Freeway System Interchange Study

Metropolitan Council and MnDOT

APRIL 2020

EXECUTIVE SUMMARY

METROPOLITAN COUNCIL

DEPARTMENT OF TRANSPORTATION

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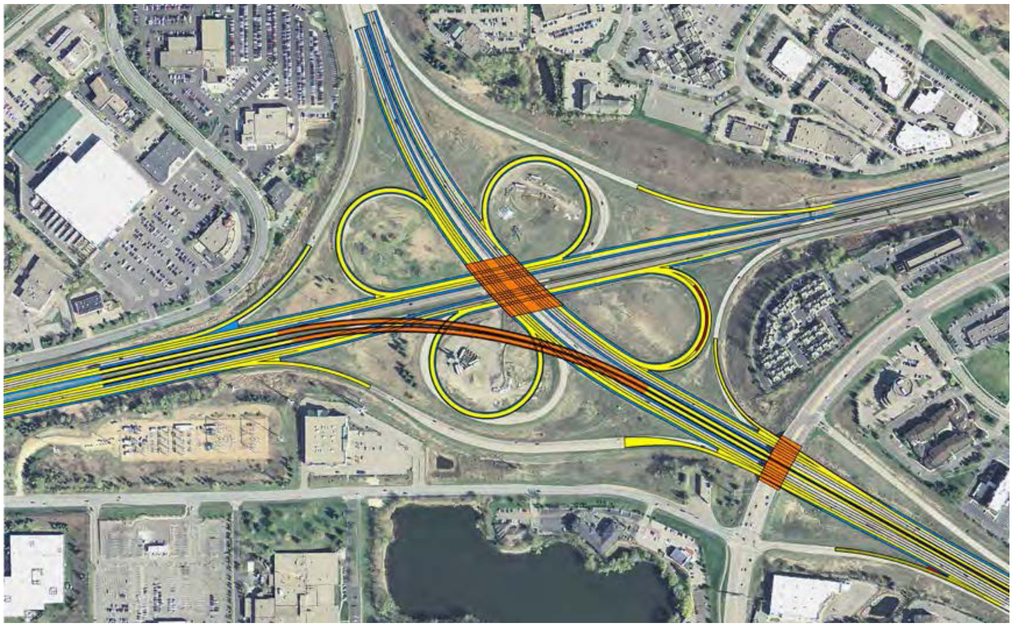
Introduction


Freeway System Interchange Example

Study Funding:

Metropolitan Council

Minnesota Department of Transportation (MnDOT)

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Project Overview

Whether driving, using public transit, or carrying freight, freeway system interchanges are an important part of a safe and efficient transportation system. The Minnesota Department of Transportation (MnDOT) and the Metropolitan Council have observed concentrations of congestion and crashes at metropolitan area freeway system interchanges and have identified numerous needs for improvement across the freeway system. Additionally, while recent major investments to freeway system interchanges (e.g., US 169/I-494, I-35E/I-694) have been made, these locations have been evaluated and selected independent from a highway system-level review. This study takes a systematic approach to evaluating system interchange deficiencies and identifying cost effective improvements to inform future regional investment opportunities.

Evaluating Where Freeways Cross

MnDOT and the Metropolitan Council have partnered to conduct a Freeway System Interchange Study of all locations in the Twin Cities Metropolitan Area where two or more existing or planned freeways meet. The outcomes of this study will address system concentrations of congestion and crashes at system interchanges in the Twin Cities Metropolitan Area.

Similar to the *Congestion Management Safety Plan, MnPASS System Study (Phase 1, 2, and 3)*, and the *Principal Arterial Intersection Conversion Study*, this study will, at a planning level, identify cost-effective improvement opportunities for consideration in the *Minnesota State Highway Investment Plan (MnSHIP)* and the Twin Cities region's transportation plan, the *2040 Transportation Policy Plan (TPP)*.

Purpose, Goals, and Outcomes

Purpose

- Systematically evaluate freeway-to-freeway interchanges throughout the region
- Identify freeway system interchange investment opportunities for the region's metropolitan transportation plan, the *2040 Transportation Policy Plan*
- Balance regional investments with "right-sized" improvement solutions

Goals

- Research the level of congestion, travel time reliability, crashes, freight, and transit
- Identify high priority freeway system interchanges for further analysis
- Consider a range of design concepts at each location
- Address concentrations of congestion and crashes at system interchanges
- Evaluate benefits and cost of design concepts

Outcome

Identify cost-effective freeway system interchange improvement opportunities for consideration in the Twin Cities region's TPP. Improvement of these freeway system interchanges will support economic vitality and quality of life in our region.

Freeway System Interchange Example

Study Process

The study process used stakeholder input and technical analysis to identify and screen freeway system interchanges, develop right-sized solutions, and find regional opportunities.

Freeway System Interchange Study Process Summary

Study Leadership

Study leadership was provided by the Project Management Team (PMT) which consisted of representatives from the following organizations:

- Minnesota Department of Transportation (MnDOT)
- Metropolitan Council
- Federal Highway Administration (FHWA)
- Consultant Team (SRF Consulting Group, Inc., Kimley-Horn and Associates, Sambatek, Inc., and Associated Consulting Services)

Engagement

The study team engaged with several stakeholder groups to seek their guidance and feedback at various stages in the study process. Technical input to the study was provided by a Technical Advisory Committee (TAC) with members from the following organizations:

- Anoka, Carver, Chisago, Dakota, Hennepin, Scott, Sherburne, Ramsey, Washington, and Wright counties
- Cities of Bloomington, Minneapolis, Saint Paul, and Woodbury
- FHWA
- MnDOT
- Metropolitan Council

The study team conducted additional stakeholder engagement with the following groups to better understand current issues and needs:

