COAST-TO-COAST PASSENGER RAIL RIDERSHIP AND COST ESTIMATE STUDY

PREPARED FOR:
Michigan Environmental Council
Grant Fiduciary: Ann Arbor Area Transportation Authority

PREPARED BY:
Transportation Economics & Management Systems, Inc.

FEBRUARY 2016

FINAL REPORT

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About the Michigan Environmental Council & Michigan By Rail

Michigan Environmental Council (MEC), a 501(c)(3) charitable organization, is a coalition of more than 70 organizations created in 1980 to lead Michigan's environmental movement to achieve positive change through the public policy process. These organizations place a high priority on transportation issues as key to Michigan's economic success and environmental quality.

MEC is a co-founder and convener of Michigan by Rail—an informal coalition of advocates working together to improve and expand passenger rail in Michigan. Coalition members include the Michigan Association of Railroad Passengers (also a co-founder of the coalition), Groundwork Center for Resilient Communities, Friends of WALLY and the Midwest High-speed Rail Association.

Michigan By Rail was involved in hosting public meetings across the state in 2010 to collect feedback for the Michigan Department of Transportation's State Rail Plan and hosted the first Michigan Rail Summit in 2011. The group is now working to advocate in support of multiple rail expansion and improvement projects across the state. Michigan By Rail led the public engagement portion of this study.

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Acknowledgements

This study was prepared by Transportation Economics & Management Systems, Inc. (TEMS) and managed by the Michigan Environmental Council. The Ann Arbor Area Transportation Authority served as the grant fiduciary for the study.

Funding was provided in part by a Federal Transit Administration Service Development and New Technology grant and supplemented by a local match generously provided by the following organizations:

- Ann Arbor DDA
- Cascade Charter Township
- City of Plymouth
- Experience Grand Rapids
- Greater Lansing Convention & Visitors Bureau
- Holland Convention & Visitors Bureau
- Ingham County Economic Development Corporation
- Livonia Chamber of Commerce
- Macatawa Area Coordinating Council
- Michigan West Coast Chamber of Commerce
- Plymouth Area Chamber of Commerce

The steering committee played an active role throughout the development of this report. Steering committee members include:

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- Julia Roberts, Ann Arbor Area Transportation Authority
- Dan Sommerville, Ann Arbor Area Transportation Authority
- Roger Hewitt, Ann Arbor DDA
- Andrea Faber, Grand Valley Metro Council
- Steve Bulthuis, Macatawa Area Coordinating Council
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- Alex Bourgeau, Southeast Michigan Council of Governments
- Ben Stupka, Southeast Michigan Regional Transit Authority
- Rick Chapla, The Right Place
- Susan Pigg, Tri-County Regional Planning Commission

Michigan Environmental Council would like to acknowledge the financial support of the Sally Mead Hands foundation, which made the contribution of our staff to this project possible.

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Chapter 1
Project Overview

SUMMARY

Chapter 1 of this report sets out the background and purpose of the Coast-to-Coast Passenger Rail Line project, including outlining the study's goal, the scope, and the methodologies used. In addition, a discussion of the Freight Railroad Principles impacting the project, particularly regarding the sharing of track with Passenger Rail, are included at the end of this chapter.

1.1 Introduction

This study provides a pre-feasibility level understanding about the basics of operating passenger rail service between Michigan's major cities: Detroit, Lansing and Grand Rapids. Using basic operating assumptions about route and technology options this report outlines estimates for the travel market, capital and operating costs, potential financial and economic benefits and highlights early public feedback about possible service along the corridor.

Since the early 1980's Michigan Department of Transportation (MDOT) and its associated Metropolitan Planning Organizations (MPO) have been interested in the development of passenger rail systems in Southern Michigan, as a mechanism to help support regional mobility and provide an alternative travel option for movement in the expanding urban areas between Holland on Lake Michigan on the western side of the Lower Peninsula and Detroit on the Detroit River and Lake St. Clair on the eastern side of the Lower Peninsula. The aim is to connect the major cities of Holland, Grand Rapids, Lansing and Detroit together with other communities such as Ann Arbor and Dearborn, Brighton, and Howell.

Over this period of time there have been many changes in the travel environment including:

- The changing demographic and socioeconomic factors that have occurred in the intervening period reflecting greater mobility and a more widely distributed population.
- Changing travel conditions for auto use due to more congestion on the interstate highway system and higher energy (gas) prices that make auto travel more time consuming and expensive.
- Changes due to Air Deregulation that has significantly reduced the amount of air service for trips under 300 miles, and reduced quality of service, due to the use of smaller aircraft in the corridor.
- The development of more cost effective rail technology due to improved locomotive performance and efficiency, as well as the introduction of modern communication systems.

As a result of these changes, rail travel has become increasingly competitive, and for example Amtrak has seen a significant use in its ridership since the year 2000 across the Midwest with Chicago-Detroit ridership increasing by 57% by 2011.

All these issues suggest the need to review the potential for rail service across Michigan / the Lower Peninsula connecting the major cities within Michigan.

1.2 Purpose and Objective

The goal of the study is to provide the Michigan Environmental Council and its associated organizations and stakeholders with a basic understanding of:

- The background history supporting the proposed development of the Coast-to-Coast Corridor.
- Potential route and technology options for the corridor.
- The market for intercity travel in the current travel environment.
- The capital and operating costs of train service.
- The financial and economic benefits that would be derived from implementing the system.
- The level of public and stakeholder support for the project by developing the pros and cons of the system for review by public and stakeholders.

Essentially, this study assesses the feasibility of each of the proposed corridor options with regards to: the need for passenger rail development in the corridor; capital costs; operation and maintenance costs; ridership and revenue; operating ratios and benefit-cost analysis; and funding and financing opportunities. In particular, the feasibility of each route and technology option will be determined by the potential benefits anticipated from the investment in transportation between the cities for each of the corridor options (ex. Grand Rapids, Lansing, Ann Arbor, Detroit, etc.). This study will not result in what is often called a “preferred alternative” in the environmental planning process nor will it exclude any route options from further analysis.

This assessment assumes an approximate +/-30% level of accuracy, with equal probability of the actual total cost moving up or down. Additional work will be needed to develop more precise estimates. This will be done if the project moves into the environmental planning process. Furthermore, based on the results of this analysis, this study will also provide recommendations for more detailed future studies of the various route options that will be needed for the next step in the Coast-to- Coast Corridor project.

1.3 Project Scope

The study approach uses TEMS RightTrack™ Business Planning System to provide a fully documented analysis of the corridor opportunity. The approach identifies existing and future markets, potential routes and capital costs, technology and operating costs, financial and economic returns and input to stakeholder and community benefits.

Specifically, key deliverables include:

- A comprehensive review of past passenger rail case studies in the Coast-to-Coast corridor that are relevant to the current proposed development for passenger rail in the corridor.
- A comprehensive intercity travel market analysis for the base and forecast years.
- An assessment of potential routes and stations based on existing and historic analysis of options.
- A review of potential train technology for 79 & 110-mph operations and its potential operating schedules and costs on different routes and for different stopping patterns.
- Both a financial and economic analysis of potential options and their ability to meet United States Department of Transportation (USDOT) Federal Railroad Administration (FRA) funding requirements.
- Output of community benefits to provide input to the stakeholder and community groups to identify the project pros and cons.
- Preparation of a conceptual level pre-feasibility report for use in assessing the project viability and its ability to achieve fundability.

1.4 Project Methodology

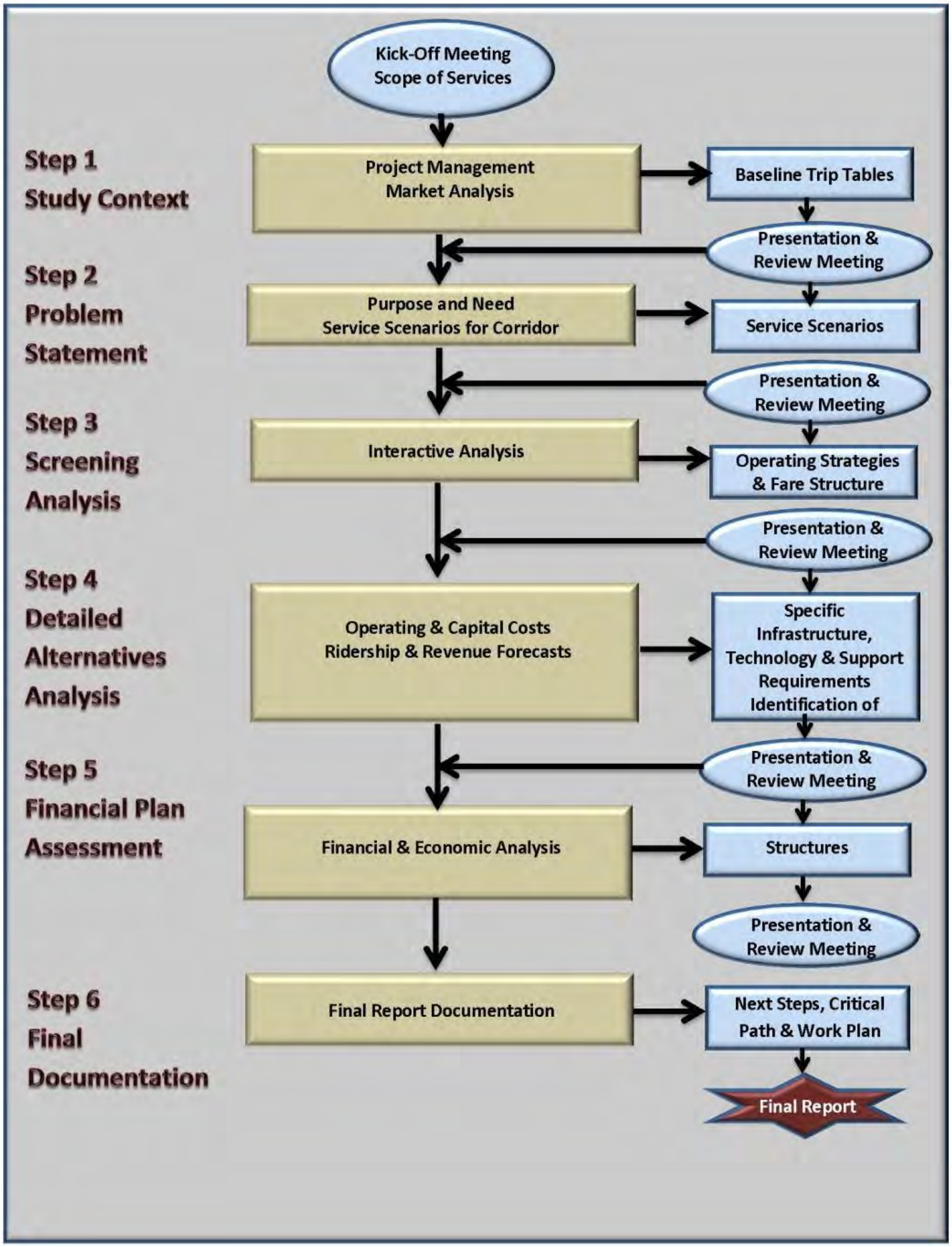
To ensure all of the FRA criteria and factors are fully evaluated, the study team has used a business plan approach. As specified by the FRA, the selection of an appropriate rail option is "market driven." The difference in the selection of one rail option over another is heavily dependent on the potential ridership and revenue. A set of reasonable alternatives have been developed for evaluation based on the potential of each alignment option to improve market access, raise train speed, or to reduce cost. These alternatives provide a full range of trade-off options for configuring the rail system to best meet Michigan's need.

To ensure that market potential is properly measured, the TEMS Business Plan Approach carries out a very detailed and comprehensive market analysis. The output of this market analysis is then used to determine the right rail technology and engineering infrastructure for the corridors.

In developing the Business Case, the TEMS team used the TEMS RightTrack™ Business Planning Process that was explicitly designed for passenger rail planning and uses the six step Business Planning Process as shown in Exhibit 1-1.

Key steps in the process are the definition of the proposed rail service in terms of its ability to serve the market; an interactive analysis to identify the best level of rail service to meet demand, and provide value for money in terms of infrastructure; ridership and revenue estimates for the specific rail service proposed; and the financial and economic assessment of each option.

Exhibit 1-1: Six Step Business Planning Process



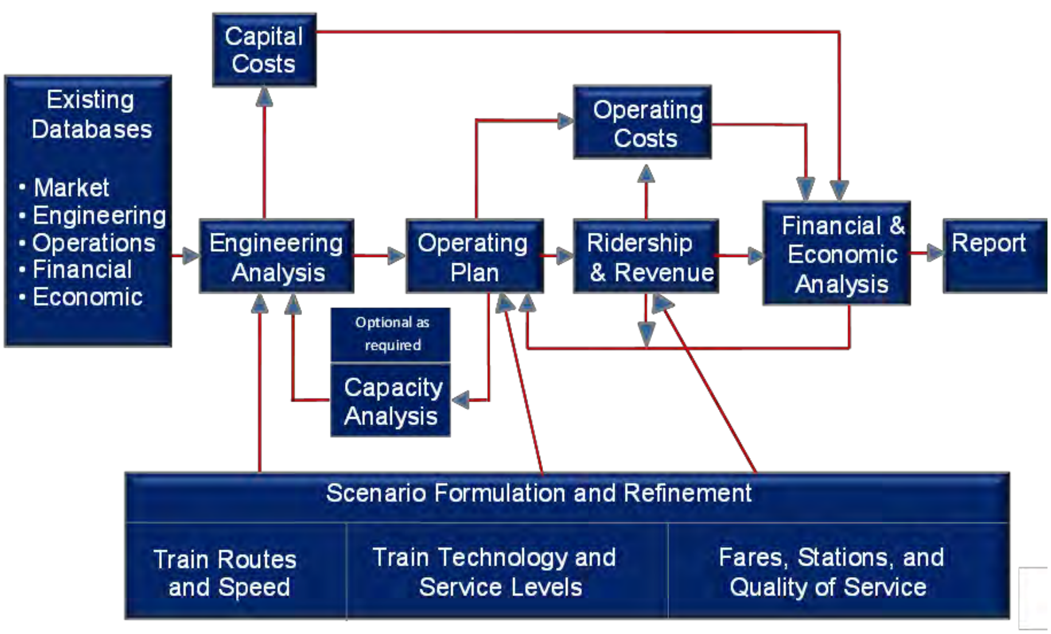
1.4.1 Study Process

The Business Planning Process is designed to provide a rapid evaluation of routes, technologies, infrastructure improvements, different operating patterns and plans to show what impact this will have on ridership and revenues, and financial and economic results.

The current study entailed an interactive and quantitative evaluation, with regular feedback and adjustments between track/technology assessments and operating plan/demand assessments. It culminated in a financial and economic assessment of alternatives. Exhibit 1-2 illustrates the process that led up to the financial and economic analysis.

The study investigated the interaction between alignments and technologies to identify optimum trade-offs between capital investments in track, signals, other infrastructure improvements, and operating speed. The engineering assessment included GOOGLE© map and/or ground inspections of significant portions of track and potential alignments, station evaluations, and identification of potential locations and required maintenance facility equipment for each option. TRACKMAN™ was used to catalog the base track infrastructure and improvements. LOCOMOTION™ was used to simulate various train technologies on the track at different levels of investment, using operating characteristics (train acceleration, curving and tilt capabilities, etc.) that were developed during the technology assessment. The study identified the infrastructure costs (on an itemized segment basis) necessary to achieve high levels of performance for the train technology options evaluated.

Exhibit 1-2: Interactive Analysis Process



A comprehensive travel demand model was developed using the latest socioeconomic data, traffic volumes (air, bus, auto, and rail) and updated network data (e.g., gas prices) to test likely ridership response to service improvements over time. The ridership and revenue demand estimates, developed using the COMPASS™ demand modeling system, are sensitive to trip purpose, service frequencies, travel times, fares, fuel prices, congestion and other trip attributes.

A detailed operating plan was developed and refined, applying train technologies and infrastructure improvements to evaluate travel times at different levels of infrastructure investment. Train frequencies were tested and refined to support and complement the ridership demand forecasts, match supply and demand, and to estimate operating costs.

Financial and economic results were analyzed for each option over a 30-year horizon using criteria recommended by USDOT FRA Cost Benefit guidelines, and the U.S. Office of Management and Budget (OMB) Social Discount Rates. The analysis provided a summary of capital costs, revenues, and operating costs for the life of the project, and developed the operating ratio and cost benefit ratio for each option.

1.5 Freight Railroad Principles

It is in the interest of passenger rail feasibility that any shared use of freight rail corridors or tracks along the Coast-to-Coast rail corridor respect the need for continued safe and economical rail freight operations. At a minimum, it is intended that the freight railroads need to be able to operate their trains as effectively as they could if passenger service did not exist. Beyond this, it is desirable to actually create benefits for freight rail service if possible while developing the infrastructure needed to support passenger services. Freight railroads must retain their ability not only to handle current traffic, but also to expand their own franchises for future traffic growth.

As such, both CSX and Norfolk Southern (like the other Class 1 railroads) have established “Letters of Principle” to provide guidance to passenger rail planners[1]. The purpose of the principles is to protect the safety of railroad employees and communities, service to freight customers, and the right-of-way and land needed to fulfill the railroads’ freight transportation mission. However, Norfolk Southern acknowledges that each passenger proposal is unique, so Norfolk Southern's application of the principles to particular proposals will often be unique as well.

With regard to High-Speed Rail (HSR) service and corridors, Norfolk Southern’s principles point out that the following special considerations are necessary:

- Norfolk Southern will work with planners to insulate higher-speed rail corridors from interference with and from NS freight corridors.
- On Norfolk Southern, passenger trains operating in excess of 79-mph require their own dedicated tracks. On Norfolk Southern, Trains operating in excess of 90-mph require their own private right-of-way.
- Where higher -speed trains share tracks with conventional freight trains, those high-speed trains will not be able to exceed 79-mph. Where shared track is concerned higher speed trains must meet the same safety standards as conventional freight trains.

[1] CSX Principles, email from Marco Turra, CSX to Elizabeth Treutel, Michigan Environmental Council, dated June 4, 2015; NS Principles, https://wideni77.files.wordpress.com/2013/09/norfolk-southern-proposed-passenger-projects-061413.pdf, retrieved on 08/06/15

CSX's principles require that:

- Access to host railroad track and property must be negotiated between the parties on a voluntary basis.
- Designing for safety is paramount and separate tracks will be needed to segregate freight and conventional passenger rail from higher-speed rail at sustained speeds in excess of 90-mph.
- Service to rail freight customers must be reliable and protected and cannot be compromised; adequate capacity must be maintained and, in some cases, built to address future freight growth.
- New infrastructure design must fully protect the host railroad's ability to serve its existing customers, both passenger and freight, and locate future new freight customers on its lines. Host railroads must be adequately compensated, especially in regard to the significantly higher maintenance cost associated with enhanced track infrastructure that will be required for high-speed rail.
- Host freight railroads need to be fully protected against any and all liability that would not have resulted but for the added presence of high-speed passenger rail service.

At present the passenger proposals laid out here are still un-negotiated, un-funded and at a pre-feasibility level. This report makes certain assumptions regarding the need for capacity enhancements along rail lines that would be utilized for providing passenger service. However, the required detailed capacity analysis for shared track segments has yet to be done. As a result, the work is not yet at a detailed enough level to satisfy the needs of the freight railroads. It is understood that in potential future detailed engineering and environmental studies, the required capacity work will be performed. These engineering and operation studies will address the details of integrating the proposed passenger operations with freight operations, and will be subject to close negotiations with the railroads. As a result, the final infrastructure need will not be known until these studies and railroad negotiations are completed. This report only suggests a starting point for the capacity analysis process and negotiations. These will need to be done if and when the Coast-to-Coast corridor moves forward into the environmental study phase.

In the meantime, this report contains preliminary data which is subject to review, verification and approval by both CSX and Norfolk Southern Railroads. As of the date of this report, this review process has not taken place. Findings are not to be construed as a commitment on the part of either CSX or Norfolk Southern to operate additional service.

1.6 Organization of the Report

1. **Chapter 1 – Project Overview:** Chapter 1 lays out the overall approach for implementing the proposed Coast-to-Coast Passenger Rail Line (Detroit - Holland) over the next 25 years. Chapter 1 of this report also sets out the background and purpose of the Coast-to-Coast Line, including outlining the goal for the project, the project scope, and the methodologies used. In addition, a discussion of the Freight Principles impacting the project, particularly regarding the sharing of track with Passenger Rail, are included at the end of this chapter.

2. **Chapter 2 – Development of the Coast-to-Coast Corridor:** The purpose of this section is to provide an extensive review of the background history and issues that have helped to focus the current analysis and that have led to the identification of a range of potential route and technology options that should be considered for the current Coast-to-Coast Study. As in the case of the Midwest Regional Rail Initiative (MWRRI) and Ohio Hub studies, the aim is to evaluate an affordable set of options that provide good service at a reasonable price.

3. **Chapter 3 – Service and Operating Plan:** This chapter discusses the development of the Service and Operating Plan and includes a discussion of the track infrastructure and train technology options. This chapter also describes the operating plan, station stopping patterns, frequencies, train times and train schedules for each route and technology option. Operating costs were also calculated for each year the system is planned to be operational using operating cost drivers such as passenger volumes, train miles, and operating hours.

4. **Chapter 4 – Prioritized Capital Plan:** This chapter discusses the development of the Prioritized Capital Plan and includes a discussion of the capital cost methodology and the capital costs for the Coast-to- Coast Passenger Rail Line including breakdowns by unit costs. The unit capital costs for estimating infrastructure, equipment, and maintenance facility capital costs for each route and technology option are also described. This chapter also presents the Capital Spending plan for the project.

5. **Chapter 5 – Socio-Demographic Transportation Databases:** This chapter is divided into subsections of introduction of the chapter, zone system, socioeconomic data, transportation network data, origin-destination data, stated preference survey process, results and analysis. This chapter describes the steps of developing the market data which includes developing a zone system, socioeconomic database of the study area, how the transportation networks were developed, how the origin and destination databases were obtained and validated, the methodology used to conduct the stated preference surveys.

6. **Chapter 6 – Coast-to-Coast Travel Demand Forecast:** This chapter also presents the analysis of the Total Travel Demand for passenger rail in the Coast-to-Coast Corridor, including presenting ridership and revenue results. The ridership and revenue forecasts for this study were developed using the COMPASS™ Travel Demand Model. The COMPASS™ Multimodal Demand Forecasting Model is a flexible demand forecasting tool used to compare and evaluate alternative passenger rail network and service scenarios. It is particularly useful in assessing the introduction or expansion of public transportation modes such as passenger rail, air, or new bus service into markets.

7. **Chapter 7 – Assessment of Benefits – Preliminary Financial and Economic Analysis:** This chapter presents a detailed financial analysis for the Coast-to-Coast Passenger Rail Line, including key financial measures such as Operating Surplus and Operating Ratio. A detailed Economic Analysis was also carried out using criteria set out by the 1997 FRA Commercial Feasibility Study[2] and including key economic measures such as NPV Surplus and Benefit/Cost Ratio which are also presented in this chapter. A sensitivity analysis was also performed on the Route 2 option using the State of Michigan's lower more conservative demographic growth assumptions.

[2] High-Speed Ground Transportation for America: Commercial Feasibility Study Report To Congress: https://www.fra.dot.gov/eLib/details/L02519

8. **Chapter 8 – Public Engagement:** This chapter outlines the Public Engagement aspect of the study and highlights the main findings of that process.

9. **Chapter 9 – Conclusions and Next Steps:** This chapter outlines the key findings of the study, and the next steps that should be taken to move the Coast-to-Coast Passenger Rail Line project forward.

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Chapter 2
Development of the Coast-to-Coast Corridor

SUMMARY

The purpose of this chapter is to provide an extensive review of the background history and issues that have helped to focus the current analysis and that have led to the identification of a range of potential route and technology options that should be considered for the current Coast-to-Coast Study. As in the case of the Midwest Regional Rail Initiative (MWRRI) and Ohio Hub studies, the aim is to evaluate an affordable set of options that would provide good service at a reasonable price. It is not expected that any true High-Speed Rail options will be reasonable as a first step in developing the Coast-to-Coast Corridor.

2.1 Background History

Since intercity passenger rail service in the Detroit – Lansing – Grand Rapids rail corridor ended in 1971, several feasibility studies have been conducted. While a variety of efforts to assess and pursue a potential re-establishment of intercity passenger rail service in the Detroit – Grand Rapids corridor have been taken up since the 1980s, Michigan today is experiencing unparalleled increases in rail ridership. As the first step in the study process, the findings of these earlier studies were reviewed and summarized. These results are presented in the next chapter. This provides an opportunity to learn from the results of the earlier studies and provides a starting point for the current assessment.

The genesis of the current study dates back to 2010 and 2011 when the Michigan By Rail (MBR) team, then made up of the Michigan Environmental Council (MEC) and Michigan Association of Railroad Passengers (MARP), held public forums to collect community input to submit as public comment for Michigan's State Rail Plan. Feedback throughout these forums called for the re-establishment of service between Michigan's east and west coasts. In Michigan Department of Transportation's (MDOT) 2011 Michigan State Rail Plan, an Alternatives Analysis (AA) and Tier I Environmental Impact Statement (EIS) were recommended for the Detroit – Lansing – Grand Rapids corridor. These recommendations were broadly supported by local governments, Chambers of commerce, community groups and organizations throughout the proposed Study corridor. The process would not have advanced without their support.

Then in the spring of 2013, the MEC and MDOT Office of Rail began discussing the potential for intercity passenger rail service between Detroit and Holland. Tim Hoeffner, Director of the MDOT Office of Rail, recommended that a new ridership feasibility study be conducted in the corridor. With this recommendation MEC began researching the previous studies of the corridor. Additionally, MEC reconvened the Michigan By Rail team under the umbrella of the Transportation for Michigan (Trans4M) coalition, a coalition for which MEC serves as the fiduciary.

Based on MEC's research, Michigan By Rail chose to seek a base ridership assessment of the Detroit – Holland rail corridor as a low-cost catalyst to start the larger conversation towards a new intercity passenger service. The expectation is that this could later progress into the full EIS and AA efforts as described in the Michigan State Rail Plan. In August 2013, the Service Development and New Technology (SDNT) grant program, facilitated by the MDOT Office of Passenger Transportation, was identified as an appropriate grant program to apply to for funding of a base ridership study. The Ann Arbor Area Transportation Authority (AAATA) agreed to submit an application for study funding listing MEC as the project manager. This application was submitted to the MDOT Office of Passenger Transportation on April 30, 2014.

In February 2014, the Chair of the Michigan House Appropriations Subcommittee on Transportation, Representative Rob VerHeulen, expressed interest in including the ridership study in the transportation budget bill for Fiscal Year 2014-2015. Under Representative VerHeulen's guidance and leadership, boilerplate language directing that this study be conducted was first included in HB 5308, and eventually became Section 712 of PA 252, Michigan's omnibus budget act for Fiscal Year 2014-2015, signed into law by Governor Rick Snyder on June 30, 2014. As a result, this study has been undertaken by Transportation Economics & Management Systems, Inc. (TEMS) to provide an updated perspective on the prospects for implementing an effective passenger rail service in the Coast-to-Coast corridor.

2.2 Coast-to-Coast Rail Corridor: Historical Review

Historically, the Chesapeake & Ohio Railway provided rail passenger service in the "Coast-to-Coast" Detroit – Lansing – Grand Rapids – Holland rail corridor. However, on May 1, 1971, Amtrak assumed responsibility for the nation's intercity rail passenger system. Communities like Flint, Lansing and Grand Rapids that were not on Amtrak's system lost all passenger service that day. Thus, Lansing went from 10 passenger trains daily on April 30th (4 trains between Grand Rapids and Detroit and 6 trains between Chicago, Lansing and Detroit/Port Huron) to zero trains on May 1st. Only Chicago to Detroit service was retained with two daily round trips via Kalamazoo. After this:

- In 1974, Amtrak with the support of MDOT re-established one daily round trip from Chicago to Port Huron, via Lansing and Flint.
- Amtrak added a third round trip from Chicago to Detroit in 1975 with introduction of the Rohr Turboliners. This lasted only until 1981 by which time all Turboliners were replaced by conventional locomotive-hauled trains. The third round trip was retained; but 40 years later, rail service in the Chicago to Detroit corridor still remains at the same level – no additional train frequencies have been added since 1975. However, the corridor ridership received a major boost when the Detroit station was switched to the New Center location and the corridor was extended to Pontiac in 1994.

- Service linking Grand Rapids with Chicago was not reestablished until 1984, again with only one daily round trip – a mere shadow of the corridor service that had formerly existed.

As a result, the northern "Coast-to-Coast" corridor cities Lansing and Grand Rapids only have minimal rail service of one round trip per day to Chicago, and have not been effectively connected to Detroit by rail since 1971. However since the early 1980's, MDOT and its associated MPO's have been interested in development of passenger rail systems in southern Michigan for connecting to Detroit. Such a rail service would help support regional mobility and provide an alternative to automobile travel. The aim is to connect Detroit to the major cities of Holland, Grand Rapids, Lansing and Ann Arbor as well as smaller communities such as Dearborn, Brighton, and Howell.

Since passenger rail service was discontinued in 1971, there have been many changes in the travel environment including:

- The changing demographic and socioeconomic factors that have occurred in the intervening period reflecting greater mobility, the greater propensity of the "millennial generation" to use public transportation[3] , and a more widely distributed population.

- Changing travel conditions for auto use due to more congestion on the interstate highway system[4] and higher energy (gas) prices[5] that make auto travel more time consuming and expensive.

- Changes due to Air Deregulation that has significantly reduced the availability of air service for short trips and reduced quality of service[6], due to the use of smaller aircraft[7] and higher prices in small markets where the competition is less. This along with airport security delays has rendered flying less competitive with surface (rail or highway) modes for trips under 300 miles.

- The development of more cost effective rail technology due to improved locomotive designs [8]and higher speeds, as well as the introduction of modern communication systems like the Positive Train Control (PTC) system[9] that was prototyped in Michigan.

As a result of these changes, rail travel has become increasingly attractive, cost effective, and competitive with other modes. For example Amtrak has seen a significant rise in its ridership since the year 2000 across the Midwest with Chicago – Detroit ridership increasing by 57% by 2011.

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[3] How transit agencies are trying to attract millennial riders, Progressive Railroading, May 2015: http://www.progressiverailroading.com/passenger_rail/article/How-transit-agencies-are-trying-to-attract-millennial-riders--44402

[4] Impacts can be estimated by using the Bureau of Public Roads function, see http://www.sierrafoot.org/local/gp/engineering.html

[5] U.S. Energy Information Administration forecasts, see http://www.eia.gov/forecasts/aeo/tables_ref.cfm retrieved on June 16, 2015.

[6] Kahn, Alfred E. The Economics of Regulation, Principles and Institutions, p. 250 . . . competition should be permitted to do its job of bringing prices closer to cost, eradicating price discrimination, controlling tendencies to excessive service inflation . . .. See: https://books.google.com/books?id=x01ew7Emw0MC&pg=PA250#v=onepage&q&f=false

[7] *Small Jets, More Trips Worsen Airport Delays*, Wall Street Journal, August 13, 2007 http://www.wsj.com/articles/SB118696365326095429

[8] Siemens Charger, as described at http://www.siemens.com/press/en/pressrelease/?press=/en/pressrelease/2014/infrastructure-cities/rail-systems/icrl201403009.htm&content[]=ICRL&content[]=MO

[9] ITCS - Incremental Train Control System, GE Transportation Systems, see http://www.getransportation.com/its/signaling-train-control/automatic-train-protection-control-systems/itcs-incremental-train-control retrieved on June 16, 2015.

All these changes suggest the need to review again the potential for rail service across Michigan's Lower Peninsula connecting the major communities of southern Michigan. Since rail service ended in 1971, a number of feasibility studies have been conducted for assessing the feasibility of re-establishing rail passenger corridor service linking Flint, Lansing, Grand Rapids to the rest of the country.

However, the major studies conducted by the Midwest Regional Rail System[10] (MWRRS) from 1996 through 2004 focused only on development of a "Chicago Hub" rather than on linking Michigan communities to Detroit. Among all the Chicago based corridors, the Detroit/Pontiac rail corridor emerged as one of the three highest priorities for investment (along with St. Louis and Milwaukee/Madison.) For the past 10 years, these three corridors have received the most attention of all the Chicago Hub corridors in terms of improving track and adding train frequencies. Although Lansing and Grand Rapids (which are not on the direct Chicago to Detroit route) each received train station improvements, as "branch line" services, the corridors have not received as much attention as the "main line" since the main focus in Michigan, up until now, has been on developing the Chicago – Detroit/Pontiac route.

The first step in conducting the Coast-to-Coast study was to review prior studies and compile and update the operating, network, demographics and ridership databases that were needed to complete the study. Where necessary, relevant literature and comparison case studies were referenced, and data utilized from pre-existing studies of the corridor. Ten specific studies were referenced by MEC or the project managers/steering committee and requested to be included in this literature review. The studies are noted by reference number. All the key studies and reports referenced here are shown in the time line of Exhibit 2-1. This time line juxtaposes the timing of each study relative to events that were occurring in the real world. This understanding is needed, for example of what rail service networks were actually being operated at the time of each study, to provide context for the study recommendations. The time line is broken down into three major eras based on time frame of the pivotal MWRRS studies. These are:

- Pre-MWRRS: 1971 - 1985[11]
- MWRRS: 1994 - 2004
- Post-MWRRS: 2005 - present

The Pre-MWRRS era was very busy starting in 1971 with the formation of Amtrak, continuing through 1976 with formation of ConRail and all the network rationalization activities that followed. There were many activities, but only a few passenger studies during this era since so much of the planning during this era was led by the federal government.

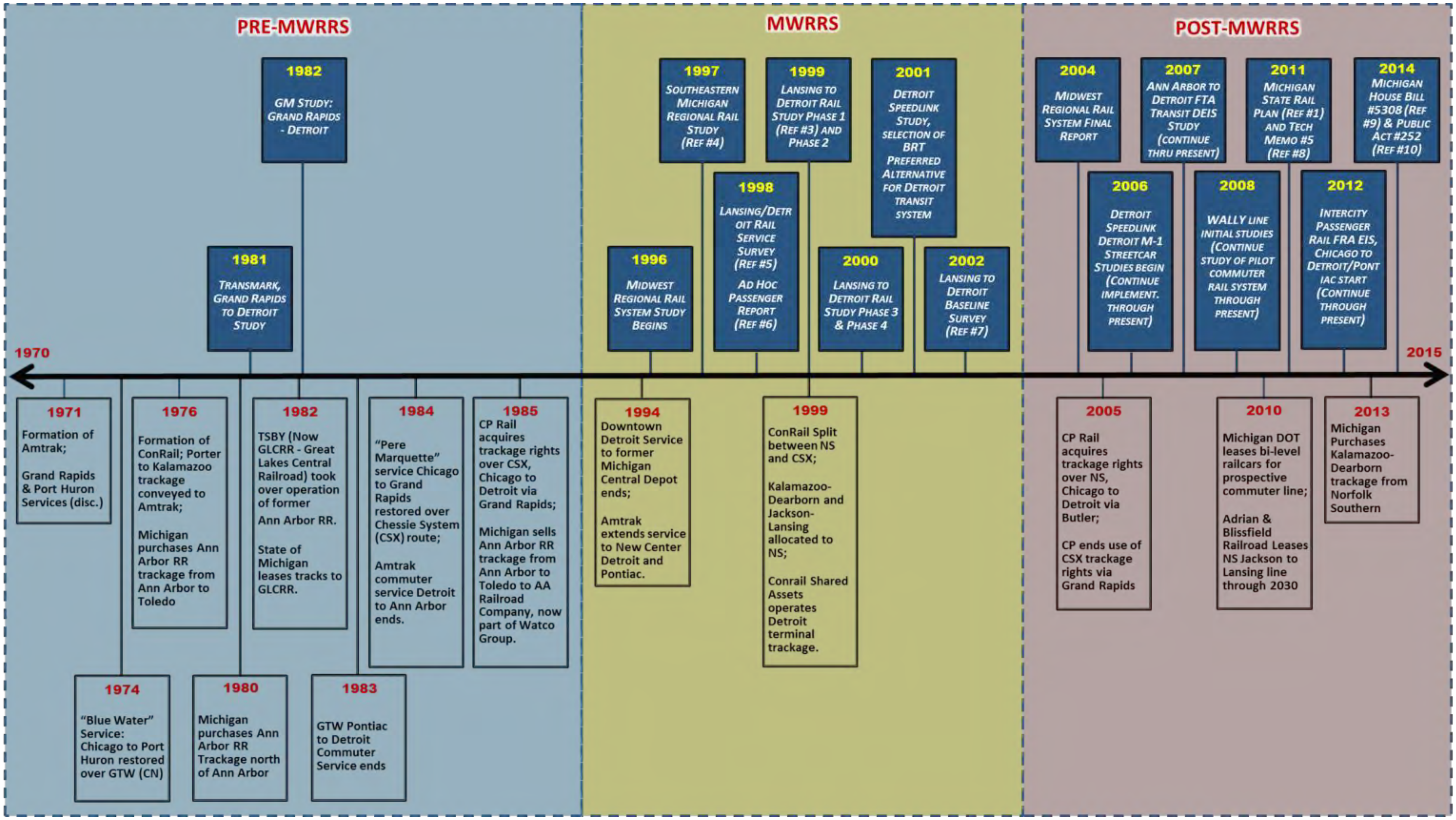
The MWRRS era started in 1994 when the service to the former Michigan Central Depot in downtown Detroit ended. At that time, Amtrak extended service to Pontiac via New Center Detroit, and Michigan's passenger rail network assumed its current form with one Chicago round trip each to Grand Rapids and Port Huron, and three Chicago round trips to Detroit/ Pontiac. There have been no changes to the train service pattern since then except for the 2004 truncation of the former International service at Port Huron.

[10] Nine Midwestern state DOTs have been working together since 1996 to develop a 3,000 mile accelerated rail system for the region based on a Chicago Hub. When this plan is fully implemented, passenger rail service will be dramatically increased and trip times significantly decreased. About 90 percent of the Midwest's population will be within a one hour car ride to a MWRRS station and/or 30 minutes of a feeder bus station. See: http://www.miprc.org/Advocacy/MidwestRegionalRailInitiative/tabid/88/Default.aspx retrieved on June 16, 2015.

[11] After the initial wave of activity triggered by rail reorganizations ending in 1985, there was an almost 10 year period of planning inactivity until the beginning of the MWRRS era in 1994, although the rail services then in place were continued.

The post-MWRRS era started in 2004 with completion of the MWRRS study which launched a round of detailed NEPA environmental studies, State Rail planning and local transit planning activities, most of which are still ongoing today.

Exhibit 2-1: Michigan Passenger Rail Timeline



2.2.1 Pre-MWRRS Era, Studies and Reports 1971-1985

➢ 1981-Transmark, Michigan High-Speed Intercity Rail Passenger Study

This early study was performed by the British Rail Research and Consulting division (Transmark)[12]. This early engagement was based on the success of the Intercity-125 diesel train[13] that had been introduced in the UK. The analysis assessed potential demand for high-speed, multiple-frequency rail service in three travel corridors:

- Grand Rapids – Lansing – Detroit
- Bay City – Saginaw – Detroit
- Detroit – Chicago

This study was conducted using the British Rail SIGNALS model, a predecessor to the COMPASS™ Model that is being used by TEMS for the current study, and based on a similar methodology. The 1985 forecasts are shown in Exhibit 2-2.

Exhibit 2-2: 1985 Intercity Rail Forecast Volumes, Transmark Study (Millions of Passenger Miles)

Transmark Study			
Maximum Speed (MPH)	79	110	150
Daily Round Trip Frequency	3	6	12
Corridor:	**Rail Volumes (Millions of PMs)**		
Grand Rapids to Detroit	11.5	23	36.7
Bay City to Detroit	9.5	18.1	28
Detroit to Chicago	114.1	214.9	319.9

British Rail clearly viewed the primary Michigan market as Chicago-based, since Detroit to Chicago forecasts are seen to be 9-10 times higher than those developed for the other two corridors. This study concluded that:

> *Forecast rail volumes on the Grand Rapids and Bay City corridors were found to approximately double with the inclusion of commuter traffic flows, an indication of the importance of appropriate scheduling for these services. In consequence, consideration was given to terminating the Grand Rapids corridor at Lansing in order to maximize the potential benefits from commuter traffic between Lansing and Detroit. This strategy appeared to be the most economical solution; potential rail traffic between Grand Rapids and Detroit would be routed via Kalamazoo in order to take advantage of connections between the Grand Rapids – Chicago and Detroit – Chicago services.*

Transmark projected that less than 50 passengers would ride each Grand Rapids – Lansing – Detroit[14] train with similar results for Bay City – Saginaw – Detroit[15]. This is not enough ridership to support

[12] Network Rail launches international arm, Railnews UK, July 9, 2012 http://www.railnews.co.uk/news/2012/07/09-network-rail-launches-international-arm.html.
[13] Testing the prototype HST in 1973, retrieved June 16, 2015 http://www.traintesting.com/HST_prototype.htm.
[14] Tables 5-8 and 5-9 on page 42 of the Transmark study
[15] Tables 5-14 and 5-15 on page 50 of the Transmark study

development of either rail service. Transmark's model did not show that Detroit was a desirable travel destination at the time, saying that:

> *The potential for intercity rail services between the Lansing – Detroit city pair and indeed all intercity corridor flows to Detroit is constrained by the absence of a clearly defined travel destination. This results from the highly dispersed nature of the trip ends in Detroit. An earlier analysis by the MDOT Modal Planning Division concludes that since the business and commuting travel market between Grand Rapids/Lansing and Detroit is very small and highly dispersed by time of day, and since the importance of Detroit as an attractor of other purpose trips is limited, levels of potential rail ridership in this part of the corridor will inevitably be lower than comparable corridors possessing more active travel attractors and less dispersed trip end locations.*

At the time of Transmark's study, the old Michigan Central Station (MCS) was still in use. When the MCS was constructed in 1913, it was placed away from the downtown area in the hope that the station would become an anchor for development. Although Henry Ford bought land near the station in the 1920s and made construction plans, the Great Depression and other circumstances squelched this and many other development efforts.[16] Fringe development instead occurred in the New Center area[17], where the Amtrak station is located today. This MCS problem clearly was also an important factor contributing to Transmark's weak forecast of Detroit's market potential.

As a result, it is clear that Transmark in 1985 considered Chicago, not Detroit trips as the primary intercity rail travel market in Michigan. Transmark recommended against development of Grand Rapids – Lansing – Detroit service. Instead, Transmark proposed to link Grand Rapids with Chicago via a branch line from Kalamazoo, and Lansing to Chicago using a branch line from Jackson, as shown in Exhibit 2-3. Thus, Grand Rapids and Lansing passengers could go either to Chicago or Detroit, although Transmark clearly expected that most of the riders would go to Chicago.

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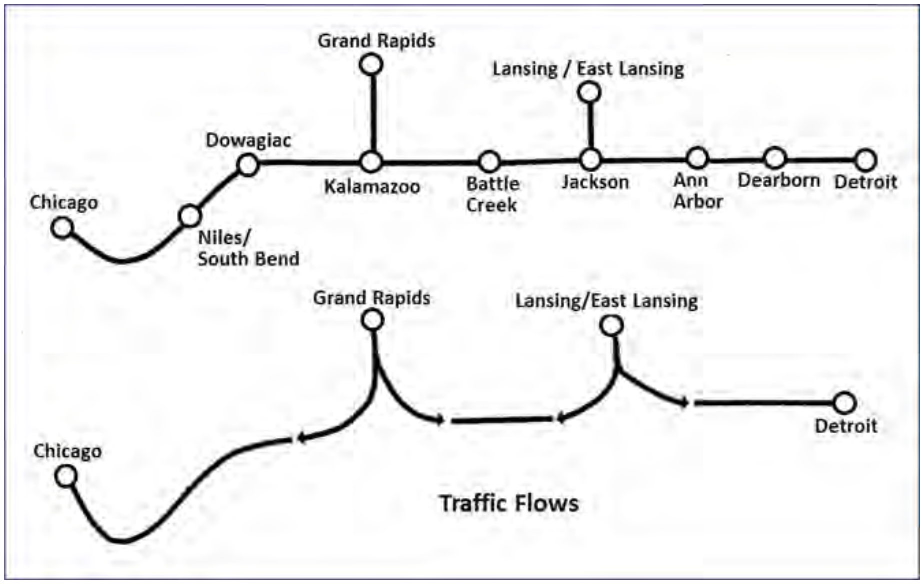
[16] Most passengers would arrive at and leave from Michigan Central Station by interurban service or streetcar due to the station's distance from downtown Detroit. Further compounding MCS's future problems was the fact that the original design included no large parking facility. So, when the interurban service was discontinued less than two decades after MCS opened, MCS was effectively isolated from a large majority of the population. Michigan Central Station: The story of its rise, fall and... *BBC News*, February 26, 2015 http://www.bbc.com/news/magazine-31596161.

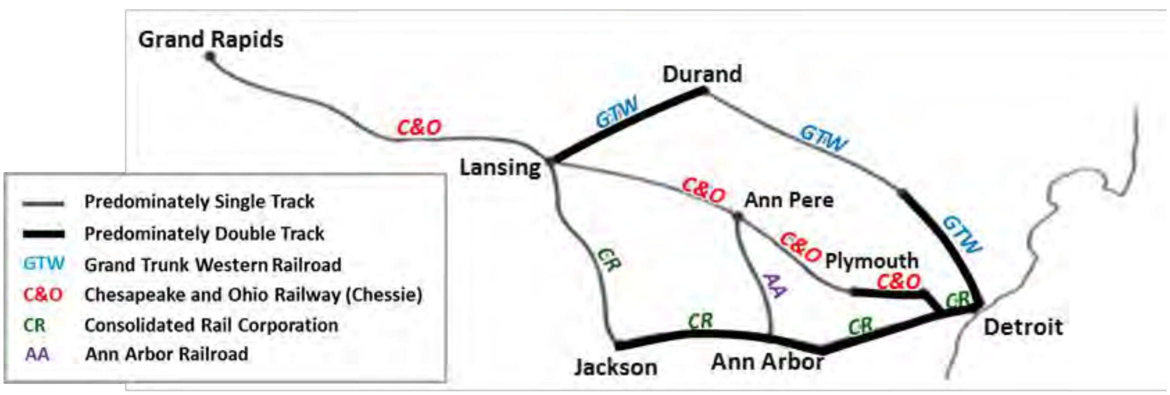
[17] The heart of New Center was developed in the 1920s as a business hub that would offer convenient access to both downtown resources and outlying factories. Some historians believe that New Center may be the original edge city—a sub-center remote from, but related to, a main urban core. The descriptor "New Center" derived its name from the New Center News, an automotive-focused free newspaper begun in 1933 that continues to operate under the name Detroit Auto Scene. From 1923 to 1996, General Motors maintained its world headquarters in New Center (in what is now Cadillac Place) before relocating downtown to the Renaissance Center; before becoming a division of GM, Fisher Body was headquartered in the Fisher Building. See: Randall Fogelman, *Detroit's New Center*, Arcadia Publishing, 2004, ISBN 0-7385-3271-1 at https://books.google.com/books?id=MJFvACrP5qwC.

Exhibit 2-3: Michigan Network Proposed by Transmark in 1985[18]



Concurrently with Transmark's ridership study, Michigan DOT in 1980 commissioned General Motors (GM) to develop a detailed operational and engineering assessment of the Detroit – Lansing – Grand Rapids corridor. The two studies were not in fact independent since GM reported that "the patronage data reviewed in this report is from a parallel study completed by another consultant to Michigan DOT" and in fact used Transmark's ridership results. Both studies evaluated four different rail routing options east of Lansing as shown in Exhibit 2-4:

Exhibit 2-4: Grand Rapids to Detroit Options Considered by 1980 GM Study[19]



The GM study developed an extremely detailed (although now very dated) assessment of engineering, operations and equipment options for the rail corridor. However, given Transmark's dim view of the prospects for rail service to Detroit in general, and weak ridership forecast for Grand Rapids – Lansing – Detroit in particular, it should come as no surprise that GM was forced to conclude that the train service would not cover its operating cost, and that its capital cost would be very high relative to the number of riders. GM's report echoed Transmark's recommendation that Grand Rapids and Lansing should be served as branches off the Chicago to Detroit main rail line. After this, there was a hiatus of over 10 years until the Midwest Regional Rail System (MWRRS) study launched in 1996.

[18] Figure 5-2 on page 48 of the Transmark Study
[19] This is Exhibit 1-1 on page 1-2 of the GM Report.

2.2.2 MWRRS Era, Studies and Reports 1994-2004

Just prior to the start of the MWRRS planning effort in 1994, Amtrak extended the Detroit corridor to Pontiac so the structure of the passenger rail network in Michigan was the same as it is today. This was the starting point for the MWRRS study in 1996.

The MWRRS was a consortium of Midwest states who together decided to study the development of an integrated Midwest network based on a Chicago Hub. Since the MWRRS was focused only on Chicago and not on the need for connections to Detroit, Michigan DOT launched several independent studies during the MWRRS era that revisited the earlier Transmark and General Motors assessments. The Detroit metropolitan area was also undertaking major transit studies at the same time. This section describes those studies.

➢ 1997 – Southeastern Michigan Regional Rail Study (Report #4)

The Southeastern Michigan study was a commuter rail study rather than intercity rail. It proposed a three-route rail system serving Ann Arbor, Pontiac and Mount Clemens. Run-through rail services were proposed between Ann Arbor and Mount Clements, and between Pontiac and Brush Street. Costs, revenues and economic benefits were only at a highly conceptual level, but this exercise did succeed in starting local and regional discussions regarding the need for developing a commuter rail system.

➢ 1998 – Lansing/Detroit Rail Service Survey (Report #5)

The Lansing/Detroit Rail Service Survey was undertaken to gauge the level of interest in intercity rail services by Lansing-area residents and commuters. A number of surveys were undertaken specifically to better understand the nature of travel demand in the Lansing/Detroit rail corridor. The survey results were considered quite positive, and confirmed the need for a full-fledged feasibility study.

➢ 1998 – Ad Hoc Passenger Report (Report #6)

This report[20] represented the work of the legislative task force established by Curtis Hertel, Speaker of the Michigan House of Representatives; chaired by Rep. Lingg Brewer, and undertaken in cooperation with the Lansing Regional Chamber of Commerce, the Tri-County Regional Planning Commission and interested agencies and citizens.

The genesis for this work was the 1996 announcement that GM was transferring many Lansing based employees to the Detroit area. Informal meetings and discussions led to a decision to form a legislative task force to review the potential for passenger train service between Lansing and Detroit. The proposed service could accommodate both GM commuters and other travelers. The task force held a number of meetings, received information and testimony from many sources, and issued a final report in June 1998. The report includes 21 specific recommendations and other information. Key conclusions included:

- An independent authority is needed to oversee the process and ensure its completion.
- Public involvement and consensus building must occur.
- Tax supported funding should be proportionate to public interest in using the system.
- A minimum of three daily round trips are required.

[20] A description of this report is given on Page 5 of the 1999 Lansing-to-Detroit Rail Study: Part 1 (Reference #3.)

- The service should be designed to meet the needs of the prospective customer in terms of departure and arrival times, total trip time, station locations and station
- Adequate parking, reliability, end-point attractions and cost efficiency should be offered.
- Adequate marketing efforts and safety programs must be considered.

➢ 1999/2000 – Lansing to Detroit Study Phases 1 through 4 (Report #3)

This study developed a detailed feasibility study for introducing commuter rail service in the Lansing to Detroit corridor[21]. The origins of this study date back to the much earlier (1981) Transmark study, which recommended against development of the Grand Rapids to Lansing segment and suggested development of only a branch line service between Detroit and Lansing.

After having truncated the corridor at Lansing, this study assessed the project as a Federal Transit Administration (FTA) commuter rail project rather than as an intercity passenger rail corridor. The Interstate Commerce Commission defined the difference between commuter and intercity rail in the case of Penn Central

Transp. Co. Discontinuance, 338 ICC 318 (1971)[22]. Therein the Commission stated that commuter and other short-haul service would "likely" include some or all of the following criteria:

- The passenger service is primarily being used by patrons traveling on a regular basis either within a metropolitan area or between a metropolitan area and its suburbs;
- The service is usually characterized by operations performed at morning and evening peak periods of travel;
- The service usually honors commutation or multiple-ride tickets at a fare reduced below the ordinary coach fare and carries the majority of its patrons on such a reduced fare basis;
- The service makes several stops at short intervals either within a zone or along the entire route;
- The equipment used may consist of little more than ordinary coaches; and
- The service should not extend more than 100 miles at the most, except in rare instances.

The truncated Detroit to Lansing corridor barely comes under the 100 mile limit; the four route options assessed in the 1999 study ranged from 87 up to 112 miles long. Since this corridor length is right at the threshold, it could qualify as either a very short intercity corridor, or as a very long commuter rail corridor. All previous studies found a reasonable ridership base from Detroit to Lansing for a service that would accommodate both the regular home to work commuter, as well as the intercity business, personal or recreational traveler.

Transmark found that:

> *Differences in demand potential between routes will depend on the relative magnitudes of trip generators/attractors between Lansing and Detroit. However, where alternatives exist, due to the short distances between node pairs in this ring, the issue is clouded by the presence of very large commuter-type flows. Although commuter traffic may be an*

[21] See: http://semcog.org/Plans-for-the-Region/Transportation/Transit/Ann-Arbor-to-Detroit-Regional-Rail-Project#888186-lansing-to-detroit-study retrieved on June 16, 2015.
[22] See: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_657.pdf page B-11

> *important source of rail ridership in each of the corridors, it is contended that since the proposed service will be intercity in character, railroad operating issues such as consist size and service frequency should be decided on the basis of longer distance trips, with commuter traffic being able to use the rail service subject to the availability of space, suitable pricing strategies and appropriate scheduling.*

It is thus seen that Transmark did not actually recommend that the Detroit – Lansing corridor be assessed as a commuter-only opportunity. In fact, since the extended "Coast-to-Coast" corridor substantially exceeds the 100-mile limit, it would more appropriate to treat the extended corridor as an intercity corridor for this study, using the economic criteria established by the Federal Railroad Administration (FRA) [23] rather than as a commuter rail corridor under FTA criteria.

The same four alignment options assumed in the 1981 study were carried forward to the 1999 study, except the corridor was truncated at Lansing rather than extending all the way through to Grand Rapids. This truncation was reflective of the recognition of additional commuter demand at Lansing, as well as the recommendation of the earlier Transmark study. The four phases of the 1999 study were:

- **Phase 1** – A review of previous studies, benchmarking and definition of the route alignments to be assessed.
- **Phase 2** – The four initial route alignment options were screened based on twelve candidate measures. It is proposed to carry forward two of these route options in the current study, modify one option and drop one option. The derivation of the current study options and their relationship to previous options will be discussed in the following paragraphs.
- **Phase 3** – A detailed analysis of the proposed Lansing – Howell – Ann Arbor – Detroit route option was carried out. Station locations, schedules, fare structure, ridership, infrastructure and equipment needs, and environmental impacts were all addressed, as were organization and oversight issues. A detailed community involvement effort was undertaken and specific local recommendations on station locations, local funding sources and organizational structure preferences were obtained.
- **Phase 4** – The final phase of the process consisted of the development of a business plan that can serve as a guide for implementing the proposed service. This contained an implementation plan and schedule, a phased capital improvement program, funding strategies, marketing strategies, and strategies for working with freight railroads. The Phase 4 document also addressed issues relating to organizational and institutional arrangements for launching the corridor as a commuter rail service.

By 1999 the travel market had changed enough so Detroit was being viewed in a much more favorable light as compared to the 1981 Transmark study. For example, the Phase 1 study introduction stated:

> *The reemergence of downtown Detroit as a destination center with increased business activity, new baseball and football stadiums, and new casinos offers many reasons for making the trip.*

As a result the ridership forecasts developed by the 1999 Detroit – Lansing study were far more robust than what Transmark earlier projected:

- The 1981 Transmark study forecasted ridership of 125,000 for Grand Rapids – Lansing – Jackson – Ann Arbor – Detroit routing (three round trips in 1985.)

[23] See: https://www.fra.dot.gov/eLib/details/L02519

- The 1999 Lansing – Detroit study forecasted ridership of 391,000 for Lansing – Jackson – Ann Arbor – Detroit routing (four round trips in 2002.)

The 1999 study projected more than three times (391,000 / 125,000 = 3.13 factor) the level of ridership as compared to Transmark, and for a shorter corridor that did not even include Grand Rapids. For developing an "apples to apples" comparison between the older and newer studies, Exhibit 2-5 (from page 45 of the Transmark Study) compares Grand Rapids and Lansing ridership. Applying this 36% increase to the 3.13 factor, if Grand Rapids had been included in the 1999 Lansing-Detroit study, the resulting ridership forecast would have been 4-5 times greater than Transmark's[24].

Exhibit 2-5: Grand Rapids vs. Lansing to Detroit Ridership, 1981 Transmark Study

Lansing-Detroit (CBD):	**13,794**
Grand Rapids-Detroit (CBD):	**7,782**
Ratio: 7,782 / (13,794 + 7,782)	**36% increase**

From Lansing to Detroit, the Phase 2 report assessed the same four route alternatives that Transmark had earlier considered. The study reported the following results:

> *The forecast results reveal that the highest 2002 ridership occurs on the two southern routes – the NS Alternative (Lansing – Jackson – Ann Arbor – Dearborn – Detroit) and the TSBY Alternative (Lansing – Howell – Ann Arbor – Dearborn – Detroit). The higher ridership is predominantly attributed to the ability of these routes to serve cities such as Ann Arbor and Dearborn.*
>
> *Conversely, the lowest ridership is forecasted for the two northern routes - the CN alternative (Lansing – Durand – Holly – Pontiac – Detroit) and the CSX Alternative (Lansing – Howell –Brighton –Plymouth – Detroit). Lower ridership is attributed to the lower population of the general service corridor and limited key travel generators.*

Since Amtrak's existing service now extends north of Detroit to Pontiac, if a new Lansing-to-Detroit service followed Amtrak's route through Dearborn and Detroit, it would logically extend to Pontiac as well. As a result, there is really no need to consider an either/or choice in regards to serving Dearborn vs. Pontiac; since the southern route alternatives can easily be extended to serve both cities (Dearborn and Pontiac) or even extended farther north to Flint. In any case an option via Durand that bypasses Flint really does not make any sense from a passenger perspective.

As a result there is little reason to advance a northern alternative that bypasses all the major population centers along the route (Ann Arbor, Dearborn and Flint) when other alternatives could include all three of these cities. On top of this, the CN corridor is the busiest freight lines in Michigan; but CN single-tracked its route from Lansing to Durand in the early 2000's, so this option is also problematical from a rail capacity point of view. As a result, and since this option did receive a detailed assessment in the 1999 study and was recommended to be screened, it is proposed that it should not receive any further consideration in this report. Similarly in the Phase 2 report, the CSX alternative via Plymouth had low

[24] But since the corridor had already been truncated at Lansing based on Transmark's earlier findings, the implications of this higher forecast on the potential for Grand Rapids service were never evaluated. This study however, will provide an opportunity to make the needed reassessment in light of the renewed strength of Detroit as both a trip attractor and trip generator.

ridership, since as originally constituted it also bypassed both important cities of Ann Arbor and Dearborn. The Phase 2 report concluded that:

> *The CSX (Lansing –Howell – Plymouth – Detroit) scored fairly well. However, the CSX route has some track capacity/congestion issues between Plymouth and Detroit and it has a marginal ridership and financial viability rating. The CSX route (in its entirety) should also be dropped from further consideration.*

Although the 1999 report suggested that both the CN and CSX alternatives be screened, for the purpose of this study, the CSX route may be improved by modifying the alternative to follow CSX south from Plymouth to Wayne, MI and then enter Detroit via Dearborn, using the same entryway as the Chicago corridor. This option at least includes the important Dearborn station as well as avoiding the expense associated with developing a parallel passenger entryway to Detroit over the CSX trackage. In terms of measuring the value added by including an Ann Arbor stop, it is valuable to retain at least one option that does not include Ann Arbor for comparison purposes. It is proposed to retain this modified CSX alternative in the current analysis.

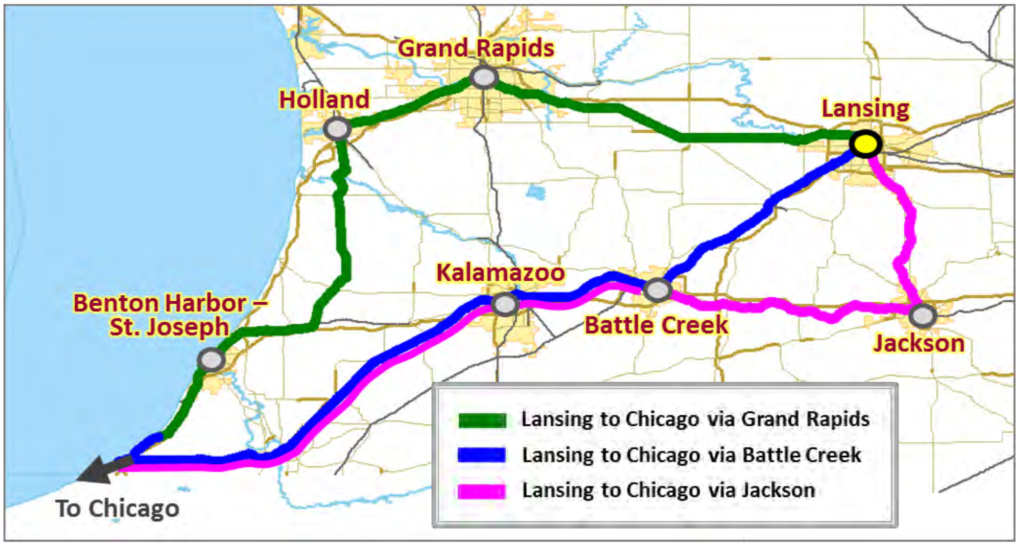
In the Phase 2 report, the two southern alternatives (via Jackson and Howell) performed best. In both the Phase 2 Lansing/Detroit report as well as the earlier Transmark study, the Jackson alternative had a higher ridership forecast than did the Howell alternative. Nonetheless the Phase 2 report concluded that the Jackson alternative should be screened, saying that:

> *The NS route has good support from a ridership and financial viability standpoint. However, this is primarily derived due to its service of Jackson and Ann Arbor. Very little patronage will originate in Lansing because the NS route cannot provide a competitive overall trip time due to the Lansing to Jackson alignment constraint issues. The NS route (in its entirety) should be dropped from further consideration.*

However, the NS Jackson alternative may be potentially "fixable" by upgrading tracks and using tilting trains to compensate for the curvature. This alternative also has the advantage of sharing the upgraded 110-mph tracks east of Jackson, which could offset some of the time loss due to curvature west of Jackson. Since this alternative had the highest ridership forecast in both previous assessments and serves both Ann Arbor and Detroit, it is worthwhile to reassess the alternative here. However, the context of the Jackson alternative makes a difference. In 1981 (as is still the case today) only one train per day operates on the direct CN route from Lansing to Chicago via Battle Creek. As shown in Exhibit 2-6, the Jackson to Lansing line could also serve Chicago trips:

- If the Port Huron route via Battle Creek remains at its current level or if the current Blue Water service were ended, it is likely that the Jackson route would attract a significant Lansing to Chicago ridership.
- If the Port Huron route via Battle Creek were improved to a level of four daily round trips, as called for by the MWRRS plan, Chicago riders would likely go direct via Battle Creek rather than via Jackson.
- If a western outlet from Grand Rapids to Chicago were developed, then Lansing to Chicago riders could go via Grand Rapids rather than via Battle Creek.

Exhibit 2-6: Three Ways to Go from Lansing to Chicago



As a result, it can be seen that there is significant interplay between the corridor options in Michigan which may influence the results of a comparison between the Jackson and Howell alternatives. These comparisons are not driven by the Detroit ridership, which are the primary focus of this study; but rather by connecting Chicago ridership, which are also included by virtue of the connecting existing train services. Absent the development of an improved direct Grand Rapids to Chicago connection, the pent-up demand for train service from Grand Rapids and Lansing to Chicago will likely artificially inflate the ridership projection of the Jackson alternative.

- If the current service were used as the base-line, then the previous studies have shown that significant numbers of Grand Rapids and Lansing riders may choose to go to Chicago via a connection at Jackson. In fact it can be seen in Exhibit 2-3 that Transmark proposed to connect Lansing to Chicago using a branch line from Jackson. However, this traffic would disappear from the study corridor if a direct outlet were developed from Lansing and Grand Rapids to Chicago.
- On the other hand, if a through corridor from Lansing to Chicago via Grand Rapids were developed, then added ridership from Lansing through to Chicago would further boost the ridership of the Coast-to-Coast route. This boost would be further enhanced even by Port Huron and Flint riders which may choose to go to Chicago via Grand Rapids rather than via Battle Creek.

Further exploration of network options for connecting Lansing and Grand Rapids to Chicago can only be addressed by a statewide study, yet they may have a significant influence on the selection of the best route for the Coast-to-Coast corridor. However, it is clear that the northern cities of Grand Rapids, Lansing and Flint need either to be connected to the main line corridor to Chicago (as Transmark proposed) or else have their own independent connection to Chicago. This issue of network interplay will need to be addressed in a future study, because a full resolution of this issue is beyond the scope of the current study. FRA's PRIIA guidance[25] suggests that State Rail Plans be updated every five years. Since Michigan's State Rail Plan was last issued in 2011, the next update is due in 2016. It may be appropriate to address this issue in the next State Rail plan update.

Finally, in the Phase 2 report, it was found that:

[25] See: https://www.fra.dot.gov/Page/P0511 retrieved on June 16, 2015.

The CSX/TSBY/AARR/NS (Lansing – Howell – Ann Arbor – Detroit) route is the clear choice for further study for providing a Lansing to Detroit passenger rail service based on the results of the route selection criteria. This route offers competitive trip times, a solid ridership base and a strong prospect for financial viability. The route effectively ties together the Lansing – Detroit corridor by connecting thru Ann Arbor and serving a growing population base in Livingston and Washtenaw counties. The route links together the major university centers at East Lansing (Michigan State University) and at Ann Arbor (University of Michigan) as well as serves major entertainment attractions such as Greenfield Village. The CSX/TSBY/ AARR/NS route utilizes a favorable geometric rail alignment that has the least freight traffic conflicts. This route also has a strong base of local support from Howell, Ann Arbor and Dearborn.

The CSX/TSBY/AARR/NS route was carried forward for further detailed study in Phase 3 of the 1999 Lansing to Detroit Passenger Rail Study. Since that time the corridor from Howell to Ann Arbor has also been the subject of separate commuter rail studies (North-South Commuter Rail line.) The main challenge associated with development of this option would appear to be the need for a new bridge and track connection in downtown Ann Arbor. However, the Phase 3 Study developed conceptual engineering for this connection and determined it to be feasible.

➢ 2002 – Lansing to Detroit Baseline Survey (Reference #7)

After the completion of the 1999 Lansing to Detroit study, the Baseline Survey developed an extensive database profiling the travel characteristics in the Lansing to Detroit corridor. Nearly 2,200 interviews were completed with an approximately equal number of interviews conducted in each major travel shed within each of the four counties as well as in the parts of the county not immediately served by a rail station. The data were then weighted so that the total numbers reflect the actual distribution of the population throughout the region. The survey also attempted to gauge the level of popular awareness and political support for the rail project. The Baseline survey found that:

- The proposed rail corridor would serve a variety of travel needs, notably:
  - Regular work commute travel to major work destinations – Lansing, Ann Arbor, Detroit
  - School commuting to/from major universities – Lansing, Ann Arbor, Dearborn, Detroit
  - Business travel to Lansing, Ann Arbor, Detroit
  - General travel throughout the corridor
- The totality of the corridor is important. This suggests that the corridor would perform better as an integrated whole (e.g. Lansing – Ann Arbor – Detroit) than as two disconnected segments.
- Awareness of proposal specifics is low; however, there is strong interest in the proposed rail corridor. More information is required before residents would support funding for the proposed service or think about using service for regular commute and/or business travel.

➢ 2004 – Midwest Regional Rail System (MWRRS) Final Report

MWRRS studies continued until 2004, finally recommending a Chicago Hub service with 7 daily round trips to Pontiac, 4 round trips via Battle Creek, Lansing and Flint to Port Huron and 4 round trips via Kalamazoo and Grand Rapids to Holland. However, it should be noted that these service plans and proposed train schedules were developed in the early 2000's when gasoline prices were still less than $1.00 per gallon. Based on today's demographics, higher oil prices and worsening traffic congestion, the market today could likely support higher train frequencies than were recommended by MWRRS-era planning.

2.2.3 Post MWRRS Era, Studies and Reports 2005-Present

In the post-MWRRS era, efforts have focused on implementing the MWRRS-recommended improvements as well as on developing numerous studies for rail commuter services and other transit services in Michigan. For intercity rail services, the State Rail planning process suggested several new corridors including Coast-to-Coast (Detroit to Holland) as well as improved rail connections linking Detroit with Traverse City, Toledo, Flint, Saginaw and Port Huron. This Coast-to-Coast study is the first major non-MWRRS corridor assessment in the post MWRRS era. Additional studies to more destinations are expected to follow shortly thereafter.

➢ 2006 – Detroit M-1 Streetcar Studies Begin

Development of the M-1 Streetcar offers an exciting enhancement to intercity passenger rail, since it will directly link the New Center train station to the Detroit Central Business District by developing a high quality rail transit service down Woodward Avenue. While the current Amtrak passenger service has effective pickup and distribution serving multiple station stops within the Detroit Metro area, the new streetcar line will provide an efficient connection to the traditional downtown. This is important to the Coast-to-Coast corridor since this downtown connection will help boost the ridership potential of the proposed new intercity rail corridor, as well as that of existing Amtrak services.

Planning for the return of rapid transit to Detroit began in 2006 when the Detroit Department of Transportation (DDOT) commissioned a study to determine expanded mass transit options along Woodward Avenue[26]. In fact, prior to 2001 when the Detroit Speedlink Study recommended Bus Rapid Transit, this segment was intended to be the first leg of a light rail transit system for Detroit. The M-1 Streetcar system is now under construction, and is expected to become operational in 2016.

➢ 2007 – Ann Arbor to Detroit Transit FTA Alternatives Analysis

The 2007 Ann Arbor to Detroit study[27] was a full Federal Transit Administration Alternatives Analysis that developed a number of commuter rail, light rail and bus options for the Ann Arbor to Detroit corridor. The study results were inconclusive since the detailed screening indicated that none of the alternatives presented to the public would be cost effective candidates for FTA New Starts[28] funding. However, feedback from the Steering Committee, the general public and local policy makers indicated that there was still a strong desire to implement rail transit in the study area. In response to both the screening results and the strong support for rail, SEMCOG began to evaluate possible strategies to implement a rail line that could either be made competitive for New Starts funding or that could be implemented without New Starts funding.

In order to test the market for rail transit, the study recommended that a demonstration project be considered. The proposed demonstration service (called "CRT 1 Modified" in the EIS documents) could be

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[26] Woodward Streetcar Project, see: http://www.michigan.gov/mdot/0,4616,7-151-9621_11058_62342---,00.html retrieved on June 16, 2015. In fact, prior to 2001 when the Detroit Speedlink Study recommended Bus Rapid Transit, this segment was intended to be the first leg of a light rail transit system for Detroit. http://www.publictransit.us/ptlibrary/specialreports/speedlinkfinalreport.pdf

[27] See: http://semcog.org/Portals/0/Documents/Plans-For-The-Region/Transportation/Transit/Ann-Arbor-To-Detroit-Regional-Rail/DetailedScreeningOfAlternativesJuly2007.pdf

[28] The Federal Transit Administration's (FTA) discretionary New Starts program is the federal government's primary financial resource for supporting locally-planned, implemented, and operated transit "guideway" capital investments. It provides up to 50% Federal matching funds for helping cover the cost of transit projects. See: http://www.fta.dot.gov/12304.html retrieved on June 16, 2015.

contracted out to Amtrak or another rail provider and utilize the existing rail infrastructure and stations along the Michigan Line. Such a service could provide significant travel time savings over automobile travel between Ann Arbor and Detroit. As demand for commuter rail services grows in the corridor, it would be possible to incrementally improve the Michigan Line, adding trains, track work, and signals as appropriate to meet service needs, and adding in-fill stations in jurisdictions interested in participating in the service. This was the genesis of the current project to develop a five-stop commuter rail service from Ann Arbor to Detroit. This commuter rail system is still under development pending completion of a capacity analysis by the freight railroads who own the tracks that would need to be used for providing commuter rail service in the corridor.

➢ 2008 – North-South Washtenaw Livingston Commuter Rail Line Studies

The proposed North-South Washtenaw Livingston Commuter rail line[29] would comprise a second Michigan commuter rail service from Howell to Ann Arbor. This line, as currently proposed, would not connect to and would operate independently of the proposed Ann Arbor to Detroit commuter rail line and existing Amtrak services. This is due to the lack of the needed track connection in downtown Ann Arbor.

➢ 2011 – Michigan State Rail Plan (Reference #1) / Tech Memo #5 (Reference #8)

The Michigan State Rail plan provides a profile and statistical summary of current Amtrak operations in Michigan; since the Rail Plan has not been updated since 2011, this document predates the implementation of 110-mph service across Michigan. The State Rail plan also describes planning efforts for the Ann Arbor to Detroit and North-South Commuter Rail line commuter rail projects; and implementation status of the MWRRI plan which today is still focusing on the development of the Chicago to Detroit/Pontiac corridor. The public outreach process was also described:

- For the existing passenger rail corridors, comments most often mentioned the Chicago - Detroit/Pontiac corridor or Wolverine service. Comments typically discussed support for ongoing investments to improve service and achieve high-speed rail along the corridor. The proposed Coast-to-Coast route would share the Wolverine service's Detroit station access and may possibly share the rail corridor as far west as Jackson.
- The Pere Marquette was mentioned by several people who submitted comments, but only a few comments mentioned the Blue Water service. This comment is specifically relevant to this study, since the proposed Coast-to-Coast corridor would use a portion of the "Pere Marquette's" route (from Holland to Grand Rapids.)
- The most common proposed service connection was to Traverse City from either Grand Rapids or Detroit. Several comments also proposed new connections to Grand Rapids. This proposed Traverse City service may potentially share part of the Coast-to-Coast routing from Detroit via Ann Arbor as far north as Howell, since this service has been proposed and promoted by the Great Lakes Central Railroad[30].
- Some comments suggested adding service to the Grand Rapids - Lansing - Detroit corridor and other comments proposed a corridor between Grand Rapids and Kalamazoo to improve access to the future high-speed rail line. These comments directly refer to the need for developing the proposed Coast-to-Coast rail corridor, as well as for improving access from Grand Rapids and Holland into Chicago.

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[29] See: http://www.theride.org/AboutUs/Initiatives/NorthSouthCommuterRail retrieved on June 16, 2015.

[30] See: http://www.glcrailroad.com/passenger.php retrieved on June 16, 2015.

- A few comments also mentioned adding passenger rail service to Toledo from Detroit to improve access from Michigan to east coast destinations.

The following passenger rail themes emerged over the course of sixteen Michigan by Rail public forums:

- Michigan's passenger rail system should include a Traverse City to southern Michigan connection. Each map at each forum included connecting Traverse City to the southern part of the state in some fashion. The southern connection points varied between Grand Rapids and the Ann Arbor area depending on where the forum was held. The maps, discussion, and comments, however, were consistent across forums regarding a Traverse City to southern Michigan passenger rail connection. Again, this Traverse City corridor would likely share at least a portion of the proposed Coast-to-Coast rail corridor from Detroit to Howell.
- Michigan's passenger rail system should connect east Michigan to west Michigan. Almost every map included connecting Michigan's east side to west side from Detroit to Lansing to Grand Rapids (and often Holland). Discussions around this passenger rail connection focused on linking together Michigan's three principal cities (without first traveling to Chicago); commuter possibilities; connecting two major universities, Michigan State University and Wayne State University; make doing business easier in the three cities; and tourist travel - sports venues in Detroit, Art Prize in Grand Rapids, the Capitol and other state government interests in Lansing. This theme identifies the importance of developing the Coast-to-Coast rail corridor in terms of connecting not only the universities and sports venues, but also the broader context for development of the rail corridor in terms of supporting the need for both social and business travel in Michigan.
- Michigan's passenger rail system should connect Michigan's universities. Participants mentioned a desire to connect Michigan's universities and colleges. Some Michigan college towns are currently served by Amtrak; increasing service frequency, re-scheduling to accommodate the academic calendar, and connecting the college and universities together were reoccurring points. The rationale that surfaced most typically in connecting the state's academic institutions was to allow for instructors and students to more easily work and study at more than one institution.
- Michigan's passenger rail system should include commuter rail connections. Participants at each forum discussed the need for some sort of commuter rail service connecting the principal cities to outlying areas, particularly Detroit, Ann Arbor, Flint and Grand Rapids. These discussions included a direct rail connection to Detroit Metropolitan Wayne County Airport (DTW). This theme mentions two of the commuter rail systems under development, both of which could share tracks with the proposed Coast-to-Coast rail system.
- Michigan's passenger rail system should connect to Toledo. Connecting Michigan's existing passenger rail system to Toledo was raised at each forum. Participants discussed that one must travel to Chicago - or by motor coach to Toledo, Ohio - to travel to points east such as New York. Connecting Toledo to the Wolverine at Ann Arbor or Detroit was typically suggested.

In addition, several comments specifically discussed the need for rail connections to Grand Rapids as this is the second largest metropolitan area in the state. Specifically, many comments supported initiating passenger rail service between Grand Rapids and Kalamazoo to connect Grand Rapids with the state’s primary high-speed rail corridor. In addition, some comments suggested studying and initiating service between Grand Rapids, Lansing and Detroit. A few comments mentioned that it is very expensive to fly out of Grand Rapids and a convenient rail connection to the Detroit airport would help facilitate travel. Furthermore, several comments expressed disappointment that the recommended Good Investment Package in the Draft Michigan State Rail Plan did not include any recommendations to initiate rail improvements for the Grand Rapids area and encouraged the rail plan team to include investments that would benefit Grand Rapids in the Good scenario.

Several comments discussed fixed-guideway transit (commuter rail, light rail and streetcar) and intercity bus services. In regards to commuter rail, several comments mentioned the proposed Detroit – Ann Arbor commuter rail line and suggested expediting this service. Some comments also discussed expediting the proposed Ann Arbor – Howell commuter rail line (North-South Commuter Rail line). Other commuter rail corridors that were suggested by people who made comments on the Draft Plan included: Grand Rapids – Kalamazoo, Ann Arbor – Kalamazoo, Ann Arbor – Jackson, and Traverse City – Kalkaska. Also, a Metro Detroit commuter rail system that would make connections between downtown Detroit and Pontiac, Utica, Port Huron and Toledo was mentioned.

A few comments discussed the need for improvements at stations. Specifically, a comment was made that East Lansing needs a new station because the current facility is outdated and portrays a poor image of the state's capital city. Also, some comments mentioned Jackson has been making improvements to their station to attract more riders, but additional improvements are needed. Furthermore, one comment mentioned that the Detroit Multimodal Transportation Center would need to accommodate Woodward Avenue light rail, Ann Arbor – Detroit commuter rail and existing and expanded Amtrak services in the future, which may require a new larger facility.

Some comments discussed the Chicago – Holland – Grand Rapids corridor, which serves the Pere Marquette passenger rail line. Typically, comments about this corridor expressed concern about the Midwest Regional Rail Initiative that proposes to reroute the corridor from its existing alignment to the Holland – Grand Rapids – Kalamazoo corridor. Communities that are currently served by the Pere Marquette would like to see service continued even if a connection between Grand Rapids and Kalamazoo is provided in the future.

Several comments also proposed new connections to Grand Rapids. Some comments suggested that the Rail Plan should consider taking steps to add service to the Grand Rapids – Lansing – Detroit corridor and inquired why this corridor is not part of the current rail investment packages proposed in the Draft State Rail Plan. Other comments suggested moving up the timeline for the implementation of the proposed corridor between Grand Rapids and Kalamazoo by placing it in the Good Investment Package instead of the Better Investment Package.

There is a strong interest in developing passenger rail service in new corridors throughout the state. The investment packages include recommendations for implementing new services to various regions of the state, including Northwest Michigan (i.e., Traverse City/Petoskey), Grand Rapids, and between Detroit and Toledo, Ohio. These recommendations are spread throughout the different investment packages in order to be consistent with the phasing required for a major corridor service development program. In accordance with the FRA corridor planning process, the first step is to conduct thorough alternatives analysis to determine feasibility, select a preferred alternative for service, determine cost and benefits and identify how the service would be funded. Depending on the outcome of the feasibility study, projects would be advanced by conducting preliminary engineering and environmental reviews. Once this phase is complete, the project moves to final engineering, construction and implementation.

The State Rail Plan incorporates this phased implementation approach by including the investment studies in the earlier investment packages. The feasibility studies for service to Grand Rapids and to Traverse City/Petoskey are included in the Good investment package, and the study of the feasibility of new service between Detroit and Toledo is included in the Better Scenario. Funding for the engineering, design and construction is only included in the investment packages for the Traverse City/ Petoskey service. However, depending on the outcome of these feasibility studies, it is possible that some of these projects may be accelerated, depending on ridership demand, cost, benefits provided, public support and the availability of funding.

The State Rail Plan identified two major issues that Michigan must address if the state wants to maintain and expand its current level of passenger rail service:

- State acquisition and rehabilitation of the Norfolk Southern (NS) rail line between Kalamazoo and Dearborn[31,] which was accomplished in 2012.
- Identifying a revenue source for subsidizing the operations of the Wolverine Service. The Wolverine service historically has been fully funded by Amtrak as part of its national system. However, Section 209 of the Passenger Rail Infrastructure and Investment Act of 2008 (PRIIA) requires Amtrak to develop and implement a single, nationwide standardized methodology for establishing and allocating the operating and capital costs among the states and Amtrak for all routes that are less than 750 miles long, beginning in October 2013. Agreements were reached with all parties, including Michigan, by the deadline, and the services continued to run without interruption.[32]

Now that these two basic issues have been addressed, to be able to develop the MWRRS vision, new sources of public funding must be found. New federal rail programs, funded through ARRA and PRIIA, could provide new revenue sources, but they require a state match and are not available to support operating costs. MDOT has been successful in obtaining over $360 million in federal rail grant funds over the past two years, including partial funding for the purchase and upgrade of the Kalamazoo to Dearborn line from NS. A state match is required for these federal capital funds, and state funds will be needed for operations. Identifying a stable and reliable source of state funding for passenger rail capital and operating costs will be very challenging in the current economic environment. MDOT is struggling to find adequate funding to support its existing programs for all modes of transportation. The 2011 State Rail plan suggests the following priorities:

- Regional rail service. Continue with the implementation of the proposed regional rail services between Ann Arbor and Detroit and between Ann Arbor and Howell (North-South Commuter Rail line). Investigate opportunities for expanding these services by adding more frequencies and extending the Ann Arbor to Detroit service to Jackson.
- New intercity routes. Conduct feasibility studies of new rail service routes. Critical analysis should include strict criteria for determining whether or not benefits are sufficient to warrant investment. Proposed studies include assessment of the feasibility of new service to:
    - Traverse City/ Petoskey with consideration of a route to Chicago via Grand Rapids or Detroit
    - Grand Rapids to Detroit via Lansing and Ann Arbor (the Coast-to-Coast corridor)
    - Expanded service on the current Pere Marquette route, or on a new direct alignment between Kalamazoo and Grand Rapids and continuing on to Holland.
    - Detroit to Toledo, Ohio.
    - True high-speed rail service (220-mph) in the Chicago to Detroit to Toronto corridor.

[31] See: http://www.michigan.gov/mdot/0,4616,7-151-9620-291086--,00.html retrieved on June 16, 2015.
[32] See: http://www.amtrak.com/pdf/factsheets/MICHIGAN13.pdf retrieved on June 16, 2015.

2012 – Intercity Passenger Rail, Chicago to Detroit/Pontiac EIS

The purpose of the Chicago to Detroit/Pontiac environmental study[33] is to enhance intercity mobility along the corridor from Chicago to Detroit/Pontiac, Michigan by providing an improved passenger rail service that would be a competitive transportation alternative to automobile, bus and air service. The need for the project arises from the inadequacies of existing passenger rail service and other modes of transportation to meet current and future mobility needs within the Corridor including:

- Limited ability to accommodate current or anticipated travel demand on the Corridor, resulting in the deterioration of transportation service quality as a result of congestion, longer trip times and decline of service reliability
- Limited intercity travel options restrict the mobility of the resident populations and the potential for economic development near station locations.
- Inadequate rail capacity in the Corridor provides uncompetitive trip times, poor reliability, and low levels of passenger comfort and convenience for travelers
- Lack of competitive advantages for modern intercity passenger service resulting in the inability to attract passenger rail travelers within the Corridor who may be currently choosing other modes of transportation.

Addressing needed infrastructure and facility improvements would bring the ability to allow higher speeds in the Corridor and increase access to passengers. Additional infrastructure investment needed to increase train speed will also allow an increase in the frequency of service. This would make the service more reliable and more likely to succeed in attracting ridership, increasing mobility and enhancing station area development opportunities near proposed stations.

Development of the Chicago to Detroit/Pontiac corridor is an integral part of the complete MWRRS system and would allow rail passengers in the Corridor to connect to all the other destinations within the system. The complete MWRRS would provide access to over 100 Midwest cities and 80% of the region's 65 million residents. It is for this reason that it is important that the Preferred Alternative identified as part of the Tier 1 EIS provide direct connection into Chicago Union Station, as this facility is envisioned as the central hub where intercity passenger rail connections can be made to other Midwest cities and regions of the country.

Development of the EIS, including the preliminary full build-out schedule is based on work that had been previously done in the Midwest Regional Rail Initiative Plan (June 2004) and updated by MDOT staff. Train performance calculator runs were used to confirm travel times. Updated ridership forecasts reflecting more recent market and demographic conditions were used to confirm schedule frequencies. Running times between Porter, Indiana and Pontiac, Michigan are based on the proposed Build Alternative improvements described in Chapter 2 of the Tier 1 EIS. The train schedule will be updated to reflect the time savings gained from infrastructure improvements in the South-of-the-Lake corridor through Indiana once a Preferred Route Alternative is selected and all of the proposed infrastructure improvements for the Corridor are confirmed.

The Chicago to Detroit/Pontiac EIS is important to the Coast-to-Coast rail corridor due to the sharing of track access into downtown Detroit, the potential under some options for sharing track as far west as Jackson, and also due to the interconnecting ridership issue. This would boost the ridership of both systems, if both the Coast-to-Coast and Chicago to Detroit/Pontiac rail corridors were fully developed.

[33] See Purpose and Need for the Chicago-Detroit/Pontiac EIS and SDP: http://greatlakesrail.org/ retrieved on June 16, 2015.

➢ 2014 – Michigan House Bill #5308 (Ref. #9)

This is an appropriations bill for the Department of Transportation for the fiscal year ending September 30, 2015. The transportation budget supports state and local highway programs, public transportation programs, aeronautics programs, and administration of the Michigan Department of Transportation (MDOT)[34]. Approximately 60% of the revenue in this budget comes from state restricted revenue, with approximately one-third from federal sources. Most of the state-restricted revenue in this budget is constitutionally restricted – from motor fuel taxes and vehicle registration taxes – and is first credited to the Michigan Transportation Fund (MTF) and then distributed in accordance with 1951 PA 51 (Act 51) to other state transportation funds and programs, including the State Trunkline Fund (STF) and the Comprehensive Transportation Fund (CTF), and to local road agencies. Language in HB 5308 (2014) directing a feasibility study of passenger rail service between Holland and Detroit, via Grand Rapids and Lansing, was written into this bill. Through the legislative process, HB 5308 (2014) and the other parallel fiscal year appropriations bills for each department of the State of Michigan were combined into House Bill 5313 (2014).

➢ 2014 – Public Act #252 (Ref. #10)

Also known as Enrolled House Bill 5313 (2014), this is the appropriations bill for all state departments and agencies, the judicial branch, and the legislative branch for the fiscal year ending September 30, 2015. Article XVII, Part 2, Section 712 directs Michigan Department of Transportation (MDOT) to conduct a feasibility study of passenger rail service between Holland and Detroit, via Grand Rapids and Lansing, including projections of corridor ridership, service capital and operating costs, as well as revenue estimates[35]. The language in Section 712 originated in HB 5308 (2014). The Coast-to-Coast study fulfills PA 252 (2014) Article XVII, Part 2, Section 712.

➢ 2015 – North-South Commuter Rail Line Studies

Initially studied in 2008 by R.L. Banks & Associates; a second series of studies[36] of the North-South Commuter Rail line are now underway by Smith Group JJR and are expected to be completed in 2016. Like Ann Arbor to Detroit commuter rail, the North-South Commuter Rail line project as currently comprised would also be funded by a combination of local, state, and federal funds.

2.3 Conclusions

This Chapter summarized the results of studies in the corridor linking Grand Rapids with Detroit dating back for almost 35 years. Early studies projected weak ridership to Detroit and recommended focusing only on Chicago-oriented corridors. However, there have been fundamental market shifts due to the development of Detroit as well as factors driving higher rail demand:

- ➢ Socioeconomic growth (Population, Income, Employment) in the Michigan market region

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[34] See: http://www.legislature.mi.gov/documents/2013-2014/billanalysis/House/pdf/2013-HLA-5308-4AFEB7E5.pdf

[35] See: https://www.michigan.gov/snyder/0,4668,7-277-57577_57657-332001--,00.html and http://www.legislature.mi.gov/documents/2013-2014/publicact/pdf/2014-PA-0252.pdf

[36] See: http://trn.trains.com/news/news-wire/2014/10/commuter-service-again-studied-along-ann-arbor-railroad and http://www.nsrailstudy.com/

- Increasing highway congestion
- Rising fuel costs

Since the length of the Coast-to-Coast corridor substantially exceeds the limit of 100 miles for commuter service, the route will need to be analyzed using FRA's criteria for intercity rail service. Although a conventional 79-mph option will also be assessed, it is expected that these criteria will be optimized in the range of 110-mph rail service and tilting train on existing corridors, as was shown by the previous MWRRS studies. In addition, to the extent that the development of an intercity passenger rail service may improve the existing rail infrastructure, it could actually facilitate the introduction of a commuter rail service at a lower cost. It has generally been found that the introduction of commuter along with intercity rail systems will boost the ridership of both systems, due to the greater potential of linked interconnecting trips, and the ability of the two systems working together to provide more and better travel options to the public.

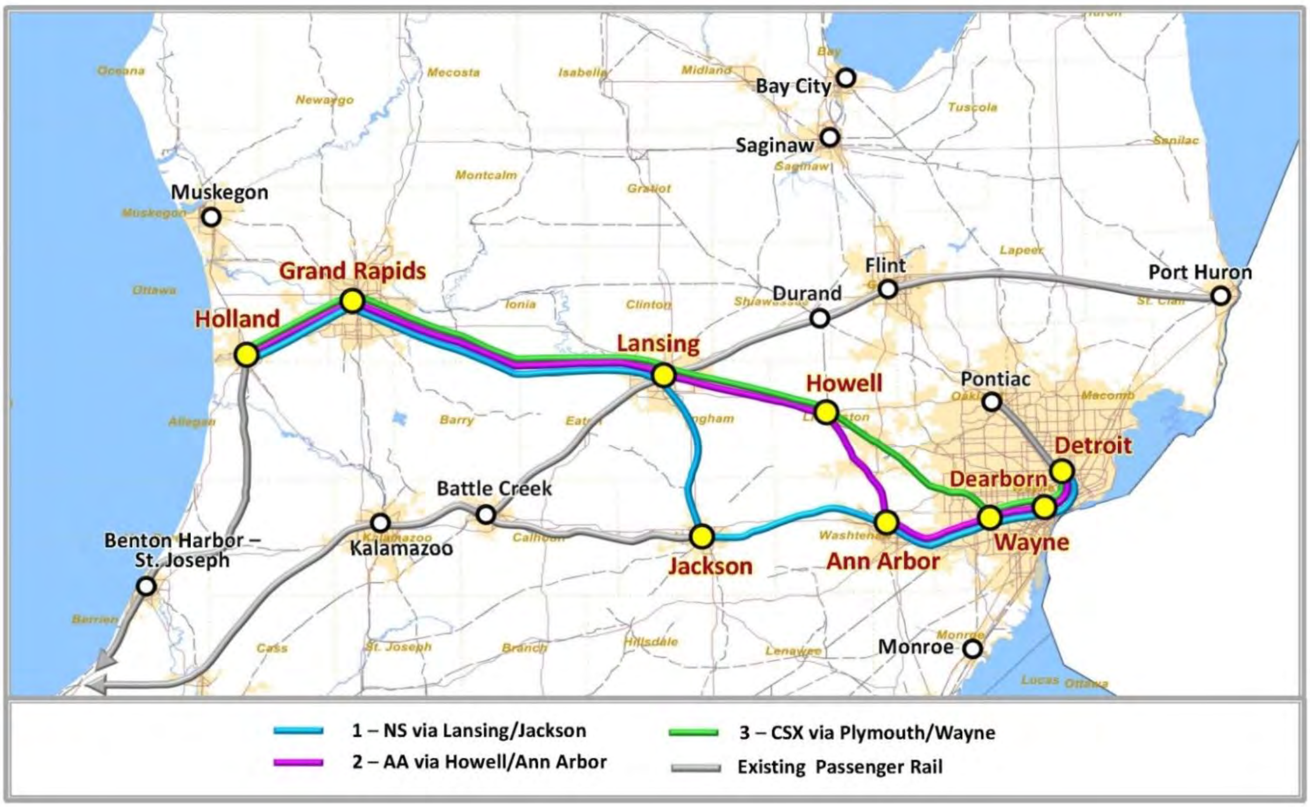
Based on the results of the earlier 1981 Transmark and 1999 Lansing to Detroit studies it is possible to propose a set of reasonable routes for the current study. As shown in Exhibit 2-7:

- The two southern options (Options 1 and 2) that were part of the original 1981 Transmark and 1999 Lansing to Detroit Passenger Rail Studies are retained and will be updated.
  - Track upgrades might make the Lansing - Jackson route faster and improve its viability as an option for connecting Lansing to Detroit. The utility of this option also depends on the statewide decision for how best to link Lansing and Flint to Chicago, as well as to Detroit.
  - The Lansing - Howell - Ann Arbor option will be assessed again. The key infrastructure needed for developing this route is a new bridge in downtown Ann Arbor linking the Norfolk Southern line over to the former Ann Arbor Railroad right-of-way. If built, this bridge could also link the two prospective Michigan commuter rail systems (North-South Commuter Rail and Ann Arbor - Detroit, currently being advanced separately) into a single corridor. The bridge could also provide a way to link Detroit to the proposed Traverse City corridor via Ann Arbor and Howell.
- The two northern options (Options 3 and 4) that were part of the original 1981 Transmark and 1999 Lansing to Detroit Passenger Rail Studies have been modified or dropped.
  - The CSX Alternative via Plymouth (Option 3) has been modified by routing trains via Wayne, MI so that they enter Detroit via Dearborn. Modifying the CSX route option via Plymouth bypasses the CSX Detroit terminal trackage, utilizes the existing passenger access into Detroit and adds the important Dearborn station to the route.
  - The 1999 Lansing to Detroit study showed that the CN Alternative (Option 4, not shown in Exhibit 2-7) via Durand is such a weak option that it is proposed that is should be dropped altogether. Any of the other Options 1-3 can easily be extended to serve Pontiac from the south as Amtrak's current service does. For a future study, it is recommended to consider extending some of the trains north from Pontiac, at least to Flint and possibly as far north as Saginaw. This extension would develop a single seat ride from Saginaw and Flint not only to Detroit, but also to points west of Detroit along either the Chicago or Coast-to-Coast corridors. Extending the current service north from Pontiac would be much more effective at developing an effective service to Flint than developing a Lansing - Durand - Pontiac route, which misses Flint altogether. However, as an alternative routing from Traverse City to Detroit, possible routings via Durand and

Pontiac, or even via Saginaw, Flint and Pontiac might make sense. These could be considered as alternatives to a Howell - Ann Arbor routing in a future study of Traverse City to Detroit route options.

Early analysis and discussion prompted the study team to determine three routes for further analysis: Routes 1-3 (Exhibit 2-7) and omit Route 4 from inclusion in this study. As a conceptual, pre-feasibility study, this analysis does in no way exclude Route 4, or any other route option for that matter, from being included in future analyses, nor does it identify a "preferred alternative" route. It does however, seek to understand the strengths and weaknesses of Routes 1-3 for consideration in potential future studies.

Exhibit 2-7: Three Coast-to-Coast Route Options Selected for the Current Study



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Chapter 3
Service and Operating Plan

SUMMARY

This chapter discusses the development of the Service and Operating Plan including identifying the route and technology options that should be considered for Coast-to-Coast study. This chapter also describes the operating plan, station stopping patterns, frequencies, train times and train schedules for each route and technology option. Operating costs were also calculated for each year the system is planned to be operational using operating cost drivers such as passenger volumes, train miles, and operating hours. As in the case of the Midwest Regional Rail Initiative (MWRRI) and Ohio Hub studies, the aim is to evaluate an affordable set of options that provide good service at a reasonable price.

3.1 Introduction

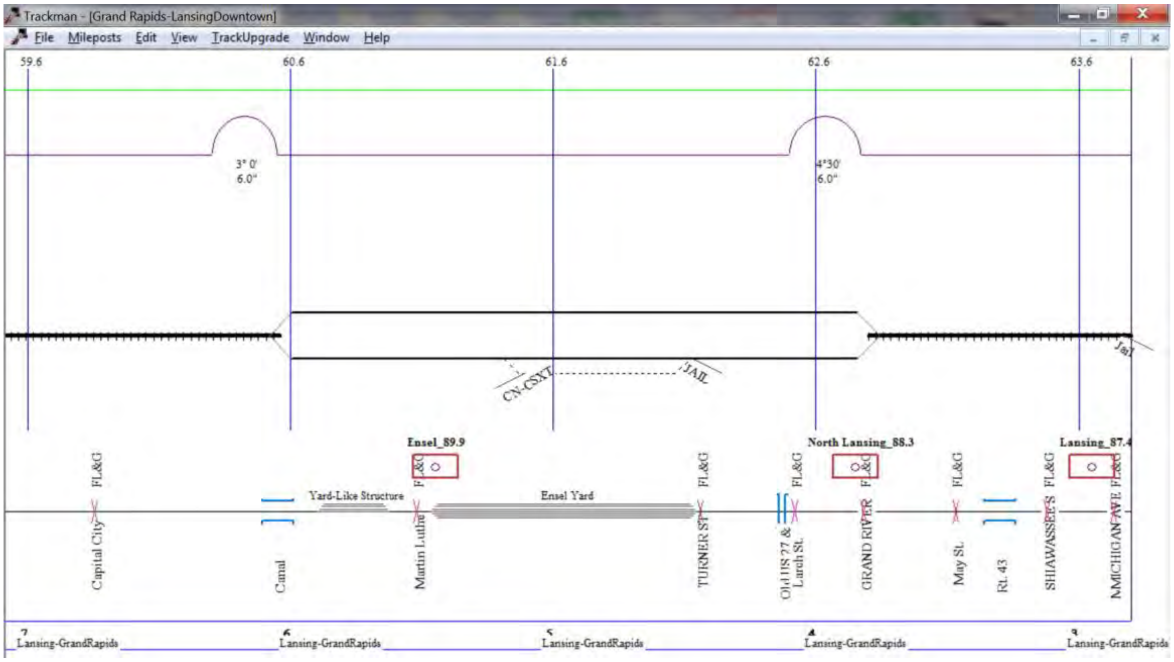
Exhibit 2-7 shows the route options proposed for the Coast-to-Coast Rail Corridor that will be used for determining Ridership and Revenue forecasts in this study. Three possible Holland to Detroit routes have been proposed: *Option 1* - Norfolk Southern (NS) via Lansing/Jackson; *Option 2* - Ann Arbor (AA) via Howell/Ann Arbor, or *Option 3* - CSX Transportation (CSX) via Plymouth/Wayne. For supporting the development of the Ridership and Revenue forecasts, the development of the operating plan and preliminary train running times based on a range of technology options are needed.

The development of the operating plan and train running times will be used as the input to the evaluation process for each of the route options. This section of the report will focus on the development of the train technology options for each route option.

3.2 Train Technology Options

For this study, TEMS' TRACKMAN™ software has been used to electronically catalog the base track infrastructure and proposed improvements for all three route options (Exhibit 3-1), thus providing a detailed track database that allows a full range of technology and train service options to be assessed.

Exhibit 3-1: Base Track Infrastructure for the North Lansing Area as Shown in TRACKMAN™



The Technology Database for the Coast-to-Coast corridor includes existing 79-mph conventional trains with one locomotive as are currently operated from Chicago to Grand Rapids; existing conventional trains with two locomotives as are currently operated up to 110-mph from Chicago to Pontiac; and proposed 110-mph tilting trains with high-speed diesel[37] engines (such as the engines that power the Siemens Charger locomotives shown on the cover of this report, which as of the date of this report are on-order for the Chicago-Pontiac corridor) along with tilting railcars, as was assumed by the earlier Midwest Regional Rail System (MWRRS) study.

The operating analysis will assess three different possible diesel train technologies that might be employed in the Coast-to-Coast rail corridor. These include:

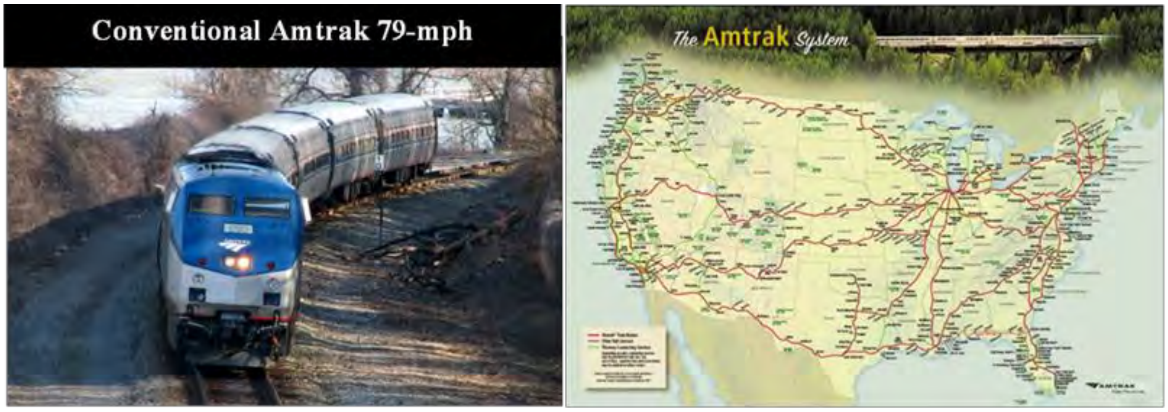
Conventional Rail – 79-mph or less: Conventional trains, as shown in Exhibit 3-2, typically operate at up to 79-mph on existing freight tracks. 79-mph represents the highest speed at which trains can legally operate in the United States without having a supplementary cab signaling system on board the locomotive. The key characteristics of these trains are that they:

- Are designed for economical operation at conventional speeds
- Can be diesel or electric powered
- Are non-tilting for simplified maintenance

Conventional rail is used by Amtrak in corridors across the country outside the Northeast corridor (Exhibit 3-3) including, for example the current Chicago to Grand Rapids service. For the Coast-to-Coast corridor study, conventional trains with one locomotive will be used for assessing the 79-mph option.

