
TABLE OF CONTENTS

Table of Contents	1
1.0. Introduction	3
1.1. Background	3
1.2. Purpose	4
2.0. Monitoring Approach	5
2.1. Program Goals and Objectives	5
2.2. Selecting the Type of Analysis to be Performed	5
2.2.1. System Impact Analysis	6
2.2.2. Benefit Cost Analysis	6
2.2.3. On-going System Monitoring and Analysis	7
2.3. Defining Geographic Scope	8
2.3.1. Localized Analysis	8
2.3.2. Corridor Analysis	9
2.3.3. Region-wide Analysis	9
2.3.4. Initial Operation	9
2.3.5. Subsequent Phases/ System wide	9
2.3.6. On-going (Real-time)	10
3.0. Performance Measures	11
3.1. Safety	11
3.2. Mobility	12
3.3. Travel Time Reliability	12
3.4. Environment	12
3.5. Throughput	12
3.6. Public Opinion	12
4.0. Data Collection and Assessment	14
4.1. Data Collection	14
4.1.1. Collection Periods	14
4.2. Data Collection Locations	15
4.2.1. Freeways	15
4.2.2. Ramps	15
4.2.3. Ramp/Arterial Intersection	15
4.2.4. Merge Areas	15
4.3. Data Needs and Tools	15
4.3.1. Traffic Volume	16
4.3.2. Mainline Vehicle Speeds	16
4.3.3. Travel Times	16
4.3.4. Crash Records	16
4.3.5. Ramp Queues and Driver Behavior	17
4.3.6. Archiving Data	17
5.0. Performance Reporting and Outreach	18
5.1. Monitoring and Reporting Frequency	18
5.1.1. Initial Observations and Monitoring	18
5.1.2. 3 Months After Initial Operation	19
5.1.3. 1 Year After Initial Operation	19

5.2.	Target Audiences.....	19
5.2.1.	The Public	19
5.2.2.	Upper Management.....	20
5.2.3.	Local leaders and Elected Officials	20
5.2.4.	NDOT and RTC Staff	20
5.2.5.	Media.....	20
5.3.	Reporting Methods and Techniques	21
5.3.1.	Formal Reports.....	21
5.3.2.	Fact Sheets, Summaries and Other Documents	21
5.3.3.	Media Releases.....	22
6.0.	Specific Monitoring Recommendations for US 95 Ramp Metering.....	22
6.1.	Objectives for Metering US 95.....	22
6.2.	Monitoring Approach	23
6.3.	Data Collection.....	23
6.3.1.	Automated Data Collection	23
6.3.2.	Manual Data Collection.....	24
6.4.	Data Analysis	24
6.5.	Data Reporting.....	24
6.5.1.	Three Month Report.....	24
6.5.2.	Annual Report	25

1.0. INTRODUCTION

This plan presents guidance on how to effectively monitor, evaluate and report the performance of ramp meters deployed in the greater Las Vegas, Nevada region and throughout the State of Nevada. Technical staff and decision makers within the Nevada Department of Transportation (NDOT) and the Regional Transportation Commission (RTC) may use this plan, and the guidance contained in it, to develop an approach to effectively monitor their metering systems so that they can be operated more effectively. NDOT and RTC can address strengths and weaknesses identified through monitoring to report metering impacts and make changes to ramp metering operations to improve freeway, ramp, and arterial conditions while generating greater public acceptance of ramp meters and improving public perception of NDOT and RTC. Monitoring can also improve intra- and inter-agency support and funding for these investments by establishing the benefits of ramp metering and by establishing the basis for operational improvements.

1.1. Background

Ramp meters have been deployed alongside freeway entrance ramps within Las Vegas in an effort to improve mobility and safety. Without metering, entering vehicles may be very closely spaced when merging onto freeways, making it difficult for each vehicle to find a gap in traffic. This phenomenon, known as “platooning”, causes drivers on the freeway to slow down to let the merging vehicles enter, and these slower speeds can contribute to time-consuming mainline freeway backups as well as dangerous sideswipe, lane change, and rear-end collisions. Ramp meters help vehicles enter the freeway in a spaced, controlled manner, allowing drivers to merge more safely and with less disruption to other freeway traffic. The purpose of ramp meters in Nevada is to balance the short wait at a ramp meter with the potential benefits that these systems provide, such as increase average travel speeds, and reduce travel times.

To date, seven freeway entrance ramps have been equipped with ramp metering systems. Four metering systems have been deployed within the I-515 corridor, and the remaining three have been deployed within the US 95 corridor. On March 29, 2005, the three systems deployed on entrance ramps to southbound US 95 were activated. The activation of these ramp meters represented the first public exposure to ramp metering within Las Vegas. The activation of meters on I-515 will follow the activation of the meters on US 95, but no timeframe has been finalized for I-515 metering.

The seven ramp meters deployed thus far represent just the initial deployment of ramp meters in Las Vegas. Plans are to deploy additional ramp meters, if the initial implementation is successful. No time frame has yet been established for expanding metering operations beyond US 95 and I-515. Currently, a study has been proposed to assess ramp metering needs for the length of the I-515 corridor to where it meets I-215.



1.2. Purpose

The primary purpose of this Plan is to improve the operation of freeways, their associated ramps, and adjacent arterials by providing guidance on how to effectively monitor the operation of ramp meters. Although this Plan has been initially developed for the Southern Nevada region, practitioners all across the state of Nevada may benefit from the guidance contained in this handbook, and may use it to ensure that ramp meters are operated consistently on a state-wide basis. This document is part of a project that will develop procedures and policies to ensure that ramp meters are deployed, operated, and monitored in an effective and consistent fashion. Use of this plan will help technical and operational staff identify the impacts of ramp meters including their effects on traffic patterns and flow. This plan will also help decision makers within NDOT and RTC make effective decisions regarding the current use and expansion of ramp meters by helping to understand and describe the past, present, and future operation of ramp meters within the Las Vegas region.

Performance monitoring provides the following.

Better Visibility of Benefits. Performance monitoring, evaluation and reporting will provide a clearer picture of freeway performance, and whether or not ramp meters are helping to satisfy program objectives. By publicizing the results of ramp meter performance monitoring and evaluation, the benefits of these systems can become more widely known. This helps develop public acceptance and support for these systems.

Better Allocation of Resources. Performance monitoring can also help NDOT and RTC make decisions on resource allocation. For instance, if ramp metering systems are providing greater benefits than another freeway management or traffic management program, decision makers may want to allocate more resources to expanding ramp metering. Or, if metering is not as effective as expected to be because there are not sufficient staff resources available, the monitoring program can point out the deficiencies and provide information to help justify increased staffing.

