WisDOT Ramp Meter Retiming Procedure

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Section 1 – Ramp Meter Retiming Introduction

Section 1.1 – Purpose of Report

The Ramp Meter Retiming Procedure (Procedure Manual) has been developed for the Wisconsin Department of Transportation (WisDOT) Traffic Management Center (TMC). The document is intended to guide an engineer and/or operator through developing timings for a new ramp meter or retiming existing ramp meters. The document is should be considered as a guide as technology, policies, traffic analysis procedures, or other factors related to ramp meter retiming change. Each ramp meter is unique in terms of geometry, traffic conditions, and infrastructure and should be analyzed as such.

Section 1.2 – Purpose of Ramp Meters

Ramp meters are traffic signals on freeway entrance ramps that break up clusters, or platoons of vehicles entering the freeway, which ideally makes merging onto the freeway easier. Ramp meters can also store and spread out the volume of vehicles entering the freeway over time so it is less likely to become congested and the overall rate of travel is minimally affected. Utilizing ramp meters along a freeway are an effective means of managing freeway traffic congestion and optimizing travel times.

Section 1.3 – Need for Ramp Meter Retiming

Ramp meters discharge vehicles based on freeway conditions. Freeway volume, speed, and occupancy can change from day to day and over the course of time. As time goes by, the amount of traffic using the freeway system can increase causing slower speeds and more congestion. Therefore, it is necessary to retime ramp meters every 5 years as budgets allow.

Ramp meters also need to be retimed during construction projects. There may be a need to extend the metering times due to lane closures or set the ramp to meter in a fixed plan if mainline freeway detectors are damaged, removed, or aimed improperly due to construction or lane closures.

Current freeway traffic information is used to develop ramp meter operating times and discharge rates. In order to retime an individual ramp meter, a person should budget approximately 24 hours for the activities noted in this Procedure Manual. Ideally, ramp meters should be retimed as a group along a freeway corridor. The use of a Gantt scheduling chart may be used to help schedule retiming efforts for groups of ramp meters. An example Gantt scheduling chart used in 2016 for the IH-43 corridor in Milwaukee County is included in Appendix A.

Section 1.4 – Ramp Meter Policies

WisDOT Bureau of Traffic Operations has outlined a policy for ramp metering. Reference the State Traffic Operations Center Standard Operating Procedures manual or ITS Design and Operations Guide, Chapter 5[1] for further information.

[1] ITS Design and Operations Guide: https://wisconsindot.gov/Pages/doing-bus/local-gov/traffic-ops/manuals-and-standards/its/05.aspx

Section 2 – Ramp Meter Definitions & General Concepts

Section 2.1 – Ramp Meter Definitions

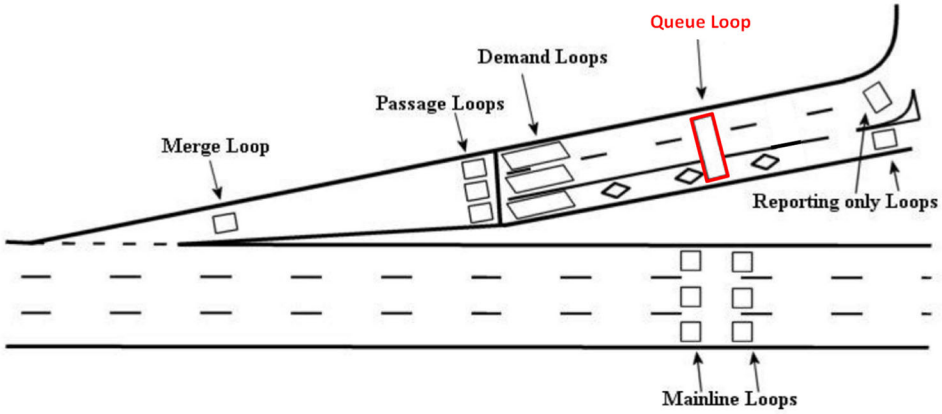
Traffic Detection – Ramp meters have a variety of traffic detection equipment associated with them. Generally, the Freeway mainline has two detectors assigned to each lane, a primary and secondary detector. This combination is known as a trap. Freeway on-ramps may have the following detectors: freeway mainline, queue, demand, passage, merge, exit, and entrance detectors. Merge detectors have only been installed since the early 2000's, so not all ramp meters in the Wisconsin freeway system will have a merge detector. An example ramp meter traffic detector diagram is included in Appendix B.

Freeway Mainline Detectors - Volume, speed, and occupancy data is retrieved from the freeway mainline detectors. These detectors are also used for adjusting signal rates according to flow characteristics on the mainline. The primary detectors are always used and are typically displayed as Ln 1 Primary, Ln 2 Primary, etc.

Merge Detector – If an on-ramp has a merge detector, it should be used for determining ramp volume. The merge detector is located near the end of the ramp, close to the point that the ramp merges with the freeway.

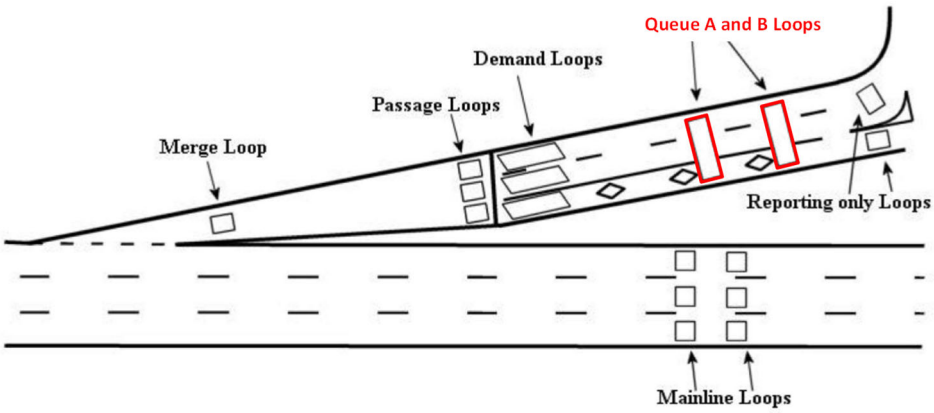
Queue Detectors – When a merge detector doesn't exist, queue detectors are used for determining the volume of the on-ramp during non-metering periods. The number and location of queue detector varies per ramp, so the ramp volume is determined as described below:

A) When ramps have 1 queue detector that extends across the entire ramp, this detector is used to determine the ramp volume. The following diagram shows this concept with loop detection.



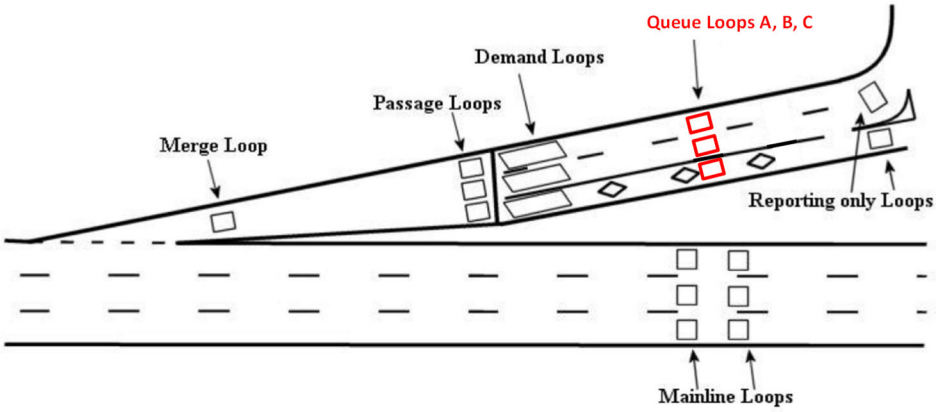
Volume during non-metering period = queue loop

B) When queue detectors are located in the middle of the ramp, and extend across all lanes, the detectors should be averaged to determine the ramp volume. The following diagram shows this concept with loop detection.



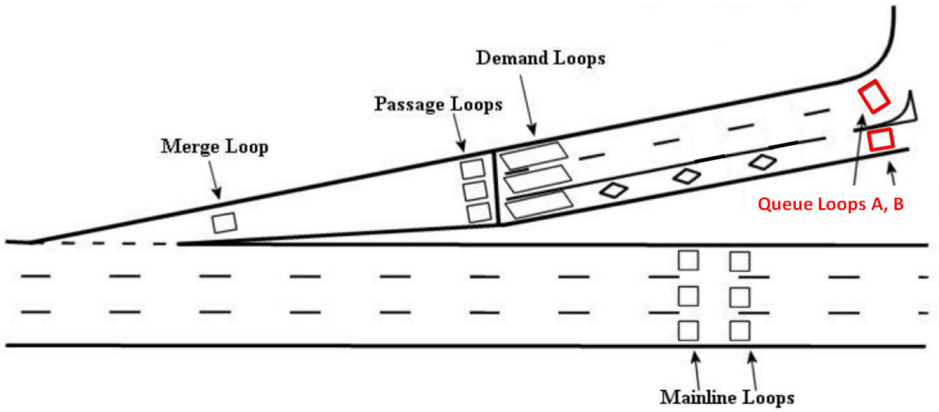
Volume during non-metering period = (queue A + queue B) / 2

C) When there is a queue detector for each lane on the ramp, the ramp volume is determined by summing the detectors. The following diagram shows this concept with loop detection.



Volume during non-metering period = queue A + queue B + queue C loops

D) When queue detectors are located at the entrance to the ramp, the ramp volume is calculated by summing the detectors. The following diagram shows this concept with loop detection.



Volume during non-metering period = queue A + queue B loops

Queue detector data is also utilized in calculating the queue occupancy threshold for ramp metering.

Demand Detectors – Demand detectors are located prior to the stop bar. These detectors detect the presence of a vehicle at the stop bar and trigger the signal to turn green to discharge the vehicle. The demand detectors are not used in the ramp meter retiming process.

Passage Detectors – Passage detectors are located just past the stop bar. These detectors sense when the vehicle has moved beyond the stop bar and trigger the signal to turn back to red. They are used to determine the volume on the ramp, during metering periods, when a merge detector doesn't exist. The volume is calculated by summing the passage detectors.

Entrance Detectors – Some ramps have detectors that are located at the entrance to the ramp. These detectors may be used to determine the turning volumes onto the ramp or summed to determine the volume on the on-ramp, as described in scenario D under "Queue Detectors." These detectors can be used when queue and passage detectors are not feasible. Entrance detectors are also located on off-ramps and can be used to determine the volume of vehicles on the off-ramp.

Ramp Meter Discharge (or Vehicle Release Type)

Single Release – The ramp has one lane, therefore the meter releases one vehicle at a time.

Simultaneous Release – When a ramp has 2 lanes, the meter releases 2 vehicles at the same time.

Dual (or Staggered) Release – When a ramp has 2 or more lanes, the meter releases vehicles one at a time.

HOV Lane Discharge – HOV lanes are metered in the same manner as single occupancy vehicle (SOV) lanes

Vehicles Released on Green – The ramp meters operating in Wisconsin each release one vehicle on green. For ramp meters that are near capacity or experience heavy queuing due to mainline delays, the operator could consider releasing two vehicles on green. Specific signing would be needed installed at the ramp meter for this type of operation.

Federal Highway Administration (FHWA) guidance[2] indicates which type of vehicles on green release may be appropriate based on the number of metered lanes and ramp volumes. The guidance is summarized below:

- One lane ramp with one vehicle on green: < 1,000 vph
- One lane ramp with two vehicles on green: 900 – 1,200 vph
- Two lane ramp with one vehicle on green: 1,200 – 1,600 vph
- Two lane ramp with two vehicles on green: 1,600 – 1,800 vph

Ramp Meter Plan Operations

Traffic Responsive – The ramp meter operates based on the local freeway traffic conditions. This is the most common type of ramp meter plan operation used in Wisconsin.

Fixed Plan – The ramp meter operates in a plan that is designated by the engineer or operator. The cycle length of the ramp meter will remain consistent based on the timings selected by the engineer or operator. Ramp meters operate in a fixed plan when mainline or ramp detectors do not exist or when they are in need of repair. This type of plan is occasionally used by WisDOT depending on the condition of the infrastructure (e.g. bad mainline detectors) or geometrics.

[2] FHWA Ramp Management and Control Handbook, Table 10-1 (January 2006)

Must/May – The must/may plan allows the ramp meter to initiate metering prior to the user defined start time if the freeway thresholds are met. It will also allow the ramp meter to shut off earlier if the thresholds are not being met. It is typical to define a must/may period 15-30 minutes prior to ramp meter initiation and 15-30 minutes prior to metering termination. This type of plan is not typical in Wisconsin.

Dependency Groups – A dependency group is used to assign metered lanes for cycle order. Programming more than one dependency group allows metered lanes to operate independent of other lanes that are controlled by the same ramp meter controller.

Section 2.2 – Ramp Meter Concepts

Ramp Meter Operations – Ramp meters can be set to operate in a fixed plan or as traffic responsive. Most of the ramp meters in Wisconsin operate as traffic responsive and require the user to enter timings and thresholds for the 6 individual plans.

Ramp Meter Interval Timings – The user must enter timings for each plan, with Plan 6 being most restrictive (i.e. the slowest release rate). Plan 1 is generally used for queue flush, or discharging vehicles as quickly as possible when the ramp is severely backed up. Ideally, thresholds will be set such that ramps generally operate in Plan 3 or Plan 4. The minimum and maximum red time varies depending on the type of discharge and are as follows:

Minimum Red Times –
Dual Discharge = 1.8 seconds
Simultaneous Discharge or Single Lane = 2.5 seconds

Maximum Red Times –
Dual Discharge = 8 seconds
Simultaneous Discharge or Single Lane = 10 seconds

It should be noted that there may be ramp meters that require the minimum red time to be less than 1.8 seconds. Ramps that have excessive volume and/or minimal storage length have a tendency to back-up onto the side streets if the red time is as great as 1.8 seconds. Therefore, the user must decrease the red time in order prevent severe back-ups.

Ramp Meter Thresholds – The user must enter the freeway lane volume, percent occupancy (percent of time vehicles are occupying the detector in a 20 second period), and speed thresholds for each of the 6 plans. Archived data from the mainline detectors is used to develop the thresholds. Queue override thresholds must also be entered and are determined from a series of calculations of ramp queue detectors.

Ramp meters can operate in a fixed plan when mainline or ramp detectors do not exist, or when they are in need of repair. The user must develop red and green times for the designated operating plan and values for the queue override thresholds. The queue override function will override the fixed plan if the ramp backs up. Freeway volume, occupancy, and speed thresholds are not required for ramp meters with a Fixed Plan.

Ramp Meter Periods – Ramp metering time periods are determined by reviewing the volume to capacity (v/c) ratio of the freeway mainline as well as the freeway speed and volume trends. Based on the Highway Capacity Manual (HCM) 6th Edition, congestion levels are critical when the v/c ratio reaches 0.7. It is common practice to begin metering when the freeway reaches a v/c ratio value of 0.7. The user must also consider freeway occupancy greater than 18%, freeway speed reduction, freeway LOS, mainline volume, downstream bottleneck conditions, the merge influence area, and ramp diversion when determining ramp metering periods.

If there are multiple ramp meters along a studied corridor the time of day start/stop settings should be analyzed as a group. Similar metering time periods for the corridor should be considered if spacing is less than one mile between ramp meters and if there is good local connectivity (i.e. alternate routes) between ramp meters. The ramp metering period should start and stop at the same time each day because of driver's expectancy. The ramp metering periods will vary on a case-by-case basis, the ramp metering operations engineer should approve the final times.

Section 3 – Retiming Process

Introduction

Section 3 of the Ramp Meter Retiming Procedure is intended to guide the user through the retiming process. This section details the required steps in the order that they must be completed. The following list summarizes the procedure:

Section 3.1: Step 1 – Collect Background Information
Section 3.2: Step 2 – Data Collection and Data Validation
Section 3.3: Step 3 – Ramp Meter Field Inspection
Section 3.4: Step 4 – Ramp Meter Retiming Data Download
Section 3.5: Step 5 – Ramp Meter Retiming Workbook
Section 3.6: Step 6 – Ramp Meter Settings Review and Acceptance
Section 3.7: Step 7 – New Timings Entry
Section 3.8: Step 8 – Ramp Meter Observation
Section 3.9: Step 9 – Documentation

Section 3.1 – Collect Background Information

General

The first step in retiming a ramp meter is to collect background information on the ramp and ramp meter. The following information is needed in order to properly retime a ramp meter:

- Current design or as-built Freeway Traffic Management System (FTMS) plan view sheets.
- Current design or as-built pavement marking plan.
- Current design or as-built signage plan.
- Current controller settings (accessed through inSIGHT), information on operation type, time-of-day schedules, and lane-by-lane detection detail.
- Documentation related to last retiming, if available.
- Assessment of detector quality and output.
- Review the most recently completed tickets/work orders and any open tickets/work orders from VUEWorks.

