

## 5.0 UNIVERSE OF ALTERNATIVES

### 5.1 Transit Technologies

The Federal Transit Administration's (FTA) New Starts program requires the Rush Line Corridor Alternatives Analysis to examine a broad range of transit technologies. This document identifies and describes the range of transit technologies for consideration, performing a general assessment of the applicability of each transit technology to the alignment alternatives identified within the Rush Line Corridor. The transit technologies are grouped into the following categories:

- Bus – Conventional and electric trolley bus
- Bus Rapid Transit – Conventional and guided bus
- Light Rail Transit
- Modern Streetcar
- Magnetic Levitation
- Heavy Rail
- Commuter Rail
- Automated Guideway Transit – People Mover, Monorail and Personal Rapid Transit.

A complete report on transit technologies considered in the Rush Line AA process is included in this report as **Appendix F**.

#### 5.1.1 Conventional Bus

##### Basic Mode Specifications

- Most common type of public transportation in the world today
- Self-propelled rubber-tired vehicles
- Flexible routes and spacing of stops
- Typically runs in mixed traffic on ordinary roadways



- Currently operating throughout the Twin Cities metropolitan area

### Applicability to the Rush Line Corridor

Conventional bus transit is a proven technology used in the Twin Cities metropolitan area. One of the advantages of a diesel bus system is that it has relatively low capital costs and offers considerable flexibility. Disadvantages are its limited capacity; buses cannot be coupled, unlike other technologies where a single driver can operate a transit unit, such as a train, that has much greater passenger capacity. The absence of the coupling capability directly affects the operating efficiency of the system when evaluated in terms of passengers moved per dollar spent. Other negative aspects of a diesel bus include point source noise and air pollution.

### **5.1.2 Electric Trolley Bus**

Basic mode specifications

- Powered by electricity from overhead wires
- Different from actual or replicas of vintage streetcars, which are commonly referred to as “trolleys.”
- Identical in size to diesel buses and can operate in the similar environments
- Appropriate for hilly terrain since they can efficiently negotiate steep grades.
- Operating in San Francisco, Boston and Seattle.



### Applicability to the Rush Line Corridor

Electric trolley buses offer nearly the same level of service as conventional standard buses. Although they are a proven technology, there are only a few systems in operation. An advantage over diesel buses is that electric trolleys emit less noise and air pollution, while potential disadvantages include a lower average operating speed, higher cost, decreased route flexibility, and the necessary overhead catenary may be perceived as visually objectionable. Additionally, the long distances (generally over 10 miles) associated with the various alignments within the Rush Line Corridor severely limit the applicability of electric trolley buses.

### **5.1.3 Bus Rapid Transit (BRT)-Conventional**

Basic Mode Specifications:

- Combines the speed of rail with the flexibility of buses
- Operates in its own lane
- Uses high-tech buses
- Has upgraded station amenities
- Employs automated fare collection system



- Includes real-time passenger information system
- Currently operating in Pittsburgh and Cleveland

#### Applicability to the Rush Line Corridor

Conventional BRT is a proven technology, currently operating in numerous cities. BRT operating on an exclusive travel lane is capable of providing moderate to high capacity for lower cost than light rail transit. BRT can utilize standard buses or it can be equipped with larger vehicles because the operation is largely confined to the exclusive travel lane where they do not interact with mixed traffic. Disadvantages of BRT may include costs associated with right-of-way acquisition and operating costs. Although the vehicles can be larger than standard buses and thereby offer more capacity, the coupling of vehicles to achieve higher efficiency is limited relative to rail transit. BRT vehicles can utilize one of several propulsion systems, each with its own distinctive environmental effects.

#### **5.1.4 BRT-Guided Bus**

Basic Mode Specifications:

- A subtype of BRT and consisting of a specialized fixed guideway and vehicles retrofitted with lateral guide wheels.
- Specialized guideway allows the buses to reach high operating speeds
- Buses can operate both on and off the guideway
- Can be implemented in confined rights-of-way because of narrow guideway
- Guided BRT systems are in operation in Australia and Europe.



#### Applicability to the Rush Line Corridor

Guided BRT has been implemented in a limited number of locations around the world, it has proven successful in its limited applications. Although it has some similarities to conventional BRT, it differs in that guided BRT operates within a fixed guideway reserved exclusively for the buses with no or few opportunities for vehicles to enter or exit the guideway. No opportunities would exist for the sharing of the travel lane with other transit vehicles.

In summary, guided BRT is a technology with limited implementation. It is less flexible than conventional BRT because it requires an exclusive travel lane, limiting the lane's use by other transit vehicles.

#### **5.1.5 Light Rail Transit (LRT)**

Basic Mode Specifications:

- Powered by electricity through an overhead wire
- Operates in its own "lane"



- Can use one train, or couple two to three trains to increase passenger capacity
- Operating in over 20 urban areas in the U.S. and Canada, including Portland, Baltimore, Buffalo, Dallas, San Diego, Los Angeles, Minneapolis and San Jose

### Applicability to the Rush Line Corridor

Light rail transit is a proven technology currently operating in numerous cities in the US, including the Hiawatha LRT line in the Twin Cities. The primary advantage of LRT is its adaptability and flexibility. It can range from a high speed, high capacity system comparable to heavy rail, to low speed, medium capacity streetcar or shuttle service. Other advantages include the relatively easy incorporation of LRT into a downtown area with station spacing close enough to provide convenient walk access. Other advantages of LRT include lower air and noise pollution than other technologies such as buses. Disadvantages of LRT include relatively high capital and implementation costs and less route flexibility than buses. Specific to the Rush Line Corridor, the maximum route length typically associated with LRT is approximately 10 to 20 miles. The Rush Line Corridor (between downtown St. Paul and Hinckley) is approximately 80 miles long.

#### **5.1.6 Modern Streetcar**

Basic mode specifications:

- Powered by electricity through an overhead wire
- Operates on street, in same lane as other traffic
- Carries fewer passengers than LRT
- Stations have simple basic amenities
- Operating in Portland and Tampa



### Applicability to the Rush Line Corridor

Modern streetcars offer a similar level of service as conventional buses. Modern streetcars are well-suited for low- to medium-ridership applications. Most of the streetcar systems (using both vintage and modern vehicles) in operation provide circulation service, typically in a downtown area, rather than rapid, line-haul service. Modern streetcars require a fixed rail and an overhead catenary, limiting its flexibility and adding to its cost.