[37] The term High-speed diesel, as used in this context does not refer to the speed of the train; rather, it refers to the revolutions per minute (RPM) at which the diesel engine is designed to operate. High speed diesel engines are lighter and produce more power than the heavy, lower RPM marine diesel engines that are typically used for rail freight applications.

Exhibit 3-2: Conventional Rail – Representative 79-mph Trains and Current Corridor Service



Conventional Rail – 90-mph: Conventional trains are able to operate at 90-mph and up to 110-mph in developing corridors in Illinois and Michigan. For operating above 79-mph, the trains need to be equipped with Positive Train Control (PTC) safety equipment, and an extra locomotive needs to be added in order to attain satisfactory acceleration or braking performance. Improved grade crossing protection (quad gates) also needs to be provided along the corridor where train speeds exceed 90-mph. However, the high center of gravity of the P-42 locomotive limits its safe speed around curves, as compared to purpose-built trainsets such as the Siemens Charger, where the locomotives are designed to have a lower center of gravity. Exhibit 3-3 shows that for the Coast-to-Coast corridor study, conventional trains with two locomotives and PTC, as are currently used on the Chicago to Detroit corridor, will be used for developing a 90-mph option.

Exhibit 3-3: Conventional Rail – Representative 90-mph Trains and Current Corridor Service

Accelerated Rail – 110-mph: A 110-mph plus service can often be incrementally developed from an existing conventional rail system by improving track conditions, adding a supplementary Positive Train Control safety system, and improving grade crossing protection. Tilt capability and a low center of gravity built into the equipment can allow trains to go around curves faster, and has proven to be very effective for improving service on existing track, often enabling a 20-30 percent reduction in running times. Trains operating at or above 110 mph, such as those proposed for the Midwest, Ohio Hub and New York State systems (See Exhibit 3-4), have generally been found to be affordable, produce auto-competitive travel times, and are typically able to generate sufficient revenues to cover their operating costs.

Higher speed trains:

- Are designed for operation at or above 110-mph on existing rail lines.
- Can be diesel or electric powered.
- Are usually tilting unless the track is very straight.

In the United States, 110-mph service, called "Accelerated Rail" in Michigan and in this report, has been seen to provide a low cost infrastructure option by using existing lightly used railroad rights-of-way that have good geometry and by upgrading highway crossings, which are relatively low cost options.

However, it may contradict some existing freight railroad passenger principles unless additional improvements are made. For example, while Norfolk Southern's passenger principles do not prohibit the operation of higher speed tilting trains, they do prohibit speeds above 79-mph on Norfolk Southern-owned rights of way. CSX policies have generally prohibited operations above 90-mph. If geometry allows 110-mph speeds or higher on a high density freight corridor, an alternative arrangement, such as the purchasing of a parallel strip of right way or right-of-way easement and separate ownership of the track like the MDOT agreement for tracks in Michigan on the Detroit-Chicago line, may be needed to comply with the requirements of the freight railroads.

For the Coast-to-Coast corridor study, tilting diesel trains with two locomotives and PTC, as were originally proposed for the MWRSS, will be used for assessing the 110-mph option.

Exhibit 3-4: Accelerated Rail Shared Use (Diesel) – Representative Trains and Corridor Service

3.2.1 Rolling Stock and Operational Assumptions

Consistent with the assumptions customarily made in feasibility-level planning and Tier I EIS studies, the following general assumptions are proposed regarding operating requirements for rolling stock for the Coast-to-Coast rail corridor for all train technology options are as follows:

- Trains will be reversible for easy push-pull operations (able to operate in either direction without turning the equipment at the terminal stations);
- Trains will be accessible from low-level station platforms for passenger access and egress, which is required to ensure compatibility with freight operations;

- Trains will have expandable capacity for seasonal fluctuations and will allow for coupling two or more trains together to double or triple capacity as required;

- Train configuration will include galley space, accommodating roll-on/roll-off cart service for on-board food service. Optionally, the trains may include a bistro area where food service can be provided during the entire trip;

- On-board space is required for stowage of small, but significant, quantities of mail and express packages, and also to provide for an optional checked baggage service for pre-arranged tour groups;

- Each end of the train will be equipped with a standard North American coupler that will allow for easy recovery of a disabled train by conventional locomotives;

- Trains will not require mid-route servicing, with the exception of food top-off. Refueling, potable water top-off, interior cleaning, required train inspections and other requirements will be conducted at night, at the layover facilities located at or near the terminal stations. Trains would be stored overnight on the station tracks, or they would be moved to a separate train layover facility. Ideally, overnight layover facilities should be located close to the passenger stations and in the outbound direction so a train can continue, without reversing direction, after its final station stop; and

- Trains must meet all applicable regulatory requirements including:

  - FRA safety requirements for crash-worthiness,
  - Requirements for accessibility for disabled persons,
  - Material standards for rail components for high-speed operations, and
  - Environmental regulations for waste disposal and power unit emissions.

3.3 Operating Plan Development

Given the development of the route options and the range of technology, operating plans can be developed for the range of alternatives. TEMS uses an Interactive Analysis (Exhibit 1-2) that first simulates the train times on the route and technology, and will then develop train schedules and operating plans that include train stopping patterns, slack time for freight train interaction and train loads between individual stations.

3.4 Train Technology Operating Characteristics

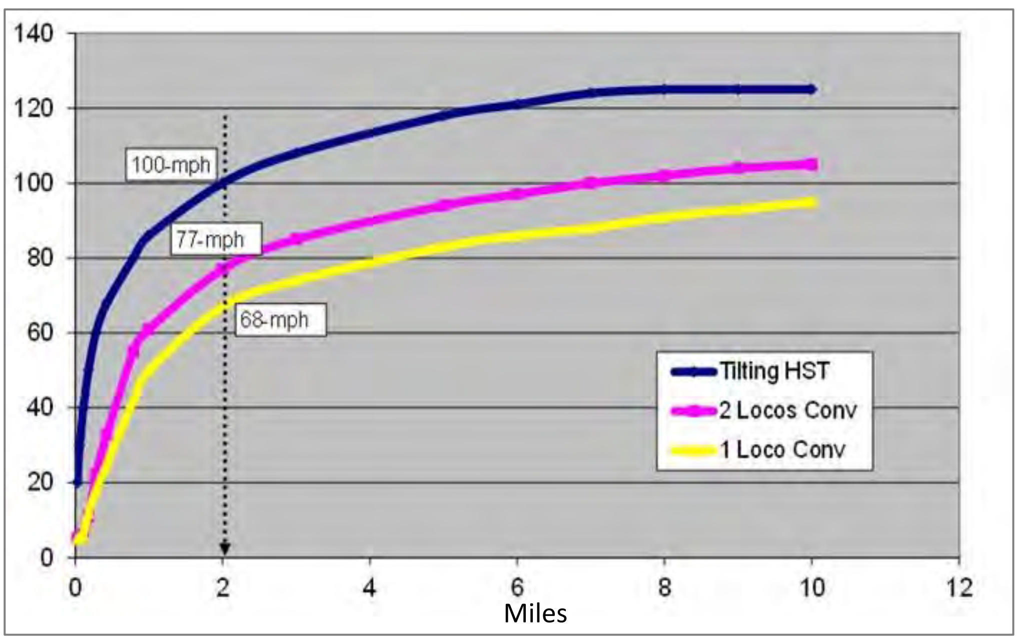
In terms of assessing rail technologies, there are two main criteria that need to be considered – type of propulsion and source of power:

- Type of Propulsion: Trains can be either locomotive-hauled or self-propelled. Self-propelled equipment has each individual railcar powered whereas conventional coaches rely on a separate locomotive to provide the power.

- Source of Power: Trains can be either diesel or electrically-powered. Diesel or electric power can be used with either the locomotive hauled or self-propelled equipment options. Turbine power has also been considered for high-speed trains, and the Rohr Turboliners in fact operated in Michigan at one time. However, due to high fuel prices turbine power does not offer any clear advantage over diesel at this time.

- Train performance curves for the three representative equipment types are shown in Exhibit 3-5. The curves reflect the acceleration capabilities of three rail technologies that are included in this study.

Exhibit 3-5: Comparative Train Acceleration Curves



Purpose-built Diesel Trains, such as the Talgo T21, can offer considerably improved performance over conventional diesel trains that are based on freight-derived designs. Conventional diesel trains with one locomotive can barely achieve 100-mph, and with two locomotives are just able to achieve a maximum of 110-mph; whereas purpose-built high-speed diesel trains can easily achieve 125-mph to 135-mph and can accelerate much faster than a conventional diesel train. Up to about 80-mph the acceleration capability of the high-speed diesel is in fact similar to that of an electric train. This type of train could even run at 130-mph on a fully grade separated corridor, but this or development of greenfield alignments is beyond the scope of the current study. However, it should be apparent from the above performance graph that the capability of the high-speed diesel train, as a purpose-built passenger train, goes considerably beyond that of the conventional Amtrak train.

- Train timetables can be developed from running times and can be used to calculate rolling stock requirements. Train frequencies and the required train seating capacity are determined via an interactive process using the demand forecast COMPASS™ Model.
- The results taken from LOCOMOTION™ will be faster than the actual times, since they are based on optimized performance of trains under ideal conditions. While it is assumed that passenger trains will have dispatching priority over freight, practical schedules still need to allow 5-10 percent slack time in case of any kind of operating problem, including the possibility of freight or commuter train interference, depending on the degree of track sharing with freight. Since the proposed accelerated rail route is based on shared freight track, an 8% Slack time allowance will be included in the train running times.

3.5 Train Schedule Development

After the track data was collected and catalogued using TRACKMAN™ (Exhibit 3-2), the LOCOMOTION™ train performance program was used to assess the performance of various train technologies at different speeds or levels of investment. The LOCOMOTION™ program reflects the different train operating characteristics (train acceleration, curving and tilt capabilities, etc.) that are associated with the different types of train technologies assumed. Speed Profiles for each of the nine combinations of route and train technology are detailed in Exhibits 3-7 through 3-15 below.

3.5.1 Option 1: NS via Lansing/Jackson

Exhibit 3-6 shows the speed profile for NS Lansing/Jackson Option 1 using a conventional Amtrak train with one locomotive and a top speed of 79-mph. East of Jackson, this train could be allowed to run faster than 79-mph but due to the limitations of having only one locomotive, it could not practically attain a top speed much higher than shown and could save only a few minutes relative to the calculated running time.

Exhibit 3-7 shows the speed profile for NS Lansing/Jackson Option 1 using a conventional Amtrak train with two locomotives and a top speed of 90-mph. The assumed top speed of 90-mph from Holland to Lansing is allowable on upgraded track according to CSX principles; but since NS owns the line from Lansing to Jackson, would likely require that this track be purchased from NS by Michigan. East of Jackson, this train is allowed to run up to 110-mph as according to current Amtrak practice and speed limits.

Exhibit 3-8 shows the speed profile for NS Lansing/Jackson Option 1 using a tilting diesel train with two locomotives and a top speed of 110-mph. In this speed profile and those to follow, the red line shows the speed limit, and the black line shows the simulated speed obtained by the train at that point. A 110-mph top speed would likely require that the Holland to Lansing track be purchased from CSX, and the Lansing to Jackson track be purchased from NS by another entity since it violates both railroads' freight principles for the tracks that they own. East of Jackson, this train is allowed to run up to 110-mph and is able to run faster than the current Amtrak trains due to its tilting capability.

Exhibit 3-6: NS Lansing/Jackson Option 1 at 79-mph

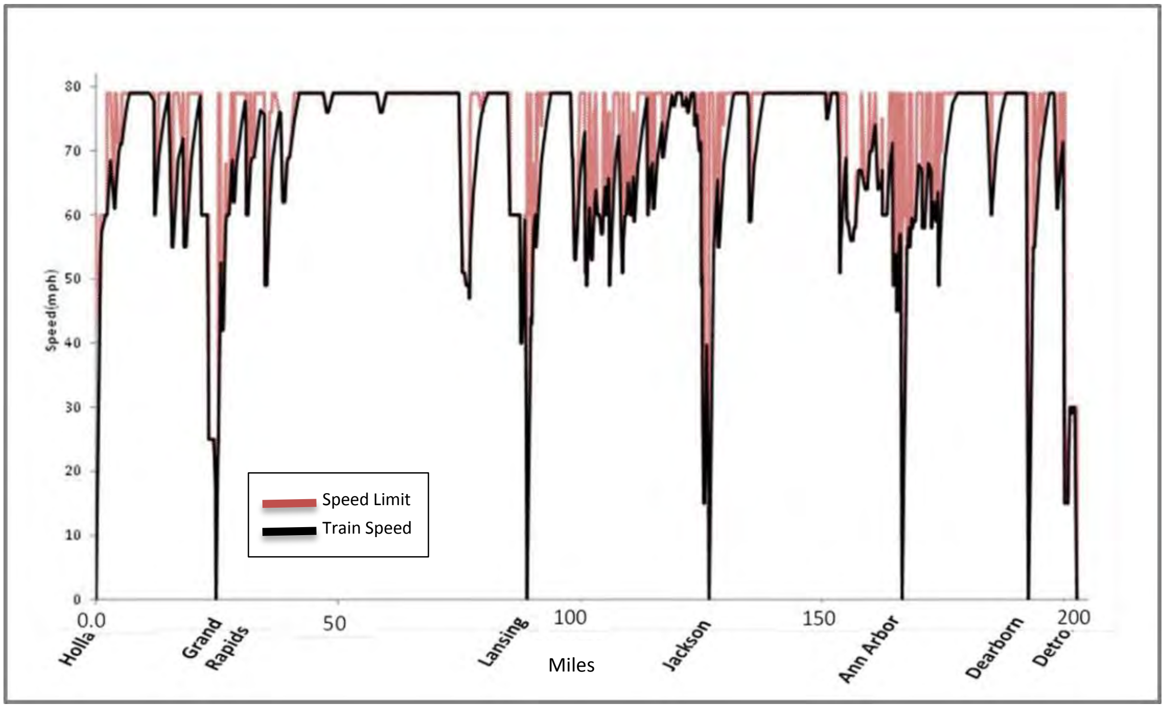


Exhibit 3-7: NS Lansing/Jackson Option 1 at 90-mph (110-mph east of Lansing)

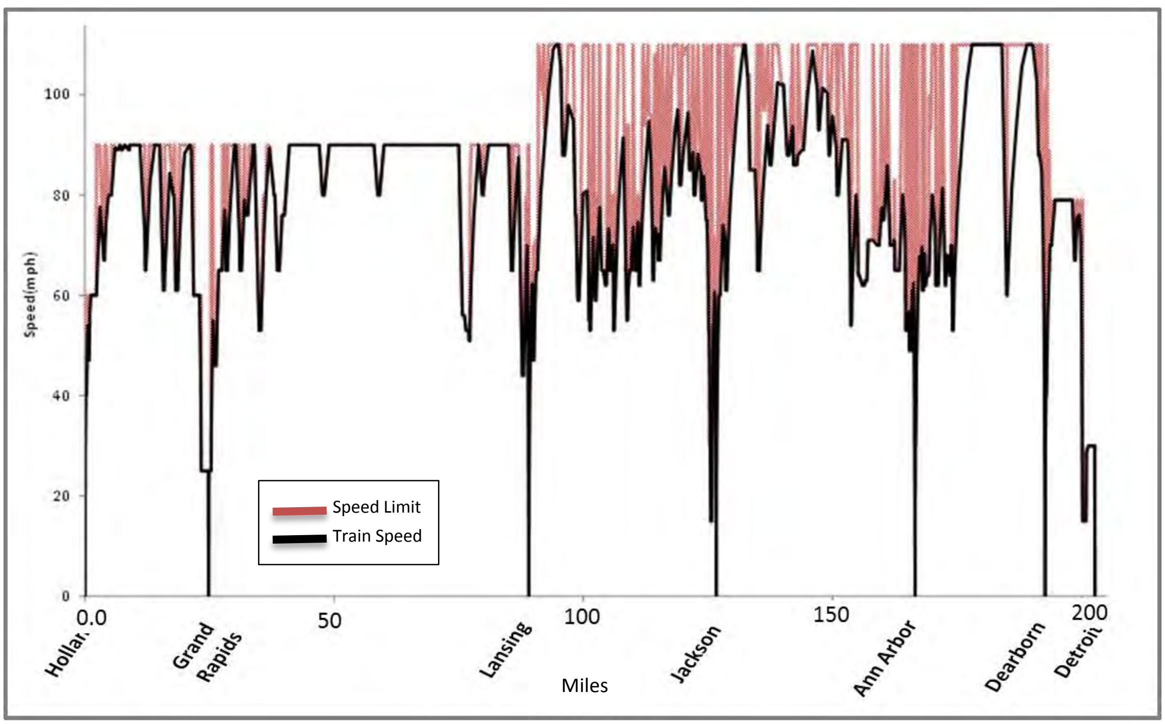
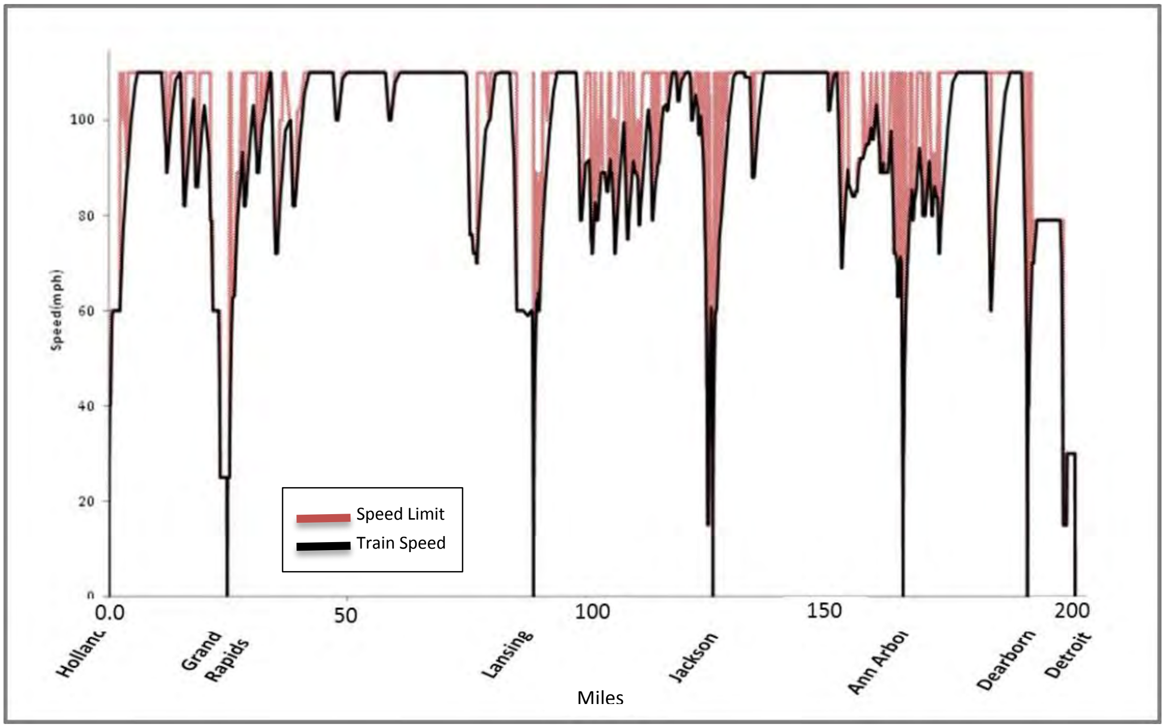


Exhibit 3-8: NS Lansing/Jackson Option 1 at 110-mph



3.5.2 Option 2: AA via Howell/Ann Arbor

Exhibit 3-9 shows the speed profile for AA Howell/Ann Arbor Option 2 using a conventional Amtrak train with one locomotive and a top speed of 79-mph. East of Ann Arbor, this train could be allowed to run faster than 79-mph but due to the limitations of having only one locomotive, it could not practically attain a top speed much higher than shown and could save only a few minutes relative to the calculated running time.

Exhibit 3-10 shows the speed profile for AA Howell/Ann Arbor Option 2 using a conventional Amtrak train with two locomotives and a top speed of 90-mph. The assumed top speed of 90-mph from Holland to Howell is allowable on upgraded track according to CSX principles; Michigan already owns the track from Howell to Ann Arbor. East of Ann Arbor, this train is allowed to run up to 110-mph as according to current Amtrak practice and speed limits.

Exhibit 3-11 shows the speed profile for AA Howell/Ann Arbor Option 2 using a tilting diesel train with two locomotives and a top speed of 110-mph. This speed would likely require that the Holland to Howell track be purchased from CSX since it violates CSX freight principles for tracks that they own. From Howell to Ann Arbor, Michigan already owns the track so train speed would only be limited by track geometry and the existence of level grade crossings. East of Ann Arbor, this train is allowed to run up to 110-mph and could run faster than the current Amtrak trains due to its tilting capability.

Exhibit 3-9: AA Howell/Ann Arbor Option 2 at 79-mph

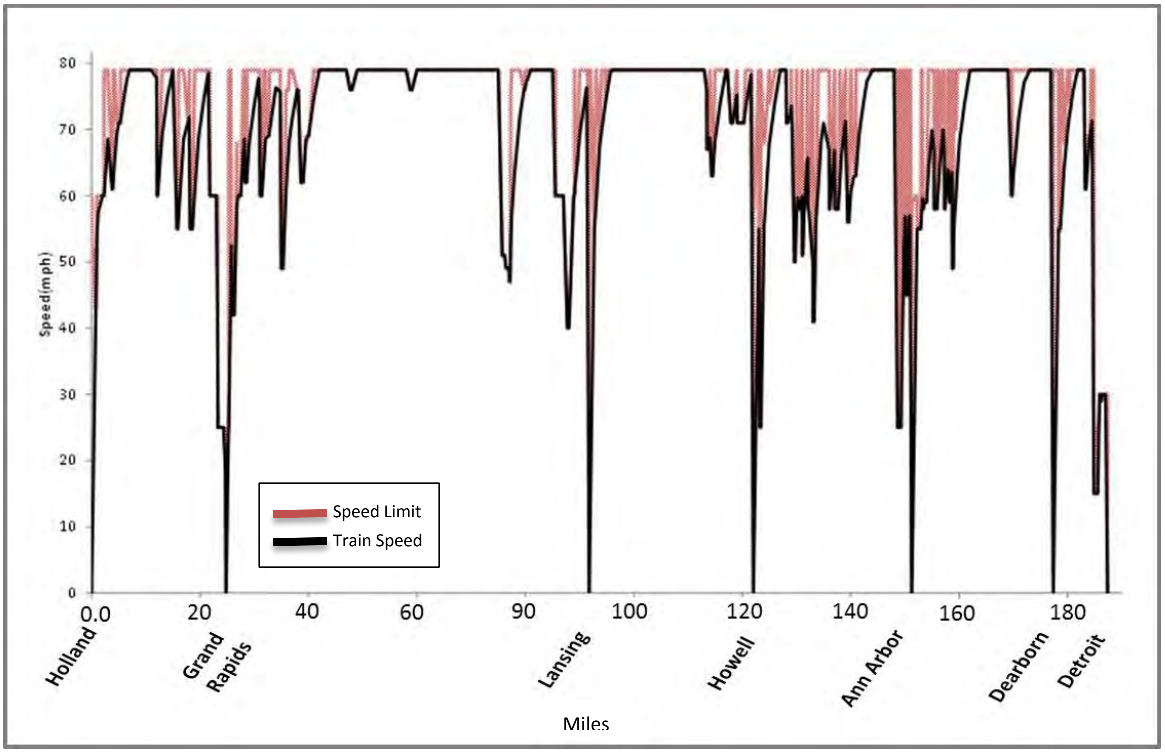


Exhibit 3-10: AA Howell/Ann Arbor Option 2 at 90-mph (110-mph east of Howell)

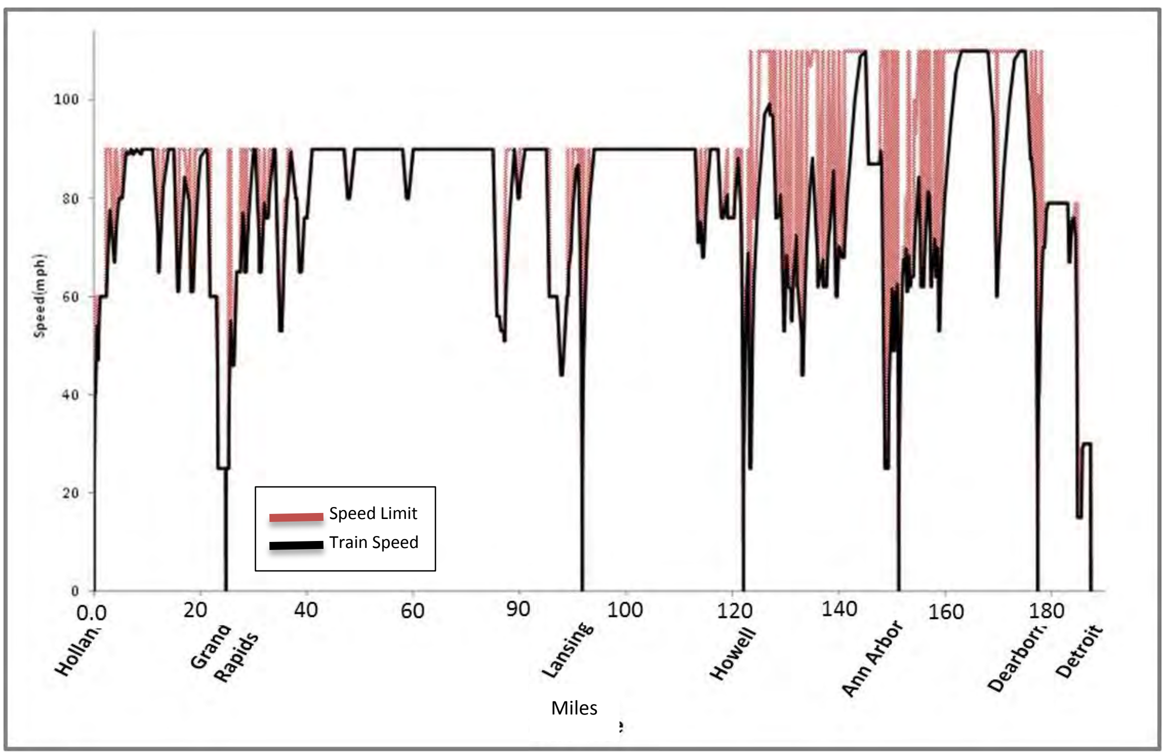
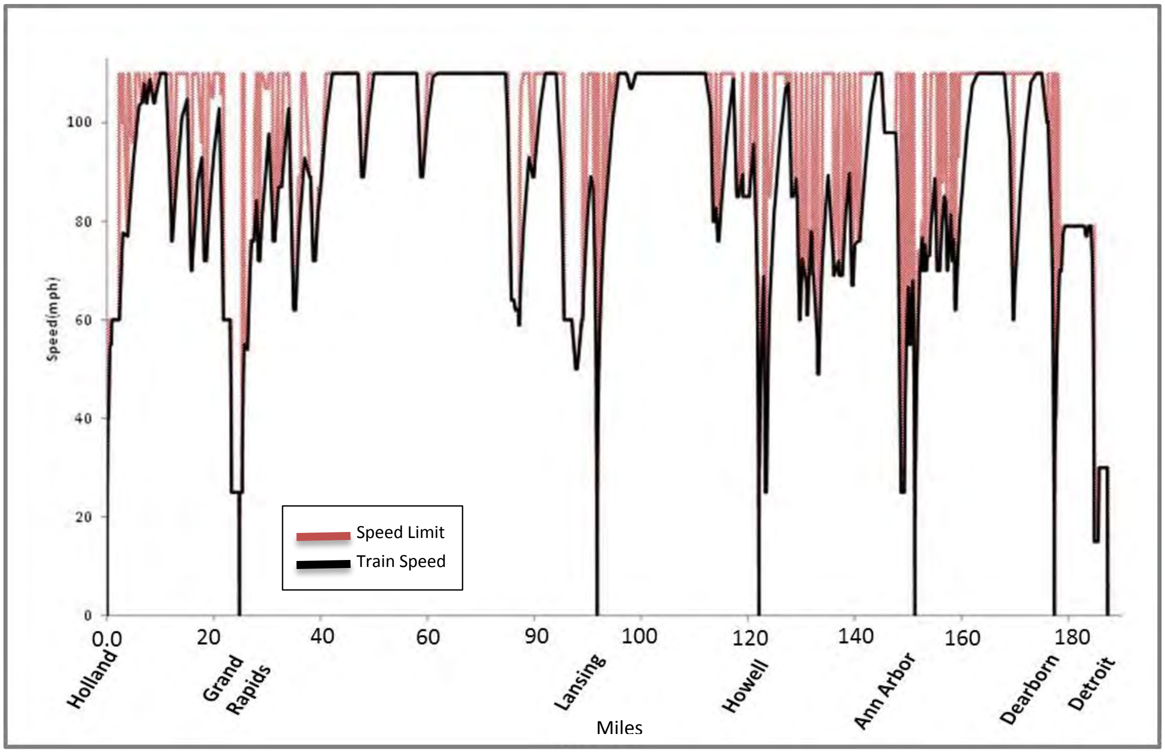


Exhibit 3-11: AA Howell/Ann Arbor Option 2 at 110-mph



3.5.3 Option 3: CSX via Plymouth/Wayne

Exhibit 3-12 shows the speed profile for CSX Plymouth/Wayne Option 3 using a conventional Amtrak train with one locomotive and a top speed of 79-mph. East of Wayne, this train could be allowed to run faster than 79-mph but due to the limitations of having only one locomotive, it could not practically attain a top speed much higher than shown and could save only a few minutes relative to the calculated running time.

Exhibit 3-13 shows the speed profile for CSX Plymouth/Wayne Option 3 using a conventional Amtrak train with two locomotives and a top speed of 90-mph. The assumed top speed of 90-mph from Holland to Plymouth to Wayne is allowable on upgraded track according to CSX principles. East of Wayne, this train is allowed to run up to 110-mph as according to current Amtrak practice and speed limits.

Exhibit 3-14 shows the speed profile for CSX Plymouth/Wayne Option 3 using a tilting diesel train with two locomotives and a top speed of 110-mph. This speed would likely require that the Holland to Plymouth track be purchased from CSX. For the relatively short distance from Plymouth to Wayne, either a dedicated track alongside the CSX main line would need to be constructed, or train speed would need to be reduced to 90-mph in line with CSX principles. East of Wayne, this train is allowed to run up to 110-mph and could run faster than the current Amtrak trains due to its tilting capability.

Exhibit 3-12: CSX Plymouth/Wayne Option 3 at 79-mph

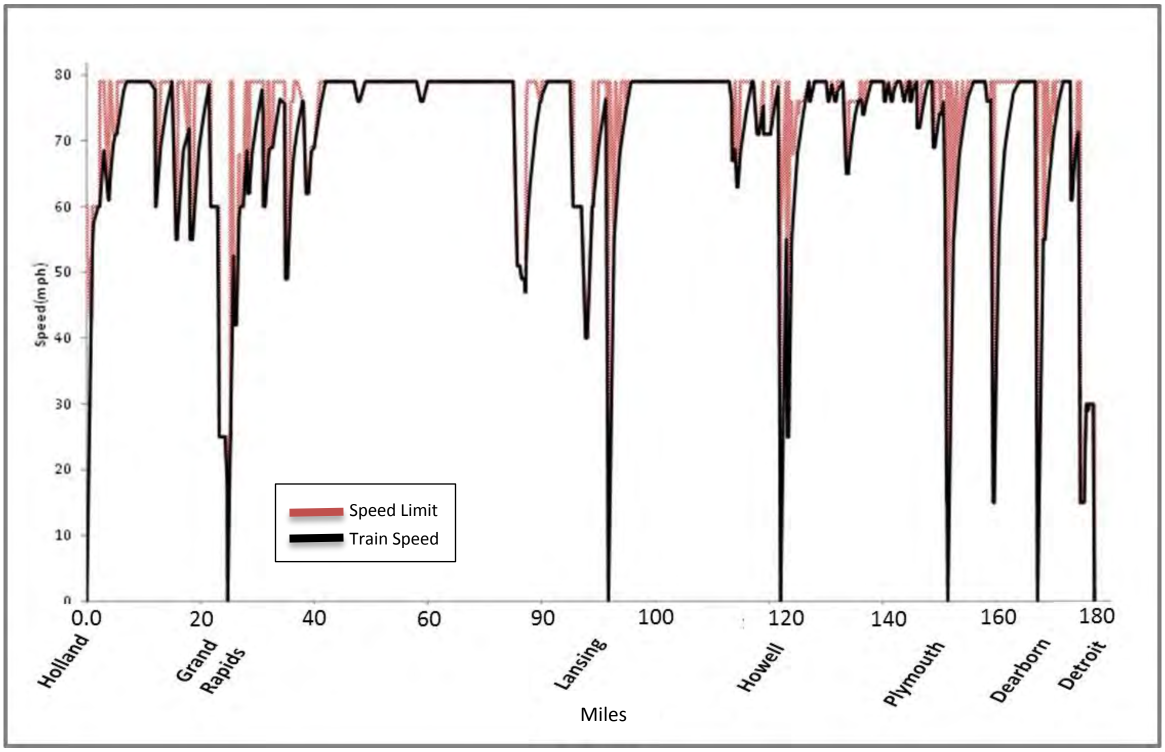


Exhibit 3-13: CSX Plymouth/Wayne Option 3 at 90-mph (110-mph east of Wayne)

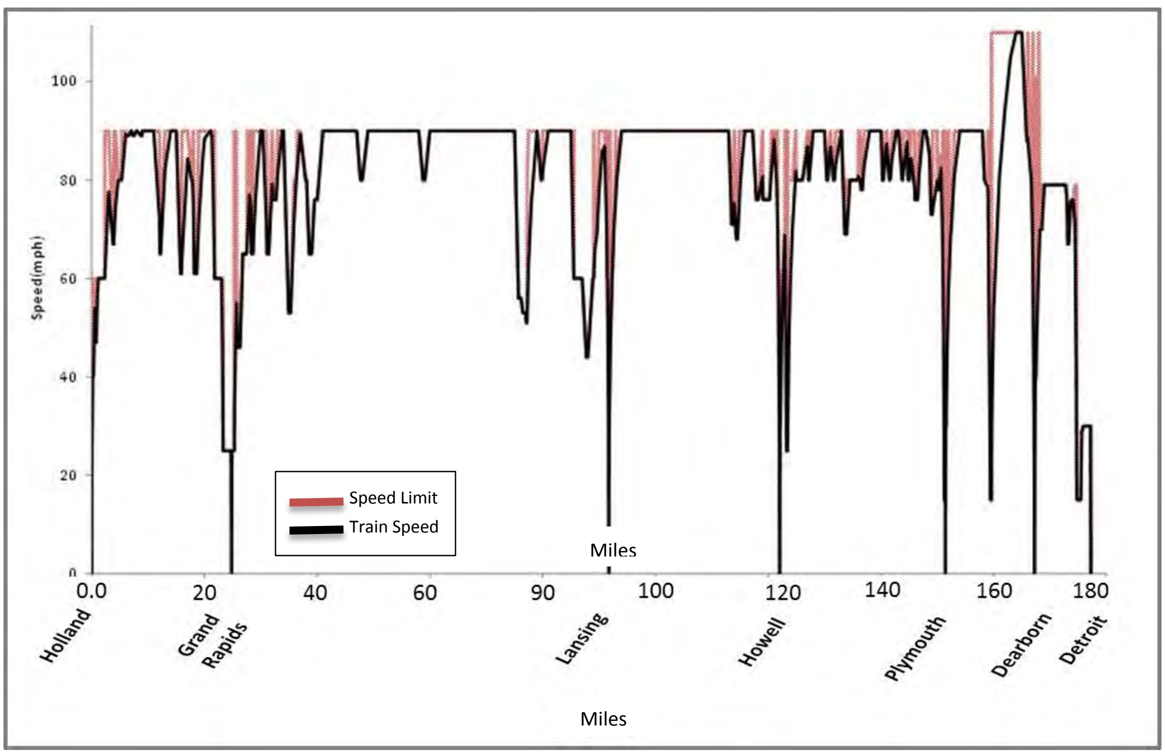
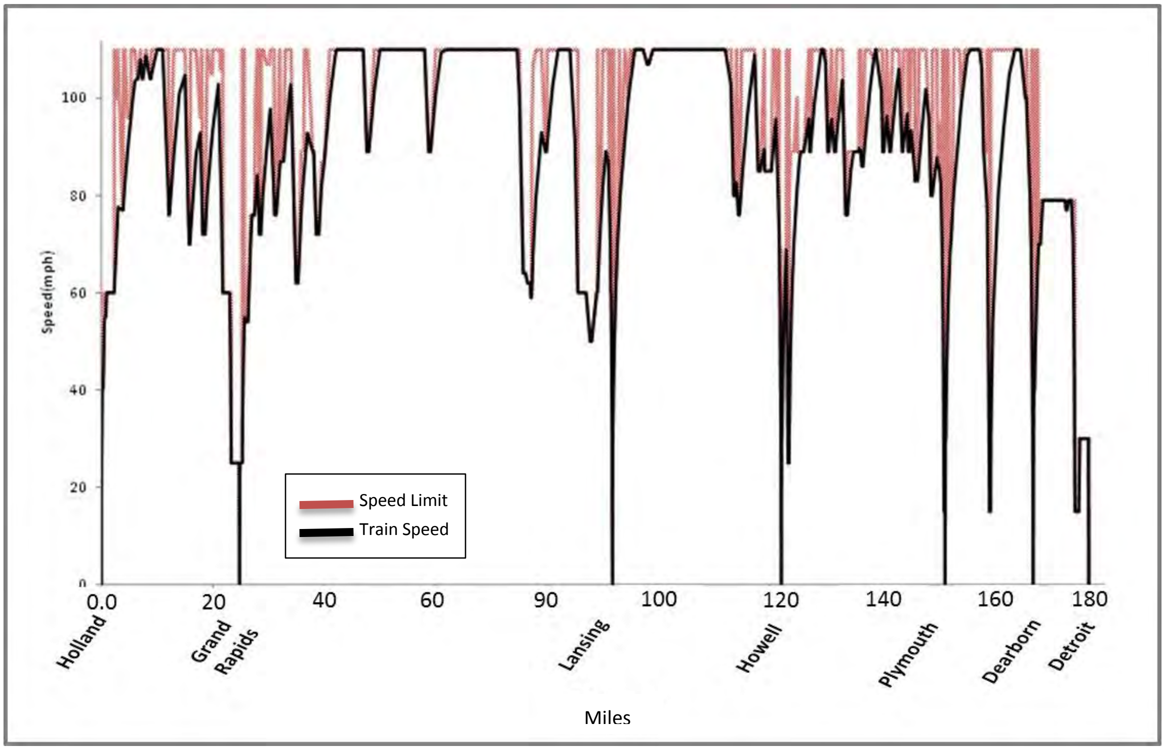


Exhibit 3-14: CSX Plymouth/Wayne Option 3 at 110-mph

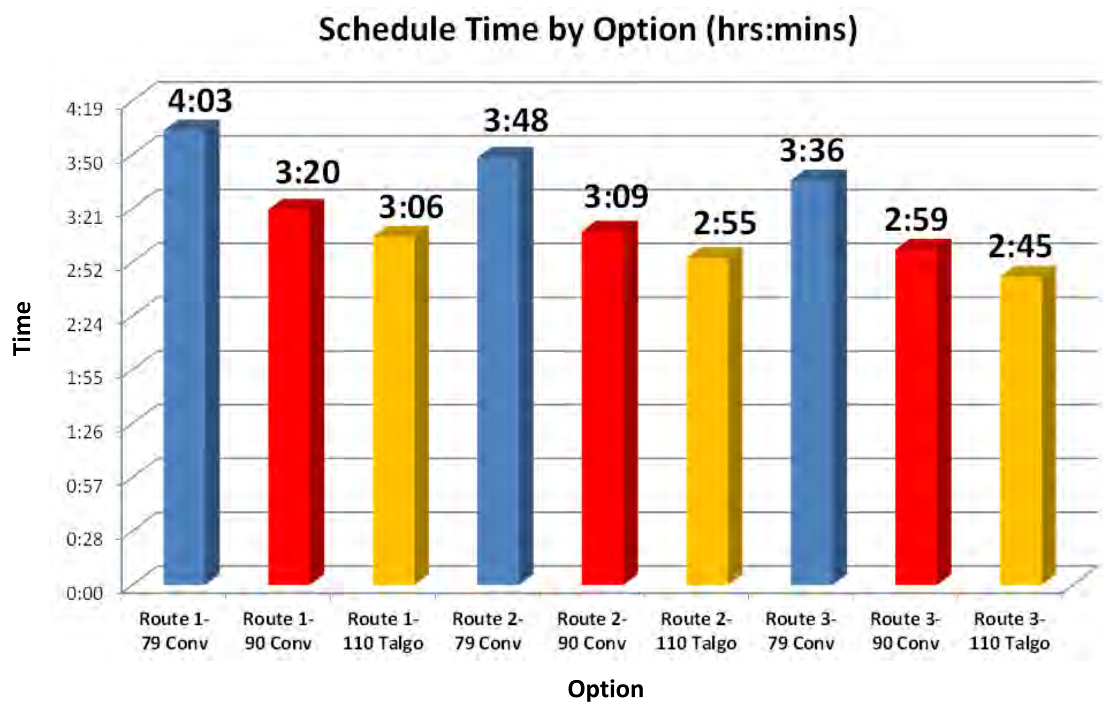


3.6 Comparative Running Times Summary

The travel times for the 79-mph conventional and 110-mph diesel tilt train technologies were evaluated for each route. The comparative train running times are summarized in Exhibit 3-15. It can be seen that Route 3 via Plymouth and Wayne is the fastest, and Route 1 via Jackson is the slowest route alternative despite benefits from being able to use the upgraded Detroit-Chicago track for the longest distance (Jackson-Detroit). Route 2 running times are intermediate to those of Routes 1 and 3; however, Route 2 is the fastest alternative which includes the major station of Ann Arbor.

Exhibit 3-15: Coast-to-Coast Running Times Summary

Coast-to-Coast Schedule Summary (hrs:mins)									
From-To	Route 1-79 Conv	Route 1-90 Conv	Route 1-110 Talgo	Route 2-79 Conv	Route 2-90 Conv	Route 2-110 Talgo	Route 3-79 Conv	Route 3-90 Conv	Route 3-110 Talgo
Holland-Grand Rapids*	0:41	0:34	0:32	0:41	0:34	0:32	0:41	0:34	0:32
Grand Rapids-Lansing Downtown	1:05	0:55	0:49						
Grand Rapids-East Lansing				1:07	0:58	0:51	1:07	0:58	0:51
Lansing Downtown-Jackson	0:43	0:36	0:33						
Jackson-Ann Arbor	0:42	0:35	0:32						
East Lansing-Howell				0:32	0:25	0:22	0:32	0:25	0:22
Howell-Ann Arbor				0:37	0:30	0:29			
Ann Arbor-Greenfield Village	0:30	0:22	0:22	0:30	0:22	0:22			
Howell-Plymouth							0:33	0:27	0:25
Plymouth-Greenfield Village							0:22	0:16	0:15
Greenfield Village-Detroit	0:20	0:16	0:16	0:20	0:16	0:16	0:20	0:16	0:16
Overall Time	***4:03***	***3:20***	***3:06***	***3:48***	***3:09***	***2:55***	***3:36***	***2:59***	***2:45***



*The Holland-Grand Rapids segment includes 10 minutes additional time for backing in and out of the Grand Rapids train station. Route 2 assumes the construction of a new bridge to allow Route 2 to connect the Ann Arbor North-South Commuter line to the Chicago-Detroit/Pontiac mainline.

3.6.1 Benchmark Comparison

There are several benchmarks to which these results could be compared. These will be addressed in turn.

- Jackson to Detroit: Amtrak today averages 1:42 to run from Jackson to Detroit. According to the Tier I EIS for the Chicago to Detroit/Pontiac corridor, this time is to be reduced to 1:15. The Route 1 90-mph option has exactly the same time of 1:15 for this route segment as does the Tier I EIS. However, as estimated by the Route 1 110-mph option, a tilting train could run the segment approximately 4 minutes faster than the non-tilting Amtrak train that was assumed by the Tier I EIS.

- Holland to Grand Rapids: Amtrak today needs one hour to run from Holland to Grand Rapids. The MWRRS plan developed a 79-mph option that would make the run in 27 minutes. Including a 10-minute allowance for backing in and out of the Grand Rapids train station, the time allowed here for making that run would range from 32 to 47 minutes.

- Plymouth to Grand Rapids: In 1941, the historical Pere Marquette timetables showed the Plymouth to Grand Rapids time as 2 hours 39 minutes. In 1946 it was 2 hours 28 minutes for an Express train. In 1970, the schedule was 2 hours 40 minutes with four intermediate stops. With track upgrades to 79-mph and two stops, the time projected here would be 2 hours and 12 minutes, which is slightly faster than the historical schedules. However, the Transmark/GM 1982 study had estimated a 1 hour 51 minute time for the same run, so the Coast-to-Coast study is considerably more conservative than Transmark's earlier assessment.

- Lansing to Detroit: The 1999 study had a 1:57 time for a 79-mph Option 1 via Lansing; the comparable time for this study is 2:17. For Option 2, the 1999 study had a 1:43 time; this study has 2:01. For Option 3, the 1999 study had 1:29; this study has 1:48 for a comparable 79-mph option. It can be seen that the train performance modeling assumed here is considerably more conservative than what was assumed by either the 1982 Transmark or 1999 Lansing-Detroit studies.

3.6.2 Conclusion

The analysis of train running times shows that the 79-mph options are all significantly slower, while the 90 to 110-mph options have travel times that are within 10-15 minutes of one another. As a result, it is proposed (as was done for the MWRRS study) to evaluate the three 79-mph options along with the three 110-mph options. This will fully bracket the range of potential study outcomes; any 90-mph option will have an intermediate value in terms of train schedule, ridership, revenue, operating cost, and financial and economic performance. It will allow a 90-mph option to be considered in future work.

3.7 Operating and Maintenance Cost Methodology

This section describes the build-up of the unit operating costs that have been used in conjunction with the operating plans, to project the total operating cost of each corridor option. A costing framework originally developed for the Midwest Regional Rail System (MWRRS) was adapted for use in this study. However, it has also been validated against current Amtrak Passenger Rail Investment and Improvement Act of 2008 Costs (PRIIA) costs as described in the following sections.

Following the MWRRS methodology[38], nine specific cost areas have been identified. As shown in Exhibit 3-17, variable train-mile driven costs include equipment maintenance, energy and fuel, and train and onboard service (OBS) crews. Passenger miles drive insurance liability, while ridership influences marketing, and sales. Fixed costs include administrative costs, station costs, and track and right-of-way maintenance costs. Signals, communications and power supply are included in the track and right-of-way costs.

This framework enables the direct development of costs based on directly-controllable and route-specific factors, and allows sensitivity analyses to be performed on the impact of specific cost drivers. It also enables direct and explicit treatment of overhead cost allocations, to ensure that costs which do not belong to a corridor are not inappropriately allocated to the corridor, as would be inherent in a simple average cost-per-train mile approach. It also allows benchmarking and direct comparability of Michigan Coast-to-Coast corridor costs with those developed by other high-speed rail studies across the nation, including those with which the proposed corridor route would connect.

Exhibit 3-16: Operating Cost Categories and Primary Cost Drivers

Drivers		Cost Categories
Train Miles	→	Equipment Maintenance Energy and Fuel Train and Engine Crews Onboard Service Crews
Passenger Miles	→	Insurance Liability
Ridership and Revenue	→	Sales and Marketing
Fixed Cost	→	Service Administration Track and ROW Maintenance Station Costs

Operating costs can be categorized as variable or fixed. As described below, fixed costs include both Route and System overhead costs. Route costs can be clearly identified to specific train services but do not change much if fewer or additional trains were operated.

[38] Follow the links under "Midwest Regional Rail Initiative (MWRRI)" at http://www.dot.state.mn.us/planning/railplan/studies.html

- Variable costs change with the volume of activity and are directly dependent on ridership, passenger miles or train miles. For each variable cost, a principal cost driver is identified and used to determine the total cost of that operating variable. An increase or decrease in any of these will directly drive operating costs higher or lower.

- Fixed costs are generally predetermined, but may be influenced by external factors, such as the volume of freight tonnage, or may include a relatively small component of activity-driven costs. As a rule, costs identified as fixed should remain stable across a broad range of service intensities. Within fixed costs are two sub-categories:

  - Route costs such as track maintenance, train control and station expense that, although fixed, can still be clearly identified at the route level.
  - Overhead or System costs such as headquarters management, call center, accounting, legal, and other corporate fixed costs that are shared across routes or even nationally. A portion of overhead cost (such as direct line supervision) may be directly identifiable but most of the cost is fixed. Accordingly, assignment of such costs becomes an allocation issue that raises equity concerns. These kinds of fixed costs are handled separately.

Operating costs have been developed based on the following premises:

- Based on results of recent studies, a variety of sources including suppliers, current operators' histories, testing programs and prior internal analysis from other passenger corridors were used to develop the cost data. However, as the rail service is implemented, actual costs will be subject to negotiation between the passenger rail authority and the contract rail operator(s).

- Freight railroads will maintain track and right-of-way that they own, but ultimately, the actual cost of track maintenance will be resolved through negotiations with the railroads. For this study, a track maintenance cost model will be used that reflects actual freight and passenger railroad cost data.

- Maintenance of train equipment will be contracted out to the equipment supplier.

- Train operating practices follow existing work rules for crew staffing and hours of service. Average operating expenses per train-mile for train operations, crews, management and supervision were estimated through a bottoms-up staffing approach based on typical passenger rail organizational needs.

The MWRRS costing framework was originally developed in conjunction with nine states that comprised the MWRRS steering committee and with Amtrak. In addition, freight railroads, equipment manufacturers and others provided input to the development of the costs. However, the costing framework has been validated with recent operating experience based on publicly available data from other sources, particularly the Midwest 403B Service trains Northern New England Passenger Rail Authority's (NNEPRA) Downeaster costs and data on Illinois operations that was provided by Amtrak. It has been updated and brought to a 2013 costing basis.

The original concept for the MWRRS was for development of a new service based on operating methods directly modeled after state-of-the-art European rail operating practice. Along with anticipated economies of scale, modern train technology could reduce operating costs when compared to existing Amtrak practice. In the original 2000 MWRRS Plan, European equipment costs were measured at 40 percent of Amtrak's costs. However, in the final MWRRS plan that was released in 2004, train-operating costs were significantly increased to a level that is more consistent with Amtrak's current cost structure. However, adopting an Amtrak cost structure for financial planning does not suggest that Amtrak would actually be selected for the corridor operation. Rather, this selection increases the flexibility for choosing an operator without excluding Amtrak, because multiple operators and vendors will be able to meet the broader performance parameters provided by this conservative approach.

3.7.1 Variable Costs

Variable costs include those that directly depend on the number of train-miles operated or passenger-miles carried. They include train equipment maintenance, train crew cost, fuel and energy, onboard service, and insurance costs.

3.7.1.1 Train Equipment Maintenance

Equipment maintenance costs include all costs for spare parts, labor and materials needed to keep equipment safe and reliable. The costs include periodical overhauls in addition to running maintenance. It also assumes that facilities for servicing and maintaining equipment are designed specifically to accommodate the selected train technology. This arrangement supports more efficient and cost-effective maintenance practices. Acquiring a large fleet of trains with identical features and components, allows for substantial savings in parts inventory and other economies of scale. In particular, commonality of rolling stock and other equipment will standardize maintenance training, enhance efficiencies and foster broad expertise in train and system repair.

The MWRRS study developed a cost of $9.87 per train mile for a 300-seat train in 2002. This cost was increased to $12.70 per train mile in 2013. The 79-mph conventional Amtrak train benchmarked at a higher cost of $15.43 due primarily to a lack of economies of scale associated with typical lighter density Amtrak corridors. For this study:

- The low frequency corridor options are only running two to four round-trips daily, so the higher $15.43 cost will be assumed for these options.
- The lower $12.70 cost will be assumed for the high frequency 8 round-trip options because of better economies of scale and better equipment utilization in these options, both of which tends toward lower average equipment unit costs.

3.7.1.2 Train and Engine Crew Costs

The train operating crew incurs crew costs. Following Amtrak staffing policies, the operating crew would consist of an engineer, a conductor and an assistant conductor and is subject to federal hours of service regulations. Costs for the crew include salary, fringe benefits, training, overtime and additional pay for split shifts and high mileage runs. An overtime allowance is included as well as scheduled time-off, unscheduled absences and time required for operating, safety and passenger handling training. Fringe benefits include health and welfare, Federal Insurance Contributions Act (FICA) and pensions. The cost of employee injury claims under Federal Employers Liability Act (FELA) is also treated as a fringe benefit for this analysis. The overall fringe benefit rate was calculated as 55 percent. In addition, an allowance was built in for spare/reserve crews on the extra board. Costing of train crews was based on Amtrak's 1999 labor agreement, adjusted for inflation to 2013.

Crew costs depend upon the level of train crew utilization, which is largely influenced by the structure of crew bases and any prior agreements on staffing locations. Train frequency strongly influences the amount of held-away-from-home-terminal time, which occurs if train crews have to stay overnight in a hotel away from their home base. Since a broad range of service frequencies and speeds have been evaluated here, a parametric approach was needed to develop a system average per train mile rate for crew costs. Such an average rate necessarily involves some approximation, but to avoid having to reconfigure a detailed crew-staffing plan whenever the train schedules change, an average rate is appropriate for a Feasibility study. A more specific and detailed level of assessment would be appropriate for a Tier 2 EIS. For this study:

- A value of $4.92 per train mile was assumed for the high frequency 110-mph 8 round-trip options that are being assessed for the Greenfield and I-85 alignments. This reflects improved crew utilization due to higher train speeds and more train frequencies. This is a moderate level of crew cost that still includes the need for some away from home layover.
- The low frequency two and four round-trip scenarios cost $6.59 per train mile. With trains operating less frequently there is less opportunity to return crews to their home base on the same day, leading to more split shifts and overnight layovers.

3.7.1.3 Fuel and Energy

An average consumption rate of 2.42 gallons/mile was estimated for a 110-mph 300-seat train, based upon nominal usage rates of all three technologies considered in Phase 3 of the MWRRS Study. While fuel prices were $3.60 a gallon in late 2012 for diesel fuel according to Energy Information Administration (EIA)[39] , at the time of this analysis, they had fallen to approximately $3/gallon, and the EIA price forecast has been lowered. Currently a fuel cost of $7.21 per train mile is being assumed rising to $10.28 per mile by 2040, consistent with the latest EIA forecasts that were used for preparation of the ridership forecasts. Even so, this more than triples (311%) the cost of diesel fuel that was prevalent at the time of the earlier MWRRS study. Obviously these much higher fuel costs will have a corresponding favorable impact on the ridership forecast as well. These energy costs are then adjusted each year in line with the relevant Energy Information Administration forecasts.

3.7.1.4 Onboard Services (OBS)

Onboard service (OBS) costs are those expenses for providing food service onboard the trains. OBS adds costs in three different areas: equipment, labor and cost of goods sold. Equipment capital and operating cost is built into the cost of the trains and is not attributed to food catering specifically. Small 200-seat trains cannot afford a dedicated dining or bistro car. Instead, if food service were to be offered, an OBS employee or food service vendor would move through the train with a trolley cart, offering food and beverages for sale to the passengers.

The goal of OBS franchising should be to ensure a reasonable profit for the provider of on-board services, while maintaining a reasonable and affordable price structure for passengers. In previous studies, it has

[39] EIA diesel retail price in 2012 excluding the taxes http://www.eia.gov/petroleum/gasdiesel/

been found that the key to attaining OBS profitability is selling enough products to recover the train mile related labor costs. For example, if small 200-seat trains were used, given the assumed OBS cost structure, even with a trolley cart service the OBS operator will be challenged to attain profitability. However, the expanded customer base on larger 300-seat trains can provide a slight positive operating margin for OBS service.

Because the trolley cart has been shown to double OBS revenues, it can result in profitable OBS operations in situations where a bistro-only service would be hard-pressed to sell enough food to recover its costs. While only a limited menu can be offered from a cart, the ready availability of food and beverages at the customer's seat is a proven strategy for increasing sales. Many customers appreciate the convenience of a trolley cart service and are willing to purchase food items that are brought directly to them. While some customers prefer stretching their legs and walking to a bistro car, other customers will not bother to make the trip.

The cost of goods sold is estimated as 50 percent of OBS revenue, based on Amtrak's route profitability reports. Labor costs, including costs for commissary support and OBS supervision, have been estimated at:

- An intermediate value of $2.56 per train mile was assumed for the high frequency 8 round trip 110-mph diesel options. This is a moderate level of crew cost that includes the need for some away from home layover.
- The low frequency 2 and 4 round trip scenarios cost $3.66 per train mile. With trains operating less frequently there is less opportunity to return crews to their home base on the same day, leading to more split shifts and overnight layovers.

These costs are generally consistent with Amtrak's level of wages and staffing approach for conventional bistro car services. However, this study recommends that an experienced food service vendor provide food services and use a trolley cart approach. A key technical requirement for providing trolley service is to ensure the doors and vestibules between cars are designed to allow a cart to easily pass through. Since trolley service is a standard feature on most European railways, most European rolling stock is designed to accommodate the carts. Although convenient passageways often have not been provided on U.S. equipment, the ability to support trolley carts is an important equipment design requirement for the planned service.

3.7.1.5 Insurance Costs

Liability costs were estimated at 1.4¢ per passenger-mile, the same rate that was assumed in the earlier MWRRS study brought to 2013. Federal Employees Liability Act (FELA) costs are not included in this category but are applied as an overhead to labor costs.

The Amtrak Reform and Accountability Act of 1997 (§161) provides for a limit of $200 Million on passenger liability claims. Amtrak carries that level of excess liability insurance, which allows Amtrak to fully indemnify the freight railroads in the event of a rail accident. This insurance protection has been a key element in Amtrak's ability to secure freight railroad cooperation. In addition, freight railroads perceive that the full faith and credit of the United States Government is behind Amtrak, while this may not be true of other potential passenger operators. However, a General Accounting Office (GAO) review[40] has concluded that this $200 Million liability cap applies to commuter railroads as well as to Amtrak. If the

[40] See: http://www.gao.gov/highlights/d04240high.pdf

GAO's interpretation is correct, the liability cap may also apply to potential franchisees. If this limitation were in fact available to potential franchisees, it would be much easier for any operator to obtain insurance that could fully indemnify a freight railroad at a reasonable cost. It is recommended that Michigan DOT seek qualified legal advice on this matter.

3.7.2 Fixed Route Costs

This cost category includes those costs that, while largely independent of the number of train-miles operated, can still be directly associated to the operation of specific routes. It includes such costs as track maintenance, which varies by train technology, and station operations.

3.7.2.1 Track and Right-of-Way Costs

Currently, it is industry practice for passenger train operators providing service on freight-owned rights-of-way to pay for track access, dispatching and track maintenance. Rates for all these activities are ultimately based upon a determination of the appropriate costs that result from negotiations between the parties. The purpose here is to provide estimates based on the best available information; however, as the project moves forward, additional study and discussions with the railroads will be needed to further refine these costs.

The costing basis assumed in this report is that of incremental or avoidable costs[41] for shared tracks. The passenger operator, however, must take full cost responsibility for maintaining any tracks that it must add to the corridor either for its own use, or for mitigating delays to freight trains. The following cost components are included within the Track and Right-of-Way category:

- **Track Maintenance Costs.** Costs for track maintenance were estimated based on Zeta-Tech's January 2004 draft technical monograph Estimating Maintenance Costs for Mixed High-Speed Passenger and Freight Rail Corridors[42]. Zeta-Tech costs have been adjusted for inflation to 2013. However, Zeta-Tech's costs are conceptual and subject to negotiation with the freight railroads.
- **Dispatching Costs and Out-of-Pocket Reimbursement.** Passenger service must also reimburse a freight railroad's added costs for dispatching its line, providing employee efficiency tests and for performing other services on behalf of the passenger operator. If the passenger operator does not contract a freight railroad to provide these services, it must provide them itself. As a result, costs for train dispatching and control are incurred on dedicated as well as shared tracks and are now shown under a separate "Operations and Dispatch" cost category.
- **Costs for Access to Track and Right-of-Way.** Access fees, particularly train mile fees incurred as an operating expense, are specifically excluded from this calculation. Any such payments would have to be calculated and negotiated on a route-specific and railroad-specific basis. Such a calculation would have to consider the value of the infrastructure improvements made to the corridor for balancing up-front capital with ongoing operating payments.[43]

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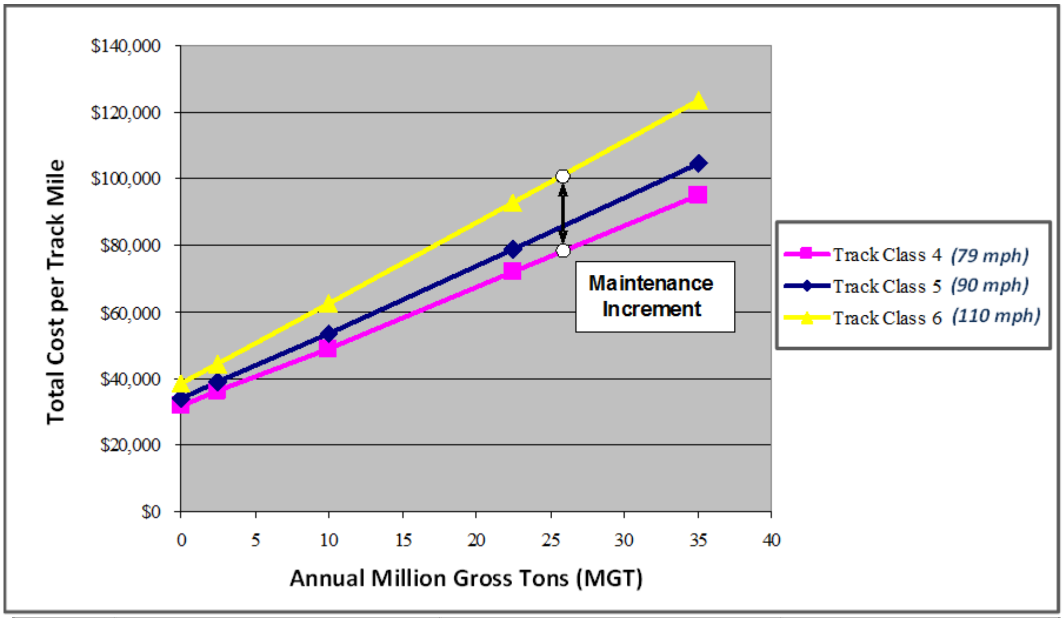
[41] Avoidable costs are those that are eliminated or saved if an activity is discontinued. The term incremental is used to reference the change in costs that results from a management action that increases volume, whereas avoidable defines the change in costs that results from a management action that reduces volume.
[42] Zeta-Tech, a subsidiary of Harsco (a supplier of track maintenance machinery) is a rail consulting firm who specializes in development of track maintenance strategies, costs and related engineering economics. See a summary of this report at http://onlinepubs.trb.org/onlinepubs/trnews/trnews255rpo.pdf. The full report is available upon request from the FRA.
[43] For 110-mph service, the level of infrastructure improvements to the corridor called for in this study should provide enough capacity to allow superior on-time performance for both freight and passenger operations

Exhibit 3-17 shows the conceptual relationship between track maintenance cost and total tonnage that was calibrated from the 2004 Zeta-Tech study. It shows a strong relationship between tonnage, FRA track class (4 through 6, corresponding to a 79-mph to 110-mph track speed) and maintenance cost. At low tonnage, the cost differential for maintaining a higher track class is not very large, but as tonnage grows, so too does the added cost. For shared track, if freight needs only Class 4 track, the passenger service would have to pay the difference, called the "maintenance increment", which for a 25 MGT line as shown in Exhibit 3-17, would come to about $22,000 per mile per year, including capital costs[44] . The required payment to reimburse a freight railroad for its added cost would be less for lower freight tonnage, more for higher freight tonnage.

Exhibit 3-17: Zeta-Tech 2004 Calibrated Track Class vs. Tonnage Total Cost Function "Middle Line" Case, in 2002



TOTAL COST	LOW		MIDDLE		HIGH	
	Intercept	Slope	Intercept	Slope	Intercept	Slope
Class 3	$17,880	$0.917	$21,683	$1.231	$25,487	$1.548
Class 4	$26,294	$1.348	$31,887	$1.810	$37,481	$2.277
Class 5	$28,072	$1.509	$33,937	$2.020	$39,801	$2.530
Class 6	$31,714	$1.837	$38,446	$2.440	$45,178	$3.035

** Intercept is where the line meets the Y axis at the 0 ton level. The slope represents the added cost per MGT.*

OPER COST	LOW		MIDDLE		HIGH	
	Intercept	Slope	Intercept	Slope	Intercept	Slope
Class 3	$6,558	$0.579	$8,216	$0.726	$9,873	$0.872
Class 4	$9,644	$0.852	$12,082	$1.067	$14,519	$1.283
Class 5	$11,283	$0.997	$14,135	$1.249	$16,987	$1.501
Class 6	$14,640	$1.293	$18,371	$1.623	$22,101	$1.953

[44] Calculated as $38,446 - $31,887 + ($2.440 – $1.810) * 25 = $22,309 per year. Note that the yellow highlighted cells in the table correspond to the three lines shown on the graph.

Exhibit 3-17 shows the total track maintenance cost per mile as a function of traffic density, it also breaks out the operating versus total cost, showing that capital (the difference between total and operating cost) is a significant share of the total cost. For track maintenance:

- **Operating Costs** cover expenses needed to keep existing assets in service and include both surfacing and a regimen of facility inspections.
- **Capital Costs** are those related to the physical replacement of the assets that wear out. They include expenditures such as for replacement of rail and ties, but these costs are not incurred until many years after construction. In addition, the regular maintenance of a smooth surface by reducing dynamic loads actually helps extend the life of the underlying rail and tie assets.

Exhibit 3-17 shows that the cost of shared track depends strongly on the level of freight tonnage, since passenger trains are relatively lightweight and do not contribute much to the total tonnage. In fact, following the Zeta-Tech methodology, the "maintenance increment" is calculated based on freight tonnage only, since a flat rate of $1.56 per train mile as used in the Zeta-Tech report (in 2002) was already added to reflect the direct cost of added passenger tonnage regardless of track class. This cost, which was developed by Zeta-Tech's TrackShare® model, includes not only directly variable costs, but also an allocation of a freight railroad's fixed cost. Accordingly, it complies with the Surface Transportation Board's definition of "avoidable cost." Inflated to 2013 (an approximate 52% increase, a higher rate of inflation than CPI, reflecting the energy-intensity of construction materials) this avoidable cost allocation would come to $2.37 per train mile.

On top of this, an allowance of 39.5¢ per train-mile (in 2002) was added by Zeta-Tech for freight railroad dispatching and out-of-pocket costs. Inflated to 2013 based on the Consumer Price Index (approx. 29% increase) this dispatching and out-of-pocket cost now comes to 50.8¢ per train mile, which is applied both to dedicated and shared tracks. This cost is now separated from track maintenance under the "Operations and Dispatch" category.

The same cost function shown in Exhibit 3-17 can also be used for costing dedicated passenger track. With dedicated track, the passenger system is assumed to cover the entire operating cost for maintaining its own track. (Freight may then have to reimburse the passenger operator on a car-mile basis for any damage it causes to the passenger track.) Because passenger train tonnage is very low however, it can be seen that the cost differential between Class 4, 5 and 6 track is very small.

Adjusting Zeta-Tech's 2002 costs shown in Exhibit 3-19 up to 2013:

- The Total Cost per track-mile for maintaining dedicated Class 4 track is about $48,468; the cost for Class 6 track rises to $58,438. The shared-use scenario assumes that the owning freight railroad will require this level of support each year for maintaining the additional tracks that it must add to its existing rail corridor, for supporting the needs of passenger rail service.

- The Operating Cost per track-mile for maintaining dedicated Class 4 track is about $18,365; the cost for Class 6 track rises to $27,924. This figure is used for Amtrak or State owned tracks since these entities will bear the maintenance cost directly. In this case a Cyclic Maintenance additive is included in the Cost Benefit ratio calculation to account for the timing of needed capital maintenance expenditures that will not need to be incurred until much later in the project life.

- The Capital Cost per track-mile for maintaining dedicated Class 4 track reflects the difference of about $30,103; similarly for Class 6 track is $30,514. The capital cost for maintaining Class 4 versus Class 6 track under light tonnage density is not much different; most of cost differential is in operating cost needed to maintain the more precise alignment of the higher class track.

While operating costs are needed every year, capital maintenance costs for dedicated tracks are gradually introduced using a table of ramp-up factors provided by Zeta-Tech, see Exhibit 3-18.

Exhibit 3-18: Capital Cost Ramp-Up Following Upgrade of a Rail Line

Year	% of Capital Maintenance	Year	% of Capital Maintenance
1	0%	11	50%
2	0%	12	50%
3	0%	13	50%
4	20%	14	50%
5	20%	15	75%
6	20%	16	75%
7	35%	17	75%
8	35%	18	75%
9	35%	19	75%
10	50%	20	100%

A fully normalized capital maintenance level is not reached until 20 years after completion of the rail construction program. This is used for calculating “Cyclic Maintenance” in the Benefit Cost Analysis. But because Cyclic Maintenance is not an Operating Cost under generally accepted accounting principles (GAAP) accounting methodology, it is not normally included in the Operating Ratio calculation.

3.7.2.2 Station Operations

A simplified fare structure, heavy reliance upon electronic ticketing and avoidance of a reservation system will minimize station personnel requirements. Station costs include personnel, ticket machines and station operating expenses.

- Staffed stations will be assumed at major stations. All stations will be assumed open for two shifts. The cost for the staffed stations includes eight positions at each new location, costing $644,640 per year, as well as the cost of utilities, ticket machines, cleaning and basic facility maintenance.

- The cost for unstaffed stations covers the cost of utilities, ticket machines, cleaning and basic facility maintenance, costing $80,580 per year. (These costs are also included in the staffed station cost.) Volunteer personnel such as Traveler's Aid, if desired could staff these stations.

It should be noted that the proposed Coast-to-Coast system would share most of its stations with existing Amtrak services. However, Route 1 would need an additional station in downtown Lansing, since this route alternative cannot use the existing Lansing station at Trowbridge. Route 2 would add a new station at Howell, and Route 3 would add stations at both Howell and Plymouth. All the other stations used by the Coast-to-Coast service would be existing Amtrak stations.

3.7.2.3 System Overhead Costs

The category of System Overhead largely consists of Service Administration or management overheads, covering such needs as the corporate procurement, human resources, accounting, finance and information technology functions as well as call center administration. A stand-alone administrative organization appropriate for the operation of a corridor system was developed for the MWRRS and later refined for the Ohio Hub studies. This organizational structure, which was developed with Amtrak's input and had a fixed cost of $8.9 Million plus $1.43 per train-mile (in 2002) for added staff requirements as the system grew. Inflated to 2013, this became $11.45 Million plus $1.84 per train mile. However, the Sales and Marketing category also has a substantial fixed cost component for advertising and call center expense, adding another $2.9 Million per year fixed cost, plus variable call center expenses of 70.9¢ per rider, all in 2013 dollars[45]. Finally, credit card (1.8% of revenue) and travel agency commissions (1%) are all variable. In addition, the system operator was allowed a 10 percent markup on certain direct costs as an allowance for operator profit.

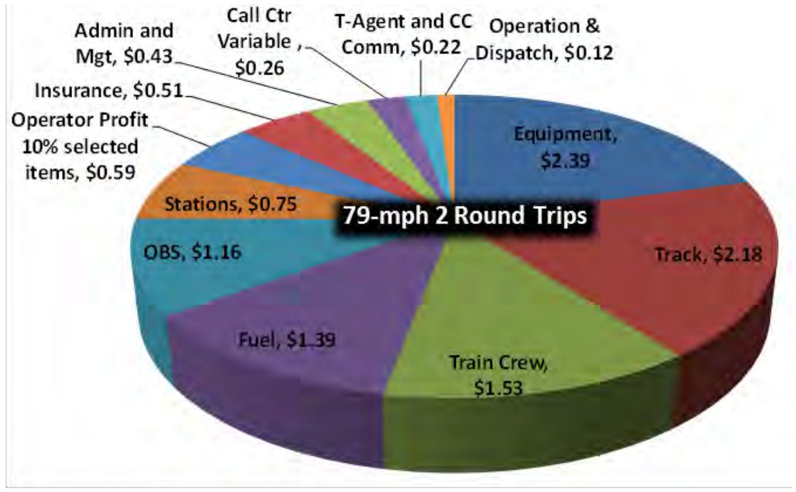
Therefore, the overall financial model for a stand-alone organization therefore has $14.35 Million ($11.45 + $2.9 Million) annually in fixed cost for administrative, sales and marketing expenses. If costed on an incremental basis the $14.35 Million in fixed administrative, sales and marketing expenses can be ignored since the rail operator would incur these costs regardless of whether the new service is added or not. The $1.84 per train mile cost for incremental management staff is still included however, along with the variable call center (70.9¢ per rider), credit card and travel agency commissions (combined, 2.8% of revenue) and 10% markup on selected items that was agreed by the MWRRS committee as a reasonable allocation to operator profit.

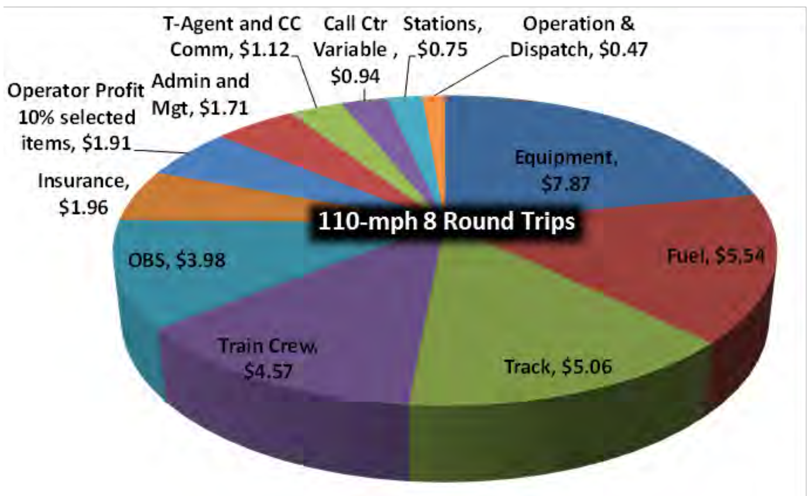
3.7.3 Operating Cost Breakdown and the Cost of Dedicated Tracks

79-mph vs. 110-mph services have different cost structures. The most important difference is that the proposed 110-mph service would be based on dedicated passenger tracks, where the passenger train operator has full cost responsibility for the tracks. For 79-mph services it is assumed that the existing freight operator would continue to be responsible for the track, but would be paid on a train-mile basis for its use. A key result is that dedicated tracks are very expensive unless the system runs enough trains to effectively utilize the investment. But if the rail system effectively utilizes the capacity, then owning track can be less expensive than paying someone else to provide it. This generally imposes minimum volume thresholds on the effective operation of dedicated systems, giving better economic results for higher service frequencies. Exhibit 3-19 compares the 2030 Operating Cost distribution of Route 2 – 79-mph – 2 round trips as compared to Route 2 – 110-mph – 8 round trips.

[45] In the MWRRS cost model, call center costs were built up directly from ridership, assuming 40 percent of all riders call for information, and that the average information call will take 5 minutes for each round trip. Call center costs, therefore, are variable by rider and not by train-mile. Assuming some flexibility for assigning personnel to accommodate peaks in volume and a 20 percent staffing contingency, variable costs came to 57¢ per rider. These were inflated to 66¢ per rider in $2008 and now 70.9¢ per rider in 2013.

Exhibit 3-19: Route 2 2030 Operating Costs for 79-vs-110-mph Service (millions per year)





Equipment, fuel, track, and crews are seen to be the largest cost drivers; in each case these five categories comprise about 75% of the total cost although the order of the categories are different. Track costs comprise a significant share of operating expenses; for the 79-mph service running two round trips the track cost is $2.18 Million per year or $1.09 Million per round trip frequency. But for the 110-mph service it is $5.06 Million per year or $0.63 Million per round trip frequency. If capital maintenance costs were included the track cost would rise to $10.53 Million per year which for 8 round trips comes to $1.32 Million per round trip frequency. This is seen to still be competitive with the cost of shared tracks provided 8 or more daily round trips are operated over those tracks.

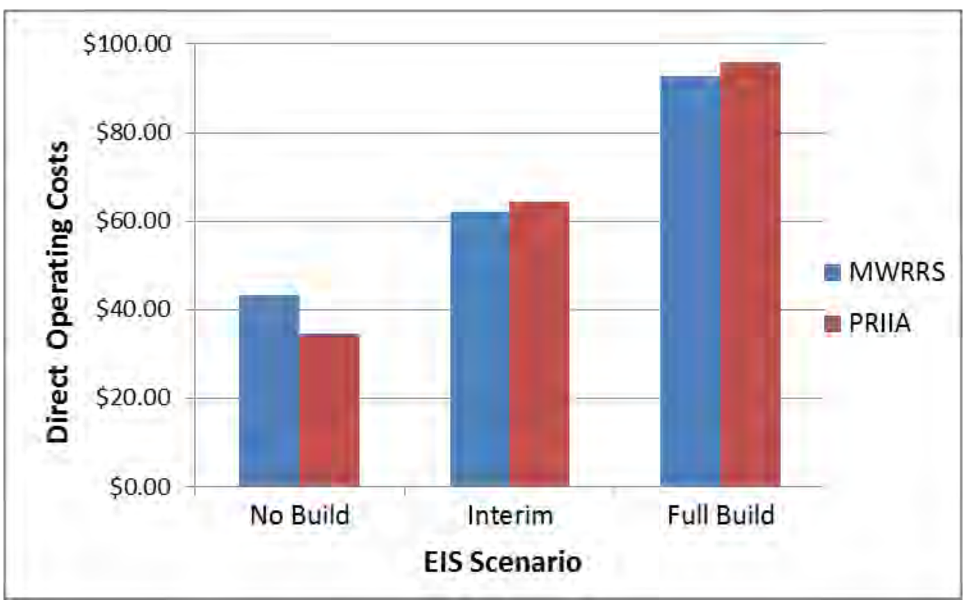
If a service is running enough passenger trains, the comparison shows that dedicated tracks are actually more cost effective than shared tracks. This is especially true if the freight railroad is still making a contribution towards the cost of track maintenance which can potentially offset a significant share of the track maintenance cost that must otherwise be borne by the passenger service.

3.7.4 Comparison to the Passenger Rail Investment and Improvement Act of 2008 Costs (PRIIA)

TEMS was asked to develop a comparison of its MWRRS-derived costs to a PRIIA costing basis. PRIIA costs are the result of a complex calculation based on Amtrak proprietary data. As a result it is impossible to precisely replicate PRIIA costs in a planning study. However, a benchmark was found in the Michigan Detroit/Chicago EIS[46] that offers a PRIIA cost basis that is suitable for comparison purposes. This reference gives the important cost drivers like revenue, ridership and train size which enabled a direct comparison between the MWRRS-derived costs used here, and a PRIIA-derived costing basis. This comparison could be developed for the three operating scenarios that were developed for the Chicago to Detroit/Pontiac rail corridor: No Build, Interim Service and Full Build and in three categories: Direct, Track and Overhead Operating Costs. This comparison was developed by entering the Cost Driver factors from the Michigan Detroit/Chicago EIS into TEMS costing model. This enables a direct comparison of the results of the two different costing approaches.

The results are shown in Exhibit 3-20, 3-21 and 3-22. Exhibits 3-20and 3-21 show that MWRRS direct and track costs match PRIIA costs very closely. For the low frequency No Build operation, the MWRRS costing basis starts a little higher and ends a little lower. This has to do with the exact economies of scale projected for the proposed 110-mph train options. Track costs similarly match closely with PRIIA costs. This should come as no surprise since the PRIIA and MWRRS methodologies use very similar approaches for estimating track cost.

Exhibit 3-20: MWRRS vs PRIIA Direct Operating Cost Comparison



[46] See: APPENDIX E: RIDERSHIP & REVENUE FORECASTS AND OPERATING & MAINTENANCE COSTS at http://greatlakesrail.org/~grtlakes/documents/PublicHearings/Appendix_E_Ridership_and_Revenue_Forecasts_and_Operating_and_Maintenance_Costs.pdf retrieved on 9-17-2015.

Exhibit 3-21: MWRRS vs PRIIA Track Maintenance Cost Comparison

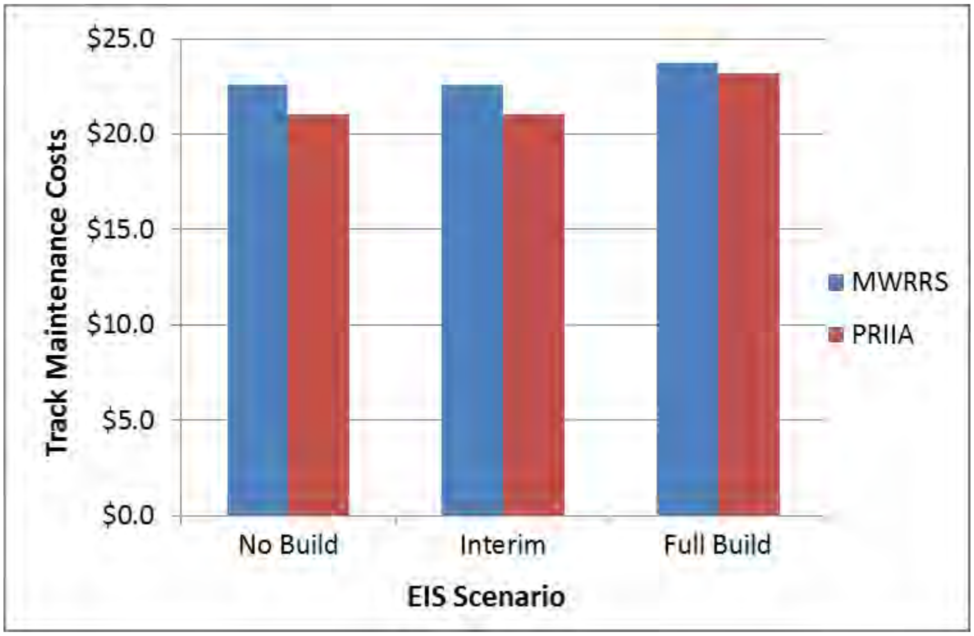


Exhibit 3-22: MWRRS vs PRIIA Overhead Cost Comparison

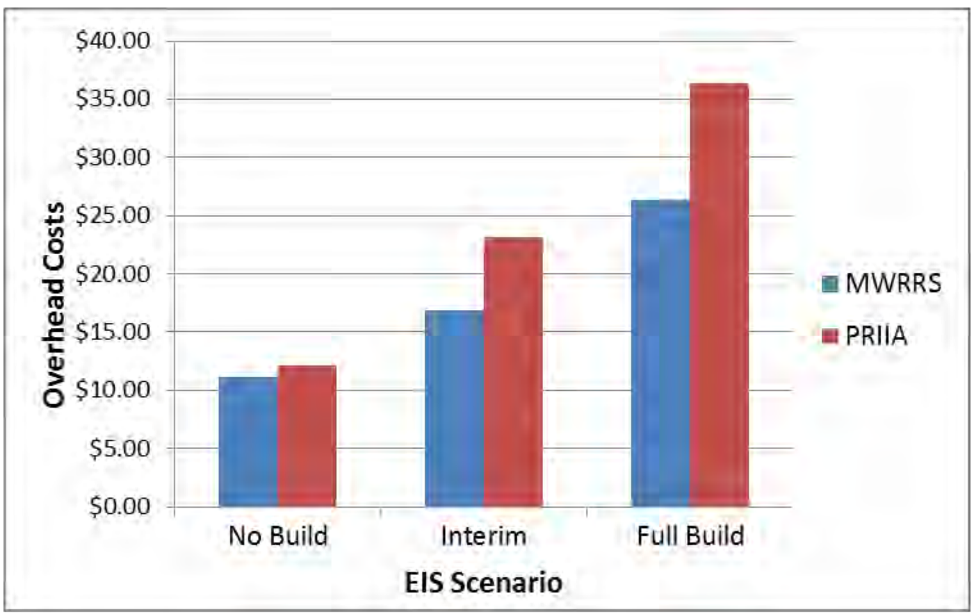
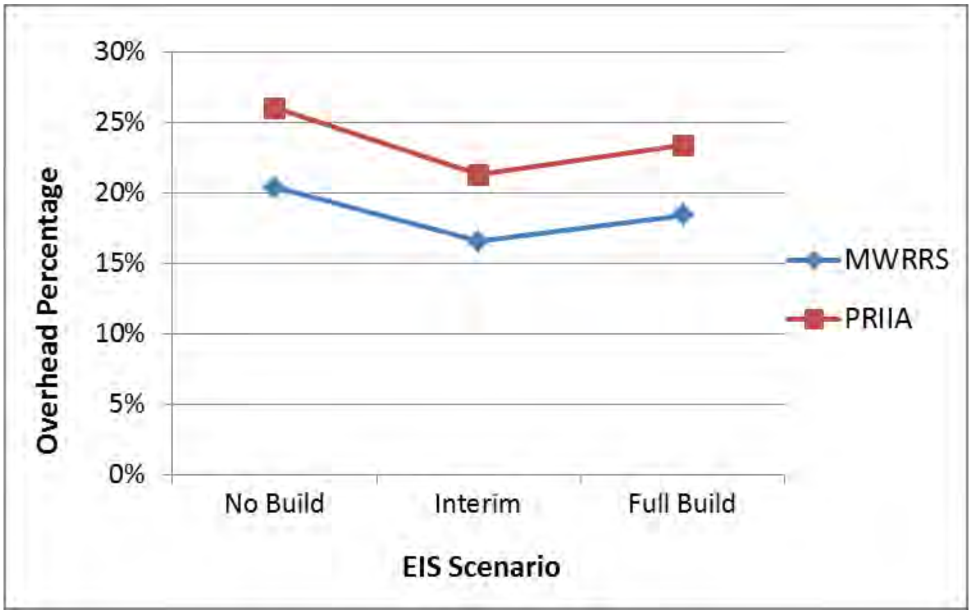


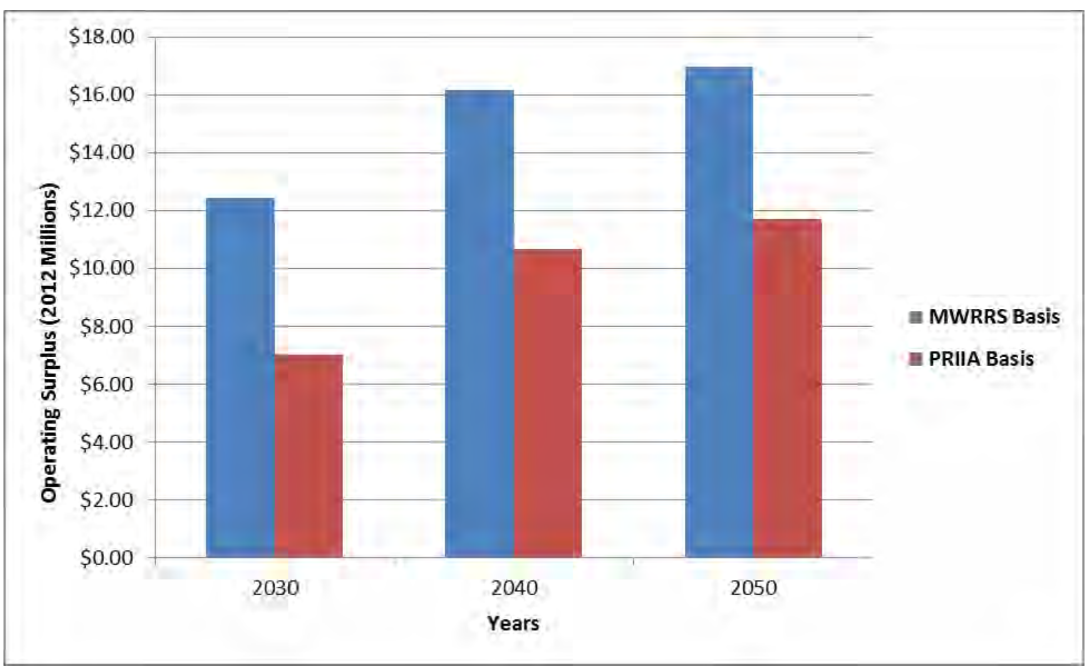
Exhibit 3-22 tells a somewhat different story. In the area of overhead cost allocations, PRIIA costs are allocating a greater share of overhead costs to Amtrak than are actually added by the system. This means that Amtrak is charging more than its actual incremental cost for running the additional service. As Michigan adds more trains, this means that Michigan must also bear more of Amtrak's existing overhead costs. As shown in Exhibit 3-23, MWRRS overhead costs are running in the 17-20% range including the 10% set-aside for operator profit; under PRIIA, overhead and administrative costs comprise about 21-26% of the total.

Exhibit 3-23: MWRRS vs PRIIA Overhead Percentage of Total Costs



By increasing the level of overhead cost allocated to a route, the PRIIA methodology reduces the operating ratio and operating surplus. PRIIA costs are seen to add about $4.50 per train mile in added overhead cost by comparison to the MWRRS methodology. In terms of understanding the impact of this, Exhibit 3-24 shows the impact on the forecasted Operating Surplus of the Route 2 8-Round Trip 110-mph Coast-to-Coast options.

Exhibit 3-24: MWRRS vs PRIIA Forecasted Operating Surplus



This suggests that for an 8-train 110-mph service, the PRIIA cost allocation methodology will likely reduce forecasted operating surpluses by 25%, due to additional overhead expenses allocated to the corridor. For this service, the impact of this larger PRIIA overhead allocation will not completely wipe out the operating surplus. But for a weaker corridor or more marginal service, this overhead allocation difference could tip the balance. For a 79-mph service that cannot even cover its direct operating cost, adding even more overhead cost allocations would further increase the level of operating subsidy needed to sustain the service.

A key point, therefore, is that Amtrak would charge an additional $4.50 per track mile over a private sector franchise. As a result, the decision on who operates the potential Coast-to-Coast Corridor severely affects the ability of the system to cover its operating cost.

Chapter 4
Prioritized Capital Plan

SUMMARY

This chapter estimates Capital Costs for the Coast-to-Coast Study alternatives and includes a discussion of the Capital Cost methodology and breakdowns of costs by rail segment. The focus of this analysis will be on development of the capital costs for each route, train speed and frequency option. These costs are consistent with the operating plan and train running times that were used as the input to the evaluation process. The unit capital costs for estimating infrastructure, equipment, and maintenance facility capital costs are also described. Planning level costs were developed by updating earlier engineering assessments of corridor segments, as well as by recent cost estimates and construction costs on comparable projects.

4.1 Introduction

Exhibit 2-7 shows the route options proposed for the Coast-to-Coast Rail Corridor that were used to estimate Capital Costs for the Coast-to-Coast Corridor. Three possible Holland to Detroit routes have been assessed: Route 1, using Norfolk Southern (NS)-owned track via Lansing/Jackson; Route 2 using Ann Arbor (AA)-owned track via Howell/Ann Arbor, and Route 3 using CSX Transportation (CSX)-owned track via Plymouth/Wayne.

For each of three route alternatives shown in Exhibit 2-7, Capital Costs were developed for:

- 79-mph services
- 110-mph services

Due to project scope and budget, the 90 mph option presented in earlier parts of this report is not included in the capital cost analysis, but could be included in further study of the corridor.

In addition, each route and technology option was also evaluated for 2 frequency options. Thus, overall, Capital Costs were developed for twelve distinct routes options as follows:

3 routes x 2 technology-speeds options x 2 frequency options = 12 options

4.2 Train Operating Assumptions

4.2.1 Sharing with Freight Railroads

For development of a 110-mph option in this study, it has been assumed that certain segments of rail line would be purchased by a public entity such as Michigan Department of Transportation (MDOT) under terms similar to what Norfolk Southern agreed for its recent conveyance of the Dearborn to Kalamazoo rail line for the accelerated rail program. This could enable the proposed 110-mph services to be operated over MDOT tracks without violating any freight railroad principles. However, the final capital plan and capital costs for shared segments as well as the possibility of track and/or right-of-way conveyance will need to be worked out in negotiations with the freight railroads. Because of this, it is possible real costs could vary greatly from this estimate.

In the meantime, this report contains preliminary data which is subject to review, verification and approval by both CSX and Norfolk Southern Railroad. As of the date of this report, this review process has not taken place. Findings are not to be construed as a commitment on the part of either CSX or Norfolk Southern to operate additional service.

4.2.2 Consistency with Train Operating Assumptions

As described in Service and Operating Plan (Chapter 3), speed profiles for the Coast-to-Coast corridor route and technology alternatives were derived using LOCOMOTION™ and MISS-IT™ rail simulation software. For this analysis, the achievable train speeds were limited based on the curvature of the track as well as civil speed restrictions. Civil speed restrictions are imposed due to non-geometric limitations such as grade crossings, rail yards, urban areas or other operating constraints where train speeds must be limited.

- Currently, train operations are slowed through the freight yards at Grand Rapids and Lansing due to track conditions. It has been assumed that main line speeds could be raised to 60-mph around the yards.

- U.S Department of Transportation, Federal Rail Administration (FRA) regulations allow operations up to 90-mph through conventional gated highway crossings, or up to 110-mph through improved highway crossings. As a result, the 79-mph option will be assessed using conventional gated crossings, and the 110-mph option with improved-crossings.

4.3 Capital Cost Engineering Assessment Methodology

The Capital Cost Engineering Assessment Methodology for the proposed Coast-to-Coast Rail Corridor has been conducted at a feasibility level of detail and accuracy. Exhibit 4-2 highlights the levels of accuracy associated with typical phases of project development and engineering design. A 30% level of accuracy is associated with the evaluation of project feasibility; while the level of accuracy of 10% is achieved during final design and production of construction documents. This phase of the study is only the first step in the project development process. As shown in Exhibit 4-1, the cost estimate is intended to be a mid-range projection with equal probability of the actual cost moving up or down.

Exhibit 4-1: Engineering Project Development Phases and Levels of Accuracy Development

Development Phases	Approximate Engineering Design Level*	Approximate Level of Accuracy**
Feasibility Study	0%	+/- 30% or worse
Project Definition/Advanced Planning	1-2%	+/- 25%
Conceptual Engineering	10%	+/- 20%
Preliminary Engineering	30%	+/- 15%
Pre-Final Engineering	65%	+/- 15%
Final Design/Construction Documents	100%	+/- 10% or better

*Percent of final design **Percent of actual costs to construct

In addition to the field inspections and extensive work with the geographic information system (GIS) and railroad track charts, the Coast-to-Coast corridor also has a long history of previous engineering studies that provide costs for upgrades along the whole route or portions of the route. For consistency with this previous work, these studies have been extensively relied upon, but updated as appropriate, in the development of the current engineering costs for each line segment.

4.3.1 Infrastructure Unit Costs

The infrastructure capital unit costs used in the development of the preliminary capital cost estimates were developed from TEMS library of Conventional and High-Speed Rail unit costs, as well as from previous studies of segments of the Coast-to-Coast corridor and from current Michigan engineering benchmarks. Some of the unit costs were estimated by updating previously developed representative unit costs from previous TEMS work in the Midwest Regional Rail studies and for the Rocky Mountain Rail Authority. Peer panels, freight railroads and construction contractors have reviewed these costs in numerous previous studies. The unit cost data base and corridor infrastructure costs are appropriate for a feasibility-level planning study. The costs will need to be further refined in future phases of work if an Alternatives Analysis for the Environmental Impact Statement (EIS) work are undertaken.

Since revenues and operating costs in this study are expressed in 2013 dollars, infrastructure capital costs are also expressed in 2013 dollars for consistency in use in the Cost Benefit analysis.

The base set of unit costs addresses typical passenger rail infrastructure construction elements including: roadbed and track work, systems, facilities, structures, and grade crossings. In the following tables (Exhibits 4-3 to 4-6), only a subset of these costs were actually used in Capital Cost development.

4.3.1.1 Track

Exhibit 4-2 shows the unit costs used for track work.

Exhibit 4-2: Unit Capital Costs, Trackwork and Right-of-Way in 2013

Item No.	Description	Unit	Unit Cost (Thousands of 2013$)
1.1	Single Track on Existing Roadbed (141# CWR, Conc. TF)	per mile	$1,246.11
1.2	Double Track on Existing Roadbed	per mile	$2,492.42
1.3	Single Track on New Roadbed & New Embankment	per mile	$1,872.29
1.4	Single Track 15’ offset added to existing corridor on 15’ fill	per mile	$2,532.29
1.8	Double Track 15’ offset added on 15’ fill	per mile	$4,807.82
1.9	Double Track 30’ offset added on 15’ fill	per mile	$5,599.85
1.10	HSR New Double Track on 15' Retained Earth Fill	per mile	$17,724.11
1.11	Timber & Surface w/ 33% Tie Replacement	per mile	$278.62
1.12	Timber & Surface w/ 66% Tie Replacement	per mile	$415.33
1.13	Relay Track w/ 136# CWR	per mile	$444.29
1.14	Freight Siding	per mile	$1,144.50
1.40	#33 High-Speed Turnout (Swing Nose Frog)	each	$712.73
1.41	#24 High-Speed Turnout (Swing Nose Frog)	each	$564.67
1.42	#15 Turnout Timber	each	$261.00
1.43	#11 Turnout Timber	each	$220.4
1.44	#33 Crossover	each	$1,425.56
1.45	#20 Crossover	each	$625.76
1.46	Interlockings and Crossovers every 10 miles (average)	Per mile	$265.00
1.47	Elastic Fasteners	per mile	$102.88

4.3.2 Structures: Approaches, Flyovers and Bridges

An inventory of bridges has been developed for each existing rail route from railroad track charts. The most important bridge project in this study is the major bridge in Ann Arbor in Route 2 that would be needed to connect the Amtrak line to the former Ann Arbor line towards Howell. While some representative bridge costs are provided below, the costs for this bridge were based on a previous detailed engineering estimate[47]. This cost has been included as a placeholder in the current estimate. Exhibit 4-3 shows the structural unit costs.

Exhibit 4-3: Unit Capital Costs, Structures in 2013

Item No.	Description (Bridges-under)	Unit	Unit Cost (Thousands of 2013$)
2.1	Four Lane Urban Expressway (Rail over Highway)	each	$6,067.52
2.2	Four Lane Rural Expressway (Rail over Highway)	each	$5,051.03
2.3	Two Lane Highway (Rail over Highway)	each	$3,832.50
2.4	Rail (New Rail over Existing Rail)	each	$3,832.50
2.5	Double Track High (50') Level Bridge	per LF	$15.27
2.6	Convert open deck bridge to ballast deck (single track)	per LF	$5.83
2.7	Convert open deck bridge to ballast deck (double track)	per LF	$11.77
2.8	Single Track on Flyover/Elevated Structure	per LF	$5.30
2.9	Single Track on Embankment w/ Retaining Wall	per LF	$3.71
2.10	Double Track on Flyover/Elevated Structure	per LF	$8.48
2.12	Double Track on Embankment w/ Retaining Wall	per LF	$6.89
2.13	Ballasted Concrete Deck Replacement Bridge	per LF	$2.65

4.3.2.1 Train Control Systems

The capital cost estimates for this study include costs to upgrade the train control and signal systems. Signal systems include train borne components and wayside equipment such as track circuits, switch operators, and wayside detectors for protection against intrusion, high water, hot bearings and dragging equipment.

Modern signal systems rely on digital communication systems for data transmission using radio, fiber optic cables or a combination or the two. In addition, the communication system provides radio for operations, supervisory control and data acquisition for power systems, passenger station public address, etc. Wayside space must be provided for ducts and enclosures to house signal and communication components. Exhibit 4-4 shows the unit costs for systems.

[47] From Lansing to Detroit Passenger Rail Study, Phase III Report, page 5-16; see http://semcog.org/Portals/0/Documents/Plans-For-The-Region/Transportation/Transit/Ann-Arbor-To-Detroit-Regional-Rail/LansingToDetroitCommuterRailStudyPhaseIIIReport.pdf, retrieved on 9/17/2015

Exhibit 4-4: Unit Capital Costs, Systems, in 2013

Item No.	Description	Unit	Unit Cost (Thousands of 2013)
3.1	Signals for Siding w/ High-Speed Turnout	each	$1,591.23
3.2	Install CTC System (Single Track)	per mile	$229.62
3.3	Install CTC System (Double Track)	per mile	$376.52
3.4	Install PTC System Overlay on top of CTC	per mile	$181.36
3.5	Control Points	each	$870.00
3.6	Intermediate Signals	each	$348.00
3.7	Equipment Defect Detectors (Every 20 miles)	each	$348.00
3.8	At-grade Active Warning Devices	each	$580.00
3.9	Switch Heaters, Propane Tanks, Generators	each	$116.00
3.10	CTC - Dispatch Center	per mile	$232.00
3.11	CTC Upgrade of ABS Territory	per mile	$580.00
3.12	Communications	per mile	$46.00
3.13	Electric Lock for Industry Turnout	each	$129.29
3.14	Signals for Crossover	each	$878.39
3.15	Signals for Turnout	each	$501.98
3.16	Signals, PTC, Communications & Dispatch (Double Track)	per mile	$1,602.00

4.3.3 Crossings

Highway/railroad crossing safety plays a critical role in future project development phases. A variety of devices were considered to improve safety including roadway geometric improvements, median barriers, barrier gates, traffic channelization devices, wayside horns, fencing and the potential closure of crossings. Exhibit 4-5 shows the unit costs for highway and railroad grade crossings.

Exhibit 4-5: Unit Capital Costs, Crossings, in 2013

Item No.	Description	Unit	Unit Cost (Thousands of 2013$)
4.1	Private Closure	each	$104.15
4.2	Four Quadrant Gates w/ Trapped Vehicle Detector	each	$617.38
4.3	Four Quadrant Gates	each	$361.45
4.4	Convert Dual Gates to Quad Gates	each	$188.26
4.5	Conventional Gates single mainline track	each	$208.30
4.6	Conventional Gates double mainline track	each	$257.30
4.7	Convert Flashers Only to Dual Gate	each	$62.79
4.8	Single Gate with Median Barrier	each	$225.91
4.9	Convert Single Gate to Extended Arm	each	$18.77
4.10	Precast Panels without Roadway Improvements	each	$100.44
4.11	Precast Panels with Roadway Improvements	each	$188.26

4.3.4 Other Costs

Contingency costs have been included as an overall percentage of the total construction cost. Contingencies are an allowance added to the estimate of costs to account for items and conditions that cannot be realistically anticipated. The contingency is estimated at 30 percent of the construction cost elements. This contingency included 15%+ for design contingency and 15%+ for construction contingency. Contingency and professional service allowances are added for infrastructure capital costs only. They are not added for land acquisition, property taking, wetland remediation or placeholder costs since these factors are the results of benchmarking rather than engineering cost comparisons.

