to-zone level, using the project's detailed zone system (approximately 400 zones). The ridership is then aggregated into a station-to-station table, based on which station is closest to each zone; that same correspondence was used in the choice model to determine each zone's access distance, time and cost to NLX, as well as the in-vehicle time and fare of each possible NLX trip. Then the train fare for each respective station pair is multiplied by the ridership, and they are summed together to get total ticket revenue.

Our initial fare assumptions will be based on the $0.29 per mile fare levels that were used in the analysis for the NLX Service Development Plan (NLX SDP). Later, optimum fares will be used for each operating plan alternative to produce the final ridership and ticket revenue.

As part of the per-mile optimum fare calculation, an unconstrained revenue maximizing analysis will be performed to determine the per-mile fare level that will maximize the ticket revenue. Higher fares will result in more ticket revenue collected per rider, but will also result in fewer overall riders, due to the decreased attractiveness of the NLX service. The revenue-maximizing analysis will determine the per-mile fare that maximizes the intercity revenue for the proposed NLX train service. To identify the revenue-maximizing fare, per-mile train fares will be varied in +/-5% increments from the NLX SDP fare level of $0.29/mile. These different levels of fares will be run back through the mode choice model, which will capture the trade-offs between fare levels and ridership.

The ticket revenue curve is usually quite flat around the revenue-maximizing fare levels (i.e. at higher or lower fares in the vicinity of the revenue-maximizing fares). This means that the corresponding ticket revenue losses at lower fares in the vicinity of the revenue-maximizing fares are usually quite minimal. Hence, setting the optimum fare levels a little lower than the revenue maximizing fare levels will also be explored. At these lower fare levels, the ridership and public benefits (which are directly dependent on the ridership levels) will be higher than those at the revenue maximizing fare levels. Given that the proposed NLX service will be a public good, it may be advisable to set fares at a level lower than the revenue maximizing level, resulting in minimal ticket revenue loss but higher ridership/public benefits gain.

Given that the intercity long distance travel is expected to constitute more than 90% of the ridership and revenue, the revenue-maximizing analysis will only be performed for the intercity travel market. Subsequently, the revenue-maximizing per-mile fare will be used for the connect air markets.

Summary:

- Ticket Revenue = Ridership x Fare, summed over all station pairs; and
- Input Items: Fare table, ramp-up factors (discussed below)

Ancillary Revenue

There may be ancillary revenue generating possibilities for the proposed NLX service. While these ancillary revenues will probably be a small fraction of the total revenue from ticket sales, these should be included in the calculation of the total revenue potential of the NLX service. These ancillary revenue may include various combinations of parking, on-board concessions, commercial development and real estate, third party use of right-of-way, advertising and sponsorship etc. High speed intercity passenger rail (HSIPR) systems have experienced various compositions of these sources, depending on the specific business environment and structures for government and private involvement for each system.

As it is quite difficult to calculate the magnitude of such ancillary revenue within the scope of HSIPR planning studies such as this one, such existing studies have calculated ancillary revenue estimates as fixed percentages of the ticket revenue. For example, for the proposed California High-Speed Rail system, ancillary revenue is calculated as 4% of net revenue. Similar percentages are assumed for Amtrak's Business and Financial Plan for its proposed NextGen HSR service in the NEC. Considering the relative service patterns in the different systems (hourly or less than hourly high-speed trains in the NEC and California, as opposed to 79-110 mph and 6-8 trains/day service for the NLX corridor) and the relative characteristics in the different corridors (presence of several major population centers and economic hubs and also higher value of real estate etc. in the NEC and California compared to the NLX corridor) , we propose to use 2% to 3% of the ticket revenue as the ancillary revenue for the proposed NLX service.

Ramp-Up

The ramp-up period is the transitional period following introduction of a new service, during which travelers become accustomed to the changed transportation environment, and steady-state conditions in terms of choice of travel mode have not yet been achieved. Travelers will need to become acquainted with the NLX service even after it opens, and adjust their trip-making habits. We propose to apply a five-year "ramp up factor" period of both ridership and revenue. This ramp-up assumption, as listed below, is consistent with other HSIPR studies in the U.S. and actual experience with operational HSIPR systems internationally.

- 60% in year 1;
- 70% in year 2;
- 80% in year 3;
- 90% in year 4; and
- 100% in year 5.

We will finalize the ramp-up assumption based on discussions with MnDOT and the peer review panel. To obtain forecasts for years in between 2020 and 2040, linear interpolation will be used on the *pre-ramp-up* forecasts to obtain levels of revenue that would occur on a fully-mature service, and the ramp-up factors will be applied to those levels.

CONTROL SHEET

Project/Proposal Name	Revenue Projection Methodology Development Memo
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Other Contributors	Masroor Hasan
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Steer Davies Gleave:	

E Service Option Schedules

Northern Lights Express

Train Operating Schedule Scenario B-1 (110 MPH)

4 Round Trip Locals

7003	**7007**	**7009**	**7013**	**Train**	**7002**	**7006**	**7010**	**7014**
Crew 1	Crew 2	Crew 3	Crew 4	**Station**	Crew 1	Crew 2	Crew 3	Crew 4
05:08	08:38	12:38	17:13	Duluth Union Station	11:12	15:12	19:47	23:22
05:24	08:54	12:54	17:29	Superior	10:56	14:56	19:31	23:06
-	-	-	-	Sandstone (Mtce Facility)	-	-	-	-
06:20	09:50	13:50	18:25	Hinckley	09:55	13:55	18:30	22:10
06:46	10:21	14:21	18:56	Cambridge	09:29	13:29	18:04	21:44
07:11	10:46	14:46	19:21	Coon Creek	09:04	13:04	17:39	21:19
07:30	11:05	15:05	19:40	Target Field Station	08:45	12:45	17:20	21:00
A	B	A	B	*Train Set*	A	B	A	B
7002	7006	7010	7014	*Relays To Train*	7009	7013	MTCE	MTCE
2'22"	2'27"	2'27"	2'27"	Trip Time	2'27"	2'27"	2'27"	2'22"

Note 1: For NLX trains which meet another NLX train, an additional 5" has been added to schedule times for each of the stations after the station at which the meet occurs. The total trip time is 2'22" without a meet and 2'27" with a meet. All train meets are scheduled to occur in the two-track segment between CP Hinckley and CP South Hinckley.

Note 2: Train 7003's arrival time at TFS is locked at 07:30 due to the operation of Northstar commuter trains.

Note 3: Train 7010's departure time from TFS is locked at 17:20 due to the operation of Northstar commuter trains.

Note 4: This schedule assumes that no layover facility is available at TFS. All trains lay over and are maintained at the Duluth Maintenance Facility (MTCE).

9Oct2014

Northern Lights Express

Train Operating Schedule Scenario B-1 (110 MPH) REVISED

6 Round Trip Locals

7001	**7003**	**7005**	**7007**	**7009**	**7011**	**Train**	**7002**	**7004**	**7006**	**7008**	**7010**	**7012**
Crew 1	Crew 2	Crew 3	Crew 4	Crew 5	Crew 6	**Station**	Crew 4	Crew 1	Crew 2	Crew 3	Crew 5	Crew 6
05:08	07:08	09:08	12:08	14:08	17:13	Duluth Union Station	09:47	11:42	14:47	16:42	19:47	23:22
05:24	07:24	09:24	12:24	14:24	17:29	Superior	09:31	11:26	14:31	16:26	19:31	23:06
06:20	08:20	10:20	13:20	15:20	18:25	Hinckley	08:25	10:25	13:25	15:25	18:30	22:10
06:46	08:51	10:51	13:51	15:51	18:56	Cambridge	07:59	09:59	12:59	14:59	18:04	21:44
07:11	09:16	11:16	14:16	16:16	19:21	Coon Creek	07:34	09:34	12:34	14:34	17:39	21:19
07:30	09:35	11:35	14:35	16:35	19:40	Target Field Station	07:15	09:15	12:15	14:15	17:20	21:00
A	B	C	D	A	B	*Train Set*	D	A	B	C	D	A
7004	7006	7008	7010	7012	7002	*Relays To Train*	7007	7009	7011	MTCE	MTCE	MTCE
2'22"	2'27"	2'27"	2'27"	2'27"	2'27"	Trip Time	2'32"	2'27"	2'32"	2'27"	2'27"	2'22"

NOTES for 6RT LOCAL 110 MPH SCENARIO:

Note 1: For NLX trains which meet another NLX train between Hinckley and South Hinckley, an additional 5" has been added to schedule times for each of the stations after the station at which the meet occurs. The total trip time is 2'22" without a meet and 2'27" with a meet. For the two northbound trains (Trains 7002 and 7006) which meet a second southbound NLX train just south of Superior, an additional 5" has been added to the schedule times at Superior and Duluth. For these two trains, the trip time is 2'32."

Note 2: Train 7001's arrival time at TFS is locked at 07:30 due to the operation of Northstar commuter trains.

Note 3: Train 7010's departure time from TFS is locked at 17:20 due to the operation of Northstar commuter trains.

Note 4: This schedule assumes a layover facility for one train at TFS. All other trains layover at Duluth. All trains are maintained at the Duluth Maintenance Facility (MTCE).

Note 5: This schedule assumes that each crew makes one round trip daily. Crews 1, 2, 3, 5 and 6 go on and off duty in Duluth. Crew 4 goes on and off duty in Minneapolis. All crews return to their home terminal each night.

Note 6: The train set that lays over in Minneapolis one night (Train 7011), lays over at Duluth the following night after arrival on Train 7012.

Note 7: This scenario requires that 4 train sets be available for service each day to operate the six round trips. A 5^{th} train set would be required for maintenance, and additional spare equipment would also be required for protection/service dependability.

Quandel Consultants
20 Oct 2014 REVISED 23Oct14

Northern Lights Express

Train Operating Schedule Scenario Split (110 MPH) -REVISED

2 RT Express, 1 RT Local, 1RT Sandstone

7051	**7003**	**7009**	**7013**	**Train**	**7002**	**7006**	**7010**	**7052**
Crew 1	Crew 2	Crew 3	Crew 4	**Station**	Crew 1	Crew 2	Crew 3	Crew 4
-	06:31	11:38	15:55	Duluth Union Station	10:14	14:12	19:34	-
-	06:47	11:54	16:11	Superior	09:58	13:56	19:18	-
06:07	-	-	-	Sandstone (Mtce Facility)	-	-	-	20:03
06:22	-	12:50	-	Hinckley	-	12:55	-	19:48
06:49	-	13:21	-	Cambridge	-	12:29	-	19:21
07:12	08:29	13:46	17:53	Coon Creek	08:16	12:04	17:36	18:58
07:30	08:45	14:05	18:09	Target Field Station	08:00	11:45	17:20	18:40
A	B	A	B	*Train Set*	A	B	A	B
7002	7006	7010	7052	*Relays To Train*	7009	7013	Layover	MTCE
1’23”	Exp.: 2’14”	Local: 2’27”	Exp.: 2’14”	Trip Time	Exp.: 2’14”	Local: 2’27”	Exp: 2’14”	1’23”

NOTES:

Note 1: For NLX trains which meet another NLX train, an additional 5” has been added to schedule times for each of the stations after the station at which the meet occurs. Meets occur at the following locations: (1) Trains 7002 and 7003 meet at/near Andover at about 0824. (2) Trains 7006 and 7009 meet between CP South Hinckley and CP Hinckley. (3) Trains 7010 and 7013 meet at/near Andover at about 17:44.

Note 2: Train 7051’s arrival time at TFS is locked at 07:30 due to the operation of Northstar commuter trains.

Note 3: Train 7010’s departure time from TFS is locked at 17:20 due to the operation of Northstar commuter trains.

Note 4: This schedule assumes that no layover facility is available at TFS. Trains lay over at Duluth Layover Facility and at the Sandstone Maintenance/Layover Facility (MTCE).

Note 5: Trains 7051 and 7052 operate between TFS and Hinckley and do not carry passengers between Hinckley and the Sandstone Maintenance/Layover Facility.

Note 6: Crew Utilization:

- Crew 1 operates Train 7051 to TFS and Train 7002 to Duluth. (Crew based in Duluth. Overnight Duluth. Rotates to Crew 4 next day.)
- Crew 2 operates Train 7003 to TFS and Train 7006 to Duluth. (Crew based in Duluth. Overnight Duluth).
- Crew 3 operates Train 7009 to TFS and Train 7010 to Duluth. (Crew based in Duluth. Overnight Duluth).
- Crew 4 operates Train 7013 to TFS and Train 7052 to Sandstone. (Crew based in Duluth. Overnight Sandstone. Rotates to Crew 1 next day.)

10Oct2014

REVISED 20 Oct 14

Northern Lights Express

Train Operating Schedule – Target Field Station to Duluth Union Depot

Scenario B4 - 8 Round Trip with 2 Express Round Trips at 110 MPH

7001	**7003**	**7005**	**7007**	**7009**	**7011**	**7013**	**7015**	**Train**	**7002**	**7004**	**7006**	**7008**	**7010**	**7012**	**7014**	**7016**
Crew 1	Crew 2	Crew 3	Crew 4	Crew 6	Crew 7	Crew 8	**Crew 5**	**Station**	Crew 4	Crew 1	Crew 2	Crew 3	Crew 5	Crew 6	Crew 7	Crew 8
05:08	07:08	09:08	11:08	13:08	15:08	17:08	19:08	Duluth Union Depot	09:28	11:47	13:47	15:47	17:47	19:33	21:42	23:42
05:24	07:24	09:24	11:24	13:24	15:24	17:24	19:24	Superior	09:12	11:31	13:31	15:31	17:31	19:17	21:26	23:26
06:20		10:20	12:20	14:20	16:20		20:20	Hinckley		10:25	12:25	14:25	16:25		20:25	22:25
06:46		10:51	12:51	14:51	16:51		20:51	Cambridge		09:59	11:59	13:59	15:59		19:59	21:59
07:11		11:16	13:16	15:16	17:16		21:16	Coon Creek		09:34	11:34	13:34	15:34		19:34	21:34
07:30	09:21	11:35	13:35	15:35	17:35	19:21	21:35	Target Field Station	07:15	09:15	11:15	13:15	15:15	17:20	19:15	21:15
A	B	C	D	A	B	C	**Note 7**	*Train Set*	D	A	B	C	D	A	B	C
7004	7006	7008	7010	7012	7014	7016	7002	*Relays To Train*	7007	7009	7011	7013	MTCE	MTCE	MTCE	MTCE
2’22”	2’13”	2’27”	2’27”	2’27”	2’27”	2’13”	2’27”	Trip Time	2’13”	2’32”	2’32”	2’32”	2’32”	2’13”	2’27”	2’27”

Northern Lights Express

Train Operating Schedule - Target Field Station to Duluth Union Depot

Scenario B5 - 5 Round Trips-Local, Split & Express at 110 MPH

7051	**7001**	**7007**	**7009**	**7011**	**Train**	**7000**	**7002**	**7004**	**7010**	**7052**
Crew 5	Crew 1	Crew 3	Crew 4	Crew 2	**Station**	Crew 3	Crew 1	Crew 2	Crew 5	Crew 4
---	06:07	10:40	15:21	16:35	Duluth Union Depot	09:42	11:27	14:27	19:13	---
---	06:23	10:56	15:37	16:51	Superior	09:26	11:06	14:11	18:57	---
06:32	---	---	---	---	Sandstone MTCE	---	---	---	---	20:13
06:47	---	11:59	16:35	17:49	Hinckley	08:28	10:08	13:13	---	19:54
07:14	---	12:26	17:09	18:23	Cambridge	08:01	09:41	12:46	---	19:31
07:42	---	12:54	17:37	18:51	Coon Creek	07:26	09:18	12:18	---	19:03
08:00	08:20	13:12	17:55	19:09	Target Field Station	07:08	09:00	12:00	17:00	18:45
B	A	C	A	B	*Train Set*	C	A	B	C	A
7004	7002	7010	7052	7000	*Relays To Train*	7007	7011	7009	L/O	MTCE
1’28”	2’13”	2’32”	2’34”	2’34”	Trip Time	2’34”	2’27”	2’27”	2’13”	1’28”

Northern Lights Express

Train Operating Schedule – Target Field Station to Duluth Union Depot

Scenario B10 - 2 Round Trip Local at 110 MPH

7003	**7009**	**Train No.**	**7002**	**7010**
Crew 1	**Crew 2**	***Station***	**Crew 1**	**Crew 2**
05:18	14:35	Duluth	10:42	20:02
05:34	14:51	Superior	10:26	19:46
06:30	15:47	Hinckley	09:30	18:50
06:56	16:13	Cambridge	09:04	18:24
07:21	16:38	Coon Creek	08:39	17:59
07:40	16:57	Target Field	08:20	17:40
A	A	*Train Set*	A	A
2’22”	*2’22”*	*Trip Time*	*2’22”*	*2’22”*
7002	*7010*	*Relays to #*	*7009*	*MTCE*

Note: Requires one train set in service and one for spare/maintenance. Requires two crews per day-one morning and one afternoon, plus weekends, vacation, extra, as in all other scenarios.

Northern Lights Express

Train Operating Schedule – Target Field Station to Duluth Union Depot

Scenario B11 - 8 Round Trip Locals at 110 MPH

7001	**7003**	**7005**	**7007**	**7009**	**7011**	**7013**	**7015**	**Train**	**7002**	**7004**	**7006**	**7008**	**7010**	**7012**	**7014**	**7016**
Crew 1	Crew 2	Crew 3	Crew 4	Crew 6	Crew 7	Crew 8	**Crew 5**	**Station**	Crew 4	Crew 1	Crew 2	Crew 3	Crew 5	Crew 6	Crew 7	Crew 8
05:08	07:08	09:08	11:08	13:08	15:08	17:08	19:08	Duluth Union Station	09:47	11:47	13:47	15:47	17:47	19:52	21:42	23:42
05:24	07:24	09:24	11:24	13:24	15:24	17:24	19:24	Superior	09:31	11:31	13:31	15:31	17:31	19:36	21:26	23:26
06:20	08:20	10:20	12:20	14:20	16:20	18:20	20:20	Hinckley	08:25	10:25	12:25	14:25	16:25	18:30	20:25	22:25
06:46	08:46	10:51	12:51	14:51	16:51	18:51	20:51	Cambridge	07:59	09:59	11:59	13:59	15:59	18:04	19:59	21:59
07:11	09:11	11:16	13:16	15:16	17:16	19:16	21:16	Coon Creek	07:34	09:34	11:34	13:34	15:34	17:39	19:34	21:34
07:30	09:30	11:35	13:35	15:35	17:35	19:35	21:35	Target Field Station	07:15	09:15	11:15	13:15	15:15	17:20	19:15	21:15
A	B	C	D	A	B	C	**Note 7**	*Train Set*	D	A	B	C	D	A	B	C
7004	7006	7008	7010	7012	7014	7016	7002	*Relays To Train*	7007	7009	7011	7013	MTCE	MTCE	MTCE	MTCE
2’22”	2’22”	2’27”	2’27”	2’27”	2’27”	2’27”	2’27”	Trip Time	2’32”	2’32”	2’32”	2’32”	2’32”	2’32”	2’27”	2’27”

Notes

Note 1: All NLX trains meet another NLX train between Coon Creek and TFS. No additional time has been added for these meets. It has been assumed that there is or will be sufficient multiple track available between Coon Creek and TFS to allow the meets to occur without adding schedule time.

Note 2: For NLX trains which meet an NLX train between Hinckley and South Hinckley, an additional 5” has been added to the schedule times for each of the stations after the station at which the meet occurs. The total trip time is 2’22” without a meet and 2’27” with a meet. For northbound trains which meet an additional southbound NLX train just south of Superior, an additional 5” has been added to the schedule times at Superior and Duluth. For these trains, the total trip time is 2’32.”

Note 3: Train 7001’s arrival time at TFS is locked at 07:30 due to the operation of Northstar commuter trains.

Note 4: Train 7012’s departure time from TFS is locked at 17:20 due to the operation of Northstar commuter trains.

Note 5: This schedule assumes that one train lays overnight on the platform track at TFS. Only minimum interior cleaning and an FRA Class I air brake test would be conducted there. See Note 7 below. All other trains layover and are maintained at the Duluth Maintenance Facility (MTCE).

Note 6: This schedule assumes that each operating crew makes one round trip daily with a work day approximating 8 hours depending on required activities at each terminal. Crews 1, 2, 3, 6, 7 and 8 go on and off duty in Duluth. Crews 4 and 5 go on and off duty at TFS in

Minneapolis. All crews return to their home terminal each night. No overnight crew lodging or use of operating crews in aggregate service is anticipated due to the expenses associated with those options. If the Duluth Maintenance Facility were to be located in Superior, each train crew required to ferry a train between the Maintenance Facility in Superior and the terminal in Duluth would have an additional 30" on duty time added to the work day. Also note that these schedules do not include any movement at the terminal stations between trips as have been shown on string line graphs. Trains are assumed to be stationery between their arrival and departure times at the terminals to allow blue signal protection, interior servicing, commissary restocking and/or locomotive fueling as needed.

Note 7: This schedule requires four train sets to each make two daily round trips. A fifth train set (the operational spare) is required for Train 7015 at Duluth each afternoon. A 6th train set is required for maintenance. When Train 7010 arrives at Duluth each afternoon, the equipment rotates into the Maintenance Facility instead of rotating back to TFS as Train 7015. Train 7015 requires a freshly inspected and serviced train set from the Duluth Maintenance Facility because that equipment lays overnight at TFS and begins service the next day as Train 7002 with only a train crew inspection and test. The equipment maintenance cycles jointly developed by operations and maintenance management personnel will rotate train sets in and out of service and maintenance as needed to meet inspection and maintenance requirements and to balance usage.

Note 8: All train sets are assumed to have the same number and type of passenger cars and the same locomotive power so that they are all interchangeable with each other without effects on either passenger capacity or operating performance. Trains are assumed to be operated in push-pull service using heavyweight PRIIA gallery type passenger cars, one of which is also equipped as a cab control car and is used as the operating cab when the train is in the "push" mode.

Northern Lights Express

Train Operating Schedule Scenario C-1 (90 MPH)

4 Round Trip Locals

7003	**7007**	**7009**	**7013**	**Train**	**7002**	**7006**	**7010**	**7014**
Crew 1	Crew 2	Crew 3	Crew 4	**Station**	Crew 1	Crew 2	Crew 3	Crew 4
04:57	08:34	12:34	17:14	Duluth Union Station	11:18	15:18	19:58	23:43
05:13	08:50	12:50	17:30	Superior	11:02	15:02	19:42	23:27
-	-	-	-	Sandstone (Mtce Facility)	-	-	-	-
06:14	09:51	13:51	18:31	Hinckley	09:56	13:56	18:36	22:26
06:44	10:26	14:26	19:06	Cambridge	09:26	13:26	18:06	21:56
07:11	10:53	14:53	19:33	Coon Creek	08:59	12:59	17:39	21:29
07:30	11:12	15:12	19:52	Target Field Station	08:40	12:40	17:20	21:10
A	B	A	B	*Train Set*	A	B	A	B
7002	7006	7010	7014	*Relays To Train*	7009	7013	MTCE	MTCE
2’33”	2’38”	2’38”	2’38”	Trip Time	2’38”	2’38”	2’38”	2’33”

Note 1: For NLX trains which meet another NLX train, an additional 5” has been added to schedule times for each of the stations after the station at which the meet occurs. The total trip time is 2’33” without a meet and 2’38” with a meet. All train meets are scheduled to occur in the two-track segment between CP Hinckley and CP South Hinckley.

Note 2: Train 7003’s arrival time at TFS is locked at 07:30 due to the operation of Northstar commuter trains.

Note 3: Train 7010’s departure time from TFS is locked at 17:20 due to the operation of Northstar commuter trains.

Note 4: This schedule assumes that no layover facility is available at TFS. All trains lay over and are maintained at the Duluth Maintenance Facility (MTCE).

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Northern Lights Express

Train Operating Schedule Scenario C-1 (90 MPH)

6 Round Trip Locals

7001	**7003**	**7005**	**7007**	**7009**	**7011**	**Train**	**7002**	**7004**	**7006**	**7008**	**7010**	**7012**
Crew 1	Crew 2	Crew 3	Crew 4	Crew 5	Crew 6	**Station**	Crew 4	Crew 1	Crew 2	Crew 3	Crew 5	Crew 6
04:57	06:57	08:57	11:57	13:57	17:14	Duluth Union Station	09:41	11:41	14:41	16:41	19:58	23:43
05:13	07:13	09:13	12:13	14:13	17:30	Superior	09:25	11:25	14:25	16:25	19:42	23:27
06:14	08:14	10:14	13:14	15:14	18:31	Hinckley	08:19	10:19	13:19	15:19	18:36	22:26
06:44	08:49	10:49	13:49	15:49	19:06	Cambridge	07:49	09:49	12:49	14:49	18:06	21:56
07:11	09:16	11:16	14:16	16:16	19:33	Coon Creek	07:22	09:22	12:22	14:22	17:39	21:29
07:30	09:35	11:35	14:35	16:35	19:52	Target Field Station	07:03	09:03	12:03	14:03	17:20	21:10
A	B	C	D	A	B	*Train Set*	D	A	B	C	D	A
7004	7006	7008	7010	7012	7002	*Relays To Train*	7007	7009	7011	MTCE	MTCE	MTCE
2’33”	2’38”	2’38”	2’38”	2’38”	2’38”	Trip Time	2’38”	2’38”	2’38”	2’38”	2’38”	2’33”

NOTES for 6RT LOCAL 90 MPH SCENARIO:

Note 1: For NLX trains which meet another NLX train between Hinckley and South Hinckley, an additional 5” has been added to schedule times for each of the stations after the station at which the meet occurs. The total trip time is 2’33” without a meet and 2’38” with a meet. (Unlike the 110 MPH scenario for the 6 RT schedule, it was not necessary to add 5” to the schedules of Trains 7002 and 7006 at Superior and Duluth because of a second NLX train meet on line.)

Note 2: Train 7003’s arrival time at TFS is locked at 07:30 due to the operation of Northstar commuter trains.

Note 3: Train 7010’s departure time from TFS is locked at 17:20 due to the operation of Northstar commuter trains.

Note 4: This schedule assumes a layover facility for one train at TFS. All other trains lay over at Duluth. All trains are maintained at the Duluth Maintenance Facility (MTCE).

Note 5: This schedule assumes that each crew makes one round trip daily. Crews 1, 2, 3, 5 and 6 go on and off duty in Duluth. Crew 4 goes on and off duty in Minneapolis. All crews return to their home terminal each night.

Note 6: The train set that lays over in Minneapolis one night (Train 7011), lays over at Duluth the following night after arrival on Train 7012.

Note 7: This scenario requires that 4 train sets be available for service each day to operate the six round trips. A 5th train set would be required for maintenance, and additional spare equipment would also be required for protection/service dependability.

Quandel Consultants
20 Oct 2014

Northern Lights Express

Train Operating Schedule Scenario Split (90 MPH) REVISED

2 RT Express, 1 RT Local, 1RT Sandstone

7051	**7003**	**7009**	**7013**	**Train**	**7002**	**7006**	**7010**	**7052**
Crew 1	Crew 2	Crew 3	Crew 4	**Station**	Crew 1	Crew 2	Crew 3	Crew 4
-	06:19	11:39	15:44	Duluth Union Station	10:26	14:23	19:46	-
-	06:35	11:55	16:00	Superior	10:10	14:07	19:30	-
06:00	-	-	-	Sandstone (Mtce Facility)	-	-	-	20:10
06:15	-	12:56	-	Hinckley	-	13:01	-	19:55
06:45	-	13:31	-	Cambridge	-	12:31	-	19:25
07:12	08:29	13:58	17:54	Coon Creek	08:16	12:04	17:36	18:58
07:30	08:45	14:17	18:10	Target Field Station	08:00	11:45	17:20	18:40
A	B	A	B	*Train Set*	A	B	A	B
7002	7006	7010	7052	*Relays To Train*	7009	7013	Layover	MTCE
1’30”	Exp.: 2’26”	Local: 2’38”	Exp.: 2’26”	Trip Time	Exp.: 2’26”	Local: 2’38”	Exp.: 2’26”	1’30”

NOTES:

Note 1: For NLX trains which meet another NLX train, an additional 5” has been added to schedule times for each of the stations after the station at which the meet occurs. Meets occur at the following locations: (1) Trains 7002 and 7003 meet at/near Andover at about 0824. (2) Trains 7006 and 7009 meet between CP South Hinckley and CP Hinckley. (3) Trains 7010 and 7013 meet at/near Andover at about 17:44.

Note 2: Train 7051’s arrival time at TFS is locked at 07:30 due to the operation of Northstar commuter trains.

Note 3: Train 7010’s departure time from TFS is locked at 17:20 due to the operation of Northstar commuter trains.

Note 4: This schedule assumes that no layover facility is available at TFS. Trains lay over at Duluth Layover Facility and at the Sandstone Maintenance/Layover Facility (MTCE).

Note 5: Trains 7051 and 7052 operate between TFS and Hinckley and do not carry passengers between Hinckley and the Sandstone Maintenance/Layover Facility.

Note 6: Crew Utilization:

- Crew 1 operates Train 7051 to TFS and Train 7002 to Duluth. (Crew based in Duluth. Overnight Duluth. Rotates to Crew 4 next day.)
- Crew 2 operates Train 7003 to TFS and Train 7006 to Duluth. (Crew based in Duluth. Overnight Duluth).
- Crew 3 operates Train 7009 to TFS and Train 7010 to Duluth. (Crew based in Duluth. Overnight Duluth).
- Crew 4 operates Train 7013 to TFS and Train 7052 to Sandstone. (Crew based in Duluth. Overnight Sandstone. Rotates to Crew 1 next day.)

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REVISED 20 Oct 14

Northern Lights Express

Train Operating Schedule - Target Field Station to Duluth Union Depot

Scenario C4 - 8 Round Trip with 2 Express Round Trips at 90 MPH

7001	7003	7005	7007	7009	7011	7013	7015	Train	7002	7004	7006	7008	7010	7012	7014	7016
Crew 1	Crew 2	Crew 3	Crew 4	Crew 6	Crew 7	Crew 8	**Crew 5**	**Station**	Crew 4	Crew 1	Crew 2	Crew 3	Crew 5	Crew 6	Crew 7	Crew 8
04:57	06:57	08:57	10:57	12:57	14:57	16:57	18:57	Duluth Union Depot	09:25	11:41	13:41	15:41	17:41	19:25	21:36	23:36
05:13	07:13	09:13	11:13	13:13	15:13	17:13	19:13	Superior	09:09	11:25	13:25	15:25	17:25	19:09	21:20	23:20
06:14		10:14	12:14	14:14	16:14		20:14	Hinckley		10:19	12:19	14:19	16:19		20:19	22:19
06:44		10:49	12:49	14:49	16:49		20:49	Cambridge		09:49	11:49	13:49	15:49		19:49	21:49
07:11		11:16	13:16	15:16	17:16		21:16	Coon Creek		09:22	11:22	13:22	15:22		19:22	21:22
07:30	09:19	11:35	13:35	15:35	17:35	19:19	21:35	Target Field Station	07:03	09:03	11:03	13:03	15:03	17:03	19:03	21:03
A	B	C	D	A	B	C	**Note 7**	*Train Set*	D	A	B	C	D	A	B	C
7004	7006	7008	7010	7012	7014	7016	7002	*Relays To Train*	7007	7009	7011	7013	MTCE	MTCE	MTCE	MTCE
2’33”	2’22”	2’38”	2’38”	2’38”	2’38”	2’22”	2’38”	Trip Time	2’22”	2’38”	2’38”	2’38”	2’38”	2’22”	2’33”	2’33”

Northern Lights Express

Train Operating Schedule - Target Field Station to Duluth Union Depot

Scenario C5 - 5 Round Trips-Local, Split & Express at 90 MPH

7051	**7001**	**7007**	**7009**	**7011**	**Train**	**7000**	**7002**	**7004**	**7010**	**7052**
Crew 5	Crew 1	Crew 3	Crew 4	Crew 2	**Station**	Crew 3	Crew 1	Crew 2	Crew 5	Crew 4
---	05:58	10:50	15:21	17:05	Duluth Union Depot	09:52	11:37	14:37	19:22	---
---	06:14	11:06	15:37	17:21	Superior	09:36	11:21	14:21	19:06	---
06:30	---	---	---	---	Sandstone MTCE	---	---	---	---	20:15
06:45	---	12:12	16:38	18:29	Hinckley	08:35	10:15	13:20	---	20:00
07:15	---	12:42	17:08	18:59	Cambridge	07:58	09:45	12:50	---	19:30
07:42	---	13:14	17:42	19:26	Coon Creek	07:26	09:18	12:18	---	18:58
08:00	08:20	13:32	18:00	19:44	Target Field Station	07:08	09:00	12:00	17:00	18:40
B	A	C	A	B	*Train Set*	C	A	B	C	A
7004	7002	7010	7052	7000	*Relays To Train*	7007	7011	7009	L/O	MTCE
1’30”	2’22”	2’42”	2’39”	2’39”	Trip Time	2’44”	2’37”	2’37”	2’22”	1’35”

Northern Lights Express

Train Operating Schedule – Target Field Station to Duluth Union Depot

Scenario C10 - 2 Round Trip Local at 90 MPH

7003	**7009**	**Train No.**	**7002**	**7010**
Crew 1	**Crew 2**	***Station***	**Crew 1**	**Crew 2**
05:07	14:24	Duluth	10:53	20:13
05:23	14:40	Superior	10:37	19:57
06:24	15:41	Hinckley	09:31	18:51
06:54	16:11	Cambridge	09:06	18:26
07:21	16:38	Coon Creek	08:39	17:59
07:40	16:57	Target Field	08:20	17:40
A	A	*Train Set*	A	A
2'33"	*2'33"*	*Trip Time*	*2'33"*	*2'33"*
7002	*7010*	*Relays to #*	*7009*	*MTCE*

Note: Requires one train set in service and one for spare/maintenance. Requires two crews per day-one morning and one afternoon, plus weekends, vacation, extra, as in all other scenarios.

Northern Lights Express

Train Operating Schedule - Target Field Station to Duluth Union Depot

Scenario C11 - 8 Round Trip Locals at 90 MPH

7001	7003	7005	7007	7009	7011	7013	7015	Train	7002	7004	7006	7008	7010	7012	7014	7016
Crew 1	Crew 2	Crew 3	Crew 4	Crew 6	Crew 7	Crew 8	**Crew 5**	**Station**	Crew 4	Crew 1	Crew 2	Crew 3	Crew 5	Crew 6	Crew 7	Crew 8
04:57	06:57	08:57	10:57	12:57	14:57	16:57	18:57	Duluth Union Station	09:41	11:41	13:41	15:41	17:41	19:41	21:36	23:36
05:13	07:13	09:13	11:13	13:13	15:13	17:13	19:13	Superior	09:25	11:25	13:25	15:25	17:25	19:25	21:20	23:20
06:14	08:14	10:14	12:14	14:14	16:14	1814	20:14	Hinckley	08:19	10:19	12:19	14:19	16:19	18:19	20:19	22:19
06:44	08:44	10:49	12:49	14:49	16:49	18:49	20:49	Cambridge	07:49	09:49	11:49	13:49	15:49	17:49	19:49	21:49
07:11	09:11	11:16	13:16	15:16	17:16	19:16	21:16	Coon Creek	07:22	09:22	11:22	13:22	15:22	17:22	19:22	21:22
07:30	09:30	11:35	13:35	15:35	17:35	19:35	21:35	Target Field Station	07:03	09:03	11:03	13:03	15:03	17:03	19:03	21:03
A	B	C	D	A	B	C	**Note 7**	*Train Set*	D	A	B	C	D	A	B	C
7004	7006	7008	7010	7012	7014	7016	7002	*Relays To Train*	7007	7009	7011	7013	MTCE	MTCE	MTCE	MTCE
2’33”	2’33”	2’38”	2’38”	2’38”	2’38”	2’38”	2’38”	Trip Time	2’38”	2’38”	2’38”	2’38”	2’38”	2’38”	2’33”	2’33”

NOTES for 8RT LOCAL 90 MPH SCENARIO:

Note 1: All NLX trains except Trains 7015 and 7016 meet another NLX train between Coon Creek and TFS. No additional time has been added for these meets. It has been assumed that there is or will be sufficient multiple track available between Coon Creek and TFS to allow the meets to occur without adding additional schedule time.

Note 2: For NLX trains which meet an NLX train between Hinckley and South Hinckley, an additional 5” has been added to the schedule times for each of the stations after the station at which the meet occurs. The total trip time is 2’33” without a meet and 2’38” with a meet. For northbound trains which meet an additional southbound NLX train just south of Superior, an additional 5” has been added to the schedule times at Superior and Duluth. For these trains, the total trip time is 2’38.”

Note 3: Train 7001’s arrival time at TFS is locked at 07:30 due to the operation of Northstar commuter trains.

Note 4: Train 7012’s departure time from TFS is no longer locked at 17:20 due to the operation of Northstar commuter trains. Rather, Train 7012 follows the memory schedule pattern of other northbound NLX departures from TFS by departing at 17:03. This is necessary to meet southbound NLX Train 7013 between Hinckley and South Hinckley.

Note 5: This schedule assumes that one train lays overnight on the platform track at TFS. Only minimum interior cleaning and an FRA Class I air brake test would be conducted there. See Note 7 below. All other trains layover and are maintained at the Duluth Maintenance Facility (MTCE).

Note 6: This schedule assumes that each operating crew makes one round trip daily with a work day between 8 and 9 hours depending on required activities at each terminal. Crews 1, 2, 3, 6, 7 and 8 go on and off duty in Duluth. Crews 4 and 5 go on and off duty at TFS in Minneapolis. All crews return to their home terminal each night. No overnight crew lodging or use of operating crews in aggregate service is anticipated due to the expenses associated with those options. If the Duluth Maintenance Facility were to be located in Superior, each train crew required to ferry a train between the Maintenance Facility in Superior and the terminal in Duluth would have an additional 30" on duty time added to the work day. Also note that these schedules do not include any movement at the terminal stations between trips as have been shown on string line graphs. Trains are assumed to be stationery between their arrival and departure times at the terminals to allow blue signal protection, interior servicing, commissary restocking and/or locomotive fueling as needed.

Note 7: This schedule requires four train sets to each make two daily round trips. A fifth train set (the operational spare) is required for Train 7015 at Duluth each afternoon. A 6th train set is required for maintenance. When Train 7010 arrives at Duluth each afternoon, the equipment rotates into the Maintenance Facility instead of rotating back to TFS as Train 7015. Train 7015 requires a freshly inspected and serviced train set from the Duluth Maintenance Facility because that equipment lays overnight at TFS and begins service the next day as Train 7002 with only a train crew inspection and test. The equipment maintenance cycles jointly developed by operations and maintenance management personnel will rotate train sets in and out of service and maintenance as needed to meet inspection and maintenance requirements and to balance usage.

Note 8: All train sets are assumed to have the same number and type of passenger cars and the same locomotive power so that they are all interchangeable with each other without effects on either passenger capacity or operating performance. Trains are assumed to be operated in push-pull service using heavyweight PRIIA gallery type passenger cars, one of which is also equipped as a cab control car and is used as the operating cab when the train is in the "push" mode.

Northern Lights Express

Train Operating Schedule Scenario D-1 (79 MPH)

4 Round Trip Locals

7003	**7007**	**7009**	**7013**	**Train**	**7002**	**7006**	**7010**	**7014**
Crew 1	Crew 2	Crew 3	Crew 4	**Station**	Crew 1	Crew 2	Crew 3	Crew 4
04:47	08:36	12:36	17:16	Duluth Union Station	11:28	15:28	20:08	23:53
05:03	08:52	12:52	17:32	Superior	11:12	15:12	19:52	23:37
-	-	-	-	Sandstone (Mtce Facility)	-	-	-	-
06:08	09:57	13:57	18:37	Hinckley	10:02	14:02	18:42	22:32
06:41	10:35	14:35	19:15	Cambridge	09:29	13:29	18:09	21:59
07:11	11:05	15:05	19:45	Coon Creek	08:59	12:59	17:39	21:29
07:30	11:24	15:24	20:04	Target Field Station	08:40	12:40	17:20	21:10
A	B	A	B	*Train Set*	A	B	A	B
7002	7006	7010	7014	*Relays To Train*	7009	7013	MTCE	MTCE
2’43”	2”48”	2’48”	2’48”	Trip Time	2’48”	2’48”	2’48”	2’43”

Note 1: For NLX trains which meet another NLX train, an additional 5” has been added to schedule times for each of the stations after the station at which the meet occurs. The total trip time is 2’43” without a meet and 2’48” with a meet. All train meets are scheduled to occur in the two-track segment between CP Hinckley and CP South Hinckley.

Note 2: Train 7003’s arrival time at TFS is locked at 07:30 due to the operation of Northstar commuter trains.

Note 3: Train 7010’s departure time from TFS is locked at 17:20 due to the operation of Northstar commuter trains.

Note 4: This schedule assumes that no layover facility is available at TFS. All trains lay over and are maintained at the Duluth Maintenance Facility (MTCE).

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Northern Lights Express

Train Operating Schedule Scenario Split (79 MPH)

2 RT Express, 1 RT Local, 1RT Sandstone

7051	**7003**	**7009**	**7013**	**Train**	**7002**	**7006**	**7010**	**7052**
Crew 1	Crew 2	Crew 3	Crew 4	**Station**	Crew 1	Crew 2	Crew 3	Crew 4
-	06:13	11:41	15:33	Duluth Union Station	10:37	14:33	19:57	-
-	06:29	11:57	15:49	Superior	10:21	14:17	19:41	-
05:54	-	-	-	Sandstone (Mtce Facility)	-	-	-	20:16
06:09	-	13:02	-	Hinckley	-	13:07	-	20:01
06:44	-	13:40	-	Cambridge	-	12:34	-	19:26
07:12	08:34	14:10	17:54	Coon Creek	08:16	12:04	17:36	18:58
07:30	08:50	14:29	18:10	Target Field Station	08:00	11:45	17:20	18:40
A	B	A	B	*Train Set*	A	B	A	B
7002	7006	7010	7052	*Relays To Train*	7009	7013	Layover	MTCE
1’36”	Exp.: 2’37”	Local: 2’48”	Exp.; 2’37”	Trip Time	Exp.: 2’37”	Local: 2’48”	Exp.: 2’37”	1’36”

NOTES:

Note 1: For NLX trains which meet another NLX train, an additional 5” has been added to schedule times for each of the stations after the station at which the meet occurs. Meets occur at the following locations: (1) Trains 7002 and 7003 meet at/near Andover at about 08:22. (2) Trains 7006 and 7009 meet between CP South Hinckley and CP Hinckley. (3) Trains 7010 and 7013 meet at/near Andover at about 17:42.

Note 2: Train 7051’s arrival time at TFS is locked at 07:30 due to the operation of Northstar commuter trains.

Note 3: Train 7010’s departure time from TFS is locked at 17:20 due to the operation of Northstar commuter trains.

Note 4: This schedule assumes that no layover facility is available at TFS. Trains lay over at Duluth or Sandstone and are maintained at the Sandstone Maintenance Facility (MTCE).

Note 5: Trains 7051 and 7052 operate between TFS and Hinckley and do not carry passengers between Hinckley and the Sandstone Maintenance Facility.

Note 6: Crew Utilization:

- Crew 1 operates Train 7051 to TFS and Train 7002 to Duluth. (Crew based in Duluth. Overnight Duluth. Rotates to Crew 4 next day.)
- Crew 2 operates Train 7003 to TFS and Train 7006 to Duluth. (Crew based in Duluth. Overnight Duluth.)
- Crew 3 operates Train 7009 to TFS and Train 7010 to Duluth. (Crew based in Duluth. Overnight Duluth.)
- Crew 4 operates 7013 to TFS and Train 7052 to Sandstone. (Crew based in Duluth. Overnight Sandstone. Rotates to Crew 1 next day.)

10Oct2014

Control Sheet

Document Title	
Northern Lights Express Ridership and Revenue Forecasting	

Document Type	
Report	

Client Contract/Project No.	SDG Project/Proposal No.
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Review

Originator
Mark Feldman

Other Contributors
Masroor Hasan, Kate Yu, Lucile Kellis, Jon Bottom, Lorenzo Casullo, Sriram Lakshman, Tom Higbee, Hannah Capek

Reviewed by

Distribution

Minnesota Department of Transportation, Quandel Consultants	Steer Davies Gleave

DNV UKAS QUALITY MANAGEMENT 013

Attachment B: Review of NLX Ridership and Revenue Forecasts by Whitehouse Group, August 13, 2015

NLX Review | Ridership and Revenue Forecasts

August 13, 2015

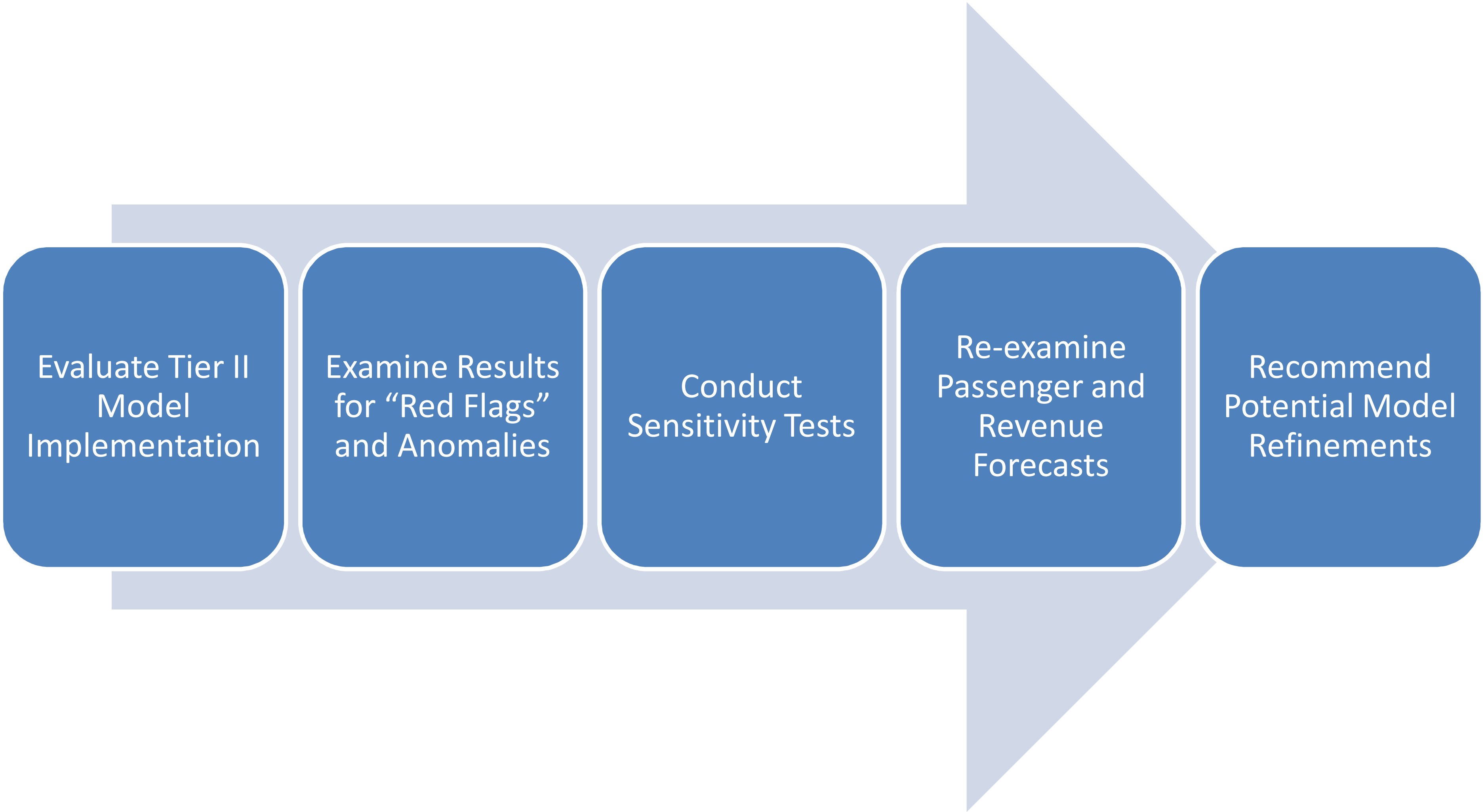
A Little Background …

- NLX Tier II EIS Draft Ridership and Revenue Forecasts
  - Updated Data
  - Updated Methods
  - Open Source Commercial Forecasting Software Platform (Cube Voyager)

Review Approach

- Evaluate Tier II EIS Forecasting Model
  - To Determine Consistency with Supplied Documentation
  - To Assess Reasonableness of Approach Compared with Other Documented Approaches Used to Develop Intercity Rail Forecasts
  - To Assess Reasonableness of Forecasts as well as Model Parameters and Coefficients
- Perform a Series of Sensitivity Tests on Key Model Parameters
- Re-examine Revenue Forecast Results
- Recommend Potential Model Refinements

Review Approach



Review Approach

- Evaluate Tier II EIS Forecasting Model
  - To Determine Consistency with Supplied Documentation
    - ***Implementation <u>is</u> Transparent & Consistent with Supplied Documentation***
  - To Assess Reasonableness of Approach Compared with Other Documented Approaches Used to Develop Intercity Rail Forecasts
    - ***Approach Used is Reasonable Compared with Other Documented Intercity Passenger Rail Forecasts***
  - To Assess Reasonableness of Forecasts as well as Model Parameters and Coefficients
    - ***Ridership Forecasts Generally Appear <u>"in Range"</u> for Proposed Service***
    - ***<u>Average and Maximum Fares were not Consistent with Expectations</u> for Reliable, High-Speed Intercity Rail for 150 Mile End-to-End Service***

Review Approach

- Findings: Maximum and Average Fares were not Consistent with Expectations for Reliable, High-Speed Intercity Rail for 150 Mile Service
- Fare Assumptions:
  - Proposed Optimal Fare of $5.00 base + $0.13 / mile
  - Yields Maximum One-way Fare of $25.00
  - Yields Average One-way Effective Fare of $15.11
  - See next 2 slides for comparison with other corridor services

Amtrak 2014 National Experience

Service	Riders 2014	Rev $ 2014	RT Trains / Day	Riders / (Train*2)	OTP	Rev/Pass 14	One-way Miles	Duration	Effective Spd	Pass/ Mile
Adirondack	133,764	$7,538,465				**$56.36**				
Albany-Niagara Falls Toronto	410,344	$24,712,104				**$60.22**				
Amtrak Cascades	782,519	$28,440,469				**$36.34**				
Blue Water	191,231	$6,487,869				**$33.93**				
Capitol Corridor	1,419,134	$27,105,046	15	47,304	93%	**$19.10**	168	3:15	52 MPH	282
Carolinian	302,601	$19,136,311				**$63.24**				
Downeaster	514,708	$8,638,103	5	51,471	20%	**$16.78**	145	3:25	42 MPH	355
Empire	1,119,959	$47,472,663	13	43,075	70%	**$42.39**	460	8:15	56 MPH	94
Ethan	52,755	$2,898,957				**$54.95**				
Heartland Flyer	77,861	$1,965,642				**$25.25**				
Hiawatha	799,638	$16,794,044	7	57,117	84%	**$21.00**	86	1:29	58 MPH	664
Hoosier State	33,930	$802,581				**$23.65**				
Illini & Saluki	315,963	$9,272,724				**$29.35**				
Illinois Zephyr & Carl Sandburg	214,951	$5,521,055				**$25.69**				

Proposed NLX Fare Structure Yields Average Revenue of $15.11 / Passenger and Maximum Fare of $25.00

Amtrak 2014 National Experience

Service	Riders 2014	Rev $ 2014	RT Trains / Day	Riders / (Train*2)	OTP	Rev/Pass 14	One-way Miles	Duration	Effective Spd	Pass/ Mile
Keystone	1,326,450	$37,804,213	13	51,017	84%	**$28.50**	195	3:50	51 MPH	262
Lincoln	633,531	$16,792,321	4	79,191	64%	**$26.51**	284	5:30	52 MPH	279
Missouri River Runner	189,402	$5,341,229				**$28.20**				
Pacific Surfliner	2,681,173	$65,514,742				**$24.44**				
Pennsylvanian	230,767	$11,447,786	1	115,384	90%	**$49.61**	444	9:20	48 MPH	260
Pere Marquette	100,961	$3,101,530				**$30.72**				
Piedmont	170,413	$3,402,929				**$19.97**				
San Joaquin	1,188,228	$38,087,608	7	84,873	74%	**$32.05**	315	6:08	51 MPH	269
Shuttles (New Haven/Springfield)	370,896	$12,238,623				**$33.00**				
Vermonter	89,640	$5,531,708				**$61.71**				
Washington Norfolk	152,135	$7,748,910				**$50.93**				
Washington Richmond	190,833	$9,594,953				**$50.28**				
Washington-Lynchburg	189,723	$12,604,973				**$66.44**				
Washington-Newport News	344,335	$22,057,190				**$64.06**				
Wolverine	477,157	$18,900,614	5	47,716	28%	**$39.61**	304	6:20	48 MPH	157
Acela Express	3,545,306	$585,770,219	20	88,633		**$165.22**	456		72 MPH	194
Northeast Regional	8,083,237	$603,529,930	18	224,534		**$74.66**	664	12:30	53 MPH	338

Proposed NLX Fare Structure Yields Average Revenue of $15.11 / Passenger and Maximum Fare of $25.00

What Causes Sensitivity to Fares?

- Reasons for Fare Sensitivity
  - Absolute Cost of Fare
  - Passenger Willingness to Pay
  - Reason for Travel
  - Number of Travelers in Party
  - Availability and Competiveness of Alternate Modes of Travel
  - Market Inertia (Constants)
  - Other Unknown, Unexplainable or Unmeasurable Factors (e.g., safety, comfort, perception, marketing, etc.)
- Together, the Last 2 Items are Treated as a Constant Term in Choice Modeling
  - Per Published Reports, NLX Constants are asserted based on stated preference survey and other experience
  - Mode choice constants can have a large impact

NLX Mode Choice Parameters

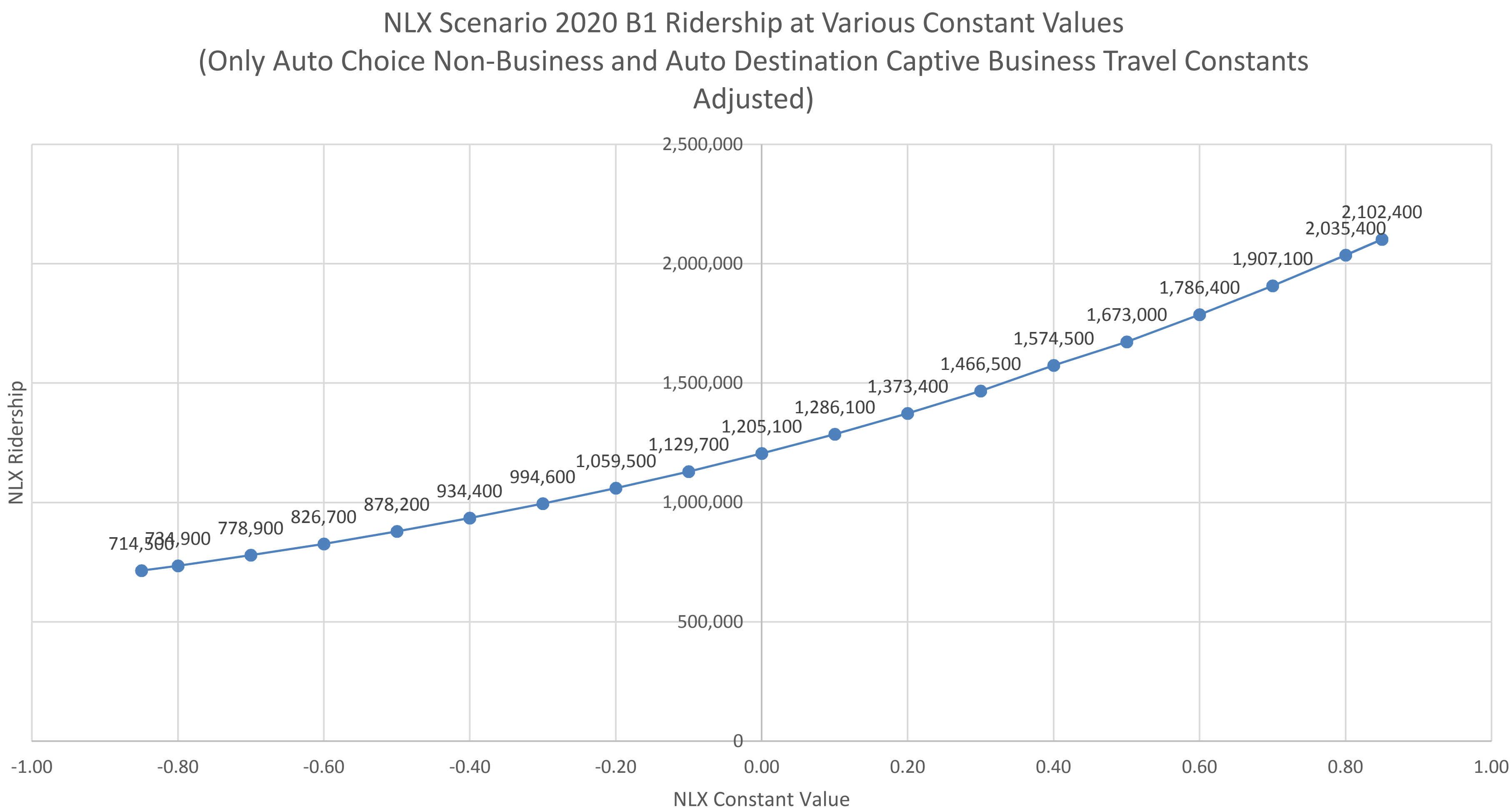
Coefficient	Auto Choice Market		Auto Destination Captive Market		Bus Market	
	Business	Non-Business	Business	Non-Business	Business	Non-Business
In-Vehicle Time	-0.01498530	-0.01498530	-0.01498530	-0.01498530	-0.02649960	-0.02649960
Wait Time	-0.03362170	-0.03362170	-0.03362170	-0.03362170	-0.02649960	-0.02649960
Access Time	-0.03362170	-0.03362170	-0.03362170	-0.03362170	-0.02649960	-0.02649960
Cost	-0.04375819	-0.07263900	-0.04375819	-0.07263900	-0.14031040	-0.14031040
Frequency Dampening	0.37290660	0.37290660	0.37290660	0.37290660	0.61529480	0.61529480
NLX Constant	**-0.42500000**	**-0.85000000**	**-0.85000000**	**-1.70000000**	**2.27882960**	**1.56116700**
Derived Statistics*						
Ratio OVT / IVT	2.24	2.24	2.24	2.24	1.00	1.00
Ratio Cost / IVT	2.92	4.85	2.92	4.85	5.29	5.29
Constant / IVT (Minutes Penalty)	**28.36**	**56.72**	**56.72**	**113.44**	**(85.99)**	**(58.91)**
Constant Hours of Penalty to NLX	**0.47**	**0.95**	**0.95**	**1.89**	**(1.43)**	**(0.98)**

*By Dividing One Coefficient Value by Another, You can Calculate the Tradeoff that Needs to Occur for One Mode to Be as Mathematically Attractive as Another

Observations

- Relative to Automobile, NLX would Need to Overcome a Constant “Penalty” of Between 28 and 113 Minutes to be “On Par”
- Relative to Bus, NLX has an “Advantage” of Between 59 and 86 Minutes, All Else Equal
- It is Worth Noting that the Model Already Accounts for In-Vehicle, Access and Egress Time for Each Mode Individually, in Addition to Cost
- What Happens If the Constant Values are Relaxed?

Limited Constant Sensitivity Tests



Additional Observations

- Constant Values Are Asserted For Auto Competing Trips (the lion's share of total trips)
- Ridership Forecasts are Sensitive to Constants
- Cost Coefficient / IVTT Coefficient Relationships Appear in Range of Expected Values. However:
  - There is Limited Information Available on These Relationships as Applied to Intercity Rail Forecasts
  - These Relationships Could Not be Successfully Estimated for NLX from Local Stated Preference Survey Data

An Example Sensitivity Test

What Happens if You Reduce All NLX Constants by 50%?

Variable	Year 2020 Alternative B1- Before	Year 2020 Alternative B1- After
Fare	**$5.00 Base + $0.13/mile**	
Maximum Fare	$25.00	$25.00
Average Effective Fare	$15.11	$15.00
NLX Directional Daily Frequency	4	4
NLX Maximum Speed	110	110
Annual Boardings (thousands)	**710**	**1,120**
Annual Revenue ($millions)	**$10.80**	**$16.78**

Resulting average effective fare is still too low
Resulting ridership is too high given 4 RT Trains / Day

Conclusions

- The Forecasting Approach Taken by the Tier II Team is Practical Given the Lack of Existing Intercity Rail Service in the Corridor.
- The Magnitude and Impact of Asserted Constants, Taken Together with Resulting Effective Fare, Plays an Important Role in the Ridership / Revenue Forecast
- A Different Mix of Constants and Fares Could Result in Comparable Ridership Patterns but a Fare Policy More in Line with Expectations for End-to-End Trips

Conclusions

- It is Worth Reexamining the Proposed Fare Matrix and Modal Constant Relationship to See if Adjustments are Warranted Given:
  - The Character of the Corridor
  - Current Pricing for Intercity Bus
  - Confidence in Stated Preference Data
  - Results of Other Studies

NLX

NORTHERN LIGHTS EXPRESS

MINNESOTA DEPARTMENT OF TRANSPORTATION

Attachment C: Supplement to May 2015 Ridership and Revenue Report, September 1, 2015

steer davies gleave

Memo

To	Charlie Quandel, Frank Loetterle
Cc	Wade White
From	Steer Davies Gleave
Date	1 September 2015
Project	Northern Lights Express Ridership and Revenue Forecasting
Project No.	22602101

Supplement to May 2015 Ridership and Revenue Report

This memo serves as an update to the Northern Lights Express (NLX) Ridership and Revenue Report[1], submitted by Steer Davies Gleave (SDG) in May 2015. Since that report was submitted, an independent review of the SDG forecasts was undertaken by the Whitehouse Group. The findings of this review, summarized both in a July 21st in-person meeting and in a presentation[2], were the following:

- The approach used by SDG is reasonable compared with other documented intercity passenger rail forecasts;
- The forecast ridership levels are reasonable given the corridor and type of service;
- The fares used between Minneapolis and Duluth ($25) were not consistent with expectations for reliable high speed intercity rail for 150 mile end-to-end service (they were lower than expected); and
- If end-to-end fares are increased, the NLX modal constants used in the mode choice models (which are asserted rather than estimated) could be made slightly more favorable to NLX in order to maintain ridership at reasonable levels even as the service becomes slightly more expensive.

Furthermore, it was pointed out at the July 21st meeting that existing bus fares between Minneapolis and Duluth are significantly more expensive than the $25 fare resulting from the previously agreed fare structure of $5 + 13 cents / mile. Passengers on intercity buses typically pay between $37 and $49 for a one way trip, though discount fares of $25 are sometimes available in off-peak hours.

SDG was asked to investigate the amount of additional revenue that could result by increasing rail fares to be more in line with bus fares. In order to keep the ridership close to the levels reported previously, SDG was also asked to modify the modal constants to make them slightly more favorable to NLX. The assumptions used and results from this investigation are reported in this memo as the “interim results.”

These interim results were presented to the Peer Panel and the FRA on August 13, 2015. Following the presentation, it was recommended to conduct a revenue maximization exercise with the modified modal constant values arrived at as part of the investigation mentioned above. This would be analogous to the exercise performed in October 2014 with the prior modal constants. The results of this exercise are also reported in this memo.

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[1] Northern Lights Express Ridership and revenue Forecasting, Report, May 2015.

[2] NLX Review, Ridership and Revenue Forecasts, Whitehouse Group, Version 5: August 13, 2015 Peer Panel Meeting (an earlier version was presented at the July 21st in-person meeting)

Assumptions For Interim Results

The values of the modal constants and fares producing the interim results were arrived at by analyzing service plan "C1" (90 mph maximum speed, 4 round trips per day), currently believed to be a reasonable service plan in terms of revenue / cost trade-offs. Since the project team was comfortable with the level of ridership previously reported for that service plan (698,000 riders in year 2020), the aim was to produce a set of model revisions that would result in a similar level of ridership.

Modal Constants

As reported in the NLX Mode Choice Models Memo (April 2014, revised August 2015), the NLX modal constants are defined for four sub-markets: Business and Non-Business trip purposes for both Non-Captive and Destination Captive passengers. SDG limited the Non-Business Non-Captive modal constant to minor revisions from the value previously used (-57 generalized minutes equivalent), because:

- It is the largest market by far (more than 50% of the overall corridor travel);
- Recent similar studies provide values of estimated constants for this type of market, but less so for business and/or destination captive markets; and
- The value previously used was already quite favorable to NLX, judged by comparing to values used in other intercity rail studies, as reported in the August 2015 revised Mode Choice Models Memo.

Conversely, SDG allowed more leeway in the amount by which the destination captive constants could be changed, since there are limited available examples for this market.

Table 1 compares the NLX modal constants previously used to the revised constants that produced the results in this memo.

Table 1: NLX Modal Constants

Captivity	Trip Purpose	NLX Modal Constant (Generalized Minutes)	
		Before	After
Non-Captive (do not need a car at non-home end)	Non-Business	-57	-50
	Business	-28	-25
Destination Captive (use car at non-home end of trip)	Non-Business	-113	-80
	Business	-57	-40

Fares

The fare policy previously used, $5 + 13 cents / train mile, was agreed upon by the project team (and subsequently approved by the peer review panel) in the fall of 2014 based on the revenue maximization exercise. This policy did not produce the absolute maximum annual ticket revenue among the fare policies tested. Rather, it was chosen intentionally to produce relatively higher ridership accompanied by only a relatively small sacrifice in ticket revenue, which in turn would lead to higher public benefit forecasts.

However, although the end-to-end fare of $25 resulting from using this formula is consistent with existing fares on comparable Amtrak services in terms of trip length and geography, it is below what most people currently pay for bus service in the Minneapolis-Duluth market, as noted above. Thus, it was decided by the project team to increase the end-to-end fare to somewhere in the $35-$40 range. Fares for shorter distance trips, however, were felt to be reasonable; for example, the Target Field – Cambridge one-way fare was $11, and since that is a trip more likely to be made by commuters, it was agreed to keep these fares at their original levels if possible.

Ultimately, SDG was able to produce the desired outcome by using the modal constants shown in Table 1, along with a fare structure of 25 cents per mile (with no boarding fee). This increased the end-to-end fare from $25 to $38, but maintained the Target Field to Cambridge fare at $11. Table 2 shows the complete set of fares used, both in the May report ($5 + 13 cents / mile) and with the proposed revisions (25 cents / mile).

Table 2: NLX Fares Assumed (2014$)

May 2015 Ridership and Revenue Report ($5 + 13 c/mile)							Interim Results (25 c/mile)						
	TG	CR	CM	HN	SP	DL		TG	CR	CM	HN	SP	DL
TG			11	15	24	25	TG			11	20	37	38
CR			9	13	22	23	CR			8	16	34	35
CM	11	9		10	19	19	CM	11	8		9	26	27
HN	15	13	10		14	15	HN	20	16	9		17	19
SP	24	22	19	14			SP	37	34	26	17		
DL	25	23	19	15			DL	38	35	27	19		

TG = Target Field, CR = Coon Rapids, CM = Cambridge, HN = Hinckley, SP = Superior, DL = Duluth

Results from Analysis With Revised Modal Constants and 25 Cents / Mile Fares

Table 3 and Table 4 show the annual ridership and revenue forecasts, respectively, both before and after the revisions described above, for five different service plans:

- Plan C10 (90 MPH maximum speed, 2 round trips per day)
- Plan C1 (90 MPH maximum speed, 4 round trips per day)
- Plan B1 (110 MPH maximum speed, 4 round trips per day)
- Plan C2 (90 MPH maximum speed, 6 round trips per day)
- Plan C11 (90 MPH maximum speed, 8 round trips per day)

Table 3: Annual Ridership Forecasts (thousands), Interim Results

	Year	Plan C10 (90 MPH, 2 RT)	Plan C1 (90 MPH, 4 RT)	Plan B1 (110 MPH, 4 RT)	Plan C2 (90 MPH, 6 RT)	Plan C11 (90 MPH, 8 RT)
Before (May 2015 Ridership and Revenue Report)	2020	431	698	753	764	804
	2040	511	919	988	1005	1060
After (Revised modal constants, 25 c/mile fares)	2020	430	703	754	771	813
	2040	513	938	1001	1026	1082

Table 4: Annual Revenue Forecasts ($millions, 2014$), Interim Results

	Year	Plan C10 (90 MPH, 2 RT)	Plan C1 (90 MPH, 4 RT)	Plan B1 (110 MPH, 4 RT)	Plan C2 (90 MPH, 6 RT)	Plan C11 (90 MPH, 8 RT)
Before (May 2015 Ridership and Revenue Report)	2020	6.90	11.14	12.16	12.22	12.92
	2040	8.18	14.53	15.79	15.94	16.86
After (Revised modal constants, 25 c/mile fares)	2020	7.93	12.98	14.15	14.26	15.17
	2040	9.49	17.08	18.54	18.81	19.99

The combination of revising the modal constants as shown in Table 1 and changing the fare structure from $5 + 13 cents / mile to a flat $25 cents / mile raised the 2020 revenue forecasts by $1.8 to $2.3 million annually and the 2040 revenue forecasts by $2.5 to $3.2 million annually[3] depending on the service plans tested. These revisions did not affect ridership significantly for any of the scenarios, because the increase in ridership due to the more favorable NLX modal constants was more or less offset by the decrease in ridership due to the increasing fares. However, the distribution of ridership shifted somewhat from longer to shorter trips, because as Table 2 shows, the fares raised were those for longer trips, while shorter trips' fares remained the same or decreased slightly.

Adopting these revisions would also likely result in minor adverse effects on the cost-benefit analysis, because:

- Consumer surplus, the difference between the generalized costs passengers are *willing* to pay vs. the generalized costs they actually *would* pay, would decrease, because of increasing fares;
- The overall amount of VMT saved from travelers shifting from auto to train trips would decrease, because of the distribution shift from longer to shorter train trips discussed above. This would in turn decrease the benefits from reductions in accidents and greenhouse gas emissions; and
- Potentially, the shift to shorter train trips could result in higher peak loading, and necessitate the earlier purchase of additional train cars.

Overall, SDG believes the project forecasts would benefit from these revisions, and that the 15-17% revenue increases shown in Table 4 would be greater in magnitude than any potential adverse impact in monetary terms on the cost-benefit analysis. It is, however, outside SDG's project responsibilities to develop the cost-benefit analysis, so this should not be considered a guarantee of results.

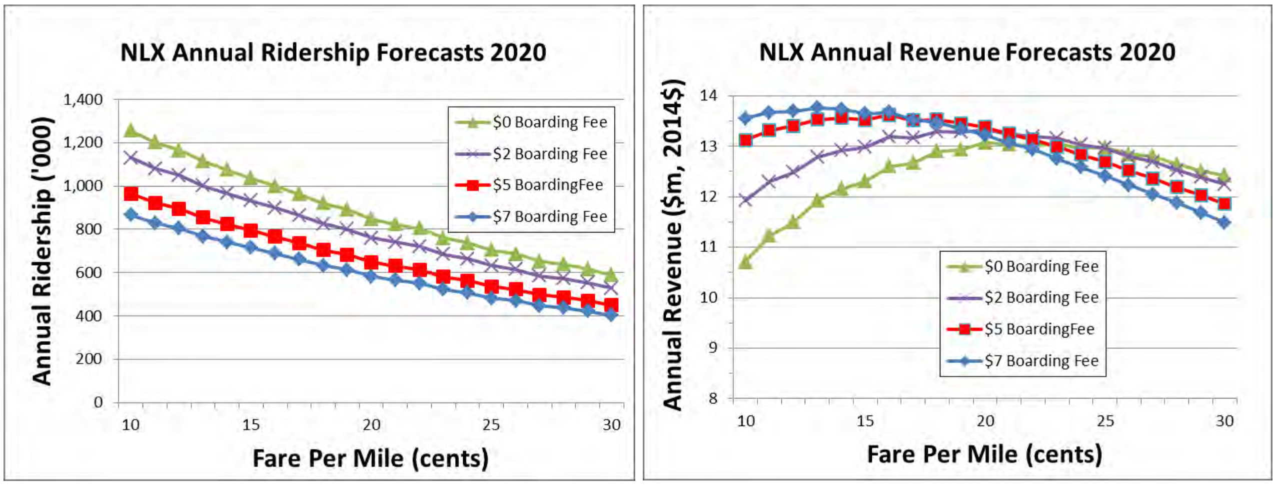
Revenue Maximization

Although the 25 cents / mile fares were determined to be reasonable for every possible O-D pair in the corridor, SDG was asked to perform a revenue maximizing analysis with the new modal constants, similar to what was done in the fall of 2014 to arrive at the $5 + 13 cents / mile fares used in the May 2015 Ridership and Revenue Report.

[3] The exception to this is plan C10, which has only 2 round trips / day and produces far fewer riders than the other plans. The revisions made in Tables 3 and 4 increase this plan's 2020 revenue by about $1 million and 2040 revenue by about $1.3 million.

Using service plan C1 as before, the fares were varied in one cent increments from 10 to 30 cents per mile, with boarding fees of $0, $2, $5 and $7.[4] The resultant ridership and revenue curves, as a function of the per mile fare, are presented in Figure 1.

Figure 1: 2020 Annual Ridership and Revenue vs. Per Mile Fare



It should be noted that both the ridership and revenue curves are slightly irregular (i.e. not entirely smooth), for the following reasons:

- Fares are rounded to the nearest whole dollar, so increasing the fare per mile assumption by one cent may result in fare increases for a subset of the origin-destination pairs.
- AirConnect ridership and revenue are included, and the results for that portion of the market are obtained from a separate model.
- Ancillary (non-ticket) revenue is included, and assumed to be a fixed percentage of passenger miles.

Similar to the results from the fall of 2014, the revenue curve is fairly flat over a wide range of possible fare per mile rates for all boarding fee amounts tested.

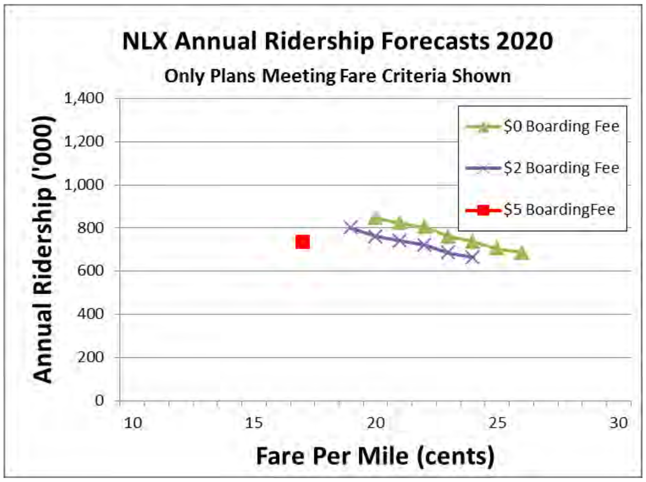
However, not all of the boarding fee and fare per mile combinations result in fares that would be realistic to implement. General opinions among the project team are that the end-to-end fare should be comparable to existing intercity bus fares, and that the Minneapolis – Cambridge fare should be near $10. If we limit the possible fare plans to those where end-to-end fare is between $30 and $40 and Minneapolis – Cambridge fare is between $8 and $12, only the following plans from Figure 1 are possible:

- $0 boarding fee, between 20 and 26 cents per mile
- $2 boarding fee, between 19 and 24 cents per mile
- $5 boarding fee, 16 cents per mile

Figure 2 shows the same results as Figure 1 with only the fare plans that meet the above criteria, which we will call "plausible" fare plans.

[4] At boarding fees of $7 and higher, it is not possible for the Target Field – Cambridge fare to be less than $13 and simultaneously for the Target Field – Duluth fare to be at least $30. Thus based on prior discussions, we think it unlikely that any fare table with a $7 or higher boarding fee would be considered plausible.

Figure 2: 2020 Annual Ridership and Revenue vs. Per Mile Fare, Restricted to "Plausible" Fare Plans



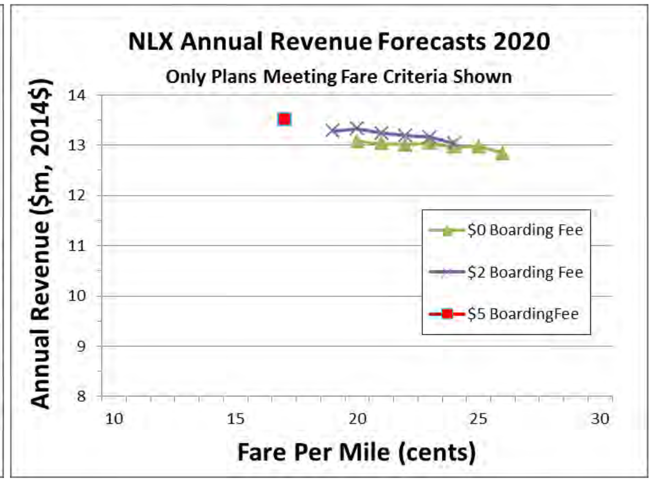


Table 5 below shows the numerical results of the fare plans in Figure 2, along with the fares that would materialize in each of these plans for three key markets (Minneapolis – Duluth, Minneapolis – Hinckley, and Minneapolis – Cambridge). Note that the 25 cents per mile row corresponds to the "interim results" discussed in prior sections.

Table 5: Fares and Ridership and Revenue Forecasts for "Plausible" Fare Plans

Fare Plan	One Way Fares (2014$) to Minneapolis from			2020 Annual Ridership ('000)	2020 Annual Revenue ($M, 2014$)
	Duluth	Hinckley	Cambridge		
20 c/mile	30	16	9	846	13.08
21 c/mile	32	16	9	824	13.03
22 c/mile	33	17	9	804	13.01
23 c/mile	35	18	10	761	13.05
24 c/mile	36	19	10	738	12.97
25 c/mile	38	20	11	703	12.98
26 c/mile	40	20	11	687	12.84
$2 + 19 c/mile	31	17	10	801	13.28
$2 + 20 c/mile	32	18	11	760	13.33
$2 + 21 c/mile	34	18	11	740	13.24
$2 + 22 c/mile	35	19	11	722	13.19
$2 + 23 c/mile	37	20	12	684	13.16
$2 + 24 c/mile	38	21	12	663	13.03
$5 + 16 c/mile	31	18	12	766	13.62

Table 5 shows that among these "plausible" fare plans, differences in annual revenue forecasts are fairly small; the highest revenue ($13.62 million at $5 + 16 cents / mile), is only 6% higher than the lowest ($12.84 million at $0 + 26 cents / mile). Therefore, like before, it might be in the project's best interests to choose a fare structure that will produce more ridership with a small sacrifice in revenue, in order to maximize public benefits within the range of fares that produce near-maximum revenue.

Next Steps

The assumptions and results of this memo serve as a starting point for any revisions that may be made to the May 2015 methodology and forecasts, but are not necessarily final. At the Peer Panel meeting on August 13th, 2015, in addition to the above revenue maximization, two other follow-up actions were identified:

- Reporting the results in this memo as the "high end" of a range of forecasts, with the "middle" being the May 2015 results, and the "low end" using modal constants which are less favorable to NLX.
- Describing the methodology by which the original NLX modal constants were derived; SDG will revise the April 2014 Mode Choice Models Memo to provide a more detailed explanation of the assertion of these constants and a table showing the analogous values used in other available intercity rail studies.

ATTACHMENT D: MnDOT Presentation – Northern Lights Express Range of Ridership and Revenue to NLX Peer Panel, September 30, 2015

NORTHERN LIGHTS EXPRESS
RANGE OF RIDERSHIP AND REVENUE
PEER PANEL REVIEW

September 30, 2015

NLX Range of Ridership/Revenue for C-1 4RTs @ 90

- Low Range: Reasonable compared to conventional speed Amtrak
- Low Range Fare: $5 + 13 cents per mile
- Low Range : $/pax-mile is 19 cents; similar to existing Amtrak service

- High Range: Reasonable based on higher speed with reliable service
- High Range Fare: $5 + 16 cents per mile
- High Range: $/pax-mile is 22 cents; less than MWRRI Chicago- Twin Cities EIS at 32 cents per mile

NLX Range of Ridership/Revenue for C-1 4RTs @ 90

	Low	High	Low	High
	2020		2040	
Ridership (000)	698	766	919	1,011
Revenue ($M)	$10.74	$13.62	$14.01	$17.77

ATTACHMENT E: MnDOT Presentation – Northern Lights Express Range of Ridership and Revenue to FRA, October 1, 2015

NORTHERN LIGHTS EXPRESS
RANGE OF RIDERSHIP AND REVENUE
FRA/MNDOT/NLX REVIEW

October 1, 2015

NLX Range of Ridership/Revenue for C-1 4RTs @ 90

- Low Range: Reasonable compared to conventional speed Amtrak
- Low Range Fare: $5 + 13 cents per mile
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NLX Range of Ridership/Revenue for C-1 4RTs @ 90

	Low	High	Low	High
	2020		2040	
Ridership (000)	698	766	919	1,011
Revenue ($M)	$10.74	$13.62	$14.01	$17.77

Capital Cost Report

DEPARTMENT OF TRANSPORTATION

U.S. Department of Transportation
Federal Railroad Administration

WISCONSIN DEPARTMENT OF TRANSPORTATION

NORTHERN LIGHTS *EXPRESS*

NORTHERN LIGHTS *EXPRESS*

TECHNICAL DOCUMENT IN SUPPORT OF THE NLX SERVICE DEVELOPMENT PLAN

Capital Cost Report

January 2017

Prepared by:

QUANDEL CONSULTANTS
161 N. Clark Street
Suite 2060
Chicago, IL 60601

QUANDEL CONSULTANTS
161 St. Anthony Avenue
Suite 940
St. Paul, MN 55103

CONTENTS

TABLES

1. INTRODUCTION

The purpose of this Technical Document is to present the estimated capital costs for Scenario C-1 for the proposed Northern Lights Express (NLX) passenger rail service between Minneapolis and Duluth, Minnesota. The Minnesota Department of Transportation (MnDOT), in association with the Federal Railroad Administration (FRA), NLX Alliance, and the Wisconsin Department of Transportation (WisDOT), is completing Preliminary Engineering and a Tier 2 Environmental Assessment (EA) for the NLX Service Development Program.

A Draft Technical Document was prepared and submitted to FRA in January 2016 as part of an initial benefit-cost analysis that considered capital and operating costs and benefits related to travel cost savings, safety improvements and emissions savings for automobile travelers; operating cost savings, emissions savings and inventory savings for freight rail; grade crossing improvements; and economic development. Draft capital costs were computed for eight service alternatives as shown in Table 1-1.

Table 1-1: Summary of NLX Scenarios

Scenario	Maximum Train Speed (MPH)	Number of Round Trips/Day
B-1	110	4
B-2	110	6
B-10	110	2
B-11	110	8
C-1	90	4
C-2	90	6
C-10	90	2
C-11	90	8

The Draft Technical Document on Capital Costs is included as Attachment A.

Following a refined benefit-cost analysis based on updated train schedules and revised ridership and revenue forecasts, MnDOT determined that the service alternative consisting of four round trips per day at a maximum speed of 90 MPH (Scenario C-1) was the preferred service alternative to be advanced into the NLX Tier 2 Environmental Assessment. Rail Traffic Control (RTC) modeling was undertaken on the NLX corridor considering the preferred service plan, and a final infrastructure investment package was identified. The following report presents the final capital costs for the preferred service alternative and the infrastructure investment package identified and approved by FRA.

The methodologies for calculating the capital costs are described in detail in the Draft Technical Document in Attachment A. This report also references Technical Memoranda and other work products that are included as appendices to the Tier 2 Environmental Assessment and/or Service Development Plan. This report summarizes the capital costs for Scenario C-1.

2. CAPITAL COST METHODOLOGY

2.1 Standard Cost Categories and Unit Costs

Capital costs were estimated for NLX Scenario C-1 following the FRA's Standard Cost Categories, presented in Table 2-1.

Table 2-1: FRA Standard Cost Categories

FRA STANDARD COST CATEGORY
10 TRACK STRUCTURES & TRACK
20 STATIONS, TERMINALS, INTERMODAL
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN.
40 SITEWORK, RIGHT OF WAY, LAND
50 COMMUNICATIONS & SIGNALING
60 ELECTRIC TRACTION
70 VEHICLES
80 PROFESSIONAL SERVICES
90 UNALLOCATED CONTINGENCY
100 FINANCE CHARGES

The costs were estimated using the *Cost Estimating Methodology for High-Speed Rail on Shared Right-of-Way (Cost Estimating Methodology)*, April 18, 2011, prepared by Quandel Consultants. Pay item unit costs have been developed either 1) specifically for the NLX, 2) from the pay item unit costs included in *Cost Estimating Methodology*, 3) from recent contractor bid tabs or 4) using engineering judgment based on all unit price data available. Unit costs for all NLX specific pay items are estimated in 2014 dollars.

Pay items sourced from *Cost Estimating Methodology* were originally developed as part of the Midwest Regional Rail Initiative (MWRRI), an ongoing collaborative effort among nine Midwestern states to develop high-speed passenger rail in the Midwest. Pay items include typical passenger rail infrastructure construction elements such as roadbed and trackwork, systems and signals, facilities, structures, and grade crossings.

Unit costs sourced from *Cost Estimating Methodology* have been updated to year 2014 dollars using the Bureau of Labor Statistics Producer Price Index (PPI) Data for series NDUBONS-BONS “Other Non-Residential Construction”. The PPI series “Other Non-Residential Construction” encompasses construction activities that include highway, street and bridge construction, airport runways, dams, docks, and tunnels, among other heavy construction work. After unit costs were escalated to 2014 dollars using PPI data, the unit costs were compared to similar costs in recent contractor bids in other rail construction jobs (when available) and adjustments made as necessary using engineering judgment.

2.2 Assumptions for Proposed Infrastructure

Berkeley Simulation Software, Inc. Rail Traffic Controller© (RTC) software was used to identify the infrastructure improvements needed to support NLX Scenario C-1. RTC simulations concluded in January 2017 and informed the capital cost estimating process. A detailed discussion of the RTC modeling process is included in Chapter 7 – Operations of the Service Development Plan.

The sub-sections below discuss the general types of infrastructure improvements needed to accommodate NLX Scenario C-1 that are associated with the FRA Standard Cost Categories listed in Table 2-1.

2.2.1 Track Structures & Track

The primary infrastructure improvements needed to maintain the projected level of 2020 freight service, as identified in the RTC model, consist of installing new higher speed turnouts and crossovers, adding new main track, upgrading and extending existing sidings, adding two new sidings, new CTC control points and the addition of CTC and PTC to new or extended tracks. The work also includes new derails at many locations. New track is assumed to be constructed at selected locations with 136# continuous welded rail (CWR) with timber ties in accordance with BNSF track standards, with mainline track built to Class 5 standards. Where locations for new track are identified as part of the needed infrastructure improvements, the type and extent of work needed to prepare the existing track right-of-way, including clearing, sub-grade preparation, and embankment widening, was estimated by analyzing the existing field conditions using a combination of online maps, Google Earth, and field visits to the site locations.

Main track tie replacement and surfacing work is not included for most of the NLX Corridor because the BNSF track is, in most locations, already able to accommodate the proposed NLX train speeds. Except for the auxiliary track on the Wayzata Subdivision between CP Stadium and CP Harrison, no main track resurfacing or tie replacement is proposed south of Coon Creek, where existing Class 4 main track is sufficient to support maximum expected passenger operating speeds of 79 mph. North of Coon Creek to Superior, replacement of ties and surfacing is limited to sidings which are being upgraded for higher speeds. In most cases, the BNSF track already meets Class 5 track standards. Between Superior and Duluth, ties and surfacing of the main track to FRA Class 3 and 4 standards are included where train speeds are being increased to accommodate NLX trains.

Costs for cross country drainage improvements and undercutting of fouled ballast are included for locations where the existing mainline track is not sufficiently stable for higher speeds due to poor drainage. New turnouts and crossovers are assumed to be constructed with timber ties, with the size and location of new turnouts and crossovers determined using the RTC model and other operating characteristics that affect maximum permissible or achievable train speeds.

Costs for new track structures are included where a new mainline track or siding is proposed parallel to an existing track over an existing physical feature such as a roadway or stream. Costs for replacement of existing overhead bridges – i.e. bridges that pass above the track - are included if sufficient horizontal clearance is not available where new track is proposed beneath an existing overhead structure. However, when proposing infrastructure improvement alternatives, the lengths and locations of new tracks and sidings were adjusted to avoid the need for constructing new overhead structures.

As a safety measure for pedestrians, fencing will be installed at grade crossings where pedestrians are typically present. One hundred feet of six-foot high chain link fencing will be installed in the quadrants specified at those grade crossing locations that are proposed to have pedestrian gates. At station locations, 1000 feet of decorative fencing is normally assumed to be installed on each side of the railroad right-of-way in the vicinity of the station building. In addition, six-foot high fencing along both sides of the right-of-way is proposed for locations where pedestrians may be present and the opportunity for trespassing may exist.

2.2.2 Stations, Terminals, Intermodal

All six station stops on the NLX route between Minneapolis and Duluth are proposed to have new station facilities or upgrades to existing stations. New station facilities are proposed in Coon Rapids, Cambridge, Hinckley, and Superior are included in the estimate. Costs at new station locations include site development, new station building and facilities, parking lots, platforms, warming shelters, communication systems and signage. Similar improvement costs are included for the new station in Cambridge which will be integrated into an existing portion of the City Center Mall. Costs are included for the existing Target Field Station in Minneapolis to be upgraded with a new station platform with additional seating and upgraded communication systems and signage. Costs are included to expand the Union Depot in Duluth for NLX service. A detailed description of the station designs and improvements for each of the NLX facilities can be found in the *Facilities Site Evaluation and Design* Technical Memorandum, which is included as an appendix to the Tier 2 EA.