#### **5.1.7 Magnetic Levitation**

Basic mode specifications:

- Uses electromagnetic forces to propel trains
- Train speeds can be competitive with air travel
- In service in Shanghai
- Under development in China, Japan and Germany



### Applicability to the Rush Line Corridor

Maglev is an unproven transit technology that is currently under development in many countries with the Shanghai Maglev being the only known revenue service application of the high-speed technology. As with any new technology, there are a large number of uncertainties such as long-term capital, operating and maintenance costs, long-term performance characteristics, system reliability, public reactions, operating environment, competing positions and structural changes of other transportation modes.

#### **5.1.8 Heavy Rail**

Basic mode specifications:

- Powered by electricity via a “third” rail
- Requires an exclusive guideway
- Has frequent service and high passenger capacity
- Operating in New York, New Jersey, Chicago and Washington D.C



### Applicability to the Rush Line Corridor

Heavy rail transit is a proven technology operating in numerous large urban areas where travel demand is extremely high. Heavy rail is fully grade-separated, which can result in relatively high implementation costs. The high costs and significant infrastructure requirements such as grade separation severely limit its application within the Rush Line Corridor.

#### **5.1.9 Conventional Commuter Rail**

Basic mode specifications:

- Powered by diesel or electricity
- May operate in existing freight railroad tracks
- Trains are 3 to 10 cars long
- Serves trips 20 to 100 miles in length
- Operating in Dallas, Washington DC, Chicago, Los Angeles, and San Diego



### Applicability to the Rush Line Corridor

Conventional commuter rail is a proven technology operating in numerous North American cities. Its advantages are numerous – it offers considerable capacity, can make use of existing rail infrastructure, and is suitable for travel distances of 20 miles or longer. There are a few existing freight railroads active within the Rush Line Corridor—along with the Chisago County, Ramsey County and Washington County Regional Railroad Authorities rights-of-way that are currently used as an interim multi-use trails along former railroad rights-of-way—which could accommodate commuter rail service. These rights-of-way could be used to provide commuter rail service to move people between various northern origins and destinations of the Rush Line Corridor and downtown St. Paul. Current planning for Minnesota’s Union Depot and preliminary engineering for the Central Corridor LRT add to the attractiveness of commuter rail that other rail modes may not offer.

### 5.1.10 Diesel Multiple Unit Commuter Rail

Basic mode specifications:

- A subtype of commuter rail, consisting of one or two vehicles semi-permanently coupled.
- Service appropriate for corridors with less freight railroad usage, lower passenger demand or constrained station sites.
- Operating characteristics similar to LRT (shorter headways, closer station spacing and faster acceleration and deceleration)
- Maximum speed of about 55 mph and an average running speed of 40 mph
- Operating in one line linking Miami, Fort Lauderdale and West Palm Beach



#### Applicability to the Rush Line Corridor

DMU commuter rail trains, while not as widely used as conventional commuter rail, have some advantages. They are self-propelled and can operate without an electric power source, which removes the cost of electrification and makes it possible for the DMU system to help in emergency evacuations. Further, DMU vehicles are capable of high speeds and can operate along standard railroad trackage. DMUs also have faster acceleration and deceleration than conventional commuter rail, allowing for closer station spacing and shorter headways.

### 5.1.11 Automated Guideway Transit: People Mover

Basic mode specifications:

- Uses steel wheel/rail or rubber-tired vehicles
- Requires exclusive guideway and full grade separation
- Has frequent service
- Has lower passenger capacity than LRT or commuter rail
- Most commonly used at airports, amusement parks and institutions
- Operating in Detroit, Miami, Indianapolis and Jacksonville



### Applicability to the Rush Line Corridor

Implementation costs for automated guideway transit systems are high due to required grade separation and the automated control system. A significant expenditure is required for maintenance of control system elements, including trackway and hardware for monitoring and operation. However, operating costs for AGT are relatively low because there is no need for operators on each vehicle. AGT is similar to heavy rail transit and monorail in that it requires a special guideway that cannot be crossed by other vehicles. People mover systems have relatively high capital and operating costs, are suitable for short trips, and currently few American public transit agencies employ the technology.

#### **5.1.12 Automated Guideway Transit: Monorail**

Basic mode specifications:

- Can be electrified or rubber-tired
- Has high passenger capacity
- Requires full grade separation
- Operating in Seattle, Las Vegas and Newark Airport



### Applicability to the Rush Line Corridor

Monorail transit systems have some advantages over other technologies: They are quiet and can use air space for its right-of-way. However, they are not common, partially due to cost and operating complications. Specifically, track or guidebeam switching is more complicated than switching with conventional rail track. This has tended to relegate monorail to shuttle or loop service within an activity center, and limited its use for line-haul applications within the US.

#### **5.1.13 Personal Rapid Transit**

Basic mode specifications:

- Technology is under development
- Requires an exclusive guideway and full grade separation
- Service provided on demand, competitive with automobile
- No system in revenue operation



### Applicability to the Rush Line Corridor

Personal Rapid Transit as conceptually envisioned would be well suited to circulation and distribution within an activity center and could be used as a support network for line-haul transit. However, there are many unknowns and challenges associated with its implementation. No PRT systems are currently in operation, making it an unproven technology. If used in the Rush Line Corridor, it may be the first real-world application of the technology. Other challenges are that a large network of elevated structures would be required to provide the proposed service. The number of stations, and correspondingly, total station cost, would likely be high. The length of the Rush Line Corridor is also ill-suited for PRT application.

## 5.2 Recommended Transit Technologies

Based on the preliminary review of transit technologies, the Rush Line Corridor AA recommends the following transit technologies for further consideration:

- Conventional Bus
- Conventional BRT
- LRT (limited application)
- Commuter Rail, including Diesel Multiple Unit (Colorado Railcar)

The FTA requires inclusion of a Baseline (conventional bus) and BRT service as part of the AA process. Therefore, this document recommends further analysis of both BRT and express bus (conventional bus) service.