The project elements included in the Professional Services category are design engineering, program management, construction management and inspection, engineering during construction, and integrated testing and commissioning. For a project of this size, an overall program manager with several section designers is needed to provide conceptual engineering, preliminary engineering, environmental studies, geotechnical engineering, final engineering and engineering during construction. Field and construction management services and integrated testing services and commissioning of various project elements also are required. Professional services and other soft costs required to develop in this study have been estimated as a percentage of the estimated construction cost and are included in the overall cost estimates as a separate line item. Overall this adds 28% on top of the base cost and contingency.

These costs include:

- Design engineering and related studies 10%
- Insurance and Bonding 2%
- Program Management 4%
- Construction management and inspection 6%
- Engineering services during construction 2%
- Integrated Testing and Commissioning 2%
- Erosion Control and Water Quality Mgmt. 2%

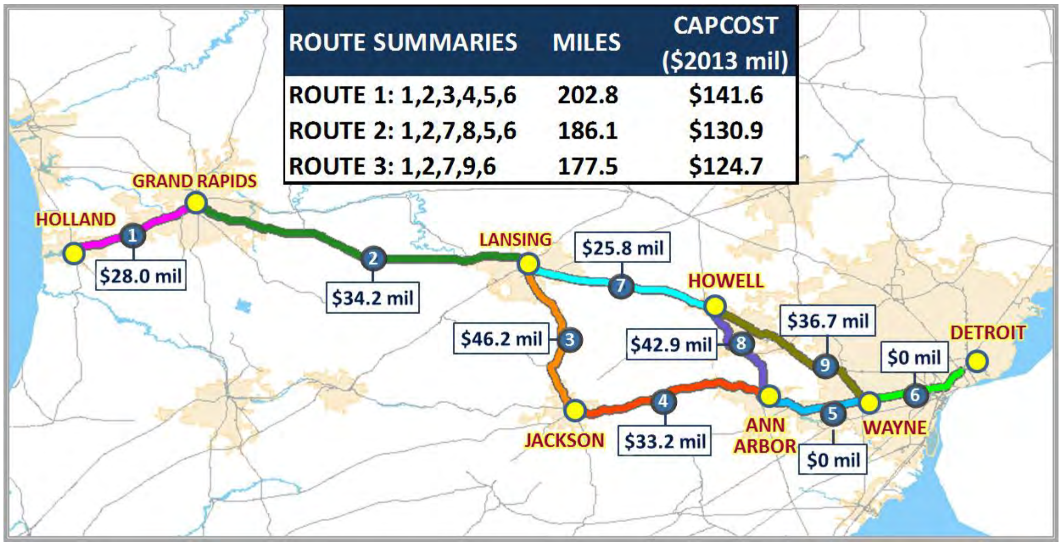
The unit costs already include built-in allowances for contingency and soft costs. That is, the unit costing basis already includes the necessary additives, so these allowances do not need to be added a second time. This is the same approach to costing that was used in the Midwest Regional Rail Study because it simplifies the presentation of the cost estimates and makes them easier to understand.

Capital Costs include allocations for special elements (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 provide lump sum budget approximations based on expert opinion rather than on an engineering estimate and are shown in the unit costs as lump sum items. Since many of these placeholders are based on benchmarking to actual projects rather than on an engineered unit cost approach, they do not include any additional allowance for contingency or soft costs. Placeholders are used where detailed engineering requirements are not fully known. These costs will require special attention as part of the environmental planning process.

4.4 Segment and Route Infrastructure Costs

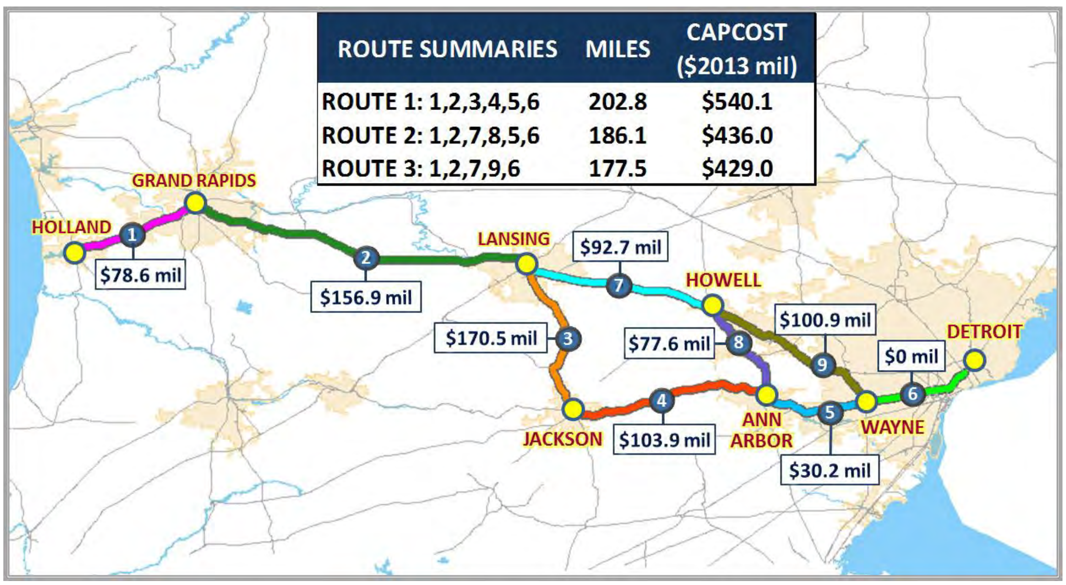
Exhibits 4-6 and 4-7 summarize the infrastructure costs that were developed for each track segment that make up the Coast-to-Coast route alternatives. Some segments are common to multiple routes, so for consistency the Engineering analysis was done on a segmented basis. Then, the infrastructure summary totals for each of the three route alternatives are calculated by summing the segment-level costs. These costs along with the segments that make up the alternative are also shown.

Exhibit 4-6: 79-mph Capital Costs by Segment



ROUTE SUMMARIES	MILES	CAPCOST ($2013 mil)
ROUTE 1: 1,2,3,4,5,6	202.8	$141.6
ROUTE 2: 1,2,7,8,5,6	186.1	$130.9
ROUTE 3: 1,2,7,9,6	177.5	$124.7

Exhibit 4-7: 110-mph Capital Costs by Segment



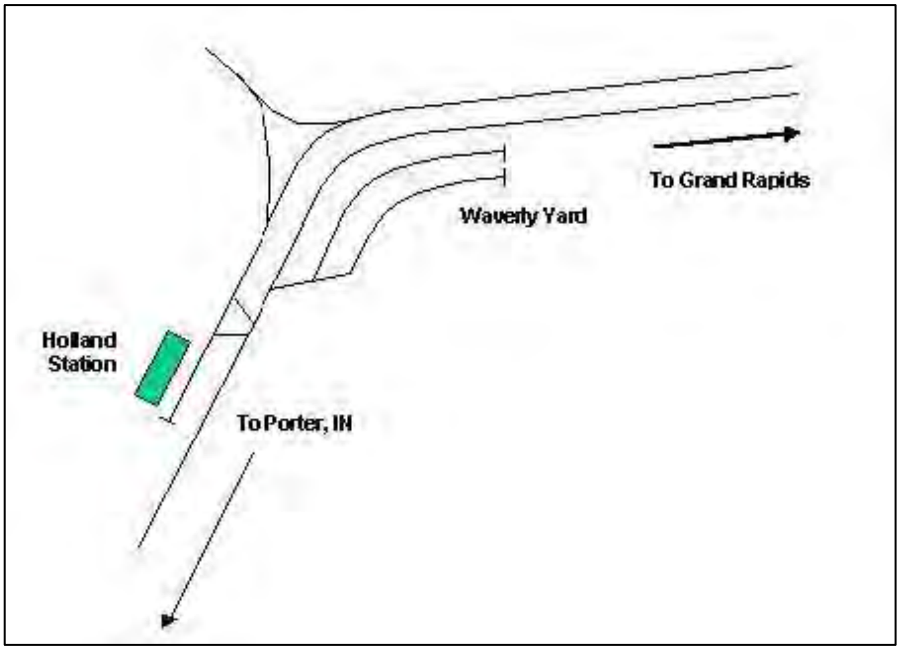
ROUTE SUMMARIES	MILES	CAPCOST ($2013 mil)
ROUTE 1: 1,2,3,4,5,6	202.8	$540.1
ROUTE 2: 1,2,7,8,5,6	186.1	$436.0
ROUTE 3: 1,2,7,9,6	177.5	$429.0

4.4.1 Costing Segment #1 – Holland to Grand Rapids

The 2004 MWRRS study estimated the capital cost for implementing a 79-mph service on this segment as $12.3 Million in 2002 dollars. MWRRS assumed gates would be installed at all remaining ungated crossings, which comprised about 25% of the total, and raised the speed to 79-mph by replacing 33% of the crossties and resurfacing track. It is assumed that the existing welded rail would not need to be replaced. Train speeds would be raised to 60-mph through and around the freight yards at Waverley and Grand Rapids.

This study updates the cost to $28.0 Million in 2013 dollars for a 79-mph based on similar assumptions, but also includes a $20 Million allowance for a train servicing facility at Waverly yard and station improvements at Holland, as were described in the 2004 MWRRS study (Exhibit 7-27) reproduced below in Exhibit 4-8.

Exhibit 4-8: Holland Station and Equipment Maintenance Facility, Proposed Layout



The cost for 110-mph service has been estimated as $78.6 Million. It is assumed that a public entity would be able purchase this track segment under similar terms to those recently offered Norfolk Southern for the Dearborn to Kalamazoo segment. A rate of $1 Million a mile was assumed based on this benchmark. This assumes that rail would not need to be replaced, but curves would be resurfaced and spirals adjusted for allowing higher speeds, a PTC overlay system capable of supporting 110-mph operations would be installed and all crossings would need to be improved for compliance with FRA regulations.

4.4.2 Costing Segment #2 – Grand Rapids to Lansing

This segment uses assumptions that are very similar to those for segment #1 since the existing conditions are very similar. For 79-mph service, about 25% of the crossings would receive new gates. 33% of the crossties would be replaced and the track resurfaced. It is assumed that the existing welded rail would not need to be replaced. Train speeds would be raised to 60-mph through and around the freight yard at Lansing. Five miles of double track would be added for allowing meets between passenger trains as well as between freight and passenger trains. This would cost $34.2 Million.

For the 110-mph option, curves would be resurfaced and spirals adjusted for allowing higher speeds, a PTC overlay system capable of supporting 110-mph operations would be installed and all crossings would be improved for compliance with FRA regulations. Ten miles of double track would be added between Grand Rapids and Lansing for allowing train meets at speed. It is assumed that a public entity would be able purchase this track segment under similar terms to those recently offered Norfolk Southern for the Dearborn to Kalamazoo segment. A rate of $1 Million a mile was assumed based on this benchmark. The overall cost for doing this would come to $156.9 Million.

4.4.3 Costing Segment #3 – Lansing to Jackson

The Lansing to Jackson rail line is owned by Norfolk Southern, but is leased and operated by the Jackson and Lansing Railroad Company (JAIL.) A key concern for both the Norfolk Southern (NS) Lansing to Jackson segment #3, as well as for the Great Lakes Central (GLC) Howell to Ann Arbor segment #8 (North-South

Commuter Rail line) is whether the existing jointed rail must be replaced to support 79-mph passenger service. In May 2015, rail line segments #3 and #8 were inspected. The rail condition was a special focus of these inspections[48]. As shown in Exhibit 4-9, the field inspection showed that with heavy rail and light traffic on the Lansing to Jackson line, the rail still looked to be in good shape overall, although there may be some isolated pockets where rail conditions may be a concern. The inspection did not show any immediate need for a wholesale rail replacement to support the needs of 79-mph passenger service. As standards for rail replacement, on page 8-5 the 1982 GM Study recommended:

- All new rail that is to be installed is continuous welded rail that weighs 132 pounds per yard of length. This rail is to be installed whenever the following conditions prevail:
    - If the maximum passenger train speed is 79-mph, when the rail in the existing track weighs less than 90 pounds per yard of length;
    - If the maximum passenger train speed is 100-mph, when the rail in the existing track weighs less than 115 pounds per yard of length;
    - If the maximum passenger train speed is to be 125-mph, when the existing FRA track class is 1 or 2 regardless of the type of rail presently installed and when the existing FRA track class is 3, 4, or 5 and the existing rail is either bolted rail or weighs less than 115 pounds per yard of length;
    - If the maximum passenger trains speed is to be 150-mph, when the existing FRA track class is 1 or 2 regardless of the type of rail presently installed and when the existing FRA track class is 3, 4, or 5 and the existing rail is either bolted rail or weighs less than 132 pounds per yard of length.

Exhibit 4-9: Good Rail Conditions on the Lansing to Jackson Line

R. L. Banks' 2008 assessment of the Washtenaw–Livingston Rail Line (North-South Commuter Rail Line) also found that wholesale rail replacement was not needed, but R. L. Banks did recommend replacing 0.3 miles of 100 pounds per yard rail located west of Whitmore Lake Siding[49]. This is consistent with GM's

[48] From Lansing to Detroit Passenger Rail Study, Phase III Report, page 5-16; see http://www.semcog.org/Portals/0/Documents/Plans-For-The-Region/Transportation/Transit/Ann-Arbor-To-Detroit-Regional-Rail/LansingToDetroitCommuterRailStudyPhaseIIIReport.pdf retrieved on 9-17-2015.

[49] See R. L. Banks (June 2008) Washtenaw Livingston Rail Line (North-South Commuter Rail line) Technical Review, Subtask 2.3. Track, Signal and Grade Crossing, page 5. Retrieved from

recommendation to change out light rail, which GM defined as 90- pounds per yard weight or less, but R. L. Bank defined as 100 pounds per yard or less. Based on the R. L. Bank's proposal for upgrading the line, as shown in Exhibit 4-10, an "All In" Rate of $820,000 per mile[50] has been developed. This (North-South Commuter Rail Comp) covers the cost for rehabilitation of jointed rail track[51], grade crossings[52], and installation of signals and PTC[53] for operations up to 79-mph.[54]

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http://www.theride.org/Portals/0/Documents/5AboutUs/WALLY/rev2.3%20Track%20Signal%20and%20Grade%20Crossing.pdf on 9-17-2015.

[50] From the same R. L. Banks reference cited above, the projected capital costs on Page 10 were $32.4 Million, but include $2.6 Million for a layover facility, $4.3 Million for stations and $4.4 Million in Other costs. The 20% contingency associated with these costs is $2.2 Million. Removing these leaves $18.9 Million for track infrastructure, grade crossings, signals and PTC for a 26.9 mile rail corridor, or $702,000 per mile in 2008 dollars. Bringing this to 2013 dollars the cost is $820,000 per mile.

[51] Track cost was compared to a recent engineering assessment of the North-South Commuter Rail corridor performed by Quandel. Quandel's estimate is more detailed than R. L. Banks, since it details the cost in four sections; two southern AA and two northern GLC. However, a lot of the track rehabilitation cost is south of the Huron River because the AA track is very bad. *But the Coast-to-Coast rail system does not use this track because it uses the new Huron River Bridge to connect to the MDOT Michigan line.* Looking only at the northern GLC segments where the track condition is better, Quandel's new cost is $176.8 thousand per mile. With the same 20% contingency that R.L .Banks used, Quandel's cost for the northern GLC segment would be $212 thousand per mile which is actually *less* than the $270K per mile R. L. Banks estimated. TEMS believes that R.L .Banks 20% engineering contingency is appropriate for basic track rehabilitation work for which costs are very well known. TEMS Segment 8 Track Cost for 79-mph is $6.9 million rising to $31.8 million for our 110-mph option. Even given the higher soft costs and contingency rate that Quandel used, the updated North-South Commuter Rail line $7.5 million cost lies toward the lower end of TEMS cost range for the northern GLC segments. As a result, Quandel's updated North-South Commuter Rail line track costs are within the range of TEMS estimates.

[52] Quandel replaced all the grade crossings for 60-mph speed; R. L. Banks did not since it is not a regulatory requirement at this speed. R. L. Banks allowed $2.2 Million for upgrading North-South Commuter Rail line crossings whereas Quandel's cost is twice that. TEMS does not agree that replacing all the crossing devices is actually needed for 60 to 79-mph operation and so has adopted R. L. Banks number for the slow speed option. However TEMS did replace all the grade crossing devices for 110-mph service. TEMS Segment 8 Crossings Cost for 79-mph is $2.1 million rising to $13.3 million for our 110-mph option. Even given the higher soft costs and contingency rate that Quandel used, the updated North-South Commuter Rail line $4.0 million cost lies toward the lower end of TEMS cost range for the northern GLC segments. As a result, Quandel's grade crossing costs are within the range of the TEMS estimates.

[53] Quandel's proposed PTC costs for the North-South Commuter Rail line are at $1.02 million per mile based on construction of a CTC system with a PTC overlay. The overlay including back office server, wayside interface unit functionality and vitality is priced at 82% of the signal system hardware based on Quandel's analysis of the MDOT GE pricing. However, other comparables suggest that the price for the wayside PTC components should be lower, more in line with R. L. Banks' original estimates:

- On Oct 2, 2015, NICTD awarded a $79.9 million contract to Parsons Corp for a 75 route-mile system or $1.06 million per mile. See: http://www.chicagotribune.com/suburbs/post-tribune/news/ct-ptb-nictd-shutdown-resolution-st-1003-20151002-story.html Of this, the wayside and back office components together cost $39.7 million, but NICTD is about 40% double track, so the average comes to $378K per track mile which is actually *less* than TEMS assumed PTC unit cost per track mile. The NICTD contract is turn-key and fixed-price, since the vendor was asked to assume all the business risk associated with the contract, undoubtedly raised the price. NICTD was advised that their existing control center and software could not be used, so the price includes a whole new control center. Finally, mobilization, training and approvals constitutes a very large (29% share) of the cost for such things as training manuals.
    - Wayside and Testing accounts for 36% of the project cost, 75 miles or $379,218 per route mile
    - Back Office accounts for 14% of the project cost, 75 miles or $150,244 per route mile
    - Vehicles account for 22% of the project cost, 131 cabs for $131,327 per cab
    - The remainder of 29% of the project cost is for training and back office software
- Alaska Railroad is implementing the I-ETMS system, which uses Track Warrant Control in dark territory and also interfaces with signals in those locations where the Alaska Railroad has them. As according to: http://www.alaskajournal.com/business-and-finance/2015-02-11/railroad-cuts-ptc-ask-aims-finance-remaining-need the total capital cost of the Alaska Railroad system is $160 million. Over 525 miles of track that would come to a capital cost of $305K per mile (for everything including control center, wayside and vehicles.) which again is substantially less than the $467K per mile that R. L. Banks estimated. Alaska Railroad is running passenger trains at 60-mph, so this solution would work for the North-South Commuter Rail line as well.

TEMS Costs for PTC and signaling in the Coast-to-Coast study are in the $410-470K per mile range, which is in line with accepted industry comparable costs. For keeping PTC cost at manageable levels in the future, it is recommended that Michigan DOT consider installing non-overlay versions of PTC (such as Alaska Railroad's system) and also obtain industry certification for the freight railroad standard I-ETMS up to 110-mph. Doing this would avoid having to install redundant (ITCS + I-ETMS) systems in shared-used territory, since the freight railroads do not want to have to equip their locomotive fleets for ITCS. FRA does not require installation of block signals in conjunction with PTC; 49 CFR § 236.1007 requires appropriate fouling circuits and broken rail detection (or equivalent safeguards) for speeds greater than 60-mph and split-point derails or equivalent for speeds greater than 90-mph. (see https://www.law.cornell.edu/cfr/text/49/236.1007)

Exhibit 4-10: Development of North-South Commuter Rail Line Comparable Cost

Costs in $thousands	Yr 2008 RLB Base	Yr 2008 RLB w/20% Contingency	Yr 2013 RLB w/20% Contingency	26.9 miles
Track Subtotal	$194	$232	$270	/ mile
Crossings	$59	$71	$83	/ mile
Signals	$336	$403	$467	/ mile
Cost/Mile	***$588***	***$706***	***$820***	/ mile

The GM Study did not assume rail replacement for either the NS Lansing to Jackson segment #3 or GLC Howell to Ann Arbor segment #8, and the 2008 North-South Commuter Rail line studies did not recommend rail replacement for the GLC Howell to Ann Arbor segment #8 either. There is a ride quality issue depending on the exact condition of the jointed rail, but not a safety issue if track is maintained to FRA Class IV standards.

For planning purposes, the overall track condition of segments #3 and #8 are considered to be very similar since the rail conditions look good, although both line segments require major tie work and surfacing, as well as installation of signals, PTC and highway grade crossing improvements. Since the exact rail conditions are not known, if it is decided to further pursue 79-mph options, then as R. L. Banks recommended[55] a more detailed Engineering inspection, including an internal rail flaw detection test should be performed on both line segments. This can be accomplished during Environmental studies of the corridor.

For the 79-mph cost estimate: as applied to the 37.6 miles from Lansing to Jackson the unit cost of $820,000 per mile would result in a cost of $30.8 Million for upgrading the line segment to passenger standards. However, an additional 5-mile long passing siding also needs to be added for train meets and overtakes to occur along this segment. Since the existing Amtrak station at Trowbridge cannot be used in conjunction with this alignment, the cost estimate also includes an allowance for a new station platform in downtown Lansing. The cost of this station platform, passing siding and related signaling equipment adds another $15.4 Million to the cost, bringing the overall estimated cost of the 79-mph Lansing-Jackson upgrade to $46.2 Million.

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[54] R. L. Banks assessed the corridor at a top speed of 60-mph: *"At present GLC, with MDOT assistance, is maintaining its track infrastructure to Federal Railroad Administration (FRA) class 3 standards. Since Class 3 standards support passenger train speeds up to 60 mph, little should change from a maintenance point of view. The track structure likely will be maintained to the upper end of Class 3 standards, with some repairs performed to improve ride quality for passengers, such as flash-butt welding to eliminate joints."* As FRA Class 3 track, the current track condition is already good enough to support passenger service at 60-mph, so very little upgrading should be needed. Nonetheless, as shown in Exhibit 4-10, R. L. Banks average cost was $270,000 per mile for the whole corridor (R. L. Banks did not provide any breakdown of their costs by segment) and this is what was used for development of the North-South Commuter Rail line comparable cost. Welded rail is not needed for 79-mph operations but because the cost for flash-butt welding existing rail was already included by R. L. Banks, it is also included in TEMS 79-mph estimate. This overall level of cost was validated by comparison to Item 1.11 in Exhibit 4-2. This shows a rate of $278,620 per mile with full contingencies for 33% tie replacement and surfacing. This is very close to the number that was derived from the R. L. Banks study. Based on the agreement of these two sources, and because track conditions north of the Huron River are much better that those south of the river, TEMS believes that this amount should be more than sufficient for bringing the track to 79-mph. We concluded that the average level of cost recommended by R. L. Banks for the whole corridor (which is higher than Quandel's track cost for the segments north of the river) and which we used in our analysis, would in fact, be sufficient to upgrade the north end of the line to 79-mph. So, we have developed it as a 79-mph cost.

[55] From the same R. L. Banks reference cited above on page 5, *"GLC confirmed that it had not performed an internal rail flaw detection test within recent history and agrees with the RLBA assertion that a thorough test must be performed to determine how much rail needs to be replaced (if any) before passenger operations begin."*

For upgrading the line condition for 110-mph (although in many places the existing route geometry won't allow this speed on Segment #3) the cost rises to $170.5 Million. This includes a $37.6 Million allowance ($1 million per mile) for purchasing this branch line track from Norfolk Southern. This provides Michigan DOT ownership of the corridor along with all new track, a 10-mile passing siding, PTC and grade crossing upgrades.

4.4.4 Costing Segment #4 – Jackson to Ann Arbor

This segment follows the existing Amtrak route from Jackson to Ann Arbor. Currently this line handles three round trip Chicago-to-Pontiac Amtrak trains each day, which are planned to increase to six round trips and finally to ten daily round trips upon completion of Chicago area line capacity improvements.

This line from Jackson to Detroit follows the former Michigan Central main line right of way, which at one time was completely double-tracked. As a result, the track bed and many of the bridge structures remain in place and can easily accommodate replacement of the double track. Even so, the average cost per mile (based on the recent Dearborn to Wayne project) is $3.32 Million per mile[56] for restoring double track on the existing Michigan Central track bed. This includes the cost for switches, signals and PTC, as well as highway grade crossing modifications needed to accommodate the new track and connect it into the existing rail line.

A 79-mph option would add 4 daily round trips leading to a combined total of 14 daily passenger round trips east of Jackson. A 110-mph option would add 8 round trips east of Jackson so 18 daily round trips would be operated. Clearly this exceeds the capacity of a single tracked line:

- For a 79-mph option it is assumed that a single 10-mile long passing area would be added between Jackson and Ann Arbor. This costs $33.2 Million.
- For a 110-mph option it is assumed that complete restoration of the double track east of Jackson would be needed to support the operation of up to 18 daily round trips. This costs $103.9 Million.

4.4.5 Costing Segment #5 – Ann Arbor to Wayne

This segment follows the existing Amtrak route from Ann Arbor to Wayne. This line segment is already being equipped for 110-mph train operations, and double track already extends from Wayne as to Ypsilanti. As such there is only a short 9.1 mile single track segment.

- For a 79-mph option, it is assumed that passenger trains can be scheduled to avoid meeting in this short stretch of track so no improvements to this line segment are proposed.
- For the 110-mph option it is proposed to complete double tracking this segment to provide enough capacity for operating up to 18 intercity passenger round trips per day. Doing this would also likely provide enough capacity to allow the operations some local commuter trains as well. Applying the same benchmark cost of $3.32 Million per mile, this would cost $30.2 Million.

[56] Schulte, Moore and Bates (2013), Michigan DOT: Design Challenges of Dearborn to Ypsilanti Double Track Project, AREMA Conference Proceedings. See: https://www.arema.org/files/library/2013_Conference_Proceedings/Michigan_DOT-Design_Challenges-Dearborn_to_Ypsilanti_Double_Track_Project.pdf. retrieved on 9-17-2015. Page 641 gives the cost for this 9-mile project as $29.87 Million, or $3.32 Million per mile.

4.4.6 Costing Segment #6 – Wayne to Detroit

As a result of the Norfolk Southern railroad purchase agreement, the Wayne to Detroit line segment is currently being completely double tracked; and a new shorter connection is under construction that will provide a conflict-free route at West Detroit for getting the passenger trains over to Detroit New Center station. Additional improvements such as additional platform, and train storage tracks are already planned within the Detroit to Chicago EIS and it is assumed that these improvements will proceed.

With all these improvements, both underway and proposed, it is assumed that this segment will be able to support the needs of the Coast-to-Coast Rail Corridor without needing significant additional cost. This is of course, subject to confirmation by a detailed capacity analysis which will need to occur as part of the environmental planning process.

4.4.7 Costing Segment #7 – Lansing to Howell

This segment uses assumptions that are very similar to those for segments #1 and #2 since the existing conditions are very similar. For 79-mph service, about 25% of the crossings would receive new gates. 33% of the crossties would be replaced and the track resurfaced. It is assumed that the existing welded rail would not need to be replaced. Five miles of double track would be added for allowing meets between passenger trains as well as between freight and passenger trains. Since there is no current train station at Howell, the estimate also includes $1 Million for the cost of station platforms. This would cost $25.8 Million.

For the 110-mph option, curves would be resurfaced and spirals adjusted for allowing higher speeds, a PTC overlay system capable of supporting 110-mph operations would be installed and all crossings would be improved for compliance with FRA regulations. Ten miles of double track would be added between Grand Rapids and Lansing for allowing train meets at speed. It is assumed that Michigan DOT would be able purchase this track segment under similar terms to those recently offered Norfolk Southern for the Dearborn to Kalamazoo segment. A rate of $1 Million a mile was assumed based on this benchmark. The overall cost for doing this would come to $92.7 Million.

4.4.8 Costing Segment #8 – Howell to Ann Arbor

Most of this route segment (also known as the North-South Commuter Rail line) is already owned by the State of Michigan and is operated by the Great Lakes Central railroad. It has received extensive rehabilitation over the past 10 years or so and operates effectively as a rail freight branch line, but the track is not up to passenger standards.

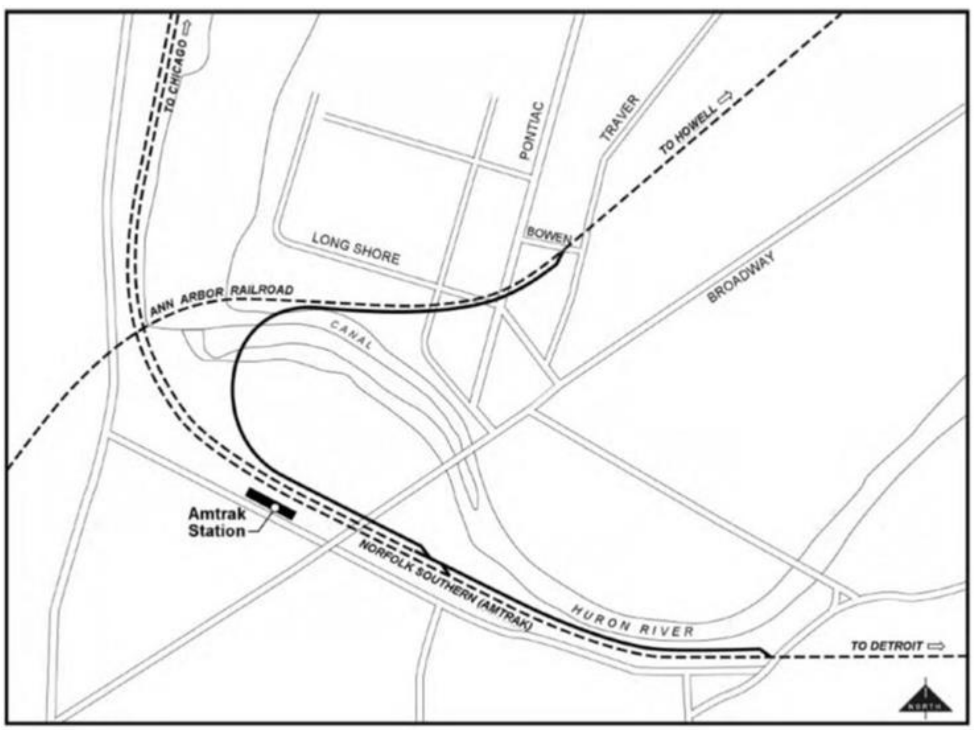
For this segment, it is important to note that service proposed for the Coast-to-Coast passenger rail line is very different from the North-South commuter rail service that (at the time of this report) is being studied at a detailed, feasibility level. First, this study assumes that the Coast-to-Coast passenger rail service will have limited stations in this corridor, most likely stopping only south of Howell at Ann Pere junction and north of downtown Ann Arbor near the existing Amtrak station. The North-South commuter rail service would have additional stops in downtown Howell and Ann Arbor, as well as Genoa Township, Hamburg and Whitmore Lake. The North-South commuter rail service would also require a new freight yard, two layover facilities, connecting bus service and costs of more complicated track and signal work south of Barton drive which at this time are assumed not to be required for the more limited-stop, longer trip service proposed in this study for the Coast-to-Coast passenger rail line.

For 79-mph service, a new track connection to the CSX line at Ann Pere junction would be needed. Track rehabilitation, grade crossing improvements and a new PTC signal system would be installed. R. L. Banks has developed a recent detailed Engineering assessment of this line (as discussed earlier under Segment #3) – the R. L. Banks benchmark rate of $820,000 per mile was used for developing the 79-mph cost estimate for this line. In addition, the Ann Arbor railroad still owns several miles of track in Ann Arbor which are needed to make the connection to Michigan DOT's current Amtrak line. The cost estimate includes the purchase of 2 miles of track at a rate of $1 million per mile.

A critical improvement needed is the construction of a new bridge at Ann Arbor (Exhibit 4-11) connecting the North-South Commuter Rail line to the former Michigan Central Amtrak route. By updating the estimate provided in the Lansing to Detroit Phase III report[57] the cost of this bridge and track connection has been estimated as $20 Million.

The $20 million Ann Arbor bridge cost estimate includes the structure only and does not include possible land acquisition or environmental mediation that may be required at this relatively complex site. These requirements would need to be addressed in a later, more in-depth engineering study.

Exhibit 4-11: Ann Arbor Bridge and Connection



As a result, the overall cost for upgrading the Howell to Ann Arbor segment for 79-mph service has been estimated as $42.9 Million. For upgrading the line condition for 110-mph (although in many places the

[57] The map is taken from the *Lansing to Detroit Passenger Rail Study, Phase III Report*, page 5-19 by Parsons Transportation Group, a reputable engineering firm; see http://www.semcog.org/Portals/0/Documents/Plans-For-The-Region/Transportation/Transit/Ann-Arbor-To-Detroit-Regional-Rail/LansingToDetroitCommuterRailStudyPhaseIIIReport.pdf retrieved on 9-17-2015 . Parsons states that "The new bridge construction involves a 12-degree curve and a 1.98 percent grade. This could be traversed at 25 mph." These curves and grades are well within the capabilities of trains. In Exhibit 3-3 the unit cost of a "Double Track High (50') Level Bridge" is $15,270 per foot so a *double* tracked 1,200' bridge would be costed as $18.3 million -- which is still less than the $20 million that TEMS developed for a *single* tracked bridge by applying inflation factors to Parsons' estimate. As a result, TEMS believes the cost for the bridge and connection is in the right range.

existing route geometry won't allow this speed on Segment #8) the cost rises to $77.6 Million. This provides public ownership of the corridor along with all new track connections at Ann Pere and Ann Arbor, PTC and grade crossing upgrades.

4.4.9 Costing Segment #9 – Howell to Wayne via Plymouth

This segment uses assumptions that are very similar to those for segments #1, #2 and #7 since the existing conditions are very similar. For 79-mph service, about 25% of the crossings would receive new gates. 33% of the crossties would be replaced and the track resurfaced. It is assumed that the existing welded rail would not need to be replaced. Since there is no current train station at Plymouth, the estimate also includes $1 Million for the cost of station platforms. For the 110-mph option, curves would be resurfaced and spirals adjusted for allowing higher speeds, a PTC overlay system capable of supporting 110-mph operations would be installed and all crossings would be improved for compliance with FRA regulations.

However, capacity as well as compliance with CSX's Letters of Principle becomes a special concern for this segment, particularly for the stretch of track between Plymouth and Wayne, which continues to remain a very busy route for freight trains and still has an approximate 2 mile section of single track in the middle. It should be noted that the earlier Ohio Hub studies that shared this same mainline corridor south of Wayne did not assume that the existing track could be shared. Rather they assumed the development of a new passenger-dedicated track from Wayne to Toledo paralleling the existing freight main line at a minimum spacing of 28'. However for the purpose of this assessment it will be assumed that the Plymouth to Wayne segment can be shared with freight trains, in accordance with CSX principles and based on the complete double tracking of the line south of Plymouth to Wayne.

The cost estimate includes 7 miles of added double track for the 79-mph option and 12 miles for the 110-mph option. The 110-mph estimate also includes an assumed $1 Million per mile payment to CSX for purchasing the rail corridor from Howell to Plymouth and for purchasing a right-of-way easement from Plymouth to Wayne.

Overall, this results in a cost of $36.7 Million for a 79-mph option and $100.9 Million for a 110-mph option.

4.5 Equipment and Overall Capital Cost Summary

For completing the Capital Cost estimate it is necessary to estimate equipment costs for each Alternative. Two speed options were developed for each of the three routes; however, two train frequency sub-options were also developed, leading to a total of 12 alternatives to be assessed[58].

[58] It is not known at this time exactly what size trainset will be procured. Capacity could be as low as 30 seats per car for a Talgo coach; conventional single level coaches seat 65-72 passengers, and bi-level cars have 100 or more seats per car. Because of this uncertainty, equipment was priced on an average cost-per-seat basis based on the size of train that would be needed to accommodate demand in 2030. This results in a consistent comparison of capital costs, that is free of the rounding errors that would otherwise be introduced by assuming a fixed seats per car configuration.

The cost of 79-mph equipment was benchmarked at $62,000 per seat; 110-mph tilting trains are slightly more expensive at $72,000 per seat due primarily to their higher horsepower requirement. Based on the estimation of required train size and equipment rotation cycles, this led to an overall equipment cost as shown in Exhibit 4-11. Based on the equipment cost calculations summarized in Exhibit 4-12 the overall capital cost for the Route Alternatives and options is summarized in Exhibit 4-13.

Exhibit 4-12: Estimation of Equipment Cost

Alternative	Daily Roundtrips	2030 Peak Segment Riders	2030 Required Train Size	Rotation Sets	Protect Sets	Total Sets	Total Seats	Cost per Seat ($2013K)	Equipment Cost ($2013M)
Route 1 79-mph	2	307,138	290	2	1	3	869	$62	$53.9
Route 1 79-mph	4	516,666	244	**4**	2	6	1,461	$62	$90.6
Route 1 110-mph	4	744,234	351	4	2	6	2,105	$72	$151.5
Route 1 110-mph	8	1,123,984	265	6	3	9	2,384	$72	$171.6
Route 2 79-mph	2	311,885	294	2	1	3	882	$62	$54.7
Route 2 79-mph	4	511,952	241	**4**	2	6	1,448	$62	$89.8
Route 2 110-mph	4	722,913	341	4	2	6	2,044	$72	$147.2
Route 2 110-mph	8	1,073,488	253	6	3	9	2,277	$72	$163.9
Route 3 79-mph	2	281,531	265	2	1	3	796	$62	$49.4
Route 3 79-mph	4	458,430	216	**4**	2	6	1,296	$62	$80.4
Route 3 110-mph	4	639,575	301	4	2	6	1,809	$72	$130.2
Route 3 110-mph	8	927,578	219	6	3	9	1,967	$72	$141.7

Exhibit 4-13: Capital Cost Summary by Alternative

Alternative	Daily Roundtrips	Equipment Cost ($2013M)	Infrastr Cost ($2013M)	TOTAL Cost ($2013M)
Route 1 79-mph	2	$53.9	$141.6	$195.5
Route 1 79-mph	4	$90.6	$141.6	$232.2
Route 1 110-mph	4	$151.5	$540.1	$691.6
Route 1 110-mph	8	$171.6	$540.1	$711.7
Route 2 79-mph	2	$54.7	$130.9	$185.6
Route 2 79-mph	4	$89.8	$130.9	$220.7
Route 2 110-mph	4	$147.2	$436.0	$583.2
Route 2 110-mph	8	$163.9	$436.0	$599.9
Route 3 79-mph	2	$49.4	$124.7	$174.1
Route 3 79-mph	4	$80.4	$124.7	$205.1
Route 3 110-mph	4	$130.2	$429.0	$559.2
Route 3 110-mph	8	$141.7	$429.0	$570.7

Chapter 5
Demographics, Socioeconomic & Transportation Databases

SUMMARY

This chapter is divided into subsections of: introduction, zone system, socioeconomic data, transportation network data, origin-destination data, the stated preference survey process, and the results of the analysis. Specifically, this chapter describes the steps for developing the market data which includes developing a zone system and socioeconomic database of the Study Area, and describes how the transportation networks were developed, how the origin and destination databases were obtained and validated, and the methodology used to conduct the stated preference surveys.

5.1 Introduction

To better represent the travel market that covers a large area, the study area is divided into zones to reflect the characteristics of travelers and trips of different origin-destinations pairs which are the basic building blocks of the COMPASS™ Model (Exhibit 1-1 in Chapter1). In order to forecast the future Total Travel Demand in the study area, base year and future socioeconomic data for each zone are developed and inputted into the model. All databases: socioeconomic characteristics, transportation networks, and trips, are also built at the zonal level. In particular, the main drivers of the travel market, namely, population, employment and income, are developed at the zonal level. The COMPASS™ Model then processes the data and outputs the Travel Demand Forecast including passenger rail ridership and revenue results, at the zonal level.

In order to understand the level of intercity travel in a corridor, a zone system is defined that allows the number of trips between one location (zone) and another (zone) to be measured. As such, the system provides a representation of the travel occurring from zone origins to zone destinations for any given market in the corridor (e.g., business, social travel). For intercity passenger rail planning, most rural zones are represented by larger areas. However, where it was important to identify more refined trip origins and destinations in urban areas, finer zones are typically used. The Travel Demand Model forecasts the total number of trip origins and destinations by mode and by zone pair.

5.2 Zone System

For the current Coast-to-Coast study, an effective zone system was developed based on the zone system that had been used for the MWRRI and the Chicago-Detroit/Pontiac Passenger Rail Corridor Investment Plan Alternatives Identification and Evaluation Study[59]. Because the MWRRI developed an integrated rail network for the Midwest, a zone system was needed that incorporated all the corridors of MWRRI. To meet this need, a 662-zone system was developed for the Midwest study area that covers 11 states. The state of Michigan has 212 of those zones. Exhibit 5-1 list the states included in the entire study area and the number of zones for each.

The zone were developed based on aggregation of the 2010 census tracts and traffic analysis zones (TAZs) of local transportation planning agencies. Exhibit 5-2 shows the zone system for the Midwest study area. Exhibit 5-3 shows the zones in the Michigan.

See Appendix 1 for a detailed description of the Zone System.

Exhibit 5-1: Study Area Description

State	Number of Zones
Iowa	44
Illinois	107
Indiana	74
Kansas	4
Kentucky	3
Michigan	212
Minnesota	37
Missouri	44
Nebraska	19
Ohio	64
Wisconsin	54
Total Number of Zones	**662**

[59] Chicago-Detroit/Pontiac Passenger Rail Corridor Investment Plan Alternatives Identification and Evaluation: TEMS Inc., June 2014.

Exhibit 5-2: Study Area Zone System

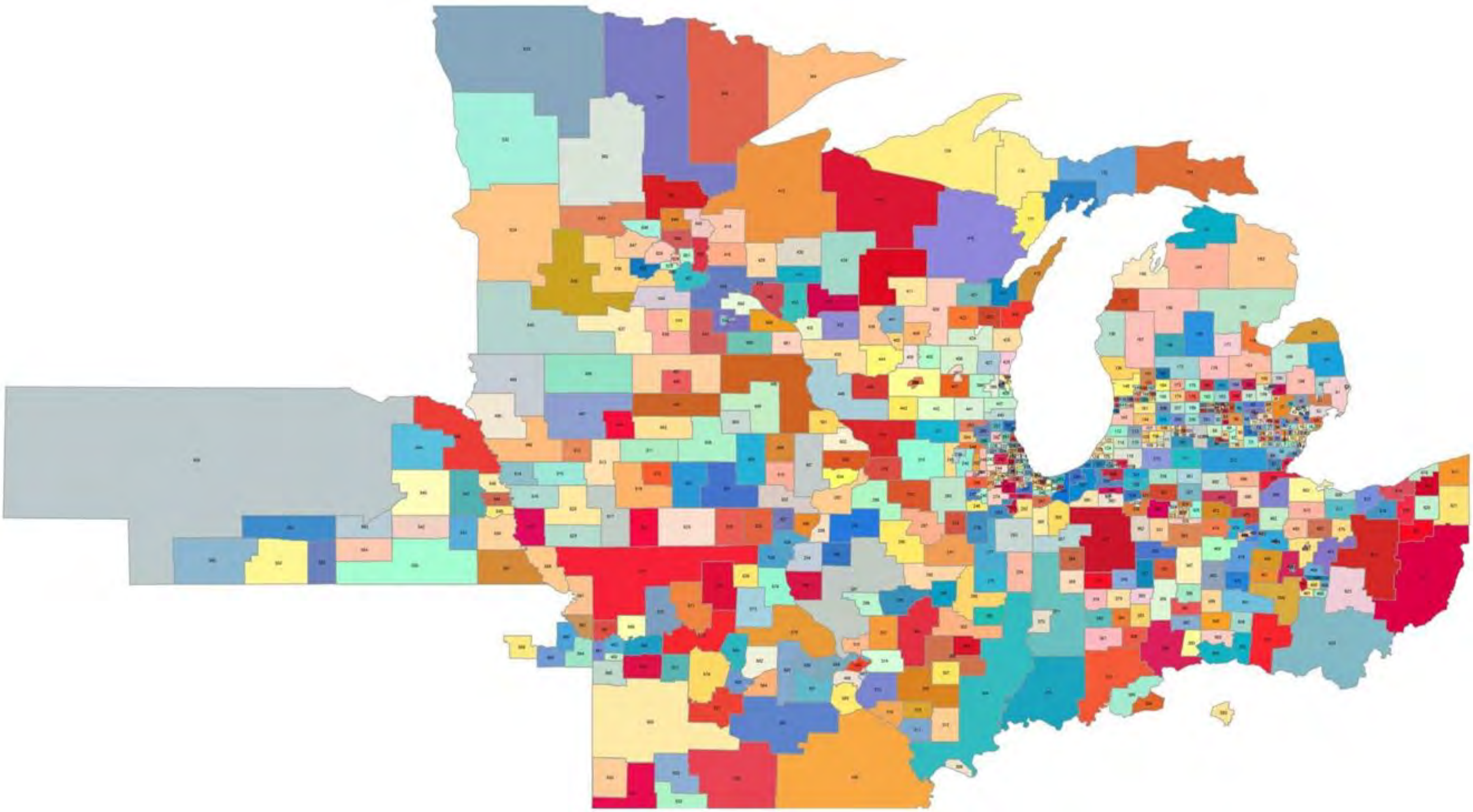
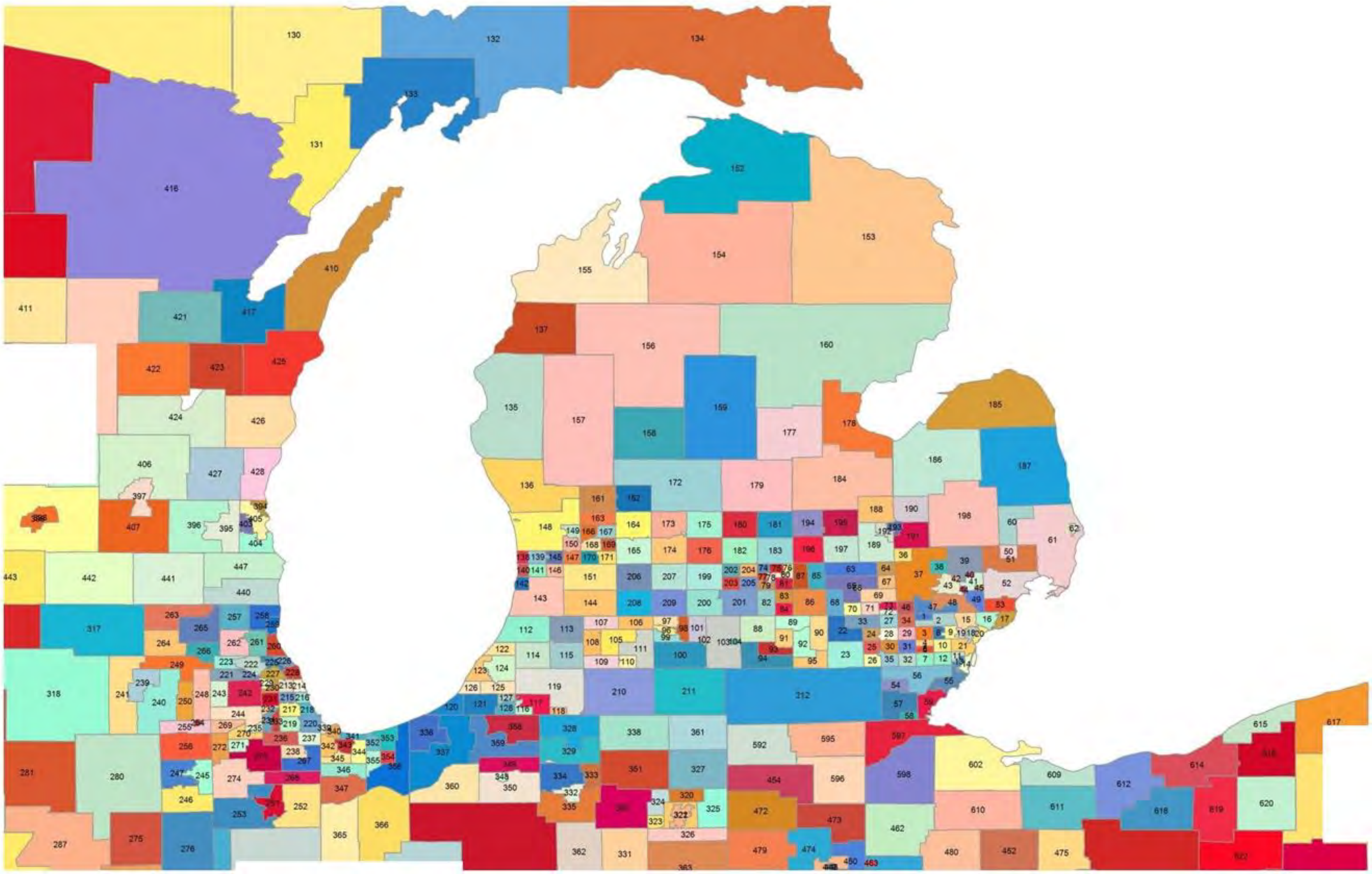


Exhibit 5-3: Michigan Zone System



5.3 Socioeconomic Database Development

In order to estimate the base and future travel market total demand, the travel demand forecasting model requires base year estimates and future growth forecasts of three socioeconomic variables of population, employment and per capita income for each of the zones in the study area. A socioeconomic database was established for the base year (2013) and for each of the forecast years (2015-2055).

5.3.1 Data Collection and Analysis

The data was developed at five-year intervals using the most recent data collected from the following sources:

- U.S. Census Bureau 2010 Census Data
- 2009-2013 American Community Survey 5-Year Estimates
- U.S. Bureau of Economic Analysis
- Woods & Poole Economics
- Michigan Department of Transportation
- Southeast Michigan Council of Governments
- Region 2 Planning Commission
- Tri-County Regional Planning Commission
- Grand Valley Metropolitan Council
- Battle Creek Area Transportation Study
- Kalamazoo Area Transportation Study
- Southwest Michigan Commission
- Chicago Metropolitan Agency for Planning

Exhibit 5-4 shows the base year and TEMS socioeconomic projections for Michigan. According to the data developed by TEMS, the population of Michigan will increase from 9.89 million in 2013 to 11.42 million in 2055, the total employment of Michigan will increase from 5.44 million to 6.45 million in 2055, and per capita income will increase from $39,055 in 2013 to $79,622 in 2055 in 2013 dollars.

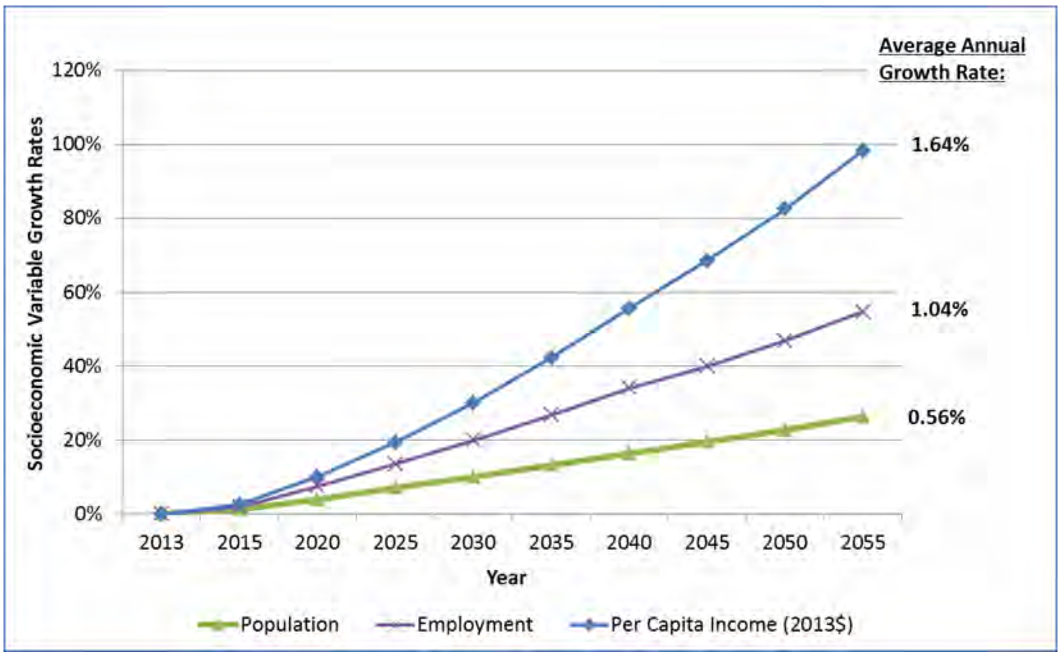
Exhibit 5-4: Michigan Base and Projected Socioeconomic Data

	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
Population	9,895,622	9,960,297	10,129,650	10,306,816	10,485,750	10,667,192	10,849,195	11,031,183	11,218,353	11,418,298
Employment	5,325,800	5,373,522	5,503,802	5,634,415	5,765,056	5,897,677	6,044,993	6,169,847	6,306,105	6,448,947
Per Capita Income (2013$)	39,055	40,187	43,207	46,889	51,204	56,152	61,727	67,108	72,962	79,622

Exhibit 5-5 shows the socioeconomic growth projections for the study area. The exhibit shows that there is higher growth of employment and income than population. Furthermore, travel increases are historically strongly correlated to increases in employment and income, in addition to changes in population. Therefore, travel in the study area is likely to continue to increase faster than the population growth rates, as changes in employment and income outpace population growth, and stimulate more demand.

The exhibits in this section show the aggregate socioeconomic projection for the whole study area. It should be noted that in applying socioeconomic projections to the model, separate projections were made for each individual zone using the data from the listed sources. Therefore, the socioeconomic projections for different zones are likely to be different and thus may lead to different future travel sub-market projections. A full description of socioeconomic data of each zone can be found in the Appendix 2: Zonal Socioeconomic Data.

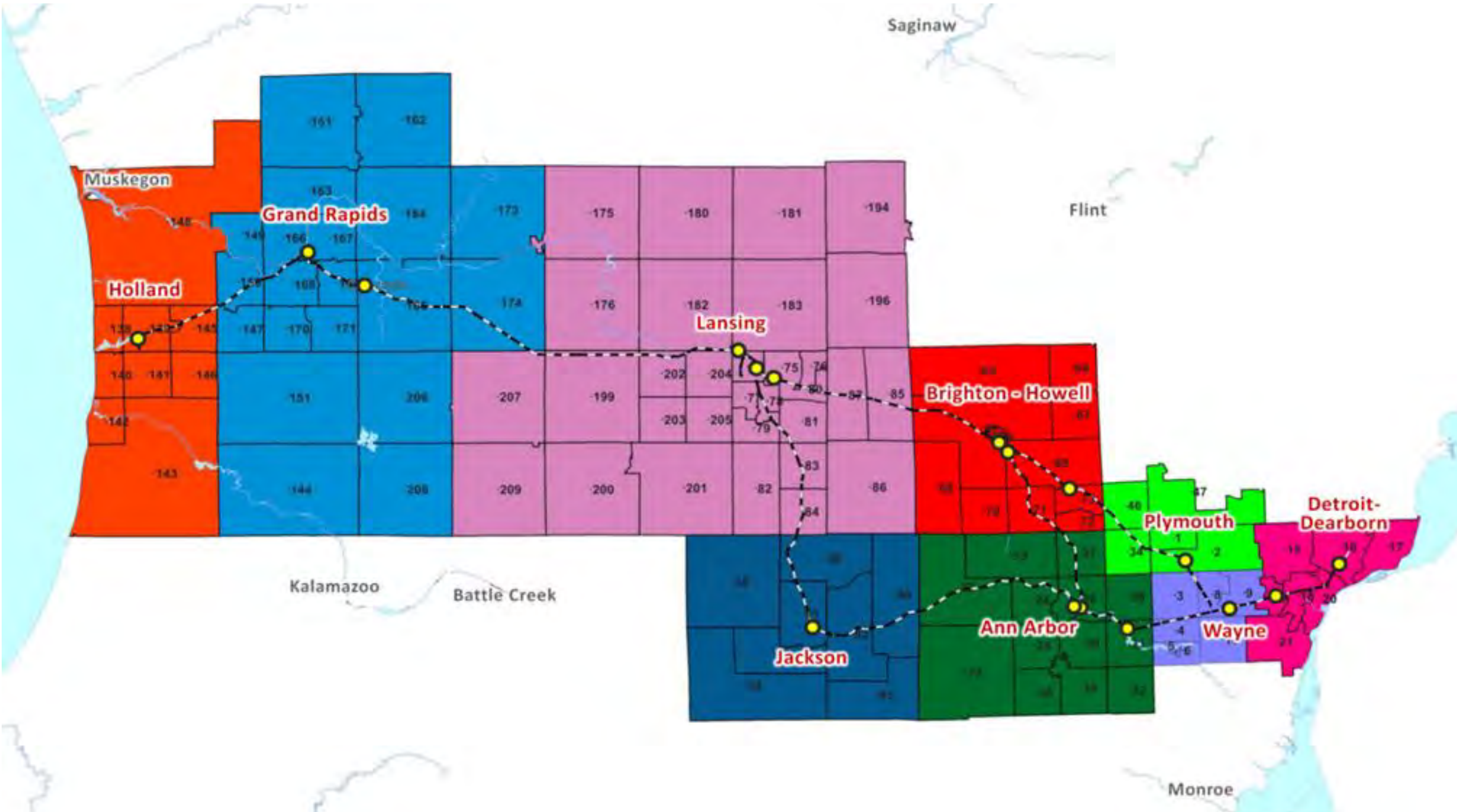
Exhibit 5-5: Study Area Socioeconomic Data Growth Rates



5.3.2 Regional Demographics and Growth

Exhibit 5-6 shows a map depicting superzones that are used to identify regional growth of population, employment, and income along the Coast-to-Coast corridor for the different options.

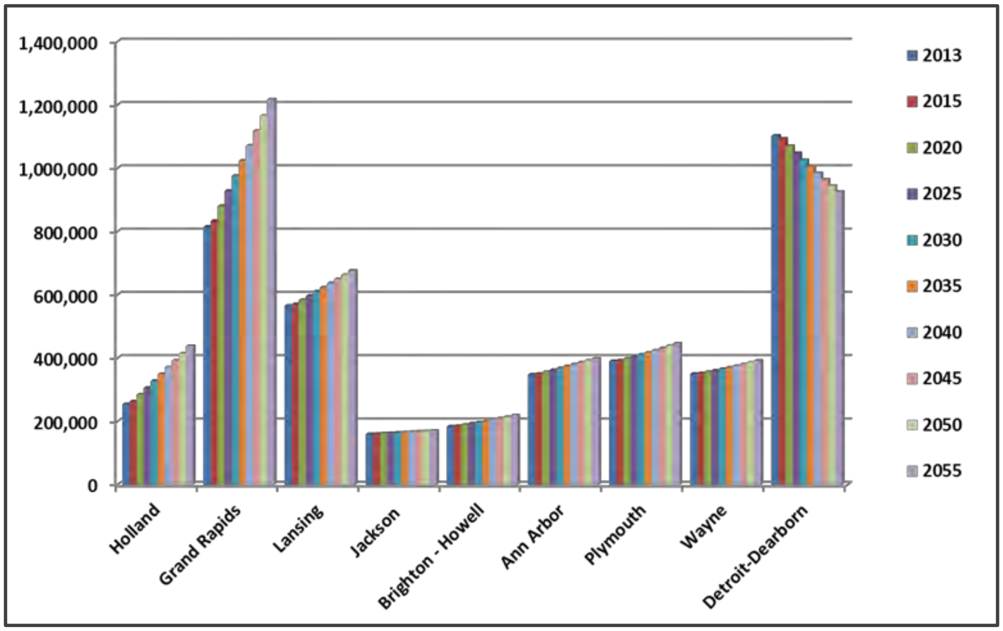
Exhibit 5-6: Coast-to-Coast Corridor Superzone Map



5.3.2.1 Population

In Exhibit 5-7 it can be seem that the population growth rates vary significantly across the corridor with negative growth in the Detroit-Dearborn region at the eastern end of the corridor, strong growth in Holland, Grand Rapids and Lansing in the west, and more modest growth in Plymouth, Wayne, Ann Arbor, and Brighton-Howell.

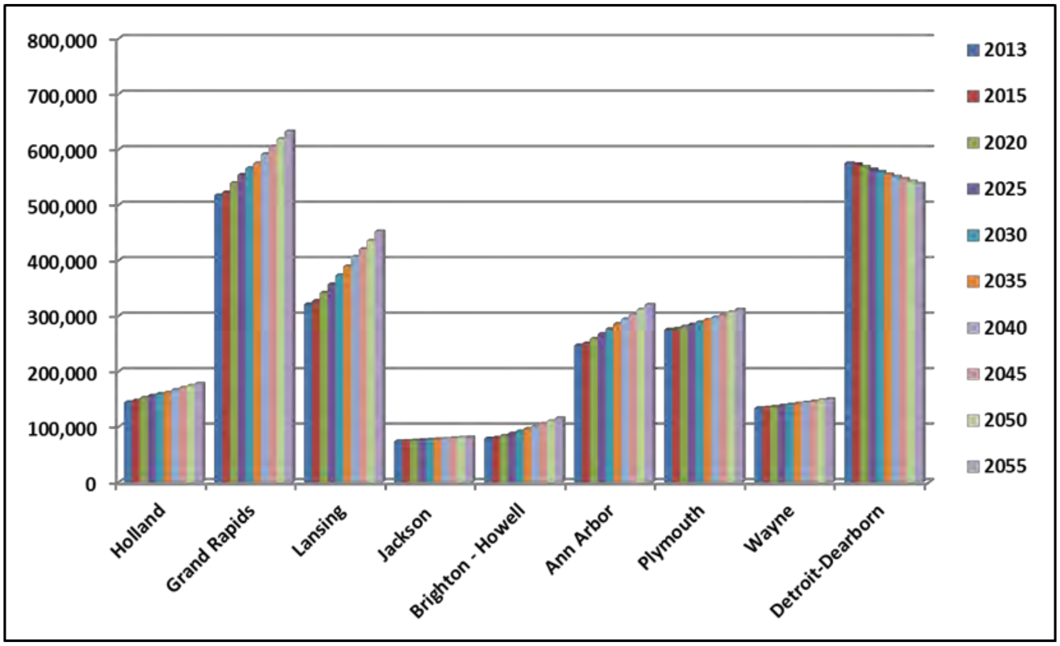
Exhibit 5-7: Population by Superzone



5.3.2.2 Employment

The growth in employment as shown in Exhibit 5-8 largely reflects the growth in population, with negative growth in Detroit-Dearborn, strong growth in Lansing, Grand Rapids, and Holland, and modest growth in Plymouth, Wayne, and Jackson. Ann Arbor and Brighton-Howell however, are the exception and have stronger growth than suggested by their population growth.

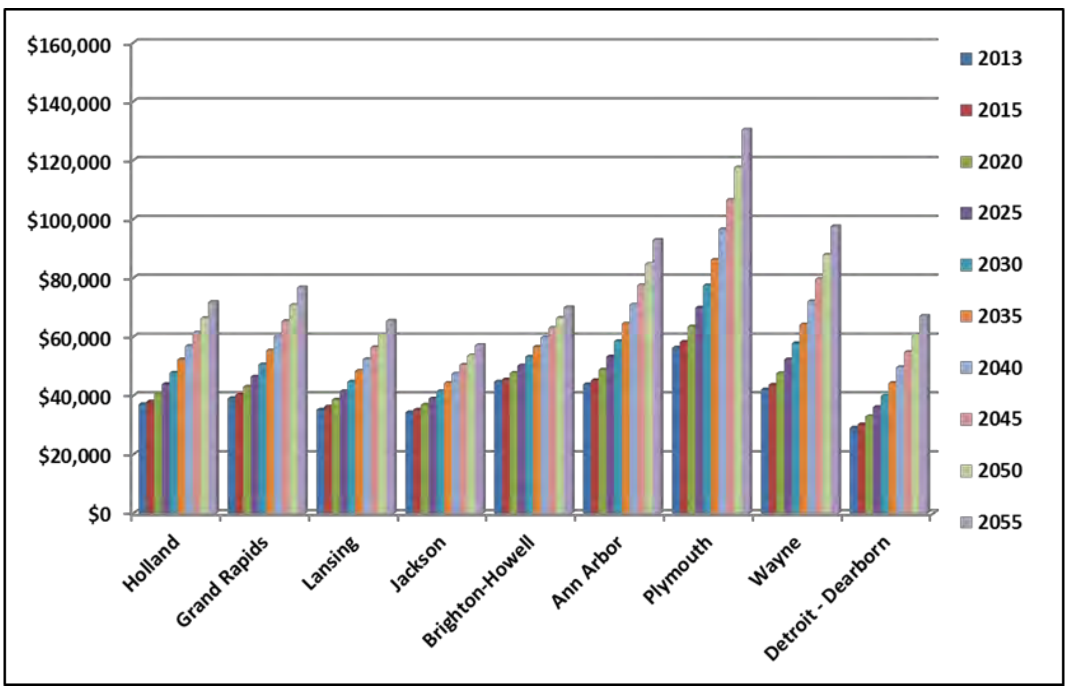
Exhibit 5-8: Employment by Superzone



5.3.2.3 Per Capita Income

As shown in Exhibit 5-9, it is anticipated that there will be strong income growth across the corridor and particularly in the Detroit exurban areas like Wayne Plymouth and Ann Arbor. Growth is also strong in Holland, Grand Rapids, and Lansing. Even Detroit – Dearborn sees growth on a per-capita basis.

Exhibit 5-9: Per Capita Income by Superzone



5.3.3 Socioeconomic Analysis Summary

The corridor shows a mixture of high and low growth. Grand Rapids and Lansing are rapidly growing while Detroit declines in population and employment. Since these are the variables typically used for forecasting urban travel, this would suggest a very modest level of growth in intercity travel. However, the growth in per capita income, which is consistently positive across the corridor will mean much stronger growth in intercity travel, as disposable income is a critical driver for particular business, long distance commuting and social and tourist intercity trips. As a result of the overall increase in demographic and socioeconomic factors, it is likely that there will be a steady increase in intercity trip making over the next forty years.

5.4 Base Transportation Database Development

To understand the existing travel market of the Coast-to-Coast Passenger Rail corridor, the existing travel networks and travel demand by mode and travel purpose in the corridor are developed. The travel modes include passenger rail, auto, bus, and air. The travel purposes are business and non -business (commuter, social, tourist and etc.) trips. This separation of business and non-business trips is important since business trips are paid for by firms who have a willingness to use more expensive options and have a high value of time (VOT), while non -business trips are paid for by individuals who look for less expensive travel choices and who typically have a much lower value of time (VOT). In addition to calculating values of time (VOTs) for different travel purposes and travel modes, generalized costs for values of frequency (VOFs) and values of access time (VOAs) are also developed for the corridor.

5.4.1 Base Transportation Networks

In transportation analysis, travel desirability/utility is measured in terms of travel cost and travel time. These variables are incorporated into the basic transportation network elements that provide by mode the connections from any origin zone to any destination zone. Correct representation of the existing and proposed travel services is vital for accurate travel forecasting. Basic network elements are called nodes and links. Each travel mode consists of a database comprised of zones and stations that are represented by nodes, and existing connections or links between them in the study area. Each node and link is assigned a set of travel attributes (time and cost). The network data assembled for the study included the following attributes for all the zone pairs.

For public travel modes (air, rail, bus):

- Access/egress times and costs (e.g., travel time to a station, time/cost of parking, time walking from a station, etc.)
- Waiting at terminal and delay times
- In-vehicle travel times
- Number of interchanges and connection times
- Fares
- Frequency of service

For private mode (auto):

- Travel time, including rest time
- Travel cost (vehicle operating cost)
- Tolls
- Parking Cost
- Vehicle occupancy

The highway network was developed to reflect the major highway segments within the study area. The sources for building the highway network in the study area are as follows:

- State and Local Departments of Transportation highway databases
- The Bureau of Transportation Statistics HPMS (Highway Performance Monitoring System) database

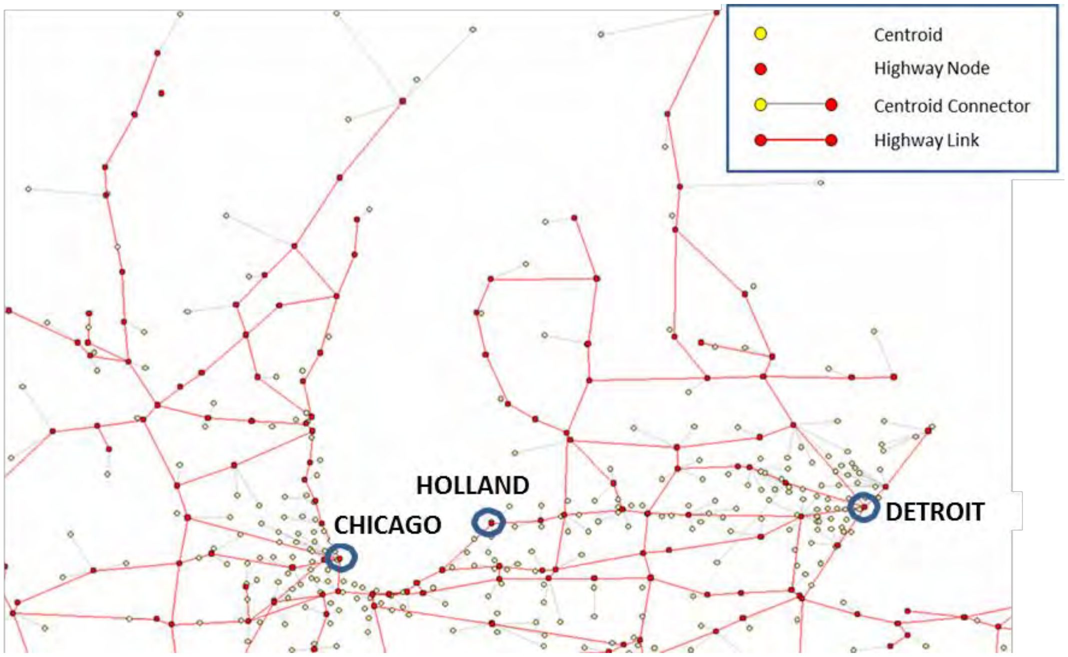
The main roads included in the highway network are shown in Exhibit 5-10.

Exhibit 5-10: Major Roads in the COMPASS™ Highway Network

Road Name	Road Description
Interstate-80	Chicago to Toledo
Interstate-90	Chicago to Toledo
Interstate-94	Chicago to Detroit
Interstate-75	Toledo to Saginaw
Interstate-96	Detroit-Grand Rapids
Interstate-69	Indianapolis-Sarnia

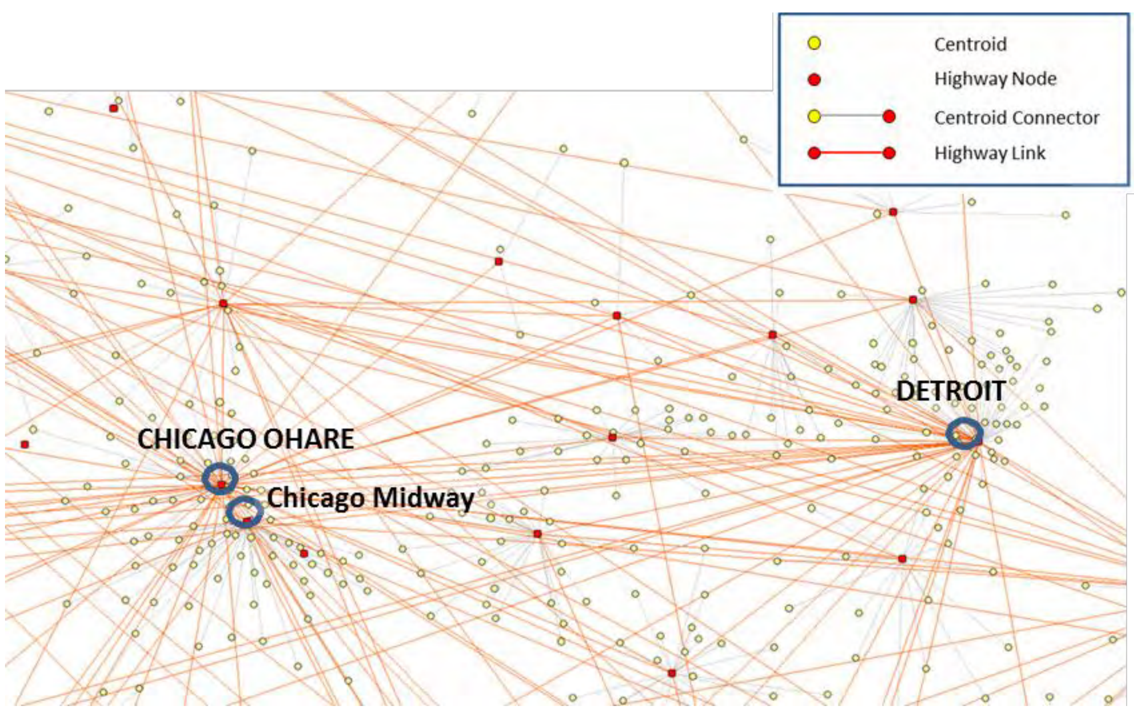
The highway network of the study area coded in COMPASS™ is shown in Exhibit 5-11. Two networks were developed: one for business travel, one for non-business travel (commuter, social, tourist and etc.)

Exhibit 5-11: COMPASS™ Highway Network for the Study Area



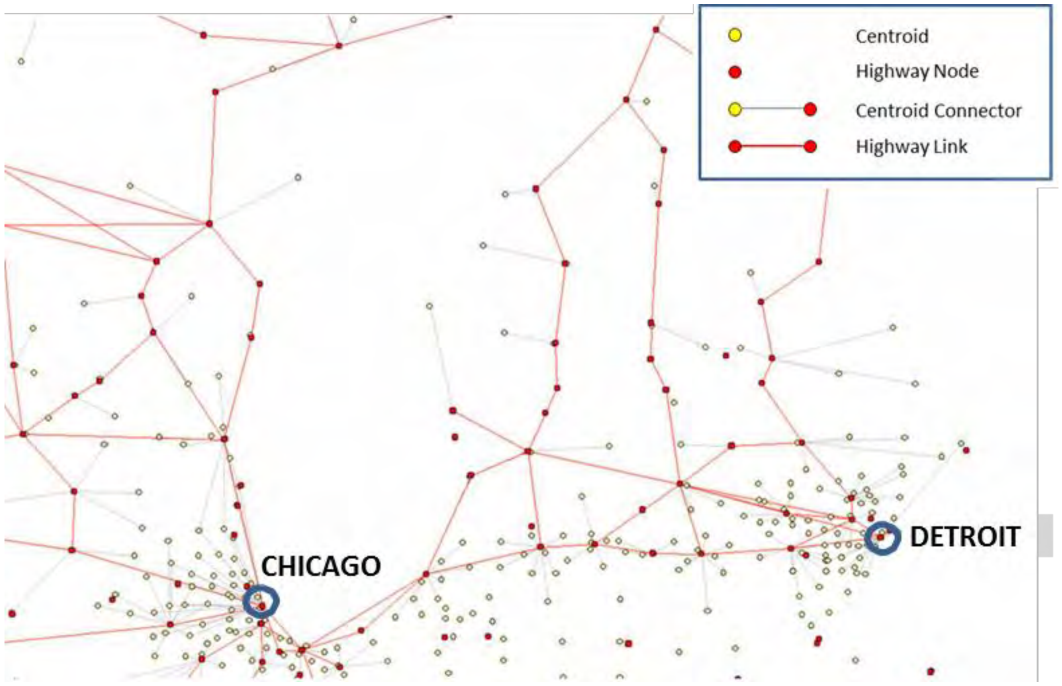
United Airlines, Delta, US Airways, and American Airlines serve study area. Air network attributes contain a range of variables that include time and distance between airports, airfares, and connection times. Travel times, frequencies and fares were derived from official airport websites, websites of the airlines serving airports in the study area, and the BTS 10% sample of airline tickets. Exhibit 5-12 shows the air network of the study area coded in COMPASS™. Again, two networks were developed: one for business travel, one for non-business travel.

Exhibit 5-12: COMPASS™ Air Network for Study Area



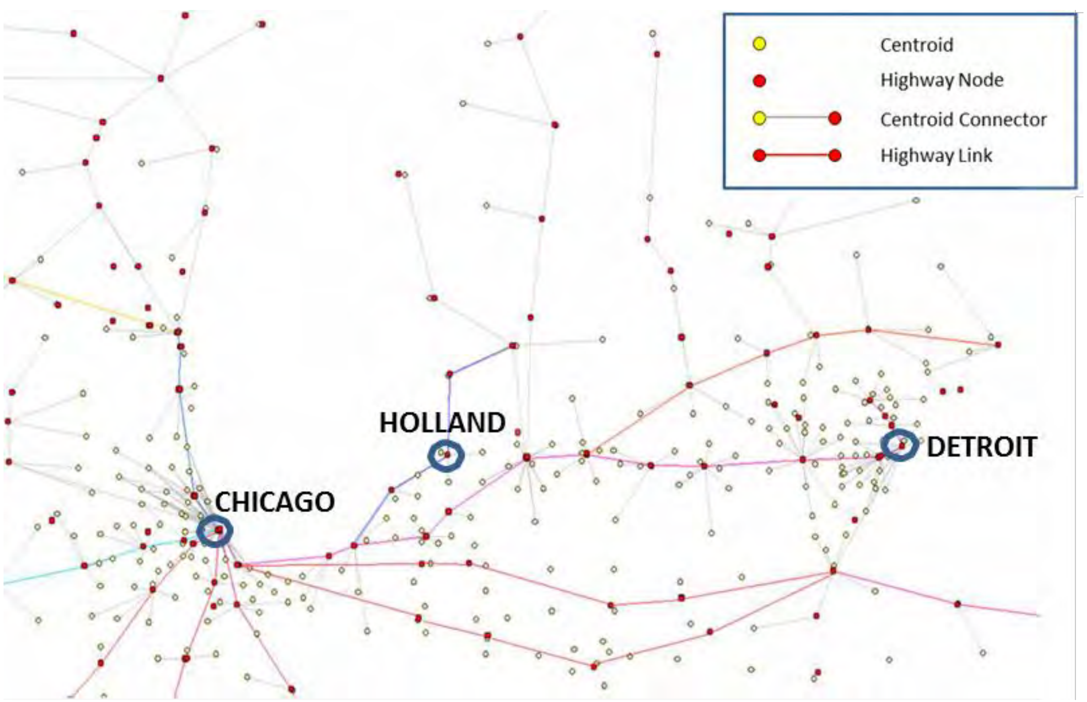
Bus travel data of travel time, fares, and frequencies, were obtained from official schedules of Greyhound, MegaBus, Indian Trails, and Lamers operators. Exhibit 5-13 shows the bus network of the study area coded in COMPASS™. Again, two networks (business, non-business) were developed.

Exhibit 5-13: COMPASS™ Bus Network for the Study Area



Passenger rail travel data of travel time, fares, and frequencies, were obtained from official schedules of Amtrak. Exhibit 5-14 shows the passenger rail network of the study area coded in COMPASS™. Two networks were developed for both business and non-business forms of travel.

Exhibit 5-14: COMPASS™ Passenger Rail Network for the Study Area



5.4.2 Origin-Destination Trip Database

The multi-modal intercity travel analyses model requires the collection of base origin-destination (O-D) trip data describing annual personal trips between zone pairs. For each O-D zone pair, the annual personal trips are identified by mode (rail, auto, air, and bus) and by trip purpose (business and non-business). Because the goal of the study is to evaluate intercity travel, the O-D data collected for the model reflects travel between zones (i.e., between counties, neighboring states and major urban areas) rather than within zones.

TEMS extracted, aggregated and validated data from a number of sources in order to estimate base travel between origin-destination pairs in the Coast-to-Coast Passenger Rail corridor. The data sources for the origin-destination trips in the study are:

- Michigan Department of Transportation
- Southeast Michigan Council of Governments
- Region 2 Planning Commission
- Tri-County Regional Planning Commission
- Battle Creek Area Transportation Study
- Kalamazoo Area Transportation Study
- Grand Valley Metropolitan Council
- Southwest Michigan Commission
- Chicago Metropolitan Agency for Planning
- Bureau of Transportation Statistics 10% Ticket Sample
- TEMS 2012 Michigan Travel Survey
- Midwest Regional Rail Initiative Study (2004)

The travel demand forecast model requires the base trip information for all modes between each zone pair. In some cases this can be achieved directly from the data sources, while in other cases the data providers only have origin-destination trip information at an aggregated level (e.g., AADT data, station-to-station trip and station volume data). Where that is the case, a data enhancement process of trip simulation and access/egress simulation needed to be conducted to estimate the zone-to-zone trip volume. The data enhancement process is shown in Exhibit 5-15.

For the auto mode, the quality of the origin-destination trip data was validated by comparing it to AADTs and traffic counts on major highways and adjustments have been made when necessary. For public travel modes, the origin- destination trip data was validated by examining station volumes and segment loadings.

Exhibit 5-15: Zone-to-Zone Origin-Destination Trip Matrix Generation and Validation

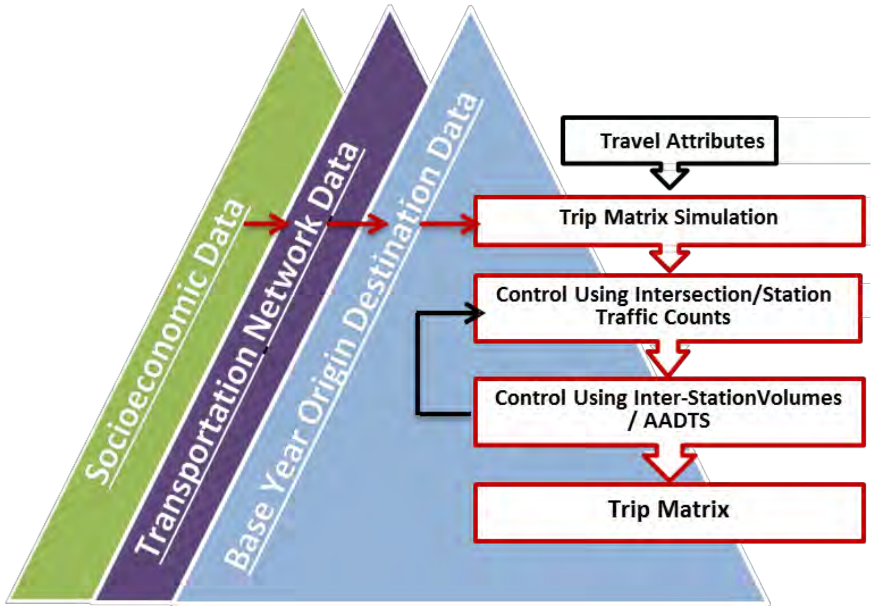
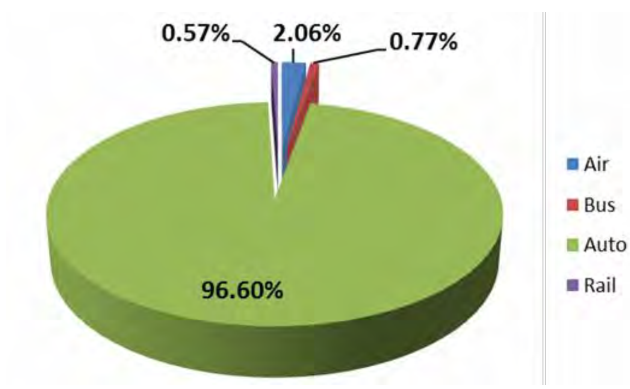


Exhibit 5-16 shows the base 2013 study area travel market share of rail, air, bus, and auto modes. It can be seen that auto mode dominates the travel market with more than 96 percent of market share. Public modes have less than four percent of travel market share, the Amtrak service in Michigan had 795,996 trips in 2013, which accounted for 0.57% of the total intercity travel market in the study area.

Exhibit 5-16:
Base Study Area Travel Market Share by Mode



5.4.3 Values of Time, Values of Frequency, and Values of Access Times

Generalized cost of travel between two zones estimates the impact of improvements in the transportation system on the overall level of trip making. Generalized Cost includes all the factors that are key to an individual's travel decision (such as travel time, fare, frequency) that are all included in the Generalized Cost equation for the COMPASS™ Model. Generalized Cost is typically defined in travel time (i.e., minutes) rather than cost (i.e., dollars). Costs are converted to time by applying appropriate conversion factors such as Value of Time, derived from Stated Preference Surveys. In this case the Michigan DOT Chicago-Detroit/Pontiac Stated Preference Survey. The generalized cost (GC) of travel between zones i and j for mode m and trip purpose p is defined as follows:

$$GC_{ijmp} = TT_{ijm} + \frac{TC_{ijmp}}{VOT_{mp}} + \frac{VOF_{mp} * OH}{VOT_{mp} * F_{ijm}}$$

Where,

TT_{ijm} = Travel Time between zones i and j for mode m (in-vehicle time + station wait time + connection time + access/egress time), with waiting, connect and access/egress time multiplied by a factor (waiting and connect time factors is 1.8, access/egress factors were determined by VOA/VOT ratios from the Michigan Detroit-Chicago SP survey) to account for the additional disutility felt by travelers for these activities.

TC_{ijmp} = Travel Cost between zones i and j for mode m and trip purpose p (fare + access/egress cost for public modes, operating costs for auto)

VOT_{mp} = Value of Time for mode m and trip purpose p

VOF_{mp} = Value of Frequency for mode m and trip purpose p

F_{ijm} = Frequency in departures per week between zones i and j for mode m

OH = Operating hours per week (sum of daily operating hours between the first and last service of the day)

Value of Time (VOT) is the amount of money (dollars/hour) an individual is willing to pay to save a specified amount of travel time, the Value of Frequency (VOF) is the amount of money (dollars/hour) an individual is willing to pay to reduce the time between departures when traveling on public transportation, and the Value of Access (VOA) is the amount of money (dollars/hour) an individual is willing to pay for reducing access time to a mode (e.g. the airport, HSR station, railroad station, bus station) to gain easier access to someplace (e.g., an airport). Access/Egress time is weighted higher than in-vehicle time in generalized costs calculation, and its weight is derived from value of access stated preference surveys. Station wait time is the time spent at the station before departure and after arrival. On trips with connections, there would be additional wait times incurred at the connecting station. Wait times are weighted higher than in-vehicle time in the generalized cost formula to reflect their higher disutility as found in previous stated preference surveys.

Exhibits 5-17, 5-18, and 5-19 shows the values of time, values of frequency, and values of access results from the TEMS Michigan Chicago-Detroit/Pontiac Stated Preference Travel Survey. These will be used in the Coast-to-Coast study, which has considerable overlap with the existing rail services.

Exhibit 5-17 VOT values by Mode and Purpose of Travel ($2013/hour)

Value of Time (VOT)	Business	Non-business
Auto	$27.89	$25.15
Bus	$20.73	$15.27
Rail	$39.77	$28.46
Air Access	$50.15	$39.86

Exhibit 5-18: VOF values by Mode and Purpose of Travel ($2013/hour)

Value of Frequency (VOF)	Business	Non-business
Bus	$5.40	$5.36
Rail	$10.59	$8.96
Air Access	$25.97	$18.68

Exhibit 5-19: VOA values by Mode and Purpose of Travel ($2013/hour)

Value of Access (VOA)	Business	Non-business
Bus	$28.28	$26.06
Rail	$54.71	$36.43
Air Access	$59.67	$47.51

5.5 Summary

The database for the COMPASS™ Model was successfully assembled and updated to base year 2013. This database included socioeconomic data, transportation networks, origin-destination trip data, and Values of Time, Access and Frequency and will be used by the COMPASS™ Demand Model to forecast ridership and revenue in the Coast-to-Coast Corridor.

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Chapter 6
Coast-to-Coast Travel Demand Forecast

SUMMARY

This chapter describes the Travel Demand Forecast for the Coast-to-Coast Passenger Rail Corridor including discussing the results of the ridership, revenue and market share analyses. These Forecasts were generated from the COMPASS™ Model based on the data that was assembled and inputted from the Demographics, Socioeconomics and Transportation databases described in Chapter 5. Two sets of projections incorporating socioeconomic and transportation network changes were used to develop the forecasts. These sets of socioeconomic projections were used to identify the overall growth of travel in the corridor. The transportation model also considered future energy cost, congestion, and vehicle fuel efficiency together with the passenger rail service improvements.

Forecasts were made on a ten year basis and then interpolated for interval years. The forecast results of rail passenger ridership were disaggregated to provide train loads between stations for capacity analysis, and station volumes for station planning.

6.1 Future Travel Market Strategies

In order to forecast the future potential for rail ridership, consideration has to be given to how future travel markets will be impacted by changing transportation conditions. The critical factors that will change future travel conditions include: fuel price, vehicle fuel efficiency, as well as highway traffic congestion. In addition, the forecasts need to assess the different levels of rail service that might be developed, and how it will compete with auto, air, and bus markets. This includes the improvements planned as part of the Detroit-Chicago improvement program that are relevant to the different route options.

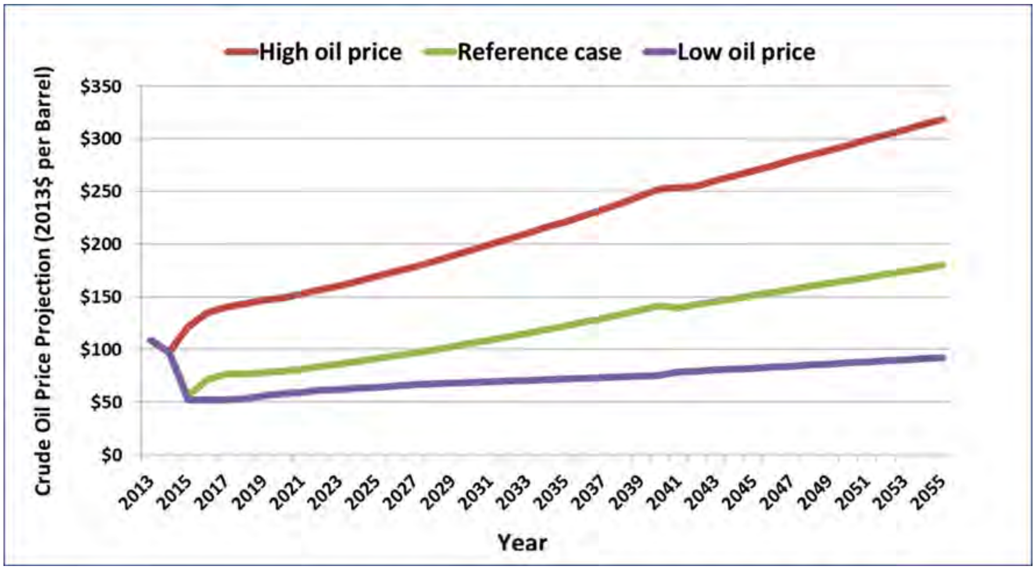
6.1.1 Fuel Price Forecasts

One of the important factors in the future attractiveness of passenger rail is fuel price. Exhibit 6-1 shows the Energy Information Agency (EIA)[60] projection of crude oil prices for three oil price cases: namely a high world oil price case that is for an aggressive oil price forecast; a reference world oil price case that is moderate and is also known as the central case forecast; and a conservative low world oil price case. In

[60] EIA periodically updates historical and projected oil prices at www.eia.gov/forecasts/aeo/tables_ref.cfm

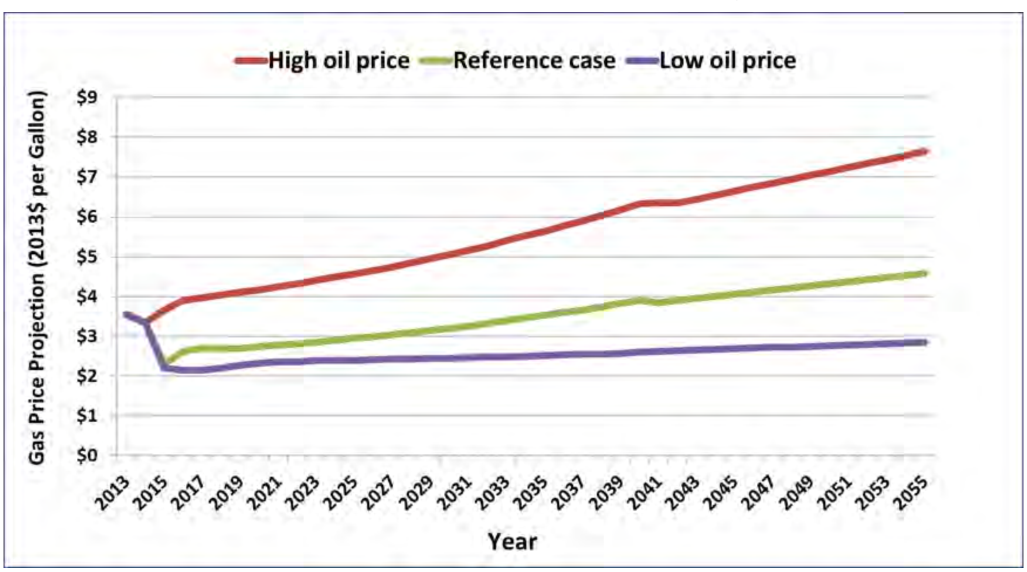
this study, the reference case oil price projection is used to estimate transportation cost in future travel market. EIA projects oil price to 2040, the estimation of oil price projections after 2040 is based on historical prices and EIA forecast trends. The EIA reference case forecast suggests that crude oil prices are expected to be $79 per barrel (2013$) in 2020 and will increase to $141 per barrel (2013$) in 2040.

Exhibit 6-1: Crude Oil Price Forecast by EIA



EIA has also developed a future retail gasoline price forecast, which is shown in Exhibit 6-2. The implication of this is a reference case gasoline price of $2.74 per gallon (2013$) in 2020, with a high case price of $4.17 per gallon, and a low case price of $2.33 per gallon. The reference case gasoline price will increase to $3.90 per gallon (2013$) in 2040. The impact of rising energy prices will clearly impact the competition between the modes of travel in the Coast-to-Coast Corridor. Typically rising energy and therefore gas prices will most severely impact auto travel followed by air mode, bus mode and finally rail. Rail is very fuel efficient and its market share typically increases with rising energy and gas prices. Increasing energy prices has been largely responsible for the recent dramatic increases in Amtrak traffic. The Detroit-Chicago Corridor increased demand by 57 percent between the year 2000 and 2011.

Exhibit 6-2: U.S. Retail Gasoline Prices Forecast by EIA



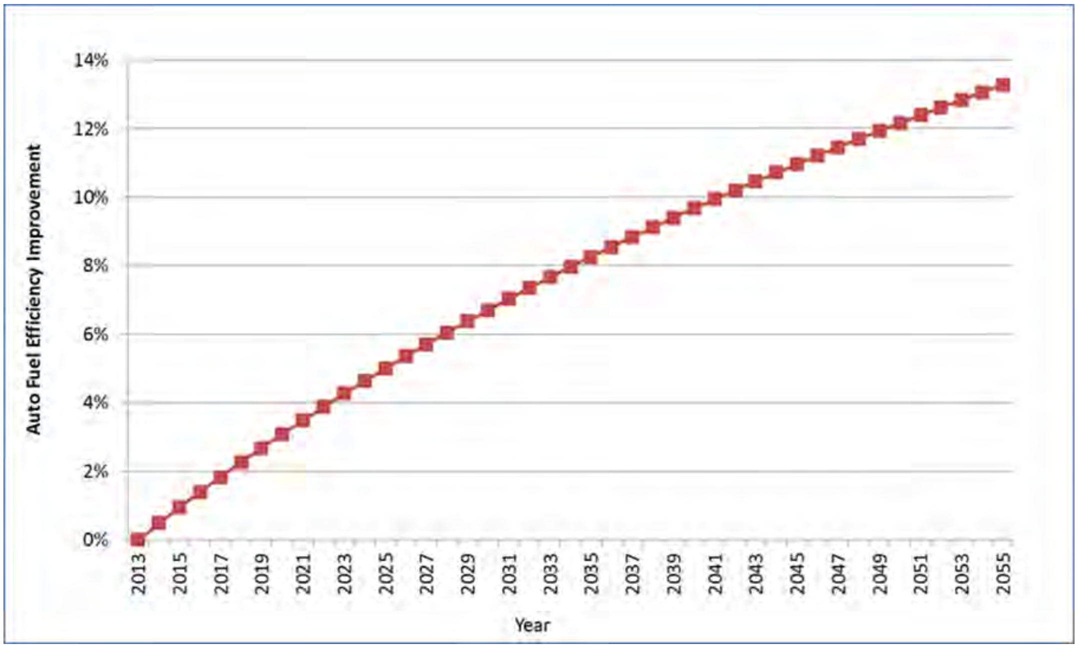
6.1.2 Vehicle Fuel Efficiency Forecasts

Future improvement in automobile technology is likely to reduce the impact of high gas prices on automobile fuel cost with better fuel efficiency. The Oak Ridge National Laboratory (ORNL) Center for Transportation Analysis (CTA) provides historical automobile highway energy usage in BTU (British thermal unit) per vehicle-mile data for automobiles since 1970 (Exhibit 6-3).

Exhibit 6-3: ORNL Historical Highway Automobile Energy Intensities Data

Exhibit 6-3 shows the historical highway automobile energy intensities from 1970 to 2012. It can be seen that automobile fuel efficiency has been improving gradually during the past few decades but the improvement perhaps surprisingly has slowed down in recent years. Future automobile fuel efficiency improvement was projected by TEMS as shown in Exhibit 6-4. The TEMS forecast reflects the actual performance of the vehicle fleet, which is much lower and slower to be implemented than the regulated Corporate Average Fuel Economy (CAFE) standards for new cars. The auto fleet simply changes at a much slower pace than the standards for new cars. It was based on the historical automobile fuel efficiency data. The TEMS forecast shows a slow but consistent increase in car fuel efficiency to 2050, and beyond. It shows that the automobile fleet fuel efficiency is expected to improve by nearly 13 percent by 2055 as compared to fuel efficiency of today.

Exhibit 6-4: Auto Fuel Efficiency Improvement Projections



6.1.3 Highway Traffic Congestion

The average annual auto travel time growth in the corridor was estimated with the projected highway traffic volume data and the Bureau of Public Roads (BPR) function that can be used to calculate travel time growth with increased traffic volumes:

$$T_f = T_b * [1 + \alpha * \left(\frac{V}{C}\right)^{\beta}]$$

where

T_f is future travel time,

T_b is highway Average travel time,

V is traffic volume,

C is highway Average capacity,

α is a calibrated coefficient (0.56), it describes the volume of traffic required for the capacity of the road to become limited by traffic (i.e., when it will begin to slow traffic speed)

β is a calibrated coefficient (3.6), it describes the slope or sensitivity of the highway to congestion once capacity becomes limited (i.e., how quickly traffic speed falls as traffic increases).

The capacity and projected highway link volumes are derived from the Michigan 2008 Base Statewide Travel Demand Model. Historic volume data are obtained from Michigan Department of Transportation, Illinois Department of Transportation and 2012 Annual Urban Mobility Report from Transportation Institute of Texas A&M University.

The projected travel times were calculated by computing travel time on each segment of the highway route between two cities. The key assumptions are as follows:

- α = 0.56
- β = 3.6

The above two coefficients are from the Highway Capacity Manual, they determine how traffic volume will affect travel speed. As an example, the highway links between Chicago and Detroit are expected to see intercity traffic volume increase from 5.7 million of vehicle miles traveled (VMT) per day to 6.0 million VMT per day between 2008 to 2035. By applying the BPR function while assuming same route intercity capacity between these two cities in the future, it can be calculated that travel time on this highway segment will increase by 0.24% per year with the BPR function.

6.2 The Travel Demand Forecast Results

Applying the COMPASS™ Total Demand Model with the data inputs discussed in Chapter 5 (demographics, socio-economics and transportation databases), generated the Total Demand Forecast presented in the follow sections of this chapter, including the rail Ridership and Revenue results.

6.2.1 Rail Scenarios

Six rail scenarios were developed for evaluation in the Ridership and Revenue Analysis. These are detailed in chapters two and three of this report and are based on three route alignments (Exhibit 2-7):

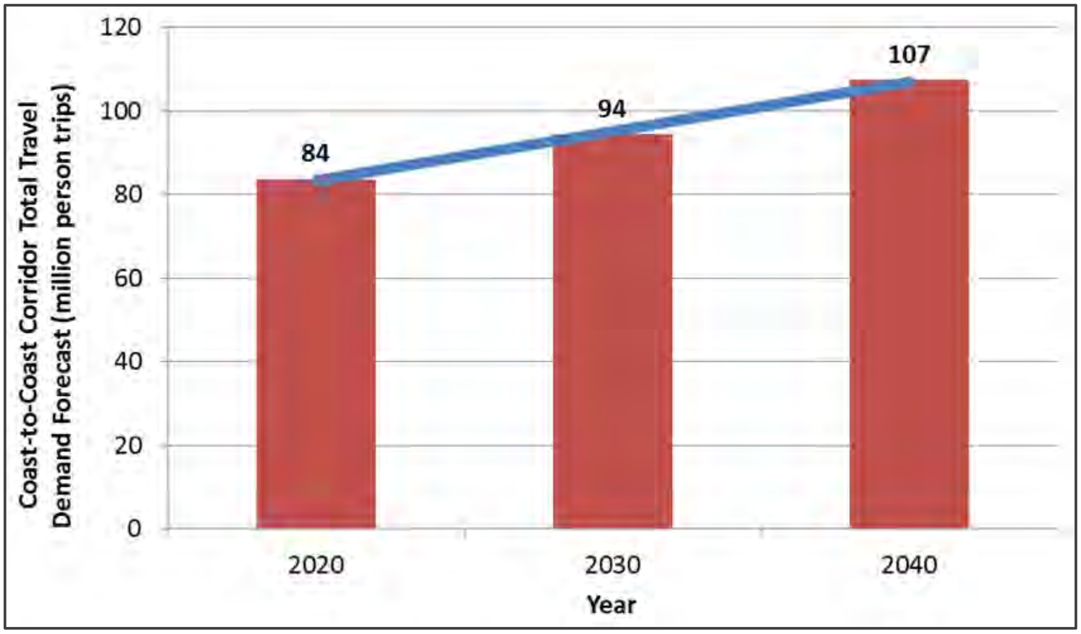
- Route 1: Holland-Grand Rapids-Lansing-Jackson-Ann Arbor-Detroit Route
- Route 2: Holland-Grand Rapids-Lansing-Howell-Ann-Arbor-Detroit Route
- Route 3: Holland-Grand Rapids-Lansing-Howell-Plymouth-Detroit Route

For the purpose of the analysis, 79-mph and 110-mph technologies will be used.

6.2.2 Total Demand

Exhibit 6-5 shows the Coast-to-Coast Corridor total intercity Travel Demand Forecasts for 2020, 2030, and 2040. It can be seen that the Coast-to-Coast Corridor travel demand will increase from 84 million in 2020, to 94 million in 2030, and increases to 107 million in 2040. The average annual corridor travel market growth rate is 1.26 percent per year, which is in line with the socioeconomic growth within the travel market for the corridor.

