Publication No. FHWA-HIF-16-018

CASE STUDY:

Demonstrating Performance-Based Practical Design

Minnesota Highway 10
Access Planning Study

Date: June 29, 2016

U.S. Department of Transportation

Federal Highway Administration

Publication No. FHWA-HIF-16-018

Case Study: Minnesota Highway 10 Access Planning Study

Agency: Minnesota Department of Transportation (MnDOT)
Location: Minneapolis-St. Paul, MN
Setting: Urban/suburban

As state and local agencies become increasingly challenged with addressing their system performance, mobility, and safety needs in the current era of financial limitations, FHWA is providing information, delivering technical assistance, and sharing resources related to Performance-Based Practical Design (PBPD), including a series of case studies that demonstrate key attributes of PBPD.

Overview

This case study illustrates how a state, with limited funding, utilized components of a PBDP approach to develop less-expensive alternatives to achieve project goals. Through quantitative analysis, MnDOT identified lower-cost alternatives that still attain the vast majority of the safety and operational benefits of the higher-cost original design concept. That is, MnDOT developed a series of projects that they estimated would attain 96 percent of the safety benefits and 90 percent of the operational benefits of a freeway at less than 50 percent of the cost. This case study has been prepared in coordination with MnDOT and their consultant Bolten-Menk, who documented their approach in the Highway 10 Access Planning Study (2015).

Performance-Based Practical Design

PBPD emphasizes evaluation of the performance impacts of highway design decisions relative to the cost of providing various design features. It is a decision making approach that helps agencies better manage transportation investments and serve both project- and system-level needs and performance priorities with limited resources. PBPD uses relevant, objective data and appropriate performance-analysis tools to inform decisions. Following a PBPD approach can help make more efficient use of scarce resources so that a greater number of improvements can be made and the performance of the overall transportation system exceeds the performance that would have otherwise been achieved if the focus was on individual project-based (as opposed to systems-based) decisions. Notable attributes of PBPD include:

- A focus on performance improvements that benefit both project and system needs
- Improved decision-making quality based upon performance analysis

- Increased return on investment by promoting scrutiny of each element of a project's scope relative to value, need, and urgency
- Strengthened emphasis on planning-level corridor or system performance needs and objectives when planning, scoping, and developing individual projects
- Ability to implement the approach within the Federal Aid Highway Program regulatory environment using existing flexibility; PBPD does not eliminate, modify, or compromise existing design standards or regulatory requirements.

Case Study Background

Highway 10 provides a critical connection between Minneapolis and St. Paul and suburban areas in Minnesota. It transitions from a freeway facility to a four-lane divided highway as it continues northwest from the Twin Cities area. Traffic volumes and safety concerns prompted various studies along a 7-mile portion of Highway 10, highlighted in Figure 1, between the Anoka/Sherburne County Line and the Rum River. Capacity analysis showed that there were 374 vehicle hours of delay in a typical afternoon rush hour along the corridor in 2013. Analysis of 10 years of crash data showed that this portion of Highway 10 had a higher than average crash rate when compared to similar roadways. The conversion of this roadway from a four-lane divided highway into a freeway has been a goal for many years, but due to budget constraints and impacts to adjacent land uses, the conversion to a freeway was not feasible. Consequently, MnDOT studied the corridor to identify less expensive alternatives that would improve safety and mobility along this section of Highway 10.

Figure 1: Vicinity Map [Source: Google]

The west portion of the corridor has agricultural and rural residential land use, while the east portion of the corridor has urban land use. The corridor has a major rail line that closely parallels Highway 10 to the north and the Mississippi River to the south, which increases the need for separated grade structures. The corridor has various transitions as the conditions gradually change from rural expressway, to signalized expressway, to suburban freeway. As such, the corridor was separated into five segments with similar conditions.

1. Ramsey West (2.3 miles)
2. Armstrong Boulevard (0.84 miles)
3. Ramsey Boulevard (1.6 miles)
4. Sunfish Lake Boulevard (0.83 miles)
5. Anoka (1.6 miles)

Figure 2 shows an aerial view of the corridor with the five segments delineated.

Figure 2: Project Corridor Segments [Source: Google]

The reported average annual daily traffic (AADT) for the five sections of the corridor are listed in Table 1. The AADT along the study area varies from 33,500 to 61,000.

Table 1: 2013 AADT

Highway 10	2013 AADT (vehicles per day)
1. Ramsey West	33,500
2. Armstrong Boulevard	33,500
3. Ramsey Boulevard	38,500-44,000
4. Sunfish Lake Boulevard	44,000-47,500
5. Anoka	47,500-60,000

The study analyzed ten-years of crash data (2003-2012). Tables 2 and 3 summarize the total number of crashes, as well as the severity and manner of collision.