2.2.3 Support Facilities: Yards, Shops, Admin.

NLX Scenario C-1 includes costs for a maintenance facility that will provide for the storage and light maintenance of NLX locomotives and passenger cars. Maintenance facility costs include a new maintenance building, maintenance equipment, track and ancillary facilities, and site development. Costs for layover facilities are included where needed based on the proposed NLX train schedules to provide for the maintenance and servicing of the train sets. Costs for wayside compressed air and 480-volt electrical power are included for the layover facility at the Target Field Station.

2.2.4 Sitework, Right-Of-Way, and Land Acquisition

Based on conceptual and preliminary designs, no land acquisition is needed in locations where new track is to be constructed. It is assumed that new track will be built within the existing track right-of-way. The right-of-way to be acquired at new and upgraded station locations, maintenance facilities, and layover facilities was estimated using the preliminary design layouts for each location.

2.2.5 Communications & Signaling

The cost estimate assumes that full corridor Centralized Traffic Control (CTC) and Positive Train Control (PTC) systems will have already been be installed by BNSF and will be operational prior to the start of any NLX construction work. Communications and signaling improvements include new CTC control points at certain junctions and existing sidings and also for new and extended sidings; signal and communications work necessary to integrate new turnouts and crossovers into the existing CTC system signal and communications networks; and new electric locks and derails for industry track turnouts. New control points are included at certain junctions and siding locations where necessary to expedite train movements in and out of sidings, over new crossovers between main tracks or to connect to new track.

Communications and signaling work at grade crossings is also included in this cost category. Roadway and grade crossing warning device upgrades are proposed to ensure the safe movement of trains, vehicles, and pedestrians at the public rail grade crossings where NLX trains will travel at higher speeds than are currently in operation. Work at the 166 public and private railroad grade crossings in the NLX corridor between Target Field and Union Depot at Duluth may include:

1. *Upgrades to advanced warning systems* which will activate grade crossing warning devices when a train is approaching. Where maximum train speeds in a segment will increase to 90 mph, costs are included to upgrade the track circuitry to allow for an increase in the warning time for gates, flashers, and any supplemental warning devices.

2. *Upgrades to grade crossing warning devices*. Warning devices for public and selected private crossings include installation of four quadrant gates, conventional (two quadrant or dual) gates, and pedestrian gates. Private grade crossings are the responsibility of BNSF.

3. *Upgrades to roadway approaches and crossings*. Improvements to roadway approaches and crossings include new precast concrete crossing panels, rubber flange and timber or concrete panel crossing surfaces at private crossings, mountable and non-mountable roadway medians barriers for channeling traffic, and roadway re-profiling to bring roadway approach grades up to MnDOT and AREMA standards. Costs for precast concrete panels are included at public crossings where panels do not currently exist.

2.2.6 Vehicles and Equipment

Costs for locomotives and coach and cab control cars represent the actual purchase price of Siemens Charger locomotives and Next Generation Intercity Passenger Rail Bi-level coach and cab control cars as part of the Midwest Equipment Procurement.

2.2.7 Professional Services

Professional services fees are included to cover design costs, program management costs, construction management and oversight costs, and integration, testing and commissioning costs. These costs are included in the estimate as a percentage of construction cost according to the table below. Table 2-2 presents the assumptions used to calculate Professional Services costs.

Table 2-2: Professional Services Costs

PROFESSIONAL SERVICES	COST AS PERCENTAGE OF CONSTRUCTION COST
DESIGN ENGINEERING (CATEGORIES 10, 40, 50, 60)	5%
DESIGN ENGINEERING FOR STATIONS AND FACILITIES (CATEGORIES 20 AND 30)	10%
PROGRAM MANAGEMENT	2%
CONSTRUCTION MANAGEMENT & INSPECTION	6%
ENGINEERING SERVICES DURING CONSTRUCTION	1%
INTEGRATION, TESTING, COMMISSIONING	1%

2.2.8 Contingency

Contingency costs are calculated as a percentage of the total capital cost for each FRA Standard Cost Category. Contingency percentages vary depending on the level of design completed for the work elements included in a particular category. An unallocated contingency of 5% is added to categories 10 through 80. Table 2-3 presents the assumptions used to calculate Contingency Costs.

Table 2-3: Contingency Cost Percentages

FRA STANDARD COST CATEGORY	CONTINGENCY COST AS PERCENTAGE OF TOTAL CAPITAL COST
10 TRACK STRUCTURES & TRACK	20%
20 STATIONS, TERMINALS, INTERMODAL	30%
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN.	30%
40 SITEWORK, RIGHT OF WAY, LAND	20%
50 COMMUNICATIONS & SIGNALING	20%
60 ELECTRIC TRACTION	Not Applicable
70 VEHICLES	20%
80 PROFESSIONAL SERVICES	0%
90 UNALLOCATED CONTINGENCY	5% of All Category 10-80 Costs
100 FINANCE CHARGES	Not Applicable

3. DESCRIPTION OF CAPITAL IMPROVEMENTS

For the purposes of capital cost estimating, the NLX corridor between Minneapolis and Duluth is separated into 'segments'. A segment is a length of track that is defined by logical end points, junctions, or population centers. A series of segments is combined to form the complete route that extends from the southern NLX terminal at Target Field Station in Minneapolis to the northern NLX terminal at the Union Depot in Duluth. The route and mileage information for each of the segments was gathered using GIS shape files obtained from state and federal GIS databases and from railroad track charts. The NLX route segments are shown in Table 3-1.

Table 3-1: NLX Route Segments

Segment Number	Segment Limits	Segment Length (miles)	Railroad Owner
1	Target Field Station to Minneapolis Junction	2.1	BNSF
2	Minneapolis Junction to University Avenue	1.4	BNSF
3	University Ave to Coon Creek	9.7	BNSF
4	Coon Creek to Isanti	23.9	BNSF
5	Isanti to Cambridge	5.6	BNSF
6	Cambridge to Hinckley	35.1	BNSF
17	Hinckley to Boylston	60.5	BNSF
18	Boylston to Superior	8.7	BNSF
19	Superior to Duluth	5.4	BNSF/NSSR at Union Depot

Track schematics showing the track infrastructure improvements proposed have been prepared and are included as an appendix to the Service Development Plan. Most of the improvements that add capacity and improve operational performance on the railroad are siding extensions, new sidings and segments of main tracks and new or expanded CTC control points. A summary of the proposed improvements for Scenario C-1 is shown below in Table 3-2.

Table 3-2: Summary of Proposed Siding, Main Track & CTC Improvements by Location

Location	Siding Upgrade/ Extension	New Siding or Main Track Segment	New or Expanded CTC Control Points
Wayzata Subdivision	Upgrade		2 expanded
Harrison St.-Van Buren		New 2nd Main Track	2 expanded
Coon Creek		Extended Main Track*	1 new, 1 expanded
Andover	Upgrade & Extend		2 new
Bethel			
Isanti			
Cambridge	Upgrade & Extend		2 new
Stanchfield		New Siding	2 new
Grasston	Upgrade		2 new
Brook Park	Upgrade		2 new
Hinckley	Upgrade & Extend		3 new
Sandstone			
Askov	Upgrade		2 new
Bruno			
Nickerson	Upgrade & Extend	New 2nd Siding	2 new
Foxboro	Upgrade		2 new
Superior	Upgrade BNSF Coal Runner to Main Track	New NLX Main Track	2 new
Superior-Duluth	Upgrade freight running track to main track		5 new

* Hinckley Subdivision main track extended south 0.8 miles to serve the new Coon Rapids NLX station.

The following sections describe the final capital improvements identified by the RTC modeling effort for Scenario C-1.

3.1 Description of Capital Improvements by Segment

3.1.1 Segment 1 – Target Field Station to Minneapolis Junction

Existing Conditions

Segment 1 is a 2.1-mile segment of the eastern end of the BNSF Wayzata Subdivision. Segment 1 is located in Minneapolis, and is the southern end of the NLX corridor. It is bounded by Target Field Station on the south and Minneapolis Junction on the north. Target Field Station is the proposed southern terminal station for the NLX, but also currently serves as the southern terminal station for the Northstar Commuter Rail system. North of Target Field Station at CP Stadium (just west of the Mississippi River, between First Street and West River Parkway), the Wayzata Subdivision narrows to a single main track, before crossing the Mississippi River main channel and the east channel on two double-tracked, multiple-span steel bridges. North of CP Stadium to Harrison Street, the Wayzata Subdivision is an existing single main track with an auxiliary track that serves as an additional main track. At Harrison Street near Minneapolis Junction, the proposed NLX route leaves the Wayzata Subdivision and takes the west leg of the wye to reach the BNSF Midway Subdivision and University Avenue.

Proposed Improvements

A new NLX platform will be integrated with the existing platform and station facilities at the Target Field Station. A new #9 turnout and auxiliary track will be constructed to serve the new platform. Between First Street and West River Parkway, the existing track will be reconfigured to provide for two tracks through CP Stadium and a universal crossover in an expanded CTC control point. The existing auxiliary track parallel to the main track between CP Stadium and CP Harrison Street will be upgraded with 33% tie replacement and surfacing. At Harrison Street, the control point will be expanded with a universal crossover and a second main track (the north wye) will be constructed to connect the Wayzata Subdivision to the Midway Subdivision. The track and signal improvements will then provide two parallel main tracks from the Wayzata Subdivision to the Midway Subdivision via the new northern leg of the wye. Grade crossing improvements are included for public crossings in this segment.

3.1.2 Segment 2 – Minneapolis Junction to University Avenue

Existing Conditions

Segment 2 is a 1.7-mile double track mainline that extends from Minneapolis Junction on the BNSF Midway Subdivision north through residential and commercial areas of Minneapolis to University Avenue. The maximum authorized speed for passenger trains in this segment is 45 mph. East of University Avenue, the

Midway Subdivision joins the BNSF's double-track St. Paul Subdivision. The St. Paul Subdivision continues a short distance to 44th Avenue at Northtown. The BNSF Staples Subdivision main tracks continue north (railroad west) from 44th Avenue around the west side of BNSF's Northtown Yard to Coon Creek and the junction with the BNSF Hinckley Subdivision.

Proposed Improvements

A #10 turnout that leads to an industry siding will be replaced at CP Van Buren. A new turnout connecting the new second main track to the Midway Subdivision will be installed. Reconfiguration of the tracks and turnouts serving the private railroad shop facilities located between the wye and the Midway Subdivision will be reconfigured to accommodate the new second main track from CP Harrison. Grade crossing improvements are proposed for public crossings in this segment.

3.1.3 Segment 3 – University Avenue to Coon Creek

Existing Conditions

Segment 3 is a 9.4-mile BNSF-owned primarily double-tracked segment between University Avenue and Coon Creek. The main tracks pass to the west side of BNSF's large Northtown Yard with a maximum speed limit of 45 mph and continue north to Coon Creek at maximum passenger train speeds of 79 mph. This segment has heavy freight train traffic and also carries both Amtrak long-distance intercity passenger trains (the Empire Builder) and Northstar commuter trains (between Big Lake and Minneapolis). At Coon Creek, the NLX Corridor leaves the double-tracked Staples Subdivision and continues north on the single track BNSF Hinckley Subdivision.

Proposed Improvements

Costs are included for a new NLX station to be located northeast of the Foley Boulevard grade crossing in Coon Rapids near MP 20.5 on the Staples Subdivision. To accommodate the new station, the Hinckley Subdivision main track will be extended south past the new station to connect with BNSF Main Track 2 between Foley Boulevard and the MN 610 overhead highway bridge. A new CTC control point with a new #20 crossover and a new #20 turnout will be located at about MP 20.3. The existing universal crossover at Coon Creek will be replaced with a new #20 universal crossover located to the north, and a crossover to the Hinckley Subdivision main track. Signal work to add crossovers and a turnout to the two CTC control points are also included. Grade crossing improvements are proposed for public crossings in this segment. Chain link fencing is proposed at selected rail grade crossings where pedestrian gates are proposed.

3.1.4 Segment 4 – Coon Creek to Isanti

Existing Conditions

Segment 4 is a 23.9-mile BNSF-owned primarily single track segment between Coon Creek and the town of Isanti. The BNSF Hinckley Subdivision currently carries only freight traffic for BNSF, CP and UPRR. The track is currently maintained to FRA Class 5 track standards at most locations with a maximum speed limit of 50 mph for freight trains[1]. The land outside the railroad right-of-way transitions from suburban to rural in Segment 4.

Proposed Improvements

The existing siding at Andover will be upgraded with 50% tie replacement and surfacing with CTC and PTC. A new CTC control point with a new #20 turnout will be installed at the south end of the siding. The turnout and signals at the north end of the siding will be removed and replaced with a new CTC control point and a new #20 universal crossover which will divide the Andover siding into two separate sections to accommodate an additional train meet. The Andover siding will be extended with CTC and PTC north 3.2 miles to a new control point with a new #20 turnout to be located at MP 124.8. Signal work to add additional turnouts to the new CTC control points is included in the costs.

In Segment 4, new electric locks and derails are proposed for 3 industry tracks; curve modifications to increase passenger train speeds are proposed for 7 curves; and cross-country drainage improvements are proposed for 6.7 miles of right-of-way. Grade crossing improvements are proposed for public crossings in this segment. Considerations for improvements to private crossings will be coordinated with BNSF and are contained in the Private Crossing Technical Memorandum. Chain link fencing is proposed for both sides of the right-of-way in four sections of Segment 4 and at selected rail grade crossings where pedestrian gates are proposed.

3.1.5 Segment 5 – Isanti to Cambridge

Existing Conditions

Segment 5 is a 5.6-mile single-track section of the BNSF Hinckley Subdivision between Isanti and Cambridge. The track is currently maintained to FRA Class 5 track standards at most locations with a maximum speed limit of 50 mph for freight trains[2].

[1] Federal Railroad Administration Track Geometry Inspection Report for the BNSF Hinckley Subdivision, dated 10/11/2016

[2] Federal Railroad Administration Track Geometry Inspection Report for the BNSF Hinckley Subdivision, dated 10/11/2016

Proposed Improvements

The existing siding at Cambridge will be upgraded with 50% tie replacement and surfacing with CTC and PTC. The existing south siding switch and signals will be removed and the siding will be extended with CTC and PTC 1.25 miles south to a new CTC control point with a new #20 turnout to be located at MP 111.0. A new CTC control point will also be installed with a new #20 turnout at the north end of the siding at MP 108.0. The existing house track in Cambridge will be extended 0.3 mile south and re-connected to the main track with a new #11 turnout, electric lock and derail at MP 107.9 to facilitate industry switching by the BNSF local freight train. This improvement releases the Cambridge siding (currently used by the local for switching purposes) for meets between trains. A new #11 turnout, electric lock and derail will also be installed on the north end of the Cambridge house track (which is in Segment 6).

In Segment 5, one curve modification to increase passenger train speeds is proposed; one mile of track undercutting and one mile of cross-country drainage improvements are also proposed. Grade crossing improvements are proposed for public crossings. Chain link fencing is proposed for both sides of the right-of-way in two sections of Segment 5 and at selected rail grade crossings where pedestrian gates are proposed.

3.1.6 Segment 6 – Cambridge to Hinckley

Existing Conditions

Segment 6 is a 35.1-mile long single-track segment of the BNSF Hinckley Subdivision. This portion of the Hinckley Subdivision runs through the towns of Braham, Grasston, Henriette, and Brook Park between Cambridge in the south and Hinckley in the north in rural Minnesota. The NLX route crosses the Snake River at Grasston and the Pokegama River at Brook Park. The track is currently maintained to FRA Class 5 track standards at most locations with a maximum speed limit of 50 mph for freight trains[3].

Proposed Improvements

The new Cambridge City Center Station will be constructed for NLX in the vicinity of MP 106.9. Costs assume that the station will be integrated into an existing portion of the City Center Mall. A new #11 turnout, electric lock and derail will also be installed on the north end of the Cambridge house track.

At Stanchfield, a new siding with CTC and PTC will be constructed on the east side of the main track at Stanchfield. The siding will extend 1.8 miles between a new CTC control point with a new #20 turnout at MP 99.3 and another new CTC control point with a new #20 turnout at MP 101.1. This improvement is necessary

[3] Federal Railroad Administration Track Geometry Inspection Report for the BNSF Hinckley Subdivision, dated 10/11/2016

to provide an additional meeting point for trains between the Cambridge and Grasston sidings where the local freight train makes multiple trips during the day.

At Grasston, the existing siding will be upgraded with 50% tie replacement and surfacing with CTC and PTC. The existing south and north switches and signals will each be replaced with a new CTC control point and a new #20 turnout. The industry track will receive a new #11 turnout, electric lock and derail.

At Brook Park, the existing siding will be upgraded with 50% tie replacement and surfacing with CTC and PTC. The existing south and north switches and signals will each be replaced with a new CTC control point and a new #20 turnout. The industry track will receive a new #11 turnout, electric lock and derail.

At Hinckley, the existing siding will be upgraded with 50% tie replacement and surfacing with CTC and PTC. The existing south siding switch and signals at MP 73.8 will be replaced with a new CTC control point and a new #20 universal crossover. The Hinckley siding will be extended 2.5 miles south from MP 73.8 with CTC and PTC to a new CTC control point with a new #20 turnout at MP 76.3. The existing north switch and signals of the Hinckley siding will be replaced with a new CTC control point including a new #20 turnout for the siding, a new #15 turnout for the St. Croix Valley Railroad connection and a new #11 turnout for the west side industry track connection. At MP 73.8 and MP 72.3, additional signal work will be performed to add turnouts and a crossover to the two new CTC control points.

In Segment 6, curve modifications to increase passenger train speeds are proposed for seven curves; 10 miles of track undercutting and cross-country drainage improvements are also proposed. Grade crossing improvements are proposed for public rail grade crossings. Considerations for improvements to selected private crossings that will be coordinated with BNSF are contained in the Private Crossing Report Technical Memorandum. Chain link fencing is proposed for both sides of the right-of-way in seven sections of Section 6 and at selected grade crossings where pedestrian gates are proposed. Decorative fencing is proposed near the Cambridge station.

3.1.7 Segment 17 – Hinckley to Boylston

Existing Conditions

Segment 17 is a 60.5-mile long BNSF-owned single-track segment of the BNSF Hinckley Subdivision from Hinckley, MN to Boylston, WI. North of Hinckley, the terrain changes from generally flat marshland to the heavily forested watershed feeding Lake Superior with many creeks and rivers. The NLX route crosses the Grindstone, Kettle, Big Willow, Net and Little Net Rivers; State Line, West Balsam, Balsam, Hubert and Norvell Creeks; the Black River and the Nemadji River. The bridges over the Black and Nemadji Rivers are long, high trestles spanning wide valleys. The track is currently maintained to FRA Class 5 track standards at most locations with a maximum speed limit of 50 mph for freight trains, although speeds are lower on several curves in the segment[4]. A 26.2 mile grade descends from Nickerson to Boylston.

The Hinckley Subdivision joins the Lakes Subdivision at Boylston. Note that on the BNSF track charts, Boylston has two different milepost locations for the same junction location: MP 11.8 on the Hinckley Subdivision and MP 12.6 on the Lakes Subdivision (Boylston to Superior).

Proposed Improvements

A new station for NLX will be constructed in Hinckley at MP 71.8 near Main Street on the north end of the community.

At Askov, the existing siding will be upgraded with 50% tie replacement and surfacing with CTC and PTC. The existing south and north switches and signals will each be replaced with a new CTC control point and a new #20 turnout. The industry track will receive a new #11 turnout, electric lock and derail.

At Nickerson, the existing siding will be upgraded with 50% tie replacement and surfacing with CTC and PTC. The existing south siding switch and signals will be removed and the siding will be extended 1.4 miles south with CTC and PTC and connected to a new CTC control point to be located at MP 38.7 with a new #20 turnout. The north siding switch and signals will be replaced with a new CTC control point and a new #20 turnout for the existing siding.

In addition, a new second Nickerson siding to be located on the west side of the main track will be constructed with CTC and PTC between the two new control points (at MP 35.9 and MP 38.7). The existing industry track will receive two new #11 turnouts, electric locks and derails. A BNSF communications facility on the west side of the main track at MP 36.60 will require relocation to accommodate the new second siding. Signal work to add the two new turnouts for the second siding to the new CTC control points has also been included in the cost estimate.

At Foxboro, the existing siding will be upgraded with 50% tie replacement and surfacing with CTC and PTC. The existing south and north switches and signals will each be replaced with a new CTC control point and a new #20 turnout. The industry track will receive two new #11 turnouts, electric locks and derails.

At Boylston, the turnout to the Lakes Subdivision wye track connection at MP 12.3 on the Hinckley Subdivision will be replaced with a new #15 turnout to permit increased train speeds on the connecting track.

[4] Federal Railroad Administration Track Geometry Inspection Report for the BNSF Hinckley Subdivision, dated 10/11/2016

In Segment 17, curve modifications to increase passenger train speeds are proposed for 36 curves. BNSF has limited the superelevation in curves to a maximum of 2.5" due to the slow, heavy unit trains which operate on the Hinckley Subdivision. This limitation reduces the maximum speeds that can be operated by the NLX passenger trains through several curves (primarily in Segment 17) where increased superelevation and longer curve re-alignments would otherwise permit higher passenger train speeds.

Other improvements in Segment 17 include 11 miles of track undercutting and cross-country drainage improvements. Grade crossing improvements are proposed for public rail grade crossings. Considerations for improvements to private crossings that will be coordinated with BNSF are contained in the Private Crossing Technical Memorandum. Chain link fencing is proposed for both sides of the right-of-way in seven sections of Section 17 and at selected grade crossings where pedestrian gates are proposed. Decorative fencing is proposed near the Hinckley station.

3.1.8 Segment 18 – Boylston to Superior

Existing Conditions

Segment 18 is a 7.9-mile long double-track CTC segment of the BNSF Lakes Subdivision between Boylston, WI and Superior, WI. Boylston is the junction at the northern end of the BNSF Hinckley Subdivision (MP 11.6) where the Hinckley Subdivision converges with the BNSF Lakes Subdivision (MP 12.8) south of Superior, WI. A 40 mph speed limit is in effect for most of the segment length, before decreasing to 10 mph south of Superior at Milepost 7.7 where the CTC signal system ends and BNSF yard track rules are in effect.

The NLX alignment switches from the BNSF Lakes Subdivision main tracks to the BNSF Coal Runner at Central Avenue (MP 8.6). The BNSF Coal Runner extends north along the eastern side of the BNSF Superior Yard complex to LST&T Jct. at approximately MP 4.0 at Winter Street in Superior (in Segment 19). BNSF's Superior Yard office is located at MP 5.4, near the 28th Street grade crossing on the Coal Runner. BNSF Lakes Subdivision mileposts officially end at Superior Yard (MP 5.4). The tracks between Superior and Duluth are not currently designated as main tracks of a BNSF subdivision. They are variously designated as running tracks and yard tracks where speeds do not exceed 20 mph and may be lower at some locations. No signal system is currently in effect between Central Avenue (MP 8.6) and LST&T Jct. on the Coal Runner, or in Segment 19 between Superior and Duluth (except at the Grassy Point Movable Span Bridge). The Magellan Pipeline is buried in the vicinity of the BNSF Coal Runner and its service road. A pumping station for the Magellan Pipeline is located north of Winter Street at LST&T Jct. in Superior.

Proposed Improvements

At Central Avenue (MP 8.6), the existing Lakes Subdivision crossover and connection to the BNSF Coal Runner will be replaced with a new #20 crossover and a new #20 turnout.

Between Central Avenue (MP 8.6) and LST&T Jct. (in Segment 19), the BNSF Coal Runner will be upgraded with 33% tie replacement and surfacing and the addition of CTC and PTC and designated as the BNSF Coal Main.

A new NLX Main track with CTC and PTC will be constructed to the east of the Coal Main between a new CTC control point with a new #15 turnout to be located at 58th Street (MP 8.0) on the Coal Main and a new CTC control point with a new #15 turnout to be located at MP 4.0 LST&T Jct. (in Segment 19).

Track shifts for the BNSF Coal Main will be required under the 21st Street Bridge and under the Belknap Street Bridges (in Segment 19 at the Superior station) to accommodate the new NLX Main track.

Between MP 8.06 and about MP 4.2, it may also be necessary to shift the BNSF Coal Main west at one or more locations to accommodate the new NLX Main and BNSF service road to avoid interference with the Magellan Pipeline which is buried along the east side of the service road from LST&T Jct. south.

A new Superior NLX station will be constructed at MP 4.5 and is described in Segment 19.

In Segment 18, curve modifications to increase passenger train speeds are proposed for curves; 2 miles of track undercutting and 5.3 miles cross-country drainage improvements are also proposed. Grade crossing improvements are proposed for public crossings. Considerations for improvements to private crossings that will be coordinated with BNSF are contained in the Private Crossing Technical Memorandum. Chain link fencing is proposed for both sides of the right-of-way in one section, on one side of the right of way in a second section and at rail grade crossings where pedestrian gates are proposed.

3.1.9 Segment 19 –Superior to Duluth

Existing Conditions

Segment 19 is a primarily single track (non-signaled) segment from Superior, WI to Duluth, MN, where the NLX alignment terminates at the Duluth Union Depot. Trains of BNSF, CP, UP, CN and NSSR use portions of the BNSF route between Superior and Duluth. BNSF does not designate a “main track” between Superior and Duluth. In Superior, the alignment turns west at 9th Street (Winter Street) and continues 5.4 miles over the Grassy Point Movable Span Bridge (a swing span) across St. Louis Bay before heading northeast on the east leg of the wye at Mike’s Yard and proceeding via the BNSF track into Duluth. Large lake vessels use the waterway at the Grassy Point Bridge. Most of the track between Superior and Duluth is considered yard or running track.

In some locations there are two running tracks. Speed is restricted to 15 mph for passenger and 10 mph for freight train operations over most of the segment into Duluth. The speed restrictions are due primarily to BNSF operating rules for yards and terminal areas, restrictions over the Grassy Point Bridge itself and the number of junctions, yard and industry track switches in this primarily non-signaled segment. The Magellan Pipeline is in the BNSF right-of-way east of the existing BNSF Coal Runner from a pumping station located at LST&T Jct. at Winter Street south into Segment 18.

Proposed Improvements

A new passenger station will be constructed for NLX in Superior at about MP 4.5 east of the new NLX Main track. The station will be located east and north of the Belknap Street (U. S. 2) overhead highway bridge in Superior near the intersection of North 14th Street and Oakes Avenue. Utility markers indicate that the Magellan Pipeline is buried in the immediate vicinity of the proposed new Superior NLX station at a point approximately 238 feet east of the existing BNSF Coal Runner track where both pass under the Belknap Street Bridge.

Continuing north from Segment 18 at MP 4.656, the re-aligned BNSF Coal Main and the new NLX Main will pass under the Belknap Street Bridge where a turnout and industry track will be removed to accommodate the new Superior station platform and facilities. Both tracks continue north to a new CTC control point with two new #15 turnouts at LST&T Jct. at MP 4.0 (Winter Street).

LST&T Jct. is currently a very slow speed (5-10 MPH) junction of yard, industry lead and freight running tracks at which movements are authorized by radio by the BNSF Yardmaster at Superior. No signals currently govern train and engine movements through LST&T Jct. The new CTC control point located at the north end of the BNSF Coal Main and the new NLX Main will govern the end of /entrance to CTC territory at that location. On the west side of LST&T Jct., an additional new CTC control point will govern the entrance to the new main track to be designated between LST&T Jct. and Duluth Union Depot. Due to the complexity and high cost of constructing and maintaining track and signal control for all 14 rail routes into and out of LST&T Jct., a petition by BNSF to the Federal Railroad Administration for a Main Track Exclusion Addendum (MTEA) for LST&T Jct. is suggested for consideration in lieu a system of continuous CTC and PTC for the distance of approximately 0.3 miles across this yard junction.

Between LST&T Jct. at MP 4.0 in Superior and Duluth Union Depot at MP X2.0, a distance of about 6.0 miles, a single track (currently designated as a freight running track) will be upgraded with 50% tie replacement and surfacing; the addition of electric locks (18) and derails (12) at junctions and industry tracks; and the addition of CTC and PTC to serve as a main track to be used by NLX trains and freight trains. The upgrade to a main track in CTC is required to enable NLX trains (and some freight trains) to operate at higher speeds (30-50 MPH) with the flexibility to increase corridor capacity and the addition of PTC as required for passenger operations.

A new CTC control point would be installed at MP 1.0* near the south end of Hallett's Dock Yard to facilitate freight train movements in the area and to cross NLX trains over to the west of the two running tracks between MP 1.0* and MP X2.0* for access to Duluth Union Depot, and to avoid slow-moving freight trains near Rice's Point Yard.

The asterisk behind milepost numbers between Superior and Duluth indicates that BNSF uses a provisional milepost system for location reference between LST&T Jct. and Duluth Union Depot. The numbers descend from MP 4.0* at LST&T Jct. to MP 0.0* near the overhead bridge serving the CN ore dock in Duluth and then ascend to MP X2.0* at Duluth Union Depot. The total distance is approximately 6.0 miles.

At the Grassy Point Bridge (MP 2.8*), the operating and control systems will be updated to increase the flexibility and reliability of the bridge operation and the train movements over it.

A maintenance & layover facility is proposed to be constructed in Duluth between Garfield Avenue (MP X1.6*) and the new CTC control point to be constructed at MP X1.9* just south of the Union Depot in Duluth. Maintenance facility costs include a new maintenance building, maintenance equipment, track and ancillary facilities, and site development. Costs for wayside compressed air and 480-volt electrical power are included for the layover track at the maintenance facility. A detailed description of the support facility designs and improvements can be found in the *Facilities Site Evaluation and Design* Technical Memorandum, which is included as an appendix to the Tier 2 EA.

Improvements at the Union Depot in Duluth include the replacement of six #9 turnouts, removal of two existing turnouts and the northernmost section of Track 1, installation of a #10 turnout and a new platform, and the extension of Track 3 to accommodate NLX trains. Duluth Union Depot is also used by the Lake Superior Railroad Museum and the North Shore Scenic Railroad.

Other improvements proposed in Segment 19 include 6 miles of cross-country drainage improvements and signal work to add additional turnouts to new CTC control points.

Grade crossing improvements are proposed for public rail grade crossings. Considerations for improvements to private crossings that will be coordinated with BNSF are contained in the Private Crossing Technical Memorandum. Chain link fencing is proposed for one side of the right of way in Superior, with decorative fencing proposed near the new Superior station. Chain link fencing is also proposed at rail grade crossings where pedestrian gates are proposed.

4. PRESENTATION OF CAPITAL COSTS

Table 4-1 presents the capital costs for Scenario C-1 that were calculated the methodology described and referenced in this report. Costs are presented in 2014$.

Table 4-1: Capital Cost Summary for NLX Scenario C-1 ($millions, year 2014)

FRA STANDARD COST CATEGORY	Capital Costs, Millions 2014$
10 TRACK STRUCTURES & TRACK	$102.8
20 STATIONS, TERMINALS, INTERMODAL	$24.7
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN.	$64.0
40 SITEWORK, RIGHT OF WAY, LAND	$1.4
50 COMMUNICATIONS & SIGNALING	$168.0
60 ELECTRIC TRACTION	$0
70 VEHICLES	$106.6
80 PROFESSIONAL SERVICES	$58.6
90 UNALLOCATED CONTINGENCY	$21.0
100 FINANCE CHARGES	$0
TOTAL CAPITAL COST	**$546.9**

ATTACHMENT A: Draft Technical Document on Capital Costs

NORTHERN LIGHTS *EXPRESS*

TECHNICAL DOCUMENT IN SUPPORT OF THE NLX SERVICE PLAN

Draft Capital Cost Report

November 2015

Prepared by:

QUANDEL CONSULTANTS
161 N. Clark Street
Suite 2060
Chicago, IL 60601

QUANDEL CONSULTANTS
161 St. Anthony Avenue
Suite 940
St. Paul, MN 55103

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TABLES

1. CAPITAL COST EXECUTIVE SUMMARY

This document presents the estimated capital costs for the eight NLX service alternatives being considered as part of the NLX Service Plan, and the methodology used to develop the capital costs. For the purpose of the NLX Service Plan, capital costs include:

- Track and civil infrastructure including track, bridges, signals, and grade crossings
- Stations, maintenance facilities, and other facilities needed for new NLX service
- Land parcels that must be acquired to construct the infrastructure items above
- Locomotives and coach cars needed to operate service under each scenario
- Professional services needed for design, construction, and service startup

The estimation and refinement of capital costs for a proposed NLX service has been ongoing since 2010, as part of the planning for the NLX service. Since the start of the project, the program needs and the scope of the proposed service - including the route alignment, the stations and facilities to be included, the estimated number of passenger trains, passenger train schedules, and the overall corridor capacity – have continued to evolve. For this reason, the design of the capital cost elements included in this report have been completed to varying degrees ranging from approximately 10% design completion (conceptual design) to approximately 30% design completion (preliminary design).

Eight service alternatives ("scenarios") are evaluated under the NLX Service Plan. Each differs according to the maximum allowable train speed in the corridor and the number of proposed round trips under each scenario. Table 1-1 presents the NLX Scenarios.

Table 1-1: NLX Scenarios

Scenario	Maximum Train Speed (MPH)	Number of Round Trips/Day
B1	110	4
B2	110	6
B10	110	2
B11	110	8
C1	90	4
C2	90	6
C10	90	2
C11	90	8

Capital costs for the eight NLX scenarios are summarized below in Table 1-2. Costs are shown in millions of dollars for year 2014, and are organized by FRA Standard Cost Categories.

Table 1-2: Capital Cost Summary for NLX Scenarios ($millions, year 2014)

FRA STANDARD COST CATEGORY	NLX SCENARIO							
	C1	C2	C10	C11	B1	B2	B10	B11
10 TRACK STRUCTURES & TRACK	$174	$206	$173	$373	$201	$226	$201	$398
20 STATIONS, TERMINALS, INTERMODAL	$26	$26	$26	$26	$26	$26	$26	$26
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN.	$64	$64	$64	$64	$64	$64	$64	$64
40 SITEWORK, RIGHT OF WAY, LAND	$0.6	$0.6	$0.6	$1.2	$0.6	$0.6	$0.6	$1.2
50 COMMUNICATIONS & SIGNALING	$143	$161	$135	$198	$181	$199	$174	$237
60 ELECTRIC TRACTION	$0	$0	$0	$0	$0	$0	$0	$0
70 VEHICLES	$62	$71	$47	$107	$71	$89	$47	$107
80 PROFESSIONAL SERVICES	$66	$73	$64	$104	$75	$82	$74	$113
90 UNALLOCATED CONTINGENCY	$27	$30	$25	$44	$31	$34	$29	$47
100 FINANCE CHARGES	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL CAPITAL COST	**$561**	**$633**	**$535**	**$917**	**$650**	**$721**	**$614**	**$992**

**APPENDICES REFERENCED IN THIS DOCUMENT ARE NOT INCLUDED IN THE SUBMITTAL OF THE JANUARY 2017 CAPITAL COST REPORT

2. METHODOLOGY

2.1 Pay Items and Unit Costs

The pay items used to produce the capital cost estimates have been developed either specifically for the NLX, or have been sourced from the technical report *Cost Estimating Methodology for High-Speed Rail on Shared Right-Of-Way (Cost Estimating Methodology)*, April 18, 2011 prepared by Quandel Consultants. The *Cost Estimating Methodology for High-Speed Rail on Shared Right-Of-Way* is included as Appendix A. Pay items sourced from *Cost Estimating Methodology* were originally developed as part of the Midwest Regional Rail Initiative (MWRRI), an ongoing collaborative effort among nine Midwestern states to develop high-speed passenger rail in the Midwest. Pay items from the *Cost Estimating Methodology* include typical passenger rail infrastructure construction elements such as roadbed and trackwork, systems and signals, facilities, structures, and grade crossings.

Pay item unit costs have been developed either 1) specifically for the NLX, 2) from the pay item unit costs included in *Cost Estimating Methodology*, 3) from recent contractor bid tabs or 4) using engineering judgment based on all unit price data available. Unit costs for all NLX specific pay items are estimated in 2014 dollars. Unit costs sourced from *Cost Estimating Methodology* have been updated to year 2014 dollars using the Bureau of Labor Statistics Producer Price Index (PPI) Data for series NDUBONS-BONS "Other Non-Residential Construction". The PPI series "Other Non-Residential Construction" encompasses construction activities that include highway, street and bridge construction, airport runways, dams, docks, and tunnels, among other heavy construction work. After unit costs were escalated to 2014 dollars using PPI data, the unit costs were compared to similar costs in recent contractor bids in other rail construction jobs (when available) and adjustments made as necessary using engineering judgment. A table of the pay items and unit costs is included as Appendix B.

2.2 Assumptions for Proposed Infrastructure

Rail Traffic Controller (RTC) software was used to identify the infrastructure improvements needed to support each of the NLX scenarios. RTC simulates passenger and freight operating conditions and produces outputs of train performance including time-distance diagrams (stringlines), timetables, and train operating statistics.

A year 2020 base case RTC model was developed that includes existing track infrastructure and 2020 projected freight volumes on the BNSF Hinckley Subdivision provided by BNSF. The base case model assumes that BNSF will have installed Centralized Train Control (CTC) signals, a Positive Train Control (PTC) system, and dual control switches in all BNSF territory in the Corridor by the year 2020. Costs for CTC, PTC, and dual control switches are not included in the capital cost estimates.

For each scenario, RTC was used to identify the minimum level of new infrastructure needed to maintain the level of service for the projected BNSF freight traffic in the year 2020, and provide sufficient track capacity to accommodate the passenger train operating characteristics of each scenario. The operating characteristics include passenger train meets, passenger train maximum speeds, and passenger train schedules.

An RTC Analysis Report has been prepared that describes the RTC modeling methodology and presents the results of the RTC analysis for each NLX scenario. The RTC Analysis Report is attached as Appendix C.

2.2.1 Track & Track Structures

The primary infrastructure improvements needed to maintain the projected level of 2020 freight service, as identified in the RTC model, consist of new turnouts and crossovers, new main track, extension of existing sidings, and new control points. All new track is assumed to be 136# continuous welded rail (CWR) with timber ties, with mainline track built to either Class 5 or Class 6 standards depending on the maximum operating speed in a specific track segment for each specific scenario. Where locations for new track are identified as part of the needed infrastructure improvements, the type and extent of work needed to prepare the existing track right-of-way – including clearing, subgrade preparation, and embankment widening - was estimated by analyzing the existing field conditions using a combination of online maps, Google Earth, and field visits to the site locations.

North of Coon Creek Junction, costs are included for the resurfacing of the existing mainline track and 1/3 tie replacement where track will be upgraded to Class 5, and 2/3 tie replacement where track will be upgraded to Class 6. No resurfacing or tie replacement is proposed south of Coon Creek Junction, where existing Class 4 main track is sufficient to support maximum expected passenger operating speeds of 79 mph. Costs for undercutting of fouled ballast are included for locations where existing mainline track is not sufficiently stable for higher speed trains due to poor drainage. All new turnouts and crossovers are assumed timber, with the size and location of new turnouts and crossovers determined using the RTC model.

Costs for new track structures are included where a new mainline track or siding is proposed parallel to an existing track over an existing physical feature such as a roadway or stream. Costs for replacement of existing overhead bridges – i.e. bridges that pass above the track - are included if sufficient horizontal clearance is not available where new track is proposed beneath an existing overhead structure. The lengths and locations of new track and sidings were modified within the RTC model whenever possible to avoid the need for new overhead structures. North of Coon Creek, track structures will be rehabilitated to support 90 mph and 110 mph operating speeds under all scenarios, with all structures being converted to ballasted deck bridges.

As a safety measure for pedestrians, fencing will be installed at grade crossings where pedestrians are typically present. One hundred fifty feet of six-foot high fencing will be installed in each quadrant at grade crossing locations that are proposed to have pedestrian gates. At station locations, 1000 feet of decorative fencing is assumed installed on each side of the railroad right-of-way in the vicinity of stations.

2.2.2 Stations & Terminals

All six station stops on the NLX route between Minneapolis and Duluth are proposed to have new station facilities or upgrades to existing stations. Costs for new station facilities in Coon Rapids, Hinckley, Superior, and Duluth are included in the estimate. Costs at new station locations include site development, new station building and facilities, parking lots, platforms, warming shelters, communication systems and signage. Similar improvement costs are included for the station stop in Cambridge. MnDOT is considering two site alternatives for an NLX station site in Cambridge. Costs for the station at Cambridge assume that the station will be integrated into an existing portion of the City Center Mall. Costs are included for the existing Target Field Station in Minneapolis to be upgraded with a new station platform with additional seating and upgraded communication systems and signage. A detailed description of the station designs and improvements included in the NLX Service Plan can be found in the technical memorandum “Facilities Site Analysis and Design”, which is Appendix D to this report.

2.2.3 Support Facilities

All eight scenarios include costs for a maintenance facility that will provide for storage and maintenance of NLX vehicles and locomotives. Maintenance facility costs include a new maintenance building, maintenance equipment and ancillary facilities, and site development. Costs for layover facilities are included where layover facilities are needed based on proposed train schedules to provide maintenance and servicing of vehicles. Costs for wayside air and power are included for those scenarios that require a layover facility at the Target Field Station. A detailed description of the support facility designs and improvements included in the NLX Service Plan are included in the technical memorandum “Facilities Site Analysis and Design” in Appendix D.

2.2.4 Sitework, Right-Of-Way, and Land Acquisition

Based on conceptual and preliminary designs, no land acquisition is needed in locations where new track is to be constructed. It is assumed that all new track will be built within the existing track right-of-way. The right-of-way to be acquired at new and upgraded station locations, maintenance facilities, and layover facilities was estimated using the preliminary design layouts for each location.

2.2.5 Communications and Signaling, including Grade Crossings

The cost estimates assume that full corridor centralized traffic control (CTC) and positive train control (PTC) will be installed by BNSF and will be operational prior to the start of any NLX construction work.

Communications and signaling equipment includes new control points at sidings, signal work and integration of existing turnouts and crossovers into the signal and communications network, and new electric locks for industry turnouts. New control points are included at siding locations in scenarios where passenger train meets will occur per the scenario operating schedule.

All work at grade crossings is also included in the cost category for communications and signaling. Roadway and grade crossing warning device upgrades are proposed to ensure the safe movement of trains, vehicles, and pedestrians at the grade crossings where NLX trains will travel at higher speeds than are currently in operation. Work at the 166 grade crossings in the NLX corridor between Target Field and Duluth Station may include:

1. *Upgrades to advanced warning systems* which will activate grade crossing warning devices when a train is approaching. Where maximum train speeds in a segment will increase to 90 mph, costs are included to upgrade the track circuitry to allow for an increase in the warning time for gates, flashers, and any supplemental warning devices. Where the maximum train speeds in a segment will increase to 110 mph, costs for an Incremental Train Control System (ITCS) are included for all crossings within the segment.

2. *Upgrades to grade crossing warning devices*. The *Northern Lights Express Grade Crossing Report* (*Grade Crossing Report*) dated May 4, 2015 identifies grade crossing warning device improvements for each of the 166 grade crossings. Warning devices include installation of four quadrant gates, conventional (two quadrant) gates, conventional gates with extended arms, and pedestrian gates. The *Grade Crossing Report* also recommends supplemental warning devices at certain crossing locations, which may include advanced warning lights and signage on roadways, cantilevered crossing warning lights, traffic signal preemption, and interconnection to the crossing warning system of another railroad at a nearby grade crossing(s). The *Grade Crossing Report* is included as Appendix E. A table that summarizes the Grade Crossing Improvement Recommendations is included as Appendix F.

3. *Upgrades to roadway approaches and crossings*. Improvements to roadway approaches and crossings includes new precast concrete crossing panels, rubber flange and hot-mix asphalt (HMA) crossing surfaces at private crossings, mountable and non-mountable roadway medians barriers for channeling traffic, and roadway re-profiling to bring roadway approach grades up to MnDOT and AREMA standards. Costs for precast concrete panels are included at public crossings where panels do not currently exist; costs for HMA and rubber flanges are included at private crossing locations where no panels currently exist, or where the crossing surface had deteriorated. The *Grade Crossing Report* lists the crossing locations where median barriers and roadway re-profiling is recommended. The report also identifies forty-two critical crossings which either have 1) steep grades on approaching roadways which pose safety hazards for low-clearance vehicles, or which have some combination of steep roadway approach grades, geometric characteristics, or proximity to parallel roadways or

adjacent intersections that require significant work to bring the crossing approaches up to standard. Lump sum costs are included in the estimates to reconstruct the critical crossings to MnDOT or AREMA standards.

2.2.6 Vehicle and Equipment

Costs for Next Generation locomotives and coach cars were provided by the Illinois Department of Transportation and represent the actual purchase price of Nippon Sharyo bi-level coach cars and Siemens locomotives as part of the Midwest Equipment Procurement.

2.2.7 Professional Services

Professional services fees are included to cover design costs, program management costs, construction management and oversight costs, and integration, testing and commissioning costs. These costs are included in the estimate as a percentage of construction cost according to the table below.

Table 2-1: Professional Service Costs

PROFESSIONAL SERVICE	COST AS PERCENTAGE OF CONSTRUCTION COST
DESIGN ENGINEERING (CATEGORIES 10, 40, 50, 60)	5%
DESIGN ENGINEERING FOR STATIONS AND FACILITIES (CATEGORIES 20 AND 30)	10%
PROGRAM MANAGEMENT	2%
CONSTRUCTION MANAGEMENT & INSPECTION	6%
ENGINEERING SERVICES DURING CONSTRUCTION	1%
INTEGRATION, TESTING, COMMISSIONING	1%

2.2.8 Contingency

Contingency costs are calculated as a percentage of the total capital cost for each FRA Standard Cost Category. Contingency percentages vary depending on the level of design completed for the work elements included in a particular category.

Table 2-2: Contingency Cost Percentages

FRA STANDARD COST CATEGORY	CONTINGENCY COST AS PERCENTAGE OF TOTAL CAPITAL COST
10 TRACK STRUCTURES & TRACK	20%
20 STATIONS, TERMINALS, INTERMODAL	30%
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN.	30%
40 SITEWORK, RIGHT OF WAY, LAND	20%
50 COMMUNICATIONS & SIGNALING	20%
60 ELECTRIC TRACTION	Not Applicable
70 VEHICLES	20%
80 PROFESSIONAL SERVICES	0%
90 UNALLOCATED CONTINGENCY	5% of All Category 10-80 Costs
100 FINANCE CHARGES	Not Applicable

3. DESCRIPTION OF CAPITAL IMPROVEMENTS BY SCENARIO

Each of the NLX scenarios uses the same route alignment between Minneapolis and Duluth. For the purposes of capital cost estimating, the NLX alignment is broken down into 'segments'. A segment is a length of track that is defined by logical end points, junctions, or population centers. A series of segments is combined to form the complete route that extends from the southern NLX terminal at Target Field Station in Minneapolis to the northern NLX terminal at the Union Depot in Duluth. The route and mileage information for each of the segments was gathered using GIS shape files obtained from state and federal GIS databases and from railroad track charts. The NLX route segments are shown in Table 3-1.

Table 3-1: NLX Route Segments

Segment Number	Segment Limits	Segment Length (miles)	Railroad Owner
1	Target Field Station to Minneapolis Junction	2.1	BNSF
2	Minneapolis Junction to University Avenue	1.4	BNSF
3	University Ave to Coon Creek Junction	9.7	BNSF
4	Coon Creek Junction to Isanti	23.9	BNSF
5	Isanti to Cambridge	5.6	BNSF
6	Cambridge to Hinckley	35.1	BNSF
17	Hinckley to Boylston	60.5	BNSF
18	Boylston to Superior	8.7	BNSF
19	Superior to Duluth	5.4	BNSF/LST&T

Track schematics showing the track infrastructure improvements proposed for each scenario are included as Appendix G. Most of the improvements that add capacity and improve operational performance on the railroad are siding extensions and new control points. A summary of the siding extensions and control points by scenario is shown below in Table 3-2.

Table 3-2: Summary of Proposed Siding Improvements by Scenario

Siding	Proposed Siding Extension								Proposed New Control Point							
	B1	B2	B10	B11	C1	C2	C10	C11	B1	B2	B10	B11	C1	C2	C10	C11
Andover		X				X										
Bethel																
Isanti						X								X		
Cambridge		X				X								X		
Grasston																
Brook Park									X	X	X		X	X	X	
Hinckley																
Sandstone																
Askov		X				X			X	X			X	X		
Bruno		X				X				X				X		
Nickerson									X	X			X	X		
Foxboro		X				X										

3.1 Description of Capital Improvements by Segment

3.1.1 Segment 1 – Target Field Station to Minneapolis Junction

Existing Conditions

Segment 1 is a 2.1-mile segment of the eastern end of the BNSF Wayzata Subdivision. Segment 1 is located in Minneapolis, and is the southern end of the NLX corridor. It is bounded by Target Field Station on the south and Minneapolis Junction on the north. Target Field Station is the proposed southern terminal station for the NLX, but also currently serves as the southern terminal station for the Northstar Commuter Rail system. North of Target Field Station, the Wayzata Subdivision is an existing single main track with an auxiliary track extending to Harrison Street that serves as a second main track. West of the Mississippi River, between First Street and West River Parkway, the Wayzata sub narrows to a single main track, before crossing the Mississippi River main channel and the east channel on two double-tracked, multiple-span steel bridges. At Harrison

Street near Minneapolis Junction, the proposed route for the NLX leaves the Wayzata Subdivision and takes the west leg of the wye to reach the BNSF Midway Subdivision and University Avenue.

Proposed Improvements – All Scenarios

A new NLX platform will be integrated with the existing platform and station facilities at the Target Field Station. A new #10 turnout and auxiliary track will be constructed to serve the new platform. Between First Street and West River Parkway, the existing track will be reconfigured to provide for two through tracks, and a second connecting track will connect the Wayzata sub to the Midway sub The track improvements will provide for two continuous through tracks from Wayzata sub to the Midway sub via the northern leg of the wye.

Three public crossings at West Island Avenue, East Island Avenue, and Harrison Street will be upgraded from conventional gates to four-quadrant gates with median barrier and new pedestrian gates.

Additional Proposed Improvements – Scenarios B2, B11, C2, C11

Based on the schedules that have been developed, Scenarios B2, B11, C2, and C11 are expected to require a layover facility in the vicinity of the Target Field Station. Costs for a layover facility have been included for each of these scenarios.

3.1.2 Segment 2 – Minneapolis Junction to University Avenue

Existing Conditions

Segment 2 is a 1.7-mile double track mainline that extends from Minneapolis Junction on the BNSF Midway Subdivision north through residential and commercial area of Minneapolis to University Avenue. The double track mainline is mostly grade separated from the roadway network. The maximum authorized speed in this segment is 55 mph. East of University Avenue, the BNSF's double-track St. Paul Subdivision joins the Midway Subdivision. Both Subdivisions terminate at University Avenue and the BNSF Staples Subdivision continues north from University Avenue through BNSF's Northtown Yard to Coon Creek Junction.

Proposed Improvements – All Scenarios

A #10 turnout that leads to an industry siding will be replaced at CP Van Buren. Grade crossing improvements are proposed to the two crossings at in Segment 2 at 12th Ave NE and 14th Ave NE.

3.1.3 Segment 3 – University Avenue to Coon Creek Junction

Existing Conditions

Segment 3 is a 9.4-mile BNSF-owned primarily double-tracked segment between University Avenue and Coon Creek Junction. The main tracks pass to the west side Northtown Yard with a maximum speed limit of 45 mph and continue north of Northtown Yard at maximum passenger train speeds of 79 mph. This segment has heavy freight traffic and is currently used for both Northstar and Amtrak passenger service. At the northern end of Segment 3 at Coon Creek Junction is the end of the BNSF Midway Subdivision.

Proposed Improvements – All Scenarios

Two #20 crossovers and two #20 turnouts will be added to CP University CP at MP 11.7 to facilitate train movements between the two main tracks on the Midway Sub. At CP Interstate at MP 15.5, a series of #20 crossovers and turnouts will be added, and existing tracks will be shifted to facilitate train movements between the two existing main tracks, and a proposed third main track between CP Interstate at MP 15.5 and Coon Creek Junction at MP 21.10. The proposed third main track is approximately 6.2 miles in length, and will be located east of the main BNSF tracks between the Fridley Northstar Station and MP 20.0, and north of MP 20.0 will be located west of the main track. Costs are included for a new NLX station in Coon Rapids near MP 20.5. To accommodate the new third main track, the existing bridge over Mississippi St will need to be reconstructed, and a new bridge is needed over Rice Creek. The four public grade crossings in Segment 3 are proposed to be upgraded from conventional gates for four-quadrant gates with three crossings having pedestrian gates.

Additional Proposed Improvements – Scenarios B11 and C11

Instead of the #20 crossovers and turnouts used in the other scenarios, #24 crossovers and turnouts will be added to CP University CP at MP 11.7 to facilitate train movements between the two main tracks on the Midway Sub. Scenarios B11 and C11 also include timber, surface, and 33% tie replacement for stabilization of the main track to support higher speeds.

3.1.4 Segment 4 – Coon Creek Junction to Isanti

Existing Conditions

Segment 4 is a 23.9-mile BNSF-owned primarily single track segment between Coon Creek Junction and the town of Isanti. The BNSF Hinckley Subdivision begins just north of Coon Creek Junction and carries only freight traffic for BNSF, CP and UPRR. It is currently FRA Class IV track with a maximum speed limit of 50 mph. The land outside the railroad right-of-way transitions from suburban to rural in Segment 4.

Proposed Improvements – All Scenarios

Timber, surface and 33% tie replacement for stabilization of the main track to support higher speeds is included for the entire 23.9-mile segment for the main track for all C scenarios and with 66% tie replacement for all B scenarios. The existing undergrade bridge over Cedar Creek at MP 124.2 will be rehabilitated to support higher speeds. Just after Coon Creek Junction, the existing turnout to the Staples Subdivision will be removed. 30 grade crossings in Segment 4 will be upgraded to have at least conventional dual gates with flashers, including 11 public grade crossings which will have four-quadrant gates.

Additional Proposed Improvements – Scenarios B2 and C2

The existing Andover siding will be extended by adding 1.1 miles of new track on new roadbed from MP 132.5 to MP 131.4. The siding extension work includes replacing the existing #11 turnout with a #15 turnout at the north end of the Andover siding, the removal of existing #11 turnout at MP 131.4, installation of a new #15 turnout and control point at the new south end of the Andover siding at MP 132.5. Costs are included for timber and surface with 50% tie replacement for the existing Andover siding track. Additionally, a new undergrade bridge will need to be constructed to accommodate a second track over Coon Creek at MP 131.5. Scenario C2 is slightly different and will replace the existing turnout just south of Isanti with a #20 turnout and two new control points for improvements to Segment 5.

Additional Proposed Improvements – Scenarios B11 and C11

The existing Andover siding will be extended by adding 1.1 miles of new track on new roadbed from MP 132.5 to MP 131.4. The siding extension work includes replacing the existing #11 turnout with a #24 turnout and control point at the north end of the Andover siding, the removal of existing #11 turnout at MP 131.4, installation of a new #24 turnout and control point at the new south end of the Andover siding at MP 132.5. Costs are included for timber and surface with 50% tie replacement for the existing Andover siding track. Additionally, a new undergrade bridge will need to be constructed to accommodate a second track over Coon Creek at MP 131.5. Scenarios B11 and C11 also include a new freight siding will be constructed south of the Andover siding from MP 135.4 to MP 132.5. The new siding work includes a new #24 turnout and #24 crossover at MP 132.5, new track construction on new roadbed from MP 135.4 to MP 132.5, a new #24 turnout and control point at MP 135.4, the replacement of the #11 turnouts on the existing maintenance spur north of Coon Creek Junction, and the closure of a private grade crossing at MP 131.48. New #15 turnouts and control points will replace the existing turnouts on either end of the existing Bethel siding. A new control point, a new #33 high speed turnout for new passenger track to the north, and a #11 turnout replacement will be installed just south of Isanti. Finally, a new #20 crossover will be installed between the tracks leading to the Staples Subdivision for scenarios B11 and C11.

3.1.5 Segment 5 – Isanti to Cambridge

Existing Conditions

Segment 5 is a 5.6-mile single-track section of the BNSF Hinckley Subdivision between Isanti and Cambridge. The track is FRA Class IV with a maximum speed limit of 50 mph.

Proposed Improvements – All Scenarios

Timber, surface and 33% tie replacement for stabilization of the main track to support higher speeds is included for the entire 5.6-mile segment for the main track for all C scenarios and with 66% tie replacement for all B scenarios. The one existing undergrade bridges at MP 112.4 and MP 111.2 will be rehabilitated to support higher speeds. All six grade crossings in Segment 5 will be upgraded to at least conventional dual-quadrant gates with flashers, including four public grade crossings which will have four-quadrant gates.

Additional Proposed Improvements – Scenario B2

The existing siding south of Cambridge will be extended by adding 1.2 miles of new track on new roadbed from MP 110.9 to MP 109.7. The siding extension work includes replacing the existing turnout with a #15 turnout and a new control point at the north end of the siding, the removal of existing turnout at MP 109.7, and installation of a new #15 turnout and control point at the new south end of siding at MP 110.9. Costs are included for timber and surface with 50% tie replacement for the existing siding track from MP 109.7 to MP 107.9.

Additional Proposed Improvements – Scenario C2

The existing siding south of Cambridge will be extended by adding three miles of new track on new roadbed from MP 112.7 to MP 109.7. The siding extension work includes replacing the existing turnout with a #20 turnout and a new control point at the north end of the siding, the removal of existing turnout at MP 109.7, installation of a new #20 crossover and control point at MP 110.9, and removal of the existing turnout at MP 112.7. Costs are included for timber and surface with 50% tie replacement for the existing siding tracks from MP 109.7 to MP 107.9 and from MP 113 to MP 112.7. Additionally, two new undergrade bridges will need to be constructed at MP 112.4 and MP 111.2 to accommodate the second track.

Additional Proposed Improvements – Scenarios B11 and C11

The existing siding south of Cambridge will be extended by adding three miles of new track on new roadbed from MP 112.7 to MP 109.7. The siding extension work includes replacing the existing turnout with a #15 turnout and a new control point at the north end of the siding, the removal of existing turnout at MP 109.7, installation of a new #15 universal crossover and control point at MP 110.9, and removal of the existing turnout at MP 112.7. Costs are included for timber and surface with 50% tie replacement for the existing siding tracks from MP 109.7 to MP 107.9 and from MP 113 to MP 112.7. A new passenger track on new roadbed will be added to the west of the existing main track through the entire segment. Associated work with the new passenger track includes installation of two #24 universal crossovers, one at MP 110.9 and another at MP 107.9. Additionally, two new undergrade bridges will need to be constructed at MP 112.4 and MP 111.2 to accommodate the new tracks.

3.1.6 Segment 6 – Cambridge to Hinckley

Existing Conditions

Segment 6 is a 35.1-mile long single-track segment of the BNSF Hinckley Subdivision. This portion of the subdivision runs through the towns of Grasston, Henriette, and Brook Park between Cambridge in the south and Hinckley in the north in rural Minnesota. The track is FRA Class IV with a maximum speed limit of 50 mph.

Proposed Improvements – All Scenarios

The new Cambridge City Center Station will be constructed for NLX. Timber, surface and 33% tie replacement for stabilization of the main track to support higher speeds is included for the entire 35.1-mile segment for the main track for all C scenarios and with 66% tie replacement for all B scenarios. Similarly, the existing Brook Park siding will also have timber, surface and 50% tie replacement from MP 80.4 to MP 78.6 and a new control point added to the north end of the siding at MP 78.6. The undergrade railroad bridges at Snake River near Grasston and at Pokegama River near Brook Park will be rehabilitated to support higher speeds. Drainage improvements and undercutting are proposed at the following locations: MP 106.0 to 105.0, MP 104.0 to 101.0, MP 96.0 to 94.0, MP 89.0 to 87.0, MP 81.0 to 80.0 and MP 76.0 to 75.0. All 43 grade crossings in Segment 6 will be upgraded to have at least conventional dual gates with flashers, including eight public grade crossings which will have four-quadrant gates. 15 of the 43 grade crossings were identified as critical and will require major roadway improvements, as explained in section 3.2.5.

Additional Proposed Improvements – Scenarios B11 and C11

A new second passenger track to the west of the existing mainline will extend for the entirety of Segment 6. Associated improvements include replacement of the #11 turnout in Cambridge, replacement of the overhead bridge of 379th Avenue at MP 101.26, replacement of the #11 turnout at MP 96.7 in Braham, new control point and #24 universal crossover just south of the existing Grasston siding, replacement of the existing Grasston siding turnouts with #15 turnouts, new control point and #15 crossover just north of the existing Grasston siding, new control point and #24 crossover just south of the existing Brook Park siding, replace two existing turnouts with #15 turnouts at the south end of the Brook Park siding, replacement of the existing turnout at the north end of the Brook Park siding with a #15 turnout, new control point and #24 crossover south of the Hinckley siding, two #20 turnouts to replace the existing turnouts to the Hinckley siding, a new #10 turnout to the St. Croix Valley Railroad just south of Hinckley at MP 72.3, and a new control point and #24 turnout at Hinckley. New bridges would need to be constructed at Snake River near Grasston, at MP 84.1, and at Pokegama River near Brook Park. Additionally, the new Southwest station and a #10 turnout accessing it will be constructed in Hinckley at MP 72.3.

3.1.7 Segment 17 – Hinckley to Boylston

Existing Conditions

Segment 17 is a 60.5-mile long BNSF-owned single-track segment of the BNSF Hinckley Subdivision from Hinckley, MN to Boylston, WI. The existing track is FRA Class IV and serves freight traffic only, with maximum speeds ranging from 40 to 50 mph. Note that on the BNSF track charts, Boylston has two different milepost locations for the same junction location: MP 11.8 on the Hinckley Subdivision and MP 12.6 on the Lakes Subdivision (Boylston to Superior).

Proposed Improvements – All Scenarios

A new station for NLX will be constructed in Hinckley and a new Maintenance facility will be constructed in Sandstone (MP 63.1), opposite the existing siding. Timber, surface and 33% tie replacement for stabilization of the main track to support higher speeds is included for the entire 60.5-mile segment for the main track for all C scenarios and with 66% tie replacement for all B scenarios. Similarly, timber, surface and 50% tie replacement is proposed at the Askov siding (MP 57.8 to 56.5) and the Nickerson siding (MP 37.3 to 35.9). New control points will be added at either end of the Askov siding (MP 57.8 and 56.5), the Nickerson siding (MP 37.3 and 35.9), and the Boylston Junction (MP 12.3 and 11.8). 60 of the 62 grade crossings in Segment 17 will be upgraded to have at least conventional dual gates with flashers, including four public grade crossings which will have four-quadrant gates. The remaining 2 grade crossings are to be closed permanently. 25 of the 62 grade crossings were identified as critical and will require major roadway improvements, as explained in section 3.2.5. Costs are included to rehabilitate existing bridges to accommodate higher speeds.

Additional Proposed Improvements – Scenarios B2 and C2

The existing Askov siding will be extended by adding 0.6 miles of new track on new roadbed to the south from MP 58.4 to 57.8 and 1.7 miles of new track on new roadbed to the north from MP 56.5 to 54.8. Work associated with the Askov siding extension also includes new control points and new #15 turnouts at each end (MP 58.4 and MP 54.8) and removal of the existing turnouts. The existing Bruno siding will be extended south by adding 2.6 miles of new track on new roadbed from MP 52.0 to 49.4. The Bruno siding extension also includes a new control point and a #15 turnout at the proposed south end of the siding at MP 52.0, a new control point and replacement of the existing northern turnout with a #15 turnout at MP 48.4, and timber and surface with 50% tie replacement on the existing siding track from MP 49.4 to 48.4. The existing Foxboro siding will also be extended by adding 0.4 miles of new track on new roadbed to the south from MP 25.1 to 24.7 and 1.1 miles of new track on new roadbed to the north from MP 23.4 to 22.3. Work associated with the Foxboro siding extension also includes new control points and new #15 turnouts at each end (MP 25.1 and MP 22.3), removal of the existing turnouts, and timber and surface with 50% tie replacement on the existing Foxboro siding track from MP 24.7 to 23.4.

Additional Proposed Improvements – Scenarios B11 and C11

Scenarios B11 and C11 incorporate all improvements from scenarios B2 and C2. In addition, a new 3-mile siding with #20 turnouts and new control points will be constructed south of Sandstone. The existing turnouts of the Sandstone siding will be replaced with #11 turnouts. The existing turnouts of the Nickerson siding will be replaced with #15 turnouts and the turnouts to the spur off of the Nickerson siding will be replaced with #11 turnouts. A new control point and #15 universal crossover will be added at MP 48.9. The turnouts to the spur off of the existing Bruno siding will be replaced with #10 turnouts. Another new 3-mile siding will be constructed between the Nickerson and Foxboro sidings, just north of MP 34.0. This new siding will have #20 turnouts and new control points at each end. For scenarios B11 and C11, the Foxboro siding extension will have #20 turnouts at each end instead of #15 turnouts and the existing spur off of the Foxboro siding will have its two turnouts replaced with #10 turnouts.

3.1.8 Segment 18 – Boylston to Superior

Existing Conditions

Segment 18 is a 7.9-mile long double-track segment on the BNSF Lakes Subdivision between Boylston, WI and Superior, WI. Boylston is the junction at the northern end of the BNSF Hinckley Subdivision (MP 11.6) where the Hinckley Subdivision converges with the BNSF Lakes Subdivision (MP 12.8) south of Superior, WI. A 40 mph speed limit is in effect for most of the segment length, before decreasing to 10 mph south of Superior at Milepost 7.7 where the CTC signal system ends and Yard Limit rules are in effect. The NLX alignment will switch from the BNSF Lakes Mainline to the BNSF Coal Main at MP 8.6

Proposed Improvements – All Scenarios

Timber, surface and 33% tie replacement for stabilization the main tracks to support higher speeds is included for the two BNSF Lakes mainline tracks from MP 12.6 to 8.6 and the BNSF Coal main from MP 8.6 to 4.656 for all C and B scenarios and with 66% tie replacement for B11. A new #20 crossover will be added between the two BNSF Lakes mains just south of the turnout to the BNSF Coal main; the existing turnout to the BNSF Coal main will be replaced with a #20 turnout. New track on new roadbed will be added to the east of the existing BNSF Coal main from MP 8.0 to 4.0 (note that some of this work will be part of Segment 19). Work associated with the new siding includes a new control point and #15 turnout at MP 8.0. Additionally, the existing coal main will need a track shift to the west under the 21st Street overhead bridge at MP 4.98. All seven grade crossings in Segment 18 will be upgraded to have at least conventional dual gates with flashers, including two public grade crossings which will have four-quadrant gates. Three grade crossings were identified as critical and will require major roadway improvements, as explained in section 3.2.5.

Additional Proposed Improvements – Scenarios B11 and C11

Scenarios B11 and C11 will add a new #24 crossover just south of the BNSF Coal main instead of a #20 crossover and a #24 turnout will be installed to the BNSF Coal main instead of a #20 in the other scenarios. Additionally, instead of adding a new track to the east of the BNSF coal main, new track on new roadbed will be added to the west of the existing BNSF Coal main just north of the new #24 turnout. Associated work with the new track includes a new control point and #20 turnout and will extend into Segment 19.

3.1.9 Segment 19 –Superior to Duluth

Existing Conditions

Segment 19 is a primarily double-track segment from Superior, WI to Duluth, MN, where the NLX alignment terminates at the Duluth Union Depot. The alignment turns west at 9th Street (Winter Street) in Superior and continues 5.4 miles on a portion of the LST&T Railroad over the Grassy Point Movable Span (Swing) Bridge across St. Louis Bay before heading northeast on the east leg of the wye at Mike's Yard and proceeding via the BNSF track into Duluth. Speed is restricted to 15 mph for passenger and 10 mph for freight train operations over most of the segment into Duluth. The speed restrictions are due to the bridge itself and Yard Limit rules which are in effect in due to the number of junctions, yard and industry track switches in this primarily non-signaled segment.

Proposed Improvements – All Scenarios

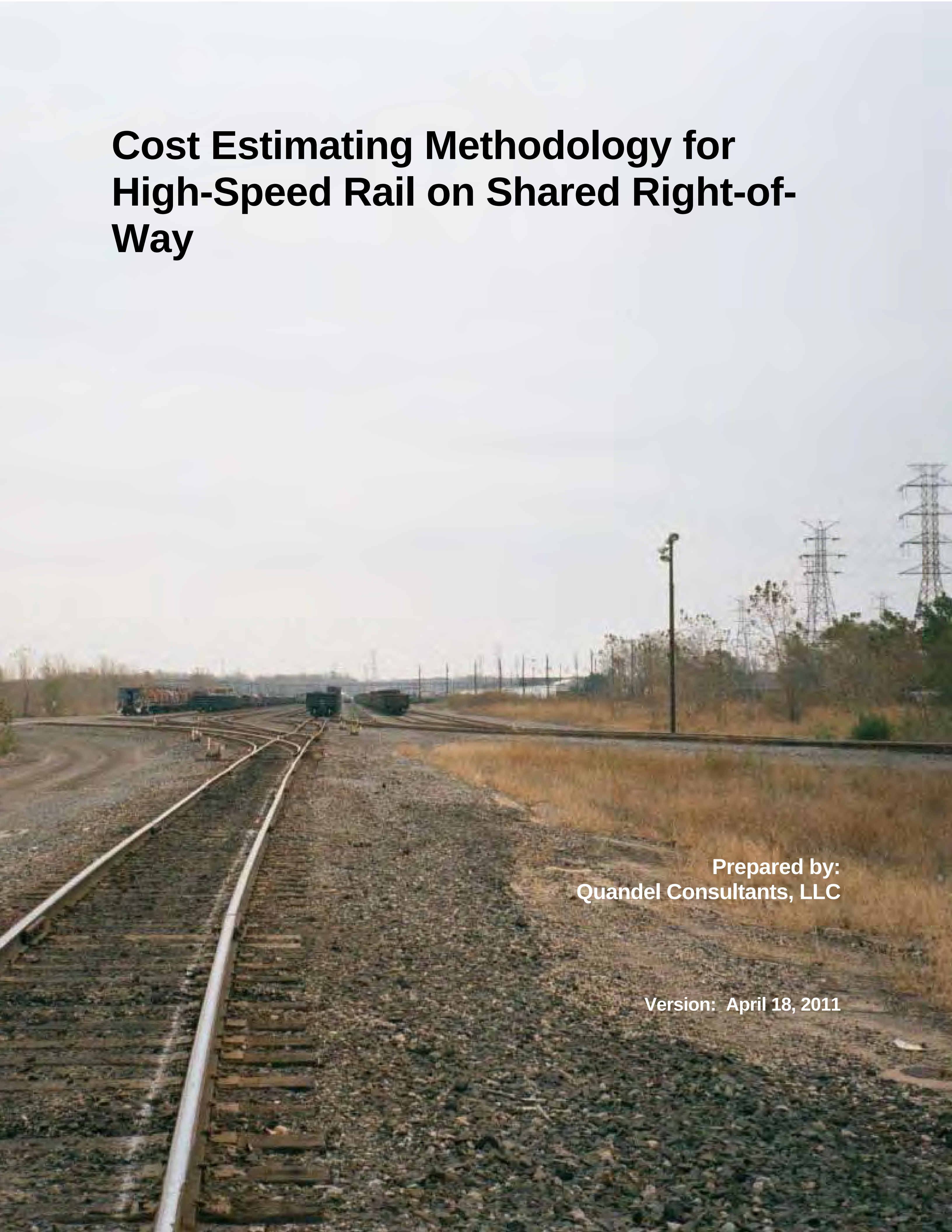
A new passenger station will be constructed for NLX in Superior. The new second track added to east of the BNSF Coal main will continue past the station until just south of the LST&T Junction. The work associated with this track before the junction includes a new #15 crossover just south of the Superior Station and a new control point and #15 turnout to end the second track. A new #15 turnout and #15 crossover will replace the existing switches as the BNSF Coal main enters the LST&T Junction. Additionally, the BNSF Coal main will be shifted west under the Belknap Street overhead bridge just south of the new Superior passenger station. Timber, surface and 33% tie replacement for all B and C scenarios and with 66% tie replacement for B11 scenarios for stabilization. The main tracks to support higher speeds is included for the tracks north of the LST&T Junction from MP 3.9* to the Duluth Union Depot where the alignment terminates (MP X2.0*). A new control point will be added north of the Grassy Point movable bridge. New track on new roadbed will be constructed to the east of the exiting mainline from MP 2.0* to 0.9* and to the west of the existing mains from MP 1.0* to X1.8*. Work associated with the new tracks includes a new control point and #15 turnout at Berwind Junction (MP 2.0*), replacement of an existing turnout with a #15 crossover at MP 0.9*, a new #10 turnout and control point at MP 1.0*, a box culvert extension, and a new control point and #10 turnout at the north end of the new track at MP X1.8*. New bridges will be constructed at the two existing undergrade bridges to accommodate the new tracks. Additionally, the existing universal crossover will be replaced with a #15 universal crossover just south of MP 1.0*, an existing turnout will be replaced with a #15 turnout south of the 37th Avenue grade crossing, three #10 hand-thrown turnouts will be removed from the existing mainline and three #10 turnouts with electric locks will be installed on the new track to the east, south of the 37th Avenue grade crossing. New #10 turnouts and #10 crossovers will be installed in two locations (MP 0.0* and X1.0*) from the NLX tracks and leading to CN tracks. Costs are included to rehabilitate the Grassy Point swing bridge and the other existing undergrade bridges to accommodate higher passenger speeds. The new Duluth Maintenance Facility will be constructed between Rice's Point Yard and the Duluth Union Depot. Improvements at the Duluth Union Depot include the replacement of six #10 turnouts, removal of two existing turnouts and Track 1, installation of a #10 turnout and a new platform, and extension of Track 3. All eight grade crossings in Segment 19 will be upgraded to have at least conventional dual gates with flashers, including Winter Street, which will have four-quadrant gates.

Additional Proposed Improvements – Scenarios B11 and C11

Scenarios B11 and C11 will not include the #15 crossover south of the Superior Station. And the #15 turnouts and crossover near the LST&T Junction will be the #20 turnouts and a #20 crossover. New track on new roadbed will be constructed on the east of the existing mains from MP 2.0* to 0.9* and will have a #20 turnout at MP 2.0*, add a new control point and replace an existing turnout with a #15 crossover at MP 0.9*, and construct a new bridge . Additionally, the existing universal crossover just south of MP 0.9* will be replaced with a #20 universal crossover. A new control point will be added and an existing turnout will be replaced with a #15 turnout south of 37th Avenue. A new control point and a #20 crossover will be installed at MP 0.0*. New track on new roadbed will be constructed to the west of the existing mainline from the Rice's Point Yard and beyond the Duluth Union Depot. Associated work with the new track includes a new control point with two #20 turnouts and a #20 crossover at the south end, a new control point and #15 turnout at the north end, and a new control point at the very end of the alignment and the end of CTC implementation. Costs are included to rehabilitate the Grassy Point swing bridge and the other existing undergrade bridges to accommodate higher passenger speeds. The new Duluth Maintenance Facility will be constructed between Rice's Point Yard and the Duluth Union Depot. Improvements at the Duluth Union Depot include the replacement of six #10 turnouts, removal of two existing turnouts and Track 1, installation of a #10 turnout and a new platform, and extension of Track 3. All eight grade crossings in Segment 19 will be upgraded to have at least conventional dual gates with flashers, including Winter Street, which will have four-quadrant gates.

ATTACHMENT B: Cost Estimating Methodology for High-Speed Rail on Shared Right-Of-Way

Cost Estimating Methodology for High-Speed Rail on Shared Right-of-Way



Prepared by:
Quandel Consultants, LLC

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Table of Contents

1. Introduction

This document provides a written methodology for establishing unit costs for pay items related to the proposed construction of high speed rail corridors on shared right-of-way and for the formulation of conceptual cost estimates for the reasonable alternatives and preferred alternative for the following projects:

- Midwest Regional Rail Initiative (MWRRI) Phase 7
- Northern Lights Express (SRF Consulting is Prime Consultant)
- Ohio PEIS (AECOM is Prime Consultant)
- Milwaukee-Twin Cities Identification of Reasonable Alternatives

These unit costs have been developed for route comparison purposes. Since the cost for stations, support facilities, and vehicles will remain essentially similar across the routes being compared, they have not been viewed as "discriminators" in the evaluation of the alternative routes and are not included in this discussion.

The cost estimates to be developed will be approached as a high level conceptual effort based on limited information regarding overall track and infrastructure conditions, railroad operations, and input from the owning railroad(s). The validity of these estimates rests on the assumptions that information gained from available railroad track charts and timetables, aerial mapping, input from state departments of transportation and visual observations of the railroads made from publicly accessible locations combined with the unit costs developed within this methodology will serve as a starting point for the continuing development of costs associated with proposed HSIPR programs.

The project team originally developed unit costs for the design and construction of high-speed passenger rail infrastructure on a series of previous planning projects. Initially the unit costs were applied to planned construction in the Midwest as a part of the Midwest Regional Rail Initiative. Later the costs were applied to capital cost estimates for high-speed rail in Florida, Ohio, Minnesota and Colorado.

The unit costs used for this effort were developed over time from detailed breakdowns of the units into their basic elements. The costs related to material, labor, equipment and overhead for these elements were accumulated and rolled up to provide an inclusive unit cost for the various components required to develop a high speed rail system. The unit costs have been refreshed and refined periodically to update them for inflation and changes in the approach to infrastructure development and technology. Most recently, on April 13, 2010, Quandel Consultants prepared a Technical Memorandum (Attached as Appendix A) outlining a strategy to update capital costs being used within the MWRRI. The unit costs employed by the MWRRI were originally developed as part of MWRRI Phase 3B in 1997. Those unit costs were based on previous high speed rail feasibility studies available at that time and cost information provided by Amtrak. Since then, each of the unit costs was updated to 2002 dollars, which were the most recent costs available for the MWRRI at the time of the update. Most recently, these 2002 costs have been updated to 2009 dollars using the inflation factors listed in the Producer Price Index (PPI) PCUBHVY 'PPI Inputs for Other Heavy Construction', which increased unit costs from 2002 by a factor of 1.43 (October 2009 was the most recent month for which PPI data was available at the time of the update).

For this cost methodology, the unit costs were updated to 2010 dollars. By again using the PPI, it was determined that March 2010 dollar values could be obtained by increasing the 2009 unit costs by an inflation factor of 1.035 (March 2010 was the most recent month for which PPI data was available at the time of this writing). Once the 2010 unit costs were derived, they were compared to current year industry cost estimates for railroad related construction; during this comparison, if a unit cost was found to be out of line with current trends, it was adjusted to better reflect current conditions in the market. The pay items and their associated unit costs were then reviewed for their applicability to the four projects mentioned above. Some of the line items were found to be not applicable to this effort and were removed; in a few cases, line items had to be added to completely address the infrastructure development being proposed for the HSR system. See Appendix B for the updated unit costs.

The revised base set of unit costs addresses typical passenger rail infrastructure construction elements expected to be found within proposed and future projects including: roadbed and trackwork, systems, facilities, structures, and grade crossings. The Unit Costs are reasonable for developing the capital costs under either normal contractor bidding procedures or under railroad force account agreements for construction.

2. Trackwork

The development of intercity passenger corridors with train operations up to 110 mph will require that the track and associated infrastructure have the ability to support the proposed speeds. Typically, freight operations occur over track complying with FRA Classes I through IV, allowing maximum speeds of 60 mph for freight and 79 mph for passenger trains; higher speed passenger operation will require track that complies with the requirements of FRA Classes V (80 mph for freight trains, 90 mph for passenger trains) & VI (110 mph for passenger trains and freight trains complying with 49 CFR Part 213.307, note 1)[1]. This means that existing tracks that will be required to support both passenger & freight operations will need to be upgraded and that new track will need to meet the higher standards required for operation at the speeds under consideration.

2.1. Design considerations

- Maximum speed on all routes will be 110 mph.
  - Where additional tracks are to be added and track center spacing of 30' cannot be provided, track speeds in excess of 79 mph will only be allowed as negotiated with the host railroad.
- For development of shared passenger & freight service operating on an existing corridor of a Class I Railroad, an additional main track will be constructed where freight levels require it.
  - For single track corridors with freight levels at and above twenty trains per day, an additional main track will be provided
  - Within corridors with two existing main tracks, freight levels of forty or more trains per day indicate the need for an additional main track
- For single track corridors where freight levels are below twenty trains per day passing sidings will be provided at regular intervals appropriate for the operations proposed:
  - 3 mile long sidings at nominal 20 mile intervals will be built for the use of freight trains being passed or meeting passenger trains. #15 turnouts within a Control Point will be used at each end of these sidings. A 500' Maintenance of Way spur will be added to these sidings. Sidings will be located to minimize excavation required for their construction.

[1] Department of Transportation, Federal Railroad Administration 49 CFR Part 213 Track Safety Standards; Final Rule June 22, 1998

- In single track territory on in double track segments where commuter trains operate, ten mile long sidings at nominal 50 mile intervals will be built for the use of passenger trains passing or meeting. #33 turnouts within a Control Point will be used at each end of these sidings. Sidings will be located to minimize excavation required for their construction.

- Where two or more main tracks are in operation, a #20 universal crossover within a Control Point will be installed every 20 miles. When possible, the universal crossover will be included within the Control Point established for a freight siding and/or a passenger siding.
- Rehabilitation guidelines for passenger operations:
  - Rail of a section that is not CWR and of at least a section of 132RE or greater will be replaced with CWR with a section of 136RE or 141RE based on the standard rail section of the owning railroad.
  - Where rail is to be replaced, it will be assumed that the new CWR noted will be of the standard section in use by the owner of the corridor segment being considered
  - Existing Class IV track will have at least 33%of the existing ties replaced and otherwise meet the requirements of Class V or VI track.
  - Existing Class III track will have at least 66% of the existing ties replaced and otherwise meet the requirements of Class V or VI track.
  - Existing Class I & II track will be removed & completely rebuilt from the subgrade up
  - Where appropriate, the track will be elevated and surfaced to address curvature issues related to operating speed and superelevation. As a placeholder, 10% of the corridor length will be assumed to require this effort.
- Fencing will be provided throughout the length of the route.
  - In municipalities, decorative fencing will be used.
  - At grade crossings and in residential areas, chain link fence will be provided.
  - Woven wire fencing will be used in all other locations.
- It is assumed that 25% of the existing private crossings within a corridor segment will be closed:
- The remaining private crossings will require the installation of crossing warning devices, at a minimum, flashers and gates
- Public crossings will require the presence of four quadrant gates at a minimum

2.2. New Track Construction

Where new track will be constructed within this program the primary unit of cost will be “HSR Track”. This unit is based on the typical section of the host railroad and is composed of the following:

- New 136 or 141 lb. Continuous Welded Rail
- 7” x 9” x 8’6” timber crossties spaced at 19.5” C-C, which results in 3249 per mile
  - 9”x11”x8’6” concrete ties can be used in place of timber crossties when needed; over recent years, relative costs have become closer and at times, scarcity of timber crossties in the market has led to concrete crossties becoming the only choice available. Concrete crossties are generally placed at 24” C-C, which results in 2640 per mile
- Two-13” double shouldered tie plates, four rail anchors, and eight track spikes (or corresponding rail seats and elastomeric fasteners) per tie
- 12” of Granite ballast (AREMA #4) placed to support the proper vertical and horizontal track alignment.

Depth of ballast is measured at the center of the tie. Additional ballast will be placed to fill the cribs between the ties and provide a ballast shoulder on the outside of each tie per the typical section required by the owning railroad.

The following figures depict railroad typical track sections:

Figure 1 – Typical Section - Single Main Track

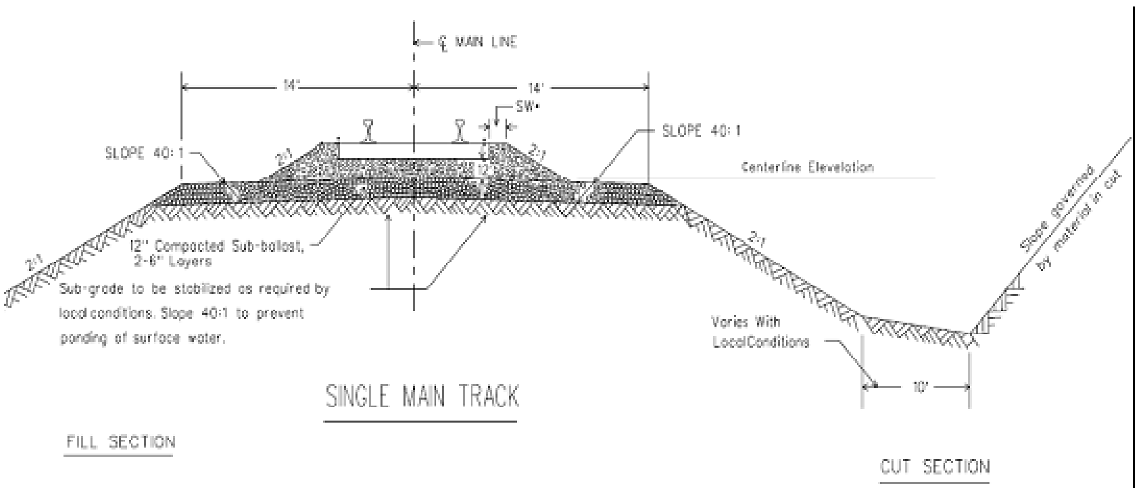


Figure 2 – Cross Section of a Double Main Track on Existing Roadbed

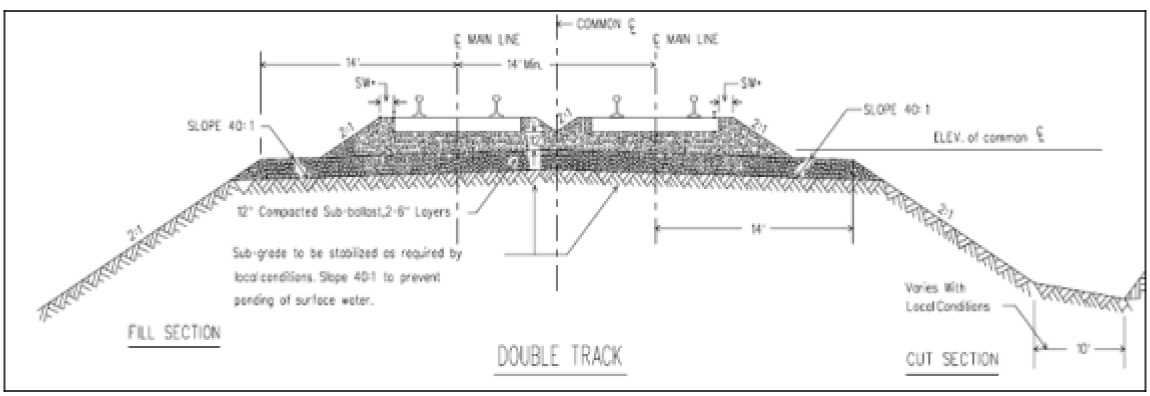
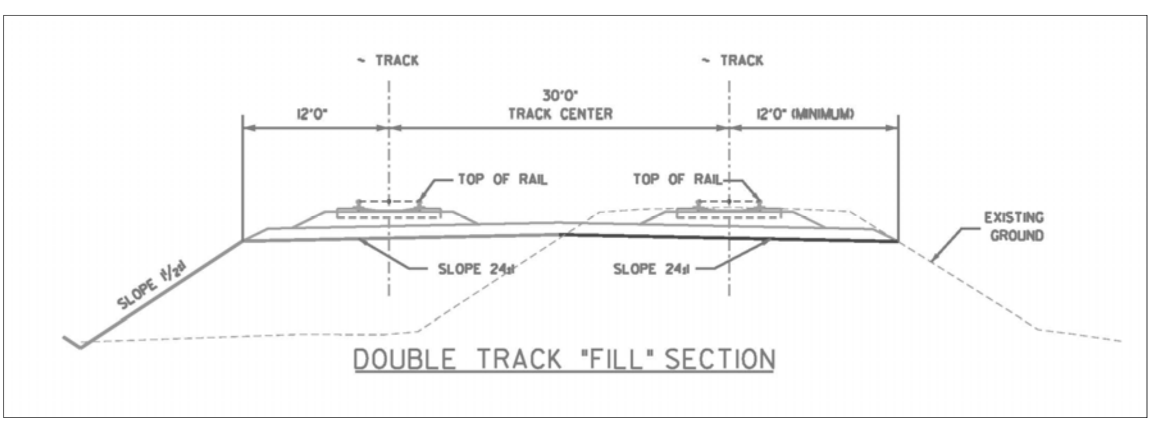


Figure 3 – Typical Section - Double Main Track on New Roadbed



2.2.1. HSR on Existing Roadbed

HSR on Existing Roadbed addresses the installation of a new track on an existing roadbed within an existing railroad right of way where track(s) has been removed. If there is an existing track present in the right of way, the new track will be built at an appropriate distance from it, generally using the same track centers as had been used before the historic second track had been removed. The track center to center distance is typically 14'. If there is no track in place, the new track will generally be centered in the right of way per the operating railroads typical track section. The work consists of leveling the roadbed, maintaining existing drainage, and placing a 6" ballast pad prior to track construction. "HSR Track" will be constructed on this base and the remaining 6" required ballast will be installed to allow final alignment and surfacing of the new track. The unit cost for this item is $1,123,000 per mile.

2.2.2. HSR on New Roadbed

HSR on New Roadbed is similar to the above, but requires subgrade preparation and the placement of 12" of compacted subballast before a ballast pad or the new track can be constructed. The unit cost for this item is $1,380,000 per mile.

2.2.3. HSR on New Roadbed with 30' Offset from Existing Track Centerline

This work item is used when building new HSR Track adjacent to an existing single or multiple main track system where the host railroad requires a minimum offset from existing operations; generally the minimum center to center offset is greater than 25' with the preferred offset being 30' from existing operations.

This work typically requires embankment widening and may also require property acquisition. Once the embankment work is completed, placement of 12" of compacted subballast, a ballast pad and the new track can be constructed. The unit cost for this item is $1,550,000 per mile.

2.2.4. HSR on New Roadbed & New Embankment

2.2.5. HSR on New Roadbed & New Embankment (Double Track)

These units are to be used when building track for HSR where no track or railroad right of way is present, or when the required track center distance to an existing freight operation places the proposed new track outside the limits of the existing roadbed and/or right of way limits. The work consists of site clearing the full width of additional roadbed or right of way (a minimum of 25 feet in width for single track and 50 feet in width for double track), preparing the subgrade (up to 5 feet above the surrounding ground elevation), establishing drainage patterns or maintaining existing drainage, and placing 12" of sub-ballast. "HSR Track" will then be constructed on this base. The unit costs for these items are $1,687,000 per mile for single track and $3,024,000 per mile for double track.