Exhibit 6-5: Coast-to-Coast Corridor Total Travel Demand Forecast (millions)



6.2.3 Ridership Forecasts

Exhibit 6-6 shows the range of the 12 forecasts produced for the calendar years 2020, 2030, and 2040 respectively. For the conventional 79-mph technology of each route, the rail ridership and revenue forecasts were produced for 2-daily roundtrips (DRTs) and 4 DRTs. For the 110-mph diesel tilt technology, the rail ridership and revenue forecasts of 4 DRTs and 8 DRTs were produced.

Exhibit 6-6: Demand Forecasts for Passenger Rail Service Scenarios

Route and Technology	2 DRTs	4 DRTs	8 DRTs
Route 1 : 79 mph Conventional	√	√	
Route 1 : 110 mph Diesel Tilt		√	√
Route 2 : 79 mph Conventional	√	√	
Route 2 : 110 mph Diesel Tilt		√	√
Route 3 : 79 mph Conventional	√	√	
Route 3 : 110 mph Diesel Tilt		√	√

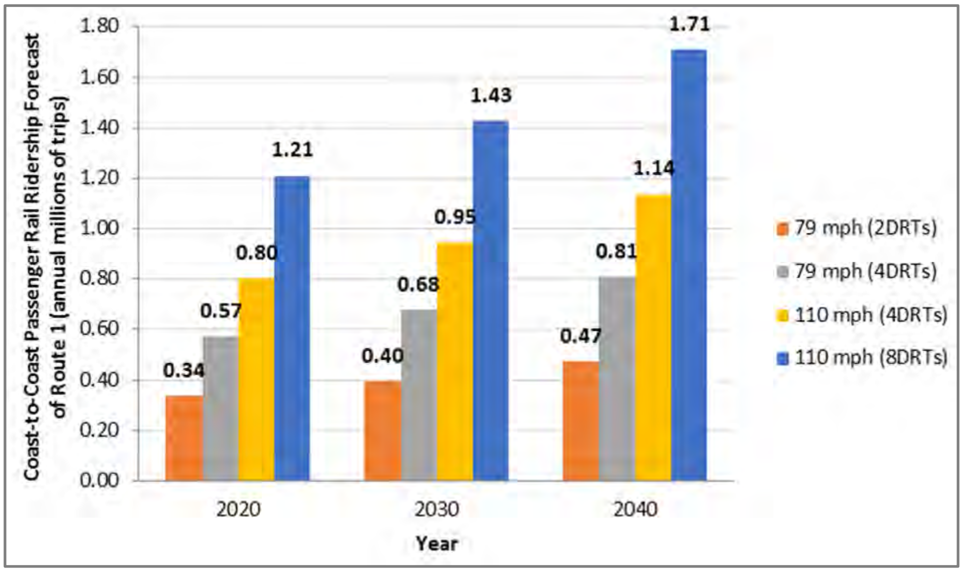
The passenger rail ridership for each scenario and year is shown in Exhibits 6-7 through 6-9 for Route 1, Route 2, and Route 3 respectively.

For **Route 1:**

- The 79-mph (2 DRTs) service is estimated to have 0.34 million trips in 2020, 0.4 million trips in 2030, and 0.47 million trips in 2040.
- The 79-mph (4 DRTs) service is estimated to have 0.57 million trips in 2020, 0.68 million trips in 2030, and 0.81 million trips in 2040.

- The 110-mph diesel tilt (4 DRTs) service is estimated to have 0.8 million trips in 2020, 0.95 million trips in 2030, and 1.14 million trips in 2040.
- The 110-mph diesel tilt (8 DRTs) service is estimated to have 1.21 million trips in 2020, 1.43 million trips in 2030, and 1.71 million trips in 2040.

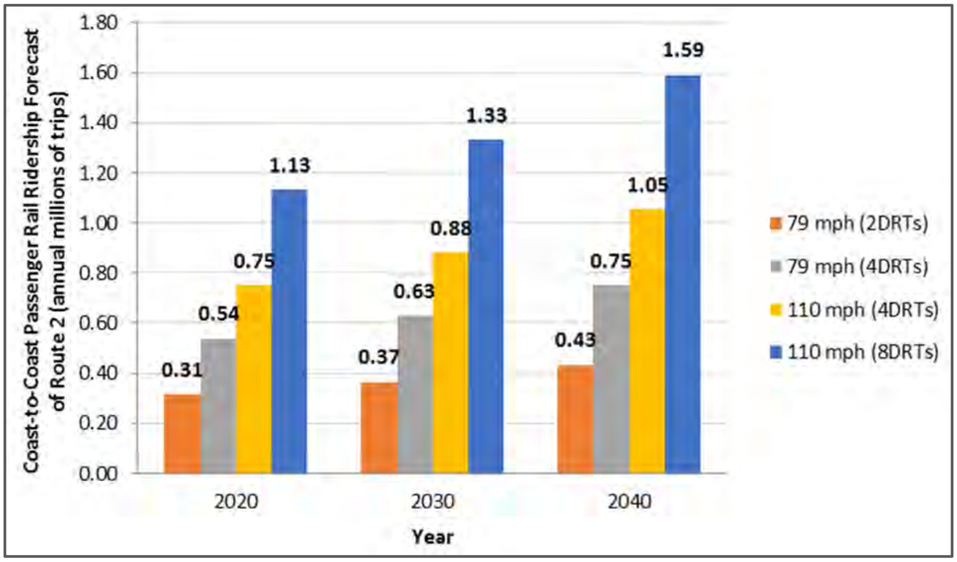
Exhibit 6-7: Coast-to-Coast Passenger Rail Ridership Forecast for Route 1 (annual millions of trips)



For **Route 2**:

- The 79-mph (2 DRTs) service is estimated to have 0.31 million trips in 2020, 0.37 million trips in 2030, and 0.43 million trips in 2040.
- The 79-mph (4 DRTs) service is estimated to have 0.54 million trips in 2020, 0.63 million trips in 2030, and 0.75 trips in 2040.
- The 110-mph diesel tilt (4 DRTs) service is estimated to have 0.75 million trips in 2020, 0.88 million trips in 2030, and 1.05 million trips in 2040.
- The 110-mph diesel tilt (8 DRTs) service is estimated to have 1.13 million trips in 2020, 1.33 million trips in 2030, and 1.59 million trips in 2040.

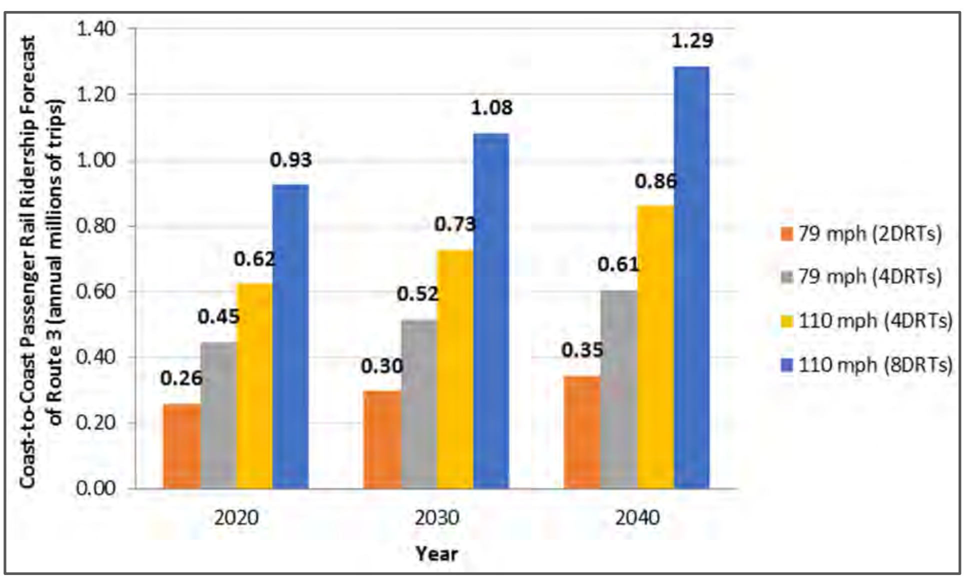
Exhibit 6-8: Coast-to-Coast Passenger Rail Ridership Forecast for Route 2 (annual millions of trips)



For **Route 3**:

- The 79-mph (2 DRTs) service is estimated to have 0.26 million trips in 2020, 0.3 million trips in 2030, and 0.35 million trips in 2040.
- The 79-mph (4 DRTs) service is estimated to have 0.45 million trips in 2020, 0.52 million trips in 2030, and 0.61 trips in 2040.
- The 110-mph diesel tilt (4DRTs) service is estimated to have 0.62 million trips in 2020, 0.73 million trips in 2030, and 0.86 million trips in 2040.
- The 110-mph diesel tilt (8 DRTs) service is estimated to have 0.93 million trips in 2020, 1.08 million trips in 2030, and 1.29 million trips in 2040.

Exhibit 6-9: Coast-to-Coast Passenger Rail Ridership Forecast for Route 3 (annual millions of trips)



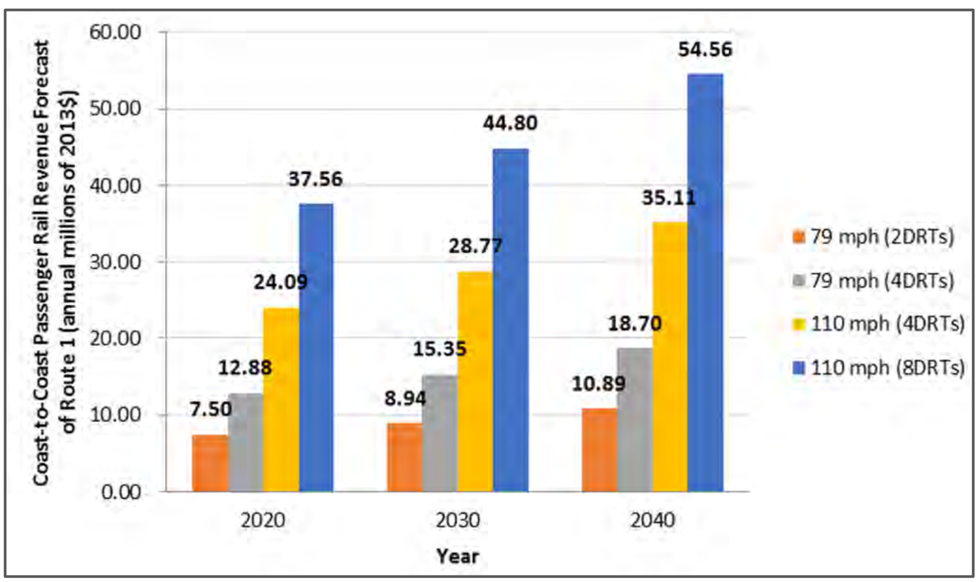
6.2.4 Revenue Forecasts

The passenger rail revenue forecast is shown in Exhibits 6-10 through 6-12. It can be seen that revenues increase strongly as both travel speed and frequency increase. In addition, as the socioeconomics, highway congestion, and gas prices increase, rail revenues are anticipated to increase by some 40-45 percent for all options over the twenty year period 2020 through 2040. This increases the ability of the options to pay for operating costs in the future as market conditions become increasingly favorable to rail.

For **Route 1:**

- The 79-mph (2 DRTs) service is estimated to have $7.5 million revenue in 2020, $8.94 million revenue in 2030, and $10.89 million revenue in 2040.
- The 79-mph (4 DRTs) service is estimated to have $12.88 million revenue in 2020, $15.35 million revenue in 2030, and $18.7 million revenue in 2040.
- The 110-mph diesel tilt (4DRTs) service is estimated to have $24.09 million revenue in 2020, $28.77 million revenue in 2030, and $35.11 million revenue in 2040.
- The 110-mph diesel tilt (8 DRTs) service is estimated to have $37.56 million revenue in 2020, $44.8 million revenue in 2030, and $54.56 million revenue in 2040.

Exhibit 6-10: Coast-to-Coast Passenger Rail Revenue Forecast for Route 1 (annual millions of 2013$)

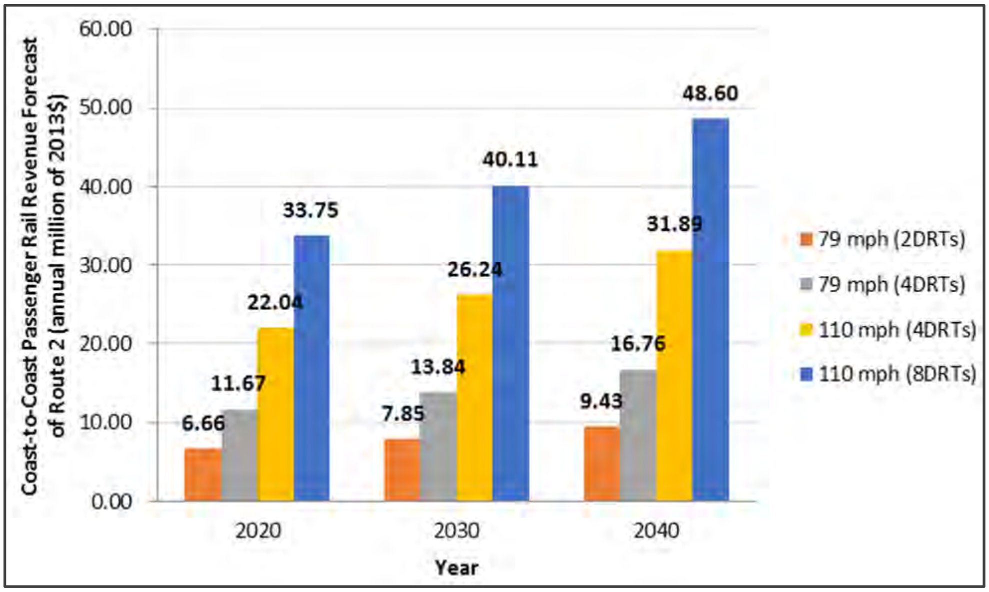


For **Route 2**:

- The 79-mph (2 DRTs) service is estimated to have $6.66 million revenue in 2020, $7.85 million revenue in 2030, and $9.43 million revenue in 2040.
- The 79-mph (4 DRTs) service is estimated to have $11.67 million revenue in 2020, $13.84 million revenue in 2030, and $16.76 million revenue in 2040.
- The 110-mph diesel tilt (4DRTs) service is estimated to have $22.04 million revenue in 2020, $26.24 million revenue in 2030, and $31.89 million revenue in 2040.

- The 110-mph diesel tilt (8 DRTs) service is estimated to have $33.75 million revenue in 2020, $40.11 million revenue in 2030, and $48.6 million revenue in 2040.

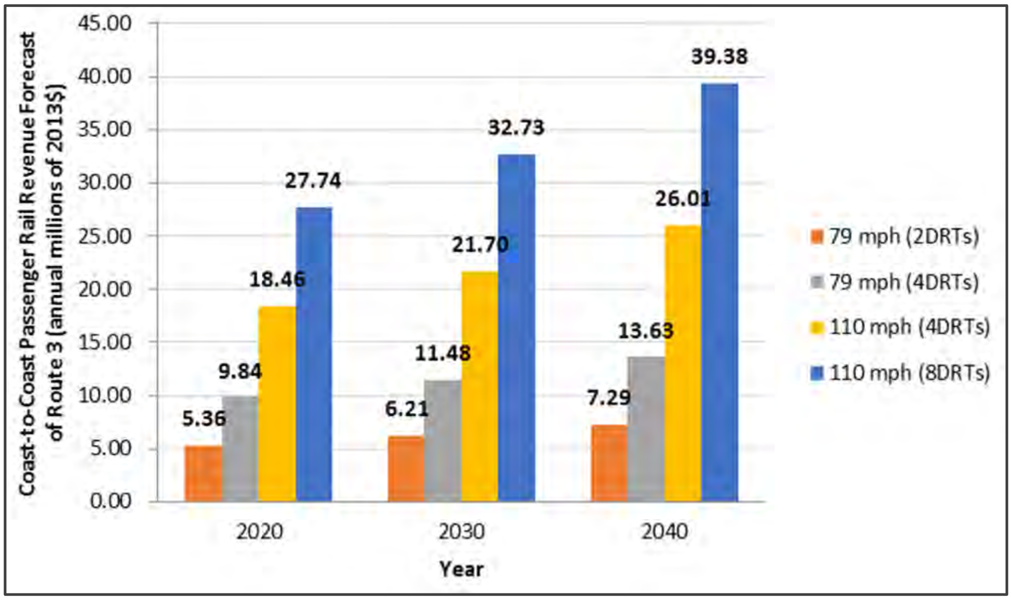
Exhibit 6-11: Coast-to-Coast Passenger Rail Revenue Forecast for Route 2



For **Route 3:**

- The 79-mph (2 DRTs) service is estimated to have $5.36 million revenue in 2020, $6.21 million revenue in 2030, and $7.29 million revenue in 2040.
- The 79-mph (4 DRTs) service is estimated to have $9.84 million revenue in 2020, $11.48 million revenue in 2030, and $13.63 million revenue in 2040.
- The 110-mph diesel tilt (4DRTs) service is estimated to have $18.46 million revenue in 2020, $21.7 million revenue in 2030, and $26.01 million revenue in 2040.
- The 110-mph diesel tilt (8 DRTs) service is estimated to have $27.74 million revenue in 2020, $32.73 million revenue in 2030, and $39.38 million revenue in 2040.

Exhibit 6-12: Coast-to-Coast Passenger Rail Revenue Forecast for Route 3 (annual millions of 2013$)



6.2.5 Station Volumes

The strongest station volumes are projected to be at Grand Rapids and Ann Arbor, with over 500,000 passengers each for eight round trips per year in 2030. Holland, Lansing, Dearborn and Detroit would likely have proximate volumes at about 350,000 passengers each for eight round trips per year in 2030. A review of the OD matrix shows that there is substantial traffic from Lansing to Chicago and it could be that an increase in passengers using the Lansing station in Route 1 could be due to individuals going to Jackson to make Chicago connections. Also, it can be seen by comparing Exhibits 6-15 and 6-16 show that the Plymouth station does not attract the same volume of passengers as Ann Arbor.

Exhibits 6-13 through 6-15 show the 2030 station volumes of each route.

Exhibit 6-13: 2030 Station Volumes for Route 1 (millions of passengers)

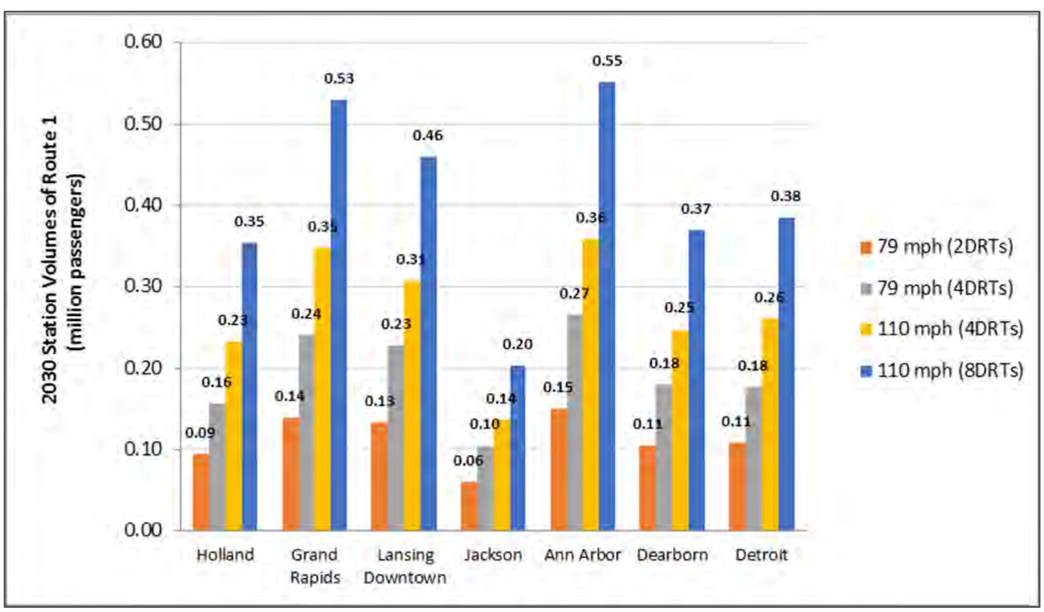


Exhibit 6-14: 2030 Station Volumes of Route 2 (millions of passengers)

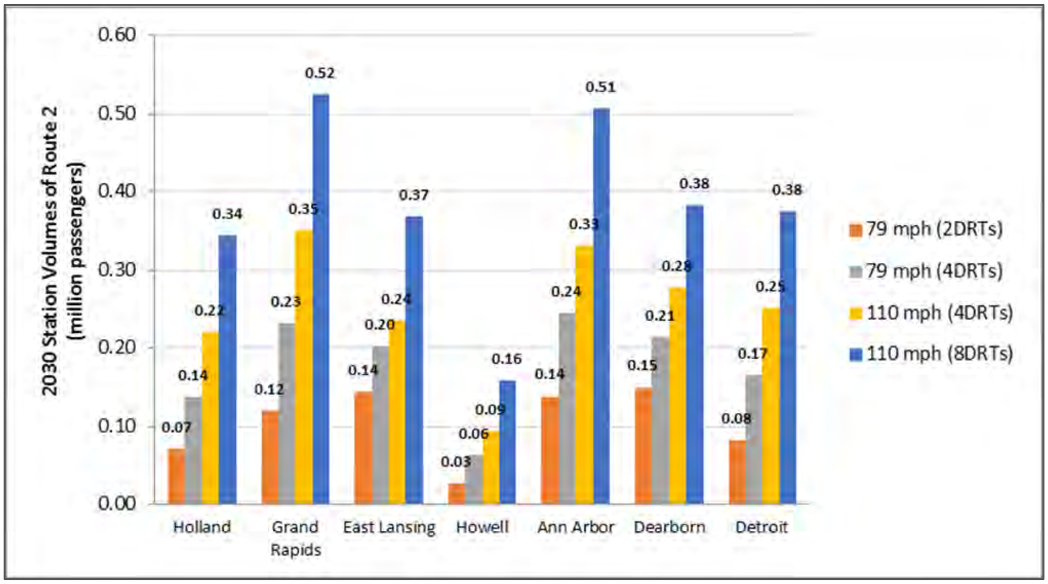
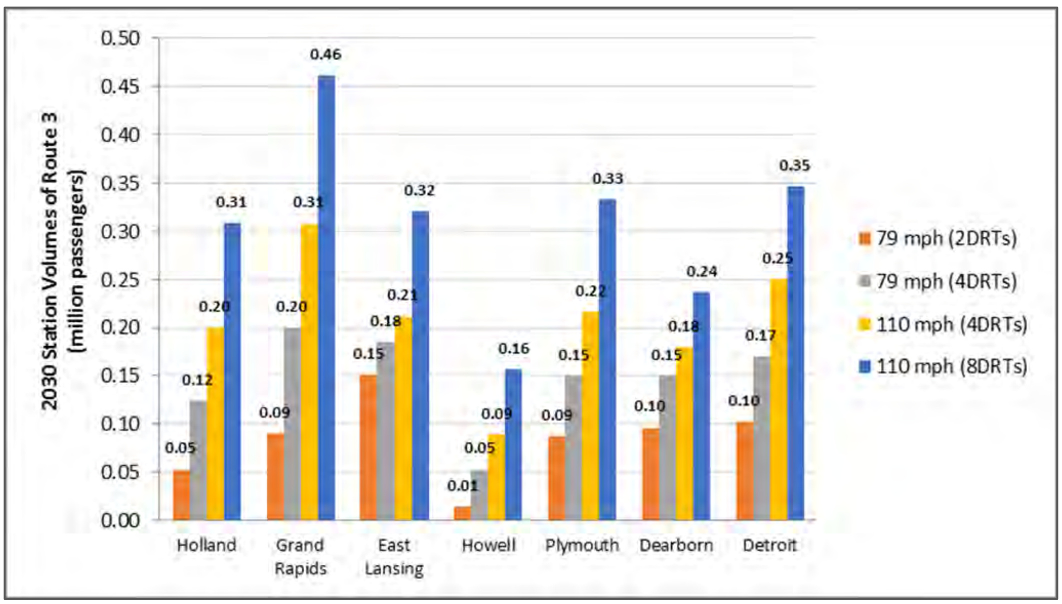


Exhibit 6-15: 2030 Station Volumes for Route 3 (millions of passengers)



6.2.6 Segment Loadings

An important factor in planning a train service is the segment loadings that reflect the number of passengers traveling between stations. This is used to size trains and ensure that there are significant seats in peak travel hours.

The segment loadings are projected to be strongest between Grand Rapids, Lansing and Ann Arbor reflecting with strong growth occurring most intensely in the middle of the corridor. From Holland to Grand Rapids and from Dearborn to Detroit, volumes would probably be weaker with volumes estimated to be half of those in the rest of the corridor.

Exhibits 6-16 through 6-18 show the 2030 segment loadings of each route as previously described.

Exhibit 6-16: 2030 Segment Loadings for Route 1 (millions of passengers)

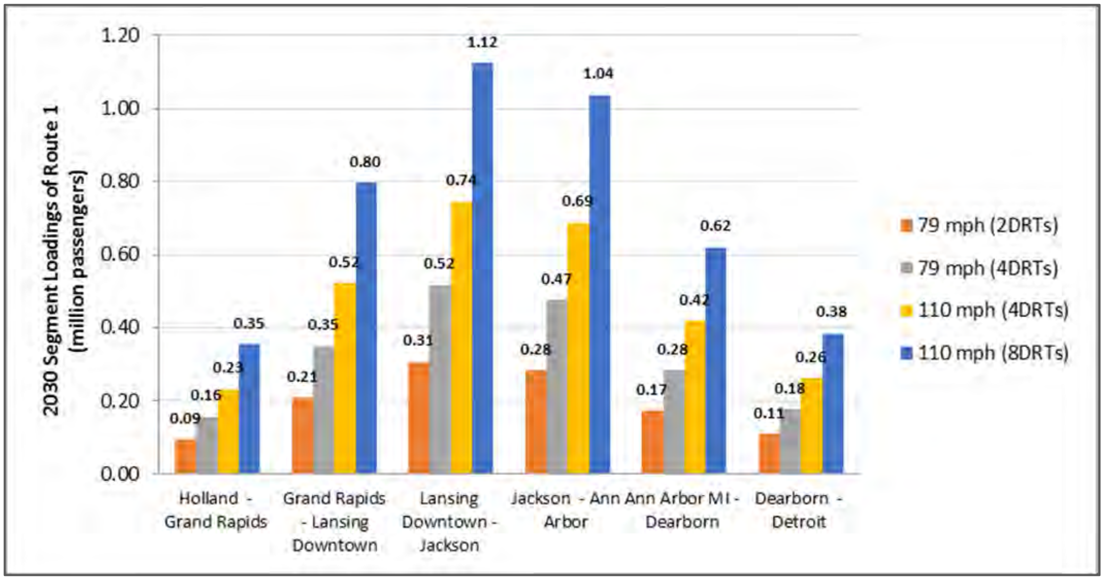


Exhibit 6-17: 2030 Segment Loadings for Route 2 (millions of passengers)

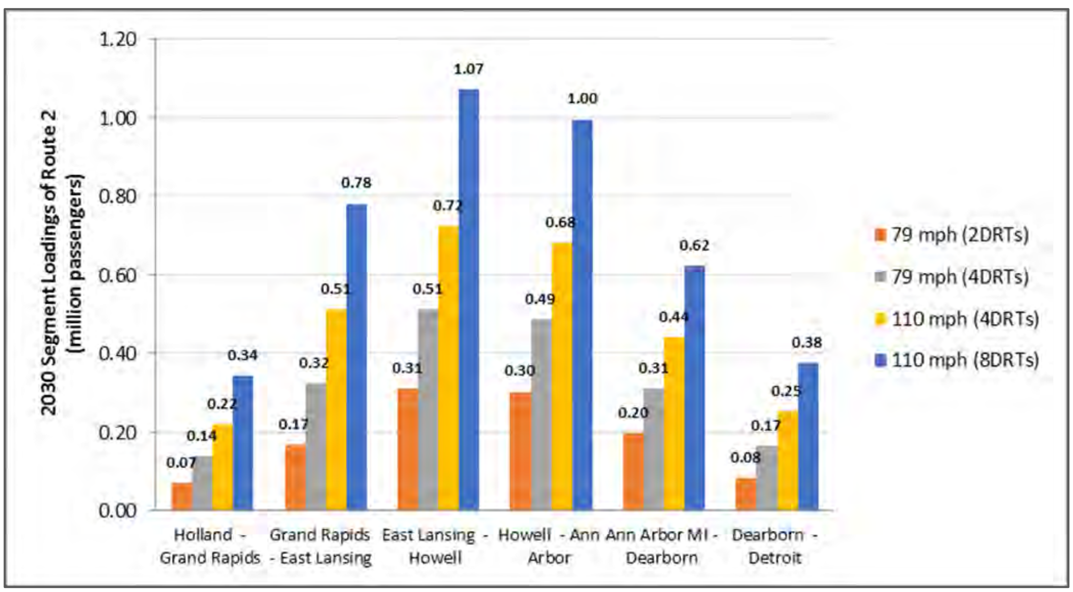
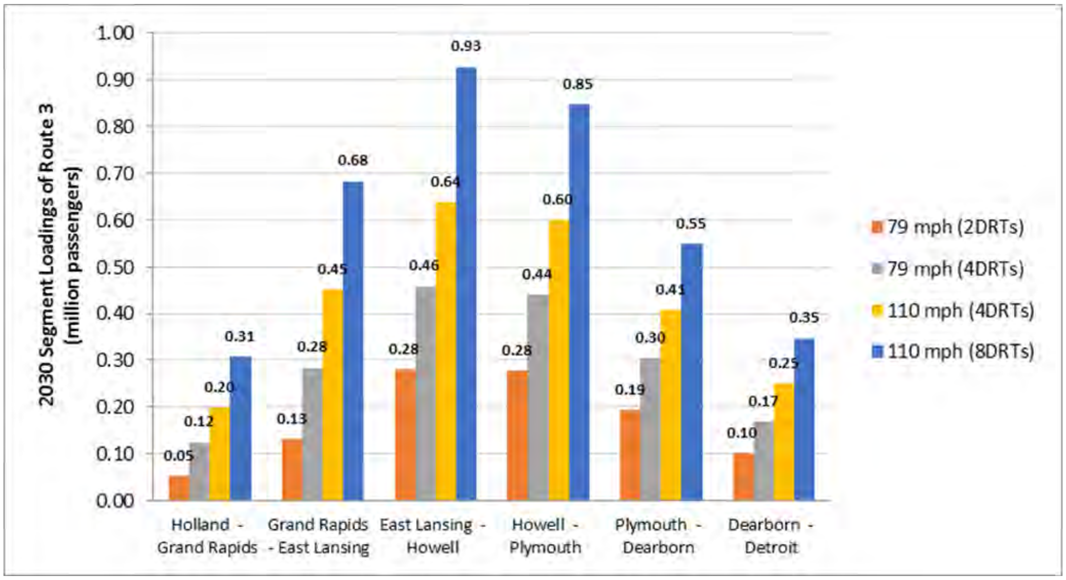


Exhibit 6-18: 2030 Segment Loadings for Route 3 (millions of passengers)



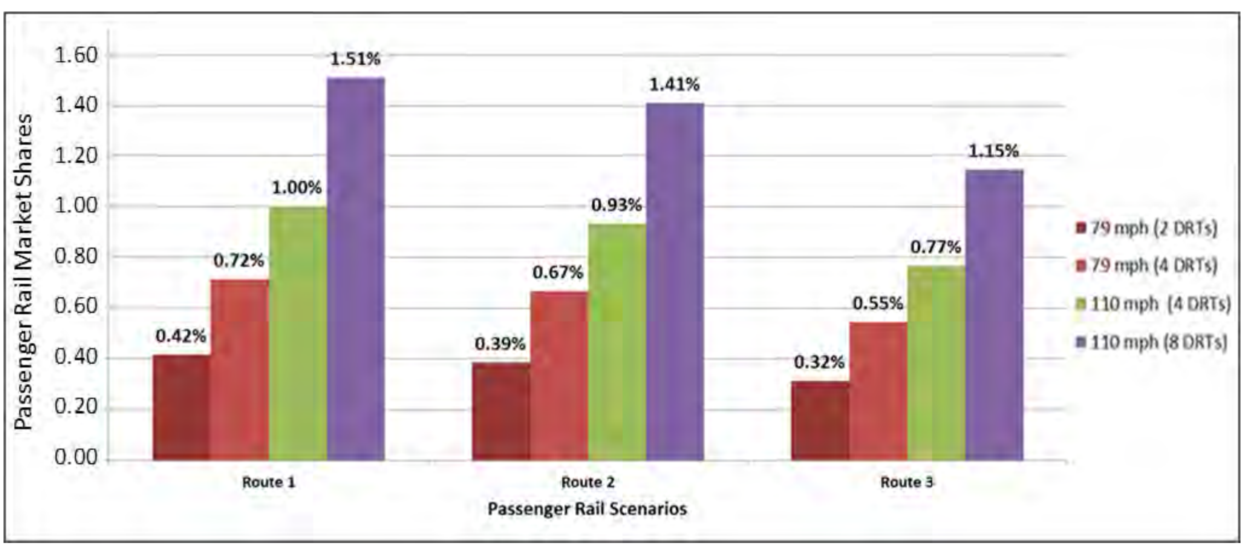
6.3 Market Shares

For rail market shares in 2030:

- 79-mph (2 DRTs) service is projected to have 0.32 percent to 0.42 percent market share in 2030,
- 79-mph (4 DRTs) service is projected to have 0.55 percent to 0.72 percent market share in 2030,
- 110-mph (4 DRTs) service is projected to have 0.77 percent to 1.00 percent market share in 2030.
- 110-mph (8 DRTs) service is projected to have 1.15 percent to 1.51 percent market share in 2030.

The 2030 Coast-to-Coast Corridor passenger rail market shares of Route 1, Route 2, and Route 3 are shown in Exhibit 6-19.

Exhibit 6-19: 2030 Coast-to-Coast Passenger Rail Market Share

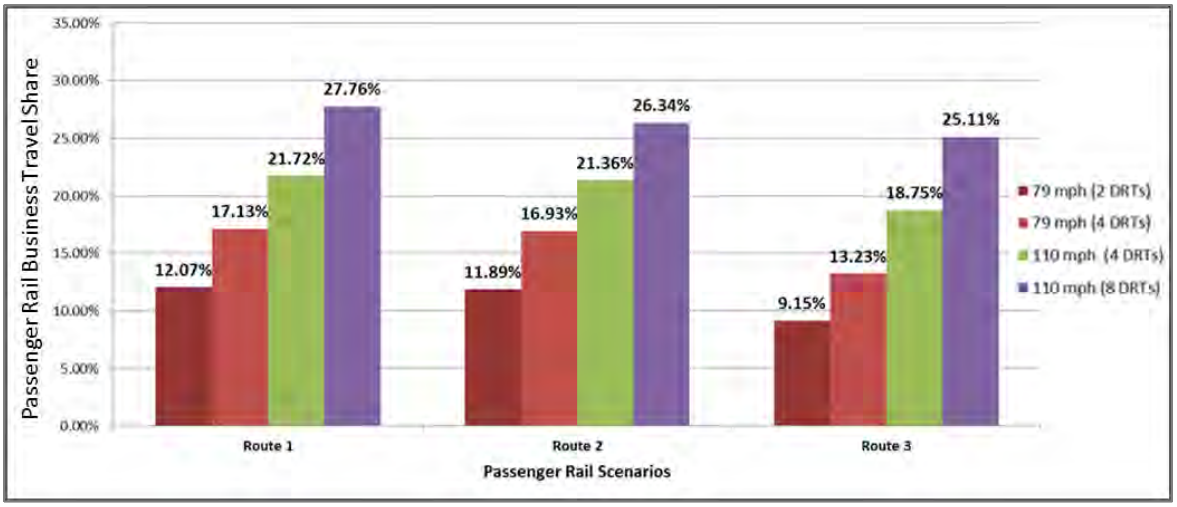


6.3.1 Purpose Split

For passenger rail business travel shares in 2030, business trips would likely account for about 9 to 12 percent for the 79-mph (2 DRTS) service, the 79-mph (4 DRTS) service would likely account for about 13 to 17 percent of business travel, the 110-mph (4 DRTS) service would likely account for about 19 to 22 percent of business travel, and the 110-mph (8 DRTS) service would likely account for about 25 to 28 percent of business travel that year. As anticipated, business travel by rail increases with speed and frequency.

The 2030 Coast-to-Coast Corridor passenger rail business travel shares of Route 1, Route 2, and Route 3 are illustrated in Exhibit 6-20.

Exhibit 6-20: 2030 Coast-to-Coast Passenger Rail Purpose Split (Business Travel Percent)



6.3.2 Source of Trips

Trips diverted from other modes are the most important source of new rail trips, which is estimated to be over 90 percent of the overall rail travel market in 2030. Induced travel demand in the corridor as a result of the new passenger rail service is projected to be approximately 6 to 7 percent of the rail travel market then as well. As for the diverted trip from other modes, most trips are expected to be from personal vehicle travel. It should be noted however that driving still dominates the future travel market because it is the most popular travel choice in the corridor.

Exhibits 6-21 through 6-23 illustrate the sources of the rail trips for the Coast-to-Coast Corridor 79-mph (2 DRTs), 79-mph (4 DRTs), 110 (4 DRTs) and 110-mph (8 DRTs) services in 2030.

Exhibit 6-21: 2030 Coast-to-Coast 79-mph (2 DTRs) Passenger Rail Trip Sources Forecast

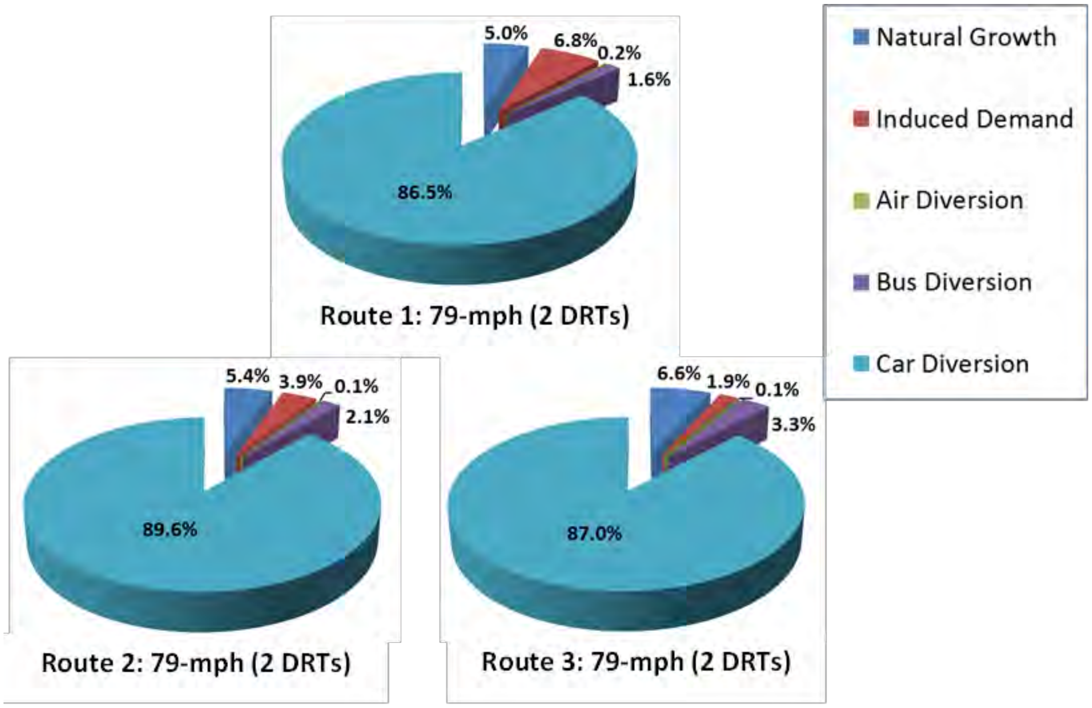


Exhibit 6-22: 2030 Coast-to-Coast 79-mph (4 DTRs) Passenger Rail Trip Sources Forecast

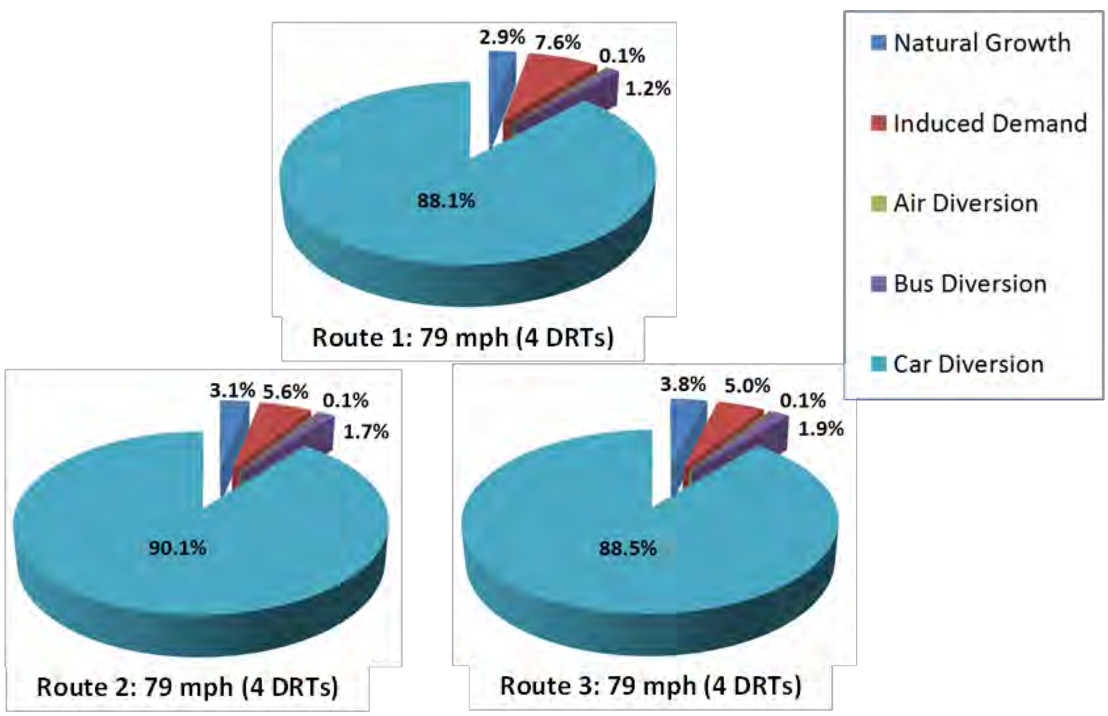
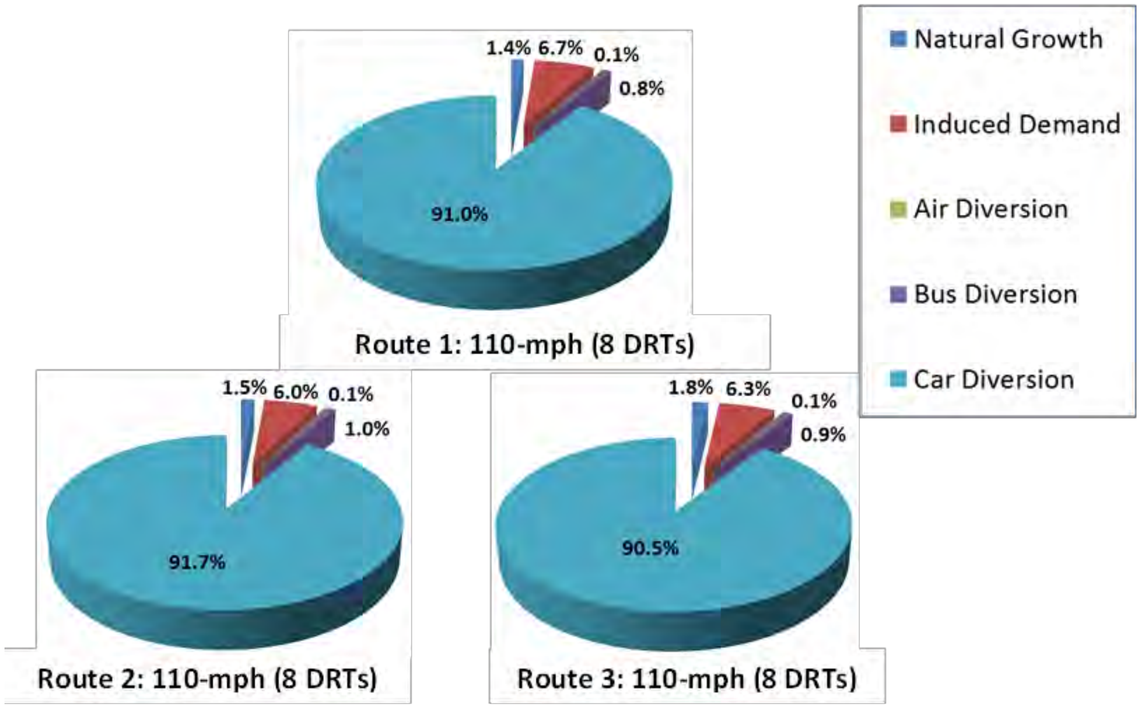


Exhibit 6-23: 2030 Coast-to-Coast 110-mph (4 DTRs) Passenger Rail Trip Sources Forcast



6.4 Critical Factors that Drive the Rail Forecast

In 2030 projections, levels-of-service improvement (travel time, frequency, on time performance, connectivity, schedule convenience) for passenger rail accounted for over 70 percent of total rail ridership. In addition, gas price and highway congestion increases account for 20 to 22 percent of rail ridership, or a 26 percent increase on what the ridership would be if gas prices and highway congestion remained at today's levels.

Exhibits 6-24 through 6-27 show the contributing factors of the increased passenger rail ridership for the Coast-to-Coast Corridor for 79-mph (2 DRTs), 79-mph (4 DRTs), 110-mph (4 DRTs) and 110-mph (8 DRTs) services in 2030.

Exhibit 6-24: 2030 Coast-to-Coast Passenger Rail Trip Sources Forecast 79-mph (2 DRTs)

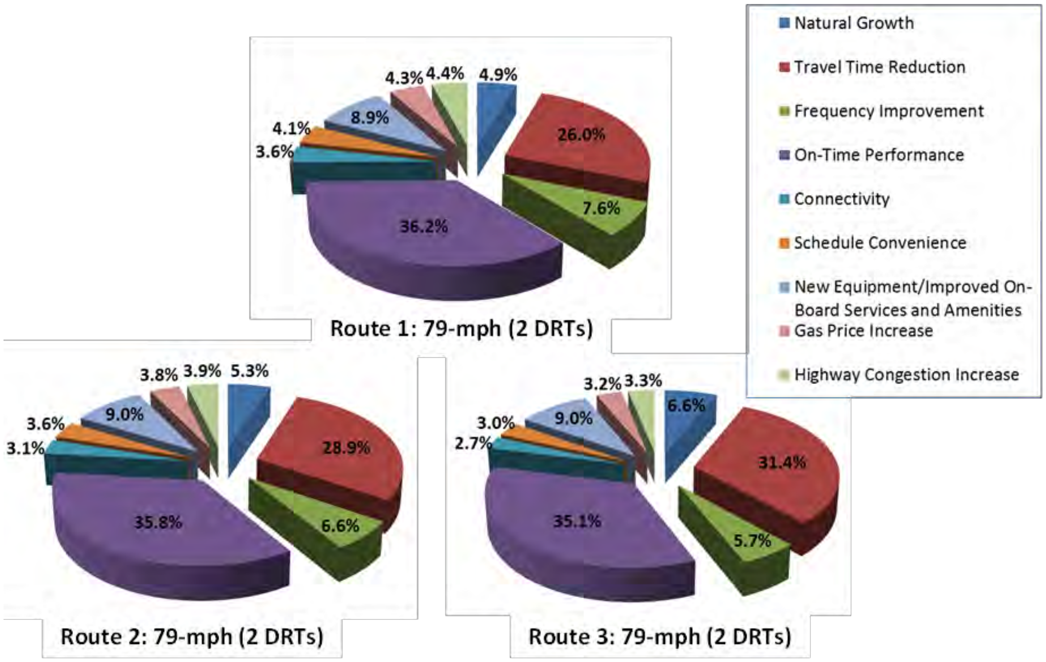


Exhibit 6-25: 2030 Coast-to-Coast Passenger Rail Trip Sources Forecast – 79 mph (4 DRTs)

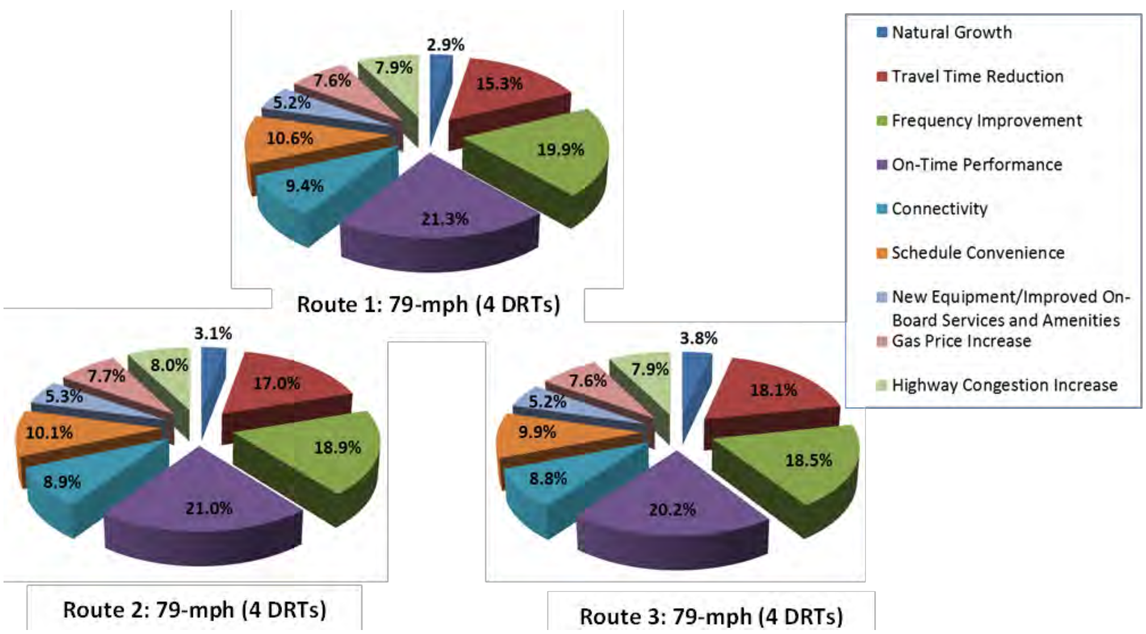


Exhibit 6-26: 2030 Coast-to-Coast Passenger Rail Trip Sources Forecast – 110 mph (4 DRTs)

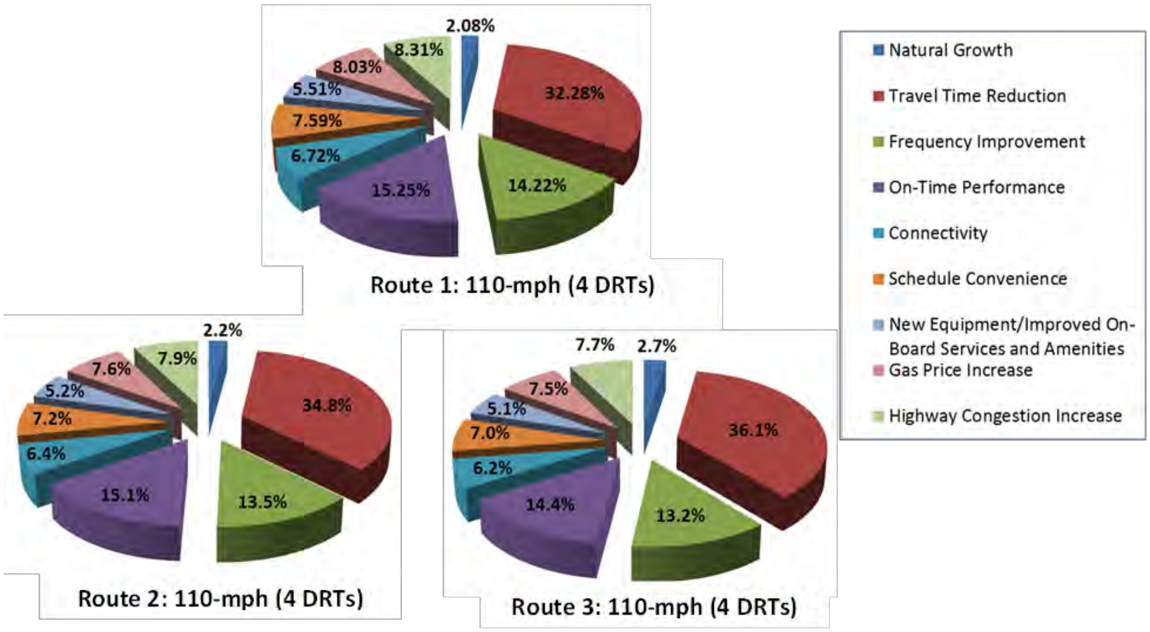
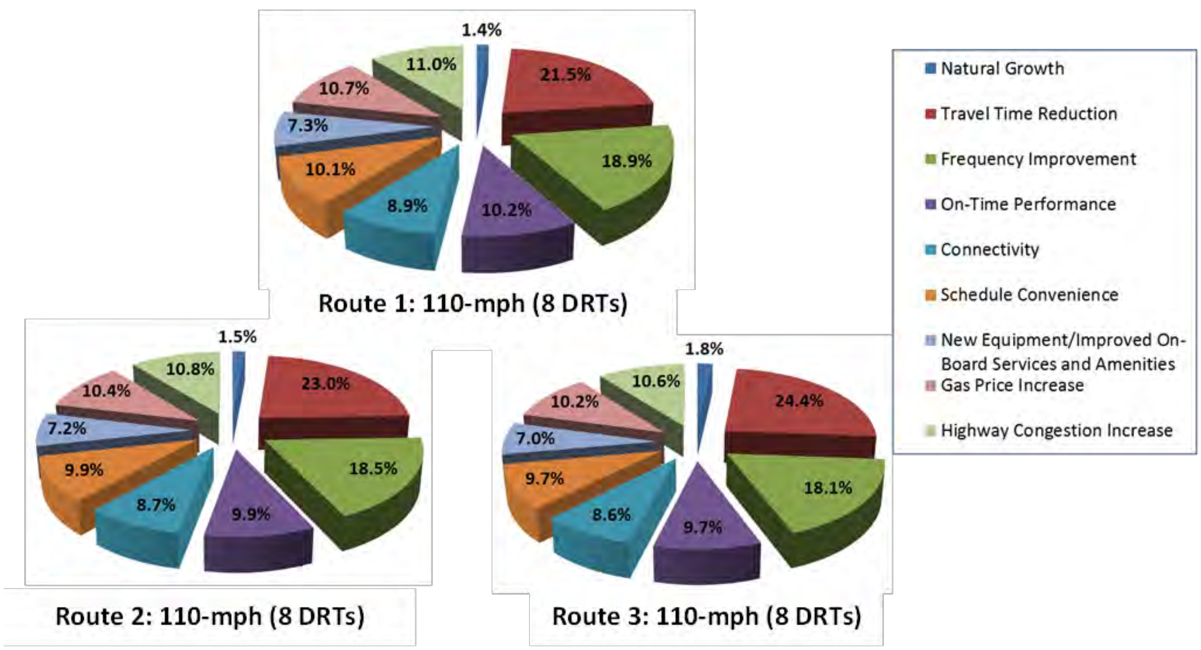


Exhibit 6-27: 2030 Coast-to-Coast Contributing Factors of Rail Trips for 110 MPH (8 DRTs)



6.5 Consistency with Regional Plans and Planning Practices for the Sensitivity Option Route 2

The development of intercity passenger rail frequently uses USDOT Federal Railroad Administration (FRA) funds for planning and construction. As such, in the planning process it is useful to be consistent with the process and procedures that they provide. This process is not, however, always in accordance with state planning process; and, as a result, it is frequently important to show the project from a state perspective to see how it relates to the state's planning framework. To meet this need TEMS reviewed the state planning process and prepared a sensitivity analysis that is compliant with the states own planning process.

6.5.1 Demographic Issues

Both the Michigan Statewide Travel Demand Model and the TEMS COMPASS™ Model use population, employment and income to forecast traffic for the state. However, while there is little difference between the employment and income forecasts used in the COMPASS™ Model and the Michigan Statewide Travel Demand Model, there is a significant difference in the population forecasts used for estimating population growth (Exhibit 6-28). The MDOT 2012 REMI forecasts (a demographic forecast prepared by the University of Michigan for MDOT, using the REMI model) which are used in the Michigan Statewide Travel Demand Model are lower than the COMPASS™ Model which uses historically based US Bureau of Economic Analysis (BEA) data for the state and for the Detroit area, in particular. Consequently, the use of Michigan Statewide Travel Demand Model forecasts reduces traffic estimates for the Coast-to-Coast corridor.

Exhibit 6-28: Population Growth in Michigan Comparison – BEA-based Forecasts over MDOT 2012 REMI Forecast

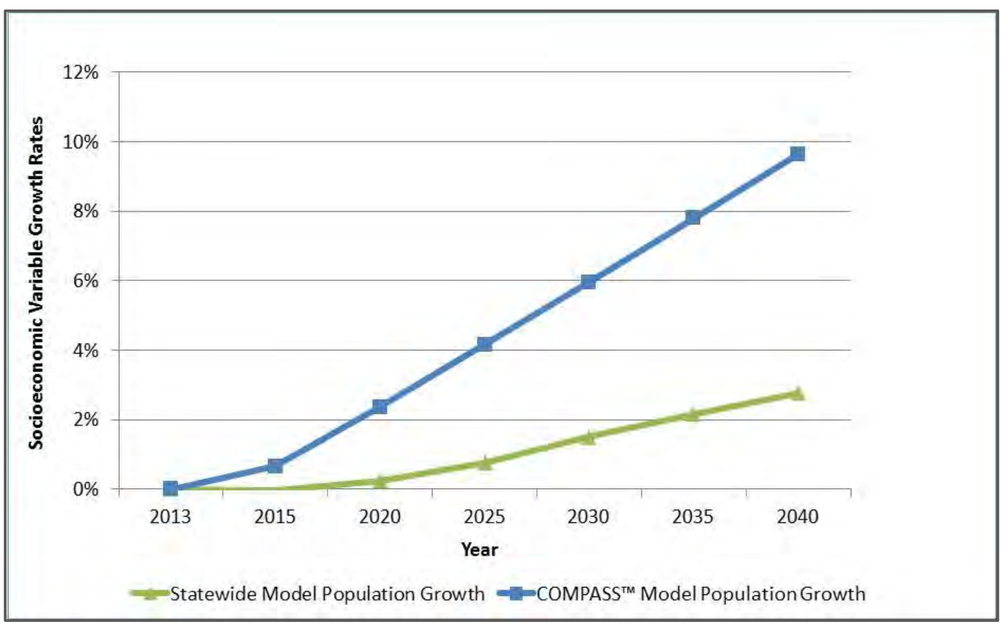
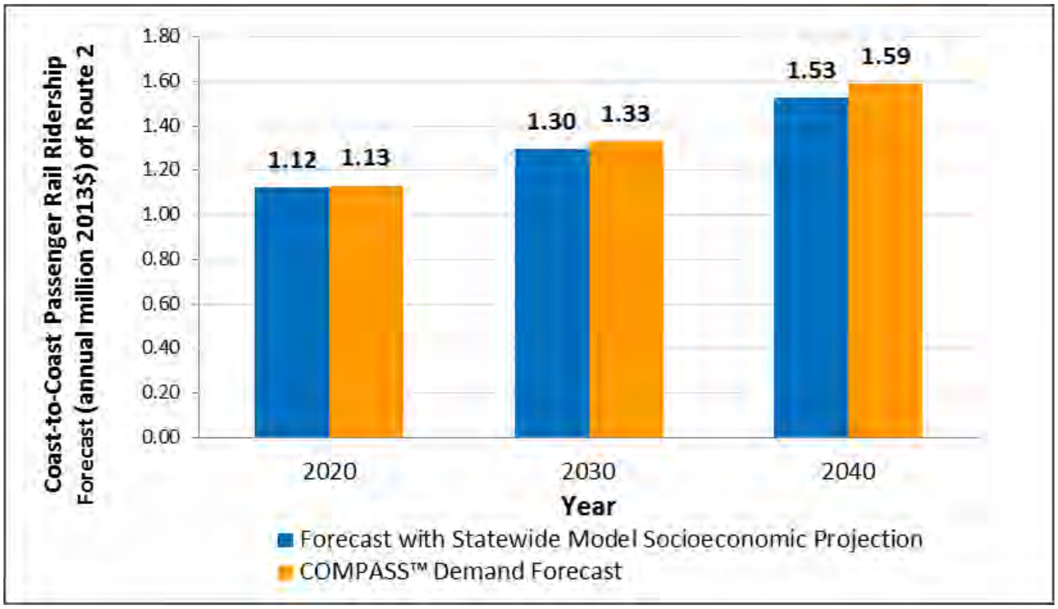


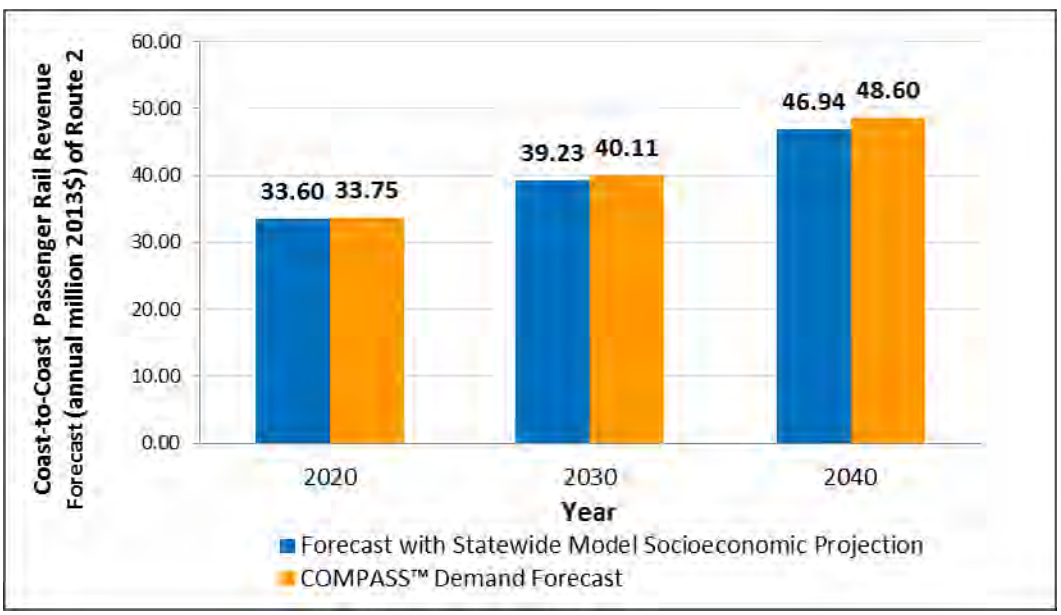
Exhibit 6-29 shows that using the state forecasts reduces the train traffic estimates in 2030 from 1.33 to 1.30 million riders. The difference gets bigger over time, as the Statewide Travel Demand Model's population growth rate increasingly diverges from the COMPASS™ Model's forecast.

Exhibit 6-29: Route 2 110 MPH 8 DRTs Ridership Forecast Results



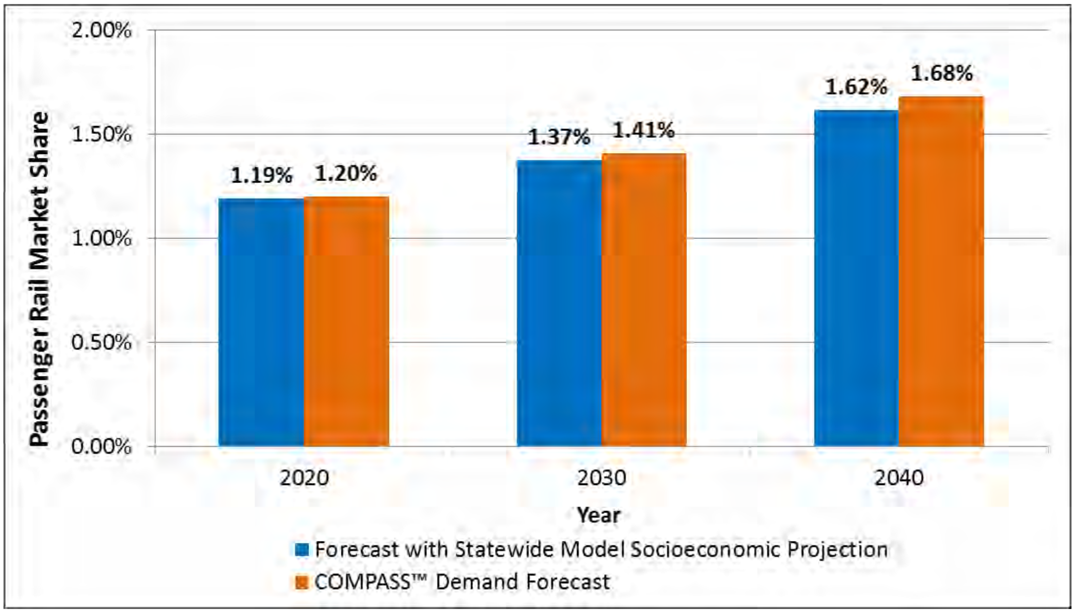
The impact on revenue estimates is to reduce it from $40.1 million to $39.2 million in 2030. See Exhibit 6-30.

Exhibit 6-30: Route 2 110 MPH 8 DRTs Revenue Forecast Results



In terms of market share estimates, the lower population numbers reduce it from 1.41% to 1.37%. See Exhibit 6-31.

Exhibit 6-31: Route 2 110 MPH 8 DRTs Market Share Forecast Results



The percent of trips by business increases slightly to 26.91% versus 26.34% in 2030 (Exhibit 6-32) due to the slight reduction in discretionary travel associated with a lower population. The contributing factors to rail trips remain largely constant, although the impact of rail service improvements is marginally stronger, since natural growth is marginally weaker with the lower population growth. See Exhibit 6-33.

Exhibit 6-32: Route 2 110 MPH 8 DRTs Business Travel Forecast Results

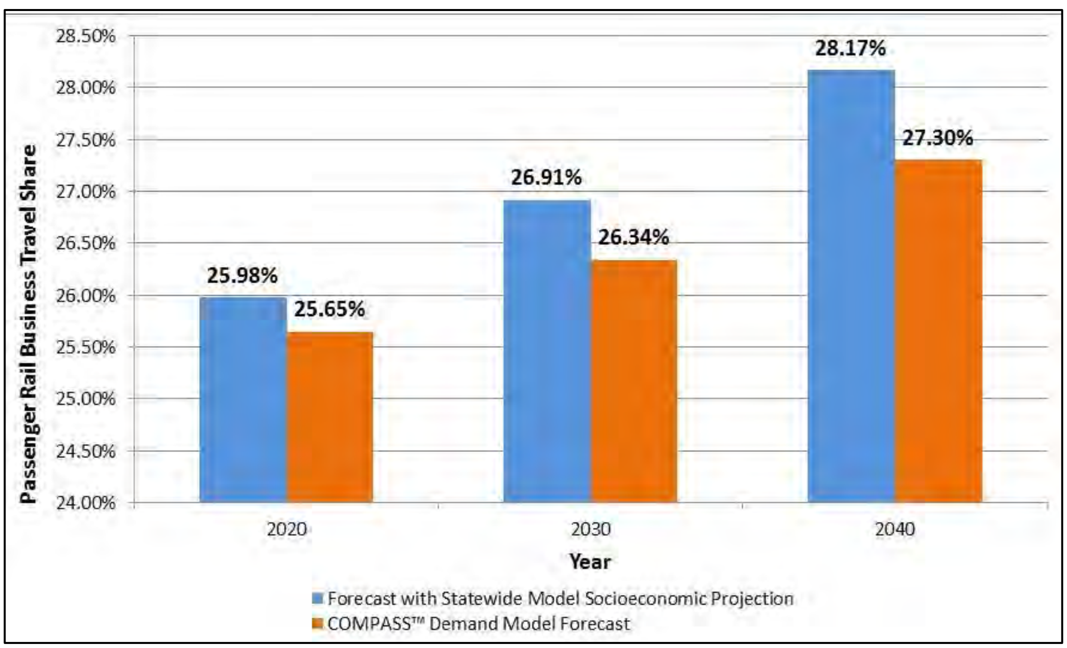
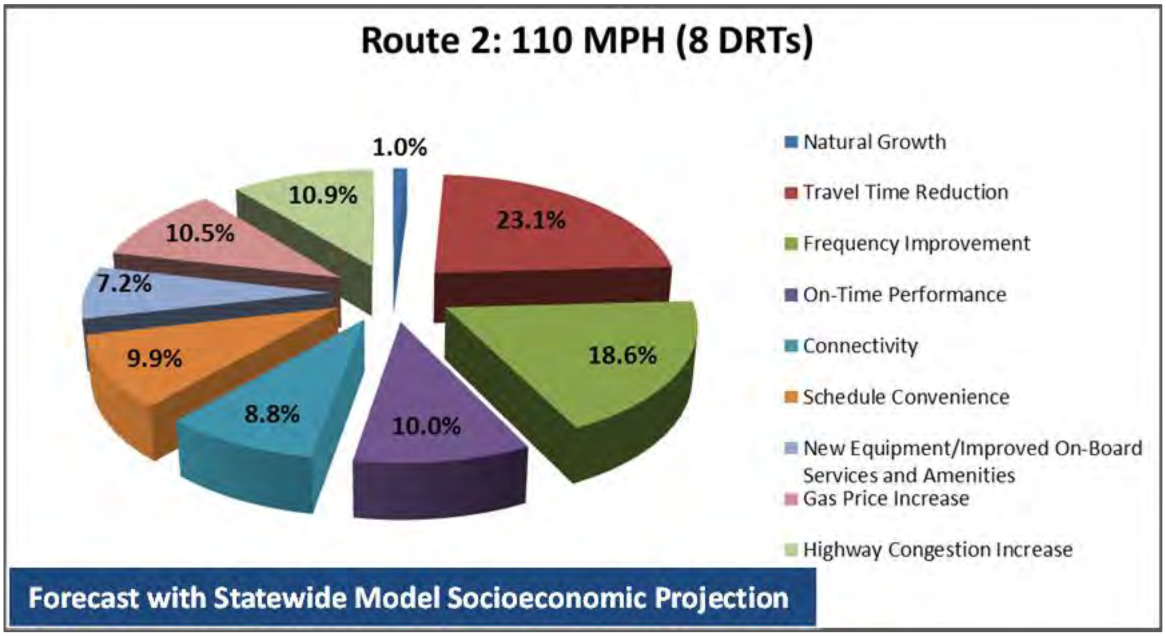
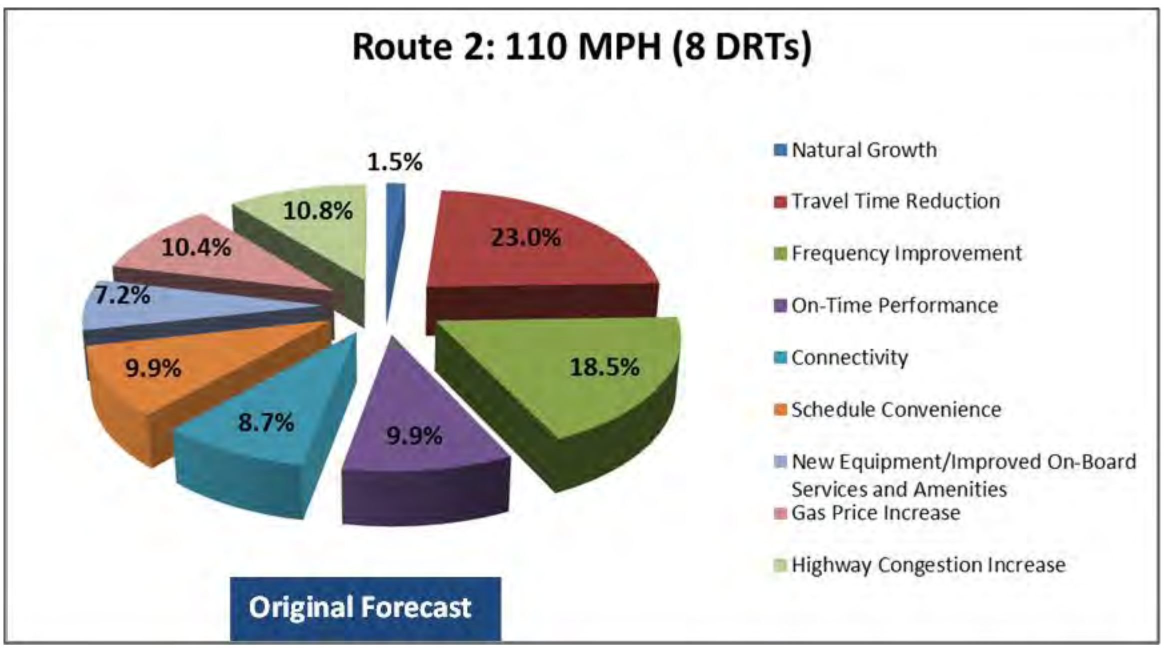


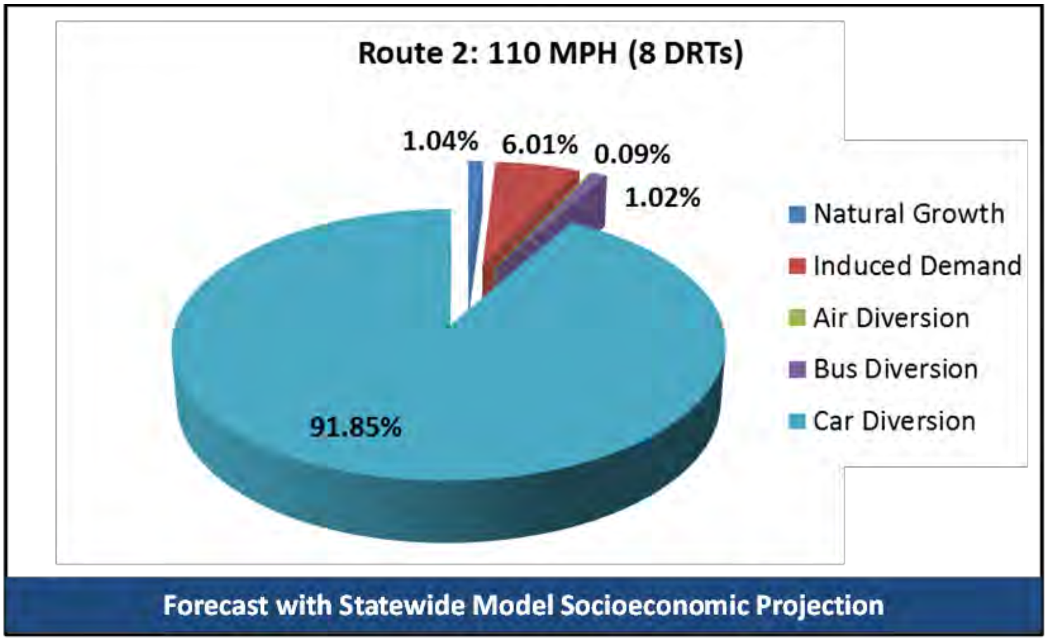
Exhibit 6-33: Statewide vs Original Forecast - Route 2 110 MPH 8 DRTs 2030 Contributing Factors of Trips Forecast Results

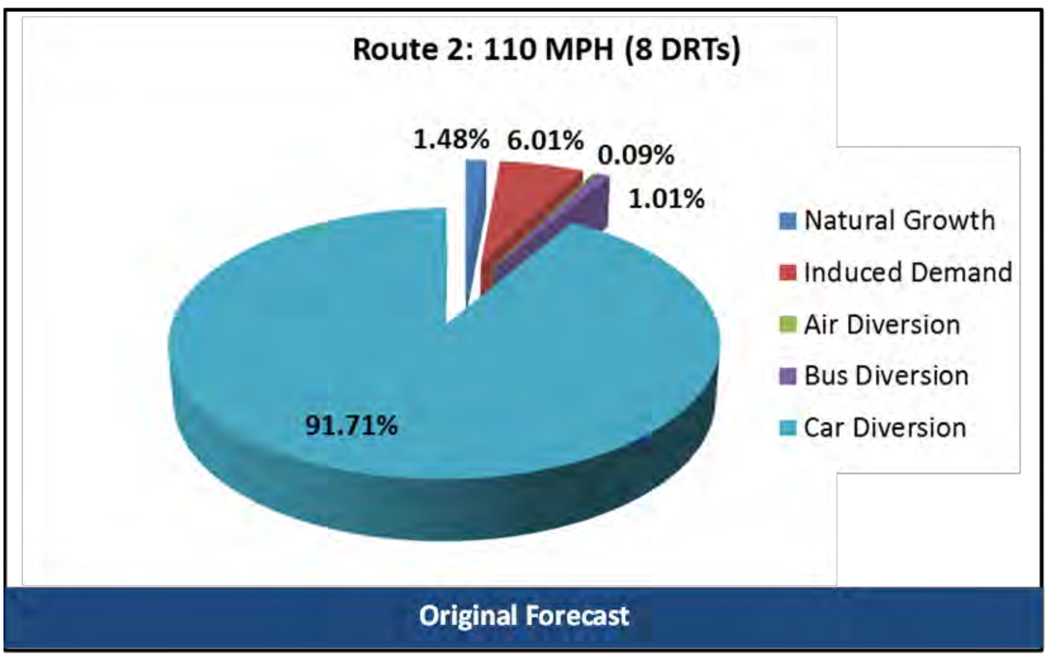




Finally, the source of trips is similar with a small decline in natural growth due to lower population forecasts. See Exhibit 6-34.

Exhibit 6-34: Statewide vs Original Forecast – Route 2 110 MPH 8 DRTs 2030
Sources of Trips Forecast Results





6.5.2 Conclusion

Overall, the Sensitivity Analysis shows that the Original Demand Forecast is comparable to the Statewide Model's with the original forecast having slightly higher ridership, revenue and market share results. However, the Statewide Model shows a higher percent share for business travel.

6.6 Benchmark Analysis

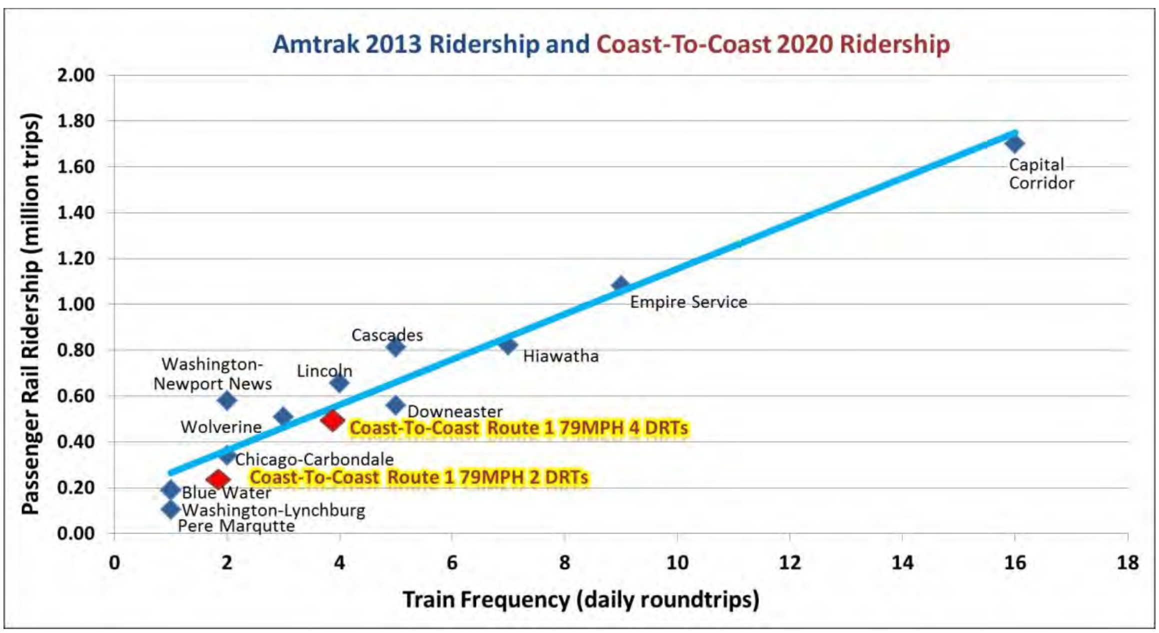
A detailed benchmark analysis was completed for 79-mph and 110-mph service in order to ensure the validity of the forecasts within a range of ± 30 percent.

6.6.1 79-mph Service

Exhibit 6-35 shows how the forecasts for Route 1, which are the highest forecasts of each of the routes, compared with the actual results for existing Amtrak service. The Amtrak 2013 ridership figures were obtained from several sources[61, 62] . The forecasts for the Coast-to-Coast Route were reduced from 2020 to 2013 by eliminating the effects of Natural and Socioeconomic growth, and increases in gas prices and highway congestion. It can be seen that the forecasts for 2 trains per day and 4 trains per day at 79-mph are below the Amtrak average (as represented by the regression line). The Coast-to-Coast route forecast is below the current carryings of Chicago-Carbondale route, and the Washington-Newport News Route. At a frequency of 4 trains at 79-mph the Coast-to-Coast route is lower than the Downeaster with 5 trains, and only 68 percent of the Lincoln train. The forecast for the 4 train option is slightly lower than the Wolverine, which only has 3 trains per day, but the Wolverine train has suffered from poor On-Time Performance (OTP) at 50 percent in terms of access to Chicago. The Coast-to-Coast Route forecast assumes a 90-95 percent OTP, which increases its ridership by 14.3 percent over the On-Time Performance currently offered by Amtrak services.

The comparison of the Wolverine can be seen in the next section where the Coast-to-Coast is compared on an apples-to-apples basis with the Wolverine. When this comparison is made, the difference between the Coast-to-Coast and Wolverine is very large, with the Coast-to-Coast being only 55 percent of the Wolverine Traffic.

Exhibit 6-35: Comparison Amtrak 2013/Coast-to Coast 2013



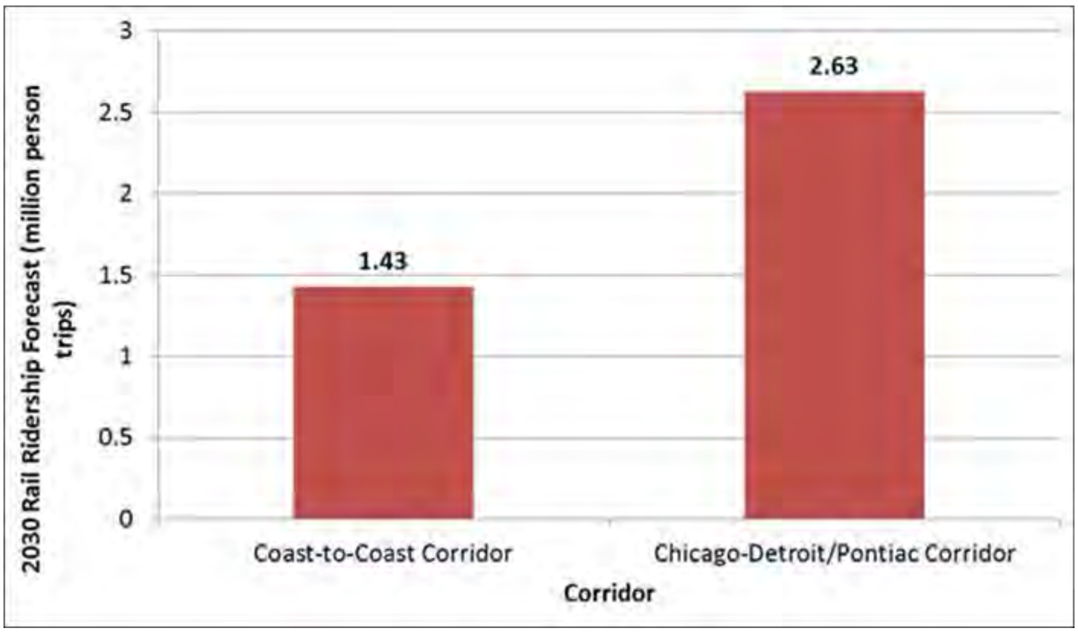
[61] Amtrak Published Schedules: http://www.amtrak.com/train-schedules-timetables
[62]Amtrak Press Release: Amtrak sets ridership record and moves the nation's economy forward. ATK-13-122, October 14, 2013

6.6.2 110-mph Service

The Coast-to-Coast rail ridership in 2030 is projected to be only 54 percent that of the Chicago-Detroit/Pontiac Corridor. This is a key benchmark as both the Chicago-Detroit/Pontiac analysis and the Coast-to-Coast rail service scenarios are almost identical in terms of travel speeds (time), frequency, connectivity and schedule convenience, as well as equipment. Equally, almost the same gas price increase and highway congestion assumptions are used. As a result the difference in trips is mainly due to lower socioeconomic levels of population and employment in the Coast-to-Coast Corridor. The Coast-to-Coast is very similar to the Chicago-Detroit/Pontiac Corridor in terms of trip rate, with an annual trip rate of 5 per 10,000 population compared to a trip rate of 5.3 per 10,000 population in the Chicago-Detroit/Pontiac Corridor. However, it lacks the anchor of the large city of Chicago, and this reduces population in the corridor by 43 percent with the associated changed in rail ridership of just over 45 percent.

Exhibit 6-36 shows the comparison of 2030 rail ridership of the Coast-to-Coast Corridor and the Chicago Detroit/Pontiac Corridor.

Exhibit 6-36: 2030 Forecast Comparison with Chicago-Detroit/Pontiac Corridor



To provide a check on the reasonableness for the Coast to-Coast forecasts a comparison has been made with other studies' rail trip rates.

Exhibit 6-37 shows the comparison of 2030 Coast-to-Coast 110-mph (8 DRTs) service forecast with the results of previous studies. The rail trips rates (i.e., the number of trips per 10,000 persons per day) are listed and it can be seen that the rail trip rate of the Coast-to-Coast Corridor as might be expected with a similar train service, is similar (but slightly lower) to those of the Chicago-Detroit/Pontiac and Chicago-St. Louis Corridors. This is due to the similarities of socioeconomics and rail proposals (110-mph option) in each corridor. However, as previously noted the smaller population of the Coast-to-Coast study corridor compared to that of Chicago-Detroit results in a much lower level of ridership overall.

Exhibit 6-37: 2030 Forecast Comparison with Previous Studies

	2030 Michigan Coast-to-Coast 110-mph	2030 Chicago-Detroit/ Pontiac 110-mph[1]	2030 Milwaukee-Green Bay 110-mph[2]	2030 Chicago-St. Louis 110-mph[3]	2030 Georgia 130-mph[4]	2030 Hampton Roads 130-mph[5]
Rail Trip Rate (trips per 10,000 persons per day)	5.0	5.3	1.7	5.4	10.3	7.1
Daily Round Trains (DRT)	8	10	7	8	10	13

[1] The Chicago-Detroit/Pontiac EIS, 2014
[2] Midwest Regional Rail Initiative Project Notebook, TEMS Inc., 2004
[3] Chicago to St. Louis 110-mph EIS, 2003
[4] Atlanta to Charlotte Passenger Rail Corridor EIS, Steer Davies Gleave, 2013
[5] Hampton Roads Passenger Rail Vision Plan Alternatives Analysis, TEMS Inc., 2014

The forecast results for the 110-mph options are much lower than the high-speed rail options developed for other corridors. The rail trip rate forecast for the Coast-to-Coast Corridor is 47 percent of the Georgia (Atlanta-Charlotte) 130-mph passenger rail forecast, and 70 percent of the Hampton Roads (Hampton Roads-Richmond-Washington) 130-mph passenger rail forecast. The difference is due to the higher speeds and frequency of train service in these other corridors, which in the Georgia and Hampton Roads cases, is the result of the building of a dedicated right-of-way that will give a very high OTP of 95 percent. The Northeast Corridor also has much higher population density.

6.7 Conclusion

The forecasts show that in the evolving environment of increased gas prices and highway congestion, passenger rail can play a larger and larger role in intercity travel in the Coast-to-Coast Corridor.

Overall, by 2020 the ridership and revenue will be greatest for Route 1 despite the fact it has the slowest timetable. The addition of the cities of Jackson and Ann Arbor, add significant ridership over Route 3 that lacks both cities. Route 2, which has a faster timetable than Route 1 and goes through Ann Arbor, has ridership and revenues that are only slightly lower by 5 to 10 percent.

Route 1 does well compared to Route 2 because its ridership benefits from individuals who want to go to Chicago using the train between Lansing and Jackson as a way to connect with trains going to Chicago from Detroit. This adds to ridership in the short term, but this traffic may well disappear if frequency is increased on the Bluewater train that gives direct access to Battle Creek and the Detroit-Chicago service, or if the Grand Rapids-Chicago service were improved. As a result, the marginal increase in ridership now shown for Route 1 would be reduced to a level comparable or less than Route 2.

In terms of technology, higher frequency and higher speeds genera ted the greatest ridership and revenue. At 79-mph, increasing train frequency from 2 to 4 trains per day in each direction almost doubles ridership, while at 110-mph, increasing train frequency from 4 to 8 trains per day in each direction increases demand by 30-40 percent. The impact of higher speed is to double ridership as the train service becomes more and more competitive with the automobile. Over the forecast period auto travel becomes more expensive due to increasing gas prices and congestion rises significantly.

In terms of station volumes, Grand Rapids, Lansing and Ann Arbor have the greatest volumes of close to 0.5 million (on and offs) passengers per year at 110-mph and 8 trains per day. Holland, Dearborn, Plymouth and Detroit have slightly fewer passengers, and the weakest is Howell. With respect to segment loadings, the greatest loads of passengers as might be expected are in the middle of the corridor between Grand Rapids-Lansing-Jackson/Howell-Ann Arbor.

The critical factors that drive the forecasts are the quality of the rail service such as time, frequency, on-time performance, which represents 40 percent of the rail demand, while gas prices and congestion, represent over 20 percent of the demand, and increase the rail forecast by 25 percent.

The Sensitivity Analysis shows that the ridership and revenue forecasts generated by the COMPASS™ Model are comparable to the Statewide Model, with the exception that the COMPASS™ forecast has slightly higher ridership, revenue and market share results. The differences here are very small and are not significant. However, the Statewide Model shows a higher share of business travel.

In terms of benchmarks and "apple-to-apples" comparisons, the forecast is 55 percent of the Chicago-Detroit/Pontiac Corridor Environmental Impact Statement (EIS) forecast. The difference in travel reflects the socioeconomic of the Coast-to-Coast Corridor. Since the corridor has a very similar trip rate to both the Chicago-Detroit/Pontiac, and Chicago-St. Louis Corridors. Clearly people in Lansing, Grand Rapids, Holland and Brighton/Howell respond very similarly to the potential for rail service. It is the fact that the corridors socioeconomics are about 55 percent of the Detroit-Chicago Corridor results in the ridership being about half of the Detroit-Chicago Corridor.

Chapter 7
Assessment of Benefits – Preliminary Economic and Financial Analysis

SUMMARY

This chapter presents a detailed financial and economic analysis for the Coast-to-Coast Passenger Rail Line, including key financial measures such as Operating Surplus and Operating Ratio. A detailed Economic Analysis was carried out using criteria set out by the 1997 FRA Commercial Feasibility Study[63] *and including key economic measures such as NPV Surplus and Benefit/Cost Ratio at a 3% discount rate which are also presented in this chapter.*

7.1 Financial Analysis

7.1.1 Introduction

The operating financial performance of the system is a key driver of the economic evaluation.

- **System Revenues:** These include the fare box revenues and revenues from onboard sales. For 110-mph dedicated track options it also includes freight railroad payments for track maintenance which can help offset a portion of the track maintenance cost.
- **Operating Costs:** These are the operating and maintenance costs associated with running the train schedules and include onboard service costs, as defined by MWRRS cost structure that would reflect the likely costs for a franchised operation.

As a result, the Operating Surplus, which is defined as Revenues minus Operating Cost, makes an important contribution to the overall business case for building the system: .

- **If the operating surplus is positive**, the system will not require any operating subsidy, and it will even be able to make a contribution towards its own Capital cost. In addition because the system is generating a positive cash flow, a Private-Public Partnership or other innovative financing methods can be used to construct and operate the system. This absolves the local entity of any

[63] High-Speed Ground Transportation for America: Commercial Feasibility Study Report To Congress: https://www.fra.dot.gov/eLib/details/L02519

need for providing an operating subsidy but more than this, it is not uncommon for the operating cash flow to be sufficient to cover the local match requirement as well.

- **If the operating surplus is negative**, the system will not only require a grant of capital to build the system, but in addition it will also require an ongoing operating subsidy. An operating subsidy not only prevents the project from being a Public Private Partnership, but casts doubt on the efficiency of the system and the reason for the project. In addition, a subsidy will reduce the economic performance of the system as it will actually offset part of the economic benefits of the system (e.g. Consumer Surplus, Environmental Benefits). This will depress the Benefit Cost ratio. If the subsidy is not too great and the capital cost is not too high, in some cases it may still be possible to maintain a positive Benefit Cost ratio. But the larger the subsidy and the higher the capital cost, the harder it is to show a positive Benefit Cost ratio. It is not uncommon for slow passenger rail systems to fail both FRA's Operating Ratio and Benefit Cost criteria.

7.1.2 Financial Results

Exhibit 7-1 shows the projected 2025 to 2050 financial results for the three route alternatives expressed in Net Present Value terms. These numbers reflect the discounted value of the operating subsidy/surplus and average operating ratio over the economic life of the system. Four train speed and frequency sub-options were assessed for each alternative: 2030 represents an early year in the implementation of the system, and so it reflects the likely financial performance of the system soon after opening.

- As can be seen, all of the **79-mph options** have negative NPV and Operating Ratios less than 1.0. This indicates that they will need subsidy through the life of the system.

- On the other hand, the **110-mph options** have operating surpluses throughout the life of the system. They will generate positive operating cash flows that can be used to recover even a portion of the capital investment made in these systems.

Exhibit 7-1: Financial Results for Routes 1, 2, and 3 (NPV 3% 2025-2050)

Financial Results Summary of Route Options		
	3% Discount Rate	
Corridor	*NPV $Millions*	*Operating Ratio*
Route Option 1		
79 mph (2 RT)	($53.55)	0.72
79 mph (4 RT)	($70.13)	0.77
110 mph (4 RT)	$80.45	1.19
110 mph (8 RT)	$200.10	1.37
Route Option2		
79 mph (2 RT)	($40.82)	0.74
79 mph (4 RT)	($58.44)	0.78
110 mph (4 RT)	$75.59	1.19
110 mph (8 RT)	$175.75	1.35
Route Option 3		
79 mph (2 RT)	($38.05)	0.71
79 mph (4 RT)	($63.74)	0.73
110 mph (4 RT)	$52.77	1.16
110 mph (8 RT)	$111.15	1.25

Exhibits 7-2 and 7-3 summarize the financial results for all the options:

- **79-mph Options** - due to the low speed of these options, a 2030 operating subsidy of $3-6 Million per year will be needed. Infrastructure improvements, introducing diesel tilting trains and raising the top speed to 90-mph may reduce the subsidy, but will not likely eliminate it.

- **110-mph Options** - Overall the 110-mph options are forecast to generate $5-$15 Million per year in free cash flow in 2030, some of which could be applied towards meeting the capital costs of the system, such as equipment and track capital maintenance costs.

Exhibit 7-2: Operating Ratio by Option (NPV 3%)

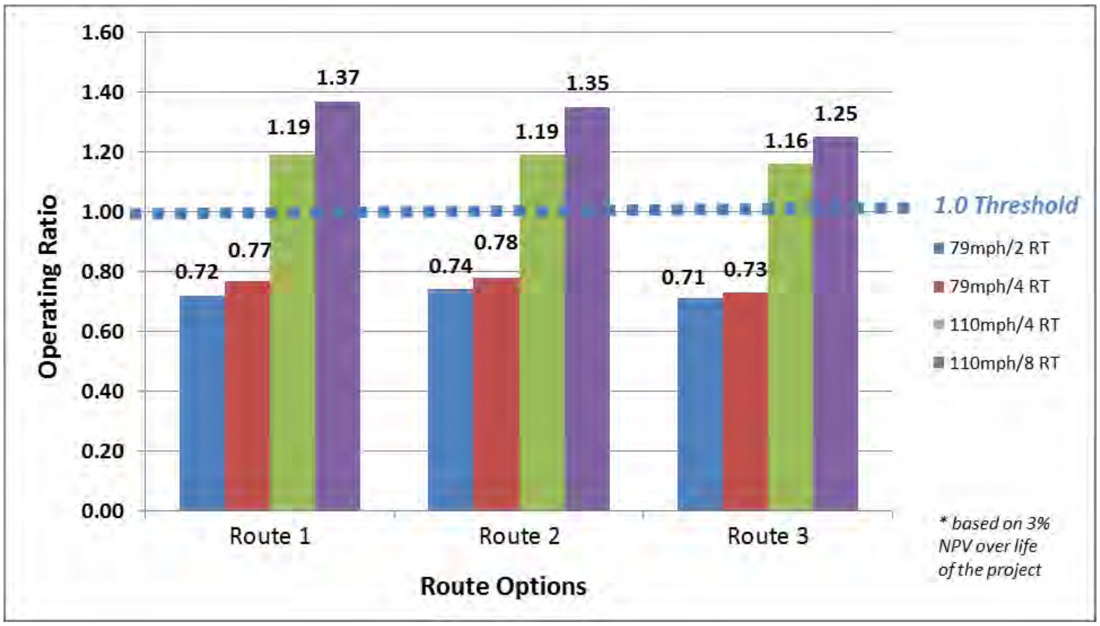
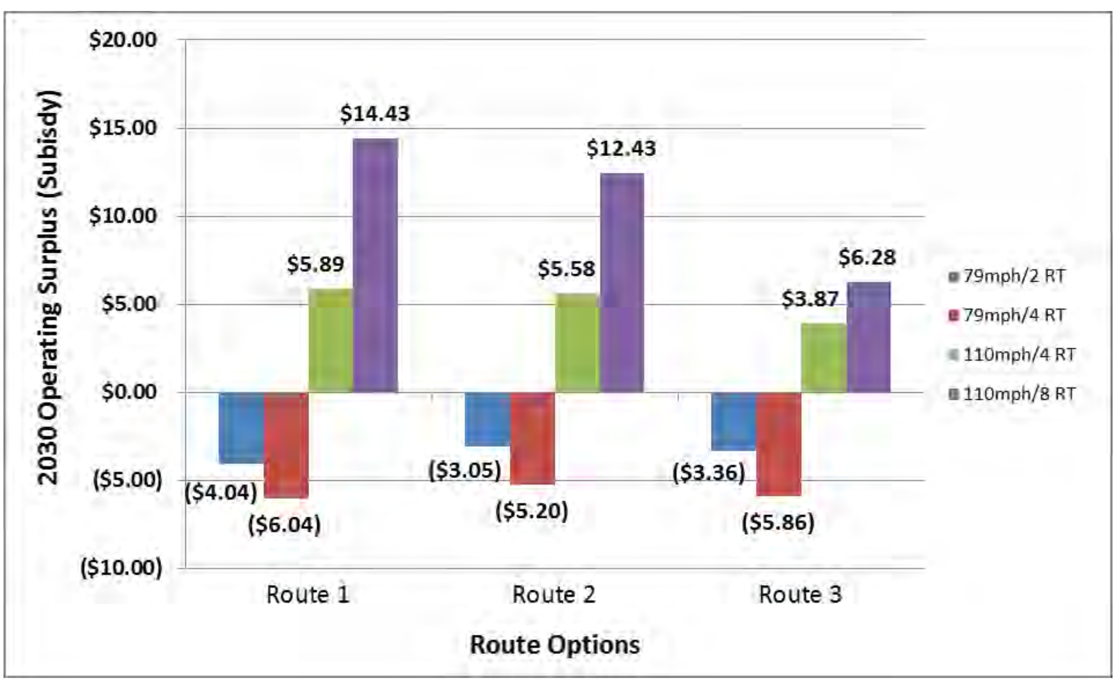


Exhibit 7-3: 2030 (Subsidy)/Surplus by Option



7.2 Economic Results

7.2.1 Introduction

A demandside economic evaluation was completed for the twelve options being assessed in this study Alternatives Analysis. This included three route alternatives, two technology options and two train frequency options for each route. This followed typical financial/economic cash flow analysis, and USDOT-Tiger Grant guidelines, as well as OMB discount procedures for the economic analysis. The analysis was completed using data derived from the Ridership and Revenue Analysis, the Infrastructure Analysis, and the Operating Analysis. This provided:

- System Revenues: Fare box, onboard and freight railroad revenue
- Operating Costs: Operating and maintenance costs
- Capital costs: Infrastructure costs

In addition, the Economic Analysis calculated other factors that are required for the analysis.

- Consumer Surplus - benefit to system users
- Highway Congestion Savings - benefits to road users of less congestion
- Airport Delay Savings - benefits to air travelers
- Safety Benefits - benefit of less accidents
- Reduced Emissions - benefit of lower emissions levels

7.2.2 Measures of Financial and Economic Benefits

Two measures, net present value (NPV) and Benefit Cost ratio were used to evaluate the economic returns of the system. Similar measures, net present value (NPV) and Operating ratio, were used to evaluate the financial returns and the potential for franchising the operations.

Both measures require the development of a project's year-by-year financial and economic returns, which are then discounted to the base year to estimate present values (PV) over the lifetime of the project. For this analysis, a 25-year project life from 2025 to 2050 was assumed, with a ten year implementation period from 2015-2024. Revenues and cost cash flows were discounted to the 2013 base year using a 3 percent discount rate. The 3 percent discount rate reflects the real cost of money in the market as reflected by the long term bond markets (5 percent).

The operating ratios reported here in this chapter, follow a commercial criteria definition; but are different from the commercial operating ratio calculations that are typically presented by freight railroads and intercity bus companies. For the current analysis, the selected feasibility criteria were as follows:

- The Operating Ratio as calculated here includes direct operating costs only. The operating ratio calculations presented here do not include capital costs, depreciation or interest. The costs used are incremental costs.

- The Operating Ratio presented here is defined as Revenues/Costs. It should be noted that freight railroads and intercity bus companies typically define it as the reciprocal Costs/Revenues.

As defined by this analysis, a positive operating ratio does not imply that a passenger service can attain full financial profitability by covering its capital costs, but it does allow the operation to be franchised and operated by the private sector. The definition puts passenger rail on the same basis as other passenger transportation modes, such as intercity bus and air, where the private sector operates the system but does not build or own the infrastructure it uses. It does, however, pay access fees to the freight railroads where they own the track. In the case of passenger rail, these would include track access costs. All calculations are performed using the standard financial formula, as follows:

Financial Measure:

$$\text{Operating Ratio} = \frac{\text{Financial Revenues (by year or PV)}}{\text{Operating Costs (by year or PV)}}$$

Economic Measures:

Net Present Value = Present Value of Benefit – Present Values of Costs

$$\text{Benefit Cost Ratio} = \frac{\text{Present Value of Revenues}}{\text{Present Value of Costs}}$$

Present Value is defined as:

$$PV = \sum_t \frac{C_t}{(1+r)^t}$$

Where:

PV = Present value of all future cash flows

C_t = Cash flow for period t

r = Discount rate reflecting the opportunity cost of money

t = Time

In terms of Economic Benefits, a positive NPV and Benefit Cost Ratio imply that the project makes a positive contribution to the economy. Consistent with standard practice, Benefit Cost ratios are calculated from the perspective of the overall society without regard to who owns particular assets receives specific benefits or incurs particular costs.