Transit modes eliminated from consideration due to limited or lack of U.S. application are the PRT, MagLev, and guided BRT. Also due to their relative high cost, shorter/longer trip lengths, or limited passenger-carrying capacity the electric trolley bus, heavy rail, monorail, people mover, monorail, modern streetcar transit modes were removed from further analysis in this AA.

**Table 5-1** on the next page presents a summary of the transit technologies considered for the Rush Line Corridor AA, including each technology's physical and operational characteristics. The transit technologies recommended for further consideration are highlighted in green.

## 5.3 Mode and Alignments Alternatives Evaluated in Screen 1

Based on the recommended alignments and transit technologies, the following alternatives were evaluated during Screen I (illustrated on the following pages):

- BRT Alternatives (**Figure 5-1**)
  - Alternative 1: via I-35E/I-35 from downtown St. Paul to Hinckley
  - Alternative 2A: via the Ramsey County Regional Railroad Authority (RCRRA) right-of-way (ROW) and U.S. Highway 61 (TH 61) from downtown St. Paul to White Bear Lake
  - Alternative 2B: via the RCRRA ROW and I-35E/I-35 from downtown St. Paul to Forest Lake.
- Commuter rail Alternatives (**Figure 5-2**)
  - Alternative 1: via the Canadian Pacific (CP) Railway, Washington County Regional Railroad Authority (WCRRA) ROW, Chisago County Regional Railroad Authority (CCRRA) ROW, and St. Croix Valley Railroad from downtown St. Paul to Hinckley
  - Alternative 2A: via the Union Pacific Railroad, RCRRA ROW, Minnesota Commercial Railroad, WCRRA ROW, CCRRA ROW, and St. Croix Valley Railroad from downtown St. Paul to Hinckley
  - Alternative 2B: via the RCRRA ROW, Minnesota Commercial Railroad, WCRRA ROW, CCRRA ROW, and St. Croix Valley Railroad from downtown St. Paul to Hinckley

- Alternative 3: via the CP Railway, Minnesota Commercial Railroad, WCRRA ROW, CCRRA ROW, and St. Croix Valley Railroad from downtown St. Paul to Hinckley
- Alternative 4: via I-35E/I-35 from downtown St. Paul to Hinckley.
- Light Rail Transit Alternatives (**Figure 5-3**)
  - Alternative 1A: via the RCRRRA ROW from downtown St. Paul to Maplewood
  - Alternative 1B: via the RCRRRA ROW and Minnesota Commercial Railroad from downtown St. Paul to White Bear Lake
  - Alternative 1C: via the LRT on RCRRRA ROW and Minnesota Commercial Railroad from downtown St. Paul to Forest Lake.
  - Alternative 2: via I-35E from downtown St. Paul to Highway 96 (CSAH 96) in White Bear Lake.

**Figures 5-1 through 5-3** show the potential alternatives analyzed in the Screen 1 evaluation.

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**Table 5-1: Characteristics of Transit Technologies Considered**