Table 2: Crash Severity, 2003-2012

Severity	Number	Percent
Fatal	13	0.8%
Incapacitating Injury	29	1.8%
Non-Incapacitating Injury	135	8.3%
Possible Injury	324	20.0%
No Injury (PDO)	1,120	69.1%
Total	*1,621*	*100.0%*

Table 3: Manner of Collision, 2003-2012

Manner of Collision	Number	Percent
Left Turn	25	1.5%
Rear End	948	58.5%
Angle (Other than Left Turn)	122	7.5%
Other	526	32.5%
Total	*1,621*	*100.0%*

A total of 1,621 crashes were reported within the Highway 10 project limits between 2003 and 2012. This included 13 fatal crashes, with several of those being pedestrian fatalities in Segment 5 (Anoka).The analysis included mapping all crashes by location along the corridor. The average annual crash frequency was 162.1 crashes per year. The calculated crash rate was 1.44 crashes per million vehicle miles, which is higher than comparable roadway segments.

Performance Improvements

Within the limited resources available to improve safety and mobility along Highway 10, MnDOT used three approaches to develop nine improvement concepts that are alternatives to a freeway. Each approach was intended to incrementally build off the other approaches.

- Approach 1 – Access Management
- Approach 2 – Westbound Highway 10 Free Flow
- Approach 3 – Eastbound and Westbound Highway 10 Free Flow

Improvement concepts:

1. Surface street extensions and new construction
2. Restricted crossing U-turn intersections (RCUT)
3. Right-of-way purchases
4. Roadway realignment
5. Revisions to left-turn treatments at T intersections

6. Construction of flyover ramps
7. Construction of overpasses and underpasses
8. Driveway removals
9. Signal removal

To provide an example of the improvement concepts, Figures 3, 4 and 5 illustrate the existing condition, the freeway concept and an at-grade alternative improvement concept at Fairoak Avenue, respectively.

Figure 3: Existing Condition at Fairoak Avenue [Source: Google]

Figure 4: Freeway Concept at Fairoak Avenue [Source: Highway 10 Access Planning Study]

Figure 5: At-Grade RCUT Alternative with Signal Removal at Fairoak Avenue [Source: Highway 10 Access Planning Study]

Greater Return on Investments

Safety Analysis

Proposed projects were analyzed using the Highway Safety Manual (HSM) to quantify the predicted safety impacts. The HSM provides guidance on how to analyze highway sections that are reasonably homogeneous with respect to key variables such as traffic volume, highway cross section, highway classification, and surrounding geometric conditions.

Crash modification factors (CMFs) used in this analysis were developed based on information from the CMF Clearinghouse, the HSM, and local experience and data. For locations where only half an intersection was being changed, the CMF was only applied to the crashes associated with the direction being modified.

The freeway alternative was estimated to reduce crashes in the corridor by 709 crashes, from 1,513 to 804 crashes during the 20-year design period. The estimated crash reductions of the other project alternatives were compared to the crash reduction estimated for the freeway alternative.

The individual projects were grouped together to simplify the analysis. The following six groups were analyzed:

- Group 1 – Access Management Projects
- Group 2 – Fairoak Signal Removal
- Group 3 – Thurston Avenue Westbound Free Flow
- Group 4 – Ramsey and Sunfish Lake Boulevard Westbound Free Flow
- Group 5 – Thurston Avenue Eastbound and Westbound Free Flow
- Group 6 – Sunfish Lake Boulevard Eastbound and Westbound Free Flow

Table 4 provides a summary of the safety analysis.

Table 4: Safety Analysis Results

Groups Analyzed	Estimated # of Crashes Reduced	Percent Benefit of Freeway Alternative
1	136	19%
1-2	428	60%
1-3	494	70%
1-4	623	88%
1-5	663	94%
1-6	683	96%

The safety analysis estimated that the six groups of proposed projects would provide 96 percent of the safety benefit of the freeway alternative with less than 50 percent of the cost to convert the roadway into a freeway. Figure 6 provides a graphical representation of the estimated safety benefit and cost for the proposed projects against the benefit and cost that would be obtained with the freeway alternative.