- Transportation Advisory Board (TAB)
- TAB's Technical Advisory Committee (TAC)
- TAC Planning Committee (TAC Planning)
- Congestion Management Process Plan (CMP) Advisory Committee
- Minnesota Freight Advisory Committee (MFAC)
- MnDOT Capital Improvements Committee

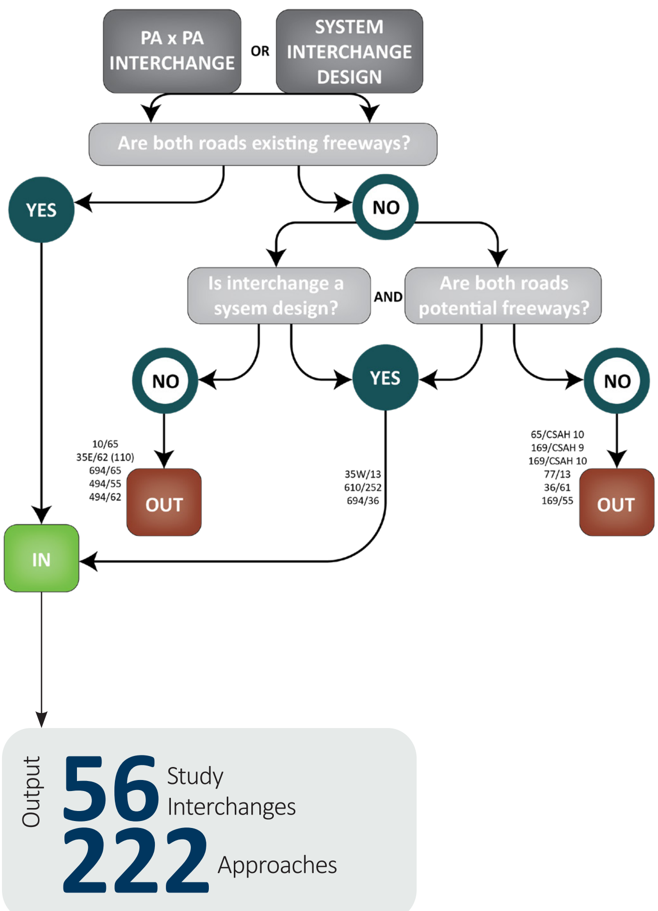
Phase 1:
Establish Freeway System Interchanges to be Studied

1. Study Interchanges

Consider type of interchange & freeway presence
Determine interchange to be studied

The first phase of the study identified all potential freeway system interchanges in the Twin Cities Metropolitan Area and filtered the interchanges to those locations that most closely align with the purpose and goals of this study.

The study interchanges selected in this phase provide critical connections between freeways or a corridor with a vision as a freeway, and have a free-flow interchange design.



Interchange Screening Process Decision Tree

Identify All Potential Freeway System Interchanges

There are nearly 90 Principal Arterial to Principal Arterial interchanges in the Twin Cities Metropolitan Area. These locations were identified as potential freeway system interchanges to be included in this study. These were grouped into one of three categories based on their current geometry:

- Downtown Commons: The pair of interchanges where two freeways are parallel for a segment and include complex local and system access in downtown Minneapolis and downtown Saint Paul
- Cloverleaf: Four-legged interchange with loop and directional ramps that provides access between two freeways
- Other Interchange Type: All other interchange types such as directional Ts, Ys, etc.

Establish Study Interchanges

The study defined and utilized a decision tree to narrow the comprehensive list of all potential freeway system interchanges to Study Interchanges.

- Both Freeways: Only certain categories of Principal Arterials are freeways. Locations where both legs of the interchange are Interstates, expressways, or freeways were included as Study Interchanges.
- Free-Flow Interchange Design: Some sections of non-freeway Principal Arterials still operate as freeways. Locations where the interchange design is characterized by uninterrupted flow on several movements at the interchange (i.e., no traffic signals nor stop signs on any of the interchange approaches) were included as Study Interchanges.
- Potential Future Freeway: Some non-freeway Principal Arterials could become freeways within the planning horizon (2040). These locations on corridors that are programmed, planned, or undergoing a freeway conversion study were included as Study Interchanges.

Phase 2:
Screen Study Interchanges to Focus Locations

2. Focus Locations

Consider magnitude of critical problems
Determine study interchanges to focus locations

The second phase of the study screened the Study Interchanges to Focus Locations by defining performance measures, collecting data, calculating measures by interchange approach, scoring each interchange approach, and screening to Focus Locations.

Define the Performance Evaluation Measures

Performance measures help identify which interchanges have the most need based on transportation performance and should be carried forward in the study. The performance measures:

- Were informed by a national literature review
- Capture typical interchange issues and deficiencies
- Leverage measures from parallel studies (such as the Congestion Management Process Plan)
- Reflect the multimodal emphasis laid out in regional planning documents

Collect the Performance Evaluation Data

Gathering evaluation data for each performance measure involved both spatial and analytical procedures.

- Mobility: Travel time delay was used to evaluate mobility performance as measured in vehicle-hours of delay (VHD)
- Reliability: The buffer time index was used to evaluate reliability. Data from MnDOT loop detectors (annual travel times in 15-minute increments) and NPMRDS was analyzed to establish the congested travel time at each Study Interchange
- Safety: The total monetary value of crashes was used to evaluate safety, as measured in 2018 dollars. Minnesota Department of Public Safety (MN DPS) crash datasets from 2016-2017 and 2012-2015 were used to identify the total number of crashes by severity at each interchange
- Freight: The performance measure evaluated for freight was truck volume, measured in Heavy Commercial Annual Average Daily Traffic (HCAADT)
- Transit: The performance measure evaluated for transit was transit ridership, measured in person throughput