VUEWorks is a software application within WisDOT BTO's Traffic Operations Asset Management System (TOAMS) program to help track and monitor the management of all non-infrastructure assets within state right of way. To access TOAMS, follow this link:
https://wisconsindot.gov/Pages/doing-bus/local-gov/traffic-ops/programs/toams.aspx

A login ID will be required to access TOAMS. Detailed support materials are in the following link:
https://wisconsindot.gov/Pages/doing-bus/local-gov/traffic-ops/manuals-and-standards/manuals.aspx

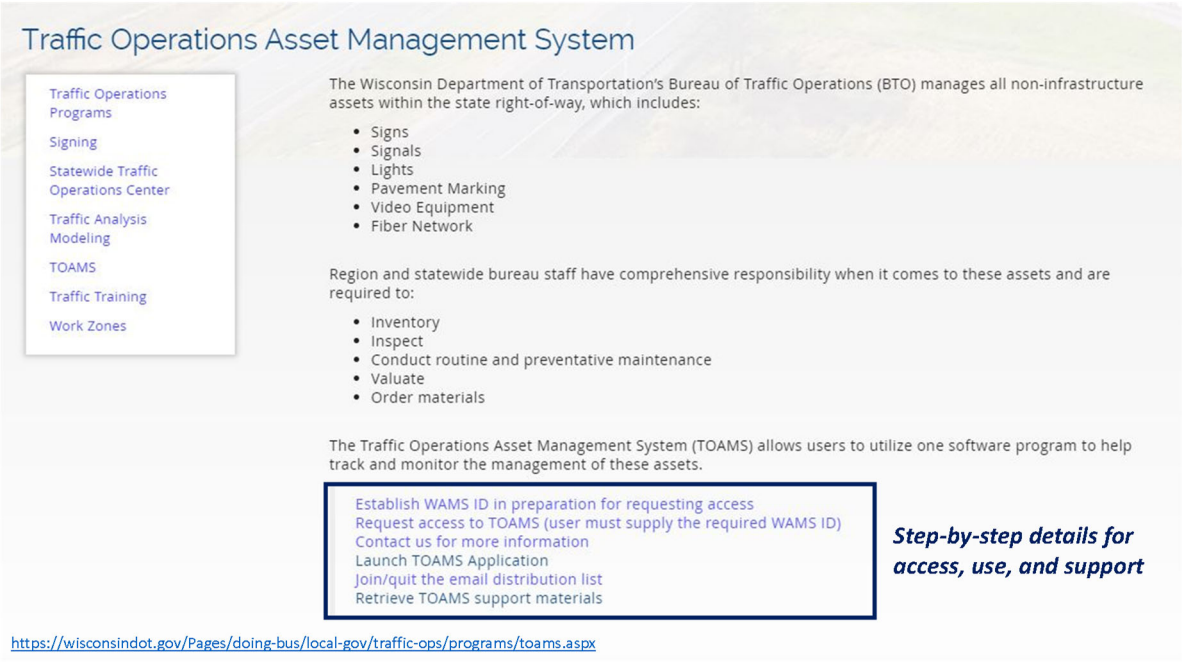


Figure 3.1.1: TOAMS / VUEWorks WisDOT Webpage

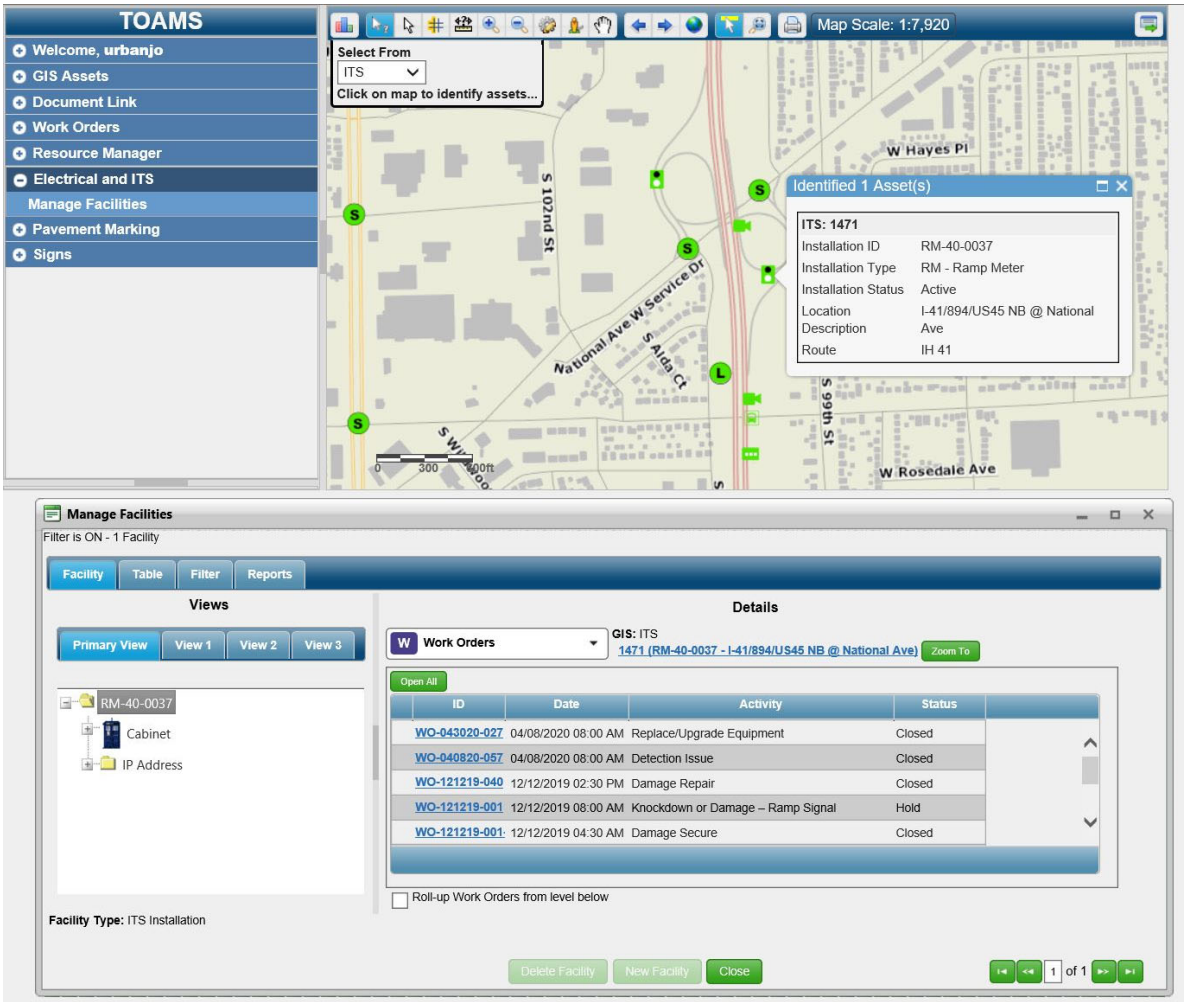


Figure 3.1.1: VUEWorks Work Order Review Example

Documentation related to last retiming may include assumptions used, traffic volumes, geometry of the ramp meter, previous and proposed timings, queue override settings, and time of day settings.

Electronic as-built plans for reach ramp meter can be found within VUEWorks.

Assessment of detector quality should be completed. The assessment process is discussed further in Section 3.2. It is recommended that VUEWorks is checked before the detector quality assessment is conducted to ensure there are no outstanding issues at the ramp meter.

Section 3.2 – Data Collection and Data Validation

General

Ramp meters are retimed based on current freeway traffic conditions. In order to get an account of current traffic conditions, archived data must be queried. The University of Wisconsin Madison Traffic Operations and Safety Laboratory (UW TOPS) manages and archives detector data for WisDOT. The detector data is accessible through the WisTransPortal system.

The WisTransPortal system contains detector data across the state from the WisDOT Advanced Traffic Management System (ATMS) dating back to 1997. The database is updated every 24 hours with WisDOT ATMS data from the previous day. Traffic volume, travel speed, and occupancy detector data is reported to the WisTransPortal database. This data is accessible through the "V-SPOC Application Suite", which requires a username and password. Access to the database must be requested through and approved by UW TOPS staff. Analysis of the availability of V-SPOC data is accessible through the "V-SPOC Data Availability Calendar Tool" (Calendar Tool), which also requires access.

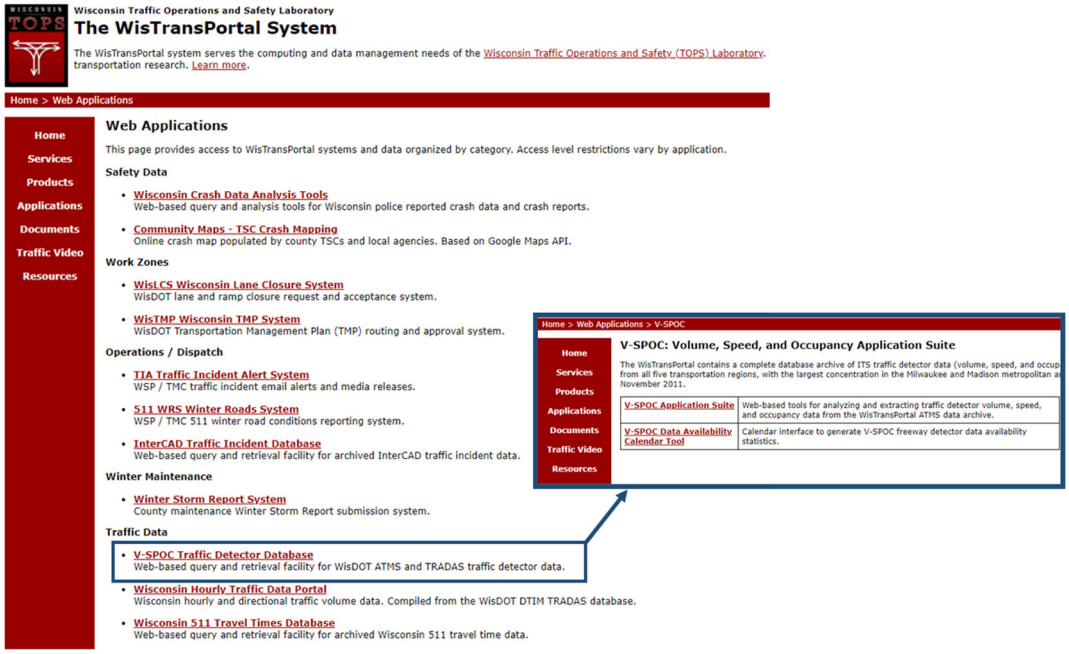


Figure 3.2.1: WisTransPortal System Website

The Calendar Tool will be used to check the quality and availability of the detectors and will also be used to determine the dates to use for data download. This will be the first tool used in the retiming process

The "Ramp Meter Retiming" application within V-SPOC Application Suite was developed to enhance the collection of data for ramp meter retiming. The Ramp Meter Retiming application will be the primary application used in the retiming process. The "General Detector Data Retrieval" application will be used to assess the data quality of individual detectors.

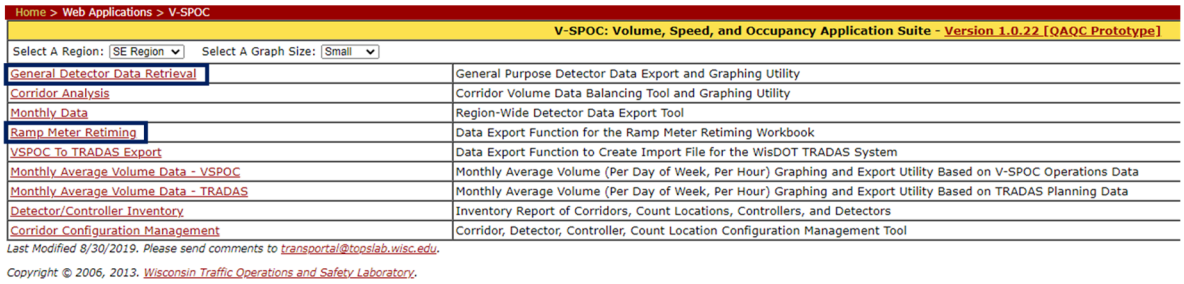


Figure 3.2.2: V-SPOC Application Suite

Procedure

Before the field inspection the following steps should be followed to check the quality and availability of the detectors and to determine dates to use for the data download.

The Calendar Tool is used in steps 1 and 2 to select the dates for the data download and to identify which detectors may have poor availability. The General Detector Data Retrieval is used in steps 3 through 7 to check the quality of each detector. The following steps need to be taken to select, download, and compare the detector data.

Steps 1 & 2 – Calendar Tool

Step 1 – Date Selection

When using the Calendar Tool the user should select 18 weekdays of detector data. The dates selected should fall on a Tuesday, Wednesday, or Thursday to capture typical weekday commuter traffic. The user should also select dates from different months to reflect the traffic during the different seasons of the year. For instance, the user could select 3 days in January, March, May, July, September, and November to total 18 days. Care should be taken in selecting data from months with winter weather, particularly if a before/after analysis is planned to be completed. The user must also avoid selecting dates that are known holidays or during special events such as Summerfest or Wisconsin State Fair in the Milwaukee area. For example, a recent retiming effort along I-43 southbound, the data analysis dates selected were from July, August, and September. The dates selected for this analysis were in the summer months and after Summerfest, providing a basis for the before/after analysis.

The user should select dates with high percent availability to obtain the most accurate data possible. The user will be prompted with the following page where the region, controller, detector, month and year can be selected in order to view the percentage of detector data availability for specific days.

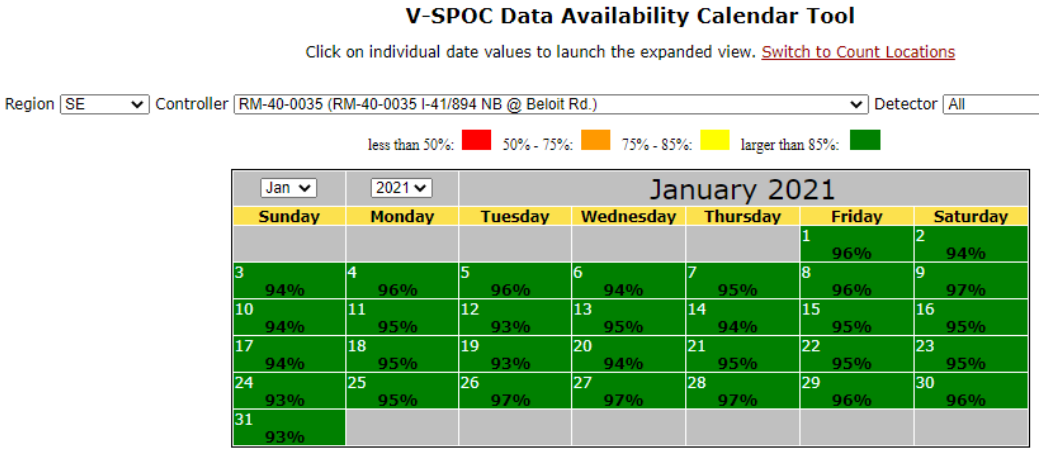


Figure 3.2.3: Controller Selection Example

Step 2 – Detector Availability

The Calendar Tool should also be used to check the data availability for individual detectors to determine if there are any detector problems. After the controller location and date is selected each detector type should be checked to determine if there are possible detection issues. Detectors that are not showing high availability should be noted for WisDOT engineers and maintenance staff. Analysis of data quality is discussed further in Step 6. Figure 3.2.4 shows are examples of varying detection availability at one ramp meter.

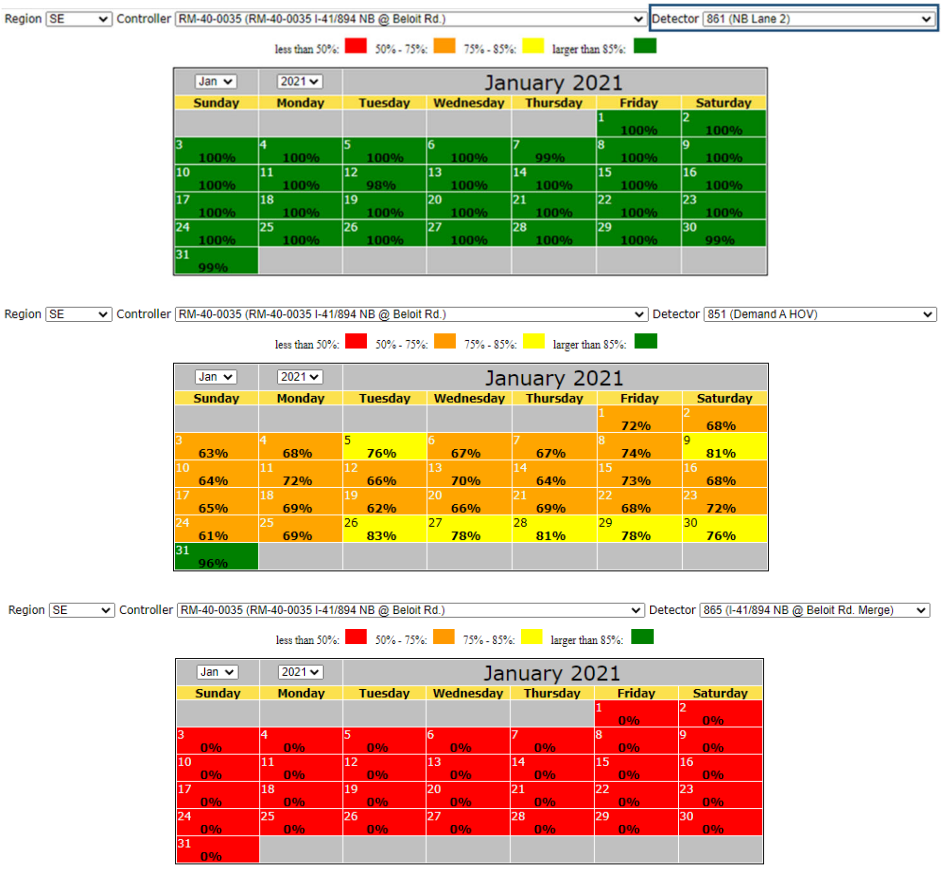


Figure 3.2.4: Data Availability Examples

Steps 3 - 7 – General Detector Data Retrieval

The detector quality analysis using the Calendar Tool can be checked using the General Detector Data Retrieval from the V-SPOC website.

