CAMBRIDGE SYSTEMATICS

I-394 MnPASS Technical Evaluation

final report

prepared for

Minnesota Department of Transportation

prepared by

Cambridge Systematics, Inc.

with

Short-Elliott-Hendrickson, Inc.
and LJR, Inc.

November 2006

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ES.1 Background

On May 16th, 2005, the Minnesota Department of Transportation (Mn/DOT) started operation of the State's first application of High-Occupancy Toll (HOT) lanes on a segment of the Interstate 394 (I-394) corridor in the Minneapolis/St. Paul region. This system, known locally as MnPASS, represents the first deployment of HOT lane strategies in Minnesota and one of the first in the United States that dynamically adjusts pricing levels in response to varying traffic conditions.

I-394 serves as the primary east/west corridor for travel between downtown Minneapolis and the I-494 beltway, and the western suburbs. Unique within the Twin Cities region, the facility also has two reversible, barrier-separated high-occupancy vehicle (HOV) lanes located in the center median between I-94 and Trunk Highway 100 (TH 100). Historically, these lanes were open only to bus and carpools with two or more passengers in the inbound (eastbound) direction from 6:00 a.m. to 1:00 p.m., and open in the outbound (westbound) direction from 2:00 p.m. to midnight on weekdays. These lanes were also opened to buses and HOV traffic on a limited basis on weekends, usually in support of special event traffic. The lanes were closed at all other times. This portion of the I-394 HOV corridor is referenced as the *reversible lane* section.

West of TH 100, the facility was built with a single, non-barrier-separated HOV lane in each direction. Prior to the introduction of MnPASS, the HOV lanes were designated for use by carpools and transit vehicles during the morning commute period (6:00 a.m. to 9:00 a.m.) for the inbound direction, and during the afternoon commute period (3:00 p.m. to 6:00 p.m.) for the outbound direction. The HOV restrictions on this section of the corridor were only applied on weekdays and the lane was available for use by all traffic for the remaining hours of the day. This portion of the I-394 HOV corridor is referenced as the *diamond lane* section.

The I-394 freeway has historically been well utilized and often experiences congestion, particularly during the commute hours. While HOV demand in the corridor has been robust, it was often less than the available capacity resulting in the perception among some residents that the HOV lanes were underutilized. As a result of this perception, Mn/DOT was directed by the Legislature in 2000 to evaluate various options for increasing the utilization of the HOV facilities, including opening the HOV lane to use by all vehicles and the conversion to a high-occupancy toll (HOT) lane operation.

ES.2 MnPASS Overview

The MnPASS system made operational on May 16th, 2005, allowed single-occupancy vehicles (SOV) to use the HOV (MnPASS) lanes by electing to pay a toll. The actual price of the toll (ranging from $0.25 to $8.00 U.S.) varies with the current congestion levels and with the distance traveled – a different toll is paid whether the MnPASS subscriber chooses to travel on the reversible section, the diamond lane section, or both. The price of the toll is advertised through the use of Dynamic Message Signs (DMS) placed at strategic locations throughout the corridor, and the toll is paid electronically through a user-obtained transponder positioned within the vehicle.

All vehicles previously eligible to use the HOV lanes, including public transit vehicles, carpools, and motorcycles, are still able to use the MnPASS lanes free of charge; however, access and egress to/from the MnPASS lane in the diamond lane section are now limited to specific entry and exit merge areas. As originally developed and implemented, the MnPASS system was intended to operate 24 hours a day, 7 days a week (24/7); however, due to some residents' concerns regarding new restrictions on SOV use of the lanes during non-peak hours and in the non-peak direction, operational hours were modified to a slightly expanded approximation of the previous operational hours and direction of HOV lane restrictions. The current operational hours for the MnPASS lane in the diamond section are 6:00 a.m. to 10:00 a.m. for the inbound direction (an addition of 1 hour of morning commute period HOV restrictions compared with historical hours), and 2:00 p.m. to 7:00 p.m. for the outbound direction (an addition of 2 hours of afternoon commute period HOV restrictions compared with historical hours). These operational hour modifications were implemented approximately 1 month after the opening of the MnPASS system.

ES.3 Evaluation Background

Recognizing the use of the I-394 MnPASS deployment as a test bed for evaluating the viability of the HOT lane concept and the broad interest in the application, Mn/DOT implemented a comprehensive evaluation effort to assess the system. Two different teams were subsequently contracted by Mn/DOT to evaluate different aspects of the I-394 MnPASS deployment. The Attitudinal Evaluation Team, headed by the University of Minnesota's Humphrey Institute State and Local Policy Program supported by NuStats, Inc., was charged with collecting and analyzing the public's perceptions regarding the MnPASS system. The Technical Evaluation Team was managed by Cambridge Systematics, Inc., and supported by Short-Elliott-Hendrickson and LJR, Inc. This team was tasked with collecting and analyzing data regarding the ability of the MnPASS system to achieve the stated project goals, and to evaluate other performance impacts observed in the corridor. This Evaluation Report only focuses on the details of the Technical Evaluation of the I-394 MnPASS deployment, and does not typically include findings from the attitudinal evaluation, except where there are notable overlaps between the two evaluations. More

information specifically related to the attitudinal evaluation can be located on the MnPASS web site: http://www.mnpass.org/.

ES.4 Evaluation Findings

The technical evaluation of the I-394 MnPASS deployment was conducted according to guidelines originally specified in the Technical Evaluation Test Plan (March 2003). This plan included the identification of multiple evaluation objectives to be assessed in the course of the evaluation. While some of these issues required the simple documentation of issues, other identified objectives specified hypotheses to be tested during the course of the evaluation. Table ES.1 presents a listing of the many key hypotheses and summarizes the outcomes of the evaluation against each impact.

In addition to the assessment of before and after conditions to assess the ability of the MnPASS system to achieve the intended objectives, the evaluation also documented additional issues surrounding the deployment. Some of the key findings include:

- MnPASS has been popular with users as evidenced by the demand for transponders and continued use of the MnPASS lane. Over 10,000 transponders have been leased by users and the average user chooses to pay the MnPASS lane toll about twice a week on average.

- The toll schedule modifications implemented in January 2005 have resulted in an increase in revenue being collected and less volatility in rate changes at lower traffic levels. After an initial decrease in usage following the modification, usage has steadily increased to surpass levels prior to the modification.

- The increased enforcement activities funded through the MnPASS program have had great success in curtailing illegal SOV use of the MnPASS lane in the I-394 corridor by giving single drivers a legal option to use to underutilized HOV lane. Violation rates in the non-MnPASS-equipped I-35W corridor are more than three times as high.

- Most transit providers have reported negligible impacts on operations as a direct result of MnPASS deployment. The limited number of issues reported generally focused on the ability of transit vehicles to merge at one specific access point in the corridor.

Table ES.1 Evaluation Hypotheses and Outcomes

Evaluation Hypothesis	Outcome
MnPASS deployment will result in an increase in vehicle throughput in the corridor	True. Based on an analysis of before and after volumes, corridor throughput increased during the peak hour by up to 5 percent. This increase occurred while regional volumes in other non-MnPASS corridors observed a decrease.
MnPASS deployment will result in an increase in vehicle speeds in the general purpose lanes	True. General purpose lane travel speeds were observed to increase at all study locations by an average of approximately 6 percent.
MnPASS deployment will result in a decrease in average person travel time in the corridor	True. Travel speeds increased in the general purpose lanes, as well as the MnPASS lane for many locations providing a reduction in travel times.
MnPASS deployment will not result in a decrease in vehicle speeds in the HOV/HOT lanes	True. Travel times were observed to hold constant or increase slightly at all study locations, with the exception of a portion of the morning operational period at Xenia.
MnPASS deployment will not result in a change in mode share in the corridor	Inconclusive. Significant deceases in the numbers and mode shares of carpools were observed on I-394; however, a significant (yet tempered) decrease in carpool usage was similarly observed on I-35W, which is not equipped with MnPASS during the same time period, suggesting a regional shift in carpool usage. The snapshot nature of the available auto occupancy data, significant variations in the day-to-day usage of the lane by HOV users, and the change in operating hours between the pre-MnPASS and post-deployment periods all served to complicate the precise identification of carpool impacts. Therefore, it can neither be confidently proven or refuted that the decrease on carpool usage on I-394 is directly attributable to the deployment of MnPASS as the observed decrease is within the margin of error of the analysis. Additionally, user survey results from the separately conducted I-394 MnPASS Attitudinal Evaluation did not reveal any changes in mode choice reported by corridor carpoolers.
MnPASS deployment will not result in an increase in illegal SOV usage of the HOV/HOT lanes	True. Violation rates on I-394 were observed to decrease dramatically following the implementation of MnPASS. Meanwhile, the violation rates on the non-MnPASS-equipped I-35W HOV section have significantly increased.
MnPASS deployment will not result in an increase in the number of crashes occurring in the corridor	True. In the year following MnPASS deployment, approximately 14 percent fewer crashes were observed when compared with previous years.
MnPASS deployment will result in a decrease in the speed differential between HOV/HOT lanes and general purpose lanes	True. The speed differential was observed to decrease at all diamond lane study locations.

Table ES.1 Evaluation Hypotheses and Outcomes (continued)

Evaluation Hypothesis	Outcome
MnPASS deployment will not result in an increase in corridor noise levels	True. Monitoring conducted by Mn/DOT revealed no significant increases in corridor noise levels.
MnPASS deployment will not result in an increase in corridor emissions (carbon monoxide (CO)) levels	True. Monitoring conducted by Mn/DOT revealed no negative CO emissions impacts.

ES.5 Conclusions

The MnPASS deployment on I-394 has enjoyed success in achieving many of the identified goals and objectives for the project. While successful in its current configuration, the initial deployment operating on a 24/7 basis did face some public criticism due to unforeseen congestion that occurred in the off-peak direction. The flexibility of Mn/DOT in adapting to these challenges was key to overcoming these barriers resulting in the current successful deployment. The success and benefits provided by the MnPASS system on I-394 warrants that the MnPASS concept be carefully considered for application to other corridors facing similar challenges to I-394. While not a panacea for all system deficiencies, the MnPASS concept can be a success if applied under the correct circumstances.

Based on lessons learned from the initial application of HOT lane strategies in Minnesota, the following recommendations are provided to stakeholders considering the broader application of MnPASS to other corridors:

- The clear provision of a benefit for potential users is key to attracting and sustaining subscribers. The consistent maintenance of near free-flow conditions on I-394 has provided users with a clear benefit and motivation for opening an account and using the system.

- It is critical that free-flow speeds in the MnPASS lanes must be maintained to sustain the benefit provided to carpoolers and transit riders. Valuable regional benefits are gained by support of these trip reducing travel modes. The I-394 MnPASS deployment maintained the travel time savings for these users, while simultaneously serving to increase the number of hours that travel on the lane was reserved for HOV travel compared with previous conditions.

- Addressing the concerns of the transit providers is critical to maintaining support of the deployment. Continuing issues of the transit community should be studied and addressed as they arise.

- The I-394 corridor is unique among regional corridors as it maintains the only reversible segment in the Twin Cities. The benefits of MnPASS in the reversible section were overwhelmingly apparent in the evaluation. The benefits in the diamond lane section, while still positive, were more mixed, particularly during the initial 24/7 operation. This was often particularly true on the fringes of the new operational period, where HOV restrictions were expanded to hours that had previously been available for general-use travel. Stakeholders should carefully consider any possible impacts of future MnPASS expansion, especially in situations that may serve to alter the hours of availability of a previous open general purpose lane.

- The funding and provision of additional enforcement had a direct impact on the success of the I-394 MnPASS deployment. An increased enforcement presence should be a key ingredient of any future expansion plans.

- The continuous and sustained monitoring and evaluation of corridor conditions following deployment of I-394 were key to identifying minor problems in the system before they had the opportunity to balloon into more serious issues. The immediate and decisive action of Mn/DOT in addressing some of these challenges provided final mitigation of many issues in a timely manner.

- Although it was not one of Mn/DOT's stated goals for implementing MnPASS, some pre-deployment promotions implied an increase in carpool usage – an impact observed in an evaluation of the I-15 HOT lane project in California – as a possible outcome of the MnPASS deployment. These statements may have inadvertently set unrealistic expectations on the possible benefits of the eventual deployment among some stakeholders. Caution should be used in making similar claims not directly tied to the stated project goals.

- Inherent difficulty in collecting data on personal auto occupancies, combined with a lack of historical data and a change in the daily time periods in which HOV restrictions were enforced, served to limit the preciseness in which impacts to carpool volumes could be evaluated in this study. It is recommended that any future expansion of the MnPASS system carefully consider and monitor these potential impacts. Auto occupancy data collected in this evaluation should provide valuable input to any future assessment.

- The involvement of a diverse set of stakeholders, including local transportation system operators, transit operators, lawmakers, and particularly the public, was a critical component to success of the I-394 MnPASS deployment. Similar outreach and involvement are recommended for any future involvement.

These lessons learned and recommendations are provided to Minnesota stakeholders considering the expansion of MnPASS to other state corridors, as well as other regions looking to the I-394 MnPASS deployment for advice on the applicability of HOT lane strategies in the their own regions.

Additional information on the MnPASS I-394 deployment and the associated evaluation effort is available on Mn/DOT's MnPASS web site at: http://www.mnpass.org/.

1.0 Introduction

1.0 Introduction

1.1 Overview

On May 16th, 2005, Mn/DOT started operation of the State's first application of HOT lanes on a segment of the Interstate 394 (I-394) corridor in the Minneapolis/St. Paul region. This system, known locally as MnPASS, represents the first deployment of HOT lane strategies in Minnesota and one of the first in the United States that dynamically adjusts pricing levels in response to varying traffic conditions.

Recognizing the use of the I-394 MnPASS deployment as a test bed for evaluating the viability of the HOT lane concept and the broad interest in the application, Mn/DOT implemented a comprehensive evaluation effort to assess the system. Two different teams were subsequently contracted by Mn/DOT to evaluate different aspects of the I-394 MnPASS deployment. The Attitudinal Evaluation Team, headed by the University of Minnesota's Humphrey Institute State and Local Policy Program supported by NuStats, Inc., was charged with collecting and analyzing the public's perceptions regarding the MnPASS system. The Technical Evaluation Team was managed by Cambridge Systematics, Inc. and supported by Short-Elliott-Hendrickson and LJR, Inc. This team was tasked with collecting and analyzing data regarding the ability of the MnPASS system to achieve the stated project goals, and to evaluate other performance impacts observed in the corridor.

This Evaluation Report focuses specifically on the technical evaluation effort and summarizes the methodology and findings of this particular effort.

1.2 Evaluation Report Structure

This Evaluation Report summarizes the technical evaluation approach, as first developed and presented in the Technical Evaluation Test Plan (March 2005) and presents the findings resulting from the implementation of the approach. This document is structured as follows:

- **Section 2.0 – Project Background –** Provides an overview and history of the I-394 MnPASS deployment, as well as the various associated evaluation efforts;
- **Section 3.0 – Evaluation Goals and Objectives –** Contains the identified goals of the evaluation effort and presents specific the hypotheses to be tested for each of the evaluation objectives;

- **Section 4.0 – Evaluation Approach –** Provides an overview of the evaluation approach, as well as detail on the collection and analysis of data related to the various performance measures;

- **Section 5.0 – Corridor Impact Findings –** Details the findings from the assessment of various corridor impacts, including vehicle and person volumes, travel speeds, mode split, violations, and safety;

- **Section 6.0 – System Performance Findings –** Summarizes the assessment of system performance issues, including revenue, system reliability, enforcement, and transit operations; and

- **Section 7.0 – Summary and Conclusions –** Summarizes the significant findings from the evaluation effort and provides a high-level assessment of the applicability of MnPASS strategies to other regional corridors.

2.0 Project Background

2.0 Project Background

2.1 I-394 MnPASS Project Background

Interstate 394 (I-394) serves as the primary east/west corridor for travel between downtown Minneapolis and the I-494 beltway, and the western suburbs. Figure 2.1 shows the location of the corridor and its environs. The roadway in its current six-lane configuration opened to traffic in October 1992. Unique within the Twin Cities region, the facility also has two reversible, barrier-separated HOV lanes located in the center median between I-94 and TH 100. Historically, these lanes were open only to bus and carpools with two or more passengers in the inbound (eastbound) direction from 6:00 a.m. to 1:00 p.m., and open in the outbound (westbound) direction from 2:00 p.m. to midnight on weekdays. These lanes were also opened to buses and HOV traffic on a limited basis on weekends, usually in support of special event traffic. The lanes were closed at all other times. This portion of the I-394 HOV corridor is referenced as the *reversible lane* section in the remainder of this document.

West of TH 100, the facility was built with a single, non-barrier-separated HOV lane in each direction. Prior to the introduction of MnPASS, the HOV lanes were designated for use by carpools and transit vehicles during the morning commute period (6:00 a.m. to 9:00 a.m.) for the inbound direction, and during the afternoon commute period (3:00 p.m. to 6:00 p.m.) for the outbound direction. The HOV restrictions on this section of the corridor were only applied on weekdays, and the lane was available for use by all traffic for the remaining hours of the day. This portion of the I-394 HOV corridor is referenced as the *diamond lane* section in the remainder of this document.

The I-394 HOV corridor is supported by an active regional HOV program, including park-and-ride parking lots along I-394, preferential access to downtown parking garages for HOV vehicles, and parking subsidies.

The I-394 freeway has historically been well utilized and often experiences congestion, particularly during the commute hours. While HOV demand in the corridor has been robust, it was often less than the available capacity resulting in the perception among some residents that the HOV lanes were underutilized. As a result of this perception, Mn/DOT was directed by the Legislature in 2000 to evaluate various options for increasing the utilization of the HOV facilities, including opening the HOV lane to use by all vehicles and the conversion to a HOT lane operation.

Figure 2.1 I-394 Corridor and Environs

Based on the results of this study, the Minnesota Legislature enacted High-Occupancy Toll Lane Legislation (160.93, Sec. 7) in 2003, authorizing Mn/DOT to implement user fees on HOV lanes in Minnesota. Highlights of the legislation were as follows:

- The goal of the legislation is to improve the operating efficiency in trunk highway corridors and provide more options to travelers;
- Fees will be collected electronically or by other methods, which may vary in amount by time of day and may vary with congestion;
- Fees collected will be used to repay the trunk highway fund or other fund sources for cost of equipment and modification in the corridor and to pay for the costs of implementing and administering the fee collection system;
- Excess revenues shall be spent as follows: one-half for capital improvements in the corridor and one-half transferred to the Metropolitan Council for expansion and improvement of bus transit services in the corridor in which the funds are collected; and
- Violators will be guilty of a petty misdemeanor.

An Implementation Team, headed by Wilbur Smith Associates, Inc., was selected by Mn/DOT to design and deploy HOT lane strategies and technologies, known locally as MnPASS, in the I-394 corridor. In addition to improving travel conditions in the I-394 corridor, the implementation of the HOT lane strategies was also intended to serve as a test

bed for evaluating the expanded use of the HOT land concept in additional corridors. Mn/DOT directed the Implementation Team to design and deploy a HOT lane system that met five project objectives:

1. Improve the efficiency of I-394 by increasing the number of people and vehicles using the HOV lanes;

2. Maintain free-flow speeds for transit and carpools in the express (HOV) lanes;

3. Use excess revenues, if available, to make transit and highway improvements in the I-394 corridor;

4. Use electronic toll collection (i.e., tags/transponders and readers) which do not require toll booths; and

5. Employ new Intelligent Transportation System (ITS) technologies, such as dynamic pricing and in-vehicle electronic enforcement.

Summary of the I-394 MnPASS Concept

The MnPASS system made operational on May 16th, 2005, allowed single-occupancy vehicles to use the HOV (MnPASS) lanes by electing to pay a toll. The actual price of the toll (ranging from $0.25 to $8.00 U.S.) varies with the current congestion levels and with the distance traveled – a different toll is paid, whether the MnPASS subscriber chooses to travel on the reversible section, the diamond lane section, or both. The price of the toll is advertised through the use of DMS placed at strategic locations throughout the corridor, and the toll is paid electronically through a user-obtained transponder positioned within the vehicle.

All vehicles previously eligible to use the HOV lanes, including public transit vehicles, carpools, and motorcycles, are still able to use the MnPASS lanes free of charge; however, access and egress to/from the MnPASS lane in the diamond lane section are now limited to specific entry and exit merge areas. As originally developed and implemented, the MnPASS system was intended to operate 24/7; however, due to some residents' concerns regarding new restrictions on SOV use of the lanes during non-peak hours and in the non-peak direction, operational hours were modified to a slightly expanded approximation of the previous operational hours and direction of HOV lane restrictions. The current operational hours for the MnPASS lane in the diamond section are 6:00 a.m. to 10:00 a.m. for the inbound direction (an addition of 1 hour of morning commute period HOV restrictions compared with historical hours), and 2:00 p.m. to 7:00 p.m. for the outbound direction (an addition of 2 hours of afternoon commute period HOV restrictions compared with historical hours). These operational hour modifications were implemented approximately 1 month after the opening of the MnPASS system.

The unexpected congestion that was observed in the off-peak direction during the initial month of MnPASS operations also prompted Mn/DOT to fast-track the planned construction of an auxiliary lane on a segment of the westbound direction of I-394. Although

not directly related to the MnPASS deployment, this addition did have the effect of impacting traffic patterns in the corridor, both on a short-term basis during the construction of the lane, as well as on a longer-term basis due to the additional capacity provided by the lane once it was opened. This auxiliary lane was opened to traffic in November 2005.

Another significant MnPASS operational change implemented by Mn/DOT was a modification to the toll rate scale that was applied for different congestion levels. Although the range of possible tolls remained unchanged, this modification typically resulted in higher average tolls being applied as the increases in toll levels were triggered by lower congestion levels. This change to the pricing algorithm was implemented in January, 2006.

More information on the actual deployment concept can be found on Mn/DOT's MnPASS web site: http://www.mnpass.org/.