Improved Operations. One of the primary goals of performance monitoring, evaluation and reporting is to obtain feedback on how successful ramp meters have been in meeting previously determined goals and objectives, and to use this knowledge to make necessary improvements. Performance monitoring helps practitioners identify the extent and precise location of traffic and safety problems so operational improvements can be made. Performance monitoring may also help identify hardware or software failures, helping to resolve problems more quickly and minimize down time.

2.0. MONITORING APPROACH

Performance monitoring, evaluation and reporting should be a continuous process that occurs throughout the life cycle of a ramp meter. In other words, evaluating the effectiveness of ramp meters (or any freeway management strategy for that matter) should not be considered a one-time activity, but should be part of a periodic review of the effectiveness of the component and of the overall system. With that said, the monitoring approach will need to be reviewed and revised as needed to reflect changes to ramp meter status and implementation.

Before NDOT and RTC begin the process of monitoring and evaluating the performance of ramp meters, several questions need to be answered and decisions need to be made to develop an effective approach for conducting these tasks. Questions that need to be answered include:

- ▶ What are the objectives of the ramp metering program?
- ▶ What impacts will be measured?
- ▶ How will impacts be measured?
- ▶ What types of data will be collected?
- ▶ Where will data collection occur?
- ▶ Who will be responsible for collecting data?
- ▶ How will the results be reported?

Answers to the above list of questions will help develop an effective approach to monitor the network of ramp meters.

2.1. Program Goals and Objectives

The monitoring approach should be linked to the goals and objectives of the ramp metering program so the results of ramp meter evaluations are as meaningful as possible and that the time and effort used to conduct these evaluations is used effectively.

The first question that must be answered is “What are the objectives of the ramp metering program?” This paves the way for selecting performance measures so measured impacts can be tied back to objectives. The objectives of ramp metering in the Las Vegas area are as follows:

- ▶ Reduce the crash rate in the metered sections of freeway.
- ▶ Increase mainline speeds in metered freeway sections.
- ▶ Keep ramp queues contained on the ramps, except in extreme situations like severe incidents.

For each objective associated with the ramp metering program (i.e., reduce the crash rate or increase mainline speeds), the appropriate measure(s) of effectiveness should be identified, along with the desired threshold level of change that will be used to determine if the facility has met the objective. Measures of effectiveness that may be applicable for NDOT /RTC’s ramp metering program are identified and discussed in greater detail in Section 3.

2.2. Selecting the Type of Analysis to be Performed

Monitoring ramp metering operations is more than a simple process of visually observing the impacts ramp meters have on traffic flow, but rather one that involves the collection and thorough analysis of data to determine if ramp metering is producing desired results. The type

of analysis to be performed is largely defined by the objectives of the evaluation and type of feedback that is desired. In other words, NDOT and RTC must first answer the question “How are we going to use performance information” before an approach to monitor ramp meters can be developed. Ramp management evaluations may be performed prior to implementation, conducted as “before” and “after” snapshot views of performance, or implemented as a continuous monitoring and evaluation process. The evaluation efforts may also be narrowly focused to analyze one specific performance impact, or may be more broadly defined to capture the comprehensive region-wide benefits of the metering application. Further, these analyses may be intended to isolate the impacts of the ramp metering by itself, or to evaluate the performance these systems as part of a combination of operational strategies.

This section summarizes the basic types of analysis NDOT and RTC may use to measure ramp metering performance. This section also discusses the implications of how each type of study has different needs that substantially influence the analysis procedures to be performed. Since ramp meter implementations are new to Nevada, and little is known about the impacts of these systems, it is recommended that monitoring approach that NDOT and RTC select begins with a system impact analysis to gain an understanding of ramp meter impacts on US 95 and I-515, and to use this understanding to adjust metering operations to maximize benefits. Upon the completion of the system impact analysis, NDOT and RTC may elect to perform a benefit/cost analysis to determine how effective ramp metering is compared to other regional freeway management initiatives. In the future, NDOT and RTC may elect to monitor ramp metering performance in real-time. This requires that I-515 and US 95, along with corridors that will be metered in the future, be equipped with systems in the field (e.g., loop detectors, signals and processors) and TMC software programs that allow performance monitoring in real-time.

2.2.1. System Impact Analysis

System impact studies are performed to identify the impact that ramp meters have on one or more particular performance measures. These studies typically involve the comparison of conditions “before” the deployment of ramp meters with conditions “after” meters are deployed. NDOT and RTC may use system impact studies to provide system operators with direct feedback on ramp meter effectiveness. For example, a system impact study may be implemented to determine how well a ramp meter improves a particular system deficiency, such as higher than expected crash rates in a merge area. Technical and operational staff may communicate the results of the system impact study to decision makers and/or the traveling public to help justify and promote ramp metering as an effective ramp management strategy. Since the deployment of ramp meters has already taken place on US 95 southbound, the system impact analysis for this implementation must rely on the limited data that was collected in the before condition. A full system impact analysis should be considered for future ramp meter deployments.

2.2.2. Benefit Cost Analysis

In many regards, benefit/cost analyses are similar to system impact studies in that both provide assessments of the impacts related to the implementation of ramp metering. Whereas system impact studies may focus on one or more particular performance measures, a benefit/cost analysis is broader and attempts to fully account for the comprehensive, multi-modal impacts of ramp metering. Benefit/cost analysis weighs the complete observed impacts of the system – including both positive impacts such as reduced travel time on the mainline facility and negative impacts such as increased emissions associated with queues on the ramp – with the cost of implementing and operating ramp meters.

The purpose of benefit/cost analysis is typically to identify the relative effectiveness of investment in one strategy by providing a common point of comparison with other potential strategies. The comparison is often used in prioritizing funding for future applications. The information generated by benefit/cost analyses are also often used to communicate the relative benefits of the system to decision makers and the traveling public.

Benefit/cost analyses are also typically based on comparisons of conditions both with and without the application of the strategy. The compared conditions may represent a snapshot view or may be based on longer-term trends, depending on the needs of the particular study. Due to the more comprehensive nature of benefit/cost analyses, these studies often make more substantial use of analysis tools and models to generate estimates of the full-range of possible impacts. Although it is too late to compare conditions before the initial deployment of ramp meters in the southbound US 95 corridor, I-515 and other metered corridors can be analyzed when metering is implemented.