Step 3 – Corridor Selection

Within the General Detector Data Retrieval section of the V-SPOC website, the user must select the desired corridor by highlighting the corridor from the corridor pull-down menu and left-clicking the mouse button.

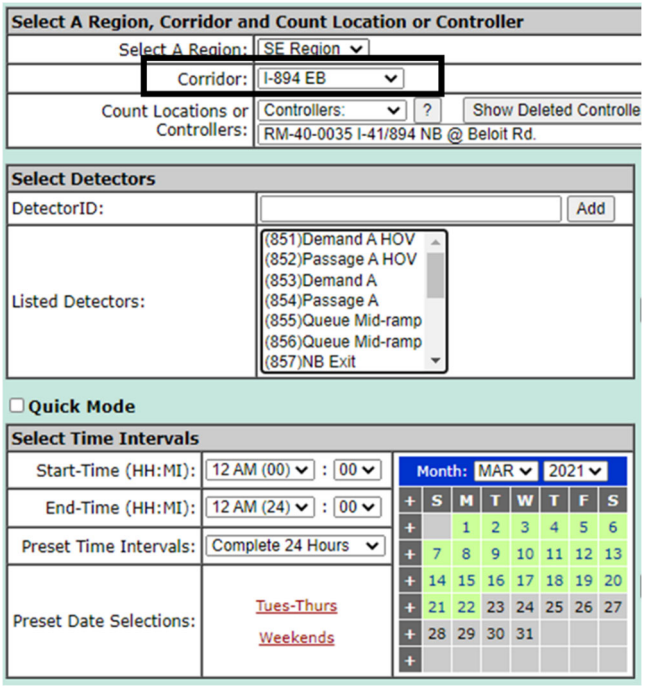


Figure 3.2.5: Corridor Selection

Step 4 – Controller Selection

The user must select the desired controller by highlighting the controller from the controller pull-down menu and left-clicking the mouse button.

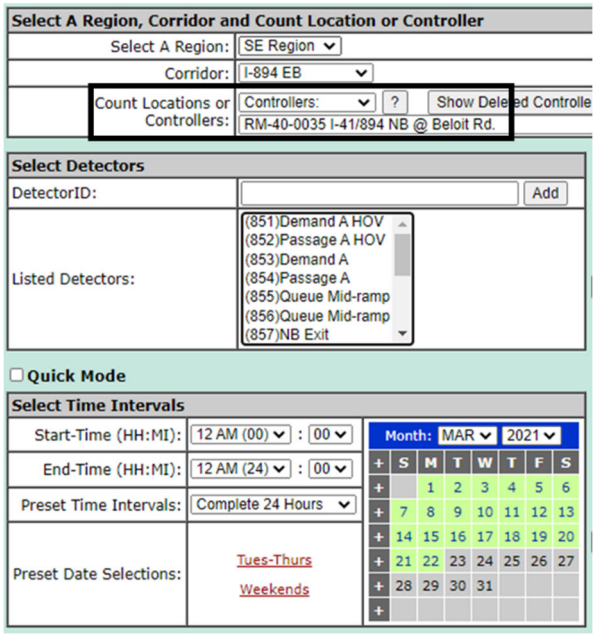


Figure 3.2.6: Controller Selection

Step 5 - Detector Selection

The user must highlight the detector from the “Listed Detectors” section and then press “Add” near the middle of the user interface. This will place the detector in the “Selected Detectors” window to the right. This step should be performed for all detectors from which data is desired.

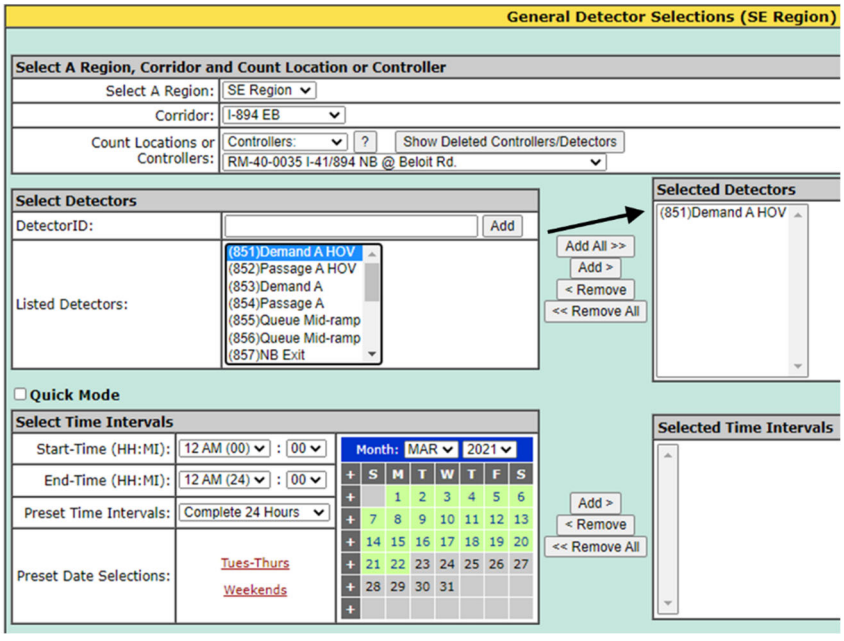


Figure 3.2.7: Detector Selection

Manual Selection

The user can manually enter the detector number if it is known. The following procedure should be used:

- Enter the detector number in the box labeled “Detector ID”
- Press the “Add” button to place the entered detector in the “Selected Detectors” window.

This process can be repeated to add more detectors.

Detector Removal

A detector can be removed from the “Selected Detectors” window by:

- Highlighting the detector by clicking the left mouse button
- Selecting the “Remove” button

This process can be repeated to remove more detectors, or the “Remove All” button can be selected to remove all selected detectors at once.

Step 6 – Date Selection

The user should select the 18 days determined using the data availability calendar. The date is selected by using the left mouse button to highlight the desired date . Clicking the “Add” button located near the middle of the user interface will move this date to the “Selected Time Intervals” window to the right. The month and year pull down menus allow the user to select dates from various months and years. Entire weeks can be selected by clicking the +/- button to the left of the desired week. The calendar also allows the user to select all Tuesday-Thursday intervals, or all weekend days by selecting the “Tue-Thurs” prompt or the ‘Weekends” prompt to the left of the calendar.

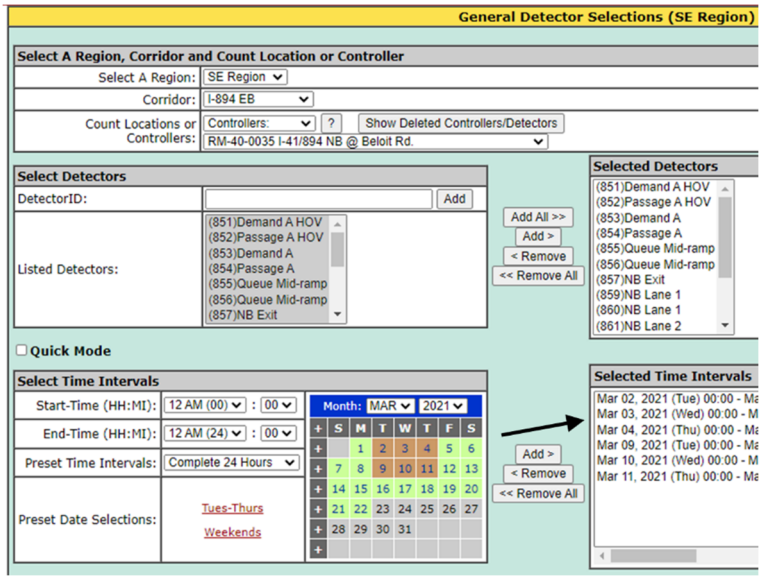


Figure 3.2.8: Date Selection

Date Removal

Any date can be removed from the "Selected Time Intervals" window by:

- Highlighting the date by clicking the left mouse button
- Selecting the "Remove" button

This process can be repeated to remove more dates, or the "Remove All" button can be selected to remove all selected dates at once.

When all desired dates are selected, the user can left-click the "Preview Detectors" button located near the bottom of the user interface for detailed quality checks of the detector data within the chosen dates. The Detector Data Retrieval QA/QC User Guide describes each of the quality checks that are shown after clicking the Preview Detectors button. This document can be accessed through VSPOC (as shown in Figure 3.2.9) and in Appendix K of this Procedure Manual. It should be noted that these quality checks are most applicable to freeway mainline detectors and are not suggested to be used for ramp detectors.

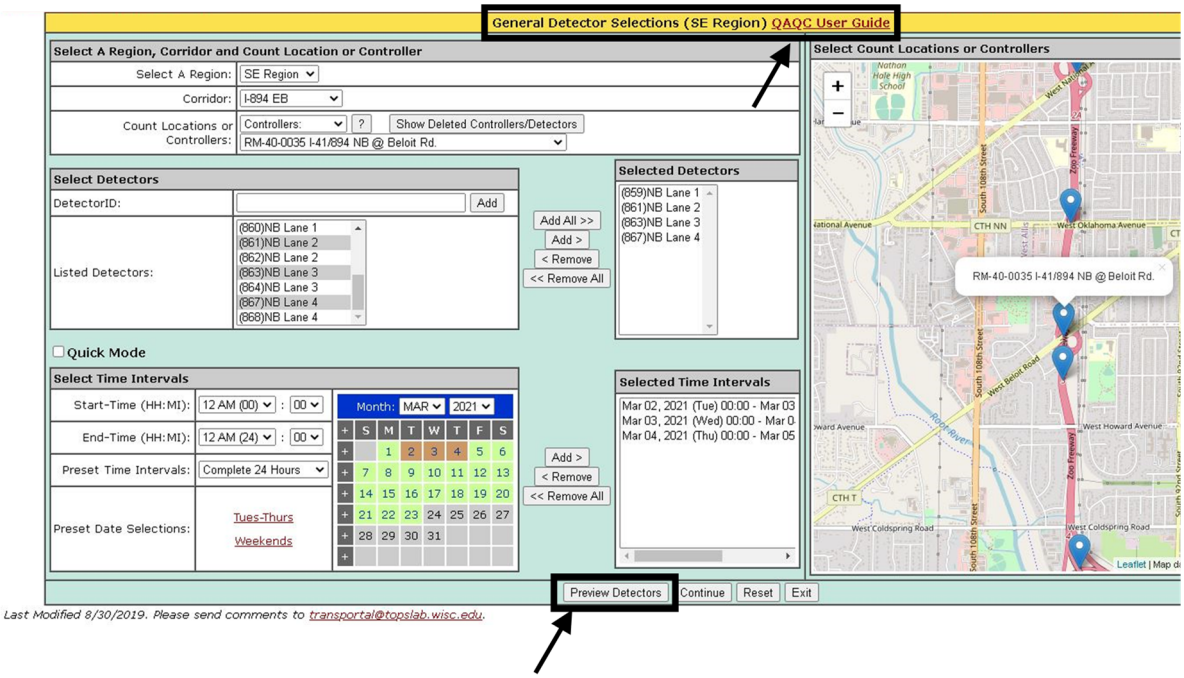
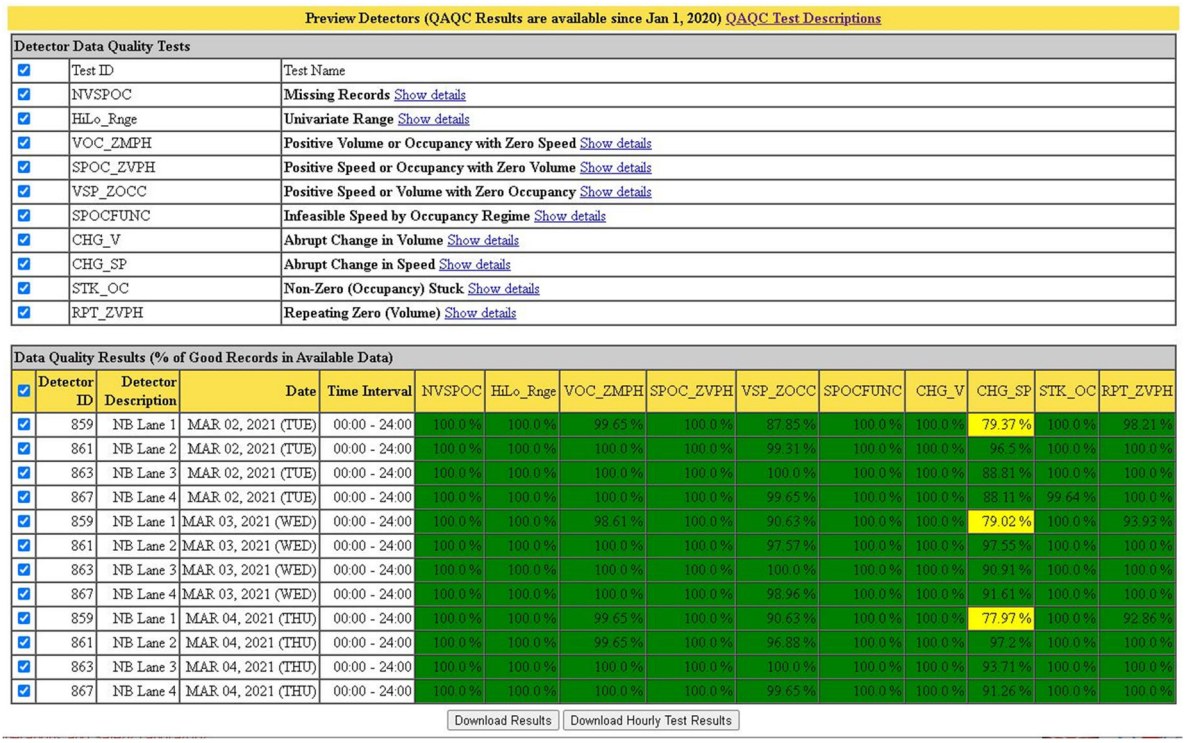


Figure 3.2.9: Preview Detectors and QA/QC User Guide

Figure 3.2.10 shows an example of the pop-up window that appears after clicking the Preview Detectors button. From this window each quality check can be reviewed in detail and the detector data and test results can be downloaded.



Preview Detectors (QAQC Results are available since Jan 1, 2020) QAQC Test Descriptions

Detector Data Quality Tests		
☑	Test ID	Test Name
☑	NVSPOC	**Missing Records** Show details
☑	HiLo_Rnge	**Univariate Range** Show details
☑	VOC_ZMPH	**Positive Volume or Occupancy with Zero Speed** Show details
☑	SPOC_ZVPH	**Positive Speed or Occupancy with Zero Volume** Show details
☑	VSP_ZOCC	**Positive Speed or Volume with Zero Occupancy** Show details
☑	SPOCFUNC	**Infeasible Speed by Occupancy Regime** Show details
☑	CHG_V	**Abrupt Change in Volume** Show details
☑	CHG_SP	**Abrupt Change in Speed** Show details
☑	STK_OC	**Non-Zero (Occupancy) Stuck** Show details
☑	RPT_ZVPH	**Repeating Zero (Volume)** Show details

Data Quality Results (% of Good Records in Available Data)

☑	Detector ID	Detector Description	Date	Time Interval	NVSPOC	HiLo_Rnge	VOC_ZMPH	SPOC_ZVPH	VSP_ZOCC	SPOCFUNC	CHG_V	CHG_SP	STK_OC	RPT_ZVPH
☑	859	NB Lane 1	MAR 02, 2021 (TUE)	00:00 - 24:00	100.0 %	100.0 %	99.65 %	100.0 %	87.85 %	100.0 %	100.0 %	79.37 %	100.0 %	98.21 %
☑	861	NB Lane 2	MAR 02, 2021 (TUE)	00:00 - 24:00	100.0 %	100.0 %	100.0 %	100.0 %	99.31 %	100.0 %	100.0 %	96.5 %	100.0 %	100.0 %
☑	863	NB Lane 3	MAR 02, 2021 (TUE)	00:00 - 24:00	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	88.81 %	100.0 %	100.0 %
☑	867	NB Lane 4	MAR 02, 2021 (TUE)	00:00 - 24:00	100.0 %	100.0 %	100.0 %	100.0 %	99.65 %	100.0 %	100.0 %	88.11 %	99.64 %	100.0 %
☑	859	NB Lane 1	MAR 03, 2021 (WED)	00:00 - 24:00	100.0 %	100.0 %	98.61 %	100.0 %	90.63 %	100.0 %	100.0 %	79.02 %	100.0 %	93.93 %
☑	861	NB Lane 2	MAR 03, 2021 (WED)	00:00 - 24:00	100.0 %	100.0 %	100.0 %	100.0 %	97.57 %	100.0 %	100.0 %	97.55 %	100.0 %	100.0 %
☑	863	NB Lane 3	MAR 03, 2021 (WED)	00:00 - 24:00	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	90.91 %	100.0 %	100.0 %
☑	867	NB Lane 4	MAR 03, 2021 (WED)	00:00 - 24:00	100.0 %	100.0 %	100.0 %	100.0 %	98.96 %	100.0 %	100.0 %	91.61 %	100.0 %	100.0 %
☑	859	NB Lane 1	MAR 04, 2021 (THU)	00:00 - 24:00	100.0 %	100.0 %	99.65 %	100.0 %	90.63 %	100.0 %	100.0 %	77.97 %	100.0 %	92.86 %
☑	861	NB Lane 2	MAR 04, 2021 (THU)	00:00 - 24:00	100.0 %	100.0 %	99.65 %	100.0 %	96.88 %	100.0 %	100.0 %	97.2 %	100.0 %	100.0 %
☑	863	NB Lane 3	MAR 04, 2021 (THU)	00:00 - 24:00	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	93.71 %	100.0 %	100.0 %
☑	867	NB Lane 4	MAR 04, 2021 (THU)	00:00 - 24:00	100.0 %	100.0 %	100.0 %	100.0 %	99.65 %	100.0 %	100.0 %	91.26 %	100.0 %	100.0 %

Download Results | Download Hourly Test Results

Figure 3.2.10: Example QA/QC Results

Step 7 – Graph and File Settings

The user must now select the desired settings for the detector data output file. The "Source Data" remains ATMS 5-Minute Detector Data by default. The 5-minute time intervals should be used for detector analysis purposes. The user should check the "Average Over Time Interval Selections" box located right of the detector dates. This will make it easier to compare the downloaded data for each detector.