2.2.6. HSR Double Track on 15' Retained Earth Fill - This unit will be used when topographic conditions require an embankment to support the new track but the proper top of rail elevation cannot be provided within the existing right of way by an embankment using a standard 2:1 slope. The work consists of site clearing, building retaining walls to an average height of 15', placing properly compacted backfill material, providing for drainage, and placing 12" of sub-ballast on the retained earth fill. "HSR Track" will then be constructed on this base. The unit cost for this item is $15,972,000 per mile.

2.2.7. 3 Mile Long Freight Siding

2.2.8. 10 Mile Long Passenger Siding

This work consists of site clearing the full width of additional right of way required for the siding, generally 50 feet in width, preparing the roadbed and, maintaining existing drainage, and placing 12" of sub-ballast. "HSR Track" will then be constructed on this base. A #15 turnout will be installed at each end of a freight siding and a #33 turnout will be installed at each end of a passenger siding.

Separately, a 500' spur track, accessible via a #10 turnout, will be added to each freight siding (see section 6.2.2). A new Control Point will be established at each end of the proposed siding including access roadway (see section 6.2.1), and the new siding will be signalized and incorporated into the existing signal system in place on the adjacent main track.

The unit costs (for track construction only) are $4,288,000 for a 3 Mile Long Freight Siding and $14,496,000 for a 10 Mile Long Passenger Siding. New Control Point, M/W Spur & Roadway Access are added to the cost estimate in Sections 4 & 6 and not included in this Unit of Cost.

Note: for sidings in multiple track territory, a crossover (or crossovers) must be added to the new Control Points at both ends of the new siding to allow a train to access the siding from either track. For freight sidings, use a #15 crossover, for passenger sidings, use a #33 crossover. In addition to the crossover, signal work must be provided separately to add the additional trackwork to the signal system (Section 4).

2.3. Turnouts & Crossovers - This work includes:

- Removal and reclamation of the standard track section where the turnout or crossover will be placed
- Leveling of the roadbed and removing & stockpiling excess ballast for re-use
- Installation of a switch panel (or assembly and installation of a switch package) which includes all rods, plates, anchors, fasteners, 136/141 lb rail, switch points, stock rails, frog and wood or concrete ties and field welds to place the turnout into operation
- Ballast – placed to ensure 12" under the ties
- Filter fabric for the footprint of the turnout to be installed
- Track surfacing to ensure proper vertical and horizontal alignment of the turnout and the track that it is connected to
- Provision of a measure to protect the operating components of the turnout from freezing due to snow and ice: these include but are not limited to hot or cold air blowers and electric cal-rod heaters
- Crossovers will include a section of track (after the frogs of each turnout) with special timbers used until the track separates enough to allow standard "HSR Track on New Roadbed" to be constructed completing the connection between the opposite ends of the crossover.

The various types of turnouts to be used for HSR are:

2.3.1. <u>#33 Turnout - Timber Ties</u> - The unit cost for this item is $696,000 each.

2.3.2. <u>#24 Turnout - Timber Ties</u> - The unit cost for this item is $509,000 each.

2.3.3. <u>#20 Turnout – Timber Ties</u> - The unit cost for this item is $183,000 each.

2.3.4. <u>#15 Turnout – Timber Ties</u> - The unit cost for this item is $148,000 each.

2.3.5. #10 Turnout – Timber Ties - The unit cost for this item is $105,000 each.

2.3.6. 16'6" Double Switch Point Derail – Timber Ties- The unit cost for this item is $34,000 each.

2.3.7. #20 Turnout – Concrete Ties - The unit cost for this item is $282,000 each.

2.3.8. #15 Turnout – Concrete Ties - The unit cost for this item is $155,000 each.

2.3.9. #10 Turnout – Concrete Ties - The unit cost for this item is $133,000 each.

2.3.10. #33 Crossover - The unit cost for this item is $1,285,000 each.

2.3.11. #20 Crossover -The unit cost for this item is $563,000 each.

2.4. Track Improvements

Based on the above discussion, several categories of track improvements and types of track construction have been developed within MWRRI. These categories form the basis for the MWRRI Unit Costs and are discussed below.

2.4.1. Tie & Surface w/ 33% Tie Replacement - This work consists of removing 1/3 of the ties and replacing them with new ties. Additionally, 600 tons of ballast per mile will be placed to support the tie renewal. Assuming 19.5" tie spacing and 3249 ties per mile, this would result in the renewal of 1083 ties per mile. The unit cost for this item is $251,000 per mile.

2.4.2. Tie & Surface w/ 66% Tie Replacement - This work consists of removing 2/3 of the ties and replacing them with new ties. Additionally, 600 tons of ballast per mile will be placed in the work area to support the tie renewal. Assuming 19.5" tie spacing and 3249 ties per mile, this would result in the renewal of 2166 ties per mile. The unit cost for this item is $374,000 per mile.

2.4.3. Relay Rail with 136/141 # CWR - This work consists of removing existing rail, spikes, plates, and anchors and installing new 136 or 141 lb CWR and appropriate plates, fasteners and longitudinal restraints on existing crossties. The unit cost for this item is $400,000 per mile.

2.4.4. Surface Curves and Adjust Superelevation - The work consists of mechanized tamping of the track to provide a continuously smooth running surface for trains. The spirals and superelevation within the full body of the curves are to be adjusted to the degree required for increased operating speed. The trackwork will require the placement of approximately 1200 tons (976 cubic yards) of ballast per mile of track. It is assumed that appropriate tie renewal has taken place before the curves are adjusted. The unit cost for this item is $66,000 per mile.

2.4.5. Curvature Reduction - The work consists of designing and constructing a new track alignment through curved sections of existing track that will better support the operation of higher speed passenger trains. In the field this means that track will be realigned using special mechanized equipment designed for this purpose. The realignment will consist of adjusting the tangent–spiral–curve–spiral–tangent relationship which includes reducing the existing degree of curvature and lengthening the spirals in some locations. The realignment will require limited grading and sub-ballast placement to allow the track to be moved. The trackwork will require the placement of approximately 1200 tons (976 cubic yards) of ballast per mile of track. It is assumed that appropriate tie renewal has taken place before the curves are adjusted. The unit cost for this item is $444,000 per mile.

2.4.6. Elastic Rail Fasteners - This work includes removing and reclaiming existing tie plates, cut spikes and rail anchors, and installing two specialized tie plates with pad, eight lag screws, and four elastomeric clips per tie. This improvement is applied in curves in high speed territory to reduce future maintenance required to keep track in proper alignment and gauge. The unit cost for this item is $93,000 per mile.

2.5. Site Work Related to HSR Track Construction

2.5.1. Highway Barrier Type 5

2.5.2. Highway Barrier Type 6

This work includes the installation of a concrete roadside barrier for highways that run parallel to a railroad and are within 50' of the railroad centerline. The barrier shall meet the requirements of Test Level 5 or Test Level 6 as established in NCHRP Report 350. Type 5 (Test Level 5) is to be used in straight roadway sections and Type 6 (Test Level 6) is to be used in curved roadway sections. The AASHTO Roadside Design Guide shall be used to select the type of barrier that meets the NCHRP standards. The cost of these pay items include all materials and installation of the barrier per lineal foot. The unit costs for these items are $200 per LF for Type 5 barriers, and $1,300 per LF for Type 6 barriers.

2.5.3. Fencing, 4 ft Woven Wire (both sides of the railroad right of way) - This work includes the installation of 4 ft galvanized steel woven wire right-of-way fencing. Included in the cost are the fencing and post materials, clearing and grubbing of the area at the right-of-way line, and installation costs. The unit cost for this item is $58,000 per mile.

2.5.4. Fencing, 6 ft Chain Link (both sides of the railroad right of way) - This work includes the installation of 6 ft galvanized steel chain link right-of-way fencing. Included in the cost are the fencing and post materials, clearing and grubbing of the area at the right-of-way line, and installation costs. The unit cost for this item is $173,000 per mile.

2.5.5. Fencing, 10 ft Chain Link (both sides of the railroad right of way) - This work includes the installation of 10 ft galvanized steel chain link right-of-way fencing. Included in the cost are the fencing and post materials, clearing and grubbing of the area at the right-of-way line, and installation costs. The unit cost for this item is $198,000 per mile.

2.5.6. Decorative Fencing (both sides of the railroad right of way) - This work includes the installation of decorative right-of-way fencing. The type of fencing will be determined by the municipality in which the fence is installed. Included in the cost are the fencing and post materials, clearing and grubbing of the area at the right-of-way line, and installation costs. The unit cost for this item is $446,000 per mile.

2.5.7. Drainage Improvements (cross country) - This work includes the installation of drainage pipe, assumed to be a maximum of 30" in diameter, at locations where new track or track sidings will be installed and/or embankment widened. It is assumed that 2 drainage pipes per mile of improvements will be installed. The unit cost for this item is $75,000 per mile.

2.6. Land Acquisition - To estimate land values, two units have been identified:

2.6.1. Land Acquisition Rural (e.g., farmland)

2.6.2. Land Acquisition Urban (e.g., high density residential, commercial, and industrial areas)

- Where the alignment falls within an existing railroad or publicly-owned right-of-way it has been assumed that no land acquisition cost will be required for that particular right-of-way.
- Where the geometric requirements take the alignment outside of the railroad or publicly owned right of way, it has been assumed that additional right-of-way, a minimum of 50' in width, will be needed for cases where land is required to expand an existing right-of-way.
- The cost development for land acquisition assumes the need for a strip of land 50' wide by 1 mile long, roughly 6.06 acres. The per acre cost for land acquisition for urban and rural settings in MN & WI was obtained from local sources.
- The unit cost for Land Acquisition – Rural is $185,680 per mile; for Land Acquisition – Urban, the cost is $557,580 per mile.

3. Structures

Similar to track infrastructure, bridges and structures will require significant capital investment to provide the capability to support new HSR passenger service on new alignments, new passenger service on existing or historical freight lines, or combined passenger & freight service along existing freight lines.

3.1. Design Considerations

General design considerations have been established to guide conceptual planning and are listed below.

- Bridges generally include superstructure, substructure, appropriate wing walls and embankment retention systems, and approach treatments in both directions from the bridge
- All timber pile trestle bridges will be completely replaced with the appropriate new bridge type based on the owning railroads standards for the operation or AREMA suggested practices
- Other than wooden structures within an existing rail corridor, structures will be rehabilitated for use as part of the proposed HSR system where possible and practical to bring them into a state of good repair. It is assumed that rehabilitation will take place where the rehabilitation cost is less than or equal to 50% of the cost of bridge replacement. Rehabilitation could include pointing of stone abutment walls, repair of spalling concrete, painting of bridges, waterproofing and replacement of bearings.
- In areas where the proposed service will allow the use of the historical track centers between an unoccupied roadbed and an adjacent existing and operating track (double track right of way), all bridges for both the existing and proposed track alignments will be rehabilitated to the required level of service or be replaced
- In areas where the proposed service will travel under existing bridges carrying highway, railroad or pedestrian traffic over the alignment, the addition of a new track at various track centers may be infeasible due to insufficient portal opening to accommodate the new track. In these instances, the overhead bridge will be replaced to accommodate the proposed alignment.
    - In some cases, it may be possible to modify the piers, abutments and other structural features of the existing overhead bridge to accommodate the new track. However, the extent to which this will be possible requires more a more detailed engineering study which is not conducted at the conceptual level. Since that is the case, a conservative assumption is made that unless there is a clear indication that the existing portals will allow the construction of a new track or tracks, the overhead structure will be replaced.

- Tunnels and very large river bridges will maintain the existing number of tracks at the existing track centers. At these locations in single track territory, a 3 mile long siding will be provided for freight trains on either side of the tunnel or bridge.
- In areas where the proposed alignment prevents the use of existing bridges or where there are no existing bridges, new bridges will be built as needed.

Structure Categories

Structures expected for the development of HSR include bridges that carry the railroad over an environmental feature, for instance, a river; these bridges are categorized as "undergrade". Bridges that carry an environmental feature over a railroad, for instance, a two lane highway, are categorized as "overhead". Additionally, other structures such as tunnels, structural culverts and retaining walls are included in this section. The type size and location of these structures will be determined during Preliminary Engineering; for these conceptual cost estimates, general categories of structures and their unit costs have been developed based on their function and an estimate of required cross section and approximate cost per square foot and are listed below. These costs are for the structures and their typical components only; the cost of any track features must be priced separately.

3.2. Bridges – Undergrade

This group of unit costs is intended to capture the level of effort required to allow the addition of a new track parallel and adjacent to an existing track as it passes over a variety of obstacles in the environment. Generally, the work will include provision of new abutments or abutment extensions, necessary grading and earth retention system to control the embankment at the abutments, any new piers or pier modification necessary and the placement of a new superstructure and track on the substructure at these locations.

3.2.1. Four Lane Urban Expressway - The unit cost for this item is $5,468,000 each.

3.2.2. Four Lane Rural Expressway - The unit cost for this item is $4,552,000 each.

3.2.3. Two Lane Highway - The unit cost for this item is $3,454,000 each.

3.2.4. Rail - The unit cost for this item is $3,454,000 each.

3.2.5. Minor River – generally, this bridge type is less than 100' between abutments with relatively short span lengths. The unit cost for this item is $916,000 each.

3.2.6. Major River - generally, this bridge type is up to several hundred feet between abutments with significant span lengths. The unit cost for this item is $9,158,000 each. Bridges having distances between abutments greater than several hundred feet should be included separately as a special allocation, specific to a given location.

3.2.7. Double Track High (50') Bridge - The unit cost for this item is $14,000 per lineal foot.

3.2.8. Ballasted Deck Replacement Bridge - The unit cost for this item is $3,200 per lineal foot.

3.2.9. Rehabilitate Existing Bridge for Higher Passenger Speeds (90-110 mph) - The unit cost for this item is $1,580 per Lineal Foot

3.2.10. Convert open deck bridge to ballast deck (single track) - The unit cost for this item is $5,000 per lineal foot.

3.2.11. Convert open deck bridge to ballast deck (double track) - The unit cost for this item is $10,575 per lineal foot.

3.2.12. Single Track on Flyover/Elevated Structure - The unit cost for this item is $10,231 per lineal foot.

3.2.13. Double Track on Flyover/Elevated Structure - The unit cost for this item is $17,904 per lineal foot.

3.2.14. Land Bridges - The unit cost for this item is $3,000 per lineal foot.

3.3. Bridges – Overhead

This group of unit costs is intended to capture the level of effort required to allow the addition of a new track parallel and adjacent to an existing track as it passes under a variety of overhead bridges along the chosen route. Generally, the work will include modifications to the existing overhead structures to allow sufficient room for the new track to be added without causing close clearances or other problems in relation to the existing track and the existing overhead bridge.

3.3.1. Four Lane Urban Expressway - The unit cost for this item is $3,312,000 each.

3.3.2. Four Lane Rural Expressway - The unit cost for this item is $2,360,000 each.

3.3.3. Two Lane Highway - The unit cost for this item is $2,152,000 each.

3.3.4. Rail - The unit cost for this item is $6,909,000 each.

3.4. Other Structures

3.4.1. Culvert Extensions - This work includes the installation of a culvert extension in locations where a new track will be built parallel and adjacent to an existing track. The culvert extension consists of a new pipe starting at the end of the existing culvert and extending to the edge of the embankment that the new track will be built upon. The cost includes connection to the existing pipe, associated grading, headwall and embankment retention associated with the culvert. It is assumed that the extension will consist of a maximum size of 36" reinforced concrete pipe. One culvert extension will be installed per mile of improvements on average. The unit cost for this item is $58,000 per mile.

3.4.2. Single Track on Approach Embankment with Retaining Wall – This work is to be performed in cases where there are significant changes in the vertical alignment of a proposed new single HSR track approaching an existing or new structure over an obstacle in the environment. It consists of providing the proper combination of embankment and retaining wall to support the grade change of the single HSR track on both sides of the structure. The unit cost for Single Track on Approach Embankment with Retaining Wall is $5,115 per lineal foot.

3.4.3. Double Track on Approach Embankment w/ Retaining Wall - Similar to Single Track on Approach Embankment with Retaining Wall, Double Track on Approach Embankment with Retaining Wall addresses changes in vertical alignment as a new double HSR Track approaching an existing or new structure over an obstacle in the environment. The unit cost for this item is $9,378 per lineal foot.

3.4.4. Two Bore Long Tunnel - The unit cost for this item is $45,540 per route foot.

3.4.5. Single Bore Short Tunnel - The unit cost for this item is $25,875 per lineal foot.

4. Systems

In all instances where passenger rail service is proposed to operate at speeds between 79 mph and 110 mph, a Centralized Traffic Control (CTC) signal system must be provided. Additionally, for the service to comply with FRA safety requirements, a Positive Train Control (PTC) signal system must be provided by 12/31/2015. These systems are designed to allow safe service when passenger and freight operations are mingled as well as safe operations at higher speeds.

4.1. Design Considerations

General design considerations have been established to guide conceptual planning and are listed below.

- All signal elements include hardware and software to design, procure, install and operate the element under consideration. This includes "signals", "communications" & "dispatch" components which together make up the interactive remote controlled signal system.
- At all locations where a train can change from one track to another, or divert from the main track to a siding, yard or railroad using remote controlled switches, a Control Point (CP) must be established. The control point links the track infrastructure and circuitry to a communications network allowing the dispatcher to maintain or change the route of a given train, as well as allow it to proceed or cause it to stop. Significant components are the remotely controlled powered switch machine, cable connecting it to logical and relays and microprocessor based control and communication equipment housed in a wayside building, a communications link between the control point and the remote dispatcher, signals to provide a train approaching from any direction with visual indications governing its movement, and a provision of commercial electrical power and backup to operate the various elements.
- At locations where a connection to an rail served industry is required, protection must be provided so that a freight or passenger train cannot be unintentionally diverted into the industry track and also so that a railcar or other vehicle occupying the siding cannot access the main track without permission from the dispatcher controlling the main line railroad. Typically at these locations, a switch is installed and "electric lock" protection is provided at the switch. Along the siding, a derail is placed as a measure to prevent an uncontrolled movement from the siding to the main or vice versa. The electric lock prevents opening the switch without the knowledge of and direct permission from the dispatcher in charge of the railroad. When the switch is opened, the track circuitry "notifies" the dispatcher and wayside signals in either direction.
- Interconnection of railroad signal control equipment and traffic signal control equipment will be considered where a signalized highway intersection exists in close proximity to a railroad crossing. Interconnection allows the normal operation of the traffic signals controlling the intersection to be preempted to operate in a special control mode when trains are approaching (see MUTCD Sections 8D.07 and 10D.05). A preemption sequence compatible with railroad crossing active warning devices such as gates and flashing lights is extremely important to provide safe vehicular, pedestrian, and train movements. Such preemption serves to ensure

that the actions of these separate traffic control devices complement rather than conflict with each other."[2]

Since almost all locations where interconnection will be considered are unique in terms of physical placement of the highway and railroad, traffic volumes for each mode and other features particular to a location, the design of any interconnection will be different as will the costs. Additionally, owning railroads and local and state authorities are likely to have their own design preferences for interconnection and close coordination between the two will be required. For these reasons and the complexity of the subject, the development of a standard cost of interconnection is not included in this methodology.

- Following a series of deadly rail accidents at various locations in the U. S., Congress passed the Rail Safety Improvement Act of 2008 (RSIA08). The RSIA mandates that PTC systems be installed by December 31, 2015 on all railroad mainline tracks that carry intercity passengers, commuters, or are part of a Class I railroad system carrying at least 5 million gross tons of freight annually and carrying any amount of poison-or toxic-by inhalation (PIH or TIH) hazardous materials. The affected railroads were required to submit their PTC Implementation Plans to the FRA for approval by April 16, 2010. Forty railroads submitted PTC Implementation Plans and other related documents in response to that mandate.
- Several of the short lines and regional railroads whose routes may potentially become part of the MWRRI network did not submit PTC Implementation Plans to the FRA because they believed that their current operations did not meet the federal requirements to do so. Many of the short lines and regional railroads which will host MWRRI routes currently operate under Track Warrant Control (TWC) systems (also known as "dark territory") and do not now use higher level signal systems in their operations. For high speed passenger train operations over routes that are in this category, each involved short line or regional railroad will need to design and install a signal system as a foundation over which the PTC system can be overlaid. (All presently-proposed PTC systems are designed to be overlays to existing systems.)

4.2. Signal Categories

General signal categories have been developed based on their function and are discussed below.

4.2.1. Install CTC System (Single Track)

4.2.2. Install CTC System (Double Track)

This signal system will serve as a foundation for the FRA mandated PTC system overlay. Installation of a CTC system includes all communications and central dispatch equipment, track circuitry, and wayside signaling to control the flow of rail traffic to avoid safety issues and collisions between trains. The unit costs for these items are $207,000 per mile for single track and $339,000 per mile for double track.

4.2.3. Install PTC System

[2] PREEMPTION OF TRAFFIC SIGNALS NEAR RAILROAD CROSSINGS, INSTITUTE OF TRANSPORTATION ENGINEERS, ***DRAFT VERSION 10,*** July 1, 2003

Installation of a PTC System includes all communications and central dispatch equipment, track circuitry, and wayside signaling to comply with the requirements of the Rail Safety Improvement Act of 2008 (RSIA08) which calls for the implementation of PTC by 12/30/2015.

All presently-proposed PTC systems are designed to be overlays to existing systems and a stand-alone PTC system is not currently available. The railroads have submitted plans to FRA to use one or more of the following three PTC systems in the MWRRI service territory:

ITCS	Amtrak
ETMS	BNSF & KCT
V-ETMS	BNSF, Amtrak, CRSH, NICTD, KCT, CSX, NS, CN, KCS, TRRA, CP, Metra, & UP

The unit cost for this item is $177,000 per route mile.

4.2.4. Electric Lock and Derail for Industry Turnout

This work involves the installation of electric lock protection and associated derail at an industry turnout. The pay item includes costs for the electric lock and layout, the wayside case, foundation, and components within the case, commercial power and power connection materials, track connections, the double switch point derail and the battery, battery box and all wire connections. Additionally, the work includes intermediate signal modifications and track circuit modifications to tie the new Electric Lock Switch location into the existing signal system. The unit cost for this item is $116,000 each.

4.2.5. New Control Point for an End of Siding Turnout – single track

4.2.6. New Control Point for an End of Siding Turnout and Crossover – double track

4.2.7. New Control Point for a Universal Crossover

This work involves installing all power operated switch machines, hardware, software, communications, cabinets and housings, and commercial power to establish and operate a new Control Point (CP). Additionally, the work includes intermediate signal modifications and track circuit modifications to tie the new CP into the existing CTC signal system present on the tracks leading into the CP. The unit cost for:

- the new End of Siding CP in single track (for a turnout only) is $650,000,
- the new End of Siding CP in double track (for a turnout and crossover) is $1,296,000
- the new Universal Crossover CP is $1,619,000

4.2.8. Signal Work to Add a Turnout to an Existing Control Point

4.2.9. Signal Work to Add a Crossover to an Existing Control Point

This work involves installing all signal components needed to put the turnout, crossover, or combination of turnouts and crossovers into operation within the CP. Some of the included components are the power operated switch machine, associated controllers, wiring/cabling and hot air blowers. The unit costs for these items to be added to an existing CP are:

- $452,000 for each turnout
- $792,000 for each crossover

4.2.10. Traffic Signal Preemption

4.2.11. Traffic Signal Preemption & Intersection signalization

This work involves installing all signal components needed to provide traffic signal preemption and traffic signal preemption with intersection signalization at a highway railroad at-grade crossing and place the crossing warning system in service. Some of the included components are the power drop, associated controllers, communications, and wiring/cabling and housing for the required equipment. The unit costs for these items are:

- $75,000 for Traffic signal preemption
- $300,000 for Traffic signal preemption with Intersection signalization

5. Crossings

The treatment of grade crossings to accommodate 110 mph operations is a major challenge to planning a high-speed rail system. Highway/railroad crossing safety will play a critical role in future project development phases and a variety of devices will be considered to improve safety, including roadway geometric improvements, median barriers, barrier gates, traffic channelization devices, wayside horns, fencing and the potential closure of crossings.

FRA guidelines require the use of four quadrant gates with constant warning time activation at public crossings for 110 mph passenger operations. Constant – warning time systems are essential to accommodate the large differential in speed between freight and passenger trains. The treatment and design of improved safety and warning devices will need further development to identify specifications and various approaches that may be advanced as part of an integrated program.

5.1. Design Considerations

Grade crossing improvements are a significant component of the capital cost estimates for passenger rail service. For the purpose of establishing a reasonable cost estimate at the conceptual design stage, the following design parameters are proposed.

- Where passenger speeds are greater than 79 mph, 25 percent of the existing crossings on the route will be closed

- Where speeds do not exceed 79 mph, private crossings will not be affected
- Where passenger speeds are greater than 79 mph, train warning systems at public crossings will be upgraded to four quadrant gates with enhanced train detection/prediction/notification capabilities, and private crossings will be upgraded to standard two quadrant gates and flashers
- Where passenger speeds do not exceed 79 mph, train warning systems will be upgraded to standard two quadrant gates and flashers with constant warning time and private crossings will be upgraded to standard two quadrant gates and flashers
- Precast crossing surface panels will be installed at all public crossings on existing track at locations where trackwork related to passenger service takes place
- Precast crossing surface panels will be installed on both new and existing tracks and the roadway will be re-profiled where new track is constructed through the crossing

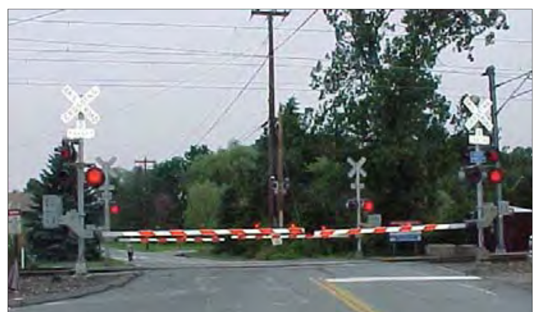
5.2. Crossing Improvement Categories

5.2.1. Crossing Closure

This work consists of completely removing the crossing surface and roadway approaches that lead across the tracks within railroad right of way. If there are any warning devices, those will be removed as well. The estimate includes the cost of modest improvements such as barricades/roadway closure treatments and alternate connection to an existing roadway. The unit cost for this item is $94,000 each.

5.2.2. Four Quadrant Gates

The work consists of installing a warning system where a roadway crosses a railroad at-grade. The four-quadrant gate system includes all hardware, software, wiring, communication equipment and commercial power with battery backup to operate the warning system. A power drop is required at each at-grade crossing. The unit cost for this item is $326,000 each.



Four Quadrant Gates at the School Street crossing on the Northeast Corridor High Speed Rail Line in Mystic, CT. (*Volpe Center photo*)

5.2.3. Four Quadrant Gates w/ Trapped Vehicle Detector

The work consists of installing a warning system where a roadway crosses a railroad at-grade. The four-quadrant gate with vehicle presence detection system includes all hardware, software, wiring, communication equipment and commercial power with battery backup to operate the warning system. A power drop is required at each at-grade crossing. The unit cost for this item is $556,000 each.

5.2.4. Convert Dual Gates to Quad Gates

Work for converting a dual gate warning system to a quad gate system includes the installation of two additional gates at each crossing and the associated software and communications changes necessary to integrate the new gates into the electrical and communications systems that the existing system utilizes. The unit cost for this item is $170,000 each.

5.2.5. <u>Conventional Gates/single mainline track</u>
5.2.6. <u>Conventional Gates/ double mainline track</u>

Work to install conventional gates for a single mainline track includes all hardware, software, wiring, communication equipment and commercial power with battery backup to operate the warning system. Additional measures for a double mainline track include the installation of <u>Manual on Uniform Traffic Control Devices (MUCTD)</u> -approved signs that specify “2 TRACKS” located on the same post as the crossbucks. The unit costs for these items are $188,000 each for single track and $232,000 each for double track.

5.2.7. <u>Convert Flashers Only to Dual Gate</u>

This work includes adding crossing barrier gates in two highway quadrants to an existing warning system consisting of flashing lights, warning bell and crossbucks to provide a dual gate warning system for the at-grade crossing. Costs for this pay item include all hardware, software, wiring, communication equipment and commercial power with battery backup to operate the modified warning system. The unit cost for this item is $57,000 each.

5.2.8. <u>Dual Gate with Median Barrier</u>

Work consists of installation of conventional gates including all hardware, software, wiring, communication equipment and commercial power with battery backup to operate the warning system. The work also includes design and construction of a median barrier between opposing lanes of traffic on both approaches to the crossing and required modifications, re-profiling and paving to the roadway surfaces as well as precast crossing surface panels within the limits of the track structure. The unit cost for this item is $204,000 each.

5.2.9. <u>Convert Dual Gates to Extended Arm</u>

This work includes the installation of an extended arm on an existing crossing device. The cost also includes the parts and labor to modify or replace, as necessary, the motor mechanism and balance weights to support the extended arm. The unit cost for this item is $17,000 each.

5.2.10. <u>Precast Panels without Roadway Improvements</u>
5.2.11. <u>Precast Panels with Roadway Improvements</u>

This work includes installing prefabricated concrete and steel crossing surface panels at a grade crossing. The crossing panels are placed within the track structure at the crossing to form a smooth running surface for vehicular traffic. The top surface of the panel will be level with the top of rail. The width of the crossing treatment will include and extend beyond associated sidewalks if present. At a minimum, the crossing panels will extend 2' beyond the paved roadway surface or sidewalk.

Where roadway improvements are required, roadway crown and superelevation in the approach pavement will be eliminated at or tapered into the crossing to match the grade and profile of the track. Additionally, the elevation of the approach pavement will be reconstructed to equal the top of rail for a minimum of 2 ft beyond the outer rail of the outermost track in each direction. Finally, the roadway surface must be within +/- 3" of the top of rail at a distance of 30' from the outermost rail unless track superelevation dictates otherwise. The unit costs for these items are $90,000 each without roadway improvements and $170,000 each with roadway improvements.

6. Allocations for Special Elements (Placeholders)

6.1. The methodology includes placeholders as conservative estimates for large and/or complex engineering projects that have not been estimated on the basis of unit costs and quantities. Placeholders are used where detailed engineering requirements are not fully known and provide lump sum budget approximations based on expert opinion rather than on an engineering estimate. These approximations will require close attention as the project moves through further phases of development. The following list highlights some of the key placeholder categories that are assumed in this analysis.

- Bottleneck mitigation

- Rail capacity preservation at yards, junctions and complex interchange networks

- Areas where the addition or expansion of railroad infrastructure is likely to impact adjacent public infrastructure

- Areas of known environmental concerns where the extent of impacts and required mitigation measures are uncertain.

Some Special Elements have been identified and assigned a cost based on previous experience with similar efforts; these are shown in the following sections. Additionally, it is expected that special elements based on the previously listed placeholder categories will be added to the cost estimate(s) based on field reviews of existing conditions and other background investigations of the proposed routes.

6.2. Allocations

Yards - In order to effectively estimate the capital costs that would be incurred to extend High Speed Rail (HSR) operations through congested freight yard and terminal areas in cities and towns without the expense of performing extensive due diligence efforts in the earliest planning stages, three categories have been established based on the expected level of capital expenditure required to mitigate the conflicts between freight and passenger traffic. Based on an investigation of six yard areas along two routes, infrastructure requirements and corresponding capital costs were derived and evaluated in terms of magnitude.

Category A: Smaller town sidings or yards and key junctions with a lower level of freight activity
Category B: Active Mainline Yards & Terminals with moderate to heavy freight activity
Category C: Major Terminal Areas with heavy freight activity and complex interchanges

A detailed evaluation of the locations considered that fall into this Category, along with the suggested infrastructure improvements and costs required to mitigate passenger & freight conflicts, is included as part of Appendix C to this document.

6.2.1. Category A has been assigned a placeholder value of $10,000,000

6.2.2. Category B has been assigned a placeholder value of $30,700,000

6.2.3. Category C has been assigned a placeholder value of $37,400,000

Track Access

6.2.4. Access to Signal/Switch Location

In order to facilitate maintenance of the railroad infrastructure, access roadways will be provided for control points, wayside signal locations, industry switch locations, and significant bridges. A 12' wide gravel road will be constructed to allow maintenance vehicles access to the right of way from a local road along with pullout locations to allow for vehicles to turn around. The unit cost for this item is $100,000 each.

6.2.5. Maintenance of Way Spur Track

To provide access for track maintenance activities in high speed territory, Maintenance of Way spur tracks will be placed at 20 mile intervals and associated with freight sidings. The spur will provide 500' of storage for track machinery to clear main tracks overnight. Additionally, it can be used as a bad order set-out track for freight trains. A power-operated #10 turnout will be used for access to the spur and split-rail derail will be installed to protect the main track and siding. A wheel stop will be provided to allow for the use of an end-of-car ramp to load/unload flat cars of track machinery. A 12' gravel access road will be constructed to allow maintenance vehicles to access the track from a local road. The unit cost for this item is $673,000 each.

Other Placeholders

6.2.6. Rail-Rail Flyovers

No rail-rail crossings (crossing diamonds), will be allowed in track segments with authorized maximum speed above 79 mph and where traffic levels would likely create delays for the proposed HSR passenger corridor. Existing crossing locations where the HSR is not operating on the "senior" railroad or where existing traffic levels on either or both of the crossing lines would be likely to impact on time performance are locations that would indicate that further investigation of the situation is needed.

If proven to be necessary, a grade separation ("flyover") will be constructed to carry the high-speed passenger route over the intersecting rail line. It is assumed that the flyover to be constructed would be a double track flyover built on a combination of embankment, retained earth and structure and that a grade of 1% would be used to accommodate freight operations. If a 1.5% grade were to be agreed to by the freight operator, savings approaching 30% could be realized. If the freight operation were left at grade and a single track flyover was built for passenger use only, savings of over 50% (compared to the double track flyover with a 1% grade) could be realized by avoiding the cost of a second track as well as being able to use a 2% grade. A placeholder of $40,000,000 has been used for cost estimating purposes.

7. Contingency & Soft Costs

Contingencies are an allowance for unexpected costs added to the estimated construction costs based on past experience for projects in early stages of definition. Their purpose is to account for items and conditions that cannot be identified with certainty during the conceptual design phase of the project. Contingency costs are added as an overall percentage of the total construction cost. The contingency for this level of detail is set at 30% of the estimated direct construction cost elements. The contingency percentage is expected to be reduced as the project advances into more detailed engineering and conceptual uncertainties are investigated and resolved. Contingencies should not be considered as potential savings. The contingency amount is expected to be expended within the project; typically, as the project develops, contingency amounts are transferred to construction cost as project details are investigated during continued design. In effect, project uncertainties become known project elements as the project matures.

Soft Costs are associated with the planning, design and coordination of the project. These include design engineering, insurance and bonding, program management, construction management and inspection, and engineering services during construction. The percentage for each project element is as follows:

Design Engineering	10%
Insurance and Bonding	2%
Program Management	4%
Construction Management & Inspection	6%
Engineering Services During Construction	2%
Total Soft Costs	24%

Appendix A: Capital Cost Technical Memorandum

Quandel Consultants, LLC
Engineering Services
161 North Clark Street, Suite 2060
Chicago, IL 60601
(312) 634-6200
Fax: (312) 634-6232
www.quandel.com

Technical Memorandum

Subject:	**Midwest Regional Rail Initiative – Phase VII** **Strategy to Update Capital Costs**
Prepared For:	**Wisconsin Department of Transportation**
Prepared By:	**Quandel Consultants, LLC**
CC:	
Date:	**April 18, 2011**

Background

The FRA Statement of Work for Task 3, Update MWRRI System Capital Costs states that "the Grantee will use proper AAR, ENR cost indices, as appropriate, and adjust corridor improvement levels to account for speed changes (IDOT), on-going capacity analysis (MoDOT, WisDOT) and other system changes".

The current unit costs employed by the MWRRI were originally developed as part of MWRRI Phase 3B in 1997. Those unit costs were based on previous high speed rail feasibility studies available at that time and cost information provided by Amtrak. Each of these unit costs has since been inflated to 2002 dollars, which are the most recent costs available for the MWRRI. The MWRRI 2002 unit costs were evaluated by peer panels, freight railroads, and contractors, and were determined to be sufficiently accurate for developing capital cost estimates for "force account" construction by the host railroads.

The purpose of this technical memorandum is to determine the appropriate cost index or indices to use in adjusting unit prices and to verify that the adjusted unit prices are reasonably in line with unit costs currently used by the freight railroads.

Available Cost Escalation Indices

Several different cost indices are used to monitor construction costs in the United States. One widely-used index is the Construction Cost Index (CCI) maintained by Engineering News Record. The CCI is a general purpose index used to track the cost of 200 hours of union labor (including fringe benefits), 1.128 tons of Portland cement, 25 cwt of fabricated structural steel, and 1,088 board-ft of 2x4 lumber. ENR also tracks a Building Cost Index (BCI), which uses the same material inputs as the CCI but with a labor component based on the wage rate for carpenters, bricklayers, and iron workers. Each of these indices is tracked nationally according to a 20-city average, and locally for each of the 20 different cities. Though both the CCI and BCI capture general construction cost trends, they are best suited for tracking building construction costs and regional cost differences.

Though some of the state DOT's also publish highway construction cost indices, such as those available from CalTrans and the Washington DOT, none publish any railroad construction cost data. Within the rail industry, the American Association of Railroads (AAR) publishes a Railroad Cost Recovery index that tracks changes in input prices to railroad operations. Some of these inputs, such as the price of diesel fuel and the cost of wages and benefits for railroad workers, are more appropriate for monitoring costs within the railroad industry. However, the AAR indices don't capture the changes in construction costs. As of this time no cost data or cost index are available from the FRA.

<u>Producer Price Index</u>

The Bureau of Labor Statistics (BLS) publishes monthly Producer Price Indices (PPI) for a defined set of industries. In the absence of actual construction cost data, PPI data provide an easy to use and readily available source for updating MWRRI capital costs. The indices measure the average change in prices received by domestic producers for goods sold outside of the industry. Each index is comprised of a fixed set of producer outputs that are representative of the industry as a whole. Several of these indices are used for cost escalation and adjustment in construction projects. The BLS does publish some construction-related PPI indices, such as the Highway and Street Construction Index (PPI Series ID *PCUBHWY*). Since the PCUBHWY is heavily influenced by the cost of petroleum products for items such as asphalt, it is not appropriate for tracking rail construction costs.

An index better suited to capture the cost increases associated with high-speed rail is the *Material and Supply Inputs to Other Heavy Construction* index (PPI Series ID *PCUBHVY*). Table 1 shows the top 25 weighted inputs to *PCUBHVY.* The index includes 'Fabricated Structural Metal Manufacturing', 'Other Concrete Product Manufacturing, and 'Other Commercial & Service Machinery Manufacturing', and 'Petroleum Refineries' as some of the most heavily weighted sectors in the index. Many of these input costs are associated with high-speed rail construction items, such as diesel fuel and heavy equipment, which have risen faster than the costs of general construction materials as a whole since 2002. Using the *PCUBHVY* index to escalate MWRRI costs from June 2002 through October 2009 (the most recently finalized index value) produces a cost escalation factor of 1.431. The PCUBHVY index and the method for calculating the escalation factor are shown in Table 2.

Table 3 shows the MWRRI unit costs updated using the PCUBHVY index. Costs are reduced to 'pure construction' unit costs for the purpose of comparing costs in this memorandum. Pure Construction unit costs remove the 31% soft costs included in the 2002 unit costs, and include only the materials and direct labor associated with each pay item.

1. Comparison of Updated Unit Costs to Other Available Data

   Other available unit cost data were compared to the newly updated unit costs to assess the validity of the PPI PCUBHVY updating methodology.

   a. Updated Phase 7 Unit Costs vs. a Multi-Index PPI Escalation

      Table 4 shows ten sample MWRRI pay items broken down into their original labor and material components. These cost breakdowns, taken from the 1998 MWRRI Phase 3B Report, are shown originally valued in 1993 dollars. This was the year that these particular sample pay items were developed into the 'subunit' costs and quantities shown in Table 4. Each of the sample pay item subunit costs is adjusted for inflation according to an appropriate PPI index, and is then summed to get an updated cost in 2009 dollars. Table 5 shows a comparison of the escalated sample unit costs in 2009 dollars, comparing the unit costs inflated using *PCUBHVY* vs. those inflated in Table 4. As Table 5 shows, the cost difference using the two methods is relatively small - less than $30,000 and 3% - for six of the ten items. The other four items show differences of between 15 and 65%. However, these differences are both positive and negative, and across all ten sample items the average difference in inflation methods is $14,820, or 6.1%.

      Table 4 also shows that a labor overhead rate of 85% was used in the original 1993 cost buildup. However, recent cost data obtained from cost estimates produced by several of the Class I freight railroads show current labor overhead rates range between 125% and 140%. The *PCUBHVY* index does include some finished goods components, which likely include any increases in labor overhead rates over time. But the index is not likely to capture the full magnitude of the cost increase when labor overhead is increased from 85% to 125% or more. Table 6 shows the resultant cost increase when the labor overhead rate increases from the 85% used in 1993 to an updated estimated rate of 133%.

      Note that some adjustments were made in Table 4 to account for certain changes in pay items since they were originally developed. Since the MWRRI now uses 136# rail as a standard, whereas the original 1993 cost buildup used 115#, the subunit cost of steel for 136# rail was increased by a factor of 136/115 = 1.18. Subunit quantities in the item 'Timber & Surface with 66% Tie replacement' were also updated to account for the new percentage of tie replacement, which has been increased from the original value of 60%. One assumption also made in Table 4 is that since the installation of concrete ties in mainline track construction is prevalent, the price of installing concrete and timber ties is converging. Thus the difference in wood vs. concrete ties can be ignored for the purpose of comparing the unit costs as a whole, and no adjustments were made to account for the more recent use of concrete ties in track construction.

b. Updated Phase 7 Unit Costs compared to Other Sample Unit Cost Data

Cost estimates for four different Midwest rail projects were also compared to the updated Phase 7 unit costs. Each of these estimates was developed separately by a different Class I freight railroad. The pay items in these jobs that were found to be similar to MWRRI pay items are listed and compared in Table 7. In most cases the unit cost estimates developed by the freights are greater than the MWRRI unit costs. Of the ten items compared in Table 7, seven items show freight estimated unit costs within 15% of the updated Phase 7 unit costs. The track work pay item, which is the most used pay item throughout the Midwest system, is within 10.5% of the freight estimated cost.

2. Unit Cost Adjustment and Final Unit Costs

Table 8 shows the unit cost adjustments and the draft Phase 7 unit costs. The draft Phase 7 unit costs are shown in October 2009 dollars, since October was the most recent month for which finalized PPI indices were published as of this writing. Table 8 also includes adjustments for the unit cost increases shown in Table 6 that were added based on the updated labor overhead rate. Additionally the average 6% cost increase over the *PCUBHVY* escalation, as shown in Table 6, was added to all track items to account for the increase in freight railroad labor overhead.

Based on the evidence discussed here we conclude that the *PCUBHVY* is the most appropriate index available for updating MWRRI unit costs. However, we also conclude that the use of this index alone does not fully capture the cost increases needed to produce estimates comparable to those used by the freight railroads in their construction estimates. Further cost adjustments are necessary in order to reconcile the difference in the cost estimation method used here, and the methods used by the freight railroads.

Table 1

PPI Index *Material and Supply Inputs to Other Heavy Construction (PCUBHVY)*

Top 25 Inputs By Weight

Sector	Relative Importance
Prefabricated metal buildings and components	12.786
Fabricated structural metal manufacturing	9.257
Petroleum refineries	8.057
Other concrete product manufacturing	6.112
Other commercial & service machinery mfg	5.101
Ready-mix concrete manufacturing	4.381
All other plastics product manufacturing	3.967
Concrete pipe manufacturing	3.464
Metal tank, heavy gauge, manufacturing	2.549
Other communication and energy wire mfg	2.463
Industrial valve manufacturing	2.102
Ornamental and architectural metal work mfg	2.017
Metal window and door manufacturing	2.000
Asphalt paving mixture & block mfg	1.861
Fluid power valve and hose fitting mfg	1.407
Iron and steel mills	1.395
Electric power distribution	1.126
Cement manufacturing	0.998
Switchgear and switchboard apparatus mfg	0.995
Other communications equipment manufacturing	0.959
Prefabricated wood building manufacturing	0.957
Paint and coating manufacturing	0.765
Wood window and door manufacturing	0.761
Plumbing fixture fitting & trim mfg	0.736

Table 2

PPI Factors for Index PCUBHVY, 1986-2009

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1986						100	98.8	98.7	99.2	98.8	98.9	98.9	
1987	99.4	99.8	100	100.5	100.7	101.1	101.7	102.4	102.8	103.5	104.5	106.2	101.9
1988	107.5	107	106.7	107.3	107.5	107.9	108.4	108.5	108.7	109.7	111.3	112.7	108.6
1989	113.8	114	114.6	115.7	116.3	115.8	115.2	115.1	115.9	116.4	116.1	115.6	115.4
1990	116.5	115.8	116.4	116.7	117.1	116.5	116.5	118.1	119.7	121	120.8	119.7	117.9
1991	119.6	118.7	118	117.9	117.8	118.1	117.9	118	118.2	117.9	117.9	117.3	118.1
1992	117.1	117.7	117.9	118.2	118.4	118.8	118.8	118.9	119.1	118.9	118.9	118.8	118.5
1993	119.5	120.2	120.8	121	120.7	120.4	120.4	120.4	120.8	121.1	121.4	121.1	120.6
1994	121.8	122.3	122.7	122.7	123.2	124.1	124.6	125.3	125.8	125.7	126.9	127	124.3
1995	128.1	128.6	129	129.9	129.9	130.1	130.3	130.4	130.5	130.1	130.3	130.5	129.8
1996	130.6	130.4	131	132	133	133	132.3	132.4	132.9	132.9	133.3	133.6	132.3
1997	134	134.4	134.5	134.8	135.2	135	134.9	135	134.9	134.5	134.4	134	134.6
1998	133.6	133.3	133.3	133.7	133.8	133.6	133.9	133.5	133.4	133.1	132.6	131.9	133.3
1999	132.4	132.2	132.6	133.7	134.2	134.5	135.7	136.2	136.4	136.1	136.3	136.9	134.8
2000	137.8	139	140	139.5	139.3	140.5	140.3	139.8	140.8	140.6	140.4	139.7	139.8
2001	140.1	140.3	139.9	140.5	141.9	141.7	139.7	139.7	140.4	137.9	137.1	136.1	139.6
2002	136.3	136.2	136.7	137.4	137.3	**137.5**	137.6	137.8	138.1	138.1	137.6	137.4	137.3
2003	138	138.8	139.2	138.8	138.6	138.9	139.2	139.5	140.3	140.3	140.6	141	139.4
2004	143.3	145.3	148.4	151.3	153.8	153.9	155.5	157.9	159	161.5	161.2	159.9	154.2
2005	162.3	163.9	166.4	167.4	166.8	167.8	169.8	171.2	174.1	177.1	173.2	174	169.5
2006	176.3	175.8	177.8	181.5	184	186.4	187.7	188.6	184.4	182.9	182.7	183.5	182.6
2007	182.6	183.9	187.1	190.3	192.6	192.6	194.6	192.3	193.1	193.3	197.4	196.1	191.3
2008	197.9	199.7	205.3	210.1	216.9	222.5	227.3	224.7	225.3	216	206	198.7	212.5
2009	198.6	195.4	193.7	193.4	195	197.3	195.5	198.3	197.4	**196.8**	198.3(P)	198.6(P)	196.5(P)
2009	201.6 (P)												
P : Preliminary. All indexes are subject to revision four months after original publication.													

Cost Escalation from June 2002 through October 2009 = 196.8/137.5 = 1.431

Table 3

Inflation of MWRRI Unit Costs

All Costs in 1000's

	Item No.	Description	Unit	MWRRI PHASE 5 Unit Costs, 2002			Escalation Factor = 1.43 →	MWRRI PHASE 7, Oct 2009		
				Total Unit Cost	Less 31% Soft Costs →	Pure Construction Cost		Pure Construction Cost	Plus 31% Soft Costs →	Total Unit Cost
				Unit Cost		Unit Cost		Unit Cost		Unit Cost
Trackwork	1.1	HSR on Existing Roadbed	Mile	993		758		1,085		1,421
Trackwork	1.2a	HSR on New Roadbed	Mile	1,059		808		1,157		1,516
Trackwork	1.2b	HSR on New Roadbed & New Embankment	Mile	1,492		1,139		1,630		2,135
Trackwork	1.2c	HSR on New Roadbed & New Embankment (Double Track)	Mile	2,674		2,041		2,922		3,827
Trackwork	1.2d	HSR Double Track on 15' Retained Earth Fill[1]	Mile	N/A		N/A		15,463		20,256
Trackwork	1.3	Timber & Surface w/ 33% Tie replacement	Mile	222		169		243		318
Trackwork	1.4	Timber & Surface w/ 66% Tie Replacement	Mile	331		253		362		474
Trackwork	1.5	Relay Track w/ 141# CWR	Mile	354		270		387		507
Trackwork	1.6	Freight Siding	Mile	912		696		996		1,305
Trackwork	1.65	Passenger Siding	Mile	1,376		1,050		1,503		1,969
Trackwork	1.71	Fencing, 4 ft Woven Wire (both sides)	Mile	51		39		56		73
Trackwork	1.72	Fencing, 6 ft Chain Link (both sides)	Mile	153		117		167		219
Trackwork	1.73	Fencing, 10 ft Chain Link (both sides)	Mile	175		134		191		250
Trackwork	1.74	Decorative Fencing (both sides)	Mile	394		301		430		564
Trackwork	1.8	Drainage Improvements (cross country)	Mile	66		50		72		94
Trackwork	1.9a	Land Acquisition Urban	Mile	327		250		357		468
Trackwork	1.9b	Land Acquisition Rural	Mile	109		83		119		156
Curves	9.1	Elevate & Surface Curves	Mile	58		44		63		83
Curves	9.2	Curvature Reduction	Mile	393		300		429		563
Curves	9.3	Elastic Fasteners	Mile	82		63		90		117
Signals	8.1	Signals for Siding w/ High Speed Turnout	Each	1,268		968		1,385		1,815
Signals	8.2	Install CTC System (Single Track)	Mile	183		140		200		262
Signals	8.21	Install CTC System (Double Track)	Mile	300		229		328		429
Signals	8.3	Install PTC System	Mile	197		150		215		282
Signals	8.4	Electric Lock for Industry Turnout	Each	103		79		113		147
Signals	8.5	Signals for Crossover	Each	700		534		765		1,002
Signals	8.6	Signals for Turnout	Each	400		305		437		573
Turnouts	4.1a	#33 High Speed Turnout[1]	Each	N/A		N/A		621		813
Turnouts	4.1	#24 High Speed Turnout	Each	450		344		492		644
Turnouts	4.2	#20 Turnout Timber	Each	124		95		135		177
Turnouts	4.3	#10 Turnout Timber	Each	69		53		75		99
Turnouts	4.4	#20 Turnout Concrete	Each	249		190		272		356
Turnouts	4.5	#10 Turnout Concrete	Each	118		90		129		169
Turnouts	4.6	#33 Crossover	Each	1,136		867		1,241		1,626
Turnouts	4.7	#20 Crossover	Each	710		542		776		1,016

Notes:

1. Item is new in Phase 7
2. Total Unit Costs include 31% in soft costs, including:
   - 7% Engineering
   - 15% Contingency
   - 3% Program Management of General Engineering Consultant
   - 4% for Construction Management and Inspection
   - 2% for Owner's Management Costs such as Alternatives Analysis or Environmental Studies
3. Pure Construction Costs Include Only Materials and Labor
4. 2009 costs escalated using the Producer Price Index *Material and Supply Inputs to Other Heavy Construction* (PCUBYVY)

Table 3

Inflation of MWRRI Unit Costs

All Costs in 1000's

Category	Item No.	Description	Unit	MWRRI PHASE 5 Unit Costs, 2002: Total Unit Cost (Unit Cost)	Less 31% Soft Costs →	Pure Construction Cost (Unit Cost)	Escalation Factor = 1.43 →	MWRRI PHASE 7, Oct 2009: Pure Construction Cost (Unit Cost)	Plus 31% Soft Costs →	Total Unit Cost (Unit Cost)
Bridges-Under	5.1	Four Lane Urban Expressway	Each	4,835		3,691		5,283		6,920
	5.2	Four Lane Rural Expressway	Each	4,025		3,073		4,398		5,761
	5.3	Two Lane Highway	Each	3,054		2,331		3,337		4,371
	5.4	Rail	Each	3,054		2,331		3,337		4,371
	5.5	Minor river	Each	810		618		885		1,159
	5.6	Major River	Each	8,098		6,182		8,848		11,591
	5.65	Double Track High (50') Level Bridge	LF	14.0		9.3		13.3		20
	5.70	Rehab for 110	LF	14		11		15		20
	5.71	Convert open deck bridge to ballast deck (single track)	LF	4.7		3.6		5.1		6.7
	5.72	Convert open deck bridge to ballast deck (double track)	LF	9.4		7.1		10.2		13.4
	5.73	Single Track on Flyover/Elevated Structure	LF	6.0		4.6		6.6		8.6
	5.8	Single Track on Approach Embankment w/ Retaining Wall	LF	3.0		2.3		3.3		4.3
	5.9	Ballasted Concrete Deck Replacement Bridge	LF	2.1		1.6		2.3		3.0
	5.10	Land Bridges	LF	2.6		2.0		2.9		3.8
	5.11	Double Track on Flyover/Elevated Structure	LF	10.5		8.0		11.5		15.0
	47	Double Track on Approach Embankment w/ Retaining Wall	LF	5.5		4.2		6.0		7.9
Bridges-Over	6.1	Four Lane Urban Expressway	Each	2,087		1,593		2,280		2,987
	6.2	Four Lane Rural Expressway	Each	2,929		2,236		3,200		4,192
	6.3	Two Lane Highway	Each	1,903		1,453		2,079		2,724
	6.4	Rail	Each	6,110		4,664		6,676		8,745
Crossings	7.1	Private Closure	Each	83		63		91		119
	7.2	Four Quadrant Gates w/ Trapped Vehicle Detector	Each	492		376		538		704
	7.3	Four Quadrant Gates	Each	288		220		315		412
	7.31	Convert Dual Gates to Quad Gates	Each	150		115		164		215
	7.4a	Conventional Gates single mainline track	Each	166		127		181		238
	7.4b	Conventional Gates double mainline track	Each	205		156		224		293
	7.41	Convert Flashers Only to Dual Gate	Each	50		38		55		72
	7.5a	Single Gate with Median Barrier	Each	180		137		197		258
	7.5b	Convert Single Gate to Extended Arm	Each	15		11		16		21
	7.71	Precast Panels without Rdway Improvements	Each	80		61		87		115
	7.72	Precast Panels with Rdway Improvements	Each	150		115		164		215
	7.8	Michigan Type Grade Crossing Surface	Each	15.0		11.5		16		21
Station/Maintenance Facilities	2.1	Full Service - New	Each	1,000		763		1,093		1,431
	2.2	Full Service - Renovated	Each	500		382		546		716
	2.3	Terminal - New	Each	2,000		1,527		2,185		2,863
	2.4	Terminal - Renovated	Each	1,000		763		1,093		1,431
	2.5a	Maintenance Facility (non-electrified track/110 mph system)	Each	10,000		7,634		10,926		14,313
	2.6	Layover Facility	Each	6,536		4,989		7,141		9,355

1. Total Unit Costs include 31% in soft costs, including:
   - 7% Engineering
   - 15% Contingency
   - 3% Program Management of General Engineering Consultant
   - 4% for Construction Management and Inspection
   - 2% for Owner's Management Costs such as Alternatives Analysis or Environmental Studies
2. Pure Construction Costs Include Only Materials and Labor
3. 2009 costs escalated using the Producer Price Index *Material and Supply Inputs to Other Heavy Construction* (PCUBYVY)

Table 4

Inflation of Sample MWRRI Pay Items (Original SubUnit Prices and Quantities) using Multiple Inflation Factors

MWRRI Item No.	Description	Unit	Reference											Unit Cost (Oct 2009)
1.1	HSR on Existing Roadbed	Mile	MWRRI Phase 3B - Item 1.1											1,112,890
		Unit	*Inflation Index Used*	*Sub Unit*	*Sub Unit Qty*	*1993 Sub Unit Cost*	*1993 Sub Unit Total*	*1993-2002 Inflation Factor*	*2002 Sub Unit Cost*	*2002 Sub Unit Total*	*2002-2009 Inflation Factor*	*Oct 2009 Sub Unit Cost*	*Oct 2009 Sub Unit Total*	*Oct 2009 Sub Unit Total*
Materials	136# - CWR	mile	1	Track Mile	1.0	121200.00	121,200	0.95	135,449	135,449	1.79	242,481	242,481	242,481
	Mainline Wood Crossties (7" x 9" x 8'-6", New)	mile	4	Each	3200	27.35	87,520	1.34	37	117,294	1.25	46	146,325	146,325
	Tie Plates (13" DS , New)	mile	1	Each	6400	5.10	32,640	0.95	4.82	30,845	1.79	8.63	55,218	55,218
	Rail Anchors (115#, New)	mile	2	Each	6400	0.85	5,440	1.07	0.91	5,832	1.91	1.74	11,125	11,125
	Track Spikes (New)	mile	2	Each	25600	0.31	7,936	1.07	0.33	8,507	1.91	0.63	16,229	16,229
	Top Ballast - 12" Depth Under Tie Area, #4 Granite	mile	3	Ton	5196	15.00	77,933	1.35	20	104,898	1.70	34	178,578	178,578
Labor	Plant Welds	mile	5	Each	128	40.00	5,120	1.31	52	6,712	1.34	70	8,981	8,981
	Field Welds	mile	5	Each	18	400.00	7,200	1.31	524	9,439	1.34	702	12,630	12,630
	Roadbed Prep	mile	5	Foot	5280	3.00	15,840	1.31	3.93	20,766	1.34	5.26	27,785	27,785
	Place Subballast (6" x 25')	mile	5	CY	2811	10.00	28,111	1.31	13	36,854	1.34	18	49,310	49,310
	Drainage	mile	5	Track Mile	1.0	5000.00	5,000	1.31	6,555	6,555	1.34	8,771	8,771	8,771
	Track Labor	mile	5	Track Mile	1.0	85500.00	85,500	1.31	112,091	112,091	1.34	149,977	149,977	149,977
	Material Handling and Distribution (5% of Matl's Subtotal)	mile	-	LS	1.0	16633.44	16,633	1.00	20,141	20,141	1.00	32,498	32,498	32,498
	Track Labor Overhead (85% of Labor)	mile	-	LS	1.0	72965.70	72,966	1.00	95,658	95,658	1.00	127,990	127,990	127,990
	Equipment (30% of Track Labor)	mile	-	LS	1.0	25650.00	25,650	1.00	33,627	33,627	1.00	44,993	44,993	44,993
		Yearly SubTotal					*594,689*			*744,668*			*1,112,890*	*1,112,890*

MWRRI Item No.	Description	Unit	Reference											Unit Cost (Oct 2009)
1.2a	HSR on New Roadbed	Mile	MWRRI Phase 3B - Item 1.2											1,183,037
		Unit	*Inflation Index Used*	*Sub Unit*	*Sub Unit Qty*	*1993 Sub Unit Cost*	*1993 Sub Unit Total*	*1993-2002 Inflation Factor*	*2002 Sub Unit Cost*	*2002 Sub Unit Total*	*2002-2009 Inflation Factor*	*Oct 2009 Sub Unit Cost*	*Oct 2009 Sub Unit Total*	*Oct 2009 Sub Unit Total*
Materials	136# - CWR	mile	1	Track Mile	1.0	121200.00	121,200	0.95	135,449	135,449	1.79	242,481	242,481	242,481
	Mainline Wood Crossties (7" x 9" x 8'-6", New)	mile	4	Each	3200	27.35	87,520	1.34	37	117,294	1.25	46	146,325	146,325
	Tie Plates (13" DS , New)	mile	1	Each	6400	5.10	32,640	0.95	4.82	30,845	1.79	8.63	55,218	55,218
	Rail Anchors (136#, New)	mile	2	Each	6400	0.85	5,440	1.07	0.91	5,832	1.91	1.74	11,125	11,125
	Track Spikes (New)	mile	2	Each	25600	0.31	7,936	1.07	0.33	8,507	1.91	0.63	16,229	16,229
	Top Ballast - 12" Depth Under Tie Area, #4 Granite	mile	3	Ton	5196	15.00	77,933	1.35	20	104,898	1.70	34	178,578	178,578
Labor	Plant Welds	mile	5	Each	128	40.00	5,120	1.31	52	6,712	1.34	70	8,981	8,981
	Field Welds	mile	5	Each	18	400.00	7,200	1.31	524	9,439	1.34	702	12,630	12,630
	Roadbed Prep	mile	5	Foot	5280	3.00	15,840	1.31	3.93	20,766	1.34	5.26	27,785	27,785
	Site Clearing	mile	5	Acre	4.24	2800.00	11,879	1.31	3,671	15,573	1.34	4,912	20,837	20,837
	Place Subballast (6" x 25')	mile	5	CY	5622	10.00	56,222	1.31	13	73,707	1.34	18	98,620	98,620
	Drainage	mile	5	Track Mile	1.0	5000.00	5,000	1.31	6,555	6,555	1.34	8,771	8,771	8,771
	Track Labor	mile	5	Track Mile	1.0	85500.00	85,500	1.31	112,091	112,091	1.34	149,977	149,977	149,977
	Material Handling and Distribution (5% of Matl's Subtotal)	mile	-	LS	1.0	16633.44	16,633	1.00	20,141	20,141	1.00	32,498	32,498	32,498
	Track Labor Overhead (85% of Labor)	mile	-	LS	1.0	72965.70	72,966	1.00	95,658	95,658	1.00	127,990	127,990	127,990
	Equipment (30% of Track Labor)	mile	-	LS	1.0	25650.00	25,650	1.00	33,627	33,627	1.00	44,993	44,993	44,993
		Yearly SubTotal					*634,679*			*797,095*			*1,183,037*	*1,183,037*

Inflation Index No.

1	*Bureau of Labor Statistics, PPI Series Id: WPU101704 - Steel Mill Products*	*Item: Hot rolled bars, plates, and structural shapes*
2	*Bureau of Labor Statistics, PPI Series Id: PCU3312223312223*	*Product: Steel nails, staples, tacks, spikes, and brads*
3	*Bureau of Labor Statistics, PPI Series Id: PCU2123132123130*	*Product: Crushed and broken granite*
4	*Bureau of Labor Statistics, PPI Series Id: PCU3211143211141*	*Product: Wood poles, piles, and posts owned and treated by the same establishment*
5	*Engineering News Record Skilled Labor Index*	
6	*Bureau of Labor Statistics, PPI Series Id: PCUBCON*	*Product: Material and Supply Inputs to construction industries*
7	*Material and Supply inputs to other heavy construction*	

Table 4

Inflation of Sample MWRRI Pay Items (Original SubUnit Prices and Quantities) using Multiple Inflation Factors

MWRRI Item No.	Description	Unit	Reference											Unit Cost (Oct 2009)
1.2b	HSR on New Roadbed & New Embankment	Mile	MWRRI Phase 3B											1,659,927
		Unit	*Inflation Index Used*	*Sub Unit*	*Sub Unit Qty*	*1993 Sub Unit Cost*	*1993 Sub Unit Total*	*1993-2002 Inflation Factor*	*2002 Sub Unit Cost*	*2002 Sub Unit Total*	*2002-2009 Inflation Factor*	*Oct 2009 Sub Unit Cost*	*Oct 2009 Sub Unit Total*	*Oct 2009 Sub Unit Total*
Materials	136# - CWR	mile	1	Track Mile	1.0	121200.00	121,200	0.95	135,449	135,449	1.79	242,481	242,481	242,481
	Mainline Wood Crossties (7" x 9" x 8'-6", New)	mile	4	Each	3200	27.35	87,520	1.34	37	117,294	1.25	46	146,325	146,325
	Tie Plates (13" DS , New)	mile	1	Each	6400	5.10	32,640	0.95	4.82	30,845	1.79	8.63	55,218	55,218
	Rail Anchors (136#, New)	mile	2	Each	6400	0.85	5,440	1.07	0.91	5,832	1.91	1.74	11,125	11,125
	Track Spikes (New)	mile	2	Each	25600	0.31	7,936	1.07	0.33	8,507	1.91	0.63	16,229	16,229
	Top Ballast - 12" Depth Under Tie Area, #4 Granite	mile	3	Ton	5196	15.00	77,933	1.35	20	104,898	1.70	34	178,578	178,578
	Embankment Material[1]	mile	-	Mile										277,800
Labor	Plant Welds	mile	5	Each	128	40.00	5,120	1.31	52	6,712	1.34	70	8,981	8,981
	Field Welds	mile	5	Each	18	400.00	7,200	1.31	524	9,439	1.34	702	12,630	12,630
	Roadbed Prep	mile	5	Foot	5280	3.00	15,840	1.31	3.93	20,766	1.34	5.26	27,785	27,785
	Grading:Embankment[1]	mile	-	Mile										185,200
	Site Clearing	mile	5	Acre	4.24	2800.00	11,879	1.31	3,671	15,573	1.34	4,912	20,837	20,837
	Place Subballast (6" x 25')	mile	5	CY	5622	10.00	56,222	1.31	13	73,707	1.34	18	98,620	98,620
	Drainage	mile	5	Track Mile	1.0	5000.00	5,000	1.31	6,555	6,555	1.34	8,771	8,771	8,771
	Track Labor	mile	5	Track Mile	1.0	85500.00	85,500	1.31	112,091	112,091	1.34	149,977	149,977	149,977
	Material Handling and Distribution (5% of Matl's Subtotal)	mile	-	LS	1.0	16633.44	16,633	1.00	20,141	20,141	1.00	46,388	46,388	46,388
	Track Labor Overhead (85% of Labor)	mile	-	LS	1.0	72965.70	72,966	1.00	95,658	95,658	1.00	127,990	127,990	127,990
	Equipment (30% of Track Labor)	mile	-	LS	1.0	25650.00	25,650	1.00	33,627	33,627	1.00	44,993	44,993	44,993
		Yearly SubTotal					*634,679*			*797,095*			*1,196,927*	*1,659,927*

MWRRI Item No.	Description	Unit	Reference											Unit Cost (Oct 2009)
1.3	Timber & Surface w/ 33% Tie replacement	Mile	MWRRI Phase 3B - Item 1.3											170,457
		Unit	*Inflation Index Used*	*Sub Unit*	*Sub Unit Qty*	*1993 Sub Unit Cost*	*1993 Sub Unit Total*	*1993-2002 Inflation Factor*	*2002 Sub Unit Cost*	*2002 Sub Unit Total*	*2002-2009 Inflation Factor*	*Oct 2009 Sub Unit Cost*	*Oct 2009 Sub Unit Total*	*Oct 2009 Sub Unit Total*
Materials	Mainline Wood Crossties (7" x 9" x 8'-6", New)	mile	4	Each	1056	27.35	28,882	1.34	36.65	38,707	1.25	45.73	48,287	48,287
	Track Spikes (New)	mile	2	Each	8448	0.31	2,619	1.07	0.33	2,807	1.91	0.63	5,355	5,355
	Ballast	mile	3	Ton	1200	15.00	18,000	1.35	20.19	24,228	1.70	34.37	41,246	41,246
Labor	Track Labor	mile	5	Track Mile	1.0	18,750.00	18,750	1.31	24,581.25	24,581	1.34	32,889.71	32,890	32,890
	Material Handling and Distribution (5% of Matl's Subtotal)	mile	-	LS	1.0	2,475.02	2,475	1.00	3,287.13	3,287	0.00	4,744.42	4,744	4,744
	Track Labor Overhead (85% of Labor)	mile	-	LS	1.0	16,001.25	16,001	1.00	20,977.64	20,978	0.00	28,068.08	28,068	28,068
	Equipment (30% of Track Labor)	mile	-	LS	1.0	5,625.00	5,625	1.00	7,374.38	7,374	0.00	9,866.91	9,867	9,867
		Yearly SubTotal					*92,352*			*121,963*			*170,457*	*170,457*

MWRRI Item No.	Description	Unit	Reference											Unit Cost (Oct 2009)
1.4	Timber & Surface w/ 66% Tie Replacement	Mile	MWRRI Phase 3B - Item 1.4											297,607
		Unit	*Inflation Index Used*	*Sub Unit*	*Sub Unit Qty*	*1993 Sub Unit Cost*	*1993 Sub Unit Total*	*1993-2002 Inflation Factor*	*2002 Sub Unit Cost*	*2002 Sub Unit Total*	*2002-2009 Inflation Factor*	*Oct 2009 Sub Unit Cost*	*Oct 2009 Sub Unit Total*	*Oct 2009 Sub Unit Total*
Materials	Mainline Wood Crossties (7" x 9" x 8'-6", New)	mile	4	Each	2112	27.35	57,763	1.34	37	77,414	1.25	46	96,574	96,574
	Track Spikes (New)	mile	2	Each	16896	0.31	5,238	1.07	0.33	5,615	1.91	0.63	10,711	10,711
	Ballast	mile	3	Ton	1200	15.00	18,000	1.35	20	24,228	1.70	34	41,246	41,246
Labor	Track Labor	mile	5	Track Mile	1.0	37500.10	37,500	1.31	49,163	49,163	1.34	65,780	65,780	65,780
	Material Handling and Distribution (5% of Matl's Subtotal)	mile	-	Track Mile	1.0	4050.05	4,050	1.00	5,363	5,363	1.00	7,427	7,427	7,427
	Track Labor Overhead (85% of Labor)	mile	-	LS	1.0	32002.59	32,003	1.00	41,955	41,955	1.00	56,136	56,136	56,136
	Equipment (30% of Track Labor)	mile	-	LS	1.0	11250.03	11,250	1.00	14,749	14,749	1.00	19,734	19,734	19,734
		Yearly SubTotal					*165,804*			*218,487*			*297,607*	*297,607*

Note

1 Embankment Costs breakdown not provided in Phase 3B

Inflation Index No.

1	*Bureau of Labor Statistics, PPI Series Id: WPU101704 - Steel Mill Products*	*Item: Hot rolled bars, plates, and structural shapes*
2	*Bureau of Labor Statistics, PPI Series Id: PCU3312223312223*	*Product: Steel nails, staples, tacks, spikes, and brads*
3	*Bureau of Labor Statistics, PPI Series Id: PCU2123132123130*	*Product: Crushed and broken granite*
4	*Bureau of Labor Statistics, PPI Series Id: PCU3211143211141*	*Product: Wood poles, piles, and posts owned and treated by the same establishment*
5	*Engineering News Record Skilled Labor Index*	
6	*Bureau of Labor Statistics, PPI Series Id: PCUBCON*	*Product: Material and Supply Inputs to construction industries*
7	*Material and Supply inputs to other heavy construction*	

Table 4

Inflation of Sample MWRRI Pay Items (Original SubUnit Prices and Quantities) using Multiple Inflation Factors

MWRRI Item No.	Description	Unit	Reference											Unit Cost (Oct 2009)
1.5	Relay Track w/ 136# CWR	Mile	MWRRI Phase 3B - Item 1.5											517,350
		Unit	*Inflation Index Used*	*Sub Unit*	*Sub Unit Qty*	*1993 Sub Unit Cost*	*1993 Sub Unit Total*	*1993-2002 Inflation Factor*	*2002 Sub Unit Cost*	*2002 Sub Unit Total*	*2002-2009 Inflation Factor*	*Oct 2009 Sub Unit Cost*	*Oct 2009 Sub Unit Total*	*Oct 2009 Sub Unit Total*
Salvage Credit	Relay Quality Rail, Tie Plates, Joint Bars, Scrap	mile	1	Track Mile	1.0	(66,601.00)	(66,601)	0.95	(62,937.95)	(62,938)	1.79	(112,671.51)	(112,672)	(112,672)
	Labor to pick up existing jointed rail and OTM	mile	5	Track Mile	1.0	10,000.00	10,000	1.31	13,110.00	13,110	1.34	17,541.18	17,541	17,541
Materials	136# - CWR	mile	1	Track Mile	1.0	121,200.00	121,200	0.95	135,449	135,449	1.79	242,480.63	242,481	242,481
	Tie Plates (13" DS , New)	mile	1	Each	6400	5.10	32,640	0.95	4.82	30,845	1.79	8.63	55,218	55,218
	Rail Anchors (136#, New)	mile	2	Each	6400	0.85	5,440	1.07	0.91	5,832	1.91	1.74	11,125	11,125
	Track Spikes (New)	mile	2	Each	25600	0.31	7,936	1.07	0.33	8,507	1.91	0.63	16,229	16,229
Labor	Plant Welds	mile	5	Each	128	40.00	5,120	1.31	52.44	6,712	1.34	70.16	8,981	8,981
	Field Welds	mile	5	Each	18	400.00	7,200	1.31	524.40	9,439	1.34	701.65	12,630	12,630
	Track Labor	mile	5	Track Mile	1.0	37,500.00	37,500	1.31	49,162.50	49,163	1.34	65,779.43	65,779	65,779
	Material Handling and Distribution (5% of Matl's Subtotal)	mile	-	LS	1.0	8,360.80	8,361	1.00	6,540.24	6,540	1.00	11,496.09	11,496	11,496
	Track Labor Overhead (85% of Labor)	mile	-	LS	1.0	32,002.50	32,003	1.00	41,955.28	41,955	1.00	56,136.16	56,136	56,136
	Equipment (30% of Track Labor)	mile	-	LS	1.0	11,250.00	11,250	1.00	14,748.75	14,749	1.00	19,733.83	19,734	19,734
		Yearly SubTotal					*278,649*			*322,301*			*517,350*	*517,350*

MWRRI Item No.	Description	Unit	Reference											Unit Cost (Oct 2009)
1.6	Freight Siding	Mile	MWRRI Phase 3B - Item 1.6											995,107
		Unit	*Inflation Index Used*	*Sub Unit*	*Sub Unit Qty*	*1993 Sub Unit Cost*	*1993 Sub Unit Total*	*1993-2002 Inflation Factor*	*2002 Sub Unit Cost*	*2002 Sub Unit Total*	*2002-2009 Inflation Factor*	*Oct 2009 Sub Unit Cost*	*Oct 2009 Sub Unit Total*	*Oct 2009 Sub Unit Total*
Materials	Rail (Relay CWR)	mile	1	Track Mile	1.0	46,750.00	46,750	0.95	44,413	44,413	1.79	79,498	79,498	79,498
	Plant Welds	mile	5	Each	294	40.00	11,760	1.31	52	15,417	1.34	70	20,628	20,628
	13" DS Tie Plates	mile	1	Each	6400	2.50	16,000	0.95	2	15,120	1.79	4	27,068	27,068
	Rail Anchors (112# New)	mile	2	Each	6400	0.85	5,440	1.07	1	5,832	1.91	2	11,125	11,125
	Track Spikes	mile	2	Each	25600	0.31	7,936	1.07	0.33	8,507	1.91	1	16,229	16,229
	Mainline Crossties	mile	4	Each	3200	27.35	87,520	1.34	37	117,294	1.25	46	146,325	146,325
	Top Ballast	mile	3	Ton	5196	15.00	77,933	1.35	20	104,898	1.70	34	178,578	178,578
Labor	Track Labor	mile	5	Track Mile	1.0	85,500.00	85,500	1.31	112,091	112,091	1.34	149,977	149,977	149,977
	Field Welds	mile	5	Each	18	400.00	7,200	1.31	524	9,439	1.34	702	12,630	12,630
	Roadbed Preparation	mile	5	Foot	5280	3.00	15,840	1.31	4	20,766	1.34	5	27,785	27,785
	Subballast in Place	mile	5	CY	5622	10.00	56,224	1.31	13	73,653	1.34	18	98,695	98,695
	Site Clearing	mile	5	Acre	4.24	2800.00	11,879	1.31	3,671	15,573	1.34	4,912	20,837	20,837
	Drainage	mile	5	Track Mile	1	5000.00	5,000	1.31	6,550	6,550	1.34	8,777	8,777	8,777
	Material Handling and Distribution (5% of Matl's Subtotal)	mile	-	LS	1.0	12666.94	12,667	1.00	2,226	2,226	1.00	23,973	23,973	23,973
	Track Labor Overhead (85% of Labor)	mile	-	LS	1.0	72,965.70	72,966	1.00	95,658.03	95,658	1.00	127,990.45	127,990	127,990
	Equipment (30% of Track Labor)	mile	-	LS	1.0	25650.00	25,650	1.00	33,627	33,627	1.00	44,993	44,993	44,993
		Yearly SubTotal					*546,264*			*681,064*			*995,107*	*995,107*

Inflation Index No.

1	*Bureau of Labor Statistics, PPI Series Id: WPU101704 - Steel Mill Products*	*Item: Hot rolled bars, plates, and structural shapes*
2	*Bureau of Labor Statistics, PPI Series Id: PCU3312223312223*	*Product: Steel nails, staples, tacks, spikes, and brads*
3	*Bureau of Labor Statistics, PPI Series Id: PCU2123132123130*	*Product: Crushed and broken granite*
4	*Bureau of Labor Statistics, PPI Series Id: PCU3211143211141*	*Product: Wood poles, piles, and posts owned and treated by the same establishment*
5	*Engineering News Record Skilled Labor Index*	
6	*Bureau of Labor Statistics, PPI Series Id: PCUBCON*	*Product: Material and Supply Inputs to construction industries*
7	*Material and Supply inputs to other heavy construction*	

Table 4

Inflation of Sample MWRRI Pay Items (Original SubUnit Prices and Quantities) using Multiple Inflation Factors

MWRRI Item No.	**Description**	**Unit**	**Reference**											**Unit Cost (Oct 2009)**
4.1a	#33 High Speed Turnout1	Each	MWRRI Phase 3B - Item 4.1											619,731
		Unit	*Inflation Index Used*	*Sub Unit*	*Sub Unit Qty*	*1993 Sub Unit Cost*	*1993 Sub Unit Total*	*1993-2002 Inflation Factor*	*2002 Sub Unit Cost*	*2002 Sub Unit Total*	*2002-2009 Inflation Factor*	*Oct 2009 Sub Unit Cost*	*Oct 2009 Sub Unit Total*	*Oct 2009 Sub Unit Total*
Materials	Switch Package, OTM, Rail, Concrete Ties, Field Welds	Each	7	Each	1.0	250,000.00	250,000	1.14	285,025.00	285,025	1.44	409,181.89	409,182	409,182
	Ballast	Each	3	Ton	753	15.00	11,295	1.35	20.25	15,248	1.79	36.25	27,297	27,297
	Filter Fabric	Each	6	SY	850	2.00	1,700	1.14	2.28	1,940	1.37	3.12	2,648	2,648
Labor	Track Labor	Each	5	Track Mile	1.0	42,000.00	42,000	1.31	55,062.00	55,062	1.34	73,672.96	73,673	73,673
	Material Handling and Distribution (5% of Matl's)	Each	-	Track Mile	1.0	13,149.75	13,150	1.00	15,110.64	15,111	1.00	21,956.37	21,956	21,956
	Track Labor Overhead (85% of Labor)	Each	-	LS	1.0	35,842.80	35,843	1.00	46,989.91	46,990	1.00	62,872.50	62,873	62,873
	Equipment	Each	7	LS	1.0	23,706.00	23,706	1.14	16,518.60	16,519	1.44	22,101.89	22,102	22,102
		Yearly SubTotal					*377,694*			*435,894*			*619,731*	*619,731*

MWRRI Item No.	**Description**	**Unit**	**Reference**											**Unit Cost (Oct 2009)**
9.1	Elevate & Surface Curves	Mile	MWRRI Phase 3B - Item 9.1											62,675
		Unit	*Inflation Index Used*	*Sub Unit*	*Sub Unit Qty*	*1993 Sub Unit Cost*	*1993 Sub Unit Total*	*1993-2002 Inflation Factor*	*2002 Sub Unit Cost*	*2002 Sub Unit Total*	*2002-2009 Inflation Factor*	*Oct 2009 Sub Unit Cost*	*Oct 2009 Sub Unit Total*	*Oct 2009 Sub Unit Total*
Materials	Ballast	Mile	3	Ton	1200	15.00	18,000	1.35	20.25	24,300	1.79	36.25	43,502	43,502
Labor	Track Labor	Mile	5	Track Mile	1.0	4,500.00	4,500	1.31	5,899.50	5,900	1.34	7,893.53	7,894	7,894
	Material Handling and Distribution (5% of Matl's)	Mile	-	Track Mile	1.0	900.00	900	1.00	1,215.00	1,215	1.00	2,175.09	2,175	2,175
	Track Labor Overhead (85% of Labor)	Mile	-	LS	1.0	3,840.30	3,840	1.00	5,034.63	5,035	1.00	6,736.34	6,736	6,736
	Equipment (30% of Labor)	Mile	-	LS	1.0	1,350.00	1,350	1.00	1,769.85	1,770	1.00	2,368.06	2,368	2,368
		Yearly SubTotal					*28,590*			*38,219*			*62,675*	*62,675*

MWRRI Item No.	**Description**	**Unit**	**Reference**											**Unit Cost (Oct 2009)**
9.3	Elastic Fasteners	Mile	MWRRI Phase 3B - Item 9.3											146,440
		Unit	*Inflation Index Used*	*Sub Unit*	*Sub Unit Qty*	*1993 Sub Unit Cost*	*1993 Sub Unit Total*	*1993-2002 Inflation Factor*	*2002 Sub Unit Cost*	*2002 Sub Unit Total*	*2002-2009 Inflation Factor*	*Oct 2009 Sub Unit Cost*	*Oct 2009 Sub Unit Total*	*Oct 2009 Sub Unit Total*
Salvage Credit	Tie Plates (Relay)	mile	1	Each	6400	(2.50)	(16,000)	0.95	(2.36)	(15,120)	1.79	(4.23)	(27,068)	(27,068)
	Rail Anchors (Relay)	mile	2	Each	6400	(0.13)	(832)	1.07	(0.14)	(892)	1.91	(0.27)	(1,701)	(1,701)
Materials	Tie Plates	mile	1	Each	6400	5.73	36,672	1.07	6.14	39,312	1.91	11.72	74,992	74,992
	Lock Spikes	mile	2	Each	25600	0.60	15,360	0.95	0.57	14,515	1.79	1.02	25,985	25,985
	Elastic Hold Down Clip	mile	6	Each	12800	1.75	22,400	1.14	2.00	25,556	1.37	2.73	34,892	34,892
Labor	Track Labor	mile	5	Track Mile	1.0	1,000.00	1,000	1.31	1,311.00	1,311	1.34	1,754.12	1,754	1,754
	Material Handling and Distribution (5% of Matl's Subtotal)	mile	-	LS	1.0	3,721.60	3,722	1.00	3,969.19	3,969	1.00	6,793.46	6,793	6,793
	Track Labor Overhead (85% of Labor)	mile	-	LS	1.0	853.40	853	1.00	1,118.81	1,119	1.00	1,496.96	1,497	1,497
	Equipment (30% of Track Labor)	mile	-	LS	1.0	300.00	300	1.00	393.30	393	1.00	526.24	526	526
		Yearly SubTotal					*80,307*			*86,176*			*146,440*	*146,440*

Inflation Index No.