Aggregate Performance Evaluation Data to Approaches

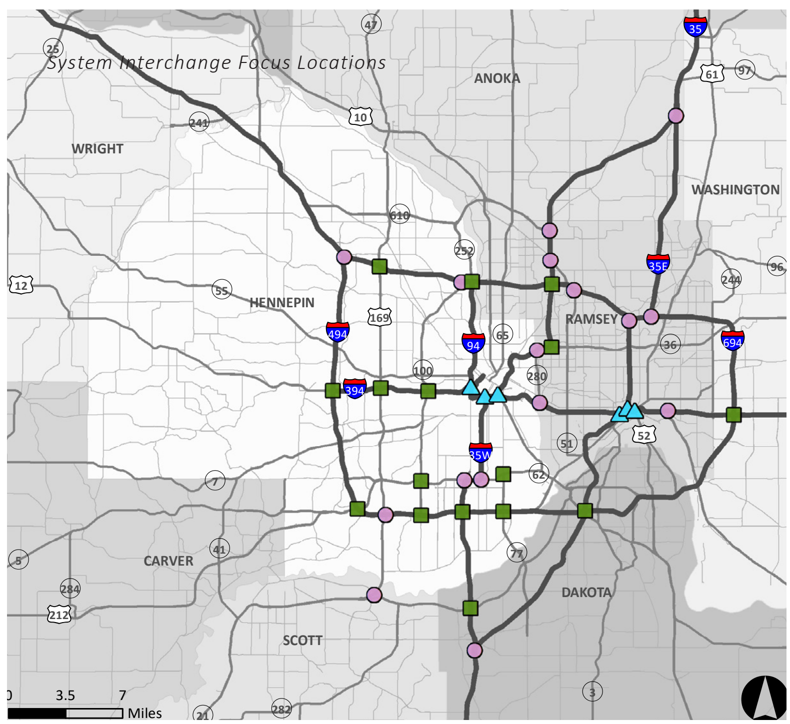
Aggregating individual performance evaluation data to the interchange approach level allowed for comparison between performance measures. The process for aggregating performance evaluation results by interchange approach included development of a performance measure index for each measure.

Composite Scoring Methodology

After the study team aggregated results for individual performance measures by interchange approach, the team then developed a composite score reflecting total performance by approach for the five performance measures.

Screen to Focus Locations

Once total scores for each interchange approach were established, the scores were evaluated with the purpose of refining the list to Focus Locations. A natural break in the total performance score after the top 63 system interchange approaches was identified.



Cloverleaf (16)
Downtown Commons (6)
Other Interchange Type (16)

Phase 3:
Screen Focus Locations to Solution Locations

3. Solution Locations

Consider recent investments, ongoing studies, and bottleneck causes
Determine focus location to solution locations

The third phase of the study screened the Focus Locations to Solution Locations by reviewing interchange asset conditions, parallel study efforts and traffic operations. The purpose of this phase was to identify locations that merited effort to develop a range of improvement concepts.

Consider Recent Investments and Assets Condition

Locations with recent major capital investments are not practical candidates for further near-term major improvements. To work toward a realistic set of Solution Locations, the study team considered the current and near-term asset conditions of all Focus Locations.

Recent Comprehensive Reconstruction

- I-494 & Hwy 169: full build completed in 2012
- I-35W & Hwy 62 (east and west junctions): full build completed in 2011
- I-694 & Hwy 51: full build completed in 2013
- I-35W & Hwy 10 (north and south junction): project underway as a part of the I-35W North MnPASS

Improvements Included Within the Regional Planning Horizon

Locations programmed in the State Transportation Improvement Program (STIP) already have established scopes for near-term improvements.

Consider Parallel Study Efforts

Some locations are under evaluation in parallel planning efforts currently underway. Parallel planning efforts may include an environmental documentation process and/or have considerations above and beyond freeway operations that drive solution development and recommendations.

Study Interchange	*Parallel Planning Effort*	*Estimated Timeline for Solution Development*
I-494/I-694 & I-94	I-94 East Metro Interchange	2020
I-94 & Hwy 280	Rethinking I-94	2021
I-35W & I-494	I-494: Airport to Hwy 169	2020-2021
I-35W & Hwy 36	I-35W North Gateway Study	2020-2021

Consider Traffic Operations and Bottleneck Causes

Traffic operations at the remaining Focus Locations were analyzed to determine the location and cause of bottlenecks in the freeway system. Understanding the bottleneck scenario at each interchange approach allows for identification of primary causes of congestion and whether the operational deficiencies are attributable to the system interchange.

Bottleneck Identification

1 Upstream

Congestion at an upstream bottleneck exists because the true conflict point is upstream of the interchange. In this condition, demand is constrained from reaching the system interchange and improvements to it would not alleviate observed congestion.

2 Interchange Bottleneck

Congestion at an interchange bottleneck is attributed to geometric and/or demand conditions in the system interchange area (i.e., within the approach, interchange, or departure). Interchange bottlenecks can cause congestion upstream and prevent full traffic flow conditions from occurring downstream.

3 Downstream

Congestion at a system interchange can exist because of a downstream conflict point. Congestion from a downstream bottleneck may queue back through a system interchange, making it appear that it is deficient when in fact the true bottleneck is downstream. Congestion downstream of an improved interchange bottleneck would worsen if more traffic were delivered.

Phase 3:
Continued

Consider Traffic Operations and Bottleneck Causes

Traffic Operations Review
A traffic operations analysis was conducted to identify the freeway interchange locations where the primary bottleneck is within and due to the interchange itself (i.e., is an interchange bottleneck and is not a symptom of a bottleneck downstream of that interchange).

Lane Assignment Process
Traffic movements at the lane level were modeled in a program developed by SRF. The program distributes the total approach traffic volume into travel lanes based on total mainline capacity and typical driver behaviors. Specifically, the modeling reflects the following typical traffic operations:

- Weaving from lane changing along the freeway
- Merging from vehicles entering the freeway or from lane drops
- Right lane concentrations (approaching exit ramps)
- Weaving between closely spaced entrance and exit ramps

The product of this lane assignment assists with identifying locations and severity of bottlenecks at interchange approaches.