After confirming all selected detectors and dates are correct, the user must press the "SaveIt" button located near the bottom of the user interface.

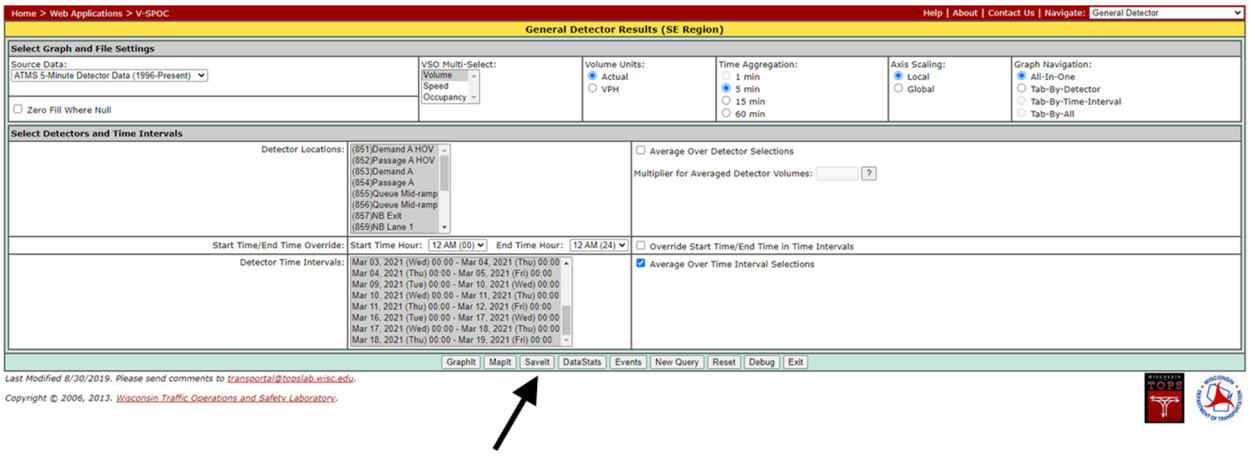


Figure 3.2.11: Downloading Data

Step 8 – Detector Data Download

The detector data will be downloaded as a ".csv" file. This file should be converted to an ".xls" or ".xlxs" file and saved in the desired location. Converting the file to ".xls" or ".xlxs" allows the user to save calculations within the workbook. A ".csv" file will not retain any calculations completed when the file is re-opened.

Step 9 – Detector By Detector Analysis

The downloaded traffic volume data should be analyzed to help determine the quality of each detector. One way to do this is to sum the 24 hour volumes for each detector and compare successive detectors. For example, a primary and secondary mainline detector in the same lane should have similar volumes because of their proximity in the same lane. This analysis can be used to find detection issues and verify potential issues spotted from the Calendar Tool. Another example would be to compare successive demand and passage detectors at a ramp meter signal.

Section 3.3 – Ramp Meter Field Inspection

General

A ramp meter field visit shall be conducted prior to retiming a ramp meter. The inspection is done in order to observe ramp meter operations, detect and report any maintenance needs, and validate signing and pavement marking. The inspection must take place during the AM or PM ramp metering period and requires a minimum of 30 minutes of observation.

Online mapping or TMC Closed-Circuit Television cameras (CCTVs) may be used for the inspector to familiarize themselves with the layout, parking access, etc. of the ramp meter prior to the field visit. Online mapping or CCTVs may also be used to partially complete the inspection report prior to field visit. Any items partially completed by these means should be verified in the field.

The user should take a blank Ramp Meter Field Inspection Report (Appendix C) with them to the field. The user should also make copies of the FTMS, Pavement Marking, and Signage plans and always return the original set to the file. The plan copies should be taken to the field and notes can be written on them if necessary.

The completed Ramp Meter Field Inspection Report, with copies of plans attached, should be given to the current WisDOT staff member responsible for ramp meter operations. The form will then be reviewed and any further needed action will be taken and documented. The responsible party will then sign, date, and file the form.

Completion of Ramp Meter Field Inspection Report

A blank Ramp Meter Field Inspection Report is located in Appendix C. The inspector must complete the form during the ramp meter field visit. Note that if the ▼ shape is marked on the form, then comments are required on the lines provided below that section. Detailed descriptions of the content of the Ramp Meter Field Inspection Report are as follows.

Ramp Meter (General Information) Section

The form requires documentation of the name of the inspector, ramp meter number and ramp location. The date, time, weather condition, and pavement condition must also be noted.

Configuration – Record the number of Single Occupancy Vehicle (SOV) lanes. Also document whether a High Occupancy Vehicle (HOV) lane is present.

Discharge – Observe the ramp meter to determine the type of discharge for the SOV lanes:

- Single Discharge – The ramp has one lane, therefore the meter releases one vehicle at a time.
- Simultaneous Discharge – When a ramp has 2 lanes, the meter releases 2 vehicles at the same time.
- Dual, or Staggered, Discharge – When a ramp has 2 or more lanes, the meter releases vehicles one at a time.

If there is an HOV lane, the discharge type must also be recorded as:

- Steady Green – the HOV lane has a steady green signal.
- Discharge with Adjacent Lane – the HOV lane discharges at the same time as the lane directly next to it.
- Discharge with Far Lane – in cases where there are 2 SOV lanes, the HOV lane discharges at the same time as the far SOV lane.
- Discharge Alone – the HOV lane discharges alone and does not discharge at the same time as the SOV lane(s).

Also observe the HOV lane for excessive violations and document on the inspection form.

Ramp and Freeway Conditions – Record the amount of vehicles waiting on the ramp to enter the freeway, also known as the queue on the ramp. This should be recorded on a lane-by-lane basis if possible. Appendix J displays a common Queueing Field Data Collection form. Queues should be recorded as they occur in their respective lane with a tally mark next to the size of the queue. A vehicle is considered part of a queue if it approaches the ramp meter or an existing queue and is traveling under 5 mph.

Also observe the freeway and estimate the average travel speed and volume. Mainline speeds should be categorized as either 0-20 mph, 20-40 mph or 40-60 mph. Mainline volumes should be estimated as either ‘light’, ‘moderate’ or ‘congested’. V-SPOC data for the can be examined when available to confirm the accuracy of the inspector’s speed and volume estimates for the observation timeframe.

Signing Review

The current signing plans are needed to complete the signing review section. Field verify that the signs listed in this section are present and in the proper

location. Also record the condition of the signs as good, damaged, turned, or obstructed. Use the comments section to record the location of the sign(s) if it is in poor condition and indicate if a photograph of the sign was taken.

Ramp Metered When Flashing Signs – Ramp Metered When Flashing Signs are typically located at the entrance to the ramp. They may also be located on the side streets or on the ramp.

Figure 3.3.1 "Ramp Metered When Flashing" Sign

Review the signing plans and record the number of "Ramp Metered When Flashing" signs per the plans.

Stop Here On Red Signs – Stop Here On Red Signs are located at the stop bar of the ramp.

Figure 3.3.2 "Stop Here On Red" Signs

Lane Designation Signs – The Lane Designation Signs are located near the stop bar. They are either mounted on the signal poles on the left and right sides of the ramp, or are mounted on the overhead signal pole.

Figure 3.3.3 Lane Designation Signs

HOV Signs – HOV Signs can be located on the ramp, side streets, or both.

Figure 3.3.4 HOV Sign

Signs on Side Streets – Review the signing plans and record the number of miscellaneous signs on the side streets. If there are miscellaneous signs on the side streets or signs that do not appear on the plans (such as bus stop signs), take notes on the location(s) and type(s) of signs along with photographs.

Pavement Markings

The current pavement marking plans are needed to complete the pavement markings section.

Review the plans and record any missing or faded pavement markings. Also document the condition of the following pavement markings if applicable:

- Stop bar
- Edge lines
- Lane skips
- Median paint
- HOV lane designation symbols

Use the comments section to record the type of pavement marking if it is missing or faded.

Pavement Condition

Pavement Type and Condition – The form requires the inspector to note the ramp pavement type as concrete or asphalt, and rate the ramp pavement condition as new, good, fair, or poor. If the pavement condition is in fair or poor condition, the observations must be documented and photographed in the comments section.

Pavement Condition In Areas of Traffic Detectors – The pavement condition in the areas of the ramp meter traffic detectors must also be recorded. The inspector must review the FTMS plan to identify the location of all traffic detectors on the ramp. Each traffic detector must be inspected.

For loop detectors, if it is difficult to identify the location of the detector, then check the corresponding box. If a loop detector location is identifiable, the form instructs the inspector to look for depressed pavement around the loop, and cracks or deterioration in the area of the loops. If poor pavement conditions exist around a loop detector, then further documentation and photographs, including the loop type (queue, passage, demand, or merge), must be recorded in the comments section. Refer to the ramp meter traffic detector diagram in Appendix B.

Hardware

Signal Heads – The inspector must observe all of the signal heads to determine that they are working. The yellow signal head is lit *only* at the time of ramp meter start-up and must be observed at that time. If the inspector is unable to observe the ramp at the time of metering initiation, the “Not Inspected” box can be checked. However, this is not desirable.

Advanced Flashers – The “Ramp Metered When Flashing” signs have flashers mounted above and below them. The inspector must also document whether or not the flashers are working.

Figure 3.3.5 Advanced Flashers

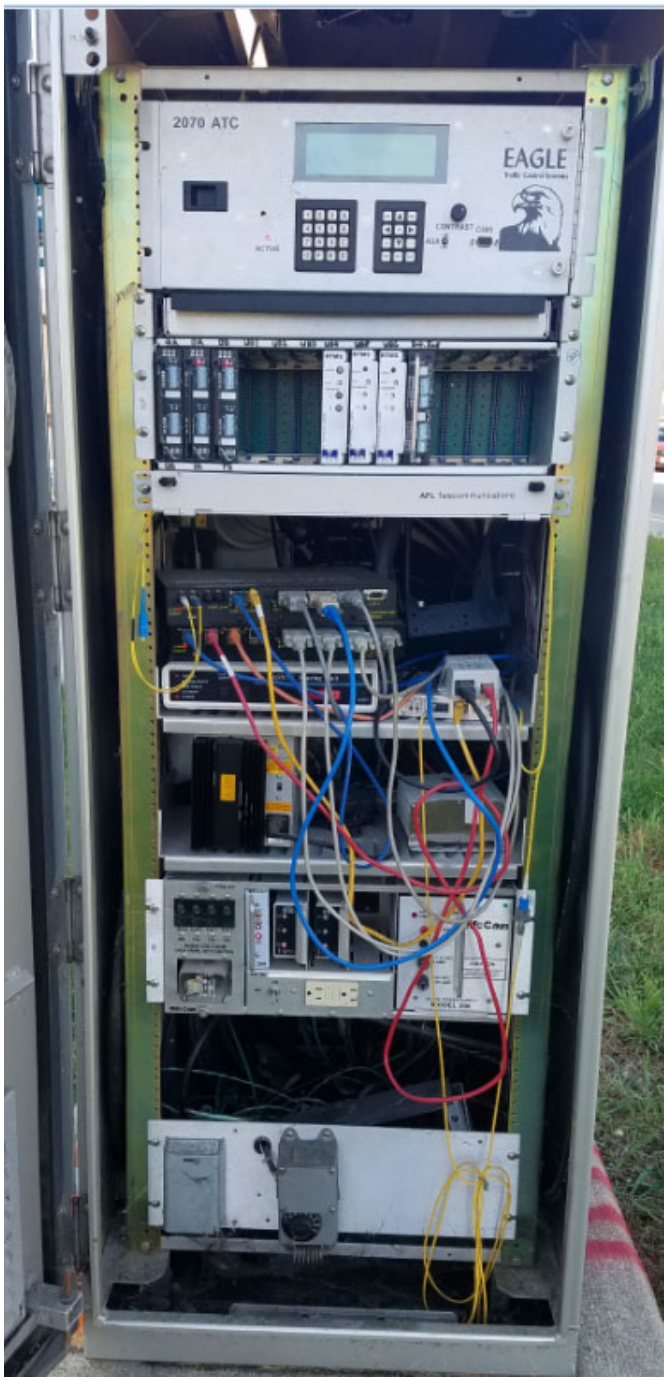
Cabinet

Cabinet Exterior – The exterior condition of the ramp meter cabinet must be examined during the field visit. The inspector should look for signs of graffiti, rust, water in or around the cabinet, and excessive weeds or tall grass around the cabinet. The inspector must also note whether or not the lock is easily accessible and works properly.

Figure 3.3.6 Exterior of Cabinet

Cabinet Interior – The inspector must also observe the interior condition of the cabinet. The inspector should note whether or not the light is working and document any signs of pests. Photographs of cabinet are shown in the following pages for Type 2070 Signal Controllers. The cabinet consists of the following 3 sections:

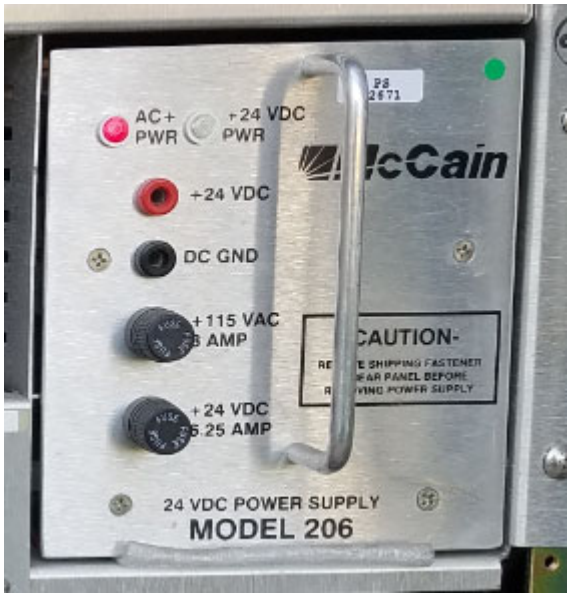
1) The Signal Controller (upper section of the cabinet)
2) The Detector Amplifiers (middle section of the cabinet)
3) The Power Source (bottom section of the cabinet)



Interior of Cabinet

Type 2070 Signal Controller
(upper section of cabinet)

Detectors Amplifiers
(middle section of cabinet)



Power Source
(bottom section of cabinet)

The following items in the controller cabinet should also be checked:

- Watchdog Failure (WDT Fail) – document if the controller is in watchdog failure. The controller is in watchdog failure when the red light is illuminated.

- MU toggle switch – record if the toggle switch is in the on or off/reset position.

- Circuit breakers – document any circuit breakers that are in the "off" position or any that appear to be missing.

- Detector Amplifiers – record any amplifiers that are pulled out of the controller. Also document if any detectors are in failure; detectors are in failure when the "FLT" (fault) light is illuminated, when the red LED light is constantly on, or if the light is not blinking when vehicles cross the detectors.

Action Taken

The inspector shall follow the current “Equipment Malfunction Procedure” for required ramp meter maintenance. The “Equipment Malfunction Procedure” is included in Appendix D. The inspector must document the action taken in the section provided on the form and submit it to the current staff member responsible for ramp meter operations. The report will be reviewed, signed, dated, and filed in the appropriate ramp meter folder by the responsible party.

Documentation

The inspector should communicate issues with the WisDOT staff member(s) currently in charge of ramp meter operations. These WisDOT staff member(s) typically communicate with the maintenance team. There are usually monthly maintenance meetings between WisDOT and the maintenance team to cover various topics (not just ramp metering).

Section 3.4 – Ramp Meter Retiming Data Download

General

The “Ramp Meter Retiming” application within V-SPOC Application Suite is used to download the necessary data for ramp meter retiming.