2.2 Evaluation Background

Recognizing the use of the I-394 MnPASS deployment as a test bed for evaluating the viability of the HOT lane concept and the broad interest in the application, Mn/DOT implemented a comprehensive evaluation effort to assess the system. The evaluation effort was initiated in April 2004, when representatives from a broad range of stakeholder agencies and organizations were invited to participate in an evaluation workshop. The purpose of this meeting was to identify the preliminary goals and objectives for the evaluation effort. Agencies and organizations represented at this initial evaluation summit included:

- Mn/DOT;
- Federal Highway Administration (FHWA);
- Metro Transit;
- University of Minnesota's Humphrey Institute State and Local Policy Program;
- Center for Transportation Studies;
- Department of Public Safety;
- Members of the MnPASS Implementation Team, including Wilbur Smith and SRF; and
- Additional researchers involved with previous HOT lane evaluations, including California Polytechnic State University and San Diego State University.

Two different teams were subsequently contracted by Mn/DOT to evaluate different aspects of the MnPASS I-394 deployment. The *Attitudinal Evaluation Team*, headed by the

University of Minnesota's Humphrey Institute State and Local Policy Program supported by NuStats, Inc., was charged with collecting and analyzing the public's perceptions regarding the MnPASS system. These perceptions were compiled through several waves of telephone surveys with residents, both before and after the MnPASS implementation.

The *Technical Evaluation Team* was managed by Cambridge Systematics, Inc., and supported by Short-Elliott-Hendrickson, Inc. and LJR, Inc. This team was tasked with collecting and analyzing data regarding the ability of the MnPASS system to achieve the stated project goals, and evaluating other performance impacts observed in the corridor.

The two teams coordinated their evaluation activities, with the assistance of Mn/DOT and a Steering Committee comprised of local agency representatives, to ensure the consistent and comprehensive assessment of the I-394 deployment. The two evaluation teams participated in numerous strategy meetings and teleconferences in the conduct of their respective efforts, and jointly presented updates and preliminary findings to the public as part of several I-394 MnPASS workshops conducted on the University of Minnesota campus.

This document, however, only focuses on the details of the Technical Evaluation of the I-394 MnPASS deployment, and does not include typically include findings from the Attitudinal Evaluation, except where there are notable overlaps between the two evaluations. More information specifically related to the Attitudinal Evaluation can be located on the MnPASS web site when finalized: http://www.mnpass.org/.

3.0 Evaluation Goals and Objectives

3.0 Evaluation Goals and Objectives

3.1 Evaluation Goals

Several broad evaluation goals were identified to help provide a framework for structuring the evaluation. These goals include:

- Provide Mn/DOT with an assessment of the success of the MnPASS I-394 HOT lane implementation in relation to the stated project goals, including:
  - Improve the efficiency of I-394 by increasing the number of people and vehicles using the HOV lanes;
  - Maintain free-flow speeds for transit and carpools in the express lanes;
  - Use excess revenues, if available, to make transit and highway improvements in the I-394 corridor;
  - Use electronic toll collection (i.e., tags/transponders and readers), which do not require toll booths; and
  - Employ new ITS technologies such as dynamic pricing and in-vehicle electronic enforcement.
- Provide the public and decision-makers with valuable information on the observed impacts of the system.
- Provide Mn/DOT and the MnPASS Implementation Team with feedback on the performance of the system.
- Help to support the evaluation of public perceptions through coordination with the Attitudinal Evaluation Team.
- Provide a solid foundation for any future decisions regarding potential expansion of the system.
- Provide a reproducible evaluation framework that can be used by Mn/DOT or researchers in the future to continue to monitor and evaluate the I-394 MnPASS deployment.

3.2 Evaluation Objectives and Hypotheses

A preliminary set of evaluation objectives that help support and provide a valid assessment of the MnPASS project goals were identified during the initial MnPASS Evaluation Workshop conducted in April 2004. Subsequent input and comments received from various stakeholders were used by the Evaluation Team to identify a set of primary and secondary evaluation objectives that were summarized in a Draft Technical Memorandum in December 2004. Comments were received on the objectives presented in the Draft Technical Memorandum from the I-394 MnPASS Steering Committee and other stakeholders. These comments were used to develop the final set of evaluation objectives presented in the *Evaluation Test Plan* (March 2005).

These identified evaluation objectives were designed to provide Mn/DOT with an assessment of the success of the I-394 MnPASS HOT lane implementation in relation to the stated MnPASS project goals. Additionally, several specific evaluation objectives were identified that provide the opportunity to assess broader potential impacts (both positive and negative) of the MnPASS implementation. For example, an improvement of safety on I-394 is not a stated goal of the MnPASS project as the implementation is presumed to have a neutral impact on safety.

For each of the identified objectives, one or more hypotheses were formulated to test the success of the project in achieving the objective. These hypotheses may predict an impact positive direction, such as "vehicle throughput will be increased in the corridor," or may be neutral in predicting an impact, such as "the number of crashes in the corridor will not increase." Other goals typically assessed by documenting observed occurrences of an event (e.g., the number of HOV violations issued by law enforcement) did not have specific hypotheses developed. Table 3.1 presents the evaluation hypotheses, mapped to the relevant MnPASS project goals.

The subsequent section describes the evaluation approach used to collect and analyze the necessary data to assess the ability of the MnPASS system to achieve the identified goals.

Table 3.1 I-394 MnPASS Project Goals and Evaluation Hypotheses

	Evaluation Hypotheses
MnPASS Goals	
• Improve efficiency of I-394	• MnPASS deployment will result in an increase in vehicle throughput in the corridor • MnPASS deployment will result in an increase in person throughput in the corridor • MnPASS deployment will result in an increase in vehicle speeds in the general purpose lanes • MnPASS deployment will result in a decrease in average person travel time in the corridor
• Maintain free-flow speeds for transit and carpools	• MnPASS deployment will not result in a decrease in vehicle speeds in the HOV/HOT lanes • MnPASS deployment will not result in an increase in travel time for transit vehicles • MnPASS deployment will not result in an increase in vehicle speed variability in the HOV/HOT lanes • MnPASS deployment will not result in a change in mode share in the corridor • MnPASS deployment will not result in an increase in illegal SOV usage of the HOV/HOT lanes
• Improve highway and transit in corridor with revenue generated	• Documented planned improvements • Documented MnPASS revenues
• Use electronic toll collection (i.e., tags/transponders and readers) that do not require toll booths • Employ new ITS technologies, such as dynamic pricing and in-vehicle electronic enforcement • Employ new electronic toll collection and ITS technologies	• Documented system downtime • Documented system error rates • Documented MnPASS revenues

Table 3.1 I-394 MnPASS Project Goals and Evaluation Hypotheses (continued)

	Evaluation Hypotheses
Additional Evaluation Areas	
• Assess safety impacts	• MnPASS deployment will not result in an increase in the number of crashes occurring in the corridor • MnPASS deployment will not result in an increase in crash rate in the corridor • MnPASS deployment will result in a decrease in the speed differential between HOV/HOT lanes and general purpose lanes
• Assess enforcement issues	• MnPASS deployment will not result in an increase in illegal SOV usage of the HOV/HOT lanes • Documented number of issued HOV lane violations • Documented number of issued double-line crossing violations
• Assess impacts to adjacent bottleneck locations (Lowry Tunnel, ramps to TAD garages)	• MnPASS deployment will not result in an increase in vehicle throughput at the bottleneck locations
• Assess environmental impacts	• MnPASS deployment will not result in an increase in corridor noise levels • MnPASS deployment will not result in an increase in corridor emissions (CO) levels

4.0 Evaluation Approach

4.0 Evaluation Approach

4.1 Overview of the Evaluation Approach

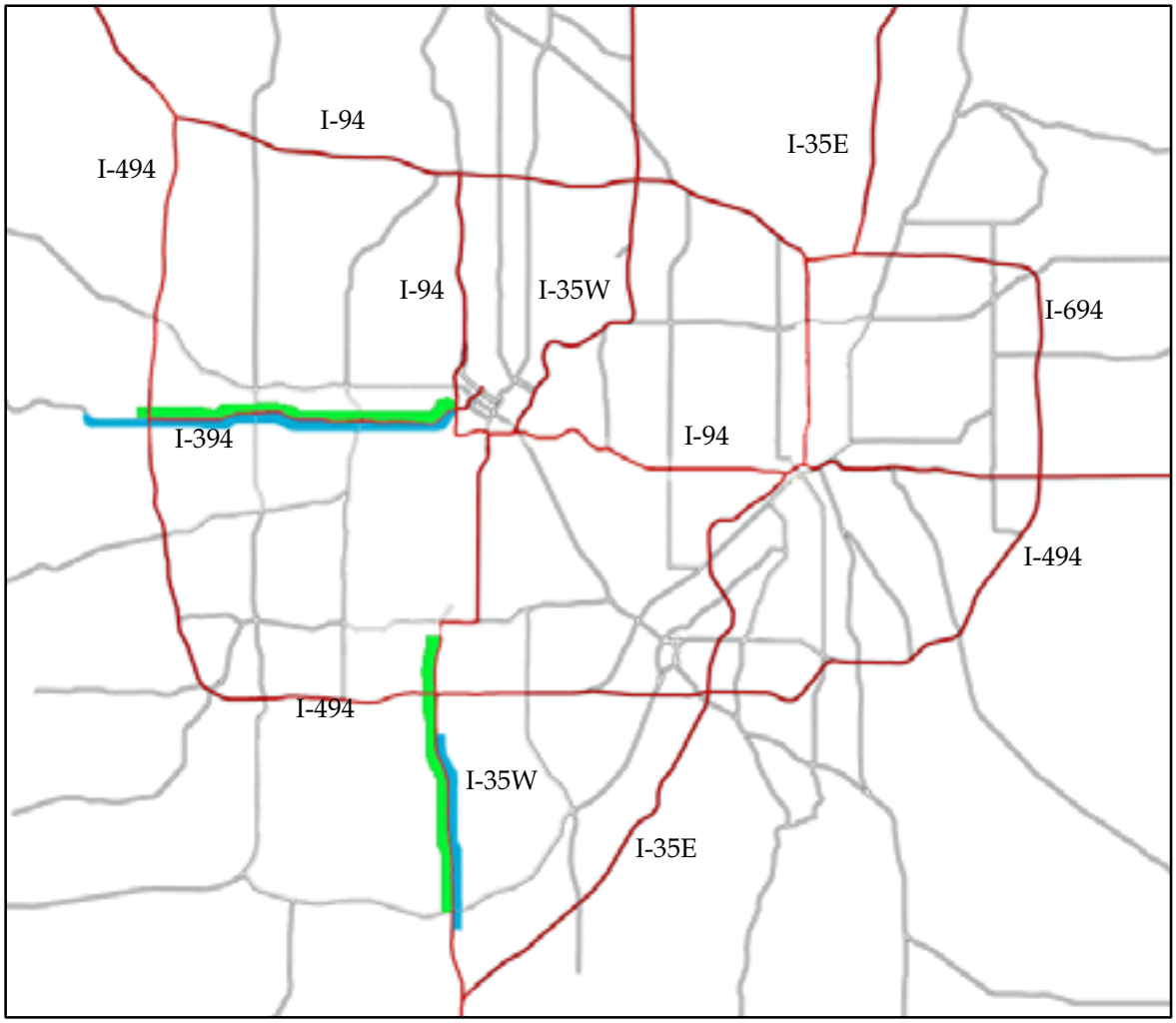
Given the dynamic nature of the traffic conditions on I-394, observed traffic patterns in the before and after periods were not anticipated to be identical even in the absence of the MnPASS deployment. Therefore, the evaluation approach was specifically designed to anticipate and control for these influencing factors, to the degree possible, in order to isolate the change in conditions directly resulting from the MnPASS strategy.

In order to isolate the impact of the MnPASS deployment, the evaluation approach was designed to analyze data collected over broad time periods both before and after the implementation to provide a wide sampling of travel conditions under a variety of influencing factors. This provides the opportunity to group and compare conditions on similar travel days both before and after the implementation, and minimizes the erroneous identification of MnPASS impacts based on averages from a limited sampling on diverse travel days. This also provides the opportunity to assess how the impacts of the MnPASS system vary based on different conditions (e.g., good weather days vs. bad weather days, Tuesdays versus Fridays, etc.) in order to provide Mn/DOT with valuable feedback on when and under which conditions the system is more or less effective.

To accomplish this, the evaluation approach was designed to make maximum use of automated data sources. The use of these automated archived data sources also provided the opportunity to obtain historical data in many cases that was further used to understand and control for cyclical variations and trends. Field data collection was used to supplement the automated data by collecting particular parameters that were unavailable through automated sources (e.g., vehicle occupancies), and was used to provide validation data for the automated sources. The reliance on these automated data sources allowed for a broader set of evaluation objectives, and provided the opportunity analyze the variability of impacts occurring over a longer time period and for a greater variety of days. This also increases the opportunity for Mn/DOT and other researchers to recreate the evaluation framework for future monitoring and evaluation efforts.

To further help control for regional changes in travel patterns, the evaluation compiled and analyzed both before and after data from a similar HOV lane equipped section of the I-35W corridor to provide control data. Figure 4.1 shows the location of the I-35W HOV control section in relation with I-394. Any changes observed on the I-35W HOV section between the before and after periods were used to represent and control for regional changes to travel patterns when analyzing the I-394 data. A by-product of this analysis was the identification of several performance measures on the I-35W HOV section.

Figure 4.1 Location of I-35W HOV Control Section in Relation to I-394



4.2 Evaluation Challenges

The implementation of MnPASS resulted in the addition of new procedures and influencing variables (e.g., toll price) to what was already a dynamic operational environment. Travel conditions on I-394 prior to MnPASS were observed to vary significantly due to cyclical patterns, including:

- Time of day;
- Day of week; and
- Month of year.

Travel conditions on I-394 were also often impacted by other less predictable factors, such as:

- Vehicle crashes and breakdowns;
- Inclement weather conditions;
- Special events; and
- Enforcement activities.

In addition to these existing factors, the evaluation team was also challenged by the dynamic nature of the MnPASS deployment itself. The tolls charged are constantly changing in response to traffic levels, complicating the comparison of traveler responses on different days. Further, the number of MnPASS subscribers has increased over time, meaning that more individuals were eligible to use the MnPASS lanes near the end of the evaluation period than during the initial months following MnPASS implementation.

One of the most significant challenges encountered by the evaluation team was the modification of the MnPASS operational hours implemented approximately one month following the implementation of the strategy. As originally envisioned and implemented, the MnPASS system was intended to operate 24/7; however, due to some residents' concerns regarding new restrictions on SOV use of the lanes during non-peak hours and in the non-peak direction, operational hours were modified to a slightly expanded approximation of the previous operational hours and direction of HOV lane restrictions. Following the modification, the operational hours for the MnPASS lane in the diamond section were 6:00 a.m. to 10:00 a.m. for the inbound direction (an addition of 1 hour of morning commute period HOV restrictions compared with historical hours), and 2:00 p.m. to 7:00 p.m. for the outbound direction (an addition of 2 hours of afternoon commute period HOV restrictions compared with historical hours). These operational hour modifications were implemented following the development of the Evaluation Plan, which was developed under the assumption that the system would be operated on a 24/7 basis. This modification impacted the relevancy of some of the previously collected before data, particularly some vehicle occupancy data, as discussed in Section 5.0.

An additional challenge resulting from changes to the operating parameters was a modification to the toll rate scale that was applied for different congestion levels. Although the range of possible tolls remained unchanged, this modification typically resulted in higher average tolls being at lower congestion levels. This change to the pricing algorithm was implemented in January 2006.

During the course of the evaluation period, several changes external to the MnPASS implementation were observed in the corridor that potentially impacted travel patterns. Although unrelated to the MnPASS deployment, these external factors presented challenges to the evaluation team since they needed to be controlled in the analysis of data in order to isolate the specific impacts of the MnPASS system. Some of the significant external challenges faced in the evaluation included the following:

- Unexpected congestion levels were observed in the off-peak direction, prompting Mn/DOT to fast-track the construction of an auxiliary lane on a segment of the

westbound direction of I-394 from TH 100 to TH 169. This addition impacted traffic patterns, both from the construction of the lane as well as through the additional capacity represented by the lane once it was opened. Construction of this auxiliary lane occurred between July and November 2005.

- Construction-related activities closed several freeway ramps connecting I-494 with I-394, temporarily diverting traffic patterns. This closure impacted traffic during September and October 2005.

- Changes in transit service and a fare increase were implemented in the corridor and regionwide.

- Gasoline prices reached all time highs in the region during the evaluation period, increasing from approximately $1.95 a gallon at the time of MnPASS opening (May 2005) to over $3.00 a gallon by July 2006.

The Evaluation Test Plan developed in March 2005 was designed to be flexible to allow the evaluation approach to adapt to unforeseen changes in the MnPASS deployment and the corridor environment. Modifications to the approach were implemented to adjust to these changes as they were observed. Strategies in the Evaluation Test Plan that specified the long-term collection of data from automated sources and the collection and analysis of data on the I-35W control corridor were both key to controlling for unforeseen changes and overcoming many of these challenges.

4.3 Data Collection and Analysis Approach

The following sections describe the methods employed to collect and analyze the required data in order to support the assessment of key evaluation objectives and hypotheses identified in Section 3.0. In addition to the data collection efforts discussed below, Mn/DOT had compiled significant data sets on the baseline performance of I-394 prior to the selection of the Evaluation Team in October 2004. These data were collected in anticipation of the evaluation effort and includes vehicle and occupancy counts, travel time data, and transit ridership data. The data was collected during May and June 2004 and includes data for both the I-394 and I-35W control corridors. Discussions of how this initial data set was used are incorporated into the discussions below.

Vehicle Volumes

Vehicle volumes were collected from Mn/DOT's Regional Transportation Management Center (RTMC) detector data. The I-394 roadway is well saturated with detector stations located throughout the length of the study section. These were used to provide a nearly continuous source of data on vehicle volumes for a period stretching from January 1, 2003 to July 15, 2006. Data were collected from all detectors located within the I-394 MnPASS

section, as well as the I-35W HOV section. Data from selected detector stations upstream and downstream of I-394 were also collected to monitor vehicle volumes at adjacent bottleneck locations. Baseline detector data were compiled and cleaned for all available days and time periods from July 15, 2003 though the MnPASS opening date. Similar data were compiled from the opening date until approximately July 15, 2006 to represent the after conditions.[1] The data were grouped and statistically analyzed to assess any meaningful changes in the lane volumes occurring during hours of MnPASS operation.

Data from each detector station is recorded every 30 seconds, but was compiled to five-minute increments for analysis. In order to provide the ability to analyze variations in the traffic volumes in relation to various influencing factors, data flags were added to the data (in addition to the time/date stamp) to indicate:

- Day-of-week (Monday, Tuesday/Wednesday/Thursday, Friday, Weekend/Holiday)[2];
- Days with inclement weather (e.g., snow/ice); and
- Presence of incidents on the roadway during the time period.

The collected data were segregated into different datasets based on the influencing factors. These various datasets were then statistically analyzed to identify the impacts of the various influencing factors on vehicle volumes. Datasets representing travel periods from identical months of year and with similar influencing factors from the baseline (before) period were compared with similar datasets from the post-implementation (after) period to identify any observed changes in vehicle volume in the I-394 corridor in excess of relative changes in volume observed on the control I-35W HOV section.

Vehicle Speeds

Vehicle speed data for the MnPASS lanes and the general purpose lanes were obtained from the RTMC detector stations following a similar collection and analysis approach to that presented for vehicle volumes. Vehicle speed data, as derived from detector density data, was analyzed separately for the general purpose and MnPASS lanes based on the recorded influencing factors.

Vehicle speeds obtained from corridor detectors are routinely used for making operational decisions and has proved to be reliable in several previous evaluation efforts. Mn/DOT maintains an aggressive maintenance and testing effort to ensure that the detectors are

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[1] New detector stations were added to I-394 due to the MnPASS deployment. These new detectors are better positioned to collect data in the HOV lanes following the reconfiguration of the lanes. The data analysis was structured to account for these changes.

[2] Data from Tuesdays, Wednesdays, and Thursdays were grouped together since these days exhibit similar traffic patterns. These patterns are different than those typically observed on Mondays and Fridays.

calibrated and continually tested against free-flow speed data collected from either laser gun measurement or an actual vehicle speedometer. On a weekly basis, this field value is compared to calculated speeds from each loop detector. Data for this is taken during the midday (10:00 a.m. to 2:00 p.m.), and the median speed from each day (in five-minute increments) is calculated. The calculation for speed (see below) from loop detectors includes the average effective vehicle length (average vehicle length plus loop detector field length). If the comparison of field speed to calculated loop detector speed for a particular detector location results in a value with a difference greater than 10 percent of the field value, the detector is recalibrated by adjusting the average effective vehicle length value that is stored for that detector until the speed values more closely match. This calibration procedure allows the detector data to be continually adjusted to changing variables, such as the truck mixture traveling the roadway. This calibration was originally begun in order to calculate traffic densities for ramp metering, but has since further allowed the estimation of travel times, which are displayed on variable message signs for the public on various corridors in the region. The formula for calculating speed from the detector data is:

Speed = (Hourly Traffic Flow * Average Effective Vehicle Length)/
(5,280 feet/mile * Occupancy)

The analysis of speed data also included a focused analysis of the speed difference observed between the general purpose and MnPASS lanes.

Vehicle Occupancy

There is currently no valid approach to collect and analyze data on vehicle occupancies using continuous, automated sources. Therefore, manual field data collection was used to collect data on auto occupancies and person throughput in the baseline data collection effort conducted by Mn/DOT in May and June 2004. This data was collected by either videotaping or direct manual observation of the traffic lanes at three overpass locations: Penn Avenue, Louisiana Avenue, and Shelard Parkway. The videotaped data was later watched by personnel who tallied the occupancies. Auto occupancy data was collected for the HOV lane, as well as for one representative general purpose lane at each location. Data was collected during each of the a.m. (6:00 to 9:00 a.m.), p.m. (3:00 to 6:00 p.m.), and off-peak periods (11:00 a.m. to 1:00 p.m.) over a two-day period. These data collection periods were selected based on previous studies and on the assumption that the MnPASS system would be operated on a 24/7 basis. Similar data was collected during a one-day period on the I-35W HOV section at TH 13 and 96th Street. This baseline data was supplemented with throughput data collected in an April 2001 Mn/DOT study of HOV operations.[3]

[3] Minnesota DOT, *Twin Cities HOV Study – Final Report*, February 2002.