Parameter	Bus		Bus Rapid Transit (BRT)		Light Rail Transit (LRT)	Modern Streetcar	Magnetic Levitation (Maglev)	Heavy Rail	Conventional Commuter Rail	Diesel Multiple Unit (DMU)	Automated Guideway Transit (AGT)		
	Conventional	Electric Trolley	Conventional	Guided							People Mover	Monorail	PRT
Capital Cost per Mile (\$ millions)	Depends on fleet size	Depends on fleet size. Electrification typically \$900,000 to \$1.4 million for new trolley systems.	\$10 million to \$40 million	\$10 million to \$50 million	\$40 million to \$100 million	\$15 million to \$30 million	\$50 million to \$90 million	\$50 million to \$120 million	\$5 million to \$20 million	\$5 million to \$10 million	\$40 million to \$60 million	\$40 million to \$80 million	System in under development; capital cost unknown.
Typical Vehicle Capacity <sup>1</sup>	60 passengers	60 passengers	81 passengers	81 passengers	166 passengers	60 passengers	70 passengers	170 passengers	120 passengers	120 passengers	80 passengers	55 passengers	12 passengers
-- Potential Number of Linked Vehicles	None	None	None	None	Three	None	Seven	Depends on station size	Depends on station size	Depends on station size	Depends on station size	Depends on station size	Depends on station size
Average Trip Length	3.7 miles	1.6 miles	5.6 miles	5.6 miles	3.1 miles	Not Available	Not Available	4.9 miles	21.3 miles	21.3 miles	5.6	NA	NA
Running Surface	Mixed traffic or separate ROW	Mixed traffic or separate ROW	Separate ROW preferred	Separate ROW	Mixed traffic or separate ROW	Mixed traffic	Exclusive ROW	Exclusive fixed guideway	Exclusive fixed guideway	Exclusive fixed guideway	Exclusive fixed guideway	Elevated guideway	Elevated fixed guideway
Speed (maximum/average)	65mph/12mph	45mph/12mph	50mph/25mph	50mph/25mph	55mph/22mph	30mph/15mph	200+mph	80mph/40mph	80mph/50mph	55mph/50mph	60mph/40mph	55mph/35mph	30mph/20mph
Power Supply	Diesel or alternative fuels	Overhead electric wire	Diesel	Diesel	Overhead electric wire	Overhead electric wire	Electrified third rail	Electrified third rail	Diesel or electric	Diesel	Electrified Third Rail	Electrified third rail	Electrified Third Rail
Operating Environment	Urban/Suburban	Urban	Urban/Suburban	Urban/Suburban	Urban/Suburban	Urban/Suburban	Urban/Suburban	Urban/Suburban	Urban/Suburban	Urban/Suburban	Activity Center/Urban	Activity Center	Activity Center
-- Grade Separation Required	No	No	Note <sup>2</sup>	Note <sup>3</sup>	Note <sup>3</sup>	Note <sup>3</sup>	Yes	Yes	No	No	Yes	Yes	Yes
-- Alignment Extension Cost	Not Applicable	Moderate	High	High	High	High	High	High	Low	Low	High	High	High
At-Grade Station Access	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No
Typical Stop/Station Spacing	Close	Close	One-half to 1 mile	One-half to 1 mile	One-quarter to 1 mile	One-eighth to one-quarter mile	50 to 150 miles	1 to 2 miles	2 to 5 miles	2 to 5 miles	1 to 2 miles	1 to 2 miles	Close (Under one-half mile)
Environmental Impacts	Emissions, noise	Visual, noise	Right-of-way, noise, emissions	Right-of-way, noise, emissions	Right-of-way, noise	Right-of-way, noise	Right-of-way	Right-of-way, noise, visual	Noise, emissions	Noise, emissions	Right-of-way, visual	Right-of-way, visual	Right-of-way, visual
Proven Technology	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No
-- Line-haul operations	Many	Few	Few	Few	Many	Few	Many	Many	Many	Few	Few	Few	None
Advantages	Can operate in mixed traffic or on its own guideway. Adaptable to a variety of fuels. Low capital costs.	Rubber-tired vehicle operates on existing pavement. Can operate in mixed traffic, low capital costs. Less noise and air pollution than diesel bus. Can negotiate steep terrain.	Moderate to high capacity system for less cost than LRT and other fixed guideway systems	Moderate to high capacity system for less cost than LRT and other fixed guideway systems, can operate within narrow guideway	Moderate to high capacity system for less cost than other fixed guideway systems, can operate in mixed traffic, less noise and emissions than buses	Moderate capacity for less cost than other fixed guideway systems, operates in mixed traffic, less noise and emissions than buses, visually enhancing	High capacity	Very high capacity system	High capacity system, good for long distance travel, low capital cost per passenger	Service characteristics of light rail at lower cost (does not require electrification)	Automated operation may reduce labor costs and shorten headways. Currently operating at the Minneapolis-St. Paul International Airport.	Narrow width of beam may be less visually obtrusive than other elevated systems.	Automated operation may reduce labor costs and shorten headways
Disadvantages	Limited capacity. High operating costs (one driver per vehicle). Subject to traffic delay.	Limited capacity. High operating costs (one driver per vehicle). Subject to traffic delay. Routing not as flexible as standard buses.	High operating costs (one driver per vehicle), travel times compromised in mixed traffic, not as flexible as standard buses, requires wide guideway	High operating costs (one driver per vehicle). Not as flexible as standard buses. Requires separate guideway.	High capital costs, not as flexible as buses	Require a rail running surface. High capital costs. Not as flexible as buses.	High capital costs.	Very high capital costs.	Slow acceleration and deceleration. Not appropriate for short station spacing and frequent stops. Diesel emissions.	Currently, Colorado Railcar is the only DMU that meets FRA requirements for operating on active freight tracks. Requires longer headways than LRT.	High cost. Limited applications in the United States.	High cost Limited applications in the United States. Switching may be a problem	Unproven technology.
Implementation Feasibility	Positive	Less Positive	Positive	Less Positive	Positive	Less Positive	Less Positive	Less Positive	Positive	Positive – Colorado Railcar	Less Positive	Less Positive	Less Positive
Applicable to the Rush Line Corridor?	<b>Yes; Required by FTA as part of Baseline Alternative</b>	No	<b>Yes; Required by FTA</b>	No	<b>Yes – Route length over 20 miles may limit applicability</b>	No	No	No	<b>Yes</b>	<b>Yes – Colorado Railcar<sup>3</sup></b>	No	No	No