Procedure

In the “Ramp Meter Retiming” application follow steps 3-7 from Section 3.2.

Step 8 – Retrieve Data

The following window will appear with the download status of the Ramp Meter Retiming Workbook. Once the download is completed, two links will appear. By selecting the .xls link on the left side of the window, the user can open the Ramp Meter Retiming Workbook and save the workbook in the appropriate location. When the workbook has been saved, the window can be closed by selecting the “Close” button.

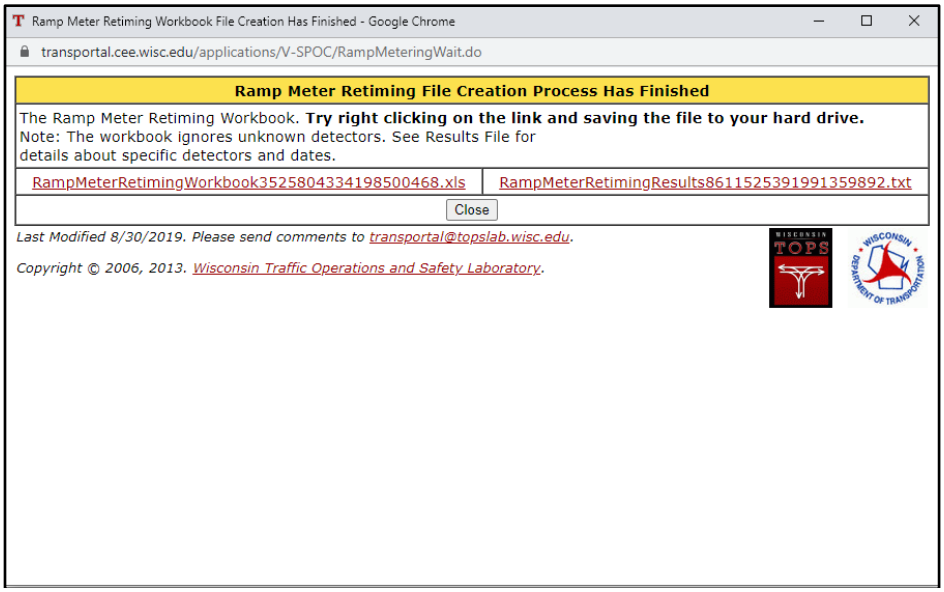


Figure 3.4.1 Retiming Workbook Download

Section 3.5 – Ramp Meter Retiming Workbook

General

The Ramp Meter Retiming Workbook is comprised of spreadsheets that are utilized for data formatting and calculations. A list of the spreadsheets, and a brief description of each, is provided below:

- Mainline Data Sheet – The queried mainline volume, occupancy, and speed data is stored in this spreadsheet.
- Ramp Data Sheet – The queried ramp volume data is stored in this spreadsheet.
- Mainline Ave Sheet – The mainline volume, occupancy, and speed data averaged for each lane and each date.
- Ramp Ave Sheet – The ramp volume averaged for each lane.
- Volume Sheet – The averaged mainline volumes per time period and averaged mainline volumes per hour. The averaged ramp volumes per hour.
- Occupancy Sheet – The averaged mainline occupancy for each lane per time period. The averaged ramp volumes per time period.
- Speeds Sheet – The averaged mainline speeds are stored in this spreadsheet.
- Capacity Sheet – Factors to analyze capacity of the mainline and ramps following HCM 6th Edition methods.
- Input Sheet – The required input for ramp meter retiming is entered into this spreadsheet. This spreadsheet is explained in further detail throughout this section.
- Suggested Settings Sheet – The suggested ramp meter timings and metering schedule are provided in this spreadsheet. Further explanation can be found throughout this section.
- Retime Sheet – Contains many of the calculations for developing the suggested ramp meter threshold volumes and metering schedule.
- Queue Override Sheet – The Queue Override spreadsheet contains calculations for developing the queue override threshold.
- Mainline V vs. C Plot Sheet – This graph presents the volume over capacity of the mainline.

- Ramp Volume Plot Sheet – This graph depicts the ramp volume over time as calculated by passage, merge, and queue detectors.

- Mainline Speed Plot Sheet – This graph displays the average speed on the freeway at a given time.

Procedure

When the user opens the Ramp Meter Retiming Workbook, they will automatically be directed to the "Input" spreadsheet. The user must enter the required input before opening the "Suggested Settings" spreadsheet to view the suggested ramp meter timings, thresholds, and schedules. These spreadsheets are described in detail in the following text. The following steps should be taken in order to use the Ramp Meter Retiming Workbook.

Step 1 – Input Spreadsheet

Enter User Defined General Data Input

The user must enter the required information in the shaded areas in order for the spreadsheet to perform the proper calculations. The Input Spreadsheet is shown in Figure 3.5.1. The data entry requirements are as follows:

General Information

RM I.D. Number – The ramp meter ID number must be entered. For example, RM-40-103 would be entered as RM 103.

RM Location – The ramp meter location must be entered. For example, the location of RM 103 is US 45 SB @ Burleigh Street.

Freeway Information

Number of Freeway lanes – The user must enter the number of freeway lanes (in each direction) as 2, 3, or 4. The number of lanes can be determined from the plans and/or from camera verification.

Peak Hour Factor – The default peak hour factor is 0.94 for urban freeways based on HCM 6th Edition guidance. The default peak hour factor values for rural multilane highways and rural freeways are 0.95 and 0.88, respectively. In Wisconsin, ramp meters are active in the Milwaukee and Madison metropolitan areas along urban freeways. An alternate peak hour factor based on field data could be entered, if desired.

Percent Trucks – The default for percent trucks is 0.05 in urban areas and 0.12 in rural areas based on HCM 6th Edition guidance. Alternate values based on field data could be entered, if desired.

Freeway Terrain – The type of freeway terrain must be entered.

- Enter “L” for level terrain. Terrain less than a 2 percent grade.
- Enter “R” for rolling terrain. Terrain where trucks are forced to slow down.
- Enter “M” for mountainous terrain. Terrain where trucks are forced to a crawl speed. This is a rare condition in Wisconsin.

Based on the HCM 6th Edition definitions, Level and Rolling terrain should be the most common options selected for Wisconsin freeways. Mountainous should not be used as there are likely no areas in Wisconsin that this would be applicable to that would warrant ramp metering. For example, US 151 near Iowa may have the grade, but traffic volumes are likely not high enough to warrant ramp metering.

Freeway Posted Speed – Enter the posted freeway speed as 50, 55, 60, 65 miles per hour (mph).

Outside of Milwaukee County, many freeway areas have a posted speed of 70 mph (as of June 2015), which would have an assumed freeflow speed of 75 mph. The base freeway lane capacity indicated in the HCM 6th Edition is 2,400 passenger cars per hour per lane for freeflow speeds of 70 mph or greater. The formulas within the workbook do not have a lookup function for a 70 mph posted speed; therefore, the user should enter 65 mph to obtain the same capacity results.

Ramp Information

Ramp Total SOV Storage – The user must calculate the ramp storage length for entry into the spreadsheet. The ramp storage length is determined by measuring the length of the SOV lane(s) only. The storage length is the distance (in feet) measured from the stop bar to the point that vehicles can back up without:

1) Spilling onto the arterial or
2) Blocking vehicles from entering the HOV lane, if applicable.

Note that if the storage length is measured from a metric plan, the number must be converted to feet for entry into the spreadsheet. An example storage length measurement is shown in Appendix E.

Average Vehicle Length – The default average vehicle length is 20 feet. This number can range from 18 to 22 feet and should only be modified by an experienced user.

Ramp Meter Discharge Type – The ramp discharge type must be entered into the spreadsheet. This can be found on the Ramp Meter

Field Inspection Report and should be verified by camera, if possible.

- If the ramp meter has a single lane, then enter “1”
- If the ramp meter has simultaneous discharge, the vehicles are released at the same time, enter “2”
- If the ramp meter has staggered discharge, the vehicles are released one at a time, enter “3”

Ramp Volume Determination – The user must validate the Ramp Volume column (Column V) is using the most accurate data. Any detectors with poor quality/availability should be avoided if possible when which detectors to use for the ramp volumes. The ramp volumes specified in this column will be the volumes used in the retiming process. The detector quality/availability analysis is described in Section 3.2.

If queue detectors were selected for ramp volume calculations, the user must calculate the appropriate queue volumes to determine the ramp volume. Refer to Section 2.1 for further details regarding ramp queue detector volume determination.

Queue Override Parameters

Queue Detector Location – The user can select up to 3 queue detectors for data retrieval. Each detector number is listed with a gray shaded box next to it. The user must enter the distance from the edge of the queue detector to the side street for each of the detectors. An example queue detector measurement is shown in Appendix E.

After the queue override parameters have been entered, the user must click the “Queue Override” button. A message will appear after the queue calculations are complete.

User Defined General Data Input:

Note: This sheet is designed to allow the user to input all the necessary data required in one place.
Data entry fields are indicated by a gray shaded area.

Explanation:	Acceptable Values/Example:	Input:
General Information:		
Ramp Meter I.D. Number	RM 60	RM 60
Ramp Meter Location	I43 SB at Capitol Drive	I-43 SB at Green Bay Ave
Freeway Information:		
Number of freeway lanes (one direction)	Use 2, 3 or 4 only.	3
Peak Hour Factor	Default = .94 (Value range .80 to .99)	**0.94**
Percent (%) trucks	Default = 0.05 Urban, 0.12 Rural	**0.05**
Freeway Terrain	L = Level, R = Rolling, M = Mountainous (Rare)	R
Freeway Posted Speed (Mi/Hr)	Use 50, 55, 65 only. Entering 65 represents 70 mph.	55
Ramp Information:		
Ramp total SOV storage (ft)	This requires plan sheet measurements	275
Average vehicle length (ft)	Default = 20 (Value range 18 to 22)	**20**
Ramp meter discharge type (SOV only)	1 = Single Lane, 2 = Two Lanes Together, 3 = Staggered	3
Ramp Volume Determination:		
Metering Schedule		
AM Starting Time	Default = Not Metering	6:00
AM Ending Time	Default = Not Metering	9:00
PM Starting Time	Default = Not Metering	14:00
PM Ending Time	Default = Not Metering	18:00
If it doesn't display "Skip this step",		Skip this step.
Required-Click to choose one option to calculate Queue Loop Volumes before continuing.		
Queue Override Parameters		
Distance from the location of queue loop to the side street (ft)		
This requires plan sheet measurements	#1 = 1452	80
Required-Click "Queue Override" button ONCE after all of the above parameters are input correctly		Queue Override
Data Quality Index Output from Data Extractor (For information purpose only):		
Percentage of Non-zero values	90%	
Percentage of Non-repeating values	90%	
Percentage of Values passed Prescreening tests	85%	

Figure 3.5.1 Example Input Spreadsheet

Ramp Interval Timings

AM Interval Timing

Plan	1	2	3	4	5	6
Green	2	2.5	2.5	2.5	2.5	2.5
Yellow	0	0	0	0	0	0
Red	1.8	2.5	3.7	4.9	6.1	7.4
Red Ext.	0	0	0	0	0	0

PM Interval Timing

Plan	1	2	3	4	5	6
Green	2	2.5	2.5	2.5	2.5	2.5
Yellow	0	0	0	0	0	0
Red	1.8	2.2	3.0	4.0	5.0	6.0
Red Ext.	0	0	0	0	0	0

Ramp Thresholds

AM Thresholds

Plan	1	2	3	4	5	6
Volume	866	969	1534	1720	1906	1988
Occupancy	5	6	13	15	17	26
Veh. Speed	63	63	54	48	42	28
Queue Occ.	0.0	0.0	0.0	0.0	0.0	0.0

PM Thresholds

Plan	1	2	3	4	5	6
Volume	982	1214	1234	1423	1612	1664
Occupancy	7	7	16	18	20	33
Veh. Speed	60	59	43	38	34	12
Queue Occ.	0.0	0.0	0.0	0.0	0.0	0.0

RAMP Time Of Day Schedules

Time	V/C >.65	Function	Time	V/C >.65	Function	Time	V/C >.65	Function	Time	V/C >.65	Function	Time	V/C >.65	Function
5:00	---	7	7:55	0.78	11	10:50	---	7	13:45	---	7	16:40	---	7
5:05	---	7	8:00	0.75	11	10:55	---	7	13:50	---	7	16:45	---	7
5:10	---	7	8:05	0.76	11	11:00	---	7	13:55	---	7	16:50	---	7
5:15	---	7	8:10	0.77	11	11:05	---	7	14:00	---	7	16:55	---	7
5:20	---	7	8:15	0.76	11	11:10	---	7	14:05	---	7	17:00	---	7
5:25	---	7	8:20	0.75	11	11:15	---	7	14:10	0.69	10	17:05	---	7
5:30	---	7	8:25	0.76	11	11:20	---	7	14:15	0.70	10	17:10	---	7
5:35	---	7	8:30	0.77	11	11:25	---	7	14:20	0.67	10	17:15	---	7
5:40	---	7	8:35	0.74	11	11:30	---	7	14:25	0.69	10	17:20	0.66	10
5:45	---	7	8:40	0.75	11	11:35	---	7	14:30	---	7	17:25	---	7
5:50	---	7	8:45	0.75	11	11:40	---	7	14:35	0.70	10	17:30	---	7
5:55	---	7	8:50	0.71	11	11:45	---	7	14:40	0.74	11	17:35	---	7
6:00	---	7	8:55	---	7	11:50	---	7	14:45	0.74	11	17:40	---	7
6:05	---	7	9:00	---	7	11:55	---	7	14:50	0.71	11	17:45	---	7
6:10	---	7	9:05	---	7	12:00	---	7	14:55	0.65	10	17:50	---	7
6:15	---	7	9:10	---	7	12:05	---	7	15:00	---	7	17:55	---	7
6:20	---	7	9:15	---	7	12:10	---	7	15:05	0.71	11	18:00	---	7
6:25	---	7	9:20	---	7	12:15	---	7	15:10	0.78	11	18:05	---	7
6:30	---	7	9:25	---	7	12:20	---	7	15:15	0.77	11	18:10	0.65	10
6:35	0.73	11	9:30	---	7	12:25	---	7	15:20	0.76	11	18:15	0.67	10
6:40	0.81	11	9:35	---	7	12:30	---	7	15:25	0.73	11	18:20	---	7
6:45	0.84	11	9:40	---	7	12:35	---	7	15:30	0.70	10	18:25	---	7
6:50	0.85	11	9:45	---	7	12:40	---	7	15:35	0.72	11	18:30	---	7
6:55	0.81	11	9:50	---	7	12:45	---	7	15:40	0.72	11	18:35	---	7
7:00	0.81	11	9:55	---	7	12:50	---	7	15:45	0.71	11	18:40	---	7
7:05	0.86	11	10:00	---	7	12:55	---	7	15:50	---	7	18:45	---	7
7:10	0.90	11	10:05	---	7	13:00	---	7	15:55	---	7	18:50	---	7
7:15	0.92	11	10:10	---	7	13:05	---	7	16:00	---	7	18:55	---	7
7:20	0.90	11	10:15	---	7	13:10	---	7	16:05	---	7	19:00	---	7
7:25	0.87	11	10:20	---	7	13:15	---	7	16:10	0.67	10	19:05	---	7
7:30	0.87	11	10:25	---	7	13:20	---	7	16:15	0.65	10	19:10	---	7
7:35	0.85	11	10:30	---	7	13:25	---	7	16:20	0.68	10	19:15	---	7
7:40	0.82	11	10:35	---	7	13:30	---	7	16:25	---	7	19:20	---	7
7:45	0.81	11	10:40	---	7	13:35	---	7	16:30	---	7	19:25	---	7
7:50	0.79	11	10:45	---	7	13:40	---	7	16:35	---	7	19:30	---	7

Figure 3.5.2 Example Configuration Parameters Spreadsheet

Step 2 – Suggested Settings Spreadsheet

The user must open the "Suggested Settings" spreadsheet after entering the required data in the "Input" spreadsheet. The pop-up window shown in Figure 3.5.3 appears when clicking on the "Suggested Settings" tab in the retiming workbook.

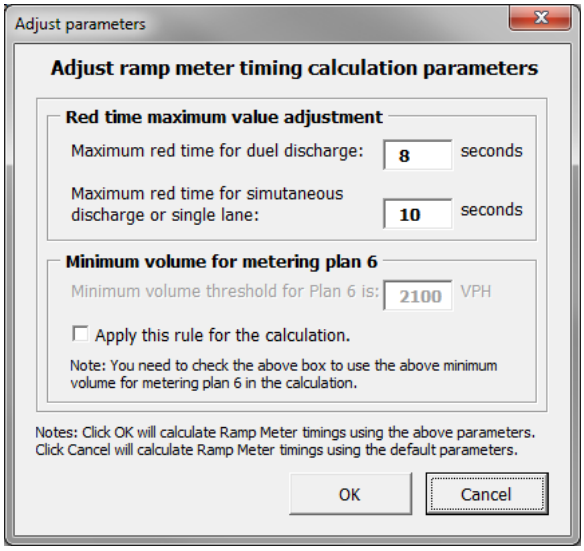


Figure 3.5.3 Pop-Up Window from "Suggested Settings" Tab

The practical thresholds listed in FHWA's *Ramp Management and Control Handbook (Pages 5-12 and 5-28)* are from 4 to 15 seconds. With a red time of 15 seconds, drivers are known to become impatient and violations increase. Based on this, the maximum red time values for dual, or staggered, discharge of 8 seconds and for simultaneous discharge of 10 seconds (shown in Figure 3.5.3) are reasonable for use in the Retiming workbook and do not need to be modified.