Data on auto occupancies was collected using direct manual observation in the post-deployment period at the same observation locations. Data was collected during two different efforts – the first during October 6 to 11, 2005; and the second during May 9 to 10, 2006. The data collection was structured to collect data during the revised hours of MnPASS lane operation (6:00 a.m. to 10:00 a.m. for the inbound direction, and 2:00 p.m. to 7:00 p.m. for the outbound direction), plus hours on the shoulders of the operational period when possible.[4]

Occupancy data from the before period were compared with data from the after period to identify any changes in mode shares for SOVs or carpoolers. This occupancy data was also used to evaluate changes in SOV violation rates in the MnPASS lane, in comparison with violation rates before implementation and with those observed on the I-35W HOV section. Violation rates in the post-deployment period were estimated by subtracting the valid number of transponder reads (representing paying MnPASS users) from the total number of SOV users observed in the MnPASS lane during the manual occupancy count period. Data was collected directly from the MnPASS system covering the number of valid MnPASS users for selected periods to help support this analysis.

Crash Occurrence

The number of crashes by severity was obtained from the State of Minnesota's Department of Public Safety's accident database representing all recorded crashes on I-394 for the period from January 1, 2003 to July 15, 2006. This database contains records of all crash reports occurring on State highways compiled from Minnesota Highway Patrol and other local jurisdictions.

The crash data was filtered to only include those crashes occurring during the time period of 5:00 a.m. to 8:00 p.m. on weekdays in recognition that the deployment of MnPASS would be unlikely to impact the number of crashes occurring at night or on weekends. The number of crashes occurring in identical calendar periods before and after MnPASS deployment was analyzed to identify any changes in the number or severity of crashes occurring on I-394 that differ from those experienced on the I-35W HOV section.

Incident Occurrence

The occurrence of incidents in the corridor was obtained from the RTMC's incident log. This information was incorporated with the data provided by the corridor detectors to provide the ability to aggregate and analyze separately those periods effected by incident occurrence.

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[4] The reduced hours of available daylight during the October 2005 data collection prohibited the accurate collection of vehicle occupancy data prior to 7:30 a.m. or after 6:30 p.m.

Noise Impacts

Noise data were collected and analyzed by the Mn/DOT Office of Environmental Services. Data on roadway noise levels were collected from field sensors temporarily deployed at several strategic locations adjacent to the roadway. This noise data was collected in close coordination with several detailed vehicle counts, documenting the number and type of vehicles using the roadway. This data was collected prior to the opening of the MnPASS lanes to provide an assessment of pre-implementation noise levels. Field noise data collection was again collected after the implementation.

Emissions Impacts

Emissions data were also collected and analyzed by the Mn/DOT Office of Environmental Services. Data on emissions (CO) levels were collected from both existing and newly deployed emissions sensing stations deployed at several strategic locations near the roadway. This data was collected prior to the opening of the MnPASS lanes to provide an assessment of pre-implementation emissions levels. This pre-implementation data was supplemented by historical emissions data from existing sensor stations located in the corridor. Field monitoring of emissions levels was again collected after the implementation of MnPASS.

Enforcement Data

A data collection form was developed and included with the *MnPASS Enforcement Plan* to collect enforcement related data for the evaluation. This form was routinely filled out by enforcement officers detailing the number and type of violation tickets issued during an enforcement shift. Enforcement activities which were documented include HOV violations (solo drivers traveling in the MnPASS lane without a valid transponder) and violations for crossing the double-white line serving as the barrier for the MnPASS lane in the diamond lane section. These enforcement measures were quantified and documented in for inclusion in this report; however, no statistical comparisons of the before and after conditions were conducted due to the absence of comparable data representing the pre-MnPASS period.

MnPASS System Performance

Data regarding the performance of the MnPASS system components (e.g., system downtime, error rates, etc.) was provided to the evaluation team by Cofiroute, the Mn/DOT contracted administrator of MnPASS operations. Data obtained from Cofiroute included:

- Number of transponders (accounts) issued;
- Usage statistics;

- Prices charged; and
- Number of valid transponder reads.

MnPASS System Revenues

Documentation of daily, weekly, and quarterly revenue was compiled by Cofiroute and supplied to the evaluation team. This data was used to track and document revenue trends.

Transit Operational Impacts

Transit providers represented a valuable source of information for this analysis. Transit operations occur on a nearly continuous basis in the corridor, and transit vehicle drivers have a first-hand, windshield view of corridor operations. With the coordination of the transit agencies, interviews were conducted with the supervisors who are responsible for overseeing the operation of transit routes utilizing I-394. These supervisors were asked to identify any noted impacts to transit operations resulting from MnPASS implementation. Although subjective, this information provided valuable insight into the perceptions of transit operators on the impacts of the MnPASS implementation on transit operations.

5.0 Corridor Impact Findings

5.0 Corridor Impact Findings

The evaluation of the MnPASS system was designed to monitor the performance of the deployed system over a period of time sufficiently long enough following deployment to allow travelers to adjust their travel patterns in response to the introduction of the strategy. Automated data sources were archived and were supplemented with several phases of field data collection. The first field data collection following the deployment was completed in fall 2005, with a second phase conducted in Spring 2006. This automated and manually collected data was used to assess the impacts of the MnPASS deployment on corridor performance related to several key hypotheses, as presented in Section 3.0.

The following sections detail the findings from the assessment of before and after conditions identifying the specific impacts of the MnPASS deployment on the I-394 corridor.

5.1 Observed Impacts to Volume/Throughput

Two primary hypotheses were developed and tested to gauge the potential impacts of MnPASS on corridor throughput. These hypotheses include the following:

- *MnPASS deployment will result in an increase in vehicle throughput in the corridor*; and
- *MnPASS deployment will result in an increase in person throughput in the corridor*.

The assessment of throughput impacts was largely based on corridor volume detector data assembled to represent one year of continuous volume data collected before the MnPASS deployment compared with one year of conditions compiled following the deployment. The analyzed data represents conditions observed for non-holiday weekdays during the periods of MnPASS peak period operations. The operational hours for the MnPASS lane in the diamond section at the time of the evaluation were 6:00 a.m. to 10:00 a.m. for the inbound direction (an addition of 1 hour of morning commute period HOV restrictions compared with historical hours), and 2:00 p.m. to 7:00 p.m. for the outbound direction (an addition of 2 hours of afternoon commute period HOV restrictions compared with historical hours). An accurate assessment of corridor volume impacts, particularly in the MnPASS lanes in the diamond lane sections, was made more difficult by the expansion of hours of HOV restrictions implemented following the change from the initial 24/7 operating hours. Comparing volumes on the diamond lane sections of MnPASS lanes during the current peak operational hours with the identical period from before MnPASS was implemented was difficult due to the fact that the lanes were open to general purpose traffic during one extra hour in the eastbound direction in the morning peak, and an extra two hours in the westbound direction during the afternoon peak.

Further, an assessment of regional conditions revealed that peak hour volumes have decreased slightly (2 percent) regionwide when compared with previous years, likely due to increased fuel prices and other factors. Transit ridership has reportedly increased significantly during this same period. This regionwide impact was obtained by collecting and analyzing traffic data from a similarly HOV segment of the I-35W corridor that was not equipped with MnPASS.

Against this backdrop of regionally decreasing travel demand, the analysis showed that traffic volumes on the newly implemented I-394 MnPASS lanes increased substantially, varying from 9 to 13 percent during the peak hours. Overall traffic volumes (MnPASS lane plus general purpose lanes) were observed to increase more modestly by up to 5 percent in the peak hour. The increase in throughput during the most congested hour of the peak verifies that MnPASS is providing a more effective utilization of the corridor capacity. The overall traffic increases observed suggest that drivers that were previously squeezed out of the peak commute hour by congestion may now be returning.

When all of the hours of MnPASS operation were considered, locations in the reversible section showed large volume increases. The number of vehicles using the MnPASS lane at Penn Avenue was observed to increase by over 30 percent in the eastbound direction during the morning peak period (6:00 a.m. to 10:00 a.m.) and over 14 percent in the westbound direction during the afternoon peak period (2:00 p.m. to 7:00 p.m.).

The findings from the throughput analysis of diamond lane locations during the entire MnPASS operational periods were more mixed. Those locations immediately upstream or downstream from the reversible section showed significant positive volume gains in the MnPASS lane. For example, MnPASS lane volumes recorded at Xenia averaged over 27 percent higher in the morning inbound direction and over 15 percent higher in the afternoon outbound direction. Meanwhile, the general purpose lanes observed a slight decrease in volumes (less than 3 percent). Total roadway volumes (MnPASS lane plus general purpose lanes) were observed to increase slightly during those periods.

Other locations on I-394 diamond lane sections observed slight decreases in the MnPASS lane volumes when evaluated over the entire operational period. This is due to the expansion of HOV requirements into additional hours under the after conditions. This means that the analysis of volumes on the MnPASS lane during the fringe hours of the current operational period results in a comparison of the lane volumes with HOV restrictions under the current period with the before period conditions without HOV restrictions when the lane was open to all traffic during the same hour of the day. Under these pre-MnPASS conditions, the diamond lane sections would typically experience a large spike in volumes on the shoulders of the HOV restriction periods as SOV drivers would move to the HOV lane to take advantage of available capacity. Under the current operating periods, SOV drivers are not able to legally use these MnPASS lanes during these fringe periods unless they are MnPASS subscribers. This has resulted in reduced volumes in the MnPASS lanes during these fringe periods which have resulted in less positive or decreased MnPASS lane volumes when the entire operational period is included. These decreased volumes during the fringes of the operational period serve to offset the volume gains observed in the peak hour.

Overall roadway volumes (MnPASS lane plus general purpose lanes) for locations in the diamond lane section were observed to experience small changes in overall volume levels, both positive and negative, but many of these changes were not statistically significant when considered alongside the observed regional reduction in travel demand.

5.2 Observed Impacts on Speed and Travel Time

Five separate hypotheses were formulated to test the impact of MnPASS on travel speed and travel time. These hypotheses included:

- *MnPASS deployment will result in an increase in vehicle speeds in the general purpose lanes*;
- *MnPASS deployment will result in a decrease in average person travel time in the corridor*;
- *MnPASS deployment will not result in a decrease in vehicle speeds in the HOV/HOT lanes*;
- *MnPASS deployment will not result in an increase in travel time for transit vehicles*; and
- *MnPASS deployment will not result in an increase in vehicle speed variability in the HOV/ HOT lanes*.

Despite the observed increases in traffic volume in the MnPASS lanes, travel speeds in the lane(s) have not been negatively impacted as most locations experienced no change or a slight increase in travel speed. Table 5.1 presents the comparison of MnPASS lane speeds for the pre-MnPASS and with MnPASS periods. Only one study location, Xenia in the eastbound morning direction, observed any decrease in speed; however, this speed change was only statistically significant during a portion of the total operational period (approximately 6:30 a.m. to 7:45 a.m.). Based on this information, the pricing algorithm has been successful in maintaining speeds in the HOV/HOT lane with this minor exception.

Speeds in the general purpose lanes were observed to experience a slight increase following the implementation of MnPASS for all locations tested when compared with similar periods from previous years. Table 5.2 summarizes the speed changes observed in the general purpose lanes at selected locations along the I-394 corridor. Although statistically significant, caution should be applied in attributing all of the speed increase to the MnPASS implementation. In many locations, the speed increase in the general purpose lane was accompanied by a slight decrease in volumes (discussed in the previous section) that may also partially be responsible for the speed increase.

Table 5.1 Comparison of Pre- and Post-MnPASS I-394 Speeds in the MnPASS Lanes

Location/Direction	Pre-MnPASS	With MnPASS	Difference
Eastbound (AM Peak Period)			
I-494	71.1	71.2	0.1%
Ridgedale	66.7	69.4	4.0%
General Mills	63.1	65.2	3.4%
Xenia	62.3	60.8	-2.6%
Penn	66.8	67.1	0.6%
Westbound (PM Peak Period)			
Penn	67.7	67.9	0.2%
Xenia	57.2	57.2	0.0%
General Mills	62.3	64.3	3.1%
Ridgedale	66.3	68.6	3.4%
I-494*	N/A	N/A	N/A

* Speed data collected from the westbound detectors in the MnPASS lane at I-494 was deemed unreliable for analysis purposes.

Table 5.2 Comparison of Pre- and Post-MnPASS Average Speeds in the I-394 General Purpose Lanes

Location/Direction	Pre-MnPASS	With MnPASS	Difference
Eastbound (AM Peak Period)			
I-494	67.2	68.1	1.2%
Ridgedale	63.8	66.5	4.2%
General Mills	57.5	65.9	14.6%
Xenia	51.0	57.1	12.0%
Penn	55.1	57.1	3.7%
Westbound (PM Peak Period)			
Penn	53.8	59.6	10.7%
Xenia	43.8	47.6	8.6%
General Mills	70.9	72.2	1.8%
Ridgedale	60.6	63.1	4.0%
I-494	64.7	65.0	0.4%

Further analysis of the speed changes observed in the general purpose lanes on I-394 revealed that the relative increase in travel speed in the general purpose lanes (compared with speeds in previous years) is even greater on days with higher volumes (e.g., the relative speed change is greater on Tuesday through Thursdays when I-394 carries higher volumes than on Mondays and Fridays), or days when there were incidents occurring in the corridor (compared with similar incident days from the before period. This observed impact suggests that MnPASS is helping to mitigate the negative impacts on the worst travel days, and is effectively reducing speed and travel time variability in the corridor.

5.3 Observed Impacts on Occupancy and Violation Rates

Two key hypotheses were formulated to evaluate the impact of MnPASS on mode share and violation rates. These hypotheses included the following:

- *MnPASS deployment will not result in a change in mode share in the corridor*; and
- *MnPASS deployment will not result in an increase in illegal SOV usage of the HOV/HOT lanes.*

Vehicle Occupancy

The analysis on mode share, which particularly focused on potential impacts to the carpoolers who use the MnPASS lane free of charge, was conducted using a combination of automatic and manually collected data. Automated data included Mn/DOT detector data which provided vehicle volumes and MnPASS system data which included the tallies of valid MnPASS subscribers utilizing the MnPASS lane. Manually collected data included vehicle occupancy counts which were collected in October 2005 and May 2006. These snapshot occupancy counts were conducted by stationing observers on freeway overpasses where they observed and recorded the number of occupants in each vehicle. These occupancy counts were then compared with similar counts collected in both 2002 and 2004 prior to the implementation of MnPASS.

In conducting the evaluation of vehicle occupancy, one severe limitation was encountered by the evaluation team. Previous data collection efforts studying vehicle occupancies prior to the implementation of MnPASS had only been collected during the then current hours of operation of the HOV lanes (6:00 a.m. to 9:00 a.m. in the eastbound direction and 3:00 p.m. to 6:00 p.m. in the westbound direction). Various off-peak and non-peak direction counts were also collected in anticipation of 24/7 operation of MnPASS; however, no counts were taken in any previous studies that specifically captured the vehicle occupancies on the shoulders of the peak (i.e., the hours immediately preceding and following the previous hours of HOV restrictions in the corridor).

MnPASS was initially envisioned and implemented to operate on a 24/7 basis, but unforeseen congestion occurring in the off-peak direction resulted in scaled back operational

hours, which approximated the previous hours and directionality of the previous HOV only restrictions, but added one additional hour of HOV restrictions in the morning peak period and an additional two hours in the afternoon peak period. This modification provided carpoolers with an extra 3 hours a day (compared with pre-MnPASS conditions) which they could enjoy the benefits of lane restrictions.

In analyzing vehicle occupancies and violation rates in this evaluation, data representing post-MnPASS conditions was compared with pre-MnPASS conditions to identify any changes that occurred between the periods. Additionally, similar occupancy data collected on the non-MnPASS equipped I-35W corridor was also compared and analyzed to identify any regional trends that might be occurring independent of MnPASS. This before-and-after analysis was limited in the case of vehicle occupancy, however, due to the lack of occupancy data representing the pre-MnPASS shoulder periods of the previous HOV restriction periods. Therefore, the before and after occupancy analysis was limited to evaluating only those hours consistent with the previous HOV restrictions and does not take into account any occupancy impacts occurring on the newly expanded hours of HOV restrictions resulting from MnPASS deployment. It is suspected that some carpools have been able to adjust the timing of their trips to take advantage of this expanded window of travel opportunity on I-394, resulting in the spreading of trips out of the peak periods into the shoulders. The limitations in the data from the pre-MnPASS period does not allow for a direct quantification of this benefit, however.

Further complicating the assessment of any MnPASS related impacts on vehicle occupancies is an observed regional decrease in the number of carpoolers. This trend was identified by evaluating the volume and mode share of SOV, carpool, motorcycles, and transit vehicles utilizing the I-35W HOV facilities, which are unaffected by the MnPASS deployment. The analysis of I-35W conditions revealed that while motorcycle and transit vehicle volumes have remained steady, carpool volumes have decreased by 14 percent in the northbound direction and by 20 percent in the southbound direction. This analysis reveals that carpool usage appears to be trending downward on a regional basis, independent of any influence resulting from MnPASS.

Against the backdrop of the regionally observed decrease in carpool volumes, carpool usage on I-394 also appears to have decreased as compared with pre-MnPASS levels. Table 5.3 summarizes a comparison of SOV and HOV volumes observed on I-394 during data collection efforts conducted prior to and following MnPASS implementation. This table shows the number and percent of vehicles for both the MnPASS lane as well as in the general purpose lanes. Table 5.3 provides a comparison of conditions only for the hours of HOV lane operation prior to the deployment of MnPASS. The lack of comparable vehicle occupancy data during the fringe hours in the pre-MnPASS scenario prohibits any comparison of data in these newly expanded operating hours.

Table 5.3 Comparison of SOV and HOV Vehicle Volumes on I-394 and I-35W, 2004 to 2006

Count Location	2004	Share	2006	Share	# Change	% Change
I-394 @ Penn Eastbound – AM Peak (6:00 to 9:00 a.m.)						
MnPASS Lanes						
HOV Volume*	3,322	96%	2,635	62%	-687	-21%
SOV Volume*	141	4%	1,599	38%	1,458	1,034%
Total Volume	3,463		4,234		771	22%
General Purpose Lanes						
HOV Volume	335	2%	375	3%	40	12%
SOV Volume	14,742	98%	14,107	97%	-635	-4%
Total Volume	15,077		14,482		-595	-4%
Total All Lanes						
HOV Volume	3,657	20%	3,010	16%	-647	-18%
SOV Volume	14,883	80%	15,706	84%	823	6%
Total Volume	18,540		18,716		176	1%
I-394 @ Penn Westbound – PM Peak (3:00 to 6:00 p.m.)						
MnPASS Lanes						
HOV Volume	3,446	88%	2,578	63%	-868	-25%
SOV Volume	226	6%	1,516	37%	1,290	571%
Total Volume	3,898		4,094		196	5%
General Purpose Lanes						
HOV Volume	1,864	13%	884	6%	-980	-53%
SOV Volume	12,782	87%	15,124	94%	2,342	18%
Total Volume	14,646		16,008		1,362	9%
Total All Lanes						
HOV Volume	5,310	29%	3,462	17%	-1,848	-35%
SOV Volume	13,008	71%	16,640	83%	3,632	28%
Total Volume	18,318		20,102		1,784	10%

Table 5.3 Comparison of SOV and HOV Vehicle Volumes on I-394 and I-35W, 2004 to 2006 (continued)

Count Location	2004	Share	2006	Share	# Change	% Change
I-394 @ Louisiana Eastbound – AM Peak (6:00 to 9:00 a.m.)						
MnPASS Lanes						
HOV Volume	2,054	89%	1,511	58%	-543	-26%
SOV Volume	254	11%	1,083	42%	829	326%
Total Volume	2,308		2,594		286	12%
General Purpose Lanes						
HOV Volume	369	3%	499	5%	130	35%
SOV Volume	11,322	97%	10,574	95%	-748	-7%
Total Volume	11,691		11,073		-618	-5%
Total All Lanes						
HOV Volume	2,423	17%	2,010	15%	-413	-17%
SOV Volume	11,576	83%	11,657	85%	81	1%
Total Volume	13,999		13,667		-332	-2%
I-394 @ Louisiana Westbound – PM Peak (3:00 to 6:00 p.m.) – Includes Addition of Auxiliary Lane in 2005						
MnPASS Lanes						
HOV Volume	2,376	76%	1,308	60%	-1,068	-45%
SOV Volume	751	24%	870	40%	119	16%
Total Volume	3,127		2,178		-949	-30%
General Purpose Lanes						
HOV Volume	414	5%	1,029	7%	615	149%
SOV Volume	7,805	95%	13,903	93%	6,098	78%
Total Volume	8,219		14,932		6,713	82%

Table 5.3 Comparison of SOV and HOV Vehicle Volumes on I-394 and I-35W, 2004 to 2006 (continued)

Count Location	2004	Share	2006	Share	# Change	% Change
I-394 @ Louisiana Westbound – PM Peak (3:00 to 6:00 p.m.) – Includes Addition of Auxiliary Lane in 2005 (continued)						
Total All Lanes						
HOV Volume	2,790	25%	2,337	14%	-453	-16%
SOV Volume	8,556	75%	14,773	86%	6,217	73%
Total Volume	11,346		17,110		5,764	51%
I-35W @ 96th NB AM (6:00 to 9:00 am.)						
HOV Lane						
HOV Volume	1,387	77%	1,193	69%	-194	-14%
SOV Volume (Violators)***	405	23%	538	31%	133	33%
Total Volume	1,792		1,731		-61	-3%
I-35W @ 96th SB PM (3:00 to 6:00 p.m.)						
HOV Lane						
HOV Volume	2,162	77%	1,738	65%	-424	-20%
SOV Volume (Violators)	631	23%	932	35%	301	48%
Total Volume	2,793		2,670		-123	-4%

*HOV volumes include all HOV eligible vehicles including carpools (2+ occupants), transit vehicles, and motorcycles.
**SOV volumes observed in the MnPASS lane in the 2004 period represent violators.
***All SOV volumes observed in the I-35W HOV lane represent violators as this control corridor is not equipped with MnPASS.

The observed decreases in HOV volumes on I-394 appear to be related to a decrease in carpool usage – an analysis of the data shows that motorcycle and transit vehicle volumes remained relatively constant between 2004 and 2006. As discussed above, some of the decrease in carpool usage in the peak hours may be a result of carpoolers switching the time of their travel to one of the shoulder periods created by the expansion of the time window of HOV only restrictions; however, these impacts cannot be quantified due to the lack of data on carpool usage in these periods prior to MnPASS implementation.