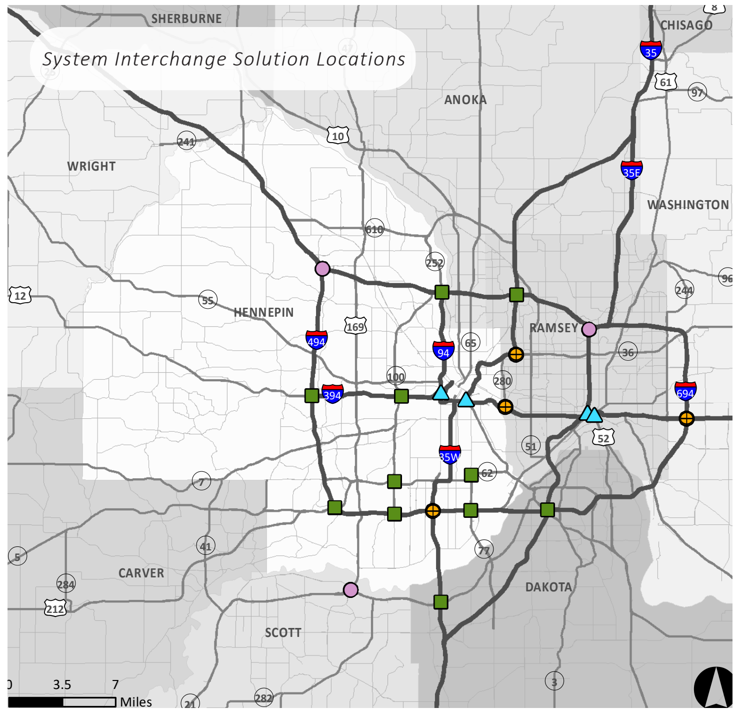
Data Collection
The following inputs were developed to conduct the lane assignment process:

- Traffic volumes
- Origin-destination information
- Lane geometry

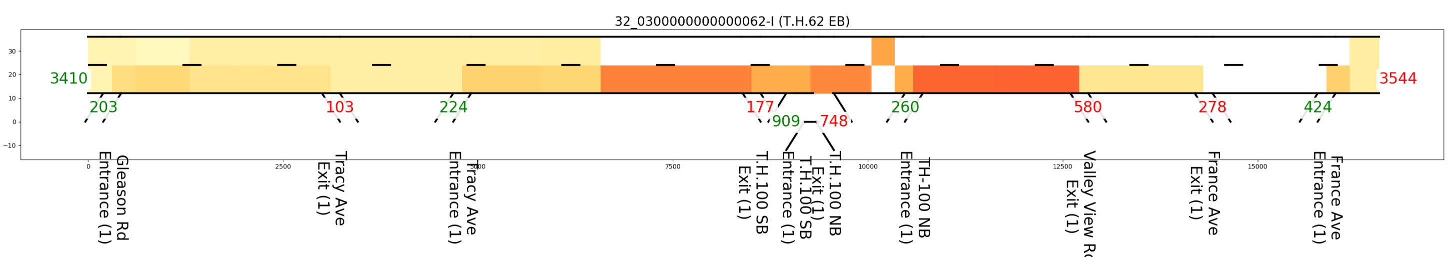
Screening Process
The primary conflict locations were identified at each of the remaining Focus Locations using the lane assignment output. Based on the primary conflict location, the interchange approach was either included or not included in the solution development phase

Screen to Solution Locations

Based on the preceding analysis, 42 approaches across 22 system interchanges were identified as interchange bottlenecks. These 42 approaches are the Solution Locations to be carried forward for solution development



Cloverleaf (11)
Downtown Commons (4)
Other Interchange Type (3)
Under Study in Parallel Planning Effort (4)



Origin	OFR Tracy Ave	OFR MN100 SB	OFR MN100 NB	OFR Valley View Rd	OFR France Ave	ML End
ML Start	92	136	660	458	111	1951
ONR Gleason Rd	10	23	29	20	13	105
ONR Tracy Ave	0	17	52	14	12	127
ONR MN100 SB	0	0	5	87	107	708
ONR MN100 NB	0	0	0	0	33	227
ONR France Ave	0	0	0	0	0	424

Lane Assignment Process Output Example

Phase 4:
Develop Right-Sized Solutions

4. Right-Sized Solutions

Consider variable improvement types and cost-effectiveness
Determine range of solutions

The fourth phase of the study process developed and evaluated a range of solutions for the Solution Locations. The solutions address the key bottleneck and safety issues present in each interchange approach. These solutions:

- Address the systematic and regional needs identified in Phases 1 and 2
- Incorporate the traffic operations analysis conducted in Phase 3
- Are consistent with the scale and scope of the recent investments

For all of the concepts developed, the return on investment (ROI) was estimated. Those found to be cost-effective were carried forward as Right-Sized Solutions.

Design Philosophy and Solution Budget
A wide range of solutions could be deployed to resolve the traffic and safety issues at system interchanges, and these solutions vary considerably in cost and feasibility. The most common solutions were grouped by similar levels of increasing complexity.