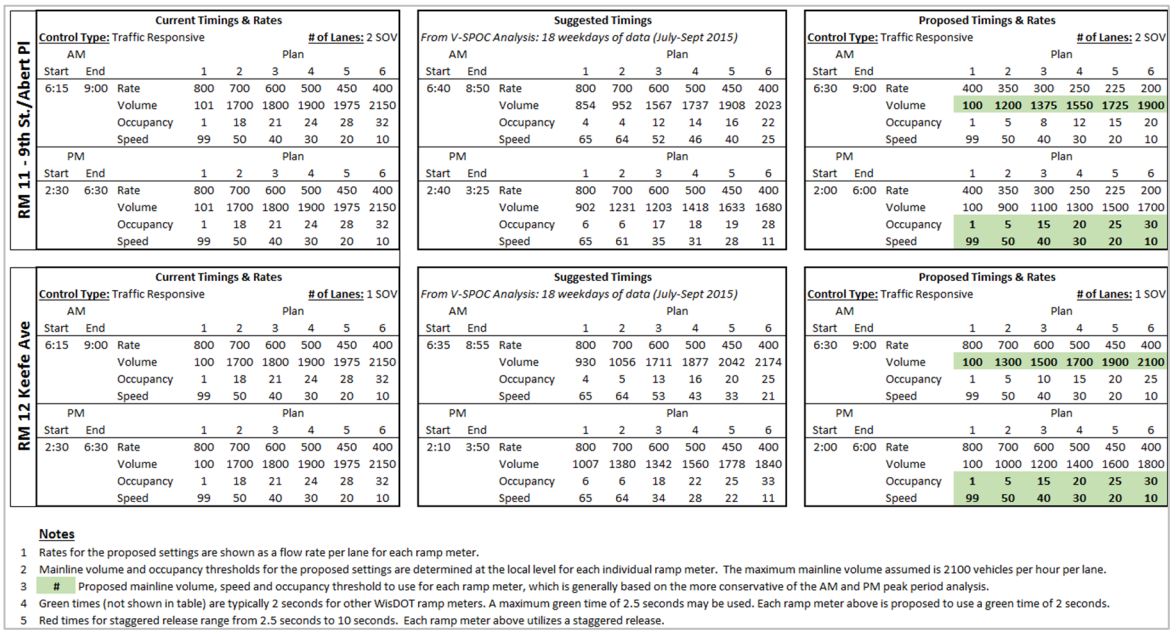
The "Suggested Settings" spreadsheet provides the user with recommended timings and threshold values for all six plans in the AM and PM metering periods. It also provides the user with recommendations for the metering periods based on the v/c ratio of the freeway. These values are basic recommendations and do not substitute good engineering practice. Thus, the values must be reviewed by the user and may require adjustments. Furthermore, the timings and thresholds must be reviewed and approved by WisDOT before being implemented. See Section 3.6 – Ramp Meter Settings Review and Acceptance for further details.

Additional ramp meter thresholds, timings, and schedule information is provided in Section 3.7 – New Timings Entry.

Step 3 – Results and Recommendations

Proposed settings should be developed for a single group of ramp meters at a time. The proposed settings cover start and stop times for TOD metering, and the volume, occupancy, and speed thresholds for each ramp meter plan.

The current ramp meter settings, the suggested ramp meter settings from the retiming workbook, and proposed ramp meter settings were summarized in a table side-by-side. This comparison table and proposed settings were discussed with WisDOT and the maintenance staff prior to the maintenance staff implementing the proposed settings in the field. Figure 3.5.4 shows an example of the proposed settings comparison table for two ramp meters along IH-43 SB.



RM 11 - 9th St./Abert Pl

Current Timings & Rates — Control Type: Traffic Responsive — # of Lanes: 2 SOV

	Start	End		1	2	3	4	5	6
AM				Plan					
	6:15	9:00	Rate	800	700	600	500	450	400
			Volume	101	1700	1800	1900	1975	2150
			Occupancy	1	18	21	24	28	32
			Speed	99	50	40	30	20	10
PM				Plan					
	2:30	6:30	Rate	800	700	600	500	450	400
			Volume	101	1700	1800	1900	1975	2150
			Occupancy	1	18	21	24	28	32
			Speed	99	50	40	30	20	10

Suggested Timings — *From V-SPOC Analysis: 18 weekdays of data (July-Sept 2015)*

	Start	End		1	2	3	4	5	6
AM				Plan					
	6:40	8:50	Rate	800	700	600	500	450	400
			Volume	854	952	1567	1737	1908	2023
			Occupancy	4	4	12	14	16	22
			Speed	65	64	52	46	40	25
PM				Plan					
	2:40	3:25	Rate	800	700	600	500	450	400
			Volume	902	1231	1203	1418	1633	1680
			Occupancy	6	6	17	18	19	28
			Speed	65	61	35	31	28	11

Proposed Timings & Rates — Control Type: Traffic Responsive — # of Lanes: 2 SOV

	Start	End		1	2	3	4	5	6
AM				Plan					
	6:30	9:00	Rate	400	350	300	250	225	200
			Volume	**100**	**1200**	**1375**	**1550**	**1725**	**1900**
			Occupancy	1	5	8	12	15	20
			Speed	99	50	40	30	20	10
PM				Plan					
	2:00	6:00	Rate	400	350	300	250	225	200
			Volume	100	900	1100	1300	1500	1700
			Occupancy	**1**	**5**	**15**	**20**	**25**	**30**
			Speed	**99**	**50**	**40**	**30**	**20**	**10**

RM 12 Keefe Ave

Current Timings & Rates — Control Type: Traffic Responsive — # of Lanes: 1 SOV

	Start	End		1	2	3	4	5	6
AM				Plan					
	6:15	9:00	Rate	800	700	600	500	450	400
			Volume	100	1700	1800	1900	1975	2150
			Occupancy	1	18	21	24	28	32
			Speed	99	50	40	30	20	10
PM				Plan					
	2:30	6:30	Rate	800	700	600	500	450	400
			Volume	100	1700	1800	1900	1975	2150
			Occupancy	1	18	21	24	28	32
			Speed	99	50	40	30	20	10

Suggested Timings — *From V-SPOC Analysis: 18 weekdays of data (July-Sept 2015)*

	Start	End		1	2	3	4	5	6
AM				Plan					
	6:35	8:55	Rate	800	700	600	500	450	400
			Volume	930	1056	1711	1877	2042	2174
			Occupancy	4	5	13	16	20	25
			Speed	65	64	53	43	33	21
PM				Plan					
	2:10	3:50	Rate	800	700	600	500	450	400
			Volume	1007	1380	1342	1560	1778	1840
			Occupancy	6	6	18	22	25	33
			Speed	65	64	34	28	22	11

Proposed Timings & Rates — Control Type: Traffic Responsive — # of Lanes: 1 SOV

	Start	End		1	2	3	4	5	6
AM				Plan					
	6:30	9:00	Rate	800	700	600	500	450	400
			Volume	**100**	**1300**	**1500**	**1700**	**1900**	**2100**
			Occupancy	1	5	10	15	20	25
			Speed	99	50	40	30	20	10
PM				Plan					
	2:00	6:00	Rate	800	700	600	500	450	400
			Volume	100	1000	1200	1400	1600	1800
			Occupancy	**1**	**5**	**15**	**20**	**25**	**30**
			Speed	**99**	**50**	**40**	**30**	**20**	**10**

Notes

1 Rates for the proposed settings are shown as a flow rate per lane for each ramp meter.
2 Mainline volume and occupancy thresholds for the proposed settings are determined at the local level for each individual ramp meter. The maximum mainline volume assumed is 2100 vehicles per hour per lane.
3 # Proposed mainline volume, speed and occupancy threshold to use for each ramp meter, which is generally based on the more conservative of the AM and PM peak period analysis.
4 Green times (not shown in table) are typically 2 seconds for other WisDOT ramp meters. A maximum green time of 2.5 seconds may be used. Each ramp meter above is proposed to use a green time of 2 seconds.
5 Red times for staggered release range from 2.5 seconds to 10 seconds. Each ramp meter above utilizes a staggered release.

Figure 3.5.4 Example Proposed Settings Table

A separate comparison focusing on current and proposed TOD settings should be developed. The basis for the timeframes of the proposed TOD settings should be from 24-hour graphs of the mainline speeds, ramp volumes, and mainline volume to capacity ratios, which are all available in the Ramp Meter Retiming spreadsheet. An example TOD settings comparison is shown in Figure 3.5.5.

Mon-Fri Time of Day operations

		Tier 1, Group 1									
		RM 126		RM 14		RM 13		RM 12		RM 11	
Period	Time	Current	Proposed	Current	Proposed	Current	Proposed	Current	Proposed	Current	Proposed
AM Peak Period	6:15	--	--	TR	--	TR	--	TR	--	TR	--
	6:30	--	FR		TR		TR		TR		TR
	6:45	FR									
	8:45										
	9:00	GR	GR	GR	GR	GR	GR	GR	GR	GR	GR
PM Peak Period	14:00	--	FR	--	TR	--	TR	--	TR	--	TR
	14:30	FR		TR		TR		TR		TR	
	15:30										
	15:45										
	17:30										
	17:45										
	18:00	GR	GR		GR		GR		GR		GR
	18:30	--	--	GR	--	GR	--	GR	--	GR	--

Notes

FR	Fixed Rate Metering
GR	Green Rest
TR	Traffic Responsive Metering
	Proposed Settings

TOD settings for current operations were reported May 19, 2016

Figure 3.5.5 Example Proposed TOD Settings Table

Section 3.6 – Ramp Meter Settings Review and Acceptance

General

Once the new ramp meter settings have been developed, the user must submit them to the person responsible for ramp meter operations. The ramp meter operations engineer will do the following:

1) Review the settings and make any necessary revisions.

   A) Field Inspection Report – Ensure that the Field Inspection Report has been completed and reviewed. Make certain that the appropriate action has been taken to correct any reported problems.

   B) Input Sheet – Check that that the user entered the correct information into the input sheet.

   C) Output Sheet – Review the suggested timings plans, thresholds, and schedule.

      a. Compare the Output Sheet to the recommendations submitted by the person doing the retiming. Ensure that the recommended settings are appropriate and make necessary revisions in red ink.

      b. Compare the recommended settings to the current settings to ensure that changes are justified and will not cause problems. (i.e. If the ramp tends to back-up easily, the user must be cautious when increasing the red times.)

   D) Corridor Review – Review the ramp meter start/stop times on a corridor basis. Ensure that recommendations are appropriate for the entire corridor. Consider bottleneck conditions, ramp diversion possibilities, etc.

2) Print a PDF of the Controller Settings Sheet from the ramp meter controller in inSIGHT. Convert the PDF to an Excel spreadsheet in order to be able to track changes. Example sections of a Controller Settings Sheet and an example spreadsheet markup of Time-of-Day settings are shown in Appendix F. Consider titling the spreadsheet with the controller ID and date modified for consistency and tracking (e.g. RM-40-0035 Controller Settings_2020-05.xlsx).

   A RM Settings Recommendations Form may be completed for each retimed ramp meter. This is an optional form that summarizes the proposed changes to the current settings and is included in Appendix G. The user can also refer to Chapter 5 of the ITS Design and Operations Guide for detailed information regarding ramp metering justification.

3) Conduct a ramp meter settings review and acceptance meeting with WisDOT. The following people should attend the meeting, if possible:

- Required Attendees:
  - Freeway Operations – Operations Project Manager
  - Reviewing Engineer
  - Inspection/Timing Development Engineers
- Desirable Attendees:
  - Freeway Operations Supervisor
  - AM and PM Lead Operators

The meeting allows TMC staff to review, modify, and approve the recommended settings. The meeting should be approximately an hour in length and should focus on key ramp metering topics like metering start/stop times, corridor coordination considerations, queue override settings, any special cases, or other related topics.

4) All ramp meter setting modifications established in the review and acceptance meeting should be reflected in the Controller Settings Sheets. The final settings should be reviewed and approved by WisDOT before they are entered into the ramp meter controller User Interface.

Section 3.7 – New Timings Entry

General

After the new ramp meter timings have been reviewed and approved, they should be entered into WisDOT's ramp meter controller program and downloaded to the controller. The ramp meter controller User Interface program is available on the computers in the control room. The user will need a user ID and password to use this program.

Ramp Meter Controller User Interface

The user must open the ramp meter controller from the inSIGHT ATMS map or Ramp Meter List. An upload of the controller configuration can be done to compare to the program currently in the inSIGHT interface.

Programming is done through the Ramp's "Configuration" option as shown in the inSIGHT map window in Figure 3.7.1. Another way to access this option is through the Ramp Meter List window as shown in Figure 3.7.2.

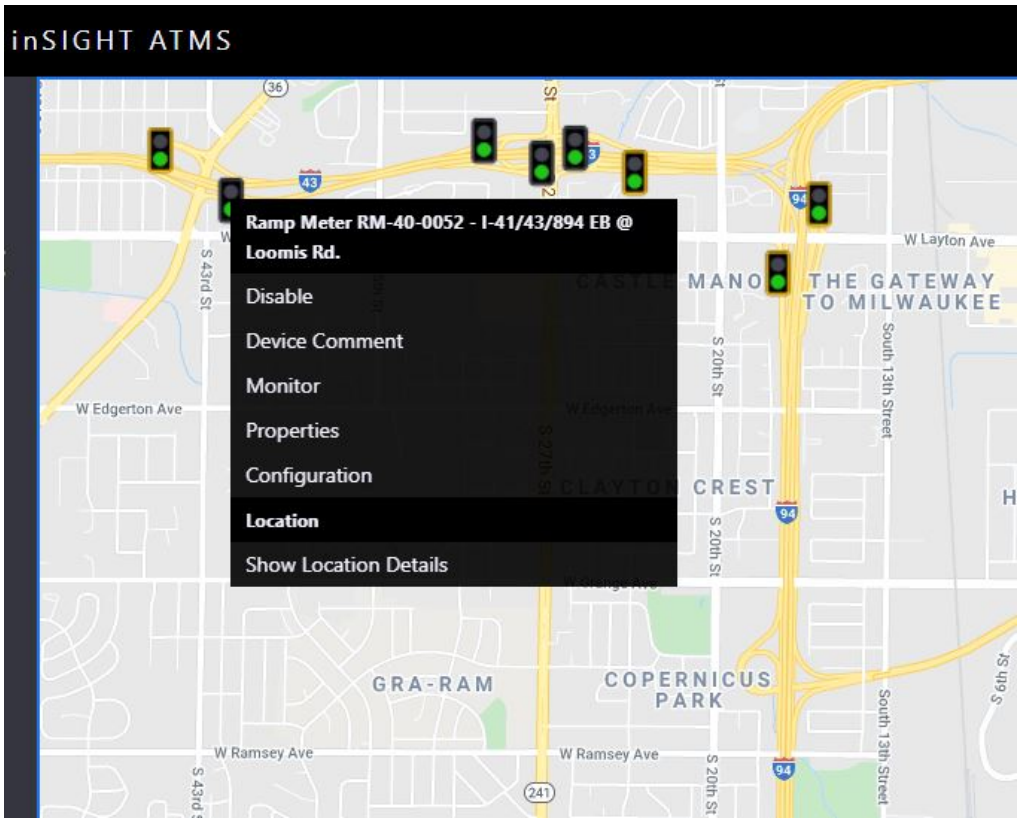


Figure 3.7.1 inSIGHT Map for Ramp Configuration

Schedules and other ramp meter setting changes are saved and can be compared with current field settings and downloaded through this program. See Figure 3.7.3 for the Ramp Meter Configuration window.