These observed decreases in carpool volumes on I-394 appear to be more substantial than the decrease observed on I-35W; however, due to variability of HOV demand, the relatively small number of HOV volumes in both the pre- and post-MnPASS periods, and the snapshot nature of the manually collected occupancy counts, it cannot be statistically concluded that the I-394 carpool decreases are greater than those observed on I-35W. Therefore, the technical evaluation of this impact was inconclusive.

The impact of mode shift was also addressed in the Attitudinal Evaluation. In that effort, the analysis did not support the finding that there had been any significant mode shifts among survey respondents. More information on the Attitudinal Evaluation findings can be accessed at: http://www.mnpass.org/.

Violation Rates

Violation rates in the MnPASS lanes were determined by identifying those SOV vehicles that were illegally using the lane. This analysis was performed using the manually obtained occupancy counts as well as automated records of the number of vehicles with valid transponders for the same time/date for the occupancy data collection. Any SOV vehicle observed using the HOV lane in the pre-MnPASS data collection was identified as a violator. In the post-MnPASS analysis, the number of valid transponder reads recorded by the MnPASS was subtracted from the total number of SOV vehicles observed in the MnPASS lane to identify the number of violators.

The analysis revealed that violation rates on I-394 decreased following MnPASS implementation. This was particularly evident in the diamond lane sections of the corridor where violation rates fell from 20 percent to 9 percent. During the same period, violation rates on I-35W, where MnPASS was not implemented, increased dramatically from 22 percent to 33 percent. Table 5.4 summarizes corridor violation rates observed prior to and after MnPASS implementation using an average of rates obtained from data collected during periods pre-MnPASS (2002 and 2004) and with MnPASS (2005 and 2006). Tables 5.5 to 5.10 provide more detail on the violation rates observed for specific locations and years.

Table 5.4 Summary Comparison of Pre- and Post-MnPASS HOV Lane Violation Rates

Location	Pre-MnPASS	With MnPASS
I-394 Reversible Section	7%	4%
I-394 Diamond Lane Section	20%	9%
I-35W HOV Control Section	23%	33%*

*I-35W control corridor not equipped with MnPASS.

Table 5.5 Vehicles Observed in EB HOV/MnPASS Lane – Observed at Louisiana Avenue During the AM Peak Period

Period Observed	HOV	SOV	Violator	MnPASS User
Pre-MnPASS (2002)	81%	19%	19%	N/A
Pre-MnPASS (2004)	89%	11%	11%	N/A
With MnPASS (2005)	62%	38%	8%	30%
With MnPASS (2006)	58%	42%	8%	34%

Table 5.6 Vehicles Observed in WB HOV/MnPASS Lane – Observed at Louisiana Avenue During the PM Peak Period

Period Observed	HOV	SOV	Violator	MnPASS User
Pre-MnPASS (2002)	76%	24%	24%	N/A
Pre-MnPASS (2004)	76%	24%	24%	N/A
With MnPASS (2005)	61%	39%	9%	30%
With MnPASS (2006)	60%	40%	11%	29%

Table 5.7 Vehicles Observed in EB HOV/MnPASS Lane – Observed at Penn Avenue During the AM Peak Period

Period Observed	HOV	SOV	Violator	MnPASS User
Pre-MnPASS (2002)	94%	6%	6%	N/A
Pre-MnPASS (2004)	96%	4%	4%	N/A
With MnPASS (2005)	63%	37%	6%	31%
With MnPASS (2006)	62%	38%	3%	34%

Table 5.8 Vehicles Observed in WB HOV/MnPASS Lane – Observed at Penn Avenue During the PM Peak Period

Period Observed	HOV	SOV	Violator	MnPASS User
Pre-MnPASS (2002)	88%	12%	12%	N/A
Pre-MnPASS (2004)	94%	6%	6%	N/A
With MnPASS (2005)	67%	33%	4%	29%
With MnPASS (2006)	63%	37%	5%	32%

Table 5.9 Vehicles Observed in NB I-35W HOV Lane – Observed During the AM Peak Period

Period Observed	HOV	SOV	Violator	MnPASS User
2002	67%	33%	33%	N/A
2004	78%	22%	22%	N/A
2005	85%	15%	15%	N/A
2006	69%	31%	31%	N/A

Table 5.10 Vehicles Observed in SB I-35W HOV Lane – Observed During the PM Peak Period

Period Observed	HOV	SOV	Violator	MnPASS User
2004	77%	23%	23%	N/A
2006	65%	35%	35%	N/A

5.4 Observed Impacts on Safety

In order to test the impact of MnPASS on corridor safety, three separate hypotheses were formulated and tested. These hypotheses included:

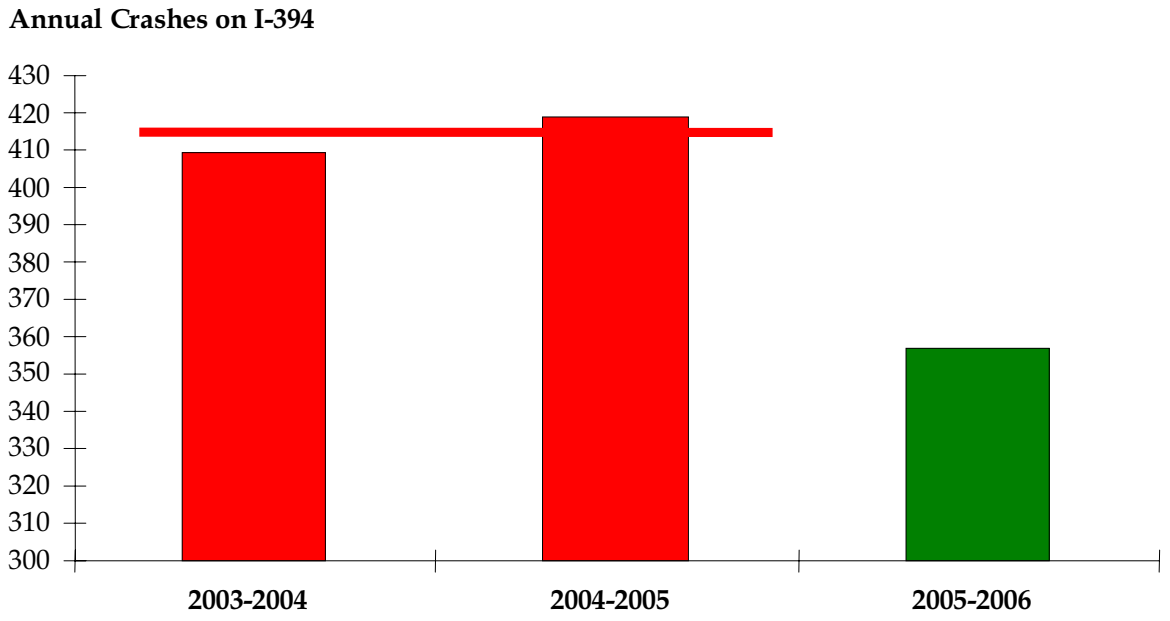
- *MnPASS deployment will not result in an increase in the number of crashes occurring in the corridor*;
- *MnPASS deployment will not result in an increase in the crash rate in the corridor*; and
- *MnPASS deployment will result in a decrease in the speed differential between HOV/HOT lanes and general purpose lanes*.

Crash Occurrence

To assess the possible impact of the MnPASS deployment on safety, crash statistics were obtained from the State of Minnesota's Department of Public Safety's crash database. The number of crashes occurring in the I-394 corridor was tallied for two years representing the pre–MnPASS period, and one year following the deployment of MnPASS. For consistency, each analyzed year started and ended on May 16th (the opening date of the MnPASS system). Also, the analyzed crashes only included those occurring between the hours of 5:00 a.m. to 8:00 p.m. to avoid including crashes occurring well outside of MnPASS operational hours.

The analysis of crash data during the before period revealed that an average of 414 crashes were observed on I-394 in the 2 years preceding the implementation of MnPASS – 409 crashes in 2003 to 2004 and 419 crashes in 2004 to 2005. During the year following MnPASS deployment, the number of observed crashes fell to 357 in 2005 to 2006, a decrease of nearly 14 percent, as shown in Figure 5.1.

Figure 5.1 Annual Crashes Recorded on I-394 – During the Weekday Hours of 5:00 a.m. to 8:00 p.m.*



*Annual years measured as May 16th to May 15th the following year.

This decrease in crashes cannot be directly attributed to the implementation of MnPASS, however. The annual number of crashes is typically a highly variable statistic, and evidence of a regional decrease in travel demand has been observed and would contribute to any decrease in accidents. The percent reduction in crashes, however, exceeds any observed percentage decrease in travel demand, suggesting that it may be minimally concluded that the deployment of MnPASS has not resulted in any increase in the crash risk on the I-394 corridor.

Speed Differential

Supplementing the analysis of actual crash occurrences in the corridor, a separate evaluation of the change in speed differential between the general purpose lanes and the MnPASS lane was performed. The speed differential metric is an often used as a proxy measurement of safety as situations where there is a great disparity between speeds observed in adjacent lanes are more likely to observe more total crashes and more crashes of a greater severity.

Speed differential between the general purpose lane and the MnPASS lane in the diamond lane section was analyzed using speed data collected from the automated detectors in the corridor. The speed differential observed in the before period was compared with the same measure in the after period and tested for statistical significance. This analysis

revealed that the speed differential decreased at nearly all tested locations, and in no location did the speed differential increase by more than a trivial amount. Table 5.11 shows the results of this analysis.

Table 5.11 Comparison of Average Pre- and Post-MnPASS Speed Differential on I-394

Location	Pre-MnPASS	With MnPASS
Eastbound (AM Peak)		
I-494	3.9	3.1
Ridgedale	2.9	2.9
General Mills	5.6	0.6
Xenia	12.6	1.7
Westbound (PM Peak)		
Xenia	13.4	9.7
General Mills	8.6	7.9
Ridgedale	5.7	5.5
I-494	6.7	4.9

5.5 Observed Impacts on Environmental Factors

In order to test the environmental impact of MnPASS, two separate hypotheses were formulated and tested. These hypotheses included:

- *MnPASS deployment will not result in an increase in corridor noise levels*; and
- *MnPASS deployment will not result in an increase in corridor emissions (CO) levels*.

Assessment of these hypotheses was performed by Mn/DOT's Office of Environmental Services. A copy of the initial analysis report (October 2005) is presented as Appendix A.[5] Additional monitoring and analysis of noise and emissions data were subsequently con-

[5] Additional monitoring and analysis of noise and emissions data was conducted in May 2006. The findings of this additional analysis confirmed the earlier results.

ducted in May 2006. Highlights of the analysis findings are presented in the sections below.

Noise Levels

Analysis of noise data collected after MnPASS deployment (in September/October 2005) revealed that there were no significant changes in noise levels noted for 23 out of the 26 separate monitoring observations (a.m. and p.m. peak periods at 13 sites) when compared with pre-deployment (April/May 2005) levels. For the three observances where a change in noise levels were noted, none exceeded a change of greater than 5 decibels; therefore, the analysis concluded that there was no substantial impact on noise levels attributable to the MnPASS deployment.

Emissions

The analysis of emissions monitoring data in the corridor concluded that the impacts on CO levels of MnPASS are considered minimal, and the CO concentrations remain well below the 30 ppm 1 hour CO air quality standard for Minnesota. Therefore, it can be concluded that the operation of the MnPASS lane did not result in a substantial impact on the air quality due to any changes in traffic patterns in the project area.

6.0 System Performance Findings

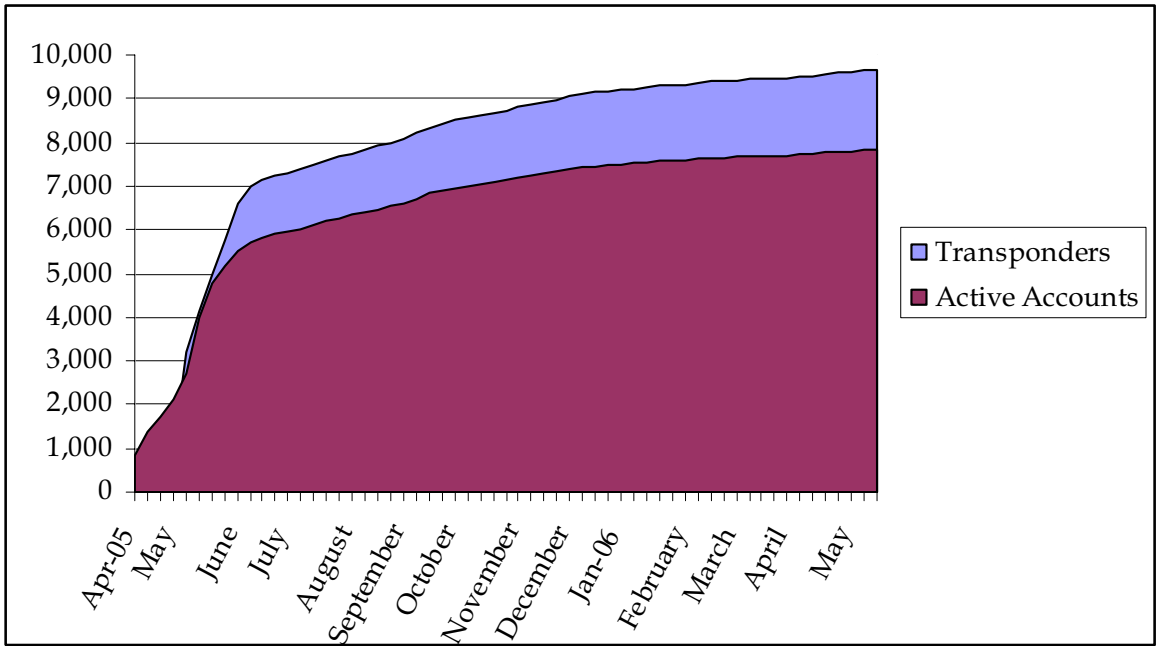
6.0 System Performance Findings

This section documents several issues related to the performance of the MnPASS system including use and revenue, and enforcement. The evaluation of these issues differs from those impacts discussed in the previous section in that no before and after analysis was performed. Instead, key findings and lessons learned regarding these issues are simply documented in the sections below.

6.1 Use and Revenue

The number of MnPASS transponders requested by users increased at a rapid pace throughout 2005, increasing from 5,650 transponders on opening day (May 2005) to over 9,000 transponders issued by January 2006. Since January, the growth in the number of transponders has continued to grow, but at a slower pace resulting in approximately 10,000 transponders currently in use. Figure 6.1 shows the growth in the number of transponders as well as the total number of transponders over time. The average subscriber uses the MnPASS lane approximately two times per week.

Figure 6.1 Active Accounts and Transponders



MnPASS lane usage increased steadily from under 10,000 weekly tolled trips during the initial weeks of operation to over 20,000 weekly tolled trips by November and December 2005. From the opening until January 2006, the increase in MnPASS lane usage tracked consistently with the growth in the number of transponders, meaning that the increased number of tolls paid was likely due to more MnPASS subscribers who were eligible to use the lane, rather than an increase in usage among individual users. The average transponder owner uses the MnPASS lane approximately two times per week. This statistic has been relatively constant over time. Usage is also typically highest on Tuesdays, Wednesdays, and Thursdays.

A modified toll rate structure was implemented in January 2006 that adjusted the toll rate scale that was applied for different congestion levels. Although the range of possible tolls remained unchanged, this modification typically resulted in higher average tolls being applied as increases in toll levels were triggered by lower congestion levels. Following this change, the number of tolled trips immediately decreased by 3,000 to 4,000 weekly trips; however, the number of tolled trips has been steadily increasing since that time and is currently tracking at a level higher than usage before the rate change, as shown in Table 6.1.

Table 6.1 Example Comparison of Usage and Revenue Before and After Rate Change (*Implemented January 2006*)

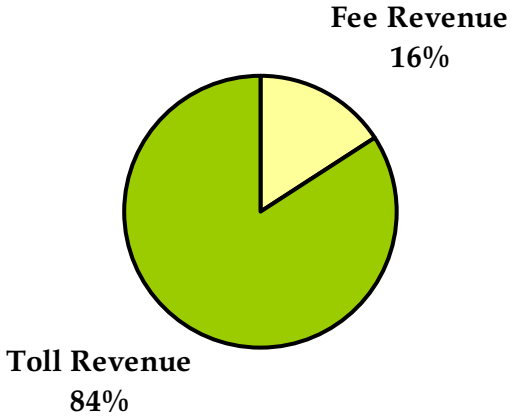
	September 2005 (Before Rate Change)	September 2006 (After Rate Change)	% Change
Average Toll	$0.55	$1.10	100%
Average Daily Trips	3,500	4,000	14%
Average Daily Revenue	$2,400	$5,700	138%

As a result of the increased rate structure, the average toll paid increased from $0.67 prior to the rate change to a value slightly above $1.00 following the change. Toll revenues likewise increased and are currently averaging more than $4,000 per weekday. The average toll level for the eastbound (morning inbound) direction tends to be higher than the westbound (outbound afternoon) direction and revenues from the eastbound direction likewise track typically higher than the westbound direction.

Total system revenue is generated from the application of the tolls, but also from transponder leases and other fees that are applied to subscribers to pay for the administrative costs related to their account. These other miscellaneous fees include charges for opening an account, replacing lost transponders, and late fees, among others. Currently, these fees account for about 16 percent of the total MnPASS revenue stream. The MnPASS accounts

require users to pre-pay their accounts and replenish the accounts through automatic credit charges as necessary to keep adequate funds available to use the system. Therefore, revenue is accrued as subscribers initially fund their accounts and subsequently replenish their accounts as the funds are depleted through toll lane use rather than recorded as individual tolls are paid. These revenues are presented as toll revenue in Figure 6.2 and make up the remaining majority (84 percent) of the total revenue stream.

Figure 6.2 Comparison of Revenue Sources



6.2 Enforcement

In conjunction with the implementation of MnPASS, enforcement activities were increased in the corridor and were funded through the operational budget for MnPASS. Additional enforcement is being provided on the corridor with the assistance of the Minnesota Highway Patrol, and the Minneapolis and Golden Valley Police Departments.

To collect enforcement related data for the evaluation, a data collection form was developed and included with the *MnPASS Enforcement Plan*. This form was routinely filled out by enforcement officers detailing the number and type of violation tickets issued during an enforcement shift. Enforcement activities which were documented include HOV violations (solo drivers traveling in the MnPASS lane without a valid transponder) and violations for crossing the double-white line serving as the barrier for the MnPASS lane in the diamond lane section.

Based on this information, public safety officers made nearly 5,000 stops on the I-394 corridor between May and December 2005. Approximately 50 percent of these stops involved HOV violations or motorists illegally crossing the double white lines. The stepped-up enforcement activities supported with MnPASS funding also included stops for speeding, seatbelt, and DWI violations, as well as accident and stalled vehicle assists.

These stepped up enforcement activities have accounted for over 2,500 corridor traffic stops for violations involving improper HOV lane use or illegal crossing of the double white line. This increased enforcement effort and visibility appears to be having a positive impact on compliance as HOV violation rates have decreased compared with conditions in the years prior to MnPASS, and the violation rates in the I-394 corridor are significantly lower than on non-MnPASS equipped HOV facilities on I-35W. Section 5.3 provides an expanded discussion on the impact the MnPASS program has had on corridor HOV violation rates.

6.3 Transit Performance

To evaluate impacts on transit operational performance associated with the I-394 MnPASS deployment, the Evaluation Team contacted local and regional transit providers and associated agencies to inquire what impacts, if any, were observed or noted as deployment of the MnPASS project progressed. The local transit systems, regional agencies, and providers that operated public transit services within the I-394 corridor during the deployment of the I-394 MnPASS project included the following:

- Metro Transit;
- Plymouth Metrolink (service operated by Metro Transit and Laidlaw);
- Prior Lake Laker Lines (service operated by Schmitty & Sons); and
- Southwest Metro Transit Commission (SWMTC).

Each of the transit systems or providers listed above were contacted by the consultant to determine what impacts, if any, occurred in the course of deployment of the I-394 MnPASS project. Each representative was asked the same open-ended questions and prompted for additional details or comments during the course of the interviews. The basic questions used to interview each of the transit service providers included:

- Has your agency observed any negative operational impacts (e.g., merge difficulties, increased travel times, reduced ridership, etc.) resulting from the deployment of MnPASS on I-394? (If any negative impacts were listed, respondents were asked to describe the impacts and were prompted for additional details, including whether or not they had data supporting the impacts, or suggestions that could help mitigate the impacts they described).

- Has your agency observed any positive operational impacts (e.g., decreased travel times during fringe peak periods, etc.) resulting from the deployment of MnPASS on I-394? (If any positive impacts were listed, respondents were asked to describe the impacts and were prompted for additional details, including whether or not they had data supporting the impacts).

- Do you have any additional comments you would like to share regarding the deployment of the MnPASS program on I-394 as they relate to your transit system's operations?

The comments received from these local transit providers and transit agency staff are anecdotal in nature and are intended to provide a qualitative assessment of impacts. This qualified assessment was selected as the preferred evaluation approach of these impacts due to difficulties in conducting a meaningful quantitative analysis, particularly due to problems in isolating the incremental impacts of the MnPASS deployment on transit travel times and ridership from larger regional changes.

During the period of time covered by this evaluation, ridership in the Twin Cities regional transit system, including Opt-Out communities, rose by approximately 10 percent systemwide. This increase in ridership occurred predominantly in peak period express, line-haul routes from suburban and exurban park and ride facilities to and from the two downtowns of Minneapolis and St. Paul. At the same time, gas prices fluctuated between $2.20 and $3.00 or more per gallon, and demand for transit service increased, especially in markets where a longer commute by car, plus the cost of parking in downtown areas, greatly impacted consumers. The I-394 corridor was one of several transit corridors within the metro area that has historically provided established express commuter transit services.

Findings

Supervisors representing three of the four transit providers interviewed (Metro Transit, Plymouth Metrolink, and Prior Lake Laker Lines) indicated that the deployment of MnPASS on I-394 has generally had a negligible impact on their operations in the I-394 corridor. There were comments from these transit providers that the agencies did have some early (prior to MnPASS implementation) concerns regarding transit operations being negatively impacted, particularly the possibility of added difficulty in merging into the MnPASS lanes given the more limited access points and potential travel time impacts caused by added traffic in the MnPASS lane. Following MnPASS deployment, however, these agencies reported that these issues have not materialized and they have not observed any negative impacts from the deployment.