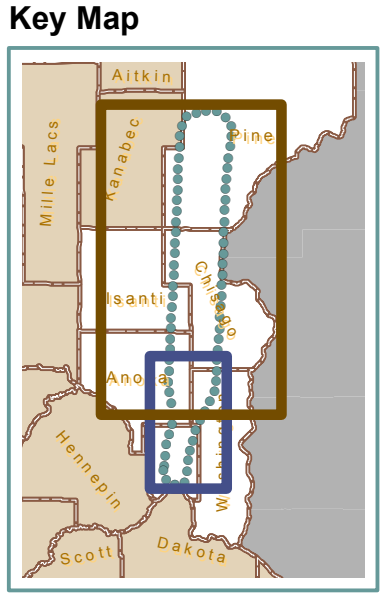
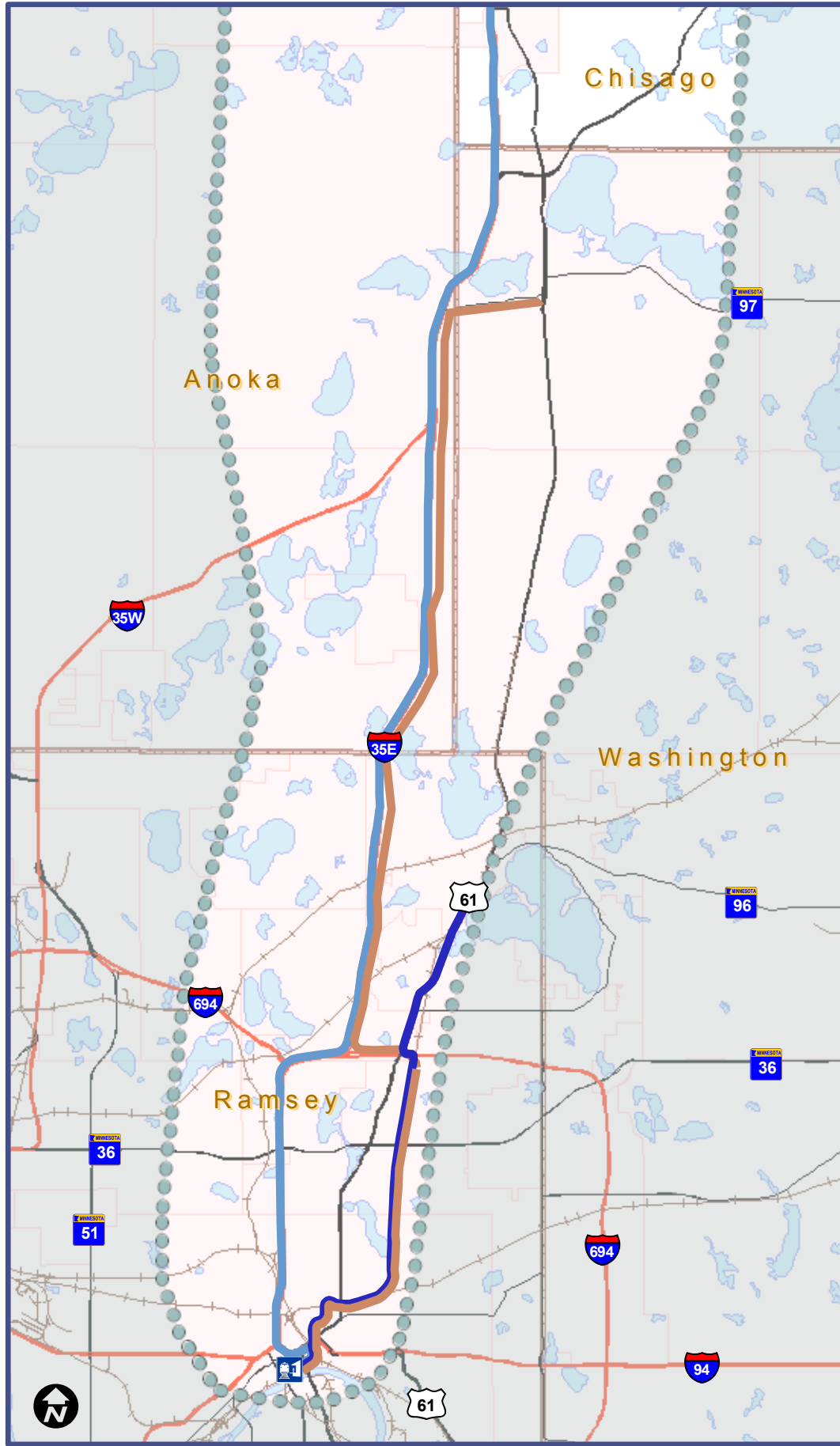
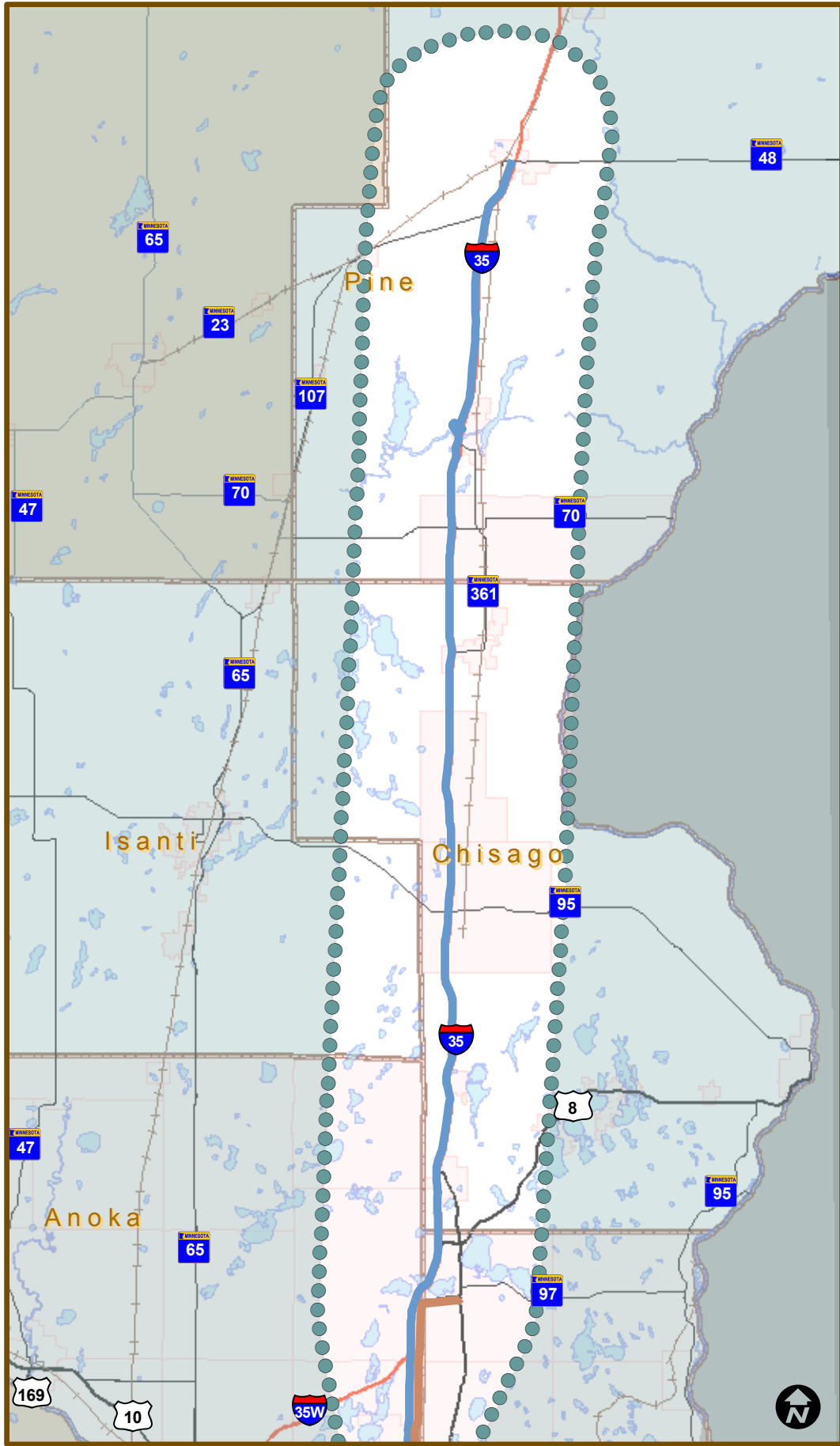
Green-shaded columns were recommended for inclusion in Screen 2 Evaluation

<sup>1</sup> Reference: Kittelson & Associates, Inc., KFH Group, Inc., Parsons Brinckerhoff Quade & Douglas, Inc., and Katherine Hunter-Zaworski (2003). *Transit Capacity and Quality of Service Manual*, second edition. *TCRP Report 100*, Transportation Research Board, National Academy Press, Washington, DC.