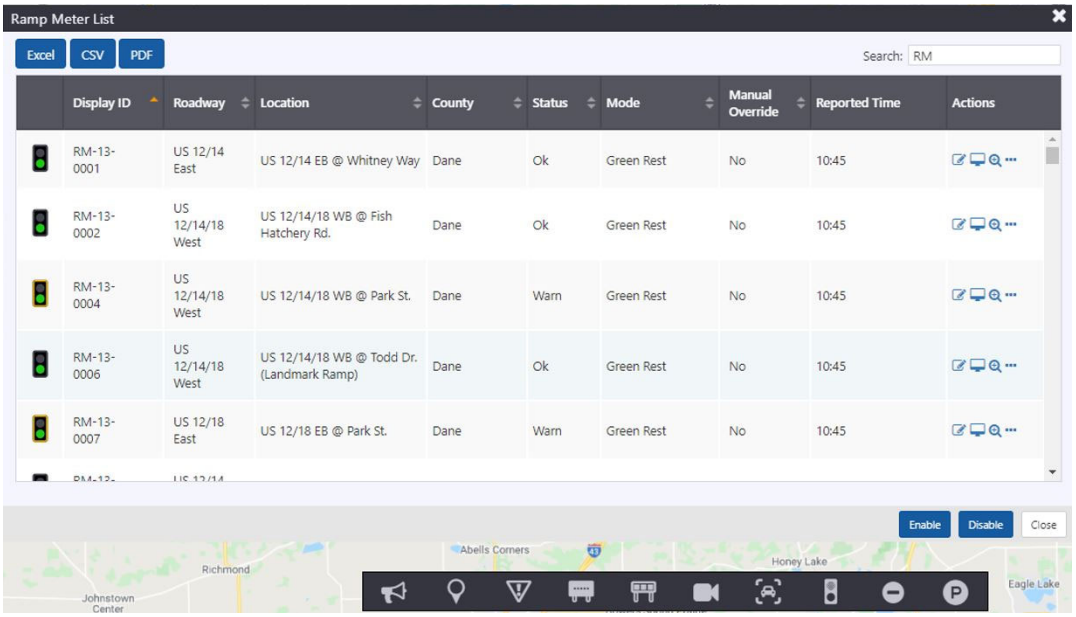


Figure 3.7.2 Ramp Meter List Window

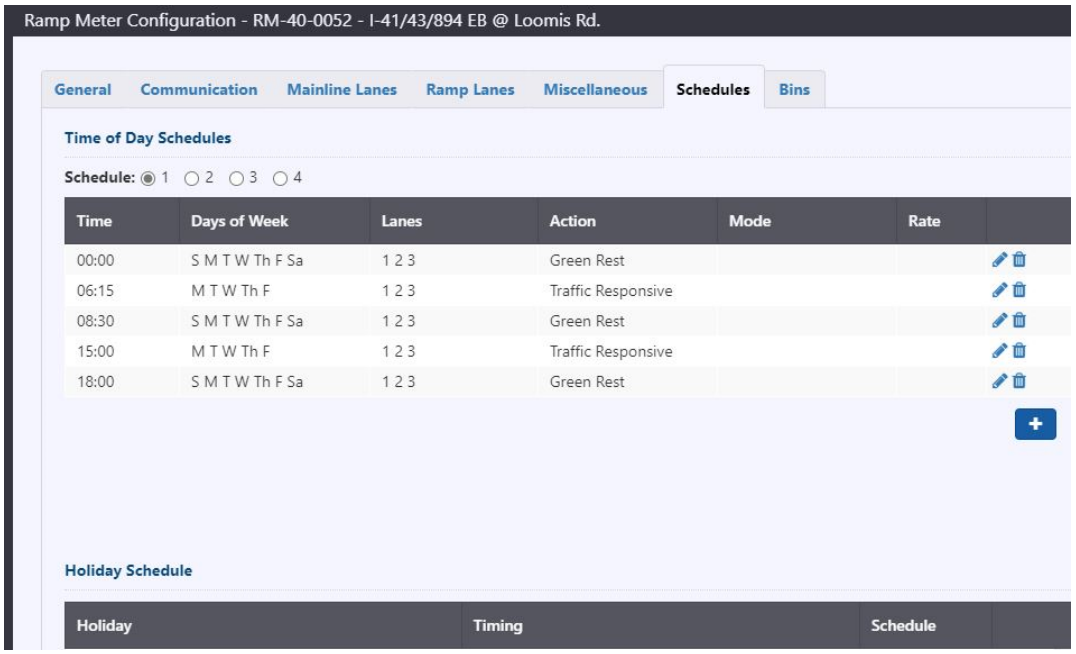


Figure 3.7.3 "Ramp Meter Configuration" Option

A description of configuration changes is entered upon saving updates.

Adding detectors to a controller, changes to the signal outputs, changing detector slot number assignments and potentially other changes require a restart of the ramp meter controller on site.

Ramp meter configuration files may be printed and saved in the paper file location or electronically on the WisDOT network.

Green Time – The green time is typically set to 2.0 or 2.5 seconds for plans 1 through 6.

Yellow Time – The yellow time is always set to 0 seconds, unless it is desirable to set the ramp meter to cycle. It is desirable to set the ramp meter to cycle with red, yellow, and green signals under certain construction scenarios or when the ramp meter is malfunctioning. However, this should only be done under the direction of the ramp meter operations engineer.

Red Time – The red time is set to a minimum value for plan 1. The minimum values are described below:

Minimum Red Times –
Dual Discharge = 1.8 seconds
Simultaneous Discharge or Single Lane = 2.5 seconds

The red time for plan 6 varies per ramp. However, the following are maximum values that should be used.

Maximum Red Times –
Dual Discharge = 8 seconds
Simultaneous Discharge or Single Lane = 10 seconds

The red time calculations are automated through the ramp meter retiming excel spreadsheet and entered for each of the 6 plans. FHWA guidance indicates that a red time should not exceed 15 seconds, as drivers may become too impatient and violate the signal indication.

Time of Day – The TOD schedules are developed during the ramp meter retiming process. The following are ramp metering functions that are most often used in ramp metering:

Non-metering – Meter rests in green.

Must/May – This function is not currently used by WisDOT.

Traffic Responsive Metering – When operating the ramp meter in traffic responsive metering, the user must also select the ramp metering mode. The controller can select the most restrictive or least restrictive metering plan based on the freeway volume, speed, and occupancy, or the plan selection can be based solely on the volume, speed, or occupancy. The current strategy is to select the least restrictive metering plan for normal operating conditions.

Fixed Plan Metering – When a fixed ramp metering plan is selected, the ramp will meter in that plan regardless of freeway conditions. Ramp meters may meter in a fixed plan when mainline detectors do not exist or are malfunctioning, or during work zone conditions.

Section 3.8 – Ramp Meter Observation

General

The user must observe the ramp meter for a minimum of 30 minutes, after the new timings are downloaded, to ensure proper metering. The user must complete the Ramp Meter Retiming Review form. The form is included in Appendix H.

Ramp Meter Retiming Field Review Form

The Ramp Meter Retiming Field Review Form is comprised of 3 main sections – Ramp Conditions, Freeway Conditions, and Recommendations for Improvement. The content of each of the 3 sections is described in the following pages.

Ramp Conditions

The user should note whether the ramp began metering during the must/may period or during the scheduled metering time. If the ramp meter does not turn on, the Equipment Malfunction Procedure should be followed in order to report the problem. The Equipment Malfunction Procedure is included in Appendix D.

The user should also check that the vehicles are properly activating the ramp meter when stopped at the stop bar. If vehicles are not receiving the green indication properly, the problem should be explained and the Equipment Malfunction Procedure should be followed.

The user should document if the ramp meter is discharging vehicles appropriately for the given freeway volume and speed. If the ramp is not discharging the vehicles appropriately, then the user should note whether the meter is discharging vehicles too fast or too slow. The timings must then be adjusted so the meter is discharging vehicles appropriately.

The user must also note the vehicle queue length on the ramp. If the vehicles are spilling onto the side street, then the timings should be adjusted to prevent it from happening.

The user should also check to see that the ramp meter is not cycling. A ramp meter is cycling when the signals change from red to green continuously, even if a vehicle is not present at the stop bar. If the ramp is cycling, the Equipment Malfunction Procedure should be followed.

Freeway Conditions

The user should document the approximate volume of the freeway as light, moderate, or congested. The user should also provide the estimated freeway speed. The approximate speed can be determined when driving to/from the ramp.

Recommendations for Improvement

The user should document any recommendations for improvement. This may include adjustments to the signal timings or thresholds. These improvements should then be implemented and further ramp meter observation must take place.

Reviewed By

The ramp meter operations engineer should review the form to ensure that the ramp was observed after the new timings were implemented. If further action is taken, it should be noted in the section provided on the review form.

Further Ramp Meter Observation

If the ramp meter requires timings or threshold adjustments, or if the ramp requires maintenance, the user must observe the ramp meter again after all adjustments and repairs are made. Depending on the scope of the retiming effort, the following forms may be completed to verify the meter is operating effectively.

- Ramp Meter Retiming Review Form from Appendix H
- Queue Data Collection form from Appendix J
- Summary email of implementation observations

The results of the implementation observations must be communicated with WisDOT.

Section 3.9 – Documentation

General

The Ramp Meter Configuration within inSIGHT, the ATMS, prompts the user to list and save the changes made before they are sent to the controller. Ramp Meter maintenance is logged in VUEWorks.

Maintenance Log – Electronic Files

The maintenance log is accessed via VUEWorks. The program is utilized to track maintenance problems and changes to FTMS equipment. See Section 3.1 for WisDOT webpage and resource links.

Filing Ramp Meter Retiming Documentation – Electronic Files

All documentation for the ramp meter retiming must be filed in either Sharepoint or Box. The following is a list of items that should be filed:

- Ramp Meter Field Inspection Report
- Updates to Controller Settings (Spreadsheet)
- New Controller Settings uploaded to ramp meter controller (PDF)
- Corridor thresholds and time of day settings review, if applicable.
- Ramp meter retiming Field Review Form
- Ramp Meter Recommendations Form

All of the documents from the previous retiming efforts should be relocated to the folder for “previous timings”.

Before/After Data Analysis (Optional)

Queue data should be collected for each individual lane of the ramp meter, if possible, during the AM and PM peak periods. The data should be collected for a minimum of 30 minutes during each peak period at each ramp meter. The inspector should also observe if the ramp meter’s queue override function appears to activate during this time. The queue data should be collected before and after ramp meter retiming and should be compared using 50th percentile, 95th percentile, and maximum queue metrics.

Freeway speeds and traffic volumes (both ramp and freeway) from V-SPOC should be compared for the before retiming and after retiming scenarios. Because 18 days of weekday data were used in the before retiming analysis, 18 days may be used for the after retiming analysis as well to help account for day-to-day variability in travel speeds. The speed and volume data from both before and after retiming should be compared in order to observe potential differences in both mainline and ramp operations.

Mainline travel time reliability could be evaluated in order to assess potential effects of the ramp meter retiming on mainline traffic. This may be completed by performing a Planning Time Index analysis using analysis days consistent with the detector speed and traffic volume analysis. Supplemental speed and volume data could also be obtained from mainline detectors between ramp meter locations in order to compare mainline operations throughout the freeway corridor.

An analysis could be performed utilizing safety data, crash rates, and/or crash frequency around merge areas.

Ramp Meter Corridor and Individual Documentation

The retiming efforts in Section 3 should be summarized in a brief document. This activity should be ongoing throughout the retiming process. This documentation should include all field inspection and observation notes, existing and proposed timing parameters, and a quantitative summary of queue and available detector data. Also include any future considerations that may not be covered by ramp meter retiming efforts such as ramp storage length, arterial signal timing, freeway merge length, potential safety concerns, or other similar aspects.

Section 4 – Ramp Meter Retiming Process Checklist

Section 4.1 – Purpose

The Ramp Meter Retiming Process Checklist, which is included in Appendix I, is an optional form for the user during the retiming process.

The checklist guides the user through the main steps in ramp meter retiming. As each item is checked off, it also confirms that the user completed each step. The checklist may be submitted, along with the other ramp meter materials to be reviewed, to the current staff member responsible for ramp meter operations.

Section 5 – Summary

Section 5.1 – Summary

This Procedure Manual is intended to assist engineers and operators with retiming ramp meters along Wisconsin freeway systems. By following this procedure, WisDOT will be assured that proper ramp meter retiming has been completed.

WisDOT Ramp Meter Retiming Procedure

Appendices

Appendix A

Example Gantt Progress Chart

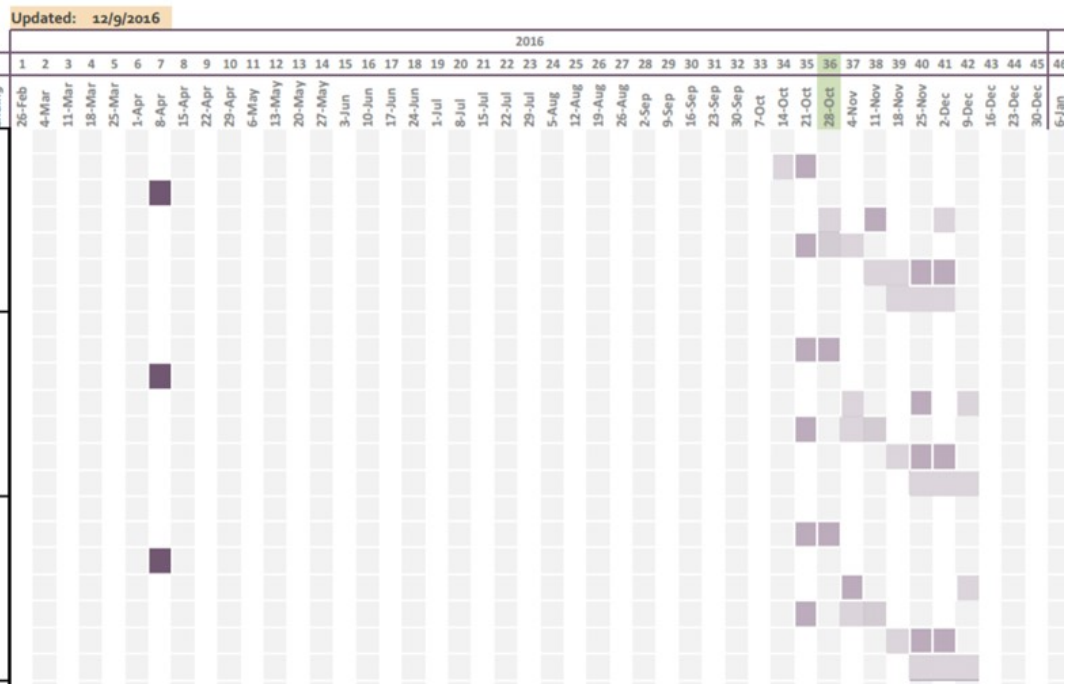
Ramp Meter Retiming

I-43 (Milwaukee County)

Period Highlight 42 | Plan | Actual | % Complete | Actual (beyond plan) | % Complete (beyond plan)

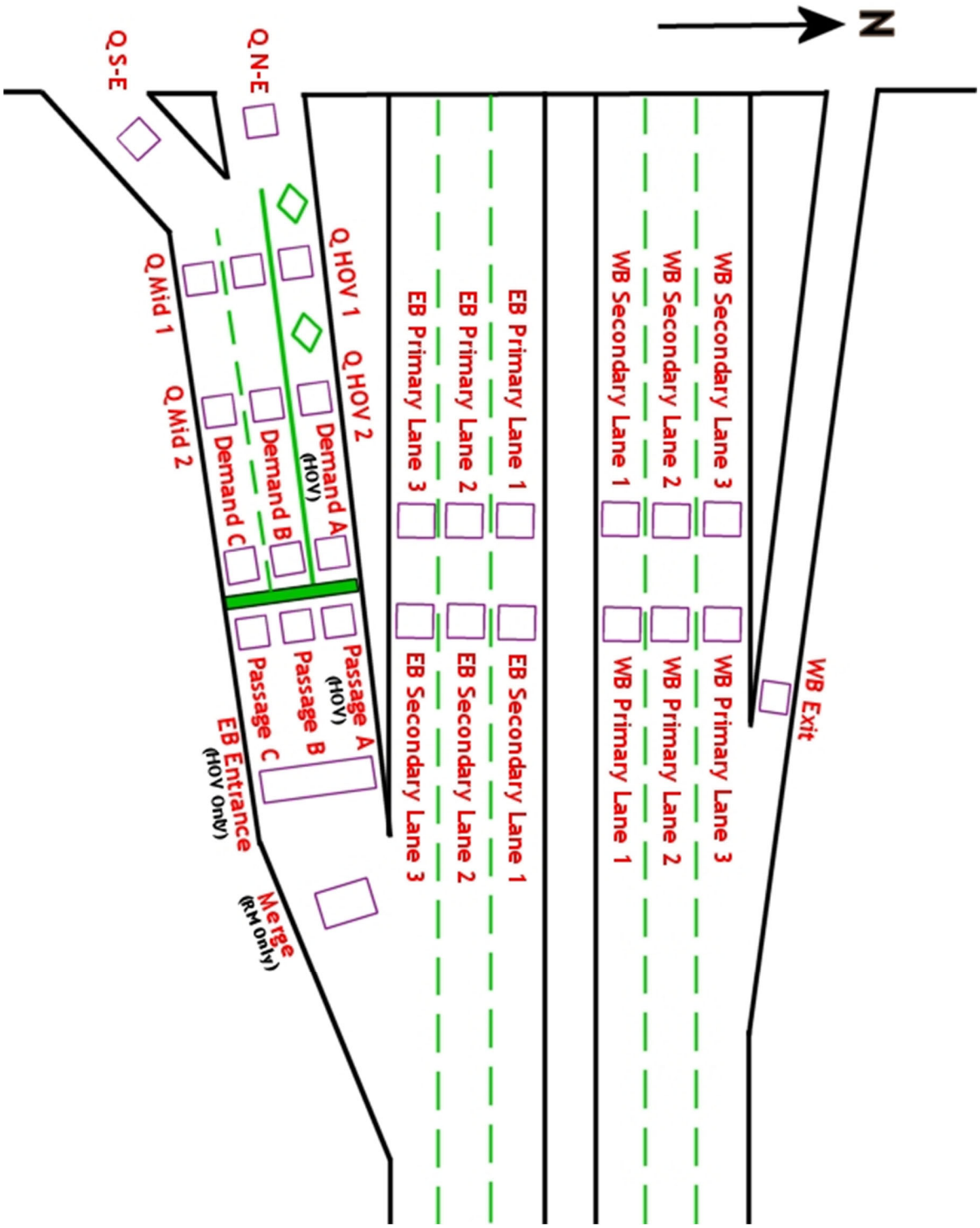
Updated: 12/9/2016

TIER	DIR	ACTIVITY	PLAN START* *Start # = Week #	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
2	NB	RM 40-00127 Fond Du Lac Ave					
		Assessment	34	3	35	1	50%
		Controller Replaced			7	1	100%
		Field Activities	36	2	37	1	50%
		Data Analysis	36	3	35	1	25%
		Timing Parameters	38	2	40	2	75%
		Implementation Observations	39	3			0%
2	NB	RM 40-0019 North Ave/7th St					
		Assessment	35	3	35	2	50%
		Controller Replaced			7	1	100%
		Field Activities	37	2	40	1	50%
		Data Analysis	37	3	35	1	25%
		Timing Parameters	39	2	40	2	75%
		Implementation Observations	40	3			0%
2	NB	RM 40-0020 Locust St/7th St					
		Assessment	35	3	35	2	50%
		Controller Replaced			7	1	100%
		Field Activities	37	2	37	1	50%
		Data Analysis	37	3	35	1	25%
		Timing Parameters	39	2	40	2	75%
		Implementation Observations	40	3			0%



Appendix B

Example Ramp Meter
Traffic Detector Diagram



Appendix C

Ramp Meter Field Inspection Report

Ramp Meter Field Inspection Report

(Observe for a **minimum of 15 minutes** during ramp metering period.)