7.2.3 Key Assumptions

The analysis projects travel demand, operating revenues and operating and maintenance costs for all years from 2025 through 2050. The financial analysis has been conducted in real terms using constant 2013 dollars. Accordingly, no inflation factor has been included and a real discounting rate of 3 percent was used. Revenues and operating costs have also been projected in constant dollars over the time frame of the financial analysis. A summary of the key efficiency measure inputs are presented below.

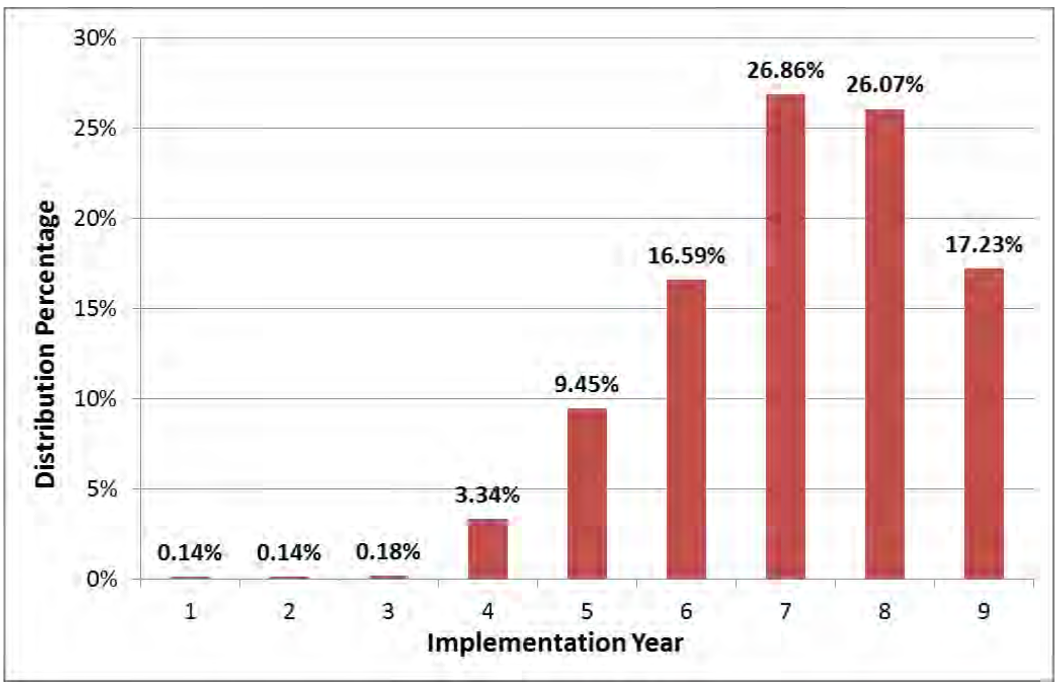
7.2.3.1 Ridership and Revenue Forecasts

Ridership and revenue forecasts were originally prepared for 2020, 2025 and 2040. Revenues in intervening years were projected based on interpolations, reflecting projected annual growth in ridership. Revenues included not only passenger fares, but also onboard service revenues.

7.2.3.2 Capital Costs

Capital costs include rolling stock, track, freight railroad right-of-way purchase or easement fees, bridges, fencing, signaling, grade crossings, maintenance facilities and station improvements. The capital cost projections are based on year-by-year projections of each cost element and include all of the capital costs, plus some selected elements of additional costs as needed to support year-by-year capacity expansion of the system. A year-by-year implementation plan was developed (as shown in Exhibit 7-14) which detailed the Capital cash flows and funding requirements. Using this information, the Benefit Cost calculations were able to be assessed. For the purpose of this study it is assumed that the Capital Costs will be spent over a nine year period with the distribution shown in Exhibit 7-4. It can be seen that the costs begin small and gradually build up during the planning period to 2018 and then accelerate during the design and construction period. Over 70 percent of funds are spent in the last four years of the implementation period as construction occurs.

Exhibit 7-4: Assumed Capital Spend Distribution



7.2.4 Operating Expenses

Major operating and maintenance expenses include equipment maintenance, track and right-of-way maintenance, administration, fuel and energy, train crew and other relevant expenses. Operating expenses were estimated in 2013 constant dollars so that they would remain comparable to revenues. However, these costs do reflect the year-by-year increase in expense that is needed to handle the forecasted ridership growth, in terms of not only directly variable expenses such as credit card commissions, but also the need to add train capacity and operate either larger trains, or more train-miles every year in order to accommodate anticipated ridership growth.

Operating costs are included as a cost, whereas system revenues are included as a benefit in the discounting calculation over the life of the system. In this way they directly offset one another in the Net Present Value calculation and are also reflected in the Benefit Cost calculation. It can be seen that a system that requires an operating subsidy, e.g., where costs exceed revenues, will tend also to reflect this in the Benefit Cost ratio. This is why slow speed options such as conventional Amtrak services often fail on both the Operating Ratio and Benefit Cost ratio criteria.

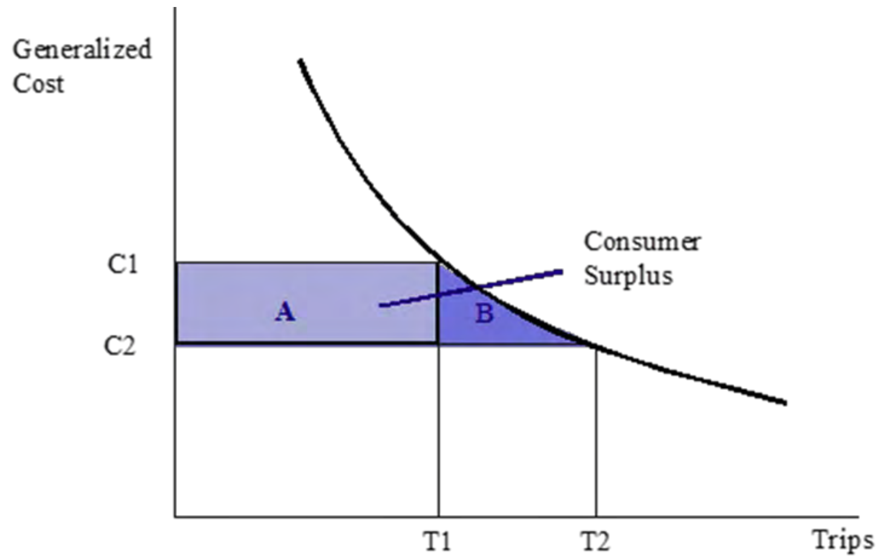
7.2.5 User Benefits

The analysis of user benefits for this study is based on the measurement of Generalized Cost of Travel, which includes both time and money. Time is converted into money by the use of Values of Time. The Values of Time (VOT) used in this study were derived from stated preference surveys conducted in the Chicago-Detroit/Pontiac EIS and used in the COMPASS™ Multimodal Demand Model for the ridership and revenue forecasts. These VOTs are consistent with previous academic and empirical research and other transportation studies conducted by TEMS.

Consumer Surplus and Revenues: Benefits to users of the rail system are measured by the sum of system revenues and consumer surplus. Consumer surplus is used to measure the demand side impact of a transportation improvement on users of the service. It is defined as the additional benefit consumers (users of the service) receive from the purchase of a commodity or service (travel), above the price actually paid for that commodity or service. Consumer surpluses exist because there are always consumers who are willing to pay a higher price than that actually charged for the commodity or service, i.e., these consumers receive more benefit than is reflected by the system revenues alone. Revenues are included in the measure of consumer surplus as a proxy measure for the consumer surplus forgone because the price of rail service is not zero. This is an equity decision made by the USDOT to compensate for the fact that highway users pay zero for use of the road system (the only exception being the use of toll roads). The benefits apply to existing rail travelers as well as new travelers who are induced (those who previously did not make a trip) or diverted (those who previously used a different mode) to the new passenger rail system.

The RENTS™ financial and economic analysis estimates passenger travel benefits (consumer surplus) by calculating the increase in regional mobility, traffic diverted to rail, and the reduction in travel cost measured in terms of generalized cost for existing rail users. The term generalized cost refers to the combination of time and fares paid by users to make a trip. A reduction in generalized cost generates an increase in the passenger rail user benefits. A transportation improvement that leads to improved mobility reduces the generalized cost of travel, which in turn leads to an increase in consumer surplus. Exhibit 7-5 presents a typical demand curve in which Area A represents the increase in consumer surplus resulting from cost savings for existing rail users and Area B represents the consumer surplus resulting from induced traffic and trips diverted to rail.

Exhibit 7-5: Consumer Surplus Concept



The formula for consumer surplus is as follows –

Consumer Surplus = $(C_1 – C_2)$*T1 + $((C_1 – C_2)*(T_2 – T_1))/2$

Where:

C_1	=	Generalized Cost users incur before the implementation of the system
C_2	=	Generalized Cost users incur after the implementation of the system
T_1	=	Number of trips before operation of the system
T_2	=	Number of trips during operation of the system

The passenger rail fares used in this analysis are the average optimal fares derived from the revenue-maximization analysis that was performed for each alternative. User benefits incorporate the measured consumer surplus, as well as the system revenues, since these are benefits are merely transferred from the rail user to the rail operator.

Other Mode and Resource Benefits: In addition to rail-user benefits, travelers using auto or air will also benefit from the rail investment, since the system will contribute to highway congestion relief and reduce travel times for users of these other modes. For purposes of this analysis, these benefits were measured by identifying the estimated number of auto passenger trips diverted to rail and multiplying each by the updated monetary values derived from previous stated preference studies updated to 2013.

Highway Congestion: The highway congestion delay savings is the time savings to the remaining highway users that results from diversion of auto users to the rail mode. To estimate travel time increase within the corridor, historical highway traffic volumes were obtained from the State DOTs and local planning agencies. The average annual travel time growth in the corridor was estimated with the historical highway traffic volume data and the BPR (Bureau of Public Roads) function that can be used to calculate travel time growth with increased traffic volumes.

The Airport Congestion Delay Savings: The Airport Congestion Delay Savings were based 1997 FRA Commercial Feasibility Study and updated to 2013 value. The Airport Congestion Delay Savings includes the airport operation delay saving and air passenger delay saving.

Auto Operating Cost (Non Business): Vehicle operating cost savings for non-business travelers have been included in the current analysis as an additional resource benefit. This reflects the fact that social/leisure travelers do not accurately value the full cost of driving when making trips. As a result, the consumer surplus calculation for commuters, social, leisure and tourist travelers has not fully reflected the real cost of operations of an automobile, but only the cost of gas. The difference between the cost of gas and the full cost of driving reflects a real savings that should be included in a Benefit Cost analysis.

Emissions: The diversion of travelers to rail from the auto mode generates emissions savings. The calculated emissions savings are based on changes in energy use with and without the proposed rail service. This methodology takes into account the region of the country, air quality regulation compliance of the counties served by the proposed rail service, the projection year, and the modes of travel used for access/egress as well as the line-haul portion of the trip. Highway Reduced Emissions were estimated from the vehicle miles traveled (VMT) and flight reductions derived from the ridership model. The assumption is that a reduction in VMT or flights is directly proportional to the reduction in emissions. The pollutant values were taken from the latest TIGER III Grant Benefit-Cost Analysis (BCA) Resource Guide[64] .

Public Safety Benefits: Public Safety is calculated from the diverted Vehicle-Miles times the NHTSA[65] fatality and injury rate per Vehicle mile and then times the values of fatality and injury from the latest TIGER III Grant Benefit-Cost Analysis (BCA) Resource Guide. This was calculated for 2025, 2035 and 2045 then interpolated or extrapolated for all other years.

7.2.6 Economic Results

The economic analysis results are shown in Exhibits 7-6 and 7-7. These exhibits summarize the results showing the overall Cost Benefit ratios calculated at 3% discount rate:

- **Option 1** via Jackson is forecasted to have the highest revenue, but also has the highest capital cost. As a result, although it has a positive NPV and a Benefit/Cost ratio greater than one, it does not have the best results of all the available options.

- **Option 3** has the lowest revenue and the lowest capital cost, but because of the lower ridership and revenue associated with this option (that misses Ann Arbor) again it does not have the best results of all the available options.

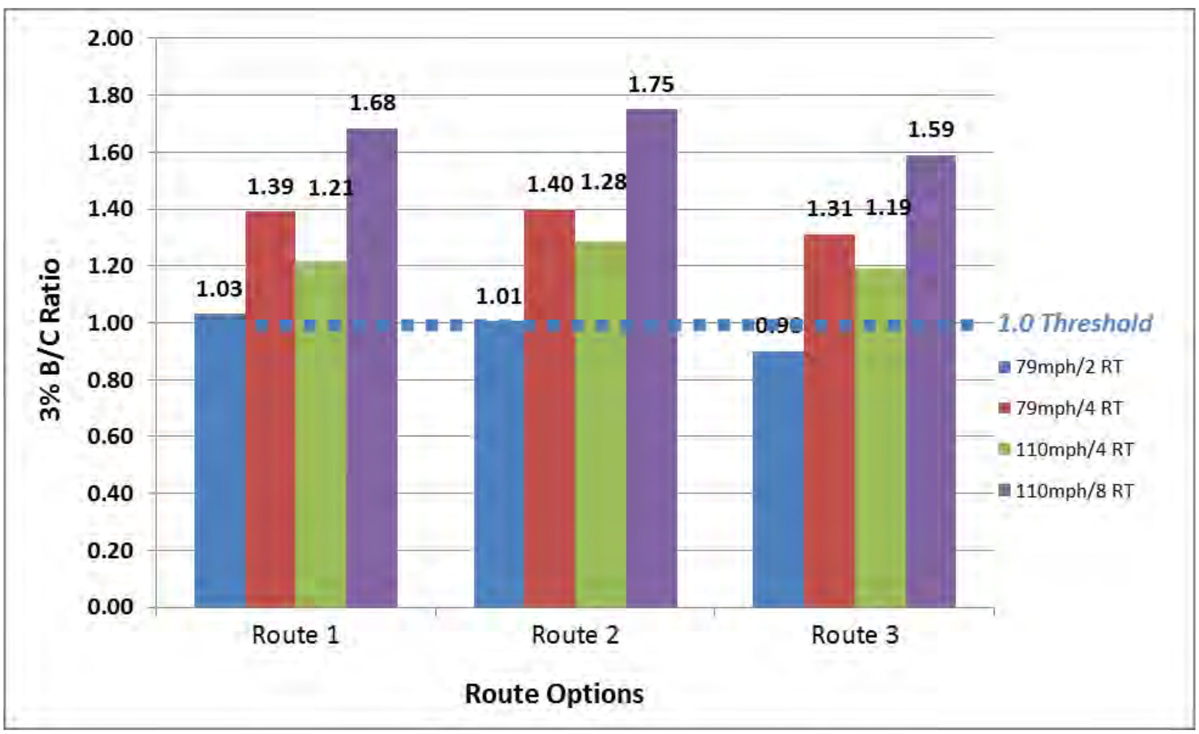
- **Option 2** via Howell and Ann Arbor optimizes the tradeoff between forecasted ridership and capital cost. It has the best results of all the available options, which optimizes the economic return for the project as a whole.

[64] http://www.dot.gov/sites/dot.dev/files/docs/TIGER_BCA_RESOURCE_GUIDE.pdf
[65] http://www.nhtsa.gov/

Exhibit 7-6: Economic Results (NPV and B/C) at 3% Discount Rate

Benefit Cost Summary of Route Options		
	3% Discount Rate	
Corridor	*NPV $Millions*	*Benefit/Cost Ratio*
Route Option 1		
79 mph (2 RT)	$9.51	1.03
79 mph (4 RT)	$184.27	1.39
110 mph (4 RT)	$208.30	1.21
110 mph (8 RT)	$757.64	1.68
Route Option2		
79 mph (2 RT)	$1.58	1.01
79 mph (4 RT)	$172.26	1.40
110 mph (4 RT)	$241.41	1.28
110 mph (8 RT)	$730.69	1.75
Route Option 3		
79 mph (2 RT)	*($24.77)*	0.90
79 mph (4 RT)	$122.15	1.31
110 mph (4 RT)	$148.83	1.19
110 mph (8 RT)	$532.86	1.59

Exhibit 7-7: Economic Summary of Results



7.3 Financial and Economic Impacts of the Sensitivity Option

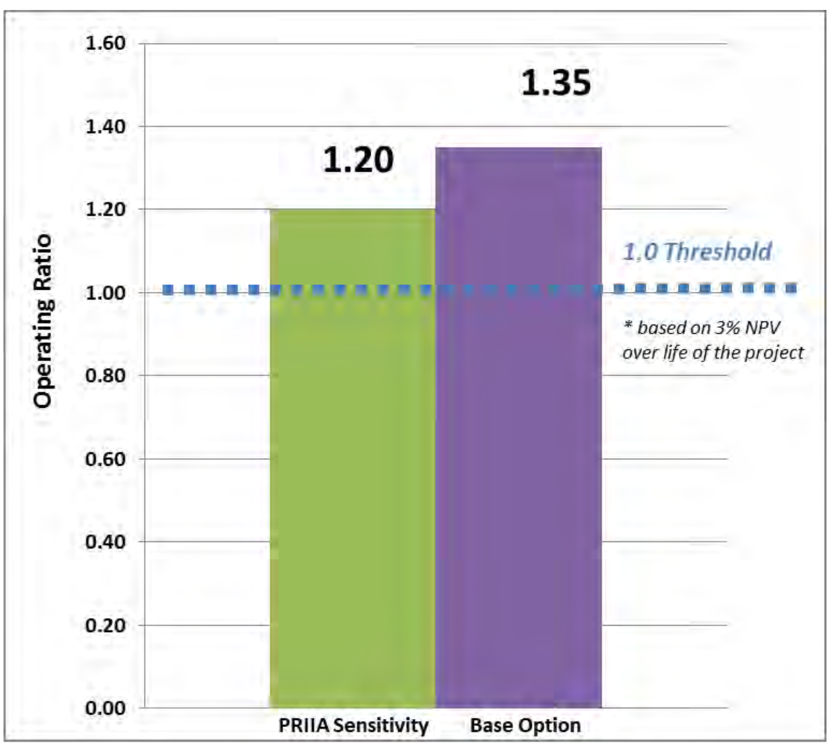
The previous sections of this report have presented the key methodologies used for developing Capital Costs, Operating Costs and Benefits, and for calculating the important Operating and Cost Benefit ratios for the different route, train technology and train frequencies that were assessed for this study. This section develops a sensitivity showing the impact of changing the demand forecasting assumptions to use the Michigan Statewide Travel Demand Model rather than projections based on historical U.S. Bureau of Economic Analysis (BEA) data that were used for the Federal assessment. In addition, section 3.7.3 of chapter 3 explained the difference between the previously adopted MWRRS costing methodology and more recent Amtrak PRIIA costs. This difference came down to an additional allocation of overhead costs which was estimated as the equivalent of $4.50 per train mile.

The study team was asked to develop a sensitivity analysis to assess the impacts of using these more conservative state ridership forecasting (zone demographics) assumptions along with Amtrak Passenger Rail Investment and Improvement Act of 2008 (PRIIA) costs. This comparison was developed for a single option: "Route 2/110-mph/8 RT" to show the potential impact of these slightly more conservative assumptions on the financial and economic viability of the Coast-to-Coast rail corridor.

7.3.1 Financial Impacts

In terms of the change on the input assumptions, slightly more conservative local demographic growth assumptions reduced the overall system revenues by 2.93% percent, while at the same time the operating cost increased by 9.00% due to allocation of additional Amtrak overhead costs to the corridor.

Exhibit 7-8: Sensitivity Impact on the Operating Ratio for Route 2 110-mph, 8 RT Options



Predictably as shown in Exhibit 7-8, this reduction in revenue and increase in operating costs reduces the operating ratio from 1.35 down to 1.20. However, the operating ratio remains positive which means that even with this increased Amtrak cost allocation, the system can still cover its operating cost and will not need an operating subsidy.

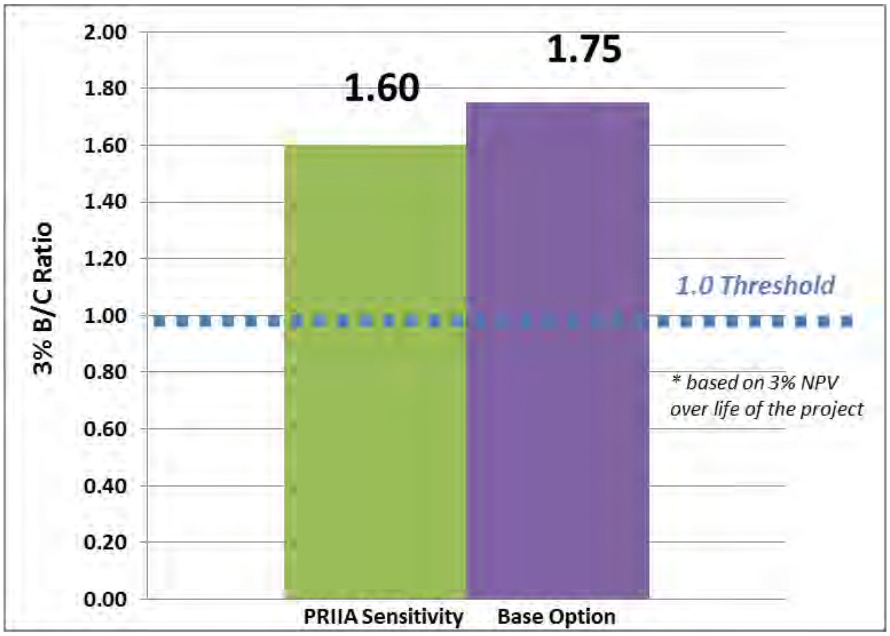
Similarly as shown in Exhibit 7-9, this reduction in revenue and increase in operating costs reduces the forecasted 2030 operating surplus from $12.43 million down to $7.02 million per year. However, the system is still able to develop a positive cash flow which means that not only can it cover all of its own operating cost and run without a subsidy, but it is even able to start covering some of its own capital costs.

Exhibit 7-9: Sensitivity Impact on the 2030 Operating Surplus for Route 2 110-mph, 8 RT Options

7.3.2 Economic Impacts

A sensitivity analysis was also developed to test the impact of the revenue reduction and increased operating cost on the economic viability of the project. (See Exhibit 7-10). Because of the ridership reduction, public benefits such as congestion relief also experienced a reduction and this had the effect of reducing the project Cost Benefit ratio from 1.75 to 1.60. However, even with PRIIA costs and reduced demographic growth rates the project remains viable and justified as a public investment since its benefits still exceed its costs by a wide margin.

Exhibit 7-10: Sensitivity Impact on the 3% Cost Benefit Ratio for Route 2 110-mph, 8 RT Options



The impact of the two adjustments population growth and PRIIA costing, is to lower the overall ridership and revenue forecasts (slightly) and the financial and economic returns. The financial operating ratio is reduced by 12 percent, the operating surplus by 44 percent and the cost benefit ratio by 9 percent.

The changes do not affect the ordering of the project alternatives, with Route 2 retaining the best results for the corridor. Under these more conservative assumptions the corridor is still viable as it continues to meet all the required USDOT FRA financial and economic criteria.

7.4 Conclusion

The results of the Preliminary Financial and Economic Analysis show that Route 2 via Howell and Ann Arbor has the best financial and economic results. The financial operating surplus for Route 1 and Route 2's 110-mph 4 and 8 round trips per day service are comparable despite Route 1 having slightly higher ridership.

With respect to the economic results, Route 2 shows consistently higher returns than Route 1 and Route 3. (See Exhibits 7-6 and 7-7). Also, the impact of frequency is clear even with the 79-mph, 4 round trip options having a strongly positive economic result.

The Sensitivity Analysis performed on Route 2 also supports it as being a viable alternative that would be able to meet the required USDOT FRA financial and economic criteria despite being subjected to the MDOT Statewide Travel Demand Model's more conservative demographic growth assumptions.

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Chapter 8
Public Engagement

SUMMARY

This chapter discusses the Public Engagement aspect of the study.

8.1 Introduction

Public Engagement was an important element of the Coast-to-Coast Passenger Rail Ridership & Cost Estimate Study. The Michigan By Rail (MBR) team, an informal coalition led by Michigan Environmental Council (MEC) that works to advance passenger rail in Michigan, managed the public engagement portion of this study.

MBR hosted 16 public meetings across the corridor to meet with residents and community leaders to share information and gather feedback for the study. Eleven[66] of the 16 meetings were traditional, town-hall style meetings held at popular local gathering places like schools, libraries and other community centers in the evenings. The remaining five[67] meetings were held on college campuses across the corridor and designed as "open house" style meetings, allowing students to stop by to learn about the study and provide feedback as they were on their way to class, lunch or the library. Meetings were publicized widely through the traditional and social media via local community organizations and public entities.

The MBR team also used the online public engagement tool, mySidewalk, to gather feedback and share information about the Coast-to-Coast study.[68] This tool, implemented by MEC, allowed the study team to gather feedback similar to that of the traditional public meetings, but reach a broader audience who may want to provide input but are not able to attend a public meeting.

Between traditional, campus and online engagement, 575 people participated in the public engagement process for this study.

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[66] "Traditional, town-hall style" meetings took place in Holland, Grand Rapids, Cascade Township, Lansing, Howell, Brighton, Dearborn, Ypsilanti, Detroit, Ann Arbor, and Plymouth in June and July of 2015.

[67] Campus meetings took place at Grand Valley State University (Grand Rapids), Michigan State University (East Lansing), University of Michigan (Ann Arbor), Hope College (Holland) and Wayne State University (Detroit) in September and October 2015.

[68] mySidewalk is a free online civic engagement tool used by over 1400 organizations around the United States. Visit mysidewalk.com/organizations/289852/coast-to-coast-passenger-rail-study to view the Coast-to-Coast study engagement page, and www2.mysidewalk.com/ to learn more about the company.

8.2 Meeting Purpose

The goals of the public engagement portion of this study were:

1. To inform leaders, stakeholders, and the general public about the project, including the concept of the study and perceived next steps.
2. To garner public feedback to inform the study, which included:
    - Travel location and destination information
    - General support or opposition
    - Fare estimates / willingness to pay
    - Frequency of travel
    - Purpose of travel
    - Amenities required and desired
    - Other comments (open-ended)
3. To connect resident feedback and interests with local and state elected officials.[69]

The information collected complements the quantitative analysis and will help inform next steps and identify gaps in this level of study. Perhaps most importantly, the public meetings and mySidewalk interface provided an opportunity for residents and stakeholders along the corridor to learn about the study and provide feedback.

8.3 Meeting Formats

As described in the introduction, the MBR team used two different meeting formats for our 16 public engagement sessions. For the "traditional, town hall style" meetings, MEC gave a short presentation, providing background on the scope of the study. Participants were then guided through group activities to gather feedback about current travel, qualities and amenities of service and potential community impacts. The meetings closed with an open-ended question and answer session. A total of 242 people attended these 11 meetings.

The campus meetings followed an "open house" format. This meeting format allowed for a high number of relatively short interactions with students and staff. The MBR team focused these interactions by sharing information about the Coast-to-Coast concept and study and asking participants complete a basic comment card. The comment cards asked two simple questions: "Would you use a passenger rail service connecting Detroit, Ann Arbor, Lansing, Grand Rapids, and Holland? Why or Why not?" and "What other comments would you like to share for the Coast-to-Coast Passenger Study?" A total of 283 people participated in the five campus meetings by completing comment cards.

[69] More than a dozen elected officials or their staff attended the public engagement meetings.

8.4 Public Feedback

8.4.1 Traditional Public Meetings

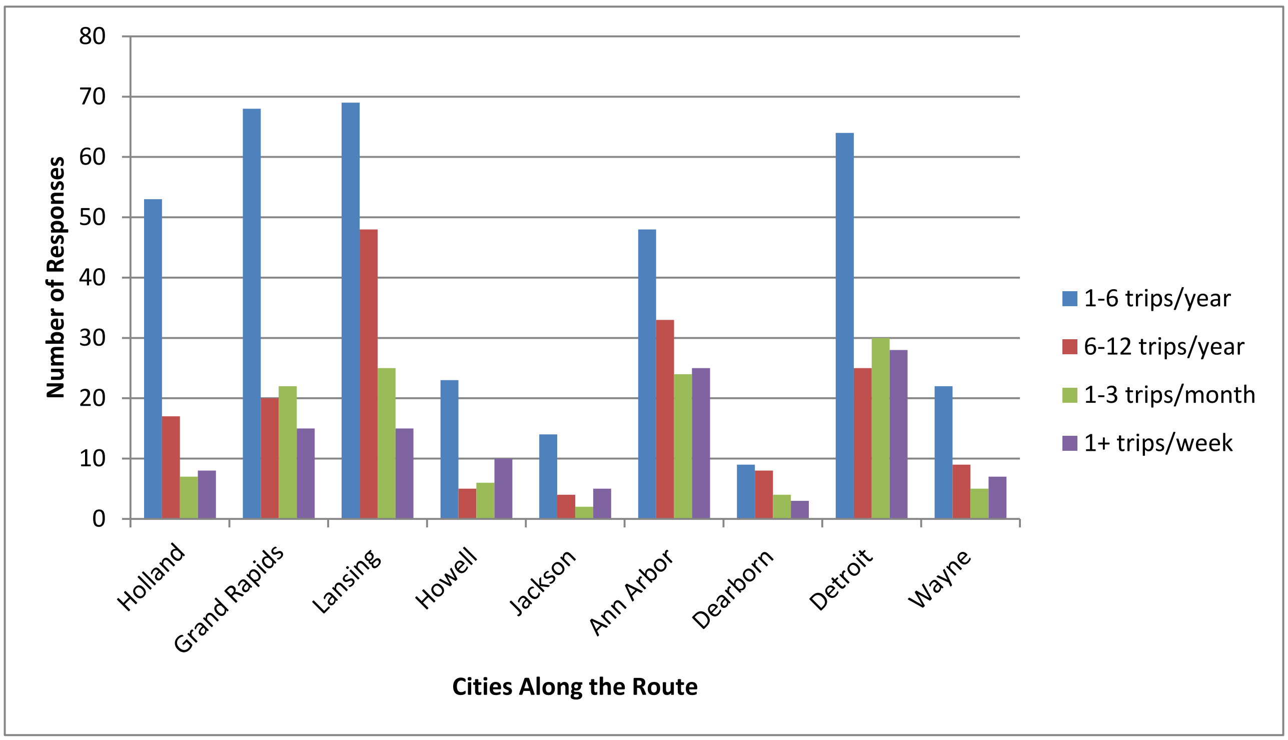
As described above, attendees of the "traditional, town hall style" meetings were asked to participate in small group activities to provide feedback about their travel patterns, potential impacts of the service and answer questions about their priorities of a service like the Coast-to-Coast.

Feedback from those three activities is summarized below.

1. Where and how often do you travel along the Coast-to-Coast corridor?

To get an anecdotal understanding of travel patterns along the corridor, participants were asked to use colored dots on a map of the proposed route to indicate the frequency and location of current travel in the corridor. The results are listed in Exhibit 8-1 below.

Exhibit 8-1: Frequency of Curent Travel to Cities on Proposed Rail Route



Meeting participants listed Grand Rapids, Lansing, Ann Arbor, and Detroit as the most frequently visited cities overall. This activity is helpful to get participants familiar with the proposed corridor and how it might impact their travel choices; however, because the sample size is not large enough to be statistically significant nor based on travel models and demographic data, it does not provide a statistically complete depiction of travel in the corridor.

2. ***Rank qualities of services and amenities are most important to you in passenger rail service like the Coast-to-Coast.***

For this activity, participants were asked to rank—with 1 being the most important and 10 being the least important—qualities and amenities of service. Participants used a pre-developed worksheet with ten options to rank and blank lines to write in additional suggestions.

Below are the combined ranking results, listed in order of most frequently listed as most important to most often listed as least important.

1. ***Frequency of Service***
2. ***Proximity to my origin and destination***
3. ***Low cost tickets***
4. ***Train and seat comfort***
5. ***Free Wi-Fi***
6. ***Special event train service***
7. ***Work space***
8. ***Station amenities***
9. ***Food and beverage service on board***

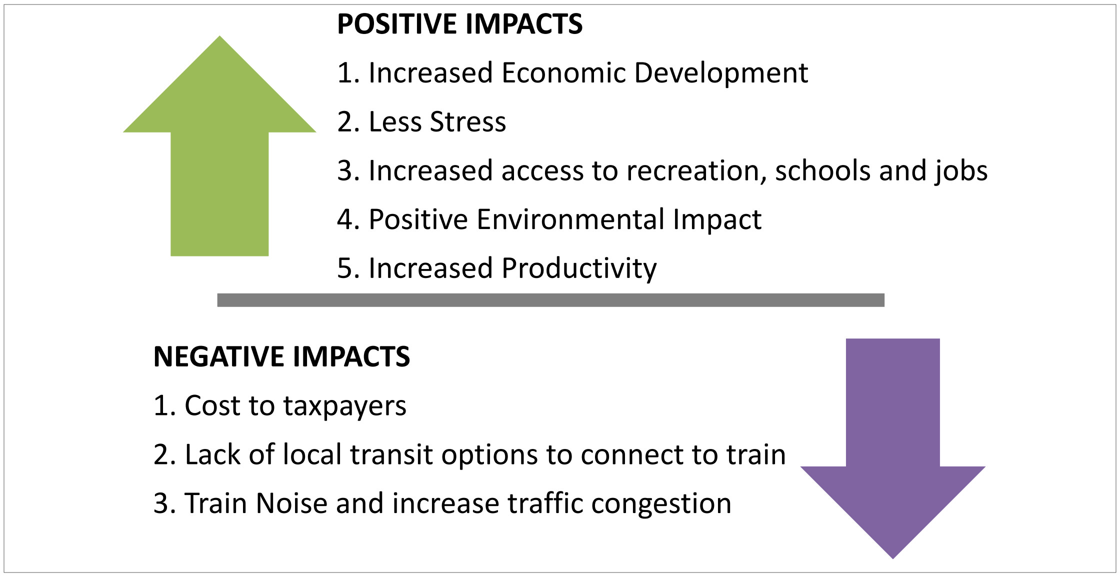
Participants also wrote-in the following service elements as important (in no particular order):

- Service reliability
- Bike storage
- Competitive with automobile travel
- Coordination with local transit service and other transportation options

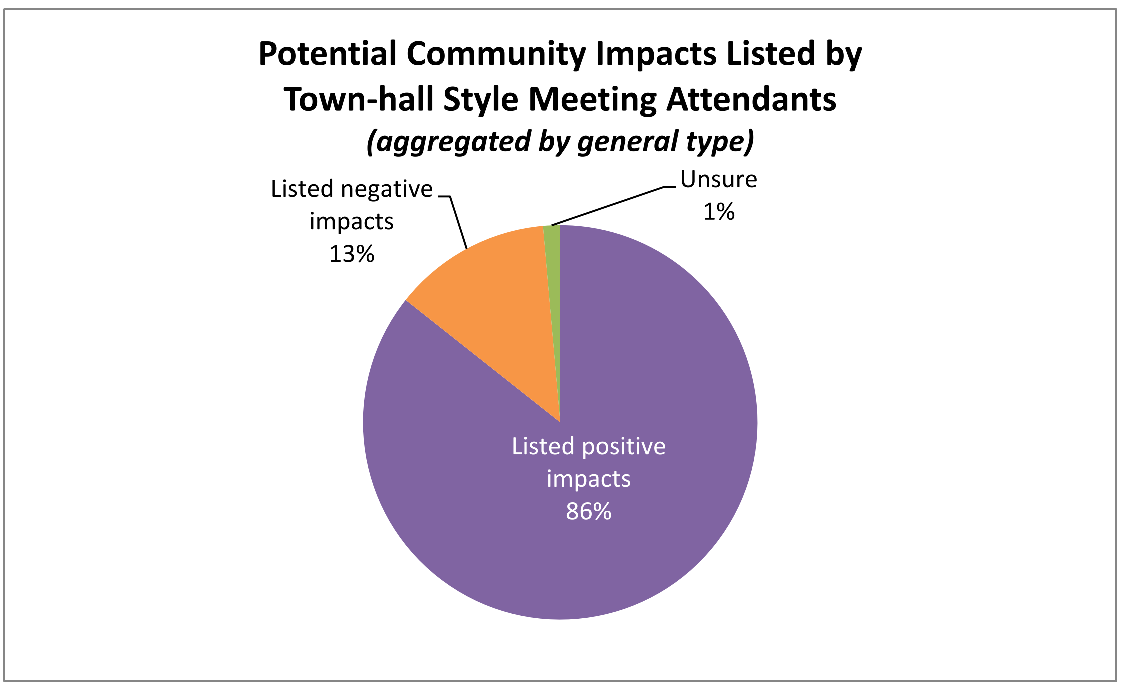
3. ***What potential positive and negative impacts do you think the Coast-to-Coast service would have on your community?***

For this activity, participants were invited to list impacts in an open-ended fashion; sometimes simply listing impacts and others providing anecdotes about perceived impacts. Exhibit 8-2 describes the most common positive and negative impacts listed by all participants.

Exhibit 8-2: Top Positive & Negative Impacts Listed



Overall, respondents were more likely to respond positively to the proposed rail system. The total number of comments garnered was 389. Eighty-six percent of individuals stated that Michigan residents would in some way benefit from a Coast-to-Coast rail system. Thirteen percent of respondents listed potential negative community impacts that this service could have on their communities or the state.



Below is a sample of anecdotal responses to this question:

"Safer commute = less stress = healthier people"

"We are in the early phase of a highway funding crisis. There is not enough funding to support the road infrastructure that we have in place via gas taxes. Rail is more efficient and lower cost to maintain in the long run."

"Difficult to travel if not in city center with lack of public transportation options"

"Increased fun and spontaneity! Would be more likely to hop on a train to Detroit for a concert or game if didn't have to deal with parking"

"Trains are safer, quieter, less stressful, and more productive but they do not usually pay for themselves"

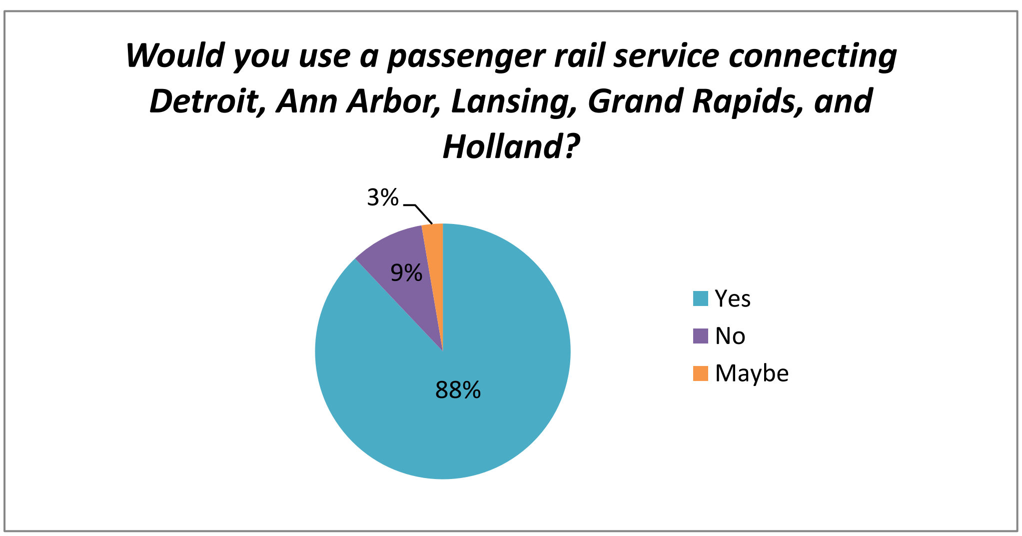
Feedback from these small group activities provides general information about the public reaction to the Coast-to-Coast rail concept. It also allowed participants to take part in a conversation about the study and, more generally, transportation in Michigan; making it more likely that meeting attendees will continue to be involved in future public engagement efforts that may take place and inform the potential development of this service.

8.4.2 Campus Meetings

In contrast to the traditional public meetings, the campus meetings were aimed at interacting with a large amount of people in a short period of time to provide information and quickly and briefly collect general feedback for the study. The MBR team went to campuses to engage students directly in the process, as students are generally less likely to participate in a traditional town hall meeting and are frequent users of the existing passenger rail service in Michigan.[70]

As depicted in Exhibit 8-3, 88 percent of college students stated that they would use a new passenger rail service like the Coast-to-Coast.

Exhibit 8-3: Campus Feedback



[70] Ridership statistics in college towns

Like the traditional meetings, most students we spoke with were largely supportive of expanding passenger rail, citing convenience, greater ability to visit family and friends and increased access to other cities as top reasons why they would use a passenger rail system. Of the students who responded "No" on comment cards, many cited that they did not have a need for passenger rail in Michigan given that they lived out of state. Students who responded with "Maybe" generally cited cost and convenience as determining factors in whether or not they would use a passenger rail system in the future.

Below is a sample of comments students shared about the Coast-to-Coast concept:

> *"Would need to go faster and be more convenient than driving."*
>
> *"Reasonable, on time performance would be my number one priority."*
>
> *"It would be time consuming."*
>
> *"We must get our railroads together - creates another way of travel, saves fuel, can create more jobs. It is essential that we have an alternate other than cars and planes."*
>
> *"Great to go to sporting events"*
>
> *"I have never really ridden a train to get anywhere because there are none in areas I need."*

Similar to the traditional public meetings, students had a variety of comments to share with common threads prioritizing reliability and competitiveness with automobile travel.

8.4.3 Online Engagement

mySidewalk provided an accessible online public engagement tool, which we used to complement the 16 public meetings. This interface spurred a surprising amount of activity from August through November 2015 with 3726 page views, 399 total responses, 7 "likes," and 406 interactions (Exhibit 8-4). While many people visited the page, we estimate that about 50 people actively provided feedback through this medium.

Exhibit 8-4: Overall mySidewalk Activity

3726	399	7	406
VIEWS	RESPONSES	LIKES	Interactions

Similar to the activities in the traditional meetings, the following prompts were posted on the mySidewalk page and received the responses also included here:

8-5: Current Travel Question & Response

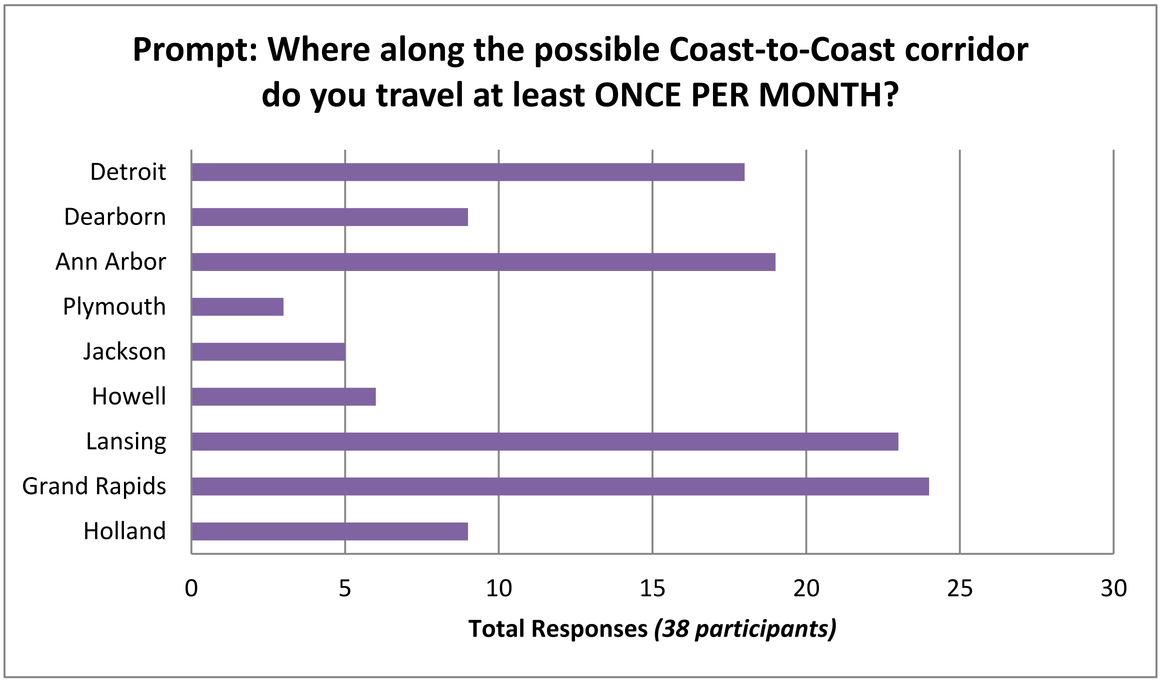


Exhibit 8-6: Community Impacts Question & Response

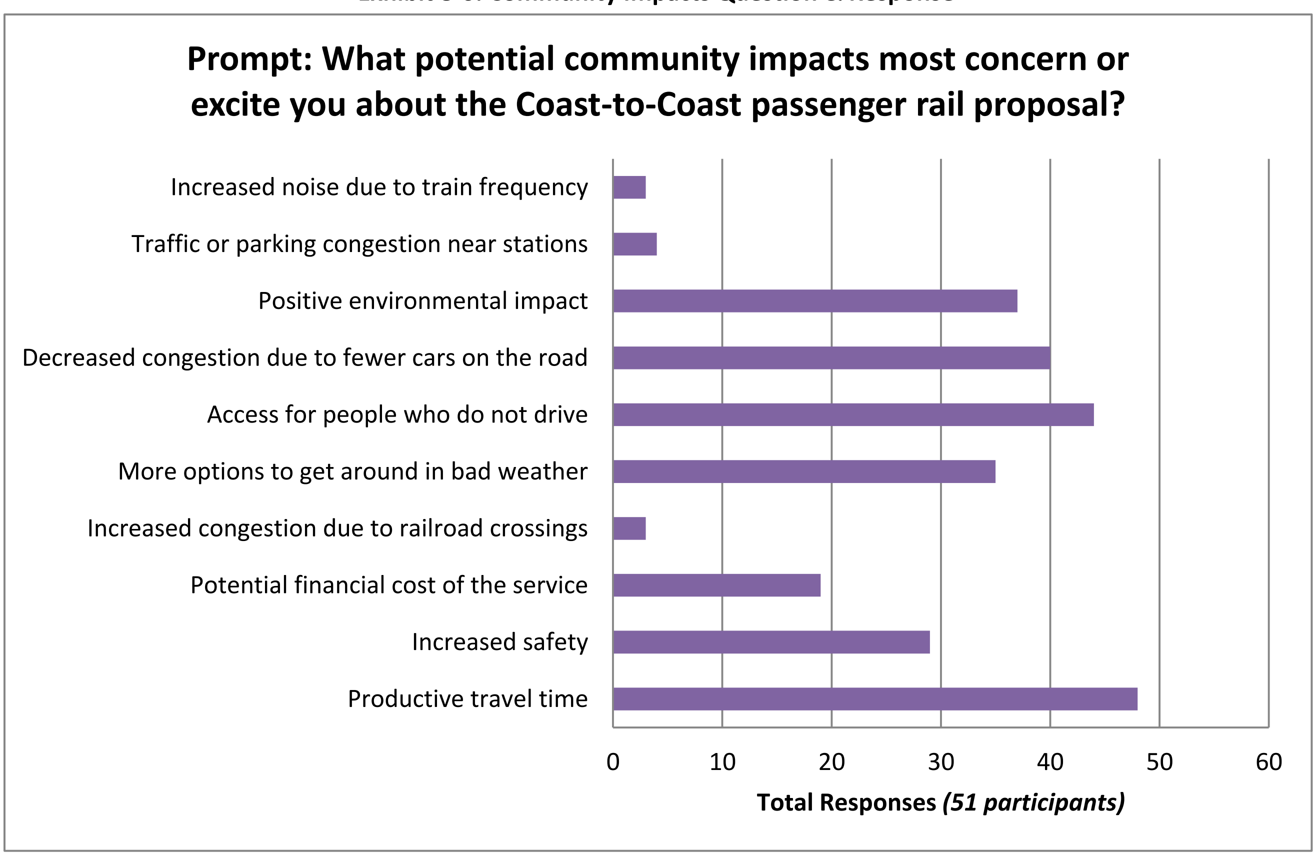


Exhibit 8-7: General Input Question

Prompt: What do you think of the idea to reconnect Detroit, Lansing, Grand Rapids and Holland via passenger rail?

A sample of responses from the question posed in Exhibit 8-7 is listed below. *There were eight participants that responded to this prompt.*

> *"The coasts themselves are less important to me than the cities along the route -- the population, employment, and education hubs of the state. I regularly travel from Ann Arbor to Detroit, Lansing, and Grand Rapids for my job: having a coast-to-coast rail option running a few times daily would give me more productive time while I travel instead of contributing to congestion."*

> *"It would be SUCH A WONDERFUL thing to hop on a train in Lake Odessa and go to Detroit! Tiger games, the International Auto Show, concerts would all be easily in reach!!!!!"*

> *"This train needs to go farther than Detroit in my honest opinion. Toledo or even Cincinnati would be much better end destinations…"*

> *"This would be an excellent, for both transportation and development. Track and grade crossing improvements would also improve safety and attract industry."*

8.5 Conclusion

Through traditional, campus and online engagement, the MBR team connected with 575 people to share information and gather feedback for this study. The public engagement process for this study is crucial for informing next steps in the process, as well as bringing stakeholders and the general public into the conversation about expanding passenger rail in Michigan.

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Chapter 9
Conclusions and Next Steps

SUMMARY

This chapter outlines the key findings of the study, and the next steps that should be taken to move the Coast-to-Coast Passenger Rail Line project forward.

9.1 Conclusions

The results of the Ridership and Preliminary Financial and Economic Analyses support a recommendation for further study on Route 1 and Route 2. These specific study recommendations are outlined in section 9.2, but should aim to understand the environmental impacts and specific engineering requirements of the service, and further analyze the relationship of the proposed service with existing and developing services in the region.

Overall, the study found that there are two viable routes among the Coast-to-Coast route options considered in this analysis:

- Route 1 has the highest forecasted ridership, although many of the trips are Chicago oriented, and further analysis would be required to fully understand the ridership demand independent to the Wolverine corridor. This option also has a higher capital cost and longer transit time than Route 2.
- Route 2 via Howell and Ann Arbor has the best financial and economic results and the second best ridership forecast.
- Route 3 has a much weaker ridership forecast and financial and economic performance because it misses the important intermediate market of Ann Arbor.

However, the study finds that 110-mph options along any of the routes could meet USDOT FRA financial and economic thresholds. At the currently projected level of capital costs, 79-mph options with four round trips meet FRA economic criteria, but fail FRA financial criteria since all 79-mph options would continue to require an operating subsidy.

In the current forecast, Route 1 ridership benefits from individuals who want to go to Chicago using the train between Lansing and Jackson as a way to connect with trains going to Chicago from Detroit. This is why Route 1 shows the highest ridership of all the options. However, as shown in Exhibit 9-1:

- If the Port Huron route via Battle Creek remains at its current level or if the current Blue Water service were ended, it is likely that the Jackson route would attract a significant Lansing to Chicago ridership.

- If the Port Huron route via Battle Creek were improved to a level of four daily round trips, as called for by the MWRRS plan, Chicago riders would likely go directly via Battle Creek rather than via Jackson.

- Alternatively, if a western outlet from Grand Rapids to Chicago were developed, then Lansing to Chicago riders could go via Grand Rapids rather than via Battle Creek. This would further bolster the economics of the west end of the proposed Coast-to-Coast intercity rail corridor.

As a result, the potential for Chicago traffic could add to Route 1 ridership in the short term, but this traffic may well disappear if either frequency were increased on the Bluewater train via Battle Creek, or if the Grand Rapids-Chicago service were fully developed. This makes the Route 1 forecast riskier than the forecasts for Route 2 and 3, which do not depend so much on Chicago traffic, although further study would be required to understand this relationship.

Exhibit 9-1: Three Ways to Go from Lansing to Chicago

As a result, the network options for connecting Lansing, Saginaw, Flint, Port Huron and Grand Rapids to Chicago can only be finally determined by a statewide study, yet they may have a significant influence on the analytical results guiding selection of the best route option for the Coast-to-Coast corridor. For example, FRA's PRIIA guidance suggests that State Rail Plans be updated every five years. Since Michigan's State Rail Plan was last issued in 2011, the next update is due in 2016. It may be appropriate to address this issue in the next State Rail plan update.

Route 2 at 110-mph also offers a very strong option in that:

- It best meets USDOT FRA criteria having the best financial and economic performance

- The Route 2 ridership forecast is the least risky since this option serves all the major markets, and the ridership base is strongly focused on Holland to Detroit ridership. There is not much potential that it will be negatively affected if the Blue Water's connections to Chicago were improved, as would be the case for Route 1. But if the Grand Rapids to Chicago service were improved, there is a strong upside potential that the Coast-to-Coast corridor's financials could be even better than have currently been projected.

- Because it produces an operating surplus, the operation can be franchised to be operated by one of a number of private passenger rail operators or Amtrak

- Offers very considerable economic and environmental benefits to the communities of southern Michigan, which is an area of very strong positive economic growth. Connecting these economically vibrant areas of Michigan to Detroit will also help Detroit, which has been economically battered by the decline in the traditional manufacturing sector, to participate in emerging "new economy" growth that Grand Rapids and Lansing have been enjoying.

Aside from the strength of Route 2 as an intercity corridor option, development of Route 2 has obvious synergy with Michigan DOT's plans for developing commuter rail services both from Howell to Ann Arbor (e.g. North-South Commuter Rail line) and from Ann Arbor to Detroit. It also is synergistic with the ability to develop a Detroit to Cadillac rail service over the tracks of the Great Lakes Central railroad, as was proposed in the 2011 Michigan State Rail plan.

By using the proposed new Huron River bridge track connection in downtown Ann Arbor, the North-South Commuter Rail service could be redirected to serve the Medical Center, where it could effectively integrate with both intercity rail services as well as the proposed high-capacity corridor link. Operationally, this would enable through-routing commuter trains with the Ann Arbor to Detroit commuter service so that a rider from Howell could travel not only to Ann Arbor, but also to Detroit as well.

Furthermore, the joint development of the Coast-to-Coast intercity service along with the commuter rail component would substantially reduce the cost of the North-South Commuter Rail line by eliminating the need for rehabilitating track south of the Huron River to passenger standards. As well, the cost for all of the North South Commuter Rail's proposed Ann Arbor stations would be eliminated if the decision to relocate the Ann Arbor Amtrak station to the Medical Center location moves forward. All of this offers the possibility for substantial improvements in ridership and also a reduction of both operating and capital cost by combining the two commuter rail lines into a single project, as compared to the current two separate and disconnected services.

This shows the criticality of completing the Huron River bridge track connection at the earliest possible date. Rail improvements on the Ann Arbor line south of the Huron River, including relocating the freight interchange, would not then be needed for passenger service but could be separately pursued using freight rail enhancement funds. This ability to restructure and integrate the proposed commuter rail service would be facilitated by the same infrastructure investment that is needed for the Route 2 intercity rail system. This synergy could be further developed and explored in a future study.

A final issue is a technical one having to do with the development and implementation of PTC technology in Michigan. Cost estimates for installation of PTC and signaling systems have recently experienced a rapid escalation as a result of the FRA's PTC mandate for all passenger services. Michigan DOT must also ascertain CSX's plans not only for retaining signaling, but also for installing PTC on its Plymouth to Grand Rapids line. It is understood that Michigan has been on the leading edge of PTC systems, since the Porter to Kalamazoo line has for a number of years served as the test-bed for new PTC development and testing. This "R&D" aspect of PTC development undoubtedly reflects in Michigan's PTC historical costs, but should not necessarily be replicated as the technology continues to mature in the future. TEMS costs for PTC and signaling in the C2C study are in the $410-470K per mile range, which is in line with accepted industry comparable costs. For keeping PTC cost at manageable levels in the future, it is recommended that Michigan DOT consider installing non-overlay versions of PTC (such as Alaska Railroad's system) and also obtain industry certification for the freight railroad standard I-ETMS up to 110-mph. Doing this would avoid having to install redundant (ITCS + I-ETMS) systems in shared-used territory, since the freight railroads do not want to have to equip their locomotive fleets for ITCS. Further work is needed to determine the most appropriate PTC standard for new installations like those proposed for the North-South Commuter Rail line and Coast-to-Coast rail corridors.

9.2 Next Steps

In order to move the project forward as a public or public/private project TEMS would advise:

- Complete a comprehensive Environmental Study of the corridor. In some areas only a Categorical Exclusion may be needed rather than a full EIS, since the work would be accomplished within existing rail rights of way.
- Develop a technical assessment of PTC options for future Michigan passenger rail projects for better compatibility with freight rail systems and reduced cost.
- Consider the potential for a PPP/franchise in order to attract private capital to the project.
- Develop a detailed Implementation Plan, outlining the short and long term actions that might be taken to initiate service at 79 mph and over time, upgrade that service to the level proposed at 110-mph.
- Work closely with the Chicago-Detroit/Pontiac corridor and North-South Commuter Rail teams to identify the additional infrastructure and facilities that they might need or could be mutually beneficial if the Coast-to-Coast project moves forward. For example, one question to consider may be whether Coast-to-Coast trains ought to terminate in downtown Detroit, or if some of them should be extended through to Pontiac or even points north, such as Flint or Saginaw.
- Complete a Statewide Study to assess the future development options for passenger rail services for connecting Lansing, Saginaw, Flint, Port Huron, Cadillac, Muskegon and Grand Rapids to both Chicago and Detroit. As part of this study, also assess potential synergies between intercity and commuter rail corridor development needs.

Exhibit 9-2 provides a summary and comparison of the results from all analyses for each of the Coast-to-Coast Corridor Route Options: Option 1, Option 2 and Option 3.

Exhibit 9-2: Coast-to-Coast Route Options: Comparison of Results for all Analyses

Coast to Coast Route Options: Comparison of Results for All Analyses

Operations / Ridership/ Financial / Economic Results		ROUTE 1				ROUTE 2				ROUTE 3			
		79 mph		110 mph		79 mph		110 mph		79 mph		110 mph	
		2 (DRTs)	4 (DRTs)	4 (DRTs)	8 (DRTs)	2 (DRTs)	4 (DRTs)	4 (DRTs)	8 (DRTs)	2 (DRTs)	4 (DRTs)	4 (DRTs)	8 (DRTs)
Travel Time (One Way)	Travel Time: Holland - Detroit	4:03	4:03	3:06	3:06	3:48	3:48	2:55	2:55	3:36	3:36	2:45	2:45
Rail Ridership	Year 2030 (Million Annual Person Trips)	0.40	0.68	0.95	1.43	0.37	0.63	0.88	1.33	0.30	0.52	0.73	1.08
Surplus (Million$)	2030 Operating Surplus/(Subsidy)	($4.04)	($6.04)	$5.89	$14.43	($3.05)	($5.20)	$5.58	$12.43	($3.36)	($5.86)	$3.87	$6.28
Financial NPV (Million$ @ 3% Disc. Rate)	Total Revenue	$136.76	$234.82	$503.33	$747.89	$119.06	$210.90	$463.49	$674.09	$92.76	$172.71	$391.23	$559.39
	NPV	($53.55)	($70.13)	$80.45	$200.10	($40.82)	($58.44)	$75.59	$175.75	($38.05)	($63.74)	$52.77	$111.15
	Operating Cost	$190.30	$304.94	$422.88	$547.79	$159.88	$269.34	$387.90	$498.34	$130.82	$236.45	$338.46	$448.23
	Operating Ratio	0.72	0.77	1.19	1.37	0.74	0.78	1.19	1.35	0.71	0.73	1.16	1.25
Capital Cost (Million$)	Capital Cost at 3% (Discount Rate)	$195.50	$232.20	$691.60	$711.70	$185.60	$220.70	$583.20	$599.90	$174.10	$205.10	$559.20	$570.70
Economic NPV (Million$ - 3% Discount Rate)	Total Benefits	$344.82	$661.48	$1,177.20	$1,866.37	$299.15	$605.31	$1,093.28	$1,705.41	$235.18	$510.75	$935.92	$1,438.19
	Total Costs	$335.31	$477.21	$968.90	$1,108.73	$297.57	$433.05	$851.87	$974.72	$259.95	$388.60	$787.09	$905.34
	NPV(Surplus)	$9.51	$184.27	$208.30	$757.64	$1.58	$172.26	$241.41	$730.69	($24.77)	$122.15	$148.83	$532.86
	Benefit/Cost Ratio	1.03	1.39	1.21	1.68	1.01	1.40	1.28	1.75	0.90	1.31	1.19	1.59

Note: All 79 & 110 mph trains use Diesel Technology. All financial and economic figures are in 2013$. Ridership is for rail corridor extending from Holland to Detroit. A trip is defined as a passenger making a one-way trip and a round trip generates two one way trips.

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Technical Appendices

Appendix A: COMPASS™ Model

The COMPASS™ Model System is a flexible multimodal demand-forecasting tool that provides comparative evaluations of alternative socioeconomic and network scenarios. It also allows input variables to be modified to test the sensitivity of demand to various parameters such as elasticities, values of time, and values of frequency. This section describes in detail the model methodology and process used in the study.

Description of the COMPASS™ Model System

The COMPASS™ model is structured on two principal models: Total Demand Model and Hierarchical Modal Split Model. For this study, these two models were calibrated separately for two trip purposes, which are Business and Non-Business. For each market segment, the models were calibrated on base year origin-destination trip data, existing network characteristics and base year socioeconomic data.

Since the models were calibrated on the base year data, when applying the models for forecasting, an incremental approach known as the “pivot point” method is used. By applying model growth rates to the base data observations, the “pivot point” method is able to preserve the unique travel flows present in the base data that are not captured by the model variables. Details on how this method is implemented are described below.

Total Demand Model

The Total Demand Model, shown in Equation 1, provides a mechanism for assessing overall growth in the travel market.

Equation 1:

$$T_{ijp} = e^{\beta_{0p}}(SE_{ijp})^{\beta_{1p}} e^{\beta_{2p} U_{ijp}}$$

Where,

T_{ijp}	=	Number of trips between zones *i* and *j* for trip purpose *p*
SE_{ijp}	=	Socioeconomic variables for zones *i* and *j* for trip purpose *p*
U_{ijp}	=	Total utility of the transportation system for zones *i* to *j* for trip purpose *p*
$\beta_{0p}, \beta_{1p}, \beta_{2p}$	=	Coefficients for trip purpose *p*

Equation 1, the total number of trips between any two zones for all modes of travel, segmented by trip purpose, is a function of the socioeconomic characteristics of the zones and the total utility of the transportation system that exists between the two zones. For this study, trip purposes include Business and Non-Business. The socioeconomic characteristics consist of population, employment and average income. The utility function provides a measure of the quality of the transportation system in terms of the times, costs, reliability and level of service provided by all modes for a given trip purpose. The Total Demand Model equation may be interpreted as meaning that travel between zones will increase as socioeconomic factors such as population and income rise or as the utility (or quality) of the transportation system is improved by providing new facilities and services that reduce travel times and/or costs. The Total Demand Model can therefore be used to evaluate the effect of changes in both socioeconomic and travel characteristics on the total demand for travel.

Socioeconomic Variables

The socioeconomic variables in the Total Demand Model show the impact of economic growth on travel demand. The COMPASS™ Model System, in line with most intercity modeling systems, uses three variables (population, employment, and average income) to represent the socioeconomic characteristics of a zone. Different combinations were tested in the calibration process and it was found, as is typically found elsewhere, that the most reasonable and statistically stable relationships consist of the following formulations:

Trip Purpose	***Socioeconomic Variable***
Business	$E_i E_j (I_i + I_j) / 2$
Non-Business	$(P_iE_j+P_jE_i) / 2 (I_i+I_j) / 2$

The Business formulation consists of a product of employment in the origin zone, employment in the destination zone, and the average income of the two zones. Since business trips are usually made between places of work, the presence of employment in the formulation is reasonable. While the income factor is correlated to the type of employment, higher income levels generate more Business trips. The Non-Business formulation consists of all socioeconomic factors, this is because commuter trips are between homes and places of work, which are closely related to population and employment, and income factor is related to the wealth of the origin zone and the type of employment in the destination zone, leisure and social trip are correlated to population in the origin zone and destination zone and the average income of the two zones.

Travel Utility

Estimates of travel utility for a transportation network are generated as a function of generalized cost (GC), as shown in Equation 2:

Equation 2:

$$U_{ijp} = f(GC_{ijp})$$

where,

GC_{ijp}=Generalized Cost of travel between zones *i* and *j* for trip purpose *p*

Because the generalized cost variable is used to estimate the impact of improvements in the transportation system on the overall level of trip making, it needs to incorporate all the key attributes that affect an individual’s decision to make trips. For the public modes (i.e., rail and bus), the generalized cost of travel includes all aspects of travel time (access, egress, in-vehicle times), travel cost (fares), and schedule convenience (frequency of service, convenience of arrival/departure times). For auto travel, full average cost of operating a car is used for Business, while only the marginal cost is used for Commuter and Other trips. In addition, tolls and parking charges are used where appropriate.

The generalized cost of travel is typically defined in travel time (i.e., minutes) rather than dollars. Costs are converted to time by applying appropriate conversion factors, as shown in Equation 3. The generalized cost (GC) of travel between zones *i* and *j* for mode m and trip purpose p is calculated as follows:

Equation 3:

$$GC_{ijmp} = TT_{ijm} + \frac{TC_{ijmp}}{VOT_{mp}} + \frac{VOF_{mp} * OH}{VOT_{mp} * F_{ijm}}$$

Where,

TT_{ijm}=Travel Time between zones *i* and *j* for mode *m* (in-vehicle time + station wait time + connection time + access/egress time), with waiting, connect and access/egress time multiplied by a factor (waiting and connect time factors is 1.8, access/egress factors were determined by VOA/VOT ratios from the SP survey) to account for the additional disutility felt by travelers for these activities.

TC_{ijmp} =Travel Cost between zones *i* and *j* for mode *m* and trip purpose *p* (fare + access/egress cost for public modes, operating costs for auto)

VOT_{mp} =Value of Time for mode *m* and trip purpose *p*

VOF_{mp} =Value of Frequency for mode *m* and trip purpose *p*

F_{ijm} =Frequency in departures per week between zones *i* and *j* for mode *m*

OH =Operating hours per week (sum of daily operating hours between the first and last service of the day)

Station wait time is the time spent at the station before departure and after arrival. On trips with connections, there would be additional wait times incurred at the connecting station. Wait times are weighted higher than in-vehicle time in the generalized cost formula to reflect their higher disutility as found from previous studies. Wait times are weighted 70 percent higher than in-vehicle time.

Similarly, access/egress time has a higher disutility than in-vehicle time. Access time tends to be more stressful for the traveler than in-vehicle time because of the uncertainty created by trying to catch the flight or train. Based on previous work, access time is weighted 80 percent higher for rail and bus travel.

The third term in the generalized cost function converts the frequency attribute into time units. Operating hours divided by frequency is a measure of the headway or time between departures. Tradeoffs are made in the stated preference surveys resulting in the value of frequencies on this measure. Although there may appear to be some double counting because the station wait time in the first term of the generalized cost function is included in this headway measure, it is not the headway time itself that is being added to the generalized cost. The third term represents the impact of perceived frequency valuations on generalized cost. TEMS has found it very effective to measure this impact as a function of the headway.

Calibration of the Total Demand Model

In order to calibrate the Total Demand Model, the coefficients are estimated using linear regression techniques. Equation 1, the equation for the Total Demand Model, is transformed by taking the natural logarithm of both sides, as shown in Equation 4:

Equation 4:

$$\log(T_{ijp}) = \beta_{0p} + \beta_{1p}\log(SE_{ijp}) + \beta_{2p}(U_{ijp})$$

Equation 4 provides the linear specification of the model necessary for regression analysis.

The segmentation of the database by trip purpose resulted in two sets of models. The results of the calibration for the Total Demand Models are displayed in Exhibit 1.

Exhibit 1: Total Demand Model Coefficients (1)

Business	$\log(T_{ij})$	=	-7.4655	+	0.5298	$\log(SE_{ij})$	+	0.6236 U_{ij}	R^2=0.87
			(21)		(613)				
	where $U_{ij} = \log[\exp(-9.8691+0.9976U_{Public}) + \exp(-0.0046\ GC_{Auto})]$								
Other	$\log(T_{ij})$	=	-4.1441	+	0.4466	$\log(SE_{ij})$	+	0.7103 U_{ij}	R^2=0.92
			(252)		(725)				
	where $U_{ij} = \log[\exp(-4.7022+0.9711U_{Public}) + \exp(-0.0056\ GC_{Auto})]$								

(1) *t-statistics are given in parentheses.*

In evaluating the validity of a statistical calibration, there are two key statistical measures: t-statistics and R^2. The *t*-statistics are a measure of the significance of the model's coefficients; values of 1.95 and above are considered "good" and imply that the variable has significant explanatory power in estimating the level of trips. R^2 is a statistical measure of the "goodness of fit" of the model to the data; any data point that deviates from the model will reduce this measure. It has a range from 0 to a perfect 1, with 0.3 and above considered "good" for large data sets. Based on these two measures, the total demand calibrations are good. The *t*-statistics are high, aided by the large size of the data set. The R^2 values imply good fits of the equations to the data.

As shown in Exhibit 1, the socioeconomic elasticity values for the Total Demand Model are 0.53 and 0.36 for business and non-business trips, meaning that each one percent growth in the socioeconomic term generates approximately a 0.53 and 0.36 percent growth in the total business and non-business travel market respectively.

The coefficient on the utility term is not strictly elasticity, but it can be considered an approximation. The utility term is related to the scale of the generalized costs, for example, utility elasticity can be high if the absolute value of transportation utility improvement is significant. This is not untypical when new transportation systems are built. In these cases, a 20 percent improvement in utility is not unusual and may impact more heavily on longer origin-destination pairs than shorter origin-destination pairs.

Incremental Form of the Total Demand Model

The calibrated Total Demand Models could be used to estimate the total travel market for any zone pair using the population, employment, per household income, and the total utility of all the modes. However, there would be significant differences between estimated and observed levels of trip making for many zone pairs despite the good fit of the models to the data. To preserve the unique travel patterns contained in the base data, the incremental approach or "pivot point" method is used for forecasting. In the incremental approach, the base travel data assembled in the database are used as pivot points, and forecasts are made by applying trends to the base data. The total demand equation as described in Equation 1 can be rewritten into the following incremental form that can be used for forecasting (Equation 5):

Equation 5:

$$\frac{T_{ijp}{}^{f}}{T_{ijp}{}^{b}} = \left(\frac{SE_{ijp}{}^{f}}{SE_{ijp}{}^{b}}\right)^{\beta_{1p}} \exp(\beta_{2p}\,(U_{ijp}{}^{f} - U_{ijp}{}^{b}))$$

Where,

T^{f}_{ijp} = Number of Trips between zones *i* and *j* for trip purpose *p* in forecast year *f*

T^{b}_{ijp} = Number of Trips between zones *i* and *j* for trip purpose *p* in base year *b*

SE^{f}_{ijp} = Socioeconomic variables for zones *i* and *j* for trip purpose *p* in forecast year *f*

SE^{b}_{ijp} = Socioeconomic variables for zones *i* and *j* for trip purpose *p* in base year *b*

U^{f}_{ijp} = Total utility of the transportation system for zones *i* to *j* for trip purpose *p* in forecast year *f*

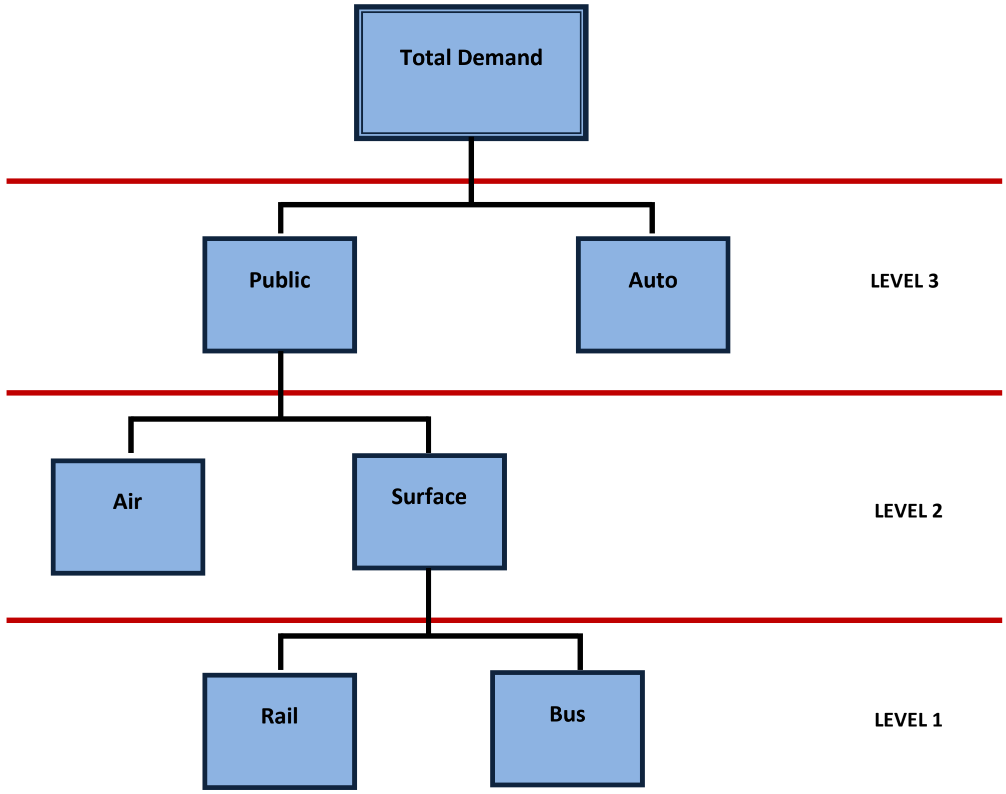
U^{b}_{ijp} = Total utility of the transportation system for zones *i* to *j* for trip purpose *p* in base year *b*

In the incremental form, the constant term disappears and only the elasticities are important.

Hierarchical Modal Split Model

The role of the Hierarchical Modal Split Model is to estimate relative modal shares, given the Total Demand Model estimate of the total market that consists of different travel modes available to travelers. The relative modal shares are derived by comparing the relative levels of service offered by each of the travel modes. The COMPASS™ Hierarchical Modal Split Model uses a nested logit structure, which has been adapted to model the interurban modal choices available in the study area. The hierarchical modal split model is shown in Exhibit 2.

Exhibit 2: Hierarchical Structure of the Modal Split Model

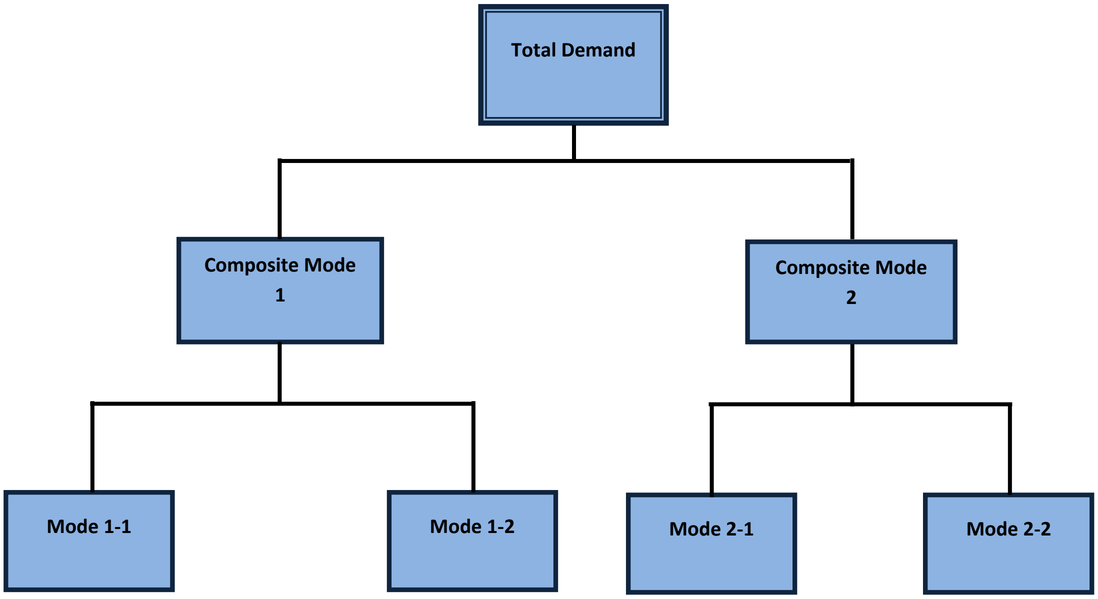


The main feature of the Hierarchical Modal Split Model structure is the increasing commonality of travel characteristics as the structure descends. The upper level of the hierarchy separates private auto travel – with its spontaneous frequency, low access/egress times, low costs and highly personalized characteristics – from the public modes. The lower separates Maglev – a faster and more comfortable public mode – from Transit, which provides slower conventional rail and bus services within the corridor.

Background of the Hierarchical Modal Split Theory

The modal split models used by TEMS derived from the standard nested logit model. Exhibit 3 shows a typical two-level standard nested model. In the nested model shown in Exhibit 3, there are four travel modes that are grouped into two composite modes, namely, Composite Mode 1 and Composite Mode 2.

Exhibit 3: A Typical Standard Nested Logit Model



Each travel mode in the above model has a utility function of U_j, j = 1, 2, 3, 4. To assess modal split behavior, the logsum utility function, which is derived from travel utility theory, has been adopted for the composite modes in the model. As the modal split hierarchy ascends, the logsum utility values are derived by combining the utility of lower-level modes. The composite utility is calculated by

$$U_{N_k} = \alpha_{N_k} + \beta_{N_k} \log \sum_{i \in N_k} \exp(\rho U_i) \qquad (1)$$

where

N_k is composite mode k in the modal split model,

i is the travel mode in each nest,

U_i is the utility of each travel mode in the nest,

ρ is the nesting coefficient.

The probability that composite mode k is chosen by a traveler is given by

$$P(N_k) = \frac{\exp(U_{N_k} / \rho)}{\sum_{N_i \in N} \exp(U_{N_i} / \rho)} \qquad (2)$$

The probability of mode i in composite mode k being chosen is

$$P_{N_k}(i) = \frac{\exp(\rho U_i)}{\sum_{j \in N_k} \exp(\rho U_j)} \qquad (3)$$

A key feature of these models is a use of utility. Typically in transportation modeling, the utility of travel between zones *i* and *j* by mode *m* for purpose *p* is a function of all the components of travel time, travel cost, terminal wait time and cost, parking cost, etc. This is measured by generalized cost developed for each origin-destination zone pair on a mode and purpose basis. In the model application, the utility for each mode is estimated by calibrating a utility function against the revealed base year mode choice and generalized cost.

Using logsum functions, the generalized cost is then transformed into a composite utility for the composite mode (e.g. Public modes in Exhibit 2). This is then used at the next level of the hierarchy to compare the next most similar mode choice (e.g. in Exhibit 2, Public mode is compared with Auto mode).

Calibration of the Hierarchical Modal Split Model

Working from the lower level of the hierarchy to the upper level, the first analysis is that of the Rail mode versus the Bus mode. As shown in Exhibit 4, the model was effectively calibrated for the two trip purposes, with reasonable parameters and R^2 and *t* values. All the coefficients have the correct signs such that demand increases or decreases in the correct direction as travel times or costs are increased or decreased, and all the coefficients appear to be reasonable in terms of the size of their impact.

Exhibit 4: Rail versus Bus Modal Split Model Coefficients [(1)]

Business	log(PRail/PBus)	=	-5.7562	-	0.0134 GCRail	+	0.0105 GCBus	R2=0.70
					(-303)		(322)	
Other	log(PRail/PBus)	=	0.9312	-	0.0062 GCRail	+	0.0048 GCBus	R2=0.75
					(-309)		(377)	

(1) *t-statistics are given in parentheses.*

The coefficients for the upper levels of the hierarchy of Surface mode versus Air mode and Public versus Auto mode are given in Exhibits 5 and 6 respectively. The utility of the composite modes is obtained by deriving the logsum of the utilities of lower level modes from the model. The model calibrations for both trip purposes are statistically significant, with good R^2 and *t* values, and reasonable coefficients.

Exhibit 5: Surface versus Air Modal Split Model Coefficients (1)

Business	log(PSurface/PAir)	=	5.6751	+	0.9795 USurf	+	0.0088 GCAir	R2=0.80
					(425)		(222)	
	where USurf = log[exp(-5.7562-0.0134GCRail) + exp(-0.0105 GCBus)]							
Other	log(PSurface/PAir)	=	-0.2423	+	0.9815 USurf	+	0.0053 GCAir	R2=0.79
					(137)		(63)	
	where USurf = log[exp(0.9312-0.0062GCRail) + exp(-0.0048 GCBus)]							

(1) *t-statistics are given in parentheses.*

Exhibit 6: Public versus Auto Modal Split Model Coefficients (1)

Business	log(PPublic/PAuto)	=	-9.8691	+	0.9976 UPublic	+	0.0046 GCAuto	R2=0.90
					(384)		(203)	
	where UPublic = log[exp(5.6751+0.9795USurface) + exp(-0.0088 GCAir)]							
Other	log(PPublic/PAuto)	=	-4.7022	+	0.9711 UPublic	+	0.0056 GCAuto	R2=0.88
					(266)		(326)	
	where UPublic = log[exp(-0.2423+0.9815USurface) + exp(-0.0053 GCAir)]							

(1) *t-statistics are given in parentheses.*

Incremental Form of the Modal Split Model

Using the same reasoning as previously described, the modal split models are applied incrementally to the base year data rather than imposing the model-estimated modal shares. Different regions of the corridor may have certain biases toward one form of travel over another and these differences cannot be captured with a single model for the entire system. Using the "pivot point" method, many of these differences can be retained. To apply the modal split models incrementally, the following reformulation of the hierarchical modal split models is used (Equation 6):

Equation 6:

$$\frac{\left(\frac{P_A^f}{P_B^f}\right)}{\left(\frac{P_A^b}{P_B^b}\right)} = e^{\beta(GC_A^f - GC_B^b) + \gamma(GC_B^f - GC_B^b)}$$

For hierarchical modal split models that involve composite utilities instead of generalized costs, the composite utilities would be used in the above formula in place of generalized costs. Once again, the constant term is not used and the drivers for modal shifts are changed in generalized cost from base conditions.

Another consequence of the pivot point method is that it prevents possible extreme modal changes from current trip-making levels as a result of the calibrated modal split model, thus avoiding over or under estimating future demand for each mode.

Induced Demand Model

Induced demand refers to changes in travel demand related to improvements in a transportation system, as opposed to changes in socioeconomic factors that contribute to growth in demand. The quality or utility of the transportation system is measured in terms of total travel time, travel cost, and worth of travel by all modes for a given trip purpose. The induced demand model uses the increased utility resulting from system changes to estimate the amount of new (latent) demand that will result from the implementation of the new system adjustments. The model works simultaneously with the mode split model coefficients to determine the magnitude of the modal induced demand based on the total utility changes in the system. It should be noted that the model will also forecast a reduction in trips if the quality of travel falls due to increased congestions, higher car operating costs, or increased tolls. The utility function acts like a demand curve, increasing or decreasing travel based on changes in price (utility) for travel. It assumes travel is a normal good and subject to the laws of supply and demand.

References

- **[Ben-Akiva and Lerman, 1985],** M.E. Ben-Akiva and S.R. Lerman, *Discrete Choice Analysis: Theory and Application to Travel Demand,* MIT Press, 1985.
- **[Cascetta, 1996],** E. Cascetta, *Proceedings of the 13th International Symposium on the Theory of Road Traffic Flow* (Lyon, France),1996.
- **[Daly, A, 1987],** A. Daly, *Estimating "tree" logit models*. Transportation Research B, 21(4):251-268, 1987.
- **[Daly, A., et.al., 2004],** A. Daly, J. Fox and J.G.Tuinenga, *Pivot-Point Procedures in Practical Travel Demand Forecasting*, RAND Europe, 2005
- **[Domenich and McFadden, 1975],** T.A. Domenich and D. McFadden, *Urban Travel Demand: A behavioral analysis,* North-Holland Publishing Company, 1975.
- **[Garling et.al., 1998],** T. Garling, T. Laitila, and K. Westin, *Theoretical Foundations of Travel Choice Modeling*, 1998.
- **[Hensher and Johnson, 1981],** D.A. Hensher and L.W. Johnson, *Applied discrete choice modelling.* Croom Helm, London, 1981
- **[Horowitz, et.al., 1986],** J.L. Horowitz, F.S. Koppelman, and S.R. Lerman, *A self-instructing course in disaggregate mode choice modeling,* Technology Sharing Program, USDOT, 1986.
- **[Koppelman, 1975],** F.S. Koppelman, *Travel Prediction with Models of Individual Choice*
- *Behavior*, PhD Submittal, Massachusetts Institute, 1975.
- **[Louviere, et.al., 2000],** *J.J.Louviere, D.A.Hensher, and J.D.Swait, Stated Choice Methods: Analysis and Application*, Cambridge, 2000
- **[Luce and Suppes, 1965],** R.D. Luce and P. Suppes, *Handbook of Mathematical Psychology*, 1965.
- **[Rogers et al., 1970],** K.G. Rogers, G.M. Townsend and A.E. Metcalf, *Planning for the work. Journey –a generalized explanation of modal choice*, Report C67, Reading, 1970.
- **[Wilson, 1967],** A.G. Wilson, *A Statistical Theory of Spatial Distribution models*, Transport Research, Vol. 1, 1967.

- **[Quarmby, 1967],** D. Quarmby, *Choice of Travel Mode for the Journey to Work: Some Findings*, Journal of Transport Economics and Policy, Vol. 1, No. 3, 1967.
- **[Yai, et.al., 1997],** T. Yai, S. Iwakura, and S. Morichi, *Multinominal probit with structured covariance for route choice behavior, Transportation Research B, 31(3):195-208,1997*

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Appendix B: Zone System and Demographics

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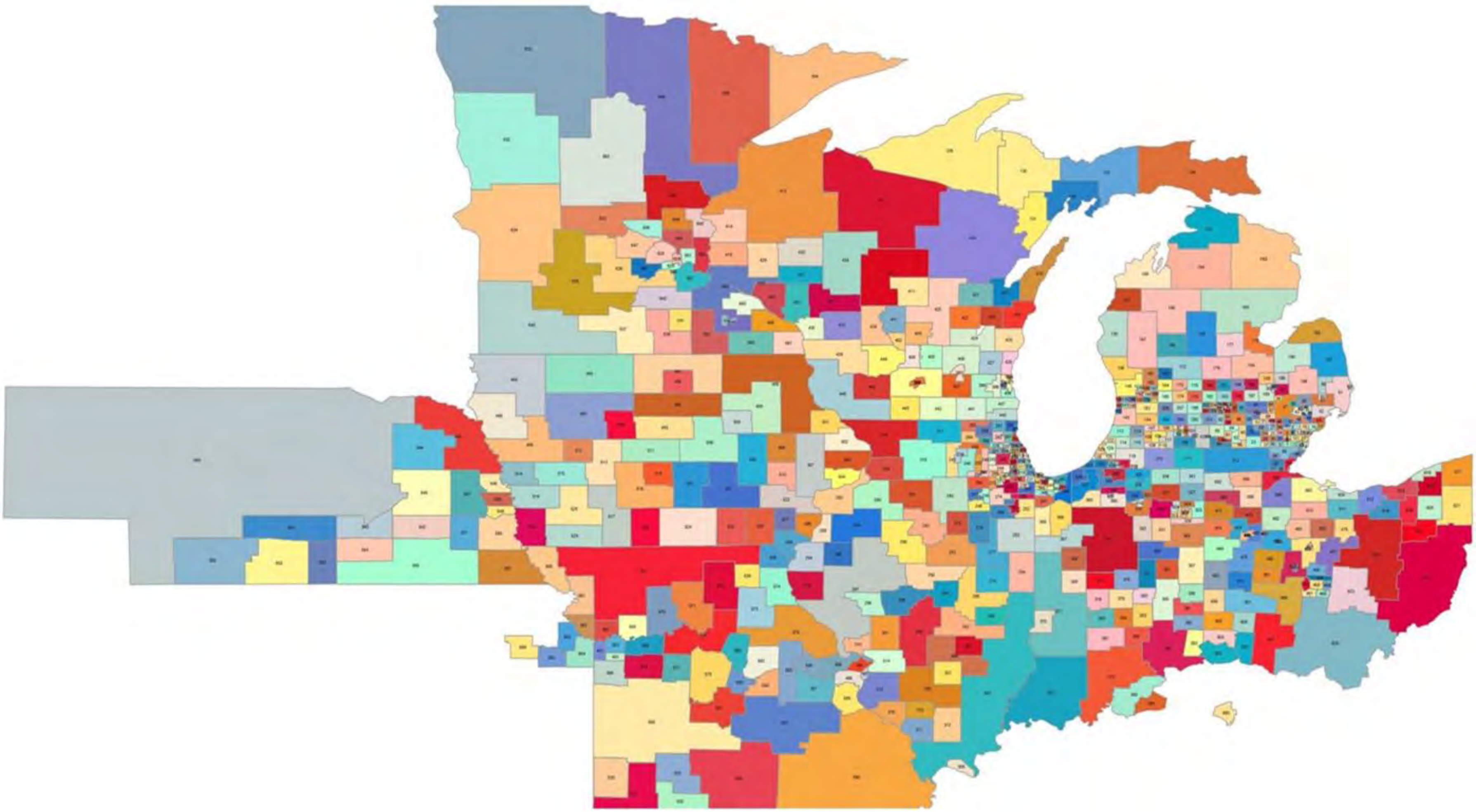
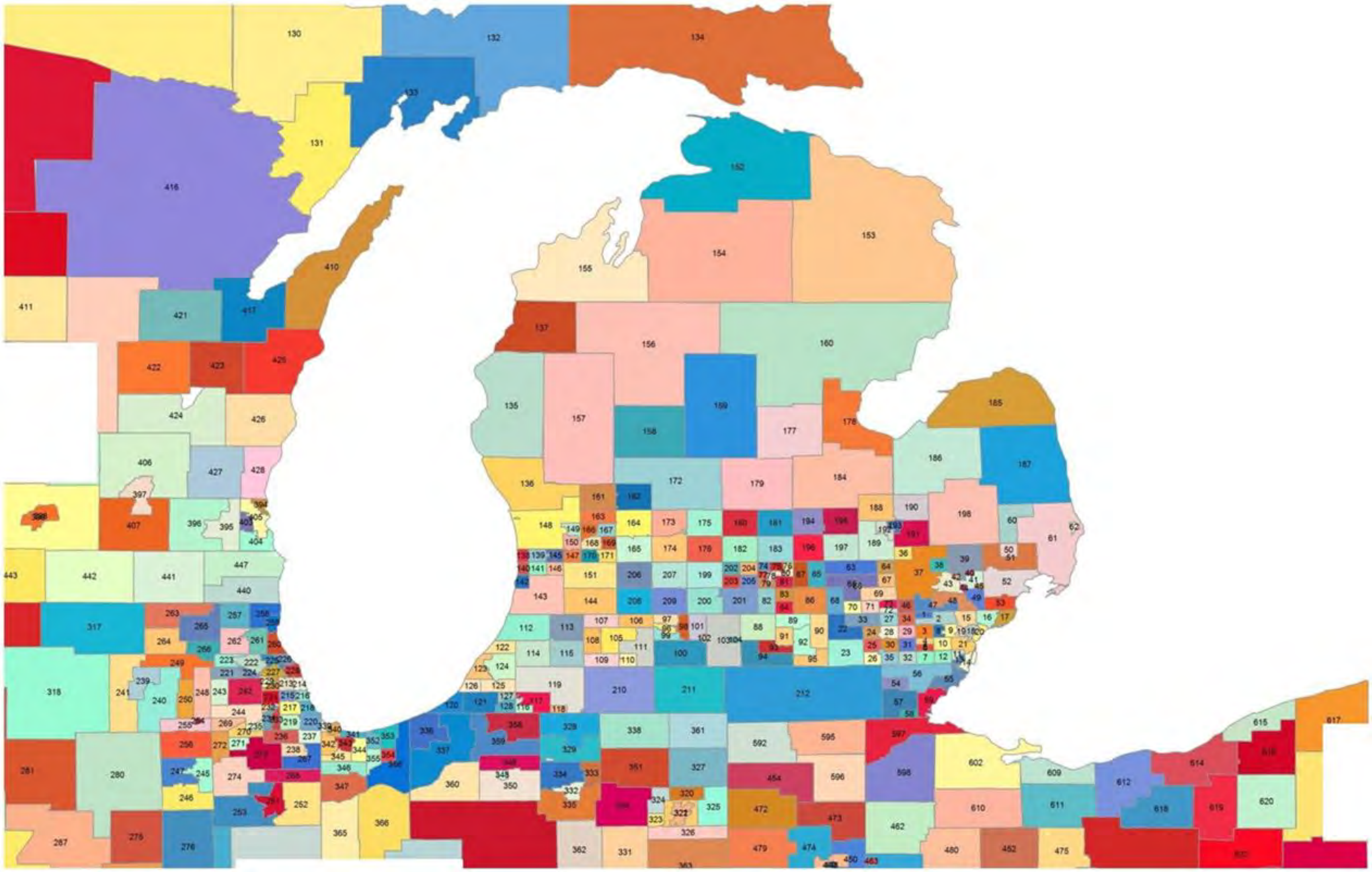
Study Area Zone Map



Michigan Region Zone Map



Zone System Description

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
1	WAYNE MI	26163	MI	26	17.60	Northville TWP
2	WAYNE MI	26163	MI	26	65.24	Plymouth - Livonia
3	WAYNE MI	26163	MI	26	36.08	Canton
4	WAYNE MI	26163	MI	26	18.60	Belleville North
5	WAYNE MI	26163	MI	26	1.19	Belleville 2
6	WAYNE MI	26163	MI	26	17.41	Belleville 1
7	WAYNE MI	26163	MI	26	37.38	Belleville South
8	WAYNE MI	26163	MI	26	21.43	Westland
9	WAYNE MI	26163	MI	26	28.34	Garden City
10	WAYNE MI	26163	MI	26	35.90	Romulus
11	WAYNE MI	26163	MI	26	15.28	Brownstown
12	WAYNE MI	26163	MI	26	35.78	Carleton
13	WAYNE MI	26163	MI	26	13.06	Flat Rock
14	WAYNE MI	26163	MI	26	30.94	Trenton
15	WAYNE MI	26163	MI	26	48.79	Detroit Northwest
16	WAYNE MI	26163	MI	26	48.84	Detroit
17	WAYNE MI	26163	MI	26	40.43	Detroit East (Grosse Pointe)
18	WAYNE MI	26163	MI	26	21.41	Dearborn
19	WAYNE MI	26163	MI	26	12.97	Dearborn West
20	WAYNE MI	26163	MI	26	21.88	Detroit West
21	WAYNE MI	26163	MI	26	48.75	Southgate
22	WASHTENAW MI	26161	MI	26	107.65	Chelsea
23	WASHTENAW MI	26161	MI	26	148.78	Manchester
24	WASHTENAW MI	26161	MI	26	34.02	Scio
25	WASHTENAW MI	26161	MI	26	34.38	Pleasant Lake Rd
26	WASHTENAW MI	26161	MI	26	34.69	Saline
27	WASHTENAW MI	26161	MI	26	36.58	Ann Arbor North

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
28	WASHTENAW MI	26161	MI	26	37.80	Ann Arbor
29	WASHTENAW MI	26161	MI	26	35.47	Superior Township
30	WASHTENAW MI	26161	MI	26	35.16	Ann Arbor South
31	WASHTENAW MI	26161	MI	26	36.16	Ypsilanti
32	WASHTENAW MI	26161	MI	26	36.69	Augusta Charter
33	WASHTENAW MI	26161	MI	26	68.90	Dexter
34	WASHTENAW MI	26161	MI	26	34.33	Plymouth West
35	WASHTENAW MI	26161	MI	26	40.16	Milan
36	OAKLAND MI	26125	MI	26	36.36	Holly
37	OAKLAND MI	26125	MI	26	305.80	White Lake
38	OAKLAND MI	26125	MI	26	36.74	Clarkston
39	OAKLAND MI	26125	MI	26	157.07	Lake Orion
40	OAKLAND MI	26125	MI	26	5.98	Rochester
41	OAKLAND MI	26125	MI	26	40.99	Rochester Hills
42	OAKLAND MI	26125	MI	26	6.01	Pontiac Northeast
43	OAKLAND MI	26125	MI	26	64.89	Pontiac
44	OAKLAND MI	26125	MI	26	5.89	Bloomfield Hills
45	OAKLAND MI	26125	MI	26	6.45	Troy
46	OAKLAND MI	26125	MI	26	35.43	South Lyon
47	OAKLAND MI	26125	MI	26	69.84	Farmington
48	OAKLAND MI	26125	MI	26	85.49	Southfield
49	OAKLAND MI	26125	MI	26	48.71	Clawson
50	MACOMB MI	26099	MI	26	36.47	Armada
51	MACOMB MI	26099	MI	26	184.48	Romeo
52	MACOMB MI	26099	MI	26	195.50	Macomb
53	MACOMB MI	26099	MI	26	66.84	Roseville
54	MONROE MI	26115	MI	26	48.52	Dundee
55	MONROE MI	26115	MI	26	73.58	Monroe North
56	MONROE MI	26115	MI	26	194.40	Maybee - Carleton
57	MONROE MI	26115	MI	26	138.26	Petersburg

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
58	MONROE MI	26115	MI	26	20.84	Lambertville
59	MONROE MI	26115	MI	26	80.14	Monroe
60	ST. CLAIR MI	26147	MI	26	144.05	Capac
61	ST. CLAIR MI	26147	MI	26	561.41	St Clair
62	ST. CLAIR MI	26147	MI	26	11.64	Port Huron
63	LIVINGSTON MI	26093	MI	26	113.63	Fowlerville
64	LIVINGSTON MI	26093	MI	26	36.64	Fenton
65	LIVINGSTON MI	26093	MI	26	138.82	Howell Surrounding Area
66	LIVINGSTON MI	26093	MI	26	5.01	Howell
67	LIVINGSTON MI	26093	MI	26	37.21	Hartland
68	LIVINGSTON MI	26093	MI	26	70.06	Gregory
69	LIVINGSTON MI	26093	MI	26	74.59	Brighton
70	LIVINGSTON MI	26093	MI	26	35.53	Pinckney
71	LIVINGSTON MI	26093	MI	26	35.97	Brighton South
72	LIVINGSTON MI	26093	MI	26	15.24	Whitmore Lake
73	LIVINGSTON MI	26093	MI	26	21.69	Brighton East
74	INGHAM MI	26065	MI	26	16.31	Lansing
75	INGHAM MI	26065	MI	26	20.15	East Lansing
76	INGHAM MI	26065	MI	26	12.05	Haslett
77	INGHAM MI	26065	MI	26	13.48	Lansing South
78	INGHAM MI	26065	MI	26	12.65	Lansing Southeast
79	INGHAM MI	26065	MI	26	21.54	Delhi Charter Twp
80	INGHAM MI	26065	MI	26	15.48	Okemos
81	INGHAM MI	26065	MI	26	33.65	Mason North
82	INGHAM MI	26065	MI	26	72.84	Mason West
83	INGHAM MI	26065	MI	26	36.43	Mason
84	INGHAM MI	26065	MI	26	36.28	Leslie
85	INGHAM MI	26065	MI	26	70.15	Webberville
86	INGHAM MI	26065	MI	26	137.82	Dansville
87	INGHAM MI	26065	MI	26	60.92	Williamston

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
88	JACKSON MI	26075	MI	26	145.08	Springport
89	JACKSON MI	26075	MI	26	72.98	Pleasant Lake
90	JACKSON MI	26075	MI	26	97.36	Grass Lake
91	JACKSON MI	26075	MI	26	51.64	Jackson
92	JACKSON MI	26075	MI	26	82.77	Jackson East
93	JACKSON MI	26075	MI	26	56.83	Spring Arbor
94	JACKSON MI	26075	MI	26	144.04	Concord
95	JACKSON MI	26075	MI	26	71.65	Brooklyn
96	CALHOUN MI	26025	MI	26	26.55	Battle Creek North
97	CALHOUN MI	26025	MI	26	40.39	Battle Creek
98	CALHOUN MI	26025	MI	26	40.70	Battle Creek East
99	CALHOUN MI	26025	MI	26	36.85	Battle Creek Southwest
100	CALHOUN MI	26025	MI	26	215.70	Athens
101	CALHOUN MI	26025	MI	26	67.99	Marshall North
102	CALHOUN MI	26025	MI	26	6.12	Marshall
103	CALHOUN MI	26025	MI	26	277.21	Eckford
104	CALHOUN MI	26025	MI	26	5.74	Albion
105	KALAMAZOO MI	26077	MI	26	109.61	Kalamazoo
106	KALAMAZOO MI	26077	MI	26	72.07	Richland
107	KALAMAZOO MI	26077	MI	26	72.90	Kalamazoo North
108	KALAMAZOO MI	26077	MI	26	72.23	Kalamazoo West
109	KALAMAZOO MI	26077	MI	26	72.94	Vicksburg
110	KALAMAZOO MI	26077	MI	26	35.67	East Vicksburg
111	KALAMAZOO MI	26077	MI	26	143.95	Galesburg
112	VAN BUREN MI	26159	MI	26	197.81	Covert
113	VAN BUREN MI	26159	MI	26	140.36	Gobles
114	VAN BUREN MI	26159	MI	26	141.36	Harford - Lawrence
115	VAN BUREN MI	26159	MI	26	142.66	Paw Paw
116	CASS MI	26027	MI	26	27.31	Niles Southeast
117	CASS MI	26027	MI	26	86.29	Edwardsburg

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
118	CASS MI	26027	MI	26	20.50	Elkhart
119	CASS MI	26027	MI	26	372.94	Jones
120	BERRIEN MI	26021	MI	26	68.28	Union Pier
121	BERRIEN MI	26021	MI	26	111.56	Buchanan
122	BERRIEN MI	26021	MI	26	54.28	Watervliet
123	BERRIEN MI	26021	MI	26	63.61	Benton Harbor
124	BERRIEN MI	26021	MI	26	112.09	Benton Harbor West
125	BERRIEN MI	26021	MI	26	69.91	Barrien Springs
126	BERRIEN MI	26021	MI	26	39.36	Bridgman
127	BERRIEN MI	26021	MI	26	21.47	Niles North
128	BERRIEN MI	26021	MI	26	39.38	Niles
129	HOUGHTON MI	26061	MI	26	6023.49	Bruce Crossing
130	MARQUETTE MI	26103	MI	26	2622.65	Ishpeming
131	MENOMINEE MI	26109	MI	26	1044.64	Bark River
132	SCHOOLCRAFT MI	26153	MI	26	2118.20	Munising
133	DELTA MI	26041	MI	26	1215.40	Rapid River
134	CHIPPEWA MI	26033	MI	26	3620.72	Newberry
135	OCEANA MI	26127	MI	26	1035.10	Ludington
136	MUSKEGON MI	26121	MI	26	512.17	Muskegon
137	MANISTEE MI	26101	MI	26	547.65	Brethren
138	OTTAWA MI	26139	MI	26	22.60	Holland East
139	OTTAWA MI	26139	MI	26	38.29	Holland
140	ALLEGAN MI	26005	MI	26	21.63	Laketown Twp
141	ALLEGAN MI	26005	MI	26	36.47	Holland South
142	ALLEGAN MI	26005	MI	26	27.61	Village of Douglas
143	ALLEGAN MI	26005	MI	26	287.60	Clyde Twp
144	ALLEGAN MI	26005	MI	26	216.08	Trowbridge Twp
145	OTTAWA MI	26139	MI	26	34.40	Zeeland Twp
146	ALLEGAN MI	26005	MI	26	35.67	Overisel Twp
147	OTTAWA MI	26139	MI	26	35.45	Jamestown Twp