<sup>2</sup> Need for grade separation depends on cross-street traffic volumes. For rapid transit operating at high frequencies, grade separation is required.

<sup>3</sup> Colorado Rail Car has gone out of business since this evaluation was conducted.

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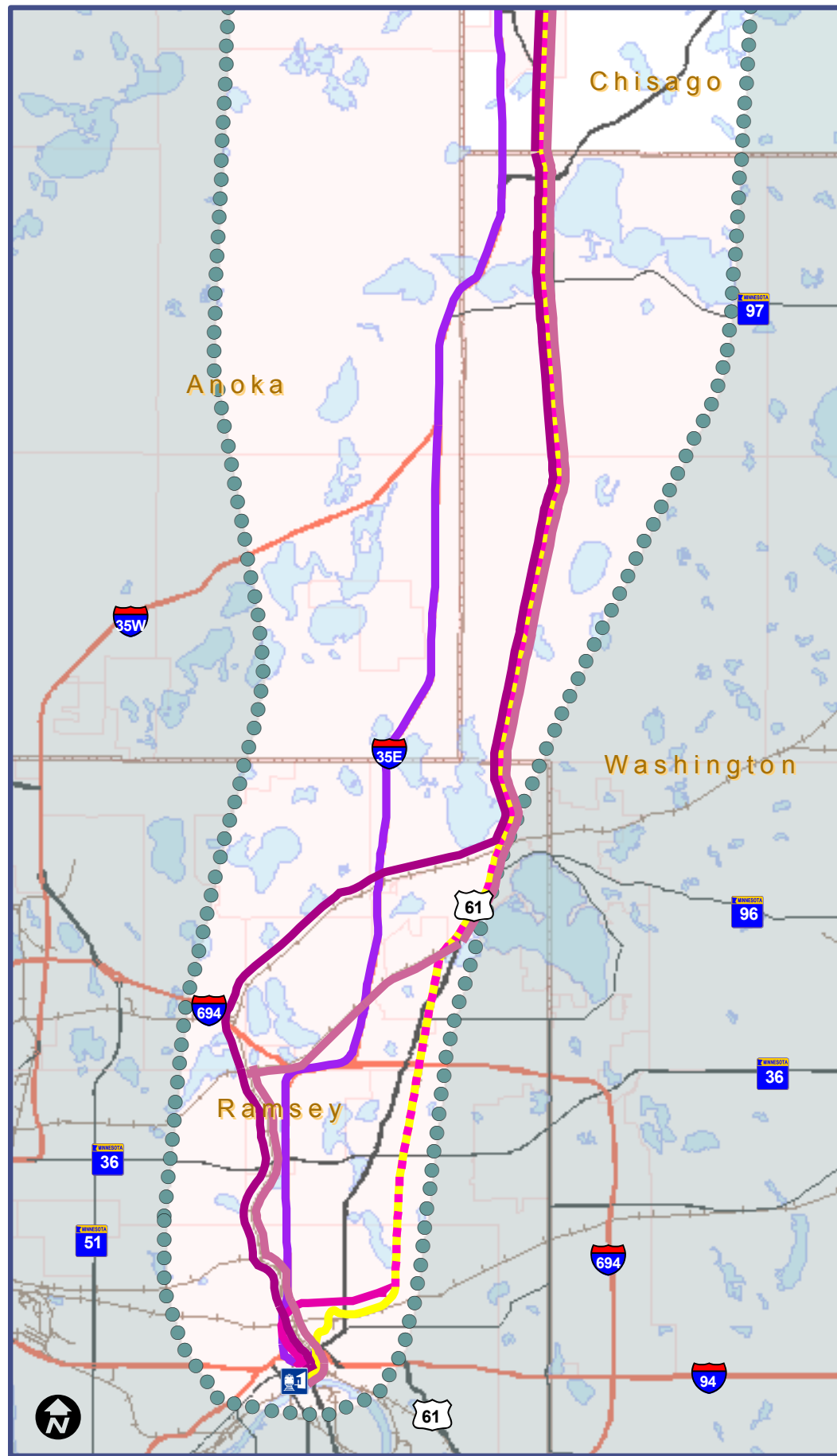
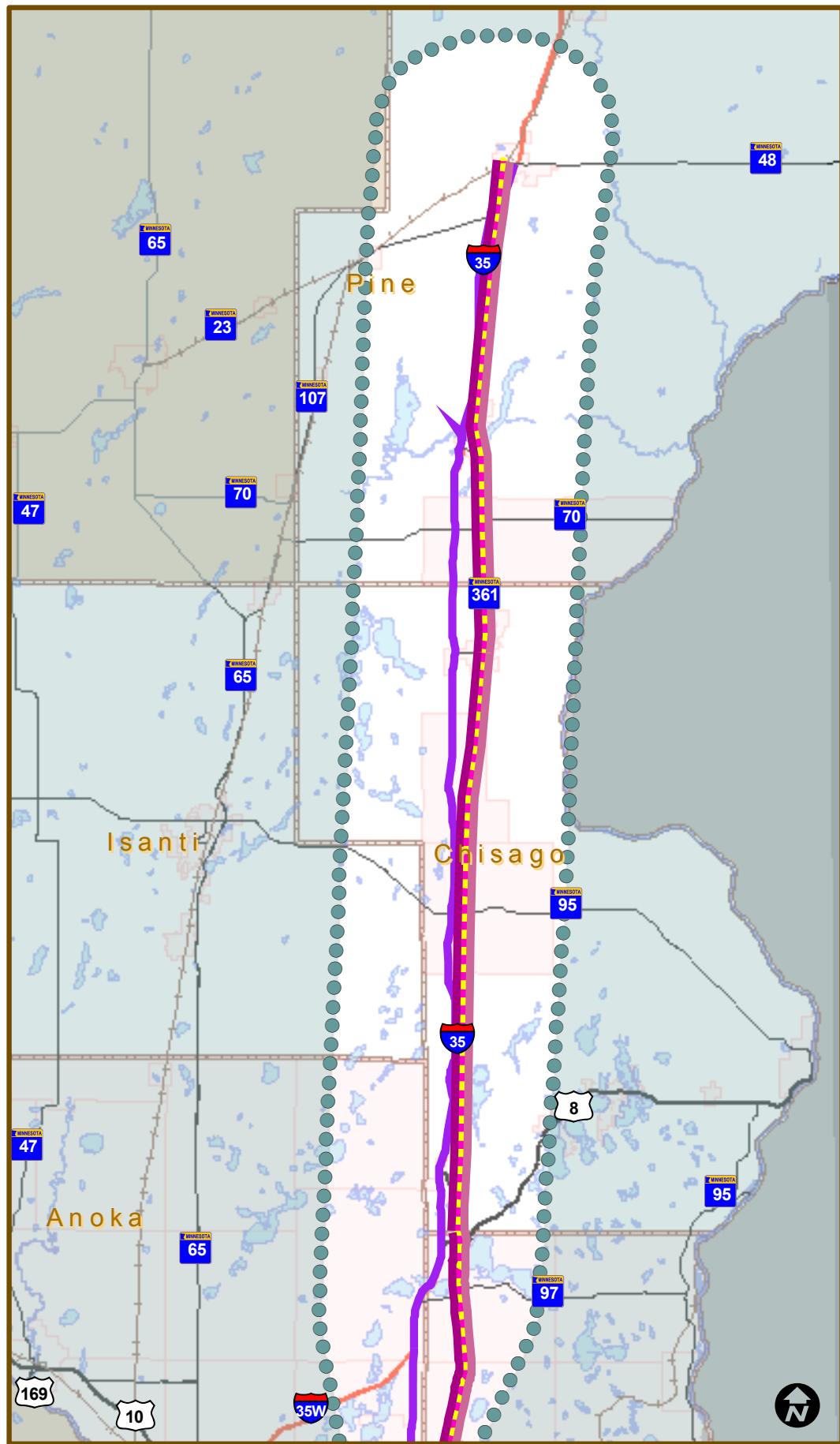
**Legend**