1	*Bureau of Labor Statistics, PPI Series Id: WPU101704 - Steel Mill Products*	*Item: Hot rolled bars, plates, and structural shapes*
2	*Bureau of Labor Statistics, PPI Series Id: PCU3312223312223*	*Product: Steel nails, staples, tacks, spikes, and brads*
3	*Bureau of Labor Statistics, PPI Series Id: PCU2123132123130*	*Product: Crushed and broken granite*
4	*Bureau of Labor Statistics, PPI Series Id: PCU3211143211141*	*Product: Wood poles, piles, and posts owned and treated by the same establishment*
5	*Engineering News Record Skilled Labor Index*	
6	*Bureau of Labor Statistics, PPI Series Id: PCUBCON*	*Product: Material and Supply Inputs to construction industries*
7	*Material and Supply inputs to other heavy construction*	

Table 5

Comparison of Unit Costs Using Two Different Inflation Methods - PPI Series *PCUBHVY* vs. Multiple PPI Indices

All Costs in 1000's, Oct 2009

			Using *PCUBHVY*	Using Multiple PPI Indices		
Item No.	**Description**	**Unit**	**Unit Cost**	**Unit Cost**	**Difference ($)**	**Difference (%)**
1.1	HSR on Existing Roadbed	Mile	1,085	1,113	28	2.6%
1.2a	HSR on New Roadbed	Mile	1,157	1,183	26	2.2%
1.2b	HSR on New Roadbed & New Embankment	Mile	1,630	1,660	30	1.8%
1.3	Timber & Surface w/ 33% Tie replacement	Mile	243	170	-72	-29.7%
1.4	Timber & Surface w/ 66% Tie Replacement	Mile	362	298	-64	-17.7%
1.5	Relay Track w/ 136# CWR	Mile	387	517	131	33.8%
1.6	Freight Siding	Mile	996	995	-1	-0.1%
4.1a	#33 High Speed Turnout	Each	621	620	-1	-0.1%
9.1	Elevate & Surface Curves	Mile	63	63	-1	-1.1%
9.3	Elastic Fasteners	Mile	90	146	57	63.5%
				Average	14.82	6.1%

Table 6

Unit Cost Comparison Using Updated Labor Overhead Rate

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All Costs in 1000's, Oct 2009

			Using Multiple PPI Indices and New Labor Overhead of 133%	Additional Unit Cost Increase Due to New Labor Overhead of 133%	% Increase Over PCUBHVY Cost
Item No.	**Description**	**Unit**	**Unit Cost**	**Unit Cost**	**Percentage**
1.1	HSR on Existing Roadbed	Mile	1,184	71	6.6%
1.2a	HSR on New Roadbed	Mile	1,255	71	6.2%
1.2b	HSR on New Roadbed & New Embankment	Mile	1,731	71	4.4%
1.3	Timber & Surface w/ 33% Tie replacement	Mile	186	16	6.5%
1.4	Timber & Surface w/ 66% Tie Replacement	Mile	329	31	8.7%
1.5	Relay Track w/ 136# CWR	Mile	549	31	8.1%
1.6	Freight Siding	Mile	1,067	71	7.2%
4.1a	#33 High Speed Turnout	Each	655	35	5.7%
9.1	Elevate & Surface Curves	Mile	66	4	5.9%
9.3	Elastic Fasteners	Mile	147	1	0.9%
				Average	5.9%

Table 7

Comparison of MWRRI Phase 7 Unit Costs vs. Costs of Similar Items in Other Projects

All Costs in 1000's

	Item No.	Description	Unit	MWRRI PHASE 7 Oct 2009 Unit Cost	Project 1 Sept 2009 Unit Cost	Project 2 Feb 2010 Unit Cost	Project 3 Aug 2009 Unit Cost	Project 4 Nov 2008 Unit Cost	*Difference in Unit Costs - Other Projects Average vs. MWRRI Phase 7 Cost*
Trackwork	1.2b	HSR on New Roadbed & New Embankment	Mile	1,630	1,802	-	-	-	*10.5%*
	1.71	Fencing, 4 ft Woven Wire (both sides)	Mile	56	63	-	-	-	*13.7%*
	1.72	Fencing, 6 ft Chain Link (both sides)	Mile	167	190	-	-	-	*13.7%*
	1.8	Drainage Improvements (cross country)	Mile	72	140	-	186	-	*126.1%*
Curves	4.1	#24 High Speed Turnout	Each	492	508	-	-	-	*3.4%*
	4.2	#20 Turnout Timber	Each	135	-	95	138	-	*-14.0%*
	4.4	#20 Turnout Concrete	Each	272	444	-	-	-	*63.1%*
	4.5	#10 Turnout Concrete	Each	129	177	-	-	-	*37.0%*
Crossings	7.4a	Conventional Gates single mainline track	Each	181	-	-	-	184	*1.4%*
	7.71	Precast Panels without Rdway Improvements	Each	87	62	-	-	125	*6.9%*

Table 8

Updated MWRRI Unit Costs

All Costs in 1000's

				MWRRI PHASE 7, Oct 2009				
				Pure Construction Cost	Adjustments For Increased Labor Overhead	Adjusted Pure Construction Cost	Plus 31% Soft Costs →	Total Unit Cost
	Item No.	Description	Unit	Unit Cost	Unit Cost	Unit Cost		Unit Cost
Trackwork	1.1	HSR on Existing Roadbed	Mile	1,085	71	1,156		1,514
	1.2a	HSR on New Roadbed	Mile	1,157	71	1,228		1,609
	1.2b	HSR on New Roadbed & New Embankment	Mile	1,630	71	1,701		2,229
	1.2c	HSR on New Roadbed & New Embankment (Double Track)	Mile	2,922	175	3,097		4,057
	1.2d	HSR Double Track on 15' Retained Earth Fill	Mile	15,463	928	16,391		21,472
	1.3	Timber & Surface w/ 33% Tie replacement	Mile	243	16	259		339
	1.4	Timber & Surface w/ 66% Tie Replacement	Mile	362	31	393		514
	1.5	Relay Track w/ 141# CWR	Mile	387	31	418		547
	1.6	Freight Siding	Mile	996	71	1,067		1,398
	1.65	Passenger Siding	Mile	1,503	90	1,594		2,088
	1.71	Fencing, 4 ft Woven Wire (both sides)	Mile	56		56		73
	1.72	Fencing, 6 ft Chain Link (both sides)	Mile	167		167		219
	1.73	Fencing, 10 ft Chain Link (both sides)	Mile	191		191		250
	1.74	Decorative Fencing (both sides)	Mile	430		430		564
	1.8	Drainage Improvements (cross country)	Mile	72		72		94
	1.9a	Land Acquisition Urban	Mile	357		357		468
	1.9b	Land Acquisition Rural	Mile	119		119		156
Curves	9.1	Elevate & Surface Curves	Mile	63	4	67		88
	9.2	Curvature Reduction	Mile	429	26	455		596
	9.3	Elastic Fasteners	Mile	90	1	91		119
Signals	8.1	Signals for Siding w/ High Speed Turnout	Each	1,385		1,385		1,815
	8.2	Install CTC System (Single Track)	Mile	200		200		262
	8.21	Install CTC System (Double Track)	Mile	328		328		429
	8.3	Install PTC System	Mile	215		215		282
	8.4	Electric Lock for Industry Turnout	Each	113		113		147
	8.5	Signals for Crossover	Each	765		765		1,002
	8.6	Signals for Turnout	Each	437		437		573
Turnouts	4.1a	#33 High Speed Turnout	Each	621	35	656		859
	4.1	#24 High Speed Turnout	Each	492	30	521		683
	4.2	#20 Turnout Timber	Each	135	8	144		188
	4.3	#10 Turnout Timber	Each	75	5	80		105
	4.4	#20 Turnout Concrete	Each	272	16	288		378
	4.5	#10 Turnout Concrete	Each	129	8	137		179
	4.6	#33 Crossover	Each	1,241	74	1,316		1,724
	4.7	#20 Crossover	Each	776	47	822		1,077

Notes:

1. Total Unit Costs include 31% in soft costs, including:
   - 7% Engineering
   - 15% Contingency
   - 3% Program Management of General Engineering Consultant
   - 4% for Construction Management and Inspection
   - 2% for Owner's Management Costs such as Alternatives Analysis or Environmental Studies
2. Pure Construction Costs Include Only Materials and Labor
3. 2009 costs escalated using the Producer Price Index *Material and Supply Inputs to Other Heavy Construction* (PCUBYVY)

Table 8

Updated MWRRI Unit Costs

				MWRRI PHASE 7, Oct 2009				
All Costs in 1000's				Pure Construction Cost	Adjustments For Increased Labor Overhead	Adjusted Pure Construction Cost	Plus 31% Soft Costs →	Total Unit Cost
	Item No.	Description	Unit	Unit Cost	Unit Cost	Unit Cost		Unit Cost
Bridges-Under	5.1	Four Lane Urban Expressway	Each	5,283		5,283		6,920
	5.2	Four Lane Rural Expressway	Each	4,398		4,398		5,761
	5.3	Two Lane Highway	Each	3,337		3,337		4,371
	5.4	Rail	Each	3,337		3,337		4,371
	5.5	Minor river	Each	885		885		1,159
	5.6	Major River	Each	8,848		8,848		11,591
	5.65	Double Track High (50') Level Bridge	LF	13		13		17
	5.70	Rehab for 110	LF	15		15		20
	5.71	Convert open deck bridge to ballast deck (single track)	LF	5		5		7
	5.72	Convert open deck bridge to ballast deck (double track)	LF	10		10		13
	5.73	Single Track on Flyover/Elevated Structure	LF	7		7		9
	5.8	Single Track on Approach Embankment w/ Retaining Wall	LF	3		3		4
	5.9	Ballasted Concrete Deck Replacement Bridge	LF	2		2		3
	5.10	Land Bridges	LF	3		3		4
	5.11	Double Track on Flyover/Elevated Structure	LF	11		11		15
	47	Double Track on Approach Embankment w/ Retaining Wall	LF	6		6		8
Bridges-Over	6.1	Four Lane Urban Expressway	Each	2,280		2,280		2,987
	6.2	Four Lane Rural Expressway	Each	3,200		3,200		4,192
	6.3	Two Lane Highway	Each	2,079		2,079		2,724
	6.4	Rail	Each	6,676		6,676		8,745
Crossings	7.1	Private Closure	Each	91		91		119
	7.2	Four Quadrant Gates w/ Trapped Vehicle Detector	Each	538		538		704
	7.3	Four Quadrant Gates	Each	315		315		412
	7.31	Convert Dual Gates to Quad Gates	Each	164		164		215
	7.4a	Conventional Gates single mainline track	Each	181		181		238
	7.4b	Conventional Gates double mainline track	Each	224		224		293
	7.41	Convert Flashers Only to Dual Gate	Each	55		55		72
	7.5a	Single Gate with Median Barrier	Each	197		197		258
	7.5b	Convert Single Gate to Extended Arm	Each	16		16		21
	7.71	Precast Panels without Rdway Improvements	Each	87		87		115
	7.72	Precast Panels with Rdway Improvements	Each	164		164		215
	7.8	Michigan Type Grade Crossing Surface	Each	16		16		21
Station/Maintenance Facilities	2.1	Full Service - New	Each	1,093		1,093		1,431
	2.2	Full Service - Renovated	Each	546		546		716
	2.3	Terminal - New	Each	2,185		2,185		2,863
	2.4	Terminal - Renovated	Each	1,093		1,093		1,431
	2.5a	Maintenance Facility (non-electrified track/110 mph system)	Each	10,926		10,926		14,313
	2.6	Layover Facility	Each	7,141		7,141		9,355

1. Total Unit Costs include 31% in soft costs, including:
   - 7% Engineering
   - 15% Contingency
   - 3% Program Management of General Engineering Consultant
   - 4% for Construction Management and Inspection
   - 2% for Owner's Management Costs such as Alternatives Analysis or Environmental Studies
2. Pure Construction Costs Include Only Materials and Labor
3. 2009 costs escalated using the Producer Price Index *Material and Supply Inputs to Other Heavy Construction* (PCUBYVY)

Appendix B: Updated Unit Costs

Cost Estimating Methodology for High-Speed Rail on Shared Right-of-Way

Unit Costs

Updated 01/17/11

Item Number	Description	Unit	2010 Unit Cost	2010 Unit Cost (1000's)
2.0	Trackwork			
2.2	New Track Construction			
2.2.1	HSR on Existing Roadbed	MI	$ 1,122,920	$ 1,123
2.2.2	HSR on New Roadbed	MI	$ 1,380,000	$ 1,380
2.2.3	HSR on New Roadbed @ 30' offset from ex. Track centerline	MI	$ 1,550,000	$ 1,550
2.2.4	HSR on New Roadbed & New Embankment	MI	$ 1,687,208	$ 1,687
2.2.5	HSR on New Roadbed & New Embankment (Double Track)		$ 3,024,000	$ 3,024
2.2.6	HSR Double Track on 15' Retained Earth Fill (Cross Country)	MI	$ 15,971,602	$ 15,972
2.2.7	Freight Siding (3 mile)	EA	$ 4,288,000	$ 4,288
2.2.8	Passenger Siding (10 mile)	EA	$ 14,496,000	$ 14,496
2.3	Turnouts & Crossovers		$ -	
2.3.1	#33 High Speed Turnout	EA	$ 695,520	$ 696
2.3.2	#24 High Speed Turnout	EA	$ 508,876	$ 509
2.3.3	#20 Turnout Timber	EA	$ 183,000	$ 183
2.3.4	#15 Turnout - Timber	EA	$ 147,500	$ 148
2.3.5	#10 Turnout Timber	EA	$ 105,000	$ 105
2.3.6	16'6" Double Switch Point Derail	EA	$ 34,000	$ 34
2.3.7	#20 Turnout Concrete	EA	$ 281,578	$ 282
2.3.8	#15 Turnout - Concrete	EA	$ 155,000	$ 155
2.3.9	#10 Turnout Concrete	EA	$ 133,439	$ 133
2.3.10	#33 Crossover	EA	$ 1,284,630	$ 1,285
2.3.11	#20 Crossover	EA	$ 563,000	$ 563
2.4	Track Improvements		$ -	
2.4.1	Timber & Surface w/ 33% Tie replacement	MI	$ 251,046	$ 251
2.4.2	Timber & Surface w/ 66% Tie Replacement	MI	$ 374,307	$ 374
2.4.3	Replace Existing Rail w/ 136#/141# CWR	MI	$ 400,316	$ 400
2.4.4	Elevate & Surface Curves	MI	$ 65,589	$ 66
2.4.5	Curvature Reduction	MI	$ 444,419	$ 444
2.4.6	Elastic Rail Fasteners	MI	$ 92,729	$ 93
2.5	Site Work Related to HSR Track Construction		$ -	
2.5.1	Highway Barrier Type 6	LF	$ 1,275	$ 1
2.5.2	Highway Barrier Type 5	LF	$ 196	$ 0
2.5.3	Fencing, 4 ft Woven Wire (both sides)	MI	$ 57,673	$ 58
2.5.4	Fencing, 6 ft Chain Link (both sides)	MI	$ 173,018	$ 173
2.5.5	Fencing, 10 ft Chain Link (both sides)	MI	$ 197,896	$ 198
2.5.6	Decorative Fencing (both sides)	MI	$ 445,549	$ 446
2.5.7	Drainage Improvements (cross country)	MI	$ 74,635	$ 75
2.6	Land Acquisition		$ -	
2.6.1	Land Acquisition Rural	MI	$ 185,860	$ 186
2.6.2	Land Acquisition Urban	MI	$ 557,580	$ 558
3.0	Structures			
3.2	Bridges - Undergrade			
3.2.1	Four Lane Urban Expressway	EA	$ 5,467,593	$ 5,468
3.2.2	Four Lane Rural Expressway	EA	$ 4,551,616	$ 4,552
3.2.3	Two Lane Highway	EA	$ 3,453,574	$ 3,454
3.2.4	Rail	EA	$ 3,453,574	$ 3,454
3.2.5	Minor river	EA	$ 915,977	$ 916
3.2.6	Major River	EA	$ 9,157,512	$ 9,158
3.2.7	Double Track High (50') Level Bridge	LF	$ 13,735	$ 14
3.2.8	Ballasted Deck Replacement Bridge	LF	$ 3,200	$ 3
3.2.9	Rehab for Higher Passenger Speeds (90 - 110 mph)	LF	$ 1,580	$ 2
3.2.10	Convert open deck bridge to ballast deck (single track)	LF	$ 5,288	$ 5
3.2.11	Convert open deck bridge to ballast deck (double track)	LF	$ 10,575	$ 11
3.2.12	Single Track on Flyover/Elevated Structure	LF	$ 10,231	$ 10
3.2.13	Double Track on Flyover/Elevated Structure	LF	$ 17,904	$ 18
3.2.14	Land Bridges	LF	$ 2,963	$ 3
3.3	Bridges - Overhead			
3.3.1	Four Lane Urban Expressway	EA	$ 3,312,219	$ 3,312
3.3.2	Four Lane Rural Expressway	EA	$ 2,360,055	$ 2,360
3.3.3	Two Lane Highway	EA	$ 2,151,981	$ 2,152
3.3.4	Rail	EA	$ 6,909,410	$ 6,909
3.4	Other Structures			
3.4.1	Culvert Extension	MI	$ 58,000	$ 58

Cost Estimating Methodology for High-Speed Rail on Shared Right-of-Way
Unit Costs

Updated 01/17/11

Item Number	Description	Unit	2010 Unit Cost	2010 Unit Cost (1000's)
3.4.2	Single Track on Approach Embankment w/ Retaining Wall	LF	$ 5,115	$ 5
3.4.3	Double Track on Approach Embankment w/ Retaining Wall	LF	$ 9,378	$ 9
3.4.4	Two Bore Long Tunnel	route ft	$ 45,540	$ 46
3.4.5	Single Bore Short Tunnel	LF	$ 25,875	$ 26
Systems				
4.2.1	Install CTC System (Single Track)	MI	$ 206,943	$ 207
4.2.2	Install CTC System (Double Track)	MI	$ 339,251	$ 339
4.2.3	Install PTC System	MI	$ 176,985	$ 177
4.2.4	Electric Lock for Industry Turnout	EA	$ 116,476	$ 116
4.2.5	New Control Point (CP) - End of siding turnout, single track	EA	$ 650,000	$ 650
4.2.6	New Control Point (CP) - End of siding turnout & crossover, double track	EA	$ 1,296,000	$ 1,296
4.2.7	New Control Point (CP) - Universal Crossover	EA	$ 1,619,000	$ 1,619
4.2.8	Signal work to add Turnout to CP	EA	$ 452,335	$ 452
4.2.9	Signal work to add Crossover to CP	EA	$ 791,585	$ 792
4.2.10	Traffic Signal Preemption	EA	$ 75,000	$ 75
4.2.11	Traffic Signal Preemption and Intersection Signalization	EA	$ 300,000	$ 300
5.0	Crossings			
5.2.1	Crossing Closure	EA	$ 93,859	$ 94
5.2.2	Four Quadrant Gates	EA	$ 325,681	$ 326
5.2.3	Four Quadrant Gates w/ Trapped Vehicle Detector	EA	$ 556,371	$ 556
5.2.4	Convert Dual Gates to Quad Gates	EA	$ 169,625	$ 170
5.2.5	Conventional Gates single mainline track	EA	$ 187,719	$ 188
5.2.6	Conventional Gates double mainline track	EA	$ 231,821	$ 232
5.2.7	Convert Flashers Only to Dual Gate	EA	$ 56,542	$ 57
5.2.8	Dual Gate with Median Barrier	EA	$ 203,551	$ 204
5.2.9	Convert Dual Gate to Extended Arm	EA	$ 16,963	$ 17
5.2.10	Precast Panels without Rdway Improvements	EA	$ 90,467	$ 90
5.2.11	Precast Panels with Rdway Improvements	EA	$ 169,625	$ 170
Station/Maintenance Facilities				
	Full Service - New - Low Volume - 500 Surface Park	EA	$ 5,175,000	$ 5,175
	Full Service - Renovated - Low Volume- 500 Surface Park	EA	$ 4,140,000	$ 4,140
	Terminal - New - Low Volume - 500 Surface Park	EA	$ 7,762,500	$ 7,763
	Terminal - Renovated - Low Volume - 500 Surface Park	EA	$ 6,210,000	$ 6,210
	Full Service - New- High Volume - Dual Platform - 1000 Surface Park	EA	$ 10,350,000	$ 10,350
	Terminal - New- High Volume - Dual Platform - 1000 Surface Park	EA	$ 15,525,000	$ 15,525
	Maintenance Facility (non-electrified track)	EA	$ 82,800,000	$ 82,800
	Maintenance Facility (electrified track)	EA	$ 103,500,000	$ 103,500
	Layover Facility	LS	$ 10,350,000	$ 10,350
Allocations for Special Elements				
6.2.1	Yard - Category A - Placeholder	LS	$ 10,000,000	$ 10,000
6.2.2	Yard - Category B - Placeholder	LS	$ 30,700,000	$ 30,700
6.2.3	Yard - Category C - Placeholder	LS	$ 37,400,000	$ 37,400
6.2.4	Access to Signal/Switch Location	LS	$ 100,000	$ 100
6.2.5	Maintenance of Way Spur	LS	$ 1,000,000	$ 1,000
6.2.6	Rail-Rail Flyovers	LS	$ 40,000,000	$ 40,000
Contingency				
	Contingency - 30% of Construction Costs (G)		30%	
Professional Services and Environmental				
	Design Engineering		10%	
	Insurance and Bonding		0%	
	Program Management		4%	
	Construction Management & Inspection		6%	
	Engineering Services During Construction		2%	
	Integrated Testing and Commissioning		2%	
	Erosion Control and Water Quality Management		0%	

Appendix C: Estimating HSR Capital Costs in Yards, Terminals and Junctions in the MWRRI Route Network

Introduction

The objective of this memorandum is to define the methodology for estimating high-speed rail (HSR) capital costs in congested areas such as yards, terminals, and junctions, in the MWRRI route network. Categories have been established to be used to rapidly and effectively estimate the capital costs that would be incurred to extend HSR operations through these congested areas without the expense of performing extensive due diligence efforts in the earliest planning stages.

Background

As planning and route evaluation efforts for the MWRRI network progress, stations, yards and junctions are identified where significant amounts of freight train activity are occurring. Sometimes the rail freight traffic involves the switching of major industries which are the railroad's customers. Other times, the rail freight traffic may involve yard switch engines, local freight trains, and complete freight train movements in and out of towns, freight classification yards, junctions and/or railroad crew change points. In all of these cases, the freight railroads are using their tracks to serve their freight customers.
The significance of these locations to MWRRI planning is that, if not properly addressed in the planning stage, these locations can represent "bottlenecks" to the movement of HSR passenger trains.

Freight trains are often moving on time-sensitive operating schedules. Regular switching schedules are necessary to properly serve industrial customers' production requirements, or to be certain that the customers' freight cars make the required connecting trains. The on-time movement of complete freight trains is necessary so that these trains make their advertised schedules and connections with other freight trains, markets, guaranteed delivery times, "just-in-time" logistical requirements, vessel sailings, and other contractual requirements. Federal hours of service regulations limit how long railroad crews can work. The terms of railroad labor agreements may limit the ability of the railroads to "just think out of the box" and develop other plans to run the freight trains. Equipment cycles involving locomotives and train sets are established for the effective re-use of arriving resources (locomotives, cars and crews) for departing trains. Crew and equipment cycles using many of the same considerations and restrictions will be used by MWRRI for the planned utilization of its HSR train sets.

Many freight trains travel long distances with trips lasting several days. The trains must pass through congested cities at certain times to avoid causing delay to commuter train and intercity train operations. They must pass through track construction and maintenance projects at times when tracks and/or bridges are in service so as not to delay the train or the project work. Delays at one point on a route often result in the failure of the train to meet its operational requirements (connecting train, vessel sailing, industry production schedule, produce market availability time) since a freight train has little or no ability to make up time lost through delays along its route.

Both MWRRI and the freight railroads expect that their trains will run on schedule. Therefore, MWRRI planning must understand the freight requirements and ensure that sufficient additional capacity and operational flexibility are constructed to permit the operation of both MWRRI's HSR trains and the host railroads' freight trains. Included in these requirements is the need to provide sufficient infrastructure capacity to allow railroad maintenance activities to be performed while both freight and passenger train operations continue.

MWRRI planning must also recognize that certain types of freight trains move on irregular schedules based on customer loading schedules (e.g. coal trains, grain trains or extra trains that may be operated due to heavier than normal freight loadings). These trains may move at varying times of the day, night, or day of the week. Some, like grain trains, may be seasonal and can be especially heavy during harvest periods. The railroad must have the capacity and flexibility to handle these trains in addition to the scheduled freight and MWRRI passenger trains.

The alternative or assumption that freight traffic schedules will simply be re-organized and that temporal separation arrangements will be made restricting freight train operations for much of the day will, in many cases, not be realistic, viable or acceptable to the host railroads and their freight customers.

For these reasons, this methodology has been developed to propose a means of properly estimating the capital costs to enhance capacity at these potential freight "bottlenecks" in the early planning stages without the need for time-consuming detailed field planning. Such planning will still be needed, but can be deferred to later preliminary engineering phases of the project when the number of routes or alternatives has been reduced.

Methodology

The following three-step process is proposed to rapidly and effectively develop capital cost estimates for these "bottleneck" areas:

(1) Conduct a brief summary review of the yard, terminal or junction using available railroad track charts, timetables and maps, operating information and Internet imagery to determine the level of complexity of the yard or terminal segment and its operations, freight traffic levels and existing passenger train operations. Also consider the MWRRI proposed operating frequency and track speeds.

(2) After completing the review, compare the yard, terminal or junction with the menu of categories described below to determine which of the categories most closely represents the complexity of the location and its parameters.

(3) Utilize the estimating method assigned to the selected category for determining the capital costs required to conduct early planning and route evaluation analyses.

Parameters

In order to establish the categories for use in the cost estimating process, a group of six railroad yards and terminal areas on three railroads in Wisconsin and Minnesota were reviewed to understand both the physical layout of the railroad and how operations were conducted at each location. The six yard areas reviewed were: Portage, Winona and Red Wing (all CP), Altoona-Eau Claire and East St. Paul (both UP), and North Milwaukee-Wiscona (CP & WSOR). For all six locations, a desktop analysis was made.

Railroad track charts, timetables and maps, and Internet imagery and other information were used to assess the routes. This information included planned MWRRI speeds through the area, the general state of maintenance of the railroad, freight traffic volumes and whether or not Amtrak trains presently use the route. Operating problems that would likely occur with the introduction of MWRRI HSR service were anticipated so that a proposed operating solution could be developed and included in the capital cost estimate for the MWRRI corridor.

Considering these parameters, a proposed operating solution for each of the six yard or terminal areas was then developed that required the construction of additional physical capacity at or near the yard or terminal that was considered to be sufficient to meet the needs of both the freight railroad(s) and MWRRI. An itemized list of four types of capital costs (track, signals, bridges and grade crossings) from the MWRRI capital cost spreadsheets was then used to estimate the capital costs that would be incurred to resolve the "bottleneck." Costs to install a Positive Train Control system are not included in these estimates.

The sum of these four types of capital costs represents the cost to get MWRRI trains through the "bottleneck" area while maintaining satisfactory freight operations. All other costs to permit HSR operations through the yard area will be determined in the capital cost estimate for the complete route segment through the yard or terminal. Special costs applicable only to a particular yard and not related to the "bottleneck" itself (such as the need to rehabilitate two major bridges near Eau Claire or the need to replace one major overhead railroad bridge at Wiscona} were not included in the actual "bottleneck" costs. To make valid yard and terminal cost comparisons, these special costs would be assigned to the route segment.

All of the information described above has been summarized in Attachment A.

Categories

The detailed cost estimates for each of the six yard areas using the established MWRRI capital cost spreadsheets are described in Appendix B. A review of these cost estimates showed that for five of the six yards, the capital costs to resolve the "bottleneck" averaged approximately $30,700,000 for the four types of construction elements and approximately $47,300,000 when the 30% contingency and the 24% professional services and environmental percentages were included. The sixth yard area (North Milwaukee to Wiscona-MWRRI Segments 3 and 4) had much higher costs due to the number of grade separations requiring rehabilitation and the complexity of the freight track network serving yards and active industries. Therefore, to simplify initial planning and estimating, three categories have been established for estimating the capital costs necessary to enhance capacity in the "bottleneck" areas for route analysis purposes:

Category A: Smaller town sidings or yards and key junctions with a lower level of freight activity-Estimate the costs for these locations at $10,000,000.

Category B: Active Mainline Yards & Terminals as described in this Methodology-Estimate the capital costs for the "bottleneck area" at the average amount of

$30,700,000.

Category C: Major Terminal Areas-Prepare an individual preliminary capital cost estimate using the desktop analysis method (railroad track charts, maps, operating information and Internet imagery) to estimate capital costs. This is necessary to accurately identify the order of magnitude of capital costs associated with improving the complicated freight track network and/or rehabilitating or replacing many structures in a grade-separated urban environment. An example of this approach is the estimate prepared for North Milwaukee-Wiscona as described in Attachment A.

Attachment A: Cost Estimates for Yards, Terminals, and Junctions

As described previously, six yard and terminal areas were analyzed and capital costs were estimated to resolve “bottleneck” areas that would negatively impact MWRRI and freight railroad operations. For each of these six areas, the following information was developed:

- Current Situation
- Operating Parameters
- MWRRI Solution
- Capital Cost Estimate.

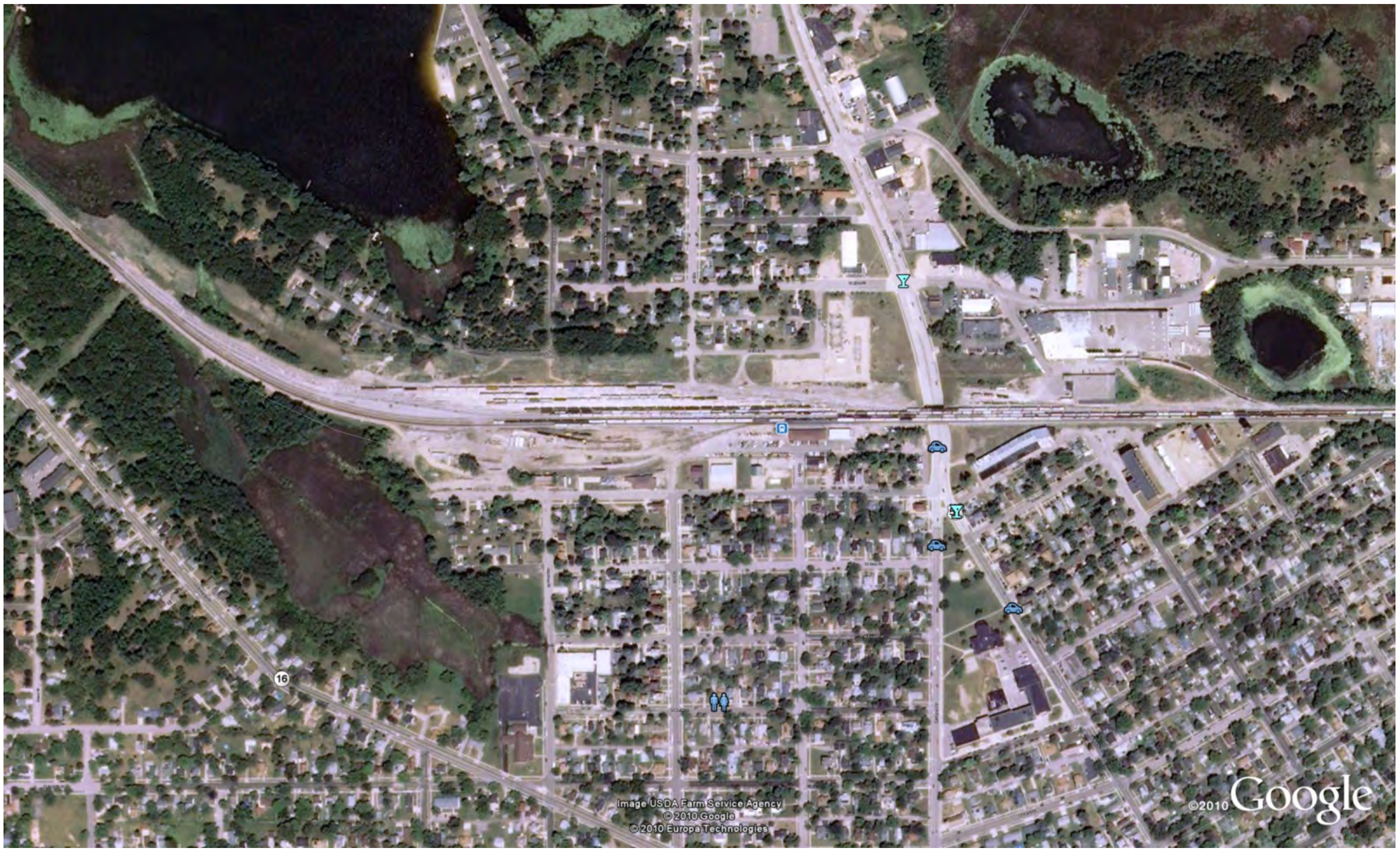
The information developed for each of these six “bottleneck” areas is described below.

Portage, WI (CP)

Current Situation:

- Junction between CP’s Milwaukee-St. Paul mainline and CP’s Madison & Portage (M&P) Subdivision (MWRRI Segments 8 and 11).
- Operational control is accomplished by Centralized Traffic Control (CTC) on the mainline, and Track Warrant Control (TWC) on the M&P Subdivision.
- Wisconsin Power & Light (WP&L) power generating station is located immediately south of Portage on the M&P Subdivision and is a destination for coal trains from Wyoming’s Powder River Basin.
- An active freight customer (Manley Brothers sand plant) is located on the east side of the M&P Subdivision opposite the WP&L power plant.
- Portage Amtrak station- Amtrak’s Empire Builder stops on the main track (currently at 12:27 PM in the eastward direction (Train No. 8) and 5:34 PM in the westward direction (Train No. 7).
- Freight trains queue at both ends of Portage (eastward trains at Portage East and westward trains at Portage West) to meet other trains arriving off the single track mainline from both directions (Milwaukee and La Crosse). Empty westward coal trains from WP&L also queue at Portage Jct. to wait for their opportunity to move west through Portage.

Figure 1 – Portage, WI



Operating Parameters:

- Maintain throughput capacity for CP mainline freight traffic and Amtrak trains while providing additional capacity for MWRRI trains to move to and from the M&P Subdivision between Portage and Madison.
- Amtrak and MWRRI trains would not meet each other between Portage Jct. and West Portage.
- Maintain existing holding capacity for CP freight trains meeting other trains between East Portage and West Portage.
- Maintain Amtrak platform station access for Amtrak and MWRRI trains, one train at a time between Portage Jct. and West Portage, to avoid the capital costs that would be incurred to relocate Portage Yard tracks, construct a second passenger platform and a fully accessible overhead pedestrian and baggage handling facility at the Portage station.
- Avoid or minimize delays related to arriving and departing WP&L coal trains.
- Minimize the effects on the business and residential areas that constrain the corridor between East Portage and West Portage by avoiding additional track construction between these two points.
- Avoid the high costs and potential environmental effects of constructing an additional HSR main track between Portage and West Portage on a high embankment within the Wisconsin River flood plain where unstable subsoil conditions exist.

MWRRI Solution:

- Add seven miles of second main track with signals and CTC between MP 0.0 and MP 7.0 on the M&P Subdivision to allow MWRRI trains to avoid WP&L coal train movements in this area.
- Construct one additional main track crossover at Portage Jct. to permit parallel movements to and from the proposed new second main track on the M&P Subdivision to permit coal trains and MWRRI trains to move simultaneously.
- Upgrade existing trackage and crossovers between Portage Jct. and West Portage to achieve and maintain optimum freight train speeds through Portage.
- Upgrade existing highway grade crossings between M&P MP 7.0 and Portage to HSR standards including trapped vehicle detection.
- Includes no major structure rehabilitation or replacement.

Capital Cost Estimate:

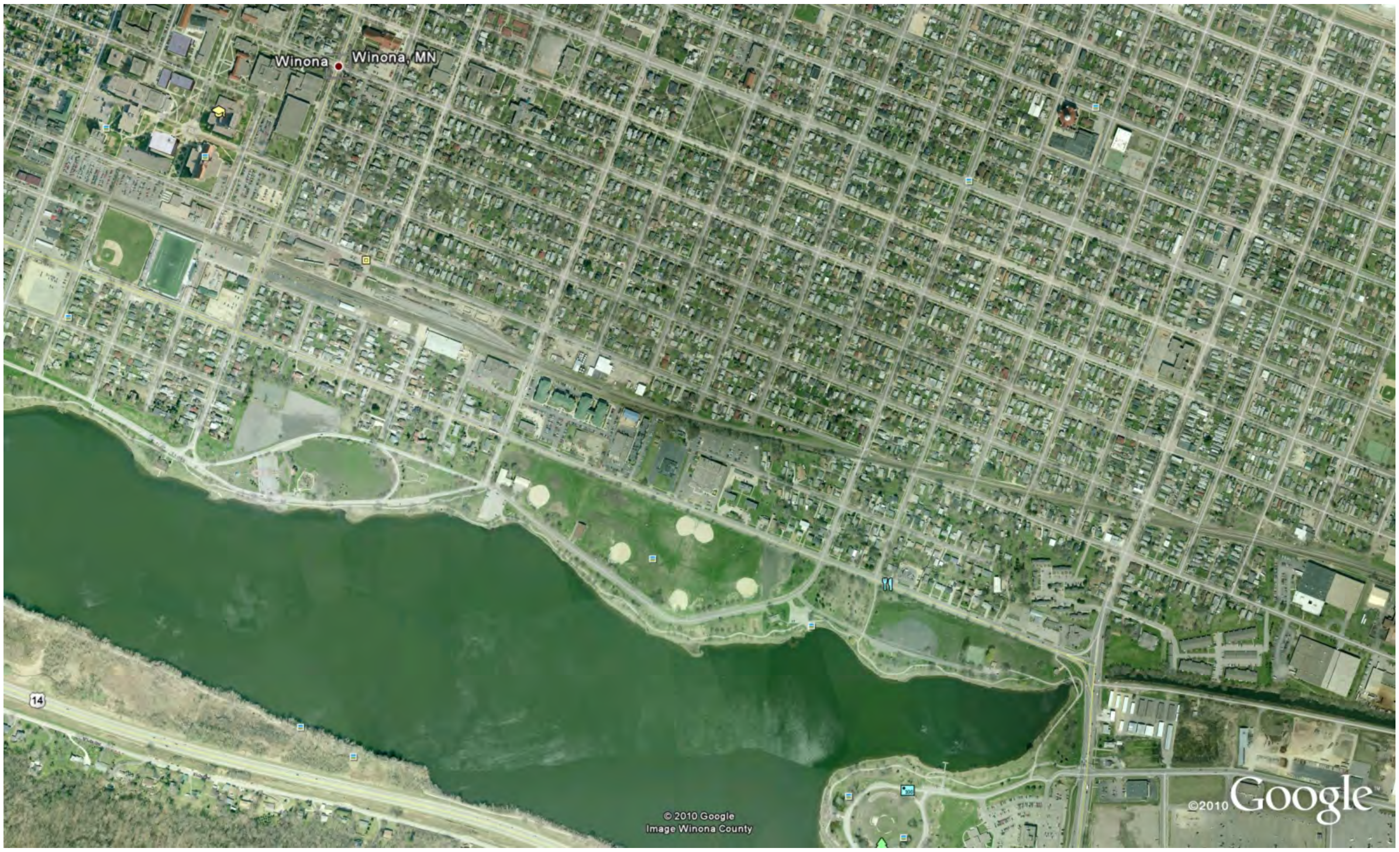
- $28,643,000 (Construction Elements Only).
- $46,173,000 (Total).

Winona, MN (CP)

Current Situation:

- Mississippi River port city on CP's Milwaukee-St. Paul mainline with active grain elevators and other industries in the port area between CP's main track and the river.
- Junction with CP's former Dakota, Minnesota & Eastern (DM&E) Railroad line to Rochester, Owatonna, Pierre, Rapid City and the Black Hills. (This route currently handles substantial grain, bentonite clay and other traffic originating in Wyoming, South Dakota and Minnesota destined to Winona and points east and south on CP. It was also the DM&E's route for some of the coal trains moving to and from DM&E's proposed Powder River Basin Expansion Project.
- Operational control is accomplished by CTC on the mainline and yard track rules on the sidings and port trackage.
- Winona Amtrak station-Amtrak's Empire Builder normally stops on the main track which uses the platform on the siding augmented by an arrangement of crossing panels to allow trains on the main track to detrain and board passengers and baggage. The existing Winona siding is between the main track and the station platform.
- Freight train movements to serve the port are concentrated near Tower CK and Minnesota City on the railroad west end of Winona.
- There is a high concentration of highway-rail grade crossings between the Winona depot (MP 308.2) and Tower CK (MP 310.1).

Figure 2 – Winona, MN



Operating Parameters:

- Maintain throughput capacity for CP mainline, port traffic and Amtrak trains.
- Increase main track capacity and flexibility to handle MWRRI trains.
- Minimize track construction activities between the Winona depot and Tower CK due to the number of grade crossings in this area. Consider rationalizing the number of highway and pedestrian grade crossings to minimize both accident exposure and construction costs. No specific reductions have been proposed. However, the costs of any crossing eliminations should be more than offset by the reduced overall cost to bring the remaining crossings up to HSR standards.
- Minimize construction activities between Tower CK and Minnesota City due to the amount of freight train activity and track connections in this area.
- Concentrate capacity enhancements railroad east of Winona depot where higher operating speeds can be achieved or maintained.
- No improvements to embankment protection have been included in this estimate.

MWRRI Solution:

- Upgrade existing CTC main track to HSR standards between CP Homer East and Tower CK.
- Upgrade second main track between CP Homer East and CP Homer West.

- Rehabilitate the twin two-span through plate girder bridges at MP 304.9 for HSR operation.
- Construct a segment of new HSR second main track CTC between CP Homer West and the east end of the Winona Siding at MP 305 including track shifts near MP 305.
- Replace the turnout at CP Homer West with universal crossovers in CTC territory.
- Upgrade the existing Winona Siding to a second HSR main track in CTC territory.
- Upgrade existing crossover and industry track turnouts and install electric locks on all hand throw switches between MP 305 and MP 309.
- Upgrade crossings to HSR standards including trapped vehicle detection.
- Replace crossing panels in existing siding at the Winona depot to allow the continued use of the existing main track to detrain and board passengers and baggage.
- Permit two HSR trains to meet each other on the enhanced trackage between MP 301.9 and MP 309.0 but only permit one train to come to platform at Winona depot at a time to avoid the need to construct accessible pedestrian and baggage handling facilities for both trains to come to platform simultaneously.

Capital Cost Estimate:

- $25,463,000 (Construction Elements Only).
- $41,047,000 (Total).

Red Wing, MN (CP)

Current Situation:

- Mississippi River port city on CP's Milwaukee-St. Paul mainline with active grain elevators and other industries on both sides of the main track.
- Major grain processing facility (ADM) is located adjacent to CP's main track with facilities on both sides of the main track. Switching activities occupy the main track between through train movements.
- Existing Red Wing siding and other available tracks in Red Wing are used for the storage and switching of grain traffic to serve ADM.
- Through freight trains stop on the main track to set out and pick up blocks of freight cars.
- Red Wing Amtrak station is located on the Red Wing siding and has a second platform to access the main track. The second platform is located between the siding and the main track.
- Operational control is accomplished by CTC on the main track and yard track rules on other tracks.
- An existing segment of two main track CTC is located west of Red Wing between CP Duke East (MP 372.7) and CP Duke West (MP 375.5).

Figure 3 – Red Wing, MN

Operating Parameters:

- Maintain throughput capacity for CP mainline freight trains and Amtrak trains.
- Maintain ability to provide local freight service to ADM plant and other customers.
- Assume that the portion of the existing siding railroad east of the Red Wing station would frequently be occupied by grain cars and industry switching activities as it is now. This track would, however be upgraded to permit HSR movements and higher speed freight train movements when the track was available.
- Increase track capacity to handle MWRRI trains.
- Upgrade grade crossings to HSR standards.
- No major structure upgrades or replacements are included in this segment.

MWRRI Solution:

- Upgrade the existing main track to HSR standards between MP 367.25 and MP 375.5.
- Upgrade the existing siding to HSR standards in CTC territory between MP 367.25 and MP 371.4.
- Upgrade the existing segment of second main track to HSR standards between MP 372.7 and MP 375.5
- Construct a new segment of second main track CTC to HSR standards between MP 371.4 and MP 372.7.

- Install high speed turnouts in CTC territory at MP 367.3 and MP 375.5.
- Install a new #20 CTC crossover at MP 371.4. Convert the existing #10 hand throw crossover to a new #20 power crossover in CTC territory at MP 371.4.
- Install new #33 power crossovers in CTC territory at MP 372.7 and MP 372.8.
- Relay existing rail with new 136# CWR in the existing Red Wing siding between MP 367.25 and MP 371.4.
- Install electric locks on all hand throw industry and yard track turnouts.
- Upgrade all grade crossings to HSR standards including trapped vehicle detection.
- Permit two HSR trains to meet each other on the enhanced trackage between MP 371.4 and MP 375.5 but only permit one train to come to platform at Red Wing depot at a time to avoid the need to construct accessible pedestrian and baggage handling facilities for both trains to come to platform simultaneously.

Capital Cost Estimate:
- $28,214,000 (Construction Elements Only)
- $45,480,000 (Total).

<u>Eau Claire, WI (UP)</u>

Current Situation:
- The area for this estimate extends from Altoona Jct. at MP 93.3 west through Altoona and Eau Claire to MP 85.0 west of Yukon Jct.
- Altoona Yard is located railroad east of Eau Claire and is a crew change point, freight car classification yard and terminal area for the Union Pacific Railroad (UP) between Chicago and the Twin Cities. Other terminals on this line are Milwaukee and Adams, WI.
- UP freight trains in both directions meet and queue at this location waiting for the arrival of trains arriving off the single track railroad in both directions. The trains may also wait for rested crews at this location.
- Operational control on the main track is accomplished by Track Warrant Control (TWC). Track warrants may be issued to trains either electronically or by radio. The railroad is equipped with an Automatic Block Signal (ABS) system, but not CTC. Yard Limit rules apply to the use of the main track in the Altoona-Eau Claire area.
- There are two major bridges (a single track bridge over the Eau Claire River and a double track bridge over the Chippewa River) in this segment. The cost to rehabilitate these two major structures has not been included in the “bottleneck” area capital cost estimate. It will be included in the line segment capital cost estimate in accordance with the methodology.
- Amtrak trains do not serve this community and do not use any portion of the mainline tracks, yard or terminal areas.
- The general maintenance condition of this freight-only railroad line is lower than that of the CP line through Portage and along the Mississippi River which handles higher speed Amtrak intercity passenger trains. Therefore, the costs to bring this terminal area up to HSR standards are higher than they might be if passenger trains currently used the line.

- There are no major active industries along the main track in the Altoona-Eau Claire yard segment.

Figure 4 – Eau Claire, WI

Operating Parameters:

- Maintain throughput capacity for UP mainline freight trains while providing additional capacity for MWRRI trains.
- Maintain existing holding capacity for arriving and departing UP freight trains at Altoona Yard. The locomotives of trains in both directions normally stop at the Altoona Yard office crossing located at MP 90.7 for easy crew access.
- An MWRRI passenger station facility would need to be located at Eau Claire. No capital costs for that station facility have been included in this estimate.
- Avoid the high cost of a second track over the Eau Claire River Bridge since this is only a single-track structure.

MWRRI Solution:

- Upgrade all existing main track, second main track and siding track with new 136# rail and 66% tie replacement. This includes the second track between Altoona Jct. and MP 89.6 west of Altoona Yard and the Altoona siding located west of the main track east of the Altoona yard office.

- Construct new second main track between the east switch at Yukon Jct. and MP 85.0 which includes the segment across the double track Chippewa River Bridge which currently has only one track across the bridge.
- Install CTC on the main track between MP 90.3 and MP 85.0, both segments of second main track and the Altoona siding.
- Install high speed HSR turnouts at MP 93.3, MP 89.6 and MP 85.0.
- Upgrade five existing turnouts to #20 powered turnouts in CTC territory to enhance the speed of arriving and departing freight trains.
- Install power crossovers in CTC territory at both end of Altoona yard to allow faster entry and exit from the yard and to permit additional flexibility for trains to overtake and/or meet each other at Altoona yard.
- Install electric locks for industry track switches.
- Replace the double track single span Forest Street Bridge (2-lane roadway under).
- Upgrade grade crossings to HSR standards including trapped vehicle detection.
- Permit two HSR trains to meet each other in available segments of two main track CTC territory, but only permit one train at a time to come to the platform at the Eau Claire station to avoid the need to construct accessible pedestrian and baggage handling facilities that would be required for both trains to come to platform simultaneously.

Capital Cost Estimate:

- $33,695,000 (Construction Elements Only).
- $54,316,000 (Total).
- Does not include rehabilitation of the Eau Claire River Bridge or the Chippewa River Bridge for HSR operations.

East St. Paul, MN (UP)

Current Situation:

- The area for this estimate extends from Hazel Park Jct. at MP 6.6 through East St. Paul to the BNSF connection at CP Westminster Street at UP MP 0.6 (for trains headed to St. Paul Union Depot) and at MP 0.0 (for trains headed to Minneapolis).
- The former C&NW East St. Paul Yard has been eliminated and most of the remaining tracks in this segment now serve active industries.
- This yard area is on the UP mainline between Chicago and St. Paul. Most UP freight trains from Chicago continue onto BNSF tracks and terminate in Minneapolis.
- Operational control on the single main track east of Hazel Park Jct. is accomplished by TWC. From Hazel Park Jct. to CP Westminster Street, the two main tracks may be used under the provisions of Yard Limit rules. An ABS system is also in effect between Eau Claire and CP Westminster Street.
- Amtrak trains do not serve this line, but they do use the BNSF through CP Westminster Street. There are no passenger stations in this yard segment and none are planned for MWRRI.

- The general maintenance of this freight-only railroad line is lower than that of the CP line through Portage and along the Mississippi River which handles higher speed Amtrak intercity passenger trains. Therefore, the costs to bring this terminal to HSR standards are higher than they might be if passenger trains currently used the line.
- There is a 4-mile long descending grade of at least 1.0% and increasing to 1.23% approaching CP Westminster Street in a westward direction on UP. A power derail is located on the UP main track on the St. Paul lead to the BNSF (MP 0.6) and on the UP main track on the Minneapolis lead to the BNSF (MP 0.0). The derails are controlled by the BNSF CP Westminster Street and were installed as protection against runaway cars and trains from the East St. Paul yard and industry tracks.
- Commuter trains are not currently planned for this UP route segment.

Figure 5 – East St. Paul, MN

Operating Parameters:

- Maintain throughput capacity for UP mainline freight trains and switch engines that serve local industries.
- Provide additional capacity and operational flexibility to accommodate MWRRI trains.
- No MWRRI, Amtrak or commuter station is planned for this segment.
- Update the power-operated derails located on UP main tracks that protect both approaches to

BNSF's CP Westminster Street.

- Upgrade trackage to HSR standards.
- Upgrade rail bridges over roadway and former rail right of way now used as a recreation corridor for HSR operation.
- Grade, curvature approaching CP Westminster Street and crossovers between MP 1.0 and MP 0.0 limit the speed of MWRRI trains at these locations.
- No other structure upgrades or replacements are included.

MWRRI Solution:

- Upgrade both main tracks between Hazel Park Jct. at MP 6.6 and CP Westminster Street to HSR standards including the replacement of 66% of the ties and the installation of new 136# CWR on both tracks.
- Install high speed turnout at Hazel Park Jct. MP 6.6.
- Install CTC on both main tracks between Hazel Park Jct. and CP Westminster Street.
- Replace all industry track turnouts on both main tracks.
- Install #20 universal power crossovers in CTC territory at MP 1.6 west of Payne Avenue overhead highway bridge.
- Replace all industry track switches with new turnouts and electric locks.
- Upgrade girder bridges over Johnson Parkway (MP 3.22) and over former GN Railway right-of-way at MP 1.84 (now converted to a recreation trail) for HSR operation.
- Upgrade grade crossings to HSR standards including trapped vehicle detection.

Capital Cost Estimate:

- $30,896,000 (Construction Elements Only).
- $49,804,000 (Total).

North Milwaukee, WI (CP/WSOR)

Current Situation:

- The segment of track between Grand Avenue Junction (on CP's Milwaukee-Watertown mainline), North Milwaukee and Wiscona has historically been a heavy manufacturing district with an elaborate track and yard network to support the rail customers. While several of the industries in the area have closed or ceased to use rail service, others are still active.
- One of the major industries is a large manufacturing plant that produces steel automobile frames. The industry is an active high-volume freight rail customer located between MP 91 and MP 92 on both sides of the right of way. A large fleet of empty rail cars is stored on many of the tracks near this industry and within the plant itself. These rail cars are held for prospective loading by the industry. The steel frames are shipped to automobile assembly plants at various locations.
- Several large industrial properties have been vacated. Some are being re-developed. The potential for increased rail freight traffic in this area exists.
- Glendale Yard, with track groups on both sides of the main track is located just south of North Milwaukee. Its purpose is to support the large industrial complex in this area.

- At North Milwaukee, Canco and Wiscona, there are several railroad junctions between the former lines of the Milwaukee Road and the Chicago & Northwestern Railroad which are now operated by CP, UP and Wisconsin Southern.
- There are no permanent highway-rail grade crossings between Grand Avenue Junction on the south and North Milwaukee on the north. The segment is totally grade-separated. However, in this same segment, there are a total of 10 roadway bridges over the track, and 6 roadway bridges under the track. All of these bridges are multiple track, multiple span bridges of varying size. Several accommodate highway intersections either immediately above or immediately below the tracks. Most of the rail bridges over the roadways require rehabilitation for HSR operation. No improvements have been planned for roadway bridges over the tracks.
- Between North Milwaukee and Wiscona, there are two highway-rail crossings at grade, no roadway bridges over the track and 3 rail bridges over roadways. The rail bridges over the roadways require rehabilitation for HSR operations.
- A multiple-span rail bridge over the Menominee River is located just north of Grand Avenue Junction. The river is channelized at this location. This was formerly a double track bridge. The east bridge has recently been replaced and is in use. The west bridge is in a deteriorated condition.
- A new multiple track ballast deck bridge over North Milwaukee Creek at North Milwaukee is of recent construction. The creek is channelized at this location.
- At Wiscona, a former C&NW (now UP) double track through riveted truss overhead rail bridge has been removed and the high embankment has been filled in effectively blocking the right-of-way and route between Wiscona and West Bend. The cost to remove the embankment and replace the structure has not been included in this estimate. In accordance with the methodology, these capital costs will be included with the line segment estimate. Approximately 0.75 miles of track have been removed at this location and vegetation has overgrown much of the area.
- No Amtrak passenger trains or commuter trains use this segment. However, Amtrak's Empire builder between Milwaukee and Portage passes through Grand Avenue Junction at the south end of this yard segment.
- Operational control of this segment is through Yard Limit rules and Track Warrant Control. There are no signal systems governing any of the main or yard tracks, except at Grand Avenue Junction (and those are part of the Milwaukee-Watertown segment).
- The main track in this segment appears to be maintained to FRA Class II standards with yard tracks maintained to FRA Class I or Class II standards. Major upgrading will be required to accommodate HSR operations.
- A large number of industry track turnouts, industrial lead switches, yard lead switches and crossovers as well as several junction switches are located in this segment and must be upgraded.
- The main tracks, industry leads and yard tracks are used as needed to make up freight trains, hold loaded and empty cars, classify freight cars and serve local industries. There is currently no provision to maintain a clear track through the corridor that could be used for HSR operations. A

main track does exist through the corridor that can be reconfigured and upgraded, along with adjacent yard tracks and industrial leads, to maintain the capacity to serve industries while permitting the passage of MWRRI HSR trains. This estimate details the requirements to do so.

- Because of the complexity of the track layout, the cost of bridge rehabilitation and the extensive use of all tracks for freight operations, an assumption has been made that only one HSR train will be accommodated between Grand Avenue Junction and Wiscona at any time. No capability to meet MWRRI trains will be provided in this segment at this time. Meets between opposing MWRRI trains must be planned to occur east of Grand Avenue Junction or north of Wiscona.

Figure 6 – North Milwaukee, WI

Operating Parameters:

- Maintain throughput capacity of the rail freight network in the segment.
- Maintain the capacity for the freight railroads to serve the existing and an expanded (renewed) freight rail customer base in the segment, including the use of the main tracks as necessary to accommodate the needed switching movements.
- Maintain the ability of freight railroads to interchange freight cars and freight trains with each other in this segment, if necessary.
- Upgrade main track, extend and/or upgrade certain industrial lead tracks, upgrade several yard tracks to replace main track capacity currently used for switching, replace all main track

turnouts and crossovers to permit HSR operation on the main track while accommodating the freight traffic needs on the other tracks.

- Install a CTC signal system to improve safety, track utilization, accommodate higher freight train operating speeds and to permit HSR operations.
- Rehabilitate or replace aging grade separation structures to HSR standards. Due to the configuration of many of the existing bridges, rehabilitation costs must consider that in most cases, adjoining spans must be disturbed to gain access to the spans to be rehabilitated for HSR operations. This will increase the unit cost for bridge work in this segment.
- Avoid the cost of installing a segment of second main track to accommodate meets between opposing MWRRI trains in this relatively short (8.2-mile) segment due to the exceptionally high infrastructure costs that would be associated with doing so.

MWRRI Solution:

- Reconstruct the entire main track segment with 66% tie replacement and replacement of existing rail with new 136# CWR between MP 88.3 and Wiscona.
- Construct one HSR main track between MP 92.0 and MP 93.0 near Wiscona to connect to the existing track to West Bend. (This same segment requires the replacement of an overhead rail bridge described above that is not included in this estimate.)
- Install CTC between Grand Avenue Junction and Wiscona.
- Extend the Miller Siding and install a main track crossover to permit switching the industry while HSR trains use the main track.
- Replace all industry track turnouts with #10 concrete turnouts and electric locks to improve safety.
- Replace 10 yard and industrial lead switches with #20 power turnouts in CTC territory to expedite freight operations and improve safety.
- Replace 5 existing hand throw crossovers with #10 crossovers in CTC territory to expedite freight operations.
- Rehabilitate 2.0 miles of yard tracks, including turnouts, with 66% tie replacement and new 136# CWR in Glendale Yard to accommodate additional freight train traffic when necessary to clear the main track for MWRRI HSR trains.
- Rehabilitate or replace 8 multiple track, multiple span rail bridges over roadways for HSR operations.
- Upgrade two highway-rail grade crossings to HSR standards including trapped vehicle detection.
- Require that meets between opposing MWRRI trains occur either east of Grand Avenue Junction or railroad west (north) of Wiscona.

Capital Cost Estimate:

- $37,427,000 (Construction Elements Only).
- $60,332,000 (Total).
- Does not include replacement of overhead rail bridge at Wiscona.

The conceptual capital cost estimates for each of the six yard and terminal "bottleneck" areas described above are included in Attachment B.

Attachment B: Conceptual Capital Cost Estimates for Yards, Terminals and Junctions

MWRRI: Milwaukee-Twin Cities Estimate

			Segment No.	Segments 8 & 11		Segments 21 & 24		Segment 24		Segments 18 & 23		Segment 23		Segments 3 & 4	
			From - To	Portage Yard		Winona Yard		Red Wing Yard		Eau Claire Yard		East St. Paul Yard		North Milwaukee Yard	
			Host Carrier	CP		CP		CP		UP		UP		CP/WSOR	
			Mileposts	7.0 to 180.4		301.9 to 309.0		367.2 to 375.5		93.3 to 85.0		6.6 to 0.6		88.3-95.5,92.0-93.0	
			Track Miles	10.4 miles		7.1 miles		8.3 miles		8.3 miles		6.0 miles		8.2 miles	
			Maximum Authorized Speed												
		Unit	2010 Unit Cost												
Trackwork															
1.1	HSR on Existing Roadbed	per mile	$ 1,123	1	$ 1,123	0.2	$ 225	1.3	$ 1,460		$ -		$ -	1.4	$ 1,572
1.2	HSR on New Roadbed	per mile	$ 1,198		$ -		$ -		$ -		$ -		$ -		$ -
1.3	HSR on New Roadbed & New Embankment	per mile	$ 1,687	7	$ 11,810		$ -		$ -		$ -		$ -		$ -
1.4	HSR on New Roadbed & New Embankment (Double Track)	per mile	$ 3,024		$ -		$ -		$ -		$ -		$ -		$ -
1.5	HSR Double Track on 15' Retained Earth Fill	per mile	$ 15,972		$ -		$ -		$ -		$ -		$ -		$ -
1.6	Timber & Surface w/ 33% Tie replacement	per mile	$ 251		$ -	10	$ 2,510	11.1	$ 2,787		$ -		$ -		$ -
1.7	Timber & Surface w/ 66% Tie Replacement	per mile	$ 374		$ -	4	$ 1,497	4.2	$ 1,572	12.7	$ 4,754	11	$ 4,117	9.2	$ 3,444
1.8	Relay Track w/ 136# CWR	per mile	$ 400		$ -		$ -	4.2	$ 1,681	12.7	$ 5,084	11	$ 4,403	9.2	$ 3,683
1.9	Freight Siding	per mile	$ 1,031		$ -		$ -		$ -		$ -		$ -		$ -
1.10	Passenger Siding	per mile	$ 1,556		$ -		$ -		$ -		$ -		$ -		$ -
1.11	Highway Barrier Type 6	lineal ft	$ 1		$ -		$ -		$ -		$ -		$ -		$ -
1.12	Highway Barrier Type 5	lineal ft	$ 0		$ -		$ -		$ -		$ -		$ -		$ -
1.13	Fencing, 4 ft Woven Wire (both sides)	per mile	$ 58		$ -		$ -		$ -		$ -		$ -		$ -
1.14	Fencing, 6 ft Chain Link (both sides)	per mile	$ 173		$ -		$ -		$ -		$ -		$ -		$ -
1.15	Fencing, 10 ft Chain Link (both sides)	per mile	$ 198		$ -		$ -		$ -		$ -		$ -		$ -
1.16	Decorative Fencing (both sides)	per mile	$ 446		$ -		$ -		$ -		$ -		$ -		$ -
1.17	Drainage Improvements (cross country)	per mile	$ 75		$ -		$ -		$ -		$ -		$ -		$ -
1.18	Land Acquisition Urban	per mile	$ -		$ -		$ -		$ -		$ -		$ -		$ -
1.19	Land Acquisition Rural	per mile	$ -		$ -		$ -		$ -		$ -		$ -		$ -
1.20	#33 High Speed Turnout	each	$ 696		$ -		$ -	2	$ 1,392	3	$ 2,088	1	$ 696		$ -
1.21	#24 High Speed Turnout	each	$ 509	1	$ 509	3	$ 1,527		$ -		$ -		$ -		$ -
1.22	#20 Turnout Timber	each	$ 183		$ -		$ -		$ -		$ -		$ -		$ -
1.23	#15 Turnout Timber	each	$ 148												
1.24	#10 Turnout Timber	each	$ 105		$ -		$ -		$ -		$ -		$ -		$ -
1.25	16'6" Double Switch Point Derail	each	$ 34		$ -		$ -		$ -		$ -		$ -		$ -
1.26	#20 Turnout Concrete	each	$ 282	3	$ 845		$ -		$ -	5	$ 1,408	1	$ 282	10	$ 2,816
1.27	#15 Turnout Concrete	each	$ 155												
1.28	#10 Turnout Concrete	each	$ 133	4	$ 534		$ -		$ -	2	$ 267	8	$ 1,068	19	$ 2,535
1.29	#33 Crossover	each	$ 1,285		$ -	1	$ 1,285	2	$ 2,569		$ -		$ -		$ -
1.30	#20 Crossover	each	$ 563	1	$ 563	1	$ 563	2	$ 1,126	2	$ 1,126	3	$ 1,689		$ -
1.31	Surface Curves and Adjust Superelevation	per mile	$ 66		$ -		$ -		$ -		$ -		$ -		$ -
1.32	Curvature Reduction	per mile	$ 444		$ -		$ -		$ -		$ -		$ -		$ -
1.33	Elastic Fasteners	per mile	$ 93		$ -		$ -		$ -		$ -		$ -		$ -
	Sub-total Trackwork (A)				$ 15,384		$ 7,607		$ 12,587		$ 14,726		$ 12,255		$ 14,050
Structures															
	Bridges-undergrade														
2.1	Four Lane Urban Expressway	each	$ 5,468		$ -		$ -		$ -		$ -		$ -		$ -
2.2	Four Lane Rural Expressway	each	$ 4,552		$ -		$ -		$ -		$ -		$ -		$ -
2.3	Two Lane Highway	each	$ 3,454		$ -		$ -		$ -	1	$ 3,454	2	$ 6,907		$ -
2.4	Rail	each	$ 3,454		$ -		$ -		$ -		$ -		$ -		$ -
2.5	Minor river	each	$ 916	2	$ 1,832		$ -		$ -		$ -		$ -		$ -
2.6	Major River	each	$ 9,158		$ -		$ -		$ -		$ -		$ -		$ -
2.7	Double Track High (50') Level Bridge	per LF	$ 14		$ -		$ -		$ -		$ -		$ -		$ -
2.8	Rehab for 110	per LF	$ 2	240	$ 379	420	$ 664		$ -		$ -		$ -	1750	$ 2,765
2.9	Convert open deck bridge to ballast deck (single track)	per LF	$ 5		$ -		$ -		$ -		$ -		$ -		$ -
2.10	Convert open deck bridge to ballast deck (double track)	per LF	$ 11		$ -		$ -		$ -		$ -		$ -		$ -
2.11	Single Track on Flyover/Elevated Structure	per LF	$ 10		$ -		$ -		$ -		$ -		$ -		$ -
2.12	Single Track on Approach Embankment w/ Retaining Wall	per LF	$ 5		$ -		$ -		$ -		$ -		$ -		$ -
2.13	Ballasted Deck Replacement Bridge	per LF	$ 3		$ -		$ -		$ -		$ -		$ -		$ -
2.14	Land Bridges	per LF	$ 3		$ -		$ -		$ -		$ -		$ -		$ -
2.15	Double Track on Flyover/Elevated Structure	per LF	$ 18		$ -		$ -		$ -		$ -		$ -		$ -
2.16	Double Track on Approach Embankment w/ Retaining Wall	per LF	$ 9		$ -		$ -		$ -		$ -		$ -		$ -
	Bridges-overhead				$ -		$ -		$ -		$ -		$ -		$ -
2.17	Four Lane Urban Expressway	each	$ 3,312		$ -		$ -		$ -		$ -		$ -		$ -
2.18	Four Lane Rural Expressway	each	$ 2,360		$ -		$ -		$ -		$ -		$ -		$ -
2.19	Two Lane Highway	each	$ 2,152		$ -		$ -		$ -		$ -		$ -		$ -
2.20	Rail	each	$ 6,909		$ -		$ -		$ -		$ -		$ -	1	$ 6,909
	Other Structures				$ -		$ -		$ -		$ -		$ -		$ -
2.21	Culvert Extensions	per mile	$ 58		$ -		$ -		$ -		$ -		$ -		$ -
2.22	Two Bore Long Tunnel	route ft	$ 45,540		$ -		$ -		$ -		$ -		$ -		$ -
2.23	Single Bore Short Tunnel	lineal ft	$ 25,875		$ -		$ -		$ -		$ -		$ -		$ -
	Sub-total Structures (B)				$ 2,211		$ 664		$ -		$ 3,454		$ 6,907		$ 9,674

Systems															
3.1	Install CTC System (Single Track)	per mile	$ 207	7	$ 1,449	4.2	$ 869	5.5	$ 1,138	3.9	$ 807		$ -	3.1	$ 642
3.2	Install CTC System (Double Track)	per mile	$ 339		$ -		$ -		$ -	4.8	$ 1,628	6.6	$ 2,239	5.1	$ 1,730
3.3	Install PTC System	per mile	$ 177		$ -		$ -		$ -		$ -		$ -		$ -
3.4	Electric Lock for Industry Turnout	each	$ 116	1	$ 116	7	$ 815	12	$ 1,398	3	$ 349	6	$ 699	12	$ 1,398
3.5	New Control Point (CP)	each	$ 1,434	1	$ 1,434	3	$ 4,302	6	$ 8,603	3	$ 4,302	1	$ 1,434		$ -
3.6	Signal work to add Crossover to CP	each	$ 792	1	$ 792	2	$ 1,583	2	$ 1,583	2	$ 1,583	3	$ 2,375	5	$ 3,958
3.7	Signal work to add Turnout to CP	each	$ 452	6	$ 2,714		$ -		$ -	8	$ 3,619	3	$ 1,357	10	$ 4,523
	Sub-total Systems (C)				$ 6,505		$ 7,569		$ 12,722		$ 12,288		$ 8,104		$ 12,251
Crossings															
4.1	Private Closure	each	$ 94	2	$ 188	6	$ 563		$ -		$ -		$ -		$ -
4.2	Four Quadrant Gates w/ Trapped Vehicle Detector	each	$ 556	6	$ 3,338	11	$ 6,120	4	$ 2,225	4	$ 2,225	5	$ 2,782	2	$ 1,113
4.3	Four Quadrant Gates	each	$ 326		$ -		$ -		$ -		$ -		$ -		$ -
4.4	Convert Dual Gates to Quad Gates	each	$ 170		$ -		$ -		$ -		$ -		$ -		$ -
4.5	Conventional Gates single mainline track	each	$ 188		$ -		$ -		$ -		$ -		$ -		$ -
4.6	Conventional Gates double mainline track	each	$ 232		$ -	2	$ 464		$ -	1	$ 232		$ -		$ -
4.7	Convert Flashers Only to Dual Gate	each	$ 57		$ -		$ -		$ -		$ -		$ -		$ -
4.8	Dual Gate with Median Barrier	each	$ 204		$ -		$ -		$ -		$ -		$ -		$ -
4.9	Convert Dual Gate to Extended Arm	each	$ 17		$ -		$ -		$ -		$ -		$ -		$ -
4.10	Precast Panels without Rdway Improvements	each	$ 90		$ -	3	$ 271		$ -	1	$ 90		$ -		$ -
4.11	Precast Panels with Rdway Improvements	each	$ 170	6	$ 1,018	13	$ 2,205	4	$ 679	4	$ 679	5	$ 848	2	$ 339
	Sub-total Crossings (D)				$ 4,544		$ 9,623		$ 2,904		$ 3,226		$ 3,630		$ 1,452
Station/Maintenance Facilities															
5.1	Full Service - New - Low Volume - 500 Surface Park	each	$ 5,175		$ -		$ -		$ -		$ -		$ -		$ -
5.2	Full Service - Renovated - Low Volume- 500 Surface Park	each	$ 4,140		$ -		$ -		$ -		$ -		$ -		$ -
5.3	Terminal - New - Low Volume - 500 Surface Park	each	$ 7,763		$ -		$ -		$ -		$ -		$ -		$ -
5.4	Terminal - Renovated - Low Volume - 500 Surface Park	each	$ 6,210		$ -		$ -		$ -		$ -		$ -		$ -
5.5	Full Service - New- High Volume - Dual Platform - 1000 Surface Park	each	$ 10,350		$ -		$ -		$ -		$ -		$ -		$ -
5.6	Terminal - New- High Volume - Dual Platform - 1000 Surface Park	each	$ 15,525		$ -		$ -		$ -		$ -		$ -		$ -
5.7	Maintenance Facility (non-electrified track)	each	$ 82,800		$ -		$ -		$ -		$ -		$ -		$ -
5.8	Layover Facility	lump sum	$ 10,350		$ -		$ -		$ -		$ -		$ -		$ -
	Sub-total Station/Maintenance Facilities (E)				$ -		$ -		$ -		$ -		$ -		$ -
Allocations for Special Elements															
6.1	Access to Signal/Switch Location	lump sum	$ 100		$ -		$ -		$ -		$ -		$ -		$ -
6.2	Access to Maintenance of Way Spur	lump sum	$ 1,000		$ -		$ -		$ -		$ -		$ -		$ -
6.3	Rail-Rail Flyovers	lump sum	$ 40,000		$ -		$ -		$ -		$ -		$ -		$ -
	Sub-Total Allocations for Special Elements (F)				$ -		$ -		$ -		$ -		$ -		$ -
	Sub-total Construction Elements (A+B+C+D+E+F)				$ 28,643		$ 25,463		$ 28,214		$ 33,695		$ 30,896		$ 37,427
Contingency															
	Design and Construction Contingency		30%		$ 8,593		$ 7,639		$ 8,464		$ 10,108		$ 9,269		$ 11,228
	Sub-total Construction Elements Including Contingency (G)				$ 37,236		$ 33,102		$ 36,678		$ 43,803		$ 40,164		$ 48,655
Professional Services and Environmental															
	Design Engineering														
	Insurance and Bonding														
	Program Management														
	Construction Management & Inspection														
	Engineering Services During Construction														
	Integrated Testing and Commissioning														
	Erosion Control and Water Quality Management														
	Sub-total Professional Services and Environmental (H)		24%		$ 8,937		$ 7,945		$ 8,803		$ 10,513		$ 9,639		$ 11,677
	Total Segment Cost (G)+(H)				$ 46,173		$ 41,047		$ 45,480		$ 54,316		$ 49,804		$ 60,332

Operating and Maintenance Costs and Capital Replacement Forecast

DEPARTMENT OF TRANSPORTATION

U.S. Department of Transportation
Federal Railroad Administration

WISCONSIN DEPARTMENT OF TRANSPORTATION

NORTHERN LIGHTS *EXPRESS*

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TECHNICAL DOCUMENT IN SUPPORT OF THE NLX SERVICE DEVELOPMENT PLAN

Operating and Maintenance Costs and Capital Replacement Forecast

January 2017

Prepared by:

QUANDEL CONSULTANTS

161 N. Clark Street, Suite 2060
Chicago, IL 60601

161 St. Anthony Avenue, Suite 940
St. Paul, MN 55103

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FIGURES

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1. INTRODUCTION

The purpose of this Technical Document is to present the operating and maintenance costs for Scenario C-1 for the proposed Northern Lights Express (NLX) passenger rail service between Minneapolis and Duluth, Minnesota. The Minnesota Department of Transportation (MnDOT), in association with the Federal Railroad Administration (FRA), NLX Alliance, and the Wisconsin Department of Transportation (WisDOT), is completing Preliminary Engineering and Project NEPA for the NLX Service Development Program.

A Draft Technical Document was prepared and submitted to FRA in February 2016 as part of an initial benefit-cost analysis that considered capital and operating costs and benefits related to travel cost savings, safety improvements and emissions savings for automobile travelers; operating cost savings, emissions savings and inventory savings for freight rail; grade crossing improvements; and economic development. Draft operating and maintenance costs were computed for eight service alternatives as shown in Table 1-1.

Table 1-1: Summary of NLX Scenarios

Scenario	Maximum Train Speed (MPH)	Number of Round Trips/Day
B-1	110	4
B-2	110	6
B-10	110	2
B-11	110	8
C-1	90	4
C-2	90	6
C-10	90	2
C-11	90	8

The Draft Technical Document on Operating and Maintenance Cost and Capital Replacement Forecast is included as Attachment A.

Following a refined benefit-cost analysis based on updated train schedules and revised ridership and revenue forecasts, MnDOT determined that the service alternative consisting of four round trips per day at a maximum speed of 90 MPH (Scenario C-1) was the preferred service alternative to be advanced into the NLX Tier 2 Environmental Assessment. Rail Traffic Control (RTC) modeling was undertaken on the NLX corridor considering the preferred service plan, and a final infrastructure investment package was identified. The following report presents the final operating and maintenance costs and capital replacement forecast for the preferred service alternative and the infrastructure investment package identified and approved by FRA.

The methodologies for calculating the operating and maintenance costs, including both expensed and capital replacement, are described in detail in the Draft Technical Document in Attachment A. This report summarizes the operating and maintenance costs and revenues over the 40-year study period for Scenario C-1.

2. OPERATING & MAINTENANCE COSTS

Operating costs for the NLX project are calculated using a methodology established under the provisions of the Passenger Rail Reinvestment and Improvement Act of 2008 (PRIIA). The PRIIA Section 209 Cost Methodology Policy (S209 Methodology) was prepared by the Section 209 State Working Group and Amtrak to outline the "single, nationwide standardized methodology for establishing and allocating the operating and capital costs among the States and Amtrak."[1] Amtrak has not been designated the operator of the NLX service, but the S209 Methodology is used to estimate NLX operating costs because it is a standardized model that will be employed by all other state-supported intercity passenger rail services. The PRIIA S209 Methodology is discussed in Section 2.2.

Maintenance of Way costs for the NLX project are calculated using the methodology presented in the *Technical Monograph: Estimating Maintenance Costs for Mixed High-Speed Passenger Rail and Freight Rail Corridors* (FRA Technical Monograph), prepared by ZETA-TECH Associates for the Federal Railroad Administration in August 2004. The Technical Monograph is included as Attachment A to the Draft Technical Document on Operating and Maintenance Costs and Capital Replacement Forecast, included as Attachment A. Maintenance of Way costs include both expensed maintenance and cyclic capital, and are presented in Section 2.1 and Section 3.1, respectively.

The FRA Technical Monograph was developed for the express purpose of providing a method of estimating the costs of right-of-way maintenance associated with the operations of high-speed and intercity passenger trains. As described in the monograph, maintenance costs include expensed maintenance costs for inspections, spot repairs, and routine maintenance, and "cyclic capital" costs such as rail replacement, tie renewal, surfacing, ballast replacement, and similar capital improvements.

Maintenance of Way costs include costs associated with track maintenance, bridge and building (B&B) maintenance, and communications and signals maintenance. The maintenance of way costs outlined in the NLX Operating and Maintenance Cost (OPEX) report are the expensed and cyclic maintenance costs required to maintain the infrastructure to an adequate condition to carry the expected volumes of traffic. Expensed maintenance costs are included with Operating and Maintenance costs; cyclic capital costs are discussed in Section 3.1 with other capital replacement cost items.

The NLX OPEX report uses minimum and maximum costs shown in the FRA Technical Monograph. As noted in the monograph, the minimum costs are based on the maintenance standards geared to FRA minimum track safety guidance, while the maximum costs reflect maintenance of high track standards to ensure good ride quality.

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[1] *Passenger Rail Investment and Improvement Act (PRIIA) of 2008 Section 209 Cost Methodology Policy, Final Version, 8/31/2011*

The following section presents the minimum and maximum expensed maintenance costs for the NLX project. The summary of cyclic capital costs is presented in Section 3.1.

2.1 Expensed Maintenance Costs

Expensed maintenance costs are the costs expended to keep a railroad in safe operating condition. Expensed maintenance activities include maintenance of train control equipment and grade crossing warning devices, track inspection, and minor maintenance and spot surfacing of rails.

Expensed maintenance costs are separated into two categories for this analysis: track, signal, bridge and building elements and PTC system elements.

2.1.1 Expensed Maintenance – Track, Signal, Bridge and Building Elements

The FRA Technical Monograph uses its Work Unit Model to estimate the expensed maintenance (non-capital) costs to maintain a defined segment of track. Expensed maintenance costs estimated by the Work Unit Model were used to develop a series of costs per mile for segments of track. The costs are presented in matrices to allow for the calculation of minimum and maximum expensed maintenance costs per mile based on a track segment's particular tonnage, mix of freight versus passenger traffic, curvature, class of track, and tie type.

The TrackShare Model, developed by ZETA-TECH, is an engineering-based cost model that allocates maintenance costs between different traffic types. TrackShare is a descendent of the Weighted System Average Cost model, which has been extensively used in North America and overseas to determine the passenger train share of maintenance of way costs. TrackShare uses engineering damage equations to calculate the portion of track damage (component life consumption) due to each defined traffic type operating over a specific track segment.

Detailed discussions of the Work Unit Model, the TrackShare Model, and the methodology employed to utilize these models to calculate annual expensed maintenance costs can be found in Attachment A – Draft Technical Document on Operating and Maintenance Costs and Capital Replacement Forecasts.

Using these two models, annual expensed maintenance costs were calculated for NLX Scenario C-1. Table 2-1 presents the annual expensed maintenance cost of track, signals, buildings and bridges for each NLX Scenario for the year 2020.

Table 2-1: Annual Expensed Maintenance Costs of Track, Signals, Buildings, and Bridges for NLX Scenario C-1 for Year 2020

Scenario	Annual Expensed Maintenance Costs, Year 2020 (2017$)
C-1	$1,749,240

Expensed maintenance costs for track, signals, buildings, and bridges are computed for years 2021 through 2059 by increasing the level of freight traffic in the corridor by 1.5% per year, keeping all other assumptions the same. Therefore, expensed maintenance costs for these elements will increase each year during the study period.

2.1.2 Expensed Maintenance – PTC System

Costs will be incurred over the life of the project to maintain the PTC system. Raul V. Bravo & Associates, the PMO's equipment procurement subconsultant, recommended an annual lump sum cost of $220,000 to cover all costs associated with maintaining the PTC equipment including the wayside, in-cab, and back office equipment.

2.1.3 Summary of Expensed Maintenance Costs

Table 2-2 presents the total annual expensed maintenance costs for NLX Scenario C-1 in 2014 dollars for the year 2020. Total expensed maintenance costs are equivalent to the sum of the expensed maintenance costs for track, signal, bridges, and buildings and costs to maintain the PTC system. Total expensed maintenance costs for 2020 through 2059 are presented in Attachment B.

Table 2-2: Total Annual Expensed Maintenance Costs for NLX Scenarios for Year 2020

Scenario	Expensed Maintenance Costs (2017$)	PTC System Maintenance Costs (2017$)	Total Annual Maintenance of Way Costs (2017$)
C-1	$1,749,240	$220,000	$1,969,240

2.2 PRIIA Costs

Under the S209 Methodology, operating and maintenance costs were calculated for the following three categories:

- Third Party Costs
- Route Costs
- Support Fees (Additives)

These cost categories and means through which the costs were estimated are consistent with the methodology developed pursuant to the PRIIA S209-recommended methodology for estimating operating costs for state supported trains. The following sub-sections summarize how the costs for each PRIIA S209 operating category were determined. Descriptions of cost elements included in each operating category were taken from the PRIIA Section 209 Cost Methodology Policy, Appendix E, October 2015 update and are included as Attachment A –Draft Technical Document on Operating and Maintenance Costs and Capital Replacement Forecasts.

2.2.1 Third Party Costs

According to PRIIA S209, third party costs are costs to a service for host railroad expenses including:

- Policing and dispatching the right-of-way
- Maintenance of Way
- Fuel and power charges

As discussed in the Draft Technical Document, policing and dispatching costs are not estimated as part of this analysis as these values will be determined during negotiations with BNSF. Maintenance of Way costs include both expensed and cyclic capital costs and are calculated using the methodology described in the FRA Technical Monograph and are presented in Section 2.1 and Section 3.1 of this technical report. Therefore, fuel and power charges are the only third party costs calculated in this analysis.

Fuel and power charges were updated from the Draft Technical Document to reflect current information on fuel and urea consumption rates of Siemens Charger locomotives, the locomotive assumed to be utilized for the NLX service. Fuel consumption for the new locomotives is expected to be 1.73 gallons of diesel fuel per train mile. These locomotives also consume a small quantity of urea along with the diesel fuel as an element of the emissions control system for EPA Tier 4-compliant locomotives. For every gallon of diesel fuel that is consumed, an additional 0.08 gallons of urea is also consumed.[2] A diesel fuel cost of $2.54 per gallon[3] and a urea cost of $2.50 per gallon are used[4] to calculate the overall cost of fuel for the NLX Service.

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[2] *Siemens*
[3] *U.S. Energy Information Administration Diesel (on-highway) cost for 1/2/2017, http://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_r20_w.htm*
[4] *Vulcan DEF price for 330 gallon tote, http://www.vulcandef.com/products/diesel-exhaust-fluid.html*

Total cost of the fuel with urea added = diesel fuel consumption cost + urea consumption cost

= (diesel fuel consumption)(cost of diesel fuel) + (urea consumption)*(cost of urea)*

and

*Urea consumption = diesel fuel consumption * (gallons of urea used/gallons of diesel fuel used)*

Therefore,

Total cost of the fuel with urea added = (1.73 gallons diesel fuel per train mile)($2.54 per gallon diesel fuel) + (1.73 gallons diesel fuel per train mile*0.08 gallons of urea used per gallon of diesel fuel used)*($2.50 per gallon urea) = $4.74 per train mile*

The annual revenue train miles, fuel consumption rate, and cost per gallon of diesel fuel and urea are assumed to remain constant during the study period. Therefore, the total annual fuel cost will also remain constant during the study period.

Table 2-3 presents the annual fuel charge for NLX Scenario C-1.

Table 2-3: Annual Fuel Cost for NLX Scenario C-1 for Year 2020

Scenario	Annual Revenue Train Miles in Year 2020	Cost per Gallon of Diesel Fuel with Urea Added (2017$)	Total Annual Fuel Cost (2017$)
C-1	447,928	$4.74	$2,131,573

2.2.2 Route Costs

Route costs are operating costs closely associated with the operation of a route. Amtrak and states monitor and evaluate sixteen categories of route costs. In order to aid in the development of the NLX route costs, two Midwest states provided PRIIA 209 costs for their state-supported intercity Amtrak services. The PRIIA costs for these two Midwest services were evaluated and applied to the NLX Service. A description of each of the route costs is provided in Attachment A –Draft Technical Document on Operating and Maintenance Costs and Capital Replacement Forecasts. The following sections present the unit costs for each PRIIA Route Cost category.

2.2.2.1 Train & Engine Crew Support

The NLX Train & Engine (T&E) Crew Support unit cost presented in the Draft Technical Document was updated for 2017 PRIIA costs provided by a Midwest state for similar state-supported service. The updated unit cost is $83.34 per T&E hour. It is assumed that this unit cost includes all labor and benefits for T&E crew.

2.2.2.2 Car & Locomotive Maintenance and Turnaround

The Car & Locomotive Maintenance and Turnaround (M&T) unit of measurement is cost per car and locomotive unit mile. Car and locomotive unit miles increase as the equipment consist size increases. As discussed in the Ridership and Revenue chapter of the SDP, equipment consist needs for Scenario C-1 were determined for low and high ends of forecasted ridership throughout the 40-year study period. Car and locomotive unit miles were then calculated for each equipment consist scenario and averaged for each year of service.

The M&T unit cost presented in the Draft Technical Document was updated for 2017 PRIIA costs provided by a Midwest state for similar state-supported service. The updated unit cost is $1.979 per car and locomotive unit mile. It is assumed that this unit cost includes all labor and benefit costs for T&E crew.

Because NLX service will utilize new equipment, M&T costs will not be as costly as for older equipment. It is assumed that the M&T cost will increase as the equipment ages according to the following schedule:

- Year 1 = 50% of total PRIIA cost
- Years 2-10 = 80% of total PRIIA cost
- Years 11-15 = 85% of total PRIIA cost
- Years 16-20 = 90% of total PRIIA cost
- Years 21 and beyond = 100% of total PRIIA cost

2.2.2.3 On Board Service Crew

On Board Service labor costs are not forecast for NLX service as food and beverage services will not be provided.

2.2.2.4 On Board Service Commissary Provisions

OBS commissary provision costs are not forecast for NLX service as food and beverage services will not be provided.

2.2.2.5 Route Advertising

It is assumed that there will be no route advertising costs for NLX service.

2.2.2.6 On-Board Passenger Technology

The Sales Distribution category was removed from the PRIIA S209 methodology and replaced by On-Board Passenger Technology, which is a category that applies only to those routes with on-board Wi-Fi service. It is assumed that the NLX Service will provide on-board Wi-Fi. On-Board Passenger Technology is driven primarily by the total number of passengers served by NLX.

The On-Board Passenger Technology unit cost is calculated by dividing the PRIIA 209 cost for On-Board Passenger Technology by the total number of passengers. The NLX On-Board Passenger Technology unit cost is $0.58 per passenger.

2.2.2.7 Reservations and Call Centers

NLX service will utilize online reservations or in-station kiosks. It is assumed that there will be no reservation and call center costs.

2.2.2.8 Stations

Facilities operating and maintenance costs were estimated by HNTB and were derived from the 2015 operating budget for the Northstar commuter rail service, a 40-mile route between Big Lake, Minnesota and downtown Minneapolis.

The O&M facility costs for the NLX service are separated into four categories of expenses:

1. Labor and benefits
2. Contracted services
3. Materials, parts & supplies
4. Other expenses

The methods by which the four categories of O&M facility costs from Northstar's operating budget are applied to the NLX Service are discussed in Appendix C to the Draft Technical Document on Operating and Maintenance Costs and Capital Replacement Forecasts.

2.2.2.9 Commissions

The Commissions unit presented in the Draft Technical Document was updated for 2017 PRIIA costs provided by a Midwest state for similar state-supported service. The updated unit cost is $0.992 per passenger.

2.2.2.10 Customer Concessions

The Customer Concessions unit presented in the Draft Technical Document was updated for 2017 PRIIA costs provided by a Midwest state for similar state-supported service. The updated unit cost is $0.119 per passenger.

2.2.2.11 Connecting Motor Coach

There will be no connecting motor coach costs for NLX service.

2.2.2.12 Regional & Local Police

Regional & Local Police services will be provided by the host railroad. It is assumed that there will be no regional & local police costs for NLX service.

2.2.2.13 Block & Tower Operations

There will be no block & tower operations costs for NLX service because Amtrak does not own any track in the NLX corridor.

2.2.2.14 Terminal Yard Operations

Terminal yard operations costs are assumed to be included in car and locomotive M&T costs. There will be no separate Terminal Yard Operations costs for NLX service.

2.2.2.15 Terminal Maintenance of Way

Terminal Maintenance of Way costs are included in the O&M cost for the facilities. There will be no separate Terminal Maintenance of Way costs for NLX service.

2.2.2.16 Insurance

Raul V. Bravo & Associates recommended budgeting $750,000 per year for insurance costs.

2.2.2.17 Route Cost Summary

The Route Cost total for NLX Scenario C-1 is calculated by adding the individual Route Cost elements (T&E Crew Support, Car and Locomotive M&T, Stations, etc.). Note that the Route Costs will increase throughout the life of the project as the number of train miles, revenue, ridership, etc. increase. Table 2-4 presents the average route costs for Year 2020 for NLX Scenario C-1.

Table 2-4: Average Annual Route Cost for NLX Scenario C-1 for Year 2020

Scenario	Average Annual Route Cost (2017$)
C-1	$10,045,100

2.2.3 Support Fees

According to the PRIIA S209 Methodology, some cost categories have an additional level of regional and national support not included in the Route Costs, and therefore also include Support Fees that are proportional to the service provided. PRIIA Support Fees are determined by applying category-specific additives to an associated route cost. There are six categories of Support Fees, identified specifically for the NLX service. The definition of these Support Fees are shown in Figure 2-1.

Figure 2-1: Definition of PRIIA Support Fees

Support Fees (Additives)						
T&E	Division (Region)-specific and system overhead rates for T&E supervision and management not otherwise included in Route Costs. Includes superintendents, crew bases, crew dispatching and management, local and national operating rule compliance, and other support. Excludes national train dispatching	Division	Division Rate	System Rate	Total	tbd
		Central	17.50%	12.90%	30.40%	
		Mid-Atlantic	18.40%	12.90%	31.30%	
		Mid-Atlantic/ Southern	20.20%	12.90%	33.10%	
		New England	16.50%	12.90%	29.40%	
		New York	24.30%	12.90%	37.20%	
		Pacific	19.50%	12.90%	32.40%	
		Southern	20.60%	12.90%	33.50%	
		South-west	16.30%	12.90%	29.20%	
		Total rate to be applied to T&E Crew Labor				
MoE	Maintenance of shops and equipment to support direct Mechanical activities. Includes mechanical superintendents, facility administration, and material control. Excludes Backshops and Fleet Engineering	27.10% of Route Cost Car & Locomotive Maintenance and Turnaround				tbd
OBS	OBS crew and commissary management and supervision	10.00% of OBS Crew & Provisions				tbd
Police	National police operations and support, security, environmental, health, and safety	$0.0050 per passenger mile				tbd
Marketing	National marketing programs, including advertising and sales; field marketing and sales; loyalty marketing; pricing and revenue management; market research; and other. The specific mix of marketing programs may be updated from time to time in consultation with the States	Region	Rate			tbd
		Base-increment routes on NEC	2.3%			
		Routes with one terminal in Chicago	2.3%			
		All other routes	1.4%			
		Rate to be applied to Ticket revenue, net				
Shared Support Services	Charge for General & Administrative support including Computer Systems, Finance, Legal, and other	3.50% of Route Costs				tbd

The NLX-specific Support Fees are shown in Table 2-5.

Table 2-5: PRIIA S209 Support Fees for the NLX Service

Additive	Factor/Basis	Rate
Train and Engine (T & E)	% of T&E cost	30.4%
Maintenance of Shops and Equipment (MoE)	% of Car & Locomotive M & T cost	27.1%
OBS	% of OBS cost	10.0%
Police	Passenger miles	$0.005
Marketing	% of total revenue	1.40%
General and Administrative (G & A)	% of total route cost	3.5%

Support fees are calculated by multiplying the additive rate presented in Table 2-5 by its respective operating or maintenance cost. For example, the T&E support fee is equal to the T&E route cost, calculated in Section 2.2.2.1, by 30.4%.

Table 2-6 presents the Support Fees for Year 2020 for NLX Scenario C-1.

Table 2-6: Total Support Fee Cost for NLX Scenario C-1 for Year 2020

Scenario	Annual Support Fee Cost (2017$)
C-1	$2,588,485

2.2.4 Summary of PRIIA Costs

The overall PRIIA cost is the sum of Third Party Costs, Route Costs, and Support Fees as calculated in Sections 2.2.1, 2.2.2, and 2.2.3, respectively. Table 2-7 presents the summary of PRIIA costs for Year 2020 for NLX Scenario C-1.

Table 2-7: Total PRIIA Costs for NLX Scenarios for Year 2020

Scenario	Annual Third Party Costs (2017$)	Annual Route Costs (2017$)	Annual Support Fees (2017$)	Annual PRIIA Costs (2017$)
C-1	$2,131,573	$10,045,100	$2,588,485	$14,765,158

2.3 Summary of Operating and Maintenance Costs

The total annual operating and maintenance cost for the NLX Service is equal to the sum of the expensed maintenance costs calculated using the FRA Technical Monograph in Section 2.1, and the PRIIA costs calculated in Section 2.2. Table 2-8 presents the summary of operating and maintenance costs for Year 2020 for NLX Scenario C-1. Total operating and maintenance costs for 2020 through 2059 are presented in Attachment C.

Table 2-8: Total Operating and Maintenance Costs for NLX Scenario C-1 for Year 2020

Scenario	Annual Expensed Maintenance Costs (2017$)	Annual PRIIA Costs (2017$)	Annual Operating and Maintenance Costs (2017$)
C-1	$1,969,240	$14,765,158	$16,734,399

3. CAPITAL REPLACEMENT COSTS

Capital replacement costs are additional capital costs, beyond those incurred in the initial implementation of the NLX service, that are anticipated to be required due to lifecycle replacement or other factors through the planning horizon of the project. The planning horizon for the NLX project is 40 years, which covers the period of 2020 through 2059.

Capital replacement costs include cyclic capital costs of track for items such as rail replacement, tie renewals, surfacing, and ballast replacement; cyclic capital costs of maintaining equipment; equipment procurement; and station expansion. Maintenance of train control equipment and grade crossing warning devices, track inspection, and minor maintenance and spot surfacing of rails are considered expensed maintenance costs and are discussed in Section 2.1.

3.1 Cyclic Capital Cost Estimating Methodology

The cyclic capital cost includes capital maintenance expenditures for replacement of track, signal, building, and bridge components as they wear out.

Cyclic capital costs are separated into two categories for this analysis: track, signal, bridge and building elements and train equipment.

3.1.1 Cyclic Capital Costs – Track, Signal, Bridge and Building Elements

The methodology for calculating cyclic capital costs of track, signal, bridge and building elements for the NLX project follows a similar methodology as is used to calculate expensed maintenance costs, discussed in Section 2.1.1, and is also found in the *Technical Monograph: Estimating Maintenance Costs for Mixed High-Speed Passenger Rail and Freight Rail Corridors* (Technical Monograph).

In the Technical Monograph, cyclic capital costs are estimated using standard lives and costs to replace track components as they wear out. The ZETA-TECH Steady State Capital Model calculates cyclic capital costs using observed lives of track components under traffic with actual railroad capital costs from Class I railroad sources for segments of mixed passenger/freight rail corridors. Annual bridge and signal expenditures were calculated in the same manner as track component expenditures.

Detailed discussions of the Steady State Model and the methodology employed to utilize this model to calculate annual cyclic capital costs can be found in Attachment A – Draft Technical Document on Operating and Maintenance Costs and Capital Replacement Forecasts.