These providers were also unable to identify any positive impacts directly attributable to MnPASS. While there was support voiced for the added hours of HOV restrictions on the diamond lane section, the agencies did not report any quantifiable impacts resulting from this operational hours expansion.

Southwest Metro Transit was the only agency contacted that voiced serious concerns regarding operational impacts related to the deployment of MnPASS on I-394. Specifically, the agency cited added difficulty in merging from northbound TH 169 to eastbound I-394, reporting that the limited merge area, combined with added traffic in MnPASS lane and aggressive behavior by drivers in the MnPASS lane resulted in difficulty for transit vehicle drivers in finding appropriate gaps in which to merge the vehicle into the MnPASS lane at this location. Transit vehicle drivers have reported that drivers in the MnPASS lane will often attempt to close any gaps ahead of their vehicles when they see a

transit vehicle attempting to merge ahead of them, making it more difficult for the transit vehicle to successfully merge into the lane. Other transit providers did not report similar merge issues; however, Southwest Metro Transit does operate a greater number of buses though the TH 169 to I-394 interchange than the other providers and may have more opportunity to experience these particular impacts. The agency reported that concerns on the merge difficulties have been voiced by their drivers and passengers alike.

Southwest Metro Transit is currently investigating operational changes to help minimize this issue, including the permanent re-routing of their vehicles to other northbound corridors (TH 100 or I-494) to avoid the I-169 to I-394 merge area, or providing additional discretion to drivers to temporarily alter the route if they encounter congestion. Neither of these solutions is perceived as ideal by the agency. The agency suggested the study of a policy change to allow transit vehicles to cross the double-white line and merge at their convenience would be their preferred short-term solution (this suggested operational change was also mirrored by Metro Transit in their interview). In the longer-term, Southwest Transit suggested the planning of transit "slip ramps" to provide increased access to the MnPASS lane and the study of improvements to TH 100 and I-494 to make them more attractive travel corridors for transit.

Southwest Metro Transit also reported several instances of aggressive, illegal driver behavior noted in the MnPASS lane. Specifically, transit vehicles have passed while in the MnPASS lane by vehicles that cross the double-white lines back into the general purpose lanes, and then re-cross the double-white line to re-enter the MnPASS lane ahead of the slower-moving bus. The agency suggested vigilant enforcement to curtail these illegal activities.

7.0 Summary and Conclusions

7.0 Summary and Conclusions

This evaluation report summarizes the results related to a comprehensive evaluation of the I-394 MnPASS deployment in the Twin Cities. This section summarizes some of the major findings in relation to the identified evaluation objectives. Further, this section also provides a high-level assessment of the MnPASS concept based on this test bed deployment on I-394 and discusses the applicability for expansion of the system.

7.1 Evaluation Summary

The technical evaluation of the I-394 MnPASS deployment was conducted according to guidelines originally specified in the Technical Evaluation Test Plan (March 2003). This plan included the identification of multiple evaluation objectives to be assessed in the course of the evaluation. While some of these issues required the simple documentation of issues, other identified objectives specified hypotheses to be tested during the course of the evaluation. Table 7.1 presents a listing of the many key hypotheses and summarizes the outcomes of the evaluation against each impact.

In addition to the assessment of before and after conditions to assess the ability of the MnPASS system to achieve the intended objectives, the evaluation also documented additional issues surrounding the deployment. Some of the key findings include:

- MnPASS has been popular with users as evidenced by the demand for transponders and continued use of the MnPASS lane. Over 10,000 transponders have been leased by users and the average user chooses to pay the MnPASS lane toll about twice a week on average.

- The toll schedule modifications implemented in January 2006 have resulted in an increase in revenue being collected and less volatility in rate changes at lower traffic levels. After an initial decrease in usage following the modification, usage has steadily increased to surpass levels prior to the modification.

- The increased enforcement activities funded through the MnPASS program have had great success in curtailing illegal SOV use of the MnPASS lane in the I-394 corridor by giving single drivers a legal option to use to underutilized HOV lane. Violation rates in the non-MnPASS equipped I-35W corridor are more than three times as high.

Table 7.1 Evaluation Hypotheses and Outcomes

Evaluation Hypothesis	Outcome
MnPASS deployment will result in an increase in vehicle throughput in the corridor	True. Based on an analysis of before and after volumes, corridor throughput increased during the peak hour by up to 5 percent. This increase occurred while regional volumes in other non-MnPASS corridors observed a decrease.
MnPASS deployment will result in an increase in vehicle speeds in the general purpose lanes	True. General purpose lane travel speeds were observed to increase at all study locations by an average of approximately 6 percent.
MnPASS deployment will result in a decrease in average person travel time in the corridor	True. Travel speeds increased in the general purpose lanes as well as the MnPASS lane for many locations providing a reduction in travel times.
MnPASS deployment will not result in a decrease in vehicle speeds in the HOV/HOT lanes	True. Travel times were observed to hold constant or increase slightly at all study locations, with the exception of a portion of the morning operational period at Xenia.
MnPASS deployment will not result in a change in mode share in the corridor	Inconclusive. Significant deceases in the numbers and mode shares of carpools were observed on I-394; however, a significant (yet tempered) decrease in carpool usage was similarly observed on I-35W, which is not equipped with MnPASS during the same time period, suggesting a regional shift in carpool usage. The snapshot nature of the available auto occupancy data, significant variations in the day-to-day usage of the lane by HOV users, and the change in operating hours between the pre-MnPASS and post-deployment periods all served to complicate the precise identification of carpool impacts. Therefore, it can neither be confidently proven or refuted that the decrease on carpool usage on I-394 is directly attributable to the deployment of MnPASS as the observed decrease is within the margin of error of the analysis. Additionally, user survey results from the separately conducted I-394 MnPASS Attitudinal Evaluation did not reveal any changes in mode choice reported by corridor carpoolers.
MnPASS deployment will not result in an increase in illegal SOV usage of the HOV/HOT lanes	True. Violation rates on I-394 were observed to decrease dramatically following the implementation of MnPASS. Meanwhile, the violation rates on the non-MnPASS equipped I-35W HOV section have significantly increased.
MnPASS deployment will not result in an increase in the number of crashes occurring in the corridor	True. In the year following MnPASS deployment, approximately 14 percent fewer crashes were observed when compared with previous years.
MnPASS deployment will result in a decrease in the speed differential between HOV/HOT lanes and general purpose lanes	True. The speed differential was observed to decrease at all diamond lane study locations.

Table 7.1 Evaluation Hypotheses and Outcomes (continued)

Evaluation Hypothesis	Outcome
MnPASS deployment will not result in an increase in corridor noise levels	True. Monitoring conducted by Mn/DOT revealed no significant increases in corridor noise levels.
MnPASS deployment will not result in an increase in corridor emissions (CO) levels	True. Monitoring conducted by Mn/DOT revealed no negative CO emissions impacts.

- Most transit providers have reported negligible impacts on operations as a direct result of MnPASS deployment. The limited number of issues reported generally focused on the ability of transit vehicles to merge at one specific access point in the corridor.

7.2 Conclusions

The MnPASS deployment on I-394 has enjoyed success in achieving many of the identified goals and objectives for the project. While successful in its current configuration, the initial deployment operating on a 24/7 basis did face some public criticism due to unforeseen congestion that occurred in the off-peak direction. The flexibility of Mn/DOT in adapting to these challenges was key to overcoming these barriers resulting in the current successful deployment. The success and benefits provided by the MnPASS system on I-394 warrants that the MnPASS concept be carefully considered for application to other corridors facing similar challenges to I-394. While not a panacea for all system deficiencies, the MnPASS concept can be a success if applied under the correct circumstances.

Based on lessons learned from the initial application of HOT lane strategies in Minnesota, the following recommendations are provided to stakeholders considering the broader application of MnPASS to other corridors:

- The clear provision of a benefit for potential users is key to attracting and sustaining subscribers. The consistent maintenance of near free-flow conditions on I-394 has provided users with a clear benefit and motivation for opening an account and using the system.

- It is critical that free-flow speeds in the MnPASS lanes must be maintained to sustain the benefit provided to carpoolers and transit riders. Valuable regional benefits are gained by support of these trip reducing travel modes. The I-394 MnPASS deployment maintained the travel time savings for these users while simultaneously serving

to increase the number of hours that travel on the lane was reserved for HOV travel compared with previous conditions.

- Addressing the concerns of the transit providers is critical to maintaining support of the deployment. Continuing issues of the transit community should be studied and addressed as they arise.

- The I-394 corridor is unique among regional corridors as it maintains the only reversible segment in the Twin Cities. The benefits of MnPASS in the reversible section were overwhelmingly apparent in the evaluation. The benefits in the diamond lane section, while still positive, were more mixed, particularly during the initial 24/7 operation. This was often particularly true on the fringes of the new operational period where HOV restrictions were expanded to hours that had previously been available for general-use travel. Stakeholders should carefully consider any possible impacts of future MnPASS expansion, especially in situations that may serve to alter the hours of availability of a previous open general purpose lane.

- The funding and provision of additional enforcement had a direct impact on the success of the I-394 MnPASS deployment. An increased enforcement presence should be a key ingredient of any future expansion plans.

- The continuous and sustained monitoring and evaluation of corridor conditions following deployment of I-394 was key to identifying minor problems in the system before they had the opportunity to balloon into more serious issues. The immediate and decisive action of Mn/DOT in addressing some of these challenges provided final mitigation of many issues in a timely manner.

- Although it was not one of Mn/DOT's stated goals for implementing MnPASS, some pre-deployment promotions implied an increase in carpool usage – an impact observed in an evaluation of the I-15 HOT lane project in California – as a possible outcome of the MnPASS deployment. These statements may have inadvertently set unrealistic expectations on the possible benefits of the eventual deployment among some stakeholders. Caution should be used in making similar claims not directly tied to the stated project goals.

- Inherent difficulty in collecting data on personal auto occupancies, combined with a lack of historical data and a change in the daily time periods in which HOV restrictions were enforced, served to limit the preciseness in which impacts to carpool volumes could be evaluated in this study. It is recommended that any future expansion of the MnPASS system carefully consider and monitor these potential impacts. Auto occupancy data collected in this evaluation should provide valuable input to any future assessment.

- The involvement of a diverse set of stakeholders including local transportation system operators, transit operators, lawmakers, and particularly the public was a critical component to success of the I-394 MnPASS deployment. Similar outreach and involvement is recommended for any future involvement.

These lessons learned and recommendations are provided to Minnesota stakeholders considering the expansion of MnPASS to other state corridors, as well as other regions looking to the I-394 MnPASS deployment for advice on the applicability of HOT lane strategies in the their own regions.

Appendix A

MnPASS Air and Noise Analysis

MnPASS

Air & Noise Analysis

Conducted & Evaluated by the
Environmental Modeling & Testing Unit
Office Of Environmental Services
Minnesota Department of Transportation

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Final Draft

October, 2005

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I. MnPASS Noise Analysis

A. Background

This study was conducted to evaluate pre and post MnPASS noise measurements in the Bryn Mawr neighborhood located on I-394 in Minneapolis, Minnesota. The goal of the study was to determine if a significant difference in noise levels occurred during A.M. and P.M. peak hours due to the allowance of single occupant vehicles (SOVs) in the directional high occupancy vehicle (HOV) lane on I-394. Pre MnPASS noise monitoring was conducted at thirteen receptors in April and May, 2005 prior to the opening of the MnPASS lane on May 16, 2005. Post MnPASS noise monitoring was conducted at the same thirteen receptors in September and October, 2005. All noise monitoring was conducted on mid-week days, (Tuesday, Wednesday or Thursday). The receptors were located in the yards of residences and varied in distances from the sound wall up to approximately 1100 feet. The receptor locations were selected in cooperation with Mr. Greg Lecker, President of the Bryn Mawr Neighborhood Association. The noise receptor locations are noted below in Table 1. Noise Receptor Locations, and portrayed on the following page in Figure 1. Noise Receptor Locations.

Table 1. Noise Receptor Locations

Noise Receptor Locations	
North of I-394	**South of I-394**
602 Upton Avenue South	1228 Cedar Lake Road South
636 Upton Avenue South	1007 Cedar Lake Road South
604 Cedar Lake Road South	1012 Thomas Avenue South
621 Thomas Avenue South	1728 Kenwood Parkway
2436 Mount View Avenue	1200 Kenwood Parkway
2436 Mount View at noise wall	1013 Kenwood Parkway
432 Morgan Avenue South	

B. Methods

Noise level measurements were conducted using Bruel and Kjaer sound level meters. All sound level meters used in this study were certified by the Minnesota Pollution Control Agency (MPCA) for accurate calibration. A minimum of five noise level measurements were taken for ten minute durations at each receptor location during A.M. peak (6:00 a.m.-9:00 a.m.), and P.M. peak (3:00 p.m.-6:00 p.m.) for a total of at least ten measurements per receptor. Manual traffic counts were made of the eastbound (EB), westbound (WB), and MnPASS directional lane, concurrent with the noise level measurements. Speed data for each lane was collected and recorded immediately following each noise level measurement. The same procedure was used for conducting both the pre and post MnPASS noise level measurements.

Figure 1. Noise Receptor Locations

The analysis of the effects of the MnPASS lane on traffic noise was done in two steps. The basis for the two step approach is based on the fact that the noise model does an excellent job tracking changes in noise levels due to changes in traffic patterns and flow characteristics. This is true only when the traffic noise from the system being modeled is the dominate noise at the measurement site. If noise sources external to the system being modeled are dominant, no determination about the effects of the MnPASS lane can be made.

Step one was carried out on the corrected "before" and "after" averages of the sets of noise measurements. By corrected measurements we mean that the average of a set of predicted levels was subtracted from the average of its complementary set of measured levels. If the difference between the averages of the corrected measurements equated to zero then step two of the analysis was carried out. If the difference in step 1 did not equate to zero then nothing could be concluded about noise changes due to the MnPASS lane, as the noise at that particular measurement site was dominated by external noise sources. To reiterate, if the difference in step 1 was equal to zero then we proceeded to

step two. Step two was a comparison of the difference between uncorrected "before" and "after" average measurements. If a statistically significant difference, different from zero was found, we can be confident that the difference is due to the traffic variations associated with the MnPASS lane.

It should be noted that the above procedure must address the random nature of the variations in measurements, and the relationship between measurements and modeling results. This was done by using the appropriate statistical analysis and testing of the data, and the results of operations on the data involved.

The mathematical approach described above is as follows:

$$\mathbf{L_m = L_p + (\Delta_c + \epsilon) + (\Delta_e + \epsilon)}$$

Where:

$\mathbf{L_m}$ = a measured level

$\mathbf{L_p}$ = the predicted (modeled) level corresponding with $\mathbf{L_m}$

$\mathbf{\epsilon}$ = a variant term such that $\epsilon \sim N(0 , \sigma^2)$ and describes random errors and/or variations in the measured levels.

$\mathbf{(\Delta_c + \epsilon)}$ = a corrective component, a true correction plus a small error that is internal to the modeling and adjusts for differences between "measured" and "predicted" levels due to variations that are not traffic related (meteorology, geometric, vehicle reference energies, etc). When traffic patterns, volume and speed changes are the only variants this term can be considered constant except for small random fluctuations.

$\mathbf{(\Delta_e + \epsilon)}$ = a component that accounts for all noise sources other than those on I-394 (local traffic, neighborhood sounds, etc.).

$$L_{m,corr} = \mathbf{L_m - L_p = (\Delta_c + \epsilon) + (\Delta_e + \epsilon)}$$

The difference between corrected "after" and "before" measured levels will equate to a difference between the model correction terms and the external sources terms.

$$L_{m,corr,A} - L_{m,corr,B} = \mathbf{(\Delta_c + \epsilon)_A - (\Delta_c + \epsilon)_B + (\Delta_e + \epsilon)_A - (\Delta_e + \epsilon)_B}$$

If the modeling and measurements are done with proper care the modeling correction terms should cancel, except for a random variant, leaving only the difference between the external sources terms.

$$L_{m,corr,A} - L_{m,corr,B} = \mathbf{(\Delta_e + \epsilon)_A - (\Delta_e + \epsilon)_B}$$

As can be seen by the above equation the difference between corrected measured levels will depend on the difference between external sources terms alone except for a random variant. By requiring the difference between corrected measurements to equate to zero

before considering the uncorrected differences we have allowed for only two cases. One case is where the I-394 noise sources dominate and have been eliminated by the corrections to the measurements. The other case occurs where the external sources dominated but were equal in both the "after" and "before" measurements and won't be cause for a false conclusion about the effects of the MnPASS lane. If the corrected measurements cannot be shown to equate to zero the procedure is stopped as no information about the effects of MNPASS can be confidently ascertained.

Where the corrected differences equate to zero we can go to step two which addresses the uncorrected differences between "after" and "before" measurements. The difference can be written as follows:

$$L_{m,A} - L_{m,B} = L_{p,A} - L_{p,B} + (\Delta_e + \epsilon)_A - (\Delta_e + \epsilon)_B$$

The result is dependent on the difference between modeled results which gives the difference due to changes in traffic characteristics caused by the MnPASS lane. The result also depends on the difference between the external sources terms. Step one guarantees that the difference between the external sources terms will equate to zero, i.e., $L_{m,A} - L_{m,B} = L_{p,A} - L_{p,B} + \epsilon$, which leaves a difference due to traffic changes on I-394. All terms and results are subject to random errors and variations and therefore all the above analysis needs to be carried out using statistical analysis and its subsequent results.

C. Results

In general the total volumes and speeds remained essentially the same pre to post, however the distribution changed somewhat. The MnPASS lanes increased in volume while the EB and WB lanes decreased. All detailed noise data can be found in Appendix A. Noise Monitoring Data.

Taking all sites into account and averaging the sites A.M. and P.M. noise level measurements, it was found that there was not a statistically significant change in the average neighborhood sound pressure level (SPL), during the hours of concern. To evaluate and explain specific noise level changes in the A.M. and P.M. peak hours, the MINNOISE model was used. The MINNOISE model uses geography, traffic, and vehicle speeds as input parameters for the program. Sound level differences between measured after and before, and modeled sound level differences between after and before were compared and tested for statistically significant changes in noise level.

Each site was statistically evaluated separately for the A.M. and P.M. peak hours by comparing to the modeled before and after. Student's T test was used to determine if there were statistically significant differences before and after noise level measurements for both uncorrected and corrected noise levels. There were only three sites and times where noise level changes can be confidently attributed to changes in traffic patterns due to the MnPASS lane. Statistically significant changes with 95% confidence limits are noted in Table 2.

Table 2. Noise Level Statistical Results

Location	Time	Noise Level Increase
621 Thomas Avenue South	A.M.	1.3 ± 0.9 dBA*
1007 Cedar Lake Road South	P.M.	2.0 ± 0.9 dBA*
636 Upton Avenue South	P.M.	3.3 ± 0.6 dBA*

* The decibel level obtained using the "A" weighting characteristic of a sound meter. The "A" weighting approximates the ear's sensitivity to sounds of various frequencies.

D. Conclusions

Three out of twenty-six measurement sets evaluated (A.M. and P.M. at thirteen sites) showed statistically significant noise level changes that are attributable, with confidence, to the MnPASS lane. However, as these statistically significant increases are not considered substantial (< 5dBA), it is concluded that the MnPASS lane had no substantial effects on noise levels in the Bryn Mawr neighborhood. Further study or a study of other external noise sources could show that other sources (i.e., local street traffic, commercial processing, etc.) may produce substantial differences in neighborhood noise levels.

II. MnPASS Air Quality Analysis

A. Background

Carbon monoxide (CO) is the traffic related pollutant of most concern in Minnesota. In Minnesota, air quality standards have been set by the MPCA to protect human health and the environment, and are more stringent than the USEPA standards for CO. The standards for CO are noted in Table 3. Carbon Monoxide Standards. The MnPASS project area is located within the Twin Cities seven county Metro area that has been designated by the United States Environmental Protection Agency (USEPA) as a maintenance area for CO.

Table 3. Carbon Monoxide Standards

Carbon Monoxide Standards	
MPCA CO Standards (ppm)*	**USEPA CO Standards (ppm)**
1 hour average: 30 ppm	1 hour average: 35 ppm
8 hour average: 9 ppm	8 hour average: 9 ppm

*parts per million

To adequately evaluate the pre and post air quality in the I-394 MnPASS project area, two air quality monitoring stations were established to provide CO levels.

Monitoring stations were located on the north and south sides of the I-394 MnPASS project area in Minneapolis, Minnesota. The south side CO monitoring site was located at the top of the ramp near the EB I-394 Penn Avenue exit. There is a large open area with railroad tracks located to the south of the monitoring site and several businesses to the west. Air samples were taken at the Minnesota Department of Transportation (Mn/DOT) right of way fence, approximately eight feet above the ground level. The monitoring equipment was located in a secured 8' X 12' environmentally controlled shelter. A heater/air conditioner system maintained the shelter's temperature between 68-72 ºF.

The north side CO monitoring site was located at the Qwest Communications Building, 2800 Wayzata Boulevard, Minneapolis, Minnesota. Theodore Wirth Park is located to the west of this monitoring site, with a school located north of the site. The east side of this monitoring location is occupied by single family dwellings. Air samples were collected in front of the Qwest building, approximately five feet above the ground level. The monitoring equipment was housed in a secured interior utility room on the lower level of the Qwest building. This equipment location was maintained at room temperature.

The CO monitoring locations are depicted in Figure 2. Air Quality Monitoring Locations on the following page.

Figure 2. Air Quality Monitoring Locations

B. Methods

CO values were measured and recorded by Thermo Environmental Instruments Model 48C monitors. The monitors were placed inside at each location. Poly sampling tubes (3/8" diameter) were put in place to draw in the air samples from the outside sampling points. The monitor's internal pump pulled in air samples continuously and determined the CO values every ten seconds. The ten second CO values were stored internally in the monitor and used to generate one hour CO averages. A paper strip chart recorder was also used at each site as a backup data collection method.

A five point calibration was performed on the monitors at the beginning of the data collection period, and repeated quarterly. USEPA certified test gasses, traceable to the National Bureau of Standards, were used for the calibration. The monitors' accuracy was checked every seven to twelve days. An Air Quality Auditor from the MPCA verified proper operation of the equipment. Test gasses of known concentrations were introduced to the monitors by the Auditor to determine the accuracy of the calibrations. Reports were produced by the Auditor stating results of the site audits. The reports confirm the

accuracy of the CO data collected from the I-394 MnPASS sites. The monitoring sites passed all MPCA audits. A copy of the Auditor's reports are located in Appendix B.