While intended to provide a comprehensive quantitative analysis of the benefits and costs of ramp metering, there are many impacts that are difficult or impossible to quantify, such as traveler perceptions. No benefit/cost analysis can fully encompass all of the possible impacts of a ramp metering system, so it is important to recognize that benefit/cost analysis provides only a partial view of the overall picture that should be evaluated in assessing the success of the strategy.

Similar to the other types of analysis, a benefit/cost analysis can be designed to isolate the particular impacts and benefits related specifically to ramp metering, or may be utilized as part of a broader evaluation designed to capture the benefits of a selected combination of traffic management strategies.

2.2.3. On-going System Monitoring and Analysis

The purpose of on-going system monitoring and analysis is to provide system operators with direct, real-time feedback on the performance of individual ramp meters allowing for more active management of the entire system. The data collected through this monitoring effort should be appropriately archived using the FAST data archive so that additional analysis may be performed to identify trends of how the impacts of ramp metering may change over time or vary under different traffic conditions.

On-going monitoring efforts typically depend on automated data sources including: loop detector data, radar or acoustic based speed detectors, closed circuit cameras, and automatic vehicle location systems, among other systems. Often times, these automated data sources may be deployed as part of a ramp metering system or a general freeway management system. Reliable access to accurate data sources such as these is a prerequisite of implementing a successful monitoring and analysis program. NDOT and RTC have access to some automated data sources on US 95 or I-515, primarily detectors and closed circuit television cameras.

Although these on-going monitoring and analysis efforts are intended to provide performance data to the system operations personnel, it is important to note that the data generated by these efforts may be utilized in other evaluation efforts. For example, automated system data, collected by the Minnesota DOT for use in monitoring the real-time performance and making operational decisions, was used extensively in the benefit/cost analysis of the Twin Cities metering system. This historical volume and speed data was used to extrapolate impacts observed during a limited data collection window to other time periods and traffic conditions.

2.3. Defining Geographic Scope

The study area selected can have significant implications on the analysis data requirements, evaluation techniques, resource requirements, and even the results. These implications are discussed in the following section to help identify the appropriate study area suitable to particular needs.

Ramp management applications can have impacts far beyond the local area in which they're implemented. Depending on travel pattern changes, impacts may be observed at freeway bottleneck locations far downstream from the ramp itself; arterial intersections located many miles from the interchange; or even on alternative modes such as transit. Failure to define the study area broadly enough may result in critical impacts not being captured and an over- or understatement of reported benefits. Meanwhile, defining the study area too broadly may result in the inefficient use of evaluation resources if efforts are diverted towards analyzing inconsequential impacts. Therefore, it is critically important to identify an appropriate study area prior to the implementation of the evaluation effort to ensure the proper assessment of system impacts.

There are no firmly established guidelines for identifying the appropriate study area; however, the decision is usually based on:

- ▶ Purpose of the study – Is the evaluation effort being undertaken to identify the ability of the ramp management strategy to mitigate a specific deficiency in a particular location, or does it intend to provide a comprehensive accounting of the region-wide benefits and costs?
- ▶ Extent of the ramp management application – Is the evaluation being focused on a single or a very limited number of ramps, or does the application involve multiple ramps?
- ▶ Knowledge of local traffic conditions – Local operations personnel usually maintain a close familiarity with the traffic conditions and should be involved in any decision regarding the extent of the study area. In addition to operations personnel, the manager of the freeway management system (FAST) will have detailed information related to regional freeway operation that others don't, and therefore should be involved in all decisions regarding the installation and operation of ramp meters.

Furthermore, factors such as the particular performance measures being evaluated, the proposed analysis tools, and the evaluation resources available have a symbiotic relationship with the determination of the appropriate study area. The intended performance measures, analysis tools and resource availability should be considered in the determination of the study area. Likewise, the identified study area may also determine the possible performance measures, the appropriate analysis tool and the evaluation resources required.

Study areas can be generalized into three categories: localized, corridor, or region-wide. These categories are discussed below with examples of when they should be used.

2.3.1. Localized Analysis

This analysis, which focuses on the impacts observed on the facilities immediately adjacent to the ramp management application, is the most appropriate for limited scale deployments or for system impact evaluations focused on a narrowly defined set of performance measures. For example, an evaluation effort that was solely focused on identifying the ability of a ramp meter application to decrease the number of collisions occurring within the merge area might limit the study area to a short distance (maybe a quarter of a mile) upstream of the merge area to a short distance (maybe a quarter of a mile) downstream of the merge area.

2.3.2. Corridor Analysis

Expanding the study area to the corridor level is more appropriate when multiple ramp locations are involved, or when the deployment is anticipated to affect any of the selected performance measures outside of the immediate region. The study corridor extent should be based on the local street pattern and knowledge of local travel demand to determine the mainline, ramp, and arterial facilities to be included.

2.3.3. Region-wide Analysis

A region-wide study area is most appropriate when a comprehensive accounting of all possible impacts is required, or the deployments are scattered across a large area. Region-wide analyses can be the most costly analysis to conduct due to the significant data requirements. Therefore, this analysis will often use various large-scale traffic analysis tools, such as regional travel demand models, to estimate the impacts, rather than depend on observed before and after data.

Not all evaluation efforts will fit neatly into the study area definitions above. Some evaluations may use multiple study area definitions within the same effort based on the performance measures being evaluated or the availability of data.

2.3.4. Initial Operation

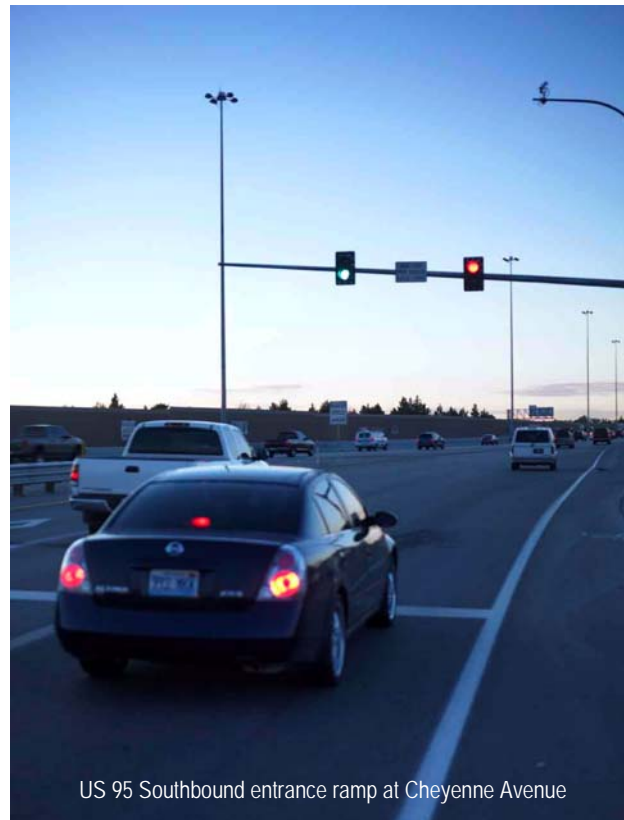
During the initial operation of ramp meters along US 95, ramp meter performance monitoring should focus on the stretch of US 95 that is currently metered.