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
148	OTTAWA MI	26139	MI	26	369.97	Port Sheldon Twp
149	OTTAWA MI	26139	MI	26	32.98	Tallmadge Twp
150	OTTAWA MI	26139	MI	26	38.11	Georgetown Twp
151	ALLEGAN MI	26005	MI	26	215.91	Salem Twp
152	EMMET MI	26047	MI	26	1645.03	Petoskey
153	ALPENA MI	26007	MI	26	3154.64	Alpena
154	KALKASKA MI	26079	MI	26	2176.02	Frederic
155	GRAND TRAVERSE	26055	MI	26	1178.00	Lake Ann
156	WEXFORD MI	26165	MI	26	1702.04	Cadillac
157	NEWAYGO MI	26123	MI	26	1419.87	Bitely
158	MECOSTA MI	26107	MI	26	568.31	Big Rapids
159	ISABELLA MI	26073	MI	26	1149.44	Clare
160	OGEMAW MI	26129	MI	26	2633.46	West Branch
161	KENT MI	26081	MI	26	146.93	Sparta - Kent City
162	KENT MI	26081	MI	26	144.86	Courtland Twp
163	KENT MI	26081	MI	26	72.89	Alpine Twp
164	KENT MI	26081	MI	26	146.04	Cannon Twp
165	KENT MI	26081	MI	26	142.75	Cascade Twp
166	KENT MI	26081	MI	26	36.84	Grand Rapids West
167	KENT MI	26081	MI	26	38.48	Grand Rapids
168	KENT MI	26081	MI	26	37.91	Grand Rapids South
169	KENT MI	26081	MI	26	29.72	Grand Rapids Southeast
170	KENT MI	26081	MI	26	34.84	Byron Twp
171	KENT MI	26081	MI	26	37.03	Gaines Twp
172	MONTCALM MI	26117	MI	26	717.25	Ionia
173	IONIA MI	26067	MI	26	137.32	Belding
174	IONIA MI	26067	MI	26	149.37	Boston Twp
175	IONIA MI	26067	MI	26	148.42	Ronald Twp
176	IONIA MI	26067	MI	26	143.92	Orange Twp
177	MIDLAND MI	26111	MI	26	522.49	Sanford

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
178	BAY MI	26017	MI	26	453.69	Midland
179	GRATIOT MI	26057	MI	26	564.76	Ithaca
180	CLINTON MI	26037	MI	26	143.79	St Johns
181	CLINTON MI	26037	MI	26	142.87	Greenbush Twp
182	CLINTON MI	26037	MI	26	142.37	Westphalia Twp
183	CLINTON MI	26037	MI	26	144.50	Olive Twp
184	SAGINAW MI	26145	MI	26	809.89	Saginaw
185	HURON MI	26063	MI	26	829.29	Bad Axe
186	TUSCOLA MI	26157	MI	26	807.09	Caro
187	SANILAC MI	26151	MI	26	963.42	Sandusky
188	GENESEE MI	26049	MI	26	145.34	Flushing - Mt. Morris - Clio
189	GENESEE MI	26049	MI	26	176.43	Clayton Twp
190	GENESEE MI	26049	MI	26	139.38	Thetford Twp
191	GENESEE MI	26049	MI	26	128.39	Grand Blanc - Davidson
192	GENESEE MI	26049	MI	26	33.53	Flint Twp
193	GENESEE MI	26049	MI	26	24.41	Flint
194	SHIAWASSEE MI	26155	MI	26	122.14	Owosso
195	SHIAWASSEE MI	26155	MI	26	144.74	New Haven Twp
196	SHIAWASSEE MI	26155	MI	26	127.28	Laingsburg
197	SHIAWASSEE MI	26155	MI	26	145.28	Shiawassee Twp
198	LAPEER MI	26087	MI	26	655.41	Lapeer
199	EATON MI	26045	MI	26	145.14	Charlotte
200	EATON MI	26045	MI	26	141.66	Kalamo Twp
201	EATON MI	26045	MI	26	149.27	Carmel Twp
202	EATON MI	26045	MI	26	35.94	Oneida Twp
203	EATON MI	26045	MI	26	35.39	Benton Twp
204	EATON MI	26045	MI	26	35.67	Delta Twp
205	EATON MI	26045	MI	26	35.39	Windsor Twp
206	BARRY MI	26015	MI	26	143.77	Hastings
207	BARRY MI	26015	MI	26	143.35	Carlton Twp

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
208	BARRY MI	26015	MI	26	144.51	Prairieville Twp
209	BARRY MI	26015	MI	26	144.44	Baltimore Twp
210	ST. JOSEPH MI	26149	MI	26	517.00	3 Rivers MI
211	BRANCH MI	26023	MI	26	516.71	Coldwater
212	LENAWEE MI	26091	MI	26	1371.40	Hudson
213	COOK IL	17031	IL	17	31.35	Chicago
214	COOK IL	17031	IL	17	23.17	Chicago
215	COOK IL	17031	IL	17	28.26	Chicago
216	COOK IL	17031	IL	17	22.04	Chicago
217	COOK IL	17031	IL	17	44.44	Chicago
218	COOK IL	17031	IL	17	29.32	Chicago
219	COOK IL	17031	IL	17	48.50	Chicago
220	COOK IL	17031	IL	17	53.73	Chicago
221	COOK IL	17031	IL	17	61.04	Streamwood
222	COOK IL	17031	IL	17	66.50	Arlington Heights
223	COOK IL	17031	IL	17	47.11	Schaumburg
224	COOK IL	17031	IL	17	19.28	Elk Grove Village
225	COOK IL	17031	IL	17	31.13	Glenview
226	COOK IL	17031	IL	17	22.38	Winnetka
227	COOK IL	17031	IL	17	38.21	Niles
228	COOK IL	17031	IL	17	32.78	Skokie
229	COOK IL	17031	IL	17	16.88	Schiller Park
230	COOK IL	17031	IL	17	20.24	Schiller Park
231	COOK IL	17031	IL	17	36.57	Bellwood
232	COOK IL	17031	IL	17	12.82	La Grange
233	COOK IL	17031	IL	17	26.25	Hickory Hills
234	COOK IL	17031	IL	17	32.73	Willow Springs
235	COOK IL	17031	IL	17	21.05	Lemont
236	COOK IL	17031	IL	17	74.12	Orland Park
237	COOK IL	17031	IL	17	47.35	South Holland

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
238	COOK IL	17031	IL	17	51.27	Matteson
239	DEKALB IL	17037	IL	17	112.28	Sycamore
240	DEKALB IL	17037	IL	17	305.93	Hinckley
241	DEKALB IL	17037	IL	17	326.65	Dekalb
242	DUPAGE IL	17043	IL	17	140.76	Lombard
243	DUPAGE IL	17043	IL	17	72.58	West Chicago
244	DUPAGE IL	17043	IL	17	122.57	Woodridge
245	GRUNDY IL	17063	IL	17	102.15	Coal City
246	GRUNDY IL	17063	IL	17	191.32	Dwight
247	GRUNDY IL	17063	IL	17	136.39	Morris
248	KANE IL	17089	IL	17	138.46	Geneva
249	KANE IL	17089	IL	17	156.39	Hampshire
250	KANE IL	17089	IL	17	100.99	Elburn
251	KANKAKEE IL	17091	IL	17	97.52	Bourbonnais
252	KANKAKEE IL	17091	IL	17	274.20	Momence
253	KANKAKEE IL	17091	IL	17	308.75	Herscher
254	KENDALL IL	17093	IL	17	6.21	Montgomery
255	KENDALL IL	17093	IL	17	98.27	Yorkville
256	KENDALL IL	17093	IL	17	217.38	Yorkville
257	LAKE IL	17097	IL	17	114.99	Lake Villa
258	LAKE IL	17097	IL	17	95.49	Gurnee
259	LAKE IL	17097	IL	17	29.64	Waukegan
260	LAKE IL	17097	IL	17	47.89	Highwood
261	LAKE IL	17097	IL	17	78.70	Vernon Hills
262	LAKE IL	17097	IL	17	113.44	Wauconda
263	MCHENRY IL	17111	IL	17	198.49	Harvard
264	MCHENRY IL	17111	IL	17	158.38	Union
265	MCHENRY IL	17111	IL	17	183.93	McHenry
266	MCHENRY IL	17111	IL	17	85.45	Lake in the Hills
267	WILL IL	17197	IL	17	111.16	Chicago Heights

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
268	WILL IL	17197	IL	17	117.10	Peotone
269	WILL IL	17197	IL	17	57.77	Bolingbrook
270	WILL IL	17197	IL	17	51.22	Lockport
271	WILL IL	17197	IL	17	37.82	Joliet
272	WILL IL	17197	IL	17	77.36	Joliet
273	WILL IL	17197	IL	17	179.72	New Lenox
274	WILL IL	17197	IL	17	246.91	Wilmington
275	LIVINGSTON IL	17105	IL	17	437.56	Pontiac
276	LIVINGSTON IL	17105	IL	17	608.18	Fairbury
277	FORD IL	17053	IL	17	806.76	Rantoul
278	CHAMPAIGN IL	17019	IL	17	669.34	Champaign
279	WHITESIDE IL	17195	IL	17	692.51	Morrison
280	LA SALLE IL	17099	IL	17	1141.99	Ottawa
281	BUREAU IL	17011	IL	17	1037.17	Princeton
282	MERCER IL	17131	IL	17	1004.35	Aledo
283	IROQUOIS IL	17075	IL	17	1112.92	Watseka
284	VERMILION IL	17183	IL	17	891.77	Danville
285	DOUGLAS IL	17041	IL	17	1200.98	Arthur
286	HENRY IL	17073	IL	17	1111.42	Geneseo
287	WOODFORD IL	17203	IL	17	937.80	Toluca
288	HENDERSON IL	17071	IL	17	380.59	Monmouth
289	KNOX IL	17095	IL	17	1258.87	Galesburg
290	PEORIA IL	17143	IL	17	1286.21	Peoria
291	MCLEAN IL	17113	IL	17	1182.07	Bloomington
292	LOGAN IL	17107	IL	17	1009.16	Lincoln
293	MCDONOUGH IL	17109	IL	17	585.00	Macomb
294	HANCOCK IL	17067	IL	17	809.95	Carthage
295	ADAMS IL	17001	IL	17	866.49	Quincy
296	MORGAN IL	17137	IL	17	572.99	Jacksonville
297	CASS IL	17017	IL	17	4815.78	Beardstown

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
298	SANGAMON IL	17167	IL	17	873.67	Springfield
299	MACON IL	17115	IL	17	586.73	Decatur
300	COLES IL	17029	IL	17	510.89	Charleston
301	MACOUPIN IL	17117	IL	17	871.76	Carlinville
302	SHELBY IL	17173	IL	17	1114.64	Shelbyville
303	EFFINGHAM IL	17049	IL	17	478.01	Effingham
304	WAYNE IL	17191	IL	17	7424.01	Harrisburg
305	MONTGOMERY IL	17135	IL	17	1791.66	Hillsboro
306	FAYETTE IL	17051	IL	17	1192.54	Vandalia
307	MARION IL	17121	IL	17	574.16	Salem
308	WASHINGTON IL	17189	IL	17	1640.43	Mt Vernon
309	MASSAC IL	17127	IL	17	240.63	Metropolis
310	JERSEY IL	17083	IL	17	372.22	Jerseyville
311	JACKSON IL	17077	IL	17	600.09	Murphysboro
312	WILLIAMSON IL	17199	IL	17	873.01	Marion
313	ST. CLAIR IL	17163	IL	17	1072.57	Belleville
314	MADISON IL	17119	IL	17	739.03	Edwardsville
315	PERRY IL	17145	IL	17	441.05	Du Quoin
316	RANDOLPH IL	17157	IL	17	588.78	Sparta
317	WINNEBAGO IL	17201	IL	17	799.09	Rockford
318	LEE IL	17103	IL	17	1488.30	Dixon
319	JO DAVIESS IL	17085	IL	17	1614.71	Mt Carroll
320	ALLEN IN	18003	IN	18	71.20	Huntertown
321	ALLEN IN	18003	IN	18	56.87	Fort Wayne
322	ALLEN IN	18003	IN	18	85.23	Fort Wayne
323	ALLEN IN	18003	IN	18	33.31	Fort Wayne
324	ALLEN IN	18003	IN	18	72.27	Huntertown
325	ALLEN IN	18003	IN	18	174.55	Grabill
326	ALLEN IN	18003	IN	18	165.72	Fort Wayne
327	DEKALB IN	18033	IN	18	363.34	Waterloo

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
328	ELKHART IN	18039	IN	18	251.21	Elkhart
329	ELKHART IN	18039	IN	18	213.09	Goshen
330	GRANT IN	18053	IN	18	579.80	Gas City
331	HUNTINGTON IN	18069	IN	18	387.23	Huntington
332	KOSCIUSKO IN	18085	IN	18	53.31	Warsaw
333	KOSCIUSKO IN	18085	IN	18	66.59	North Webster
334	KOSCIUSKO IN	18085	IN	18	170.70	Warsaw
335	KOSCIUSKO IN	18085	IN	18	263.07	Claypool
336	LAPORTE IN	18091	IN	18	174.22	La Porte
337	LAPORTE IN	18091	IN	18	431.05	La Porte
338	LAGRANGE IN	18087	IN	18	386.14	Lagrange
339	LAKE IN	18089	IN	18	11.75	Whiting
340	LAKE IN	18089	IN	18	25.35	East Chicago
341	LAKE IN	18089	IN	18	22.52	Gary
342	LAKE IN	18089	IN	18	52.01	Hammond
343	LAKE IN	18089	IN	18	36.08	Gary
344	LAKE IN	18089	IN	18	54.23	Hobart
345	LAKE IN	18089	IN	18	43.28	Schererville
346	LAKE IN	18089	IN	18	94.55	Crown Point
347	LAKE IN	18089	IN	18	178.40	Lowell
348	MARSHALL IN	18099	IN	18	14.07	Plymouth
349	MARSHALL IN	18099	IN	18	146.07	Bremen
350	MARSHALL IN	18099	IN	18	288.99	Plymouth
351	NOBLE IN	18113	IN	18	416.85	Albion
352	PORTER IN	18127	IN	18	34.64	Portage
353	PORTER IN	18127	IN	18	64.87	Chesterton
354	PORTER IN	18127	IN	18	29.89	Valparaiso
355	PORTER IN	18127	IN	18	46.19	Valparaiso
356	PORTER IN	18127	IN	18	252.88	Valparaiso
357	RANDOLPH IN	18135	IN	18	836.45	Winchester

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
358	ST. JOSEPH IN	18141	IN	18	200.53	South Bend
359	ST. JOSEPH IN	18141	IN	18	260.16	South Bend
360	STARKE IN	18149	IN	18	311.77	Knox
361	STEUBEN IN	18151	IN	18	322.00	Angola
362	WABASH IN	18169	IN	18	420.44	Wabash
363	WELLS IN	18179	IN	18	709.33	Bluffton
364	WHITLEY IN	18183	IN	18	337.44	Columbia City
365	NEWTON IN	18111	IN	18	397.20	Morocco
366	JASPER IN	18073	IN	18	558.48	Rensselaer
367	WHITE IN	18181	IN	18	904.01	Monticello
368	TIPPECANOE IN	18157	IN	18	497.85	Lafayette
369	MONTGOMERY IN	18107	IN	18	497.55	Crawfordsville
370	VIGO IN	18167	IN	18	398.53	Terre Haute
371	CLAY IN	18021	IN	18	3679.86	Brazil
372	PIKE IN	18125	IN	18	4037.63	Evansville
373	ORANGE IN	18117	IN	18	2785.87	Bedford
374	CASS IN	18017	IN	18	2924.12	Kokomo
375	BOONE IN	18011	IN	18	418.96	Lebanon
376	HAMILTON IN	18057	IN	18	404.57	Noblesville
377	MADISON IN	18095	IN	18	443.23	Anderson
378	HENDRICKS IN	18063	IN	18	409.32	Avon
379	MARION IN	18097	IN	18	402.39	Indianapolis
380	HANCOCK IN	18059	IN	18	306.46	Greenfield
381	DELAWARE IN	18035	IN	18	396.13	Muncie
382	MORGAN IN	18109	IN	18	405.11	Martinsville
383	SHELBY IN	18145	IN	18	410.35	Shelbyville
384	JOHNSON IN	18081	IN	18	320.03	Franklin
385	RUSH IN	18139	IN	18	801.17	Spiceland
386	WAYNE IN	18177	IN	18	401.93	Richmond
387	MONROE IN	18105	IN	18	722.06	Bloomington

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
388	BARTHOLOMEW IN	18005	IN	18	411.07	Columbus
389	FLOYD IN	18043	IN	18	1016.70	Clarksville
390	RIPLEY IN	18137	IN	18	1783.05	Madison
391	FAYETTE IN	18041	IN	18	380.28	Connersville
392	FRANKLIN IN	18047	IN	18	388.81	Brookville
393	DEARBORN IN	18029	IN	18	394.79	Lawrenceburg
394	MILWAUKEE WI	55079	WI	55	23.82	Milwaukee
395	WAUKESHA WI	55133	WI	55	181.82	Waukesha
396	WAUKESHA WI	55133	WI	55	397.30	Delafield
397	DODGE WI	55027	WI	55	127.77	Watertown
398	DANE WI	55025	WI	55	90.68	Madison
399	DANE WI	55025	WI	55	1146.70	Sun Prairie
400	COLUMBIA WI	55021	WI	55	436.48	Portage
401	ADAMS WI	55001	WI	55	531.25	Adams
402	ADAMS WI	55001	WI	55	190.55	Wisconsin Dells
403	MILWAUKEE WI	55079	WI	55	34.53	Milwaukee
404	MILWAUKEE WI	55079	WI	55	94.41	South Milwaukee
405	MILWAUKEE WI	55079	WI	55	87.86	Milwaukee
406	DODGE WI	55027	WI	55	813.33	Beaver Dam
407	JEFFERSON WI	55055	WI	55	534.72	Jefferson
408	COLUMBIA WI	55021	WI	55	313.01	Portage
409	MARQUETTE WI	55077	WI	55	460.98	Montello
410	DOOR WI	55029	WI	55	805.21	Sturgeon Bay
411	PORTAGE WI	55097	WI	55	807.06	Stevens Point
412	MARATHON WI	55073	WI	55	2378.83	Wausau
413	WASHBURN WI	55129	WI	55	7703.03	Rice Lake
414	POLK WI	55095	WI	55	941.42	Balsam Lake
415	ONEIDA WI	55085	WI	55	6176.14	Rhinelander
416	OCONTO WI	55083	WI	55	6136.91	Shawano
417	BROWN WI	55009	WI	55	535.90	Green Bay

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
418	ST. CROIX WI	55109	WI	55	723.92	New Richmond
419	PEPIN WI	55091	WI	55	7.80	River Falls
420	WAUSHARA WI	55137	WI	55	1772.16	Berlin
421	OUTAGAMIE WI	55087	WI	55	638.36	Appleton
422	WINNEBAGO WI	55139	WI	55	585.17	Oshkosh
423	CALUMET WI	55015	WI	55	396.66	Chilton
424	FOND DU LAC WI	55039	WI	55	716.95	Fond du Lac
425	MANITOWOC WI	55071	WI	55	603.04	Manitowoc
426	SHEBOYGAN WI	55117	WI	55	530.46	Sheboygan
427	WASHINGTON WI	55131	WI	55	433.65	West Bend
428	OZAUKEE WI	55089	WI	55	243.74	Saukville
429	DUNN WI	55033	WI	55	862.84	Menomonie
430	CHIPPEWA WI	55017	WI	55	1030.00	Chippewa Falls
431	EAU CLAIRE WI	55035	WI	55	643.73	Eau Claire
432	BUFFALO WI	55011	WI	55	684.40	Durand
433	TREMPEALEAU WI	55121	WI	55	743.68	Whitehall
434	CLARK WI	55019	WI	55	2193.78	Abbotsford
435	JACKSON WI	55053	WI	55	985.69	Black River Falls
436	LA CROSSE WI	55063	WI	55	473.32	La Crosse
437	MONROE WI	55081	WI	55	908.83	Tomah
438	JUNEAU WI	55057	WI	55	805.21	New Lisbon
439	VERNON WI	55123	WI	55	1385.19	Richland Center
440	KENOSHA WI	55059	WI	55	281.55	Kenosha
441	WALWORTH WI	55127	WI	55	571.92	Elkhorn
442	ROCK WI	55105	WI	55	723.25	Janesville
443	GREEN WI	55045	WI	55	588.26	Monroe
444	SAUK WI	55111	WI	55	848.13	Baraboo
445	IOWA WI	55049	WI	55	770.61	Dodgeville
446	GRANT WI	55043	WI	55	2381.39	Platteville
447	RACINE WI	55101	WI	55	340.36	Racine

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
448	ALLEN OH	39003	OH	39	9.24	Lima
449	ALLEN OH	39003	OH	39	85.62	Lima
450	ALLEN OH	39003	OH	39	182.34	Lima
451	CHAMPAIGN OH	39021	OH	39	360.08	Urbana
452	CRAWFORD OH	39033	OH	39	402.19	Bucyrus
453	DARKE OH	39037	OH	39	599.10	Greenville
454	DEFIANCE OH	39039	OH	39	413.62	Defiance
455	DELAWARE OH	39041	OH	39	179.90	Delaware
456	FRANKLIN OH	39049	OH	39	107.39	Columbus
457	FRANKLIN OH	39049	OH	39	76.74	Hilliard
458	FRANKLIN OH	39049	OH	39	107.63	Columbus
459	FRANKLIN OH	39049	OH	39	68.27	Columbus
460	FRANKLIN OH	39049	OH	39	87.82	Groveport
461	FRANKLIN OH	39049	OH	39	95.08	Grove City
462	HANCOCK OH	39063	OH	39	533.88	Findlay
463	HARDIN OH	39065	OH	39	12.00	Ada
464	HARDIN OH	39065	OH	39	14.51	Kenton
465	HARDIN OH	39065	OH	39	443.55	Kenton
466	LOGAN OH	39091	OH	39	466.23	Bellefontaine
467	MARION OH	39101	OH	39	33.25	Marion
468	MARION OH	39101	OH	39	493.90	Marion
469	MERCER OH	39107	OH	39	659.82	Celina
470	MIAMI OH	39109	OH	39	409.21	Troy
471	MORROW OH	39117	OH	39	708.66	Mt Gilead
472	PAULDING OH	39125	OH	39	418.29	Defiance
473	PUTNAM OH	39137	OH	39	344.02	Ottawa
474	ALLEN OH	39003	OH	39	268.79	Delphos
475	RICHLAND OH	39139	OH	39	350.92	Mansfield
476	SHELBY OH	39149	OH	39	624.70	Jackson Center
477	UNION OH	39159	OH	39	24.20	Marysville

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
478	UNION OH	39159	OH	39	481.46	Marysville
479	VAN WERT OH	39161	OH	39	409.91	Van Wert
480	WYANDOT OH	39175	OH	39	407.03	Upper Sandusky
481	JACKSON MO	29095	MO	29	202.72	Kansas City
482	JACKSON MO	29095	MO	29	135.03	Lee's Summit
483	JACKSON MO	29095	MO	29	275.26	Independence
484	ST. LOUIS MO	29189	MO	29	188.97	Florissant
485	ST. LOUIS MO	29189	MO	29	330.45	St Louis
486	DES MOINES IA	19057	IA	19	441.37	Burlington
487	ST. LOUIS CITY MO	29510	MO	29	65.68	St Louis
488	SIOUX IA	19167	IA	19	2931.10	Sheldon
489	PALO ALTO IA	19147	IA	19	2899.75	Emmetsburg
490	CERRO GORDO IA	19033	IA	19	574.48	Clear Lake
491	WORTH IA	19195	IA	19	2335.22	Grafton
492	FRANKLIN IA	19069	IA	19	1744.29	Hampton
493	HAMILTON IA	19079	IA	19	1144.90	Story City
494	WEBSTER IA	19187	IA	19	711.50	Fort Dodge
495	WOODBURY IA	19193	IA	19	1738.83	Sioux City
496	CRAWFORD IA	19047	IA	19	1851.17	Denison
497	POCAHONTAS IA	19151	IA	19	2741.09	Pocahontas
498	CHICKASAW IA	19037	IA	19	3728.80	Clermont
499	FAYETTE IA	19065	IA	19	1731.31	Oelwein
500	BLACK HAWK IA	19013	IA	19	574.49	Waterloo
501	DUBUQUE IA	19061	IA	19	615.11	Farley
502	JACKSON IA	19097	IA	19	647.59	Maquoketa
503	CLINTON IA	19045	IA	19	717.54	De Witt
504	SCOTT IA	19163	IA	19	465.50	Davenport
505	HOOKER NE	31091	NE	31	48101.16	North Platte
506	MARSHALL IA	19127	IA	19	1796.44	Marshalltown
507	CEDAR IA	19031	IA	19	1612.72	Lowden

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
508	LINN IA	19113	IA	19	720.90	Cedar Rapids
509	BENTON IA	19011	IA	19	1305.92	Van Horne
510	JOHNSON IA	19103	IA	19	619.55	Iowa City
511	BOONE IA	19015	IA	19	1141.00	Ames
512	CARROLL IA	19027	IA	19	570.75	Carroll
513	GUTHRIE IA	19077	IA	19	1155.93	Panora
514	HARRISON IA	19085	IA	19	697.41	Woodbine
515	SHELBY IA	19165	IA	19	1033.12	Harlan
516	POTTAWATTAMIE	19155	IA	19	957.08	Council Bluffs
517	UNION IA	19175	IA	19	1538.81	Creston
518	POLK IA	19153	IA	19	587.90	Des Moines
519	MADISON IA	19121	IA	19	1717.50	Winterset
520	JASPER IA	19099	IA	19	1292.69	Pella
521	MAHASKA IA	19123	IA	19	1728.01	Sigourney
522	WASHINGTON IA	19183	IA	19	985.23	Washington
523	DECATUR IA	19053	IA	19	960.36	Osceola
524	WAYNE IA	19185	IA	19	1920.41	Corydon
525	DAVIS IA	19051	IA	19	940.38	Ottumwa
526	VAN BUREN IA	19177	IA	19	927.09	Stockport
527	HENRY IA	19087	IA	19	434.42	Mt Pleasant
528	MONTGOMERY IA	19137	IA	19	1402.34	Griswold
529	PAGE IA	19145	IA	19	1084.55	Clarinda
530	NEWTON MO	29145	MO	29	1256.90	Carthage
531	BARRY MO	29009	MO	29	1887.76	Monett
532	TANEY MO	29213	MO	29	1139.58	Branson
533	GREENE MO	29077	MO	29	1239.97	Nixa
534	DOUGLAS MO	29067	MO	29	4916.92	Ava
535	FREMONT IA	19071	IA	19	968.19	Shenandoah
536	LEE IA	19111	IA	19	534.57	Donnellson
537	HARRISON MO	29081	MO	29	6959.93	Bethany

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
538	CLARK MO	29045	MO	29	509.73	Kahoka
539	KNOX MO	29103	MO	29	504.75	Kirksville
540	PLATTE NE	31141	NE	31	2118.37	Columbus
541	LANCASTER NE	31109	NE	31	841.83	Lincoln
542	YORK NE	31185	NE	31	1143.26	Seward
543	HALL NE	31079	NE	31	1084.93	Grand Island
544	MADISON NE	31119	NE	31	2009.98	Norfolk
545	THURSTON NE	31173	NE	31	2928.01	South Sioux City
546	WASHINGTON NE	31177	NE	31	387.96	Blair
547	SAUNDERS NE	31155	NE	31	1303.62	Schuyler
548	DOUGLAS NE	31055	NE	31	337.27	Omaha
549	SARPY NE	31153	NE	31	242.34	Papillion
550	FRONTIER NE	31063	NE	31	3154.68	McCook
551	DAWSON NE	31047	NE	31	1991.90	Litchfield
552	FURNAS NE	31065	NE	31	2281.61	Holdrege
553	FRANKLIN NE	31061	NE	31	1083.22	Minden
554	ADAMS NE	31001	NE	31	1139.38	Hastings
555	THAYER NE	31169	NE	31	4278.26	Hebron
556	OTOE NE	31131	NE	31	1170.69	Syracuse
557	PAWNEE NE	31133	NE	31	1759.96	Tecumseh
558	ATCHISON MO	29005	MO	29	1019.95	Rock Port
559	SHAWNEE KS	20177	KS	20	554.64	Topeka
560	DOUGLAS KS	20045	KS	20	472.87	Lawrence
561	BUCHANAN MO	29021	MO	29	843.66	St Joseph
562	PLATTE MO	29165	MO	29	428.00	Weston
563	LEAVENWORTH KS	20103	KS	20	465.06	Leavenworth
564	JOHNSON KS	20091	KS	20	633.78	Kansas City
565	ST. CLAIR MO	29185	MO	29	7839.20	Nevada
566	CASS MO	29037	MO	29	695.94	Harrisonville
567	CLAY MO	29047	MO	29	407.76	Liberty

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
568	RAY MO	29177	MO	29	571.70	Richmond
569	LAFAYETTE MO	29107	MO	29	629.64	Higginsville
570	CARROLL MO	29033	MO	29	1235.28	Chillicothe
571	CHARITON MO	29041	MO	29	1382.66	Brookfield
572	MACON MO	29121	MO	29	1372.75	Kirksville
573	MONROE MO	29137	MO	29	1169.33	Shelbina
574	LEWIS MO	29111	MO	29	955.69	Quincy
575	SALINE MO	29195	MO	29	1712.10	Fayette
576	JOHNSON MO	29101	MO	29	834.18	Warrensburg
577	PETTIS MO	29159	MO	29	674.88	Sedalia
578	PIKE MO	29163	MO	29	2509.34	Bowling Green
579	MONITEAU MO	29135	MO	29	1594.65	California
580	BOONE MO	29019	MO	29	688.60	Columbia
581	CAMDEN MO	29029	MO	29	1307.94	Lake Ozark
582	CALLAWAY MO	29027	MO	29	844.56	Fulton
583	COLE MO	29051	MO	29	402.45	Jefferson City
584	OSAGE MO	29151	MO	29	594.46	Jefferson City
585	GASCONADE MO	29073	MO	29	1056.69	Hermann
586	WARREN MO	29219	MO	29	433.55	Warrenton
587	FRANKLIN MO	29071	MO	29	928.71	Washington
588	ST. CHARLES MO	29183	MO	29	583.03	O'Fallon
589	JEFFERSON MO	29099	MO	29	658.90	Hillsboro
590	WAYNE MO	29223	MO	29	12286.21	Cape Girardeau
591	PHELPS MO	29161	MO	29	4020.61	Rolla
592	WILLIAMS OH	39171	OH	39	417.45	Montpelier
593	FAYETTE KY	21067	KY	21	289.06	Lexington
594	JEFFERSON KY	21111	KY	21	399.10	Louisville
595	FULTON OH	39051	OH	39	399.67	Wauseon
596	HENRY OH	39069	OH	39	413.28	Hamler
597	LUCAS OH	39095	OH	39	345.46	Toledo

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
598	WOOD OH	39173	OH	39	615.29	Bowling Green
599	PREBLE OH	39135	OH	39	422.49	Eaton
600	BUTLER OH	39017	OH	39	470.40	Hamilton
601	MONTGOMERY OH	39113	OH	39	880.64	Dayton
602	SANDUSKY OH	39143	OH	39	687.22	Oak Harbor
603	HAMILTON OH	39061	OH	39	408.77	Cincinnati
604	KENTON KY	21117	KY	21	579.48	Covington
605	CLERMONT OH	39025	OH	39	455.74	Batavia
606	WARREN OH	39165	OH	39	401.72	Lebanon
607	HIGHLAND OH	39071	OH	39	1484.96	Hillsboro
608	MADISON OH	39097	OH	39	1263.24	Springfield
609	ERIE OH	39043	OH	39	252.52	Sandusky
610	SENECA OH	39147	OH	39	546.80	Tiffin
611	HURON OH	39077	OH	39	494.28	Norwalk
612	LORAIN OH	39093	OH	39	490.82	Elyria
613	COSHOCTON OH	39031	OH	39	3165.29	Wooster
614	CUYAHOGA OH	39035	OH	39	462.49	Cleveland
615	LAKE OH	39085	OH	39	232.65	Painesville
616	GEAUGA OH	39055	OH	39	406.75	Chardon
617	ASHTABULA OH	39007	OH	39	713.37	Geneva
618	MEDINA OH	39103	OH	39	419.74	Medina
619	SUMMIT OH	39153	OH	39	418.27	Akron
620	PORTAGE OH	39133	OH	39	505.28	Ravenna
621	TRUMBULL OH	39155	OH	39	1063.03	Niles
622	STARK OH	39151	OH	39	574.88	Canton
623	FAIRFIELD OH	39045	OH	39	1597.24	Newark
624	GUERNSEY OH	39059	OH	39	5337.73	Cambridge
625	JACKSON OH	39079	OH	39	6002.23	Chillicothe
626	HENNEPIN MN	27053	MN	27	78.88	Minneapolis
627	MOWER MN	27099	MN	27	565.49	Rochester

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
628	HENNEPIN MN	27053	MN	27	417.69	Minneapolis
629	HENNEPIN MN	27053	MN	27	109.71	Minneapolis
630	KANABEC MN	27065	MN	27	1618.49	Mora
631	OLMSTED MN	27109	MN	27	89.11	Rochester
632	BECKER MN	27005	MN	27	6934.83	Moorhead
633	PENNINGTON MN	27113	MN	27	14465.79	Thief River Falls
634	STEVENS MN	27149	MN	27	6568.04	Montevideo
635	RENVILLE MN	27129	MN	27	3819.21	Willmar
636	MCLEOD MN	27085	MN	27	2101.25	Hutchinson
637	BLUE EARTH MN	27013	MN	27	1899.37	Mankato
638	FREEBORN MN	27047	MN	27	1150.74	Albert Lea
639	STEELE MN	27147	MN	27	427.46	Owatonna
640	MURRAY MN	27101	MN	27	5732.91	Worthington
641	MOWER MN	27099	MN	27	1138.68	Austin
642	LE SUEUR MN	27079	MN	27	977.71	Northfield
643	STEARNS MN	27145	MN	27	1789.24	St Cloud
644	ITASCA MN	27061	MN	27	9053.84	Grand Rapids
645	ST. LOUIS MN	27137	MN	27	7612.57	Duluth
646	SHERBURNE MN	27141	MN	27	440.53	Zimmerman
647	WRIGHT MN	27171	MN	27	707.40	Buffalo
648	CHISAGO MN	27025	MN	27	446.93	Lindstrom
649	ISANTI MN	27059	MN	27	452.48	Cambridge
650	ANOKA MN	27003	MN	27	441.87	Minneapolis
651	RAMSEY MN	27123	MN	27	170.13	St Paul
652	WASHINGTON MN	27163	MN	27	431.49	St Paul
653	CARVER MN	27019	MN	27	370.83	Waconia
654	LAKE MN	27075	MN	27	3919.44	Silver Bay
655	GOODHUE MN	27049	MN	27	1585.89	Red Wing
656	SCOTT MN	27139	MN	27	1.95	Shakopee
657	DAKOTA MN	27037	MN	27	579.51	St Paul

Zone ID	Centroid County	Centroid County FIPS	State	State FIPS	Area (square miles)	Name
658	WABASHA MN	27157	MN	27	542.84	Plainview
659	WINONA MN	27169	MN	27	640.70	Winona
660	FILLMORE MN	27045	MN	27	850.82	Preston
661	HOUSTON MN	27055	MN	27	569.61	Spring Grove
662	CASS MN	27021	MN	27	6260.11	Brainerd

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Zonal Socioeconomic Data: Population

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
1	30,720	31,241	32,584	33,984	35,444	36,968	38,556	40,213	41,941	43,744
2	177,936	177,869	177,703	177,537	177,371	177,205	177,039	176,874	176,708	176,543
3	88,133	89,183	91,864	94,626	97,471	100,401	103,419	106,528	109,731	113,030
4	14,951	15,206	15,863	16,548	17,262	18,008	18,785	19,596	20,443	21,325
5	3,881	3,944	4,104	4,272	4,446	4,627	4,815	5,011	5,216	5,428
6	13,162	13,357	13,858	14,377	14,916	15,475	16,055	16,657	17,282	17,930
7	9,361	9,428	9,596	9,767	9,942	10,119	10,300	10,484	10,671	10,862
8	75,601	75,590	75,562	75,534	75,506	75,478	75,449	75,421	75,393	75,365
9	131,386	131,197	130,723	130,251	129,781	129,312	128,845	128,380	127,916	127,455
10	23,410	23,723	24,522	25,349	26,204	27,087	28,001	28,945	29,921	30,929
11	20,376	20,545	20,975	21,414	21,862	22,320	22,787	23,264	23,751	24,248
12	15,525	15,935	17,006	18,150	19,370	20,673	22,063	23,547	25,130	26,820
13	22,268	22,672	23,716	24,808	25,950	27,144	28,394	29,701	31,068	32,498
14	45,922	46,116	46,605	47,099	47,598	48,103	48,613	49,128	49,649	50,175
15	278,509	275,311	267,475	259,862	252,466	245,280	238,299	231,516	224,927	218,525
16	221,619	219,161	213,136	207,277	201,579	196,037	190,648	185,407	180,310	175,353
17	201,355	199,287	194,207	189,256	184,432	179,731	175,150	170,685	166,334	162,095
18	99,717	99,381	98,549	97,723	96,904	96,092	95,287	94,489	93,697	92,912
19	42,690	42,874	43,338	43,808	44,283	44,763	45,248	45,738	46,233	46,734
20	81,653	80,590	77,992	75,478	73,045	70,691	68,412	66,207	64,073	62,007
21	177,099	176,636	175,484	174,340	173,202	172,073	170,950	169,835	168,727	167,627
22	14,370	14,631	15,305	16,010	16,747	17,518	18,189	18,903	19,616	20,329
23	9,758	10,017	10,695	11,418	12,190	13,014	13,688	14,425	15,161	15,898
24	20,543	20,751	21,278	21,818	22,373	22,941	23,468	24,012	24,556	25,100
25	4,301	4,315	4,351	4,387	4,423	4,460	4,495	4,531	4,567	4,603
26	3,803	4,008	4,569	5,210	5,940	6,772	7,323	7,991	8,660	9,328
27	8,458	8,510	8,641	8,774	8,909	9,046	9,177	9,311	9,445	9,578
28	93,161	93,233	93,415	93,597	93,780	93,963	94,145	94,327	94,509	94,692

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
29	13,386	13,594	14,127	14,682	15,259	15,858	16,391	16,951	17,512	18,073
30	63,554	63,711	64,105	64,502	64,902	65,303	65,698	66,095	66,492	66,890
31	74,467	74,606	74,955	75,305	75,656	76,010	76,358	76,709	77,059	77,410
32	6,883	7,067	7,549	8,064	8,614	9,201	9,680	10,204	10,729	11,253
33	13,033	13,105	13,289	13,474	13,662	13,853	14,047	14,243	14,442	14,643
34	5,793	5,875	6,085	6,302	6,527	6,760	7,002	7,252	7,511	7,779
35	22,729	23,057	23,895	24,764	25,665	26,598	27,566	28,569	29,608	30,684
36	11,582	11,735	12,124	12,525	12,941	13,370	13,813	14,271	14,744	15,233
37	199,239	201,262	206,410	211,690	217,105	222,659	228,354	234,195	240,186	246,330
38	36,442	36,656	37,198	37,748	38,307	38,873	39,448	40,031	40,623	41,224
39	92,128	93,424	96,744	100,183	103,743	107,430	111,248	115,202	119,296	123,536
40	17,356	17,467	17,747	18,032	18,321	18,615	18,914	19,218	19,526	19,839
41	92,326	93,562	96,726	99,996	103,377	106,872	110,486	114,222	118,084	122,076
42	16,093	16,147	16,284	16,421	16,560	16,699	16,840	16,982	17,126	17,270
43	123,500	123,859	124,760	125,667	126,581	127,502	128,429	129,364	130,304	131,252
44	11,334	11,265	11,095	10,928	10,763	10,601	10,441	10,283	10,128	9,975
45	16,119	16,129	16,154	16,179	16,204	16,229	16,254	16,279	16,304	16,330
46	26,988	27,593	29,166	30,830	32,588	34,446	36,410	38,486	40,681	43,001
47	149,076	150,210	153,082	156,009	158,993	162,033	165,131	168,289	171,507	174,786
48	249,100	250,178	252,894	255,639	258,414	261,219	264,055	266,922	269,819	272,748
49	190,358	190,299	190,152	190,006	189,859	189,712	189,566	189,420	189,273	189,127
50	5,500	5,606	5,879	6,166	6,467	6,782	7,113	7,460	7,824	8,205
51	47,923	49,234	52,669	56,344	60,275	64,480	68,979	73,792	78,940	84,448
52	498,899	502,969	513,289	523,821	534,570	545,538	556,732	568,156	579,814	591,711
53	302,446	301,920	300,608	299,302	298,001	296,706	295,417	294,133	292,855	291,583
54	6,672	6,799	7,126	7,468	7,827	8,203	8,598	9,011	9,444	9,898
55	37,629	37,915	38,642	39,382	40,136	40,905	41,689	42,488	43,301	44,131
56	23,885	24,061	24,508	24,963	25,427	25,899	26,379	26,869	27,368	27,876
57	23,627	23,783	24,178	24,580	24,988	25,404	25,826	26,255	26,691	27,135
58	21,237	21,376	21,727	22,083	22,445	22,814	23,188	23,568	23,955	24,348

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
59	37,326	37,429	37,687	37,947	38,209	38,473	38,739	39,006	39,276	39,547
60	13,143	13,227	13,441	13,658	13,879	14,103	14,331	14,562	14,797	15,036
61	134,714	135,692	138,168	140,689	143,256	145,870	148,532	151,242	154,002	156,812
62	12,612	12,793	13,254	13,732	14,228	14,741	15,273	15,824	16,395	16,986
63	11,282	11,423	11,785	12,158	12,544	12,941	13,351	13,774	14,210	14,660
64	10,211	10,291	10,493	10,699	10,910	11,124	11,343	11,566	11,794	12,025
65	37,188	37,902	39,750	41,687	43,719	45,850	48,085	50,429	52,887	55,464
66	9,647	9,701	9,837	9,975	10,115	10,257	10,402	10,548	10,696	10,846
67	14,921	15,045	15,358	15,677	16,003	16,336	16,676	17,023	17,378	17,739
68	7,311	7,381	7,561	7,745	7,933	8,125	8,323	8,525	8,732	8,944
69	45,961	46,114	46,500	46,890	47,282	47,678	48,078	48,480	48,886	49,295
70	8,424	8,462	8,559	8,656	8,755	8,855	8,955	9,057	9,160	9,265
71	21,600	21,611	21,639	21,667	21,694	21,722	21,750	21,778	21,806	21,834
72	5,650	5,669	5,719	5,769	5,820	5,871	5,922	5,974	6,026	6,079
73	12,250	12,270	12,323	12,376	12,429	12,482	12,535	12,589	12,643	12,697
74	47,581	47,717	48,111	48,553	49,001	49,446	49,902	50,271	50,689	51,110
75	69,496	69,696	70,271	70,916	71,570	72,221	72,886	73,425	74,036	74,651
76	17,317	17,366	17,510	17,670	17,833	17,995	18,161	18,295	18,448	18,601
77	47,200	47,335	47,726	48,164	48,608	49,050	49,502	49,868	50,283	50,701
78	27,786	27,866	28,096	28,353	28,615	28,875	29,141	29,356	29,601	29,847
79	14,472	14,514	14,634	14,768	14,904	15,040	15,178	15,290	15,418	15,546
80	11,459	11,492	11,587	11,693	11,801	11,909	12,018	12,107	12,208	12,309
81	2,971	2,980	3,004	3,032	3,060	3,088	3,116	3,139	3,165	3,191
82	7,078	7,099	7,157	7,223	7,289	7,356	7,424	7,478	7,541	7,603
83	9,081	9,107	9,182	9,266	9,352	9,437	9,524	9,594	9,674	9,754
84	4,363	4,375	4,411	4,452	4,493	4,534	4,575	4,609	4,648	4,686
85	5,330	5,345	5,390	5,439	5,489	5,539	5,590	5,631	5,678	5,725
86	7,358	7,379	7,440	7,508	7,578	7,647	7,717	7,774	7,839	7,904
87	10,743	10,774	10,863	10,962	11,064	11,164	11,267	11,350	11,445	11,540
88	11,642	11,668	11,748	11,839	11,932	12,024	12,118	12,192	12,277	12,363

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
89	10,168	10,192	10,261	10,341	10,422	10,502	10,585	10,649	10,723	10,798
90	8,763	8,783	8,843	8,912	8,982	9,051	9,122	9,177	9,242	9,306
91	69,247	69,406	69,879	70,421	70,972	71,520	72,082	72,518	73,026	73,536
92	19,804	19,849	19,985	20,140	20,297	20,454	20,615	20,740	20,885	21,031
93	17,479	17,520	17,639	17,776	17,915	18,053	18,195	18,305	18,433	18,562
94	13,056	13,086	13,175	13,277	13,381	13,484	13,590	13,673	13,768	13,864
95	10,209	10,233	10,303	10,383	10,464	10,545	10,627	10,692	10,767	10,842
96	38,188	38,266	38,460	38,654	38,772	39,411	39,452	39,695	39,937	40,114
97	14,037	14,117	14,318	14,522	14,567	14,745	14,930	15,091	15,252	15,425
98	9,530	9,644	9,934	10,233	10,509	10,852	11,125	11,421	11,717	12,021
99	25,276	25,398	25,705	26,015	26,296	26,855	27,078	27,417	27,756	28,063
100	13,604	14,063	15,279	16,600	17,100	17,883	19,144	20,143	21,142	22,356
101	8,913	9,077	9,502	9,947	10,413	10,901	11,411	11,945	12,505	13,090
102	4,491	4,518	4,586	4,655	4,726	4,797	4,869	4,943	5,018	5,093
103	15,830	16,031	16,544	17,075	17,622	18,186	18,769	19,371	19,991	20,632
104	5,143	5,140	5,133	5,126	5,119	5,112	5,105	5,098	5,091	5,084
105	164,300	165,779	167,358	169,433	172,039	175,175	177,299	179,775	182,252	184,673
106	12,575	12,689	12,880	13,068	13,284	13,461	13,657	13,851	14,044	14,244
107	14,199	14,256	14,363	14,479	14,606	14,743	14,840	14,955	15,070	15,181
108	37,546	38,293	39,999	42,219	44,871	48,075	49,339	51,489	53,638	55,632
109	10,941	11,064	11,257	11,453	11,649	11,182	11,622	11,734	11,845	12,075
110	4,369	4,390	4,432	4,487	4,545	4,615	4,650	4,701	4,752	4,799
111	12,794	12,860	13,028	13,238	13,547	13,904	14,013	14,238	14,462	14,653
112	23,215	23,306	23,534	23,765	23,997	24,232	24,470	24,710	24,952	25,196
113	14,309	14,587	15,304	16,057	16,847	17,676	18,546	19,458	20,415	21,420
114	12,913	13,027	13,316	13,611	13,912	14,221	14,536	14,858	15,187	15,524
115	25,017	25,535	26,878	28,291	29,778	31,344	32,992	34,726	36,552	38,473
116	14,015	14,178	14,601	15,038	15,476	15,914	16,355	16,771	17,201	17,653
117	3,288	3,326	3,426	3,528	3,631	3,734	3,837	3,935	4,036	4,142
118	3,322	3,361	3,461	3,564	3,668	3,772	3,877	3,975	4,077	4,184

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
119	31,285	31,506	32,065	32,635	33,215	33,805	34,405	35,016	35,638	36,271
120	9,658	9,643	9,614	9,597	9,581	9,565	9,551	9,517	9,495	9,471
121	13,796	13,773	13,733	13,707	13,685	13,662	13,643	13,594	13,562	13,529
122	15,108	15,083	15,039	15,011	14,986	14,961	14,940	14,887	14,852	14,815
123	54,491	54,401	54,243	54,142	54,052	53,962	53,886	53,693	53,567	53,436
124	14,812	14,788	14,745	14,717	14,693	14,668	14,647	14,595	14,561	14,525
125	14,157	14,134	14,093	14,067	14,043	14,020	14,000	13,950	13,917	13,883
126	7,799	7,786	7,763	7,749	7,736	7,723	7,712	7,685	7,667	7,648
127	6,963	6,952	6,932	6,919	6,907	6,896	6,886	6,862	6,845	6,829
128	18,468	18,437	18,383	18,349	18,319	18,288	18,262	18,197	18,154	18,110
129	80,865	80,872	81,074	81,328	81,552	81,730	81,931	82,109	82,303	82,495
130	93,798	94,105	95,095	96,159	97,196	98,186	99,209	100,166	101,161	102,173
131	23,791	23,806	23,899	24,009	24,111	24,201	24,298	24,383	24,476	24,568
132	17,769	17,807	17,944	18,095	18,239	18,375	18,517	18,648	18,785	18,924
133	36,905	36,987	37,278	37,597	37,906	38,196	38,497	38,776	39,069	39,364
134	56,259	56,432	56,996	57,604	58,197	58,762	59,345	59,891	60,458	61,035
135	54,850	55,302	56,549	57,836	59,106	60,344	61,598	62,830	64,077	65,371
136	171,008	171,862	174,359	176,957	179,477	181,884	184,327	186,791	189,254	191,776
137	24,450	24,473	24,591	24,730	24,864	24,989	25,123	25,230	25,352	25,475
138	19,421	20,072	21,710	23,368	25,022	26,667	28,322	29,952	31,596	33,434
139	68,706	71,012	76,806	82,670	88,524	94,343	100,199	105,965	111,780	118,281
140	4,836	4,998	5,406	5,819	6,231	6,640	7,053	7,458	7,868	8,325
141	10,577	10,932	11,824	12,727	13,628	14,524	15,425	16,313	17,208	18,209
142	4,983	5,150	5,570	5,996	6,420	6,842	7,267	7,685	8,107	8,578
143	23,371	24,155	26,126	28,121	30,112	32,092	34,083	36,045	38,023	40,234
144	36,380	37,601	40,669	43,774	46,874	49,955	53,056	56,109	59,188	62,630
145	15,217	15,728	17,011	18,310	19,606	20,895	22,192	23,469	24,757	26,197
146	7,393	7,641	8,264	8,895	9,525	10,151	10,781	11,402	12,028	12,727
147	5,520	5,706	6,171	6,642	7,113	7,580	8,051	8,514	8,981	9,504
148	100,087	103,447	111,887	120,429	128,957	137,435	145,964	154,365	162,836	172,306

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
149	7,993	8,262	8,936	9,618	10,299	10,976	11,657	12,328	13,005	13,761
150	55,756	57,628	62,329	67,088	71,839	76,561	81,313	85,993	90,712	95,988
151	24,991	25,830	27,937	30,070	32,200	34,317	36,446	38,544	40,659	43,024
152	84,995	87,462	93,749	100,160	106,592	113,016	119,513	125,733	132,098	139,150
153	70,460	71,149	72,988	74,852	76,666	78,414	80,164	82,008	83,807	85,686
154	78,599	79,850	83,104	86,402	89,658	92,855	96,064	99,310	102,541	105,990
155	129,162	130,338	133,558	136,879	140,161	143,375	146,631	149,811	153,037	156,400
156	70,955	71,565	73,245	74,983	76,697	78,376	80,077	81,735	83,419	85,172
157	59,387	61,021	65,165	69,365	73,553	77,711	81,896	86,019	90,176	94,760
158	43,108	43,605	44,931	46,288	47,628	48,941	50,267	51,583	52,906	54,298
159	101,005	101,127	101,676	102,303	102,902	103,451	104,034	104,546	105,100	105,656
160	111,657	112,391	114,481	116,655	118,798	120,882	123,005	125,057	127,151	129,311
161	40,773	41,633	43,842	46,086	48,318	50,527	52,752	54,949	57,162	59,562
162	22,300	22,770	23,978	25,206	26,426	27,635	28,851	30,053	31,263	32,576
163	45,883	46,850	49,336	51,861	54,373	56,859	59,363	61,835	64,326	67,026
164	37,501	38,292	40,324	42,387	44,440	46,472	48,518	50,539	52,575	54,782
165	41,894	42,777	45,047	47,353	49,646	51,916	54,202	56,459	58,733	61,199
166	64,329	65,685	69,170	72,710	76,232	79,717	83,228	86,694	90,186	93,972
167	109,741	112,054	118,000	124,039	130,047	135,993	141,981	147,894	153,851	160,310
168	122,975	125,566	132,230	138,997	145,729	152,392	159,102	165,729	172,404	179,642
169	89,457	91,342	96,190	101,113	106,010	110,857	115,738	120,559	125,414	130,680
170	17,232	17,595	18,529	19,477	20,420	21,354	22,294	23,223	24,158	25,173
171	29,615	30,239	31,844	33,474	35,095	36,700	38,315	39,911	41,519	43,262
172	63,105	63,817	65,720	67,667	69,590	71,474	73,375	75,264	77,163	79,158
173	15,323	15,496	15,958	16,431	16,898	17,355	17,817	18,275	18,736	19,221
174	12,874	13,020	13,408	13,805	14,197	14,582	14,970	15,355	15,742	16,149
175	23,466	23,731	24,438	25,162	25,877	26,578	27,285	27,987	28,693	29,435
176	12,410	12,550	12,924	13,307	13,685	14,056	14,429	14,801	15,174	15,567
177	83,919	84,005	84,422	84,903	85,360	85,777	86,223	86,609	87,030	87,451
178	106,832	106,654	106,460	106,342	106,190	105,983	105,806	105,578	105,382	105,182

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
179	41,968	41,982	42,117	42,284	42,438	42,572	42,719	42,839	42,975	43,111
180	6,614	6,750	7,096	7,450	7,805	8,160	8,516	8,859	9,210	9,589
181	20,541	20,963	22,040	23,138	24,241	25,343	26,451	27,516	28,605	29,783
182	10,776	10,998	11,563	12,139	12,717	13,295	13,877	14,436	15,007	15,625
183	38,808	39,607	41,641	43,716	45,799	47,881	49,975	51,987	54,045	56,271
184	196,542	196,139	195,596	195,193	194,723	194,153	193,638	193,031	192,482	191,928
185	32,224	32,224	32,303	32,406	32,498	32,575	32,661	32,729	32,808	32,886
186	54,263	54,441	55,015	55,634	56,239	56,819	57,420	57,974	58,554	59,144
187	41,823	42,071	42,790	43,547	44,294	45,023	45,770	46,472	47,199	47,947
188	85,623	85,633	85,864	86,158	86,427	86,654	86,908	87,108	87,340	87,570
189	67,845	67,854	68,036	68,270	68,482	68,662	68,863	69,022	69,206	69,388
190	45,384	45,389	45,511	45,667	45,810	45,930	46,064	46,171	46,294	46,416
191	97,520	97,531	97,793	98,129	98,435	98,694	98,982	99,211	99,475	99,737
192	34,939	34,943	35,037	35,157	35,267	35,359	35,463	35,544	35,639	35,733
193	84,065	84,076	84,301	84,591	84,855	85,077	85,326	85,523	85,751	85,977
194	22,801	22,884	23,148	23,430	23,707	23,973	24,248	24,503	24,769	25,040
195	13,791	13,841	14,001	14,171	14,339	14,500	14,666	14,820	14,981	15,145
196	15,682	15,740	15,921	16,115	16,305	16,488	16,678	16,853	17,036	17,222
197	16,626	16,687	16,879	17,085	17,287	17,481	17,682	17,867	18,061	18,259
198	88,389	89,672	93,070	96,559	100,039	103,491	106,993	110,345	113,776	117,427
199	4,668	4,731	4,895	5,063	5,232	5,401	5,571	5,732	5,898	6,074
200	11,099	11,250	11,638	12,039	12,441	12,842	13,247	13,630	14,025	14,443
201	24,179	24,507	25,354	26,226	27,102	27,977	28,859	29,692	30,553	31,463
202	11,660	11,819	12,227	12,648	13,070	13,492	13,917	14,319	14,734	15,173
203	4,233	4,291	4,439	4,592	4,745	4,899	5,053	5,199	5,349	5,509
204	42,600	43,179	44,671	46,207	47,750	49,292	50,845	52,314	53,830	55,434
205	9,909	10,044	10,391	10,748	11,107	11,466	11,827	12,169	12,521	12,894
206	20,097	20,458	21,395	22,348	23,295	24,230	25,172	26,103	27,041	28,049
207	15,302	15,577	16,291	17,017	17,737	18,449	19,167	19,876	20,590	21,357
208	14,730	14,995	15,681	16,380	17,074	17,759	18,449	19,132	19,819	20,558

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
209	8,968	9,129	9,548	9,973	10,395	10,813	11,233	11,649	12,067	12,517
210	60,964	61,279	62,201	63,164	64,104	65,007	65,925	66,832	67,748	68,687
211	43,649	43,997	44,960	45,949	46,920	47,862	48,813	49,767	50,721	51,712
212	145,289	145,852	147,609	149,484	151,324	153,099	154,930	156,628	158,401	160,209
213	473,611	478,799	492,018	505,602	519,562	533,907	548,648	563,795	579,361	595,357
214	467,893	474,786	492,467	510,807	529,829	549,560	570,025	591,253	613,271	636,109
215	409,960	415,955	431,329	447,271	463,802	480,945	498,721	517,153	536,268	556,088
216	318,979	324,684	339,397	354,777	370,853	387,658	405,225	423,588	442,782	462,847
217	419,520	421,906	427,932	434,044	440,243	446,530	452,908	459,376	465,937	472,591
218	297,276	302,621	316,409	330,825	345,898	361,657	378,135	395,363	413,376	432,210
219	272,313	273,716	277,257	280,843	284,475	288,155	291,882	295,657	299,481	303,355
220	303,336	307,553	318,354	329,534	341,106	353,085	365,485	378,320	391,606	405,358
221	232,182	233,926	238,343	242,844	247,430	252,102	256,863	261,713	266,655	271,690
222	309,570	312,434	319,709	327,155	334,773	342,569	350,547	358,710	367,064	375,611
223	27,605	28,086	29,325	30,619	31,970	33,381	34,854	36,392	37,998	39,674
224	25,702	25,959	26,612	27,282	27,968	28,672	29,394	30,133	30,891	31,669
225	73,382	74,842	78,622	82,592	86,763	91,145	95,748	100,583	105,663	110,999
226	42,815	43,844	46,527	49,374	52,395	55,602	59,004	62,614	66,446	70,512
227	187,404	189,931	196,400	203,089	210,006	217,158	224,554	232,202	240,110	248,288
228	280,790	285,444	297,418	309,894	322,894	336,439	350,552	365,257	380,579	396,544
229	16,215	16,369	16,762	17,164	17,575	17,996	18,428	18,869	19,322	19,785
230	140,595	141,579	144,069	146,603	149,181	151,805	154,475	157,191	159,956	162,769
231	181,601	182,946	186,353	189,823	193,357	196,958	200,625	204,361	208,167	212,043
232	57,925	58,282	59,183	60,098	61,028	61,971	62,930	63,903	64,891	65,894
233	88,751	89,565	91,633	93,749	95,914	98,129	100,394	102,713	105,084	107,511
234	17,335	17,709	18,680	19,705	20,785	21,925	23,127	24,396	25,733	27,145
235	21,232	21,686	22,866	24,109	25,420	26,802	28,259	29,796	31,416	33,125
236	208,606	212,186	221,405	231,026	241,064	251,539	262,469	273,873	285,773	298,191
237	169,768	171,630	176,374	181,249	186,260	191,408	196,699	202,136	207,724	213,466
238	127,282	130,658	139,495	148,929	159,002	169,755	181,236	193,494	206,580	220,552

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
239	69,213	72,014	72,014	76,328	80,731	85,162	89,603	91,962	95,530	99,260
240	25,258	26,834	31,218	36,318	42,251	49,153	57,183	66,525	77,393	90,037
241	11,114	11,565	11,565	12,258	12,965	13,677	14,390	14,769	15,342	15,941
242	443,787	449,963	465,783	482,160	499,112	516,659	534,824	553,628	573,092	593,241
243	113,564	115,106	119,052	123,133	127,355	131,721	136,237	140,908	145,738	150,735
244	365,452	372,693	391,430	411,109	431,777	453,484	476,282	500,227	525,375	551,788
245	33,969	33,944	33,882	33,820	33,759	33,697	33,635	33,574	33,513	33,451
246	6,633	7,033	7,033	7,641	8,259	8,881	9,506	9,840	10,343	10,882
247	9,462	10,033	10,033	10,900	11,782	12,669	13,560	14,037	14,754	15,523
248	361,514	369,811	391,397	414,243	438,422	464,013	491,097	519,763	550,101	582,211
249	58,824	62,519	72,803	84,779	98,724	114,964	133,875	155,897	181,542	211,405
250	51,784	53,854	59,400	65,516	72,262	79,703	87,910	96,962	106,946	117,958
251	80,096	81,121	81,121	83,803	86,565	89,341	92,113	93,468	95,653	97,854
252	17,422	17,795	17,795	18,383	18,989	19,598	20,206	20,523	21,010	21,503
253	15,473	15,803	15,803	16,326	16,864	17,405	17,945	18,226	18,658	19,096
254	19,994	21,056	23,965	27,275	31,043	35,331	40,212	45,767	52,089	59,285
255	71,396	74,357	82,306	91,106	100,847	111,629	123,563	136,774	151,397	167,584
256	24,976	25,586	27,176	28,866	30,661	32,567	34,591	36,742	39,026	41,452
257	159,246	163,273	173,793	184,990	196,908	209,594	223,098	237,472	252,772	269,057
258	114,883	116,854	121,932	127,231	132,760	138,529	144,548	150,830	157,384	164,223
259	111,801	114,121	120,134	126,463	133,126	140,140	147,523	155,296	163,478	172,091
260	81,860	84,334	90,851	97,871	105,434	113,581	122,358	131,813	141,999	152,971
261	136,291	139,070	146,269	153,840	161,803	170,178	178,987	188,252	197,996	208,244
262	98,018	99,946	104,933	110,170	115,667	121,439	127,499	133,861	140,541	147,554
263	22,503	23,503	26,201	29,210	32,563	36,302	40,470	45,117	50,297	56,072
264	21,593	22,236	23,928	25,748	27,707	29,815	32,084	34,525	37,152	39,978
265	127,415	132,620	146,583	162,016	179,074	197,928	218,767	241,800	267,258	295,397
266	182,042	187,561	202,103	217,772	234,655	252,848	272,451	293,574	316,335	340,860
267	78,691	82,444	92,628	104,070	116,925	131,368	147,596	165,828	186,312	209,326
268	12,699	13,246	14,719	16,356	18,176	20,197	22,444	24,940	27,714	30,796

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
269	155,770	160,439	172,731	185,966	200,215	215,555	232,071	249,853	268,997	289,607
270	65,061	67,486	73,950	81,034	88,796	97,301	106,622	116,835	128,027	140,290
271	115,875	119,446	128,863	139,023	149,983	161,808	174,565	188,327	203,175	219,193
272	133,441	138,845	153,332	169,330	186,998	206,509	228,056	251,851	278,129	307,148
273	131,034	137,693	155,859	176,422	199,697	226,043	255,865	289,622	327,832	371,083
274	26,299	27,474	30,645	34,183	38,129	42,530	47,440	52,916	59,024	65,838
275	18,843	18,789	18,702	18,630	18,554	18,471	18,394	18,299	18,214	18,129
276	14,040	14,000	13,935	13,881	13,825	13,762	13,706	13,634	13,571	13,508
277	36,269	36,559	37,366	38,202	39,028	39,836	40,658	41,451	42,261	43,102
278	180,150	182,609	189,149	195,866	202,560	209,188	215,907	222,360	228,958	235,954
279	58,150	58,189	58,417	58,679	58,917	59,117	59,328	59,543	59,760	59,976
280	113,295	113,203	113,253	113,397	113,514	113,583	113,693	113,697	113,761	113,820
281	40,521	40,375	40,108	39,876	39,636	39,379	39,138	38,854	38,595	38,337
282	163,802	163,961	164,725	165,593	166,390	167,085	167,812	168,541	169,279	170,016
283	29,446	29,308	29,035	28,787	28,533	28,267	28,013	27,727	27,459	27,194
284	81,147	80,912	80,497	80,121	79,699	79,220	78,746	78,321	77,877	77,434
285	51,391	51,567	52,123	52,714	53,286	53,826	54,379	54,922	55,474	56,034
286	56,202	56,210	56,361	56,549	56,714	56,850	56,998	57,133	57,278	57,421
287	51,357	51,871	53,255	54,669	56,056	57,405	58,760	60,139	61,509	62,942
288	7,186	7,139	7,040	6,946	6,853	6,758	6,666	6,563	6,465	6,371
289	70,307	69,809	68,742	67,744	66,738	65,716	64,727	63,620	62,578	61,565
290	322,864	322,753	323,257	324,020	324,698	325,233	325,879	326,259	326,793	327,315
291	171,240	174,184	181,775	189,433	196,972	204,351	211,727	219,331	226,830	234,860
292	46,688	46,552	46,324	46,133	45,929	45,704	45,495	45,250	45,025	44,801
293	32,549	32,443	32,258	32,101	31,939	31,764	31,604	31,404	31,226	31,048
294	18,949	18,790	18,439	18,107	17,774	17,437	17,111	16,749	16,405	16,075
295	67,152	67,150	67,305	67,512	67,698	67,853	68,029	68,160	68,318	68,474
296	35,424	35,402	35,431	35,487	35,531	35,559	35,598	35,615	35,645	35,673
297	132,413	132,129	131,748	131,478	131,181	130,830	130,530	130,091	129,731	129,366
298	198,269	198,385	199,148	200,064	200,923	201,687	202,517	203,209	203,982	204,753

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
299	110,262	109,879	109,181	108,563	107,912	107,208	106,536	105,799	105,102	104,410
300	53,732	54,114	55,190	56,308	57,412	58,487	59,581	60,639	61,718	62,835
301	47,462	47,493	47,688	47,923	48,148	48,352	48,574	48,749	48,951	49,153
302	33,281	33,328	33,519	33,730	33,927	34,103	34,284	34,468	34,653	34,838
303	34,274	34,809	36,217	37,662	39,104	40,534	41,985	43,375	44,798	46,317
304	242,334	242,345	242,969	243,792	244,545	245,198	245,928	246,458	247,105	247,744
305	82,194	82,205	82,432	82,722	82,990	83,217	83,474	83,670	83,901	84,130
306	35,832	35,910	36,188	36,487	36,772	37,035	37,305	37,574	37,845	38,120
307	39,070	38,985	38,869	38,789	38,701	38,599	38,513	38,380	38,273	38,165
308	91,286	91,800	93,294	94,860	96,397	97,889	99,410	100,875	102,373	103,913
309	15,282	15,420	15,795	16,179	16,557	16,923	17,291	17,665	18,036	18,424
310	22,850	23,046	23,587	24,145	24,694	25,230	25,774	26,308	26,848	27,410
311	60,055	60,071	60,260	60,501	60,728	60,931	61,156	61,320	61,519	61,716
312	106,076	106,609	108,190	109,853	111,485	113,064	114,680	116,223	117,809	119,435
313	302,120	303,585	307,953	312,557	317,076	321,443	325,913	330,176	334,561	339,051
314	268,373	268,659	270,034	271,634	273,172	274,596	276,121	277,386	278,798	280,213
315	22,182	22,177	22,220	22,282	22,339	22,387	22,444	22,477	22,524	22,570
316	33,218	33,144	33,042	32,968	32,889	32,799	32,722	32,604	32,509	32,413
317	347,452	351,770	363,266	375,031	386,682	398,140	409,712	421,106	432,609	444,749
318	88,627	89,041	90,286	91,602	92,894	94,144	95,424	96,637	97,889	99,170
319	85,116	85,009	84,945	84,944	84,917	84,850	84,808	84,714	84,651	84,585
320	42,392	43,451	43,451	45,111	46,818	48,537	50,258	51,153	52,528	53,930
321	165,770	169,908	169,908	176,399	183,077	189,798	196,527	200,028	205,405	210,887
322	79,506	81,493	81,493	84,606	87,809	91,033	94,260	95,939	98,518	101,148
323	36,062	36,963	36,963	38,375	39,828	41,290	42,754	43,515	44,685	45,878
324	6,239	6,395	6,395	6,639	6,890	7,143	7,397	7,528	7,731	7,937
325	13,908	14,252	14,252	14,797	15,357	15,921	16,485	16,779	17,230	17,689
326	14,447	14,807	14,807	15,372	15,954	16,540	17,126	17,431	17,900	18,378
327	42,253	43,761	43,761	46,093	48,478	50,881	53,292	54,560	56,491	58,495
328	169,048	172,510	172,510	178,002	183,662	189,347	195,021	197,979	202,523	207,115

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
329	24,651	25,158	25,158	25,959	26,785	27,614	28,441	28,873	29,535	30,205
330	82,336	81,990	81,990	81,604	81,274	80,936	80,574	80,304	79,989	79,676
331	37,044	37,406	37,406	38,028	38,684	39,341	39,995	40,315	40,831	41,340
332	30,885	31,392	31,392	32,202	33,043	33,889	34,732	35,163	35,835	36,508
333	14,596	14,834	14,834	15,217	15,614	16,014	16,412	16,616	16,933	17,251
334	15,136	15,382	15,382	15,779	16,191	16,605	17,019	17,229	17,558	17,888
335	16,910	17,185	17,185	17,628	18,089	18,552	19,014	19,249	19,616	19,985
336	84,075	84,367	84,367	84,942	85,582	86,218	86,834	87,104	87,583	88,043
337	27,235	27,329	27,329	27,516	27,723	27,929	28,129	28,216	28,371	28,520
338	37,463	38,039	38,039	38,972	39,942	40,919	41,893	42,386	43,160	43,934
339	18,564	18,808	18,808	19,205	19,620	20,035	20,448	20,658	20,988	21,315
340	23,121	23,424	23,424	23,919	24,435	24,953	25,467	25,729	26,139	26,547
341	14,172	14,358	14,358	14,661	14,978	15,295	15,610	15,771	16,022	16,272
342	169,113	171,324	171,324	174,945	178,720	182,505	186,269	188,182	191,181	194,164
343	78,160	79,189	79,189	80,862	82,607	84,357	86,097	86,982	88,368	89,747
344	48,531	49,169	49,169	50,209	51,292	52,378	53,459	54,008	54,869	55,725
345	67,522	68,410	68,410	69,855	71,363	72,874	74,377	75,141	76,339	77,530
346	54,526	55,243	55,243	56,411	57,628	58,848	60,062	60,679	61,647	62,609
347	20,541	20,811	20,811	21,251	21,709	22,169	22,626	22,859	23,223	23,586
348	12,012	12,186	12,186	12,468	12,763	13,059	13,355	13,504	13,739	13,973
349	16,047	16,278	16,278	16,656	17,049	17,445	17,840	18,039	18,352	18,665
350	18,998	19,272	19,272	19,719	20,185	20,654	21,122	21,357	21,727	22,098
351	47,509	48,827	48,827	50,886	53,002	55,131	57,263	58,377	60,083	61,831
352	47,153	48,970	48,970	51,775	54,640	57,522	60,411	61,944	64,264	66,682
353	28,841	29,957	29,957	31,673	33,426	35,189	36,956	37,894	39,314	40,794
354	43,498	45,180	45,180	47,769	50,412	53,071	55,736	57,151	59,292	61,524
355	16,121	16,745	16,745	17,704	18,684	19,669	20,657	21,181	21,975	22,802
356	29,555	30,697	30,697	32,456	34,251	36,058	37,869	38,830	40,285	41,801
357	47,308	46,980	46,980	46,584	46,236	45,897	45,556	45,279	44,964	44,658
358	245,529	248,254	248,254	252,843	257,685	262,565	267,437	269,791	273,613	277,398

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
359	21,165	21,403	21,403	21,799	22,216	22,637	23,057	23,260	23,590	23,917
360	23,267	23,783	23,783	24,598	25,435	26,276	27,116	27,556	28,230	28,913
361	34,190	34,743	34,743	35,630	36,553	37,480	38,406	38,877	39,614	40,352
362	32,650	32,698	32,698	32,824	32,977	33,127	33,270	33,319	33,425	33,525
363	62,131	62,791	62,791	63,888	65,042	66,200	67,351	67,920	68,831	69,731
364	33,274	34,144	34,144	35,511	36,915	38,329	39,745	40,482	41,614	42,770
365	14,151	14,252	14,537	14,834	15,126	15,411	15,701	15,982	16,268	16,563
366	33,398	33,871	35,118	36,391	37,653	38,894	40,147	41,385	42,632	43,957
367	33,365	33,275	33,149	33,063	32,980	32,895	32,830	32,679	32,574	32,467
368	175,628	178,204	184,960	191,837	198,643	205,336	212,077	218,795	225,534	232,698
369	38,215	38,096	37,912	37,774	37,641	37,505	37,393	37,180	37,021	36,860
370	108,084	107,945	107,905	107,992	108,086	108,166	108,311	108,196	108,221	108,239
371	199,333	200,596	204,247	208,083	211,889	215,618	219,435	222,993	226,694	230,512
372	455,714	459,961	471,612	483,656	495,594	507,323	519,230	530,705	542,425	554,657
373	190,856	191,484	193,549	195,798	198,027	200,191	202,448	204,414	206,538	208,698
374	261,201	260,615	259,893	259,475	259,074	258,637	258,359	257,456	256,886	256,305
375	58,009	60,137	65,391	70,648	75,844	80,965	86,074	91,354	96,549	102,383
376	282,977	296,590	329,698	362,727	395,369	427,545	459,599	492,924	525,611	563,065
377	131,027	130,335	128,995	127,824	126,679	125,531	124,475	123,028	121,789	120,566
378	148,623	159,882	186,527	213,017	239,188	264,998	290,661	317,535	343,794	374,959
379	912,242	912,160	914,517	917,907	921,330	924,587	928,380	930,137	932,984	935,800
380	70,466	73,489	80,890	88,281	95,586	102,786	109,963	117,407	124,718	133,022
381	117,575	116,853	115,399	114,101	112,827	111,555	110,368	108,815	107,456	106,123
382	69,217	69,816	71,474	73,192	74,894	76,564	78,261	79,892	81,560	83,297
383	44,511	44,656	45,136	45,661	46,184	46,694	47,227	47,682	48,179	48,685
384	141,796	149,051	166,636	184,169	201,495	218,575	235,585	253,290	270,646	290,626
385	66,532	66,268	65,806	65,425	65,056	64,681	64,353	63,838	63,421	63,007
386	68,557	68,050	66,990	66,024	65,074	64,129	63,235	62,114	61,113	60,140
387	154,762	155,321	157,126	159,089	161,040	162,945	164,929	166,649	168,512	170,410
388	77,930	78,138	78,868	79,679	80,486	81,272	82,100	82,785	83,547	84,319

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
389	225,554	228,124	235,019	242,093	249,097	255,978	262,936	269,763	276,667	283,929
390	125,882	126,562	128,577	130,704	132,814	134,872	136,988	138,943	140,986	143,086
391	31,532	31,497	31,501	31,542	31,584	31,622	31,679	31,661	31,683	31,703
392	23,042	23,354	24,179	25,021	25,858	26,681	27,513	28,331	29,157	30,032
393	56,050	57,522	61,250	65,018	68,762	72,468	76,188	79,907	83,630	87,720
394	59,721	59,507	59,113	58,763	58,395	57,998	57,619	57,204	56,811	56,421
395	231,202	237,100	252,096	267,287	282,409	297,393	312,466	327,398	342,413	358,886
396	159,998	164,080	174,457	184,970	195,434	205,804	216,235	226,568	236,959	248,359
397	28,491	28,898	29,971	31,067	32,154	33,226	34,308	35,372	36,446	37,588
398	244,795	251,393	268,159	285,167	302,135	318,982	335,950	352,621	369,455	387,995
399	251,967	258,758	276,016	293,522	310,986	328,328	345,793	362,952	380,279	399,363
400	22,716	22,943	23,555	24,183	24,801	25,405	26,015	26,622	27,232	27,870
401	13,230	13,691	14,849	16,022	17,194	18,360	19,535	20,687	21,850	23,155
402	3,559	3,634	3,827	4,023	4,218	4,412	4,607	4,798	4,992	5,202
403	173,830	173,207	172,061	171,043	169,970	168,815	167,711	166,504	165,360	164,224
404	175,583	174,953	173,796	172,767	171,685	170,518	169,403	168,183	167,027	165,880
405	534,641	532,724	529,200	526,068	522,770	519,217	515,822	512,109	508,589	505,095
406	77,460	78,415	80,962	83,570	86,154	88,697	91,266	93,789	96,339	99,030
407	66,632	67,669	70,385	73,155	75,905	78,617	81,354	84,050	86,770	89,671
408	30,013	30,312	31,122	31,951	32,768	33,566	34,372	35,174	35,980	36,823
409	15,308	15,468	15,900	16,342	16,778	17,205	17,637	18,065	18,495	18,946
410	33,666	34,024	34,983	35,961	36,922	37,859	38,802	39,756	40,707	41,703
411	70,136	70,883	72,900	74,974	77,026	79,040	81,079	83,074	85,095	87,215
412	208,966	212,148	220,518	229,077	237,591	246,006	254,511	262,801	271,211	280,174
413	162,309	163,239	165,927	168,733	171,481	174,139	176,846	179,487	182,170	184,929
414	43,905	44,225	45,121	46,049	46,960	47,847	48,748	49,631	50,526	51,451
415	118,637	119,750	122,788	125,917	129,008	132,034	135,101	138,102	141,143	144,317
416	154,670	155,595	158,233	160,965	163,627	166,191	168,785	171,393	174,002	176,687
417	238,437	245,173	262,246	279,557	296,828	313,980	331,249	348,231	365,371	384,306
418	82,488	86,824	97,440	108,130	118,796	129,400	140,041	150,641	161,265	173,544

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
419	7,417	7,567	7,952	8,343	8,731	9,116	9,503	9,886	10,271	10,688
420	95,825	96,828	99,524	102,281	104,994	107,643	110,316	112,994	115,673	118,481
421	178,013	182,428	193,687	205,108	216,487	227,771	239,131	250,330	261,620	273,986
422	167,860	170,052	175,837	181,726	187,538	193,235	198,971	204,727	210,481	216,565
423	49,288	50,940	55,093	59,302	63,507	67,692	71,904	76,035	80,210	84,878
424	97,543	97,905	99,037	100,243	101,421	102,548	103,706	104,806	105,941	107,096
425	81,098	81,094	81,276	81,519	81,738	81,916	82,119	82,273	82,457	82,639
426	115,235	116,234	118,988	121,830	124,637	127,384	130,170	132,885	135,642	138,513
427	132,186	137,494	150,675	163,974	177,234	190,408	203,638	216,788	229,984	244,926
428	86,708	88,729	93,891	99,127	104,337	109,496	114,686	119,825	124,995	130,635
429	43,871	44,443	45,958	47,509	49,045	50,556	52,082	53,585	55,102	56,707
430	62,676	63,633	66,144	68,703	71,242	73,746	76,272	78,764	81,276	83,953
431	99,788	101,617	106,356	111,174	115,960	120,688	125,451	130,162	134,904	140,006
432	13,466	13,442	13,415	13,397	13,376	13,347	13,322	13,290	13,262	13,235
433	29,098	29,271	29,770	30,292	30,804	31,302	31,810	32,299	32,799	33,314
434	55,263	55,549	56,382	57,249	58,092	58,900	59,721	60,542	61,365	62,210
435	20,506	20,656	21,077	21,515	21,945	22,365	22,793	23,207	23,629	24,066
436	115,420	117,524	122,979	128,525	134,035	139,477	144,960	150,382	155,841	161,711
437	44,953	45,288	46,226	47,199	48,159	49,094	50,045	50,969	51,908	52,882
438	26,673	27,114	28,263	29,433	30,595	31,741	32,898	34,039	35,190	36,420
439	47,913	48,219	49,087	49,988	50,872	51,728	52,595	53,451	54,316	55,208
440	166,874	167,811	170,541	173,404	176,221	178,956	181,750	184,421	187,164	189,982
441	102,619	104,156	108,196	112,317	116,408	120,441	124,510	128,518	132,563	136,869
442	160,345	161,652	165,251	168,950	172,581	176,108	179,672	183,238	186,811	190,521
443	36,901	37,249	38,194	39,163	40,117	41,047	41,987	42,924	43,864	44,845
444	62,353	64,132	68,639	73,210	77,772	82,303	86,868	91,350	95,876	100,881
445	23,709	23,979	24,702	25,442	26,173	26,888	27,610	28,328	29,049	29,807
446	84,499	84,795	85,711	86,674	87,594	88,455	89,333	90,236	91,130	92,039
447	189,510	189,993	191,647	193,443	195,182	196,824	198,528	200,117	201,775	203,453
448	33,187	33,246	33,246	33,397	33,580	33,768	33,953	34,006	34,137	34,260

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
449	42,376	42,450	42,450	42,643	42,877	43,116	43,353	43,420	43,587	43,745
450	16,938	16,968	16,968	17,045	17,138	17,234	17,329	17,356	17,422	17,485
451	33,587	34,082	34,082	34,883	35,717	36,557	37,393	37,816	38,481	39,145
452	43,348	43,024	43,024	42,619	42,254	41,895	41,532	41,259	40,934	40,619
453	52,666	52,874	52,874	53,283	53,744	54,212	54,677	54,858	55,204	55,539
454	38,911	39,023	39,023	39,265	39,544	39,829	40,112	40,211	40,417	40,615
455	153,240	166,492	166,492	186,160	205,943	225,715	245,444	256,559	272,715	290,463
456	293,187	298,980	298,980	308,189	317,719	327,316	336,919	341,829	349,469	357,182
457	118,188	120,525	120,525	124,237	128,079	131,947	135,818	137,798	140,878	143,987
458	425,817	434,232	434,232	447,607	461,449	475,386	489,334	496,465	507,562	518,764
459	184,061	187,700	187,700	193,481	199,465	205,489	211,518	214,601	219,398	224,240
460	76,681	78,197	78,197	80,605	83,098	85,608	88,119	89,404	91,402	93,419
461	83,890	85,547	85,547	88,182	90,909	93,655	96,403	97,808	99,994	102,201
462	79,216	80,093	80,093	81,588	83,167	84,760	86,354	87,116	88,362	89,596
463	6,890	6,904	6,904	6,940	6,985	7,031	7,078	7,089	7,121	7,152
464	8,622	8,638	8,638	8,683	8,739	8,797	8,856	8,870	8,910	8,948
465	16,374	16,406	16,406	16,492	16,597	16,707	16,819	16,846	16,922	16,994
466	45,678	46,582	46,582	48,071	49,609	51,158	52,707	53,499	54,731	55,977
467	45,587	45,542	45,542	45,571	45,655	45,755	45,859	45,815	45,855	45,888
468	28,727	28,698	28,698	28,716	28,769	28,832	28,898	28,870	28,895	28,916
469	64,158	64,487	64,487	65,094	65,764	66,443	67,115	67,398	67,909	68,405
470	102,867	103,401	103,401	104,394	105,490	106,598	107,701	108,164	109,002	109,815
471	65,829	67,995	67,995	71,194	74,463	77,743	81,019	82,787	85,434	88,164
472	19,441	19,492	19,492	19,606	19,739	19,875	20,010	20,055	20,153	20,246
473	25,154	25,234	25,234	25,407	25,604	25,805	26,003	26,076	26,223	26,364
474	22,579	22,653	22,653	22,808	22,985	23,165	23,344	23,409	23,541	23,668
475	109,398	109,067	109,067	108,778	108,594	108,424	108,247	107,974	107,758	107,537
476	71,876	72,538	72,538	73,665	74,864	76,070	77,274	77,844	78,784	79,710
477	21,251	22,167	22,167	23,565	24,984	26,405	27,824	28,600	29,752	30,960
478	37,700	39,327	39,327	41,807	44,324	46,846	49,364	50,741	52,784	54,927

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
479	28,685	28,583	28,583	28,482	28,410	28,340	28,268	28,183	28,105	28,028
480	22,582	22,636	22,636	22,760	22,906	23,055	23,202	23,250	23,356	23,458
481	424,236	424,293	425,471	426,990	428,399	429,617	430,981	431,996	433,213	434,418
482	65,088	65,097	65,278	65,511	65,727	65,914	66,123	66,279	66,465	66,650
483	186,317	186,342	186,860	187,527	188,145	188,680	189,279	189,725	190,259	190,789
484	421,931	422,893	426,321	430,094	433,763	437,242	440,876	444,139	447,614	451,125
485	577,794	579,111	583,806	588,973	593,996	598,761	603,737	608,206	612,964	617,773
486	40,301	40,018	39,414	38,849	38,279	37,699	37,139	36,512	35,921	35,348
487	318,955	313,323	299,973	286,969	273,987	260,985	248,171	234,582	221,406	209,595
488	78,306	78,186	78,081	78,041	77,980	77,885	77,817	77,681	77,584	77,484
489	68,352	68,217	68,042	67,917	67,768	67,583	67,420	67,222	67,046	66,867
490	43,932	44,199	44,970	45,777	46,572	47,348	48,141	48,894	49,670	50,469
491	56,453	56,514	56,801	57,130	57,438	57,720	58,019	58,286	58,573	58,860
492	38,624	38,485	38,223	37,988	37,738	37,466	37,201	36,931	36,666	36,403
493	32,939	32,759	32,384	32,032	31,668	31,289	30,916	30,531	30,155	29,786
494	37,626	37,390	36,887	36,411	35,920	35,411	34,910	34,395	33,890	33,398
495	127,078	127,288	128,118	129,048	129,939	130,770	131,642	132,427	133,264	134,106
496	33,512	33,570	33,795	34,045	34,286	34,507	34,741	34,955	35,180	35,407
497	57,548	57,346	56,977	56,648	56,299	55,922	55,561	55,172	54,801	54,432
498	92,874	92,969	93,413	93,913	94,372	94,773	95,195	95,618	96,045	96,472
499	66,163	66,375	67,059	67,794	68,508	69,189	69,887	70,551	71,237	71,933
500	131,468	131,942	133,436	135,033	136,590	138,084	139,622	141,070	142,571	144,098
501	94,411	94,629	95,371	96,163	96,906	97,583	98,274	99,003	99,717	100,439
502	19,737	19,726	19,739	19,761	19,772	19,769	19,768	19,778	19,784	19,789
503	48,896	48,848	48,833	48,845	48,831	48,784	48,742	48,720	48,691	48,661
504	167,080	168,877	173,771	178,843	183,911	188,936	194,062	198,858	203,828	209,049
505	231,294	234,946	244,480	254,178	263,786	273,246	282,768	292,253	301,768	311,923
506	70,877	70,963	71,347	71,785	72,203	72,587	72,994	73,352	73,740	74,128
507	81,887	82,437	83,966	85,527	87,036	88,479	89,928	91,453	92,944	94,481
508	213,425	216,553	224,748	233,086	241,332	249,438	257,598	265,753	273,920	282,604

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
509	42,294	42,575	43,354	44,150	44,920	45,656	46,395	47,172	47,933	48,716
510	134,034	139,629	153,589	167,751	181,949	196,125	210,416	224,277	238,364	254,376
511	117,060	117,641	119,365	121,179	122,957	124,676	126,433	128,118	129,846	131,616
512	20,732	20,669	20,560	20,465	20,364	20,251	20,145	20,029	19,919	19,810
513	20,098	20,030	19,905	19,796	19,679	19,552	19,431	19,301	19,176	19,052
514	14,729	14,772	14,912	15,065	15,214	15,355	15,501	15,637	15,779	15,923
515	18,090	17,941	17,611	17,295	16,974	16,645	16,322	15,985	15,656	15,339
516	92,962	93,164	93,892	94,693	95,467	96,197	96,959	97,653	98,387	99,127
517	25,242	25,142	24,949	24,774	24,590	24,394	24,204	24,004	23,810	23,619
518	438,307	442,852	455,162	467,828	480,372	492,692	505,171	517,332	529,678	542,613
519	131,763	134,735	142,350	150,087	157,792	165,432	173,130	180,699	188,340	196,660
520	70,028	70,179	70,719	71,314	71,885	72,421	72,979	73,497	74,039	74,587
521	51,660	51,612	51,606	51,631	51,631	51,602	51,580	51,564	51,548	51,530
522	33,182	33,406	34,029	34,666	35,281	35,870	36,461	37,083	37,690	38,318
523	17,619	17,606	17,614	17,635	17,651	17,657	17,668	17,670	17,678	17,686
524	36,040	35,864	35,508	35,177	34,833	34,470	34,118	33,750	33,392	33,040
525	44,224	44,064	43,765	43,499	43,218	42,913	42,621	42,309	42,010	41,713
526	24,317	24,276	24,233	24,211	24,183	24,145	24,117	24,064	24,024	23,984
527	20,188	20,168	20,166	20,181	20,190	20,191	20,199	20,189	20,189	20,189
528	28,391	28,204	27,806	27,427	27,042	26,645	26,256	25,845	25,448	25,061
529	22,094	22,000	21,820	21,655	21,486	21,306	21,133	20,943	20,764	20,586
530	175,355	179,914	191,621	203,592	215,619	227,642	239,826	251,383	263,266	276,339
531	96,994	97,702	99,758	101,936	104,121	106,286	108,508	110,498	112,613	114,805
532	84,229	87,373	95,192	103,069	110,908	118,681	126,481	134,290	142,097	150,888
533	356,955	370,427	403,911	437,641	471,207	504,494	537,887	571,334	604,766	642,439
534	144,505	146,528	151,887	157,377	162,834	168,225	173,677	178,979	184,365	190,082
535	22,274	22,216	22,125	22,051	21,972	21,883	21,802	21,702	21,613	21,524
536	35,736	35,616	35,406	35,226	35,040	34,842	34,658	34,430	34,227	34,025
537	127,091	127,330	128,235	129,245	130,219	131,135	132,099	132,956	133,873	134,799
538	7,035	6,986	6,883	6,785	6,688	6,589	6,492	6,385	6,283	6,184

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
539	4,099	4,061	3,974	3,891	3,806	3,721	3,636	3,548	3,462	3,379
540	56,521	56,660	57,141	57,666	58,176	58,660	59,160	59,621	60,106	60,596
541	289,873	298,057	318,714	339,582	360,330	380,877	401,512	422,119	442,752	465,536
542	30,586	30,667	30,948	31,257	31,561	31,855	32,161	32,428	32,716	33,008
543	68,521	68,709	69,345	70,035	70,706	71,345	72,009	72,618	73,259	73,908
544	57,853	58,067	58,742	59,464	60,173	60,857	61,560	62,213	62,894	63,589
545	58,421	58,279	58,066	57,892	57,703	57,485	57,282	57,047	56,833	56,617
546	20,234	20,362	20,728	21,110	21,486	21,852	22,224	22,584	22,951	23,329
547	57,475	57,679	58,327	59,018	59,693	60,341	61,007	61,634	62,284	62,946
548	524,697	531,538	549,690	568,254	586,656	604,768	623,057	641,052	659,223	678,443
549	162,728	168,513	182,955	197,526	212,036	226,431	240,884	255,296	269,735	285,938
550	17,609	17,553	17,456	17,371	17,277	17,174	17,075	16,972	16,873	16,773
551	71,141	71,501	72,571	73,701	74,814	75,897	77,006	78,048	79,128	80,235
552	19,556	19,513	19,452	19,402	19,348	19,281	19,221	19,154	19,091	19,027
553	9,699	9,680	9,655	9,637	9,616	9,588	9,564	9,536	9,510	9,485
554	37,836	37,864	38,023	38,209	38,386	38,543	38,711	38,858	39,017	39,177
555	63,195	62,930	62,436	62,003	61,562	61,099	60,668	60,139	59,664	59,193
556	40,949	41,357	42,469	43,617	44,754	45,871	47,003	48,101	49,218	50,387
557	23,437	23,278	22,941	22,630	22,315	21,995	21,687	21,337	21,010	20,691
558	10,376	10,278	10,058	9,845	9,630	9,410	9,195	8,970	8,750	8,540
559	178,378	179,438	182,479	185,642	188,737	191,725	194,759	197,756	200,781	203,893
560	112,210	115,582	124,075	132,656	141,199	149,668	158,177	166,645	175,139	184,558
561	106,738	106,853	107,401	108,034	108,639	109,195	109,788	110,295	110,852	111,410
562	90,842	96,317	109,603	122,960	136,279	149,519	162,793	176,074	189,354	204,864
563	77,002	77,905	80,323	82,803	85,259	87,676	90,119	92,512	94,935	97,485
564	711,295	734,500	792,690	851,448	909,949	967,973	1,026,248	1,084,293	1,142,485	1,207,386
565	215,578	217,687	223,438	229,363	235,230	240,982	246,813	252,490	258,257	264,286
566	99,875	105,888	120,481	135,153	149,782	164,325	178,905	193,492	208,079	225,114
567	225,116	234,367	257,287	280,387	303,400	326,250	349,180	372,064	394,981	420,970
568	23,290	23,563	24,297	25,047	25,792	26,524	27,264	27,990	28,724	29,496

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
569	33,188	33,158	33,166	33,200	33,225	33,236	33,258	33,252	33,262	33,271
570	24,267	24,207	24,118	24,047	23,969	23,882	23,803	23,703	23,615	23,527
571	20,322	20,171	19,842	19,530	19,212	18,887	18,569	18,232	17,905	17,589
572	41,118	41,232	41,615	42,031	42,436	42,821	43,222	43,589	43,976	44,368
573	15,072	15,027	14,949	14,882	14,810	14,732	14,658	14,574	14,497	14,419
574	38,997	38,993	39,075	39,187	39,288	39,370	39,464	39,532	39,616	39,699
575	58,761	58,873	59,295	59,762	60,212	60,632	61,074	61,474	61,898	62,326
576	53,517	53,828	54,730	55,676	56,607	57,511	58,434	59,317	60,224	61,157
577	42,146	42,545	43,636	44,759	45,871	46,961	48,066	49,142	50,235	51,376
578	107,420	109,374	114,419	119,528	124,584	129,560	134,559	139,590	144,609	150,005
579	53,623	54,055	55,256	56,499	57,724	58,921	60,134	61,318	62,520	63,769
580	165,776	172,926	190,608	208,432	226,199	243,850	261,567	279,217	296,907	317,045
581	68,685	70,932	76,569	82,262	87,932	93,559	99,211	104,831	110,471	116,762
582	44,276	45,547	48,758	52,005	55,237	58,441	61,663	64,862	68,075	71,627
583	76,228	77,244	79,936	82,687	85,414	88,099	90,809	93,478	96,172	99,024
584	13,842	13,986	14,375	14,776	15,172	15,561	15,954	16,339	16,729	17,138
585	27,211	27,236	27,365	27,517	27,662	27,797	27,941	28,059	28,192	28,325
586	32,667	33,366	35,152	36,956	38,742	40,503	42,268	44,052	45,828	47,754
587	101,569	102,529	105,142	107,830	110,481	113,072	115,693	118,280	120,889	123,613
588	365,101	375,014	399,997	425,159	450,091	474,692	499,326	524,324	549,155	576,486
589	219,636	224,538	237,030	249,645	262,137	274,448	286,792	299,275	311,699	325,207
590	469,000	473,323	485,154	497,354	509,409	521,221	533,185	544,867	556,719	569,081
591	172,361	173,467	176,653	179,994	183,304	186,540	189,849	192,960	196,181	199,504
592	37,623	37,757	38,182	38,639	39,087	39,518	39,965	40,375	40,805	41,243
593	300,843	306,320	320,518	334,958	349,305	363,476	377,755	391,868	406,080	421,363
594	746,580	747,501	751,682	756,524	761,226	765,637	770,354	774,200	778,532	782,878
595	42,601	42,720	43,119	43,555	43,978	44,384	44,805	45,188	45,593	46,003
596	28,164	28,188	28,314	28,462	28,603	28,729	28,866	28,982	29,110	29,238
597	433,516	432,857	432,233	431,921	431,464	430,786	430,228	429,464	428,831	428,181
598	127,325	127,662	128,811	130,064	131,284	132,448	133,659	134,758	135,921	137,099

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
599	42,050	42,440	43,511	44,621	45,723	46,808	47,912	48,965	50,046	51,174
600	369,650	372,751	381,346	390,250	399,059	407,691	416,461	424,921	433,558	442,539
601	699,021	697,668	695,947	694,742	693,320	691,555	689,999	688,038	686,323	684,587
602	93,115	93,284	93,928	94,644	95,333	95,976	96,649	97,261	97,909	98,562
603	802,481	798,265	789,796	782,077	774,257	766,192	758,480	749,590	741,347	733,246
604	372,648	378,976	395,441	412,196	428,827	445,238	461,772	478,138	494,609	512,253
605	198,417	205,644	223,628	241,738	259,747	277,591	295,483	313,456	331,396	351,556
606	215,274	230,407	266,710	303,099	339,315	375,265	411,234	447,603	483,773	526,514
607	130,012	131,859	136,729	141,702	146,633	151,494	156,400	161,230	166,105	171,282
608	209,886	210,495	212,525	214,722	216,863	218,905	221,022	222,972	225,019	227,094
609	68,351	68,509	69,064	69,672	70,259	70,812	71,387	71,919	72,477	73,041
610	52,399	52,342	52,321	52,340	52,342	52,317	52,306	52,269	52,249	52,227
611	59,390	59,521	59,987	60,499	60,993	61,457	61,940	62,386	62,854	63,327
612	301,720	303,617	309,083	314,819	320,500	326,060	331,755	337,087	342,618	348,322
613	394,484	396,154	401,302	406,801	412,222	417,483	422,910	427,885	433,111	438,449
614	1,264,745	1,257,914	1,243,531	1,229,793	1,215,388	1,200,114	1,184,933	1,170,373	1,155,582	1,141,109
615	229,850	230,674	233,282	236,076	238,808	241,434	244,144	246,665	249,295	251,971
616	93,610	95,734	101,227	106,853	112,505	118,156	123,897	129,309	134,890	140,979
617	97,524	97,793	98,698	99,679	100,632	101,537	102,476	103,346	104,256	105,178
618	173,252	181,152	200,851	220,923	241,153	261,477	282,085	301,537	321,576	344,535
619	541,592	543,037	547,934	553,251	558,412	563,308	568,384	573,090	578,014	583,001
620	163,387	164,843	168,874	173,066	177,239	181,358	185,564	189,511	193,597	197,857
621	445,825	444,637	442,663	440,959	439,055	436,874	434,766	432,698	430,638	428,580
622	375,348	376,085	378,816	381,828	384,724	387,430	390,253	392,857	395,594	398,353
623	350,226	360,028	384,784	409,800	434,678	459,315	484,063	508,755	533,490	560,787
624	530,793	531,924	536,025	540,552	544,934	549,066	553,384	557,290	561,434	565,619
625	535,937	539,069	548,196	557,797	567,287	576,549	586,022	594,927	604,152	613,644
626	435,958	439,076	447,845	456,944	465,902	474,627	483,490	492,124	500,898	509,974
627	35,406	36,581	39,528	42,504	45,470	48,412	51,369	54,307	57,256	60,549
628	472,671	476,052	485,559	495,424	505,137	514,596	524,206	533,567	543,079	552,920

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
629	261,994	263,868	269,138	274,605	279,989	285,232	290,559	295,748	301,020	306,475
630	58,242	59,046	61,169	63,339	65,489	67,607	69,745	71,851	73,977	76,230
631	110,657	114,330	123,540	132,842	142,111	151,307	160,546	169,729	178,946	189,238
632	168,611	170,204	174,549	179,023	183,446	187,778	192,165	196,458	200,807	205,348
633	164,350	166,117	170,882	175,776	180,617	185,370	190,175	194,890	199,660	204,665
634	111,078	111,259	111,977	112,782	113,555	114,274	115,029	115,708	116,432	117,160
635	132,198	132,792	134,584	136,480	138,336	140,127	141,960	143,708	145,507	147,346
636	74,664	74,786	75,268	75,809	76,329	76,812	77,320	77,776	78,263	78,752
637	90,107	91,093	93,745	96,468	99,161	101,806	104,481	107,106	109,761	112,548
638	50,175	50,636	51,897	53,197	54,480	55,736	57,008	58,254	59,516	60,832
639	36,512	36,848	37,765	38,711	39,645	40,559	41,484	42,391	43,309	44,267
640	123,312	123,513	124,310	125,203	126,061	126,860	127,698	128,452	129,256	130,064
641	59,411	59,957	61,450	62,989	64,508	65,996	67,502	68,977	70,471	72,030
642	92,343	93,306	95,910	98,584	101,228	103,822	106,446	109,022	111,627	114,356
643	189,809	194,700	207,126	219,706	232,227	244,631	257,105	269,482	281,916	295,567
644	87,787	88,999	92,199	95,470	98,710	101,903	105,125	108,300	111,503	114,900
645	234,552	236,522	241,968	247,598	253,159	258,597	264,114	269,484	274,941	280,615
646	89,120	92,971	102,497	112,101	121,677	131,191	140,743	150,250	159,783	170,637
647	126,142	131,454	144,610	157,876	171,102	184,243	197,434	210,563	223,729	238,690
648	53,691	55,455	59,879	64,348	68,801	73,219	77,657	82,069	86,497	91,437
649	38,078	39,707	43,740	47,805	51,858	55,885	59,928	63,952	67,987	72,577
650	330,560	346,523	385,775	425,323	464,768	503,979	543,332	582,519	621,803	666,909
651	515,732	517,493	523,091	529,072	534,888	540,436	546,142	551,575	557,175	562,869
652	243,739	258,373	293,933	329,724	365,435	400,965	436,605	472,126	507,716	549,279
653	92,770	96,740	106,564	116,469	126,345	136,158	146,009	155,813	165,645	176,830
654	12,763	12,877	13,191	13,514	13,834	14,147	14,464	14,773	15,088	15,415
655	87,129	88,330	91,502	94,742	97,953	101,116	104,308	107,454	110,628	113,994
656	132,774	138,562	152,871	167,299	181,683	195,977	210,326	224,607	238,928	255,244
657	402,306	419,540	462,182	505,180	548,049	590,644	633,404	675,963	718,641	767,197
658	21,549	21,783	22,414	23,062	23,702	24,329	24,966	25,590	26,221	26,883