Prior to NLX Service starting operations on the BNSF-owned track, rail, ties, and ballast will be upgraded to a state of good repair along the entire corridor. According to the FRA Technical Monograph, a railroad that has been substantially upgraded "will require maintenance, but little or no renewal of track components for a number of years. Therefore, costs shown in the matrices may be adjusted downward during the first few years of operations to account for this fact. Maintenance costs are unaffected, since even new track requires maintenance. But some cyclic capital costs can be deferred." Table 3-1 shows the cost adjustment by year of service.

Table 3-1: Adjustment of Cyclic Capital Costs

Year of Service	% of Cyclic Capital
1-3	20
4-6	35
7-9	50
10-13	75
14-40	100

Annual cyclic capital costs were calculated for NLX Scenario C-1. Table 3-2 presents the annual cyclic capital cost of track, signals, buildings and bridges for each NLX Scenario for the year 2020.

Table 3-2: Annual Cyclic Capital Cost of Track, Signals, Buildings, and Bridges for NLX Scenarios for Year 2020

Scenario	Cyclic Capital Cost of Track, Signals, Buildings, and Bridges for Year 2020 (2017$)
C-1	$249,225

Cyclic capital costs are computed for years 2021 through 2059 by increasing the level of freight traffic in the corridor by 1.5% per year, keeping all other assumptions the same. Therefore, cyclic capital costs will increase each year during the study period.

3.1.2 Cyclic Capital Cost of Equipment

The cyclic capital cost of equipment is the annualized cost of maintaining the NLX locomotives and coaches to a state of good repair. It is assumed that all NLX scenarios will utilize PRIIA 305-compliant "Next Generation" locomotives and coaches.

For Amtrak-operated services, capital investments in equipment and other assets are made by Amtrak and a proportional share of the investments are charged to the states. Because the average age of Amtrak equipment is over 28 years[5], the cyclic capital cost of maintaining Amtrak is equipment will be greater than the cyclic capital cost of maintaining brand new equipment. For this reason, the cyclic capital cost of maintaining NLX equipment is not based on Amtrak data.

MnDOT anticipates that the cyclic capital cost of equipment will be paid for using state bond funds and has recommended that a 10-year cycle be implemented for capital investments. A value equal to 20% of the capital cost of the equipment is used for the cyclic capital cost of NLX equipment. Note that the cyclic capital cost of NLX equipment will increase when additional cars are added to the initial consist. The discussion of equipment procurement is found in Section 3.2.

Table 3-3 presents the cyclic capital cost of equipment for the first 10-year cycle (Year 2029) for each of the NLX operating scenarios.

Table 3-3: Cyclic Capital Cost of Equipment for NLX Scenarios for First 10-Year Cycle (Year 2029)

Scenario	Cyclic Capital Cost of Equipment, First 10-Year Cycle (2017$)
C-1	$22,176,000

3.1.3 Summary of Cyclic Capital Costs

Table 3-4 presents the total annual cyclic capital costs for each of the NLX operating scenarios in 2014 dollars for the year 2020. Total cyclic capital costs are equivalent to the sum of the cyclic capital costs for track, signal, bridges, and buildings and the cyclic cost of equipment. Because the cyclic capital cost of equipment is not expended until Year 2029, it is not shown in Table 3-4. Total cyclic capital costs for 2020 through 2059 are presented in Attachment D.

[5] *Amtrak Fleet Strategy Plan, Version 3.1, March, 2012*

Table 3-4: Total Annual Cyclic Capital Costs for NLX Scenarios for Year 2020

Scenario	Total Annual Cyclic Capital Costs (2014$)
C-1	$249,225

3.2 Equipment Procurement

Additional coach cars will be procured for the NLX service throughout the 40 year planning horizon based on the point in time at which ridership meets the seating capacity on the existing consist. Using the 2020 ridership forecast, the ratio of business to non-business travelers, and direction of peak travel, the number of riders per train in the AM and PM peak periods are calculated for northbound and southbound directions for the first year of service. The peak load, or the number of cars needed to support the ridership in the greatest peak period, is computed by dividing the peak directional ridership by the number of seats per car. The initial number of cars needed for NLX service implementation is the highest value of northbound AM, northbound PM, southbound AM, and southbound PM peak loads.

The peak load is computed for subsequent years. As ridership increases, peak directional ridership will also increase. When the peak directional ridership increases enough to meet the current train car capacity, an additional car per consist will be procured. As discussed in the Ridership and Revenue chapter of the Service Development Plan, equipment consist needs for Scenario C-1 were determined for low and high ends of forecasted ridership throughout the 40-year study period. The initial consist make-up and year(s) in which additional cars are required are different for the low and high ends of ridership. An average equipment procurement cost is presented. Table 3-5 shows the Year 0 (average initial equipment procurement), Years 1-40 average equipment procurement costs, and total average equipment procurement costs through the project study period for Scenario C-1.

Table 3-5: Average Equipment Procurement Costs for Scenario C-1

Scenario	Average Equipment Procurement Cost - Year 0 (2014$)	Average Equipment Procurement Cost - Years 1-40 (2014$)	Total Average Equipment Procurement Cost (2014$)
C-1	$106,560,000	$17,280,000	$123,840,000

3.3 Station Platform Extension

Platforms at each of the NLX stations will be constructed to a length of 500 feet. A 500 foot platform can accommodate the unloading of a 581.5 foot train comprised of one 71.5-foot locomotive and six 85-foot bi-level cars. The locomotive would be positioned completely off the platform, but all bi-level car doors would be positioned on the platform.

When additional cars are added to the consist and increase the length of the train over 581.5 feet (greater than a 6-coach car consist), the platforms must be extended. It is assumed that the platform at each station will be extended by 100 feet in 2045 for Scenario C-1. A total cost of $786,240 (in 2014$) is included in the Capital Replacement Forecast for extending the platforms at all NLX stations.

Costs to extend the platforms and increase the capacity of maintenance and layover facilities to accommodate consists greater than seven cars in length have not been considered in this analysis. Stations and facilities will be reevaluated during final design, if applicable.

4. SUMMARY OF REVENUES AND EXPENSES

Financial performance of NLX Scenario C-1 is evaluated by analyzing the operating cash flows. The financial analysis integrates the operating and maintenance costs and the revenue projections for the 40 year planning horizon.

4.1 Description of Revenues

Operating revenues include two types of revenue: ticket revenues and ancillary revenues. Ticket revenues are based on projected travel demand and fare structure. Ancillary revenues include parking, commercial development and real estate, advertising and sponsorship. Ancillary revenues were assumed to be equal to 3.7% of ticket revenues.

4.2 Description of Expenses

Costs include the following operating and maintenance expenses:

- Expensed maintenance costs
- PRIIA Operating and Maintenance costs
- Cyclic capital costs
- Equipment procurement capital costs
- Station platform extension capital costs

4.3 Presentation of Operating Budget from 2020 to 2059

The following table presents the total revenues and expenses for NLX Service for Scenario C-1. The total operating budget is presented for years 2020 through 2059 and is shown in 2017$ unless otherwise noted. A simple summary of the operating budget for NLX Scenario C-1 is presented in Attachment E.

Table 4-1: Operating Budget for Scenario C-1 – Summary of Study Period 2020 through 2059

Operating Budget	Total 2020 through 2059
Revenues (2014$)	
Ticket Revenue	$624,182,058
Ancillary Revenue	$21,358,492
Total Revenue	*$645,540,550*
Expensed Maintenance Costs	
Expensed Maintenance Costs for Track, Signals, Buildings, and Bridges	$81,310,157
Expensed Maintenance for PTC System	$8,800,000
Total Expensed Maintenance Costs	*$90,110,157*
PRIIA Section 209 Costs	
Fuel Cost	$85,262,925
Train & Engine Crew Costs	$130,664,724
Car & Locomotive Maintenance and Turnaround	$247,455,748
On-Board Passenger Technology	$20,446,700
Station O&M Costs	$43,366,396
Layover Facility O&M Costs	$ -
Maintenance Facility O&M Costs	$32,571,400
Commissions	$34,935,908
Customer Concessions	$4,192,309
Insurance	$30,000,000
Support Fees	$148,067,743

Operating Budget	Total 2020 through 2059
Total PRIIA Section 209 Costs	*$776,963,854*
Capital Replacement Costs	
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	$48,524,971
Total Capital Replacement Costs	*$48,524,971*
Total Operating Budget	**$915,598,982**
Operating Surplus	**($270,058,432)**

Attachment A: Draft Technical Document on Operating and Maintenance Cost and Capital Replacement Forecast

NORTHERN LIGHTS *EXPRESS*

TECHNICAL DOCUMENT IN SUPPORT OF THE NLX SERVICE PLAN

Draft Operating and Maintenance Costs and Capital Replacement Forecast

February 2016

Prepared by:

QUANDEL CONSULTANTS

161 N. Clark Street, Suite 2060
Chicago, IL 60601

161 St. Anthony Avenue, Suite 940
St. Paul, MN 55103

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1. INTRODUCTION

The purpose of this Technical Document is to describe the process used to develop the Operating and Maintenance costs for each operating scenario for the proposed Northern Lights Express passenger rail service between Minneapolis and Duluth, Minnesota. The Minnesota Department of Transportation (MnDOT), in association with the Federal Railroad Administration (FRA), NLX Alliance, and the Wisconsin Department of Transportation (WisDOT), is completing Preliminary Engineering and Project NEPA for the NLX Service Development Program.

This document details the annual cost for operating and maintaining the NLX infrastructure and equipment. These costs are dependent upon the number of round trips per day, maximum operating speed, and equipment configuration.

Table 1-1 summarizes the NLX scenarios analyzed in the technical memorandum.

Table 1-1: Summary of NLX Scenarios

Scenario	Maximum Train Speed (MPH)	Number of Round Trips/Day
B1	110	4
B2	110	6
B10	110	2
B11	110	8
C1	90	4
C2	90	6
C10	90	2
C11	90	8

The following sections describe the operating plans created for each scenario, the methodology used to calculating the operating and maintenance costs, including both expensed and capital replacement, and present the summary of revenues and expenses over the 40-year study period.

2. OPERATING & MAINTENANCE COSTS

Operating costs for the NLX project are calculated using a methodology established under the provisions of the Passenger Rail Reinvestment and Improvement Act of 2008 (PRIIA). The PRIIA Section 209 Cost Methodology Policy (S209 Methodology) was prepared by the Section 209 State Working Group and Amtrak to outline the "single, nationwide standardized methodology for establishing and allocating the operating and capital costs among the States and Amtrak."[1] Amtrak has not been designated the operator of the NLX service, but the S209 Methodology is used to estimate NLX operating costs because it is a standardized model that will be employed by all other state-supported intercity passenger rail services. The PRIIA S209 Methodology is discussed in detail in Section 2.3.

Maintenance of Way costs for the NLX project are calculated using the methodology presented in the *Technical Monograph: Estimating Maintenance Costs for Mixed High-Speed Passenger Rail and Freight Rail Corridors* (FRA Technical Monograph), prepared by ZETA-TECH Associates for the Federal Railroad Administration in August 2004. The Technical Monograph is included as Appendix A. Maintenance of Way costs include both expensed maintenance and cyclic capital, and are discussed in Section 2.1 and Section 3.1, respectively.

The FRA Technical Monograph was developed for the express purpose of providing a method of estimating the costs of right-of-way maintenance associated with the operations of high-speed and intercity passenger trains. As described in the monograph, maintenance costs include expensed maintenance costs for inspections, spot repairs, and routine maintenance, and "cyclic capital" costs such as rail replacement, tie renewal, surfacing, ballast replacement, and similar capital improvements.

Maintenance of Way costs include costs associated with track maintenance, bridge and building (B&B) maintenance, and communications and signals maintenance. The maintenance of way costs outlined in the NLX Operating and Maintenance Cost (OPEX) report are the expensed and cyclic maintenance costs required to maintain the infrastructure to an adequate condition to carry the expected volumes of traffic. Expensed maintenance costs are included with Operating and Maintenance costs; cyclic capital costs are discussed in Section 3.1 with other capital replacement cost items.

The NLX OPEX report uses minimum and maximum costs shown in the FRA Technical Monograph. As noted in the monograph, the minimum costs are based on the maintenance standards geared to FRA minimum track safety guidance, while the maximum costs reflect maintenance of high track standards to ensure good ride quality.

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[1] *Passenger Rail Investment and Improvement Act (PRIIA) of 2008 Section 209 Cost Methodology Policy, Final Version, 8/31/2011*

The equation relating the Maintenance of Way Cost elements is as follows:

$$\textit{Maintenance of Way}_{min,\,max} = \textit{Expensed Maintenance}_{min,max} + \textit{Cyclic Capital}_{min,max}$$

The following section describes the methodology presented in the FRA Technical Monograph to estimate the minimum and maximum expensed maintenance costs for the NLX project. The methodology to calculate cyclic capital costs is discussed in Section 3.1.

2.1 Expensed Maintenance Cost Estimating Methodology

Expensed maintenance costs are the costs expended to keep a railroad in safe operating condition. Expensed maintenance activities include maintenance of train control equipment and grade crossing warning devices, track inspection, and minor maintenance and spot surfacing of rails.

Expensed maintenance costs are separated into two categories for this analysis: track, signal, bridge and building elements and PTC system elements.

2.1.1 Expensed Maintenance – Track, Signal, Bridge and Building Elements

The FRA Technical Monograph uses the Work Unit Model to estimate the expensed maintenance (non-capital) costs to maintain a defined segment of track. The Work Unit Model has been used on several Class I railroad routes to determine and allocate budget for different territories. The Model has been validated based on field audits and comparison to other related models.

The expensed maintenance costs estimated by the Work Unit Model were used to develop a series of costs per mile for segments of track. The costs are presented in matrices to allow for the calculation of minimum and maximum expensed maintenance costs per mile based on a track segment's particular tonnage, mix of freight versus passenger traffic, curvature, class of track, and tie type. Costs in the FRA Technical Monograph are presented in 2003 dollars. The 2003 costs are inflated using a Producer Price Index rate of 1.7986 to bring the costs to 2014 dollars.

Figure 2-1 is a sample matrix included in the FRA Technical Monograph that depicts the maximum total Maintenance of Way costs per track mile for a track segment with wood ties.

Figure 2-1: Matrix 20 – Total Cost per Track Mile, Wood, Maximum – Maintenance + Cyclic Capital

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$38,748	$47,507	$66,570	$97,664	4	$39,632	$49,283	$69,464	$102,356	4	$40,986	$52,085	$74,111	$109,884
Pred. Frght	5	$42,189	$52,331	$73,422	$108,988	5	$43,255	$54,323	$76,619	$114,189	5	$44,864	$57,425	$81,688	$122,424
	6	$47,849	$59,930	$84,192	$126,621	6	$49,184	$62,253	$87,856	$132,603	6	$51,165	$65,816	$93,574	$141,921
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$42,842	$57,976	$85,400	*	4	$43,926	$60,262	$89,212	*	4	$45,557	$63,771	$95,129	*
	5	$45,750	$63,042	$93,287	*	5	$46,990	$65,556	$97,452	*	5	$48,839	$69,380	$103,861	*
	6	$52,215	$73,532	$109,567	*	6	$53,763	$76,518	$114,467	*	6	$56,039	$80,998	$121,897	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$46,640	$71,721	*	*	4	$47,909	$74,677	*	*	4	$49,796	$79,113	*	*
	5	$50,194	$79,124	*	*	5	$51,650	$82,421	*	*	5	$53,799	$87,331	*	*
	6	$54,822	$88,301	*	*	6	$56,497	$92,006	*	*	6	$58,949	$97,482	*	*

A total of 50 matrices are provided in the Technical Monograph that allow a user to calculate minimum and maximum total costs per track mile for expensed maintenance, cyclic capital, and total Maintenance of Way (expensed maintenance + cyclic capital) costs for wood and concrete ties. The methodology to calculate expensed maintenance costs uses six different matrices.

There are several steps involved in calculating the expensed maintenance costs. Each of the steps is discussed in detail below.

Step 1: Calculate Total Maintenance of Way costs (minimum and maximum) for *<u>Class 4</u>* *track for all rail traffic*

In this step, the total Maintenance of Way cost (expensed maintenance + cyclic capital) is calculated using Matrix 19 (minimum cost, wood ties) and Matrix 20 (maximum cost, wood ties). This calculation represents the total maintenance cost for all rail types on the NLX route assuming that the track is maintained to Class 4 standards.

A spreadsheet modeling the calculations required to use the matrices is employed to calculate total MoW costs for the NLX route for each operating scenario. Figure 2-2 presents an output of the spreadsheet used to calculate the total MoW costs for the route. Note that the route depicted in Figure 2-2 is fictional as some of the freight data used in the calculations is proprietary and cannot be provided to the public. As illustrated in the figure, routes are separated into segments of similar geometric configuration, tonnage, and track class to ensure proper cost assignments.

Figure 2-2: Spreadsheet Used to Calculate Total Maintenance of Way Costs

Segment and Track Details								Predom. Traffic			No. of Trains per Day		MGT/ Track/year	FRA Track Class			MGT				Curvature			Total Maintenance Cost per Track Mile (Min)	Total Maintenance Cost (Min)
Segment	From CP	To CP	No of tracks	MP Begin	MP End	Segment Length	Total Track Miles	P	E	F	P	F	P + F	4	5	6	< 5	5-15	15-30	> 30	Lgt	Mod	Sev		
1	Alpha	Bravo	2	11.44	9.54	1.90	3.80			F	24	7	13.5	■				■				■		$32,089	$121,937
2	Bravo	Charlie	2	9.54	13.9	4.36	8.72			F	24	111	22.3	■					■		■			$38,018	$331,519
3	Charlie	Delta	2	13.9	15.5	1.60	3.20			F	24	92	22.3		■				■		■			$38,018	$121,658
4	Delta	Echo	1	15.5	21.1	5.60	5.60			F	24	31	44.6		■					■	■			$55,260	$309,453
5	Echo	Foxtrot	1	136.9	107.4	29.50	29.50			F	24	13	43.8		■					■	■			$54,671	$1,612,782
6	Foxtrot	Golf	1	107.4	72.3	35.10	35.10			F	24	13	43.8		■					■	■			$54,671	$1,918,938
7	Golf	Hotel	1	72.3	63.1	9.20	9.20			F	24	13	43.8		■					■	■			$54,687	$503,122
8	Hotel	India	1	63.1	25.2	37.90	37.90			F	24	13	43.8		■					■		■		$56,728	$2,149,992
9	India	Juliet	1	25.2	11.8	13.40	13.40			F	24	13	43.8		■					■			■	$59,965	$803,537
10	Juliet	Kilo	2	12.6	10.3	2.30	4.60			F	24	27	43.7		■					■	■			$54,601	$251,162
11	Kilo	Lima	2	10.3	8.65	1.65	3.30			F	24	22	33.8	■						■			■	$51,183	$168,904
12	Lima	Mike	3	8.65	4.2	4.45	13.35			F	24	22	22.5	■					■		■			$38,203	$510,006
13	Mike	November	1	4.2	1.11	3.09	3.09		E		24	5	20.7	■					■		■			$44,885	$138,696
							170.76																	Total Maintenance Costs	$8,941,708

Step 2: Calculate the passenger rail portion of Maintenance of Way costs (minimum and maximum) for Class 4 track

The total MoW cost calculated in Step 1 is the combined MOW cost for all types of rail service in a shared corridor – passenger and freight. The next step is to calculate the share of the total MoW cost assigned to passenger rail in order to understand the total MoW cost that will be incurred by NLX each year, assuming that the track will be maintained to Class 4 standards.

The TrackShare Model, developed by ZETA-TECH, is an engineering-based cost model that allocates maintenance costs between different traffic types. TrackShare is a descendent of the Weighted System Average Cost model, which has been extensively used in North America and overseas to determine the passenger train share of maintenance of way costs. TrackShare uses engineering damage equations to calculate the portion of track damage (component life consumption) due to each defined traffic type operating over a specific track segment. The development of the TrackShare Model is described in detail in Appendix A starting on page 17.

The TrackShare Model first allocates Class 4 track costs between passenger and freight trains by defining the portion of track damage due to passenger and freight traffic using the following parameters:

- Grade
- Curvature
- Track characteristics (weight of rail, tie type, type of rail, etc.)
- Track miles per route mile
- Traffic density per track mile, in MGT, for each defined traffic type

Total MoW costs for Class 4 track are distributed to passenger and freight based on the proportion of track damage caused by each rail type. For track maintained to Class 5 and Class 6 standards, 100% of the incremental cost over Class 4 is assigned to passenger trains since freight does not benefit from higher track classes. Matrices were generated to allow for the calculation of minimum and maximum MoW costs per passenger train mile based on a segment's particular tonnage, curvature, class of track, and tie type.

In Step 2, the total Maintenance of Way cost (expensed + cyclic capital) for passenger rail traffic is calculated using Matrix 43 (wood ties, minimum) and Matrix 44 (wood ties, maximum). This calculation represents the total MoW cost for passenger rail traffic in the NLX Corridor assuming that the track is maintained to Class 4 standards.

Step 3: Calculate the freight rail portion of Maintenance of Way costs (minimum and maximum) for Class 4 track

The freight rail portion of the MoW cost is calculated by subtracting the portion of MoW costs attributed to passenger rail traffic from the total MoW cost for Class 4 track. Subtract the results of Step 2 from the results of Step 1.

Step 4: Calculate Total Maintenance of Way costs (minimum and maximum) for Class 5 track for all rail traffic

Follow the same procedure as in Step 1 to calculate the total MoW costs for Class 5 track for all rail traffic.

Step 5: Calculate the passenger rail portion of Maintenance of Way costs (minimum and maximum) for Class 5 track

Since we know that the total MoW cost is equal to the sum of the passenger portion and the freight portion of the MoW cost, the portion of MoW cost attributed to passenger rail for Class 5 track is computed by subtracting the results of Step 3 from the results of Step 4.

Step 6: Calculate the ratio of expensed maintenance to total Maintenance of Way costs (minimum and maximum) for passenger rail in Cost per Passenger Train Mile

An assumption is made that the ratio of expensed maintenance to total MoW costs for passenger rail is the same whether computed in Cost per Passenger Train Mile or Cost per Track Mile. Since we can directly calculate the passenger maintenance costs using the TrackShare Model, we can compute the ratio in order to be able to calculate expensed maintenance costs as a portion of the total MoW costs calculated in Step 5.

The following matrices are used to calculate the ratio of expensed maintenance cost to total MoW cost for passenger rail: Matrix 39, Matrix 40, Matrix 41, and Matrix 42.

Ratio = Expensed Maintenance Cost / (Expensed Maintenance Cost + Cyclic Capital Cost)

Step 7: Calculate the total Expensed Maintenance costs (minimum and maximum) for passenger rail for Class 5

Compute the total expensed maintenance cost for passenger rail for Class 5 by multiplying the results of Step 6 by the results of Step 5.

Step 8: Calculate the Expensed Maintenance cost (minimum and maximum) for NLX traffic for Class 5

There are three types of passenger services operating in the NLX Corridor: NLX Service, Amtrak's *Empire Builder* service, and Northstar commuter service. The expensed maintenance cost attributed to NLX Service is equal to the proportion of NLX tonnage to the overall passenger tonnage in the corridor multiplied by the results of Step 7.

Following the eight steps outlined above, annual expensed maintenance costs were calculated for each NLX Scenario. Table 2-1 presents the annual expensed maintenance cost of track, signals, buildings and bridges for each NLX Scenario for the year 2020.

Table 2-1: Annual Expensed Maintenance Costs of Track, Signals, Buildings, and Bridges for NLX Scenarios for Year 2020

Scenario	Expensed Maintenance Costs (2014$)
B1	$5,176,094
B2	$5,457,672
B10	$4,819,256
B11	$6,680,685
C1	$2,015,961
C2	$2,280,773
C10	$1,751,301
C11	$3, 117,446

Expensed maintenance costs are computed for years 2021 through 2059 by increasing the level of freight traffic in the corridor by 1.5% per year, keeping all other assumptions the same. Therefore, expensed maintenance costs will increase each year during the study period.

2.1.2 Expensed Maintenance – PTC System

Costs will be incurred over the life of the project to maintain the PTC system. Raul V. Bravo & Associates, the PMO's equipment procurement subconsultant, recommended an annual lump sum cost of $220,000 to cover all costs associated with maintaining the PTC equipment including the wayside, in-cab, and back office equipment.

2.1.3 Summary of Expensed Maintenance Costs

Table 2-2 presents the total annual expensed maintenance costs for each of the NLX operating scenarios in 2014 dollars for the year 2020. Total expensed maintenance costs are equivalent to the sum of the expensed maintenance costs for track, signal, bridges, and buildings and costs to maintain the PTC system. Total expensed maintenance costs for 2020 through 2059 are presented in Appendix B.

Table 2-2: Total Annual Expensed Maintenance Costs for NLX Scenarios for Year 2020

Scenario	Expensed Maintenance Costs (2014$)	PTC System Maintenance Costs (2014$)	Total Annual Maintenance of Way Costs (2014$)
B1	$5,176,094	$220,000	$5,396,094
B2	$5,467,672	$220,000	$5,687,672
B10	$4,819,256	$220,000	$5,039,256
B11	$6,680,685	$220,000	$6,900,685
C1	$2,015,961	$220,000	$2,235,961
C2	$2,280,773	$220,000	$2,500,773
C10	$1,751,301	$220,000	$1,971,301
C11	$3, 117,446	$220,000	$3,337,446

2.2 PRIIA Costs

Under the S209 Methodology, operating and maintenance costs are calculated for the following three categories:

- Third Party Costs
- Route Costs

- Support Fees (Additives)

These cost categories and means through which the costs were estimated are consistent with the methodology developed pursuant to the PRIIA S209-recommended methodology for estimating operating costs for state supported trains. The following sub-sections describe how the costs for each PRIIA S209 operating category are determined. Descriptions of cost elements included in each operating category were taken from the *PRIIA Section 209 Cost Methodology Policy*, Appendix E, October 2015 update.

2.2.1 Third Party Costs

According to PRIIA S209, third party costs are costs to a service for host railroad expenses including:

- Policing and dispatching the right-of-way
- Maintenance of Way
- Fuel and power charges

Policing and dispatching costs are not estimated as part of this analysis as these values will be determined during negotiations with BNSF. Maintenance of Way costs are defined as payments to host railroads for incremental costs, primarily maintenance of way, associated with passenger operations. Maintenance of Way costs include both expensed and cyclic capital costs and are calculated using the methodology described in the FRA Technical Monograph. Expensed maintenance costs are presented in Section 2.1 and cyclic capital costs are presented in Section 3.1 of this technical report. Therefore, fuel and power charges are the only third party costs calculated in this analysis.

Fuel and power charges are forecast using a rate of fuel consumption (based on equipment consist type and size), number of revenue train miles (based on operating plan), and cost per gallon of diesel fuel. For the assumed NLX equipment, fuel consumption rates for an average consist size of one locomotive and seven passenger cars were calculated for two maximum speed scenarios: 2.1 gallons per revenue train mile for 90 MPH service and 2.29 gallons per revenue train mile for 110 MPH service. Diesel fuel prices have been volatile over the past three years as have other energy prices. As a result, the NLX estimate assumes that locomotive fuel will be purchased at a cost of $3.50 per gallon, a price that is within the range of recent volatility.

The annual revenue train miles, fuel consumption rate, and cost per gallon of diesel fuel are assumed to remain constant during the study period. Therefore, the total annual fuel cost will also remain constant during the study period.

Table 2-3 presents the fuel charges for each NLX scenario.

Table 2-3: Total Annual Fuel Cost for NLX Scenarios

Scenario	Annual Revenue Train Miles	Fuel Consumption Rate (gallons per revenue mile)	Cost per Gallon of Diesel Fuel (2014$)	Total Annual Fuel Cost (2014$)
B1	447,928	2.29	3.50	$3,590,143
B2	671,892	2.29	3.50	$5,385,214
B10	223,964	2.29	3.50	$1,795,071
B11	895,856	2.29	3.50	$7,180,286
C1	447,928	2.10	3.50	$3,292,271
C2	671,892	2.10	3.50	$4,938,406
C10	223,964	2.10	3.50	$1,646,135
C11	895,856	2.10	3.50	$6,584,542

2.2.2 Route Costs

Route costs are operating costs closely associated with the operation of a route. Amtrak and states monitor and evaluate sixteen categories of route costs. In order to aid in the development of the NLX route costs, two Midwest states provided PRIIA 209 costs for their state-supported intercity Amtrak services. The PRIIA costs for these two Midwest services were evaluated and applied to the NLX Service. A description of each of the route costs and determination of the unit costs are provided below.

2.2.2.1 Train & Engine Crew Support

Train & Engine Crew (T&E) costs are based on annual conductor and engineer labor hours. Total annual conductor and engineer labor hours are estimated for NLX service using two factors: calculated annual train hours and estimated crew overtime and vacation hours. Annual train hours are calculated using the operating plan. To compensate for crew overtime and vacation hours, 12% is added to the annual train hours. It is assumed that three crew members are utilized per train. The annual T&E hours are presented in the O&M operating plan for each scenario.

The T&E unit of measurement is cost per annual total of conductor and engineer labor hours. The T&E unit cost is calculated by dividing the PRIIA 209 cost for T&E Crew Labor by the Total of Conductor and Engineer Labor Hours. The NLX T&E Crew Support unit cost is $74.89 per T&E hour. It is assumed that this unit cost includes all labor and benefits for T&E crew.

2.2.2.2 Car & Locomotive Maintenance and Turnaround

Car & Locomotive Maintenance and Turnaround (M&T) is the cost of maintaining cars and locomotives and the cost of transporting the cars and locomotives to and from a maintenance or layover facility. Car & Locomotive M&T costs are based on the annual train miles of car and locomotive units and are calculated by multiplying the annual train miles operated by the number of cars and locomotive units per train. The annual Car & Locomotive M&T hours are presented in the O&M operating plan for each scenario.

The M&T unit of measurement is cost per car and locomotive unit mile. The M&T unit cost is calculated by dividing the PRIIA 209 cost for Car & Locomotive M&T by the Locomotive and Car Unit Miles. The NLX Car & Locomotive M&T unit cost is $1.376 per car and locomotive unit mile. It is assumed that this unit cost includes all labor and benefit costs for T&E crew.

Because NLX service will utilize new equipment, M&T costs will not be as costly as for older equipment. It is assumed that the M&T cost will increase as the equipment ages according to the following schedule:

- Year 1 = 50% of total PRIIA cost
- Years 2-10 = 80% of total PRIIA cost
- Years 11-15 = 85% of total PRIIA cost
- Years 16-20 = 90% of total PRIIA cost
- Years 21 and beyond = 100% of total PRIIA cost

2.2.2.3 On Board Service Crew

On Board Service labor costs are not forecast for NLX service as food and beverage services will not be provided.

2.2.2.4 On Board Service Commissary Provisions

OBS commissary provision costs are not forecast for NLX service as food and beverage services will not be provided.

2.2.2.5 Route Advertising

It is assumed that there will be no route advertising costs for NLX service.

2.2.2.6 Sales Distribution

Sales distribution costs are driven primarily by the total number of passengers served by NLX.

The Sales Distribution unit of measurement is cost per number of passengers. The Sales Distribution unit cost is calculated by dividing the PRIIA 209 cost for Sales Distribution by the total number of passengers. The NLX Sales Distribution unit cost is $0.357 per passenger.

2.2.2.7 Reservations and Call Centers

NLX service will utilize online reservations or in-station kiosks. It is assumed that there will be no reservation and call center costs.

2.2.2.8 Stations

HNTB prepared a Technical Memorandum on NLX Facilities Operations and Maintenance Costs for the NLX Service. The Technical Memorandum is included as Appendix C. As described in the memo, much of the facilities operating and maintenance cost data for the stations serving the NLX service was derived from the 2015 operating budget for the Northstar commuter rail service, a 40-mile route between Big Lake, Minnesota and downtown Minneapolis. After researching a number of different railroad properties throughout the Midwest, it was determined that Northstar has the most features in common with the NLX from an operating facilities perspective, including a similar number of stations (Northstar has six), station amenities, downtown Minneapolis station, and service level (Northstar operates 12 round trips per weekday). Budget data from the Metropolitan Council's application for a 2015 operating grant from the Counties Transit Improvement Board for the Northstar Line was supplemented with detailed information on organization staffing, utilities costs, and facility equipment provided by Metropolitan Council staff in its Metro Transit Northstar operating division.

The O&M facility costs for Northstar are separated into four categories of expenses:

1. Labor and benefits
2. Contracted services
3. Materials, parts & supplies
4. Other expenses

The methods by which the four categories of O&M facility costs from Northstar's operating budget are applied to the NLX Service are discussed below.

Labor and Benefits

Labor includes a facilities technician and janitor to maintain each layover facility, maintenance facility, and station. Labor costs include 15% overtime. Benefits include vacation/sick/holiday, pension, FICA, insurance, workers compensation, and a tool allowance and are approximately 87% of labor costs.

All other labor and benefits costs for passenger rail personnel, including management and track and equipment maintainers, are included in the Car and Locomotive M&T PRIIA S209 cost.

Contracted Services

Northstar contracts facility security, snow plowing, and maintenance services to third-party providers. Maintenance services include facilities maintenance items like grounds keeping and maintenance of parking and sidewalks. It is assumed that NLX will also contract these services. The unit cost is based on the 2015 Northstar budget for contracted services and the total cost for NLX is computed based on the number of stations and facilities.

Materials, Parts & Supplies

Materials, parts and supplies include office and shop supplies and small equipment. The unit cost is based on the 2015 Northstar budget for office supplies and the total cost for NLX is computed based on the number of stations and facilities.

Other Expenses

The 'Other Expenses' category includes O&M costs for utilities and lease and rental of equipment. Metro Transit provided detailed information on 2014 utility costs for each station and maintenance facility in the Northstar corridor. These costs were used to compute NLX 2015 costs based on the number of stations and facilities. Utilities include electric, natural gas, water, refuse collection and telephone/internet services. Utility costs for electricity also incorporate head-end power at the maintenance facility.

Certain small equipment used for maintenance of facilities and other assets will be rented and/or leased for NLX service. The leases and rentals costs are computed based on the number of stations and facilities.

Contingency

A 10% contingency is added to the facilities O&M costs to reflect uncertainties at the current level of project development.

2.2.2.9 Commissions

Commissions are charged for credit card and travel agent commissions. Commission costs are driven by total revenue and the number of passengers.

The Commission unit of measurement is cost per passenger. The Commission unit cost is calculated by dividing the PRIIA 209 cost for Commission by the number of passengers. The NLX Commission unit cost is $0.82 per passenger.

2.2.2.10 Customer Concessions

Customer concessions are costs set aside to compensate passengers for food, lodging, and alternate transportation during service interruptions. Customer concession expenses are forecast based on the incremental increase in passenger miles.

The Customer Concession unit of measurement is cost per passenger. The Customer Concession unit cost is calculated by dividing the PRIIA 209 cost for Customer Concession by the total number of passengers. The NLX Customer Concession unit cost is $0.164 per passenger.

2.2.2.11 Connecting Motor Coach

There will be no connecting motor coach costs for NLX service.

2.2.2.12 Regional & Local Police

Regional & Local Police services will be provided by the host railroad. It is assumed that there will be no regional & local police costs for NLX service.

2.2.2.13 Block & Tower Operations

There will be no block & tower operations costs for NLX service because Amtrak does not own any track in the NLX corridor.

2.2.2.14 Terminal Yard Operations

Terminal yard operations costs are assumed to be included in car and locomotive M&T costs. There will be no separate Terminal Yard Operations costs for NLX service.

2.2.2.15 Terminal Maintenance of Way

Terminal Maintenance of Way costs are included in the O&M cost for the facilities, shown in Section 2.2.2.8 - Stations. There will be no separate Terminal Maintenance of Way costs for NLX service.

2.2.2.16 Insurance

Raul V. Bravo & Associates recommended budgeting $750,000 per year for insurance costs.

2.2.2.17 Route Cost Summary

The Route Cost total for each NLX Scenario is calculated by adding the individual Route Cost elements (T&E Crew Support, Car and Locomotive M&T, Stations, etc.). Note that the Route Costs will increase throughout the life of the project as the number of train miles, revenue, ridership, etc. increase. Table 2-4 presents the route costs for Year 2020 for each NLX scenario.

Table 2-4: Total Annual Route Cost for NLX Scenarios for Year 2020

Scenario	Annual Route Cost (2014$)
B1	$8,843,589
B2	$11,078,775
B10	$5,815,896
B11	$13,562,207
C1	$8,493,382
C2	$10,984,778
C10	$5,770,560
C11	$13,526,832

2.2.3 Support Fees

According to the PRIIA S209 Methodology, some cost categories have an additional level of regional and national support not included in the Route Costs, and therefore also include Support Fees that are proportional to the service provided. PRIIA Support Fees are determined by applying category-specific additives to an associated route cost. There are six categories of Support Fees, identified specifically for the NLX service. The definition of these Support Fees are shown in Figure 2-3.

Figure 2-3: Definition of PRIIA Support Fees

Additives						
T&E	Division-specific and system overhead rates for T&E supervision and management. Includes road foremen, superindendents, crew bases, crew dispatching, local and national operating rule compliance, and other support. Excludes national train dispatching	Division	Division Rate	System Rate	Total
		Central	13.50%	12.90%	26.40%
		Mid-Atlantic	18.40%	12.90%	31.30%
		Mid-Atlantic/Southern	20.20%	12.90%	33.10%
		New England	16.50%	12.90%	29.40%
		New York	24.30%	12.90%	37.20%
		Pacific	19.50%	12.90%	32.40%
		Southern	20.60%	12.90%	33.50%
		Southwest	16.30%	12.90%	29.20%
		Total rate to be applied to T&E Crew Labor			
MoE	Maintenance of shops and equipment to support direct Mechanical activities. Excludes Backshops and Fleet Engineering	27.10% of Route Cost Car & Locomotive Maintenance and Turnaround			
OBS	OBS and commissary management and supervision	10.00% of OBS Crew & Provisions			
Police	National police operations and support	$0.0050 per passenger mile			
Marketing	National marketing programs, including national advertising; loyalty marketing; timetables; personnel in support of Route Advertising; shows, exhibits & special events; and other	Region		Rate	
		Base-increment routes on NEC		2.80%	
		Routes with one terminal in Chicago		2.80%	
		All other routes		1.90%	
		Rate to be applied to Total Revenue			
General & Administrative	Charge for General & Administrative support including Computer Systems, Finance, Legal, and other	2.00% of Route Costs			

The NLX-specific Support Fees are shown in Table 2-5.

Table 2-5: PRIIA S209 Support Fees for the NLX Service

Additive	Factor/Basis	Rate
Train and Engine (T & E)	% of T&E cost	26.4%
Maintenance of Shops and Equipment (MoE)	% of Car & Locomotive M & T cost	27.1%
OBS	% of OBS cost	10.0%
Police	Passenger miles	$0.005
Marketing	% of total revenue	1.90%
General and Administrative (G & A)	% of total route cost	2.0%

Support fees are calculated by multiplying the additive rate presented in Table 2.2-3 by its respective operating or maintenance cost. For example, the T&E support fee is equal to the T&E route cost, calculated in Section 2.2.2.1, by 26.4%.

Table 2-6 presents the Support Fees for Year 2020 for each NLX scenario.

Table 2-6: Total Support Fee Cost for NLX Scenarios for Year 2020

Scenario	Annual Support Fee Cost (2014$)
B1	$2,781,730
B2	$2,600,516
B10	$1,126,864
B11	$3,352,908
C1	$1,968,987
C2	$2,582,908
C10	$1,097,604
C11	$3,326,978

2.2.4 Summary of PRIIA Costs

The overall PRIIA cost is the sum of Third Party Costs, Route Costs, and Support Fees as calculated in Sections 2.2.1, 2.2.2, and 2.2.3, respectively. Table 2-7 presents the summary of PRIIA costs for Year 2020 for each NLX scenario.

Table 2-7: Total PRIIA Costs for NLX Scenarios for Year 2020

Scenario	Annual Third Party Costs (2014$)	Annual Route Costs (2014$)	Annual Support Fees (2014$)	Annual PRIIA Costs (2014$)
B1	$3,590,143	$8,843,589	$2,781,730	$15,215,462
B2	$5,385,214	$11,078,775	$2,600,516	$19,064,506
B10	$1,795,071	$5,815,896	$1,126,864	$8,737,832
B11	$7,180,286	$13,562,207	$3,352,908	$24,065,402
C1	$3,292,271	$8,493,382	$1,968,987	$13,754,640
C2	$4,938,406	$10,984,778	$2,582,908	$18,506,092
C10	$1,646,135	$5,770,560	$1,097,604	$8,514,299
C11	$6,584,542	$13,526,832	$3,326,978	$23,438,351

2.3 Summary of Operating and Maintenance Costs

The total annual operating and maintenance cost for the NLX Service is equal to the sum of the expensed maintenance costs calculated using the FRA Technical Monograph in Section 2.1, and the PRIIA costs calculated in Section 2.2. Table 2-8 presents the summary of operating and maintenance costs for Year 2020 for each NLX scenario. Total operating and maintenance costs for 2020 through 2059 are presented in Appendix D.

Table 2-8: Total Operating and Maintenance Costs for NLX Scenarios for Year 2020

Scenario	Annual Expensed Maintenance Costs (2014$)	Annual PRIIA Costs (2014$)	Annual Operating and Maintenance Costs (2014$)
B1	$5,396,094	$15,215,462	$20,611,556
B2	$5,687,672	$19,064,506	$24,752,178
B10	$5,039,256	$8,737,832	$13,777,088
B11	$6,900,685	$24,065,402	$30,966,087
C1	$2,235,961	$13,754,640	$15,990,601
C2	$2,500,773	$18,506,092	$21,006,865
C10	$1,971,301	$8,514,299	$10,485,600
C11	$3,337,446	$23,438,351	$26,775,797

3. CAPITAL REPLACEMENT COSTS

Capital replacement costs are additional capital costs, beyond those incurred in the initial implementation of the NLX service, that are anticipated to be required due to lifecycle replacement or other factors through the planning horizon of the project. The planning horizon for the NLX project is 40 years, which covers the period of 2020 through 2059.

Capital replacement costs include cyclic capital costs of track for items such as rail replacement, tie renewals, surfacing, and ballast replacement; cyclic capital costs of maintaining equipment; equipment procurement; and station expansion. Maintenance of train control equipment and grade crossing warning devices, track inspection, and minor maintenance and spot surfacing of rails are considered expensed maintenance costs and are discussed in Section 2.1.

3.1 Cyclic Capital Cost Estimating Methodology

The cyclic capital cost includes capital maintenance expenditures for replacement of track, signal, building and bridge components as they wear out.

Cyclic capital costs are separated into two categories for this analysis: track, signal, bridge and building elements and train equipment.

3.1.1 Cyclic Capital Costs – Track, Signal, Bridge and Building Elements

The methodology for calculating cyclic capital costs of track, signal, bridge and building elements for the NLX project follows a similar methodology as is used to calculate expensed maintenance costs, discussed in Section 2.2.1, and is also found in the *Technical Monograph: Estimating Maintenance Costs for Mixed High-Speed Passenger Rail and Freight Rail Corridors* (Technical Monograph), prepared by ZETA-TECH Associates for the Federal Railroad Administration in August 2004. The Technical Monograph is included as Appendix A.

In the Technical Monograph, cyclic capital costs are estimated using standard lives and costs to replace track components as they wear out. The ZETA-TECH Steady State Capital Model includes the following components in its methodology:

- rail
- ties (concrete and wood)
- turnouts
- surfacing/ballasting

The model incorporates a relationship between traffic density and environment that allows the model to predict component life under a defined set of conditions. In addition, the model addresses how curvature impacts a component's life. Using a linear relationship between tonnage and rail life and turnouts, and a nonlinear relationship between tonnage and ties and ballast, the model predicts a life expectancy for each component category.

Cyclic capital costs are calculated using observed lives of track components under traffic with actual railroad capital costs from Class I railroad sources for five segments of mixed passenger/freight rail corridors:

- Chicago to Buffington Harbor
- Buffington Harbor to Ft. Wayne
- Delta Junction to Cleveland
- Madison to Watertown
- Seattle to Portland

Annual bridge and signal expenditures were calculated in the same manner as track component expenditures. Included in the total cyclic capital costs are:

- Track cyclic capital costs
- Bridge and building cyclic capital costs
- Communications and signal cyclic capital costs

The total cyclic capital costs estimated by the Steady State Model were used to develop a series of costs per mile for segments of track. The costs are presented in matrices to allow for the calculation of minimum and maximum cyclic capital costs per mile based on a track segment's particular tonnage, mix of freight versus passenger traffic, curvature, class of track, and tie type. Costs in the FRA Technical Monograph are presented in 2003 dollars. The 2003 costs are inflated using a Producer Price Index rate of 1.7986 to bring the costs to 2014 dollars.

Figure 3-1 is a sample matrix included in the FRA Technical Monograph that depicts the maximum total Maintenance of Way costs per track mile for a track segment with wood ties.

Figure 3-1: Matrix 20 – Total Cost per Track Mile, Wood, Maximum – Maintenance + Cyclic Capital

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$38,748	$47,507	$66,570	$97,664	4	$39,632	$49,283	$69,464	$102,356	4	$40,986	$52,085	$74,111	$109,884
Pred. Frght	5	$42,189	$52,331	$73,422	$108,988	5	$43,255	$54,323	$76,619	$114,189	5	$44,864	$57,425	$81,688	$122,424
	6	$47,849	$59,930	$84,192	$126,621	6	$49,184	$62,253	$87,856	$132,603	6	$51,165	$65,816	$93,574	$141,921
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$42,842	$57,976	$85,400	*	4	$43,926	$60,262	$89,212	*	4	$45,557	$63,771	$95,129	*
	5	$45,750	$63,042	$93,287	*	5	$46,990	$65,556	$97,452	*	5	$48,839	$69,380	$103,861	*
	6	$52,215	$73,532	$109,567	*	6	$53,763	$76,518	$114,467	*	6	$56,039	$80,998	$121,897	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$46,640	$71,721	*	*	4	$47,909	$74,677	*	*	4	$49,796	$79,113	*	*
	5	$50,194	$79,124	*	*	5	$51,650	$82,421	*	*	5	$53,799	$87,331	*	*
	6	$54,822	$88,301	*	*	6	$56,497	$92,006	*	*	6	$58,949	$97,482	*	*

A total of 50 matrices are provided in the Technical Monograph that allow a user to calculate minimum and maximum total costs per track mile for expensed maintenance, cyclic capital, and total Maintenance of Way (expensed maintenance + cyclic capital) costs for wood and concrete ties. The methodology to calculate cyclic capital costs uses six different matrices.

The steps required to calculate the cyclic capital costs of track, signal, buildings, and bridges is very similar to the steps used to calculate expensed maintenance costs. An abridged version of these steps are provided below. For the full description, see Section 2.1.1 of this report.

Step 1: Calculate Total Maintenance of Way costs (minimum and maximum) for Class 4 track for all rail traffic

In this step, the total Maintenance of Way cost (expensed maintenance + cyclic capital) is calculated using Matrix 19 (minimum cost, wood ties) and Matrix 20 (maximum cost, wood ties). This calculation represents the total maintenance cost for all rail types on the NLX route assuming that the track is maintained to Class 4 standards.

Step 2: Calculate the passenger rail portion of Maintenance of Way costs (minimum and maximum) for Class 4 track

The total MoW cost calculated in Step 1 is the combined MOW cost for all types of rail service in a shared corridor – passenger and freight. The next step is to calculate the share of the total MoW cost assigned to passenger rail in order to understand the total MoW cost that will be incurred by NLX each year, assuming that the track will be maintained to Class 4 standards.

Total MoW costs for Class 4 track are distributed to passenger and freight based on the proportion of track damage caused by each rail type. For track maintained to Class 5 and Class 6 standards, 100% of the incremental cost over Class 4 is assigned to passenger trains since freight does not benefit from higher track classes. Matrices were generated to allow for the calculation of minimum and maximum MoW costs per passenger train mile based on a segment's particular tonnage, curvature, class of track, and tie type.

In Step 2, the total Maintenance of Way cost (expensed + cyclic capital) for passenger rail traffic is calculated using Matrix 43 (wood ties, minimum) and Matrix 44 (wood ties, maximum). This calculation represents the total MoW cost for passenger rail traffic in the NLX Corridor assuming that the track is maintained to Class 4 standards.

Step 3: Calculate the freight rail portion of Maintenance of Way costs (minimum and maximum) for Class 4 track

The freight rail portion of the MoW cost is calculated by subtracting the portion of MoW costs attributed to passenger rail traffic from the total MoW cost for Class 4 track. Subtract the results of Step 2 from the results of Step 1.

Step 4: Calculate Total Maintenance of Way costs (minimum and maximum) for Class 5 track for all rail traffic

Follow the same procedure as in Step 1 to calculate the total MoW costs for Class 5 track for all rail traffic.

Step 5: Calculate the passenger rail portion of Maintenance of Way costs (minimum and maximum) for Class 5 track

Since we know that the total MoW cost is equal to the sum of the passenger portion and the freight portion of the MoW cost, the portion of MoW cost attributed to passenger rail for Class 5 track is computed by subtracting the results of Step 3 from the results of Step 4.

Step 6: Calculate the ratio of cyclic capital to total Maintenance of Way costs (minimum and maximum) for passenger rail in Cost per Passenger Train Mile

An assumption is made that the ratio of cyclic capital to total MoW costs for passenger rail is the same whether computed in Cost per Passenger Train Mile or Cost per Track Mile. Since we can directly calculate the passenger maintenance costs using the TrackShare Model, we can compute the ratio in order to be able to calculate cyclic capital costs as a portion of the total MoW costs calculated in Step 5.

The following matrices are used to calculate the ratio of cyclic capital cost to total MoW cost for passenger rail: Matrix 39, Matrix 40, Matrix 41, and Matrix 42.

Ratio = Cyclic Capital Cost / (Expensed Maintenance Cost + Cyclic Capital Cost)

Step 7: Calculate the total Cyclic Capital costs (minimum and maximum) for passenger rail for Class 5

Compute the total cyclic capital cost for passenger rail for Class 5 by multiplying the results of Step 6 by the results of Step 5.

Step 8: Calculate the Cyclic Capital cost (minimum and maximum) for NLX traffic for Class 5

There are three types of passenger services operating in the NLX Corridor: NLX Service, Amtrak's *Empire Builder* service, and Northstar commuter service. The cyclic capital cost attributed to NLX Service is equal to the proportion of NLX tonnage to the overall passenger tonnage in the corridor multiplied by the results of Step 7.

Step 9: Adjust Cyclic Capital costs to account for upgrade of existing rail, ties, and ballast

Prior to NLX Service starting operations on the BNSF-owned track, rail, ties, and ballast will be upgraded to a state of good repair along the entire corridor. According to the FRA Technical Monograph, a railroad that has been substantially upgraded "will require maintenance, but little or no renewal of track components for a number of years. Therefore, costs shown in the matrices may be adjusted downward during the first few years of operations to account for this fact. Maintenance costs are unaffected, since even new track requires maintenance. But some cyclic capital costs can be deferred." Table 3-1 shows the cost adjustment by year of service.

Table 3-1: Adjustment of Cyclic Capital Costs

Year of Service	% of Cyclic Capital
1-3	20
4-6	35
7-9	50
10-13	75
14-40	100

Following the nine steps outlined above, annual cyclic capital costs were calculated for each NLX Scenario. Table 3-2 presents the annual cyclic capital cost of track, signals, buildings and bridges for each NLX Scenario for the year 2020.

Table 3-2: Annual Cyclic Capital Cost of Track, Signals, Buildings, and Bridges for NLX Scenarios for Year 2020

Scenario	Annual Cyclic Capital Cost of Track, Signals, Buildings, and Bridges (2014$)
B1	$458,462
B2	$498,948
B10	$423,352
B11	$624,265
C1	$287,226
C2	$335,354
C10	$247,790
C11	$465,487

Cyclic capital costs are computed for years 2021 through 2059 by increasing the level of freight traffic in the corridor by 1.5% per year, keeping all other assumptions the same. Therefore, cyclic capital costs will increase each year during the study period.

3.1.2 Cyclic Capital Cost of Equipment

The cyclic capital cost of equipment is the annualized cost of maintaining the NLX locomotives and coaches to a state of good repair. It is assumed that all NLX scenarios will utilize PRIIA 305-compliant "Next Generation" locomotives and coaches.

For Amtrak-operated services, capital investments in equipment and other assets are made by Amtrak and a proportional share of the investments are charged to the states. Because the average age of Amtrak equipment is over 28 years[2], the cyclic capital cost of maintaining Amtrak is equipment will be greater than the cyclic capital cost of maintaining brand new equipment. For this reason, the cyclic capital cost of maintaining NLX equipment is not based on Amtrak data.

MnDOT anticipates that the cyclic capital cost of equipment will be paid for using state bond funds and has recommended that a 10-year cycle be implemented for capital investments. A value equal to 20% of the capital cost of the equipment is used for the cyclic capital cost of NLX equipment. Note that the cyclic capital

[2] *Amtrak Fleet Strategy Plan, Version 3.1, March, 2012*

cost of NLX equipment will increase when additional cars are added to the initial consist. The discussion of equipment procurement is found in Section 3.2.

Table 3-3 presents the cyclic capital cost of equipment for the first 10-year cycle (Year 2029) for each of the NLX operating scenarios.

Table 3-3: Cyclic Capital Cost of Equipment for NLX Scenarios for First 10-Year Cycle (Year 2029)

Scenario	Cyclic Capital Cost of Equipment, First 10-Year Cycle (2014$)
B1	$14,817,600
B2	$21,672,000
B10	$9,878,400
B11	$26,460,000
C1	$14,817,600
C2	$14,918,400
C10	$9,878,400
C11	$22,377,600

3.1.3 Summary of Cyclic Capital Costs

Table 3.1-3 presents the total annual cyclic capital costs for each of the NLX operating scenarios in 2014 dollars for the year 2020. Total cyclic capital costs are equivalent to the sum of the cyclic capital costs for track, signal, bridges, and buildings and the cyclic cost of equipment. Because the cyclic capital cost of equipment is not expended until Year 2029, it is not shown in Table 3-4. Total cyclic capital costs for 2020 through 2059 are presented in Appendix E.

Table 3-4: Total Annual Cyclic Capital Costs for NLX Scenarios for Year 2020

Scenario	Total Annual Cyclic Capital Costs (2014$)
B1	$458,462
B2	$498,948
B10	$423,352
B11	$624,265
C1	$287,226
C2	$335,354
C10	$247,790
C11	$465,487

3.2 Equipment Procurement

Additional coach cars will be procured for the NLX service throughout the 40 year planning horizon based on the point in time at which ridership meets the seating capacity on the existing consist. Using the 2020 ridership forecast, the ratio of business to non-business travelers, and direction of peak travel, the number of riders per train in the AM and PM peak periods are calculated for northbound and southbound directions for the first year of service. The peak load, or the number of cars needed to support the ridership in the greatest peak period, is computed by dividing the peak directional ridership by the number of seats per car. The initial number of cars needed for NLX service implementation is the highest value of northbound AM, northbound PM, southbound AM, and southbound PM peak loads.

The peak load is computed for subsequent years. As ridership increases, peak directional ridership will also increase. When the peak directional ridership increases enough to meet the current train car capacity, an additional car per consist will be procured. The initial consist make-up and year(s) in which additional cars are required varies among all NLX scenarios. Table 3-5 shows the Year 0 (initial equipment procurement), Years 1-40 equipment procurement costs, and total equipment procurement costs through the project study period.

Table 3-5: Equipment Procurement Costs for NLX Scenarios

Scenario	Equipment Procurement Cost - Year 0 (2014$)	Equipment Procurement Cost - Years 1-40 (2014$)	Total Equipment Procurement Cost (2014$)
B1	$74,088,000	$9,072,000	$83,160,000
B2	$93,240,000	$45,360,000	$138,600,000
B10	$49,392,000	$6,048,000	$55,440,000
B11	$111,888,000	$81,648,000	$193,536,000
C1	$65,016,000	$18,144,000	$83,160,000
C2	$74,592,000	$36,288,000	$110,880,000
C10	$49,392,000	-	$49,392,000
C11	$111,888,000	$61,236,000	$173,124,000

3.3 Station Platform Extension

Platforms at each of the NLX stations will be constructed to a length of 500 feet. A 500 foot platform can accommodate the unloading of a 581.5 foot train comprised of one 71.5-foot locomotive and six 85-foot bi-level cars. The locomotive would be positioned completely off the platform, but all bi-level car doors would be positioned on the platform.

When additional cars are added to the consist and increase the length of the train over 581.5 feet (greater than a 6-coach car consist), the platforms must be extended. It is assumed that the platform at each station will be extended by 100 feet in 2045 for all scenarios. A total cost of $786,240 (in 2014$) is included in the Capital Replacement Forecast for extending the platforms at all NLX stations.

Costs to extend the platforms and increase the capacity of maintenance and layover facilities to accommodate consists greater than seven cars in length have not been considered in this analysis. Stations and facilities will be reevaluated during final design, if applicable.

4. SUMMARY OF REVENUES AND EXPENSES

Financial performance of the NLX scenarios is evaluated by analyzing the operating cash flows. The financial analysis integrates the operating and maintenance costs and the revenue projections for the 40 year planning horizon.

4.1 Description of Revenues

Operating revenues include two types of revenue: ticket revenues and ancillary revenues. Ticket revenues are based on projected travel demand and fare structure. Ancillary revenues include parking, commercial development and real estate, advertising and sponsorship. Ancillary revenues were assumed to be equal to 3.7% of ticket revenues.

4.2 Description of Expenses

Costs include the following operating and maintenance expenses:

- Expensed maintenance costs
- PRIIA Operating and Maintenance costs
- Cyclic capital costs
- Equipment procurement capital costs
- Station platform extension capital costs

4.3 Presentation of Operating Budget from 2020 to 2059

The following table presents the total revenues and expenses for NLX service for Scenario C-1. The total operating budget is presented for years 2020 through 2059 and is shown in 2014$. A simple summary of the operating budget for each NLX Scenario is presented in Appendix F.

Table 4-1: Operating Budget for Scenario C1 – Summary of Study Period 2020 through 2059

Operating Budget	Total 2020 through 2059
Revenues	
Ticket Revenue	$560,082,993
Ancillary Revenue	$20,725,988
Total Revenue	*$580,808,980*
Expensed Maintenance Costs	
Expensed Maintenance Costs for Track, Signals, Buildings, and Bridges	$93,708,153
Expensed Maintenance for PTC System	$8,800,000
Total Expensed Maintenance Costs	*$102,508,153*
PRIIA Section 209 Costs	
Fuel Cost	$131,690,832
Train & Engine Crew Costs	$122,421,130
Car & Locomotive Maintenance and Turnaround	$164,226,153
Sales Distribution	$11,841,754
Station O&M Costs	$43,366,396
Layover Facility O&M Costs	$ -
Maintenance Facility O&M Costs	$32,571,400
Commissions	$27,229,769
Customer Concessions	$5,450,966
Insurance	$30,000,000
Support Fees	$108,683,236

Operating Budget	Total 2020 through 2059
Total PRIIA Section 209 Costs	*$677,481,635*
Capital Replacement Costs	
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	$55,923,954
Total Capital Replacement Costs	*$55,923,954*
Total Operating Budget	**$835,913,741**
Operating Surplus	**($255,104,761)**

APPENDIX A. *Technical Monograph: Estimating Maintenance Costs for Mixed High Speed Passenger and Freight Rail Corridors*, ZETA-TECH, August 2004

U.S. Department of Transportation
Federal Railroad Administration

Technical Monograph: Estimating Maintenance Costs for Mixed High Speed Passenger and Freight Rail Corridors

Office of Railroad Development
Washington, D.C. 20590

DOT/FRA/ORD-

Final Report
August 2004

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Dr. Allan M. Zarembski, President
Randolph R. Resor, Project Manager
For the sponsoring agency:
John F. Cikota and Richard U. Cogswell</td><td colspan="2">8. Performing Organization Report No.</td></tr>
<tr><td colspan="2">9. Performing Organization Name and Address
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ZETA-TECH Associates, Incorporated
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Cherry Hill, NJ 08034
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Several states have indicated a desire to upgrade existing railroad corridors between well-populated cities for improved passenger rail service that is time competitive with air and/or auto on a door-to-door basis for trips in the approximate range of 100 to 500 miles. Once a corridor is upgraded for higher-speed operation, this monograph presents a number of matrices of “steady state” infrastructure maintenance costs to meet varying traffic, track and operating conditions. “Steady state” costs are defined here as amounts that must be spent annually to keep a particular railroad track at a defined level of service (operating speed) indefinitely. This monograph presents examples of track segment specific maintenance cost ranges and corresponding maintenance costs per passenger train mile that may be of assistance to States that are contemplating similar rail passenger service projects.</td></tr>
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I. Purpose

The Rail Planner's Handbook is intended as an aid to planners of new high speed rail operations. It seems most likely that future high speed rail operations will make use of trackage shared, at least in part, by freight trains. Since most railroad trackage in North America is privately owned, it will be necessary to negotiate access agreements with the private owners. These agreements will also have to specify how costs are to be shared.

To provide guidance to planners of high speed rail systems, the Planner's Handbook includes a number of matrices of "steady state" infrastructure maintenance costs. Steady state costs are defined here as amounts that must be spent annually to keep a particular railroad track at a defined level of service (operating speed) indefinitely. Since the components of railroad track are long-lived, annual expenditures may fluctuate for a particular track segment, but over an entire network, the annual level of investment should remain constant if components are replaced as they wear out. If the replacement rate is less, track condition will deteriorate. Infrastructure costs presented here include track, bridge and building (B&B), and communications and signal (C&S) costs. The one-time costs of upgrading for high speed operation are not included.

The costs are presented both in terms of a total cost per track mile and in terms of cost per passenger train mile. To develop a cost per passenger train mile, costs must first be allocated between passenger and freight traffic sharing a rail line. There are a number of methods for allocating costs. The costs presented here have been allocated through the use of one specific cost allocation model. All costs are in 2003 dollars.

In practice, operation of publicly-funded passenger trains on private freight railroads will require negotiation of access charges, and the negotiated charges may not be (in fact, probably will not be) the same as costs shown in the matrices. However, the cost matrices do indicate the expected total spending that will be required (on a "steady state" basis), as well as providing an example allocation of costs.

The cost matrices cover a range of combinations of traffic and track configuration. Minimum and maximum costs were developed for each cell in the cost matrices. The minimum costs are based on maintenance standards geared to FRA minimum track safety standards, while the maximum costs reflect maintenance of higher track standards to ensure good ride quality. The minimum costs are for typical Class I freight railroad practice, such as where passenger trains currently operate on a freight railroad right of way, while the maximum costs reflect maintenance practices on existing high speed railroad track such as Amtrak's Northeast Corridor.

The following sections of the Planner's Handbook provide a description of the analytic models used to generate the costs, and the process by which those models were calibrated to actual cost data to develop costs for a wide range of traffic and track combinations.

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Operating Scenarios for High Speed Rail

The Federal Railroad Administration (FRA) defines "high speed rail" as operation at above 90 MPH. Overseas, the definition of high-speed rail generally means operation at more than 125 MPH, and new high-speed rail lines in Europe and Asia are being designed for maximum speeds of 180 or even 200 MPH. These lines, however, are dedicated for passenger train use. Operation in mixed traffic (i.e., with freight and commuter trains) typically occurs at much lower maximum speeds.

The highest speed operation in North America occurs on Amtrak's Northeast Corridor, where speeds of 150 MPH are permitted on two short stretches of FRA Class 8 track. Simultaneous operation of freight and passenger trains is prohibited on FRA track classes 8 and 9 (maximum speeds of 160 and 200 MPH, respectively). Most of the rest of the NEC is FRA Class 7 track (125 mph), which passenger trains share with freight and commuter trains. The railroad is almost entirely grade separated and entirely electrified, and consists of multiple main tracks at most locations.

Recognizing that any likely high-speed rail in the United States will at least share a right of way, and may share track with, freight operations, planners elsewhere in the United States have set more modest goals than the emulation of the NEC. Rather than attempting 150 MPH, or even 125 MPH, speeds, planners have proposed the construction or upgrade of tracks to a maximum of FRA Class 6, for operation at up to 110 MPH. In some cases, this Class 6 track will be dedicated for passenger operations, but at many locations, particularly routes into major cities, freight and passenger trains will have to share tracks.

Future high-speed rail projects in the U.S. will probably look much like the network proposed by the Midwest Regional Rail Initiative (MWRRI). MWRRI contemplates a network of routes linking Chicago with other Midwest cities such as St. Louis, Detroit, and Cleveland. These routes will be partially single track, they will have grade crossings, and on some portions of each route, tracks will be shared with freight trains. Total passenger train volume is expected to be relatively modest, in the range of 16 to 20 daily trains. Other mixed passenger and freight operations include corridors such as the Seattle-Portland corridor, which has recently seen the introduction of a new generation of Talgo passenger trains on a heavy-traffic BNSF freight line.

Several scenarios are envisioned for mixed passenger and freight traffic corridors:

- Heavy freight routes where passenger trains share trackage to reach city terminals or where right-of-way constraints exist, but at maximum speed of 79 MPH for passenger trains (FRA Class 4)
- Moderate to heavy freight corridors with superimposed high speed passenger trains on the same track
- Lighter density freight routes, with passenger trains sharing trackage with minimal to moderate freight traffic (up to about 15 MGT annually), at passenger speeds of 110 MPH (FRA Class 6)
- Heavy-tonnage freight routes between cities with passenger trains operating at 110 MPH on a parallel single track with passing sidings. Interconnections to the freight

trackage will permit reciprocal use of tracks in emergencies, and local freight trains may use the passenger track to access yard and industrial tracks.

- Very low density freight corridors with superimposed high-speed passenger trains on the same tracks.

The purpose of the Planner's Handbook is to provide a reference for planners of high-speed rail service that will enable them to estimate the costs of right of way maintenance associated with the operation of high-speed passenger trains. As used in this handbook, right of way maintenance costs include "cyclic capital" costs such as rail replacement, tie renewals, surfacing, ballast replacement, etc., which are normally capitalized for accounting purposes as well as the expensed maintenance costs such as inspections, spot repairs, routine maintenance, etc.

Included in these right of way maintenance costs are:

- Track maintenance costs
- Bridge and Building (B&B) maintenance costs
- Signal maintenance costs

Capital upgrade costs, which are not cyclic in nature, but represent a one time upgrade costs are excluded from this handbook. The focus of the costs presented here are annual maintenance costs which are ongoing in nature. All costs are "steady state"; that is, the presumption is that track has been upgraded for high-speed operation, and what is required is to maintain it in adequate condition to carry the expected volumes of traffic.

This handbook presents a series of matrices which have been constructed to illustrate the costs associated with the operation of defined volumes of passenger traffic on tracks shared with freight trains. These matrices of right of way maintenance costs includes sensitivity to the following key factors:

- Annual tonnage (MGT) by tonnage categories
    - Light < 5 MGT
    - Low 5-15
    - Medium 15- 30,
    - High > 30 MGT
- Track geometry by broad curvature category
    - Light
    - Moderate
    - Severe
- Maximum operating speed
    - FRA Class 4 (80 passenger)
    - FRA Class 5 (90 passenger)
    - FRA Class 6 (110 passenger)
- Mix of passenger and freight
    - Predominantly passenger
    - Equal passenger and freight tonnage
    - Predominantly freight

- Tie type
    - Wood
    - Concrete

In this handbook matrices have been developed for:

- Total right of way maintenance costs
    - Track, B&B and signal maintenance costs
- Passenger share of cost per train mile

The purpose of these matrices is to allow a transportation planner to estimate the annual right of way maintenance costs by building up these costs using the individual elements of the matrices.

As noted above, costs have been generated for three operating scenarios, covering a range of tonnage and traffic mix, as follows:

1. Predominantly freight
    a. 80% of annual tonnage is freight, 20% passenger
    b. A maximum of 50 passenger trains per day[1]

2. Mixed traffic
    a. Tonnage divided 50/50 between passenger and freight
    b. A maximum of 60 passenger trains per day

3. Predominantly passenger
    a. Tonnage 80% passenger, 20% freight
    b. A maximum of 60 passenger trains per day

Each of these scenarios has been applied to a range of annual gross tonnages, from five million gross tons (MGT) per track mile per year to 50 MGT[2] per track mile per year. In each case, passenger train weight has been fixed at 550 tons total, including cars and locomotives, and freight train weight at 5,900 tons. The cost models used in this analysis take account both number of trains and total tonnage. In each scenario, the number of trains operating is driven by tonnage. Thus, in the "predominantly freight" category, at 5 MGT there are 4 MGT of freight traffic (2 freight trains) and one MGT of passenger traffic (5 passenger trains) per day. Higher annual gross tonnages will result in more trains of each type.

For each scenario, costs have been generated for the four ranges of annual tonnage noted above, using two proprietary track maintenance cost models described in subsequent sections of this report. Costs are "steady state" costs, the costs of maintaining the track at a specified FRA class

[1] Where this volume of passenger service is operated, freight trains are assumed to operate primarily at night, to avoid interference with passenger traffic. Note, at this volume of traffic, there may be difficulty in gaining track access for MoW activites, with a resulting increase in unit MoW costs.
[2] Several elements of the matrix which represent an unrealistic combinations of tonnage and high-speed passenger trains have been intentionally left out. These include predominantly passenger operations with tonnage levels above 15 MGT and equal passenger-freight operations with tonnage levels above 30 MGT.

once any required upgrades have been completed. A total cost per track mile has been calculated, including:

- MOW operating expenses
- Cyclic capital expenditures for track
- Bridge & building costs (maintenance and capital)
- Communications and signals costs (maintenance and capital)

These costs have been allocated between passenger and freight trains, allowing for the calculation of a cost per passenger train mile.

The results of the model applications are provided in the form of matrices, appended to this handbook, that allow planners to select the appropriate maintenance/capital cost for any segment of proposed high speed passenger railroad. This is expected to be a significant aid in the planning of high-speed rail service throughout the United States.

The following sections describe the models employed, and the process of developing costs for each of 216 combinations of track, topology, traffic mix, and operating speed. The process of calibrating these costs to five actual track corridors (four on the MWRRI network and one-Seattle-Portland corridor) is described, and finally the costs are presented.

II. Development of Cost Estimates

In order to determine the range of right of way maintenance costs (to include both maintenance and cyclic capital costs) for these mixed high-speed passenger-freight operations, two ZETA-TECH models were utilized:

- ZETA-TECH's Work Unit Model, which calculates the level of "work" required to maintain a defined segment of track or territory and which is used here to estimate non-capital track maintenance expenditures associated with specific track segments and territories

- ZETA-TECH's Steady State Capital Model, which uses standard lives and costs for track components to estimate future or "steady state" spending required to replace components as they wear out. This is used to calculate the cyclic capital costs.

Minimum and maximum costs were developed for each cell in the cost matrices. The minimum costs are based on maintenance standards geared to FRA minimum track safety standards, while the maximum costs reflect maintenance of higher track standards to ensure good ride quality. The minimum costs are for typical Class I freight railroad practice, such as where passenger trains currently operate on a freight railroad right of way, while the maximum costs reflect maintenance practices on existing high speed railroad track such as Amtrak's Northeast Corridor.

The Work Unit Model

The Work Unit Model is an engineering based model designed to calculate the equivalent level of work required to maintain different and dissimilar segments of track. As such it addresses and incorporates each of the key work effort drivers such as miles of track, class of track (speed of operation), number of turnouts, traffic density (MGT and number of trains), number of passenger trains, curvature, climate, accessibility, etc. The Work Unit Model addresses only "maintenance of way operating expenses", the expensed costs for track inspection and minor maintenance.

The Work Unit Model was developed in cooperation with a large U.S. freight railroad, and has been applied on both freight and high speed passenger railroad systems. It quantifies the maintenance effort required on any segment of track in terms of "work units", which represent a "level of effort" required to maintain a segment of track. The number of work units assigned to a particular part of the track structure (a turnout, for example) varies according to its characteristics and also according to the volume of traffic it carries. Main track is assigned more work units per track mile than branch line or yard track. The number of work units is determined both by tonnage and by the number of trains per day (more trains per day make access more difficult), as well as by various other track, traffic, and environmental factors.

Summing across all track territories, a total for all work units on the railroad is obtained. MOW operating expenses are then divided by these work units to obtain a cost per work unit. Applying this cost per work unit to the number of work units calculated for individual line segments, the appropriate level of expenditure for each line segment can be determined. The focus is on the level of effort required of local track maintenance forces to maintain a particular piece of railroad.

The Work Unit Model is used to allocate maintenance budget across defined territories. Work units are calculated per track segment as a function of track and traffic characteristics that include:

- Track miles: Main Line, Sidings, Branch Line, Yard
- Miles of curves; by severity (tangent, moderate, severe)
- Traffic: Both annual MGT and trains/day
- Number of turnouts, diamonds, road crossings
- Miles of concrete ties, CWR
- Rail defects/mile, TQI[3] (Condition)
- Road crossings/mile (Accessibility)
- Climate (rain, snow, heat, cold)

<u>Work Unit Equations</u>

There are four individual work unit equations based on track type:

- Main line track

[3] Track geometry measurement cars usually employ software to generate a single scalar number to indicate the overall geometric condition of the track. This is called a track quality index (TQI).

- Sidings
- Branch Lines
- Yard Track

Each equation is sensitive to key maintenance factors associated with that type of track. The Work Unit equations reflect results of field audits and sensitivity analyses. Field verification was performed on all key input data. This was done by auditing 13 Roadmaster territories on a major US Class 1 railroad and surveying work effort distribution. ZETA-TECH also compared earlier Work Unit Model equations with other "work unit" type models:

- AREA[4]
- Canadian National[5]
- Other ZETA-TECH maintenance models[6]

Note, these models were precursors to the ZETA-TECH work unit model, and provided input into the Work Unit Model, which deals more extensively with the key parameters of interest here. Neither the AREA model nor the CN model was actually used in this analysis.

A 1999 audit found the overall model format to be fundamentally sound in concept and approach. Equations realistically reflect work effort based on surveys, audits, and comparative studies. Quantitative terms such as, Condition, Climate, and Accessibility, provide a quantitative rather than qualitative way to distinguish between territories.

Various other factors were "fine tuned" through review of available data. These included:

- Curvature effect
- MGT vs. train effect
- Yard effect
- Turnout effect

The model has also been modified to improve ease of use. In many cases, look up tables were replaced with continuous functions, and the generation of consolidated and summary reports was automated. The model can import supplemental data from various sources (e.g. TQIs). Please note however that TQI data was not used in the analysis described here.

<u>Territory Characteristics</u>

Territory characteristic parameters were implemented to replace more subjective factors. "Condition" is based on TQI (TQI actual vs. TQI desired). The higher the ratio the poorer the track condition. Desired TQI can be set as function of class of track; in most railroad

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[4] The American Railway Engineering Association (AREA) Committee 16 introduced "Equated Mileage" parameters in 1994 that were intended to provide a basis for comparison of track maintainability. This methodology may be found in *Manual for Railway Engineering 2003,*American Railway Engineering and Maintenance Association (Washington, DC: 2003), Chapter 16, Part 11, page 16-11-1

[5] CN's model is proprietary.

[6] These include RaiLife© and TieLife©

applications and in generating the costs included in this report, it has been set to one value system wide. Alternately, a TQI Ratio (TQIR) can be calculated separately (based on TQI desired) for high speed and conventional track.

Climate characteristics include:

- Rainfall, annual inches
- Snowfall, annual inches
- Excessive heat (# of days above 90 degrees)
- Excessive cold (# of days below 0 degrees)

Accessibility is based on number of road crossings per mile (rcpm). The value varies between high, medium and low degrees of accessibility (rcpm) The overall Territory Characteristic Factor is calculated as a function of the three factors: condition, climate and accessibility.

Main Line Track Equation

The primary work unit equation for main line track is:

Work Units (Main Line) = [MGT Factor * Train Factor * Territory Factor]*
[Track Mile Term + Curve Term + Special Track Work Term + Crossing Term]

where:

- **MGT Factor** is function of Annual MGT
- **Train Factor** is function of Number of Trains/Day
- **Territory Factor** is a function of Condition (TQI), Climate (rain, snow, heat, cold), Accessibility (road crossings/mile)
- **Track Mile Term** is function of Track Miles, defects/mile and % CWR
- **Curve Term** is function of miles of moderate curves (2-6º), miles of sharp curves (> 6º), and miles of concrete ties
- **Special Track Work Term** is function of number of turnouts and crossing diamonds
- **Crossing Term** is a function of number of road crossings (public > 40’, public < 40’, and private)

Table 1 provides an example of a model application to main track.

Table 1: Work Unit Model Application to Main Track

Term	Value	Factor
MGT (annual)	8.8	1.18
# of Trains	3	1.00
Territory (cond./access/climate)	2.4+2.6+2	1.13
Track miles	222	269.73
Miles of Curves/Mi. of severe curves	34+1	58.39
Number of turnouts and crossings	45	59.85

Number of Rail/Highway Crossings (>40 ft. + ≤40 ft. + private)	1+65+54	21.3

Taking MGT first, it can be seen that the segment carries 8.8 MGT. This is more than the system average tonnage, so a factor of 1.18 is used. The number of trains is at the system average, so the factor is 1.0.

The "territory" term combines three variables. The first is condition, and is set to 2.4 in this example. The second is accessibility (defined as the number of rail/highway crossings). This is set to 2.6. Finally, the climate variable is set to 2.0. This produces a weighting factor of 1.13

The track mile term is affected by number of defects and percent of CWR. There are 222 actual track miles in this example, but they are increased to 269.73 to reflect a relatively high defect rate and a smaller than average percentage of CWR.

The curve term accumulates the miles of curves. Here there are 34 miles of moderate curves and one mile of sharp curves, equating to an equivalent 58.39 tangent track miles.

There are 45 turnouts and crossing diamonds, equating to 59.85 track miles. Finally, there is one public crossing with a width greater than 40 feet, 65 public crossings with a width of less than 40 feet, and 54 private crossings (width not recorded).

Thus, Work Units (ML) = (1.18*1.00*1.13)*(269.73+58.39+59.85+21.3) or 547.27 for this territory.

Branch Line Track Equation

Work Units (Branch Line) = k * [Territory Factor] *[Track Mile Term + Curve Term + Special Track Work Term + Crossing Term]

where:

- **Territory Factor** is a function of Condition (TQI), Climate (rain, snow, heat, cold), Accessibility (road crossings/mile)
- **Track Mile Term** is function of Track Miles, defects/mile and % CWR
- **Curve Term** is function of miles of moderate curves (2-6º), miles of sharp curves (> 6º), and miles of concrete ties
- **Special Track Work Term** is function of number of turnouts and crossing diamonds (constants differ from Main Line equation)
- **Crossing Term** is a function of number of road crossings (public > 40', public < 40', and private)

and k is the branch line weighting factor (0.49 in this application)

The Work Unit Model also contains equations for siding and yard tracks similar to those shown above. However, in the generation of cost numbers for this handbook, only main tracks were modeled. No branch lines, sidings, or yards were included in the analysis.

However, in the calibration of Work Unit Model results to two actual segments (Buffington Harbor to Ft. Wayne and Watertown to Madison, WI) all existing industry turnouts and diamond crossings were modeled. This will be described more fully in the Calibration section of this report.

Sensitivity Analysis

Extensive sensitivity analyses have been performed to examine relationship between key factors. Among these analyses were:

- Annual MGT
- Trains/Day (passenger and freight)
- Miles of Track
- Curvature

which are presented here.

Sensitivity to traffic volume (MGT and Freight trains/day) is shown in Table 2. Here the system average number of trains per day is 22, and the system average tonnage is 37.4, producing a total of 644 work units on the territory. As the table shows, changing the number of trains can increase or decrease work units, but the increase/decrease is a step function reflecting the change in accessibility. The relationship between work units and annual tonnage (holding trains per day constant) is a continuous function.

Table 2: Work Units as a Function of Traffic Volume

Annual MGT	Trains/Day							
	10	15	20	**22**	30	40	50	60
10	496	496	496	496	546	546	645	645
20	552	552	552	552	607	607	717	717
30	605	605	605	605	666	666	787	787
37.4	644	644	644	**644**	709	709	837	837
40	658	658	658	658	723	723	855	855
50	709	709	709	709	780	780	922	922
60	761	761	761	761	837	837	989	989
70	811	811	811	811	892	892	1054	1054
80	861	861	861	861	947	947	1120	1120
90	911	911	911	911	1002	1002	1184	1184
100	961	961	961	961	1057	1057	1249	1249
110	1010	1010	1010	1010	1111	1111	1313	1313
120	1059	1059	1059	1059	1164	1164	1376	1376
130	1107	1107	1107	1107	1218	1218	1439	1439
140	1156	1156	1156	1156	1271	1271	1502	1502
150	1204	1204	1204	1204	1324	1324	1565	1565

Table 3 illustrates the non-linear relationship between work units and miles of track maintained. Here the average territory consists of 160 track miles (which is likely a mix of main tracks, sidings, branch lines, and yards).

If track mileage is doubled, for example, work units increase 82%. In the same way, a reduction of 75% in track mileage maintained produces only a 53% reduction in work units. This reflects the nonlinearities in track maintenance, where there is not a one-to-one correspondence between the size of a territory and the labor required to maintain it.

Table 3: Work Units as a Function of Miles of Track Per Territory

Miles of Track	Work Units	% Change
20	424	-34%
40	455	-29%
60	486	-24%
80	517	-19%
100	548	-15%
120	579	-10%
140	610	-5%
160	641	0%
180	712	11%
200	780	22%
220	847	32%
240	912	42%
260	977	52%
280	1040	62%
300	1103	72%
320	1166	82%
340	1228	91%
360	1289	101%
380	1351	111%
400	1412	120%

Maintenance effort is increased in high curvature territory where degradation in increased. Thus curvature plays a significant role in determining the number of work units in each territory. Re-gauging of track is required more frequently on curves of two degrees and greater, so one of the drivers in the work unit calculation is the miles of curves greater than two degrees in each territory.

Again, the typical territory, with 644 work units, includes 17.4 miles of curves greater than 2 degrees Table 4 shows work units as a function of the miles of curves > two degrees.

Again, it must be remembered that the Work Unit Model addresses only track maintenance, and not the renewal of rail in curves. Rail renewal is capitalized; minor curve maintenance is not.

Table 4: Work Units as a Function of Miles of Curvature

Miles of Curves > 2 Degrees	Work Units	% Change from Avg.
5	617	(4%)
10	627	(3%)
17.4	644	0%
20	652	1%
30	713	6%
40	740	11%
50	767	15%
60	793	19%
70	820	23%
80	832	27%
90	849	32%
100	879	37%
110	909	41%
120	938	46%
130	968	50%
140	997	55%
150	1027	59%

Finally, Table 5 shows the relationship between work units and track class. If track class is increased from FRA Class 4 to FRA Class 6, work units increase by about 40%, reflecting the added maintenance burden of maintaining to a higher track standard.

Table 5: Work Units as a Function of Track Class

FRA Track Class	Work Units (at 15 MGT)
1	538
2	605
3	690
4	803
5	939
6	1100

Summary

The Work Unit Model calculates the "level of effort" required to maintain a segment of track, exclusive of component replacement (capital) costs. It has been used on several Class 1 railroads to determine and allocate maintenance budget for different territories. As noted above, the model has been validated based on field audits and comparison to other related models.

However, since the Work Unit Model calculates only work units, it was necessary to determining the proper cost per work unit to be used in developing the cost matrices. This was done by calibrating the work unit model to several sets of maintenance expenses, to include actual railroad maintenance budgets and a dedicated "bottom up" cost analysis for two Midwestern routes that have been proposed for high speed rail use. The bottom-up costs were developed by subcontractor HNTB, Inc. The process of calibrating the Work Unit Model is described in the Calibration section of this handbook.

It should be noted that, while the Work Unit Model can include many different categories of maintenance cost, the cost of pole line maintenance has not been included in this analysis. It has been assumed that any upgrade of railroad track for high speed operation would include replacement of any existing pole line with radio frequency control of signals and switches.This revised and validated model was applied to generate the cost matrices presented in the Planner's Handbook. In this application here, the model includes only main tracks and passing sidings. No yard or industry trackage has been included.

The Steady State Capital Model

Predicting "steady state" capital requirements is a somewhat different process than estimating MOW operating expenses. Many capital costs are driven by traffic volume (in MGT), while many MOW operating expenses (such as track inspection) have at best an indirect relationship with traffic volume. Also, capital costs are less affected by differences in local conditions than MOW operating expenses.

The critical step in formulating a capital model is the development of appropriate life expectancies for track components. The ZETA-TECH capital model includes the following components:

- Rail
- Ties (concrete and wood)
- Turnouts
- Surfacing/ballasting (surfacing cycle in years)

In this analysis, ZETA-TECH also considered bridge capital costs and communications and signals (C&S) capital costs. These costs are also related to traffic volume, since bridge lives are determined in part by the frequency of loadings by train traffic. C&S costs may initially appear unrelated to traffic, but are in fact are a function of "relay events". Each time a signal changes to a different aspect, or grade crossing gates and flashers activate, there is wear on components. The heavier the rail traffic, the more frequent the relay events, and the shorter the lives of installed components. Furthermore, a significant portion of C&S capital costs involve the installation and replacement of grade crossing components, where again, operations (and component lives) are directly related to traffic, specifically number of trains.

<u>Model Application</u>

The Steady State Capital Model was originally developed by ZETA-TECH for a Class I railroad to calculate steady state (condition independent) annual track capital costs. The objective was to provide the railroad with a neutral and scientific method of programming track capital renewals for rail, ties, and ballast/surfacing. To do this, the model had to properly account for the physical and environmental characteristics that determined track component degradation.

For each of the three component categories (rail, ties, ballast) the model incorporates a relationship between traffic density and environment, expressed mathematically, that allows the model to predict component life in years (and therefore the required date of replacement) under a defined set of conditions. Environmental factors dominate at low tonnages, while traffic (measured in MGT) dominates at higher tonnage levels

In addition to the density/environment relationship, the model also addresses curvature, a very important determinant of rail life. Data on the length and degree of curves was available from the MWRRI database and BNSF track charts. However, in order to reduce the level of complexity of the analysis, three levels of curvature were defined and used in the model:

- Tangent (curves of less than 2°)
- Moderate (2° to < 6°)
- Severe (≥ 6°)

The model uses standard component lives (in MGT) and adjusts them upwards or downwards according to the mathematical relationships included in the model, to obtain an expected life on each segment for each combination of traffic density and curvature.

In this application of the Capital Allocation Model, lives are calculated for each track component on each segment, taking into account total tonnage over each segment, curvature, operating speed, and other factors such as environment. For example, the relationship between rail life and tonnage is linear, since general practice in the rail industry is to express rail life interchangeably in either cumulative tonnage (MGT) or years. However, annual tonnage on many segments is low enough (1 MGT or less) to produce improbably long life for rail. At some point, rail must be replaced due to technological obsolescence or environmental decay (rust and corrosion) even if no traffic uses a rail line. Therefore, the Steady State Capital Model caps rail life at 100 years even on low-tonnage segments.

For turnouts, a similar relationship is used. However, maximum life of turnouts in main track is set at 30 years.

For ties and ballast, relationships are nonlinear due to the substitution of traffic damage for environmental decay as traffic increases. This substitution of mechanisms leads to a less-than-linear decrease in the life of these components as traffic increases. Again, however, a maximum life in years is established, due to the effects of environment on low-tonnage lines.

The model addresses high-speed operation in several ways. First, of course, the dynamic impact of vehicles on the track varies with speed. Second, the lives of turnouts (in MGT) are reduced on Class 5 and Class 6 track from the Class 4 "base case." Finally, surfacing cycles are more frequent at higher track classes (surfacing frequency depends not only on traffic, but also on FRA track standards-and therefore on maximum operating speed.)

The model then uses component life relationships and traffic data to predict a life for each of the component categories (rail, ties, ballast/surfacing, and turnouts) on each line segment under analysis. Using these component lives, and standard unit costs, the model produces the following:

- Steady state renewal requirements for each component (in units)
- Steady state capital budget requirements (in $), by component category
- A total capital cost for steady state track component renewal

Note that the effect of current component condition or maintenance history is not taken into account, since this is a "steady state" analysis.

Track Component Lives Used in the Model

Lives used in this analysis for each component are shown in the following tables:

For surfacing, the cycle is reduced at higher track classes, to account for the need to maintain a higher track geometry standard. For turnouts, component life in MGT is reduced, again to reflect the dynamic impacts generated at higher speeds as well as the need to maintain tighter standards.

At low annual tonnages, the lives of many capital components are capped. Maximum life of rail was set at 100 years. Concrete tie life was capped at 60 years, and turnout life was limited to 30 years. This life limit produced some anomalies. The capital cost of concrete-tie track is higher than for wood tie track, so at low annual tonnages and high track class (where turnout and surfacing costs also are high), the annualized cost for concrete is higher, producing a higher total cost when maintenance and capital costs are added together.

Table 6: Rail

Component	Cost per Mile		Life in MGT	
	Low	High	Low	High
Rail (CWR)	$350,000	$420,000	800	1200
Rail (jointed)	$320,800	$360,000	600	960
Rail (curve)	$388,500	$480,000	400	800
Rail (sharp curve)	$388,500	$480,000	200	400

Note: Maximum life capped at 100 years

Table 7: Ties

Component	Cost per Tie		Life in Years	
	Low	High	Low	High
Ties	$80	$90	30	36
Ties (curve)	$80	$90	24	27
Ties (sharp curve)	$80	$90	16	18
Ties (concrete)	$130	$160	50	60

Note: Concrete tie life capped at 60 years.

Table 8: Turnouts, Crossings+

Component	Cost per Each		Life in MGT	
	Low*	High*	Low	High
Turnout (Class 4)	$70,000	$90,000	400	800
Turnout (Class 5)	$70,000	$90,000	375	750
Turnout (Class 6)	$70,000	$90,000	350	700

Note: Maximum life of mainline turnout capped at 30 years

+These are wood-tie, #20 to #24 turnouts

* This cost does not include C&S costs (see below).

For #16 turnouts and larger, an additional $50,000 C&S cost has been added to account for the fact that these are generally power-operated turnouts with associated signals. See the section on calibration of the Steady State Capital Model.