- ▶ Cheyenne Avenue to southbound entrance ramp
- ▶ Eastbound Lake Mead Boulevard to southbound entrance ramp
- ▶ Westbound Lake Mead Boulevard to southbound entrance ramp

When metering is initiated on I-515, performance monitoring should focus on:

- ▶ Las Vegas Boulevard northbound entrance ramp
- ▶ Fourth Street/Casino Center Boulevard northbound entrance ramp
- ▶ Eastern Avenue northbound entrance ramp

In each of these cases, a corridor analysis should be undertaken. If there are specific areas with high collision rates, it may be appropriate to focus the safety analyses on those localized areas.



US 95 Southbound entrance ramp at Cheyenne Avenue

2.3.5. Subsequent Phases/ System wide

Subsequent phases of ramp metering have been discussed, but no firm plans are in place. Decisions on system expansion will be based, to a certain extent, on the results of the

performance monitoring effort for the US 95 and I-515 implementation. However, when two or more corridors are implemented with ramp meters, NDOT should consider starting a region-wide analysis of ramp metering performance.

2.3.6. On-going (Real-time)

The purpose of on-going system monitoring and analysis is to provide staff with direct, real-time feedback on the performance of the ramp metering system and to allow for more active management of it. On-going monitoring efforts must, therefore, rely on automated data sources including: loop detectors, radar or acoustic based speed detectors, closed circuit cameras, and automatic vehicle location systems, among other systems. Reliable access to data sources such as these is a prerequisite of implementing a successful monitoring and analysis program.

Currently, detector data and closed circuit television cameras are available on US 95 and I-515 eliminating the need to deploy additional devices. Data collected through these devices is currently archived in the FAST system. The FAST archive may be used to archive data from other sources, and used to identify trends of how the impacts of ramp meters may change over time. On-going system monitoring should be established as early in ramp metering as possible.



3.0. PERFORMANCE MEASURES

Performance measures provide the basis for evaluating the performance of ramp meters and identifying the location and severity of traffic problems such as congestion and high collision rates. Another aspect of performance measurement is sharing and providing managers and users with access to real-time and archived system performance data.

Monitoring information can be used to

- ▶ track changes in system performance over time,
- ▶ identify systems or corridors with poor performance,
- ▶ identify the degree to which the freeway facilities are meeting goals and objectives established for those facilities,
- ▶ identify potential causes and associated remedies,
- ▶ identify specific areas of a freeway management program or system that requires improvement/enhancements, and
- ▶ provide performance information to decision-makers and the public.

In essence, performance measures are used to measure how ramp meters perform in relation to the entire transportation system and to the overall vision and adopted policies for it.

Agencies have instituted performance measures and the associated monitoring, evaluation, and reporting processes for a variety of reasons:

- ▶ to provide better information about the transportation system to the public and decision makers (in part due, no doubt, to a greater expectation for accountability of all government agencies);
- ▶ to improve management access to relevant performance data; and
- ▶ to generally improve agency efficiency and effectiveness, particularly where demands on the transportation agency have increased while the available resources have become more limited.

3.1. Safety

Travel safety is most often measured through the change in the number of crashes, segmented by severity (e.g., fatal, injury, property damage only, etc.). This performance measure may also be segmented by crash type (e.g., rear-end, side-swipe, etc.). The data supporting this performance measure is most typically obtained from crash records kept by one or more emergency response agencies or the department of transportation. The format and availability of the regional crash data greatly influences the format of the performance measure used to evaluate safety impacts.

NDOT and RTC should use caution in the development of performance measures and in the actual analysis of the data related to crashes. Crashes are randomly occurring events and may be based on limited sample sizes, particularly in the case of less frequently occurring crashes such as those involving fatalities. Thus, a limited number of crashes may cause the rate to spike over short periods or in particular locations. These spikes in the data may be misinterpreted as being related to the ramp metering deployment. Therefore, longer-term historical data should be used to validate the crash rate, or the evaluators should consider consolidating some of the crash segmentations to ensure an adequate sample size. Furthermore, it may be more appropriate to evaluate the change in the crash rate (e.g., number

of crashes per mile traveled) rather than the actual number of observed crashes to help control for changes in travel demand.

3.2. Mobility

Travel mobility impacts are typically measured as a change in travel time, speed or delay. These measures are targeted at capturing the user's travel experience. Therefore, these measures are most effective when captured on a per trip basis, such as the change in travel time for a door-to-door trip. Use of aggregate system measures such as total system person hours of travel (PHT) may not accurately capture user benefits. Likewise, spot measurements of speed may not accurately reflect the individual's overall travel experience.

3.3. Travel Time Reliability

Measures of travel time reliability are important to aid in the evaluation of ramp management improvements and the analysis of many other operational improvements. These measures are intended to capture the impact of reducing travel time variability and making travel times more predictable. More predictable travel times allow travelers to better budget their travel schedules and more often avoid unexpected delays. Ramp metering systems have been shown to reduce travel time variability and have a significant impact on this measure.

3.4. Environment

Environmental performance measures used in ramp management analyses typically include changes in emissions and the change in fuel consumption. Identifying effective environmental performance measures that may be successfully evaluated within the framework and available resources can be a challenge. The implementation of ramp metering can simultaneously reduce emissions and fuel use on the freeway mainline, while increasing these factors at the queue location. Therefore, the data collection and analysis methodology for these performance measures must be sensitive to this situation.

3.5. Throughput

These performance measures are targeted toward representing the system operator's perspective and typically include one or more of the following: throughput (vehicle or person volumes), level of service (LOS), facility speeds, volume to capacity (V/C) ratio, or queuing measures (length and frequency). The particular performance measure(s) selected in this category greatly influences the format of the data that needs to be collected. In general, performance measures targeted toward assessing vehicle occupancy rates or throughput are more difficult to collect than vehicle based measures, but often these person based measures can provide a much more accurate picture of the changes in traveler behavior. For the majority of smaller scale ramp management evaluations, vehicle occupancies would not be anticipated to change significantly, which allows the vehicle measures to be used without a significant loss of accuracy. Currently, NDOT obtains vehicle occupancy rates from crash records.