- Alternative 1
- Alternative 2A
- Alternative 2B
- Study Area
- +— Railroad
- Lake, River
- Municipality
- County

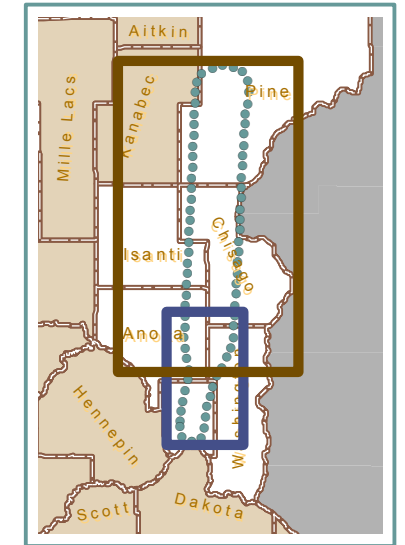


Data Sources: Minnesota Department of Transportation, Metropolitan Council, Department of Natural Resources

Figure 5 -1  
**Potential Alignments for BRT**



Key Map

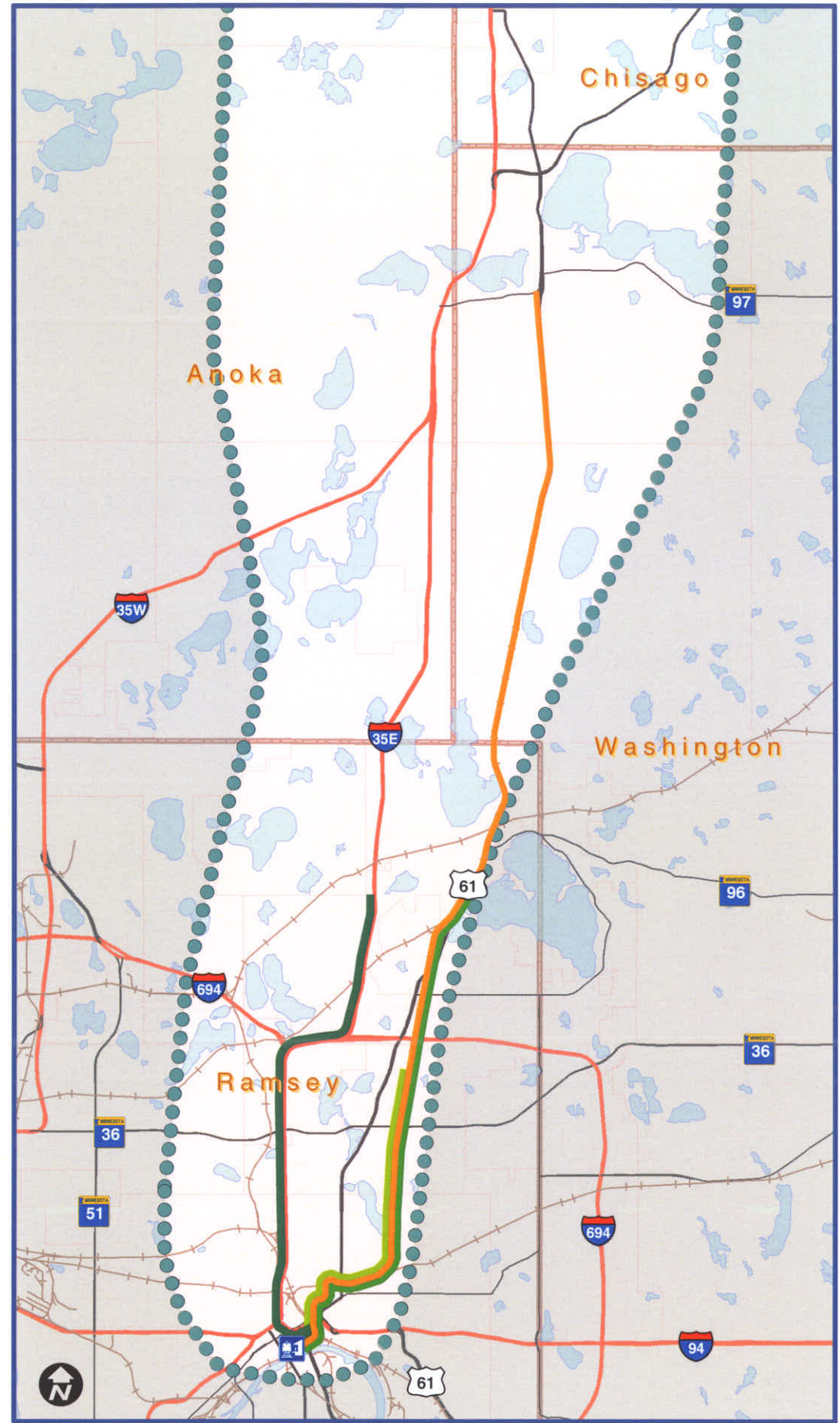
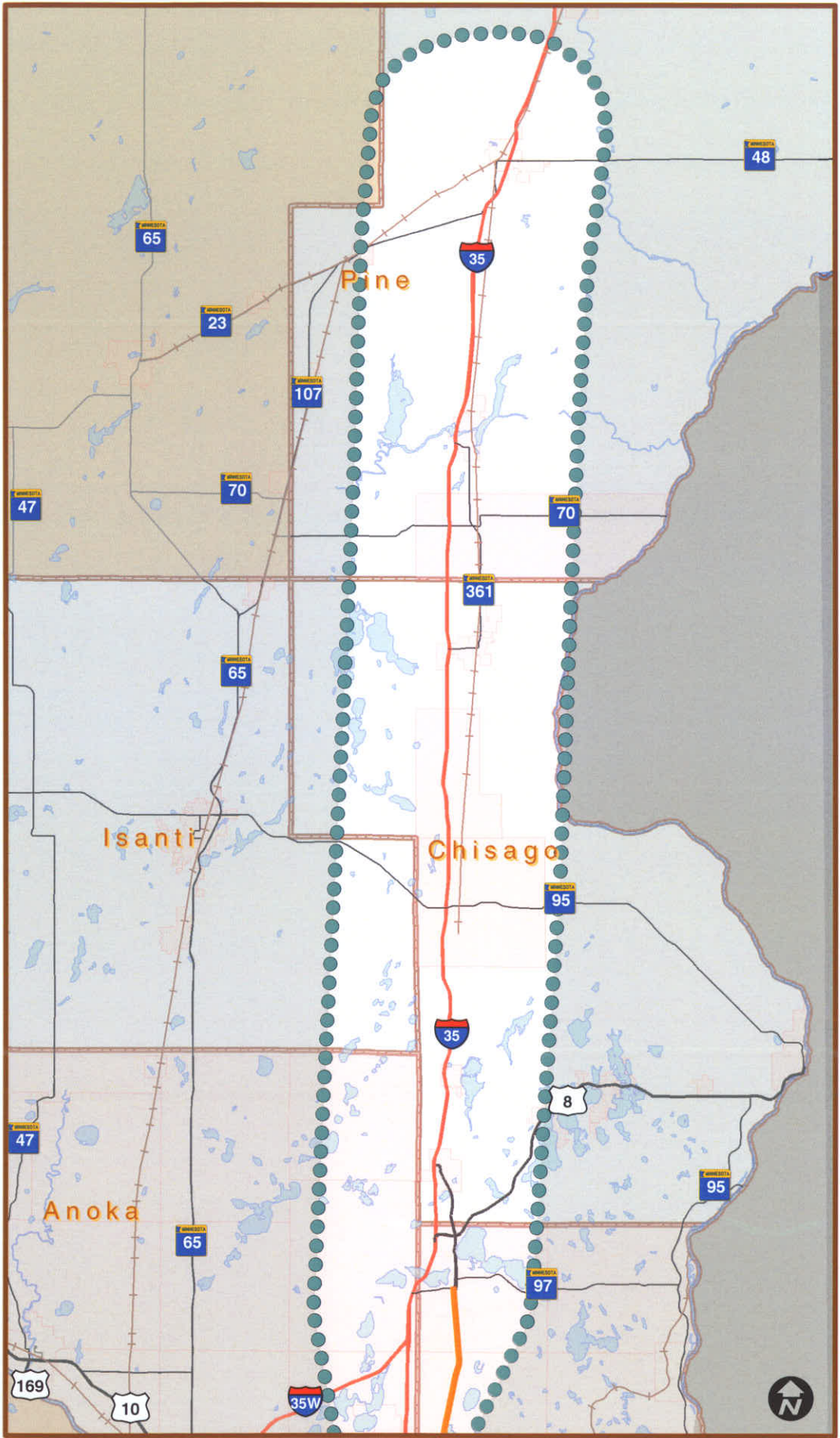


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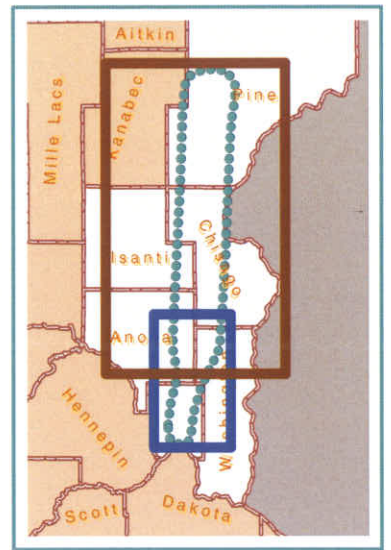
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- Alternative 2A
- Alternative 2B
- Alternative 3
- Alternative 4
- Study Area
- Railroad
- Lake, River
- Municipality
- County

Figure 5 - 2  
**Potential Alignments for  
Commuter Rail**







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Key Map



Legend

-  Alternative 1
-  Alternative 1B
-  Alternative 1C
-  Alternative 2
-  Study Area
-  Railroad
-  Lake, River
-  Municipality
-  County



Data Sources: Minnesota Department of Transportation, Metropolitan Council, Department of Natural Resources

Figure 5 - 3  
**Potential Alignments for LRT**