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
659	51,328	51,725	52,830	53,974	55,101	56,202	57,318	58,407	59,513	60,660
660	20,870	20,825	20,761	20,713	20,657	20,592	20,533	20,462	20,398	20,334
661	18,915	18,957	19,107	19,271	19,431	19,580	19,736	19,880	20,030	20,183
662	162,814	165,315	171,869	178,552	185,182	191,718	198,310	204,818	211,377	218,368

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Employment

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
1	9,896	9,926	10,000	10,076	10,151	10,228	10,305	10,382	10,460	10,539
2	128,504	128,555	128,681	128,807	128,933	129,060	129,186	129,313	129,440	129,567
3	17,116	17,376	18,043	18,736	19,455	20,202	20,977	21,783	22,619	23,487
4	11,082	11,070	11,040	11,010	10,980	10,951	10,921	10,892	10,862	10,833
5	6,112	6,137	6,200	6,264	6,328	6,393	6,459	6,525	6,592	6,660
6	810	815	829	844	858	873	888	903	919	934
7	585	611	680	756	842	936	1,042	1,159	1,290	1,435
8	36,471	36,545	36,731	36,918	37,106	37,294	37,484	37,675	37,866	38,059
9	26,734	26,858	27,172	27,489	27,809	28,134	28,462	28,794	29,130	29,470
10	35,472	35,690	36,242	36,803	37,372	37,950	38,537	39,132	39,738	40,352
11	19,935	20,107	20,542	20,988	21,442	21,907	22,382	22,867	23,362	23,868
12	8,746	8,797	8,927	9,058	9,190	9,325	9,462	9,601	9,742	9,885
13	15,349	15,343	15,330	15,317	15,303	15,290	15,277	15,263	15,250	15,237
14	11,846	11,898	12,031	12,165	12,301	12,438	12,577	12,717	12,859	13,002
15	60,858	60,492	59,587	58,697	57,819	56,955	56,103	55,264	54,438	53,624
16	226,457	225,611	223,510	221,428	219,366	217,323	215,300	213,295	211,308	209,341
17	62,908	62,722	62,259	61,799	61,342	60,889	60,439	59,992	59,549	59,109
18	49,490	49,545	49,682	49,819	49,957	50,096	50,234	50,373	50,513	50,653
19	75,504	75,316	74,848	74,384	73,922	73,463	73,007	72,554	72,103	71,656
20	43,778	43,492	42,784	42,088	41,404	40,730	40,068	39,416	38,775	38,144
21	56,113	56,085	56,014	55,944	55,873	55,803	55,733	55,663	55,593	55,523
22	7,763	7,836	8,024	8,216	8,412	8,614	8,801	8,994	9,187	9,380
23	2,371	2,409	2,506	2,607	2,712	2,822	2,918	3,020	3,123	3,225
24	14,250	14,385	14,726	15,076	15,435	15,801	16,143	16,495	16,847	17,199
25	595	608	641	676	713	752	785	820	856	891
26	281	293	323	357	395	436	467	502	537	572
27	1,830	1,871	1,978	2,090	2,209	2,335	2,440	2,555	2,669	2,783
28	110,055	111,349	114,650	118,048	121,547	125,151	128,445	131,870	135,294	138,719
29	11,544	11,738	12,235	12,754	13,295	13,859	14,355	14,880	15,404	15,929

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
30	51,198	51,974	53,964	56,031	58,176	60,404	62,389	64,477	66,565	68,652
31	38,033	38,597	40,043	41,544	43,100	44,715	46,157	47,672	49,188	50,703
32	926	936	964	993	1,023	1,054	1,082	1,111	1,140	1,169
33	3,456	3,500	3,613	3,730	3,851	3,975	4,104	4,236	4,373	4,515
34	231	239	258	279	302	327	353	382	414	448
35	4,814	4,879	5,047	5,221	5,401	5,586	5,779	5,978	6,183	6,396
36	3,586	3,702	4,008	4,339	4,698	5,086	5,507	5,962	6,455	6,988
37	61,247	62,189	64,610	67,124	69,737	72,451	75,271	78,201	81,245	84,407
38	7,757	7,952	8,460	9,001	9,576	10,187	10,838	11,531	12,267	13,051
39	43,661	44,461	46,524	48,682	50,941	53,305	55,779	58,367	61,075	63,909
40	4,222	4,319	4,571	4,838	5,121	5,420	5,737	6,072	6,427	6,803
41	93,311	94,527	97,636	100,848	104,165	107,591	111,130	114,785	118,561	122,460
42	4,960	5,032	5,218	5,411	5,611	5,818	6,033	6,256	6,487	6,727
43	104,832	105,404	106,846	108,309	109,791	111,294	112,817	114,362	115,927	117,514
44	9,238	9,364	9,689	10,024	10,371	10,731	11,102	11,487	11,885	12,296
45	6,989	7,012	7,069	7,126	7,184	7,243	7,302	7,361	7,421	7,482
46	8,541	8,823	9,569	10,378	11,256	12,208	13,240	14,360	15,575	16,892
47	128,079	129,208	132,073	135,002	137,996	141,056	144,184	147,382	150,650	153,991
48	257,116	258,394	261,615	264,877	268,180	271,524	274,909	278,337	281,807	285,321
49	180,861	181,851	184,352	186,887	189,457	192,062	194,703	197,381	200,095	202,846
50	1,819	1,858	1,960	2,068	2,182	2,301	2,428	2,561	2,702	2,851
51	14,984	15,220	15,825	16,455	17,110	17,790	18,498	19,234	19,999	20,795
52	202,263	203,734	207,458	211,250	215,112	219,044	223,048	227,126	231,278	235,505
53	181,547	181,926	182,875	183,830	184,789	185,754	186,724	187,698	188,678	189,663
54	3,930	3,963	4,046	4,132	4,219	4,308	4,398	4,491	4,586	4,682
55	9,299	9,383	9,597	9,815	10,039	10,267	10,501	10,740	10,984	11,234
56	5,830	5,881	6,011	6,144	6,280	6,419	6,561	6,707	6,855	7,007
57	3,245	3,279	3,364	3,451	3,541	3,633	3,727	3,824	3,923	4,025
58	6,662	6,715	6,850	6,987	7,127	7,270	7,416	7,564	7,716	7,871
59	28,839	29,019	29,474	29,937	30,407	30,884	31,369	31,861	32,362	32,869

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
60	2,512	2,566	2,708	2,857	3,015	3,181	3,356	3,541	3,736	3,942
61	56,608	57,118	58,413	59,738	61,092	62,477	63,894	65,343	66,824	68,339
62	3,285	3,363	3,567	3,783	4,013	4,256	4,514	4,787	5,077	5,385
63	1,217	1,257	1,362	1,476	1,600	1,734	1,880	2,037	2,208	2,393
64	124	129	144	161	180	200	223	249	277	309
65	9,304	9,490	9,972	10,479	11,011	11,570	12,157	12,775	13,424	14,105
66	8,436	8,536	8,793	9,058	9,330	9,610	9,900	10,197	10,504	10,820
67	11,547	11,785	12,402	13,051	13,733	14,452	15,208	16,004	16,841	17,723
68	8,244	8,388	8,757	9,143	9,546	9,966	10,405	10,864	11,342	11,842
69	24,981	25,366	26,355	27,382	28,449	29,557	30,709	31,906	33,150	34,441
70	687	687	689	690	691	693	694	695	697	698
71	4,702	4,805	5,073	5,355	5,653	5,968	6,301	6,651	7,022	7,413
72	4,217	4,331	4,630	4,950	5,292	5,657	6,048	6,465	6,912	7,389
73	5,513	5,617	5,885	6,166	6,461	6,770	7,093	7,432	7,787	8,159
74	82,430	83,815	87,215	90,618	94,023	97,424	100,823	104,060	107,401	110,948
75	46,224	47,000	48,907	50,815	52,725	54,632	56,538	58,353	60,226	62,216
76	9,974	10,142	10,553	10,965	11,377	11,788	12,200	12,591	12,995	13,425
77	19,796	20,128	20,945	21,762	22,580	23,397	24,213	24,990	25,792	26,644
78	18,699	19,013	19,784	20,556	21,329	22,100	22,871	23,606	24,363	25,168
79	2,953	3,003	3,124	3,246	3,368	3,490	3,612	3,728	3,847	3,975
80	7,010	7,128	7,417	7,707	7,996	8,286	8,575	8,850	9,134	9,436
81	3,198	3,252	3,384	3,516	3,648	3,780	3,912	4,038	4,167	4,305
82	581	591	615	639	663	687	711	733	757	782
83	6,255	6,360	6,618	6,876	7,135	7,393	7,651	7,896	8,150	8,419
84	1,177	1,197	1,245	1,294	1,342	1,391	1,439	1,486	1,533	1,584
85	2,596	2,639	2,746	2,853	2,961	3,068	3,175	3,277	3,382	3,494
86	1,321	1,343	1,398	1,452	1,507	1,561	1,616	1,668	1,721	1,778
87	3,529	3,588	3,733	3,879	4,025	4,170	4,316	4,455	4,598	4,749
88	1,850	1,859	1,879	1,899	1,918	1,936	1,954	1,977	1,997	2,017
89	1,595	1,603	1,620	1,637	1,654	1,669	1,685	1,704	1,721	1,739

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
90	2,001	2,011	2,033	2,054	2,075	2,095	2,114	2,138	2,160	2,182
91	46,540	46,763	47,271	47,766	48,248	48,708	49,148	49,722	50,225	50,741
92	7,947	7,985	8,072	8,156	8,238	8,317	8,392	8,490	8,576	8,664
93	8,372	8,412	8,503	8,592	8,679	8,762	8,841	8,944	9,034	9,127
94	2,507	2,519	2,547	2,573	2,599	2,624	2,648	2,679	2,706	2,734
95	3,255	3,270	3,306	3,340	3,374	3,406	3,437	3,477	3,512	3,548
96	30,899	31,121	31,683	32,255	32,452	32,657	33,276	33,700	34,123	34,627
97	1,721	1,798	2,004	2,234	2,265	2,301	2,538	2,682	2,825	3,025
98	3,424	3,540	3,849	4,185	4,238	4,296	4,649	4,864	5,079	5,371
99	17,829	18,081	18,725	19,392	19,920	20,543	21,180	21,798	22,415	23,076
100	622	629	648	667	675	684	704	719	734	751
101	1,555	1,567	1,598	1,630	1,662	1,695	1,728	1,762	1,797	1,833
102	4,622	4,655	4,740	4,825	4,913	5,001	5,092	5,184	5,277	5,373
103	3,403	3,403	3,404	3,404	3,405	3,405	3,406	3,407	3,407	3,408
104	2,912	2,944	3,025	3,108	3,193	3,281	3,372	3,464	3,560	3,658
105	115,538	116,376	120,076	123,380	127,511	132,015	134,723	138,264	141,806	145,229
106	4,548	4,592	4,751	4,903	5,087	5,307	5,426	5,589	5,752	5,908
107	2,367	2,372	2,450	2,511	2,571	2,634	2,686	2,744	2,802	2,861
108	7,628	7,686	7,914	8,131	8,375	8,670	8,843	9,068	9,293	9,510
109	3,831	3,841	3,939	4,009	4,097	4,195	4,255	4,333	4,410	4,484
110	798	795	811	823	832	847	853	863	872	881
111	10,833	10,838	11,039	11,170	11,336	11,514	11,625	11,769	11,912	12,048
112	9,103	9,140	9,234	9,329	9,424	9,521	9,618	9,717	9,816	9,917
113	2,441	2,453	2,486	2,518	2,551	2,585	2,619	2,653	2,688	2,723
114	3,123	3,141	3,186	3,231	3,277	3,324	3,372	3,420	3,469	3,518
115	11,663	11,889	12,471	13,082	13,723	14,396	15,101	15,841	16,617	17,432
116	1,200	1,215	1,256	1,300	1,346	1,396	1,451	1,487	1,532	1,580
117	4,530	4,585	4,741	4,905	5,080	5,270	5,475	5,611	5,781	5,963
118	0	0	0	0	0	0	0	0	0	0
119	9,612	9,669	9,814	9,961	10,110	10,261	10,415	10,571	10,729	10,889

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
120	5,503	5,525	5,591	5,660	5,732	5,809	5,891	5,978	6,058	6,144
121	2,339	2,348	2,376	2,405	2,436	2,469	2,503	2,541	2,575	2,611
122	4,936	4,956	5,015	5,077	5,142	5,211	5,284	5,362	5,434	5,511
123	41,502	41,669	42,168	42,688	43,235	43,813	44,427	45,084	45,693	46,337
124	3,471	3,485	3,527	3,570	3,616	3,664	3,715	3,770	3,821	3,875
125	6,395	6,421	6,498	6,578	6,662	6,751	6,846	6,947	7,041	7,140
126	3,302	3,315	3,355	3,396	3,439	3,485	3,534	3,587	3,635	3,686
127	1,189	1,194	1,208	1,223	1,239	1,255	1,273	1,292	1,309	1,328
128	13,267	13,321	13,480	13,647	13,821	14,006	14,202	14,413	14,607	14,813
129	37,396	37,594	39,580	41,650	43,817	46,078	48,442	49,927	51,900	53,999
130	52,437	53,099	55,727	58,398	61,106	63,852	66,639	68,958	71,544	74,309
131	10,709	10,695	10,920	11,148	11,387	11,639	11,901	12,041	12,251	12,462
132	7,597	7,637	7,965	8,290	8,615	8,931	9,251	9,515	9,814	10,127
133	18,570	18,910	19,878	20,866	21,875	22,901	23,949	24,866	25,852	26,918
134	27,295	27,511	28,923	30,360	31,819	33,296	34,801	35,947	37,302	38,742
135	25,191	25,561	26,766	27,993	29,249	30,529	31,861	32,953	34,170	35,478
136	81,698	82,415	84,392	86,583	89,026	91,756	94,819	96,500	98,852	101,338
137	10,754	10,747	11,076	11,400	11,729	12,053	12,376	12,606	12,896	13,189
138	2,408	2,469	2,620	2,731	2,823	2,882	3,029	3,138	3,248	3,358
139	62,818	63,837	65,691	66,885	67,812	68,387	70,185	71,443	72,702	73,961
140	1,584	1,593	1,681	1,792	1,876	1,942	2,039	2,125	2,211	2,298
141	14,620	14,729	15,347	15,950	16,362	16,650	17,272	17,760	18,249	18,738
142	3,922	4,008	4,339	4,661	4,906	5,099	5,434	5,712	5,989	6,267
143	6,417	6,480	6,817	7,186	7,465	7,689	8,040	8,343	8,647	8,950
144	23,615	24,054	25,876	27,702	29,103	30,208	32,062	33,622	35,181	36,741
145	4,956	6,331	6,334	6,340	6,359	6,365	6,774	6,968	7,162	7,356
146	746	749	790	835	870	894	936	972	1,008	1,044
147	2,312	2,334	2,410	2,475	2,531	2,570	2,645	2,705	2,766	2,826
148	46,860	47,289	48,684	49,824	50,745	51,377	52,733	53,793	54,853	55,913
149	2,126	2,140	2,192	2,242	2,287	2,327	2,379	2,425	2,472	2,519

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
150	19,739	20,089	21,059	21,826	22,450	22,874	23,821	24,551	25,281	26,010
151	10,580	10,766	11,609	12,508	13,209	13,768	14,643	15,399	16,155	16,911
152	50,020	51,570	57,020	62,960	69,404	76,400	83,969	88,530	94,623	101,616
153	30,982	31,025	31,949	32,817	33,641	34,440	35,184	35,899	36,661	37,432
154	35,691	36,144	38,411	40,783	43,270	45,882	48,648	50,482	52,811	55,346
155	85,407	86,352	90,783	95,289	99,878	104,549	109,289	113,068	117,401	122,027
156	30,433	30,932	32,604	34,337	36,133	37,990	39,925	41,420	43,146	45,016
157	20,710	21,166	22,631	24,222	25,948	27,839	29,887	31,132	32,782	34,618
158	19,136	19,338	20,359	21,419	22,510	23,644	24,818	25,662	26,687	27,786
159	51,435	51,878	54,068	56,257	58,449	60,668	62,918	64,771	66,856	69,056
160	40,658	41,102	42,897	44,730	46,612	48,571	50,606	52,141	53,943	55,863
161	16,720	16,969	17,719	18,422	19,056	19,562	20,320	20,980	21,641	22,301
162	2,934	2,955	3,022	3,075	3,112	3,134	3,199	3,246	3,294	3,341
163	24,041	24,319	25,162	25,923	26,552	27,028	27,875	28,573	29,270	29,967
164	15,208	15,269	15,584	15,904	16,188	16,399	16,720	17,003	17,286	17,568
165	41,674	41,941	42,990	43,955	44,749	45,295	46,350	47,207	48,064	48,922
166	46,588	46,908	48,033	49,072	49,928	50,536	51,673	52,603	53,533	54,463
167	110,262	111,639	115,250	118,225	120,513	121,991	125,615	128,351	131,087	133,823
168	87,186	87,877	89,864	91,613	92,951	93,775	95,815	97,365	98,915	100,465
169	69,450	69,873	71,634	73,195	74,340	75,040	76,798	78,133	79,469	80,805
170	12,603	12,767	13,283	13,775	14,209	14,570	15,089	15,547	16,004	16,462
171	11,277	11,475	11,994	12,455	12,842	13,145	13,668	14,100	14,532	14,964
172	20,411	20,364	20,570	21,003	21,424	21,761	22,042	22,371	22,701	23,030
173	5,144	5,188	5,215	5,219	5,240	5,263	5,289	5,312	5,335	5,357
174	5,895	5,943	6,020	6,075	6,131	6,181	6,256	6,320	6,383	6,446
175	11,547	11,659	11,861	12,052	12,221	12,381	12,592	12,780	12,968	13,156
176	4,312	4,356	4,422	4,473	4,517	4,557	4,624	4,678	4,732	4,786
177	48,134	49,056	50,656	52,378	54,218	56,188	58,292	59,988	61,858	63,873
178	47,362	47,710	48,561	49,468	50,441	51,474	52,579	53,384	54,335	55,323
179	18,463	18,569	18,852	19,139	19,419	19,704	19,986	20,265	20,546	20,835

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
180	1,250	1,291	1,402	1,528	1,672	1,837	2,029	2,112	2,248	2,404
181	12,498	12,907	14,015	15,274	16,714	18,369	20,284	21,113	22,474	24,036
182	6,143	6,344	6,889	7,507	8,215	9,029	9,970	10,378	11,046	11,814
183	10,824	11,178	12,138	13,228	14,475	15,908	17,567	18,285	19,463	20,816
184	105,871	107,661	111,614	116,152	121,409	127,530	134,699	138,030	143,170	148,798
185	16,981	17,101	17,443	17,803	18,190	18,625	19,113	19,401	19,784	20,186
186	16,937	16,847	16,959	17,081	17,212	17,358	17,521	17,524	17,618	17,705
187	17,377	17,448	17,760	18,073	18,389	18,707	19,030	19,300	19,601	19,909
188	26,243	26,725	27,115	27,352	27,525	27,910	28,281	28,616	28,950	29,284
189	20,934	21,236	21,417	21,455	21,477	21,653	21,804	21,934	22,064	22,193
190	10,170	10,338	10,453	10,504	10,529	10,627	10,734	10,822	10,909	10,997
191	42,525	43,298	44,018	44,441	44,811	45,510	46,168	46,776	47,384	47,992
192	38,032	38,842	38,975	38,983	38,927	39,138	39,373	39,537	39,701	39,865
193	51,921	52,783	53,378	53,603	53,751	54,185	54,744	55,178	55,611	56,045
194	8,643	8,653	8,797	9,046	9,290	9,462	9,654	9,852	10,049	10,247
195	6,340	6,323	6,446	6,649	6,847	6,992	7,142	7,302	7,461	7,621
196	3,702	3,698	3,768	3,883	3,989	4,066	4,153	4,242	4,331	4,420
197	3,521	3,515	3,559	3,647	3,731	3,792	3,853	3,919	3,986	4,052
198	32,783	33,207	34,526	35,821	37,091	38,339	39,568	40,825	42,077	43,402
199	1,475	1,512	1,602	1,694	1,788	1,884	1,981	2,067	2,159	2,260
200	1,919	1,966	2,084	2,203	2,326	2,450	2,577	2,689	2,809	2,940
201	11,065	11,337	12,012	12,703	13,409	14,127	14,857	15,503	16,194	16,948
202	3,451	3,536	3,746	3,962	4,182	4,406	4,633	4,835	5,051	5,286
203	902	924	979	1,035	1,093	1,151	1,211	1,264	1,320	1,381
204	20,588	21,094	22,350	23,636	24,949	26,285	27,643	28,845	30,130	31,533
205	4,285	4,390	4,652	4,920	5,193	5,471	5,753	6,004	6,271	6,563
206	6,252	6,332	6,419	6,544	6,672	6,772	6,894	7,011	7,127	7,244
207	11,373	11,537	11,975	12,439	12,873	13,226	13,696	14,125	14,554	14,983
208	3,839	3,883	4,018	4,163	4,298	4,405	4,549	4,681	4,813	4,945
209	1,364	1,372	1,406	1,446	1,484	1,514	1,551	1,586	1,622	1,657

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
210	28,078	28,680	29,480	30,258	31,016	31,759	32,500	33,498	34,341	35,248
211	20,068	20,303	21,274	22,254	23,251	24,261	25,284	26,133	27,082	28,093
212	59,191	59,438	60,509	61,644	62,846	64,135	65,507	66,384	67,519	68,686
213	227,296	230,694	239,411	248,458	257,846	267,589	277,701	288,194	299,084	310,386
214	288,646	291,175	297,594	304,154	310,859	317,712	324,716	331,874	339,190	346,668
215	158,243	160,075	164,749	169,560	174,511	179,607	184,851	190,249	195,804	201,521
216	180,472	183,076	189,751	196,669	203,840	211,272	218,974	226,958	235,233	243,810
217	167,377	170,044	176,899	184,030	191,449	199,167	207,197	215,550	224,239	233,279
218	113,238	114,627	118,176	121,835	125,607	129,495	133,505	137,638	141,899	146,292
219	125,343	125,687	126,551	127,421	128,297	129,180	130,068	130,962	131,863	132,769
220	116,309	122,059	137,709	155,366	175,287	197,762	223,118	251,726	284,002	320,416
221	125,552	128,440	135,956	143,911	152,332	161,245	170,680	180,667	191,239	202,429
222	159,515	160,712	163,745	166,835	169,983	173,191	176,460	179,790	183,182	186,639
223	14,022	14,380	15,315	16,311	17,371	18,500	19,703	20,984	22,348	23,801
224	14,269	14,772	16,106	17,561	19,147	20,877	22,763	24,819	27,061	29,506
225	34,798	35,449	37,131	38,893	40,739	42,672	44,697	46,817	49,039	51,366
226	17,615	17,824	18,357	18,906	19,471	20,054	20,653	21,271	21,907	22,562
227	92,029	92,664	94,271	95,906	97,569	99,261	100,982	102,733	104,515	106,327
228	134,997	135,447	136,580	137,722	138,874	140,035	141,206	142,387	143,578	144,779
229	7,864	7,765	7,524	7,290	7,063	6,843	6,630	6,424	6,224	6,031
230	70,038	70,779	72,665	74,601	76,589	78,630	80,725	82,876	85,085	87,352
231	84,803	85,448	87,082	88,747	90,444	92,173	93,935	95,732	97,562	99,428
232	26,807	27,039	27,630	28,233	28,849	29,479	30,123	30,780	31,453	32,139
233	41,779	42,407	44,019	45,693	47,430	49,234	51,105	53,048	55,065	57,159
234	8,049	7,923	7,616	7,321	7,037	6,765	6,503	6,251	6,009	5,776
235	10,561	10,816	11,482	12,189	12,939	13,736	14,581	15,479	16,432	17,443
236	100,580	102,841	108,716	114,927	121,493	128,434	135,772	143,529	151,729	160,398
237	69,285	70,586	73,945	77,465	81,152	85,014	89,061	93,300	97,740	102,392
238	58,336	60,222	65,210	70,610	76,457	82,789	89,645	97,068	105,107	113,811
239	35,736	36,407	38,012	39,747	41,611	43,603	45,721	47,081	48,835	50,715

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
240	14,086	14,997	17,539	20,513	23,990	28,058	32,815	38,378	44,885	52,494
241	5,676	5,783	6,038	6,313	6,609	6,926	7,262	7,478	7,757	8,055
242	226,930	229,244	235,133	241,172	247,367	253,721	260,239	266,924	273,780	280,813
243	60,230	61,904	66,296	70,999	76,036	81,430	87,207	93,394	100,020	107,116
244	191,609	195,959	207,270	219,234	231,889	245,274	259,432	274,407	290,247	307,000
245	17,101	18,555	22,754	27,903	34,217	41,960	51,455	63,098	77,376	94,885
246	3,113	3,173	3,313	3,462	3,619	3,785	3,959	4,088	4,240	4,403
247	4,790	4,896	5,170	5,460	5,766	6,089	6,430	6,791	7,171	7,573
248	176,570	182,500	198,211	215,274	233,806	253,933	275,794	299,536	325,321	353,327
249	29,798	31,945	38,013	45,234	53,826	64,051	76,218	90,696	107,924	128,425
250	26,643	29,052	36,068	44,779	55,593	69,020	85,689	106,383	132,076	163,974
251	35,502	35,980	37,017	38,091	39,191	40,305	41,426	42,580	43,705	44,901
252	7,808	7,913	8,141	8,377	8,619	8,864	9,110	9,364	9,611	9,875
253	7,373	7,472	7,687	7,910	8,139	8,370	8,603	8,842	9,076	9,324
254	11,164	12,066	14,653	17,794	21,608	26,240	31,865	38,696	46,991	57,065
255	36,596	39,413	47,441	57,104	68,735	82,735	99,586	119,870	144,285	173,672
256	12,768	14,205	18,544	24,208	31,603	41,257	53,860	70,312	91,791	119,830
257	82,160	85,197	93,293	102,157	111,863	122,492	134,131	146,875	160,830	176,112
258	58,173	60,356	66,180	72,565	79,567	87,244	95,662	104,893	115,014	126,111
259	44,351	43,923	42,869	41,841	40,837	39,858	38,902	37,969	37,058	36,169
260	39,385	40,902	44,953	49,405	54,298	59,676	65,587	72,083	79,222	87,069
261	71,065	72,298	75,474	78,790	82,251	85,865	89,637	93,575	97,686	101,978
262	50,149	52,266	57,956	64,267	71,264	79,023	87,627	97,168	107,747	119,479
263	11,984	12,617	14,350	16,320	18,561	21,110	24,009	27,306	31,055	35,320
264	10,292	10,829	12,297	13,963	15,855	18,004	20,444	23,215	26,361	29,933
265	66,702	70,106	79,394	89,912	101,824	115,314	130,591	147,893	167,486	189,676
266	94,908	99,490	111,938	125,943	141,700	159,429	179,376	201,819	227,069	255,479
267	36,454	38,936	45,905	54,121	63,807	75,228	88,692	104,566	123,282	145,347
268	7,254	8,267	11,463	15,893	22,036	30,554	42,363	58,737	81,439	112,917
269	81,112	86,598	101,994	120,126	141,482	166,634	196,258	231,149	272,242	320,641

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
270	31,047	32,339	35,809	39,651	43,906	48,618	53,835	59,611	66,008	73,091
271	52,982	53,724	55,624	57,592	59,629	61,738	63,922	66,183	68,523	70,947
272	66,448	69,439	77,521	86,542	96,614	107,858	120,410	134,424	150,068	167,532
273	68,719	73,867	88,489	106,005	126,988	152,125	182,237	218,309	261,522	313,289
274	13,657	15,164	19,699	25,589	33,242	43,182	56,095	72,870	94,661	122,968
275	8,459	8,605	8,817	9,034	9,258	9,490	9,734	9,981	10,219	10,475
276	5,886	5,987	6,135	6,286	6,442	6,603	6,773	6,944	7,110	7,288
277	17,436	17,602	18,371	19,156	19,972	20,811	21,681	22,326	23,094	23,909
278	89,903	91,109	96,558	102,296	108,346	114,730	121,460	125,952	131,632	137,802
279	27,680	28,199	29,666	31,275	33,047	35,007	37,183	38,440	40,147	42,023
280	53,674	53,835	54,128	54,442	54,747	55,019	55,234	55,604	55,904	56,202
281	19,647	19,709	19,796	19,895	20,006	20,113	20,222	20,331	20,439	20,549
282	79,013	80,504	84,213	88,225	92,565	97,286	102,427	105,823	110,062	114,684
283	14,352	14,497	14,841	15,197	15,570	15,955	16,352	16,692	17,059	17,444
284	34,142	34,226	34,233	34,268	34,328	34,409	34,501	34,556	34,625	34,697
285	24,967	25,260	25,690	26,069	26,415	26,723	26,998	27,533	27,927	28,341
286	27,307	27,791	29,120	30,526	32,015	33,573	35,224	36,455	37,895	39,457
287	25,485	26,221	27,747	29,302	30,889	32,513	34,170	35,749	37,356	39,125
288	3,554	3,588	3,732	3,874	4,022	4,174	4,322	4,448	4,588	4,734
289	30,915	31,380	32,929	34,555	36,256	38,031	39,874	41,260	42,887	44,639
290	154,267	158,520	165,802	173,431	181,475	189,963	198,958	206,769	215,024	224,091
291	89,695	92,134	101,498	111,545	122,278	133,698	145,801	153,707	163,809	175,283
292	20,527	20,826	21,757	22,724	23,729	24,771	25,858	26,704	27,674	28,715
293	15,077	15,179	15,346	15,475	15,565	15,616	15,628	15,848	15,962	16,079
294	9,497	9,744	10,433	11,162	11,938	12,767	13,650	14,274	15,027	15,865
295	33,592	34,142	35,755	37,493	39,374	41,412	43,623	45,037	46,847	48,813
296	16,993	17,182	17,733	18,303	18,895	19,516	20,165	20,670	21,248	21,859
297	59,996	60,948	63,439	65,981	68,584	71,256	73,983	76,387	78,956	81,703
298	100,040	101,747	108,182	114,805	121,600	128,540	135,592	141,312	147,783	154,817
299	49,950	50,863	52,537	54,285	56,116	58,041	60,076	61,837	63,706	65,715

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
300	24,791	25,118	26,653	28,209	29,779	31,354	32,927	34,257	35,738	37,331
301	22,562	22,722	23,222	23,666	24,057	24,379	24,629	25,152	25,547	25,948
302	15,336	15,404	15,563	15,692	15,791	15,858	15,902	16,083	16,195	16,310
303	17,748	18,139	19,158	20,181	21,207	22,231	23,246	24,254	25,270	26,372
304	102,814	103,674	105,512	107,284	109,001	110,657	112,261	114,222	115,994	117,830
305	36,165	36,901	38,843	40,946	43,231	45,731	48,482	50,207	52,430	54,874
306	15,897	16,080	16,298	16,483	16,642	16,782	16,891	17,192	17,390	17,598
307	17,616	17,835	18,331	18,779	19,178	19,519	19,816	20,363	20,784	21,223
308	43,856	44,644	46,883	49,107	51,307	53,500	55,662	57,832	60,011	62,353
309	6,487	6,562	6,809	7,072	7,357	7,667	8,011	8,217	8,490	8,784
310	11,112	11,253	11,767	12,264	12,747	13,208	13,644	14,128	14,596	15,090
311	26,664	26,796	27,894	28,940	29,926	30,846	31,695	32,626	33,548	34,500
312	45,325	46,233	49,652	53,347	57,328	61,631	66,272	69,108	72,869	77,053
313	138,627	140,521	146,600	153,039	159,874	167,132	174,834	180,190	186,743	193,779
314	128,023	130,113	135,488	141,135	147,109	153,465	160,256	165,251	171,117	177,441
315	9,015	9,176	9,474	9,763	10,049	10,321	10,584	10,918	11,214	11,528
316	14,331	14,490	14,603	14,659	14,655	14,597	14,492	14,721	14,772	14,831
317	160,274	163,601	170,187	177,437	185,328	193,835	202,915	209,548	217,338	225,789
318	42,872	43,476	45,409	47,518	49,826	52,344	55,089	56,732	58,927	61,300
319	41,246	41,614	42,485	43,395	44,360	45,370	46,428	47,274	48,223	49,213
320	19,992	20,423	21,547	22,687	23,841	25,003	26,171	27,290	28,435	29,680
321	73,979	75,573	79,731	83,951	88,219	92,521	96,841	100,983	105,219	109,827
322	39,528	40,380	42,601	44,856	47,136	49,435	51,743	53,956	56,219	58,682
323	17,685	18,066	19,060	20,069	21,089	22,118	23,150	24,140	25,153	26,255
324	3,132	3,200	3,376	3,554	3,735	3,917	4,100	4,275	4,455	4,650
325	6,714	6,859	7,236	7,619	8,006	8,397	8,789	9,165	9,549	9,967
326	7,561	7,724	8,148	8,580	9,016	9,456	9,897	10,320	10,753	11,224
327	19,944	20,576	22,290	24,158	26,195	28,418	30,843	32,350	34,309	36,533
328	77,602	79,285	83,674	88,229	92,976	97,938	103,147	107,735	112,564	117,909
329	14,110	14,416	15,214	16,042	16,905	17,807	18,754	19,589	20,467	21,438

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
330	35,069	35,971	38,615	41,679	45,211	49,262	53,881	55,817	59,091	62,784
331	17,964	18,186	18,764	19,373	20,014	20,690	21,409	21,983	22,623	23,306
332	14,326	14,669	15,574	16,503	17,458	18,445	19,467	20,343	21,289	22,331
333	7,290	7,465	7,925	8,398	8,884	9,387	9,907	10,352	10,834	11,364
334	7,100	7,270	7,719	8,179	8,652	9,141	9,648	10,082	10,551	11,068
335	9,090	9,308	9,883	10,472	11,078	11,704	12,353	12,909	13,509	14,170
336	35,772	36,090	36,757	37,477	38,238	39,038	39,867	40,534	41,281	42,058
337	12,996	13,111	13,354	13,615	13,892	14,182	14,483	14,726	14,997	15,279
338	15,801	16,173	17,157	18,174	19,224	20,307	21,425	22,441	23,499	24,671
339	7,848	7,896	8,015	8,160	8,327	8,514	8,718	8,809	8,959	9,113
340	7,210	7,254	7,364	7,497	7,650	7,822	8,009	8,093	8,231	8,372
341	5,426	5,459	5,542	5,642	5,757	5,886	6,028	6,091	6,194	6,301
342	78,523	79,004	80,197	81,646	83,317	85,185	87,230	88,140	89,641	91,177
343	27,974	28,145	28,570	29,086	29,681	30,347	31,075	31,400	31,934	32,481
344	21,449	21,580	21,906	22,302	22,758	23,269	23,827	24,076	24,485	24,905
345	32,924	33,125	33,626	34,233	34,934	35,717	36,575	36,956	37,585	38,229
346	25,935	26,094	26,488	26,966	27,518	28,135	28,811	29,111	29,607	30,114
347	9,854	9,914	10,064	10,246	10,456	10,690	10,947	11,061	11,249	11,442
348	5,447	5,579	5,918	6,257	6,594	6,928	7,255	7,596	7,932	8,298
349	7,753	7,941	8,424	8,905	9,386	9,860	10,327	10,812	11,289	11,810
350	9,126	9,346	9,915	10,482	11,047	11,606	12,155	12,726	13,288	13,901
351	22,025	22,575	24,018	25,516	27,072	28,689	30,369	31,815	33,368	35,091
352	21,642	22,353	24,197	26,299	28,719	31,524	34,801	36,109	38,382	40,984
353	14,515	14,993	16,229	17,639	19,262	21,144	23,342	24,219	25,743	27,488
354	21,409	22,113	23,937	26,017	28,411	31,186	34,428	35,721	37,970	40,544
355	7,827	8,084	8,751	9,511	10,387	11,401	12,586	13,059	13,881	14,823
356	15,108	15,605	16,892	18,359	20,049	22,007	24,295	25,208	26,794	28,611
357	21,412	21,276	20,918	20,583	20,263	19,945	19,626	19,325	19,012	18,710
358	114,389	117,000	123,796	130,800	138,012	145,437	153,078	159,285	166,254	173,836
359	10,086	10,316	10,915	11,533	12,169	12,824	13,497	14,045	14,659	15,328

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
360	9,204	9,324	9,639	9,950	10,255	10,562	10,857	11,164	11,468	11,787
361	17,386	18,062	19,918	21,992	24,308	26,894	29,779	31,306	33,505	36,051
362	14,919	15,188	15,901	16,662	17,486	18,380	19,357	19,969	20,761	21,622
363	28,834	29,170	30,038	30,897	31,725	32,539	33,313	34,246	35,099	35,996
364	16,389	16,716	17,554	18,398	19,239	20,081	20,925	21,803	22,658	23,589
365	6,578	6,639	6,872	7,134	7,424	7,755	8,129	8,306	8,581	8,876
366	15,586	15,856	16,734	17,675	18,678	19,746	20,896	21,660	22,618	23,666
367	15,507	15,562	15,646	15,710	15,751	15,765	15,752	15,872	15,925	15,979
368	84,854	86,904	92,584	98,472	104,542	110,786	117,180	122,570	128,486	134,994
369	17,886	17,985	18,227	18,409	18,519	18,559	18,524	18,823	18,958	19,093
370	47,073	47,331	48,302	49,230	50,096	50,881	51,570	52,519	53,360	54,213
371	87,602	88,628	92,636	96,763	101,027	105,446	110,026	113,495	117,561	121,901
372	223,288	227,153	237,300	248,059	259,510	271,729	284,857	294,188	305,370	317,484
373	83,715	84,686	86,945	89,117	91,177	93,131	94,957	97,349	99,462	101,667
374	115,591	117,497	120,058	122,505	124,793	126,906	128,830	132,150	134,710	137,417
375	28,128	29,223	32,577	36,282	40,342	44,755	49,512	52,419	56,264	60,725
376	145,083	152,308	177,052	205,388	237,655	274,143	315,109	334,499	364,676	401,067
377	55,613	55,266	55,039	54,816	54,554	54,220	53,774	53,448	53,103	52,735
378	74,795	79,027	93,536	110,826	131,295	155,339	183,331	193,714	212,777	236,305
379	430,619	434,591	445,756	456,349	466,297	475,546	484,108	495,423	505,444	515,822
380	34,750	36,275	41,274	47,080	53,803	61,564	70,481	74,266	80,581	88,145
381	50,403	50,160	50,559	50,856	51,024	51,038	50,883	51,121	51,212	51,271
382	32,085	32,444	33,629	34,749	35,789	36,747	37,598	38,773	39,805	40,880
383	22,091	22,455	23,512	24,600	25,711	26,837	27,976	28,981	30,061	31,219
384	71,704	74,704	84,514	95,457	107,598	120,987	135,683	143,827	155,270	168,735
385	27,281	27,271	27,519	27,737	27,928	28,077	28,197	28,393	28,562	28,726
386	29,715	29,633	29,874	30,080	30,233	30,340	30,403	30,553	30,677	30,791
387	72,123	72,540	75,301	78,026	80,683	83,245	85,700	88,054	90,532	93,100
388	37,653	38,556	40,015	41,472	42,916	44,333	45,710	47,416	48,936	50,574
389	110,588	112,752	118,171	123,945	130,084	136,620	143,572	148,667	154,671	161,203

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
390	57,569	58,658	61,232	63,912	66,706	69,611	72,642	75,160	77,924	80,910
391	12,508	12,510	12,763	13,018	13,268	13,522	13,763	13,950	14,175	14,399
392	11,057	11,315	12,201	13,108	14,021	14,937	15,848	16,668	17,545	18,512
393	28,084	28,781	31,278	33,941	36,761	39,732	42,820	45,003	47,668	50,652
394	31,321	31,611	32,122	32,595	33,034	33,443	33,826	34,415	34,893	35,390
395	126,009	131,938	148,038	165,803	185,343	206,774	230,206	244,353	263,095	285,092
396	88,555	92,722	104,036	116,520	130,253	145,313	161,780	171,723	184,894	200,352
397	14,960	15,421	16,667	17,997	19,407	20,901	22,474	23,629	24,995	26,531
398	139,956	142,637	152,755	163,409	174,628	186,441	198,882	207,546	218,190	229,932
399	278,761	284,101	304,254	325,476	347,821	371,350	396,128	413,386	434,587	457,975
400	12,154	12,340	12,932	13,518	14,103	14,684	15,260	15,817	16,388	16,999
401	5,416	5,577	6,084	6,629	7,215	7,846	8,527	8,966	9,527	10,164
402	1,674	1,709	1,821	1,937	2,058	2,184	2,316	2,417	2,533	2,662
403	91,434	92,281	93,772	95,154	96,436	97,629	98,748	100,467	101,862	103,314
404	88,362	89,181	90,622	91,957	93,197	94,350	95,431	97,092	98,441	99,843
405	230,958	233,097	236,864	240,355	243,594	246,607	249,434	253,776	257,300	260,967
406	39,908	41,177	44,688	48,455	52,468	56,731	61,215	64,444	68,312	72,676
407	35,904	36,991	39,877	42,944	46,190	49,619	53,234	55,923	59,076	62,613
408	15,850	16,093	16,864	17,629	18,392	19,150	19,901	20,627	21,372	22,169
409	7,131	7,216	7,467	7,710	7,946	8,174	8,397	8,641	8,875	9,122
410	17,901	18,168	19,117	20,101	21,123	22,190	23,297	24,132	25,112	26,169
411	37,167	37,800	40,257	42,808	45,453	48,184	51,001	53,142	55,651	58,389
412	108,106	110,136	117,398	125,035	133,080	141,556	150,508	156,785	164,452	172,879
413	77,968	79,009	83,122	87,296	91,525	95,804	100,148	103,782	107,823	112,156
414	21,872	22,152	23,329	24,528	25,747	26,986	28,250	29,273	30,432	31,676
415	57,592	58,299	61,435	64,643	67,923	71,281	74,722	77,404	80,510	83,844
416	73,991	74,466	77,019	79,518	81,946	84,315	86,624	88,831	91,140	93,535
417	122,937	125,639	134,575	143,932	153,730	163,984	174,717	182,656	192,049	202,434
418	44,679	46,083	51,020	56,529	62,700	69,641	77,500	81,352	87,186	93,966
419	27,123	27,732	30,045	32,472	35,003	37,648	40,406	42,407	44,811	47,489

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
420	46,351	46,919	48,602	50,289	51,991	53,701	55,451	57,033	58,704	60,473
421	95,754	98,169	104,974	112,180	119,814	127,917	136,525	142,715	150,114	158,338
422	86,244	87,886	91,757	95,649	99,568	103,517	107,498	111,395	115,325	119,553
423	26,107	26,709	28,422	30,315	32,402	34,712	37,281	38,744	40,749	42,987
424	51,661	52,589	54,898	57,069	59,076	60,890	62,497	64,956	67,005	69,176
425	41,807	42,136	43,082	43,975	44,808	45,587	46,305	47,257	48,099	48,967
426	60,481	62,024	65,521	69,358	73,601	78,339	83,667	86,821	90,999	95,659
427	73,835	76,902	84,974	93,751	103,251	113,459	124,352	131,744	140,889	151,435
428	46,727	48,283	52,098	56,067	60,178	64,428	68,800	72,522	76,568	81,104
429	22,505	22,931	24,534	26,218	27,987	29,854	31,819	33,191	34,874	36,728
430	31,898	32,817	35,574	38,508	41,640	44,978	48,542	50,992	54,003	57,397
431	53,936	55,313	59,644	64,222	69,060	74,169	79,558	83,414	88,056	93,241
432	7,000	7,022	7,574	8,151	8,757	9,389	10,050	10,439	10,981	11,569
433	14,827	15,077	15,751	16,423	17,094	17,765	18,430	19,090	19,755	20,467
434	26,533	26,911	28,326	29,792	31,311	32,894	34,550	35,776	37,229	38,797
435	9,457	9,522	10,072	10,648	11,253	11,887	12,553	12,969	13,522	14,116
436	62,254	63,260	67,830	72,638	77,689	82,989	88,552	92,340	97,077	102,286
437	21,733	22,020	23,229	24,473	25,752	27,070	28,425	29,464	30,677	31,984
438	12,611	12,800	13,545	14,324	15,145	16,012	16,932	17,560	18,339	19,188
439	23,082	23,433	24,690	26,026	27,456	29,004	30,688	31,733	33,100	34,591
440	80,829	82,026	85,474	89,140	93,010	97,059	101,280	104,472	108,195	112,184
441	53,128	54,492	58,922	63,575	68,439	73,489	78,695	82,702	87,350	92,529
442	77,316	78,217	81,401	84,552	87,657	90,704	93,697	96,654	99,667	102,848
443	19,742	19,975	20,900	21,817	22,722	23,614	24,489	25,327	26,197	27,120
444	33,656	34,493	37,149	40,010	43,093	46,425	50,017	52,309	55,257	58,560
445	12,998	13,242	14,103	14,994	15,912	16,864	17,842	18,608	19,489	20,451
446	42,928	43,594	45,863	48,253	50,766	53,438	56,286	58,250	60,665	63,285
447	91,448	92,629	95,080	97,630	100,303	103,130	106,143	108,594	111,292	114,153
448	12,529	12,673	13,048	13,429	13,815	14,204	14,595	14,973	15,357	15,761
449	19,880	20,108	20,703	21,308	21,920	22,538	23,158	23,757	24,367	25,009

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
450	8,514	8,611	8,866	9,125	9,387	9,652	9,917	10,174	10,435	10,710
451	15,203	15,432	16,036	16,642	17,243	17,832	18,392	18,997	19,587	20,209
452	18,746	18,863	19,059	19,242	19,410	19,569	19,716	19,932	20,112	20,297
453	24,466	24,941	26,177	27,422	28,655	29,870	31,053	32,218	33,410	34,681
454	17,906	18,190	18,926	19,671	20,421	21,184	21,956	22,670	23,414	24,209
455	79,610	83,888	96,132	110,772	128,380	149,657	175,465	182,629	198,904	218,689
456	157,925	163,323	177,655	192,825	208,803	225,541	242,964	255,679	270,882	287,938
457	64,498	66,702	72,556	78,751	85,277	92,113	99,229	104,421	110,631	117,596
458	206,852	213,923	232,695	252,565	273,493	295,417	318,238	334,892	354,805	377,145
459	93,535	96,732	105,220	114,205	123,668	133,582	143,901	151,432	160,436	170,538
460	34,784	35,973	39,130	42,471	45,991	49,677	53,515	56,316	59,664	63,421
461	41,612	43,034	46,811	50,808	55,018	59,429	64,019	67,370	71,375	75,869
462	39,757	41,103	44,681	48,444	52,394	56,520	60,818	64,170	68,003	72,328
463	2,818	2,820	2,825	2,827	2,822	2,814	2,802	2,815	2,815	2,816
464	3,445	3,448	3,455	3,456	3,451	3,441	3,426	3,442	3,442	3,443
465	7,362	7,367	7,381	7,385	7,373	7,351	7,319	7,355	7,355	7,357
466	21,219	21,544	22,367	23,173	23,948	24,692	25,396	26,282	27,076	27,921
467	17,404	17,406	17,433	17,449	17,455	17,448	17,431	17,465	17,474	17,483
468	14,800	14,802	14,825	14,839	14,844	14,838	14,824	14,853	14,860	14,868
469	31,780	31,907	32,263	32,583	32,860	33,079	33,222	33,811	34,161	34,530
470	49,850	50,854	53,492	56,161	58,824	61,459	64,022	66,649	69,266	72,083
471	31,975	32,497	33,871	35,271	36,701	38,156	39,626	40,900	42,284	43,758
472	8,582	8,684	8,948	9,213	9,468	9,715	9,953	10,187	10,428	10,678
473	12,723	12,875	13,279	13,672	14,053	14,405	14,726	15,127	15,496	15,877
474	11,748	11,889	12,261	12,624	12,976	13,301	13,598	13,968	14,308	14,660
475	47,583	48,003	48,988	50,046	51,185	52,412	53,738	54,632	55,737	56,891
476	35,068	35,737	37,464	39,179	40,874	42,523	44,101	45,994	47,724	49,596
477	8,782	9,045	9,777	10,595	11,507	12,524	13,653	14,282	15,155	16,150
478	18,984	19,553	21,135	22,902	24,875	27,073	29,513	30,873	32,761	34,912
479	13,791	13,880	14,133	14,387	14,651	14,922	15,198	15,433	15,690	15,954

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
480	11,335	11,509	11,949	12,383	12,801	13,215	13,617	14,071	14,499	14,955
481	197,922	199,150	203,428	207,055	209,970	212,133	213,518	218,019	221,046	224,100
482	34,233	34,445	35,185	35,813	36,317	36,691	36,930	37,709	38,233	38,761
483	90,271	90,831	92,782	94,437	95,766	96,753	97,384	99,437	100,818	102,211
484	203,483	208,791	222,969	237,782	253,223	269,280	285,937	299,354	314,416	331,083
485	298,590	306,379	327,185	348,920	371,579	395,141	419,583	439,271	461,373	485,831
486	19,020	19,342	20,332	21,329	22,338	23,349	24,363	25,295	26,276	27,331
487	148,718	150,803	157,276	164,471	172,328	180,774	189,753	195,481	202,885	210,841
488	41,993	42,708	44,269	45,770	47,183	48,497	49,687	51,397	52,851	54,387
489	36,162	36,814	38,237	39,652	41,056	42,451	43,833	45,318	46,745	48,272
490	23,529	23,880	25,032	26,189	27,351	28,515	29,681	30,751	31,879	33,086
491	28,940	29,141	29,642	30,110	30,540	30,939	31,313	31,833	32,280	32,740
492	19,533	19,970	21,061	22,360	23,913	25,788	28,026	28,842	30,337	32,026
493	16,213	16,313	17,072	17,862	18,686	19,550	20,453	21,037	21,796	22,601
494	18,512	18,635	19,019	19,378	19,711	20,021	20,312	20,688	21,024	21,370
495	65,283	65,975	68,651	71,257	73,774	76,191	78,491	80,979	83,416	85,974
496	16,369	16,646	17,337	18,048	18,778	19,533	20,309	20,981	21,705	22,481
497	29,304	29,816	31,026	32,305	33,664	35,100	36,616	37,782	39,118	40,557
498	49,651	50,685	53,262	55,942	58,739	61,667	64,744	67,205	69,964	72,971
499	33,268	33,736	35,336	37,013	38,778	40,625	42,561	43,971	45,655	47,467
500	66,210	67,290	70,220	73,133	76,003	78,799	81,491	84,423	87,259	90,277
501	50,704	51,819	54,525	57,408	60,491	63,788	67,325	69,869	72,892	76,207
502	10,261	10,404	10,843	11,303	11,779	12,282	12,809	13,206	13,669	14,165
503	24,504	24,732	25,557	26,487	27,537	28,723	30,059	30,700	31,687	32,742
504	84,121	86,141	91,839	97,884	104,268	110,968	117,974	123,246	129,405	136,208
505	120,051	122,650	130,354	138,470	147,034	156,083	165,649	172,603	180,879	189,991
506	33,826	34,196	35,009	35,797	36,575	37,347	38,119	38,959	39,758	40,596
507	41,514	42,230	44,084	46,084	48,255	50,610	53,197	54,865	56,977	59,272
508	113,731	116,248	123,000	129,859	136,820	143,876	151,021	157,550	164,406	171,881
509	22,896	23,355	24,299	25,302	26,371	27,502	28,718	29,660	30,726	31,882

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
510	75,620	77,596	85,266	93,563	102,521	112,187	122,597	128,923	137,351	146,935
511	63,879	64,834	69,078	73,474	78,030	82,737	87,606	91,198	95,490	100,163
512	11,510	11,749	12,448	13,159	13,882	14,616	15,358	16,019	16,725	17,493
513	10,017	10,082	10,315	10,545	10,761	10,969	11,173	11,392	11,605	11,825
514	7,620	7,667	7,877	8,084	8,289	8,493	8,698	8,881	9,077	9,281
515	9,203	9,252	9,397	9,520	9,621	9,710	9,776	9,926	10,036	10,147
516	48,350	49,293	51,969	54,724	57,559	60,469	63,464	65,982	68,747	71,752
517	12,844	13,007	13,387	13,755	14,114	14,460	14,802	15,194	15,559	15,944
518	233,039	238,545	259,364	281,305	304,368	328,554	353,850	371,789	393,629	418,069
519	69,198	71,359	80,047	89,814	100,793	113,116	126,906	133,550	143,791	155,764
520	34,360	34,898	36,494	38,118	39,771	41,451	43,165	44,663	46,276	48,006
521	26,439	26,891	27,971	29,096	30,282	31,542	32,885	33,912	35,088	36,357
522	17,302	17,573	18,534	19,567	20,685	21,896	23,210	24,012	25,073	26,232
523	8,424	8,485	8,746	8,993	9,236	9,466	9,681	9,920	10,152	10,391
524	16,122	16,289	16,817	17,359	17,919	18,491	19,081	19,565	20,105	20,674
525	20,556	20,579	20,752	20,898	21,023	21,126	21,207	21,361	21,483	21,603
526	12,425	12,715	13,619	14,613	15,728	16,961	18,341	19,085	20,143	21,331
527	9,632	9,849	10,446	11,038	11,632	12,225	12,812	13,392	13,979	14,618
528	13,985	14,120	14,382	14,628	14,855	15,069	15,272	15,564	15,808	16,062
529	9,983	9,971	10,015	10,052	10,082	10,106	10,129	10,154	10,179	10,204
530	82,119	85,041	91,248	97,752	104,567	111,704	119,170	125,398	132,198	139,833
531	42,387	43,161	44,674	46,151	47,586	48,983	50,345	51,998	53,492	55,085
532	37,819	38,835	41,739	44,796	48,003	51,377	54,920	57,585	60,695	64,162
533	174,260	178,725	192,496	207,009	222,304	238,407	255,352	267,712	282,423	298,832
534	55,847	56,908	59,445	62,012	64,614	67,242	69,915	72,447	75,043	77,840
535	11,118	11,257	11,692	12,145	12,614	13,115	13,632	14,023	14,480	14,966
536	16,312	16,307	16,380	16,431	16,471	16,494	16,519	16,569	16,607	16,645
537	57,454	57,917	59,785	61,574	63,220	64,710	66,070	67,854	69,458	71,117
538	3,090	3,096	3,147	3,198	3,249	3,301	3,352	3,393	3,440	3,488
539	1,872	1,892	1,985	2,079	2,175	2,268	2,362	2,443	2,533	2,627

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
540	29,626	30,304	31,328	32,363	33,407	34,457	35,524	36,723	37,832	39,029
541	157,813	161,579	173,919	187,061	201,069	216,001	231,929	242,669	256,055	270,993
542	16,289	16,668	17,467	18,280	19,110	19,962	20,843	21,659	22,500	23,416
543	36,288	37,271	38,771	40,251	41,713	43,163	44,597	46,366	47,935	49,640
544	31,564	32,466	34,748	37,119	39,587	42,129	44,735	46,948	49,362	52,039
545	29,380	29,843	30,909	31,943	32,966	33,954	34,907	36,018	37,050	38,144
546	10,709	10,899	11,508	12,135	12,783	13,455	14,153	14,702	15,329	16,010
547	29,503	29,859	30,736	31,554	32,309	33,005	33,630	34,557	35,336	36,150
548	272,041	278,637	298,982	320,062	341,819	364,193	387,106	405,884	426,882	450,090
549	84,543	87,850	99,316	112,393	127,315	144,309	163,628	172,427	186,440	203,058
550	9,085	9,177	9,478	9,777	10,083	10,394	10,709	10,984	11,281	11,593
551	38,693	40,094	43,743	47,692	51,956	56,553	61,494	64,825	68,953	73,663
552	9,977	10,094	10,354	10,606	10,845	11,082	11,306	11,581	11,830	12,090
553	5,125	5,207	5,381	5,550	5,707	5,859	6,002	6,190	6,355	6,530
554	19,678	20,152	21,458	22,847	24,323	25,899	27,575	28,766	30,199	31,786
555	31,034	31,488	32,508	33,518	34,531	35,538	36,555	37,600	38,624	39,712
556	21,590	22,059	23,279	24,548	25,863	27,229	28,656	29,817	31,109	32,522
557	11,054	11,132	11,567	12,023	12,494	12,996	13,522	13,868	14,312	14,779
558	5,214	5,226	5,221	5,210	5,200	5,187	5,161	5,171	5,164	5,156
559	86,223	86,713	89,825	92,722	95,378	97,757	99,831	102,625	105,149	107,735
560	61,644	62,961	68,037	73,495	79,324	85,522	92,057	96,362	101,841	107,945
561	51,425	52,422	54,058	55,557	56,895	58,056	59,038	61,045	62,521	64,084
562	49,262	52,114	61,887	73,788	88,245	105,733	126,758	133,121	146,623	163,505
563	32,446	32,971	34,982	37,051	39,165	41,312	43,492	45,281	47,292	49,472
564	372,313	383,701	419,467	458,126	499,724	544,264	591,735	623,126	662,734	707,700
565	90,062	91,086	94,949	98,818	102,696	106,578	110,492	113,961	117,695	121,653
566	50,427	52,450	59,253	66,686	74,753	83,422	92,659	98,510	106,110	114,969
567	118,419	123,113	137,876	154,254	172,343	192,250	214,071	226,491	243,628	263,641
568	10,924	11,144	11,883	12,642	13,417	14,208	15,008	15,684	16,429	17,245
569	16,267	16,284	16,395	16,455	16,466	16,423	16,323	16,454	16,475	16,493

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
570	11,182	11,283	11,647	11,990	12,309	12,605	12,878	13,227	13,543	13,871
571	8,798	8,830	8,976	9,091	9,186	9,250	9,290	9,435	9,530	9,625
572	18,105	18,123	18,815	19,522	20,258	21,013	21,800	22,285	22,942	23,623
573	6,861	6,866	6,993	7,115	7,234	7,359	7,484	7,575	7,686	7,798
574	18,169	18,653	20,077	21,667	23,432	25,395	27,574	28,776	30,460	32,364
575	25,620	25,757	26,276	26,774	27,261	27,740	28,217	28,685	29,162	29,652
576	22,585	22,824	23,725	24,571	25,349	26,047	26,661	27,539	28,302	29,096
577	19,330	19,769	20,733	21,684	22,625	23,550	24,463	25,470	26,426	27,461
578	48,155	49,245	52,184	55,334	58,719	62,360	66,271	68,937	72,219	75,840
579	21,975	22,190	22,924	23,640	24,346	25,045	25,735	26,415	27,107	27,831
580	87,073	89,094	95,672	102,585	109,856	117,500	125,546	131,376	138,350	146,092
581	31,230	31,632	33,765	35,986	38,303	40,708	43,212	44,951	47,109	49,459
582	21,872	22,314	23,727	25,189	26,698	28,251	29,852	31,140	32,594	34,185
583	38,267	38,738	40,366	42,028	43,728	45,479	47,284	48,740	50,382	52,131
584	6,833	6,944	7,225	7,496	7,763	8,017	8,260	8,547	8,814	9,097
585	12,602	12,762	13,257	13,768	14,292	14,840	15,418	15,865	16,377	16,924
586	15,468	15,844	16,669	17,509	18,349	19,213	20,078	20,925	21,778	22,707
587	49,305	50,938	55,202	59,809	64,810	70,246	76,162	79,996	84,848	90,361
588	194,289	200,539	218,655	238,466	260,195	284,110	310,486	326,005	346,873	370,736
589	110,525	114,364	125,407	137,331	150,191	164,041	178,929	188,739	201,093	215,218
590	198,760	202,013	215,051	228,939	243,700	259,467	276,276	287,125	301,070	316,370
591	63,640	64,339	66,855	69,396	71,962	74,558	77,180	79,452	81,926	84,540
592	17,851	18,130	18,559	18,969	19,368	19,747	20,116	20,629	21,060	21,517
593	156,091	159,457	169,161	179,015	188,980	199,015	209,075	218,359	228,096	238,705
594	355,698	362,903	380,103	397,880	416,186	434,961	454,138	471,210	489,322	508,912
595	20,987	21,636	23,126	24,715	26,416	28,242	30,223	31,632	33,312	35,196
596	13,432	13,616	14,104	14,611	15,134	15,673	16,233	16,699	17,212	17,757
597	196,635	199,615	207,266	215,078	223,055	231,203	239,530	246,972	254,858	263,270
598	64,051	65,705	69,944	74,387	79,036	83,894	88,963	92,998	97,549	102,577
599	20,229	20,554	21,408	22,238	23,025	23,760	24,432	25,320	26,108	26,941

one ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
600	178,318	182,660	195,764	209,129	222,644	236,190	249,642	262,129	275,231	289,630
601	319,411	324,614	344,443	364,924	386,138	408,194	431,201	448,350	468,606	490,668
602	45,690	46,799	48,214	49,667	51,171	52,723	54,329	56,077	57,705	59,468
603	388,430	392,134	402,488	411,300	418,371	423,531	426,648	438,174	445,667	453,299
604	192,081	199,740	223,160	248,930	277,152	307,957	341,399	361,526	388,355	419,574
605	101,264	107,392	128,406	153,279	182,607	217,042	257,305	272,286	299,688	333,717
606	107,006	112,597	131,174	152,608	177,189	205,174	236,792	251,258	274,263	302,121
607	56,968	58,161	62,800	67,595	72,531	77,588	82,740	86,824	91,508	96,682
608	93,780	95,470	99,855	104,476	109,379	114,562	120,050	124,149	128,933	134,114
609	32,673	33,598	34,618	35,691	36,820	38,011	39,263	40,593	41,836	43,195
610	25,971	26,214	27,174	28,162	29,176	30,226	31,303	32,139	33,106	34,126
611	27,908	28,331	28,616	28,930	29,277	29,661	30,087	30,559	30,978	31,430
612	138,739	141,324	147,025	153,158	159,758	166,858	174,502	180,004	186,520	193,576
613	179,759	182,670	189,607	196,860	204,478	212,467	220,881	227,588	235,112	243,184
614	593,025	602,391	625,575	649,396	673,906	699,145	725,177	747,780	772,053	798,007
615	119,911	122,025	125,589	129,396	133,443	137,716	142,210	146,089	150,212	154,625
616	46,241	47,444	49,680	51,957	54,278	56,637	59,033	61,447	63,825	66,419
617	41,775	42,377	43,268	44,210	45,207	46,261	47,373	48,392	49,434	50,539
618	89,932	93,247	101,502	110,493	120,275	130,918	142,480	150,016	159,517	170,376
619	262,351	266,724	276,508	286,449	296,523	306,695	316,927	326,959	337,065	347,843
620	82,890	85,008	90,821	96,962	103,451	110,289	117,479	122,859	129,152	136,131
621	194,668	196,946	202,307	208,121	214,368	221,038	228,130	233,278	239,375	245,820
622	174,580	176,703	181,913	187,429	193,268	199,460	206,026	210,979	216,716	222,793
623	167,338	171,483	183,792	196,834	210,584	225,028	240,109	251,347	264,571	279,240
624	227,234	229,701	237,054	244,839	253,124	261,910	271,265	277,859	285,842	294,296
625	206,970	208,591	218,869	229,616	240,856	252,615	264,899	273,008	283,402	294,477
626	239,024	245,993	265,907	286,778	308,590	331,317	354,922	373,389	394,506	418,142
627	79,926	82,646	92,249	102,701	114,043	126,306	139,528	147,592	158,294	170,666
628	253,272	260,655	281,756	303,872	326,984	351,065	376,077	395,645	418,021	443,065
629	139,915	143,994	155,651	167,868	180,636	193,939	207,756	218,566	230,927	244,763

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
630	27,795	28,207	29,994	31,845	33,747	35,714	37,744	39,267	41,069	43,026
631	59,820	61,856	69,044	76,867	85,355	94,533	104,430	110,465	118,475	127,735
632	85,323	87,248	93,466	100,095	107,184	114,782	122,931	128,322	135,110	142,656
633	77,370	79,013	84,182	89,760	95,802	102,343	109,474	113,905	119,684	126,094
634	56,704	57,523	60,447	63,445	66,535	69,711	72,979	75,578	78,538	81,723
635	71,092	72,357	76,586	80,968	85,516	90,229	95,114	98,902	103,271	108,024
636	39,052	39,616	41,630	43,695	45,822	48,010	50,260	52,050	54,090	56,283
637	50,314	51,539	55,270	59,193	63,313	67,632	72,166	75,540	79,510	83,915
638	25,938	26,415	27,875	29,406	31,019	32,722	34,533	35,836	37,394	39,095
639	19,391	19,748	20,839	21,984	23,190	24,463	25,817	26,791	27,956	29,228
640	64,360	65,289	68,607	72,011	75,517	79,122	82,831	85,781	89,141	92,756
641	30,411	30,970	32,681	34,477	36,368	38,364	40,487	42,015	43,842	45,837
642	48,359	49,401	52,560	55,882	59,379	63,060	66,953	69,794	73,168	76,886
643	103,448	107,022	116,586	126,810	137,744	149,424	161,906	170,651	181,249	193,298
644	38,498	39,069	41,544	44,109	46,742	49,467	52,278	54,389	56,884	59,595
645	112,752	114,957	123,277	132,240	141,891	152,287	163,486	170,403	179,516	189,635
646	46,044	47,481	51,922	56,712	61,865	67,403	73,369	77,244	82,172	87,782
647	66,345	68,450	74,484	80,982	88,000	95,579	103,770	109,105	115,860	123,536
648	27,159	27,830	29,941	32,155	34,476	36,901	39,431	41,334	43,563	46,041
649	19,185	19,943	22,283	24,911	27,873	31,214	35,005	36,881	39,697	43,009
650	180,303	186,981	206,005	226,706	249,206	273,637	300,131	316,873	338,470	363,331
651	258,460	261,686	271,720	282,331	293,586	305,554	318,312	327,191	338,028	349,603
652	129,549	134,494	150,573	168,595	188,796	211,452	236,845	249,784	268,901	291,330
653	49,938	51,656	56,329	61,340	66,698	72,419	78,511	82,778	87,958	93,846
654	6,505	6,660	7,157	7,683	8,248	8,856	9,511	9,939	10,481	11,087
655	24,571	25,179	27,206	29,360	31,649	34,079	36,662	38,428	40,612	43,057
656	71,613	73,842	80,777	88,208	96,170	104,694	113,808	119,890	127,509	136,170
657	224,125	232,906	258,975	287,614	319,054	353,517	391,270	413,615	443,629	478,509
658	11,886	12,117	12,644	13,147	13,632	14,087	14,518	15,076	15,570	16,098
659	28,616	28,943	30,387	31,819	33,233	34,628	36,005	37,283	38,634	40,070

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
660	10,623	10,799	11,330	11,881	12,456	13,055	13,683	14,167	14,724	15,326
661	10,151	10,213	10,572	10,922	11,267	11,609	11,948	12,249	12,576	12,916
662	76,478	78,207	85,216	92,862	101,221	110,405	120,536	126,078	133,940	142,852

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Per Capita Income (2013$)

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
1	83,019	86,130	93,586	102,578	113,098	125,201	140,306	154,545	170,229	188,586
2	51,423	53,350	57,968	63,538	70,054	77,551	86,907	95,727	105,441	116,812
3	55,569	57,652	62,642	68,661	75,703	83,804	93,915	103,446	113,944	126,231
4	40,302	41,813	45,432	49,797	54,904	60,780	68,113	75,025	82,639	91,550
5	43,474	45,103	49,007	53,716	59,225	65,563	73,473	80,929	89,142	98,755
6	50,797	52,700	57,262	62,764	69,201	76,606	85,849	94,561	104,158	115,389
7	41,252	42,798	46,502	50,971	56,198	62,212	69,718	76,793	84,586	93,708
8	40,089	41,592	45,192	49,535	54,615	60,459	67,753	74,629	82,203	91,067
9	35,181	36,500	39,659	43,470	47,928	53,057	59,458	65,492	72,139	79,918
10	33,167	34,411	37,389	40,982	45,185	50,020	56,055	61,743	68,009	75,343
11	43,719	45,357	49,283	54,019	59,559	65,932	73,887	81,385	89,645	99,311
12	43,890	45,535	49,476	54,230	59,792	66,190	74,176	81,703	89,995	99,700
13	44,304	45,965	49,943	54,742	60,357	66,815	74,877	82,476	90,845	100,642
14	51,496	53,426	58,050	63,628	70,154	77,661	87,031	95,863	105,591	116,978
15	25,606	26,566	28,866	31,639	34,884	38,617	43,276	47,668	52,505	58,167
16	22,702	23,553	25,592	28,051	30,928	34,238	38,368	42,262	46,551	51,571
17	37,870	39,289	42,690	46,792	51,591	57,112	64,003	70,498	77,652	86,026
18	21,998	22,822	24,798	27,181	29,968	33,175	37,178	40,951	45,106	49,971
19	42,444	44,035	47,847	52,444	57,822	64,010	71,733	79,013	87,031	96,416
20	21,576	22,385	24,323	26,660	29,394	32,539	36,465	40,166	44,242	49,013
21	37,350	38,750	42,104	46,150	50,883	56,328	63,124	69,530	76,586	84,845
22	45,914	47,345	51,217	56,030	61,694	68,181	75,557	83,169	91,679	101,391
23	41,995	42,952	45,525	48,796	52,643	57,001	62,362	67,693	73,672	80,526
24	58,646	60,957	67,269	75,071	84,324	95,065	106,933	119,551	133,726	149,949
25	62,794	65,710	73,746	83,699	95,614	109,624	125,138	142,009	161,166	183,275
26	48,112	47,931	47,572	47,748	48,236	48,908	52,043	54,554	57,589	61,277
27	40,361	41,433	44,323	47,949	52,210	57,058	62,123	67,237	72,788	78,966
28	47,573	49,098	53,229	58,357	64,397	71,321	78,625	86,171	94,440	103,706
29	49,496	50,341	52,616	55,614	59,165	63,173	67,511	71,681	76,192	81,228

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
30	45,646	47,030	50,771	55,429	60,907	67,173	73,750	80,497	87,864	96,097
31	30,879	31,834	34,418	37,633	41,415	45,744	50,295	54,976	60,094	65,818
32	34,059	34,262	34,841	35,830	37,087	38,528	40,451	42,135	44,006	46,160
33	54,402	56,017	60,382	65,821	72,217	79,525	87,165	94,982	103,500	113,002
34	45,625	46,980	50,641	55,202	60,566	66,695	73,103	79,659	86,803	94,772
35	43,520	44,812	48,304	52,655	57,772	63,618	69,730	75,983	82,797	90,399
36	42,089	43,361	47,334	52,225	58,001	64,678	72,276	79,683	87,848	97,288
37	51,779	53,343	58,231	64,248	71,353	79,568	88,915	98,027	108,072	119,685
38	53,635	55,256	60,319	66,551	73,912	82,421	92,104	101,542	111,948	123,977
39	56,281	57,981	63,294	69,834	77,557	86,487	96,647	106,551	117,470	130,092
40	71,463	73,622	80,367	88,671	98,478	109,816	122,717	135,292	149,156	165,184
41	61,558	63,417	69,228	76,381	84,829	94,595	105,708	116,540	128,483	142,289
42	26,560	27,362	29,869	32,956	36,601	40,814	45,609	50,283	55,436	61,392
43	53,395	55,008	60,048	66,253	73,580	82,051	91,690	101,086	111,445	123,421
44	90,050	92,771	101,271	111,735	124,092	138,379	154,635	170,481	187,952	208,148
45	55,506	57,183	62,423	68,873	76,490	85,296	95,316	105,084	115,853	128,302
46	51,058	52,600	57,420	63,353	70,360	78,460	87,677	96,662	106,568	118,019
47	58,063	59,817	65,298	72,045	80,013	89,225	99,706	109,924	121,188	134,211
48	65,844	67,834	74,049	81,700	90,736	101,183	113,069	124,656	137,430	152,197
49	52,569	54,157	59,120	65,228	72,442	80,783	90,273	99,523	109,722	121,512
50	44,796	46,033	49,196	53,070	57,641	62,917	68,931	74,570	80,672	87,641
51	40,394	41,510	44,361	47,855	51,977	56,734	62,157	67,243	72,744	79,028
52	41,360	42,502	45,422	48,999	53,219	58,091	63,643	68,850	74,484	80,918
53	33,244	34,162	36,509	39,384	42,777	46,692	51,155	55,340	59,868	65,040
54	36,514	37,349	39,285	41,640	44,404	47,567	50,900	54,102	57,506	61,261
55	37,540	38,399	40,389	42,811	45,652	48,904	52,330	55,623	59,122	62,983
56	39,594	40,500	42,599	45,153	48,150	51,579	55,194	58,666	62,357	66,429
57	42,888	43,870	46,143	48,910	52,156	55,871	59,786	63,547	67,545	71,956
58	45,578	46,621	49,037	51,977	55,427	59,375	63,535	67,533	71,781	76,468
59	36,447	37,280	39,212	41,563	44,322	47,479	50,806	54,002	57,400	61,148

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
60	32,612	33,430	35,592	38,182	41,202	44,654	48,374	51,980	55,856	60,183
61	36,249	37,158	39,561	42,441	45,797	49,634	53,769	57,778	62,086	66,895
62	38,883	39,859	42,437	45,526	49,126	53,241	57,677	61,977	66,598	71,757
63	35,993	36,614	38,388	40,498	42,945	45,713	48,358	51,016	53,820	56,829
64	45,638	46,425	48,675	51,351	54,454	57,964	61,318	64,687	68,242	72,058
65	41,429	42,144	44,187	46,616	49,432	52,619	55,663	58,722	61,949	65,414
66	32,270	32,827	34,418	36,310	38,504	40,986	43,357	45,740	48,254	50,952
67	44,306	45,071	47,255	49,853	52,865	56,273	59,529	62,800	66,251	69,956
68	39,589	40,272	42,224	44,545	47,236	50,281	53,191	56,114	59,198	62,508
69	50,362	51,231	53,713	56,666	60,090	63,963	67,664	71,383	75,306	79,517
70	45,889	46,681	48,943	51,634	54,753	58,283	61,655	65,043	68,618	72,455
71	48,943	49,788	52,201	55,070	58,398	62,162	65,759	69,373	73,185	77,278
72	44,132	44,894	47,070	49,657	52,657	56,052	59,295	62,553	65,991	69,681
73	47,409	48,227	50,564	53,343	56,566	60,213	63,696	67,197	70,890	74,854
74	26,281	27,286	29,057	31,199	33,640	36,338	39,376	42,518	45,910	49,632
75	33,872	35,167	37,450	40,210	43,356	46,833	50,749	54,798	59,170	63,966
76	47,641	49,463	52,674	56,557	60,981	65,872	71,379	77,075	83,224	89,970
77	29,084	30,196	32,156	34,526	37,227	40,213	43,575	47,052	50,806	54,924
78	35,618	36,980	39,380	42,283	45,591	49,247	53,365	57,622	62,220	67,263
79	42,887	44,527	47,417	50,913	54,895	59,298	64,256	69,383	74,919	80,991
80	63,498	65,925	70,205	75,380	81,277	87,796	95,136	102,727	110,923	119,914
81	63,573	66,004	70,288	75,470	81,374	87,901	95,249	102,849	111,055	120,057
82	39,390	40,896	43,551	46,762	50,420	54,464	59,017	63,726	68,810	74,388
83	35,886	37,258	39,677	42,602	45,935	49,619	53,767	58,057	62,689	67,771
84	35,210	36,556	38,929	41,799	45,069	48,684	52,754	56,963	61,508	66,494
85	36,598	37,997	40,464	43,447	46,845	50,603	54,833	59,208	63,932	69,115
86	36,370	37,761	40,212	43,177	46,554	50,288	54,492	58,840	63,535	68,685
87	58,056	60,275	64,188	68,920	74,311	80,271	86,982	93,923	101,416	109,637
88	36,852	37,849	39,637	41,883	44,533	47,563	50,991	54,187	57,584	61,373
89	33,477	34,382	36,006	38,047	40,454	43,207	46,321	49,224	52,310	55,752

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
90	44,607	45,813	47,977	50,696	53,903	57,571	61,721	65,589	69,700	74,287
91	27,345	28,085	29,412	31,079	33,045	35,293	37,837	40,209	42,729	45,541
92	36,947	37,946	39,739	41,991	44,648	47,686	51,123	54,327	57,732	61,531
93	43,308	44,479	46,580	49,220	52,334	55,895	59,923	63,679	67,671	72,124
94	41,059	42,170	44,162	46,665	49,617	52,993	56,813	60,374	64,158	68,380
95	41,819	42,950	44,979	47,528	50,535	53,974	57,864	61,491	65,345	69,645
96	27,335	28,197	29,960	32,103	34,584	37,381	40,535	43,623	46,947	50,652
97	34,489	35,576	37,801	40,505	43,634	47,163	51,143	55,040	59,233	63,907
98	41,018	42,311	44,957	48,173	51,895	56,092	60,825	65,459	70,447	76,006
99	47,739	49,244	52,324	56,067	60,398	65,283	70,792	76,185	81,990	88,460
100	43,778	45,158	47,983	51,415	55,387	59,867	64,919	69,865	75,188	81,121
101	44,886	46,300	49,196	52,715	56,788	61,381	66,561	71,632	77,089	83,173
102	46,886	48,364	51,389	55,065	59,319	64,117	69,527	74,825	80,525	86,880
103	29,841	30,782	32,707	35,047	37,755	40,808	44,252	47,623	51,251	55,296
104	23,238	23,971	25,470	27,292	29,400	31,778	34,460	37,085	39,911	43,060
105	35,003	35,807	37,770	40,240	43,147	46,457	49,963	53,317	56,897	60,875
106	54,855	56,116	59,191	63,063	67,618	72,805	78,299	83,556	89,167	95,400
107	40,007	40,926	43,169	45,993	49,315	53,098	57,105	60,939	65,031	69,577
108	50,472	51,632	54,462	58,024	62,215	66,988	72,043	76,880	82,042	87,778
109	44,244	45,260	47,741	50,864	54,537	58,721	63,152	67,393	71,918	76,945
110	39,776	40,689	42,919	45,727	49,030	52,791	56,775	60,587	64,655	69,175
111	38,600	39,487	41,651	44,376	47,581	51,231	55,097	58,796	62,744	67,131
112	30,143	30,716	32,686	35,036	37,745	40,805	44,040	47,134	50,445	54,141
113	38,168	38,894	41,388	44,364	47,794	51,669	55,765	59,683	63,876	68,555
114	27,525	28,049	29,847	31,993	34,467	37,261	40,215	43,041	46,065	49,439
115	35,617	36,295	38,622	41,399	44,600	48,216	52,038	55,694	59,607	63,973
116	37,153	38,178	40,269	42,821	45,791	49,164	52,956	56,562	60,414	64,709
117	38,241	38,932	41,015	43,450	46,256	49,430	52,746	55,900	59,243	62,929
118	31,760	32,335	34,064	36,087	38,417	41,053	43,807	46,427	49,203	52,265
119	36,886	37,554	39,562	41,912	44,618	47,679	50,878	53,920	57,145	60,700

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
120	51,449	52,964	55,915	59,535	63,762	68,567	74,043	79,248	84,819	91,051
121	37,871	38,986	41,158	43,823	46,934	50,471	54,502	58,333	62,434	67,021
122	35,153	36,189	38,204	40,678	43,566	46,849	50,591	54,147	57,954	62,212
123	44,404	45,712	48,258	51,383	55,031	59,178	63,904	68,396	73,204	78,583
124	28,183	29,014	30,630	32,613	34,928	37,561	40,560	43,412	46,463	49,877
125	30,520	31,419	33,169	35,317	37,824	40,674	43,923	47,011	50,315	54,012
126	44,782	46,101	48,669	51,820	55,499	59,681	64,448	68,978	73,827	79,251
127	34,562	35,580	37,562	39,995	42,834	46,062	49,741	53,237	56,979	61,166
128	31,487	32,356	34,129	36,291	38,809	41,667	44,881	47,937	51,201	54,842
129	32,398	32,920	35,734	39,116	43,032	47,492	52,589	57,239	62,300	68,199
130	36,743	37,622	40,341	43,578	47,265	51,367	55,937	60,351	65,114	70,470
131	34,290	35,298	37,846	40,888	44,383	48,336	52,793	57,142	61,849	67,146
132	30,318	31,132	33,734	36,811	40,338	44,302	48,711	53,066	57,812	63,175
133	33,630	34,793	37,597	40,911	44,698	48,938	53,639	58,474	63,744	69,616
134	32,317	32,675	35,162	38,132	41,516	45,316	49,576	53,388	57,492	62,239
135	34,719	35,633	38,235	41,304	44,808	48,736	52,947	57,175	61,741	66,806
136	32,405	33,272	35,080	37,297	39,888	42,842	46,139	49,261	52,595	56,317
137	32,490	33,030	35,407	38,325	41,690	45,516	49,865	53,777	57,996	62,874
138	49,209	50,371	53,898	58,264	63,431	69,403	75,425	81,463	87,984	95,224
139	31,570	32,316	34,578	37,379	40,694	44,525	48,389	52,263	56,446	61,091
140	49,472	50,640	54,185	58,574	63,769	69,773	75,827	81,897	88,454	95,732
141	40,981	41,949	44,885	48,522	52,825	57,798	62,813	67,842	73,273	79,302
142	46,595	47,695	51,034	55,168	60,061	65,715	71,418	77,135	83,310	90,165
143	34,494	35,308	37,780	40,840	44,463	48,648	52,870	57,102	61,673	66,749
144	35,042	35,870	38,381	41,490	45,170	49,422	53,711	58,011	62,655	67,810
145	36,678	37,544	40,173	43,427	47,278	51,729	56,218	60,718	65,579	70,976
146	34,825	35,647	38,143	41,233	44,890	49,116	53,378	57,651	62,266	67,390
147	44,172	45,215	48,380	52,300	56,938	62,298	67,704	73,124	78,978	85,477
148	37,929	38,825	41,543	44,908	48,891	53,494	58,136	62,790	67,816	73,397
149	42,259	43,256	46,285	50,034	54,471	59,600	64,771	69,956	75,557	81,774

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
150	40,932	41,899	44,832	48,464	52,762	57,729	62,739	67,761	73,186	79,208
151	35,943	36,792	39,367	42,556	46,330	50,692	55,091	59,501	64,264	69,553
152	39,095	39,744	42,450	45,902	50,011	54,751	59,555	64,146	69,091	74,662
153	32,908	33,458	35,716	38,479	41,695	45,360	49,350	53,017	56,957	61,447
154	32,803	33,367	35,649	38,469	41,789	45,598	49,661	53,442	57,511	62,137
155	41,663	42,523	45,403	48,936	53,012	57,586	62,541	67,264	72,344	78,061
156	29,020	29,822	32,114	34,832	37,951	41,462	45,256	49,068	53,201	57,811
157	30,754	31,276	33,381	35,983	39,050	42,587	46,187	49,634	53,339	57,496
158	29,459	29,936	31,792	34,001	36,517	39,321	42,280	45,085	48,076	51,408
159	30,980	31,800	34,083	36,749	39,751	43,063	46,780	50,434	54,374	58,769
160	30,378	31,043	33,449	36,340	39,683	43,487	47,673	51,670	56,003	60,930
161	37,298	38,461	41,120	44,446	48,394	52,961	57,753	62,597	67,848	73,688
162	38,820	40,030	42,798	46,259	50,369	55,121	60,109	65,151	70,616	76,694
163	42,200	43,516	46,524	50,287	54,755	59,921	65,343	70,824	76,765	83,373
164	58,425	60,246	64,411	69,621	75,806	82,959	90,466	98,054	106,278	115,426
165	57,509	59,302	63,401	68,529	74,617	81,658	89,047	96,516	104,612	113,616
166	36,321	37,453	40,042	43,281	47,126	51,573	56,239	60,956	66,069	71,757
167	39,108	40,327	43,116	46,603	50,743	55,531	60,556	65,635	71,140	77,264
168	30,739	31,697	33,889	36,630	39,884	43,647	47,597	51,589	55,916	60,729
169	39,031	40,247	43,030	46,510	50,642	55,421	60,435	65,505	70,999	77,111
170	45,491	46,909	50,153	54,209	59,025	64,594	70,439	76,347	82,751	89,874
171	38,512	39,713	42,458	45,892	49,969	54,684	59,633	64,634	70,056	76,086
172	27,389	28,132	29,754	31,749	34,105	36,826	39,809	42,654	45,702	49,113
173	25,955	26,659	28,196	30,087	32,319	34,898	37,725	40,420	43,309	46,541
174	30,012	30,827	32,604	34,790	37,371	40,353	43,622	46,739	50,079	53,817
175	23,262	23,894	25,271	26,966	28,966	31,278	33,811	36,227	38,816	41,713
176	36,255	37,239	39,386	42,027	45,145	48,747	52,696	56,461	60,496	65,011
177	46,228	47,288	50,222	53,922	58,315	63,373	69,150	74,370	79,985	86,439
178	35,293	36,160	38,512	41,455	44,939	48,957	53,616	57,836	62,388	67,639
179	33,277	34,252	36,477	39,124	42,137	45,519	49,333	53,060	57,069	61,537

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
180	31,547	32,009	34,154	36,743	39,829	43,458	47,308	50,797	54,544	58,835
181	30,859	31,310	33,409	35,941	38,959	42,509	46,275	49,688	53,353	57,551
182	46,924	47,610	50,802	54,653	59,242	64,640	70,367	75,556	81,129	87,512
183	40,611	41,205	43,967	47,300	51,272	55,943	60,900	65,391	70,214	75,739
184	33,383	34,288	36,436	39,105	42,235	45,798	50,001	53,843	57,979	62,721
185	41,923	42,728	45,649	49,190	53,291	57,945	63,232	68,038	73,208	79,143
186	30,923	31,414	33,328	35,631	38,310	41,367	44,789	47,829	51,076	54,795
187	34,154	34,751	36,964	39,606	42,670	46,165	50,010	53,524	57,284	61,556
188	28,987	29,662	31,694	34,219	37,202	40,637	44,598	48,196	52,083	56,575
189	39,773	40,700	43,488	46,953	51,045	55,759	61,194	66,130	71,464	77,627
190	31,270	31,999	34,191	36,915	40,133	43,839	48,112	51,993	56,187	61,032
191	41,301	42,264	45,159	48,756	53,006	57,900	63,545	68,670	74,209	80,609
192	33,138	33,911	36,234	39,120	42,530	46,457	50,986	55,099	59,543	64,678
193	22,883	23,417	25,021	27,014	29,369	32,081	35,208	38,048	41,117	44,663
194	28,290	29,029	30,825	32,974	35,476	38,330	41,530	44,560	47,812	51,467
195	32,857	33,716	35,801	38,297	41,204	44,518	48,234	51,754	55,530	59,776
196	35,739	36,673	38,941	41,656	44,817	48,422	52,465	56,293	60,400	65,019
197	29,202	29,965	31,818	34,037	36,620	39,566	42,869	45,997	49,353	53,127
198	34,720	35,528	37,551	39,869	42,492	45,409	48,379	51,425	54,662	58,148
199	30,129	30,873	32,857	35,187	37,846	40,820	43,834	46,945	50,278	53,895
200	32,357	33,156	35,287	37,789	40,645	43,838	47,075	50,417	53,996	57,880
201	29,753	30,487	32,447	34,747	37,373	40,310	43,286	46,359	49,650	53,222
202	36,876	37,787	40,215	43,066	46,322	49,961	53,650	57,459	61,538	65,964
203	34,265	35,111	37,368	40,017	43,042	46,423	49,851	53,390	57,180	61,293
204	40,837	41,845	44,535	47,692	51,297	55,327	59,412	63,630	68,147	73,049
205	34,315	35,162	37,422	40,075	43,104	46,491	49,924	53,468	57,263	61,382
206	36,413	37,087	39,503	42,534	46,138	50,306	54,742	58,861	63,289	68,322
207	30,315	30,876	32,887	35,411	38,411	41,881	45,574	49,003	52,689	56,880
208	41,075	41,834	44,560	47,979	52,045	56,746	61,750	66,396	71,390	77,068
209	36,927	37,611	40,061	43,135	46,790	51,017	55,515	59,692	64,182	69,287

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
210	32,177	33,029	35,287	37,961	41,011	44,423	48,117	51,792	55,748	60,132
211	30,541	31,305	33,294	35,689	38,455	41,548	44,953	48,241	51,770	55,709
212	33,313	34,139	35,964	38,167	40,722	43,616	46,864	49,912	53,157	56,781
213	22,839	23,419	25,064	27,092	29,457	32,149	35,188	38,055	41,155	44,687
214	46,315	47,492	50,827	54,939	59,737	65,194	71,359	77,172	83,459	90,621
215	18,315	18,780	20,099	21,725	23,623	25,781	28,218	30,517	33,003	35,835
216	54,082	55,457	59,352	64,153	69,756	76,128	83,327	90,115	97,457	105,820
217	16,352	16,768	17,945	19,397	21,091	23,018	25,194	27,247	29,466	31,995
218	20,321	20,838	22,301	24,105	26,210	28,605	31,309	33,860	36,619	39,761
219	27,619	28,321	30,310	32,762	35,623	38,878	42,554	46,021	49,770	54,041
220	18,092	18,552	19,855	21,461	23,336	25,467	27,876	30,146	32,602	35,400
221	31,715	32,521	34,805	37,620	40,906	44,643	48,864	52,845	57,150	62,054
222	36,129	37,048	39,650	42,857	46,600	50,857	55,666	60,201	65,105	70,692
223	59,636	61,152	65,446	70,740	76,918	83,945	91,883	99,368	107,464	116,685
224	27,299	27,993	29,959	32,382	35,210	38,427	42,060	45,487	49,193	53,414
225	48,631	49,867	53,369	57,686	62,724	68,454	74,927	81,031	87,632	95,152
226	84,662	86,814	92,911	100,427	109,197	119,173	130,442	141,069	152,561	165,653
227	33,122	33,964	36,349	39,289	42,721	46,623	51,032	55,189	59,685	64,807
228	35,179	36,073	38,606	41,729	45,374	49,519	54,201	58,617	63,392	68,832
229	25,839	26,496	28,356	30,650	33,327	36,371	39,811	43,054	46,561	50,557
230	25,692	26,345	28,195	30,476	33,138	36,165	39,585	42,810	46,297	50,270
231	29,279	30,023	32,132	34,731	37,764	41,214	45,111	48,787	52,761	57,289
232	44,092	45,213	48,388	52,303	56,870	62,066	67,935	73,469	79,454	86,273
233	26,887	27,570	29,506	31,893	34,679	37,847	41,425	44,800	48,450	52,608
234	40,726	41,761	44,694	48,309	52,528	57,327	62,748	67,860	73,388	79,686
235	38,851	39,838	42,636	46,085	50,110	54,688	59,859	64,735	70,009	76,017
236	30,279	31,049	33,230	35,918	39,054	42,622	46,652	50,453	54,563	59,246
237	20,603	21,127	22,610	24,439	26,574	29,001	31,743	34,330	37,126	40,312
238	27,692	28,396	30,390	32,848	35,717	38,980	42,665	46,141	49,900	54,182
239	22,640	23,151	24,530	26,308	28,472	31,022	33,686	36,193	38,887	41,930

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
240	28,208	28,844	30,562	32,777	35,474	38,650	41,969	45,093	48,450	52,241
241	26,143	26,733	28,325	30,378	32,877	35,822	38,898	41,793	44,904	48,417
242	35,736	36,443	39,191	42,572	46,519	51,007	55,656	60,215	65,148	70,684
243	33,116	33,772	36,318	39,451	43,108	47,268	51,576	55,801	60,372	65,502
244	43,705	44,570	47,931	52,066	56,892	62,382	68,067	73,643	79,675	86,446
245	28,217	28,858	30,237	31,974	34,021	36,357	38,855	41,213	43,715	46,485
246	27,049	27,664	28,985	30,651	32,613	34,852	37,246	39,507	41,906	44,561
247	31,724	32,445	33,994	35,948	38,249	40,875	43,683	46,335	49,148	52,262
248	28,072	28,705	30,415	32,620	35,304	38,465	41,768	44,877	48,218	51,990
249	35,080	35,871	38,008	40,763	44,116	48,067	52,195	56,080	60,255	64,969
250	42,439	43,396	45,981	49,314	53,371	58,151	63,144	67,844	72,895	78,598
251	22,706	23,306	24,496	25,950	27,632	29,517	31,632	33,648	35,792	38,167
252	24,363	25,006	26,284	27,844	29,648	31,671	33,940	36,103	38,403	40,952
253	28,679	29,437	30,941	32,778	34,902	37,282	39,954	42,500	45,208	48,208
254	28,109	28,482	28,866	29,773	31,150	32,957	34,725	36,089	37,507	39,159
255	32,325	32,754	33,196	34,238	35,823	37,901	39,934	41,503	43,133	45,033
256	30,811	31,220	31,641	32,635	34,145	36,126	38,063	39,559	41,112	42,923
257	29,865	30,503	32,813	35,730	39,217	43,273	47,529	51,628	56,080	61,141
258	31,020	31,682	34,082	37,112	40,734	44,947	49,367	53,625	58,249	63,506
259	17,348	17,718	19,060	20,755	22,780	25,136	27,608	29,989	32,575	35,516
260	66,031	67,440	72,547	78,998	86,707	95,675	105,084	114,146	123,990	135,181
261	47,703	48,721	52,411	57,071	62,641	69,120	75,917	82,464	89,575	97,660
262	46,179	47,164	50,736	55,247	60,639	66,911	73,491	79,828	86,712	94,539
263	25,184	25,751	27,285	29,263	31,671	34,507	37,470	40,259	43,256	46,640
264	31,850	32,569	34,509	37,010	40,055	43,642	47,389	50,917	54,707	58,987
265	31,001	31,700	33,588	36,023	38,986	42,477	46,125	49,558	53,247	57,413
266	32,173	32,899	34,858	37,386	40,461	44,084	47,870	51,433	55,262	59,585
267	23,933	24,541	26,264	28,389	30,868	33,688	36,874	39,878	43,126	46,827
268	29,255	29,999	32,105	34,702	37,733	41,180	45,074	48,746	52,717	57,241
269	36,311	37,047	38,470	40,358	42,685	45,422	48,128	50,696	53,400	56,359

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
270	27,812	28,376	29,466	30,912	32,694	34,791	36,863	38,830	40,901	43,168
271	21,906	22,349	23,208	24,347	25,751	27,402	29,034	30,583	32,215	34,000
272	29,743	30,345	31,511	33,058	34,964	37,206	39,422	41,525	43,740	46,164
273	34,408	35,105	36,454	38,243	40,448	43,041	45,606	48,039	50,601	53,405
274	27,648	28,208	29,292	30,730	32,501	34,585	36,646	38,601	40,660	42,913
275	24,206	24,992	26,560	28,378	30,422	32,676	35,279	37,866	40,643	43,709
276	24,121	24,904	26,466	28,278	30,314	32,561	35,155	37,733	40,500	43,556
277	23,998	24,375	25,713	27,329	29,185	31,261	33,520	35,578	37,763	40,218
278	26,037	26,445	28,122	30,178	32,551	35,213	38,042	40,682	43,504	46,681
279	24,525	25,275	27,339	29,828	32,730	36,060	39,874	43,565	47,598	52,212
280	25,709	26,251	27,563	29,223	31,182	33,415	35,963	38,231	40,643	43,384
281	26,759	27,695	29,145	30,950	33,069	35,486	38,295	41,003	43,903	47,131
282	26,472	27,235	29,274	31,767	34,675	37,988	41,774	45,395	49,331	53,820
283	25,098	25,798	27,689	29,907	32,451	35,325	38,654	41,826	45,258	49,155
284	21,225	21,777	22,938	24,388	26,100	28,062	30,380	32,459	34,680	37,216
285	26,159	26,985	28,148	29,483	30,992	32,664	34,475	36,380	38,389	40,513
286	27,088	27,897	30,003	32,463	35,260	38,396	41,942	45,445	49,241	53,498
287	29,726	30,848	33,058	35,598	38,469	41,668	45,063	48,748	52,735	57,042
288	25,902	26,876	28,476	30,408	32,660	35,212	38,240	41,183	44,353	47,899
289	22,027	22,890	24,943	27,384	30,208	33,422	37,226	41,020	45,201	49,987
290	28,270	29,218	31,491	34,223	37,381	40,963	45,040	49,079	53,480	58,451
291	30,460	31,524	34,586	38,274	42,579	47,518	52,857	58,443	64,618	71,590
292	23,305	23,935	25,832	28,037	30,537	33,333	36,520	39,622	42,988	46,793
293	20,042	20,485	21,606	22,946	24,457	26,119	28,050	29,828	31,720	33,842
294	23,714	24,942	27,713	30,948	34,683	38,969	44,075	49,493	55,577	62,559
295	24,217	24,977	26,976	29,417	32,271	35,535	39,272	42,897	46,857	51,382
296	24,337	24,935	26,500	28,393	30,558	32,981	35,751	38,350	41,138	44,282
297	23,109	23,896	25,655	27,672	29,956	32,509	35,409	38,338	41,510	45,034
298	29,974	30,988	33,809	37,152	40,970	45,241	50,037	54,954	60,353	66,439
299	26,232	27,029	28,902	31,151	33,727	36,613	39,982	43,213	46,706	50,654

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
300	21,970	22,358	23,921	25,772	27,863	30,167	32,651	35,032	37,587	40,446
301	24,658	25,579	27,296	29,248	31,431	33,835	36,466	39,282	42,316	45,591
302	23,030	23,948	25,218	26,628	28,188	29,887	31,742	33,814	36,021	38,334
303	27,051	27,709	29,373	31,423	33,791	36,444	39,163	41,905	44,840	48,048
304	21,726	22,303	23,794	25,558	27,572	29,824	32,363	34,812	37,447	40,399
305	22,307	22,888	24,636	26,688	29,040	31,684	34,697	37,589	40,721	44,274
306	21,813	22,301	23,456	24,829	26,388	28,113	30,048	31,871	33,805	35,948
307	21,887	22,661	24,510	26,661	29,096	31,806	34,850	37,989	41,410	45,217
308	25,365	26,164	28,168	30,499	33,137	36,075	39,242	42,531	46,096	50,020
309	22,046	22,425	23,965	25,826	27,996	30,475	33,181	35,672	38,350	41,403
310	25,467	26,231	27,903	29,782	31,872	34,164	36,555	39,113	41,849	44,778
311	20,527	21,049	22,809	24,873	27,208	29,794	32,624	35,465	38,554	42,012
312	22,410	23,257	25,383	27,897	30,799	34,103	37,779	41,598	45,803	50,535
313	26,841	27,719	29,927	32,556	35,598	39,057	42,880	46,737	50,940	55,657
314	27,407	28,347	30,441	32,912	35,752	38,965	42,564	46,192	50,129	54,521
315	19,716	20,336	21,852	23,606	25,609	27,844	30,344	32,858	35,581	38,611
316	21,976	22,540	24,113	25,972	28,061	30,361	32,919	35,437	38,147	41,163
317	24,711	25,129	26,387	28,048	30,072	32,439	34,995	37,240	39,629	42,364
318	26,143	26,796	28,702	31,008	33,691	36,745	40,142	43,382	46,885	50,852
319	25,703	26,417	28,157	30,304	32,823	35,703	39,014	42,111	45,455	49,265
320	31,481	32,269	34,282	36,731	39,555	42,724	46,021	49,332	52,880	56,776
321	20,232	20,738	22,033	23,606	25,421	27,458	29,577	31,704	33,985	36,489
322	24,033	24,635	26,172	28,041	30,197	32,616	35,133	37,661	40,370	43,344
323	43,153	44,233	46,993	50,349	54,221	58,564	63,084	67,622	72,486	77,827
324	30,049	30,801	32,723	35,061	37,756	40,781	43,928	47,088	50,475	54,194
325	23,326	23,910	25,402	27,216	29,309	31,657	34,100	36,553	39,182	42,069
326	27,062	27,740	29,471	31,576	34,003	36,727	39,562	42,408	45,458	48,807
327	22,827	23,194	24,877	26,959	29,414	32,244	35,181	37,962	40,963	44,365
328	20,966	21,254	22,528	24,118	25,980	28,099	30,307	32,337	34,502	36,946
329	22,100	22,403	23,747	25,422	27,385	29,618	31,947	34,086	36,368	38,944

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
330	20,486	21,101	22,659	24,553	26,783	29,359	32,345	35,162	38,225	41,739
331	22,601	23,122	24,814	26,824	29,129	31,722	34,488	37,216	40,161	43,446
332	25,909	26,507	28,446	30,751	33,393	36,366	39,536	42,664	46,040	49,805
333	28,474	29,131	31,262	33,794	36,698	39,965	43,450	46,887	50,596	54,735
334	21,574	22,072	23,687	25,606	27,806	30,282	32,922	35,526	38,337	41,473
335	22,863	23,391	25,102	27,135	29,467	32,090	34,888	37,648	40,627	43,950
336	22,063	22,488	23,589	24,975	26,609	28,470	30,599	32,468	34,451	36,712
337	25,289	25,777	27,039	28,627	30,500	32,633	35,074	37,216	39,489	42,081
338	19,356	19,825	21,123	22,659	24,416	26,385	28,368	30,416	32,612	34,998
339	19,374	19,746	20,712	21,965	23,482	25,245	27,264	28,999	30,844	32,973
340	13,698	13,961	14,644	15,530	16,602	17,849	19,277	20,503	21,808	23,313
341	20,150	20,536	21,541	22,845	24,422	26,256	28,355	30,159	32,078	34,293
342	25,474	25,962	27,232	28,880	30,874	33,193	35,847	38,128	40,553	43,353
343	16,505	16,821	17,644	18,712	20,004	21,506	23,226	24,704	26,276	28,090
344	22,259	22,685	23,795	25,236	26,978	29,004	31,323	33,316	35,436	37,882
345	30,140	30,717	32,220	34,170	36,529	39,273	42,413	45,112	47,982	51,295
346	29,994	30,569	32,064	34,005	36,352	39,083	42,208	44,893	47,749	51,046
347	24,871	25,348	26,588	28,197	30,144	32,408	34,999	37,226	39,595	42,328
348	17,422	17,710	18,897	20,286	21,859	23,602	25,383	27,137	29,013	31,080
349	21,588	21,946	23,416	25,137	27,087	29,246	31,453	33,627	35,951	38,512
350	25,077	25,492	27,200	29,199	31,464	33,972	36,536	39,061	41,761	44,735
351	21,889	22,420	23,887	25,624	27,611	29,838	32,081	34,397	36,879	39,578
352	24,526	24,859	26,256	28,151	30,571	33,557	36,805	39,513	42,421	45,869
353	31,016	31,437	33,202	35,600	38,659	42,436	46,542	49,968	53,645	58,005
354	28,658	29,047	30,678	32,893	35,720	39,209	43,004	46,169	49,567	53,595
355	34,684	35,155	37,129	39,811	43,232	47,455	52,047	55,878	59,991	64,866
356	29,726	30,130	31,822	34,120	37,052	40,671	44,607	47,890	51,415	55,593
357	20,530	21,146	22,707	24,605	26,840	29,422	32,414	35,237	38,306	41,829
358	23,431	24,149	26,306	28,874	31,835	35,192	38,905	42,657	46,770	51,422
359	24,417	25,165	27,413	30,089	33,175	36,673	40,543	44,453	48,739	53,586