Solution Toolbox Examples

Basic

- Auxiliary lanes
- Buffer lanes
- Acceleration lanes
- Escape lanes
- Signage enhancements
- Active traffic management strategies

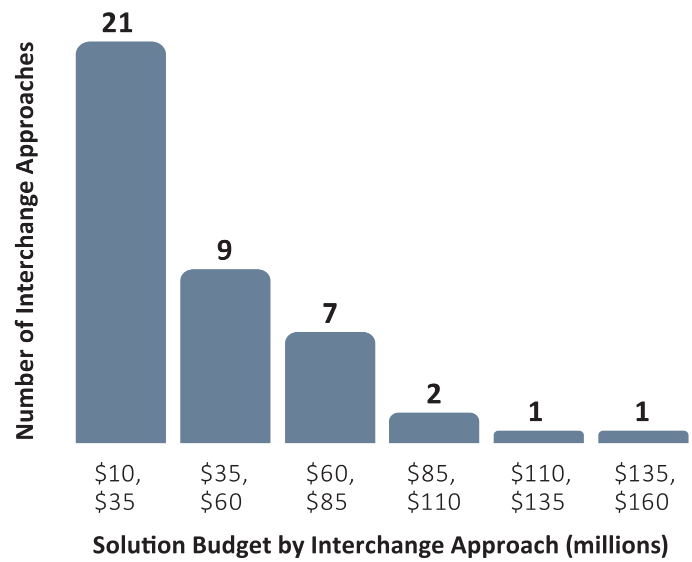
Moderate

- Collector-distributor road
- Ramp consolidation
- Two-lane ramp
- Access control
- Ramp geometric enhancements

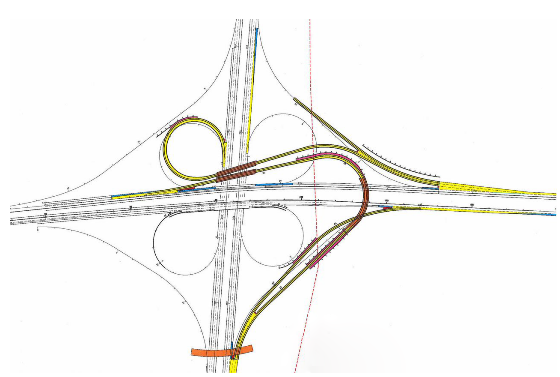
Complex

- Bridge braids
- Flyovers
- Turbine ramps

Additionally, with this "right-sized investment" philosophy, the scale of the improvements at each location should be within the scale of the issues being resolved. This philosophy was implemented by developing a problem cost and solution budget for each Solution Location.



Develop Potential Geometric Improvements
For each Solution Location, geometric improvements were identified that are consistent in scale with its solution budget that may resolve the traffic operations and/or bottleneck issue present at the approach. The consultant team met with MnDOT and Metropolitan Council staff to review the design concept methodology, cost estimation, traffic evaluation, and to ensure overall consistency with accepted design practices.



Solution Concept Example

N

Phase 4:
Continued

Develop Potential Geometric Improvements

Capital Costs
Planning-level cost estimates were generated by applying MnDOT bid prices to key quantities for each improvement.

- Pavement
- Bridge area
- Earthwork (embankments and excavation)
- Retaining walls
- Curb and gutter
- Concrete median barrier
- Removals

In addition to calculating the raw material cost, the following additional factors were applied to each improvement:

- Drainage = 30%
- Traffic control = 5%
- Mobilization = 5%

Finally, a contingency allowance was made for each improvement.

- Improvements costing less than $10M = 15% contingency allowance
- Improvements costing between $10M and 40M = 30% contingency allowance
- Improvements costing more than $40M = 50% contingency allowance

Reduction of Traffic Delay (Reduction of Congestion)
Traffic benefits from each improvement were quantified by comparing the level of congestion at the approach before and after the improvement. The level of congestion at the approach before the improvement was quantified. The level of congestion at the approach after the improvement used the same general data and process: conduct a lane assignment process with the improvement, evaluate the bottleneck type (if any), and quantify the delay per vehicle at the approach (vehicle per hour per lane). Additionally, the impact of each potential improvement was calibrated against observed congestion reduction realized from similar improvements.

Solution Evaluation

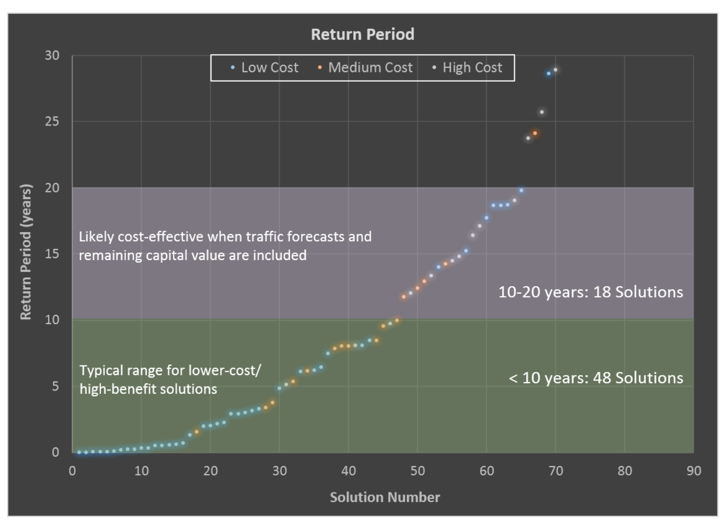
The cost and benefits that were generated for each improvement were used to calculate a ROI and evaluate the cost-effectiveness of each solution. The ROI was quantified as a return period (i.e. the estimated number of years it would take to repay the investment). This return period was calculated as the estimated capital cost divided by the annualized traffic benefits of that improvement.

$$\textit{Return Period} = \frac{\textit{Estimated Capital Costs}}{\textit{Annual Benefits}}$$

The annual traffic benefits included both the traffic delay savings and the crash cost savings. Appendix C shows the estimated annual traffic delay savings, the annual crash cost savings, and the return periods for each potential geometric improvement.

- Annual traffic delay savings: Reduction in congestion applied to annual delay cost
- Annual crash cost savings: Congestion reduction applied to congestion-related crashes. Only these crash types in the peak period were considered:
  - Read end
  - Sideswipe
  - Run off road
  - Head on

The following figure plots the return periods for each geometric solution. The geometric improvements had a variety of return periods ranging from less than one year to over 30 years. Those improvements with return periods of 20 years or less were considered cost-effective, and locations with cost-effective return periods proceeded to the fifth phase of study, Regional Opportunities. Although some individual improvements were removed from consideration, all Solution Locations had at least one cost-effective solution, many at multiple toolbox levels.