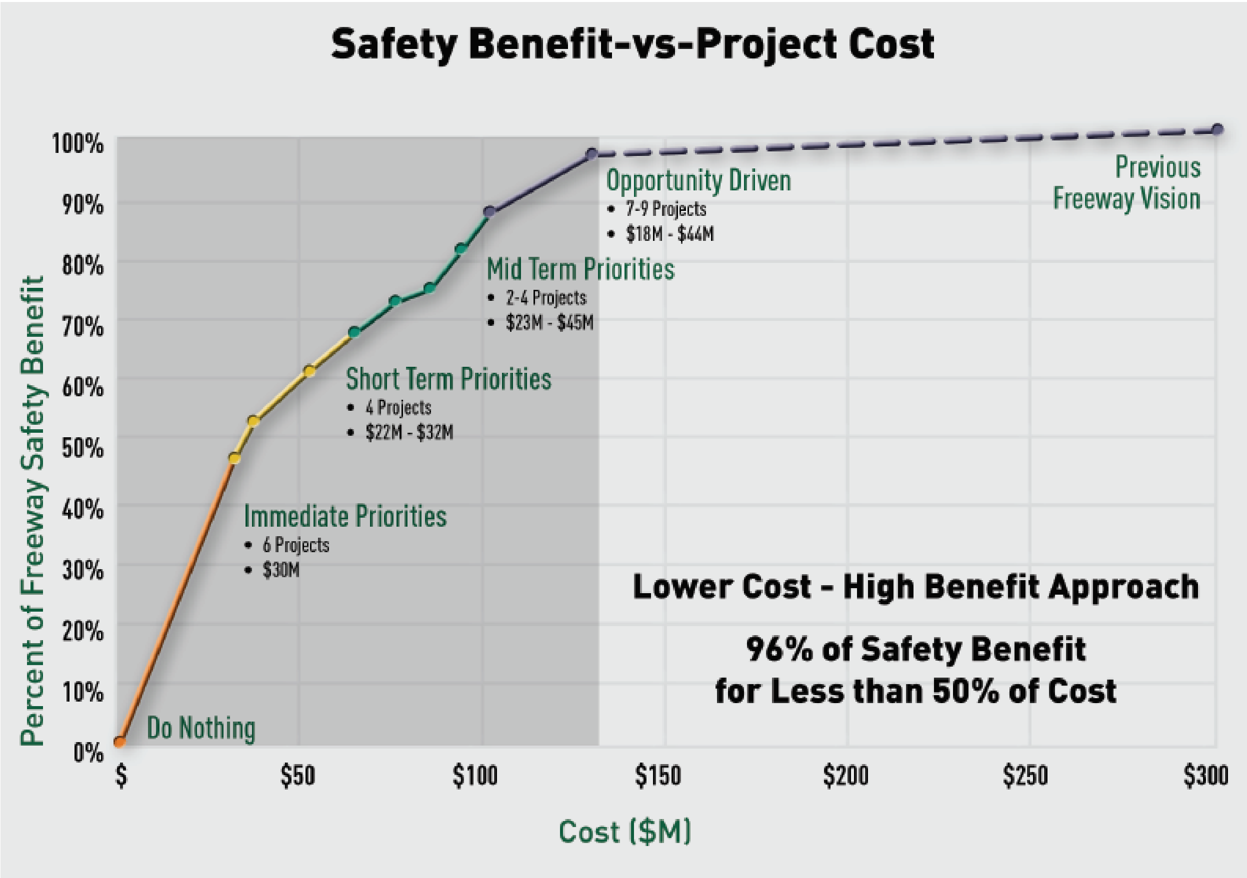

Figure 6: Safety Benefit versus Project Cost [Source: Highway 10 Access Planning Study]

Traffic Operations Analysis

The VISSIM software and FHWA's Microsoft Excel based Capacity Analysis for the Planning of Junctions (CAP-X) tool were used to analyze the operational conditions of the roadway and alternatives. VISSIM was used to analyze flow through the corridor and to provide a simulation of traffic conditions, while CAP-X was used to evaluate the operational conditions of the innovative junction designs to provide planning level capacity assessment at each crossing. The analysis evaluated the existing conditions in 2013 and three alternatives for 2030. The three alternatives for 2030 included a no-build analysis of existing conditions, the full freeway alternative and the implementation of the six groups of projects included in the safety analysis. Table 5 shows the results of the evening rush hour analysis.

Table 5: Evening Peak Delay Analysis

Scenario	Afternoon Rush Total Delay (vehicle hour)	Afternoon Rush Decrease in Delay (vehicle hour)
2013 Volumes - Existing Geometry	374	-
2030 Forecasted Volumes - Existing Geometry	575	-
2030 Forecasted Volumes – Full Freeway Improvement	38	537
2030 Forecasted Volumes-Proposed Projects (6 groups)	88	487

The difference in delay for the freeway alternative and the proposed projects was compared against the difference in delay between the freeway alternative and the "do nothing" case. The freeway alternative is able to reduce the delay by 537 vehicle hours in the afternoon rush. However, the 487 vehicle hour reduction of the 6 groups of proposed projects is approximately 90 percent of the operational benefit that would be observed with the construction of a freeway along Highway 10 but with a substantially lower cost. Figure 7 illustrates the operational benefit and cost associated with the proposed projects against the benefit and cost that was estimated for the freeway alternative.