The one hour CO readings from the monitors were collected via phone/modem or direct connection to a laptop computer by using software provided by the monitor manufacturer. The one hour CO averages were recorded for the A.M. and P.M. peak hours of the I-394 MnPASS lane at the north and south CO monitoring sites for the pre and post MnPASS lane operation.

The CO readings were also exported to a spreadsheet where the eight hour CO values were determined. Each hour of data collected, plus the previous seven hours collected, were averaged to calculate the eight hour CO average. A monthly report was generated from the data noting the top ten one hour and eight hour CO averages for each month of operation. Copies of the monthly CO reports can be found in Appendix B.

C. Results

The one hour CO averages were compared for A.M. and P.M. peak hours, for pre and post MnPASS lane operation for the same dates that the noise monitoring was conducted and traffic counts were taken. The average results are documented in Table 4. North Site CO Monitoring Results, and Table 5. South Site CO Monitoring Results. A detailed summary of the date specific CO monitoring is located in Appendix B.

Table 4. North Site CO Monitoring Results

North Site CO Monitoring Results			
A.M. Peak		**P.M. Peak**	
Pre MnPASS 1 hr. avg. CO (ppm)*	**Post MnPASS 1 hr. avg. CO (ppm)***	**Pre MnPASS 1 hr. avg. CO (ppm)***	**Post MnPASS 1 hr. avg. CO (ppm)***
0.39	0.59	0.23	0.20

*parts per million

Table 5. South Site CO Monitoring Results

South Site CO Monitoring Results			
A.M. Peak		**P.M. Peak**	
Pre MnPASS 1 hr. avg. CO (ppm)*	**Post MnPASS 1 hr. avg. CO (ppm)***	**Pre MnPASS 1 hr. avg. CO (ppm)***	**Post MnPASS 1 hr. avg. CO (ppm)***
0.38	0.67	0.26	0.27

*parts per million

D. Conclusions

When evaluating the pre and post CO monitoring results, a 0.20 ppm CO one hour average increase was found in the A.M. peak hours at the north monitoring site, with a 0.03 ppm CO decrease in the P.M. peak hours. At the south monitoring site a one hour average increase of 0.29 ppm CO was found during A.M. peak hours, and a 0.01 ppm increase for the P.M. peak hours. The increases in the one hour average CO levels are considered minimal, and the CO concentrations remain well below the 30 ppm one hour CO air quality standard for Minnesota, as set by the MPCA. Therefore, it can be concluded that the operation of the MnPASS lane did not result in a substantial impact on the air quality due to any changes in traffic patterns in the project area.

Appendix A

Noise Monitoring Data

SITE	DATE	TIME	L10	L50	WB AUTO	WB MED.	WB HVY.	SPEED	HOV AUTO	HOV MED.	HOV HVY.	SPEED	EB AUTO	EB MED.	EB HVY.	SPEED
1007 Cedar Lake Rd	04/20/05	7:00	68.0	66.0	3432	186	72	59	696	156	6	60	4200	78	72	51
1007 Cedar Lake Rd	04/20/05	7:20	68.5	66.5	5898	348	66	60	1524	174	6	57	5598	48	78	24
1007 Cedar Lake Rd	04/20/05	7:40	67.5	66.0	5604	204	96	29	1422	138	6	62	5316	54	54	34
1007 Cedar Lake Rd	04/20/05	8:00	68.0	66.5	5286	174	96	35	1488	168	0	55	5292	78	84	54
1007 Cedar Lake Rd	04/20/05	8:20	68.0	65.5	4824	186	120	47	984	108	0	59	5322	78	108	48
1007 Cedar Lake Rd	04/20/05	8:40	68.5	66.5	5406	288	72	60	906	96	0	61	5460	96	96	58
1007 Cedar Lake Rd	04/20/05	15:00	66.5	64.5	4974	96	60	55	546	84	0	64	3954	150	108	52
1007 Cedar Lake Rd	04/20/05	15:20	67.0	65.0	5706	144	54	52	582	114	0	61	4506	168	84	58
1007 Cedar Lake Rd	04/20/05	15:40	67.0	65.0	5826	84	36	40	756	114	0	62	4542	132	66	60
1007 Cedar Lake Rd	04/20/05	16:00	66.5	64.0	5376	54	60	54	654	60	0	64	4290	96	66	57
1007 Cedar Lake Rd	04/20/05	16:20	66.5	64.0	5880	84	24	31	1062	174	0	63	4596	150	18	29
1007 Cedar Lake Rd	04/20/05	16:40	67.5	65.0	5574	42	54	26	1278	162	0	55	4746	96	36	21
1007 Cedar Lake Rd	10/06/05	15:00	69.5	67.5	5058	102	42	54	822	30	0	56	4032	72	150	56
1007 Cedar Lake Rd	10/06/05	15:20	69.0	67.0	5142	102	102	52	816	66	0	59	4638	90	114	51
1007 Cedar Lake Rd	10/06/05	15:40	68.0	66.0	5226	84	66	50	966	96	0	57	4146	96	84	61
1007 Cedar Lake Rd	10/06/05	16:00	69.0	66.5	4932	114	54	53	1074	108	0	54	3948	78	90	55
1007 Cedar Lake Rd	10/06/05	16:20	68.5	66.5	5688	78	84	50	1098	138	0	55	4470	78	96	52
1007 Cedar Lake Rd	10/11/05	7:00	67.0	65.0	4146	174	102	58	1500	186	0	58	5130	36	66	39
1007 Cedar Lake Rd	10/11/05	7:20	67.5	65.5	5436	174	66	54	1962	168	0	61	4872	24	42	22
1007 Cedar Lake Rd	10/11/05	7:40	67.0	65.5	6000	168	114	49	2280	132	0	59	4470	18	78	22
1007 Cedar Lake Rd	10/11/05	8:00	68.0	65.0	5670	192	132	56	1824	174	0	62	4038	24	96	14
1007 Cedar Lake Rd	10/11/05	8:20	66.5	64.5	5220	180	144	57	1680	132	0	52	4728	36	108	47
1012 S Thomas Ave	05/03/05	7:00	69.5	66.5	4374	150	150	60	870	174	12	59	5274	54	48	52
1012 S Thomas Ave	05/03/05	7:20	69.5	67.0	5856	192	108	51	1380	150	0	54	5352	78	42	40
1012 S Thomas Ave	05/03/05	7:40	70.5	68.0	6678	186	78	57	1164	108	12	56	5358	54	54	58
1012 S Thomas Ave	05/03/05	8:00	70.5	68.5	5472	162	126	56	1194	156	6	60	3978	36	36	62
1012 S Thomas Ave	05/03/05	15:00	68.0	65.0	5124	114	48	58	576	36	6	57	4080	234	96	57
1012 S Thomas Ave	05/03/05	15:20	68.5	65.5	5706	96	72	60	630	90	0	63	4800	114	108	57
1012 S Thomas Ave	05/03/05	15:40	69.0	65.5	5598	78	54	56	774	96	0	57	4386	96	60	57
1012 S Thomas Ave	05/03/05	16:00	68.5	66.0	5436	48	84	53	762	60	0	58	4128	54	84	56
1012 S Thomas Ave	10/06/05	15:00	70.5	68.5	5058	102	42	54	822	30	0	56	4032	72	150	56
1012 S Thomas Ave	10/06/05	15:20	70.0	68.5	5142	102	102	52	816	66	0	59	4638	90	114	51
1012 S Thomas Ave	10/06/05	15:40	70.0	67.5	5226	84	66	50	966	96	0	57	4146	96	84	61
1012 S Thomas Ave	10/06/05	16:00	70.5	68.5	4932	114	54	53	1074	108	0	54	3948	78	90	55
1012 S Thomas Ave	10/06/05	16:20	69.5	67.5	5688	78	84	50	1098	138	0	55	4470	78	96	52
1012 S Thomas Ave	10/11/05	7:00	70.0	68.0	4146	174	102	58	1500	186	0	58	5130	36	66	39
1012 S Thomas Ave	10/11/05	7:20	71.0	68.5	5436	174	66	54	1962	168	0	61	4872	24	42	22
1012 S Thomas Ave	10/11/05	7:40	70.0	68.0	6000	168	114	49	2280	132	0	59	4470	18	78	22
1012 S Thomas Ave	10/11/05	8:00	69.5	68.0	5670	192	132	56	1824	174	0	62	4038	24	96	14
1012 S Thomas Ave	10/11/05	8:20	69.5	67.5	5220	180	144	57	1680	132	0	52	4728	36	108	47

SITE	DATE	TIME	L10	L50	WB AUTO	WB MED.	WB HVY.	SPEED	HOV AUTO	HOV MED.	HOV HVY.	SPEED	EB AUTO	EB MED.	EB HVY.	SPEED
1013 Kenwood Pkwy	04/20/05	7:00	69.0	67.0	3432	186	72	59	696	156	6	60	4200	78	72	51
1013 Kenwood Pkwy	04/20/05	7:20	70.0	66.0	5898	348	66	60	1524	174	6	57	5598	48	78	24
1013 Kenwood Pkwy	04/20/05	7:40	69.5	64.5	5604	204	96	29	1422	138	6	62	5316	54	54	34
1013 Kenwood Pkwy	04/20/05	8:00	70.5	66.0	5286	174	96	35	1488	168	0	55	5292	78	84	54
1013 Kenwood Pkwy	04/20/05	8:20	70.0	66.5	4824	186	120	47	984	108	0	59	5322	78	108	48
1013 Kenwood Pkwy	04/20/05	8:40	69.5	66.5	5406	288	72	60	906	96	0	61	5460	96	96	58
1013 Kenwood Pkwy	04/20/05	15:00	70.5	66.0	4974	96	60	55	546	84	0	64	3954	150	108	52
1013 Kenwood Pkwy	04/20/05	15:20	69.0	64.5	5706	144	54	52	582	114	0	61	4506	168	84	58
1013 Kenwood Pkwy	04/20/05	15:40	69.5	64.5	5826	84	36	40	756	114	0	62	4542	132	66	60
1013 Kenwood Pkwy	04/20/05	16:00	68.5	63.0	5376	54	60	54	654	60	0	64	4290	96	66	57
1013 Kenwood Pkwy	04/20/05	16:20	69.0	64.0	5880	84	24	31	1062	174	0	63	4596	150	18	29
1013 Kenwood Pkwy	04/20/05	16:40	68.0	61.5	5574	42	54	26	1278	162	0	55	4746	96	36	21
1013 Kenwood Pkwy	09/29/05	7:00	68.5	64.5	4344	102	204	56	1242	210	0	52	5100	66	66	48
1013 Kenwood Pkwy	09/29/05	7:20	69.5	64.5	5556	96	186	48	1830	108	0	57	4614	72	54	48
1013 Kenwood Pkwy	09/29/05	7:40	70.0	63.5	6456	114	156	46	2250	132	0	55	5112	72	42	36
1013 Kenwood Pkwy	09/29/05	8:00	69.5	64.5	5844	108	120	58	1938	168	0	59	4314	60	54	57
1013 Kenwood Pkwy	09/29/05	8:20	69.0	65.0	4902	102	150	54	1794	108	0	58	4860	108	60	51
1013 Kenwood Pkwy	10/06/05	15:00	71.0	68.0	5058	102	42	54	822	30	0	56	4032	72	150	56
1013 Kenwood Pkwy	10/06/05	15:20	69.5	66.5	5142	102	102	52	816	66	0	59	4638	90	114	51
1013 Kenwood Pkwy	10/06/05	15:40	69.5	66.0	5226	84	66	50	966	96	0	57	4146	96	84	61
1013 Kenwood Pkwy	10/06/05	16:00	69.5	65.5	4932	114	54	53	1074	108	0	54	3948	78	90	55
1013 Kenwood Pkwy	10/06/05	16:20	69.5	66.0	5688	78	84	50	1098	138	0	55	4470	78	96	52
1200 Kenwood Pkwy	05/03/05	7:00	70.0	69.0	4374	150	150	60	870	174	12	59	5274	54	48	52
1200 Kenwood Pkwy	05/03/05	7:20	69.0	68.0	5856	192	108	51	1380	150	0	54	5352	78	42	40
1200 Kenwood Pkwy	05/03/05	7:40	68.5	67.5	6678	186	78	57	1164	108	12	56	5358	54	54	58
1200 Kenwood Pkwy	05/03/05	8:00	70.0	68.5	5472	162	126	56	1194	156	6	60	3978	36	36	62
1200 Kenwood Pkwy	05/03/05	8:20	70.0	68.5	5064	162	48	60	1662	150	0	60	5226	78	132	47
1200 Kenwood Pkwy	05/03/05	15:00	70.0	68.5	5124	114	48	58	576	36	6	57	4080	234	96	57
1200 Kenwood Pkwy	05/03/05	15:20	68.5	67.0	5706	96	72	60	630	90	0	63	4800	114	108	57
1200 Kenwood Pkwy	05/03/05	15:40	68.0	66.5	5598	78	54	56	774	96	0	57	4386	96	60	57
1200 Kenwood Pkwy	05/03/05	16:00	68.5	67.0	5436	48	84	53	762	60	0	58	4128	54	84	56
1200 Kenwood Pkwy	05/03/05	16:20	67.0	65.5	5664	24	60	57	882	132	0	56	4020	102	54	28
1200 Kenwood Pkwy	10/03/05	15:00	68.5	67.0	4638	132	54	58	684	66	0	59	3822	72	126	59
1200 Kenwood Pkwy	10/03/05	15:20	68.5	67.0	5142	132	114	58	702	60	0	58	4212	84	120	57
1200 Kenwood Pkwy	10/03/05	15:40	68.0	66.5	5124	108	60	57	828	114	0	57	4464	144	78	59
1200 Kenwood Pkwy	10/03/05	16:00	68.5	66.5	4644	48	84	55	852	54	0	60	4218	84	132	56
1200 Kenwood Pkwy	10/03/05	16:20	68.5	67.0	5124	108	42	58	1320	204	0	57	4560	84	120	56
1200 Kenwood Pkwy	10/06/05	7:00	71.5	70.0	4710	240	72	54	1368	132	0	56	5352	36	30	52
1200 Kenwood Pkwy	10/06/05	7:20	70.5	69.0	5724	246	90	46	1824	168	0	58	5070	42	72	48
1200 Kenwood Pkwy	10/06/05	7:40	71.0	70.0	6204	138	126	50	2154	120	0	57	4788	24	78	57
1200 Kenwood Pkwy	10/06/05	8:00	72.0	70.5	5508	180	114	55	1842	174	0	58	4458	42	60	54
1200 Kenwood Pkwy	10/06/05	8:20	71.5	70.0	4932	198	78	50	1662	114	0	58	4788	108	90	51

SITE	DATE	TIME	L10	L50	WB AUTO	WB MED.	WB HVY.	SPEED	HOV AUTO	HOV MED.	HOV HVY.	SPEED	EB AUTO	EB MED.	EB HVY.	SPEED
1228 Cedar Lake Rd	04/20/05	7:00	71.0	69.0	3432	186	72	59	696	156	6	60	4200	78	72	51
1228 Cedar Lake Rd	04/20/05	7:20	71.5	70.0	5898	348	66	60	1524	174	6	57	5598	48	78	24
1228 Cedar Lake Rd	04/20/05	7:40	71.0	69.5	5604	204	96	29	1422	138	6	62	5316	54	54	34
1228 Cedar Lake Rd	04/20/05	8:00	71.0	69.5	5286	174	96	35	1488	168	0	55	5292	78	84	54
1228 Cedar Lake Rd	04/20/05	8:20	70.5	69.0	4824	186	120	47	984	108	0	59	5322	78	108	48
1228 Cedar Lake Rd	04/20/05	8:40	71.5	69.5	5406	288	72	60	906	96	0	61	5460	96	96	58
1228 Cedar Lake Rd	04/20/05	15:00	69.5	67.5	4974	96	60	55	546	84	0	64	3954	150	108	52
1228 Cedar Lake Rd	04/20/05	15:20	70.0	68.0	5706	144	54	52	582	114	0	61	4506	168	84	58
1228 Cedar Lake Rd	04/20/05	15:40	70.0	68.5	5826	84	36	40	756	114	0	62	4542	132	66	60
1228 Cedar Lake Rd	04/20/05	16:00	69.5	67.5	5376	54	60	54	654	60	0	64	4290	96	66	57
1228 Cedar Lake Rd	04/20/05	16:20	70.0	67.5	5880	84	24	31	1062	174	0	63	4596	150	18	29
1228 Cedar Lake Rd	04/20/05	16:40	70.0	67.5	5574	42	54	26	1278	162	0	55	4746	96	36	21
1228 Cedar Lake Rd	10/11/05	7:00	69.5	68.0	4146	174	102	58	1500	186	0	58	5130	36	66	39
1228 Cedar Lake Rd	10/11/05	7:20	71.0	68.5	5436	174	66	54	1962	168	0	61	4872	24	42	22
1228 Cedar Lake Rd	10/11/05	7:40	70.0	68.5	6000	168	114	49	2280	132	0	59	4470	18	78	22
1228 Cedar Lake Rd	10/11/05	8:00	70.5	68.0	5670	192	132	56	1824	174	0	62	4038	24	96	14
1228 Cedar Lake Rd	10/11/05	8:20	69.0	67.5	5220	180	144	57	1680	132	0	52	4728	36	108	47
1228 Cedar Lake Rd	10/11/05	15:00	69.5	66.0	4758	120	66	54	786	42	0	55	3750	162	96	57
1228 Cedar Lake Rd	10/11/05	15:20	69.0	66.5	4800	102	54	48	780	102	0	64	4338	96	90	59
1228 Cedar Lake Rd	10/11/05	15:40	68.5	66.0	5154	90	90	59	858	120	0	62	4368	120	84	59
1228 Cedar Lake Rd	10/11/05	16:00	68.5	66.5	5052	114	54	54	1092	156	0	60	4176	96	24	57
1228 Cedar Lake Rd	10/11/05	16:20	68.0	66.5	5334	54	54	54	1446	162	0	56	4536	84	72	54
1728 Kenwood Pkwy	04/27/05	7:02	59.0	57.5	4146	216	120	54	894	162	0	54	5376	42	48	54
1728 Kenwood Pkwy	04/27/05	7:20	61.0	59.0	5316	270	84	52	1290	120	6	58	5640	54	36	28
1728 Kenwood Pkwy	04/27/05	7:40	61.0	58.0	6276	126	132	49	1434	114	6	61	4890	36	66	27
1728 Kenwood Pkwy	04/27/05	8:10	59.0	57.5	5796	174	168	59	1242	144	6	59	5082	66	102	37
1728 Kenwood Pkwy	04/27/05	8:30	58.5	56.5	4722	168	102	57	912	78	6	55	5154	96	60	32
1728 Kenwood Pkwy	04/27/05	15:06	59.0	57.0	5082	102	54	53	774	42	0	60	4056	132	120	51
1728 Kenwood Pkwy	04/27/05	15:20	60.0	56.5	5598	120	72	55	708	96	0	63	4650	114	108	55
1728 Kenwood Pkwy	04/27/05	15:40	61.0	58.0	5376	54	60	44	846	90	0	58	4416	84	102	40
1728 Kenwood Pkwy	04/27/05	16:00	57.5	55.5	5250	42	30	58	558	48	0	59	4332	66	54	56
1728 Kenwood Pkwy	04/27/05	16:20	59.0	57.5	5766	66	36	47	954	162	6	65	4296	144	108	59
1728 Kenwood Pkwy	10/03/05	15:00	53.0	50.5	4638	132	54	58	684	66	0	59	3822	72	126	59
1728 Kenwood Pkwy	10/03/05	15:20	52.5	50.5	5142	132	114	58	702	60	0	58	4212	84	120	57
1728 Kenwood Pkwy	10/03/05	15:40	52.0	50.0	5124	108	60	57	828	114	0	57	4464	144	78	59
1728 Kenwood Pkwy	10/03/05	16:00	53.0	50.0	4644	48	84	55	852	54	0	60	4218	84	132	56
1728 Kenwood Pkwy	10/03/05	16:20	52.5	50.5	5124	108	42	58	1320	204	0	57	4560	84	120	56
1728 Kenwood Pkwy	10/06/05	7:00	61.0	60.0	4710	240	72	54	1368	132	0	56	5352	36	30	52
1728 Kenwood Pkwy	10/06/05	7:20	63.0	61.0	5724	246	90	46	1824	168	0	58	5070	42	72	48
1728 Kenwood Pkwy	10/06/05	7:40	63.0	61.5	6204	138	126	50	2154	120	0	57	4788	24	78	57
1728 Kenwood Pkwy	10/06/05	8:00	62.5	61.0	5508	180	114	55	1842	174	0	58	4458	42	60	54
1728 Kenwood Pkwy	10/06/05	8:20	62.5	60.5	4932	198	78	50	1662	114	0	58	4788	108	90	51