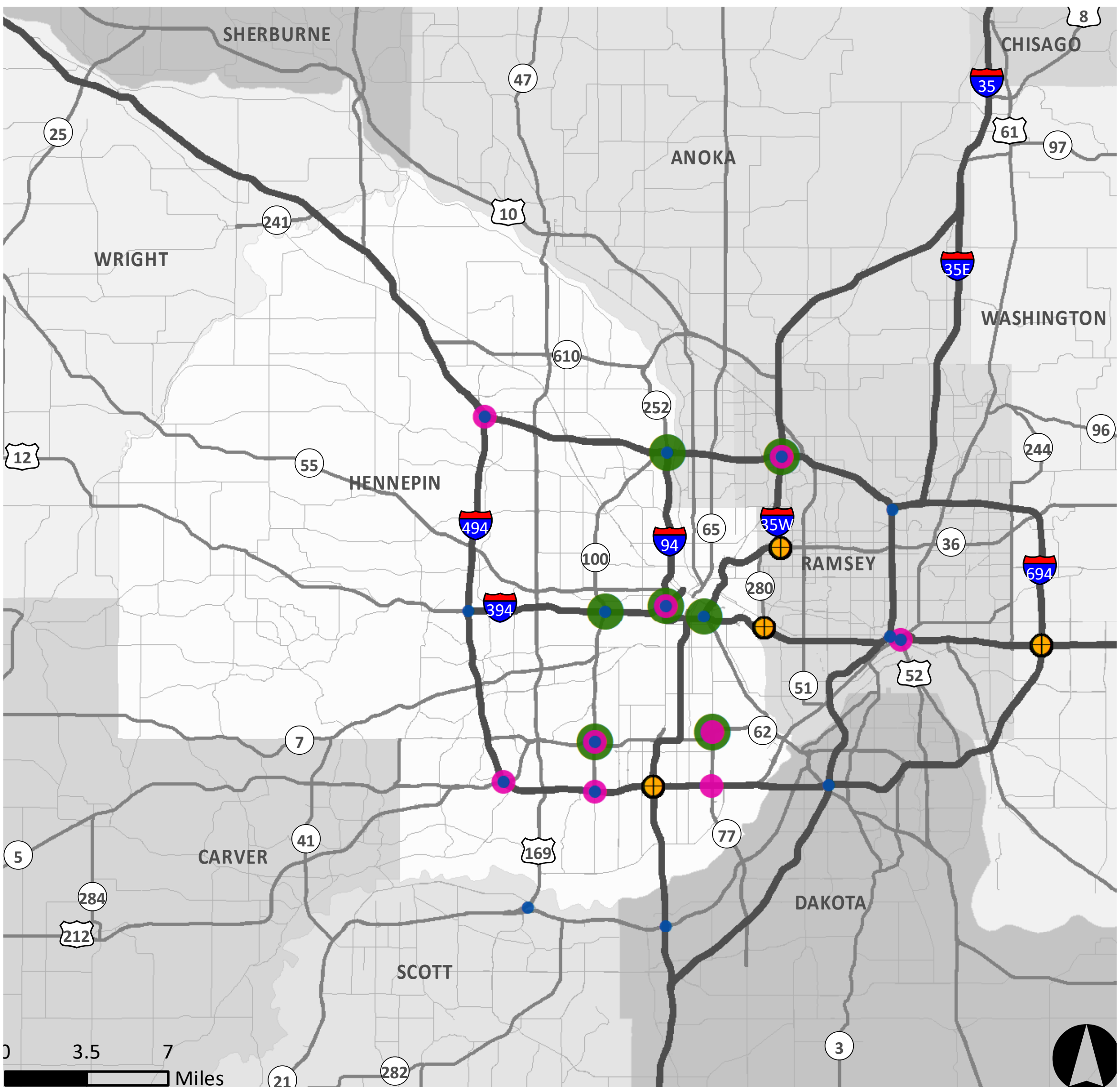


Return Periods of All Potential Geometric Improvements

Phase 4:
Continued

Solution Evaluation

The estimated capital costs, annual benefits (including traffic delay savings and crash cost savings), and return periods for every geometric solution developed are available in the technical memorandum. The figure below maps the locations of these Right-Sized Solutions and indicates the cost category (Lower-Medium-High) of the solutions at that location. Many interchanges have multiple Right-Sized Solutions in each cost category.



Lower-Cost

Medium-Cost

High-Cost

Under Study in Other Projects

*A return period of 20 years used to identify Right-Sized Solutions.
Many interchanges have multiple Right-Sized Solutions in each cost category.

Phase 5:
Identify Regional Opportunities

5. Regional Opportunities

Consider future investment characteristics
Determine improvement opportunities

This phase of the study adds context to the right-sized solutions by considering the future funding outlook and the right-sized solution portfolio at each location. Regional Opportunity categories are developed to inform project scoping and future funding decisions.

Preservation projects should be used as a catalyst to address other identified safety, mobility, freight, transit, bicycle, and pedestrian needs. Integrating these right-sized solutions with preservation projects:

- Minimizes costs
- Reduces inconvenience to travelers
- Addresses multiple policy objectives

Location Future Funding Outlook

The future funding outlook was reviewed at every Solution Location to identify potential coordination opportunities between right-sized solutions and anticipated preservation projects. The future funding outlook was defined as:

- 2019-2022 State Transportation Improvement Program (STIP): 0-4 year outlook
- 2023-2028 Capital Highway Investment Plan (CHIP): 5-10 year outlook
- 2023-2028, 2029-2038, and 2039-2044 Bridge Replacement and Improvement Management System (BRIM): 25 year bridge needs outlook
- TPP projects (MnPASS, Strategic Capacity, CMSP)

Based on this review of the funding outlook, each Solution Location was given a Future Funding Outlook category:

- **Lots of Options:** Has a bridge (BRIM) project planned in the current revenue scenario as well as additional preservation need (pavement (CHIP), TPP, and/or STIP).
- **Bridge Funding Only:** Has a bridge (BRIM) need identified but no pavement work planned.
- **Some Options:** Has a pavement (CHIP), TPP, and/or STIP, but no bridge work planned.
- **Timing Challenged:** Has STIP/TIP project but no future planned project in the current revenue scenario.