Table 9: Surfacing

Component	Cost per Mile		Cycle in Years	
	Low	High	Low	High
Surfacing	$10,000	$12,000	3.0	4.0
Surfacing (curve)	$10,000	$12,000	2.5	3.4
Surfacing (sharp curve)	$10,000	$12,000	2.2	2.9

Note: Cycle based in 30 MGT and FRA Class 4 Track

Table 10: Surfacing Cycle by Track Class (Tangent Track)

Component	Cost per Mile		Cycle in Years	
	Low	High	Low	High
Surfacing (Class 4)	$10,000	$12,000	3.0	4.0
Surfacing (Class 5)	$10,000	$12,000	2.6	3.4
Surfacing (Class 6)	$10,000	$12,000	2.0	2.6

As with the Work Unit Model, results of the Steady State Capital Model were calibrated to actual costs on several Class I railroads. This is discussed further in the Calibration section.

The TrackShare® Model

ZETA-TECH's TrackShare model is an engineering based cost allocation model, designed to allocate track maintenance costs between different traffic types, including both freight and passenger trains. TrackShare is a direct descendent of the Weighted System Average Cost (WSAC) model, which has been extensively applied both in North America and overseas to determine the passenger train share of MOW cost. WSAC has been used before, and accepted by, the Interstate Commerce Commission as the "best available" method for determining the incremental costs of passenger train operation[7].

TrackShare makes use of engineering damage equations to calculate the portion of track damage (component life consumption) due to each defined traffic type operating over a specific track segment. This calculated cumulative damage is then used to allocate track maintenance costs in an auditable and accountable manner.

A. Track Data Development

To use TrackShare for MOW costing, the rail network under analysis must be divided into a network of unique track segments, without overlapping. For each of these segments, data must be obtained on the following parameters:

- Grade
- Curvature
- Track characteristics (e.g. weight of rail, tie type, type of rail, etc.)
- Track miles per route mile
- Traffic density per track mile, in MGT, for each defined traffic type

Track segments may be of any length permitted by data availability. Values for curvature may be averaged over the length of segments.

B. Traffic Data Development

Traffic types are defined by axle load, operating speed, and suspension characteristics. Any number of traffic types may be defined -- a typical number might be four types of freight traffic and a passenger category that includes both Amtrak and commuter rail services (if their operating speeds are the same). For each segment, a weighted average operating speed is calculated for each traffic type based on speed limits, geographic speed restrictions, and any special restrictions applying to particular traffic types. For example, passenger trains may operate at up to 150 m.p.h., while the freight maximum speed may be limited to 40 m.p.h.

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7 INTERSTATE COMMERCE COMMISSION DECISION, Finance Docket No. 32467, "National Railroad Passenger Corporation and Consolidated Rail Corporation: Application under Section 402(a) of the Rail Passenger Service Act for an order fixing just compensation". Decided December 29, 1995.

Not all traffic types need operate on every track segment. Costs are only assigned to traffics which actually operate on each segment. The sum of all assigned costs for any track segment is the total variable MOW cost for the segment.

C. Costs

In many U.S. applications, ZETA-TECH has used cost data from R-1 reports filed by the Class I freight railroads with the Surface Transportation Board. For commuter rail operators and Amtrak, internal financial reports are the usual data source. Here, TrackShare has been applied to track mile costs developed through use of the Work Unit and Steady State Capital models, to apportion costs between passenger and freight trains.

D. Some Caveats

Although TrackShare has been widely used, it is only one of many possible methods for allocating track maintenance costs between traffics. Actual payments by passenger train operations for use of privately owned freight tracks will be determined by negotiation. The numbers shown in the Planner's Handbook may be used for guidance, but should not be considered definitive.

III. Model Calibration

All track maintenance cost models must be calibrated against actual costs in order to ensure that their estimates are correct. The calibration exercise consists of applying the model to a track segment – or multiple segments – for which costs are known, and making adjustments until the model can properly predict the costs of the known segments. Then the model, if properly specified, should be able to accurately predict costs for segments with very different track and traffic characteristics.

The model calibration was carried out separately for the Work Unit Model and for the Capital Model. For the Work Unit Model, the primary analysis issue was the determination of an appropriate cost per work unit. This was done through calibration of the model with:

- A "bottom up" estimation of maintenance costs on two line segments[8].
- Known Class 1 railroad maintenance costs (to include non-capital maintenance expenses are reported on R-1 reports to the Surface Transportation Board)

For the Steady State Capital Model, model predictions were compared to average capital cost per track mile for several Class I railroads from R-1 reports to the STB.

The following sections describe the process of calibration for the two models.

[8] These costs (including B&B and C&S) were developed for ZETA-TECH by HNTB Inc. as a subcontractor. HNTB assigned an engineer to the task who had formerly worked for Amtrak, and was thus familiar with maintenance practices on high-speed rail lines.

Calibration of Work Unit Model

The primary calibration of the Work Unit Model was to costs developed on two track segments, both in the Midwest (and parts of the MWRRI):

- Buffington Harbor to Ft. Wayne, IN
- Watertown to Madison, WI

The first of these segments has five freight trains per day, for a total of about 15 MGT annually, and an operating speed of 40 MPH. The second has two freight trains per day, for a total of less than five MGT, and an operating speed of 25 MPH.

For the purposes of the “bottom-up” costing exercise, it was assumed that both segments would be upgraded to FRA Class 4, with 60 MPH freight operation and 79 MPH passenger train operation, and Class 6, with 60 MPH freight operation and 110 MPH passenger train operation. The bottom-up cost estimate was prepared by HNTB Inc. as a subcontractor to ZETA-TECH. HNTB, which was familiar with these two segments from its MWRRI support activities, conducted a field inspection of the Indiana line. HNTB then used available data to inventory all the track, signals, bridges, grade crossings, and structures to be maintained on these two routes, and then developed a table of organization for the staff required to inspect and maintain the railroad in each case. The bottom-up cost estimate covered maintenance of way operating expenses only.

Costs were built up based on activities necessary to keep the railroad in safe condition for operations. For example, a force of signal maintainers would be required to maintain train control equipment and grade crossing protection. Track would have to be inspected twice per week. Forces would need to be available to perform minor maintenance and spot surfacing.

In performing an exercise of this kind, there are a number of issues that tend to increase estimated costs. One is indivisibility: working with a track segment as short as Watertown to Madison, for example (36.1 miles), the planners must assign at least one track inspector even if he/she could, in theory, cover more territory. There are similar issues for other maintenance activities. Another issue is the increment in labor required to maintain track at a higher class. In the capital model, this is fairly straightforward – higher speeds mean, among other things, that surfacing cycles must be more frequent. But the estimation of the additional spot surfacing required, or how frequently track must be re-gauged on curves, is mostly a judgment call.

Notwithstanding these caveats, the bottom-up cost estimates provided a starting place for the calibration of the work unit model. Perhaps the single most valuable output of this “bottom up” costing exercise was the estimation of the incremental additional cost of maintaining a Class 6 railroad. This cost turned out to be substantial. Table 11 presents the summary bottom up results for the Buffington Harbor to Ft. Wayne, IN segment. Table 12 shows the costs for the same segment maintained to FRA Class 4 standards. These numbers can be directly compared, and it can be seen that expenditures for Class 6 track on the Buffington Harbor – Ft. Wayne segment are 66% higher than for Class 4 track.

Track expenditures are only about 50% higher for Class 6 than for Class 4; most of the remaining cost increase is due to higher C&S costs. Specifically, all public highway crossings are assumed to have been fitted with four-quadrant gates. This will double the number of units to be maintained if the crossing already has gates. A number of public crossings on the line do not have any kind of active protection at present, and of course no private crossings have active protection. For operation at Class 6, all public crossings will have four-quadrant gates, with the exit gate descent delayed to prevent vehicles from becoming "trapped". ` All private crossings will have active protection (two-quadrant gates, flashers, and bells). The differential cost is clearly evident from comparison of the C&S columns on Table 11 and Table 12.

Finally, Table 13 shows costs for Watertown, WI to Madison. The short length of this segment, plus the use of concrete ties, produces even higher costs for Class 6 operation. However, as noted earlier, this is also due in part to the short length of the segment. A breakdown of C&S and B&B costs was not available for this segment.

TABLE 11: Bottom Up Cost Analysis: Maintenance Expense for Buffington Harbor to Ft Wayne

MWRRI – Buffington Harbor to Ft. Wayne
Maintenance Cost Model FRA Class 6
Wood Tie System (CSX) - Single Track

Low Volume Freight (5 to 15 MGTs)	
Total Number of Passenger Trains Per Day	16
Total Number of Route Miles	128.5
Total Number of Track Miles	153.7

Maintenance Category	Maintenance Item	Budgeted Cost	Comments / Notes	TRACK Class 6	B&B Class 6	C&S Class 6	TOTAL Class 6
Management	Service Delivery	$512,000.00	4 managers on the line	$256,000		$256,000	$512,000
Professional Services	Engineering	$125,000.00	BP Estimates	$57,500	$21,600	$45,900	$125,000
Roadway Maintenance Services	Infrastructure Services	$313,965.00	Detailed Estimate	$313,965			$313,965
Labor	Straight Time	$2,349,776.00	Labor to maintain class #6	$1,281,696	$308,100	$759,980	$2,349,776
	Overtime	$422,960.00	At 18% of Straight Time	$230,705	$55,458	$136,796	$422,960
	Overhead	$1,802,278.00	At 65% of Straight Time & Overtime	$983,061	$236,313	$582,905	$1,802,278
Materials	Track	$382,400.00	Detailed Listing of materials	$382,400			$382,400
	C&S	$83,700.00	Detailed Listing of materials			$83,700	$83,700
	Structures	$100,000.00	BP Estimates		$100,000		$100,000
	Electric Traction	NA					
	Work Equipment	$115,000.00	BP Estimates	$80,500	$17,250	$17,250	$115,000
Small Tools & Safety Equipment	Service Delivery	$83,397.00	At $1,458.00 Per person	$45,490	$10,935	$26,973	$83,398
Roadway Equipment	Rental	$25,000.00	Assume, Vehicles are leased	$5,000	$10,000	$10,000	$25,000
Vehicle	Rental						
	Maintenance	$72,450.00	At 3,150 Per Vehicle	$37,674	$17,388	$17,388	$72,450
	Administration	$18,000.00	BP Estimates	$9,360	$4,320	$4,320	$18,000
Support & Other	Service Delivery	$152,501.00	Percentage of labor with detailed description	$83,182	$19,996	$49,323	$152,500
Extraordinary Maintenance	Storms and Wrecks	$215,000.00	BP Estimates	$111,800	$33,024	$70,176	$215,000
Communications	Phone	$6,360.00	Detailed Estimate	$7,285	$2,152	$4,573	$14,010
	Radio	$7,650.00	Detailed Estimate				
Environmental	Compliance and Safety	$75,000.00	BP Estimates	$20,000	$17,600	$37,400	$75,000
Training	Safety and Technical	$85,800.00	BP Estimates	$44,616	$13,179	$28,005	$85,800
	Grand Total:	**$6,948,237.00**		$3,950,234	$867,314	$2,130,689	$6,948,237

Note: BP = ballpark estimate

Table 12: Bottom Up Cost Estimate, Buffington Harbor to Ft. Wayne
FRA Class 4
Wood Tie System (CSX) - Single Track

Low Volume Freight (5 to 15 MGT's)

Total Number of Passenger Trains Per Day	16
Total Number of Route Miles	128.5
Total Number of Track Miles	153.7

Maintenance Category	Maintenance Item	Total Cost	Track Only	B&B	C&S
Management	Service Delivery	**$256,000**	$128,000		$128,000
Professional Services	Engineering	**$50,000**	$50,000		
Roadway Maintenance Services	Infrastructure Services	**$148,640**	$148,640		
Labor	Straight Time	**$1,495,312**	$879,112	$246,480	$369,720
	Overtime	**$164,484**	$96,702	$27,113	$40,699
	Overhead	**$1,078,868**	$634,279	$177,835	$266,753
Materials	Track	**$229,400**	$229,400		
	C&S	**$73,700**			$73,700
	Structures	**$100,000**		$100,000	
	Work Equipment	**$80,000**	$80,000		
Small Tools & Safety Equipment	Service Delivery	**$53,071**	$31,201	$13,122	$8,748
Roadway Equipment	Rental	**$25,000**	$25,000		
Vehicle	Maintenance	**$53,550**	$31,595	$8,568	$13,388
	Administration	**$15,000**	**$8,850**	$2,400	$3,750
Support & Other	Service Delivery	**$91,289**	$53,670	$15,048	$22,571
Extraordinary Maintenance	Storms and Wrecks	**$165,000**	$97,350	$26,400	$41,250
Communications	Phone and Radio	**$9,560**	$5,640	$1,530	$2,390
Environmental	Compliance and Safety	**$50,000**	$29,500	$8,000	$12,500
Training	Safety and Technical	**$54,600**	$32,214	$8,736	$13,650
	Grand Total:	**$4,193,474**	$2,561,153	$635,231	$997,089

Note: BP = ballpark cost estimate

Table 13: Bottom Up Cost Estimate Watertown to Madison
FRA Class 6
Concrete Tie System - Single Track
Predominantly Passenger (Freight < 5 MGT)

Total Number of Passenger Trains Per Day	20
Total Number of Freight Trains Per Day	2
Total Number of Track Miles	37.5

Maintenance Category	Maintenance Item	Budgeted Cost	Comments / Notes
Management	Service Delivery	**$229,500.00**	2 management employees
Professional Services	Engineering	**$ 30,000.00**	BP Estimate
Roadway Maintenance Services	Infrastructure Services	**$106,490.00**	Detailed Estimate
Labor	Straight Time	**$915,200.00**	Labor to maintain a class #6 single track
	Overtime	**$ 91,520.00**	At 10% of straight time & overtime
	Overhead	**$352,352.00**	At 35% of total straight time & overtime
Materials	Track	**$ 119,575.00**	Detailed listing of materials
	C&S	**$45,700.00**	Detailed listing of materials
	Structures	**$30,000.00**	BP Estimate
	Work Equipment	**$ 65,000.00**	BP Estimate
Small Tools & Safety Equipment	Service Delivery	**$28,440.00**	At $1,200.00 per person
Roadway Equipment	Rental	**$12,000.00**	Assumes equipment is primarily owned
Vehicle	Rental	**$172,800.00**	Assumes vehicles are leased
	Maintenance	**$31,500.00**	Fuel, PM, Misc. BP estimate
	Administration	**$18,000.00**	BP assume, already in place
Support & Other	Service Delivery	**$55,370.00**	Percentage of labor with detailed description
Extraordinary Maintenance	Storms and Wrecks	**$60,000.00**	BP Estimate
Communications	Phone	**$ 3,300.00**	Detailed Estimate
	Radio	**$3,150.00**	Detailed Estimate
Environmental	Compliance and Safety	**$ 30,000.00**	BP Estimate
Training	Safety and Technical	**$28,440.00**	BP Estimate
	TOTAL	**$ 2,428,337.00**	

Using the bottom-up cost analysis performed by HNTB, ZETA-TECH was able to determine a cost per work unit for the calculated number of work units on each line, such that the total maintenance cost predicted by the Work Unit Model matched the bottom-up cost calculation. This is presented in Table 14 together with the corresponding costs per track mile.

TABLE 14: Calculation of Cost per Work Unit

	Track Cost	**B&B**	**C&S**	**TOTAL**
	Class 6	**Class 6**	**Class 6**	**Class 6**
Total maintenance cost (Operating)	**$3,950,234**	$867,314	$2,130,689	$6,948,237
Work Units	716			
$/Work Unit	$5,517	$1,211	$2,976	$9,704
Maintenance cost (Operating) $/Trk Mile	$25,785	$5,661	$13,908	$45,354

However, it was noted that the resulting cost per mile was noticeably higher than the cost per mile on several Class I railroads examined. This is in fact consistent with maintenance costs on Amtrak and on foreign high-speed lines, which show significantly higher costs than on typical US Class 1 freight operations. However, all the available data for U.S. railroads indicated that costs should be lower.

In order to address this issue, it was decided to present a range of costs in each cost matrix, with the minimum cost representing a number calibrated to U.S. freight railroad "average" costs and the maximum a number matching the bottom-up cost calculations. The result was a "low" value based on available railroad data, and a "high" value based on the HNTB bottom up analysis. Noting that the minimum cost was based on predominately freight traffic and the maximum cost was based on predominately passenger traffic, a range of cost/work unit values was developed for the three passenger/freight traffic distributions and the corresponding operating speeds (classes of track). Table 15 presents the minimum and maximum work unit values used.

TABLE 15: Minimum and Maximum Cost per Work Unit

	Track	**B&B**	**C&S**
Minimum	$3000	$650	$1600
Maximum	$5500	$1200	$3000

This produced reasonable agreement with costs on the Buffington Harbor to Ft. Wayne segment, but continued to understate costs on the Watertown – Madison segment. HNTB suggested that, because of the short length of Watertown – Madison, there were issues of divisibility, and the workforce could probably maintain an additional 20 track miles without additional resources. This brought the cost per mile into the range predicted by the work unit model.

The resulting costs were then used to develop a series of costs per mile for individual matrix elements for maintenance costs. These cost elements were then calibrated against a full model application for five specific segments:

- Chicago to Buffington Harbor, (MWRRI)
- Buffington Harbor to Ft. Wayne, IN (MWRRI)
- Delta Junction, OH to Cleveland, OH (MWRRI)
- Watertown, WI to Madison, WI (MWRRI)
- Seattle WA to Portland OR (BNSF)

In each case, the values for MGT, number of trains, operating speeds, and other factors were input into the two models, and the results were compared with numbers obtained from the cost matrices. These calibration costs are presented in Appendix A together with the corresponding "handbook" costs (after calibration) for the same five segments.

After calibration a full set of maintenance unit cost elements was developed and applied to a range of combinations of traffic volume, traffic mix, and track configuration. These results are presented in Appendix B.

In using these cost matrices, planners should take cognizance of the conditions prevailing on specific track segments. The costs presented in the matrices cover a broad range. However, in calibrating the values in the matrices, ZETA-TECH adjusted for the difference in maintenance cost between passenger and freight by reducing the maximum costs in the "predominantly freight" matrices, and by increasing the minimum costs in the "predominantly passenger" matrices. This reflects the extra inspection and maintenance activity on high-speed passenger railroads, and also the difficulty of access when large numbers of trains per day operate. This means that the analyst need only select the correct matrices for a particular situation, and both minimum and maximum expected costs will accurately reflect operating conditions.

Calibration of the Steady State Capital Model

Since the Steady State Capital Model is based on the predicted life of the key track capital components (e.g. rail, ties, ballast, etc.), this model was calibrated against observed lives of track components under traffic, together with actual railroad capital costs from Class 1 railroad sources Although actual component condition will effect the schedule of component capital replacement, since track assets are long-lived, and replacements are highly cyclical in nature, if a long enough time series covering a large enough number of track miles is used, a steady state analysis can be used to develop cyclic capital maintenance costs for planning purpose.

Current traffic levels and track geometry are used in the track component life models within the Steady State Capital Model to calculate steady state requirements for rail, ties, and ballast. For the case of the five calibration track segments, presented in Appendix A, the actual traffic levels, curvature, and other key data was input into the ZETA-TECH Steady State Capital Model, together with industry average costs (as noted previously) to calculate the annual cyclic capital cost per mile for maintaining railroad track.

Annual bridge and signal expenditures were likewise calculated using a steady state approach and calibrated to Class 1 railroad data. In the case of bridges, a design life of 80 years was used together with unit costs (cost per foot) as shown in Table 13. In the case of signals, a design life of 80 years was again used (based on industry standards for treating very long life assets) together with unit costs (cost per track mile) as shown in Table 16.

TABLE 16: Minimum and Maximum Capital Cost for Bridges and Signals

	B&B Cost/foot	**C&S Cost/mile[9]**
Minimum	$4000	$220,000
Maximum	$6000	$320,000

As with the MOW operating expense matrices, care should be taken in selecting costs within these ranges. The minimum cost is typical of U.S. Class I freight railroad practice[10]. The maximum cost is more appropriate for high-speed passenger rail lines, and will cover additional active protection at grade crossings, four-quadrant gates, and more sophisticated signal systems.

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IV. Production of Cost Matrices

To obviate the need for planners to actually run the Work Unit and Steady State Capital models, ZETA-TECH generated two sets of matrices (one for wood ties, one for concrete ties). Each matrix is composed of 108 cells, each of which provides a value (cost per track mile) for both operating and capital expenditures for some combination of tonnage, traffic mix, operating speed, and curvature. All segments assumed use of heavy CWR and good quality ballast. Ties, as noted above, were either wood or concrete.

The key variables used to make up these matrices are:

<u>Annual Tonnage (MGT)</u>

- ≤ 5 MGT per track mile per year
- 5 – 15 MGT
- 15 – 30 MGT
- > 30 MGT

Traffic Mix:

- Predominantly freight traffic
- Traffic equal between freight and passenger
- Predominantly passenger traffic

Curvature

- Light
- Moderate
- Severe

[9] Note, this cost per mile includes al $50,000 per turnout C&S costs to reflect the cost of switch machines and signals associated with remote-control turnouts. Based on an averhge of 0.4 turnouts per mile, this represents an turnout C&S capital cost of $20,000 per mile. Note, the C&S costs represents costs with different lives, which are annualized separately later in this report.

[10] Based on Class 1 freight railroads on which passenger trains operate.

Class of Track

- FRA Class 4
- FRA Class 5
- FRA Class 6

Tie Type

- Wood
- Concrete

The final matrices contain a set of 108 values for wood tie track, and another 108 for concrete tie track.

Table 17 shows the traffic mixes used in generating the matrices.

Table 17: Traffic Mixes

Traffic Mix	**% of MGT**	
	Passenger	Freight
Predominantly freight	20	80
Equal	50	50
Predominantly passenger	80	20

Note: Number of daily passenger trains capped at 50 for the first two cases, 60 for the third. In the predominantly freight case, at 50 passenger trains per day, freight is assumed to operate predominantly (only) at night.

The number of trains of each type was calculated for the following annual gross tonnages:

- ≤ 5 MGT per track mile per year
- > 5 – 15 MGT
- > 15 – 30 MGT
- > 30 MGT

[Note that in the calculation of the costs in the matrices, values of 5, 15, 30, and 50 MGT respectively were used for these four tonnage categories.]

Passenger trains were assigned a gross weight of 550 tons, freight trains a gross weight of 5,900 tons.

Note, however, that several elements of the matrix would have produced unrealistic combinations of passenger and freight track and as such were excluded (and are so indicated by an * in the matrix element). These unrealistic cases included:

- Equal 50/50 passenger/freight traffic and annual tonnage >30 MGT
- Predominantly passenger traffic and 15 – 30 MGT
- Predominantly passenger traffic and > 30 MGT

Note also that traffic densities are per track. It is extremely unlikely that any predominately passenger operation will ever exceed 15 MGT per track mile. As a comparison, the most heavily used portion of Amtrak's Northeast Corridor, between Newark and New York's Penn Station, carries about 150 trains per day on two tracks, for a total of about 40 MGT annually or 20 MGT on each track. There is no freight traffic. The heaviest segment with freight traffic is between Perryville, MD and Baltimore, where the 20 MGT of total traffic (split 50/50 between freight and passenger) runs on two or three main tracks depending on location.

In addition to traffic mix and annual gross tonnage, ranges of curvature were also used as shown in Table 18.

Table 18: Ranges of Curvature

Category	% of Total Distance in Each Category		
	< 2 deg.	2 – 6 deg.	> 6 deg.
Light curvature	96%	4%	0%
Moderate curvature	90%	8%	2%
Severe Curvature	82%	12%	6%

Finally, costs are provided for three track classes:

Table 19: Track Classes

FRA Class of Track	Maximum Speed	
	Passenger	Freight
Class 4	80	60
Class 5	90	80
Class6	110	80

However, it should be noted that while the maximum posted freight speed for Classes 5 and 6 is 80 mph, most freight cars can not travel faster than 60 mph and as such 60 mph was used as the practical maximum freight train speed for all three classes of track.

The combination of all these factors produced a matrix of 108 cells for wood-tie track. A second 108-cell matrix was run for concrete-tie track. Minimum and maximum costs are presented for each element, thus providing a range of costs to account for variations in operations, track characteristics, local costs, environmental effects, topographical variations and other such factors.

Cost Per Track Mile

The matrices for Annual Total Maintenance Cost Per Track Mile[11] are presented in Tables 17, 18, 19, and 20 (corresponding to Matrices 19, 20, 37, and 38 in Appendix B). Matrices for the individual elements that make up these total costs are presented in Appendix B.

Costs included in the matrices (and presented in Appendix B) are:

- Track maintenance (MOW operating expenses)
- Track cyclic capital
- Signal maintenance

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[11] Includes both cyclic capital and expensed maintenance costs.

- Signal capital
- B&B maintenance
- B&B capital

These costs are further summed as follows:

- Maintenance Cost per Track Mile [Minimum and Maximum]
- Capital (Cyclic) Cost per Track Mile [Minimum and Maximum]

Finally, a single set of total (Maintenance + Cycle Capital) costs per track mile are developed; again with a minimum-maximum range of values. These are presented in Tables 21, 22, 23, and 24 below.

Adjustment to Account for Upgrading

One other adjustment should be considered by users of the cost matrices included in this Planner's Handbook. The assumption in developing costs has been that of "steady state", the expenditures (both capital and maintenance) required to keep each line in service at a defined operating speed (track class).

Prior to the start of high speed rail operations, any routes included in a high speed rail network will have to be upgraded. In many cases, this will involve complete replacement of rail, ties, and ballast. Such a "new" railroad of this kind will require maintenance, but little or no renewal of track components for a number of years. Therefore, costs shown in the matrices may be adjusted downward during the first few years of operations to account for this fact. Maintenance costs are unaffected, since even new track requires maintenance. But some cyclic capital costs can be deferred. Table 20 shows the suggested adjustment to costs to account for new construction.

Table 20: Cost Adjustments Following Upgrade of a Rail Line

Year	% of Cyclic Capital	Year	% of Cyclic Capital
0	0%	11	50%
1	0%	12	50%
2	0%	13	50%
3	0%	14	50%
4	20%	15	75%
5	20%	16	75%
6	20%	17	75%
7	35%	18	75%
8	35%	19	75%
9	35%	20	100%
10	50%		

This table is a recommendation based on the relative percentage of costs accounted for by rail, ties, and ballast, and by the average life of each component. Note that these percentages apply only to capital costs, such as those shown in Matrices 40, 42, 46,and 48 in Appendix B. Maintenance costs are unaffected.

Using the Matrices

To use the matrices, a planner need only select a value from the appropriate cell for each segment of track and multiply the per mile cost by the number of miles in the segment. For long segments with different combinations of traffic and tonnage, the costs are built up by dividing the long segment into shorter segments corresponding to an individual matrix element, multiply the cost per mile for each element by the corresponding mileage, and then summing up these costs to obtain a cost for the line segment. Section V presents an example to illustrate how the matrices are used to build up costs for a complex line segment containing different traffic mixes, tonnages, curvatures, etc.

Using these elements the actual cost of maintaining the infrastructure can be calculated for any defined line segment or route by building up the elements of the route and using the appropriate cost per track mile multiplied by the number of miles corresponding to each element.

Selection of the correct matrices is important. The range of costs is higher for the "predominantly passenger" matrices, to reflect the need for more complex highway crossing protection, more limited track time for maintenance work and a higher level of inspection and maintenance. Costs are lower for "predominantly freight" matrices, reflecting the efficiencies achieved by the freight railroads in maintaining heavy-tonnage but moderate-speed trackage. Within each matrix, the minimum cost may be considered to reflect current Class I freight railroad practice[12]. The maximum cost reflects the maintenance of good ride quality for high speed passenger trains, along with a higher level of grade crossing protection and more sophisticated C&S.

The range of costs shown is based on calibration both to actual freight railroad spending and to the "bottom up" costs developed by subcontractor HNTB.

[12] Based on Class 1 freight railroads on which passenger trains operate.

Table 21: Annual Total Cost[13] Per Track Mile (Minimum) for Wood Tie Track

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$26,554	$31,046	$42,008	$60,833	4	$27,107	$32,007	$43,460	$63,136	4	$27,918	$33,503	$45,763	$66,784
Pred. Frght	5	$29,172	$34,408	$46,816	$68,778	5	$29,846	$35,523	$48,484	$71,442	5	$30,826	$37,231	$51,086	$75,592
	6	$32,962	$39,329	$53,833	$80,265	6	$33,808	$40,662	$55,807	$83,442	6	$35,026	$42,672	$58,836	$88,304
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$29,393	$38,149	$54,725	*	4	$30,084	$39,457	$56,797	*	4	$31,087	$41,431	$59,958	*
	5	$31,500	$41,476	$59,946	*	5	$32,288	$42,935	$62,253	*	5	$33,425	$45,120	$65,741	*
	6	$35,816	$48,291	$70,573	*	6	$36,801	$50,060	$73,363	*	6	$38,211	$52,675	$77,521	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$31,879	$47,206	*	*	4	$32,691	$48,955	*	*	4	$33,861	$51,540	*	*
	5	$34,408	$52,073	*	*	5	$35,337	$54,049	*	*	5	$36,670	$56,948	*	*
	6	$37,543	$58,074	*	*	6	$38,612	$60,319	*	*	6	$40,139	$63,594	*	*

[13] Maintenance + Cyclic Capital

Table 22: Annual Total Cost[14] Per Track Mile (Maximum) for Wood Tie Track

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$38,748	$47,507	$66,570	$97,664	4	$39,632	$49,283	$69,464	$102,356	4	$40,986	$52,085	$74,111	$109,884
Pred. Frght	5	$42,189	$52,331	$73,422	$108,988	5	$43,255	$54,323	$76,619	$114,189	5	$44,864	$57,425	$81,688	$122,424
	6	$47,849	$59,930	$84,192	$126,621	6	$49,184	$62,253	$87,856	$132,603	6	$51,165	$65,816	$93,574	$141,921
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$42,842	$57,976	$85,400	*	4	$43,926	$60,262	$89,212	*	4	$45,557	$63,771	$95,129	*
	5	$45,750	$63,042	$93,287	*	5	$46,990	$65,556	$97,452	*	5	$48,839	$69,380	$103,861	*
	6	$52,215	$73,532	$109,567	*	6	$53,763	$76,518	$114,467	*	6	$56,039	$80,998	$121,897	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$46,640	$71,721	*	*	4	$47,909	$74,677	*	*	4	$49,796	$79,113	*	*
	5	$50,194	$79,124	*	*	5	$51,650	$82,421	*	*	5	$53,799	$87,331	*	*
	6	$54,822	$88,301	*	*	6	$56,497	$92,006	*	*	6	$58,949	$97,482	*	*

[14] Maintenance + Cyclic Capital

Table 23: Annual Total Cost[15] Per Track Mile (Minimum) for Concrete Tie Track

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$27,002	$30,808	$40,377	$58,218	4	$27,436	$31,622	$41,621	$60,169	4	$28,084	$32,913	$43,636	$63,330
Pred. Frght	5	$29,598	$34,145	$45,149	$66,101	5	$30,120	$35,069	$46,549	$68,312	5	$30,889	$36,514	$48,780	$71,835
	6	$33,359	$39,029	$52,114	$77,501	6	$34,006	$40,112	$55,060	$80,083	6	$34,947	$41,776	$56,278	$84,122
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$29,816	$37,851	$52,986	*	4	$30,350	$38,912	$54,672	*	4	$31,134	$40,545	$57,300	*
	5	$31,907	$41,152	$58,166	*	5	$32,510	$43,323	$60,023	*	5	$33,391	$44,108	$62,887	*
	6	$36,189	$47,914	$68,711	*	6	$36,934	$49,309	$72,240	*	6	$38,013	$51,405	$74,264	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$32,280	$46,616	*	*	4	$32,900	$47,984	*	*	4	$33,804	$50,043	*	*
	5	$34,790	$51,407	*	*	5	$35,494	$52,938	*	*	5	$36,515	$55,221	*	*
	6	$37,901	$57,319	*	*	6	$38,706	$59,044	*	*	6	$39,869	$61,597	*	*

[15] Maintenance + Cyclic Capital

Table 24: Annual Total Cost[16] Per Track Mile (Maximum) for Concrete Tie Track

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$38,387	$47,330	$65,072	$94,860	4	$39,090	$48,881	$67,648	$99,015	4	$40,800	$52,128	$72,922	$107,601
Pred. Frght	5	$41,798	$52,118	$71,872	$106,096	5	$42,636	$53,825	$74,668	$110,618	5	$44,474	$57,213	$80,140	$119,534
	6	$47,413	$59,662	$82,564	$123,596	6	$48,448	$61,608	$87,000	$128,683	6	$50,332	$65,049	$91,245	$137,712
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$42,446	$57,710	$83,742	*	4	$43,292	$59,625	$86,973	*	4	$44,846	$63,014	$92,703	*
	5	$45,329	$62,738	$91,567	*	5	$46,291	$64,817	$95,054	*	5	$48,050	$68,500	$101,243	*
	6	$51,743	$73,147	$107,722	*	6	$52,929	$75,567	$113,041	*	6	$54,704	$79,264	$117,946	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$46,211	$71,014	*	*	4	$47,189	$73,395	*	*	4	$48,675	$77,036	*	*
	5	$49,734	$78,303	*	*	5	$50,851	$80,928	*	*	5	$52,530	$84,907	*	*
	6	$54,327	$87,345	*	*	6	$55,604	$90,264	*	*	6	$57,505	$94,651	*	*

[16] Maintenance + Cyclic Capital

Cost Per Passenger Train Mile

In addition to the total cost matrices presented, a series of matrices for Cost per Passenger Train Mile were calculated (see Appendix C). These costs were determined by first separating passenger and freight costs using the following methodology:

1. ZETA-TECH's TrackShare® Model is used to allocate Class 4 costs between passenger and freight trains (based on a maximum freight speed of 60 mph and a passenger speed of 80 mph).

2. 100% of the calculated incremental cost of Class 5 or Class 6 track (over Class 4) is assigned to passenger trains, since it is only the passenger trains that benefit from the higher track class.

As in the case of the Total Cost per Track Mile, two sets of 108 cell matrices are generated, for wood-tie and concrete tie track respectively. Again, minimum and maximum costs are presented for each element, thus providing a range of costs to account for variations in operations, track characteristics, local costs, environmental effects, topographical variations and other such factors.

The matrices for Total Maintenance Cost Per Passenger Train Mile[17] are presented in Tables 21, 22, 23, and 24 (corresponding to Matrices 43, 44, 49, and 50 in Appendix C). Matrices for the individual elements that make up these total costs are presented in Appendix C.

Again, costs included in the matrices (and presented in Appendix C) are:

- Track maintenance (MOW operating expenses)
- Track cyclic capital
- Signal maintenance
- Signal capital
- B&B maintenance
- B&B capital

These costs are further summed as follows:

- Maintenance Cost per Passenger Train Mile [Minimum and Maximum]
- Capital (Cyclic) Cost per Passenger Train Mile [Minimum and Maximum]

Finally, a single set of total (Maintenance + Cycle Capital) costs per passenger train mile are developed; again with a minimum-maximum range of values. These are presented in Tables 25, 26, 27 and 28 below.

[17] Includes both cyclic capital and expensed maintenance costs.

Some Comments on Cost Allocation

There are a number of ways to allocate costs between passenger and freight trains, or between different types of freight trains, sharing the same track. ZETA-TECH's TrackShare is only one of these.[18] Amtrak is, by law, guaranteed access to freight railroad tracks at "avoidable" cost – the cost the railroads incur solely due to the operation of Amtrak trains. Freight railroads pay each other trackage rights fees based on track maintenance and communications and signal (C&S) costs, plus some allowance for train dispatching cost and overhead. Shippers have used methodologies such as the Speed Factored Gross Tonnage (SFGT) model and "stand alone costing" to determine the cost of particular train movements in rate disputes.

It is also possible to allocate costs based solely on gross ton miles of each traffic type.

Access fees for use of private railroad tracks by publicly operated trains will be determined by negotiation between the parties, ultimately. While the allocations presented attempt to apportion costs based on engineering relationships, they are intended as examples only. As such, they may serve as a starting point for negotiations between passenger service providers and the private railroads.

[18] In its 1995 decision, the Interstate Commerce Commission found TrackShare "best available" method to determine incremental track maintenance cost in a dispute between Conrail and Amtrak over payments by Amtrak to use Conrail tracks.

Table 25: Total Cost Per Passenger Train Mile (Minimum) for Wood Tie Track

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	**No. of Pass. Train**	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$1.97	$0.77	$0.52	$0.45	4	$2.01	$0.79	$0.54	$0.47	4	$2.08	$0.83	$0.57	$0.50
Pred. Frght	5	$3.41	$1.39	$0.96	$0.89	5	$3.52	$1.44	$1.00	$0.93	5	$3.67	$1.51	$1.05	$0.98
(80% Frght. 20% Pass.)	6	$5.50	$2.29	$1.60	$1.52	6	$5.70	$2.38	$1.67	$1.59	6	$5.98	$2.51	$1.77	$1.68
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght	4	$2.49	$1.08	$0.96	*	4	$2.55	$1.11	$1.00	*	4	$2.63	$1.17	$1.06	*
(50% Frght. 50% Pass.)	5	$2.95	$1.32	$1.20	*	5	$3.03	$1.37	$1.25	*	5	$3.14	$1.44	$1.32	*
	6	$3.90	$1.82	$1.69	*	6	$4.02	$1.89	$1.76	*	6	$4.20	$1.99	$1.86	*
	No. of Pass. Train	20	60			No. of Pass. Train	20	60			No. of Pass. Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$3.13	$1.55	*	*	4	$3.21	$1.60	*	*	4	$3.33	$1.69	*	*
(20% Frght. 80% Pass.)	5	$3.48	$1.77	*	*	5	$3.57	$1.84	*	*	5	$3.71	$1.94	*	*
	6	$3.91	$2.04	*	*	6	$4.02	$2.12	*	*	6	$4.19	$2.24	*	*

Table 26: Total Cost Per Passenger Train Mile (Maximum) for Wood Tie Track

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$2.88	$1.18	$0.82	$0.73	4	$2.95	$1.22	$0.86	$0.76	4	$3.05	$1.29	$0.92	$0.82
Pred. Frght	5	$4.77	$2.06	$1.45	$1.35	5	$4.94	$2.15	$1.52	$1.41	5	$5.18	$2.27	$1.61	$1.51
(80% Frght. 20% Pass.)	6	$7.89	$3.45	$2.44	$2.32	6	$8.20	$3.60	$2.55	$2.42	6	$8.64	$3.81	$2.70	$2.58
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght	4	$3.63	$1.64	$1.51	*	4	$3.72	$1.70	$1.57	*	4	$3.86	$1.80	$1.68	*
(50% Frght. 50% Pass.)	5	$4.27	$2.01	$1.87	*	5	$4.39	$2.09	$1.95	*	5	$4.58	$2.21	$2.08	*
	6	$5.69	$2.78	$2.61	*	6	$5.88	$2.89	$2.73	*	6	$6.16	$3.06	$2.90	*
	No. of Pass. Train	20	60			No. of Pass. Train	20	60			No. of Pass. Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$4.58	$2.35	*	*	4	$4.71	$2.44	*	*	4	$4.89	$2.59	*	*
(20% Frght. 80% Pass.)	5	$5.07	$2.69	*	*	5	$5.22	$2.80	*	*	5	$5.44	$2.97	*	*
	6	$5.71	$3.11	*	*	6	$5.89	$3.24	*	*	6	$6.15	$3.43	*	*

Table 27: Total Cost Per Passenger Train Mile (Minimum) for Concrete Tie Track

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$2.01	$0.76	$0.50	$0.43	4	$2.04	$0.78	$0.52	$0.45	4	$2.09	$0.82	$0.54	$0.47
Pred. Frght.	5	$3.44	$1.38	$0.94	$0.87	5	$3.52	$1.42	$0.97	$0.90	5	$3.63	$1.48	$1.01	$0.94
(80% Frght. 20% Pass.)	6	$5.50	$2.27	$1.58	$1.49	6	$5.65	$2.34	$1.75	$1.54	6	$5.86	$2.44	$1.70	$1.61
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght.	4	$2.52	$1.07	$0.93	*	4	$2.57	$1.10	$0.96	*	4	$2.63	$1.14	$1.01	*
(50% Frght. 50% Pass.)	5	$2.98	$1.31	$1.17	*	5	$3.04	$1.35	$1.21	*	5	$3.13	$1.40	$1.27	*
	6	$3.92	$1.81	$1.65	*	6	$4.02	$1.86	$1.77	*	6	$4.15	$1.94	$1.79	*
	No. of Pass. Train	20	60			No. of Pass. Train	20	60			No. of Pass. Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$3.17	$1.53	*	*	4	$3.23	$1.57	*	*	4	$3.32	$1.64	*	*
(20% Frght. 80% Pass.)	5	$3.52	$1.75	*	*	5	$3.59	$1.80	*	*	5	$3.69	$1.88	*	*
	6	$3.94	$2.02	*	*	6	$4.03	$2.08	*	*	6	$4.15	$2.17	*	*

Table 28: Total Cost Per Passenger Train Mile (Maximum) for Concrete Tie Track

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$2.85	$1.17	$0.81	$0.71	4	$2.91	$1.21	$0.84	$0.74	4	$3.03	$1.29	$0.90	$0.80
Pred. Frght	5	$4.73	$2.05	$1.43	$1.32	5	$4.86	$2.12	$1.48	$1.37	5	$5.05	$2.22	$1.57	$1.46
(80% Frght. 20% Pass.)	6	$7.82	$3.43	$2.41	$2.29	6	$8.05	$3.54	$2.61	$2.37	6	$8.28	$3.66	$2.58	$2.46
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght	4	$3.59	$1.63	$1.48	*	4	$3.66	$1.68	$1.53	*	4	$3.79	$1.78	$1.63	*
(50% Frght. 50% Pass.)	5	$4.23	$2.00	$1.84	*	5	$4.32	$2.06	$1.90	*	5	$4.50	$2.18	$2.03	*
	6	$5.64	$2.76	$2.58	*	6	$5.78	$2.85	$2.73	*	6	$5.96	$2.97	$2.79	*
	No. of Pass. Train	20	60			No. of Pass. Train	20	60			No. of Pass. Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$4.54	$2.32	*	*	4	$4.63	$2.40	*	*	4	$4.78	$2.52	*	*
(20% Frght. 80% Pass.)	5	$5.02	$2.66	*	*	5	$5.14	$2.75	*	*	5	$5.31	$2.88	*	*
	6	$5.65	$3.07	*	*	6	$5.79	$3.18	*	*	6	$5.99	$3.33	*	*

V. Example Application

Two hypothetical examples are presented here to illustrate how the handbook and its matrices are used to calculate a route segment's total maintenance cost and passenger train cost. Note, to use the matrices, a route must first be defined.

Example A.

Example A is illustrative of a 100-mile route that begins in an urban area, representative of a major city terminal area. The first ten miles are shared with heavy freight traffic on a Class 4 railroad. The passenger trains then enter a primarily passenger track (minimal freight traffic) for 50 miles, transitioning to a 30 mile segment on a secondary freight line, still at Class 6 but carrying 15 MGT or perhaps five trains per day of freight. Finally, the line enters another terminal in the destination city, sharing a heavy freight line at FRA Class 4. The entire route is wood tie track.

Table 29: Route Characteristics, Hypothetical Case A

Segment Length (Miles)	**Characteristics**			
	Traffic	FRA Class	MGT Range	Curvature
10	Pred. Freight.	4	> 30	Moderate
50	Pred. Passenger.	6	< 5	Light
30	50/50	6	5 – 15	Moderate
10	Pred. Freight.	4	> 30	Severe

To estimate a cost per track mile, the analyst need only choose the appropriate cost per mile for each segment, and multiply by the number of track miles to obtain the total cost of maintenance plus cyclic capital. Minimum costs are from Table 21 and maximum costs are from Table 22. Costs include Track, C&S and B&B. Note, if separate maintenance and cyclic capital costs are desired they can be built up by using individual maintenance (expensed) and capital cost tables from Appendix B.

Table 30: Total Steady-State Maintenance[19] Cost Calculation Using Minimum Cost (From Table 21)

Segment Length (Miles)	**Costs**	
	Cost per Mile	**Total Segment Cost**
10	$63,136	$631,360
50	$37,543	$1,877,150
30	$50,060	$1,501,800
10	$66,784	$667,840
Total Annual Route Cost		**$4,678,150**

[19] Includes both cyclic capital and expensed maintenance costs.

This is the minimum total expenditure a high-speed rail authority might expect to make on this route. The corresponding maximum cost is obtained by using the maximum value for each cost element in exactly the same manner, as shown in Table 31.

Table 31: Total Maintenance Cost Calculation Using Maximum Cost (From Table 22)

Segment Length (Miles)	Costs	
	Cost per Mile	**Total Segment Cost**
10	$102,356	$1,023,560
50	$54,822	$2,741,100
30	$76,518	$2,295,540
10	$109,884	$1,098,840
Total Annual Route Cost		**$7,159,040**

As noted earlier, the analyst will have to make a judgment as to whether to use minimum, maximum, or mean costs in the analysis. Tables 32 and 33 show the calculations for minimum and maximum costs respectively. Costs include track, B&B, and C&S.

Table 32: Cost per Passenger Train Mile Using Minimum Cost (from Table 25)

Total Segment Cost	Costs	
	Cost per Passenger Train Mile	**Total Segment Cost**
10	$0.47	$4.70
50	$3.91	$195.50
30	$1.89	$56.70
10	$0.50	$5.00
Total Passenger Train Cost per One-Way Trip		**$261.90**

Note that this is the minimum total expenditure a high-speed rail authority might expect to make on this route. The corresponding maximum cost is obtained by using the maximum value for each cost element in exactly the same manner.

Table 33: Cost per Passenger Train Mile Using Maximum Cost (from Table 26)

Segment Length (Miles)	Costs	
	Cost per Passenger Train Mile	**Total Segment Cost**
10	$0.76	$7.60

50	$5.71	$285.50
30	$2.89	$86.70
10	$0.82	$8.20
Total Passenger Train Cost per One-Way Trip		**$388.00**

Example B.

Example B is illustrative of a somewhat longer (150 mile) route that again begins in an urban area, representative a major city terminal area. These first twenty miles are conventional wood tie track shared with heavy freight traffic on a Class 4 railroad. The passenger trains then enters mixed freight and passenger segment (wood ties) of Class 5 track, 30 miles in length. The next 50 miles are primarily passenger track (minimal freight traffic) on concrete ties, transitioning to 30 mile severe curvature concrete tie segment of Class 6 track carrying 15 MGT of traffic equally divided between passenger and freight. Finally, the line enters another terminal in the terminating city, sharing a heavy freight line on wood tie track.

Table 34: Route Characteristics, Hypothetical Case B

Segment Length (Miles)	**Characteristics**				
Length	**Traffic**	**FRA Class**	**MGT**	**Curvature**	**Ties**
20	PRED. Freight.	4	>30	Severe	W
30	50/50	5	15-30	Moderate	W
50	PRED. Passenger	6	<5	Moderate	C
30	50/50	5	5-15	Severe	C
20	PRED. Freight.	4	>30	Moderate	W

As in the case of the earlier example A, to estimate a cost per track mile, the analyst chooses the appropriate cost per mile for each segment, and multiplies this cost by the number of track miles to obtain the total cost of maintenance plus cyclic capital, as shown in Tables 35 and 36 for minimum and maximum costs respectively. Since this route has both wood and concrete tie track, values must be taken from both sets of matrices. Thus, minimum costs are from Tables 21 and 23 while maximum costs are from Tables 22 and 24. Costs include Track, C&S and B&B. Again, if separate maintenance and cyclic capital costs are desired they can be built up by using individual maintenance (expensed) and capital cost tables from Appendix B.

Table 35: Total Maintenance[20] Cost Calculation Using Minimum Cost (from Tables 21 and 23)

Segment Length (Miles)	**Costs**	
	Cost per Mile	**Total Segment Cost**
20	$66,784	$1,335,680
30	$62,253	$1,867,590

[20] Includes both cyclic capital and expensed maintenance costs.

50	$38,706	$1,935,300
30	$44,108	$1,323,240
20	$63,136	$1,262,720
Total Annual Route Cost		**$7,724,530**

This is the minimum total expenditure a high-speed rail authority might expect to make on this route. The corresponding Maximum cost is obtained by using the maximum value for each cost element in exactly the same manner, as shown in Table 36.

Table 36: Total Maintenance Cost Calculation Using Maximum Cost (from Tables 22 and 24)

Segment Length (Miles)	Costs	
	Cost per Mile	**Total Segment Cost**
20	$109,884	$2,197,680
30	$97,452	$2,923,560
50	$55,604	$2,780,200
30	$68,500	$2,055,000
20	$102,356	$2,047,120
Total Annual Route Cost		**$12,003,560**

Determining the cost per passenger train mile is equally easy. Tables 37 and 38 show the calculations for minimum and maximum costs respectively. Minimum costs are from Tables 25 and 27 and maximum costs are from Tables 26 and 28. Costs include Track, C&S and B&B.

Table 37: Cost per Passenger Train Mile Using Minimum Cost (from Tables 25 and 27)

Segment Length (Miles)	Costs	
	Cost per Passenger Train Mile	**Total Segment Cost**
20	$0.50	$10.00
30	$1.25	$37.50
50	$4.03	$201.50
30	$1.40	$42.00
20	$0.47	$9.40
Total Passenger Train Cost per One-Way Trip		**$300.40**

Note that this is the minimum total expenditure a high-speed rail authority might expect to make on this route. The corresponding maximum cost is obtained by using the maximum value for each cost element in exactly the same manner.

Table 38: Cost per Passenger Train Mile Using Maximum Cost (from Tables 26 and 28)

Segment Length (Miles)	**Costs**	
	Cost per Passenger Train Mile	**Total Segment Cost**
20	$0.82	$16.40
30	$1.95	$58.50
50	$5.79	$289.50
30	$2.18	$65.40
20	$0.76	$15.20
Total Passenger Train Cost per One-Way Trip		**$445.00**

Thus, using the tables presented in this Handbook, transportation planners can estimate the range of Right of Way maintenance costs for a proposed passenger corridor sharing freight right of ways together with the corresponding passenger train trip cost for a range of track and traffic conditions and operations.

VI. A Simplified Method for Calculating Costs

Purpose

The purpose of this section is to describe a simplified method for estimating track maintenance costs. This method relies on costs from the ZETA-TECH matrices, but provides an easier format for planners to use, with less judgment required as to which factors to select for a particular analysis case.

To use this process, the planner must divide the route into more-or-less homogeneous segments, with segment boundaries located wherever a significant change occurs in one of the route characteristics. Characteristics included are those which make a significant difference in cost:

- Annual gross tonnage
- Mix of passenger and freight trains
- Curvature (a single value for the segment)
- FRA track class
- "Maintenance difficulty" (a combined factor that accounts for traffic volume, complexity of the infrastructure, difficulty of access, and environmental factors)

Although the ZETA-TECH matrices calculate costs separately for track with concrete and wood ties, no concrete vs. wood factor is used here due to the small difference in cost between concrete and wood.

Segmenting is done by assessing one variable at a time, and then the process is repeated for each variable until the route has been assessed for all of the variables. Each defined segment should have at least one different characteristic (or significantly different variable value) from either of the adjacent segments.

With each round of segmenting, the milepost boundaries for any further division of segments are recorded on the Cost Calculation Table (Appendix D, Table D.1), along with the cost factor or variable category for the route characteristic being assessed. Cost factors and variable categories are given in these instructions. When all the cost factors and variable categories for a segment have been recorded on the Cost Calculation Table, the total track maintenance cost for that segment will be automatically calculated and shown in the table.

This process permits the analyst to quantify the effect of adding (or subtracting) individual trains (passenger or freight), or of incremental changes in other cost-determining variables. Working with a route map or diagram will help in determining where route characteristics change, and in keeping track of segment boundaries during the process.

In the Cost Calculation Table, Columns with headings and entries in *italics* are automatically calculated from other entries.

Specific instructions for determining the values for each of the variables are provided in the next section.

Process Instructions

Mileposts

Enter the beginning and ending mileposts for each segment in Columns 1 and 2 of Table D-1. Enter the number of tracks in Column 3. Total track mileage for the segment will be automatically calculated in Column 4. For routes that are partially double track, create a new segment whenever the number of tracks changes.

FRA Track Class

Beginning at the low-numbered milepost end of the route, make a mark on the route map, and note the milepost, wherever the FRA track class changes. The FRA track classes are shown in Table 39. The higher of passenger or freight maximum speed for the segment will govern the choice. (Choose Class 4 also for locations where maximum speed is lower than 60 MPH).

Enter the mileposts where changes occur in Columns 1 and 2 of the Cost Calculation Table. In Column 8 enter the FRA track class.

Table 39: FRA Track Class

Maximum Allowable Speed (MPH)		FRA Track Class
Passenger	**Freight**	
80	60	4
90	80	5

110	80	6

Number of Trains and Tonnage

This data should be obtained from the owner of the railroad, or from the planners of future higher-speed train service. The analyst should obtain information for both:

- Number of freight and passenger trains per day; and
- Total annual gross tonnage

If both these data elements are unavailable, the number of trains may be estimated, and total annual tonnage calculated through use of an average weight of 550 tons for passenger trains and 5,900 tons for freight trains.

In the Cost Calculation Table for each segment, enter the number of passenger trains per day (average over the 7-day week) in Column 5 and number of freight trains in Column 6 that pass in either direction over the segment track being evaluated. Once entered, the Ratio of Passenger to Freight Trains will be automatically calculated and entered into Column 7. If actual annual gross tonnage is known, it may be directly entered into column 10. If annual tonnage is not known, the spreadsheet will calculate it from the numbers of trains entered and default values of 550 tons and 5,900 tons for passenger and freight trains, respectively. (These two values will be used later to determine Base Cost Factors).

Where the number of trains per day (either passenger or freight) changes within an existing segment, make a mark on the route map, note the milepost, and create a new segment line in the Cost Calculation Table where that milepost fits into the route sequence. To create an intermediate (new) segment in the Cost Calculation table, copy the whole table line with the next higher milepost directly above that line. Then change the entry for Ending Milepost to the correct new number. Now add the number of trains in the corresponding columns for this newly-created segment.

Maintenance Difficulty Factor

This factor is intended to capture a number of factors that influence track maintenance costs. These include:

- Complexity of the infrastructure to be maintained (frequency of highway crossings, turnouts, bridges, diamond crossings)
- Difficulty of access (due both to train volume and to the number of access points)
- Environmental factors (warm and wet vs. cold and dry)

Beginning at the low-numbered milepost end of the route, for each segment, note the relative amount of track and roadway infrastructure present, and relative ease of access for its maintenance. This infrastructure includes the number and size of bridges, turnouts, interlockings, crossings, signal system equipment, drainage structures, and other roadway infrastructure present.

Select the most descriptive infrastructure category from the table below, and use the Total Tonnage shown in Column 10 of the Cost Calculation Table (Appendix D, Table D-1) to determine the appropriate Maintenance Difficulty Factor. Enter this factor in Column 11 of the Cost Calculation Table.

Table 40: Maintenance Difficulty Factor

Infrastructure Concentration and Difficulty of Access for Maintenance		**Total Annual Traffic (Million Gross Tons/Year: MGT)**			
Category	**Description**	**≤ 5**	**5-15**	**15-30**	**≥30**
High	Frequent turnouts, bridges, crossings, some interlockings etc. Some areas have difficult maintenance access. Typical of urban centers.	1.46	1.53	1.59	1.62
Medium	Frequent crossings, but fewer than 3 bridges and turnouts per mile. Only occasional short sections with impeded maintenance access. Typical of smaller cities or metropolitan suburbs.	1.23	1.26	1.29	1.31
Low	Rural: mostly open track. Maintenance access rarely impeded.	1.00	1.00	1.00	1.00

Where the infrastructure density and ease of maintenance access changes within an existing segment, make a mark on the route map, note the milepost, and create a new segment line in the Cost Calculation Table where that milepost fits into the route sequence. Now add the Infrastructure Density Factor in the corresponding column for this newly-created segment.

Track Curvature

For each segment, add the length of track (mileage) which has a curvature greater than 2° and divide that by the total segment length, to find the % of track in each segment with curvature greater than 2°. Use Table 41 to find the Curvature Category that most closely matches each segment and enter the Curve Factor in Column 9 of the Cost Calculation Table (Table D-1).

At this point, the segmenting process is done. After two more factors (below) are added to each segment in the Cost Calculation Table, the maintenance costs will be calculated.

Table 41: Curvature Category

% of Track with Curvature > 2^0	**Curvature Category**	**Curve Factor**
≤ 4%	Low	1.00

10%	Medium	1.04
≥ 18%	High	1.09

Base Case Cost Factors

Use the table of Base Case Track Maintenance Cost Factors (Table 42) to determine two base case factors for each segment – one factor for cost per track mile and one for cost per train mile. Referring again to Table D.1, use the Ratio Pass/Frt (from Column 5) and the FRA Track Class (from Column 6) to determine the appropriate reference row in the Base Case table (Table 42). Again from the Cost Calculation Table, use the Total Tonnage (from Column 8) to then determine the appropriate reference columns in the Base Case table, and enter the resulting Base Case Factors in the Cost Calculation Table: in Column 12 for Cost Per Track Mile and in Column 15 for Cost Per Train Mile.

The costs in Table 42 are from Tables 21 (Annual Total Cost Per Track Mile (Minimum) for Wood Tie Track) and 25 (Annual Total Cost Per Passenger Traink Mile (Minimum) for Wood Tie Track) in Section IV.

Annual Track Maintenance Costs

Once all the entries for a segment are filled in the Cost Calculation Table (Table D-1), the annual track maintenance costs are automatically calculated: cost per track mile in Column 13 and total cost for the segment in Column 14, and cost per train mile in Column 16 and total cost for one trip through that segment in Column 16. Total annual cost for the route (sum of the segments) is shown at the bottom of Column 14, and total annual cost corresponding to a one-way trip over the route is shown at the bottom of Column 16.

Equations used in Table D-1 are shown in Table D-2, Appendix D.

An Example Application

Route Segmentation

Table D-1 in Appendix D contains an example application of the simplified methodology. The example consists of three segments. The first of these begins at milepost 13.4 and extends to MP 38.1, so these numbers are entered in Columns 1 and 2 of the Cost Calculation Sheet. This segment is double track, so “2” is entered in Column 3. The total track mileage of 49.4 is calculated by the spreadsheet.

There is a milepost “equation” at MP 38.1 (perhaps the route runs onto a different railroad line). The next segment begins at MP 248.3 and extends to 259.5. It is single track, so a “1” is entered in Column 3. Again, total track mileage is calculated. If there was a passing siding on this segment, it would have been entered as a separate, double-track segment.

Finally, there is a segment from MP 259.5 to MP 272.7, also single track. The mileposts are entered into columns 1 and 2, the number of tracks is set at "1", and again a track mileage is calculated.

Table 42: Base Case Track Maintenance Cost Factors

Ratio of Passenger to Freight Trains	FRA Track Class	Cost Per Track Mile ($1,000) Total Tonnage (MGT) 5 or Less	5-15	15-30	30 or More	Cost Per Train Mile ($) Total Tonnage (MGT) 5 or Less	5-15	15-30	30 or More
2 Pass: 1 Frt	4	26.6	31.0	42.0	60.8	1.97	0.77	0.52	0.45
	5	29.2	34.4	46.8	68.8	3.41	1.39	0.96	0.89
	6	33.0	39.3	53.8	80.3	5.50	2.29	1.60	1.52
10 Pass: 1 Frt	4	29.4	38.1	54.7	***	2.49	1.08	0.96	***
	5	31.5	41.5	59.9	***	2.95	1.32	1.20	***
	6	35.8	48.3	70.6	***	3.90	1.82	1.69	***
40 Pass: 1 Frt	4	31.9	47.2	***	***	3.13	1.55	***	***
	5	34.4	52.1	***	***	3.48	1.77	***	***
	6	37.5	58.1	***	***	3.91	2.04	***	***

Number of Trains and Tonnage

Numbers of trains are entered in columns 5 and 6. For the first segment, there are 16 passenger and 16 freight trains. For the second segment there are 16 passenger and 1 freight train. For the third segment there are 16 passenger and 10 freight trains per day. The ratio of passenger to freight trains, which will be used in selecting base cost (see Table 42) is calculated from these numbers and is shown in Column 7 of Table D-1.. Annual gross tonnage, if known, should be entered in column 10. In this example, annual tonnage is not known. In this case, no entry is made in column 10 and the tonnage is calculated from the entered numbers of passenger and freight trains and default gross tonnage of 550 tons and 5,900 tons, respectively.

FRA Track Class

This information is obtained for each segment and entered in Column 8. Two of the segments in this application are FRA Class 4 (79 MPH for passenger trains) and one is Class 6 (110 MPH).

Curvature Factor

Curvature for each of the three segments is obtained from track charts or condensed profiles. A review of data for the example segments indicates that two of the three have “medium” curvature (curve factor of 1.04 per Table 41), while the third has “low” curvature (curve factor of 1.00 per Table 41) .

Maintenance Difficulty Factor (MDF)

For all three of the segments, maintenance difficulty is determined to be “medium” as defined in Table 40. However, noting the differences in total tonnage (column 10), three different values for the Maintenance Difficulty Factor (MDF) are obtained for the three segments. Thus for the highest tonnage segment, segment 1 with an annual tonnage of 38 MGT, the MDF is 1.31. For the second segment, with a low tonnage of 5 MGT, the MDF is 1.23. For the third segment, with an annual tonnage of 25 MGT, the MDF is 1.29. These values are entered in column 11.

Base Case Costs

Base case costs are selected from Table 42 based on the ratio of passenger to freight trains and total annual tonnage.

As can be seen from Table D.1, the base case cost for the first of the three segments is $61,000 per mile, obtained from Table 42 as follows. The closest passenger to freight ratio is 2:1[21], the FRA track class is 4, and the total annual tonnage is greater than 30 MGT, so a cost of $60,800 per track mile is selected. This is then multiplied by the curvature factor and the maintenance difficulty factor to produce the cost per mile in column 13 of Table D.1.

For the second segment, where tonnage is lower, the ratio of passenger to freight is 16:1[22], the annual tonnage is 5 MGT, but track class is still FRA Class 4, so the base cost of $31,900 is selected from Table 42.

The third segment has a 2:1 ratio of passenger to freight, annual MGT of 25, and is FRA Class 6, resulting in the selection of a base case of $53,800 per track mile. A similar process is used to select base case costs per train mile.

Calculation of Costs

With values supplied for all variables, the spreadsheet will calculate a cost per track mile, a cost per train mile, a total track maintenance cost per segment, and a segment cost per train trip. For the example here the total annual route maintenance cost is $5,484,201 and the cost per train trip is $101.74.

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[21] While the actual ratio is 1:1, the closest ratio in Table 42 is 2:1,

[22] This ratio of 16;1 is greater than the 10:1 category and less than the 40:1 category. However, to be conservative, the 40:1 category was selected.

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Appendix A: Analysis of Five Study Line Segments

Calibration

Corridors	Track Miles	Min Track Capital	Max Track Capital	Min B&B Capital	Max B&B Capital	Min C&S Capital	Max C&S Capital	Min Track Operating	Max Track Operating	Min B&B Operating	Max B&B Operating	Min C&S Operating	Max C&S Operating	Min Operating Trk+B&B+ C&S	Max Operating Trk+B&B+ C&S	Min Capital Trk+B&B+ C&S	Max Capital Trk+B&B+C&S
Chicago to Buffington Harbor (Tolleston)	48.50	$ 912,595	$1,569,617	$203,215	$304,629	$121,250	$181,875	$903,289	$1,342,727	$195,306	$292,959	$488,265	$732,397	$1,586,860	$2,368,083	$1,237,060	$2,056,121
Buffington Harbor (Tolleston) to Ft. Wayne (Mike)	152.20	$2,361,123	$4,009,765	$641,908	$962,249	$383,000	$574,500	$2,728,726	$4,056,214	$589,995	$884,992	$1,474,987	$2,212,480	$4,793,708	$7,153,687	$3,386,031	$5,546,514
Delta Junction to Cleveland	188.80	$3,829,920	$ 6,521,862	$791,072	$1,185,853	$472,000	$708,000	$3,430,317	$5,099,120	$741,690	$1,112,535	$1,854,225	$2,781,338	$6,026,232	$8,992,993	$5,092,992	$8,415,715
Madison to Watertown	36.10	$444,797	$629,204	$151,259	$226,744	$90,250	$135,375	$587,525	$873,348	$127,032	$190,549	$317,581	$476,372	$1,032,139	$1,540,269	$686,306	$991,323
Seattle to Portland	384.73	$8,157,984	$15,281,722	$1,508,316	$2,261,034	$899,950	$1,349,925	$6,199,636	$9,215,675	$1,340,462	$2,010,693	$3,351,155	$5,026,732	$10,891,252	$16,253,099	$10,566,250	$18,892,682

Matrix 1

Corridors	Track Miles	Min Track Operating	Max. Track Operating	Min B&B Operating	Max B&B Operating	Min C&S Operating	Max C&S Operating	MinTrack Capital	Max Track Capital	Min B&B Capital	Max B&B Capital	Min C&S Capital	Max C&S Capital	Min Operating Trk+B&B+ C&S	Max Operating Trk+B&B+ C&S	Min Capital Trk+B&B+ C&S	Max-Capital Trk+B&B+ C&S
Chicago to Buffington Harbor (Tolleston)	48.50	$911,688	$1,370,700	$197,537	$299,048	$486,227	$747,655	$983,796	$1,625,874	$203,215	$304,629	$121,250	$181,875	$1,595,451	$2,417,403	$1,308,261	$2,112,378
Buffington Harbor (Tolleston) to Ft. Wayne (Mike)	152.20	$2,966,764	$4,441,973	$642,821	$969,112	$1,582,272	$2,422,871	$2,418,526	$3,849,198	$641,908	$962,249	$383,000	$574,500	$5,191,857	$7,833,955	$3,443,434	$5,385,947
Delta Junction to Cleveland	188.80	$2,307,846	$3,475,016	$500,051	$758,191	$1,230,765	$1,895,483	$3,370,029	$5,283,751	$791,072	$1,185,853	$472,000	$708,000	$4,038,662	$6,128,690	$4,633,101	$7,177,604
Madison to Watertown	36.10	$550,308	$824,366	$119,238	$179,855	$293,493	$449,661	$501,068	$788,496	$151,259	$226,744	$90,250	$135,375	$963,040	$1,453,881	$742,577	$1,150,615
Seattle to Portland	384.73	$4,975,056	$7,536,830	$1,077,854	$1,644,899	$2,653,370	$4,110,810	$9,780,644	$17,176,206	$1,508,316	$2,261,034	$899,950	$1,349,925	$8,706,281	$13,292,539	$12,188,911	$20,787,165

Matrix 2

Appendix B: Handbook Cost Matrices for High Speed Passenger and Mixed Freight Corridors

Track Maintenance Cost per Track Mile Wood (Minimum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% - 2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$4,851	$6,069	$8,548	$14,440	4	$5,087	$6,365	$8,965	$15,144	4	$5,414	$6,775	$9,541	$16,118
Pred. Frght	5	$6,243	$7,811	$11,002	$18,584	5	$6,547	$8,192	$11,537	$19,490	5	$6,968	$8,719	$12,280	$20,743
	6	$8,196	$10,255	$14,444	$24,399	6	$8,596	$10,755	$15,147	$25,587	6	$9,148	$11,447	$16,122	$27,233
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$6,473	$10,129	$15,816	*	4	$6,788	$10,622	$16,586	*	4	$7,225	$11,305	$17,653	*
	5	$7,574	$11,850	$18,504	*	5	$7,942	$12,428	$19,406	*	5	$8,453	$13,227	$20,654	*
	6	$9,827	$15,376	$24,010	*	6	$10,306	$16,125	$25,179	*	6	$10,968	$17,162	$26,799	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$7,893	$15,304	*	*	4	$8,278	$16,050	*	*	4	$8,810	$17,082	*	*
	5	$9,235	$17,906	*	*	5	$9,685	$18,778	*	*	5	$10,308	$19,986	*	*
	6	$10,814	$20,966	*	*	6	$11,341	$21,988	*	*	6	$12,070	$23,402	*	*

Matrix 3

Build. and Bridges Maintenance Cost per Track Mile Wood (Minimum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% - 2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$1,051	$1,315	$1,852	$3,129	4	$1,102	$1,379	$1,942	$3,281	4	$1,173	$1,468	$2,067	$3,492
Pred. Frght	5	$1,353	$1,692	$2,384	$4,027	5	$1,419	$1,775	$2,500	$4,223	5	$1,510	$1,889	$2,661	$4,494
	6	$1,776	$2,222	$3,129	$5,286	6	$1,862	$2,330	$3,282	$5,544	6	$1,982	$2,480	$3,493	$5,901
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$1,403	$2,195	$3,427	*	4	$1,471	$2,301	$3,594	*	4	$1,565	$2,449	$3,825	*
	5	$1,641	$2,568	$4,009	*	5	$1,721	$2,693	$4,205	*	5	$1,832	$2,866	$4,475	*
	6	$2,129	$3,332	$5,202	*	6	$2,233	$3,494	$5,456	*	6	$2,376	$3,719	$5,806	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$1,710	$3,316	*	*	4	$1,794	$3,477	*	*	4	$1,909	$3,701	*	*
	5	$2,001	$3,880	*	*	5	$2,098	$4,069	*	*	5	$2,233	$4,330	*	*
	6	$2,343	$4,543	*	*	6	$2,457	$4,764	*	*	6	$2,615	$5,070	*	*

Comm. and Signal Maintenance Cost per Track Mile – Wood (Minimum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$2,587	$3,237	$4,559	$7,701	4	$2,713	$3,395	$4,781	$8,077	4	$2,888	$3,613	$5,089	$8,596
Pred. Frght	5	$3,330	$4,166	$5,867	$9,912	5	$3,492	$4,369	$6,153	$10,394	5	$3,716	$4,650	$6,549	$11,063
	6	$4,371	$5,469	$7,703	$13,013	6	$4,584	$5,736	$8,079	$13,647	6	$4,879	$6,105	$8,598	$14,524
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$3,452	$5,402	$8,435	*	4	$3,621	$5,665	$8,846	*	4	$3,853	$6,029	$9,415	*
	5	$4,039	$6,320	$9,869	*	5	$4,236	$6,628	$10,350	*	5	$4,508	$7,054	$11,015	*
	6	$5,241	$8,201	$12,805	*	6	$5,496	$8,600	$13,429	*	6	$5,850	$9,153	$14,293	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$4,210	$8,162	*	*	4	$4,415	$8,560	*	*	4	$4,699	$9,110	*	*
	5	$4,925	$9,550	*	*	5	$5,165	$10,015	*	*	5	$5,498	$10,659	*	*
	6	$5,767	$11,182	*	*	6	$6,048	$11,727	*	*	6	$6,437	$12,481	*	*

Track Maintenance Cost per Track Mile – Wood (Maximum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$7,349	$9,195	$12,950	$21,876	4	$7,707	$9,643	$13,581	$22,942	4	$8,202	$10,263	$14,454	$24,417
Pred. Frght	5	$9,295	$11,630	$16,380	$27,670	5	$9,748	$12,197	$17,178	$29,018	5	$10,375	$12,981	$18,283	$30,884
	6	$12,244	$15,321	$21,578	$36,450	6	$12,841	$16,067	$22,629	$38,226	6	$13,667	$17,100	$24,084	$40,684
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$9,670	$15,131	$23,627	*	4	$10,141	$15,868	$24,778	*	4	$10,794	$16,889	$26,372	*
	5	$11,314	$17,703	$27,644	*	5	$11,865	$18,566	$28,990	*	5	$12,629	$19,760	$30,855	*
	6	$14,720	$23,033	$35,966	*	6	$15,437	$24,155	$37,718	*	6	$16,430	$25,709	$40,144	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$11,824	$22,925	*	*	4	$12,400	$24,042	*	*	4	$13,197	$25,588	*	*
	5	$13,834	$26,822	*	*	5	$14,508	$28,129	*	*	5	$15,441	$29,938	*	*
	6	$16,199	$31,407	*	*	6	$16,988	$32,937	*	*	6	$18,080	$35,056	*	*

Matrix 6

Build. and Bridges Maintenance Cost per Track Mile – Wood (Maximum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$1,603	$2,006	$2,825	$4,773	4	$1,681	$2,104	$2,963	$5,005	4	$1,790	$2,239	$3,154	$5,327
Pred. Frght	5	$2,028	$2,538	$3,574	$6,037	5	$2,127	$2,661	$3,748	$6,331	5	$2,264	$2,832	$3,989	$6,738
	6	$2,672	$3,343	$4,708	$7,953	6	$2,802	$3,506	$4,937	$8,340	6	$2,982	$3,731	$5,255	$8,877
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$2,110	$3,301	$5,155	*	4	$2,213	$3,462	$5,406	*	4	$2,355	$3,685	$5,754	*
	5	$2,469	$3,863	$6,031	*	5	$2,589	$4,051	$6,325	*	5	$2,755	$4,311	$6,732	*
	6	$3,212	$5,025	$7,847	*	6	$3,368	$5,270	$8,229	*	6	$3,585	$5,609	$8,759	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$2,580	$5,002	*	*	4	$2,705	$5,245	*	*	4	$2,879	$5,583	*	*
	5	$3,018	$5,852	*	*	5	$3,165	$6,137	*	*	5	$3,369	$6,532	*	*
	6	$3,534	$6,852	*	*	6	$3,706	$7,186	*	*	6	$3,945	$7,649	*	*

Matrix 7

C&S Main. Cost per Track Mile – Wood (Maximum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$4,008	$5,015	$7,064	$11,932	4	$4,204	$5,260	$7,408	$12,514	4	$4,474	$5,598	$7,884	$13,318
Pred. Frght	5	$5,070	$6,344	$8,935	$15,093	5	$5,317	$6,653	$9,370	$15,828	5	$5,659	$7,081	$9,973	$16,846
	6	$6,679	$8,357	$11,770	$19,882	6	$7,004	$8,764	$12,343	$20,850	6	$7,455	$9,327	$13,137	$22,191
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$5,275	$8,253	$12,887	*	4	$5,532	$8,655	$13,515	*	4	$5,887	$9,212	$14,385	*
	5	$6,171	$9,656	$15,078	*	5	$6,472	$10,127	$15,813	*	5	$6,888	$10,778	$16,830	*
	6	$8,029	$12,563	$19,618	*	6	$8,420	$13,176	$20,573	*	6	$8,962	$14,023	$21,897	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$6,449	$12,504	*	*	4	$6,764	$13,114	*	*	4	$7,199	$13,957	*	*
	5	$7,546	$14,630	*	*	5	$7,913	$15,343	*	*	5	$8,422	$16,330	*	*
	6	$8,836	$17,131	*	*	6	$9,266	$17,966	*	*	6	$9,862	$19,121	*	*

Matrix 8

Track Cyclic Capital Cost per Track Mile – Wood (Minimum)

	Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%					Severe Curve (82% - 12% - 6%)			
	5	15	30	50		5	15	30	50		5	15	30	50
4	$10,709	$13,067	$19,692	$28,207	4	$10,848	$13,512	$20,415	$29,278	4	$11,087	$14,291	$21,709	$31,221
5	$10,890	$13,382	$20,207	$28,899	5	$11,032	$13,830	$20,937	$29,978	5	$11,275	$14,616	$22,241	$31,934
6	$11,262	$14,026	$21,200	$30,211	6	$11,409	$14,484	$21,942	$31,307	6	$11,660	$15,284	$23,266	$33,289

Matrix 9

Build. and Bridges Cyclical Capital Cost per Track Mile Wood (Minimum)

Bridge Capital Cost				
Average Feet/Mile	**Cost/feet**	**$/Mile**	**Life in years**	**$/Mile/Year**
83.75	4000	$335,000	80	$4,190

Comm. and Signal Capital Cost per Track Mile – Wood (Minimum)

Signal Capital Cost		
$/Mile	**Life in years**	**$/Mile/Year**
$200,000	80	$2,500
$ 20,000[23]	30	$ 667
$220,000		$3,167

[23] Based on 0.4 turnouts per mile at $50,000 per turnout.

Track Cyclic Capital Cost per Track Mile – Wood (Maximum)

	Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
4	$14,756	$20,259	$32,700	$48,052	4	$15,009	$21,245	$34,481	$50,864	4	$15,489	$22,954	$37,588	$55,790
5	$14,765	$20,789	$33,502	$49,157	5	$15,032	$21,781	$35,292	$51,981	5	$15,535	$23,499	$38,413	$56,924
6	$15,223	$21,879	$35,106	$51,305	6	$15,506	$22,886	$36,916	$54,155	6	$16,030	$24,626	$40,066	$59,137

Build. and Bridges Cyclic Capital Cost per Track Mile – Wood (Maximum)

Bridge Capital Cost				
Average Feet/Mile	**Cost/feet**	**$/Mile**	**Life in years**	**$/Mile/Year**
Wood+Steel+Stone				
83.75	6000	$502,500	80	$6,281

Comm. and Signal Cyclic Capital Cost per Track Mile Wood (Maximum)

Signal Capital Cost		
$/Mile	**Life in years**	**$/Mile/Year**
$300,000	80	$3,750
$ 20,000[24]	20	$ 1,000
$320,000		$4,750

[24] Based on 0.4 turnouts per mile at $50,000 per turnout.

Total Maintenance Cost per Track Mile – Wood (Minimum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$8,489	$10,621	$14,959	$25,270	4	$8,902	$11,139	$15,688	$26,501	4	$9,475	$11,855	$16,697	$28,206
Pred. Frght	5	$10,925	$13,670	$19,253	$32,523	5	$11,457	$14,336	$20,191	$34,107	5	$12,194	$15,258	$21,489	$36,301
	6	$14,343	$17,947	$25,276	$42,698	6	$15,042	$18,821	$26,508	$44,778	6	$16,010	$20,032	$28,213	$47,658
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$11,328	$17,725	$27,677	*	4	$11,880	$18,588	$29,025	*	4	$12,644	$19,784	$30,892	*
	5	$13,254	$20,738	$32,382	*	5	$13,899	$21,748	$33,960	*	5	$14,793	$23,147	$36,144	*
	6	$17,197	$26,908	$42,017	*	6	$18,035	$28,219	$44,064	*	6	$19,195	$30,034	$46,898	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$13,813	$26,782	*	*	4	$14,486	$28,087	*	*	4	$15,418	$29,893	*	*
	5	$16,161	$31,335	*	*	5	$16,949	$32,861	*	*	5	$18,039	$34,975	*	*
	6	$18,924	$36,691	*	*	6	$19,846	$38,479	*	*	6	$21,122	$40,954	*	*

Matrix 15

Total Cyclic Capital Cost per Track Mile – Wood (Minimum)

	Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
4	$18,065	$20,424	$27,048	$35,563	4	$18,205	$20,868	$27,771	$36,634	4	$18,443	$21,647	$29,066	$38,578
5	$18,247	$20,738	$27,564	$36,255	5	$18,389	$21,187	$28,293	$37,335	5	$18,631	$21,973	$29,597	$39,291
6	$18,619	$21,383	$28,556	$37,567	6	$18,766	$21,841	$29,299	$38,664	6	$19,017	$22,640	$30,623	$40,645

Matrix 16

Total Maintenance Cost per Track Mile – Wood (Maximum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$12,960	$16,216	$22,839	$38,581	4	$13,592	$17,006	$23,952	$40,461	4	$14,466	$18,100	$25,492	$43,063
Pred. Frght.	5	$16,393	$20,511	$28,888	$48,800	5	$17,192	$21,511	$30,296	$51,177	5	$18,298	$22,894	$32,244	$54,469
	6	$21,595	$27,020	$38,055	$64,284	6	$22,647	$28,336	$39,909	$67,416	6	$24,103	$30,159	$42,476	$71,752
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght.	4	$17,055	$26,686	$41,670	*	4	$17,886	$27,986	$43,700	*	4	$19,036	$29,786	$46,510	*
	5	$19,954	$31,223	$48,753	*	5	$20,926	$32,744	$51,129	*	5	$22,272	$34,850	$54,417	*
	6	$25,961	$40,622	$63,430	*	6	$27,226	$42,601	$66,520	*	6	$28,977	$45,341	$70,799	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$20,853	$40,431	*	*	4	$21,869	$42,401	*	*	4	$23,275	$45,128	*	*
	5	$24,398	$47,304	*	*	5	$25,586	$49,609	*	*	5	$27,232	$52,800	*	*
	6	$28,568	$55,391	*	*	6	$29,960	$58,089	*	*	6	$31,887	$61,826	*	*

Matrix 17

Total Cyclic Capital Cost per Track Mile – Wood (Maximum)

	Light Curve (96% - 4% - 0%)					**Moderate Curve (90% - 8% -2%)**					**Severe Curve (82% - 12% - 6%)**			
	<=5	**5-15**	**15-30**	**>=30**		**<=5**	**5-15**	**15-30**	**>=30**		**<=5**	**5-15**	**15-30**	**>=30**
4	$25,787	$31,290	$43,731	$59,083	**4**	$26,040	$32,276	$45,512	$61,896	**4**	$26,520	$33,985	$48,619	$66,821
5	$25,796	$31,820	$44,534	$60,188	**5**	$26,064	$32,812	$46,323	$63,012	**5**	$26,567	$34,531	$49,444	$67,955
6	$26,254	$32,910	$46,137	$62,337	**6**	$26,537	$33,917	$47,947	$65,186	**6**	$27,061	$35,657	$51,098	$70,168

Matrix 18

Total Cost per Track Mile – Wood (Minimum) - Maintenance + Cyclic Capital

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$26,554	$31,046	$42,008	$60,833	4	$27,107	$32,007	$43,460	$63,136	4	$27,918	$33,503	$45,763	$66,784
Pred. Frght	5	$29,172	$34,408	$46,816	$68,778	5	$29,846	$35,523	$48,484	$71,442	5	$30,826	$37,231	$51,086	$75,592
	6	$32,962	$39,329	$53,833	$80,265	6	$33,808	$40,662	$55,807	$83,442	6	$35,026	$42,672	$58,836	$88,304
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$29,393	$38,149	$54,725	*	4	$30,084	$39,457	$56,797	*	4	$31,087	$41,431	$59,958	*
	5	$31,500	$41,476	$59,946	*	5	$32,288	$42,935	$62,253	*	5	$33,425	$45,120	$65,741	*
	6	$35,816	$48,291	$70,573	*	6	$36,801	$50,060	$73,363	*	6	$38,211	$52,675	$77,521	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$31,879	$47,206	*	*	4	$32,691	$48,955	*	*	4	$33,861	$51,540	*	*
	5	$34,408	$52,073	*	*	5	$35,337	$54,049	*	*	5	$36,670	$56,948	*	*
	6	$37,543	$58,074	*	*	6	$38,612	$60,319	*	*	6	$40,139	$63,594	*	*

Matrix 19

Total Cost per Track Mile – Wood (Maximum) – Maintenance + Cyclic Capital

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$38,748	$47,507	$66,570	$97,664	4	$39,632	$49,283	$69,464	$102,356	4	$40,986	$52,085	$74,111	$109,884
Pred. Frght	5	$42,189	$52,331	$73,422	$108,988	5	$43,255	$54,323	$76,619	$114,189	5	$44,864	$57,425	$81,688	$122,424
	6	$47,849	$59,930	$84,192	$126,621	6	$49,184	$62,253	$87,856	$132,603	6	$51,165	$65,816	$93,574	$141,921
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$42,842	$57,976	$85,400	*	4	$43,926	$60,262	$89,212	*	4	$45,557	$63,771	$95,129	*
	5	$45,750	$63,042	$93,287	*	5	$46,990	$65,556	$97,452	*	5	$48,839	$69,380	$103,861	*
	6	$52,215	$73,532	$109,567	*	6	$53,763	$76,518	$114,467	*	6	$56,039	$80,998	$121,897	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$46,640	$71,721	*	*	4	$47,909	$74,677	*	*	4	$49,796	$79,113	*	*
	5	$50,194	$79,124	*	*	5	$51,650	$82,421	*	*	5	$53,799	$87,331	*	*
	6	$54,822	$88,301	*	*	6	$56,497	$92,006	*	*	6	$58,949	$97,482	*	*

Matrix 20

Track Maintenance Cost per Track Mile Concrete (Minimum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$4,809	$6,017	$8,475	$14,316	4	$4,978	$6,229	$8,772	$14,819	4	$5,212	$6,521	$9,184	$15,515
Pred. Frght	5	$6,189	$7,744	$10,907	$18,425	5	$6,407	$8,016	$11,290	$19,072	5	$6,708	$8,393	$11,820	$19,967
	6	$8,126	$10,167	$14,320	$24,190	6	$8,411	$10,524	$14,822	$25,039	6	$8,806	$11,018	$15,518	$26,214
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$6,418	$10,042	$15,680	*	4	$6,643	$10,394	$16,230	*	4	$6,955	$10,882	$16,992	*
	5	$7,509	$11,749	$18,346	*	5	$7,772	$12,161	$18,990	*	5	$8,137	$12,732	$19,881	*
	6	$9,743	$15,244	$23,804	*	6	$10,085	$15,780	$24,639	*	6	$10,558	$16,520	$25,796	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$7,826	$15,050	*	*	4	$8,100	$15,578	*	*	4	$8,481	$16,310	*	*
	5	$9,156	$17,609	*	*	5	$9,477	$18,227	*	*	5	$9,922	$19,083	*	*
	6	$10,721	$20,619	*	*	6	$11,097	$21,342	*	*	6	$11,618	$22,345	*	*

Matrix 21

Build. and Bridges Maintenance Cost per Track Mile Concrete (Minimum)

		Light Curve (96% - 4% - 0%					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$1,042	$1,304	$1,836	$3,102	4	$1,079	$1,350	$1,901	$3,211	4	$1,129	$1,413	$1,990	$3,361
Pred. Frght	5	$1,341	$1,678	$2,363	$3,992	5	$1,388	$1,737	$2,446	$4,132	5	$1,453	$1,818	$2,561	$4,326
	6	$1,761	$2,203	$3,103	$5,241	6	$1,822	$2,280	$3,212	$5,425	6	$1,908	$2,387	$3,362	$5,680
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$1,390	$2,176	$3,397	*	4	$1,439	$2,252	$3,517	*	4	$1,507	$2,358	$3,682	*
	5	$1,627	$2,546	$3,975	*	5	$1,684	$2,635	$4,114	*	5	$1,763	$2,759	$4,308	*
	6	$2,111	$3,303	$5,158	*	6	$2,185	$3,419	$5,339	*	6	$2,288	$3,579	$5,589	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$1,696	$3,261		*	4	$1,755	$3,375	*	*	4	$1,837	$3,534	*	*
	5	$1,984	$3,815	*	*	5	$2,053	$3,949	*	*	5	$2,150	$4,135	*	*
	6	$2,323	$4,467	*	*	6	$2,404	$4,624	*	*	6	$2,517	$4,841	*	*

Matrix 22

Comm. and Signal Maintenance Cost per Track Mile Concrete (Minimum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$2,565	$3,209	$4,520	$7,635	4	$2,655	$3,322	$4,679	$7,903	4	$2,780	$3,478	$4,898	$8,274
Pred. Frght	5	$3,301	$4,130	$5,817	$9,827	5	$3,417	$4,275	$6,021	$10,172	5	$3,577	$4,476	$6,304	$10,649
	6	$4,334	$5,423	$7,637	$12,901	6	$4,486	$5,613	$7,905	$13,354	6	$4,697	$5,877	$8,276	$13,981
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$3,423	$5,356	$8,363	*	4	$3,543	$5,544	$8,656	*	4	$3,709	$5,804	$9,063	*
	5	$4,005	$6,266	$9,784	*	5	$4,145	$6,486	$10,128	*	5	$4,340	$6,791	$10,603	*
	6	$5,196	$8,130	$12,695	*	6	$5,378	$8,416	$13,141	*	6	$5,631	$8,811	$13,758	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$4,174	$8,027	*	*	4	$4,320	$8,309	*	*	4	$4,523	$8,699	*	*
	5	$4,883	$9,391	*	*	5	$5,055	$9,721	*	*	5	$5,292	$10,177	*	*
	6	$5,718	$10,997	*	*	6	$5,919	$11,383	*	*	6	$6,196	$11,917	*	*

Track Maintenance Cost per Track Mile Concrete (Maximum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$7,286	$9,116	$12,839	$21,688	4	$7,541	$9,436	$13,290	$22,450	4	$7,896	$9,879	$13,914	$23,504
Pred. Frght	5	$9,215	$11,531	$16,240	$27,433	5	$9,539	$11,935	$16,810	$28,396	5	$9,987	$12,496	$17,599	$29,729
	6	$12,140	$15,189	$21,393	$36,138	6	$12,566	$15,722	$22,144	$37,406	6	$13,156	$16,461	$23,183	$39,162
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$9,587	$15,002	$23,425	*	4	$9,924	$15,528	$24,247	*	4	$10,390	$16,257	$25,385	*
	5	$11,217	$17,552	$27,407	*	5	$11,611	$18,168	$28,369	*	5	$12,156	$19,021	$29,701	*
	6	$14,594	$22,836	$36,658	*	6	$15,106	$23,637	$36,909	*	6	$15,816	$24,747	$38,642	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$11,723	$22,545	*	*	4	$12,134	$23,336	*	*	4	$12,704	$24,432	*	*
	5	$13,715	$26,377	*	*	5	$14,197	$27,303	*	*	5	$14,863	$28,585	*	*
	6	$16,060	$30,886	*	*	6	$16,624	$31,970	*	*	6	$17,404	$33,471	*	*

Matrix 24

Build. and Bridges Maintenance Cost per Track Mile Concrete (Maximum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$1,590	$1,989	$2,801	$4,732	4	$1,645	$2,059	$2,900	$4,898	4	$2,328	$2,913	$4,102	$6,930
Pred. Frght	5	$2,011	$2,516	$3,543	$5,985	5	$2,081	$2,604	$3,668	$6,195	5	$2,724	$3,408	$4,800	$8,108
	6	$2,649	$3,314	$4,668	$7,885	6	$2,742	$3,430	$4,831	$8,161	6	$3,189	$3,990	$5,620	$9,494
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$2,092	$3,273	$5,111	*	4	$2,165	$3,388	$5,290	*	4	$2,519	$3,941	$6,154	*
	5	$2,447	$3,829	$5,980	*	5	$2,533	$3,964	$6,190	*	5	$2,947	$4,611	$7,200	*
	6	$3,184	$4,982	$7,780	*	6	$3,296	$5,157	$8,053	*	6	$3,451	$5,399	$8,431	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$2,558	$4,919	*	*	4	$2,647	$5,091	*	*	4	$2,772	$5,331	*	*
	5	$2,992	$5,755	*	*	5	$3,097	$5,957	*	*	5	$3,243	$6,237	*	*
	6	$3,504	$6,739	*	*	6	$3,627	$6,975	*	*	6	$3,797	$7,303	*	*

Matrix 25

Comm. and Signal Maintenance Cost per Track Mile Concrete (Maximum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$3,974	$4,972	$7,003	$11,830	4	$4,114	$5,147	$7,249	$12,245	4	$4,307	$5,389	$7,589	$12,820
Pred. Frght	5	$5,027	$6,289	$8,858	$14,963	5	$5,203	$6,510	$9,169	$15,489	5	$5,447	$6,816	$9,599	$16,216
	6	$6,622	$8,285	$11,669	$19,711	6	$6,854	$8,576	$12,078	$20,403	6	$7,176	$8,979	$12,645	$21,361
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$5,230	$8,183	$12,777	*	4	$5,413	$8,470	$13,226	*	4	$5,667	$8,868	$13,847	*
	5	$6,119	$9,574	$14,949	*	5	$6,333	$9,910	$15,474	*	5	$6,631	$10,375	$16,200	*
	6	$7,960	$12,456	$19,450	*	6	$8,240	$12,893	$20,132	*	6	$8,627	$13,498	$21,077	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$6,394	$12,297	*	*	4	$6,619	$12,729	*	*	4	$6,929	$13,326	*	*
	5	$7,481	$14,388	*	*	5	$7,744	$14,893	*	*	5	$8,107	$15,592	*	*
	6	$8,760	$16,847	*	*	6	$9,067	$17,438	*	*	6	$9,493	$18,257	*	*

Matrix 26

Track Cyclic Capital Cost per Track Mile Concrete (Minimum)

	Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
4	$11,229	$12,921	$18,189	$25,808	4	$11,368	$13,365	$18,913	$26,879	4	$11,607	$14,144	$20,207	$28,823
5	$11,410	$13,235	$18,705	$26,500	5	$11,552	$13,684	$19,434	$27,580	5	$11,795	$14,470	$20,738	$29,536
6	$11,782	$13,880	$19,697	$27,812	6	$11,929	$14,338	$21,764	$28,908	6	$12,180	$15,137	$21,764	$30,890

Build. and Bridges Cyclic Capital Cost per Track Mile Concrete (Minimum)

Bridge Capital Cost				
Average Feet/Mile	**Cost/feet**	**$/Mile**	**Life in years**	**$/Mile/Year**
83.75	4000	$335,000	80	$4,190

Comm. & Signal Cyclic Capital Cost per Track Mile Concrete (Minimum)

Signal Capital Cost		
$/Mile	**Life in years**	**$/Mile/Year**
$200,000	80	$2,500
$20,000[25]	30	$ 667
$220,000		$3,167

[25] Based on 0.4 turnouts per mile at $50,000 per turnout.