3.6. Public Opinion

The perceptions of the traveling public regarding the benefits of the ramp management system and their acceptance of the system performance can be extremely important to measure depending on the purpose of the study. Public opinion is often used to support the findings from the data collection in the field and can be used to identify areas where perceptions differ from reality. Public opinion is often collected through the conduct of one or more waves of focus groups, telephone surveys, intercept surveys, or panel survey groups. The collection of this data often requires significant resources to complete. Nevertheless, the information on public

perceptions gained through these methods can be invaluable in shaping public information campaigns.

The screenshot shows a web browser window displaying the RTC Ramp Meters website. The page features a header with the RTC logo and navigation links: RTC Home, Email Updates, Search, Site Map, and Contact Us. A sub-header reads: "A partnership between the Regional Transportation Commission of Southern Nevada and the Nevada Department of Transportation". The main title is "RTC RAMP METERS" with the Nevada DOT logo. A navigation menu includes: En Español, Home, Locations, How To Use, Media Page, FAQ's, and Comments. A sidebar on the left lists: The RTC, In the Community, Planning, Streets, News, MAX, Citizens Area Transit, Other Transit Services, and Club Ride. The main content area contains a survey form with the following questions and input fields:

Please fill out the form below to help us better serve you. We want to hear from you!

Do you believe this project will benefit our community?

Yes No

Why or why not?

What concerns do you have about the project or future service?

Is there anything else you would like to share with us?

4.0. DATA COLLECTION AND ASSESSMENT

4.1. Data Collection

In order to fully assess the performance of ramp meters, staff will need to collect data. Data collection is not only needed to ensure that ramp meters are providing desired benefits, but also to justify the use of public funds used to purchase and deploy these systems. Both qualitative data (e.g., observations, agency and public feedback, etc.) and quantitative data (e.g., speeds, crashes, queue length, etc.) will be needed to analyze ramp metering impacts during peak periods and to ensure that these systems are operating as intended.

Since the results of data collection will be used to make operational and program-level decisions, NDOT and RTC must take great care in making sure that collected data are of superior quality. High quality data will lead to better conclusions and therefore will contain more value to agency decision makers. High quality data collection systems are necessary to collect high quality data and NDOT/RTC should analyze the possibilities for improving data collection efforts as funding and policy permits. However, data collection efforts must fall in line with agency budgets. Where possible the quickest, least costly means should be used to collect data, as long as the objectives of data collection are fully satisfied. Data collection should begin with an analysis of the data archived in the FAST system, and after this, a determination of the data that still need to be collected should be made.

4.1.1. Collection Periods

As previously stated, qualitative and quantitative data will need to be collected before and after ramp meters are deployed and subsequently turned on. These data are needed to assess the performance of ramps meters and to ensure that these systems are operating as intended. Every effort should be made to collect before data before ramp meters are turned on.

4.1.1.1. Before (baseline)

Data need to be collected before ramp meters are set into operation to establish the baseline from which the impacts of ramp meters will be analyzed. The types of data that need to be collected will depend on the types of analysis that will be conducted. Generally speaking the following types of data are needed when assessing the performance of ramp meters:

- ▶ Traffic volumes and speeds
- ▶ Travel times (if feasible)
- ▶ Ramp queue length and frequencies
- ▶ Crash records
- ▶ Driver and system observations

The collection of before data should focus on the proposed local metered segments, the metered freeway corridor, metered ramps, and adjacent arterials. As the ramp metering system grows to include additional ramps or freeway corridors, “before” data should be collected in the appropriate corridor prior to each expansion of the system.

4.1.1.2. After

NDOT/RTC should also collect data after ramp meters have been deployed and turned on to complete the assessment of ramp meter performance. Typically, the collection of “after data” occurs several times during the first year of operation (See Section 5.1 for more details), and annually thereafter. The data collected in the “after” phase should be compared against data

collected in the “before” phase to assess what significant changes, if any, have occurred in the data due to the operation of ramp meters.

4.2. Data Collection Locations

Determining the location where data need to be collected is essential to assessing the full impact of newly deployed ramp meters. Focusing evaluation and monitoring efforts on the metered ramps alone will likely only capture a portion of the effects ramp metering has on traffic flow. Some motorists may divert from using a newly metered ramp to other upstream and downstream ramps because they do not want to wait at the ramp meter.

When collecting data for a ramp meter evaluation, NDOT and RTC should focus their efforts on locations that are most likely to be affected by metering. These locations, which are discussed below, include:

- ▶ Ramps
- ▶ Freeways
- ▶ Adjacent Arterials
- ▶ Freeway/ Ramp merge area

4.2.1. Freeways

Conditions on the metered segments of area freeways should be monitored to determine the impacts ramp metering has on vehicle speeds, throughput, and crashes. Ramp meter research has shown that ramp meters can increase vehicle speeds by up to 25 mph and throughput by up to 25 percent while reducing crashes by up to 40 percent. .

4.2.2. Ramps

Conditions on the ramp will need to be monitored to determine if queue storage at ramp meters is adequate and that metering operations are not resulting in excessive delay or improper driver behavior

4.2.3. Ramp/Arterial Intersection

When monitoring conditions on the ramp, it is also recommended that conditions at the ramp/arterial intersection be monitored. If ramp meters do not release vehicles fast enough, queues may build at the ramp meter and may back up into the ramp/arterial intersection. This will adversely affect operations on the arterial.

4.2.4. Merge Areas

Ramp metering has the potential to significantly improve traffic operations at and immediately upstream of entrance ramp merge areas. This is because ramp metering restricts excessive demand from entering the freeway and breaks up platoons. Ramp metering allows vehicles to enter the freeway facility in regulated intervals allowing released vehicles to enter the freeway facility in a controlled, smooth manner. Crash analysis should focus on specific high collision locations within the metered segment, such as ramp merge areas. However, crash analysis should not be limited to merge areas. As mentioned above, ramp metering can result in reduced crash rates throughout the metered corridor.

4.3. Data Needs and Tools

Specific types of data are needed to evaluate the impacts of ramp meters, depending on the previously agreed-upon performance measures. In general, traffic data should be collected at

metered ramps and along the metered corridors both before and after meters are turned on and become operational. Data should be collected during the proposed metering periods on non-holiday weekdays (i.e., Monday thru Friday). If resources are very limited, data for Tuesday-Thursday should be used in the analysis. Ideally, however, data should be collected for every day of the week that the meters will be operated and analysis should look at daily stratification as well as aggregation over all weekdays.