Right Sized Solution Portfolio

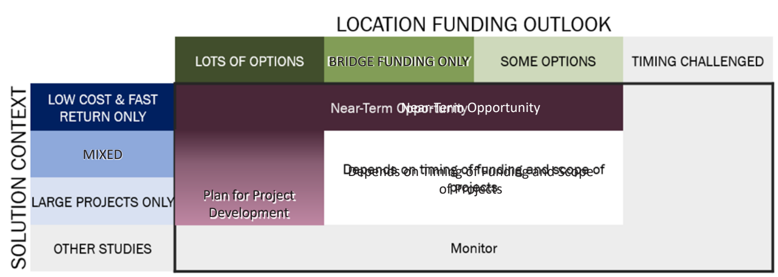
The scale of the right-sized solutions influences whether coordination with a preservation project is necessary (and viable). Right-sized solutions with very small capital costs that have very fast return periods could be good mobility project candidates outside of preservation funding. However, right-sized solutions with large capital costs (regardless of return period) would need to be coordinated and programmed into any future location's funding scenario. To inform the level of coordination that will be necessary, each Solution Location was given a Right-Sized Solution Context category, as follows:

- Lower Cost and Fast Return Only: Only lower cost and fast return projects identified
- Mixed: A mixture of lower, medium, and high cost projects identified
- Large Projects Only: Only high cost projects identified
- Other Studies: Solutions being developed in other studies
- Solved elsewhere: Issue resolved by a solution in another approach

Regional Opportunity Observations

Based on the right-sized solution category and the location funding outlook, each Solution Location was observed to fall into one of three categories:

- **Near Term Opportunity:** Solution Location with near-term programming and lower-cost solution(s) with quick returns. A project here could be considered separately from or combined with known programming.
- **Plan for Project Development:** Solution Locations where the number (and/or scale) of solutions and funding opportunities necessitate a more detailed planning and programming effort.
- **Monitor:** Locations with solutions being developed in other studies.



Relationship Between Location Funding Outlook and Solution Portfolio

Phase 5:
Continued

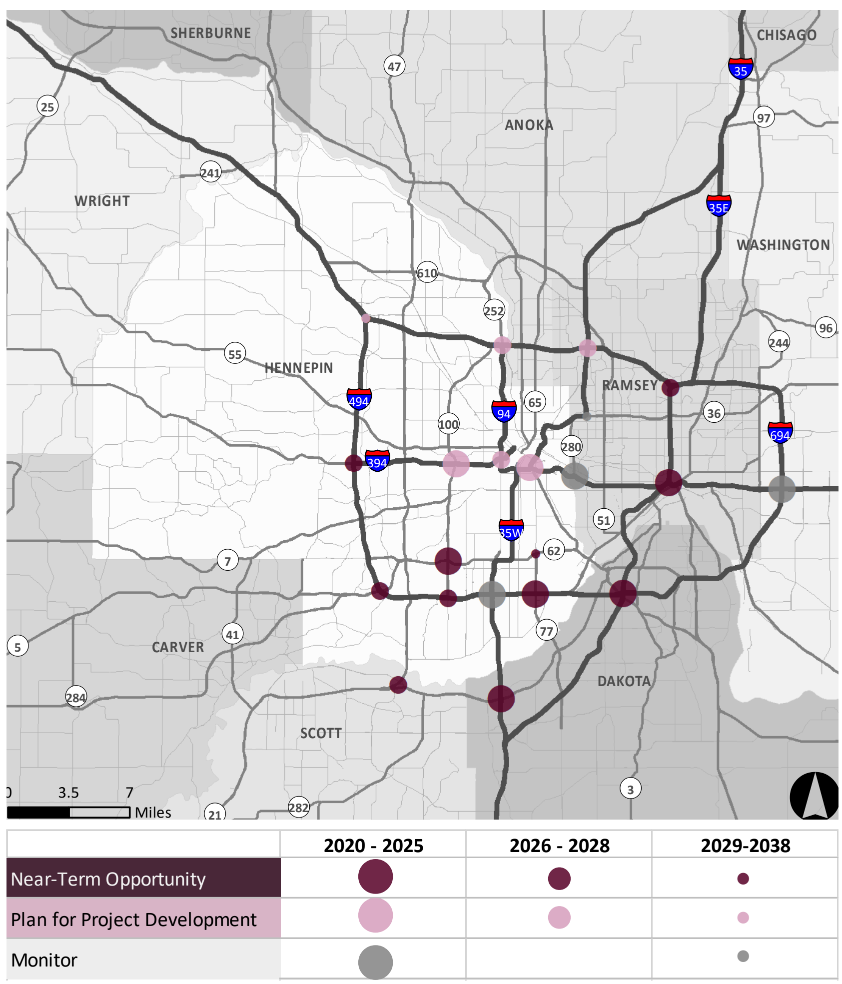
Regional Opportunity Observations

Each of the Solution Locations was placed into an anticipated time frame, corresponding to its most likely preservation funding partner. Ten Solution Locations have programmed projects slated for 2020-2025. Eight more Solution Locations have preservations projects slated for 2026-2028. And the remaining four Solution Locations have no identified funding opportunities until 2029 or later.