Track Cyclic Capital Cost per Track Mile Concrete (Maximum)

	Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
4	$14,506	$20,222	$31,398	$45,578	4	$14,758	$21,208	$33,179	$48,391	4	$15,239	$22,917	$36,286	$53,316
5	$14,514	$20,751	$32,200	$46,683	5	$14,782	$21,744	$33,990	$49,507	5	$15,285	$23,462	$37,111	$54,450
6	$14,972	$21,842	$33,804	$48,832	6	$15,255	$22,848	$36,916	$51,681	6	$15,780	$24,588	$38,764	$56,663

Build. and Bridges Cyclic Capital Cost per Track Mile Concrete (Maximum)

Bridge Capital Cost				
Average Feet/Mile	**Cost/feet**	**$/Mile**	**Life in years**	**$/Mile/Year**
83.75	6000	$502,500	80	$6,281

Comm. and Signal Cyclic Capital Cost per Track Mile Concrete (Maximum)

Signal Capital Cost		
$/Mile	**Life in years**	**$/Mile/Year**
$300,000	80	$3,750
$20,000[26]	20	$1,000
$320,000		$4,750

[26] Based on 0.4 turnouts per mile at $50,000 per turnout.

Total Maintenance Cost per Track Mile Concrete (Minimum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$8,416	$10,531	$14,831	$25,054	4	$8,712	$10,900	$15,352	$25,933	4	$9,121	$11,412	$16,073	$27,150
Pred. Frght	5	$10,832	$13,553	$19,088	$32,244	5	$11,212	$14,028	$19,758	$33,376	5	$11,738	$14,687	$20,685	$34,943
	6	$14,221	$17,793	$25,060	$42,332	6	$14,720	$18,418	$25,939	$43,818	6	$15,411	$19,282	$27,157	$45,875
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$11,231	$17,573	$27,440	*	4	$11,625	$18,190	$28,403	*	4	$12,171	$19,044	$29,737	*
	5	$13,140	$20,560	$32,105	*	5	$13,601	$21,282	$33,232	*	5	$14,240	$22,281	$34,792	*
	6	$17,050	$26,678	$41,657	*	6	$17,648	$27,614	$43,119	*	6	$18,477	$28,911	$45,144	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$13,695	$26,338	*	*	4	$14,175	$27,262	*	*	4	$14,841	$28,542	*	*
	5	$16,023	$30,815	*	*	5	$16,585	$31,897	*	*	5	$17,364	$33,394	*	*
	6	$18,762	$36,083	*	*	6	$19,420	$37,349	*	*	6	$20,332	$39,103	*	*

Matrix 33

Total Cyclic Capital Cost per Track Mile Concrete (Minimum))

	Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
4	$18,585	$20,278	$25,546	$33,165	4	$18,725	$20,722	$26,269	$34,236	4	$18,963	$21,501	$27,564	$36,179
5	$18,767	$20,592	$26,061	$33,857	5	$18,909	$21,041	$26,791	$34,936	5	$19,151	$21,826	$28,095	$36,892
6	$19,139	$21,236	$27,054	$35,169	6	$19,286	$21,694	$29,121	$36,265	6	$19,537	$22,494	$29,121	$38,247

Matrix 34

Total Maintenance Cost per Track Mile Concrete (Maximum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$12,849	$16,077	$22,644	$38,251	4	$13,300	$16,642	$23,438	$39,593	4	$14,530	$18,180	$25,605	$43,254
Pred. Frght.	5	$16,253	$20,336	$28,641	$48,382	5	$16,823	$21,050	$29,646	$50,080	5	$18,158	$22,719	$31,998	$54,053
	6	$21,410	$26,789	$37,729	$63,734	6	$22,161	$27,729	$39,053	$65,971	6	$23,521	$29,430	$41,449	$70,017
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght.	4	$16,909	$26,457	$41,313	*	4	$17,502	$27,386	$42,763	*	4	$18,576	$29,066	$45,386	*
	5	$19,783	$30,955	$48,336	*	5	$20,478	$32,042	$50,032	*	5	$21,734	$34,007	$53,101	*
	6	$25,739	$40,274	$62,887	*	6	$26,642	$41,687	$65,094	*	6	$27,893	$43,645	$68,150	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$20,674	$39,761	*	*	4	$21,400	$41,156	*	*	4	$22,405	$43,089	*	*
	5	$24,189	$46,520	*	*	5	$25,038	$48,153	*	*	5	$26,213	$50,414	*	*
	6	$28,324	$54,472	*	*	6	$29,318	$56,384	*	*	6	$30,694	$59,031	*	*

Matrix 35

Total Cyclic Capital Cost per Track Mile Concrete (Maximum)

	Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
4	$25,537	$31,253	$42,429	$56,609	4	$25,789	$32,239	$44,210	$59,422	4	$26,270	$33,948	$47,317	$64,347
5	$25,546	$31,783	$43,232	$57,714	5	$25,813	$32,775	$45,021	$60,538	5	$26,316	$34,493	$48,142	$65,481
6	$26,004	$32,873	$44,835	$59,863	6	$26,286	$33,880	$47,947	$62,712	6	$26,811	$35,620	$49,796	$67,695

Matrix 36

Total Cost per Track Mile Concrete (Minimum) – Maintenance + Cyclic Capital

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$27,002	$30,808	$40,377	$58,218	4	$27,436	$31,622	$41,621	$60,169	4	$28,084	$32,913	$43,636	$63,330
Pred. Frght	5	$29,598	$34,145	$45,149	$66,101	5	$30,120	$35,069	$46,549	$68,312	5	$30,889	$36,514	$48,780	$71,835
	6	$33,359	$39,029	$52,114	$77,501	6	$34,006	$40,112	$55,060	$80,083	6	$34,947	$41,776	$56,278	$84,122
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$29,816	$37,851	$52,986	*	4	$30,350	$38,912	$54,672	*	4	$31,134	$40,545	$57,300	*
	5	$31,907	$41,152	$58,166	*	5	$32,510	$43,323	$60,023	*	5	$33,391	$44,108	$62,887	*
	6	$36,189	$47,914	$68,711	*	6	$36,934	$49,309	$72,240	*	6	$38,013	$51,405	$74,264	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$32,280	$46,616	*	*	4	$32,900	$47,984	*	*	4	$33,804	$50,043	*	*
	5	$34,790	$51,407	*	*	5	$35,494	$52,938	*	*	5	$36,515	$55,221	*	*
	6	$37,901	$57,319	*	*	6	$38,706	$59,044	*	*	6	$39,869	$61,597	*	*

Matrix 37

Total Cost per Track Mile Concrete (Maximum) – Maintenance + Cyclic Capital

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
	4	$38,387	$47,330	$65,072	$94,860	4	$39,090	$48,881	$67,648	$99,015	4	$40,800	$52,128	$72,922	$107,601
Pred. Frght	5	$41,798	$52,118	$71,872	$106,096	5	$42,636	$53,825	$74,668	$110,618	5	$44,474	$57,213	$80,140	$119,534
	6	$47,413	$59,662	$82,564	$123,596	6	$48,448	$61,608	$87,000	$128,683	6	$50,332	$65,049	$91,245	$137,712
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Equal Frght	4	$42,446	$57,710	$83,742	*	4	$43,292	$59,625	$86,973	*	4	$44,846	$63,014	$92,703	*
	5	$45,329	$62,738	$91,567	*	5	$46,291	$64,817	$95,054	*	5	$48,050	$68,500	$101,243	*
	6	$51,743	$73,147	$107,722	*	6	$52,929	$75,567	$113,041	*	6	$54,704	$79,264	$117,946	*
		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$46,211	$71,014	*	*	4	$47,189	$73,395	*	*	4	$48,675	$77,036	*	*
	5	$49,734	$78,303	*	*	5	$50,851	$80,928	*	*	5	$52,530	$84,907	*	*
	6	$54,327	$87,345	*	*	6	$55,604	$90,264	*	*	6	$57,505	$94,651	*	*

Matrix 38

Appendix C: Handbook Cost Matrices for High Speed Passenger and Mixed Freight Corridors -- Cost per Passenger Train Mile

Total Maintenance Cost per Passenger Train Mile Wood (Minimum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$0.63	$0.26	$0.19	$0.19	4	$0.66	$0.28	$0.19	$0.20	4	$0.70	$0.29	$0.21	$0.21
Pred. Frght	5	$1.97	$0.82	$0.58	$0.59	5	$2.07	$0.86	$0.61	$0.62	5	$2.20	$0.92	$0.65	$0.65
(80% Frght. 20% Pass.)	6	$3.85	$1.61	$1.13	$1.15	6	$4.04	$1.68	$1.19	$1.20	6	$4.30	$1.79	$1.26	$1.28
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght	4	$0.96	$0.50	$0.49	*	4	$1.01	$0.52	$0.51	*	4	$1.07	$0.56	$0.54	*
(50% Frght. 50% Pass.)	5	$1.38	$0.72	$0.70	*	5	$1.45	$0.76	$0.74	*	5	$1.54	$0.80	$0.79	*
	6	$2.25	$1.17	$1.15	*	6	$2.36	$1.23	$1.20	*	6	$2.51	$1.31	$1.28	*
	No. of Pass. Train	20	60				20	60				20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30		<=5	5-15	15-30	>=30
Pred. Pass.	4	$1.36	$0.88	*	*	4	$1.42	$0.92	*	*	4	$1.51	$0.98	*	*
(20% Frght. 80% Pass.)	5	$1.68	$1.09	*	*	5	$1.76	$1.14	*	*	5	$1.87	$1.21	*	*
	6	$2.06	$1.33	*	*	6	$2.16	$1.40	*	*	6	$2.30	$1.49	*	*

Matrix 39

Total Cyclic Capital Cost per Passenger Train Mile – Wood (Minimum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$1.34	$0.51	$0.34	$0.26	4	$1.35	$0.52	$0.34	$0.27	4	$1.37	$0.54	$0.36	$0.29
Pred. Frght	5	$1.44	$0.56	$0.38	$0.30	5	$1.45	$0.58	$0.39	$0.31	5	$1.47	$0.60	$0.41	$0.33
(80% Frght. 20% Pass.)	6	$1.65	$0.68	$0.47	$0.37	6	$1.66	$0.70	$0.48	$0.38	6	$1.69	$0.72	$0.50	$0.40
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght	4	$1.53	$0.58	$0.48	*	4	$1.54	$0.59	$0.49	*	4	$1.56	$0.61	$0.51	*
(50% Frght. 50% Pass.)	5	$1.57	$0.60	$0.50	*	5	$1.58	$0.61	$0.51	*	5	$1.60	$0.63	$0.54	*
	6	$1.65	$0.65	$0.55	*	6	$1.66	$0.66	$0.56	*	6	$1.69	$0.68	$0.58	*
	No. of Pass. Train	20	60			No. of Pass. Train	20	60			No. of Pass. Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$1.77	$0.67	*	*	4	$1.79	$0.68	*	*	4	$1.81	$0.71	*	*
(20% Frght. 80% Pass.)	5	$1.80	$0.68	*	*	5	$1.81	$0.70	*	*	5	$1.84	$0.72	*	*
	6	$1.85	$0.71	*	*	6	$1.87	$0.73	*	*	6	$1.89	$0.75	*	*

Matrix 40

Total Maintenance Cost per Passenger Train Mile Wood (Maximum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$0.96	$0.40	$0.28	$0.39	4	$1.01	$0.42	$0.30	$0.30	4	$1.08	$0.45	$0.32	$0.32
Pred. Frght	5	$2.85	$1.19	$0.84	$0.85	5	$2.99	$1.25	$0.88	$0.89	5	$3.18	$1.33	$0.93	$0.95
(80% Frght. 20% Pass.)	6	$5.71	$2.38	$1.68	$1.70	6	$5.99	$2.50	$1.76	$1.78	6	$6.38	$2.66	$1.87	$1.90
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght	4	$1.44	$0.75	$0.73	*	4	$1.51	$0.79	$0.77	*	4	$1.61	$0.84	$0.82	*
(50% Frght. 50% Pass.)	5	$2.08	$1.09	$1.06	*	5	$2.18	$1.14	$1.11	*	5	$2.32	$1.21	$1.18	*
	6	$3.40	$1.77	$1.73	*	6	$3.57	$1.86	$1.82	*	6	$3.80	$1.98	$1.93	*
	No. of Pass. Train	20	60			No. of Pass. Train	20	60			No. of Pass. Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$2.05	$1.32	*	*	4	$2.15	$1.39	*	*	4	$2.29	$1.48	*	*
(20% Frght. 80% Pass.)	5	$2.54	$1.64	*	*	5	$2.66	$1.72	*	*	5	$2.83	$1.83	*	*
	6	$3.11	$2.01	*	*	6	$3.26	$2.11	*	*	6	$3.47	$2.24	*	*

Matrix 41

Total Cyclic Capital Cost per Passenger Train Mile Wood (Maximum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$1.92	$0.78	$0.54	$0.44	4	$1.94	$0.80	$0.56	$0.46	4	$1.97	$0.84	$0.60	$0.50
Pred. Frght	5	$1.92	$0.87	$0.62	$0.50	5	$1.95	$0.90	$0.64	$0.52	5	$2.00	$0.94	$0.68	$0.56
(80% Frght. 20% Pass.)	6	$2.17	$1.07	$0.76	$0.62	6	$2.21	$1.10	$0.79	$0.64	6	$2.27	$1.15	$0.83	$0.68
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght	4	$2.18	$0.88	$0.77	*	4	$2.20	$0.91	$0.80	*	4	$2.24	$0.96	$0.86	*
(50% Frght. 50% Pass.)	5	$2.18	$0.92	$0.81	*	5	$2.21	$0.95	$0.84	*	5	$2.25	$1.00	$0.89	*
	6	$2.28	$1.00	$0.88	*	6	$2.31	$1.03	$0.91	*	6	$2.36	$1.08	$0.97	*
	No. of Pass. Train	20	60			No. of Pass. Train	20	60			No. of Pass. Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$2.53	$1.02	*	*	4	$2.56	$1.06	*	*	4	$2.60	$1.11	*	*
(20% Frght. 80% Pass.)	5	$2.53	$1.05	*	*	5	$2.56	$1.08	*	*	5	$2.61	$1.14	*	*
	6	$2.60	$1.10	*	*	6	$2.63	$1.13	*	*	6	$2.68	$1.19	*	*

Matrix 42

Total Cost per Passenger Train Mile Wood Maintenance + Cyclic Capital (Minimum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	**No. of Pass. Train**	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$1.97	$0.77	$0.52	$0.45	4	$2.01	$0.79	$0.54	$0.47	4	$2.08	$0.83	$0.57	$0.50
Pred. Frght	5	$3.41	$1.39	$0.96	$0.89	5	$3.52	$1.44	$1.00	$0.93	5	$3.67	$1.51	$1.05	$0.98
(80% Frght. 20% Pass.)	6	$5.50	$2.29	$1.60	$1.52	6	$5.70	$2.38	$1.67	$1.59	6	$5.98	$2.51	$1.77	$1.68
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght	4	$2.49	$1.08	$0.96	*	4	$2.55	$1.11	$1.00	*	4	$2.63	$1.17	$1.06	*
(50% Frght. 50% Pass.)	5	$2.95	$1.32	$1.20	*	5	$3.03	$1.37	$1.25	*	5	$3.14	$1.44	$1.32	*
	6	$3.90	$1.82	$1.69	*	6	$4.02	$1.89	$1.76	*	6	$4.20	$1.99	$1.86	*
	No. of Pass. Train	20	60			No. of Pass. Train	20	60			No. of Pass. Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$3.13	$1.55	*	*	4	$3.21	$1.60	*	*	4	$3.33	$1.69	*	*
(20% Frght. 80% Pass.)	5	$3.48	$1.77	*	*	5	$3.57	$1.84	*	*	5	$3.71	$1.94	*	*
	6	$3.91	$2.04	*	*	6	$4.02	$2.12	*	*	6	$4.19	$2.24	*	*

Matrix 43

Total Cost per Passenger Train Mile Wood – Maintenance + Cyclic Capital (Maximum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$2.88	$1.18	$0.82	$0.73	4	$2.95	$1.22	$0.86	$0.76	4	$3.05	$1.29	$0.92	$0.82
Pred. Frght	5	$4.77	$2.06	$1.45	$1.35	5	$4.94	$2.15	$1.52	$1.41	5	$5.18	$2.27	$1.61	$1.51
(80% Frght. 20% Pass.)	6	$7.89	$3.45	$2.44	$2.32	6	$8.20	$3.60	$2.55	$2.42	6	$8.64	$3.81	$2.70	$2.58
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght	4	$3.63	$1.64	$1.51	*	4	$3.72	$1.70	$1.57	*	4	$3.86	$1.80	$1.68	*
(50% Frght. 50% Pass.)	5	$4.27	$2.01	$1.87	*	5	$4.39	$2.09	$1.95	*	5	$4.58	$2.21	$2.08	*
	6	$5.69	$2.78	$2.61	*	6	$5.88	$2.89	$2.73	*	6	$6.16	$3.06	$2.90	*
	No. of Pass. Train	20	60			No. of Pass. Train	20	60			No. of Pass. Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$4.58	$2.35	*	*	4	$4.71	$2.44	*	*	4	$4.89	$2.59	*	*
(20% Frght. 80% Pass.)	5	$5.07	$2.69	*	*	5	$5.22	$2.80	*	*	5	$5.44	$2.97	*	*
	6	$5.71	$3.11	*	*	6	$5.89	$3.24	*	*	6	$6.15	$3.43	*	*

Matrix 44

Total Maintenance Cost per Passenger Train Mile Concrete (Minimum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass.Train	5	15	30	50	No. of Pass.Train	5	15	30	50	No. of Pass.Train	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$0.63	$0.26	$0.18	$0.19	4	$0.65	$0.27	$0.19	$0.19	4	$0.68	$0.28	$0.20	$0.20
Pred. Frght	5	$1.95	$0.81	$0.57	$0.58	5	$2.02	$0.84	$0.59	$0.60	5	$2.12	$0.88	$0.62	$0.63
(80% Frght. 20% Pass.)	6	$3.82	$1.59	$1.12	$1.14	6	$3.95	$1.65	$1.16	$1.18	6	$4.14	$1.73	$1.22	$1.23
	No. of Pass.Train	12	37	60		No. of Pass.Train	12	37	60		No. of Pass.Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght	4	$0.95	$0.50	$0.48	*	4	$0.98	$0.51	$0.50	*	4	$1.03	$0.54	$0.52	*
(50% Frght. 50% Pass.)	5	$1.37	$0.71	$0.70	*	5	$1.42	$0.74	$0.72	*	5	$1.49	$0.77	$0.76	*
	6	$2.23	$1.16	$1.14	*	6	$2.31	$1.20	$1.18	*	6	$2.42	$1.26	$1.23	*
	No. of Pass.Train	20	60			No. of Pass.Train	20	60			No. of Pass.Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$1.35	$0.86	*	*	4	$1.39	$0.89	*	*	4	$1.46	$0.93	*	*
(20% Frght. 80% Pass.)	5	$1.67	$1.07	*	*	5	$1.72	$1.10	*	*	5	$1.80	$1.16	*	*
	6	$2.04	$1.31	*	*	6	$2.11	$1.35	*	*	6	$2.21	$1.42	*	*

Matrix 45

Total Cyclic Capital Cost per Passenger Train Mile Concrete (Minimum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$1.38	$0.50	$0.32	$0.25	4	$1.39	$0.51	$0.33	$0.25	4	$1.41	$0.53	$0.34	$0.27
Pred. Frght	5	$1.48	$0.56	$0.36	$0.28	5	$1.49	$0.57	$0.37	$0.29	5	$1.51	$0.59	$0.39	$0.31
(80% Frght. 20% Pass.)	6	$1.69	$0.68	$0.45	$0.36	6	$1.70	$0.69	$0.59	$0.37	6	$1.72	$0.71	$0.48	$0.38
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght	4	$1.57	$0.57	$0.45	*	4	$1.58	$0.58	$0.46	*	4	$1.60	$0.61	$0.49	*
(50% Frght. 50% Pass.)	5	$1.61	$0.60	$0.47	*	5	$1.62	$0.61	$0.49	*	5	$1.65	$0.63	$0.51	*
	6	$1.69	$0.64	$0.52	*	6	$1.71	$0.66	$0.59	*	6	$1.73	$0.68	$0.56	*
	No. of Pass. Train	20	60			No. of Pass. Train	20	60			No. of Pass. Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$1.83	$0.66	*	*	4	$1.84	$0.68	*	*	4	$1.86	$0.70	*	*
(20% Frght. 80% Pass.)	5	$1.85	$0.68	*	*	5	$1.86	$0.69	*	*	5	$1.89	$0.72	*	*
	6	$1.90	$0.71	*	*	6	$1.92	$0.72	*	*	6	$1.94	$0.75	*	*

Matrix 46

Total Maintenance Cost per Passenger Train Mile Concrete (Maximum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$0.96	$0.40	$0.28	$0.28	4	$0.99	$0.41	$0.29	$0.29	4	$1.08	$0.45	$0.32	$0.32
Pred. Frght	5	$2.83	$1.18	$0.83	$0.84	5	$2.93	$1.22	$0.86	$0.87	5	$3.08	$1.28	$0.90	$0.92
(80% Frght. 20% Pass.)	6	$5.66	$2.36	$1.66	$1.69	6	$5.86	$2.44	$1.72	$1.75	6	$6.02	$2.51	$1.77	$1.79
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght	4	$1.43	$0.75	$0.73	*	4	$1.48	$0.77	$0.75	*	4	$1.57	$0.82	$0.80	*
(50% Frght. 50% Pass.)	5	$2.06	$1.08	$1.05	*	5	$2.14	$1.11	$1.09	*	5	$2.27	$1.18	$1.15	*
	6	$3.37	$1.76	$1.72	*	6	$3.49	$1.82	$1.78	*	6	$3.62	$1.89	$1.84	*
	No. of Pass. Train	20	60			No. of Pass. Train	20	60			No. of Pass. Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$2.03	$1.30	*	*	4	$2.10	$1.35	*	*	4	$2.20	$1.41	*	*
(20% Frght. 80% Pass.)	5	$2.51	$1.61	*	*	5	$2.60	$1.67	*	*	5	$2.72	$1.75	*	*
	6	$3.08	$1.98	*	*	6	$3.19	$2.05	*	*	6	$3.34	$2.14	*	*

Matrix 47

Total Cyclic Capital Cost per Passenger Train Mile Concrete (Maximum)

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$1.90	$0.77	$0.53	$0.42	4	$1.92	$0.80	$0.55	$0.44	4	$1.95	$0.84	$0.59	$0.48
Pred. Frght	5	$1.90	$0.87	$0.60	$0.48	5	$1.93	$0.90	$0.62	$0.50	5	$1.98	$0.94	$0.66	$0.54
(80% Frght. 20% Pass.)	6	$2.15	$1.07	$0.75	$0.60	6	$2.19	$1.10	$0.89	$0.62	6	$2.25	$1.15	$0.81	$0.66
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght	4	$2.16	$0.88	$0.75	*	4	$2.18	$0.91	$0.78	*	4	$2.22	$0.96	$0.83	*
(50% Frght. 50% Pass.)	5	$2.16	$0.92	$0.78	*	5	$2.19	$0.95	$0.82	*	5	$2.23	$1.00	$0.87	*
	6	$2.26	$1.00	$0.86	*	6	$2.29	$1.03	$0.95	*	6	$2.34	$1.08	$0.95	*
	No. of Pass. Train	20	60			No. of Pass. Train	20	60			No. of Pass. Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$2.51	$1.02	*	*	4	$2.53	$1.06	*	*	4	$2.58	$1.11	*	*
(20% Frght. 80% Pass.)	5	$2.51	$1.05	*	*	5	$2.54	$1.08	*	*	5	$2.59	$1.14	*	*
	6	$2.57	$1.10	*	*	6	$2.60	$1.13	*	*	6	$2.65	$1.19	*	*

Matrix 48

Total Cost per Passenger Train Mile Concrete (Minimum) – Maintenance + Cyclic Capital

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$2.01	$0.76	$0.50	$0.43	4	$2.04	$0.78	$0.52	$0.45	4	$2.09	$0.82	$0.54	$0.47
Pred. Frght.	5	$3.44	$1.38	$0.94	$0.87	5	$3.52	$1.42	$0.97	$0.90	5	$3.63	$1.48	$1.01	$0.94
(80% Frght. 20% Pass.)	6	$5.50	$2.27	$1.58	$1.49	6	$5.65	$2.34	$1.75	$1.54	6	$5.86	$2.44	$1.70	$1.61
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght.	4	$2.52	$1.07	$0.93	*	4	$2.57	$1.10	$0.96	*	4	$2.63	$1.14	$1.01	*
(50% Frght. 50% Pass.)	5	$2.98	$1.31	$1.17	*	5	$3.04	$1.35	$1.21	*	5	$3.13	$1.40	$1.27	*
	6	$3.92	$1.81	$1.65	*	6	$4.02	$1.86	$1.77	*	6	$4.15	$1.94	$1.79	*
	No. of Pass. Train	20	60			No. of Pass. Train	20	60			No. of Pass. Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$3.17	$1.53	*	*	4	$3.23	$1.57	*	*	4	$3.32	$1.64	*	*
(20% Frght. 80% Pass.)	5	$3.52	$1.75	*	*	5	$3.59	$1.80	*	*	5	$3.69	$1.88	*	*
	6	$3.94	$2.02	*	*	6	$4.03	$2.08	*	*	6	$4.15	$2.17	*	*

		Light Curve (96% - 4% - 0%)					Moderate Curve (90% - 8% -2%)					Severe Curve (82% - 12% - 6%)			
	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50	No. of Pass. Train	5	15	30	50
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
	4	$2.85	$1.17	$0.81	$0.71	4	$2.91	$1.21	$0.84	$0.74	4	$3.03	$1.29	$0.90	$0.80
Pred. Frght	5	$4.73	$2.05	$1.43	$1.32	5	$4.86	$2.12	$1.48	$1.37	5	$5.05	$2.22	$1.57	$1.46
(80% Frght. 20% Pass.)	6	$7.82	$3.43	$2.41	$2.29	6	$8.05	$3.54	$2.61	$2.37	6	$8.28	$3.66	$2.58	$2.46
	No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60		No. of Pass. Train	12	37	60	
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Equal Frght	4	$3.59	$1.63	$1.48	*	4	$3.66	$1.68	$1.53	*	4	$3.79	$1.78	$1.63	*
(50% Frght. 50% Pass.)	5	$4.23	$2.00	$1.84	*	5	$4.32	$2.06	$1.90	*	5	$4.50	$2.18	$2.03	*
	6	$5.64	$2.76	$2.58	*	6	$5.78	$2.85	$2.73	*	6	$5.96	$2.97	$2.79	*
	No. of Pass. Train	20	60			No. of Pass. Train	20	60			No. of Pass. Train	20	60		
	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30	Trk Class/MGT	<=5	5-15	15-30	>=30
Pred. Pass.	4	$4.54	$2.32	*	*	4	$4.63	$2.40	*	*	4	$4.78	$2.52	*	*
(20% Frght. 80% Pass.)	5	$5.02	$2.66	*	*	5	$5.14	$2.75	*	*	5	$5.31	$2.88	*	*
	6	$5.65	$3.07	*	*	6	$5.79	$3.18	*	*	6	$5.99	$3.33	*	*

Matrix 50

Appendix D: Simplified Example Application

Table D-1: Track Maintenance Cost Calculation Sheet

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
				No. of Trains Per Day						
Start Milepost	Ending Milepost	# of Tracks	*Segment Length (Miles)*	Passenger	Freight	*Ratio Pass/Frt*	FRA Track Class	Curve Factor	*Total Tonnage (MGT)*	Maintenance Difficulty Factor
13.4	38.1	2	*49.4*	16	16	***1***	**4**	1.04	***38***	**1.31**
248.3	259.5	1	*11.2*	16	1	***16***	**4**	1	***5***	**1.23**
259.5	272.7	1	*13.2*	16	10	***2***	**6**	1.04	***25***	**1.29**
	Route Length		*73.8*							

Cost Per Track Mile		
12	*13*	*14*
Base Case Cost (000)	***Cost Per Track Mile***	***Segment Cost/Yr***
$61	*$82,834*	*$4,091,996*
$32	*$39,237*	*$439,454*
$54	*$72,178*	*$952,751*
	Total Route Cost	*$5,484,201*

Cost Per Train Mile		
15	*16*	*17*
Base Case Cost	***Cost Per Train Mile***	***Segment Cost/Trip***
0.45	*$0.61*	*$30*
3.13	*$3.85*	*$43*
1.60	*$2.15*	*$28*
	Total Cost Per Trip	*$101.74*

Table D.2: Track Maintenance Cost Calculation -- Equations

Column #	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
	A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***
Row #			No. of Trains Per Day						
	Ending Milepost	*Segment Length (Miles)*	Passenger	Freight	*Ratio Pass/Frt*	FRA Track Class	Curve Factor	*Total Tonnage (MGT)*	Maintenance Difficulty Factor
6	0.0	*A6*			*C6/(D6 + 0.025)*			*((C6*550 + D6*5900)*365)/1000000*	
7		*A7-A6*			*C7/(D7 + 0.025)*			*((C7*550 + D7*5900)*365)/1000000*	
8		*A8-A7*			*C8/(D8 + 0.025)*			*((C8*550 + D8*5900)*365)/1000000*	
9		*A9-A8*			*C9/(D9 + 0.025)*			*((C9*550 + D9*5900)*365)/1000000*	
10		*A10-A9*			*C10/(D10 + 0.025)*			*((C10*550 + D10*5900)*365)/1000000*	
	Route Length	*SUM(B6:B10)*							

Cost Per Track Mile				Cost Per Train Mile		
10	*11*	*12*		*13*	*14*	*15*
K	***L***	**M**	***N***	***O***	***P***	***Q***
Base Case Cost	***Cost Per Track Mile***	***Segment Cost/Yr***		Base Case Cost	***Cost Per Train Mile***	***Segment Cost/Trip***
	*G6*I6*K6*1000*	*B6*L6*			*G6*I6*O6*	*B6*P6*
	*G7*I7*K7*1000*	*B7*L7*			*G7*I7*O7*	*B7*P7*
	*G8*I8*K8*1000*	*B8*L8*			*G8*I8*O8*	*B8*P8*
	*G9*I9*K9*1000*	*B9*L9*			*G9*I9*O9*	*B9*P9*
	*G10*I10*K10*1000*	*B10*L10*			*G10*I10*O10*	*B10*P10*
	Total Route Cost	*SUM(M6:M10)*			*Total Cost Per Trip*	*SUM(Q6:Q10)*

APPENDIX B. Summary of NLX Expensed Maintenance Costs for 2020 through 2059

NLX Operating and Maintenance Costs - 2020 through 2059

Target Field - Duluth

SDG May 2015 Ridership and Revenue Forecasting Results

2014$

Scenario C-1	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Operating Expenses																			
Expensed Maintenance Cost	**$ 93,708,153**	$ 2,015,961	$ 2,028,677	$ 2,041,674	$ 2,054,955	$ 2,068,525	$ 2,082,387	$ 2,096,545	$ 2,111,002	$ 2,125,763	$ 2,140,832	$ 2,156,213	$ 2,171,909	$ 2,187,926	$ 2,204,267	$ 2,220,937	$ 2,237,941	$ 2,255,281	$ 2,272,965
PTC System Maintenance Cost	**$ 8,800,000**	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
Total Annual Maintenance of Way Costs (2014$)	**$ 102,508,153**	**$ 2,235,961**	**$ 2,248,677**	**$ 2,261,674**	**$ 2,274,955**	**$ 2,288,525**	**$ 2,302,387**	**$ 2,316,545**	**$ 2,331,002**	**$ 2,345,763**	**$ 2,360,832**	**$ 2,376,213**	**$ 2,391,909**	**$ 2,407,926**	**$ 2,424,267**	**$ 2,440,937**	**$ 2,457,941**	**$ 2,475,281**	**$ 2,492,965**

Scenario C-2	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Operating Expenses																			
Expensed Maintenance Cost	**$ 102,687,902**	$ 2,280,773	$ 2,291,285	$ 2,302,089	$ 2,313,190	$ 2,324,590	$ 2,336,294	$ 2,348,305	$ 2,360,627	$ 2,373,263	$ 2,386,219	$ 2,399,497	$ 2,413,102	$ 2,427,038	$ 2,441,308	$ 2,455,919	$ 2,470,872	$ 2,486,174	$ 2,501,828
PTC System Maintenance Cost	**$ 8,800,000**	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
Total Annual Maintenance of Way Costs (2014$)	**$ 111,487,902**	**$ 2,500,773**	**$ 2,511,285**	**$ 2,522,089**	**$ 2,533,190**	**$ 2,544,590**	**$ 2,556,294**	**$ 2,568,305**	**$ 2,580,627**	**$ 2,593,263**	**$ 2,606,219**	**$ 2,619,497**	**$ 2,633,102**	**$ 2,647,038**	**$ 2,661,308**	**$ 2,675,919**	**$ 2,690,872**	**$ 2,706,174**	**$ 2,721,828**

Scenario C-10	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Operating Expenses																			
Expensed Maintenance Cost	**$ 84,452,658**	$ 1,751,301	$ 1,765,885	$ 1,780,737	$ 1,795,860	$ 1,811,259	$ 1,826,936	$ 1,842,895	$ 1,859,142	$ 1,875,679	$ 1,892,511	$ 1,909,641	$ 1,927,075	$ 1,944,816	$ 1,962,869	$ 1,981,238	$ 1,999,928	$ 2,018,943	$ 2,038,288
PTC System Maintenance Cost	**$ 8,800,000**	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
Total Annual Maintenance of Way Costs (2014$)	**$ 93,252,658**	**$ 1,971,301**	**$ 1,985,885**	**$ 2,000,737**	**$ 2,015,860**	**$ 2,031,259**	**$ 2,046,936**	**$ 2,062,895**	**$ 2,079,142**	**$ 2,095,679**	**$ 2,112,511**	**$ 2,129,641**	**$ 2,147,075**	**$ 2,164,816**	**$ 2,182,869**	**$ 2,201,238**	**$ 2,219,928**	**$ 2,238,943**	**$ 2,258,288**

Scenario C-11	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Operating Expenses																			
Expensed Maintenance Cost	**$ 132,501,570**	$ 3,117,446	$ 3,122,988	$ 3,128,847	$ 3,135,024	$ 3,141,524	$ 3,148,350	$ 3,155,506	$ 3,162,996	$ 3,170,824	$ 3,178,993	$ 3,187,508	$ 3,196,372	$ 3,205,589	$ 3,215,165	$ 3,225,102	$ 3,235,405	$ 3,246,078	$ 3,257,127
PTC System Maintenance Cost	**$ 8,800,000**	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
Total Annual Maintenance of Way Costs (2014$)	**$ 141,301,570**	**$ 3,337,446**	**$ 3,342,988**	**$ 3,348,847**	**$ 3,355,024**	**$ 3,361,524**	**$ 3,368,350**	**$ 3,375,506**	**$ 3,382,996**	**$ 3,390,824**	**$ 3,398,993**	**$ 3,407,508**	**$ 3,416,372**	**$ 3,425,589**	**$ 3,435,165**	**$ 3,445,102**	**$ 3,455,405**	**$ 3,466,078**	**$ 3,477,127**

Scenario B-1	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Operating Expenses																			
Expensed Maintenance Cost	**$ 250,000,025**	$ 5,176,094	$ 5,220,068	$ 5,264,806	$ 5,310,321	$ 5,356,622	$ 5,403,721	$ 5,451,628	$ 5,500,356	$ 5,549,916	$ 5,600,320	$ 5,651,579	$ 5,703,705	$ 5,756,712	$ 5,810,611	$ 5,865,415	$ 5,921,137	$ 5,977,791	$ 6,035,388
PTC System Maintenance Cost	**$ 8,800,000**	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
Total Annual Maintenance of Way Costs (2014$)	**$ 258,800,025**	**$ 5,396,094**	**$ 5,440,068**	**$ 5,484,806**	**$ 5,530,321**	**$ 5,576,622**	**$ 5,623,721**	**$ 5,671,628**	**$ 5,720,356**	**$ 5,769,916**	**$ 5,820,320**	**$ 5,871,579**	**$ 5,923,705**	**$ 5,976,712**	**$ 6,030,611**	**$ 6,085,415**	**$ 6,141,137**	**$ 6,197,791**	**$ 6,255,388**

Scenario B-2	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Operating Expenses																			
Expensed Maintenance Cost	**$ 259,599,269**	$ 5,467,672	$ 5,508,852	$ 5,550,810	$ 5,593,557	$ 5,637,103	$ 5,681,460	$ 5,726,638	$ 5,772,649	$ 5,819,504	$ 5,867,215	$ 5,915,793	$ 5,965,251	$ 6,015,600	$ 6,066,852	$ 6,119,022	$ 6,172,120	$ 6,226,160	$ 6,281,156
PTC System Maintenance Cost	**$ 8,800,000**	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
Total Annual Maintenance of Way Costs (2014$)	**$ 268,399,269**	**$ 5,687,672**	**$ 5,728,852**	**$ 5,770,810**	**$ 5,813,557**	**$ 5,857,103**	**$ 5,901,460**	**$ 5,946,638**	**$ 5,992,649**	**$ 6,039,504**	**$ 6,087,215**	**$ 6,135,793**	**$ 6,185,251**	**$ 6,235,600**	**$ 6,286,852**	**$ 6,339,022**	**$ 6,392,120**	**$ 6,446,160**	**$ 6,501,156**

Scenario B-10	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Operating Expenses																			
Track Maintenance Cost	**$ 237,317,547**	$ 4,819,256	$ 4,865,462	$ 4,912,418	$ 4,960,133	$ 5,008,619	$ 5,057,887	$ 5,107,949	$ 5,158,815	$ 5,210,498	$ 5,263,009	$ 5,316,360	$ 5,370,563	$ 5,425,632	$ 5,481,577	$ 5,538,413	$ 5,596,152	$ 5,654,806	$ 5,714,391
Expensed Maintenance Cost	**$ 8,800,000**	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
Total Annual Maintenance of Way Costs (2014$)	**$ 246,117,547**	**$ 5,039,256**	**$ 5,085,462**	**$ 5,132,418**	**$ 5,180,133**	**$ 5,228,619**	**$ 5,277,887**	**$ 5,327,949**	**$ 5,378,815**	**$ 5,430,498**	**$ 5,483,009**	**$ 5,536,360**	**$ 5,590,563**	**$ 5,645,632**	**$ 5,701,577**	**$ 5,758,413**	**$ 5,816,152**	**$ 5,874,806**	**$ 5,934,391**

Scenario B-11	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Operating Expenses																			
Expensed Maintenance Cost	**$ 303,166,760**	$ 6,680,685	$ 6,715,230	$ 6,750,577	$ 6,786,736	$ 6,823,719	$ 6,861,536	$ 6,900,198	$ 6,939,715	$ 6,980,101	$ 7,021,364	$ 7,063,519	$ 7,106,575	$ 7,150,546	$ 7,195,442	$ 7,241,278	$ 7,288,064	$ 7,335,814	$ 7,384,541
PTC System Maintenance Cost	**$ 8,800,000**	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
Total Annual Maintenance of Way Costs (2014$)	**$ 311,966,760**	**$ 6,900,685**	**$ 6,935,230**	**$ 6,970,577**	**$ 7,006,736**	**$ 7,043,719**	**$ 7,081,536**	**$ 7,120,198**	**$ 7,159,715**	**$ 7,200,101**	**$ 7,241,364**	**$ 7,283,519**	**$ 7,326,575**	**$ 7,370,546**	**$ 7,415,442**	**$ 7,461,278**	**$ 7,508,064**	**$ 7,555,814**	**$ 7,604,541**

2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 2,290,994	$ 2,309,376	$ 2,328,114	$ 2,347,213	$ 2,366,678	$ 2,386,515	$ 2,406,727	$ 2,427,321	$ 2,448,302	$ 2,469,674	$ 2,491,444	$ 2,513,617	$ 2,536,198	$ 2,559,194	$ 2,582,609	$ 2,606,450	$ 2,630,723	$ 2,655,433	$ 2,680,588	$ 2,706,193	$ 2,732,254	$ 2,758,778
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 2,510,994	**$ 2,529,376**	**$ 2,548,114**	**$ 2,567,213**	**$ 2,586,678**	**$ 2,606,515**	**$ 2,626,727**	**$ 2,647,321**	**$ 2,668,302**	**$ 2,689,674**	**$ 2,711,444**	**$ 2,733,617**	**$ 2,756,198**	**$ 2,779,194**	**$ 2,802,609**	**$ 2,826,450**	**$ 2,850,723**	**$ 2,875,433**	**$ 2,900,588**	**$ 2,926,193**	**$ 2,952,254**	**$ 2,978,778**

2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 2,517,840	$ 2,534,213	$ 2,550,952	$ 2,568,062	$ 2,585,548	$ 2,603,415	$ 2,621,667	$ 2,640,311	$ 2,659,350	$ 2,678,791	$ 2,698,638	$ 2,718,896	$ 2,739,573	$ 2,760,672	$ 2,782,199	$ 2,804,161	$ 2,826,564	$ 2,849,412	$ 2,872,712	$ 2,896,471	$ 2,920,694	$ 2,945,388
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 2,737,840	**$ 2,754,213**	**$ 2,770,952**	**$ 2,788,062**	**$ 2,805,548**	**$ 2,823,415**	**$ 2,841,667**	**$ 2,860,311**	**$ 2,879,350**	**$ 2,898,791**	**$ 2,918,638**	**$ 2,938,896**	**$ 2,959,573**	**$ 2,980,672**	**$ 3,002,199**	**$ 3,024,161**	**$ 3,046,564**	**$ 3,069,412**	**$ 3,092,712**	**$ 3,116,471**	**$ 3,140,694**	**$ 3,165,388**

2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 2,057,967	$ 2,077,986	$ 2,098,348	$ 2,119,060	$ 2,140,126	$ 2,161,551	$ 2,183,340	$ 2,205,499	$ 2,228,032	$ 2,250,946	$ 2,274,246	$ 2,297,937	$ 2,322,025	$ 2,346,515	$ 2,371,414	$ 2,396,728	$ 2,422,462	$ 2,448,623	$ 2,475,216	$ 2,502,249	$ 2,529,727	$ 2,557,657
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 2,277,967	**$ 2,297,986**	**$ 2,318,348**	**$ 2,339,060**	**$ 2,360,126**	**$ 2,381,551**	**$ 2,403,340**	**$ 2,425,499**	**$ 2,448,032**	**$ 2,470,946**	**$ 2,494,246**	**$ 2,517,937**	**$ 2,542,025**	**$ 2,566,515**	**$ 2,591,414**	**$ 2,616,728**	**$ 2,642,462**	**$ 2,668,623**	**$ 2,695,216**	**$ 2,722,249**	**$ 2,749,727**	**$ 2,777,657**

2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 3,268,554	$ 3,280,365	$ 3,292,565	$ 3,305,157	$ 3,318,147	$ 3,331,540	$ 3,345,341	$ 3,359,553	$ 3,374,183	$ 3,389,236	$ 3,404,716	$ 3,420,629	$ 3,436,981	$ 3,453,777	$ 3,471,022	$ 3,488,722	$ 3,506,882	$ 3,525,509	$ 3,544,609	$ 3,564,187	$ 3,584,250	$ 3,604,803
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 3,488,554	**$ 3,500,365**	**$ 3,512,565**	**$ 3,525,157**	**$ 3,538,147**	**$ 3,551,540**	**$ 3,565,341**	**$ 3,579,553**	**$ 3,594,183**	**$ 3,609,236**	**$ 3,624,716**	**$ 3,640,629**	**$ 3,656,981**	**$ 3,673,777**	**$ 3,691,022**	**$ 3,708,722**	**$ 3,726,882**	**$ 3,745,509**	**$ 3,764,609**	**$ 3,784,187**	**$ 3,804,250**	**$ 3,824,803**

2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 6,093,944	$ 6,153,470	$ 6,213,982	$ 6,275,494	$ 6,338,019	$ 6,401,573	$ 6,466,169	$ 6,531,824	$ 6,598,551	$ 6,666,368	$ 6,735,288	$ 6,805,329	$ 6,876,506	$ 6,948,835	$ 7,022,334	$ 7,097,019	$ 7,172,908	$ 7,250,017	$ 7,328,365	$ 7,407,970	$ 7,488,849	$ 7,571,021
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 6,313,944	**$ 6,373,470**	**$ 6,433,982**	**$ 6,495,494**	**$ 6,558,019**	**$ 6,621,573**	**$ 6,686,169**	**$ 6,751,824**	**$ 6,818,551**	**$ 6,886,368**	**$ 6,955,288**	**$ 7,025,329**	**$ 7,096,506**	**$ 7,168,835**	**$ 7,242,334**	**$ 7,317,019**	**$ 7,392,908**	**$ 7,470,017**	**$ 7,548,365**	**$ 7,627,970**	**$ 7,708,849**	**$ 7,791,021**

2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 6,337,119	$ 6,394,065	$ 6,452,006	$ 6,510,956	$ 6,570,930	$ 6,631,942	$ 6,694,007	$ 6,757,139	$ 6,821,353	$ 6,886,665	$ 6,953,089	$ 7,020,643	$ 7,089,341	$ 7,159,201	$ 7,230,237	$ 7,302,468	$ 7,375,910	$ 7,450,580	$ 7,526,496	$ 7,603,675	$ 7,682,136	$ 7,761,897
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 6,557,119	**$ 6,614,065**	**$ 6,672,006**	**$ 6,730,956**	**$ 6,790,930**	**$ 6,851,942**	**$ 6,914,007**	**$ 6,977,139**	**$ 7,041,353**	**$ 7,106,665**	**$ 7,173,089**	**$ 7,240,643**	**$ 7,309,341**	**$ 7,379,201**	**$ 7,450,237**	**$ 7,522,468**	**$ 7,595,910**	**$ 7,670,580**	**$ 7,746,496**	**$ 7,823,675**	**$ 7,902,136**	**$ 7,981,897**

2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 5,774,918	$ 5,836,403	$ 5,898,858	$ 5,962,298	$ 6,026,737	$ 6,092,190	$ 6,158,672	$ 6,226,198	$ 6,294,783	$ 6,364,442	$ 6,435,192	$ 6,507,048	$ 6,580,026	$ 6,654,144	$ 6,729,417	$ 6,805,863	$ 6,883,499	$ 6,962,342	$ 7,042,411	$ 7,123,723	$ 7,206,296	$ 7,290,149
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 5,994,918	**$ 6,056,403**	**$ 6,118,858**	**$ 6,182,298**	**$ 6,246,737**	**$ 6,312,190**	**$ 6,378,672**	**$ 6,446,198**	**$ 6,514,783**	**$ 6,584,442**	**$ 6,655,192**	**$ 6,727,048**	**$ 6,800,026**	**$ 6,874,144**	**$ 6,949,417**	**$ 7,025,863**	**$ 7,103,499**	**$ 7,182,342**	**$ 7,262,411**	**$ 7,343,723**	**$ 7,426,296**	**$ 7,510,149**

2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 7,434,257	$ 7,484,977	$ 7,536,713	$ 7,589,479	$ 7,643,289	$ 7,698,157	$ 7,754,098	$ 7,811,126	$ 7,869,256	$ 7,928,502	$ 7,988,881	$ 8,050,407	$ 8,113,096	$ 8,176,964	$ 8,242,028	$ 8,308,303	$ 8,375,807	$ 8,444,556	$ 8,514,567	$ 8,585,858	$ 8,658,447	$ 8,732,351
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 7,654,257	**$ 7,704,977**	**$ 7,756,713**	**$ 7,809,479**	**$ 7,863,289**	**$ 7,918,157**	**$ 7,974,098**	**$ 8,031,126**	**$ 8,089,256**	**$ 8,148,502**	**$ 8,208,881**	**$ 8,270,407**	**$ 8,333,096**	**$ 8,396,964**	**$ 8,462,028**	**$ 8,528,303**	**$ 8,595,807**	**$ 8,664,556**	**$ 8,734,567**	**$ 8,805,858**	**$ 8,878,447**	**$ 8,952,351**

APPENDIX C. *Technical Memorandum: NLX Facilities Operations and Maintenance Costs*, HNTB, May 8, 2015

NLX Facilities Operations and Maintenance Costs

Technical Memo

May 8, 2015

About the NLX

The Northern Lights Express is a proposed 152-mile long, high-speed intercity passenger rail service between Minneapolis and Duluth, Minnesota, a portion of which will travel through Douglas County, Wisconsin. Service along the route will reach speeds between 90 and 110 miles per hour with service frequencies of two to eight round trips per day. The proposed build alternative includes terminals at Downtown Minneapolis Station (near Target Field) and the historic Duluth Union Depot. Four additional stations are proposed at Coon Rapids – Foley Station, Cambridge, Hinckley and Superior. Layover facilities are being considered near the two terminal stations and a light maintenance facility is also being planned along the line.

Operating & Maintenance Cost Model

Under the scope of work, an operating and maintenance (O&M) cost model has been developed for the station, layover, and maintenance facilities on the Northern Lights Express (NLX) project. The O&M model includes four intermediate station sites, two terminal station sites, one layover facility and one light maintenance facility. Depending on the location of the maintenance facility and service scenario chosen, there may be more than one layover facility.

Annual O&M costs are estimated over a 20 year time horizon. Factors that are considered within the O&M model include usage allocation of shared operations with other rail services; personnel expenses to staff the facilities; maintenance costs; ongoing utility costs for heating and lighting; grounds keeping for mowing, leaf removal and snow removal; and maintenance of parking lots, driveways and walkways.

Source Data

Much of the facilities operating and maintenance cost data for the NLX was derived from the 2015 operating budget for the Northstar commuter rail service, a 40-mile route between Big Lake, Minnesota and downtown Minneapolis. After researching a number of different railroad properties throughout the Midwest, it has been determined that Northstar has the most features in common with the NLX from an operating facilities perspective, including a similar number of stations (Northstar has six), station amenities, downtown Minneapolis station, and service level (Northstar has 12 round trips per weekday). Budget data from the Metropolitan Council's application for a 2015 operating grant from the Counties Transit Improvement Board for the Northstar Line was supplemented with detailed information on organization staffing, utilities costs, and facility equipment provided by Metropolitan Council staff in its Metro Transit Northstar operating division.

O&M Facilities Cost Categories

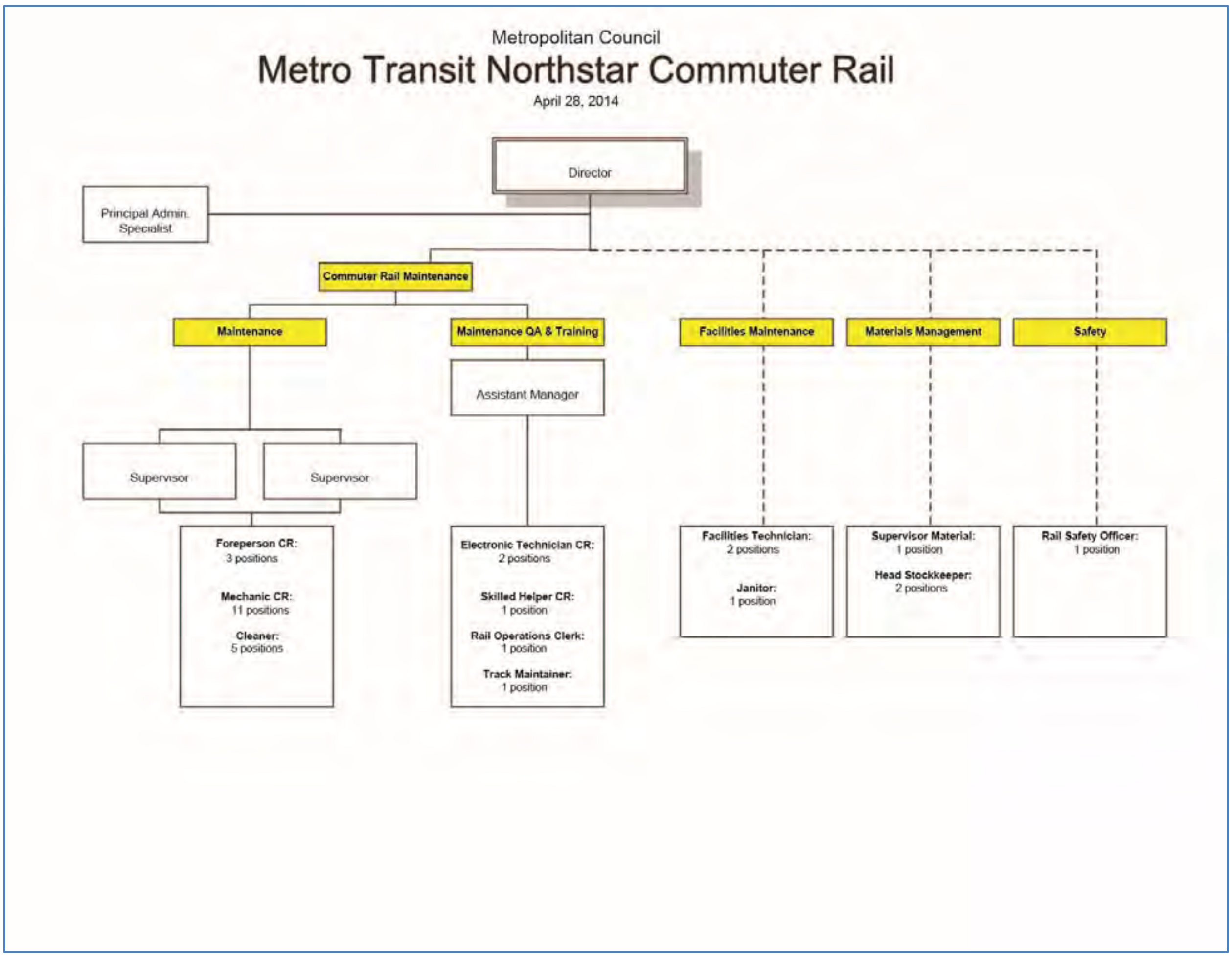
O&M facility costs are categorized into five broad categories based on the Northstar budget presentation – labor and benefits; contracted services; materials, parts and supplies, other expenses; and allocated expenses. Facilities O&M costs are allocated into year of expenditure and projected over 20 years, assuming 3% inflation annually.

Labor and Benefits

Labor includes all of the job classifications necessary to maintain the light maintenance facility. Based on Northstar's organization chart for facilities maintenance, shown in Figure 1, it is suggested that three full time employees (FTE) are needed to operate the NLX, including two Facilities Technicians and one Janitor. In 2015 dollars, the labor cost for these positions is $139,942 based on current midpoint salary rates for Metropolitan Council job classifications. Total labor costs include 15% overtime based on Northstar's 2015 budget.

Benefits include vacation/sick/holiday, pension, FICA, insurance, workers compensation, and a tool allowance. In the 2014 Northstar budget, benefits are approximately 87% of labor costs. Facilities-related benefits covering the three facilities maintenance employees are valued at $121,428. Total labor and benefits costs for the three FTEs are approximately $261,371. A total benefit package for NLX will be determined by the selected operator.

Figure 1: Northstar Commuter Rail organization chart



Contracted Services

Northstar contracts security, snow plowing and maintenance services to third-party providers. Maintenance services include facilities maintenance items like grounds keeping and maintenance of parking and sidewalks. The breakdown in contracted service categories is described in Table 1. Northstar's contract costs in 2015 are allocated based on the number of stations and facilities. Seven total facilities on Northstar thus yields a 14% higher cost for NLX's eight total facilities.

Table 1: Operating Costs – Contracted Services

Services	Northstar 2015 Cost	Cost Driver	Northstar Unit Cost	NLX Units	NLX Cost
Security	$4,116	Stations + Facilities	$588	8	$4,704
Snow Plowing	$150,000	Stations + Facilities	$21,429	8	$171,429
Maintenance Contracts	$137,190	Stations + Facilities	$19,599	8	$156,789
TOTAL	**$291,306**				**$332,921**

Materials, Parts & Supplies

Materials, parts and supplies include office and shop supplies and small equipment. Northstar's costs in 2015 are allocated based on the number of stations and facilities. Seven total facilities on Northstar thus yields a 14% higher cost for NLX's eight total facilities, as shown in Table 2.

Table 2: Operating Costs – Materials, Parts & Supplies

Services	Northstar 2015 Cost	Cost Driver	Northstar Unit Cost	NLX Units	NLX Cost
Office & Small Shop Supplies	$128,131	Stations + Facilities	$18,304	8	$146,435
TOTAL					**$146,435**

Utility Expenses

Metro Transit provided detailed information on 2014 utility costs for each station and maintenance facility. These costs were used to allocate 2015 budget values presented as a system total. Utilities include electric, natural gas, water, refuse collection and telephone/internet services. Utility costs for electricity also incorporate head-end power at the maintenance facility. In 2015, utilities and other expenses were valued at $870,057 as shown in Table 3.

Table 3: Operating Costs – Utility Expenses

Services	Northstar 2015 Cost	Cost Driver	Northstar Unit Cost	NLX Units	NLX Cost
Stations					
Electric	$205,527	Stations	$34,254	6	$205,527
Natural Gas	$44,734	Stations	$44,734	6	$268,405
Water	$1,549	Stations	$775	6	$4,648
Layover Facility					
Electric	$361,584	Layover Facilities	$34,254	1	$34,254
Natural Gas	$40,570	Layover Facilities	$44,734	1	$44,734
Water	$9,511	Layover Facilities	$775	1	$775
Maint. Facility					
Electric	$52,221	Maint. Facilities	$361,584	1	$361,584
Natural Gas	$14,116	Maint. Facilities	$40,570	1	$40,570
Water	$205,527	Maint. Facilities	$9,511	1	$9,511
Refuse	$44,734	Stations + Facilities	$7,460	8	$59,681
Telephone	$1,549	Stations + Facilities	$2,017	8	$16,133
TOTAL					**$1,045,822**

Leases and Rentals

Northstar leases or rents certain small equipment used for maintenance of facilities and other assets. Northstar's costs in 2015 are allocated based on the number of stations and facilities. Seven total facilities on Northstar thus yields a 14% higher cost for NLX's eight total facilities, as shown in Table 4. Other costs not included here include fuel and rolling stock parts.

Table 5: Operating Costs – Leases and Rentals

Services	Northstar 2015 Cost	Cost Driver	Northstar Unit Cost	NLX Units	NLX Cost
Small Equipment	$140,245	Stations + Facilities	$20,035	8	$160,280
TOTAL					**$160,280**

Allocated Expenses

Northstar has certain allocated costs assigned to Metro Transit and the Metropolitan Council. These allocated costs cover administration, planning, police, marketing, and customer relations. In 2015, these costs represented about 9.5 percent of total operating expenses. No allowance for agency overhead is included in the NLX cost estimate.

Contingency

A 10% contingency is added to the above costs to reflect uncertainties at the current level of project development. The contingency amount is $194,683.

Total Facilities O&M Costs

As shown in Table 5, total operating and maintenance costs for the facilities, including the six stations, the layover facility, and the maintenance facility on the NLX are $2,141,512 for 2015. For consistency with capital cost estimates presented in 2014 dollars, the total cost in 2015 dollars as developed above was adjusted to 2014 dollars using a 3% deflation factor.

Table 5: Facilities Operating and Maintenance Cost Summary

Category	NLX Cost
Labor	$139,942
Benefits	$121,428
Contracted Services	$332,921
Materials, Parts, and Supplies	$146,435
Utilities	$1,045,822
Leases and Rentals	$160,280
Contingency (10%)	$194,683
TOTAL (2015 dollars)	**$2,141,512**
Adjust to 2014 Dollars (3%)	($62,374)
TOTAL (2015 dollars)	**$2,079,138**

APPENDIX D. Summary of NLX Operating and Maintenance Costs for 2020 through 2059

NLX Operating and Maintenance Costs - 2020 through 2059
Target Field - Duluth
SDG May 2015 Ridership and Revenue Forecasting Results

2014$

Scenario C-1	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
O&M Costs																									
Route Costs	**333,774,839**	8,075,250	8,075,250	8,075,250	8,075,250	8,075,250	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526	8,176,526
Car and Locomotive Maintenance Cost	**212,015,964**	2,387,119	3,819,391	3,819,391	3,819,391	3,819,391	4,455,956	4,455,956	4,455,956	4,455,956	4,455,956	4,734,453	4,734,453	4,734,453	4,734,453	4,734,453	5,012,950	5,012,950	5,012,950	5,012,950	5,012,950	5,569,945	5,569,945	5,569,945	5,569,945
Expensed Maintenance Cost	**93,708,153**	2,015,961	2,028,677	2,041,674	2,054,955	2,068,525	2,082,387	2,096,545	2,111,002	2,125,763	2,140,832	2,156,213	2,171,909	2,187,926	2,204,267	2,220,937	2,237,941	2,255,281	2,272,965	2,290,994	2,309,376	2,328,114	2,347,213	2,366,678	2,386,515
PTC System Maintenance Cost	**8,800,000**	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000
Fuel Cost	**131,690,832**	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271	3,292,271
Total O&M Costs	779,989,788	*15,990,601*	*17,435,589*	*17,448,586*	*17,461,867*	*17,475,437*	*18,227,139*	*18,241,297*	*18,255,754*	*18,270,516*	*18,285,585*	*18,579,462*	*18,595,159*	*18,611,176*	*18,627,517*	*18,644,187*	*18,939,687*	*18,957,028*	*18,974,711*	*18,992,741*	*19,011,123*	*19,586,855*	*19,605,954*	*19,625,420*	*19,645,256*

Scenario C-2	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
O&M Costs																									
Route Costs	**437,681,062**	10,583,787	10,583,787	10,583,787	10,583,787	10,583,787	10,583,787	10,583,787	10,583,787	10,583,787	10,583,787	10,813,115	10,813,115	10,813,115	10,813,115	10,813,115	10,813,115	10,813,115	10,813,115	10,813,115	10,813,115	11,066,583	11,066,583	11,066,583	11,066,583
Car and Locomotive Maintenance Cost	**281,680,057**	2,983,899	4,774,238	4,774,238	4,774,238	4,774,238	4,774,238	4,774,238	4,774,238	4,774,238	4,774,238	6,087,154	6,087,154	6,087,154	6,087,154	6,087,154	6,445,222	6,445,222	6,445,222	6,445,222	6,445,222	8,354,917	8,354,917	8,354,917	8,354,917
Expensed Maintenance Cost	**102,687,902**	2,280,773	2,291,285	2,302,089	2,313,190	2,324,590	2,336,294	2,348,305	2,360,627	2,373,263	2,386,219	2,399,497	2,413,102	2,427,038	2,441,308	2,455,919	2,470,872	2,486,174	2,501,828	2,517,840	2,534,213	2,550,952	2,568,062	2,585,548	2,603,415
PTC System Maintenance Cost	**8,800,000**	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000
Fuel Cost	**197,536,248**	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406	4,938,406
Total O&M Costs	1,028,385,268	*21,006,865*	*22,807,716*	*22,818,521*	*22,829,621*	*22,841,022*	*22,852,725*	*22,864,736*	*22,877,058*	*22,889,695*	*22,902,650*	*24,458,172*	*24,471,777*	*24,485,713*	*24,499,984*	*24,514,594*	*24,887,615*	*24,902,917*	*24,918,571*	*24,934,583*	*24,950,956*	*27,130,857*	*27,147,968*	*27,165,454*	*27,183,321*

Scenario C-10	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
O&M Costs																									
Route Costs	**219,027,101**	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678	5,475,678
Car and Locomotive Maintenance Cost	**101,512,241**	1,392,486	2,227,978	2,227,978	2,227,978	2,227,978	2,227,978	2,227,978	2,227,978	2,227,978	2,227,978	2,367,226	2,367,226	2,367,226	2,367,226	2,367,226	2,506,475	2,506,475	2,506,475	2,506,475	2,506,475	2,784,972	2,784,972	2,784,972	2,784,972
Expensed Maintenance Cost	**84,452,658**	1,751,301	1,765,885	1,780,737	1,795,860	1,811,259	1,826,936	1,842,895	1,859,142	1,875,679	1,892,511	1,909,641	1,927,075	1,944,816	1,962,869	1,981,238	1,999,928	2,018,943	2,038,288	2,057,967	2,077,986	2,098,348	2,119,060	2,140,126	2,161,551
PTC System Maintenance Cost	**8,800,000**	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000
Fuel Cost	**65,845,416**	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135	1,646,135
Total O&M Costs	479,637,416	*10,485,600*	*11,335,676*	*11,350,528*	*11,365,651*	*11,381,049*	*11,396,727*	*11,412,686*	*11,428,933*	*11,445,470*	*11,462,301*	*11,618,681*	*11,636,115*	*11,653,856*	*11,671,909*	*11,690,278*	*11,848,216*	*11,867,231*	*11,886,576*	*11,906,255*	*11,926,274*	*12,225,134*	*12,245,845*	*12,266,911*	*12,288,336*

Scenario C-11	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
O&M Costs																									
Route Costs	**530,369,377**	12,875,278	12,875,278	12,875,278	12,875,278	12,875,278	12,875,278	12,875,278	12,875,278	12,875,278	12,875,278	13,118,370	13,118,370	13,118,370	13,118,370	13,118,370	13,118,370	13,118,370	13,118,370	13,118,370	13,118,370	13,396,887	13,396,887	13,396,887	13,396,887
Car and Locomotive Maintenance Cost	**391,487,536**	3,978,532	6,365,651	6,365,651	6,365,651	6,365,651	6,365,651	6,365,651	6,365,651	6,365,651	6,365,651	8,116,205	8,116,205	8,116,205	8,116,205	8,116,205	8,593,629	8,593,629	8,593,629	8,593,629	8,593,629	11,139,889	11,139,889	11,139,889	11,139,889
Expensed Maintenance Cost	**132,501,570**	3,117,446	3,122,988	3,128,847	3,135,024	3,141,524	3,148,350	3,155,506	3,162,996	3,170,824	3,178,993	3,187,508	3,196,372	3,205,589	3,215,165	3,225,102	3,235,405	3,246,078	3,257,127	3,268,554	3,280,365	3,292,565	3,305,157	3,318,147	3,331,540
PTC System Maintenance Cost	**8,800,000**	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000
Fuel Cost	**263,381,664**	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542	6,584,542
Total O&M Costs	1,326,540,147	*26,775,797*	*29,168,459*	*29,174,317*	*29,180,494*	*29,186,994*	*29,193,821*	*29,200,977*	*29,208,467*	*29,216,295*	*29,224,464*	*31,226,624*	*31,235,488*	*31,244,706*	*31,254,281*	*31,264,218*	*31,751,945*	*31,762,619*	*31,773,667*	*31,785,094*	*31,796,906*	*34,633,882*	*34,646,475*	*34,659,465*	*34,672,858*

Scenario B-1	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
O&M Costs																									
Route Costs	**367,172,771**	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	8,840,347	9,518,292	9,518,292	9,518,292	9,518,292
Car and Locomotive Maintenance Cost	**218,938,609**	2,784,972	4,455,956	4,455,956	4,455,956	4,455,956	4,455,956	4,455,956	4,455,956	4,455,956	4,455,956	4,734,453	4,734,453	4,734,453	4,734,453	4,734,453	5,012,950	5,012,950	5,012,950	5,012,950	5,012,950	6,365,651	6,365,651	6,365,651	6,365,651
Expensed Maintenance Cost	**250,000,025**	5,176,094	5,220,068	5,264,806	5,310,321	5,356,622	5,403,721	5,451,628	5,500,356	5,549,916	5,600,320	5,651,579	5,703,705	5,756,712	5,810,611	5,865,415	5,921,137	5,977,791	6,035,388	6,093,944	6,153,470	6,213,982	6,275,494	6,338,019	6,401,573
PTC System Maintenance Cost	**8,800,000**	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000
Fuel Cost	**143,605,717**	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143	3,590,143
Total O&M Costs	988,517,122	*20,611,556*	*22,326,513*	*22,371,252*	*22,416,766*	*22,463,067*	*22,510,166*	*22,558,074*	*22,606,802*	*22,656,362*	*22,706,765*	*23,036,521*	*23,088,648*	*23,141,655*	*23,195,554*	*23,250,358*	*23,584,577*	*23,641,231*	*23,698,828*	*23,757,384*	*23,816,910*	*25,908,068*	*25,969,580*	*26,032,105*	*26,095,658*

Scenario B-2	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
O&M Costs																									
Route Costs	**438,325,022**	10,695,392	10,695,392	10,695,392	10,695,392	10,695,392	10,676,764	10,676,764	10,676,764	10,676,764	10,676,764	10,676,764	10,676,764	10,676,764	10,676,764	10,676,764	10,937,879	10,937,879	10,937,879	10,937,879	10,937,879	10,937,879	10,937,879	10,937,879	10,937,879
Car and Locomotive Maintenance Cost	**297,793,111**	2,983,899	4,774,238	4,774,238	4,774,238	4,774,238	5,729,086	5,729,086	5,729,086	5,729,086	5,729,086	6,087,154	6,087,154	6,087,154	6,087,154	6,087,154	7,519,425	7,519,425	7,519,425	7,519,425	7,519,425	8,354,917	8,354,917	8,354,917	8,354,917
Expensed Maintenance Cost	**259,599,269**	5,467,672	5,508,852	5,550,810	5,593,557	5,637,103	5,681,460	5,726,638	5,772,649	5,819,504	5,867,215	5,915,793	5,965,251	6,015,600	6,066,852	6,119,022	6,172,120	6,226,160	6,281,156	6,337,119	6,394,065	6,452,006	6,510,956	6,570,930	6,631,942
PTC System Maintenance Cost	**8,800,000**	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000
Fuel Cost	**215,408,575**	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214	5,385,214
Total O&M Costs	1,219,925,977	*24,752,178*	*26,583,697*	*26,625,655*	*26,668,402*	*26,711,949*	*27,692,525*	*27,737,703*	*27,783,714*	*27,830,569*	*27,878,280*	*28,284,926*	*28,334,383*	*28,384,732*	*28,435,985*	*28,488,154*	*30,234,639*	*30,288,679*	*30,343,675*	*30,399,638*	*30,456,584*	*31,350,017*	*31,408,967*	*31,468,941*	*31,529,953*

Scenario B-10	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
O&M Costs																									
Route Costs	**224,703,650**	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275	5,550,275
Car and Locomotive Maintenance Cost	**105,490,773**	1,392,486	2,227,978	2,227,978	2,227,978	2,227,978	2,227,978	2,227,978	2,227,978	2,227,978	2,227,978	2,367,226	2,367,226	2,367,226	2,367,226	2,367,226	2,506,475	2,506,475	2,506,475	2,506,475	2,506,475	2,784,972	2,784,972	2,784,972	2,784,972
Track Maintenance Cost	**237,317,547**	4,819,256	4,865,462	4,912,418	4,960,133	5,008,619	5,057,887	5,107,949	5,158,815	5,210,498	5,263,009	5,316,360	5,370,563	5,425,632	5,481,577	5,538,413	5,596,152	5,654,806	5,714,391	5,774,918	5,836,403	5,898,858	5,962,298	6,026,737	6,092,190
Expensed Maintenance Cost	**8,800,000**	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000
PTC System Maintenance Cost	**71,802,858**	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071	1,795,071
Total O&M Costs	648,114,828	*13,777,088*	*14,658,786*	*14,705,742*	*14,753,457*	*14,801,943*	*14,851,211*	*14,901,273*	*14,952,139*	*15,003,822*	*15,056,333*	*15,248,932*	*15,303,136*	*15,358,204*	*15,414,150*	*15,470,985*	*15,667,973*	*15,726,628*	*15,786,212*	*15,846,740*	*15,908,224*	*16,249,176*	*16,312,616*	*16,377,055*	*16,442,509*

Scenario B-11	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
O&M Costs																									
Route Costs	**534,871,750**	12,906,584	12,906,584	12,906,584	12,906,584	12,906,584	13,121,454	13,121,454	13,121,454	13,121,454	13,121,454	13,121,454	13,121,454	13,121,454	13,121,454	13,121,454	13,304,893	13,304,893	13,304,893	13,304,893	13,304,893	13,304,893	13,304,893	13,304,893	13,304,893
Car and Locomotive Maintenance Cost	**412,971,608**	3,978,532	6,365,651	6,365,651	6,365,651	6,365,651	7,638,781	7,638,781	7,638,781	7,638,781	7,638,781	8,116,205	8,116,205	8,116,205	8,116,205	8,116,205	10,025,900	10,025,900	10,025,900	10,025,900	10,025,900	11,139,889	11,139,889	11,139,889	11,139,889
Expensed Maintenance Cost	**303,166,760**	6,680,685	6,715,230	6,750,577	6,786,736	6,823,719	6,861,536	6,900,198	6,939,715	6,980,101	7,021,364	7,063,519	7,106,575	7,150,546	7,195,442	7,241,278	7,288,064	7,335,814	7,384,541	7,434,257	7,484,977	7,536,713	7,589,479	7,643,289	7,698,157
PTC System Maintenance Cost	**8,800,000**	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000
Fuel Cost	**287,211,434**	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286	7,180,286
Total O&M Costs	1,547,021,552	*30,966,087*	*33,387,751*	*33,423,098*	*33,459,257*	*33,496,240*	*35,022,057*	*35,060,718*	*35,100,236*	*35,140,621*	*35,181,885*	*35,701,463*	*35,744,520*	*35,788,490*	*35,833,387*	*35,879,222*	*38,019,143*	*38,066,893*	*38,115,620*	*38,165,336*	*38,216,056*	*39,381,780*	*39,434,547*	*39,488,357*	*39,543,225*

2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 8,176,526	$ 8,657,871	$ 8,657,871	$ 8,657,871	$ 8,657,871	$ 8,657,871	$ 8,657,871	$ 8,657,871	$ 8,657,871	$ 8,657,871	$ 8,657,871	$ 8,657,871	$ 8,657,871	$ 8,657,871	$ 8,657,871	$ 8,657,871
$ 5,569,945	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651
$ 2,406,727	$ 2,427,321	$ 2,448,302	$ 2,469,674	$ 2,491,444	$ 2,513,617	$ 2,536,198	$ 2,559,194	$ 2,582,609	$ 2,606,450	$ 2,630,723	$ 2,655,433	$ 2,680,588	$ 2,706,193	$ 2,732,254	$ 2,758,778
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 3,292,271	$ 3,292,271	$ 3,292,271	$ 3,292,271	$ 3,292,271	$ 3,292,271	$ 3,292,271	$ 3,292,271	$ 3,292,271	$ 3,292,271	$ 3,292,271	$ 3,292,271	$ 3,292,271	$ 3,292,271	$ 3,292,271	$ 3,292,271
$ 19,665,469	***$ 20,963,114***	***$ 20,984,095***	***$ 21,005,467***	***$ 21,027,237***	***$ 21,049,410***	***$ 21,071,991***	***$ 21,094,986***	***$ 21,118,402***	***$ 21,142,243***	***$ 21,166,516***	***$ 21,191,226***	***$ 21,216,381***	***$ 21,241,985***	***$ 21,268,047***	***$ 21,294,571***

2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 11,066,583	$ 11,066,583	$ 11,066,583	$ 11,066,583	$ 11,066,583	$ 11,066,583	$ 11,066,583	$ 11,066,583	$ 11,066,583	$ 11,066,583	$ 11,066,583	$ 11,542,660	$ 11,542,660	$ 11,542,660	$ 11,542,660	$ 11,542,660
$ 8,354,917	$ 8,354,917	$ 8,354,917	$ 8,354,917	$ 8,354,917	$ 8,354,917	$ 8,354,917	$ 8,354,917	$ 8,354,917	$ 8,354,917	$ 8,354,917	$ 9,548,476	$ 9,548,476	$ 9,548,476	$ 9,548,476	$ 9,548,476
$ 2,621,667	$ 2,640,311	$ 2,659,350	$ 2,678,791	$ 2,698,638	$ 2,718,896	$ 2,739,573	$ 2,760,672	$ 2,782,199	$ 2,804,161	$ 2,826,564	$ 2,849,412	$ 2,872,712	$ 2,896,471	$ 2,920,694	$ 2,945,388
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 4,938,406	$ 4,938,406	$ 4,938,406	$ 4,938,406	$ 4,938,406	$ 4,938,406	$ 4,938,406	$ 4,938,406	$ 4,938,406	$ 4,938,406	$ 4,938,406	$ 4,938,406	$ 4,938,406	$ 4,938,406	$ 4,938,406	$ 4,938,406
$ 27,201,573	***$ 27,220,217***	***$ 27,239,256***	***$ 27,258,696***	***$ 27,278,543***	***$ 27,298,802***	***$ 27,319,478***	***$ 27,340,577***	***$ 27,362,105***	***$ 27,384,067***	***$ 27,406,469***	***$ 29,098,955***	***$ 29,122,255***	***$ 29,146,014***	***$ 29,170,237***	***$ 29,194,931***

2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 5,475,678	$ 5,475,678	$ 5,475,678	$ 5,475,678	$ 5,475,678	$ 5,475,678	$ 5,475,678	$ 5,475,678	$ 5,475,678	$ 5,475,678	$ 5,475,678	$ 5,475,678	$ 5,475,678	$ 5,475,678	$ 5,475,678	$ 5,475,678
$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972
$ 2,183,340	$ 2,205,499	$ 2,228,032	$ 2,250,946	$ 2,274,246	$ 2,297,937	$ 2,322,025	$ 2,346,515	$ 2,371,414	$ 2,396,728	$ 2,422,462	$ 2,448,623	$ 2,475,216	$ 2,502,249	$ 2,529,727	$ 2,557,657
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 1,646,135	$ 1,646,135	$ 1,646,135	$ 1,646,135	$ 1,646,135	$ 1,646,135	$ 1,646,135	$ 1,646,135	$ 1,646,135	$ 1,646,135	$ 1,646,135	$ 1,646,135	$ 1,646,135	$ 1,646,135	$ 1,646,135	$ 1,646,135
$ 12,310,125	***$ 12,332,284***	***$ 12,354,818***	***$ 12,377,731***	***$ 12,401,031***	***$ 12,424,722***	***$ 12,448,810***	***$ 12,473,300***	***$ 12,498,199***	***$ 12,523,513***	***$ 12,549,247***	***$ 12,575,408***	***$ 12,602,001***	***$ 12,629,034***	***$ 12,656,512***	***$ 12,684,442***

2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 13,396,887	$ 13,396,887	$ 13,396,887	$ 13,396,887	$ 13,396,887	$ 13,396,887	$ 13,715,992	$ 13,715,992	$ 13,715,992	$ 13,715,992	$ 13,715,992	$ 13,576,814	$ 13,576,814	$ 13,576,814	$ 13,576,814	$ 13,576,814
$ 11,139,889	$ 11,139,889	$ 11,139,889	$ 11,139,889	$ 11,139,889	$ 11,139,889	$ 12,731,302	$ 12,731,302	$ 12,731,302	$ 12,731,302	$ 12,731,302	$ 14,322,715	$ 14,322,715	$ 14,322,715	$ 14,322,715	$ 14,322,715
$ 3,345,341	$ 3,359,553	$ 3,374,183	$ 3,389,236	$ 3,404,716	$ 3,420,629	$ 3,436,981	$ 3,453,777	$ 3,471,022	$ 3,488,722	$ 3,506,882	$ 3,525,509	$ 3,544,609	$ 3,564,187	$ 3,584,250	$ 3,604,803
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 6,584,542	$ 6,584,542	$ 6,584,542	$ 6,584,542	$ 6,584,542	$ 6,584,542	$ 6,584,542	$ 6,584,542	$ 6,584,542	$ 6,584,542	$ 6,584,542	$ 6,584,542	$ 6,584,542	$ 6,584,542	$ 6,584,542	$ 6,584,542
$ 34,686,658	***$ 34,700,871***	***$ 34,715,501***	***$ 34,730,553***	***$ 34,746,034***	***$ 34,761,947***	***$ 36,688,816***	***$ 36,705,612***	***$ 36,722,857***	***$ 36,740,557***	***$ 36,758,718***	***$ 38,229,580***	***$ 38,248,679***	***$ 38,268,257***	***$ 38,288,320***	***$ 38,308,873***

2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 9,518,292	$ 9,518,292	$ 9,518,292	$ 9,518,292	$ 9,518,292	$ 9,518,292	$ 9,518,292	$ 9,518,292	$ 9,518,292	$ 9,518,292	$ 9,518,292	$ 9,518,292	$ 9,518,292	$ 9,518,292	$ 9,518,292	$ 9,518,292
$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651	$ 6,365,651
$ 6,466,169	$ 6,531,824	$ 6,598,551	$ 6,666,368	$ 6,735,288	$ 6,805,329	$ 6,876,506	$ 6,948,835	$ 7,022,334	$ 7,097,019	$ 7,172,908	$ 7,250,017	$ 7,328,365	$ 7,407,970	$ 7,488,849	$ 7,571,021
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 3,590,143	$ 3,590,143	$ 3,590,143	$ 3,590,143	$ 3,590,143	$ 3,590,143	$ 3,590,143	$ 3,590,143	$ 3,590,143	$ 3,590,143	$ 3,590,143	$ 3,590,143	$ 3,590,143	$ 3,590,143	$ 3,590,143	$ 3,590,143
$ 26,160,255	***$ 26,225,909***	***$ 26,292,637***	***$ 26,360,453***	***$ 26,429,374***	***$ 26,499,414***	***$ 26,570,591***	***$ 26,642,921***	***$ 26,716,420***	***$ 26,791,105***	***$ 26,866,994***	***$ 26,944,103***	***$ 27,022,451***	***$ 27,102,055***	***$ 27,182,934***	***$ 27,265,106***

2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 10,937,879	$ 10,937,879	$ 10,937,879	$ 10,937,879	$ 10,937,879	$ 10,937,879	$ 11,401,222	$ 11,401,222	$ 11,401,222	$ 11,401,222	$ 11,401,222	$ 11,401,222	$ 11,401,222	$ 11,401,222	$ 11,401,222	$ 11,401,222
$ 8,354,917	$ 8,354,917	$ 8,354,917	$ 8,354,917	$ 8,354,917	$ 8,354,917	$ 9,548,476	$ 9,548,476	$ 9,548,476	$ 9,548,476	$ 9,548,476	$ 9,548,476	$ 9,548,476	$ 9,548,476	$ 9,548,476	$ 9,548,476
$ 6,694,007	$ 6,757,139	$ 6,821,353	$ 6,886,665	$ 6,953,089	$ 7,020,643	$ 7,089,341	$ 7,159,201	$ 7,230,237	$ 7,302,468	$ 7,375,910	$ 7,450,580	$ 7,526,496	$ 7,603,675	$ 7,682,136	$ 7,761,897
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 5,385,214	$ 5,385,214	$ 5,385,214	$ 5,385,214	$ 5,385,214	$ 5,385,214	$ 5,385,214	$ 5,385,214	$ 5,385,214	$ 5,385,214	$ 5,385,214	$ 5,385,214	$ 5,385,214	$ 5,385,214	$ 5,385,214	$ 5,385,214
$ 31,592,018	***$ 31,655,150***	***$ 31,719,364***	***$ 31,784,675***	***$ 31,851,100***	***$ 31,918,654***	***$ 33,644,255***	***$ 33,714,114***	***$ 33,785,150***	***$ 33,857,381***	***$ 33,930,823***	***$ 34,005,493***	***$ 34,081,409***	***$ 34,158,588***	***$ 34,237,049***	***$ 34,316,810***

2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 5,550,275	$ 5,550,275	$ 5,550,275	$ 5,550,275	$ 5,550,275	$ 5,550,275	$ 5,819,541	$ 5,819,541	$ 5,819,541	$ 5,819,541	$ 5,819,541	$ 5,819,541	$ 5,819,541	$ 5,819,541	$ 5,819,541	$ 5,819,541
$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 2,784,972	$ 3,182,825	$ 3,182,825	$ 3,182,825	$ 3,182,825	$ 3,182,825	$ 3,182,825	$ 3,182,825	$ 3,182,825	$ 3,182,825	$ 3,182,825
$ 6,158,672	$ 6,226,198	$ 6,294,783	$ 6,364,442	$ 6,435,192	$ 6,507,048	$ 6,580,026	$ 6,654,144	$ 6,729,417	$ 6,805,863	$ 6,883,499	$ 6,962,342	$ 7,042,411	$ 7,123,723	$ 7,206,296	$ 7,290,149
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 1,795,071	$ 1,795,071	$ 1,795,071	$ 1,795,071	$ 1,795,071	$ 1,795,071	$ 1,795,071	$ 1,795,071	$ 1,795,071	$ 1,795,071	$ 1,795,071	$ 1,795,071	$ 1,795,071	$ 1,795,071	$ 1,795,071	$ 1,795,071
$ 16,508,990	***$ 16,576,516***	***$ 16,645,101***	***$ 16,714,760***	***$ 16,785,510***	***$ 16,857,366***	***$ 17,597,464***	***$ 17,671,582***	***$ 17,746,855***	***$ 17,823,301***	***$ 17,900,937***	***$ 17,979,780***	***$ 18,059,849***	***$ 18,141,161***	***$ 18,223,734***	***$ 18,307,587***

2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 13,304,893	$ 13,618,707	$ 13,618,707	$ 13,618,707	$ 13,618,707	$ 13,618,707	$ 13,618,707	$ 13,618,707	$ 13,618,707	$ 13,618,707	$ 13,618,707	$ 13,977,660	$ 13,977,660	$ 13,977,660	$ 13,977,660	$ 13,977,660
$ 11,139,889	$ 12,731,302	$ 12,731,302	$ 12,731,302	$ 12,731,302	$ 12,731,302	$ 12,731,302	$ 12,731,302	$ 12,731,302	$ 12,731,302	$ 12,731,302	$ 14,322,715	$ 14,322,715	$ 14,322,715	$ 14,322,715	$ 14,322,715
$ 7,754,098	$ 7,811,126	$ 7,869,256	$ 7,928,502	$ 7,988,881	$ 8,050,407	$ 8,113,096	$ 8,176,964	$ 8,242,028	$ 8,308,303	$ 8,375,807	$ 8,444,556	$ 8,514,567	$ 8,585,858	$ 8,658,447	$ 8,732,351
$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
$ 7,180,286	$ 7,180,286	$ 7,180,286	$ 7,180,286	$ 7,180,286	$ 7,180,286	$ 7,180,286	$ 7,180,286	$ 7,180,286	$ 7,180,286	$ 7,180,286	$ 7,180,286	$ 7,180,286	$ 7,180,286	$ 7,180,286	$ 7,180,286
$ 39,599,166	***$ 41,561,421***	***$ 41,619,550***	***$ 41,678,797***	***$ 41,739,176***	***$ 41,800,702***	***$ 41,863,391***	***$ 41,927,259***	***$ 41,992,323***	***$ 42,058,598***	***$ 42,126,101***	***$ 44,145,216***	***$ 44,215,227***	***$ 44,286,519***	***$ 44,359,107***	***$ 44,433,012***

APPENDIX E. Summary of NLX Cyclic Capital Costs for 2020 through 2059

NLX Cyclic Capital Costs - 2020 through 2059
Target Field - Duluth
SDG May 2015 Ridership and Revenue Forecasting Results
2014$

Scenario C-1	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Cyclic Capital Cost	**$ 55,923,954**	$ 287,226	$ 288,790	$ 290,391	$ 511,055	$ 513,992	$ 516,998	$ 742,962	$ 747,455	$ 752,050	$ 1,135,121	$ 1,142,323	$ 1,149,682	$ 1,542,935	$ 1,553,175	$ 1,563,634	$ 1,574,313	$ 1,585,215	$ 1,596,343	$ 1,607,700
Cyclic Capital Cost - Equipment	**$ 62,899,200**										$ 14,817,600									
Total Cyclic Capital Cost	***$ 118,823,154***	***$ 287,226***	***$ 288,790***	***$ 290,391***	***$ 511,055***	***$ 513,992***	***$ 516,998***	***$ 742,962***	***$ 747,455***	***$ 752,050***	***$ 15,952,721***	***$ 1,142,323***	***$ 1,149,682***	***$ 1,542,935***	***$ 1,553,175***	***$ 1,563,634***	***$ 1,574,313***	***$ 1,585,215***	***$ 1,596,343***	***$ 1,607,700***