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
360	19,773	20,101	21,448	23,024	24,809	26,787	28,809	30,800	32,929	35,274
361	23,975	24,360	26,128	28,314	30,893	33,865	36,950	39,871	43,023	46,596
362	21,201	21,691	23,277	25,163	27,326	29,758	32,352	34,912	37,674	40,756
363	21,992	22,653	24,325	26,358	28,752	31,518	34,723	37,747	41,035	44,808
364	24,614	25,182	27,024	29,213	31,723	34,547	37,559	40,531	43,737	47,315
365	25,594	26,457	27,936	29,724	31,827	34,257	36,929	39,582	42,426	45,561
366	24,297	24,911	26,289	27,980	29,977	32,274	34,702	37,056	39,569	42,351
367	23,503	24,114	25,446	27,039	28,870	30,918	33,245	35,450	37,801	40,421
368	23,691	24,330	25,964	27,960	30,270	32,873	35,593	38,345	41,311	44,580
369	22,679	23,081	24,594	26,362	28,341	30,512	32,935	35,202	37,625	40,348
370	21,192	21,608	23,148	25,063	27,347	29,988	33,026	35,734	38,663	42,081
371	21,835	22,369	24,083	26,138	28,532	31,276	34,327	37,240	40,401	43,999
372	24,923	25,404	26,971	28,887	31,119	33,651	36,394	38,950	41,685	44,769
373	21,336	21,833	23,267	24,939	26,838	28,958	31,270	33,520	35,931	38,610
374	22,644	23,318	24,773	26,532	28,559	30,848	33,449	35,958	38,656	41,675
375	37,482	38,991	42,139	46,037	50,690	56,099	61,597	67,578	74,139	81,360
376	39,521	40,369	43,936	48,456	53,921	60,344	66,896	73,417	80,574	88,726
377	21,527	21,996	23,417	25,180	27,247	29,607	32,434	34,914	37,584	40,695
378	29,830	30,295	32,143	34,934	38,611	43,161	47,811	51,923	56,388	61,643
379	24,124	24,672	26,229	28,146	30,365	32,857	35,623	38,228	41,023	44,174
380	28,111	28,638	30,496	32,908	35,886	39,444	43,102	46,500	50,165	54,351
381	20,854	21,292	22,793	24,589	26,640	28,941	31,579	34,017	36,643	39,642
382	25,781	26,251	27,865	29,659	31,643	33,805	36,023	38,260	40,637	43,209
383	24,459	25,291	27,203	29,406	31,877	34,598	37,522	40,635	44,005	47,678
384	28,575	28,914	30,478	32,575	35,168	38,234	41,207	43,929	46,830	50,106
385	21,109	21,548	22,887	24,434	26,175	28,100	30,316	32,367	34,557	37,023
386	21,114	21,579	23,123	24,966	27,067	29,407	32,169	34,696	37,421	40,552
387	23,306	23,630	25,142	26,967	29,047	31,356	33,920	36,234	38,706	41,521
388	27,359	28,040	29,766	31,932	34,495	37,442	40,772	43,844	47,148	50,913
389	25,084	25,704	27,390	29,418	31,774	34,453	37,319	40,118	43,127	46,479

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
390	21,309	21,879	23,577	25,592	27,902	30,502	33,347	36,170	39,231	42,664
391	19,257	19,679	21,079	22,739	24,654	26,821	29,263	31,547	34,009	36,811
392	24,085	24,959	27,244	29,835	32,737	35,948	39,253	42,964	47,025	51,430
393	26,883	27,223	28,878	30,909	33,304	36,047	38,813	41,393	44,144	47,229
394	42,514	43,854	46,893	50,600	54,911	59,806	65,525	70,971	76,871	83,580
395	36,519	37,655	41,217	45,521	50,539	56,278	62,256	68,567	75,518	83,295
396	39,106	40,322	44,136	48,746	54,120	60,265	66,666	73,424	80,868	89,196
397	23,587	24,309	26,239	28,498	31,059	33,910	36,899	40,057	43,486	47,245
398	31,180	31,642	33,334	35,541	38,189	41,251	44,335	47,187	50,223	53,628
399	36,172	36,708	38,672	41,232	44,304	47,856	51,434	54,743	58,265	62,215
400	27,442	28,242	30,170	32,400	34,912	37,690	40,611	43,665	46,949	50,515
401	23,019	23,334	24,911	26,845	29,131	31,774	34,438	36,955	39,656	42,696
402	24,197	24,717	26,286	28,158	30,323	32,777	35,308	37,804	40,476	43,425
403	28,352	29,245	31,272	33,744	36,619	39,884	43,698	47,330	51,264	55,738
404	30,430	31,389	33,564	36,218	39,304	42,807	46,900	50,799	55,022	59,824
405	18,456	19,037	20,357	21,966	23,838	25,962	28,445	30,810	33,371	36,283
406	24,379	25,122	27,224	29,663	32,398	35,400	38,559	41,935	45,606	49,624
407	26,545	27,358	29,453	31,923	34,743	37,910	41,222	44,696	48,462	52,596
408	28,767	29,606	31,627	33,964	36,598	39,510	42,572	45,774	49,216	52,955
409	23,490	23,972	25,543	27,420	29,572	31,987	34,559	37,044	39,707	42,674
410	26,064	26,571	28,654	31,197	34,155	37,509	41,123	44,584	48,337	52,602
411	24,972	25,443	27,384	29,725	32,422	35,452	38,689	41,812	45,188	48,994
412	27,021	27,620	29,609	32,032	34,855	38,065	41,458	44,769	48,345	52,355
413	24,095	24,781	26,752	29,082	31,744	34,727	37,976	41,256	44,819	48,797
414	25,751	26,462	28,594	31,124	34,022	37,278	40,798	44,350	48,212	52,528
415	25,102	25,724	27,666	29,995	32,674	35,692	38,918	42,126	45,598	49,477
416	23,644	24,341	26,051	28,047	30,309	32,826	35,543	38,320	41,313	44,604
417	27,613	27,843	29,240	31,077	33,286	35,834	38,367	40,613	42,991	45,681
418	32,271	32,739	34,402	36,724	39,693	43,312	46,955	50,164	53,592	57,535
419	24,366	25,166	27,158	29,469	32,092	35,014	38,026	41,285	44,825	48,671

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
420	25,037	25,569	27,296	29,367	31,756	34,454	37,351	40,137	43,130	46,483
421	28,186	28,590	30,095	32,039	34,363	37,043	39,753	42,249	44,900	47,874
422	26,955	27,481	29,196	31,294	33,716	36,431	39,294	42,044	44,986	48,263
423	28,907	29,730	30,716	32,036	33,697	35,699	37,650	39,622	41,698	43,914
424	26,346	27,176	29,228	31,567	34,142	36,921	39,852	43,030	46,462	50,162
425	25,825	26,376	28,299	30,569	33,149	36,019	39,212	42,261	45,547	49,254
426	26,126	26,905	29,006	31,555	34,528	37,936	41,689	45,397	49,436	53,997
427	32,020	32,545	34,571	37,115	40,130	43,586	46,922	50,211	53,731	57,612
428	42,041	42,914	45,741	49,218	53,268	57,862	62,531	67,152	72,116	77,609
429	22,499	23,086	24,711	26,636	28,828	31,275	33,885	36,513	39,345	42,474
430	24,628	25,192	26,854	28,933	31,395	34,232	37,267	40,158	43,273	46,789
431	25,287	25,809	27,427	29,457	31,861	34,631	37,544	40,306	43,271	46,606
432	24,500	25,637	28,465	31,774	35,567	39,855	44,723	50,006	55,912	62,590
433	25,017	25,901	27,956	30,377	33,133	36,211	39,536	43,042	46,858	51,062
434	21,604	22,189	23,906	25,940	28,263	30,864	33,749	36,598	39,686	43,155
435	21,849	22,311	24,021	26,068	28,423	31,077	33,980	36,767	39,783	43,196
436	26,270	26,574	28,422	30,725	33,431	36,525	39,780	42,751	45,943	49,595
437	23,456	23,973	25,865	28,139	30,758	33,713	36,929	40,048	43,431	47,257
438	23,343	23,880	25,572	27,606	29,968	32,657	35,497	38,282	41,287	44,643
439	22,717	23,462	25,517	27,974	30,834	34,114	37,787	41,466	45,502	50,087
440	26,514	27,284	28,967	31,002	33,371	36,055	39,007	41,898	45,004	48,456
441	27,130	27,858	30,007	32,519	35,350	38,477	41,667	45,053	48,714	52,699
442	24,094	24,513	26,204	28,223	30,536	33,131	35,918	38,555	41,386	44,571
443	27,060	27,847	29,744	32,015	34,611	37,521	40,617	43,773	47,176	50,917
444	25,988	26,347	27,704	29,499	31,676	34,218	36,798	39,129	41,606	44,408
445	26,625	27,413	29,166	31,250	33,642	36,316	39,123	42,021	45,132	48,523
446	22,225	22,814	24,507	26,511	28,790	31,332	34,220	37,013	40,034	43,443
447	27,371	28,051	29,746	31,749	34,029	36,577	39,387	42,109	45,018	48,244
448	15,729	16,096	17,134	18,374	19,792	21,375	23,144	24,825	26,628	28,652
449	25,901	26,504	28,214	30,256	32,591	35,197	38,110	40,879	43,848	47,181

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
450	24,693	25,268	26,898	28,845	31,071	33,555	36,333	38,972	41,803	44,980
451	23,252	23,880	25,602	27,635	29,951	32,531	35,310	38,109	41,130	44,475
452	21,478	21,876	23,235	25,130	27,601	30,714	34,148	37,062	40,223	44,007
453	22,511	23,161	24,983	27,105	29,498	32,143	35,044	37,996	41,197	44,750
454	22,739	23,241	24,966	26,970	29,228	31,729	34,482	37,163	40,051	43,285
455	41,529	42,297	44,925	48,590	53,367	59,386	66,026	71,659	77,772	85,088
456	35,041	35,872	38,607	41,907	45,711	49,984	54,395	58,875	63,724	69,097
457	29,927	30,636	32,972	35,791	39,040	42,689	46,456	50,282	54,424	59,013
458	25,518	26,123	28,115	30,518	33,289	36,401	39,613	42,875	46,407	50,319
459	26,228	26,850	28,897	31,367	34,215	37,413	40,715	44,068	47,698	51,719
460	22,840	23,382	25,165	27,316	29,795	32,581	35,455	38,376	41,536	45,039
461	25,860	26,473	28,492	30,927	33,735	36,889	40,143	43,450	47,028	50,994
462	25,646	26,338	28,237	30,480	33,034	35,879	38,945	42,032	45,364	49,053
463	14,645	15,040	16,125	17,405	18,864	20,489	22,239	24,002	25,905	28,011
464	17,319	17,787	19,069	20,583	22,308	24,230	26,300	28,385	30,635	33,126
465	22,937	23,556	25,254	27,260	29,544	32,089	34,830	37,592	40,571	43,871
466	22,878	23,496	25,190	27,190	29,469	32,007	34,742	37,496	40,468	43,759
467	18,091	18,426	19,571	21,167	23,248	25,870	28,763	31,217	33,880	37,067
468	29,310	29,852	31,707	34,293	37,665	41,913	46,599	50,575	54,889	60,052
469	25,189	25,917	27,956	30,330	33,008	35,967	39,214	42,518	46,100	50,076
470	25,369	26,101	28,155	30,546	33,243	36,224	39,494	42,821	46,428	50,433
471	24,370	24,821	26,363	28,514	31,317	34,849	38,746	42,051	45,639	49,932
472	22,714	23,216	24,939	26,940	29,196	31,694	34,445	37,122	40,007	43,237
473	24,982	25,563	27,213	29,182	31,434	33,948	36,758	39,428	42,292	45,506
474	25,233	25,821	27,486	29,476	31,750	34,289	37,127	39,824	42,717	45,964
475	21,709	22,111	23,484	25,400	27,897	31,044	34,515	37,459	40,655	44,479
476	23,891	24,581	26,515	28,767	31,307	34,114	37,193	40,326	43,724	47,495
477	23,002	23,623	25,326	27,337	29,629	32,181	34,930	37,699	40,687	43,996
478	31,331	32,177	34,496	37,236	40,357	43,832	47,577	51,349	55,419	59,926
479	22,790	23,320	24,825	26,622	28,676	30,969	33,532	35,968	38,581	41,513

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
480	22,382	22,987	24,644	26,601	28,831	31,313	33,989	36,683	39,591	42,811
481	24,541	25,102	26,755	28,725	30,954	33,407	36,099	38,716	41,522	44,643
482	31,355	32,072	34,183	36,700	39,548	42,682	46,122	49,465	53,050	57,038
483	27,675	28,307	30,171	32,392	34,906	37,673	40,709	43,659	46,824	50,344
484	23,269	23,805	25,920	28,488	31,461	34,826	38,579	42,211	46,184	50,741
485	43,212	44,209	48,136	52,904	58,425	64,676	71,644	78,389	85,768	94,230
486	24,408	25,310	27,595	30,314	33,439	36,958	41,060	45,187	49,728	54,899
487	23,048	23,822	25,928	28,569	31,701	35,307	39,941	44,136	48,772	54,318
488	25,248	26,564	28,450	30,653	33,133	35,860	38,891	42,329	46,071	50,084
489	29,028	30,075	32,351	35,077	38,215	41,751	45,794	49,849	54,263	59,217
490	27,292	28,093	30,063	32,458	35,231	38,360	41,771	45,167	48,839	52,934
491	25,025	25,688	27,250	29,126	31,277	33,675	36,337	38,920	41,688	44,762
492	25,687	27,255	29,907	33,318	37,693	43,301	50,630	57,539	65,389	75,020
493	24,851	25,983	28,120	30,679	33,624	36,962	40,894	44,931	49,366	54,366
494	24,204	25,101	26,734	28,677	30,872	33,296	36,191	39,055	42,145	45,590
495	24,185	24,948	26,656	28,648	30,886	33,344	36,011	38,781	41,764	45,019
496	23,906	24,509	26,183	28,207	30,558	33,238	36,268	39,119	42,195	45,688
497	24,996	25,970	27,817	30,050	32,669	35,667	39,184	42,639	46,398	50,649
498	25,069	25,943	28,131	30,752	33,770	37,182	41,053	44,954	49,226	54,053
499	26,513	27,428	29,512	31,951	34,718	37,784	41,170	44,681	48,491	52,697
500	24,273	24,934	26,574	28,525	30,715	33,091	35,608	38,213	41,007	44,047
501	26,254	26,984	28,678	30,795	33,299	36,180	39,486	42,556	45,865	49,639
502	24,493	24,957	27,147	29,751	32,776	36,223	40,191	43,855	47,853	52,507
503	25,966	26,700	28,412	30,506	32,967	35,796	39,080	42,128	45,413	49,163
504	28,948	29,759	32,096	34,942	38,283	42,123	46,319	50,440	54,929	60,010
505	24,776	25,390	27,029	29,045	31,400	34,084	36,939	39,724	42,718	46,058
506	25,649	26,417	28,090	30,061	32,297	34,785	37,551	40,311	43,273	46,540
507	25,817	26,386	28,296	30,649	33,433	36,653	40,278	43,614	47,226	51,389
508	29,943	30,620	32,470	34,719	37,301	40,182	43,155	46,123	49,294	52,770
509	27,181	28,191	29,955	32,025	34,398	37,078	40,014	43,069	46,357	49,939

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
510	29,592	30,032	32,043	34,554	37,525	40,946	44,296	47,552	51,046	54,939
511	26,247	26,921	29,228	31,976	35,140	38,716	42,676	46,571	50,821	55,646
512	25,430	26,508	28,939	31,841	35,168	38,921	43,218	47,704	52,656	58,237
513	27,190	28,150	30,079	32,330	34,886	37,735	40,976	44,258	47,801	51,722
514	26,184	27,057	28,683	30,517	32,581	34,872	37,384	39,997	42,792	45,813
515	27,890	29,018	31,117	33,563	36,336	39,422	43,045	46,734	50,740	55,193
516	25,847	26,843	28,924	31,309	33,989	36,950	40,207	43,690	47,476	51,613
517	23,840	24,722	26,667	28,940	31,518	34,373	37,675	41,032	44,688	48,774
518	30,442	31,538	34,396	37,809	41,736	46,160	50,920	55,971	61,523	67,706
519	32,487	33,368	36,642	40,567	45,208	50,617	56,454	62,316	68,786	76,191
520	25,177	26,066	28,012	30,324	32,965	35,925	39,212	42,585	46,248	50,311
521	24,033	24,823	26,629	28,765	31,214	33,958	37,135	40,253	43,632	47,434
522	25,711	26,627	28,571	30,859	33,489	36,462	39,716	43,076	46,721	50,746
523	21,290	22,097	23,773	25,723	27,938	30,414	33,170	36,047	39,174	42,623
524	22,223	23,024	25,019	27,381	30,100	33,160	36,705	40,262	44,163	48,589
525	22,602	23,392	24,969	26,834	28,956	31,322	34,027	36,742	39,673	42,926
526	25,668	26,686	29,235	32,331	35,965	40,148	45,082	50,003	55,461	61,767
527	22,687	23,606	25,656	28,043	30,736	33,696	37,049	40,606	44,505	48,829
528	24,239	25,042	26,770	28,833	31,190	33,831	36,920	39,926	43,177	46,835
529	23,580	24,353	25,757	27,433	29,329	31,436	33,911	36,319	38,899	41,761
530	21,531	22,098	23,545	25,322	27,406	29,786	32,174	34,626	37,265	40,154
531	18,851	19,158	20,554	22,195	24,072	26,186	28,463	30,610	32,919	35,528
532	20,799	21,002	22,074	23,499	25,246	27,302	29,360	31,172	33,096	35,289
533	23,876	24,015	25,165	26,744	28,697	30,999	33,286	35,233	37,293	39,663
534	17,681	18,104	19,361	20,818	22,474	24,328	26,261	28,217	30,319	32,627
535	27,045	28,128	30,083	32,349	34,944	37,897	41,309	44,768	48,516	52,680
536	22,649	23,261	24,630	26,290	28,194	30,318	32,790	35,110	37,593	40,386
537	20,133	20,528	21,996	23,671	25,530	27,557	29,763	31,921	34,235	36,803
538	20,278	20,911	22,516	24,340	26,387	28,678	31,334	33,950	36,785	39,968
539	20,946	21,647	23,960	26,652	29,705	33,120	37,151	41,211	45,716	50,900

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
540	24,964	25,817	27,373	29,241	31,380	33,757	36,390	39,076	41,960	45,115
541	27,141	27,535	29,010	30,938	33,264	35,965	38,735	41,249	43,927	46,955
542	28,291	29,456	31,618	34,113	36,924	40,024	43,462	47,160	51,172	55,540
543	23,823	24,767	26,469	28,511	30,850	33,468	36,355	39,389	42,676	46,278
544	24,444	25,411	27,715	30,436	33,539	37,013	40,807	44,879	49,357	54,327
545	22,270	23,240	24,998	27,037	29,336	31,873	34,733	37,804	41,146	44,802
546	29,328	30,037	32,361	35,098	38,235	41,760	45,595	49,369	53,455	58,041
547	26,561	27,352	29,007	30,921	33,071	35,444	38,005	40,641	43,460	46,516
548	29,180	29,777	31,997	34,725	37,877	41,417	45,138	48,788	52,734	57,156
549	30,189	30,911	33,435	36,624	40,515	45,156	50,071	54,800	59,975	65,926
550	23,669	24,345	26,234	28,484	31,086	34,021	37,411	40,662	44,196	48,224
551	23,232	24,147	26,660	29,695	33,243	37,320	41,890	46,664	51,981	58,051
552	25,013	25,925	27,730	29,883	32,335	35,113	38,297	41,485	44,937	48,789
553	27,238	27,968	30,031	32,365	34,964	37,839	41,027	44,217	47,656	51,465
554	25,281	25,987	28,108	30,675	33,655	37,040	40,905	44,626	48,687	53,332
555	23,586	24,552	26,548	28,868	31,488	34,391	37,712	41,191	44,992	49,207
556	28,185	29,313	31,232	33,407	35,853	38,568	41,419	44,598	48,022	51,663
557	23,396	23,935	26,115	28,700	31,669	35,028	39,017	42,731	46,799	51,545
558	24,462	24,836	26,109	27,671	29,501	31,585	34,166	36,260	38,482	41,101
559	26,057	26,614	28,445	30,640	33,138	35,907	38,877	41,778	44,896	48,367
560	26,342	26,172	27,367	28,950	30,852	33,042	35,188	36,868	38,628	40,693
561	22,503	22,935	24,404	26,097	27,982	30,032	32,268	34,429	36,735	39,287
562	35,143	35,242	37,840	41,438	46,015	51,595	57,365	62,290	67,638	74,026
563	27,017	27,162	28,897	30,984	33,365	36,008	38,791	41,256	43,879	46,867
564	34,404	35,031	37,285	40,181	43,642	47,638	51,604	55,462	59,608	64,232
565	19,560	19,912	21,331	23,007	24,925	27,086	29,399	31,605	33,977	36,644
566	27,463	27,464	28,771	30,539	32,721	35,277	37,620	39,646	41,782	44,206
567	29,406	29,810	31,755	34,247	37,269	40,823	44,399	47,717	51,284	55,336
568	24,549	25,062	26,871	28,847	31,022	33,400	35,833	38,362	41,069	43,999
569	23,637	23,780	25,210	26,832	28,643	30,635	32,844	34,747	36,761	39,063

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
570	22,174	22,718	24,517	26,645	29,057	31,749	34,799	37,742	40,933	44,551
571	20,432	20,941	22,570	24,461	26,581	28,920	31,653	34,258	37,079	40,281
572	19,559	19,885	21,191	22,769	24,578	26,600	28,877	30,942	33,155	35,681
573	19,915	20,330	21,982	23,910	26,118	28,589	31,420	34,076	36,957	40,259
574	21,231	21,862	23,966	26,500	29,471	32,893	36,913	40,774	45,040	50,014
575	18,846	19,154	20,385	21,832	23,471	25,294	27,347	29,216	31,212	33,478
576	21,547	22,213	23,744	25,512	27,478	29,617	31,927	34,350	36,956	39,787
577	19,709	20,157	21,563	23,235	25,145	27,282	29,575	31,823	34,242	36,936
578	21,024	21,325	22,831	24,636	26,738	29,136	31,659	34,015	36,546	39,414
579	20,008	20,342	21,695	23,308	25,155	27,226	29,482	31,580	33,828	36,366
580	26,895	27,242	29,206	31,633	34,500	37,810	41,093	44,242	47,633	51,444
581	21,716	21,925	23,117	24,677	26,564	28,763	30,973	32,941	35,033	37,413
582	23,171	23,265	24,609	26,287	28,271	30,546	32,842	34,843	36,966	39,393
583	26,160	26,516	28,060	30,022	32,363	35,070	37,996	40,571	43,320	46,481
584	22,629	23,125	24,665	26,411	28,352	30,484	32,700	34,958	37,372	39,998
585	21,456	22,082	23,770	25,750	28,009	30,537	33,366	36,172	39,215	42,625
586	24,692	25,260	26,831	28,674	30,796	33,195	35,625	38,086	40,716	43,584
587	24,742	25,325	27,648	30,387	33,545	37,141	41,065	44,944	49,190	54,019
588	31,586	31,969	34,341	37,221	40,623	44,569	48,693	52,493	56,590	61,278
589	24,792	25,361	27,465	29,906	32,719	35,922	39,244	42,607	46,259	50,328
590	20,073	20,460	22,042	23,916	26,075	28,520	31,168	33,700	36,437	39,538
591	19,983	20,463	21,953	23,697	25,687	27,911	30,332	32,710	35,275	38,138
592	21,350	21,766	23,266	25,042	27,061	29,313	31,770	34,110	36,623	39,444
593	29,251	29,568	31,177	33,202	35,562	38,215	40,908	43,377	45,995	48,925
594	27,925	28,609	30,864	33,614	36,803	40,410	44,451	48,324	52,533	57,334
595	24,771	25,409	27,085	29,155	31,598	34,416	37,599	40,563	43,762	47,411
596	23,347	23,876	25,577	27,566	29,813	32,298	35,030	37,692	40,555	43,752
597	23,862	24,342	25,652	27,308	29,268	31,511	34,130	36,409	38,840	41,643
598	26,326	26,903	28,500	30,497	32,865	35,593	38,667	41,450	44,432	47,842
599	23,374	24,030	25,651	27,485	29,526	31,771	34,091	36,557	39,201	42,045

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
600	26,813	27,593	30,008	32,793	35,921	39,372	43,016	46,877	51,085	55,717
601	26,170	26,918	29,432	32,402	35,800	39,615	43,963	48,272	53,004	58,406
602	24,560	25,324	27,050	29,149	31,591	34,364	37,476	40,520	43,811	47,505
603	29,681	30,347	32,786	35,690	38,954	42,512	46,505	50,399	54,618	59,375
604	28,018	29,057	32,254	36,116	40,671	45,956	51,769	57,872	64,694	72,505
605	28,761	29,785	33,542	38,081	43,501	49,903	56,784	64,160	72,493	82,102
606	33,172	33,650	36,107	39,541	43,922	49,249	54,632	59,582	64,980	71,270
607	20,851	21,077	22,866	24,921	27,234	29,797	32,457	35,036	37,820	40,948
608	22,734	23,303	24,926	26,901	29,199	31,817	34,738	37,513	40,508	43,904
609	26,472	27,400	29,203	31,453	34,116	37,180	40,653	44,044	47,718	51,857
610	22,512	23,006	24,573	26,374	28,373	30,536	33,036	35,408	37,951	40,803
611	22,257	22,641	23,910	25,483	27,331	29,441	31,809	33,905	36,139	38,694
612	26,030	26,725	28,530	30,686	33,193	36,055	39,234	42,289	45,581	49,286
613	21,662	22,233	23,738	25,545	27,634	30,000	32,614	35,143	37,869	40,927
614	27,430	28,317	30,748	33,691	37,105	40,982	45,531	49,940	54,776	60,338
615	29,132	29,825	31,662	33,898	36,511	39,488	42,798	45,901	49,228	52,982
616	34,455	34,896	36,699	38,959	41,638	44,722	47,826	50,674	53,691	57,064
617	19,872	20,369	21,485	22,775	24,206	25,738	27,470	29,173	30,981	32,956
618	30,707	31,032	32,371	34,232	36,582	39,398	42,112	44,505	47,034	49,895
619	27,818	28,568	30,979	33,930	37,407	41,421	46,007	50,366	55,137	60,653
620	25,332	25,895	27,804	30,172	32,973	36,205	39,794	43,142	46,771	50,938
621	23,316	23,946	25,838	28,136	30,825	33,909	37,522	40,890	44,560	48,808
622	24,453	25,054	26,784	28,877	31,319	34,107	37,276	40,233	43,424	47,065
623	26,092	26,538	27,855	29,506	31,479	33,757	36,015	38,164	40,441	42,951
624	21,879	22,372	23,878	25,692	27,796	30,187	32,893	35,403	38,104	41,181
625	20,150	20,544	22,055	23,821	25,833	28,090	30,555	32,910	35,447	38,305
626	33,303	34,473	37,624	41,442	45,848	50,815	56,202	61,856	68,078	75,050
627	33,820	34,857	37,652	41,124	45,212	49,896	54,608	59,595	65,038	71,045
628	39,325	40,706	44,427	48,935	54,139	60,004	66,365	73,041	80,389	88,621
629	41,125	42,569	46,461	51,175	56,617	62,750	69,403	76,384	84,068	92,676

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
630	22,473	22,967	24,632	26,588	28,813	31,296	33,913	36,518	39,323	42,432
631	34,154	35,201	38,024	41,530	45,659	50,389	55,147	60,184	65,680	71,747
632	25,182	26,073	28,212	30,783	33,777	37,212	40,990	44,846	49,065	53,802
633	24,206	24,981	26,940	29,276	31,968	35,015	38,314	41,688	45,359	49,447
634	27,253	28,076	30,499	33,347	36,591	40,227	44,278	48,367	52,833	57,859
635	26,525	27,343	29,654	32,374	35,474	38,945	42,766	46,662	50,913	55,670
636	26,254	27,046	29,381	32,124	35,250	38,752	42,655	46,594	50,897	55,738
637	25,361	26,169	28,272	30,760	33,599	36,774	40,177	43,721	47,577	51,842
638	25,689	26,361	28,322	30,625	33,245	36,174	39,327	42,493	45,914	49,712
639	27,259	27,972	30,052	32,496	35,277	38,385	41,730	45,090	48,720	52,750
640	25,212	25,973	28,215	30,849	33,850	37,214	40,962	44,744	48,876	53,525
641	26,387	27,077	29,091	31,457	34,148	37,157	40,396	43,648	47,162	51,063
642	26,098	26,844	28,898	31,321	34,082	37,170	40,480	43,861	47,523	51,580
643	25,736	26,493	28,333	30,600	33,249	36,260	39,334	42,523	45,970	49,754
644	24,024	24,551	26,331	28,422	30,800	33,455	36,252	39,037	42,035	45,360
645	25,649	26,263	27,842	29,816	32,144	34,810	37,764	40,518	43,473	46,816
646	28,071	28,323	29,616	31,351	33,501	36,048	38,531	40,711	43,013	45,622
647	29,623	29,912	31,263	33,065	35,294	37,933	40,489	42,757	45,153	47,853
648	27,914	28,325	29,778	31,592	33,746	36,226	38,635	40,934	43,370	46,052
649	25,482	25,791	27,508	29,686	32,351	35,531	38,782	41,719	44,879	48,513
650	30,628	30,789	32,007	33,723	35,890	38,482	40,938	43,023	45,214	47,710
651	29,484	30,515	32,697	35,422	38,624	42,282	46,399	50,474	54,905	59,901
652	36,645	36,358	37,618	39,631	42,298	45,569	48,693	50,955	53,323	56,190
653	37,457	37,745	39,216	41,229	43,760	46,788	49,695	52,192	54,814	57,785
654	28,185	28,853	31,219	34,066	37,353	41,086	45,144	49,118	53,442	58,338
655	28,773	29,608	32,123	35,125	38,582	42,490	46,627	50,896	55,556	60,750
656	35,467	35,666	37,036	38,925	41,289	44,095	46,755	49,027	51,410	54,108
657	34,828	35,289	37,471	40,326	43,820	47,946	52,084	55,881	59,955	64,592
658	28,283	29,088	31,116	33,453	36,084	38,983	41,977	45,149	48,560	52,250
659	23,421	23,942	25,714	27,834	30,250	32,944	35,945	38,819	41,922	45,429

Zone ID	2013	2015	2020	2025	2030	2035	2040	2045	2050	2055
660	25,249	26,030	28,306	30,968	34,012	37,433	41,322	45,200	49,443	54,248
661	26,450	26,786	28,843	31,207	33,861	36,807	40,033	43,031	46,254	49,913
662	24,593	25,181	27,382	30,043	33,148	36,707	40,518	44,295	48,424	53,109

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Technical Appendix C: Capital Costs

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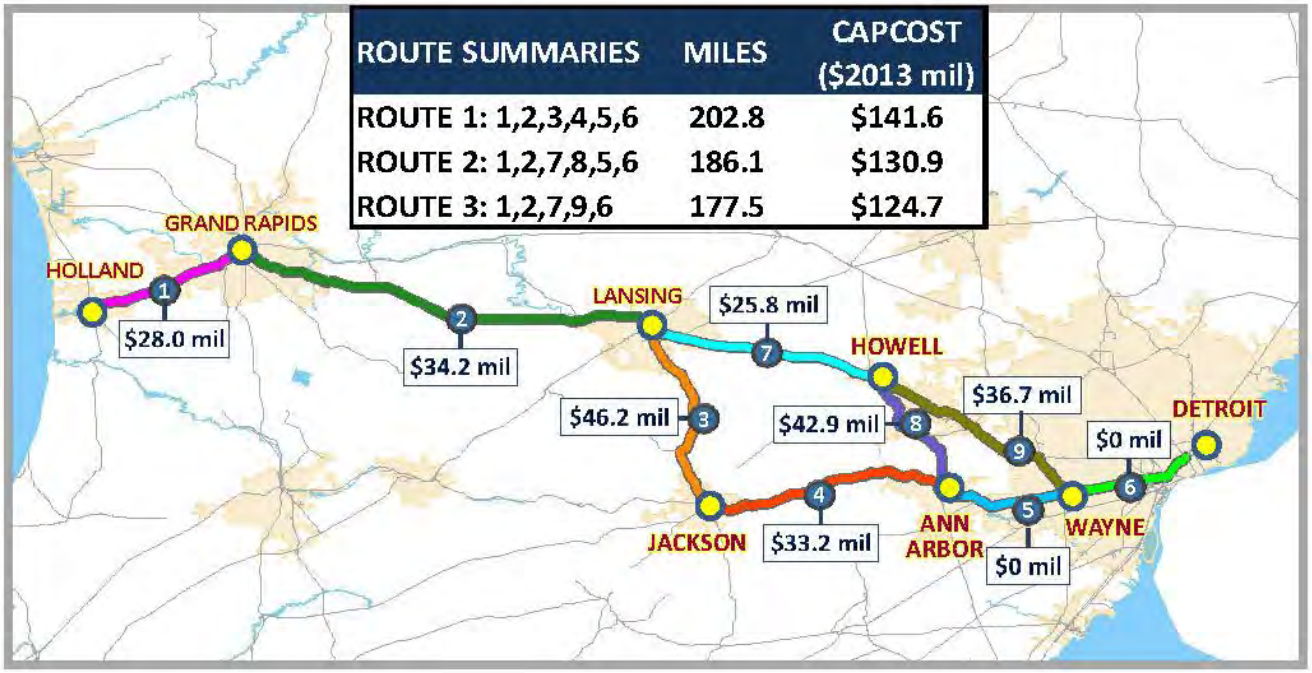
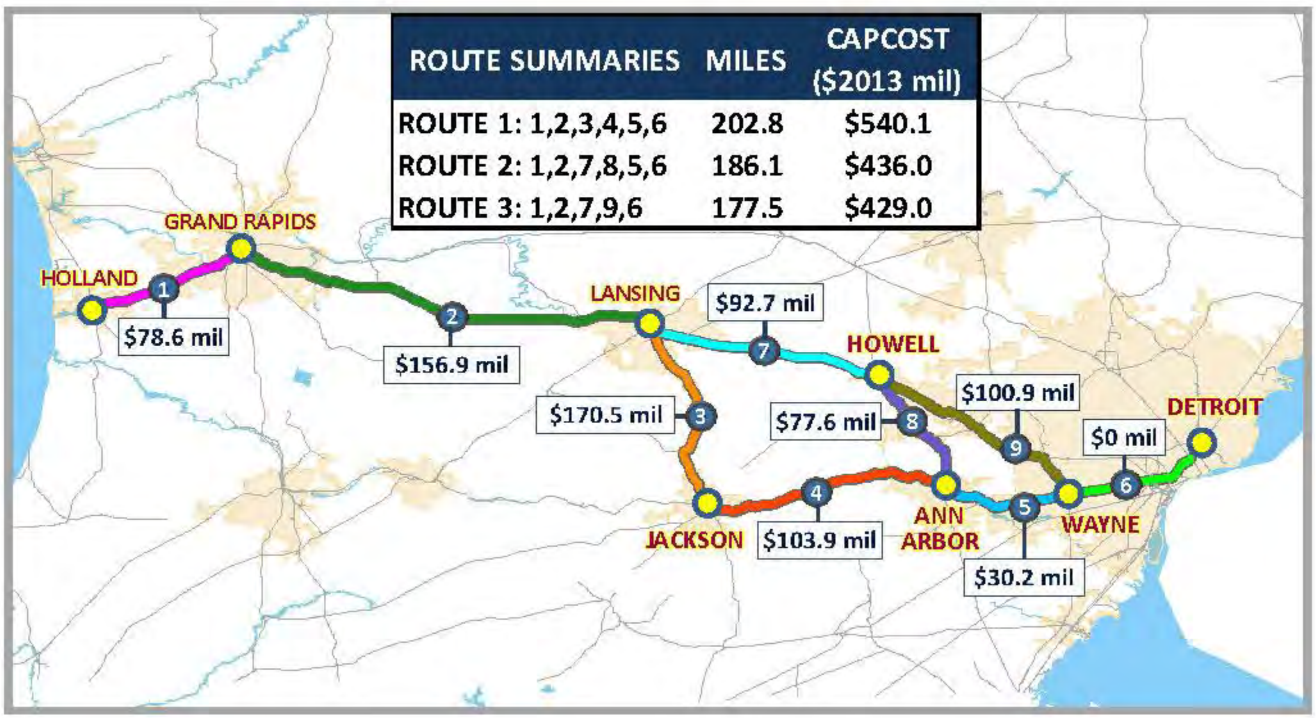
Michigan Coast-to-Coast Infrastructure
Capital Costs: 79 mph



ROUTE SUMMARIES	MILES	CAPCOST ($2013 mil)
ROUTE 1: 1,2,3,4,5,6	202.8	$141.6
ROUTE 2: 1,2,7,8,5,6	186.1	$130.9
ROUTE 3: 1,2,7,9,6	177.5	$124.7

Michigan Coast-to-Coast Infrastructure
Capital Costs: 110 mph



Michigan Coast-to-Coast Network
Equipment Capital Costs

Alternative	Daily Roundtrips	2030 Peak Segment Riders	2030 Required Train Size	Rotation Sets	Protect Sets	Total Sets	Total Seats	Cost per Seat ($2013K)	Equipment Cost ($2013M)
Route 1 79-mph	2	307,138	290	2	1	3	869	$62	$53.9
Route 1 79-mph	4	516,666	244	4	2	6	1,461	$62	$90.6
Route 1 110-mph	4	744,234	351	4	2	6	2,105	$72	$151.5
Route 1 110-mph	8	1,123,984	265	6	3	9	2,384	$72	$171.6
Route 2 79-mph	2	311,885	294	2	1	3	882	$62	$54.7
Route 2 79-mph	4	511,952	241	4	2	6	1,448	$62	$89.8
Route 2 110-mph	4	722,913	341	4	2	6	2,044	$72	$147.2
Route 2 110-mph	8	1,073,488	253	6	3	9	2,277	$72	$163.9
Route 3 79-mph	2	281,531	265	2	1	3	796	$62	$49.4
Route 3 79-mph	4	458,430	216	4	2	6	1,296	$62	$80.4
Route 3 110-mph	4	639,575	301	4	2	6	1,809	$72	$130.2
Route 3 110-mph	8	927,578	219	6	3	9	1,967	$72	$141.7

Michigan Coast-to-Coast Network
Capital Costs Summary

Alternative	Daily Roundtrips	Equipment Cost ($2013M)	Infrastr Cost ($2013M)	TOTAL Cost ($2013M)
Route 1 79-mph	2	$53.9	$141.6	$195.5
Route 1 79-mph	4	$90.6	$141.6	$232.2
Route 1 110-mph	4	$151.5	$540.1	$691.6
Route 1 110-mph	8	$171.6	$540.1	$711.7
Route 2 79-mph	2	$54.7	$130.9	$185.6
Route 2 79-mph	4	$89.8	$130.9	$220.7
Route 2 110-mph	4	$147.2	$436.0	$583.2
Route 2 110-mph	8	$163.9	$436.0	$599.9
Route 3 79-mph	2	$49.4	$124.7	$174.1
Route 3 79-mph	4	$80.4	$124.7	$205.1
Route 3 110-mph	4	$130.2	$429.0	$559.2
Route 3 110-mph	8	$141.7	$429.0	$570.7

Infrastructure Cost Estimates for 79 mph and 110 mph Options

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COAST-TO-COAST RAIL STUDY

Infrastructure Cost Estimate for Holland to Detroit at 79-mph maximum speed

Revised on 11/18/2015

				Segment 1		Segment 2		Segment 3		Segment 4		Segment 5		Segment 6		Segment 7		Segment 8		Segment 9	
				CSX		CSX		NS/J&L		MDOT/NS		MDOT/NS		MDOT/NS/CN		CSX		GLC/AA		CSX	
				Holland to Grand Rapids		Grand Rapids to Downtown Lansing		Downtown Lansing to Jackson		Jackson to Ann Arbor		Ann Arbor to Wayne		Wayne to Detroit New Center		Downtown Lansing to Ann Pere Jct		Ann Pere Jct to Ann Arbor		Ann Pere Jct to Wayne	
				24.8 miles		64.3 miles		37.6 miles		38.9 miles		19.5 miles		17.7 miles		34.3 miles		25.5 miles		36.4 miles	
Item		Unit	YR 2015 Unit Cost (1000s)	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
Trackwork																					
1.1	Single Track on Existing Roadbed (141# CWR, Conc. TF)	per mile	$ 1,246		-		-		-		-		-		-		-		-		-
1.2b	HSR on New Roadbed & New Embankment	per mile	$ 1,873		-	5.0	9,364	5.0	9,364		-		-		-	5.0	9,364		-	7.0	13,110
1.3	Timber & Surface w/ 33% Tie replacement	per mile	$ 279	24.8	6,910	64.3	17,915		-		-		-		-	34.3	9,557		-	36.4	10,142
Total Track Costs					6,910		27,279		9,364		-		-		-		18,921		-		23,251
Turnouts																					
4.1	#24 High Speed Turnout	each	$ 565		-	2	1,129	2	1,129		-		-		-	2	1,129		-	6	3,388
Total Turnouts Cost					-		1,129		1,129		-		-		-		1,129		-		3,388
Curves																					
9.1	Elevate & Surface Curves	per mile	$ 93		-		-		-		-		-		-		-		-		-
Total Curves Cost					-		-		-		-		-		-		-		-		-
Signals																					
8.2	Install CTC System (Single Track)	per mile	$ 230		-	5.0	1,148	5.0	1,148		-		-		-	5.0	1,148		-	7.0	1,607
8.21	Install CTC System (Double Track)	per mile	$ 377		-		-		-		-		-		-		-		-		-
8.3	Install PTC System Overlay on top of CTC	per mile	$ 181		-		-		-		-		-		-		-		-		-
8.6	Control Points	each	$ 870			2	1,740	2	1,740							2	1,740			4	3,480
8.7	Signals for Turnout	each	$ 502		-	2	1,004	2	1,004		-		-		-	2	1,004		-	6	3,012
Total Signals Cost					-		3,892		3,892		-		-		-		3,892		-		8,099
Stations / Facilities																					
2.1	Full Service - New	each	$ 1,000		-		-	1	1,000		-		-		-	1	1,000		-	1	1,000
Total Station Cost					-		-		1,000		-		-		-		1,000		-		1,000
Crossings																					
7.41	Convert Flashers Only to Dual Gate	each	$ 75	15	1,125	25	1,875		-		-		-		-	11	825		-	13	975
Total Crossings Cost					1,125		1,875		-		-		-		-		825		-		975
Segment Totals					**8,035**		**34,176**		**15,385**		**0**		**0**		**0**		**25,767**		**0**		**36,714**
Placeholders																					
	"All In" Rate for High Speed Double Track (Dearborn to Wayne Comp)	each	$ 3,320		-		-		-	10.0	33,200		-		-		-		-		-
	"All In" Rate for 79-mph Rehab Jointed Train (WALLY Comp)	per mile	$ 820					37.6	30,832									25.5	20,910		
	Purchase Mainline Track (at MDOT NS Rate)	per mile	$ 1,000		-		-		-		-		-		-		-		-		-
	Purchase Branchline Track (at MDOT NS Rate)	per mile	$ 1,000		-		-		-		-		-		-		-	2	2,000		-
	Turnaround Servicing Base at Holland	each	$ 20,000	1	20,000		-		-		-		-		-		-		-		-
	Bridge at Ann Arbor	each	$ 20,000		-		-		-		-		-		-		-	1	20,000		-
		each																			
TOTAL					**28,035**		**34,176**		**46,217**		**33,200**		**-**		**-**		**25,767**		**42,910**		**36,714**

NOTES

MDOT Purchased NS line $140 million for 135 miles of track
or approx 1 million per mile

COAST-TO-COAST RAIL STUDY

Infrastructure Cost Estimate for Holland to Detroit at 110-mph maximum speed

Revised on 11/18/2015

TEMS

Item		Unit	YR 2015 Unit Cost (1000s)	Segment 1 CSX Holland to Grand Rapids 24.8 miles Quantity	Amount	Segment 2 CSX Grand Rapids to Downtown Lansing 64.3 miles Quantity	Amount	Segment 3 NS/J&L Downtown Lansing to Jackson 37.6 miles Quantity	Amount	Segment 4 MDOT/NS Jackson to Ann Arbor 38.9 miles Quantity	Amount	Segment 5 MDOT/NS Ann Arbor to Wayne 19.5 miles Quantity	Amount	Segment 6 MDOT/NS/CN Wayne to Detroit New Center 17.7 miles Quantity	Amount	Segment 7 CSX Downtown Lansing to Ann Pere Jct 34.3 miles Quantity	Amount	Segment 8 GLC/AA Ann Pere Jct to Ann Arbor 25.5 miles Quantity	Amount	Segment 9 CSX Ann Pere Jct to Wayne 36.4 miles Quantity	Amount
Trackwork																					
1.1	Single Track on Existing Roadbed (141# CWR, Conc. TF)	per mile	$ 1,246		-		-	37.6	46,854		-		-		-		-	25.5	31,776		-
1.2b	HSR on New Roadbed & New Embankment	per mile	$ 1,873		-	10.0	18,728	10.0	18,728		-		-		-	10.0	18,728		-	12.0	22,473
1.3	Timber & Surface w/ 33% Tie replacement	per mile	$ 279	24.8	6,910	64.3	17,915		-		-		-		-	34.3	9,557		-	36.4	10,142
Total Track Costs					6,910		36,643		65,582		-		-		-		28,285		31,776		32,615
Turnouts																					
4.1	#24 High Speed Turnout	each	$ 565		-	2	1,129	2	1,129		-		-		-	2	1,129		-	6	3,388
Total Turnouts Cost					-		1,129		1,129		-		-		-		1,129		-		3,388
Curves																					
9.1	Elevate & Surface Curves	per mile	$ 93	3.40	316	9.50	884		-		-		-		-	5.2	484		-	8.2	763
Total Curves Cost					316		884		-		-		-		-		484		-		763
Signals																					
8.2	Install CTC System (Single Track)	per mile	$ 230		-	10.0	2,296	27.6	6,338		-		-		-	10.0	2,296	25.5	5,855	12.0	2,755
8.21	Install CTC System (Double Track)	per mile	$ 377		-		-	10.0	3,765		-		-		-		-		-		-
8.3	Install PTC System Overlay on top of CTC	per mile	$ 181	25	4,498	64.3	11,661	37.6	6,819		-		-		-	34.3	6,221	25.5	4,625	36.4	6,602
8.6	Control Points	each	$ 870			2	1,740	2	1,740							2	1,740			4	3,480
8.7	Signals for Turnout	each	$ 502		-	2	1,004	2	1,004		-		-		-	2	1,004		-	6	3,012
Total Signals Cost					4,498		16,702		19,666		-		-		-		11,261		10,480		15,849
Stations / Facilities																					
2.1	Full Service - New	each	$ 1,000		-		-	1	1,000		-		-		-	1	1,000		-	1	1,000
Total Station Cost					-		-		1,000		-		-		-		1,000		-		1,000
Crossings																					
7.3	Four Quadrant Gates	each	$ 361	61	22,048	103	37,229	126	45,543		-		-		-	45	16,265	37	13,374	30	10,844
Total Crossings Cost					22,048		37,229		45,543		-		-		-		16,265		13,374		10,844
Segment Totals					**33,772**		**92,587**		**132,919**		**0**		**0**		**0**		**58,424**		**55,629**		**64,458**
Placeholders																					
	"All In" Rate for Double Track (Dearborn to Wayne)	each	$ 3,320		-		-		-	31.3	103,916	9	30,212		-		-		-		-
	Purchase Mainline Track (at MDOT NS Rate)	per mile	$ 1,000	24.8	24,800	64.3	64,300		-		-		-		-	34	34,300		-	36.4	36,400
	Purchase Branchline Track (at MDOT NS Rate)	per mile	$ 1,000		-		-	37.6	37,600		-		-		-		-	2	2,000		-
	Turnaround Servicing Base at Holland	each	$ 20,000	1	20,000		-		-		-		-		-		-		-		-
	Bridge at Ann Arbor	each	$ 20,000		-		-		-		-		-		-		-	1	20,000		-
TOTAL					**78,572**		**156,887**		**170,519**		**103,916**		**30,212**		**-**		**92,724**		**77,629**		**100,858**

Costing Segment Detail Maps

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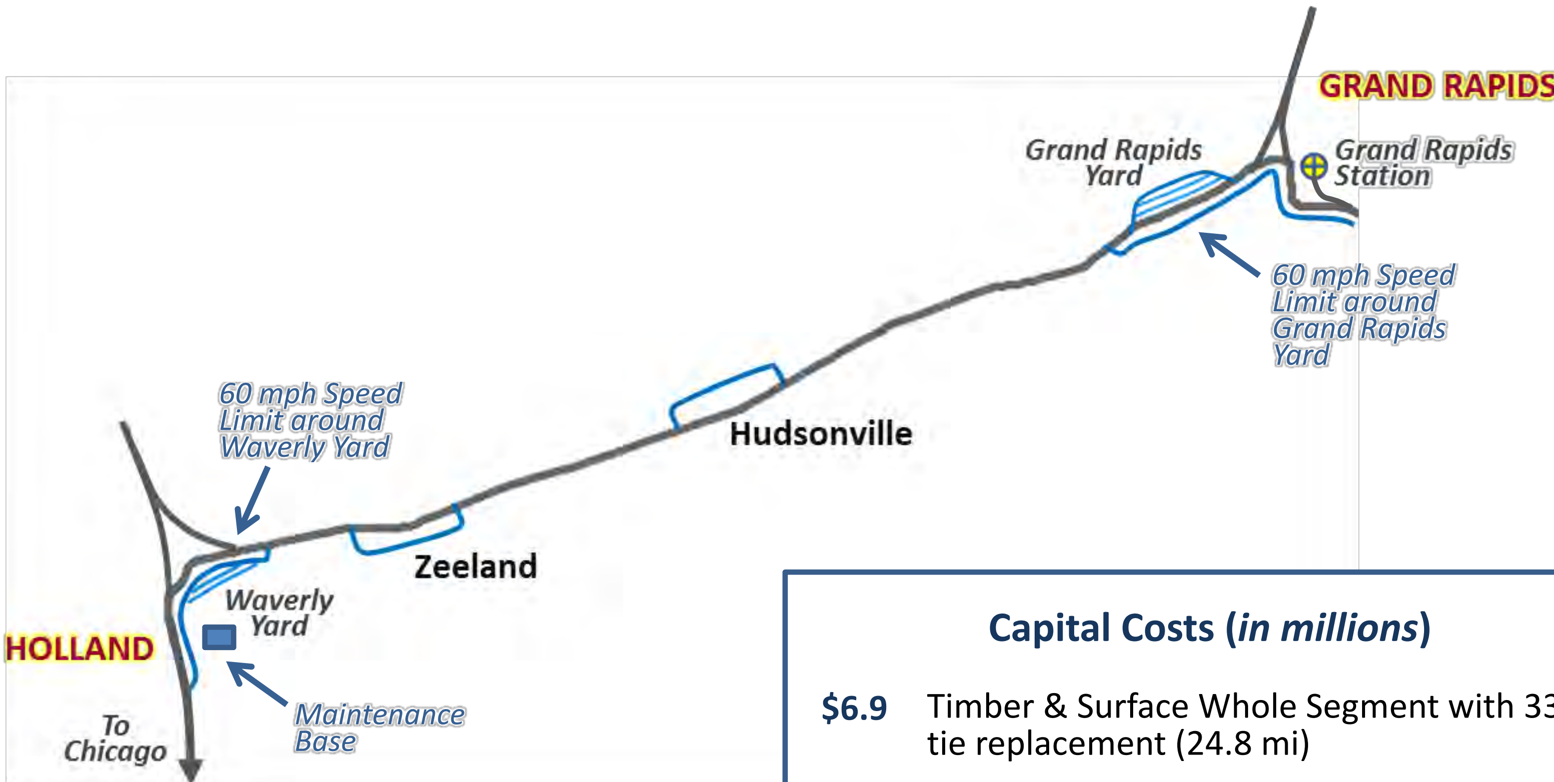
Holland to Grand Rapids (Segment 1): 79 mph Upgrade



Capital Costs (*in millions*)

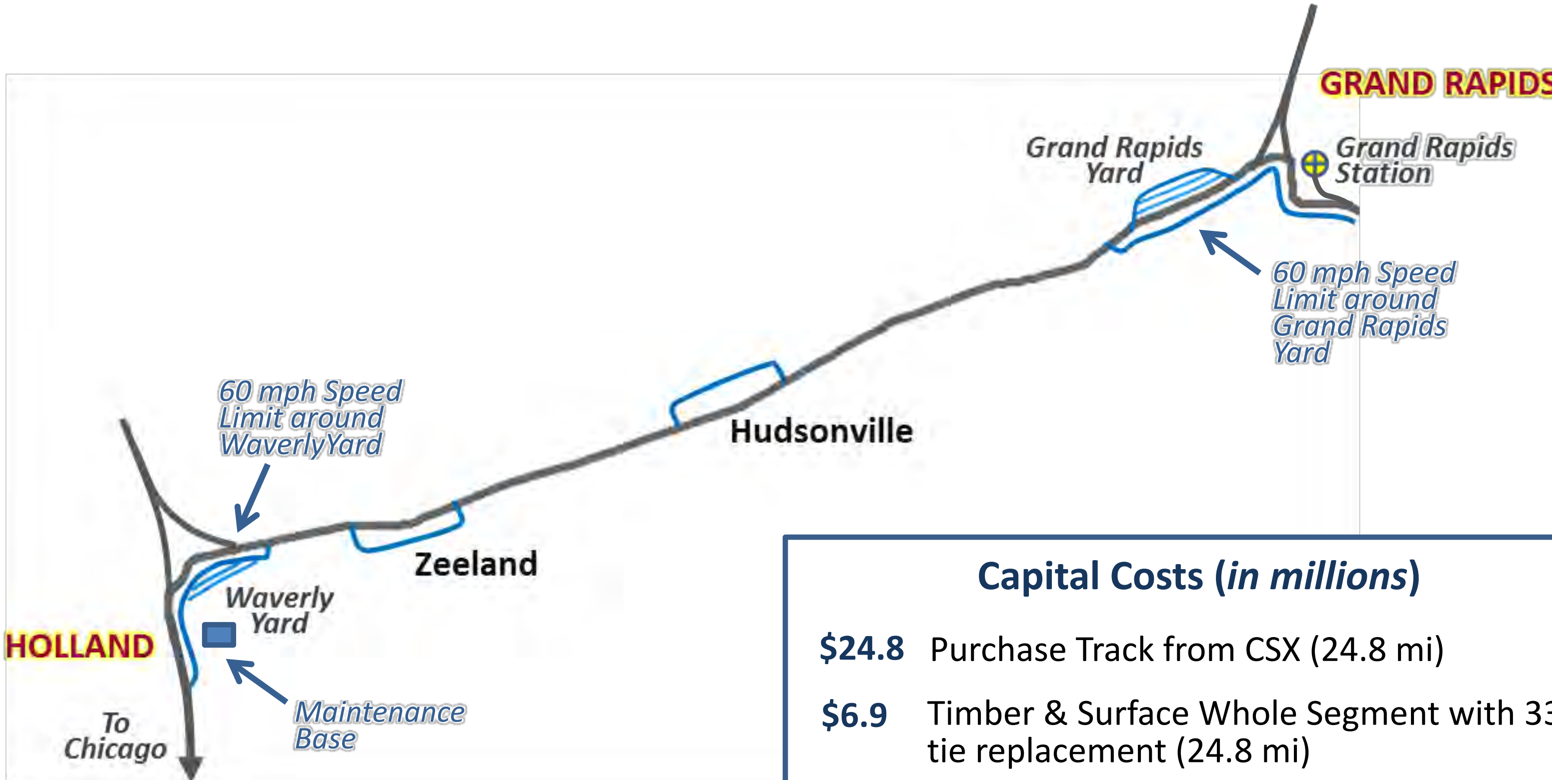
$6.9 Timber & Surface Whole Segment with 33% tie replacement (24.8 mi)

$1.1 Convert Flashes to Dual Gates – 15 Crossings

$20.0 Turnaround / Maintenance Base

$28.0 **Segment Total**

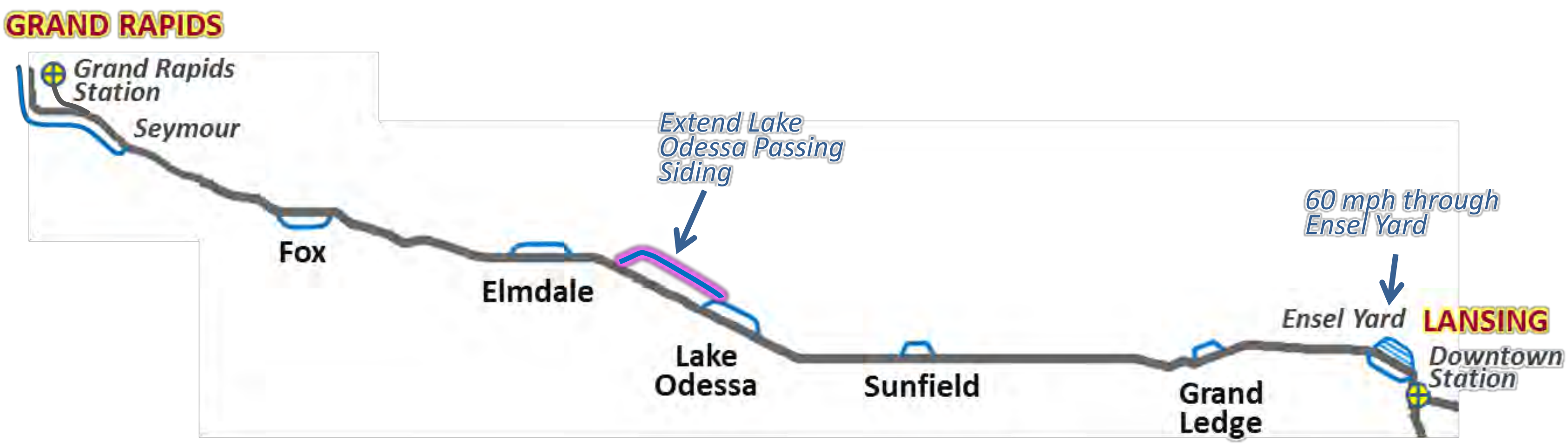
Holland to Grand Rapids (Segment 1): 110 mph Upgrade



Capital Costs (*in millions*)

$24.8	Purchase Track from CSX (24.8 mi)
$6.9	Timber & Surface Whole Segment with 33% tie replacement (24.8 mi)
$0.3	Elevate and Surface Curves
$4.5	PTC Overlay
$22.1	Quad Gate - 61 Crossings
$20.0	Turnaround / Maintenance Base
$78.6	**Segment Total**

Grand Rapids to Lansing (Segment 2): 79 mph Upgrade



Capital Costs (*in millions*)

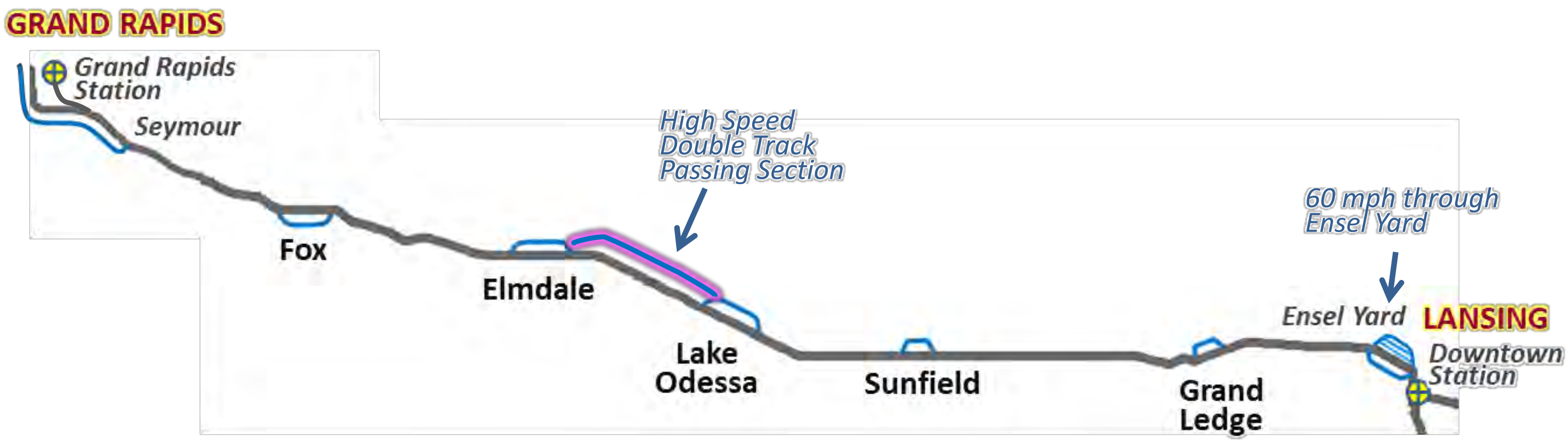
$17.9 Timber & Surface Whole Segment with 33% tie replacement (64.3 mi)

$14.4 Extended Passing Track with Signals

$1.9 Convert Flashers to Dual Gates

$34.2 **Segment Total**

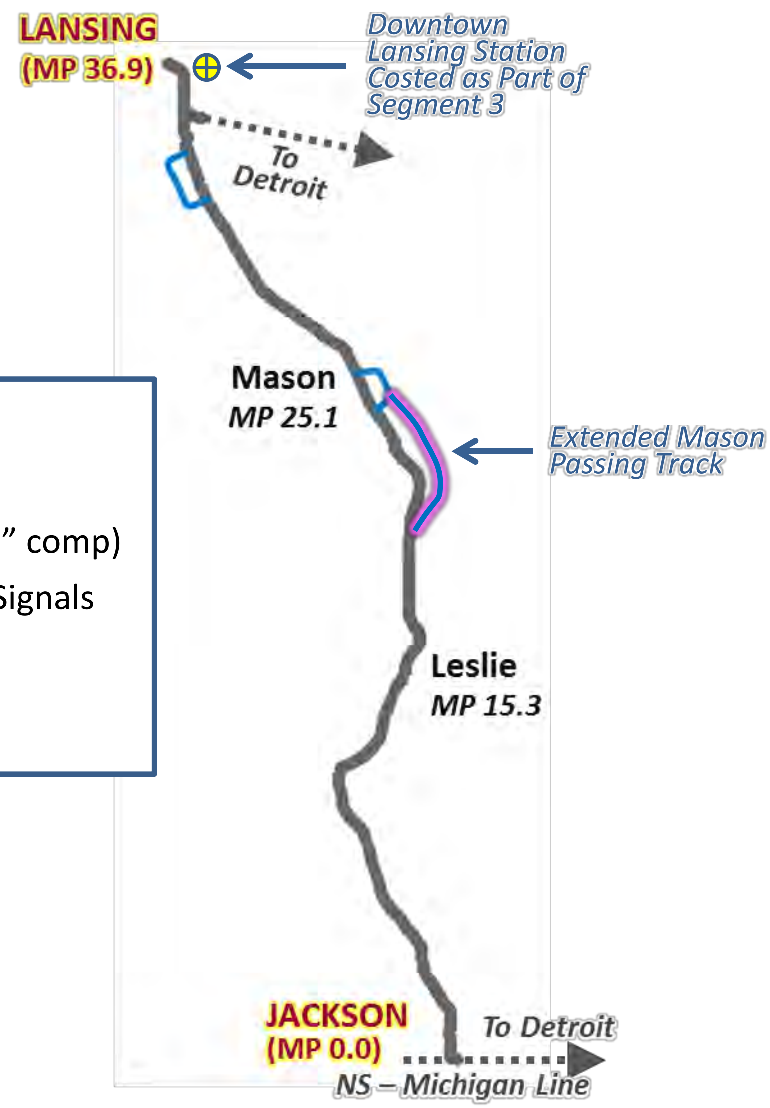
Grand Rapids to Lansing (Segment 2): 110 mph Upgrade



Capital Costs (*in millions*)

$64.3	Purchase Track from CSX
$17.9	Timber & Surface Whole Segment with 33% tie replacement (64.3 mi)
$24.9	High Speed Passing Track with Signals
$0.9	Elevate and Surface Curves
$37.2	Quad Gates for 103 Crossings
$11.7	PTC Overlay
$156.9	**Segment Total**

Lansing to Jackson (Segment 3): 79 mph Option



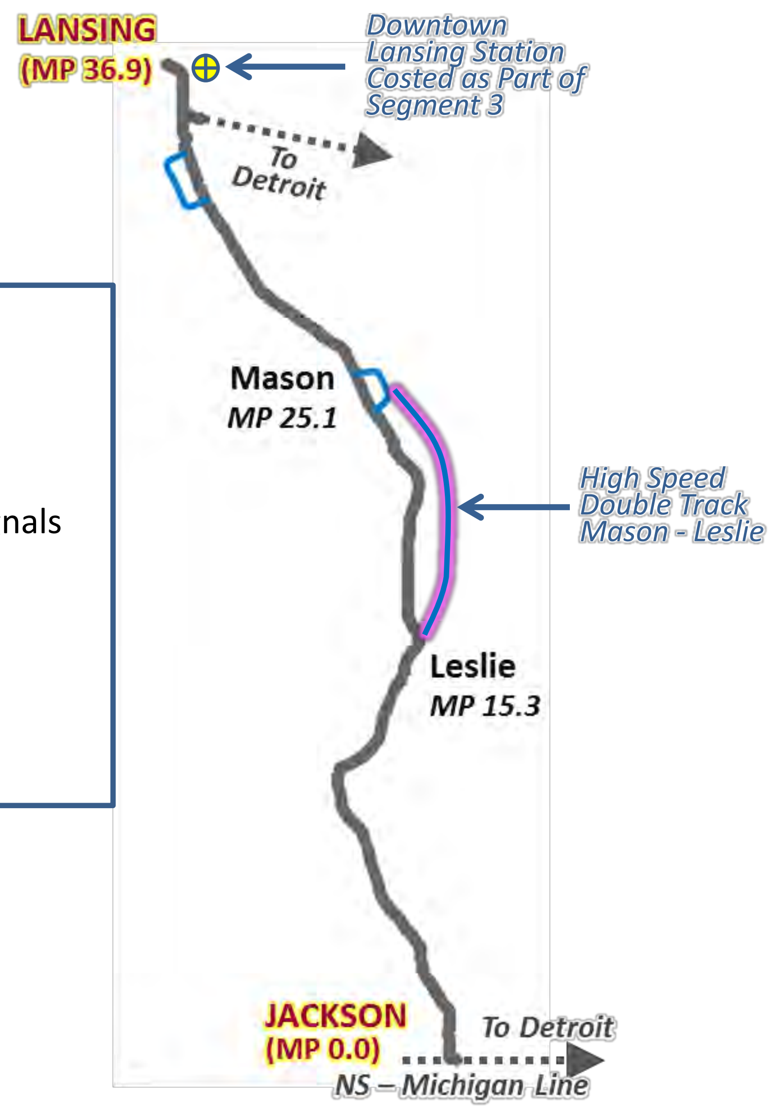
Capital Costs (*in millions*)

$30.8	Rehab and Signal for 79 mph ("North-South Commuter Rail" comp)
$14.4	Extended Mason Siding with Signals
$1.0	Stations (Platforms only)
$46.2	**Segment Total**

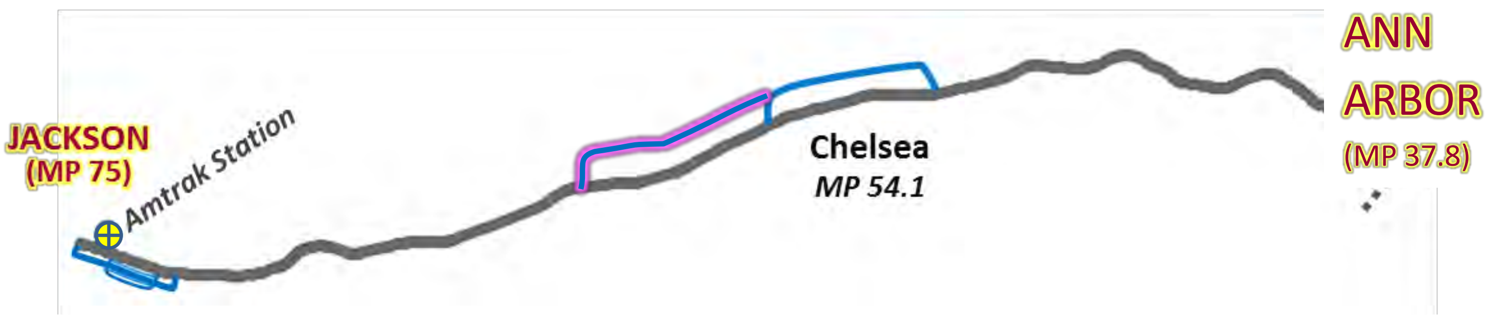
Lansing to Jackson (Segment 3): 110 mph Option

Capital Costs (*in millions*)

$37.6	Purchase Track from NS
$46.9	Rebuild with Welded Rail
$22.6	High Speed Passing Track with Signals
$16.9	CTC with PTC Overlay
$1.0	Stations (Platforms only)
$45.5	Quad Gate - 103 Crossings
$170.5	**Segment Total**



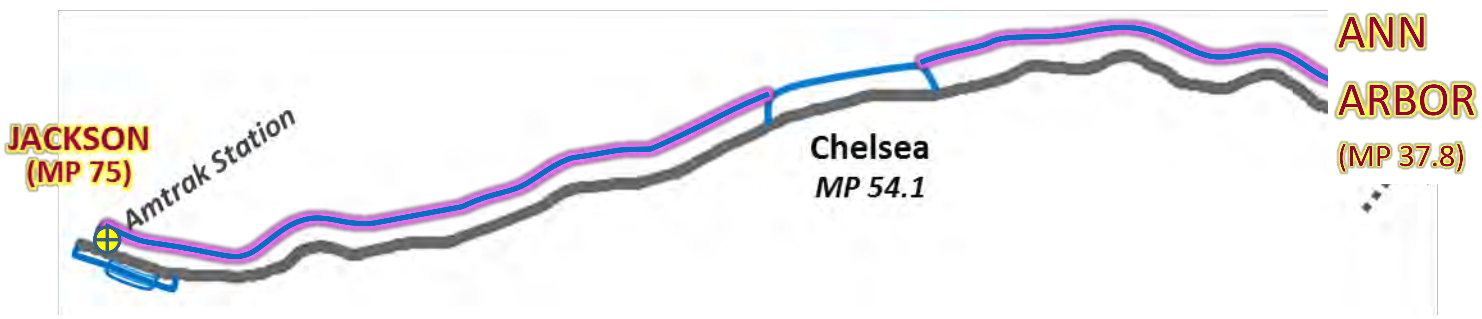
Jackson to Ann Arbor (Segment 4): 79 mph



Capital Costs (*in millions*)

$33.2	Double Track 10.0 miles "All In Rate from Dearborn to Wayne Comp"
$33.2	**Segment Total**

Jackson to Ann Arbor (Segment 4): 110 mph



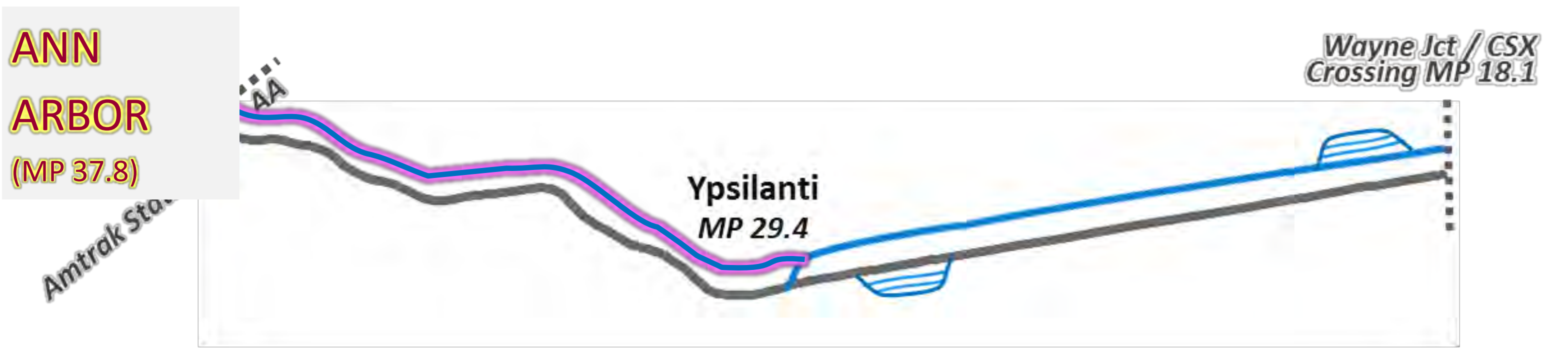
Capital Costs (*in millions*)

$103.9	Double Track 31.3 miles "All In Rate from Dearborn to Wayne Comp"
$103.9	**Segment Total**

Ann Arbor to Wayne (Segment 5): 79 mph

No Improvement for the 79 mph Option

Ann Arbor to Wayne (Segment 5): 110 mph

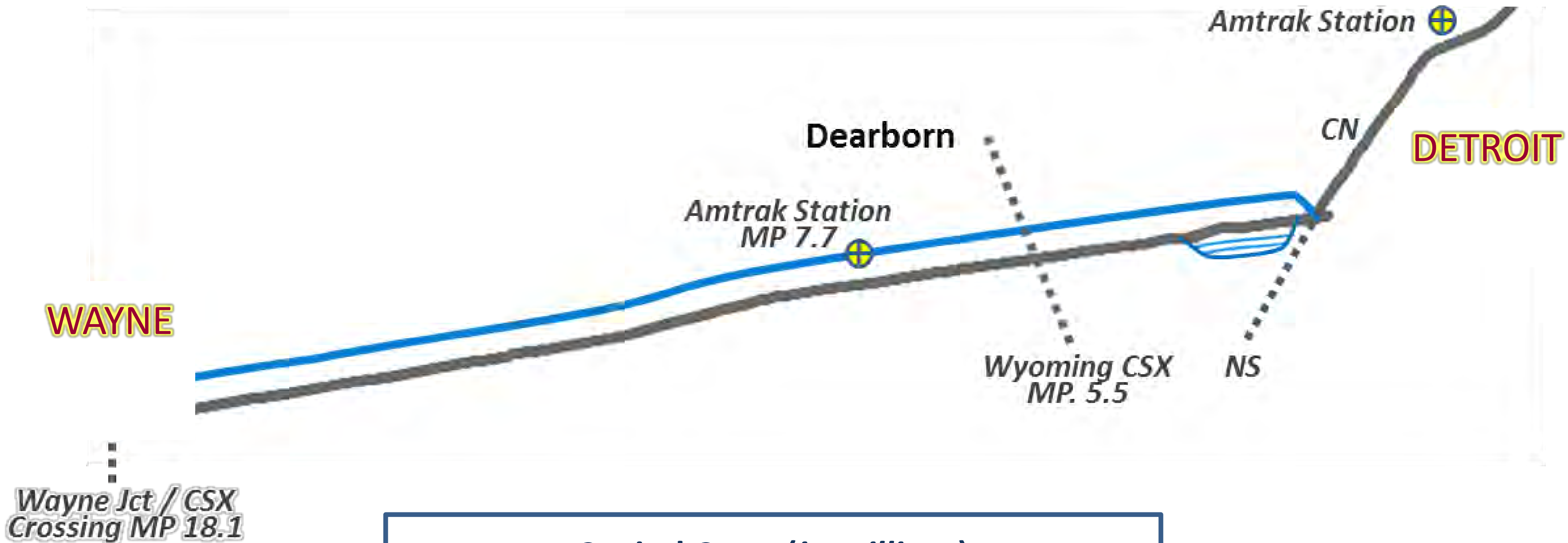


Capital Costs (*in millions*)

$30.2 Double Track 9.0 miles
"All In Rate from Dearborn to Wayne Comp"

$30.2 **Segment Total**

Wayne to Detroit (Segment 6): 79 mph

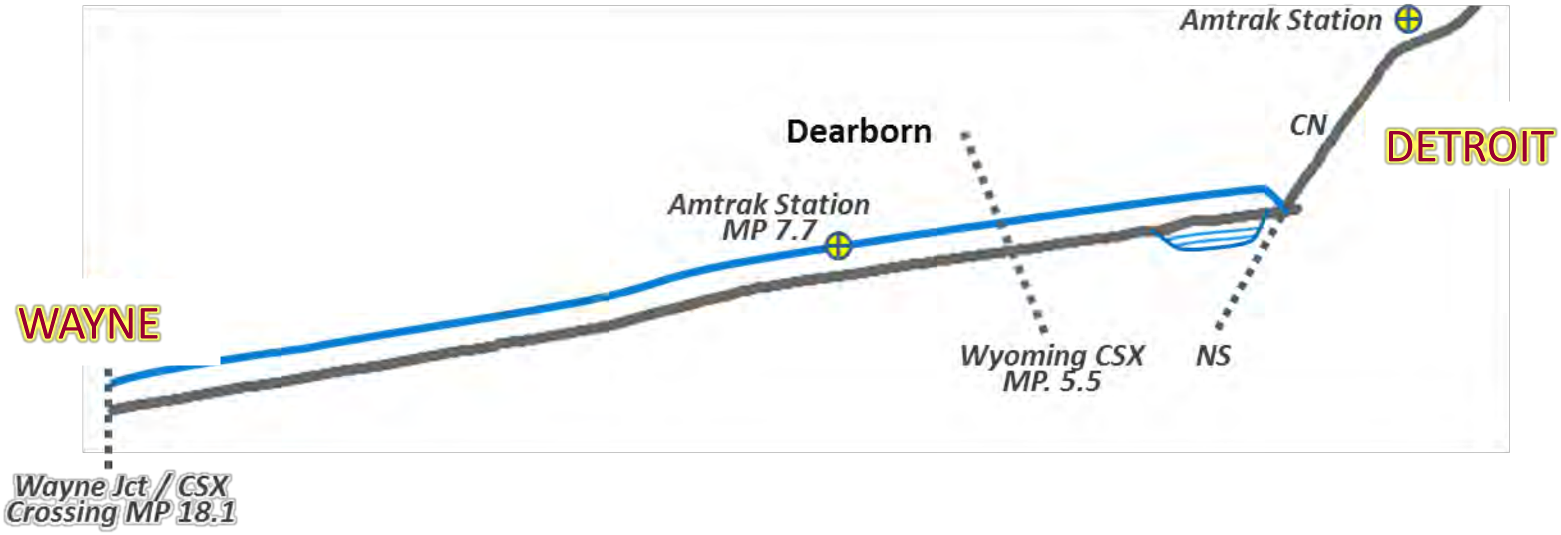


Capital Costs (*in millions*)

$0.0 All Chicago – Detroit EIS Improvements Assumed for the 79 mph Option.

No additional improvements beyond the EIS

Wayne to Detroit (Segment 6): 110 mph

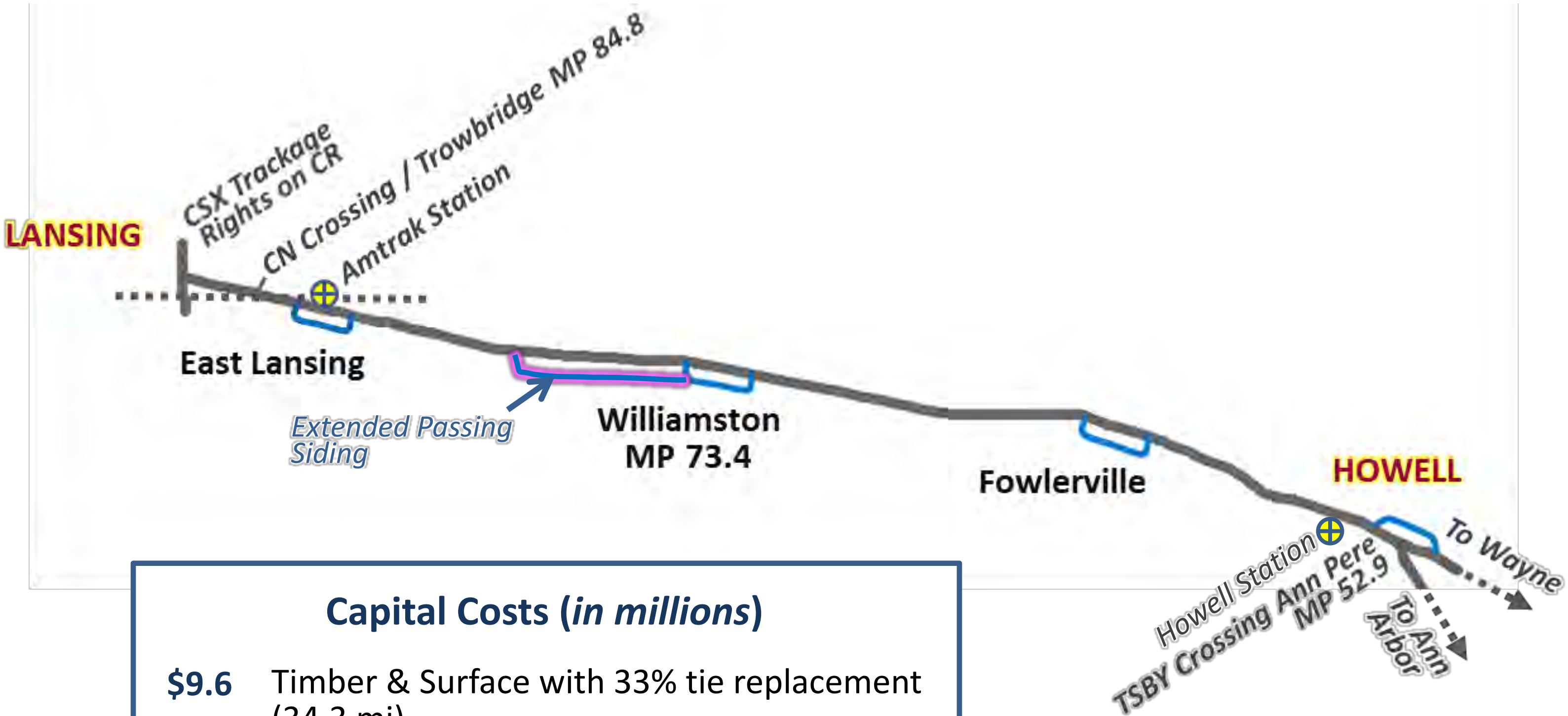


Capital Costs (*in millions*)

$0.0 All Chicago – Detroit EIS Improvements Assumed for the 110 mph Option.

No additional improvements beyond the EIS

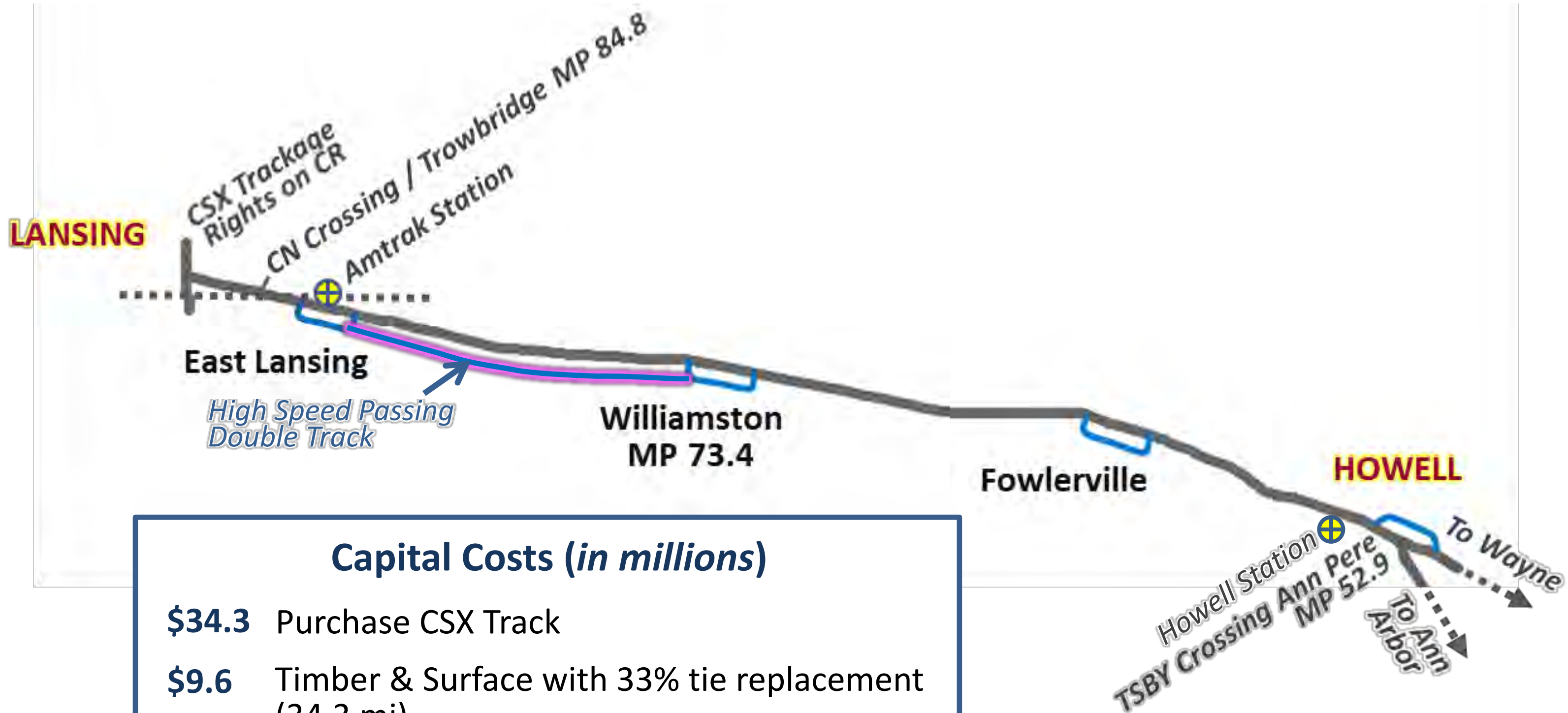
Lansing to Ann Pere Jct. (Segment 7): 79 mph Option



Capital Costs (*in millions*)

$9.6	Timber & Surface with 33% tie replacement (34.3 mi)
$14.4	Extend Passing Siding
$1.0	Elevate and Surface Curves
$1.0	Howell Station (Platform Only)
$0.8	Convert Flashers to Dual Gates – 11 Crossings
$25.8	**Segment Total**

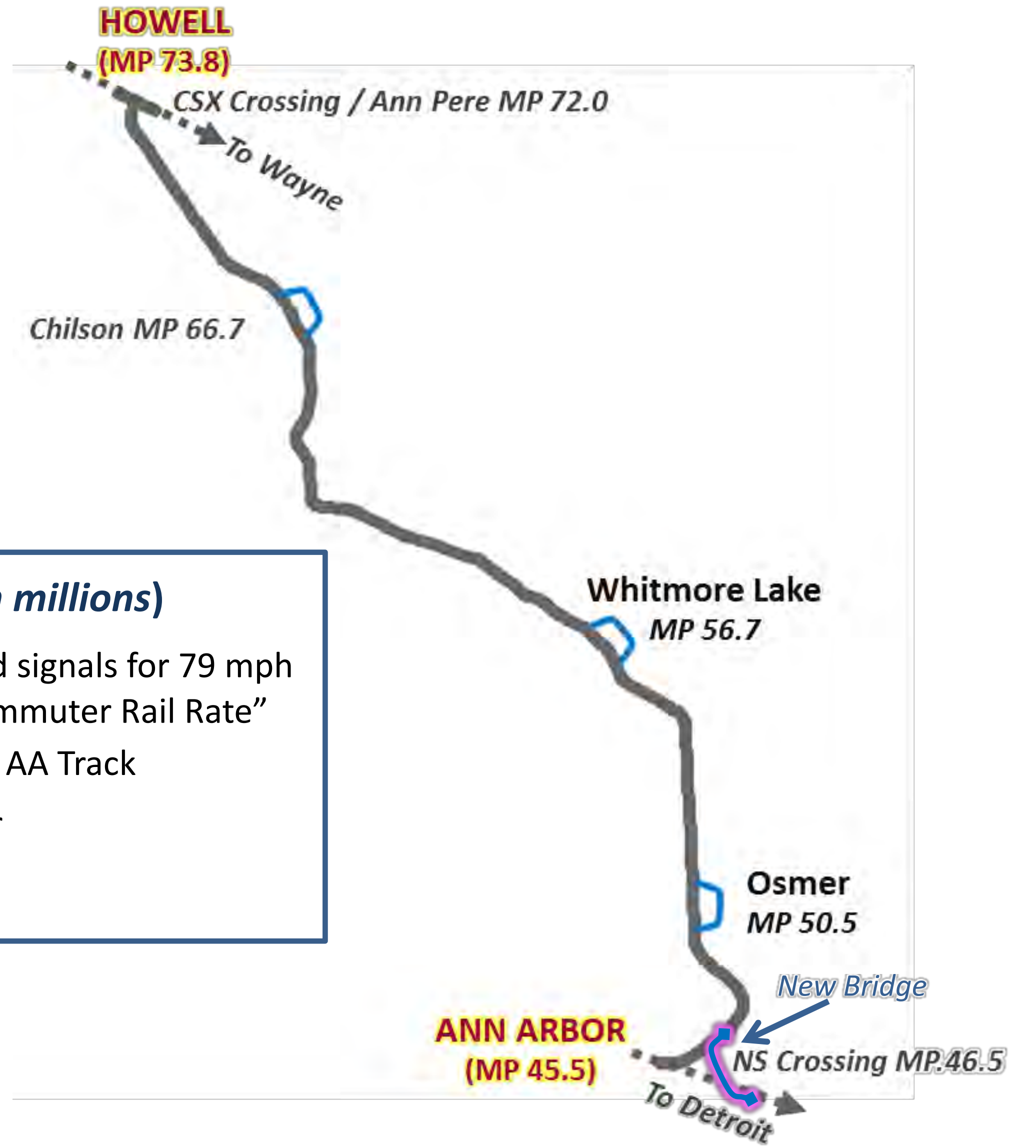
Lansing to Ann Pere Jct. (Segment 7): 110 mph Option



Capital Costs (*in millions*)

$34.3	Purchase CSX Track
$9.6	Timber & Surface with 33% tie replacement (34.3 mi)
$24.9	High Speed Passing Siding with Signals
$0.5	Elevate and Surface Curves
$1.0	Howell Station (Platform Only)
$16.2	Quad Gates – 45 Crossings
$6.2	PTC Overlay
$92.7	**Segment Total**

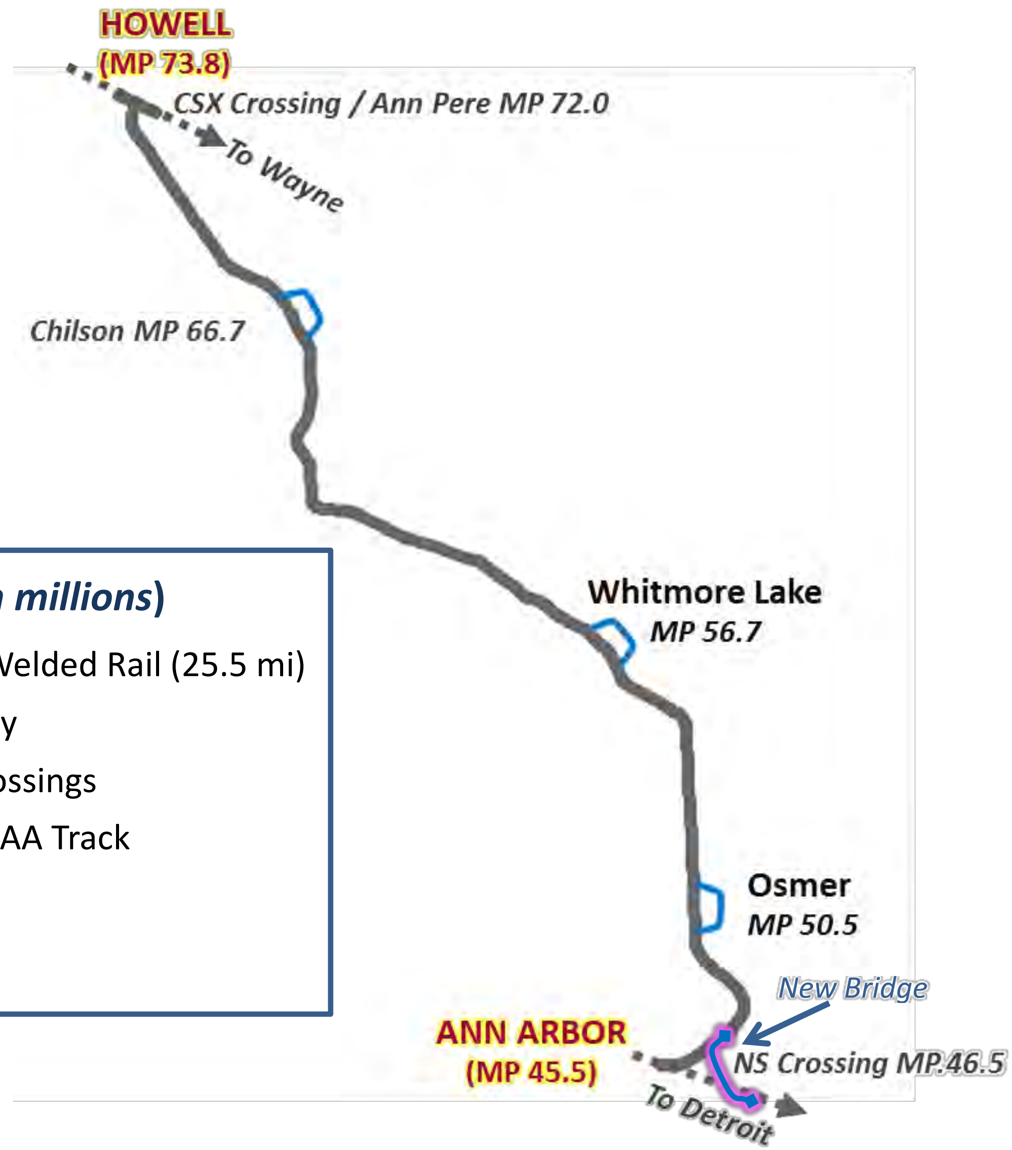
Ann Pere Jct. to Ann Arbor (Segment 8): 79 mph



Capital Costs (*in millions*)

$20.9	Rehab track and add signals for 79 mph at "North-South Commuter Rail Rate"
$2.0	Purchase 2 miles of AA Track
$20.0	Bridge at Ann Arbor
$42.9	**Segment Total**

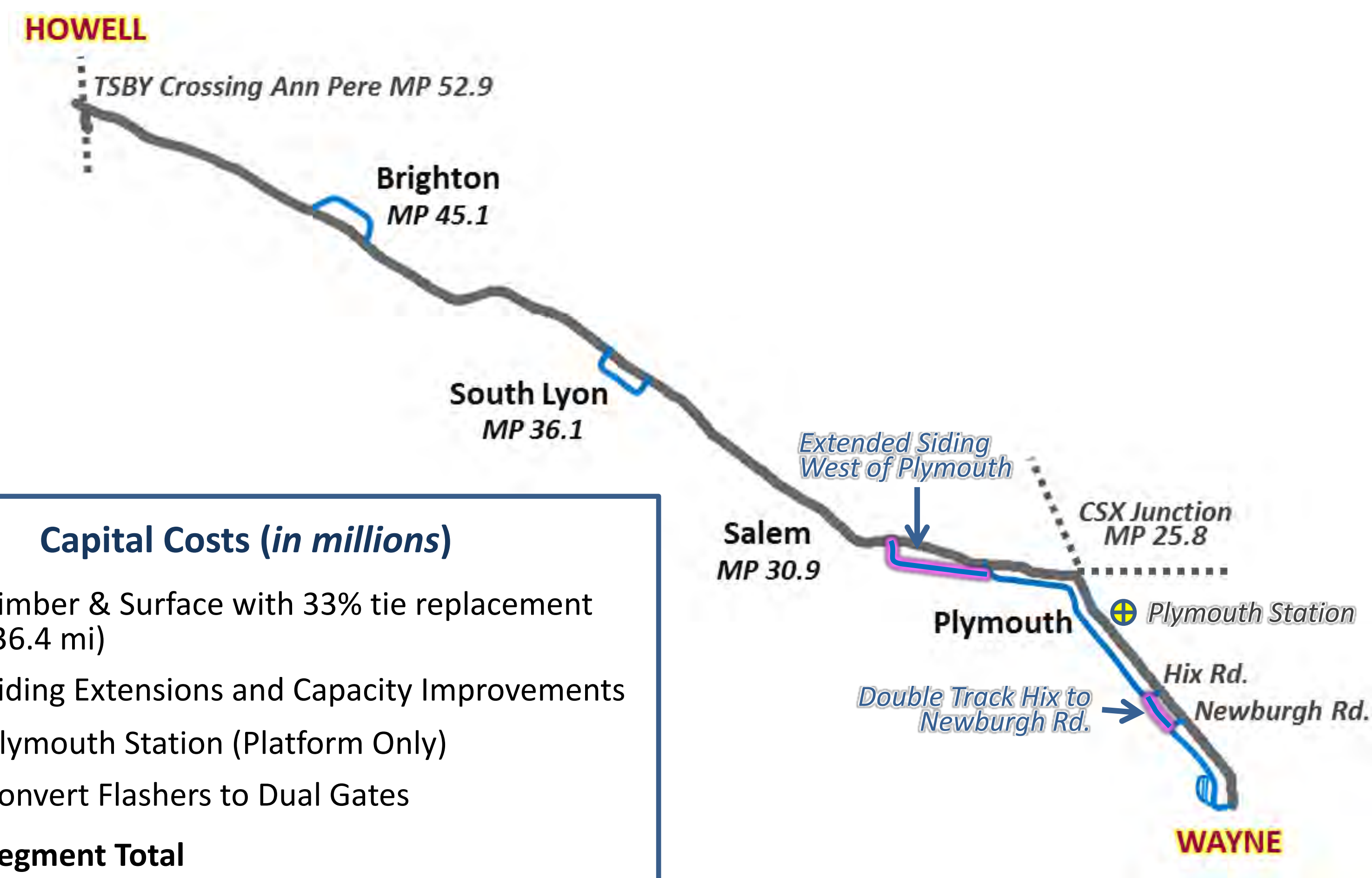
Ann Pere Jct. to Ann Arbor (Segment 8): 110 mph



Capital Costs (*in millions*)

$31.8	Rebuild Track with Welded Rail (25.5 mi)
$10.5	CTC with PTC Overlay
$13.3	Quad Gates – 37 Crossings
$2.0	Purchase 2 miles of AA Track
$20.0	Bridge at Ann Arbor
$77.6	**Segment Total**

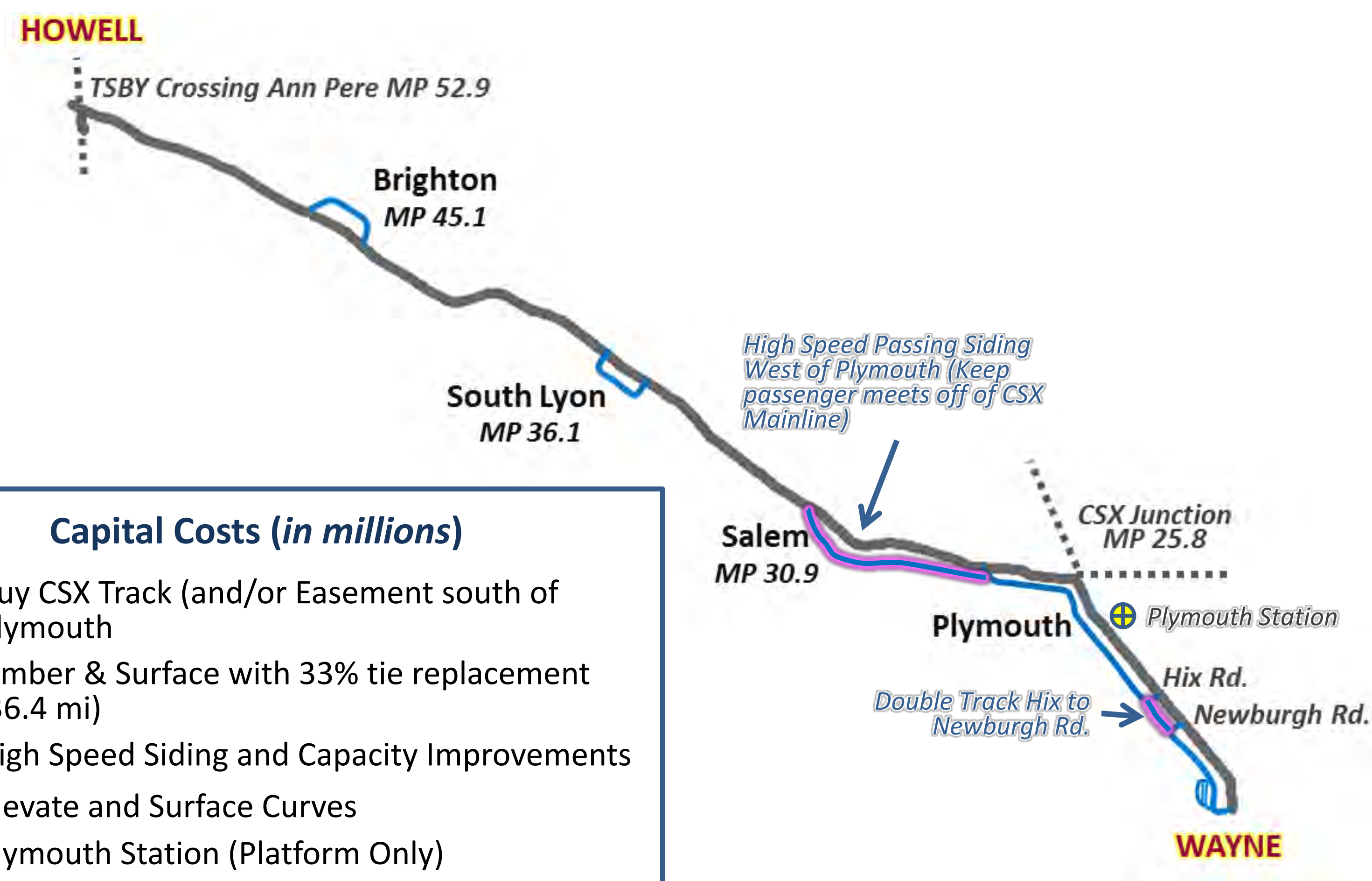
Ann Pere Jct. to Wayne (Segment 9): 79 mph



Capital Costs (*in millions*)

$10.1	Timber & Surface with 33% tie replacement (36.4 mi)
$24.6	Siding Extensions and Capacity Improvements
$1.0	Plymouth Station (Platform Only)
$1.0	Convert Flashers to Dual Gates
$36.7	**Segment Total**

Ann Pere Jct. to Wayne (Segment 9): 110 mph



Capital Costs (*in millions*)

$36.4	Buy CSX Track (and/or Easement south of Plymouth
$10.1	Timber & Surface with 33% tie replacement (36.4 mi)
$35.1	High Speed Siding and Capacity Improvements
$0.8	Elevate and Surface Curves
$1.0	Plymouth Station (Platform Only)
$10.9	Quad Gates – 30 Crossings
$6.6	PTC Overlay
$100.9	**Segment Total**