Ultimately, all of the Solution Locations have opportunities for meaningful improvements, regardless of Regional Opportunity observation. These findings are intended to inform project scoping and programming decisions along with key highway investment principles. Again, preservation projects should be used as a catalyst for mobility projects and mobility investments should be made in lower cost projects that produce high benefits and avoid exceeding the point of diminishing returns. Funding plans, funding decisions, and project priorities will be proposed by MnDOT and the Metropolitan Council separate from this study process, and this document and the Solution Locations within it will be updated regularly as new data and funding is available.

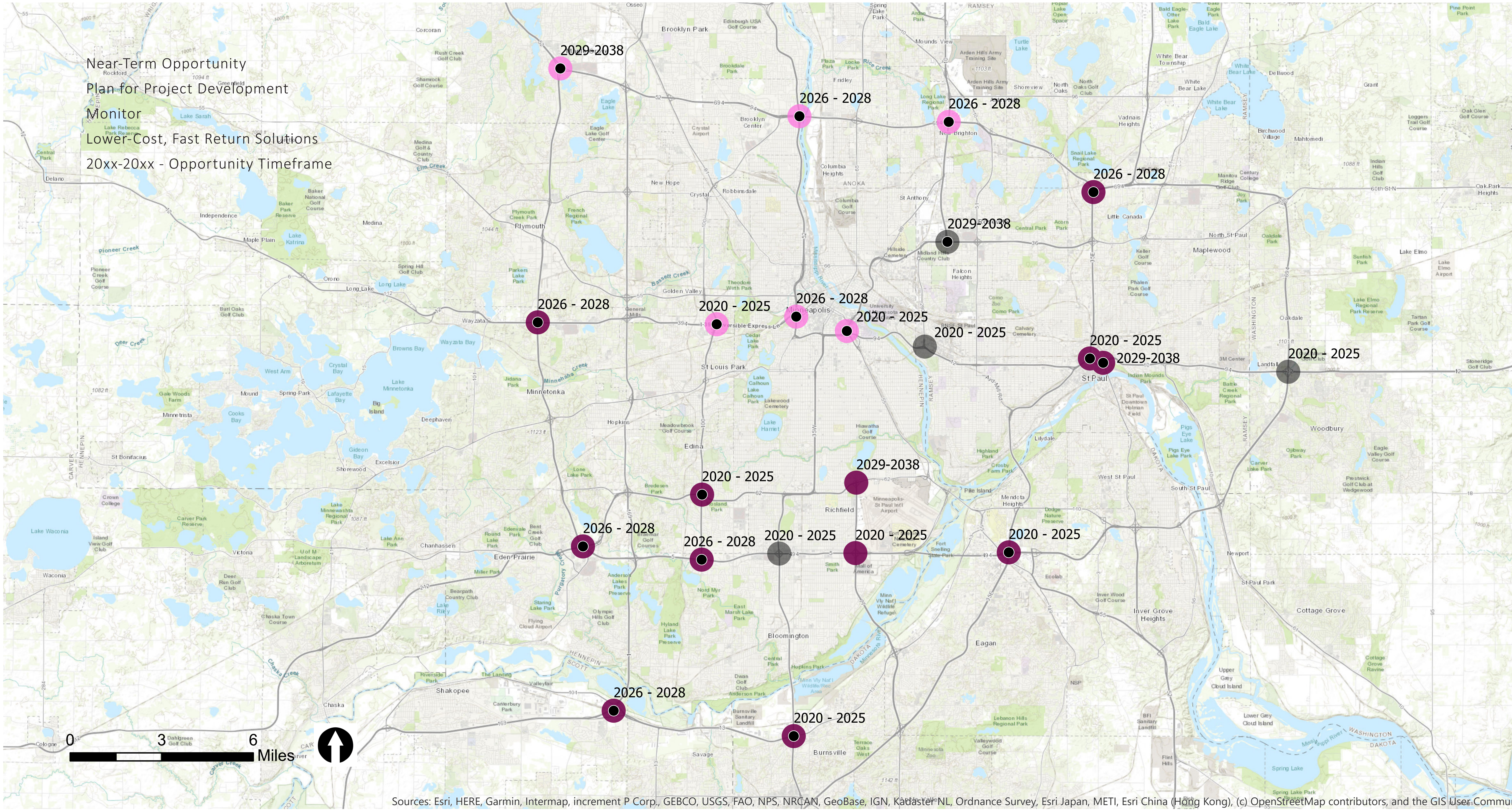
Regional Opportunity Observation	*2020-2025 Preservation Project is Imminent*	*2026-2028 Preservation Project Slated for the End of this Decade*	*2029-2038 No Preservation Project Until 2029 or Later*	*Number of Solution Locations*
Near-Term Opportunity	5	5	2	12
Plan for Project Development	2	3	1	6
Monitor	3	0	1	4
Grand Total	10	8	4	22

Timing of Regional Opportunity Observations



Regional Opportunities Map

Regional opportunities reflect the right-sized solution portfolio and funding outlook at each location. These are categorized as near-term opportunities, plan for project development, or monitor, and are placed into three time frames for most likely investment; 2020-2025, 2026-2028, 2029-2038.



Conclusion

This Freeway System Interchange Study identified cost-effective freeway system interchange improvement opportunities for inclusion in the Twin Cities region's Transportation Policy Plan. Improvement of these freeway system interchanges will help the state and region advance the Thrive MSP 2040 outcomes: stewardship, prosperity, equity, livability, and sustainability.

The opportunities and evaluation processes identified in this study should be used by project sponsors as decision-making resources for freeway system improvements, for example, in developing funding plans and in scoping of geometric improvements in the STIP/ TIP, CHIP, and TPP. Funding plans, funding decisions, and project priorities will be developed by MnDOT, the Transportation Advisory Board to the Metropolitan Council, and the Metropolitan Council separate from this study process.

The Study Locations, Focus Locations, and Solutions Locations, as well as the Right Sized Solutions themselves and the Regional Opportunity observations, are all products of the moment in time in which this study was conducted. This document and the observations within it can be updated as conditions change and new data and funding is available.

Freeway System Interchange Example

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