SITE	DATE	TIME	L10	L50	WB AUTO	WB MED.	WB HVY.	SPEED	HOV AUTO	HOV MED.	HOV HVY.	SPEED	EB AUTO	EB MED.	EB HVY.	SPEED
2436 Mt View Av	04/21/05	7:00	63.5	61.5	4380	210	138	49	894	186	0	58	5346	48	30	50
2436 Mt View Av	04/21/05	7:20	62.5	61.5	5526	252	96	57	1422	168	0	59	5856	66	54	27
2436 Mt View Av	04/21/05	7:40	63.5	61.5	6354	300	78	54	1626	114	24	60	5244	60	42	50
2436 Mt View Av	04/21/05	8:00	63.0	61.0	5724	198	78	55	1224	234	0	58	5124	48	12	57
2436 Mt View Av	04/21/05	8:20	63.5	62.0	5406	270	150	58	1026	132	6	64	5610	48	66	50
2436 Mt View Av	04/21/05	8:40	63.5	62.0	4614	168	120	63	900	90	0	63	4956	66	102	57
2436 Mt View Av	04/21/05	15:00	62.5	60.5	5196	36	114	59	846	24	0	71	4362	150	114	56
2436 Mt View Av	04/21/05	15:20	61.0	59.5	5304	120	48	60	738	120	6	63	4638	120	114	55
2436 Mt View Av	04/21/05	15:40	61.0	59.0	5640	78	36	31	858	126	0	59	4554	108	108	46
2436 Mt View Av	04/21/05	16:00	60.0	58.0	5028	72	30	34	1236	90	0	53	4272	96	138	30
2436 Mt View Av	04/21/05	16:20	61.0	59.5	6078	66	24	52	1184	180	0	55	3822	72	102	34
2436 Mt View Av	04/21/05	16:40	59.5	57.5	4836	24	42	16	1188	138	0	61	4356	96	30	28
2436 Mt View Av	09/29/05	7:00	65.0	64.0	4344	102	204	56	1242	210	0	52	5100	66	66	48
2436 Mt View Av	09/29/05	7:20	65.5	64.0	5556	96	186	48	1830	108	0	57	4614	72	54	48
2436 Mt View Av	09/29/05	7:40	65.5	64.0	6456	114	156	46	2250	132	0	55	5112	72	42	36
2436 Mt View Av	09/29/05	8:00	66.0	65.0	5844	108	120	58	1938	168	0	59	4314	60	54	57
2436 Mt View Av	09/29/05	8:20	66.0	64.5	4902	102	150	54	1794	108	0	58	4860	108	60	51
2436 Mt View Av	09/29/05	15:00	65.5	63.5	4374	66	96	11	1146	60	0	56	4218	186	78	47
2436 Mt View Av	09/29/05	15:20	64.5	62.0	4008	66	66	21	1110	108	0	53	4422	96	48	41
2436 Mt View Av	09/29/05	15:40	65.0	63.0	5172	102	60	36	1098	66	0	59	4368	150	72	29
2436 Mt View Av	09/29/05	16:00	66.0	64.5	4752	18	54	55	1230	84	0	57	4344	66	36	53
2436 Mt View Av	09/29/05	16:20	67.0	65.5	5274	42	24	49	1380	168	0	57	4956	156	54	59
2436 MtView (at wall)	04/21/05	15:00	75.5	73.5	5196	36	114	59	846	24	0	71	4362	150	114	56
2436 MtView (at wall)	04/21/05	15:20	75.5	73.5	5304	120	48	60	738	120	6	63	4638	120	114	55
2436 MtView (at wall)	04/21/05	15:40	74.0	71.0	5640	78	36	31	858	126	0	59	4554	108	108	46
2436 MtView (at wall)	04/21/05	16:00	72.0	69.0	5028	72	30	34	1236	90	0	53	4272	96	138	30
2436 MtView (at wall)	04/21/05	16:20	74.5	72.5	6078	66	24	52	1184	180	0	55	3822	72	102	34
2436 MtView (at wall)	04/21/05	16:40	71.5	69.0	4836	24	42	16	1188	138	0	61	4356	96	30	28
2436 MtView (at wall)	09/29/05	7:00			4344	102	204	56	1242	210	0	52	5100	66	66	48
2436 MtView (at wall)	09/29/05	7:20	77.5	76.0	5556	96	186	48	1830	108	0	57	4614	72	54	48
2436 MtView (at wall)	09/29/05	7:40	77.5	76.0	6456	114	156	46	2250	132	0	55	5112	72	42	36
2436 MtView (at wall)	09/29/05	8:00	78.0	76.5	5844	108	120	58	1938	168	0	59	4314	60	54	57
2436 MtView (at wall)	09/29/05	8:20	78.0	76.0	4902	102	150	54	1794	108	0	58	4860	108	60	51
2436 MtView (at wall)	09/29/05	15:00	75.0	73.0	4374	66	96	11	1146	60	0	56	4218	186	78	47
2436 MtView (at wall)	09/29/05	15:20	74.0	71.0	4008	66	66	21	1110	108	0	53	4422	96	48	41
2436 MtView (at wall)	09/29/05	15:40	74.5	71.5	5172	102	60	36	1098	66	0	59	4368	150	72	29
2436 MtView (at wall)	09/29/05	16:00	76.5	74.5	4752	18	54	55	1230	84	0	57	4344	66	36	53
2436 MtView (at wall)	09/29/05	16:20	77.0	75.5	5274	42	24	49	1380	168	0	57	4956	156	54	59

SITE	DATE	TIME	L10	L50	WB AUTO	WB MED.	WB HVY.	SPEED	HOV AUTO	HOV MED.	HOV HVY.	SPEED	EB AUTO	EB MED.	EB HVY.	SPEED
432 Morgan	05/03/05	7:00	53.0	51.5	4374	150	150	60	870	174	12	59	5274	54	48	52
432 Morgan	05/03/05	7:20	53.0	49.5	5856	192	108	51	1380	150	0	54	5352	78	42	40
432 Morgan	05/03/05	7:40	51.0	48.5	6678	186	78	57	1164	108	12	56	5358	54	54	58
432 Morgan	05/03/05	8:00	53.5	49.0	5472	162	126	56	1194	156	6	60	3978	36	36	62
432 Morgan	05/03/05	8:20	52.0	50.5	5064	162	48	60	1662	150	0	60	5226	78	132	47
432 Morgan	05/03/05	15:00	52.5	47.5	5124	114	48	58	576	36	6	57	4080	234	96	57
432 Morgan	05/03/05	15:20	51.5	48.0	5706	96	72	60	630	90	0	63	4800	114	108	57
432 Morgan	05/03/05	15:40	53.0	49.5	5598	78	54	56	774	96	0	57	4386	96	60	57
432 Morgan	05/03/05	16:00	51.5	47.5	5436	48	84	53	762	60	0	58	4128	54	84	56
432 Morgan	05/03/05	16:20	50.5	47.5	5664	24	60	57	882	132	0	56	4020	102	54	28
432 Morgan	09/29/05	7:00	59.0	58.0	4344	102	204	56	1242	210	0	52	5100	66	66	48
432 Morgan	09/29/05	7:20	59.5	58.5	5556	96	186	48	1830	108	0	57	4614	72	54	48
432 Morgan	09/29/05	7:40	59.0	58.0	6456	114	156	46	2250	132	0	55	5112	72	42	36
432 Morgan	09/29/05	8:00	62.0	59.0	5844	108	120	58	1938	168	0	59	4314	60	54	57
432 Morgan	09/29/05	8:20	59.0	57.5	4902	102	150	54	1794	108	0	58	4860	108	60	51
432 Morgan	09/29/05	15:00	58.5	56.0	4374	66	96	11	1146	60	0	56	4218	186	78	47
432 Morgan	09/29/05	15:20	60.5	55.0	4008	66	66	21	1110	108	0	53	4422	96	48	41
432 Morgan	09/29/05	15:40	58.0	56.5	5172	102	60	36	1098	66	0	59	4368	150	72	29
432 Morgan	09/29/05	16:00	61.0	58.5	4752	18	54	55	1230	84	0	57	4344	66	36	53
432 Morgan	09/29/05	16:20	60.0	59.0	5274	42	24	49	1380	168	0	57	4956	156	54	59
602 Thomas	04/26/05	7:00	55.5	54.0												
602 Thomas	04/26/05	7:15	55.0	53.0												
602 Thomas	04/26/05	7:30	56.0	54.0												
602 Thomas	04/26/05	7:45	56.0	53.5												
602 Thomas	04/26/05	8:00	56.0	54.0												
602 Thomas	04/26/05	15:45	57.0	51.5												
602 Thomas	04/26/05	16:10	53.0	51.0												
602 Thomas	04/26/05	16:30	52.0	50.0												
602 Thomas	10/11/05	7:00	60.5	59.0	4146	174	102	58	1500	186	0	58	5130	36	66	39
602 Thomas	10/11/05	7:20	60.5	59.0	5436	174	66	54	1962	168	0	61	4872	24	42	22
602 Thomas	10/11/05	7:40	59.0	58.0	6000	168	114	49	2280	132	0	59	4470	18	78	22
602 Thomas	10/11/05	8:00	57.5	56.0	5670	192	132	56	1824	174	0	62	4038	24	96	14
602 Thomas	10/11/05	8:20	57.0	55.0	5220	180	144	57	1680	132	0	52	4728	36	108	47
602 Thomas	10/11/05	15:00	56.0	53.0	4758	120	66	54	786	42	0	55	3750	162	96	57
602 Thomas	10/11/05	15:20	58.5	55.0	4800	102	54	48	780	102	0	64	4338	96	90	59
602 Thomas	10/11/05	15:40	56.5	54.5	5154	90	90	59	858	120	0	62	4368	120	84	59
602 Thomas	10/11/05	16:00	57.0	54.5	5052	114	54	54	1092	156	0	60	4176	96	24	57
602 Thomas	10/11/05	16:20	56.5	54.5	5334	54	54	54	1446	162	0	56	4536	84	72	54

SITE	DATE	TIME	L10	L50	WB AUTO	WB MED.	WB HVY.	SPEED	HOV AUTO	HOV MED.	HOV HVY.	SPEED	EB AUTO	EB MED.	EB HVY.	SPEED
602 Upton	04/27/05	7:00	56.0	53.5	4146	216	120	54	894	162	0	54	5376	42	48	54
602 Upton	04/27/05	7:20	56.5	54.0	5316	270	84	52	1290	120	6	58	5640	54	36	28
602 Upton	04/27/05	7:40	56.0	53.0	6276	126	132	49	1434	114	6	61	4890	36	66	27
602 Upton	04/27/05	8:10	59.0	54.0	5796	174	168	59	1242	144	6	59	5082	66	102	37
602 Upton	04/27/05	8:30	55.5	53.0	4722	168	102	57	912	78	6	55	5154	96	60	32
602 Upton	04/27/05	15:00	56.5	54.5	5082	102	54	53	774	42	0	60	4056	132	120	51
602 Upton	04/27/05	15:20	56.5	53.5	5598	120	72	55	708	96	0	63	4650	114	108	55
602 Upton	04/27/05	15:40	58.5	56.0	5376	54	60	44	846	90	0	58	4416	84	102	40
602 Upton	04/27/05	16:00	63.0	53.0	5250	42	30	58	558	48	0	59	4332	66	54	56
602 Upton	04/27/05	16:20	60.5	55.5	5766	66	36	47	954	162	6	65	4296	144	108	59
602 Upton	09/27/05	7:10	60.5	56.5	5340	216	90	51	1812	114	0	53	4764	30	24	31
602 Upton	09/27/05	7:30	61.0	56.5	5832	180	138	61	1908	180	0	60	4782	24	42	11
602 Upton	09/27/05	7:50	60.5	56.0	5712	186	138	52	1956	108	0	54	4908	30	48	43
602 Upton	09/27/05	8:10	58.5	56.5	4836	162	78	55	1950	144	6	54	4674	36	66	47
602 Upton	09/27/05	8:30	58.5	56.0	4722	204	126	52	1518	174	0	52	4824	48	72	50
602 Upton	09/28/05	15:00	60.0	56.0	4662	90	60	53	750	36	0	55	4080	180	84	57
602 Upton	09/28/05	15:20	59.5	56.0	5118	60	66	58	666	96	0	56	4152	144	60	60
602 Upton	09/28/05	15:40	58.5	55.5	5112	78	36	32	942	90	0	56	4404	168	42	53
602 Upton	09/28/05	16:00	65.0	55.0	5040	54	60	58	1002	114	0	54	4134	90	42	64
602 Upton	09/28/05	16:20	58.5	55.5	5448	54	78	58	1398	132	0	64	4338	96	24	54
604 Cedar Lake Rd	05/03/05	7:00	63.0	52.0	4374	150	150	60	870	174	12	59	5274	54	48	52
604 Cedar Lake Rd	05/03/05	7:20	62.0	52.0	5856	192	108	51	1380	150	0	54	5352	78	42	40
604 Cedar Lake Rd	05/03/05	7:40	61.5	50.5	6678	186	78	57	1164	108	12	56	5358	54	54	58
604 Cedar Lake Rd	05/03/05	8:00	63.5	51.5	5472	162	126	56	1194	156	6	60	3978	36	36	62
604 Cedar Lake Rd	05/03/05	8:20	60.0	50.0	5064	162	48	60	1662	150	0	60	5226	78	132	47
604 Cedar Lake Rd	05/03/05	15:00	58.0	48.5	5124	114	48	58	576	36	6	57	4080	234	96	57
604 Cedar Lake Rd	05/03/05	15:20	63.0	50.5	5706	96	72	60	630	90	0	63	4800	114	108	57
604 Cedar Lake Rd	05/03/05	15:40	62.5	51.5	5598	78	54	56	774	96	0	57	4386	96	60	57
604 Cedar Lake Rd	05/03/05	16:00	65.0	51.0	5436	48	84	53	762	60	0	58	4128	54	84	56
604 Cedar Lake Rd	05/03/05	16:20	59.5	50.5	5664	24	60	57	882	132	0	56	4020	102	54	28
604 Cedar Lake Rd	09/27/05	7:10	62.0	56.5	5340	216	90	51	1812	114	0	53	4764	30	24	31
604 Cedar Lake Rd	09/27/05	7:30	63.5	55.5	5832	180	138	61	1908	180	0	60	4782	24	42	11
604 Cedar Lake Rd	09/27/05	7:50	62.5	55.0	5712	186	138	52	1956	108	0	54	4908	30	48	43
604 Cedar Lake Rd	09/27/05	8:10	63.0	55.5	4836	162	78	55	1950	144	6	54	4674	36	66	47
604 Cedar Lake Rd	09/27/05	8:30	62.0	55.0	4722	204	126	52	1518	174	0	52	4824	48	72	50
604 Cedar Lake Rd	09/27/05	15:00	63.0	58.0	4986	102	90	56	894	66	0	59	3792	96	114	59
604 Cedar Lake Rd	09/27/05	15:20	63.0	57.0	5166	90	72	54	792	102	6	57	4140	108	102	57
604 Cedar Lake Rd	09/27/05	15:40	61.0	57.0	5316	114	108	53	984	90	6	53	4128	108	84	55
604 Cedar Lake Rd	09/27/05	16:00	64.5	59.5	4890	66	66	42	1068	132	0	60	4572	60	126	57
604 Cedar Lake Rd	09/27/05	16:20	63.0	59.0	5298	90	66	50	1206	138	6	61	4620	132	42	56

SITE	DATE	TIME	L10	L50	WB AUTO	WB MED.	WB HVY.	SPEED	HOV AUTO	HOV MED.	HOV HVY.	SPEED	EB AUTO	EB MED.	EB HVY.	SPEED
621 Thomas	04/27/05	7:00	64.0	62.5	4146	216	120	54	894	162	0	54	5376	42	48	54
621 Thomas	04/27/05	7:20	64.5	63.0	5316	270	84	52	1290	120	6	58	5640	54	36	28
621 Thomas	04/27/05	7:40	63.5	62.0	6276	126	132	49	1434	114	6	61	4890	36	66	27
621 Thomas	04/27/05	8:10	63.5	62.0	5796	174	168	59	1242	144	6	59	5082	66	102	37
621 Thomas	04/27/05	8:30	63.0	61.0	4722	168	102	57	912	78	6	55	5154	96	60	32
621 Thomas	04/27/05	15:00	64.5	63.0	5082	102	54	53	774	42	0	60	4056	132	120	51
621 Thomas	04/27/05	15:20	63.5	62.0	5598	120	72	55	708	96	0	63	4650	114	108	55
621 Thomas	04/27/05	15:40	64.5	62.5	5376	54	60	44	846	90	0	58	4416	84	102	40
621 Thomas	04/27/05	16:00	63.5	61.5	5250	42	30	58	558	48	0	59	4332	66	54	56
621 Thomas	04/27/05	16:20	65.0	63.0	5766	66	36	47	954	162	6	65	4296	144	108	59
621 Thomas	09/27/05	7:10	65.0	63.5	5340	216	90	51	1812	114	0	53	4764	30	24	31
621 Thomas	09/27/05	7:30	65.0	63.5	5832	180	138	61	1908	180	0	60	4782	24	42	11
621 Thomas	09/27/05	7:50	64.5	63.5	5712	186	138	52	1956	108	0	54	4908	30	48	43
621 Thomas	09/27/05	8:10	65.5	63.5	4836	162	78	55	1950	144	6	54	4674	36	66	47
621 Thomas	09/27/05	8:30	65.0	64.0	4722	204	126	52	1518	174	0	52	4824	48	72	50
621 Thomas	09/28/05	15:00	64.5	63.0	4662	90	60	53	750	36	0	55	4080	180	84	57
621 Thomas	09/28/05	15:20	64.0	62.5	5118	60	66	58	666	96	0	56	4152	144	60	60
621 Thomas	09/28/05	15:40	64.0	62.5	5112	78	36	32	942	90	0	56	4404	168	42	53
621 Thomas	09/28/05	16:00	64.0	63.0	5040	54	60	58	1002	114	0	54	4134	90	42	64
621 Thomas	09/28/05	16:20	64.5	63.5	5448	54	78	58	1398	132	0	64	4338	96	24	54
636 Upton	04/21/05	7:00	67.5	64.5	4380	210	138	49	894	186	0	58	5346	48	30	50
636 Upton	04/21/05	7:20	68.0	65.0	5526	252	96	57	1422	168	0	59	5856	66	54	27
636 Upton	04/21/05	7:40	67.5	65.0	6354	300	78	54	1626	114	24	60	5244	60	42	50
636 Upton	04/21/05	8:00	67.5	64.5	5724	198	78	55	1224	234	0	58	5124	48	12	57
636 Upton	04/21/05	8:20	68.5	65.0	5406	270	150	58	1026	132	6	64	5610	48	66	50
636 Upton	04/21/05	8:40	68.5	66.0	4614	168	120	63	900	90	0	63	4956	66	102	57
636 Upton	04/21/05	15:00	66.5	63.5	5196	36	114	59	846	24	0	71	4362	150	114	56
636 Upton	04/21/05	15:20	65.5	63.0	5304	120	48	60	738	120	6	63	4638	120	114	55
636 Upton	04/21/05	15:40	66.5	63.0	5640	78	36	31	858	126	0	59	4554	108	108	46
636 Upton	04/21/05	16:00	66.0	62.5	5028	72	30	34	1236	90	0	53	4272	96	138	30
636 Upton	04/21/05	16:20	66.0	62.5	6078	66	24	52	1184	180	0	55	3822	72	102	34
636 Upton	04/21/05	16:40	66.5	61.5	4836	24	42	16	1188	138	0	61	4356	96	30	28
636 Upton	09/27/05	7:10	69.5	67.5	5340	216	90	51	1812	114	0	53	4764	30	24	31
636 Upton	09/27/05	7:30	69.5	67.0	5832	180	138	61	1908	180	0	60	4782	24	42	11
636 Upton	09/27/05	7:50	69.0	67.0	5712	186	138	52	1956	108	0	54	4908	30	48	43
636 Upton	09/27/05	8:10	69.0	67.0	4836	162	78	55	1950	144	6	54	4674	36	66	47
636 Upton	09/27/05	8:30	69.5	67.0	4722	204	126	52	1518	174	0	52	4824	48	72	50
636 Upton	09/27/05	15:00	70.0	67.0	4986	102	90	56	894	66	0	59	3792	96	114	59
636 Upton	09/27/05	15:20	69.5	66.5	5166	90	72	54	792	102	6	57	4140	108	102	57
636 Upton	09/27/05	15:40	69.0	66.5	5316	114	108	53	984	90	6	53	4128	108	84	55
636 Upton	09/27/05	16:00	69.5	67.5	4890	66	66	42	1068	132	0	60	4572	60	126	57
636 Upton	09/27/05	16:20	69.5	66.5	5298	90	66	50	1206	138	6	61	4620	132	42	56

Appendix B

MPCA Air Quality Auditor's Report
Monthly Carbon Monoxide Reports
Air Quality Monitoring Data

Minnesota Pollution Control Agency
Environmental Analysis Section
Air Monitoring Unit

Carbon Monoxide Monitor Performance Audit Form

Site and Equipment Information

Site No. 394N Location Qwest site 394 North Date 5/2/2005

Start Time 12:50 End Time 14:30 Operator MNDOT Auditor R:D

Mon tor Mfr TEI Mode. 48C S.N. 386 Cal. Date 3/31/2005

Zero Pol internal Span Pol internal Inlet Flow 1 L/m:n

Prec Cyl Mfg S.N. Cert. Date PPM
Span Cyl.Mfg S.N. Cert. Date PPM

Audit Equitment

Dilution System Environics Model 6100 S N 2926 Cert. Date 4/1/2005

QA Cyl Mf Air Product S N ap001726 PPM 2968.00 Cert. Date 2/14/2005

Audit Results

Sc. Point	Gas		Air		Tota	Adj1	Monitor	PPM	Percent	Tele.
	Cal Display	Actual Flow	Cal Display	Actual Flow	Flow cc/m:n	Value PPM	Value PPM	Diff	Diff	Volts/ % Chart
Zero			4	4474	4474.00	0.00	0.10	0.100 ns		
3.0-8.0	8.00	8.4	3	3352	3370.40	8.000	7.60	-0.400	-5.00	
15.0-20.0	20.00	21.2	3	3352	3383.20	20.000	19.50	-0.500	-2.50	
40.0-45.0	43.00	45.5	2.75	3089	3134.50	43.000	42.30	-0.700	1.63	
								Avg. =	-3.04	

Slope (m) = 0.9842 Intercept (b) = -0.0938 Correlation (r) = 1.0000

SOP logs net filter change date 3/31/2005

Telemetry check
Display ok
Output V

Recommendations

PASS XX FAIL

Minnesota Pollution Control Agency
Environmental Analysis Section
Air Monitoring Unit

Carbon Monoxide Monitor Performance Audit Form

Site and Equipment Information

Site No. 394B Location 394 & Penn Ave MPLS Date 5/2/2005

Start Time 11:00 End Time 12:30 Operator MNDOT Auditor RID

Monitor Mfr TEI Model 48C S.N. 377 Cal. Date 3/31/2005

Zero Pol Internal Span Pol Interna Inlet Flow 1 L/min

Prod Cyl Mfg ____ S.N. ____ Cert. Date ____ PPM ____
Span Cyl Mfg ____ S.N. ____ Cert. Date ____ PPM ____