Since the initial set of ramp meters along US 95 have already been turned on, it is no longer possible to collect data for the before period at these locations. It may be possible to evaluate the performance of these ramp meters because some data was collected before metering started. Results may not be as robust because limited data was collected.

4.3.1. Traffic Volume

Traffic volume is defined as the number of vehicles observed or predicted to pass over a given point or section of a lane or roadway during a given time. Volume is typically used to track historical trends and to predict the future occurrence of congestion on specified freeway sections. In terms of measuring the performance of ramp meters, analysis of traffic volumes at upstream and downstream locations along the mainline and on ramps in the corridor can provide useful insights regarding the efficiency of the freeway and changing traffic patterns in the corridor.

4.3.2. Mainline Vehicle Speeds

Mainline vehicle speeds are frequently used to describe traffic operations because it is a measure most drivers experience directly and can easily understand. Speed measurements are typically taken for individual vehicles at specific locations and averaged to characterize the traffic stream as a whole. Measured speeds can be compared to optimum values to estimate how the freeway is operating when ramp meters are operational.

4.3.3. Travel Times

Travel time data measures the time it takes a vehicle to travel a certain distance, usually the length of the metered corridor. Travel time data are usually collected before and after the freeway facility is deployed with ramp meters. The differences in travel times between the before and after situations can then be compared to determine the affects of ramp metering.

Travel time data for the freeway and individual ramps can be obtained using a number of methods. The simplest, and most commonly used, is referred to by a variety of names including the "floating car" and "maximum car" techniques. Both refer to the use of a test vehicle making a series of trips along a stretch of freeway or ramp and measuring travel times.

Travel times can also be estimated or calculated based on other traffic measurements, such as speed or volume and lane occupancy.

4.3.4. Crash Records

A comparison of crash records before and after ramp meters are installed can be made to determine if there are any significant reductions in crash rates on the mainline, on ramps, or in the merge areas. Of specific interest to ramp meter evaluations are crashes recorded as "rear-end," "lane change," or "sideswipe". In many cases, ramp metering has the potential to reduce rear-end collisions by reducing or eliminating stop-and-go driving behavior on both the mainline and merge areas. Similarly, the staggered release of metered vehicles smoothes the flow of vehicles merging with freeway traffic, which may result in a reduction in sideswipe or lane change crashes at the ramp/freeway merge area and at the back of a mainline queue.

4.3.5. Ramp Queues and Driver Behavior

To a large part, the success of ramp metering depends on the ability to smooth the flow of traffic onto the freeway while adequately serving demand to the ramp. Part of ramp meter monitoring should focus on queues that form on ramps as a result of ramp meter operations. When demand exceeds the metering flow rate, and storage on the ramp cannot contain the excess demand, traffic may back up on the adjacent arterial, causing traffic and safety problems. Ramp metering approaches must consider whether and how ramp queues may be managed. Before and after analysis of ramp queue observations can indicate whether or not ramp meters are negatively affecting operations on the ramp or if queues are spilling onto the adjacent arterial.

Whenever new traffic control devices are installed, such as ramp meters, it is a good idea to monitor driver behavior, either through closed circuit television cameras deployed in the field and in sight of ramp meters, or manually, to assess drivers' ability to conform to the traffic control device. When ramp meters are deployed, drivers may unintentionally or intentionally ignore the traffic control device. In either case, ignoring the ramp meter may confuse other drivers on the ramp, which in turn, may result in similar driving behavior. Ignoring the ramp meter indication may also defeat the purpose of ramp meters which is to smooth the flow of traffic entering the freeway facility.

An assessment of ramp queuing and driver behavior should be made through observations made by personnel stationed in the field or viewing images from closed circuit television cameras. If personnel observe queues that spill back into the arterial and affect arterial traffic operations, operators should adjust metering rates or the parameters that are used in ramp meter algorithms in an effort to quickly resolve queue related problems. Similarly, if drivers are not obeying the ramp meter, metering rates may have to be adjusted to reduce driver frustration, or ramp meter compliance may need to be actively enforced.

4.3.6. Archiving Data

Data collected during the ramp meter evaluation should be archived in the FAST data archive so it can be used in other, future evaluations. This helps to lower the cost of performance monitoring efforts over time and provides more and better information for managing and operating ramp meters.

5.0. PERFORMANCE REPORTING AND OUTREACH

This section discusses how to report ramp metering performance and to whom it should be reported. Reporting is the bridge from monitoring performance and using that information to improve strategies and refine goals and objectives. Reporting is also key to building support for ramp metering by showing the benefits of those systems.

Due to the wide range of reporting formats and audiences, the needs of the reporting phase of the evaluation should receive substantial consideration early in the evaluation effort. The format of the eventual report and the intended audience should be factors guiding the selection of performance measures, the development of data collection plans, and the identification of analysis techniques and tools.

Performance reporting and outreach seeks to build understanding of ramp metering benefits. Agencies responsible for the implementation of ramp meters should actively market the benefits of ramp meters. Agencies should seek to inform the public, local agencies and the media at various points during the operation of ramp meters to keep these groups abreast of project progress and the benefits observed to date. Agencies should also undertake internal efforts to inform personnel at various levels within their organization of the benefits ramp metering provides and the proposed timeline for their implementation. In-reach also provides a beneficial mechanism to promote ramp management and disseminate information about ramp management to outside groups.

Monitoring and managing initial operation also includes documenting the software and hardware that has been installed and the control parameter settings used to control ramp meters. Documentation should include system errors, how they were resolved, and any system updates that were incorporated to prevent the errors from occurring in the future. In the initial phases of a ramp metering program, documentation will help keep an up-to-date record of activities that may be used to address future hardware and software problems. Documentation should be carried beyond the initial operation of ramp meters and should be viewed as a life cycle activity that needs to be continually conducted in operating and maintaining these systems.

5.1. Monitoring and Reporting Frequency

After ramp meters are deployed, tested and initially operated, they should be monitored and managed to determine if and how the strategies should be adjusted for optimal performance. System operation should be analyzed on a continual basis and more formal evaluations should be conducted and reported several times within the first year, and at least annually thereafter.

System operation should be observed in the field and confirmed in the operations center. If problems are observed or reported, adjustments, maintenance or other responsive action should be performed. Likewise, problems reported via other agencies and the public needs to be investigated, addressed and corrected.

5.1.1. Initial Observations and Monitoring

During the first weeks that meters are operational, operations staff should monitor conditions to determine if and how the new metering operations should be adjusted to improve traffic flow. Any improvements that need to be made should be performed as soon as they can be implemented. Staff should also monitor how well drivers are responding to the new meters. Often times reminders to drivers (usually through the media) on how to react to meters can be effective at improving driver response.