Scenario C-2	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Cyclic Capital Cost	**$ 62,927,084**	$ 335,354	$ 336,603	$ 337,893	$ 593,642	$ 596,045	$ 598,521	$ 858,675	$ 862,427	$ 866,289	$ 1,305,391	$ 1,311,516	$ 1,317,810	$ 1,765,700	$ 1,774,551	$ 1,783,634	$ 1,792,953	$ 1,802,511	$ 1,812,310	$ 1,822,352
Cyclic Capital Cost - Equipment	**$ 74,188,800**										$ 14,918,400									
Total Cyclic Capital Cost	***$ 137,115,884***	***$ 335,354***	***$ 336,603***	***$ 337,893***	***$ 593,642***	***$ 596,045***	***$ 598,521***	***$ 858,675***	***$ 862,427***	***$ 866,289***	***$ 16,223,791***	***$ 1,311,516***	***$ 1,317,810***	***$ 1,765,700***	***$ 1,774,551***	***$ 1,783,634***	***$ 1,792,953***	***$ 1,802,511***	***$ 1,812,310***	***$ 1,822,352***

Scenario C-10	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Cyclic Capital Cost	**$ 50,365,980**	$ 247,790	$ 249,657	$ 251,558	$ 443,618	$ 447,072	$ 450,591	$ 648,822	$ 654,037	$ 659,347	$ 997,132	$ 1,005,390	$ 1,013,797	$ 1,363,142	$ 1,374,757	$ 1,386,580	$ 1,398,613	$ 1,410,858	$ 1,423,318	$ 1,435,997
Cyclic Capital Cost - Equipment	**$ 39,513,600**										$ 9,878,400									
Total Cyclic Capital Cost	***$ 89,879,580***	***$ 247,790***	***$ 249,657***	***$ 251,558***	***$ 443,618***	***$ 447,072***	***$ 450,591***	***$ 648,822***	***$ 654,037***	***$ 659,347***	***$ 10,875,532***	***$ 1,005,390***	***$ 1,013,797***	***$ 1,363,142***	***$ 1,374,757***	***$ 1,386,580***	***$ 1,398,613***	***$ 1,410,858***	***$ 1,423,318***	***$ 1,435,997***

Scenario C-11	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Cyclic Capital Cost	**$ 81,804,334**	$ 465,487	$ 465,916	$ 466,390	$ 817,094	$ 818,086	$ 819,160	$ 1,171,882	$ 1,173,656	$ 1,175,550	$ 1,766,350	$ 1,769,559	$ 1,772,955	$ 2,368,719	$ 2,373,752	$ 2,379,042	$ 2,384,590	$ 2,390,400	$ 2,396,473	$ 2,402,813
Cyclic Capital Cost - Equipment	**$ 114,004,800**										$ 22,377,600									
Total Cyclic Capital Cost	***$ 195,809,134***	***$ 465,487***	***$ 465,916***	***$ 466,390***	***$ 817,094***	***$ 818,086***	***$ 819,160***	***$ 1,171,882***	***$ 1,173,656***	***$ 1,175,550***	***$ 24,143,950***	***$ 1,769,559***	***$ 1,772,955***	***$ 2,368,719***	***$ 2,373,752***	***$ 2,379,042***	***$ 2,384,590***	***$ 2,390,400***	***$ 2,396,473***	***$ 2,402,813***

Scenario B-1	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Cyclic Capital Cost	**$ 94,397,978**	$ 458,462	$ 462,205	$ 466,014	$ 822,311	$ 829,218	$ 836,247	$ 1,204,858	$ 1,215,258	$ 1,225,839	$ 1,854,909	$ 1,871,340	$ 1,888,057	$ 2,540,084	$ 2,563,150	$ 2,586,612	$ 2,610,476	$ 2,634,748	$ 2,659,434	$ 2,684,539
Cyclic Capital Cost - Equipment	**$ 62,899,200**										$ 14,817,600									
Total Cyclic Capital Cost	***$ 157,297,178***	***$ 458,462***	***$ 462,205***	***$ 466,014***	***$ 822,311***	***$ 829,218***	***$ 836,247***	***$ 1,204,858***	***$ 1,215,258***	***$ 1,225,839***	***$ 16,672,509***	***$ 1,871,340***	***$ 1,888,057***	***$ 2,540,084***	***$ 2,563,150***	***$ 2,586,612***	***$ 2,610,476***	***$ 2,634,748***	***$ 2,659,434***	***$ 2,684,539***

Scenario B-2	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Cyclic Capital Cost	**$ 100,626,227**	$ 498,948	$ 502,511	$ 506,144	$ 892,234	$ 898,842	$ 905,578	$ 1,303,489	$ 1,313,483	$ 1,323,667	$ 2,001,063	$ 2,016,919	$ 2,033,070	$ 2,732,696	$ 2,755,037	$ 2,777,789	$ 2,800,958	$ 2,824,548	$ 2,848,567	$ 2,873,020
Cyclic Capital Cost - Equipment	**$ 98,784,000**										$ 21,672,000									
Total Cyclic Capital Cost	***$ 199,410,227***	***$ 498,948***	***$ 502,511***	***$ 506,144***	***$ 892,234***	***$ 898,842***	***$ 905,578***	***$ 1,303,489***	***$ 1,313,483***	***$ 1,323,667***	***$ 23,673,063***	***$ 2,016,919***	***$ 2,033,070***	***$ 2,732,696***	***$ 2,755,037***	***$ 2,777,789***	***$ 2,800,958***	***$ 2,824,548***	***$ 2,848,567***	***$ 2,873,020***

Scenario B-10	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Cyclic Capital Cost	**$ 89,309,112**	$ 423,352	$ 427,321	$ 431,356	$ 762,050	$ 769,345	$ 776,759	$ 1,120,422	$ 1,131,364	$ 1,142,484	$ 1,730,677	$ 1,747,904	$ 1,765,410	$ 2,377,599	$ 2,401,701	$ 2,426,192	$ 2,451,078	$ 2,476,363	$ 2,502,054	$ 2,528,157
Cyclic Capital Cost - Equipment	**$ 40,723,200**										$ 9,878,400									
Total Cyclic Capital Cost	***$ 130,032,312***	***$ 423,352***	***$ 427,321***	***$ 431,356***	***$ 762,050***	***$ 769,345***	***$ 776,759***	***$ 1,120,422***	***$ 1,131,364***	***$ 1,142,484***	***$ 11,609,077***	***$ 1,747,904***	***$ 1,765,410***	***$ 2,377,599***	***$ 2,401,701***	***$ 2,426,192***	***$ 2,451,078***	***$ 2,476,363***	***$ 2,502,054***	***$ 2,528,157***

Scenario B-11	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Cyclic Capital Cost	**$ 119,441,222**	$ 624,265	$ 627,224	$ 630,257	$ 1,108,388	$ 1,113,958	$ 1,119,661	$ 1,607,855	$ 1,616,390	$ 1,625,123	$ 2,451,083	$ 2,464,787	$ 2,478,798	$ 3,324,161	$ 3,343,680	$ 3,363,626	$ 3,384,003	$ 3,404,819	$ 3,426,077	$ 3,447,785
Cyclic Capital Cost - Equipment	**$ 130,334,400**										$ 26,460,000									
Total Cyclic Capital Cost	***$ 249,775,622***	***$ 624,265***	***$ 627,224***	***$ 630,257***	***$ 1,108,388***	***$ 1,113,958***	***$ 1,119,661***	***$ 1,607,855***	***$ 1,616,390***	***$ 1,625,123***	***$ 28,911,083***	***$ 2,464,787***	***$ 2,478,798***	***$ 3,324,161***	***$ 3,343,680***	***$ 3,363,626***	***$ 3,384,003***	***$ 3,404,819***	***$ 3,426,077***	***$ 3,447,785***

2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 1,619,289	$ 1,631,112	$ 1,643,173	$ 1,655,474	$ 1,668,018	$ 1,680,810	$ 1,693,850	$ 1,707,144	$ 1,720,694	$ 1,734,503	$ 1,748,575	$ 1,762,912	$ 1,777,520	$ 1,792,400	$ 1,807,556	$ 1,822,993	$ 1,838,713	$ 1,854,721	$ 1,871,019	$ 1,887,613	$ 1,904,506
$ 14,817,600										$ 16,632,000										$ 16,632,000
$ 16,436,889	***$ 1,631,112***	***$ 1,643,173***	***$ 1,655,474***	***$ 1,668,018***	***$ 1,680,810***	***$ 1,693,850***	***$ 1,707,144***	***$ 1,720,694***	***$ 1,734,503***	***$ 18,380,575***	***$ 1,762,912***	***$ 1,777,520***	***$ 1,792,400***	***$ 1,807,556***	***$ 1,822,993***	***$ 1,838,713***	***$ 1,854,721***	***$ 1,871,019***	***$ 1,887,613***	***$ 18,536,506***

2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 1,832,641	$ 1,843,180	$ 1,853,971	$ 1,865,017	$ 1,876,322	$ 1,887,888	$ 1,899,719	$ 1,911,817	$ 1,924,186	$ 1,936,829	$ 1,949,750	$ 1,962,951	$ 1,976,436	$ 1,990,208	$ 2,004,272	$ 2,018,630	$ 2,033,286	$ 2,048,244	$ 2,063,508	$ 2,079,081	$ 2,094,967
$ 17,337,600										$ 19,756,800										$ 22,176,000
$ 19,170,241	***$ 1,843,180***	***$ 1,853,971***	***$ 1,865,017***	***$ 1,876,322***	***$ 1,887,888***	***$ 1,899,719***	***$ 1,911,817***	***$ 1,924,186***	***$ 1,936,829***	***$ 21,706,550***	***$ 1,962,951***	***$ 1,976,436***	***$ 1,990,208***	***$ 2,004,272***	***$ 2,018,630***	***$ 2,033,286***	***$ 2,048,244***	***$ 2,063,508***	***$ 2,079,081***	***$ 24,270,967***

2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 1,448,896	$ 1,462,020	$ 1,475,370	$ 1,488,951	$ 1,502,765	$ 1,516,815	$ 1,531,104	$ 1,545,636	$ 1,560,415	$ 1,575,442	$ 1,590,723	$ 1,606,259	$ 1,622,055	$ 1,638,114	$ 1,654,440	$ 1,671,037	$ 1,687,908	$ 1,705,056	$ 1,722,486	$ 1,740,202	$ 1,758,208
$ 9,878,400										$ 9,878,400										$ 9,878,400
$ 11,327,296	***$ 1,462,020***	***$ 1,475,370***	***$ 1,488,951***	***$ 1,502,765***	***$ 1,516,815***	***$ 1,531,104***	***$ 1,545,636***	***$ 1,560,415***	***$ 1,575,442***	***$ 11,469,123***	***$ 1,606,259***	***$ 1,622,055***	***$ 1,638,114***	***$ 1,654,440***	***$ 1,671,037***	***$ 1,687,908***	***$ 1,705,056***	***$ 1,722,486***	***$ 1,740,202***	***$ 11,636,608***

2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 2,409,423	$ 2,416,305	$ 2,423,461	$ 2,430,895	$ 2,438,610	$ 2,446,609	$ 2,454,893	$ 2,463,467	$ 2,472,334	$ 2,481,496	$ 2,490,957	$ 2,500,720	$ 2,510,789	$ 2,521,165	$ 2,531,854	$ 2,542,858	$ 2,554,180	$ 2,565,825	$ 2,577,795	$ 2,590,095	$ 2,602,728
$ 26,460,000										$ 30,542,400										$ 34,624,800
$ 28,869,423	***$ 2,416,305***	***$ 2,423,461***	***$ 2,430,895***	***$ 2,438,610***	***$ 2,446,609***	***$ 2,454,893***	***$ 2,463,467***	***$ 2,472,334***	***$ 2,481,496***	***$ 33,033,357***	***$ 2,500,720***	***$ 2,510,789***	***$ 2,521,165***	***$ 2,531,854***	***$ 2,542,858***	***$ 2,554,180***	***$ 2,565,825***	***$ 2,577,795***	***$ 2,590,095***	***$ 37,227,528***

2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 2,710,069	$ 2,736,031	$ 2,762,430	$ 2,789,272	$ 2,816,565	$ 2,844,313	$ 2,872,525	$ 2,901,206	$ 2,930,362	$ 2,960,002	$ 2,990,131	$ 3,020,757	$ 3,051,887	$ 3,083,528	$ 3,115,688	$ 3,148,373	$ 3,181,591	$ 3,215,351	$ 3,249,659	$ 3,284,524	$ 3,319,953
$ 14,817,600										$ 16,632,000										$ 16,632,000
$ 17,527,669	***$ 2,736,031***	***$ 2,762,430***	***$ 2,789,272***	***$ 2,816,565***	***$ 2,844,313***	***$ 2,872,525***	***$ 2,901,206***	***$ 2,930,362***	***$ 2,960,002***	***$ 19,622,131***	***$ 3,020,757***	***$ 3,051,887***	***$ 3,083,528***	***$ 3,115,688***	***$ 3,148,373***	***$ 3,181,591***	***$ 3,215,351***	***$ 3,249,659***	***$ 3,284,524***	***$ 19,951,953***

2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 2,897,913	$ 2,923,251	$ 2,949,041	$ 2,975,290	$ 3,002,003	$ 3,029,187	$ 3,056,849	$ 3,084,995	$ 3,113,631	$ 3,142,765	$ 3,172,404	$ 3,202,554	$ 3,233,223	$ 3,264,418	$ 3,296,146	$ 3,328,415	$ 3,361,232	$ 3,394,606	$ 3,428,543	$ 3,463,053	$ 3,498,142
$ 24,696,000										$ 24,696,000										$ 27,720,000
$ 27,593,913	***$ 2,923,251***	***$ 2,949,041***	***$ 2,975,290***	***$ 3,002,003***	***$ 3,029,187***	***$ 3,056,849***	***$ 3,084,995***	***$ 3,113,631***	***$ 3,142,765***	***$ 27,868,404***	***$ 3,202,554***	***$ 3,233,223***	***$ 3,264,418***	***$ 3,296,146***	***$ 3,328,415***	***$ 3,361,232***	***$ 3,394,606***	***$ 3,428,543***	***$ 3,463,053***	***$ 31,218,142***

2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 2,554,677	$ 2,581,621	$ 2,608,995	$ 2,636,805	$ 2,665,058	$ 2,693,759	$ 2,722,916	$ 2,752,534	$ 2,782,622	$ 2,813,184	$ 2,844,230	$ 2,875,765	$ 2,907,796	$ 2,940,332	$ 2,973,379	$ 3,006,945	$ 3,041,037	$ 3,075,663	$ 3,110,831	$ 3,146,549	$ 3,182,825
$ 9,878,400										$ 9,878,400										$ 11,088,000
$ 12,433,077	***$ 2,581,621***	***$ 2,608,995***	***$ 2,636,805***	***$ 2,665,058***	***$ 2,693,759***	***$ 2,722,916***	***$ 2,752,534***	***$ 2,782,622***	***$ 2,813,184***	***$ 12,722,630***	***$ 2,875,765***	***$ 2,907,796***	***$ 2,940,332***	***$ 2,973,379***	***$ 3,006,945***	***$ 3,041,037***	***$ 3,075,663***	***$ 3,110,831***	***$ 3,146,549***	***$ 14,270,825***

2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
$ 3,469,948	$ 3,492,571	$ 3,515,662	$ 3,539,225	$ 3,563,268	$ 3,587,796	$ 3,612,816	$ 3,638,334	$ 3,664,357	$ 3,690,892	$ 3,717,945	$ 3,745,523	$ 3,773,634	$ 3,802,283	$ 3,831,480	$ 3,861,230	$ 3,891,542	$ 3,922,422	$ 3,953,879	$ 3,985,920	$ 4,018,553
$ 30,542,400										$ 34,624,800										$ 38,707,200
$ 34,012,348	***$ 3,492,571***	***$ 3,515,662***	***$ 3,539,225***	***$ 3,563,268***	***$ 3,587,796***	***$ 3,612,816***	***$ 3,638,334***	***$ 3,664,357***	***$ 3,690,892***	***$ 38,342,745***	***$ 3,745,523***	***$ 3,773,634***	***$ 3,802,283***	***$ 3,831,480***	***$ 3,861,230***	***$ 3,891,542***	***$ 3,922,422***	***$ 3,953,879***	***$ 3,985,920***	***$ 42,725,753***

APPENDIX F. Summary of NLX Operating Budget for 2020 through 2059

NLX Operating Budget - 2020 through 2059
Target Field - Duluth
SDG May 2015 Ridership and Revenue Forecasting Results

2014$

Scenario C-1	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Revenues																								
Total Revenue	**$ 580,808,980**	$ 8,915,199	$ 10,163,548	$ 11,443,651	$ 11,596,486	$ 11,751,361	$ 11,908,305	$ 12,067,346	$ 12,228,510	$ 12,391,826	$ 12,557,324	$ 12,725,032	$ 12,894,980	$ 13,067,198	$ 13,241,716	$ 13,418,565	$ 13,597,775	$ 13,779,379	$ 13,963,409	$ 14,149,896	$ 14,338,874	$ 14,530,376	$ 14,724,435	$ 14,921,087
Expensed Maintenance Costs																								
Total Expensed Maintenance Costs	**$ 102,508,153**	$ 2,235,961	$ 2,248,677	$ 2,261,674	$ 2,274,955	$ 2,288,525	$ 2,302,387	$ 2,316,545	$ 2,331,002	$ 2,345,763	$ 2,360,832	$ 2,376,213	$ 2,391,909	$ 2,407,926	$ 2,424,267	$ 2,440,937	$ 2,457,941	$ 2,475,281	$ 2,492,965	$ 2,510,994	$ 2,529,376	$ 2,548,114	$ 2,567,213	$ 2,586,678
PRIIA Section 209 Costs																								
Total PRIIA Section 209 Costs	**$ 677,481,635**	$ 13,754,640	$ 15,186,912	$ 15,186,912	$ 15,186,912	$ 15,186,912	$ 15,924,753	$ 15,924,753	$ 15,924,753	$ 15,924,753	$ 15,924,753	$ 16,203,250	$ 16,203,250	$ 16,203,250	$ 16,203,250	$ 16,203,250	$ 16,481,747	$ 16,481,747	$ 16,481,747	$ 16,481,747	$ 16,481,747	$ 17,038,741	$ 17,038,741	$ 17,038,741
Capital Replacement Costs																								
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	**$ 55,923,954**	$ 287,226	$ 288,790	$ 290,391	$ 511,055	$ 513,992	$ 516,998	$ 742,962	$ 747,455	$ 752,050	$ 1,135,121	$ 1,142,323	$ 1,149,682	$ 1,542,935	$ 1,553,175	$ 1,563,634	$ 1,574,313	$ 1,585,215	$ 1,596,343	$ 1,607,700	$ 1,619,289	$ 1,631,112	$ 1,643,173	$ 1,655,474
Total Operating Budget	**$ 835,913,741**	$ 16,277,827	$ 17,724,378	$ 17,738,977	$ 17,972,922	$ 17,989,429	$ 18,744,137	$ 18,984,259	$ 19,003,210	$ 19,022,566	$ 19,420,706	$ 19,721,785	$ 19,744,841	$ 20,154,111	$ 20,180,693	$ 20,207,821	$ 20,514,000	$ 20,542,243	$ 20,571,054	$ 20,600,441	$ 20,630,412	$ 21,217,967	$ 21,249,127	$ 21,280,893
Operating Surplus	**$ (255,104,761)**	$ (7,362,628)	$ (7,560,830)	$ (6,295,325)	$ (6,376,436)	$ (6,238,068)	$ (6,835,832)	$ (6,916,913)	$ (6,774,700)	$ (6,630,739)	$ (6,863,382)	$ (6,996,753)	$ (6,849,861)	$ (7,086,913)	$ (6,938,977)	$ (6,789,256)	$ (6,916,225)	$ (6,762,864)	$ (6,607,646)	$ (6,450,545)	$ (6,291,538)	$ (6,687,591)	$ (6,524,692)	$ (6,359,807)

Scenario C-1	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
Revenues																	
Total Revenue	$ 15,120,364	$ 15,322,304	$ 15,526,940	$ 15,734,309	$ 15,944,448	$ 16,157,393	$ 16,373,183	$ 16,591,854	$ 16,813,446	$ 17,037,998	$ 17,265,548	$ 17,496,138	$ 17,729,807	$ 17,966,597	$ 18,206,550	$ 18,449,707	$ 18,696,112
Expensed Maintenance Costs																	
Total Expensed Maintenance Costs	$ 2,606,515	$ 2,626,727	$ 2,647,321	$ 2,668,302	$ 2,689,674	$ 2,711,444	$ 2,733,617	$ 2,756,198	$ 2,779,194	$ 2,802,609	$ 2,826,450	$ 2,850,723	$ 2,875,433	$ 2,900,588	$ 2,926,193	$ 2,952,254	$ 2,978,778
PRIIA Section 209 Costs																	
Total PRIIA Section 209 Costs	$ 17,038,741	$ 17,038,741	$ 18,315,793	$ 18,315,793	$ 18,315,793	$ 18,315,793	$ 18,315,793	$ 18,315,793	$ 18,315,793	$ 18,315,793	$ 18,315,793	$ 18,315,793	$ 18,315,793	$ 18,315,793	$ 18,315,793	$ 18,315,793	$ 18,315,793
Capital Replacement Costs																	
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	$ 1,668,018	$ 1,680,810	$ 1,693,850	$ 1,707,144	$ 1,720,694	$ 1,734,503	$ 1,748,575	$ 1,762,912	$ 1,777,520	$ 1,792,400	$ 1,807,556	$ 1,822,993	$ 1,838,713	$ 1,854,721	$ 1,871,019	$ 1,887,613	$ 1,904,506
Total Operating Expenses	$ 21,313,274	$ 21,346,278	$ 22,656,964	$ 22,691,239	$ 22,726,161	$ 22,761,740	$ 22,797,984	$ 22,834,903	$ 22,872,506	$ 22,910,802	$ 22,949,799	$ 22,989,509	$ 23,029,939	$ 23,071,102	$ 23,113,005	$ 23,155,660	$ 23,199,076
Operating Surplus	$ (6,192,910)	$ (6,023,974)	$ (7,130,024)	$ (6,956,929)	$ (6,781,713)	$ (6,604,346)	$ (6,424,802)	$ (6,243,049)	$ (6,059,060)	$ (5,872,804)	$ (5,684,251)	$ (5,493,371)	$ (5,300,132)	$ (5,104,504)	$ (4,906,455)	$ (4,705,952)	$ (4,502,964)

NLX Operating Budget - 2020 through 2059
Target Field - Duluth
SDG May 2015 Ridership and Revenue Forecasting Results

2014$

Scenario C-2	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Revenues																								
Total Revenue	**$ 637,070,730**	$ 9,779,387	$ 11,148,712	$ 12,552,862	$ 12,720,474	$ 12,890,325	$ 13,062,443	$ 13,236,860	$ 13,413,606	$ 13,592,711	$ 13,774,209	$ 13,958,129	$ 14,144,506	$ 14,333,371	$ 14,524,758	$ 14,718,701	$ 14,915,233	$ 15,114,389	$ 15,316,205	$ 15,520,716	$ 15,727,957	$ 15,937,966	$ 16,150,778	$ 16,366,433
Expensed Maintenance Costs																								
Total Expensed Maintenance Costs	**$ 111,487,902**	$ 2,500,773	$ 2,511,285	$ 2,522,089	$ 2,533,190	$ 2,544,590	$ 2,556,294	$ 2,568,305	$ 2,580,627	$ 2,593,263	$ 2,606,219	$ 2,619,497	$ 2,633,102	$ 2,647,038	$ 2,661,308	$ 2,675,919	$ 2,690,872	$ 2,706,174	$ 2,721,828	$ 2,737,840	$ 2,754,213	$ 2,770,952	$ 2,788,062	$ 2,805,548
PRIIA Section 209 Costs																								
Total PRIIA Section 209 Costs	**$ 916,897,366**	$ 18,506,092	$ 20,296,431	$ 20,296,431	$ 20,296,431	$ 20,296,431	$ 20,296,431	$ 20,296,431	$ 20,296,431	$ 20,296,431	$ 20,296,431	$ 21,838,675	$ 21,838,675	$ 21,838,675	$ 21,838,675	$ 21,838,675	$ 22,196,743	$ 22,196,743	$ 22,196,743	$ 22,196,743	$ 22,196,743	$ 24,359,906	$ 24,359,906	$ 24,359,906
Capital Replacement Costs																								
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	**$ 62,927,084**	$ 335,354	$ 336,603	$ 337,893	$ 593,642	$ 596,045	$ 598,521	$ 858,675	$ 862,427	$ 866,289	$ 1,305,391	$ 1,311,516	$ 1,317,810	$ 1,765,700	$ 1,774,551	$ 1,783,634	$ 1,792,953	$ 1,802,511	$ 1,812,310	$ 1,822,352	$ 1,832,641	$ 1,843,180	$ 1,853,971	$ 1,865,017
Total Operating Expenses	**$ 1,091,312,352**	$ 21,342,219	$ 23,144,319	$ 23,156,414	$ 23,423,263	$ 23,437,066	$ 23,451,247	$ 23,723,411	$ 23,739,486	$ 23,755,984	$ 24,208,041	$ 25,769,688	$ 25,789,587	$ 26,251,413	$ 26,274,534	$ 26,298,228	$ 26,680,569	$ 26,705,428	$ 26,730,881	$ 26,756,935	$ 26,783,597	$ 28,974,037	$ 29,001,939	$ 29,030,471
Operating Surplus	**$ (454,241,622)**	$ (11,562,832)	$ (11,995,607)	$ (10,603,552)	$ (10,702,789)	$ (10,546,742)	$ (10,388,803)	$ (10,486,551)	$ (10,325,880)	$ (10,163,273)	$ (10,433,833)	$ (11,811,559)	$ (11,645,081)	$ (11,918,042)	$ (11,749,776)	$ (11,579,527)	$ (11,765,336)	$ (11,591,039)	$ (11,414,676)	$ (11,236,219)	$ (11,055,640)	$ (13,036,072)	$ (12,851,160)	$ (12,664,038)

Scenario C-2	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
Revenues																	
Total Revenue	$ 16,584,967	$ 16,806,419	$ 17,030,828	$ 17,258,234	$ 17,488,676	$ 17,722,195	$ 17,958,832	$ 18,198,629	$ 18,441,628	$ 18,687,871	$ 18,937,403	$ 19,190,267	$ 19,446,507	$ 19,706,168	$ 19,969,297	$ 20,235,939	$ 20,506,142
Expensed Maintenance Costs																	
Total Expensed Maintenance Costs	$ 2,823,415	$ 2,841,667	$ 2,860,311	$ 2,879,350	$ 2,898,791	$ 2,918,638	$ 2,938,896	$ 2,959,573	$ 2,980,672	$ 3,002,199	$ 3,024,161	$ 3,046,564	$ 3,069,412	$ 3,092,712	$ 3,116,471	$ 3,140,694	$ 3,165,388
PRIIA Section 209 Costs																	
Total PRIIA Section 209 Costs	$ 24,359,906	$ 24,359,906	$ 24,359,906	$ 24,359,906	$ 24,359,906	$ 24,359,906	$ 24,359,906	$ 24,359,906	$ 24,359,906	$ 24,359,906	$ 24,359,906	$ 24,359,906	$ 26,029,543	$ 26,029,543	$ 26,029,543	$ 26,029,543	$ 26,029,543
Capital Replacement Costs																	
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	$ 1,876,322	$ 1,887,888	$ 1,899,719	$ 1,911,817	$ 1,924,186	$ 1,936,829	$ 1,949,750	$ 1,962,951	$ 1,976,436	$ 1,990,208	$ 2,004,272	$ 2,018,630	$ 2,033,286	$ 2,048,244	$ 2,063,508	$ 2,079,081	$ 2,094,967
Total Operating Expenses	$ 29,059,643	$ 29,089,462	$ 29,119,936	$ 29,151,073	$ 29,182,883	$ 29,215,373	$ 29,248,552	$ 29,282,429	$ 29,317,013	$ 29,352,314	$ 29,388,339	$ 29,425,099	$ 31,132,241	$ 31,170,500	$ 31,209,522	$ 31,249,318	$ 31,289,898
Operating Surplus	$ (12,474,676)	$ (12,283,043)	$ (12,089,108)	$ (11,892,840)	$ (11,694,207)	$ (11,493,178)	$ (11,289,720)	$ (11,083,800)	$ (10,875,386)	$ (10,664,442)	$ (10,450,936)	$ (10,234,833)	$ (11,685,735)	$ (11,464,332)	$ (11,240,225)	$ (11,013,379)	$ (10,783,756)

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Scenario C-10	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Revenues																								
Total Revenue	**$ 325,588,680**	$ 5,515,367	$ 6,258,319	$ 7,013,679	$ 7,074,189	$ 7,135,221	$ 7,196,779	$ 7,258,869	$ 7,321,494	$ 7,384,659	$ 7,448,369	$ 7,512,629	$ 7,577,443	$ 7,642,817	$ 7,708,755	$ 7,775,261	$ 7,842,341	$ 7,910,000	$ 7,978,243	$ 8,047,074	$ 8,116,499	$ 8,186,523	$ 8,257,152	$ 8,328,389
Expensed Maintenance Costs																								
Total Expensed Maintenance Costs	**$ 93,252,658**	$ 1,971,301	$ 1,985,885	$ 2,000,737	$ 2,015,860	$ 2,031,259	$ 2,046,936	$ 2,062,895	$ 2,079,142	$ 2,095,679	$ 2,112,511	$ 2,129,641	$ 2,147,075	$ 2,164,816	$ 2,182,869	$ 2,201,238	$ 2,219,928	$ 2,238,943	$ 2,258,288	$ 2,277,967	$ 2,297,986	$ 2,318,348	$ 2,339,060	$ 2,360,126
PRIIA Section 209 Costs																								
Total PRIIA Section 209 Costs	**$ 386,384,758**	$ 8,514,299	$ 9,349,791	$ 9,349,791	$ 9,349,791	$ 9,349,791	$ 9,349,791	$ 9,349,791	$ 9,349,791	$ 9,349,791	$ 9,349,791	$ 9,489,039	$ 9,489,039	$ 9,489,039	$ 9,489,039	$ 9,489,039	$ 9,628,288	$ 9,628,288	$ 9,628,288	$ 9,628,288	$ 9,628,288	$ 9,906,785	$ 9,906,785	$ 9,906,785
Capital Replacement Costs																								
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	**$ 50,365,980**	$ 247,790	$ 249,657	$ 251,558	$ 443,618	$ 447,072	$ 450,591	$ 648,822	$ 654,037	$ 659,347	$ 997,132	$ 1,005,390	$ 1,013,797	$ 1,363,142	$ 1,374,757	$ 1,386,580	$ 1,398,613	$ 1,410,858	$ 1,423,318	$ 1,435,997	$ 1,448,896	$ 1,462,020	$ 1,475,370	$ 1,488,951
Total Operating Expenses	**$ 530,003,396**	$ 10,733,390	$ 11,585,333	$ 11,602,086	$ 11,809,269	$ 11,828,122	$ 11,847,318	$ 12,061,508	$ 12,082,969	$ 12,104,817	$ 12,459,433	$ 12,624,071	$ 12,649,912	$ 13,016,997	$ 13,046,666	$ 13,076,858	$ 13,246,829	$ 13,278,089	$ 13,309,894	$ 13,342,252	$ 13,375,170	$ 13,687,153	$ 13,721,216	$ 13,755,862
Operating Surplus	**$ (204,414,715)**	$ (5,218,023)	$ (5,327,014)	$ (4,588,407)	$ (4,735,080)	$ (4,692,901)	$ (4,650,539)	$ (4,802,640)	$ (4,761,476)	$ (4,720,158)	$ (5,011,064)	$ (5,111,442)	$ (5,072,469)	$ (5,374,180)	$ (5,337,912)	$ (5,301,597)	$ (5,404,488)	$ (5,368,089)	$ (5,331,652)	$ (5,295,178)	$ (5,258,671)	$ (5,500,630)	$ (5,464,064)	$ (5,427,473)

Scenario C-10	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
Revenues																	
Total Revenue	$ 8,400,241	$ 8,472,714	$ 8,545,811	$ 8,619,539	$ 8,693,903	$ 8,768,909	$ 8,844,561	$ 8,920,867	$ 8,997,831	$ 9,075,458	$ 9,153,756	$ 9,232,729	$ 9,312,383	$ 9,392,725	$ 9,473,759	$ 9,555,493	$ 9,637,932
Expensed Maintenance Costs																	
Total Expensed Maintenance Costs	$ 2,381,551	$ 2,403,340	$ 2,425,499	$ 2,448,032	$ 2,470,946	$ 2,494,246	$ 2,517,937	$ 2,542,025	$ 2,566,515	$ 2,591,414	$ 2,616,728	$ 2,642,462	$ 2,668,623	$ 2,695,216	$ 2,722,249	$ 2,749,727	$ 2,777,657
PRIIA Section 209 Costs																	
Total PRIIA Section 209 Costs	$ 9,906,785	$ 9,906,785	$ 9,906,785	$ 9,906,785	$ 9,906,785	$ 9,906,785	$ 9,906,785	$ 9,906,785	$ 9,906,785	$ 9,906,785	$ 9,906,785	$ 9,906,785	$ 9,906,785	$ 9,906,785	$ 9,906,785	$ 9,906,785	$ 9,906,785
Capital Replacement Costs																	
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	$ 1,502,765	$ 1,516,815	$ 1,531,104	$ 1,545,636	$ 1,560,415	$ 1,575,442	$ 1,590,723	$ 1,606,259	$ 1,622,055	$ 1,638,114	$ 1,654,440	$ 1,671,037	$ 1,687,908	$ 1,705,056	$ 1,722,486	$ 1,740,202	$ 1,758,208
Total Operating Expenses	$ 13,791,101	$ 13,826,940	$ 13,863,388	$ 13,900,454	$ 13,938,146	$ 13,976,473	$ 14,015,444	$ 14,055,069	$ 14,095,355	$ 14,136,314	$ 14,177,953	$ 14,220,284	$ 14,263,315	$ 14,307,058	$ 14,351,521	$ 14,396,715	$ 14,442,650
Operating Surplus	$ (5,390,859)	$ (5,354,226)	$ (5,317,577)	$ (5,280,915)	$ (5,244,243)	$ (5,207,565)	$ (5,170,883)	$ (5,134,202)	$ (5,097,525)	$ (5,060,855)	$ (5,024,198)	$ (4,987,555)	$ (4,950,932)	$ (4,914,333)	$ (4,877,761)	$ (4,841,221)	$ (4,804,718)

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Scenario C-11	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Revenues																								
Total Revenue	**$ 674,320,521**	$ 10,332,789	$ 11,780,583	$ 13,265,418	$ 13,443,664	$ 13,624,304	$ 13,807,372	$ 13,992,900	$ 14,180,920	$ 14,371,468	$ 14,564,575	$ 14,760,277	$ 14,958,609	$ 15,159,606	$ 15,363,304	$ 15,569,739	$ 15,778,947	$ 15,990,967	$ 16,205,836	$ 16,423,592	$ 16,644,274	$ 16,867,921	$ 17,094,573	$ 17,324,271
Expensed Maintenance Costs																								
Total Expensed Maintenance Costs	**$ 141,301,570**	$ 3,337,446	$ 3,342,988	$ 3,348,847	$ 3,355,024	$ 3,361,524	$ 3,368,350	$ 3,375,506	$ 3,382,996	$ 3,390,824	$ 3,398,993	$ 3,407,508	$ 3,416,372	$ 3,425,589	$ 3,435,165	$ 3,445,102	$ 3,455,405	$ 3,466,078	$ 3,477,127	$ 3,488,554	$ 3,500,365	$ 3,512,565	$ 3,525,157	$ 3,538,147
PRIIA Section 209 Costs																								
Total PRIIA Section 209 Costs	**$ 1,185,238,577**	$ 23,438,351	$ 25,825,471	$ 25,825,471	$ 25,825,471	$ 25,825,471	$ 25,825,471	$ 25,825,471	$ 25,825,471	$ 25,825,471	$ 25,825,471	$ 27,819,117	$ 27,819,117	$ 27,819,117	$ 27,819,117	$ 27,819,117	$ 28,296,540	$ 28,296,540	$ 28,296,540	$ 28,296,540	$ 28,296,540	$ 31,121,318	$ 31,121,318	$ 31,121,318
Capital Replacement Costs																								
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	**$ 81,804,334**	$ 465,487	$ 465,916	$ 466,390	$ 817,094	$ 818,086	$ 819,160	$ 1,171,882	$ 1,173,656	$ 1,175,550	$ 1,766,350	$ 1,769,559	$ 1,772,955	$ 2,368,719	$ 2,373,752	$ 2,379,042	$ 2,384,590	$ 2,390,400	$ 2,396,473	$ 2,402,813	$ 2,409,423	$ 2,416,305	$ 2,423,461	$ 2,430,895
Total Operating Expenses	**$ 1,408,344,482**	$ 27,241,285	$ 29,634,375	$ 29,640,707	$ 29,997,588	$ 30,005,080	$ 30,012,981	$ 30,372,859	$ 30,382,123	$ 30,391,845	$ 30,990,813	$ 32,996,183	$ 33,008,443	$ 33,613,425	$ 33,628,034	$ 33,643,260	$ 34,136,535	$ 34,153,018	$ 34,170,140	$ 34,187,908	$ 34,206,328	$ 37,050,187	$ 37,069,936	$ 37,090,361
Operating Surplus	**$ (734,023,960)**	$ (16,908,496)	$ (17,853,792)	$ (16,375,289)	$ (16,553,924)	$ (16,380,776)	$ (16,205,609)	$ (16,379,959)	$ (16,201,202)	$ (16,020,377)	$ (16,426,238)	$ (18,235,906)	$ (18,049,834)	$ (18,453,819)	$ (18,264,730)	$ (18,073,522)	$ (18,357,588)	$ (18,162,051)	$ (17,964,304)	$ (17,764,316)	$ (17,562,055)	$ (20,182,266)	$ (19,975,363)	$ (19,766,090)

Scenario C-11	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
Revenues																	
Total Revenue	$ 17,557,055	$ 17,792,968	$ 18,032,050	$ 18,274,345	$ 18,519,896	$ 18,768,746	$ 19,020,940	$ 19,276,522	$ 19,535,539	$ 19,798,036	$ 20,064,061	$ 20,333,660	$ 20,606,882	$ 20,883,775	$ 21,164,389	$ 21,448,773	$ 21,736,978
Expensed Maintenance Costs																	
Total Expensed Maintenance Costs	$ 3,551,540	$ 3,565,341	$ 3,579,553	$ 3,594,183	$ 3,609,236	$ 3,624,716	$ 3,640,629	$ 3,656,981	$ 3,673,777	$ 3,691,022	$ 3,708,722	$ 3,726,882	$ 3,745,509	$ 3,764,609	$ 3,784,187	$ 3,804,250	$ 3,824,803
PRIIA Section 209 Costs																	
Total PRIIA Section 209 Costs	$ 31,121,318	$ 31,121,318	$ 31,121,318	$ 31,121,318	$ 31,121,318	$ 31,121,318	$ 31,121,318	$ 33,031,835	$ 33,031,835	$ 33,031,835	$ 33,031,835	$ 33,031,835	$ 34,484,070	$ 34,484,070	$ 34,484,070	$ 34,484,070	$ 34,484,070
Capital Replacement Costs																	
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	$ 2,438,610	$ 2,446,609	$ 2,454,893	$ 2,463,467	$ 2,472,334	$ 2,481,496	$ 2,490,957	$ 2,500,720	$ 2,510,789	$ 2,521,165	$ 2,531,854	$ 2,542,858	$ 2,554,180	$ 2,565,825	$ 2,577,795	$ 2,590,095	$ 2,602,728
Total Operating Expenses	$ 37,111,468	$ 37,133,267	$ 37,155,764	$ 37,178,968	$ 37,202,888	$ 37,227,530	$ 37,252,905	$ 39,189,537	$ 39,216,401	$ 39,244,022	$ 39,272,411	$ 39,301,575	$ 40,783,760	$ 40,814,504	$ 40,846,053	$ 40,878,415	$ 40,911,601
Operating Surplus	$ (19,554,413)	$ (19,340,299)	$ (19,123,714)	$ (18,904,623)	$ (18,682,992)	$ (18,458,785)	$ (18,231,965)	$ (19,913,015)	$ (19,680,862)	$ (19,445,986)	$ (19,208,350)	$ (18,967,915)	$ (20,176,878)	$ (19,930,729)	$ (19,681,664)	$ (19,429,642)	$ (19,174,623)

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Scenario B-1	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Revenues																								
Total Revenue	**$ 630,855,292**	$ 9,724,987	$ 11,084,503	$ 12,478,097	$ 12,642,211	$ 12,808,483	$ 12,976,941	$ 13,147,616	$ 13,320,535	$ 13,495,729	$ 13,673,226	$ 13,853,059	$ 14,035,256	$ 14,219,850	$ 14,406,871	$ 14,596,353	$ 14,788,326	$ 14,982,825	$ 15,179,881	$ 15,379,530	$ 15,581,804	$ 15,786,739	$ 15,994,369	$ 16,204,729
Expensed Maintenance Costs																								
Total Expensed Maintenance Costs	**$ 258,800,025**	$ 5,396,094	$ 5,440,068	$ 5,484,806	$ 5,530,321	$ 5,576,622	$ 5,623,721	$ 5,671,628	$ 5,720,356	$ 5,769,916	$ 5,820,320	$ 5,871,579	$ 5,923,705	$ 5,976,712	$ 6,030,611	$ 6,085,415	$ 6,141,137	$ 6,197,791	$ 6,255,388	$ 6,313,944	$ 6,373,470	$ 6,433,982	$ 6,495,494	$ 6,558,019
PRIIA Section 209 Costs																								
Total PRIIA Section 209 Costs	**$ 729,717,097**	$ 15,215,462	$ 16,886,445	$ 16,886,445	$ 16,886,445	$ 16,886,445	$ 16,886,445	$ 16,886,445	$ 16,886,445	$ 16,886,445	$ 16,886,445	$ 17,164,943	$ 17,164,943	$ 17,164,943	$ 17,164,943	$ 17,164,943	$ 17,443,440	$ 17,443,440	$ 17,443,440	$ 17,443,440	$ 17,443,440	$ 19,474,086	$ 19,474,086	$ 19,474,086
Capital Replacement Costs																								
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	**$ 94,397,978**	$ 458,462	$ 462,205	$ 466,014	$ 822,311	$ 829,218	$ 836,247	$ 1,204,858	$ 1,215,258	$ 1,225,839	$ 1,854,909	$ 1,871,340	$ 1,888,057	$ 2,540,084	$ 2,563,150	$ 2,586,612	$ 2,610,476	$ 2,634,748	$ 2,659,434	$ 2,684,539	$ 2,710,069	$ 2,736,031	$ 2,762,430	$ 2,789,272
Total Operating Expenses	**$ 1,082,915,101**	$ 21,070,018	$ 22,788,718	$ 22,837,266	$ 23,239,077	$ 23,292,285	$ 23,346,413	$ 23,762,932	$ 23,822,059	$ 23,882,201	$ 24,561,674	$ 24,907,862	$ 24,976,705	$ 25,681,739	$ 25,758,703	$ 25,836,970	$ 26,195,053	$ 26,275,979	$ 26,358,262	$ 26,441,922	$ 26,526,979	$ 28,644,099	$ 28,732,009	$ 28,821,377
Operating Surplus	**$ (452,059,808)**	$ (11,345,031)	$ (11,704,215)	$ (10,359,169)	$ (10,596,867)	$ (10,483,803)	$ (10,369,472)	$ (10,615,316)	$ (10,501,524)	$ (10,386,472)	$ (10,888,448)	$ (11,054,803)	$ (10,941,449)	$ (11,461,889)	$ (11,351,832)	$ (11,240,617)	$ (11,406,727)	$ (11,293,154)	$ (11,178,381)	$ (11,062,392)	$ (10,945,175)	$ (12,857,360)	$ (12,737,641)	$ (12,616,648)

Scenario B-1	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
Revenues																	
Total Revenue	$ 16,417,857	$ 16,633,788	$ 16,852,558	$ 17,074,206	$ 17,298,770	$ 17,526,286	$ 17,756,796	$ 17,990,337	$ 18,226,949	$ 18,466,674	$ 18,709,552	$ 18,955,624	$ 19,204,932	$ 19,457,520	$ 19,713,429	$ 19,972,705	$ 20,235,390
Expensed Maintenance Costs																	
Total Expensed Maintenance Costs	$ 6,621,573	$ 6,686,169	$ 6,751,824	$ 6,818,551	$ 6,886,368	$ 6,955,288	$ 7,025,329	$ 7,096,506	$ 7,168,835	$ 7,242,334	$ 7,317,019	$ 7,392,908	$ 7,470,017	$ 7,548,365	$ 7,627,970	$ 7,708,849	$ 7,791,021
PRIIA Section 209 Costs																	
Total PRIIA Section 209 Costs	$ 19,474,086	$ 19,474,086	$ 19,474,086	$ 19,474,086	$ 19,474,086	$ 19,474,086	$ 19,474,086	$ 19,474,086	$ 19,474,086	$ 19,474,086	$ 19,474,086	$ 19,474,086	$ 19,474,086	$ 19,474,086	$ 19,474,086	$ 19,474,086	$ 19,474,086
Capital Replacement Costs																	
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	$ 2,816,565	$ 2,844,313	$ 2,872,525	$ 2,901,206	$ 2,930,362	$ 2,960,002	$ 2,990,131	$ 3,020,757	$ 3,051,887	$ 3,083,528	$ 3,115,688	$ 3,148,373	$ 3,181,591	$ 3,215,351	$ 3,249,659	$ 3,284,524	$ 3,319,953
Total Operating Expenses	$ 28,912,223	$ 29,004,568	$ 29,098,434	$ 29,193,842	$ 29,290,816	$ 29,389,376	$ 29,489,546	$ 29,591,349	$ 29,694,808	$ 29,799,948	$ 29,906,793	$ 30,015,366	$ 30,125,694	$ 30,237,802	$ 30,351,714	$ 30,467,458	$ 30,585,060
Operating Surplus	$ (12,494,366)	$ (12,370,781)	$ (12,245,876)	$ (12,119,636)	$ (11,992,046)	$ (11,863,089)	$ (11,732,750)	$ (11,601,012)	$ (11,467,859)	$ (11,333,274)	$ (11,197,241)	$ (11,059,743)	$ (10,920,762)	$ (10,780,282)	$ (10,638,285)	$ (10,494,753)	$ (10,349,669)

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Scenario B-2	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Revenues																								
Total Revenue	**$ 687,411,844**	$ 10,586,413	$ 12,066,908	$ 13,584,641	$ 13,763,943	$ 13,945,611	$ 14,129,676	$ 14,316,171	$ 14,505,128	$ 14,696,579	$ 14,890,557	$ 15,087,095	$ 15,286,227	$ 15,487,988	$ 15,692,411	$ 15,899,533	$ 16,109,388	$ 16,322,014	$ 16,537,446	$ 16,755,721	$ 16,976,878	$ 17,200,953	$ 17,427,986	$ 17,658,016
Expensed Maintenance Costs																								
Total Expensed Maintenance Costs	**$ 268,399,269**	$ 5,687,672	$ 5,728,852	$ 5,770,810	$ 5,813,557	$ 5,857,103	$ 5,901,460	$ 5,946,638	$ 5,992,649	$ 6,039,504	$ 6,087,215	$ 6,135,793	$ 6,185,251	$ 6,235,600	$ 6,286,852	$ 6,339,022	$ 6,392,120	$ 6,446,160	$ 6,501,156	$ 6,557,119	$ 6,614,065	$ 6,672,006	$ 6,730,956	$ 6,790,930
PRIIA Section 209 Costs																								
Total PRIIA Section 209 Costs	**$ 951,526,708**	$ 19,064,506	$ 20,854,845	$ 20,854,845	$ 20,854,845	$ 20,854,845	$ 21,791,065	$ 21,791,065	$ 21,791,065	$ 21,791,065	$ 21,791,065	$ 22,149,133	$ 22,149,133	$ 22,149,133	$ 22,149,133	$ 22,149,133	$ 23,842,519	$ 23,842,519	$ 23,842,519	$ 23,842,519	$ 23,842,519	$ 24,678,011	$ 24,678,011	$ 24,678,011
Capital Replacement Costs																								
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	**$ 100,626,227**	$ 498,948	$ 502,511	$ 506,144	$ 892,234	$ 898,842	$ 905,578	$ 1,303,489	$ 1,313,483	$ 1,323,667	$ 2,001,063	$ 2,016,919	$ 2,033,070	$ 2,732,696	$ 2,755,037	$ 2,777,789	$ 2,800,958	$ 2,824,548	$ 2,848,567	$ 2,873,020	$ 2,897,913	$ 2,923,251	$ 2,949,041	$ 2,975,290
Total Operating Expenses	**$ 1,320,552,204**	$ 25,251,126	$ 27,086,208	$ 27,131,799	$ 27,560,637	$ 27,610,791	$ 28,598,103	$ 29,041,192	$ 29,097,197	$ 29,154,236	$ 29,879,343	$ 30,301,845	$ 30,367,454	$ 31,117,428	$ 31,191,022	$ 31,265,943	$ 33,035,597	$ 33,113,228	$ 33,192,242	$ 33,272,658	$ 33,354,496	$ 34,273,268	$ 34,358,009	$ 34,444,231
Operating Surplus	**$ (633,140,360)**	$ (14,664,713)	$ (15,019,300)	$ (13,547,158)	$ (13,796,694)	$ (13,665,180)	$ (14,468,427)	$ (14,725,021)	$ (14,592,069)	$ (14,457,657)	$ (14,988,786)	$ (15,214,750)	$ (15,081,227)	$ (15,629,441)	$ (15,498,611)	$ (15,366,410)	$ (16,926,208)	$ (16,791,214)	$ (16,654,796)	$ (16,516,937)	$ (16,377,619)	$ (17,072,314)	$ (16,930,022)	$ (16,786,215)

Scenario B-2	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
Revenues																	
Total Revenue	$ 17,891,082	$ 18,127,224	$ 18,366,483	$ 18,608,900	$ 18,854,517	$ 19,103,376	$ 19,355,519	$ 19,610,990	$ 19,869,834	$ 20,132,094	$ 20,397,815	$ 20,667,044	$ 20,939,826	$ 21,216,209	$ 21,496,240	$ 21,779,967	$ 22,067,439
Expensed Maintenance Costs																	
Total Expensed Maintenance Costs	$ 6,851,942	$ 6,914,007	$ 6,977,139	$ 7,041,353	$ 7,106,665	$ 7,173,089	$ 7,240,643	$ 7,309,341	$ 7,379,201	$ 7,450,237	$ 7,522,468	$ 7,595,910	$ 7,670,580	$ 7,746,496	$ 7,823,675	$ 7,902,136	$ 7,981,897
PRIIA Section 209 Costs																	
Total PRIIA Section 209 Costs	$ 24,678,011	$ 24,678,011	$ 24,678,011	$ 24,678,011	$ 24,678,011	$ 24,678,011	$ 24,678,011	$ 26,334,913	$ 26,334,913	$ 26,334,913	$ 26,334,913	$ 26,334,913	$ 26,334,913	$ 26,334,913	$ 26,334,913	$ 26,334,913	$ 26,334,913
Capital Replacement Costs																	
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	$ 3,002,003	$ 3,029,187	$ 3,056,849	$ 3,084,995	$ 3,113,631	$ 3,142,765	$ 3,172,404	$ 3,202,554	$ 3,233,223	$ 3,264,418	$ 3,296,146	$ 3,328,415	$ 3,361,232	$ 3,394,606	$ 3,428,543	$ 3,463,053	$ 3,498,142
Total Operating Expenses	$ 34,531,956	$ 34,621,205	$ 34,711,998	$ 34,804,358	$ 34,898,306	$ 34,993,865	$ 35,091,057	$ 36,846,808	$ 36,947,337	$ 37,049,568	$ 37,153,527	$ 37,259,238	$ 37,366,725	$ 37,476,015	$ 37,587,132	$ 37,700,102	$ 37,814,952
Operating Surplus	$ (16,640,874)	$ (16,493,981)	$ (16,345,515)	$ (16,195,458)	$ (16,043,789)	$ (15,890,490)	$ (15,735,538)	$ (17,235,818)	$ (17,077,503)	$ (16,917,474)	$ (16,755,712)	$ (16,592,194)	$ (16,426,899)	$ (16,259,806)	$ (16,090,892)	$ (15,920,135)	$ (15,747,513)

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Scenario B-10	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Revenues												
Total Revenue	**$ 354,628,516**	$ 6,013,104	$ 6,822,786	$ 7,645,920	$ 7,711,526	$ 7,777,694	$ 7,844,430	$ 7,911,738	$ 7,979,624	$ 8,048,093	$ 8,117,149	$ 8,186,798
Expensed Maintenance Costs												
Total Expensed Maintenance Costs	**$ 246,117,547**	$ 5,039,256	$ 5,085,462	$ 5,132,418	$ 5,180,133	$ 5,228,619	$ 5,277,887	$ 5,327,949	$ 5,378,815	$ 5,430,498	$ 5,483,009	$ 5,536,360
PRIIA Section 209 Costs												
Total PRIIA Section 209 Costs	**$ 401,997,281**	$ 8,737,832	$ 9,573,324	$ 9,573,324	$ 9,573,324	$ 9,573,324	$ 9,573,324	$ 9,573,324	$ 9,573,324	$ 9,573,324	$ 9,573,324	$ 9,712,573
Capital Replacement Costs												
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	**$ 89,309,112**	$ 423,352	$ 427,321	$ 431,356	$ 762,050	$ 769,345	$ 776,759	$ 1,120,422	$ 1,131,364	$ 1,142,484	$ 1,730,677	$ 1,747,904
Total Operating Expenses	**$ 737,423,940**	$ 14,200,440	$ 15,086,107	$ 15,137,097	$ 15,515,507	$ 15,571,288	$ 15,627,971	$ 16,021,695	$ 16,083,503	$ 16,146,306	$ 16,787,010	$ 16,996,836
Operating Surplus	**$ (382,795,424)**	$ (8,187,336)	$ (8,263,321)	$ (7,491,177)	$ (7,803,981)	$ (7,793,594)	$ (7,783,541)	$ (8,109,957)	$ (8,103,878)	$ (8,098,213)	$ (8,669,861)	$ (8,810,039)

Scenario B-10	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Revenues												
Total Revenue	$ 8,257,044	$ 8,327,893	$ 8,399,350	$ 8,471,420	$ 8,544,108	$ 8,617,420	$ 8,691,361	$ 8,765,937	$ 8,841,152	$ 8,917,013	$ 8,993,525	$ 9,070,693
Expensed Maintenance Costs												
Total Expensed Maintenance Costs	$ 5,590,563	$ 5,645,632	$ 5,701,577	$ 5,758,413	$ 5,816,152	$ 5,874,806	$ 5,934,391	$ 5,994,918	$ 6,056,403	$ 6,118,858	$ 6,182,298	$ 6,246,737
PRIIA Section 209 Costs												
Total PRIIA Section 209 Costs	$ 9,712,573	$ 9,712,573	$ 9,712,573	$ 9,712,573	$ 9,851,821	$ 9,851,821	$ 9,851,821	$ 9,851,821	$ 9,851,821	$ 10,130,318	$ 10,130,318	$ 10,130,318
Capital Replacement Costs												
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	$ 1,765,410	$ 2,377,599	$ 2,401,701	$ 2,426,192	$ 2,451,078	$ 2,476,363	$ 2,502,054	$ 2,528,157	$ 2,554,677	$ 2,581,621	$ 2,608,995	$ 2,636,805
Total Operating Expenses	$ 17,068,546	$ 17,735,803	$ 17,815,851	$ 17,897,178	$ 18,119,050	$ 18,202,991	$ 18,288,266	$ 18,374,896	$ 18,462,901	$ 18,830,797	$ 18,921,611	$ 19,013,861
Operating Surplus	$ (8,811,502)	$ (9,407,910)	$ (9,416,501)	$ (9,425,758)	$ (9,574,942)	$ (9,585,570)	$ (9,596,905)	$ (9,608,960)	$ (9,621,749)	$ (9,913,784)	$ (9,928,086)	$ (9,943,167)

Scenario B-10	2043	2044	2045	2046	2047	2048	2049	2050	2051
Revenues									
Total Revenue	$ 9,148,524	$ 9,227,022	$ 9,306,194	$ 9,386,045	$ 9,466,581	$ 9,547,808	$ 9,629,732	$ 9,712,360	$ 9,795,696
Expensed Maintenance Costs									
Total Expensed Maintenance Costs	$ 6,312,190	$ 6,378,672	$ 6,446,198	$ 6,514,783	$ 6,584,442	$ 6,655,192	$ 6,727,048	$ 6,800,026	$ 6,874,144
PRIIA Section 209 Costs									
Total PRIIA Section 209 Costs	$ 10,130,318	$ 10,130,318	$ 10,130,318	$ 10,130,318	$ 10,130,318	$ 10,130,318	$ 10,130,318	$ 10,797,438	$ 10,797,438
Capital Replacement Costs									
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	$ 2,665,058	$ 2,693,759	$ 2,722,916	$ 2,752,534	$ 2,782,622	$ 2,813,184	$ 2,844,230	$ 2,875,765	$ 2,907,796
Total Operating Expenses	$ 19,107,566	$ 19,202,749	$ 19,299,432	$ 19,397,635	$ 19,497,382	$ 19,598,695	$ 19,701,596	$ 20,473,229	$ 20,579,378
Operating Surplus	$ (9,959,043)	$ (9,975,728)	$ (9,993,238)	$ (10,011,591)	$ (10,030,801)	$ (10,050,886)	$ (10,071,864)	$ (10,760,870)	$ (10,783,683)

Scenario B-10	2052	2053	2054	2055	2056	2057	2058	2059
Revenues								
Total Revenue	$ 9,879,747	$ 9,964,519	$ 10,050,019	$ 10,136,253	$ 10,223,226	$ 10,310,946	$ 10,399,418	$ 10,488,650
Expensed Maintenance Costs								
Total Expensed Maintenance Costs	$ 6,949,417	$ 7,025,863	$ 7,103,499	$ 7,182,342	$ 7,262,411	$ 7,343,723	$ 7,426,296	$ 7,510,149
PRIIA Section 209 Costs								
Total PRIIA Section 209 Costs	$ 10,797,438	$ 10,797,438	$ 10,797,438	$ 10,797,438	$ 10,797,438	$ 10,797,438	$ 10,797,438	$ 10,797,438
Capital Replacement Costs								
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	$ 2,940,332	$ 2,973,379	$ 3,006,945	$ 3,041,037	$ 3,075,663	$ 3,110,831	$ 3,146,549	$ 3,182,825
Total Operating Expenses	$ 20,687,187	$ 20,796,680	$ 20,907,882	$ 21,020,817	$ 21,135,512	$ 21,251,992	$ 21,370,283	$ 21,490,413
Operating Surplus	$ (10,807,440)	$ (10,832,161)	$ (10,857,863)	$ (10,884,565)	$ (10,912,286)	$ (10,941,046)	$ (10,970,865)	$ (11,001,763)

NLX Operating Budget - 2020 through 2059
Target Field - Duluth
SDG May 2015 Ridership and Revenue Forecasting Results

2014$

Scenario B-11	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Revenues												
Total Revenue	**$ 721,097,322**	$ 11,092,437	$ 12,644,379	$ 14,235,510	$ 14,424,177	$ 14,615,345	$ 14,809,046	$ 15,005,315	$ 15,204,185	$ 15,405,691	$ 15,609,867	$ 15,816,749
Expensed Maintenance Costs												
Total Expensed Maintenance Costs	**$ 311,966,760**	$ 6,900,685	$ 6,935,230	$ 6,970,577	$ 7,006,736	$ 7,043,719	$ 7,081,536	$ 7,120,198	$ 7,159,715	$ 7,200,101	$ 7,241,364	$ 7,283,519
PRIIA Section 209 Costs												
Total PRIIA Section 209 Costs	**$ 1,235,054,792**	$ 24,065,402	$ 26,452,521	$ 26,452,521	$ 26,452,521	$ 26,452,521	$ 27,940,521	$ 27,940,521	$ 27,940,521	$ 27,940,521	$ 27,940,521	$ 28,417,945
Capital Replacement Costs												
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	**$ 119,441,222**	$ 624,265	$ 627,224	$ 630,257	$ 1,108,388	$ 1,113,958	$ 1,119,661	$ 1,607,855	$ 1,616,390	$ 1,625,123	$ 2,451,083	$ 2,464,787
Total Operating Expenses	**$ 1,666,462,774**	$ 31,590,352	$ 34,014,975	$ 34,053,355	$ 34,567,646	$ 34,610,198	$ 36,141,717	$ 36,668,573	$ 36,716,626	$ 36,765,744	$ 37,632,968	$ 38,166,250
Operating Surplus	**$ (945,365,452)**	$ (20,497,915)	$ (21,370,596)	$ (19,817,845)	$ (20,143,468)	$ (19,994,853)	$ (21,332,671)	$ (21,663,258)	$ (21,512,441)	$ (21,360,053)	$ (22,023,102)	$ (22,349,501)

Scenario B-11	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Revenues												
Total Revenue	$ 16,026,373	$ 16,238,776	$ 16,453,993	$ 16,672,063	$ 16,893,023	$ 17,116,912	$ 17,343,768	$ 17,573,630	$ 17,806,539	$ 18,042,535	$ 18,281,659	$ 18,523,952
Expensed Maintenance Costs												
Total Expensed Maintenance Costs	$ 7,326,575	$ 7,370,546	$ 7,415,442	$ 7,461,278	$ 7,508,064	$ 7,555,814	$ 7,604,541	$ 7,654,257	$ 7,704,977	$ 7,756,713	$ 7,809,479	$ 7,863,289
PRIIA Section 209 Costs												
Total PRIIA Section 209 Costs	$ 28,417,945	$ 28,417,945	$ 28,417,945	$ 28,417,945	$ 30,511,079	$ 30,511,079	$ 30,511,079	$ 30,511,079	$ 30,511,079	$ 31,625,068	$ 31,625,068	$ 31,625,068
Capital Replacement Costs												
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	$ 2,478,798	$ 3,324,161	$ 3,343,680	$ 3,363,626	$ 3,384,003	$ 3,404,819	$ 3,426,077	$ 3,447,785	$ 3,469,948	$ 3,492,571	$ 3,515,662	$ 3,539,225
Total Operating Expenses	$ 38,223,317	$ 39,112,652	$ 39,177,067	$ 39,242,848	$ 41,403,146	$ 41,471,712	$ 41,541,697	$ 41,613,121	$ 41,686,003	$ 42,874,352	$ 42,950,208	$ 43,027,582
Operating Surplus	$ (22,196,944)	$ (22,873,876)	$ (22,723,074)	$ (22,570,785)	$ (24,510,123)	$ (24,354,800)	$ (24,197,929)	$ (24,039,491)	$ (23,879,464)	$ (24,831,817)	$ (24,668,550)	$ (24,503,630)

Scenario B-11	2043	2044	2045	2046	2047	2048	2049	2050
Revenues								
Total Revenue	$ 18,769,456	$ 19,018,214	$ 19,270,268	$ 19,525,664	$ 19,784,444	$ 20,046,654	$ 20,312,339	$ 20,581,546
Expensed Maintenance Costs								
Total Expensed Maintenance Costs	$ 7,918,157	$ 7,974,098	$ 8,031,126	$ 8,089,256	$ 8,148,502	$ 8,208,881	$ 8,270,407	$ 8,333,096
PRIIA Section 209 Costs								
Total PRIIA Section 209 Costs	$ 31,625,068	$ 31,625,068	$ 33,530,295	$ 33,530,295	$ 33,530,295	$ 33,530,295	$ 33,530,295	$ 33,530,295
Capital Replacement Costs								
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	$ 3,563,268	$ 3,587,796	$ 3,612,816	$ 3,638,334	$ 3,664,357	$ 3,690,892	$ 3,717,945	$ 3,745,523
Total Operating Expenses	$ 43,106,493	$ 43,186,962	$ 45,174,237	$ 45,257,885	$ 45,343,154	$ 45,430,067	$ 45,518,646	$ 45,608,914
Operating Surplus	$ (24,337,037)	$ (24,168,748)	$ (25,903,968)	$ (25,732,221)	$ (25,558,710)	$ (25,383,413)	$ (25,206,307)	$ (25,027,368)

Scenario B-11	2051	2052	2053	2054	2055	2056	2057	2058	2059
Revenues									
Total Revenue	$ 20,854,320	$ 21,130,710	$ 21,410,763	$ 21,694,527	$ 21,982,053	$ 22,273,389	$ 22,568,586	$ 22,867,696	$ 23,170,770
Expensed Maintenance Costs									
Total Expensed Maintenance Costs	$ 8,396,964	$ 8,462,028	$ 8,528,303	$ 8,595,807	$ 8,664,556	$ 8,734,567	$ 8,805,858	$ 8,878,447	$ 8,952,351
PRIIA Section 209 Costs									
Total PRIIA Section 209 Costs	$ 33,530,295	$ 33,530,295	$ 33,530,295	$ 33,530,295	$ 35,480,661	$ 35,480,661	$ 35,480,661	$ 35,480,661	$ 35,480,661
Capital Replacement Costs									
Cyclic Capital Cost of Track, Signals, Buildings, and Bridges	$ 3,773,634	$ 3,802,283	$ 3,831,480	$ 3,861,230	$ 3,891,542	$ 3,922,422	$ 3,953,879	$ 3,985,920	$ 4,018,553
Total Operating Expenses	$ 45,700,893	$ 45,794,606	$ 45,890,078	$ 45,987,332	$ 48,036,758	$ 48,137,650	$ 48,240,398	$ 48,345,028	$ 48,451,565
Operating Surplus	$ (24,846,572)	$ (24,663,896)	$ (24,479,315)	$ (24,292,804)	$ (26,054,705)	$ (25,864,261)	$ (25,671,812)	$ (25,477,332)	$ (25,280,796)

Attachment B: Summary of NLX Expensed Maintenance Costs for 2020 through 2059

NLX Expensed Maintenance Costs - 2020 through 2059
Target Field Station - Duluth

Scenario C-1	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Expensed Maintenance Costs (2017$)													
Expensed Maintenance Costs for Track, Signals, Buildings, and Bridges	$ 81,310,157	$ 1,749,240	$ 1,760,274	$ 1,771,552	$ 1,783,076	$ 1,794,850	$ 1,806,878	$ 1,819,163	$ 1,831,707	$ 1,844,515	$ 1,857,591	$ 1,870,936	$ 1,884,556
Expensed Maintenance for PTC System	$ 8,800,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
Total Expensed Maintenance Costs	*$ 90,110,157*	*$ 1,969,240*	*$ 1,980,274*	*$ 1,991,552*	*$ 2,003,076*	*$ 2,014,850*	*$ 2,026,878*	*$ 2,039,163*	*$ 2,051,707*	*$ 2,064,515*	*$ 2,077,591*	*$ 2,090,936*	*$ 2,104,556*

Scenario C-1	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expensed Maintenance Costs (2017$)														
Expensed Maintenance Costs for Track, Signals, Buildings, and Bridges	$ 1,898,454	$ 1,912,633	$ 1,927,098	$ 1,941,851	$ 1,956,898	$ 1,972,241	$ 1,987,886	$ 2,003,836	$ 2,020,094	$ 2,036,667	$ 2,053,556	$ 2,070,768	$ 2,088,307	$ 2,106,176
Expensed Maintenance for PTC System	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
Total Expensed Maintenance Costs	*$ 2,118,454*	*$ 2,132,633*	*$ 2,147,098*	*$ 2,161,851*	*$ 2,176,898*	*$ 2,192,241*	*$ 2,207,886*	*$ 2,223,836*	*$ 2,240,094*	*$ 2,256,667*	*$ 2,273,556*	*$ 2,290,768*	*$ 2,308,307*	*$ 2,326,176*

Scenario C-1	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
Expensed Maintenance Costs (2017$)														
Expensed Maintenance Costs for Track, Signals, Buildings, and Bridges	$ 2,124,381	$ 2,142,925	$ 2,161,815	$ 2,181,054	$ 2,200,648	$ 2,220,601	$ 2,240,918	$ 2,261,605	$ 2,282,667	$ 2,304,108	$ 2,325,934	$ 2,348,151	$ 2,370,765	$ 2,393,779
Expensed Maintenance for PTC System	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
Total Expensed Maintenance Costs	*$ 2,344,381*	*$ 2,362,925*	*$ 2,381,815*	*$ 2,401,054*	*$ 2,420,648*	*$ 2,440,601*	*$ 2,460,918*	*$ 2,481,605*	*$ 2,502,667*	*$ 2,524,108*	*$ 2,545,934*	*$ 2,568,151*	*$ 2,590,765*	*$ 2,613,779*

Attachment C: Summary of NLX Operating and Maintenance Costs for 2020 through 2059

Summary of NLX Operating and Maintenance Costs - 2020 through 2059
Target Field Station - Duluth

Scenario C-1	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Expensed Maintenance Costs (2017$)													
Total Expensed Maintenance Costs	*$ 90,110,157*	*$ 1,969,240*	*$ 1,980,274*	*$ 1,991,552*	*$ 2,003,076*	*$ 2,014,850*	*$ 2,026,878*	*$ 2,039,163*	*$ 2,051,707*	*$ 2,064,515*	*$ 2,077,591*	*$ 2,090,936*	*$ 2,104,556*
PRIIA Costs (2017$)													
Total PRIIA Costs	*$ 776,963,854*	*$ 14,765,158*	*$ 17,115,709*	*$ 17,115,709*	*$ 17,115,709*	*$ 17,115,709*	*$ 17,554,816*	*$ 17,554,816*	*$ 17,554,816*	*$ 17,554,816*	*$ 17,554,816*	*$ 17,961,621*	*$ 17,961,621*
Total Operating and Maintenance Costs (2017$)	*$ 867,074,010*	*$ 16,734,399*	*$ 19,095,983*	*$ 19,107,260*	*$ 19,118,785*	*$ 19,130,559*	*$ 19,581,694*	*$ 19,593,979*	*$ 19,606,523*	*$ 19,619,332*	*$ 19,632,407*	*$ 20,052,557*	*$ 20,066,177*

Scenario C-1	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expensed Maintenance Costs (2017$)														
Total Expensed Maintenance Costs	*$ 2,118,454*	*$ 2,132,633*	*$ 2,147,098*	*$ 2,161,851*	*$ 2,176,898*	*$ 2,192,241*	*$ 2,207,886*	*$ 2,223,836*	*$ 2,240,094*	*$ 2,256,667*	*$ 2,273,556*	*$ 2,290,768*	*$ 2,308,307*	*$ 2,326,176*
PRIIA Costs (2017$)														
Total PRIIA Costs	*$ 17,961,621*	*$ 17,961,621*	*$ 17,961,621*	*$ 19,099,314*	*$ 19,099,314*	*$ 19,099,314*	*$ 19,099,314*	*$ 19,099,314*	*$ 19,971,038*	*$ 19,971,038*	*$ 19,971,038*	*$ 19,971,038*	*$ 19,971,038*	*$ 20,829,231*
Total Operating and Maintenance Costs (2017$)	*$ 20,080,075*	*$ 20,094,254*	*$ 20,108,718*	*$ 21,261,165*	*$ 21,276,212*	*$ 21,291,556*	*$ 21,307,200*	*$ 21,323,150*	*$ 22,211,133*	*$ 22,227,705*	*$ 22,244,595*	*$ 22,261,807*	*$ 22,279,345*	*$ 23,155,407*

Scenario C-1	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
Expensed Maintenance Costs (2017$)														
Total Expensed Maintenance Costs	*$ 2,344,381*	*$ 2,362,925*	*$ 2,381,815*	*$ 2,401,054*	*$ 2,420,648*	*$ 2,440,601*	*$ 2,460,918*	*$ 2,481,605*	*$ 2,502,667*	*$ 2,524,108*	*$ 2,545,934*	*$ 2,568,151*	*$ 2,590,765*	*$ 2,613,779*
PRIIA Costs (2017$)														
Total PRIIA Costs	*$ 20,829,231*	*$ 20,829,231*	*$ 20,829,231*	*$ 20,829,231*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*
Total Operating and Maintenance Costs (2017$)	*$ 23,173,612*	*$ 23,192,156*	*$ 23,211,046*	*$ 23,230,285*	*$ 24,086,224*	*$ 24,106,177*	*$ 24,126,494*	*$ 24,147,181*	*$ 24,168,243*	*$ 24,189,684*	*$ 24,211,510*	*$ 24,233,727*	*$ 24,256,340*	*$ 24,279,355*

QUANDEL CONSULTANTS

ATTACHMENT D: Summary of NLX Cyclic Capital Costs for 2020 through 2059

Summary of NLX Cyclic Capital Costs - 2020 through 2059
Target Field Station - Duluth

Scenario C-1	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Cyclic Capital Costs													
Cyclic Capital Costs for Track, Signals, Buildings, and Bridges (2017$)	$ 48,524,971	$ 249,225	$ 250,582	$ 251,971	$ 443,440	$ 445,989	$ 448,597	$ 644,665	$ 648,564	$ 652,551	$ 984,940	$ 991,189	$ 997,574
Cyclic Capital Cost of Equipment (2014$)	$ 93,888,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 22,176,000	$ -	$ -

Scenario C-1	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Cyclic Capital Costs														
Cyclic Capital Costs for Track, Signals, Buildings, and Bridges (2017$)	$ 1,338,798	$ 1,347,684	$ 1,356,758	$ 1,366,024	$ 1,375,484	$ 1,385,140	$ 1,394,994	$ 1,405,050	$ 1,415,309	$ 1,425,774	$ 1,436,447	$ 1,447,332	$ 1,458,431	$ 1,469,747
Cyclic Capital Cost of Equipment (2014$)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 23,040,000	$ -	$ -	$ -	$ -	$ -	$ -

Scenario C-1	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
Cyclic Capital Costs														
Cyclic Capital Costs for Track, Signals, Buildings, and Bridges (2017$)	$ 1,481,282	$ 1,493,039	$ 1,505,021	$ 1,517,231	$ 1,529,671	$ 1,542,346	$ 1,555,257	$ 1,568,409	$ 1,581,803	$ 1,595,443	$ 1,609,333	$ 1,623,475	$ 1,637,874	$ 1,652,531
Cyclic Capital Cost of Equipment (2014$)	$ -	$ -	$ -	$ 23,904,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 24,768,000

QUANDEL CONSULTANTS

ATTACHMENT E: Summary of NLX Operating Budget for 2020 through 2059

NLX Operating Budget - 2020 through 2059
Target Field Station - Duluth

Scenario C-1	Total Through 2059	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Revenues (2014$)													
Ticket Revenue	$ 624,182,058	$ 9,576,927	$ 10,918,149	$ 12,293,537	$ 12,457,968	$ 12,624,598	$ 12,793,457	$ 12,964,574	$ 13,137,980	$ 13,313,705	$ 13,491,781	$ 13,672,239	$ 13,855,110
Ancillary Revenue	*$ 21,358,492*	*$ 329,619*	*$ 375,679*	*$ 422,889*	*$ 428,429*	*$ 434,041*	*$ 439,727*	*$ 445,487*	*$ 451,322*	*$ 457,234*	*$ 463,224*	*$ 469,292*	*$ 475,439*
Total Revenue	*$ 645,540,550*	*$ 9,906,546*	*$ 11,293,828*	*$ 12,716,427*	*$ 12,886,397*	*$ 13,058,639*	*$ 13,233,183*	*$ 13,410,061*	*$ 13,589,302*	*$ 13,770,940*	*$ 13,955,005*	*$ 14,141,531*	*$ 14,330,549*
Expensed Maintenance Costs (2017$)													
Expensed Maintenance Costs for Track, Signals, Buildings, and Bridges	$ 81,310,157	$ 1,749,240	$ 1,760,274	$ 1,771,552	$ 1,783,076	$ 1,794,850	$ 1,806,878	$ 1,819,163	$ 1,831,707	$ 1,844,515	$ 1,857,591	$ 1,870,936	$ 1,884,556
Expensed Maintenance for PTC System	$ 8,800,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
Total Expensed Maintenance Costs	*$ 90,110,157*	*$ 1,969,240*	*$ 1,980,274*	*$ 1,991,552*	*$ 2,003,076*	*$ 2,014,850*	*$ 2,026,878*	*$ 2,039,163*	*$ 2,051,707*	*$ 2,064,515*	*$ 2,077,591*	*$ 2,090,936*	*$ 2,104,556*
PRIIA Section 209 Costs (2017$)													
Fuel Cost	$ 85,262,925	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573
Train & Engine Crew Costs	$ 130,664,724	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618
Car & Locomotive Maintenance and Turnaround	$ 247,455,748	$ 2,892,398	$ 4,627,836	$ 4,627,836	$ 4,627,836	$ 4,627,836	$ 4,983,824	$ 4,983,824	$ 4,983,824	$ 4,983,824	$ 4,983,824	$ 5,295,313	$ 5,295,313
On-Board Passenger Technology	$ 20,446,700	$ 424,770	$ 424,770	$ 424,770	$ 424,770	$ 424,770	$ 439,217	$ 439,217	$ 439,217	$ 439,217	$ 439,217	$ 439,217	$ 439,217
Station O&M Costs	$ 43,366,396	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160
Layover Facility O&M Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Maintenance Facility O&M Costs	$ 32,571,400	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285
Commissions	$ 34,935,908	$ 725,776	$ 725,776	$ 725,776	$ 725,776	$ 725,776	$ 750,461	$ 750,461	$ 750,461	$ 750,461	$ 750,461	$ 750,461	$ 750,461
Customer Concessions	$ 4,192,309	$ 87,093	$ 87,093	$ 87,093	$ 87,093	$ 87,093	$ 90,055	$ 90,055	$ 90,055	$ 90,055	$ 90,055	$ 90,055	$ 90,055
Insurance	$ 30,000,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000
Support Fees	$ 148,067,743	$ 2,588,485	$ 3,203,597	$ 3,203,597	$ 3,203,597	$ 3,203,597	$ 3,244,622	$ 3,244,622	$ 3,244,622	$ 3,244,622	$ 3,244,622	$ 3,339,938	$ 3,339,938
Total PRIIA Section 209 Costs	*$ 776,963,854*	*$ 14,765,158*	*$ 17,115,709*	*$ 17,115,709*	*$ 17,115,709*	*$ 17,115,709*	*$ 17,554,816*	*$ 17,554,816*	*$ 17,554,816*	*$ 17,554,816*	*$ 17,554,816*	*$ 17,961,621*	*$ 17,961,621*
Capital Replacement Costs (2017$)													
Cyclic Capital Costs for Track, Signals, Buildings, and Bridges	$ 48,524,971	$ 249,225	$ 250,582	$ 251,971	$ 443,440	$ 445,989	$ 448,597	$ 644,665	$ 648,564	$ 652,551	$ 984,940	$ 991,189	$ 997,574
Total Capital Replacement Costs	*$ 48,524,971*	*$ 249,225*	*$ 250,582*	*$ 251,971*	*$ 443,440*	*$ 445,989*	*$ 448,597*	*$ 644,665*	*$ 648,564*	*$ 652,551*	*$ 984,940*	*$ 991,189*	*$ 997,574*
Total Operating Budget (2017$)	**$ 915,598,982**	$ 16,983,623	$ 19,346,564	$ 19,359,231	$ 19,562,224	$ 19,576,548	$ 20,030,291	$ 20,238,644	$ 20,255,087	$ 20,271,882	$ 20,617,347	$ 21,043,746	$ 21,063,751

NLX Operating Budget - 2020 through 2059
Target Field Station - Duluth

Scenario C-1	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Revenues (2014$)														
Ticket Revenue	$ 14,040,427	$ 14,228,223	$ 14,418,531	$ 14,611,384	$ 14,806,817	$ 15,004,863	$ 15,205,559	$ 15,408,939	$ 15,615,039	$ 15,823,896	$ 16,035,547	$ 16,250,028	$ 16,467,378	$ 16,687,636
Ancillary Revenue	$ 481,667	$ 487,977	$ 494,369	$ 500,845	$ 507,406	$ 514,053	$ 520,786	$ 527,608	$ 534,520	$ 541,522	$ 548,615	$ 555,802	$ 563,083	$ 570,459
Total Revenue	*$ 14,522,095*	*$ 14,716,200*	*$ 14,912,900*	*$ 15,112,229*	*$ 15,314,223*	*$ 15,518,916*	*$ 15,726,345*	*$ 15,936,547*	*$ 16,149,559*	*$ 16,365,418*	*$ 16,584,162*	*$ 16,805,830*	*$ 17,030,461*	*$ 17,258,094*
Expensed Maintenance Costs (2017$)														
Expensed Maintenance Costs for Track, Signals, Buildings, and Bridges	$ 1,898,454	$ 1,912,633	$ 1,927,098	$ 1,941,851	$ 1,956,898	$ 1,972,241	$ 1,987,886	$ 2,003,836	$ 2,020,094	$ 2,036,667	$ 2,053,556	$ 2,070,768	$ 2,088,307	$ 2,106,176
Expensed Maintenance for PTC System	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
Total Expensed Maintenance Costs	*$ 2,118,454*	*$ 2,132,633*	*$ 2,147,098*	*$ 2,161,851*	*$ 2,176,898*	*$ 2,192,241*	*$ 2,207,886*	*$ 2,223,836*	*$ 2,240,094*	*$ 2,256,667*	*$ 2,273,556*	*$ 2,290,768*	*$ 2,308,307*	*$ 2,326,176*
PRIIA Section 209 Costs (2017$)														
Fuel Cost	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573
Train & Engine Crew Costs	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618
Car & Locomotive Maintenance and Turnaround	$ 5,295,313	$ 5,295,313	$ 5,295,313	$ 6,007,288	$ 6,007,288	$ 6,007,288	$ 6,007,288	$ 6,007,288	$ 6,674,764	$ 6,674,764	$ 6,674,764	$ 6,674,764	$ 6,674,764	$ 7,119,748
On-Board Passenger Technology	$ 439,217	$ 439,217	$ 439,217	$ 490,604	$ 490,604	$ 490,604	$ 490,604	$ 490,604	$ 490,604	$ 490,604	$ 490,604	$ 490,604	$ 490,604	$ 559,466
Station O&M Costs	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160
Layover Facility O&M Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Maintenance Facility O&M Costs	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285
Commissions	$ 750,461	$ 750,461	$ 750,461	$ 838,262	$ 838,262	$ 838,262	$ 838,262	$ 838,262	$ 838,262	$ 838,262	$ 838,262	$ 838,262	$ 838,262	$ 955,922
Customer Concessions	$ 90,055	$ 90,055	$ 90,055	$ 100,591	$ 100,591	$ 100,591	$ 100,591	$ 100,591	$ 100,591	$ 100,591	$ 100,591	$ 100,591	$ 100,591	$ 114,711
Insurance	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000
Support Fees	$ 3,339,938	$ 3,339,938	$ 3,339,938	$ 3,615,933	$ 3,615,933	$ 3,615,933	$ 3,615,933	$ 3,615,933	$ 3,820,181	$ 3,820,181	$ 3,820,181	$ 3,820,181	$ 3,820,181	$ 4,032,748
Total PRIIA Section 209 Costs	*$ 17,961,621*	*$ 17,961,621*	*$ 17,961,621*	*$ 19,099,314*	*$ 19,099,314*	*$ 19,099,314*	*$ 19,099,314*	*$ 19,099,314*	*$ 19,971,038*	*$ 19,971,038*	*$ 19,971,038*	*$ 19,971,038*	*$ 19,971,038*	*$ 20,829,231*
Capital Replacement Costs (2017$)														
Cyclic Capital Costs for Track, Signals, Buildings, and Bridges	$ 1,338,798	$ 1,347,684	$ 1,356,758	$ 1,366,024	$ 1,375,484	$ 1,385,140	$ 1,394,994	$ 1,405,050	$ 1,415,309	$ 1,425,774	$ 1,436,447	$ 1,447,332	$ 1,458,431	$ 1,469,747
Total Capital Replacement Costs	*$ 1,338,798*	*$ 1,347,684*	*$ 1,356,758*	*$ 1,366,024*	*$ 1,375,484*	*$ 1,385,140*	*$ 1,394,994*	*$ 1,405,050*	*$ 1,415,309*	*$ 1,425,774*	*$ 1,436,447*	*$ 1,447,332*	*$ 1,458,431*	*$ 1,469,747*
Total Operating Budget (2017$)	$ 21,418,873	$ 21,441,938	$ 21,465,477	$ 22,627,190	$ 22,651,696	$ 22,676,695	$ 22,702,194	$ 22,728,199	$ 23,626,441	$ 23,653,479	$ 23,681,042	$ 23,709,139	$ 23,737,776	$ 24,625,154

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NLX Operating Budget - 2020 through 2059
Target Field Station - Duluth

Scenario C-1	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059
Revenues (2014$)														
Ticket Revenue	$ 16,910,839	$ 17,137,028	$ 17,366,242	$ 17,598,522	$ 17,833,909	$ 18,072,444	$ 18,314,169	$ 18,559,128	$ 18,807,364	$ 19,058,919	$ 19,313,839	$ 19,572,169	$ 19,833,954	$ 20,099,241
Ancillary Revenue	$ 577,931	$ 585,502	$ 593,172	$ 600,942	$ 608,814	$ 616,789	$ 624,869	$ 633,054	$ 641,347	$ 649,748	$ 658,259	$ 666,882	$ 675,618	$ 684,468
Total Revenue	*$ 17,488,770*	*$ 17,722,530*	*$ 17,959,414*	*$ 18,199,464*	*$ 18,442,723*	*$ 18,689,233*	*$ 18,939,038*	*$ 19,192,182*	*$ 19,448,710*	*$ 19,708,667*	*$ 19,972,099*	*$ 20,239,051*	*$ 20,509,572*	*$ 20,783,709*
Expensed Maintenance Costs (2017$)														
Expensed Maintenance Costs for Track, Signals, Buildings, and Bridges	$ 2,124,381	$ 2,142,925	$ 2,161,815	$ 2,181,054	$ 2,200,648	$ 2,220,601	$ 2,240,918	$ 2,261,605	$ 2,282,667	$ 2,304,108	$ 2,325,934	$ 2,348,151	$ 2,370,765	$ 2,393,779
Expensed Maintenance for PTC System	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000	$ 220,000
Total Expensed Maintenance Costs	*$ 2,344,381*	*$ 2,362,925*	*$ 2,381,815*	*$ 2,401,054*	*$ 2,420,648*	*$ 2,440,601*	*$ 2,460,918*	*$ 2,481,605*	*$ 2,502,667*	*$ 2,524,108*	*$ 2,545,934*	*$ 2,568,151*	*$ 2,590,765*	*$ 2,613,779*
PRIIA Section 209 Costs (2017$)														
Fuel Cost	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573	$ 2,131,573
Train & Engine Crew Costs	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618	$ 3,266,618
Car & Locomotive Maintenance and Turnaround	$ 7,119,748	$ 7,119,748	$ 7,119,748	$ 7,119,748	$ 7,564,732	$ 7,564,732	$ 7,564,732	$ 7,564,732	$ 7,564,732	$ 7,564,732	$ 7,564,732	$ 7,564,732	$ 7,564,732	$ 7,564,732
On-Board Passenger Technology	$ 559,466	$ 559,466	$ 559,466	$ 559,466	$ 622,731	$ 622,731	$ 622,731	$ 622,731	$ 622,731	$ 622,731	$ 622,731	$ 622,731	$ 622,731	$ 622,731
Station O&M Costs	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160	$ 1,084,160
Layover Facility O&M Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Maintenance Facility O&M Costs	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285	$ 814,285
Commissions	$ 955,922	$ 955,922	$ 955,922	$ 955,922	$ 1,064,018	$ 1,064,018	$ 1,064,018	$ 1,064,018	$ 1,064,018	$ 1,064,018	$ 1,064,018	$ 1,064,018	$ 1,064,018	$ 1,064,018
Customer Concessions	$ 114,711	$ 114,711	$ 114,711	$ 114,711	$ 127,682	$ 127,682	$ 127,682	$ 127,682	$ 127,682	$ 127,682	$ 127,682	$ 127,682	$ 127,682	$ 127,682
Insurance	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000	$ 750,000
Support Fees	$ 4,032,748	$ 4,032,748	$ 4,032,748	$ 4,032,748	$ 4,239,776	$ 4,239,776	$ 4,239,776	$ 4,239,776	$ 4,239,776	$ 4,239,776	$ 4,239,776	$ 4,239,776	$ 4,239,776	$ 4,239,776
Total PRIIA Section 209 Costs	*$ 20,829,231*	*$ 20,829,231*	*$ 20,829,231*	*$ 20,829,231*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*	*$ 21,665,576*
Capital Replacement Costs (2017$)														
Cyclic Capital Costs for Track, Signals, Buildings, and Bridges	$ 1,481,282	$ 1,493,039	$ 1,505,021	$ 1,517,231	$ 1,529,671	$ 1,542,346	$ 1,555,257	$ 1,568,409	$ 1,581,803	$ 1,595,443	$ 1,609,333	$ 1,623,475	$ 1,637,874	$ 1,652,531
Total Capital Replacement Costs	*$ 1,481,282*	*$ 1,493,039*	*$ 1,505,021*	*$ 1,517,231*	*$ 1,529,671*	*$ 1,542,346*	*$ 1,555,257*	*$ 1,568,409*	*$ 1,581,803*	*$ 1,595,443*	*$ 1,609,333*	*$ 1,623,475*	*$ 1,637,874*	*$ 1,652,531*
Total Operating Budget (2017$)	$ 24,654,893	$ 24,685,195	$ 24,716,067	$ 24,747,516	$ 25,615,895	$ 25,648,523	$ 25,681,752	$ 25,715,590	$ 25,750,046	$ 25,785,127	$ 25,820,843	$ 25,857,203	$ 25,894,214	$ 25,931,886

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