Audit Equipment

Dilution System Environics Model 6100 S.N. 2920 Cert. Date 4/1/2005

QA Cyl. Mf Air Product S.N. hr001726 PPM 2996.00 Cert. Date 2/14/2005

Audit Results

Set Point	Gas Cs Display	Gas Actua Flow	Air Cs Display	Air Actua Flow	Total Flow ccm/in	Audit Value PPM	Monitor Value PPM	PPM Diff	Percent Diff	Tele. Volts/ % Chart
Zero			4	4474	4474.00	0.00	0.10	0.100	na	
3.0-8.0	8.00	8.4	3	3362	3370.40	8.000	7.70	-0.300	-3.75	
15.0-20.0	20.00	21.2	3	3362	3383.20	20.000	19.70	-0.300	-1.50	
40.0-45.0	43.00	45.5	2.75	3089	3134.50	43.000	42.80	-0.200	-0.47	
								Avg. =	-1.91	

Slope (m) = 0.9957 Intercept (b) = -0.0979 Correlation (r) = 1.0000

SCP logs Inlet filter change date 3/21/2005

Telemetry check
Display ok
Output mV ____

Recommendations

PASS XX FAIL ____

Minnesota Pollution Control Agency
Environmental Analysis Section
Air Monitoring Unit

Carbon Monoxide Monitor Performance Audit Form

Site and Equipment Information

Site No: Qwest Location: 394 west Date: 10/10/2005

Start Time: 12:30 End Time: 14:00 Operator: MNDOT Auditor: RID

Monitor Mfr: TEI Mode: 48C S.N.: 386 Cal Date: 9/14/2005

Zero Pot: internal Span Pot: internal Inlet Flow: 1 L/min

Prec Cyl Mfg: _____ S.N.: _____ Cert Date: _____ PPM: _____
Span Cyl Mfg: _____ S.N.: _____ Cert Date: _____ PPM: _____

Audit Equipment

Dilution System: Environics Model: 6100 S.N.: 2926 Cert. Date: 4/1/2005

QA Cyl Mfr: Air Product S.N.: BR001726 PPM: 2966.00 Cert. Date: 2/1/2005

Audit Results

Set Point	Gas		Air		Total Flow	Audit Value	Monitor Value	PPM Diff	Percent Diff	Tele. Volts/ % Chart
	Cal Display	Actual Flow	Cal Display	Actual Flow	cc/min	PPM	PPM			
Zero			4	4474	4474.00	0.00	0.20	0.200	na	
3.0-8.0	8.00	8.4	3	3362	3370.40	8.000	7.73	-0.270	-3.37	
15.0-20.0	20.00	21.2	3	3362	3383.20	20.000	19.70	-0.300	-1.50	
40.0-45.0	43.00	45.5	2.75	3089	3134.50	43.000	42.60	-0.400	-0.93	
								Avg. =	-1.92	

Slope (m) = 0.9883 Intercept (b) = 0.0046 Correlation (r) = 1.0000

SOP: ogs Inlet filter change date: 7/1/2005

Telemetry check
Display: ok
Output: mV

Recommendations:
Record inlet filter changes in site log book

PASS: XX FAIL: _____

Minnesota Pollution Control Agency
Environmental Analysis Section
Air Monitoring Unit

Carbon Monoxide Monitor Performance Audit Form

Site and Equipment Information

Site No 394 B Location Penn Ave Date 10/10/2005

Start Time 11:00 End Time 12:30 Operator MNDOT Auditor RID ____

Monitor Mfr TEI Model 48C S.N. 377 Cal. Date 9/13/05

Zero Pot internal Span Pot interna Inlet Flow 1 L/min ____

Prec Cyl Mfg ____ S.N. ____ Cert. Date ____ PPM ____
Span Cyl Mfg ____ S.N. ____ Cert. Date ____ PPM ____

Audit Equitment

Dilution System Environics Model 6100 S.N 2926 Cert. Date 4/1/2005

QA Cyl. Mfr Air Produc S.N BR001726 PPM 2368.00 Cert. Date 2/1/2005

Audit Results

Set Point	Gas		Air		Total Flow cc/min	Audit Value PPM	Monitor Value PPM	PPM Diff	Percent Diff	Tele. Volts/ % Chart
	Csi Display	Actual Flow	Csi Display	Actual Flow						
Zero			4	4474	4474.00	0.00	0.20	0.200	na	
3.0-8.0	8.00	8.4	3	3362	3370.40	8.000	7.70	-0.300	-3.75	
15.0-20.0	20.00	21.2	3	3362	3383.20	20.000	19.60	-0.400	-2.00	
40.0-45.0	43.00	46.5	2.75	3089	3134.50	43.000	42.60	-0.400	-0.93	
								Avg. =	-2.23	

Slope (m) = 0.9890 Intercept (b) = -0.0290 Correlation (r) = 0.9999

SOP ngs Inlet filter change date 7/1/2005

Telemetry check
Display ok
Output mV ____

Recommendations
Record inlet filter changes in site log book

PASS XX **FAIL** ____

MN/DOT Air Quality Report

Carbon Monoxide 1 Hour Average High Values For

April 2005

Site: 0000 (Qwest Building)

		CO PPM 1 hour Average
14-Apr	8:00	1.26
14-Apr	9:00	1.23
17-Apr	0:00	1.11
16-Apr	15:00	1.05
17-Apr	1:00	1.03
8-Apr	0:00	0.99
16-Apr	22:00	0.96
14-Apr	7:00	0.94
16-Apr	14:00	0.94
15-Apr	8:00	0.94

MN/DOT Air Quality Report

Carbon Monoxide 8 Hour Average High Values for

April 2005

Site: 0000 (Qwest Building)

		CO PPM 8 hour Average
14-Apr	3:00:00	0.88
14-Apr	4:00:00	0.88
14-Apr	2:00:00	0.87
14-Apr	5:00:00	0.87
14-Apr	10:00:00	0.85
14-Apr	11:00:00	0.85
14-Apr	1:00:00	0.85
14-Apr	16:00:00	0.84
14-Apr	12:00:00	0.83
14-Apr	15:00:00	0.83

MN/DOT Air Quality Report

Carbon Monoxide 1 Hour Average High Values For

April 2005

Site: 0000 (I394 & Penn Avenue)

		CO PPM 1 hour Average
2-Apr	7:00:00	1.15
2-Apr	8:00:00	1.14
2-Apr	5:00:00	1.10
3-Apr	7:00:00	1.09
3-Apr	3:00:00	1.06
3-Apr	5:00:00	1.06
3-Apr	4:00:00	1.05
2-Apr	1:00:00	1.02
2-Apr	6:00:00	1.02
2-Apr	2:00:00	1.02

MN/DOT Air Quality Report

Carbon Monoxide 8 Hour Average High Values for

April 2005

Site: 0000 (I394 & Penn Avenue)

		CO PPM 8 hour Average
2-Apr	8:00:00	1.05
2-Apr	7:00:00	1.03
2-Apr	9:00:00	1.03
2-Apr	8:00:00	1.00
3-Apr	8:00:00	1.00
2-Apr	6:00:00	0.99
2-Apr	10:00:00	0.99
3-Apr	8:00:00	0.99
3-Apr	9:00:00	0.99
3-Apr	7:00:00	0.99

MN/DOT Air Quality Report

Carbon Monoxide 1 Hour Average High Values For

May 2005

Site: 0000 (Qwest Building)

		CO PPM 1 hour Average
16-May	7:00	0.77
13-May	10:00	0.71
16-May	0:00	0.70
16-May	8:00	0.69
4-May	0:00	0.69
3-May	23:00	0.67
4-May	7:00	0.67
4-May	1:00	0.67
3-May	22:00	0.66
16-May	6:00	0.66

MN/DOT Air Quality Report

Carbon Monoxide 8 Hour Average High Values for

May 2005

Site: 0000 (Qwest Building)

		CO PPM 8 hour Average
16-May	7:00:00	0.57
16-May	8:00:00	0.57
16-May	6:00:00	0.55
16-May	9:00:00	0.54
16-May	5:00:00	0.53
16-May	10:00:00	0.52
20-May	15:00:00	0.52
20-May	18:00:00	0.51
16-May	4:00:00	0.50
16-May	11:00:00	0.50

MN/DOT Air Quality Report

Carbon Monoxide 1 Hour Average High Values For

May 2005

Site: 0000 (I394 & Penn Avenue)

		CO PPM 1 hour Average
31-May	0:00:00	1.39
30-May	23:00:00	1.08
31-May	1:00:00	0.94
25-May	10:00:00	0.75
11-May	0:00:00	0.73
30-May	22:00:00	0.70
10-May	23:00:00	0.67
31-May	8:00:00	0.65
25-May	9:00:00	0.65
10-May	22:00:00	0.65

MN/DOT Air Quality Report

Carbon Monoxide 8 Hour Average High Values for

May 2005

Site: 0000 (I394 & Penn Avenue)

		CO PPM 8 hour Average
31-May	5:00:00	0.65
31-May	3:00:00	0.64
31-May	4:00:00	0.64
31-May	2:00:00	0.63
31-May	1:00:00	0.62
31-May	6:00:00	0.62
31-May	0:00:00	0.59
31-May	1:00:00	0.59
31-May	2:00:00	0.58
31-May	3:00:00	0.58

MN/DOT Air Quality Report

Carbon Monoxide 1 Hour Average High Values For

June 2005

Site: 0000 (Qwest Building)

		CO PPM 1 hour Average
16-Jun	9:00	1.26
18-Jun	0:00	0.92
11-Jun	1:00	0.88
17-Jun	9:00	0.80
22-Jun	3:00	0.77
22-Jun	2:00	0.77
5-Jun	1:00	0.76
22-Jun	8:00	0.74
22-Jun	7:00	0.73
10-Jun	10:00	0.72

MN/DOT Air Quality Report

Carbon Monoxide 8 Hour Average High Values for

June 2005

Site: 0000 (Qwest Building)

		CO PPM 8 hour Average
22-Jun	8:00:00	0.57
22-Jun	9:00:00	0.57
22-Jun	7:00:00	0.55
22-Jun	6:00:00	0.54
22-Jun	10:00:00	0.53
22-Jun	5:00:00	0.52
5-Jun	4:00:00	0.52
5-Jun	5:00:00	0.51
22-Jun	11:00:00	0.50
22-Jun	4:00:00	0.50

MN/DOT Air Quality Report

Carbon Monoxide 1 Hour Average High Values For

June 2005

Site: 0000 (I394 & Penn Avenue)

		CO PPM 1 hour Average
22-Jun	1:00	0.89
10-Jun	23:00	0.87
11-Jun	1:00	0.84
11-Jun	0:00	0.83
24-Jun	9:00	0.82
17-Jun	8:00	0.81
22-Jun	2:00	0.80
18-Jun	0:00	0.79
22-Jun	3:00	0.78
1-Jun	20:00	0.77

MN/DOT Air Quality Report

Carbon Monoxide 8 Hour Average High Values for

June 2005

Site: 0000 (I394 & Penn Avenue)

		CO PPM 8 hour Average
22-Jun	6:00:00	0.71
22-Jun	7:00:00	0.70
22-Jun	5:00:00	0.68
22-Jun	8:00:00	0.68
11-Jun	3:00:00	0.66
17-Jun	9:00:00	0.66
11-Jun	2:00:00	0.65
17-Jun	8:00:00	0.65
22-Jun	4:00:00	0.65
11-Jun	1:00:00	0.64

MN/DOT Air Quality Report

Carbon Monoxide 1 Hour Average High Values For

July 2005

Site: 0000 (Qwest Building)

		CO PPM 1 hour Average
14-Jul	9:00	0.85
16-Jul	0:00	0.82
25-Jul	4:00	0.80
25-Jul	5:00	0.79
25-Jul	1:00	0.76
25-Jul	3:00	0.76
25-Jul	2:00	0.75
16-Jul	1:00	0.72
24-Jul	22:00	0.71
25-Jul	0:00	0.70

MN/DOT Air Quality Report

Carbon Monoxide 8 Hour Average High Values for

July 2005

Site: 0000 (Qwest Building)

		CO PPM 8 hour Average
25-Jul	5:00:00	0.75
25-Jul	6:00:00	0.74
25-Jul	7:00:00	0.73
25-Jul	8:00:00	0.71
25-Jul	4:00:00	0.69
25-Jul	9:00:00	0.69
25-Jul	10:00:00	0.64
25-Jul	3:00:00	0.62
25-Jul	11:00:00	0.59
25-Jul	2:00:00	0.56

MN/DOT Air Quality Report

Carbon Monoxide 1 Hour Average High Values For

July 2005

Site: 0000 (I394 & Penn Avenue)

		CO PPM 1 hour Average
25-Jul	3:00	0.97
25-Jul	0:00	0.85
25-Jul	4:00	0.85
25-Jul	2:00	0.82
25-Jul	5:00	0.75
25-Jul	1:00	0.72
14-Jul	7:00	0.56
22-Jul	0:00	0.52
14-Jul	8:00	0.52
12-Jul	19:00	0.49

MN/DOT Air Quality Report

Carbon Monoxide 8 Hour Average High Values for

July 2005

Site: 0000 (I394 & Penn Avenue)

		CO PPM 8 hour Average
25-Jul	6:00:00	0.71
25-Jul	7:00:00	0.70
25-Jul	5:00:00	0.68
25-Jul	4:00:00	0.68
25-Jul	8:00:00	0.66
25-Jul	9:00:00	0.66
25-Jul	3:00:00	0.65
25-Jul	10:00:00	0.65
25-Jul	2:00:00	0.65
25-Jul	11:00:00	0.64

MN/DOT Air Quality Report

Carbon Monoxide 1 Hour Average High Values For

August 2005

Site: 0000 (Qwest Building)

		CO PPM 1 hour Average
17-Aug	9:00	0.94
23-Aug	8:00	0.75
11-Aug	9:00	0.67
23-Aug	9:00	0.63
10-Aug	0:00	0.60
11-Aug	15:00	0.59
17-Aug	8:00	0.58
31-Aug	7:00	0.58
26-Aug	23:00	0.58
27-Aug	0:00	0.58

MN/DOT Air Quality Report

Carbon Monoxide 8 Hour Average High Values for

August 2005

Site: 0000 (Qwest Building)

		CO PPM 8 hour Average
11-Aug	16:00:00	0.54
11-Aug	15:00:00	0.53
11-Aug	17:00:00	0.51
11-Aug	14:00:00	0.49
11-Aug	18:00:00	0.49
11-Aug	19:00:00	0.49
11-Aug	20:00:00	0.49
11-Aug	22:00:00	0.49
11-Aug	21:00:00	0.48
11-Aug	23:00:00	0.48

MN/DOT Air Quality Report

Carbon Monoxide 1 Hour Average High Values For

August 2005

Site: 0000 (I394 & Penn Avenue)

		CO PPM 1 hour Average
23-Aug	7:00	1.02
31-Aug	2:00	0.80
23-Aug	8:00	0.78
29-Aug	9:00	0.69
23-Aug	9:00	0.66
31-Aug	5:00	0.65
31-Aug	3:00	0.64
31-Aug	1:00	0.64
30-Aug	8:00	0.64
31-Aug	0:00	0.63

MN/DOT Air Quality Report

Carbon Monoxide 8 Hour Average High Values for

August 2005

Site: 0000 (I394 & Penn Avenue)

		CO PPM 8 hour Average
23-Aug	9:00:00	0.64
31-Aug	6:00:00	0.64
23-Aug	10:00:00	0.63
31-Aug	7:00:00	0.63
31-Aug	5:00:00	0.62
31-Aug	8:00:00	0.62
23-Aug	8:00:00	0.60
31-Aug	9:00:00	0.60
23-Aug	11:00:00	0.59
31-Aug	4:00:00	0.59

MN/DOT Air Quality Report

Carbon Monoxide 1 Hour Average High Values For

September 2005

Site: 0000 (Qwest Building)

		CO PPM 1 hour Average
21-Sep	0:00	1.42
20-Sep	23:00	1.17
20-Sep	22:00	1.06
9-Sep	9:00	0.90
3-Sep	4:00	0.87
21-Sep	1:00	0.86
3-Sep	3:00	0.85
8-Sep	0:00	0.78
20-Sep	21:00	0.75
20-Sep	20:00	0.72

MN/DOT Air Quality Report

Carbon Monoxide 8 Hour Average High Values for

September 2005

Site: 0000 (Qwest Building)

		CO PPM 8 hour Average
21-Sep	3:00:00	0.90
21-Sep	2:00:00	0.88
21-Sep	4:00:00	0.86
21-Sep	1:00:00	0.84
21-Sep	5:00:00	0.80
21-Sep	0:00:00	0.75
21-Sep	6:00:00	0.71
21-Sep	7:00:00	0.63
3-Sep	7:00:00	0.62
3-Sep	6:00:00	0.61

MN/DOT Air Quality Report

Carbon Monoxide 1 Hour Average High Values For

September 2005

Site: 0000 (I394 & Penn Avenue)

		CO PPM 1 hour Average
3-Sep	3:00	1.25
21-Sep	0:00	1.22
3-Sep	4:00	1.12
20-Sep	23:00	1.04
3-Sep	2:00	0.90
21-Sep	1:00	0.89
23-Sep	0:00	0.88
22-Sep	9:00	0.85
3-Sep	5:00	0.84
23-Sep	9:00	0.79

MN/DOT Air Quality Report

Carbon Monoxide 8 Hour Average High Values for

September 2005

Site: 0000 (I394 & Penn Avenue)

		CO PPM 8 hour Average
3-Sep	7:00:00	0.81
3-Sep	6:00:00	0.80
21-Sep	5:00:00	0.80
3-Sep	8:00:00	0.79
21-Sep	4:00:00	0.79
3-Sep	5:00:00	0.77
21-Sep	6:00:00	0.76
3-Sep	9:00:00	0.75
21-Sep	3:00:00	0.75
3-Sep	4:00:00	0.71

MN/DOT Air Quality Report

Carbon Monoxide 1 Hour Average High Values For

October 2005

Site: 0000 (Qwest Building)

		CO PPM 1 hour Average
24-Oct	11:00	2.04
20-Oct	9:00	1.91
24-Oct	9:00	1.88
20-Oct	8:00	1.67
20-Oct	10:00	1.45
20-Oct	0:00	1.26
13-Oct	22:00	1.24
12-Oct	19:00	1.23
11-Oct	9:00	1.18
16-Oct	8:00	1.13

MN/DOT Air Quality Report

Carbon Monoxide 8 Hour Average High Values for

October 2005

Site: 0000 (Qwest Building)

		CO PPM 8 hour Average
20-Oct	10:00:00	1.14
20-Oct	11:00:00	1.11
20-Oct	9:00:00	1.06
20-Oct	12:00:00	1.05
20-Oct	8:00:00	0.95
20-Oct	13:00:00	0.94
20-Oct	5:00:00	0.92
20-Oct	6:00:00	0.92
14-Oct	3:00:00	0.91
14-Oct	2:00:00	0.90

MN/DOT Air Quality Report

Carbon Monoxide 1 Hour Average High Values For

October 2005

Site: 0000 (I394 & Penn Avenue)

		CO PPM 1 hour Average
16-Oct	4:00	1.64
20-Oct	1:00	1.42
16-Oct	5:00	1.41
20-Oct	7:00	1.36
16-Oct	7:00	1.35
20-Oct	2:00	1.32
16-Oct	6:00	1.23
20-Oct	4:00	1.21
20-Oct	9:00	1.20
16-Oct	3:00	1.19

MN/DOT Air Quality Report

Carbon Monoxide 8 Hour Average High Values for

October 2005

Site: 0000 (I394 & Penn Avenue)

		CO PPM 8 hour Average
16-Oct	8:00:00	1.26
16-Oct	7:00:00	1.24
16-Oct	9:00:00	1.22
20-Oct	7:00:00	1.21
20-Oct	8:00:00	1.21
20-Oct	9:00:00	1.18
16-Oct	6:00:00	1.17
20-Oct	6:00:00	1.17
20-Oct	5:00:00	1.15
20-Oct	10:00:00	1.14

Date	Time	CO Value PPM	CO Value PPM	CO AM Avg	CO AM Avg	CO PM Avg	CO PM Avg
		North Side	South Side	North Side	South Side	North Side	South Side
04/19/05	7:00	0.70	0.42	0.70	0.42		
04/20/05	7:00	0.27	0.37	0.28	0.38		
04/20/05	8:00	0.28	0.38				
04/20/05	3:00	0.22	0.29			0.22	0.33
04/20/05	4:00	0.22	0.37				
04/21/05	7:00	0.42	0.49	0.51	0.48		
04/21/05	8:00	0.59	0.47				
04/21/05	3:00	0.35	0.27			0.37	0.24
04/21/05	4:00	0.39	0.21				
04/26/05	7:00	0.35	0.29	0.35	0.31		
04/26/05	8:00	0.34	0.32				
04/26/05	3:00	0.17	0.24			0.19	0.25
04/26/05	4:00	0.20	0.25				
04/27/05	7:00	0.23	0.27	0.23	0.27		
04/27/05	8:00	0.23	0.26				
04/27/05	3:00	0.24	0.22			0.24	0.23
04/27/05	4:00	0.24	0.23				
05/03/05	7:00	0.28	0.44	0.27	0.43		
05/03/05	8:00	0.25	0.41				
05/03/05	3:00	0.13	0.24			0.12	0.24
05/03/05	4:00	0.11	0.24				
			Average	**0.39**	**0.38**	**0.23**	**0.26**

Date	Time	CO Value PPM	CO Value PPM	CO AM Avg	CO AM Avg	CO PM Avg	CO PM Avg
		North Side	South Side	North Side	South Side	North Side	South Side
09/27/05	7:10	0.73	0.64	0.63	0.67		
09/27/05	8:10	0.53	0.70				
09/27/05	15:00	0.17	0.30			0.16	0.31
09/27/05	16:00	0.15	0.31				
09/28/05	15:00	0.04	0.43			0.03	0.43
09/28/05	16:00	0.02	0.42				
09/29/05	7:00	0.50	0.56	0.48	0.56		
09/29/05	8:00	0.46	0.56				
09/29/05	15:00	0.15	0.28			0.14	0.29
09/29/05	16:00	0.13	0.29				
10/03/05	15:00	0.39	0.46			0.38	0.47
10/03/05	16:00	0.36	0.48				
10/06/05	7:00	0.16	0.53	0.16	0.54		
10/06/05	8:00	0.16	0.55				
10/06/05	15:00	0.14	0.07			0.16	0.07
10/06/05	16:00	0.17	0.06				
10/11/05	7:00	0.98	0.91	1.08	0.93		
10/11/05	8:00	1.18	0.94				
10/11/05	15:00	0.32	0.07			0.32	0.08
10/11/05	16:00	0.32	0.08				
			Average	**0.59**	**0.67**	**0.20**	**0.27**