All calls and letters from the public concerning the new ramp meters should be investigated and corrective action taken if appropriate. If it is not possible to make changes to address public

concerns, the respondent should be contacted and the situation should be explained. The objective is to make all contacts positive and informative. Each citizen that is able to talk in a better informed manner is likely to pass on accurate information to their family, friends, and neighbors with a positive attitude.

5.1.2. 3 Months After Initial Operation

Three months after initial operation, ramp meters should be formally evaluated to determine if meters are performing as expected. The results of this evaluation should be recorded, documented, and reported to those responsible for making adjustments to the systems, decision makers, and the public. Any resulting adjustments that need to be made should be done as soon as possible.

5.1.3. 1 Year After Initial Operation

One year after initial operation and every year thereafter, ramp meter operations should be evaluated to determine if these systems are providing expected benefits. Data should be collected on an annual basis and compared against the data that were collected before metering began. As the ramp meter system becomes more mature, data collected for the current year can be compared to the data collected in previous years to determine if system adjustments made from year-to-year have been beneficial and to determine trends in traffic conditions and traffic patterns.

NDOT and RTC should formally document and report ramp meter performance on an annual basis.

5.2. Target Audiences

NDOT/RTC should report ramp meter performance results to local leaders, motorists, the media, and external agencies to strengthen support for the expansion of the ramp metering program. Continual support from these groups will help successfully implement ramp metering systems now and in the future. Information on ramp meter performance should be tailored to the specific needs and concerns of each group.

Interest exists in the results of these evaluations among not only those within the transportation community, but also among decision makers, special interest groups, and the general public. The challenge to transportation professionals is to conduct accurate and objective evaluations of ramp meters that focus on key criteria, so that the results are meaningful and understood by all groups.

5.2.1. The Public

Public support and understanding of ramp metering programs is critical to ensure that these programs can successfully meet their objectives. Public opposition to the implementation of ramp meters poses a challenge that can significantly delay or eliminate meter implementation or operation. To reduce the possibility of misunderstandings leading to public opposition, practitioners should take all the steps necessary to educate the public of the benefits of metering before and after meters are turned on.

Reporting on the performance of ramp meters can help offset some drivers' initial impression that ramp meters do not provide sufficient benefit. Initially, some motorists may fail to visualize the benefits of metering, and instead may focus on the few, but more noticeable negative impacts such as ramp queues. By actively publicizing the benefits of ramp metering observed through performance monitoring and evaluation, NDOT and RTC staff can mitigate adverse public opinion that may exist regarding ramp metering. NDOT and RTC should frequently disseminate information on the benefits of ramp meters, using various techniques that enhance

public understanding. For example, public service announcements, leaflets, and radio spots are all acceptable techniques. Each of these can be prepared/conducted in English and Spanish.

5.2.2. Upper Management

The results of ramp meter performance monitoring and evaluations can be valuable in conveying to upper management the importance and benefits of ramp metering. Similar to the public, upper management support and understanding is needed for metering programs to be successful. Without upper management support, ramp metering programs may not receive the funding or resources needed to continue operation or implement planned and needed expansion. Upper management can use performance information to develop agency directives that support ramp metering programs and to allocate funding to implement them. Ramp meter performance information can help upper management visualize the need for continuous improvements and can help secure funding for maintaining and expanding the existing network of ramp meters. Performance results need to demonstrate how well ramp metering contributes to the goals and objectives of the agency, the region, and the overall freeway management program.

5.2.3. Local leaders and Elected Officials

Local leaders (elected and appointed officials especially) can be valuable advocates or powerful opponents of ramp metering. It is important that staff determine if local leaders are predisposed to either advocacy or opposition to metering. Based on these findings, staff should develop an outreach program that targets both the advocates and the opponents.

Staff should reach out to advocates to mobilize their support for current and proposed ramp metering efforts. It is equally important that staff reach out to opponents or potential opponents to understand their concerns. Some of these concerns may be ones that can be addressed in the design or operation of the ramp meters. Others may be the product of misconception that can be lessened by providing accurate information that addresses those concerns.

Staff should also reach out to local leaders to determine if there are any issues with metering. If there are none, no significant follow through with local leaders would be necessary and resources could be expended on other aspects of the outreach efforts or other aspects of strategy implementation.

5.2.4. NDOT and RTC Staff

NDOT and RTC staff and managers need ramp performance information to identify where improvements to ramp metering can be made. With this information these individuals can more easily identify and assess problems associated with the operation of ramp meters, and are able to fix these problems more quickly and easily. NDOT and RTC staff may also use this information to make more informed decisions regarding other elements of their ITS program. For instance, through performance monitoring, NDOT staff may find that ramp metering is more effective than other ITS strategies and, consequently, propose that ramp metering is implemented more widely or more quickly.

5.2.5. Media

The media can be a valuable player in widely disseminating information on the benefits of ramp meters to the public. For this reason alone it is critical that NDOT and RTC develop a good relationship with the media. This may pave the way for the media to act as the advocate for the ramp metering program.

Information released to the public, local agencies and the media should be truthful and accurate to reduce the chance that the voracity of released information will be called into question at a

later date. This also reduces the potential “surprise factor” that, when left unchecked, can lead to public frustration and contempt for proposed strategies.

5.3. Reporting Methods and Techniques

The most important consideration in reporting the evaluation results is ensuring that the findings are presented in a manner appropriate to their intended audience. Results reported to non-technical decision-makers or the public should not be presented using technical jargon or assume any prerequisite knowledge of operational concepts. Instead, reports to non-technical audiences should present the findings as clearly and concisely as possible, focusing on those performance measures of greatest importance to the target audience. Conversely, reporting evaluation findings to a more technical audience should provide sufficient detail on the evaluation methodology and empirical evidence to support the findings. Evaluators may want to consider developing more than one evaluation report to meet the needs of diverse audiences.

The eventual format of the evaluation report can be extremely varied based on the particular needs of the evaluation. It may be a formal document intended to be widely distributed, or an informal report intended for internal agency use only. The evaluation findings may not even be disseminated with a traditional document, but instead may be communicated through use of presentations, web sites, press releases, or other media.

5.3.1. Formal Reports

Of the various reporting methods discussed in this plan, formal reports are the most comprehensive, often providing the most detail regarding a system evaluation. Therefore, formal reports are typically used to report system performance to a technical audience that require as much detail as is available. This audience may include the following individuals:

- ▶ Upper management and agency decision makers
- ▶ Transportation management system operators
- ▶ Educators
- ▶ Researchers

Although reports are the most comprehensive and detailed reporting method, they should report findings in an easy to understand fashion, similar to other reporting methods discussed below. Therefore, it is beneficial to use tables, charts and illustrations so findings can be understood quickly.