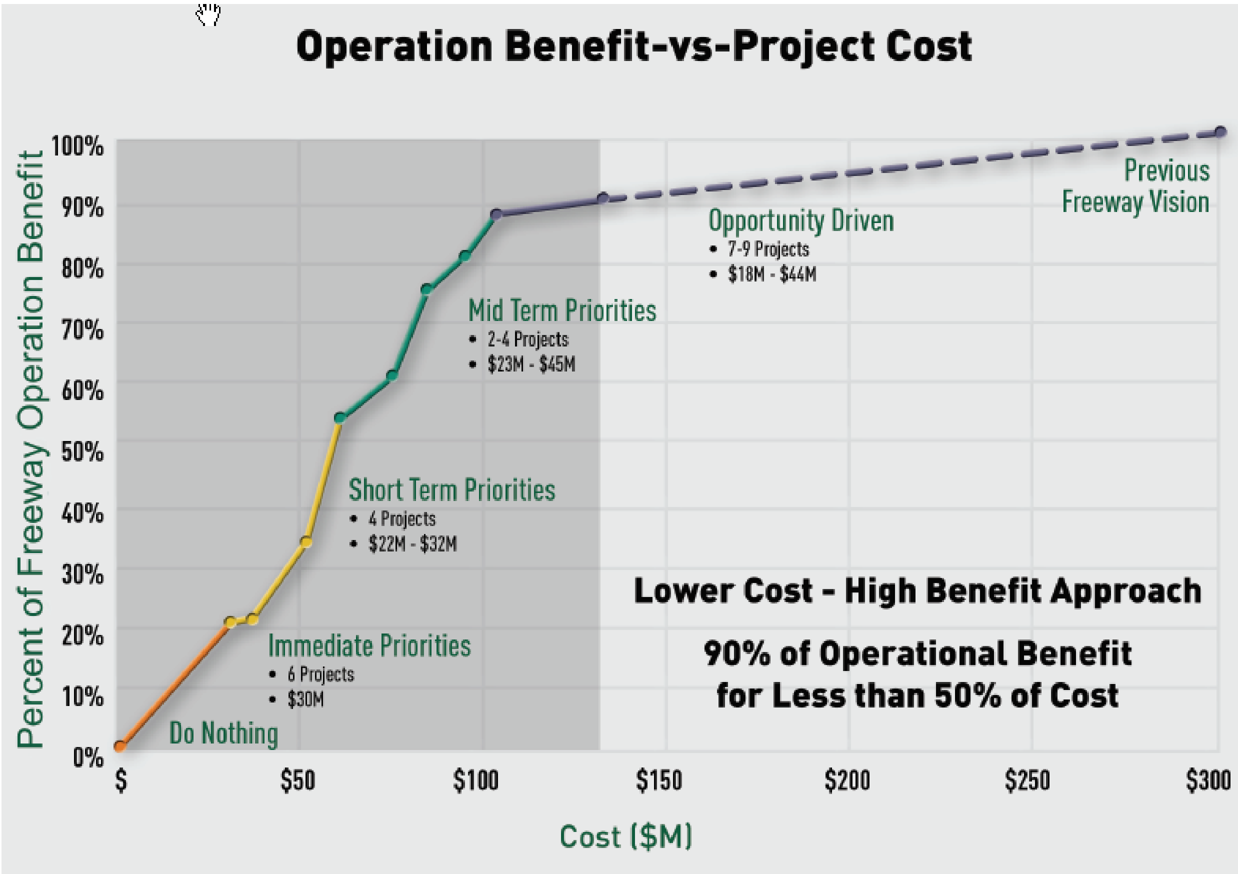

Figure 7: Operational Benefit versus Project Cost [Source: Highway 10 Access Planning Study]

Summary

A 7-mile segment along Highway 10 in Minnesota currently has a higher crash rate than similar roadways of its kind. The ultimate goal for this principal arterial had been to convert this portion of roadway to a freeway. Due to budgetary constraints and potential impacts to adjacent land uses, it is not possible to implement the freeway conversion. As such, MnDOT's consultant, Bolten & Menk, analyzed the corridor and recommended the implementation of 20 projects that would provide the vast majority of the safety and mobility benefits of the freeway conversion at a fraction of the cost. As an example of Performance Based Practical Design, the project team was able to quantify that the 20 proposed projects would provide 96% of the safety benefit and 90% of the operational benefits of the freeway alternative at less than 50% of the cost of the freeway.

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References and Resources

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