At a minimum, ramp meter performance reports should contain discussions of the following;

- ▶ Purpose of the report
- ▶ Systems that were evaluated or geographic scope
- ▶ Data collection methods
- ▶ Performance measures
- ▶ Aspects of the system(s) that were evaluated
- ▶ Findings

5.3.2. Fact Sheets, Summaries and Other Documents

Similar to reports, information contained in facts sheets and summaries should report system performance findings in a manner where information can be understood quickly. Unlike, reports, however, fact sheets and summaries are useful for reporting findings to non-technical

audiences such as local-elected officials, and the general public. Fact sheets and summaries should focus on the impacts of ramp meters, without going into great detail on how the impacts were derived. Any discussion on the details on how the evaluation was conducted is likely to either confuse readers or be ignored altogether.

5.3.3. Media Releases

The media can provide practitioners a means to gain positive support for ramp metering from motorists and local leaders. Media releases, in either electronic or hardcopy format, can be used to express the benefits of ramp meters prior to and during construction. The local media should be notified of program goals, objectives, and benefits well in advance of when meters are expected to be turned on. This will help form a working relationship with the media that will be needed to publicize the benefits of ramp meters later on.



Although the media can aid in acquiring public support, the media can also be obstructive if not handled properly. If the benefits of ramp metering are oversold and unrealistic, credibility of the implementing agency can be questioned.

6.0. SPECIFIC MONITORING RECOMMENDATIONS FOR US 95 RAMP METERING

This section contains specific recommendations for monitoring the operation of the ramp meters on US 95. Metering began on March 29, 2005.

6.1. Objectives for Metering US 95

The objectives of ramp metering on US 95 are as follows:

- ▶ Reduce crash rate in the metered section of freeway.
- ▶ Increase mainline speeds in metered freeway sections.

- ▶ Keep ramp queues contained on the ramps, except when severe incidents occur.

The measures that best reflect these objectives are:

- ▶ Crash rates,
- ▶ Mainline speeds (or travel times), and
- ▶ Ramp queue lengths (or time in queue).

6.2. Monitoring Approach

As mentioned in Section 2, a corridor approach should be taken for monitoring performance of the initial ramp metering implementation on US 95. The geographic extent of the corridor analysis should be southbound only from roughly Ann Road to the interchange with US 93/I-15 (Spaghetti Bowl).

6.3. Data Collection

Two types of data will need to be collected in order to monitor the US 95 ramp meter operation, automated data and field observation/manual data.

6.3.1. Automated Data Collection

There are two types of automated data that will need to be collected. These data are listed and described below:

- ▶ Crash Data
- ▶ Mainline Speed Data

6.3.1.1. Crash Data

Crash rates will be important information to collect. This data will not be available for several months and because crash rates spike at different times of year, generally one year of after data is needed to derive statistically significant conclusions. Crash data analysis should be part of the one-year evaluation report.

6.3.1.2. Mainline Speed Data

Detector data (volume and speed) will be collected on the mainline at the following locations:

- ▶ SB 95 between Craig and Cheyenne
- ▶ SB 95 between Cheyenne and Lake Mead
- ▶ SB 95 between Lake Mead and Rainbow curve

Ramp volumes will also be collected at the following locations:

- ▶ SB to Cheyenne off ramp
- ▶ Cheyenne to SB on ramp (general purpose and HOV)
- ▶ SB to Lake Mead off ramp
- ▶ WB Lake Mead to SB on ramp (general purpose and HOV)
- ▶ EB Lake Mead to SB on ramp (general purpose and HOV).

Automated data collection spanned three week days prior to the initiation of ramp metering and should continue throughout the ramp metering operation. The FAST system is being used to the extent possible to collect this data.

6.3.2. Manual Data Collection

Manual data collection (observations) have been or are being made in two ways. First, 24-hour time lapse recording from cameras in the field are used to observe flows on the mainline and metered ramps before and after metering starts. The recordings were for made for three week days before the start of ramp metering. After ramp metering began, video recordings should continue to be made for comparison purposes.

The second manual data collection method to be used are field observations. Field observations should be made while ramps are metered. Observers should record the extent of queues at the three ramps metered on US 95:

- ▶ Cheyenne to SB on ramp
- ▶ WB Lake Mead to SB on ramp
- ▶ EB Lake Mead to SB on ramp.

Ideally, each ramp was visited at least once every 15 minutes while the ramps are being metered each day the first week of metering. The second week, observations were recommended for 3 days during metered times. After the second week, field observations should be on an as needed basis, during metered times.

6.4. Data Analysis

The analysis of data for the initial ramp metering operation should consist of:

- ▶ Comparison of before and after crash rates (after sufficient time has passed to collect statistically valid sample of crash records).
- ▶ Comparison of before and after mainline speeds. Averages and standard deviations should be compared. Care should be given to make sure sample sizes reflect statistically valid results.
- ▶ Average queue lengths after metering starts.
- ▶ Qualitative assessment of overall ramp observations.

6.5. Data Reporting

NDOT and RTC should be prepared to provide qualitative assessment of the operation of the ramp metering system on the first day of operation. As soon as possible, information on mainline speeds and volumes should be prepared and released to the media, the public, and decision makers. Simple graphs and charts and explanatory text should be provided in the form of press releases and fact sheets.

6.5.1. Three Month Report

NDOT and RTC should plan on releasing a quantitative and qualitative report on the first 3-months of ramp metering operation. The report should include:

- ▶ A description of ramp metering on US 95 and plans for metering elsewhere in the region.
- ▶ An explanation of the data collected and analyzed.
- ▶ Results of the analysis, both qualitative and quantitative. Qualitative analysis should include any public survey results and summaries of field observations. Quantitative analysis should include mainline speed comparisons, ramp queue observations, and identification of safety issues.
- ▶ Actions taken over the course of the metered operation.

- ▶ Conclusions from the analysis and recommendations for improvements.

6.5.2. Annual Report

NDOT and RTC should plan on producing and distributing an annual report on the ramp metering operation. The format and analyses should be similar to that of the 3-month report, with collision and benefit-cost analyses added. Region-wide analyses and travel time reliability measures should be added as additional corridors are metered and travel time measures are implemented.

The exact format of the annual report should be revisited and finalized after the 3-month report has been distributed and judgments can be made regarding its effectiveness.