RM # _____ Location_____

Date _____ Time _____ Observed by _____

Weather Conditions _____ Pavement Conditions _____

Ramp Meter (General Information)

A. Configuration:

Number of SOV lanes _____

Is there a HOV lane? Yes ☐ No ☐

B. Discharge:

SOV Lanes: Staggered ☐ Lanes Released together ☐ N/A (Single Lane) ☐

HOV Lane: N/A ☐ Steady Green ☐ Discharge with Adjacent lane ☐

Discharge with Far lane Discharge Alone

Excessive HOV Violations: Yes ▼ No

Comments – Required When ▼ is checked:

_____

_____

_____

C. Ramp and Freeway Conditions:

Observed During Normal Metering Period

Queue Length: 0-3 Cars ½ Ramp ¾ Ramp Full ▼ Spilling into Arterial ▼

Freeway Average Speed: 0-20 mph 20-40 mph 40-60 mph

Freeway Average Volume: Light Moderate Congested

Comments – Required When ▼ is checked:

_____

_____

_____

Signing (Compare to Plans)

A. "Ramp Metered When Flashing" Signs:

Number of Signs (per plans) _____

Signs Missing? No Yes ▼

Condition of Signs: Good Damaged ▼ Turned ▼ Obstructed ▼

Comments – Required When ▼ is checked:

_____

_____

_____

B. "Stop Here On Red" Signs:

Number of Signs (per plans) _____

Signs Missing? No Yes ▼

Condition of Signs: Good Damaged ▼ Turned ▼ Obstructed ▼

Comments – Required When ▼ is checked:

_____

_____

_____

C. Lane Designation Signs:

Right Lane: N/A Good Missing ▼ Damaged ▼ Turned ▼ Obstructed ▼

Center Lane: N/A Good Missing ▼ Damaged ▼ Turned ▼ Obstructed ▼

Left Lane: N/A Good Missing ▼ Damaged ▼ Turned ▼ Obstructed ▼

Comments – Required When ▼ is checked:

_____

_____

_____

D. HOV Signs:

N/A

Signs on Ramp:

Number of Signs (per plans) _____

Signs Missing? No Yes ▼

Condition of Signs: Good Damaged ▼ Turned ▼ Obstructed ▼

Comments – Required When ▼ is checked:

_____

_____

_____

Signs on Side Streets:

Number of Signs (per plans) _____

Signs Missing? No Yes ▼

Condition of Signs: Good Damaged ▼ Turned ▼ Obstructed ▼

Comments – Required When ▼ is checked:

_____

_____

_____

Pavement Markings (Compare to Plans)

A. Pavement Markings:

Stop Bar: Present Missing ▼

Condition: Good Faded ▼

Edge Lines: Present Missing ▼

Condition: Good Faded ▼

Lane Skips: N/A Present Missing ▼

Condition: Good Faded ▼

Median Paint: N/A Present Missing ▼

Condition: Good Faded ▼

HOV Symbols: N/A Present Missing ▼

Condition: Good Faded ▼

B. Comments – Required When ▼ is checked:

_____

_____

_____

Pavement Condition

A. Pavement Type: Concrete Asphalt

B. Pavement Condition: New Good Fair ▼ Poor ▼

Comments – Required When ▼ is checked:

_____

_____

_____

C. Pavement Condition in Areas of Loop Detectors:

Cannot identify where loop detector are located

Pavement is depressed in loop slots ▼

Cracks or deterioration in pavement around loops ▼

Comments – Required When ▼ is checked:

_____

_____

_____

Hardware

A. Signal Heads:

Red (upper heads): Working Not working ▼

Red (lower heads): Working Not working ▼

Yellow (upper heads): Working Not working ▼ Not inspected ▼

Green (upper heads): Working Not working ▼

Green (lower heads): Working Not working ▼

Enforcement Signal: N/A Working Not working ▼

B. Advanced Flashes: Working Not working ▼

C. Comments – Required When ▼ is checked:

_____

_____

_____

Cabinet

A. Exterior Condition: Good Fair Needs work ▼

B. Is the Lock Easily Accessible? Yes No ▼

C. Maintenance Around Cabinet (grass, weeds, etc.): Good Needs Work ▼

D. Water in or Around Cabinet: Yes ▼ No

E. Interior Condition:

Lights: Working Not Working ▼

Is the controller in watchdog failure (WDT Fail)? Yes ▼ No

MU toggle switch: On Off/Reset

Are any circuit breakers in "off" position? Yes ▼ No

Are there any signs of pests (bugs, mice etc.)? Yes ▼ No

Are any of the detector amplifiers pulled out? Yes ▼ No

Are any of the detectors in failure? Yes ▼ No

F. Comments – Required When ▼ is checked:

_____

_____

_____

Action Taken:

_____

_____

_____

_____

****

This section is to be completed by person responsible for Ramp Meter Operations

Reviewed By: _____ Date: _____

☐ Created ticket or preliminary report for:

_____

_____

_____

_____

Further Action Taken:

_____

_____

_____

_____

Appendix D

Equipment Malfunction Procedures

Equipment Malfunction Procedures

If an operator or staff member is aware of a system field component malfunctioning they should check the maintenance database under reports or tickets to verify if the trouble has been reported. If there is no open ticket or report for the device the operator should report maintenance issues in the maintenance ticketing software.

For General Ramp Meter Failures

Follow maintenance ticketing procedures detailed in the *TMC Control Room SOP Manual for ITS Maintenance*.

For Emergency Ramp Meter Failures

Follow maintenance ticketing procedures detailed in the *TMC Control Room SOP Manual for ITS Maintenance*.

AND

Contact TAPCO via 24-hour on-call line (262) 814-7000 ext. 1.

Examples of emergency failures include stuck red, conflicting ramp meter signals (e.g. red + green), or knockdowns.

Active maintenance tickets can be checked any time in the maintenance ticketing software. This will show a list of all uncleared tickets. As field maintenance personnel respond to tickets they will call the control room to provide updates on the status of the ticket. Upon receiving a call from the field the operator should open the ticket from the maintenance ticket software and update the status. Other fields will be filled in by maintenance personnel later.

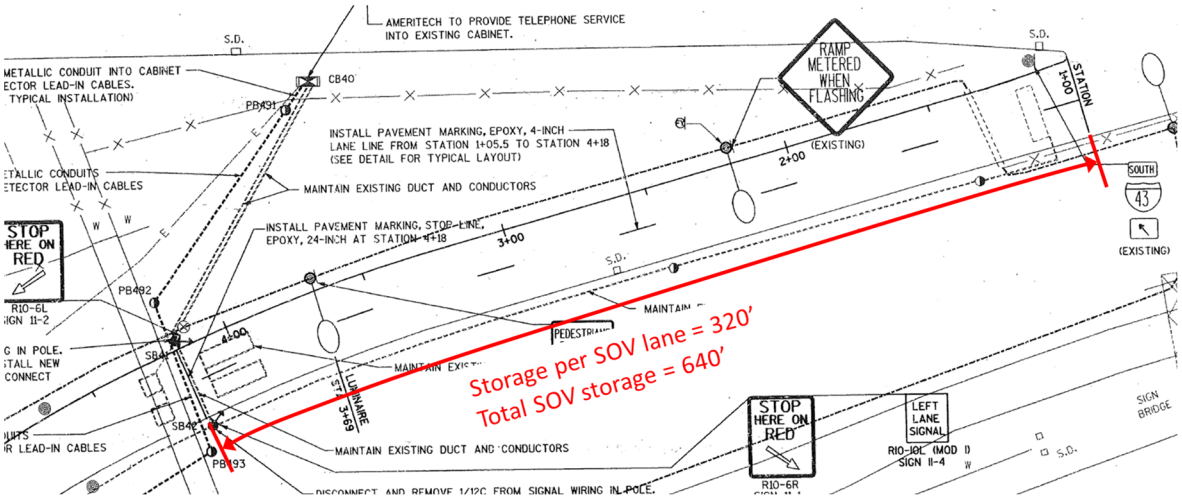
If a ticket has not been generated yet the operator should make a ticket upon receiving a call from the field. A list of active preliminary reports is emailed daily and reviewed by maintenance personnel. If a problem still exists a ticket is generated and report is cleared, if no problem is found it is noted and the report is cancelled.

The ATMS maintenance contractor is required to be available 7AM – 4PM. After these hours operators can call the TAPCO 24-hour on-call notification line below: (262) 814-7000 ext. 1.

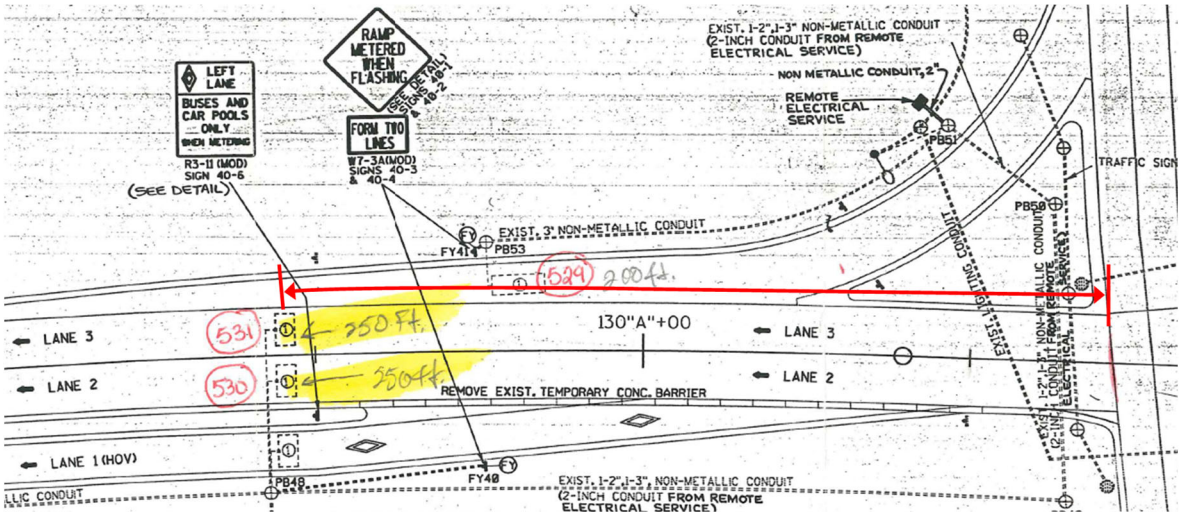
Appendix E

Ramp Storage and Queue Length Measurement Examples

Storage Length Measurement Example



Queue Detector to Side-Street Measurement Example



SOV queue detectors to sidestreet = 250 feet.

Appendix F

Controller Settings Sheet

Settings Comparison

General

Details

ID: 74

Setting	ATMS	Field
Display ID	RM-40-0035	RM-40-0035
Contract ID		
AMS ID	RM-40-0035	RM-40-0035
Description	I-41/894 NB @ Beloit Rd.	I-41/894 NB @ Beloit Rd.
Public Name		
Public Description		
Organization	WisDOT	WisDOT

Location

Setting	ATMS	Field
Road Name	I-41/894 North	I-41/894 North
Latitude	42.98056	42.98056
Longitude	-88.038141	-88.038141
Display Latitude		
Display Longitude		

Communication

Communication

Setting	ATMS	Field
Protocol	0	0
Channel Type	0	0
Polling Cycle (s)	20	20

General Settings

Detectors

Lane: 1 **Description:** RampLane-1

Setting	ATMS	Field
Demand Detector Number	1	1
Demand Detector Pin Description	I1U/Detector 1	I1U/Detector 1
Demand Detector Pin Number	39	39
Demand Detector External Ref ID	851	851
Demand Detector Mode	Enable No Metering If Fail	Enable No Metering If Fail
Demand Detector Description	Demand A HOV	Demand A HOV
Demand Detector Erratic Count	30	30
Demand Detector Max Presence Threshold	20	20
Demand Detector No Activity Threshold	180	180
Passage Detector Number	9	9
Passage Detector Pin Description	I1L/Detector 2	I1L/Detector 2
Passage Detector Pin Number	40	40
Passage Detector External Ref ID	852	852
Passage Detector Mode	Enable Call If Fail	Enable Call If Fail

Setting	ATMS	Field
Passage Detector Description	Passage A HOV	Passage A HOV
Passage Detector Erratic Count	30	30
Passage Detector Max Presence Threshold	20	20
Passage Detector No Activity Threshold	180	180

Ramp Detector Detail

Traffic Responsive

Lane: 1 **Description:** RampLane-1

Setting	ATMS	Field
Mainline Lanes in TR	4,5,6	4,5,6
Mode	Least Restrictive	Least Restrictive
Collection Interval (s)	20	20
Smoothing Intervals	3	3
Rate Level 1: Rate / Flow Rate / Occ / Speed	740 / 101 / 1 / 99	740 / 101 / 1 / 99
Rate Level 2: Rate / Flow Rate / Occ / Speed	600 / 1600 / 12 / 50	600 / 1600 / 12 / 50
Rate Level 3: Rate / Flow Rate / Occ / Speed	480 / 1700 / 15 / 40	480 / 1700 / 15 / 40
Rate Level 4: Rate / Flow Rate / Occ / Speed	420 / 1800 / 20 / 30	420 / 1800 / 20 / 30

Setting	ATMS	Field
Rate Level 5: Rate / Flow Rate / Occ / Speed	360 / 1950 / 25 / 20	360 / 1950 / 25 / 20
Rate Level 6: Rate / Flow Rate / Occ / Speed	240 / 2100 / 30 / 10	240 / 2100 / 30 / 10

Lane: 2 **Description:** RampLane-2

Setting	ATMS	Field
Mainline Lanes in TR	4,5,6	4,5,6
Mode	Least Restrictive	Least Restrictive
Collection Interval (s)	20	20
Smoothing Intervals	3	3
Rate Level 1: Rate / Flow Rate / Occ / Speed	740 / 101 / 1 / 99	740 / 101 / 1 / 99
Rate Level 2: Rate / Flow Rate / Occ / Speed	600 / 1600 / 12 / 50	600 / 1600 / 12 / 50
Rate Level 3: Rate / Flow Rate / Occ / Speed	480 / 1700 / 15 / 40	480 / 1700 / 15 / 40
Rate Level 4: Rate / Flow Rate / Occ / Speed	420 / 1800 / 20 / 30	420 / 1800 / 20 / 30
Rate Level 5: Rate / Flow Rate / Occ / Speed	360 / 1950 / 25 / 20	360 / 1950 / 25 / 20
Rate Level 6: Rate / Flow Rate / Occ / Speed	240 / 2100 / 30 / 10	240 / 2100 / 30 / 10

Traffic Responsive Metering Thresholds

Schedules

TOD

Schedules: 1 **Entry:** 1

Setting	ATMS	Field
Time	00:00	00:00
Days of Week	S,M,T,W,Th,F,Sa	S,M,T,W,Th,F,Sa
Lanes	1,2	1,2
Action	Green Rest	Green Rest
Mode	Rate	Rate
Rate	740	740

Schedules: 1 **Entry:** 2

Setting	ATMS	Field
Time	05:30	05:30
Days of Week	M,T,W,Th,F	M,T,W,Th,F
Lanes	1,2	1,2
Action	Traffic Responsive	Traffic Responsive
Mode	Rate	Rate
Rate	740	740

Schedules: 1 **Entry:** 3

Setting	ATMS	Field
Time	09:00	09:00
Days of Week	M,T,W,Th,F	M,T,W,Th,F
Lanes	1,2	1,2
Action	Green Rest	Green Rest
Mode	Rate	Rate
Rate	900	900

Time-of-Day Settings

	A	B	C	D	E	F	G	H
	Schedules							Recommended Updates May 2020
	TOD							
417	**Schedules:** 1	**Entry:** 1						
418		Setting			ATMS		Field	
419		Time			00:00		00:00	
420		Days of Week			S,M,T,W,Th,F,Sa		S,M,T,W,Th,F,Sa	
421		Lanes			1,2		1,2	
422		Action			Green Rest		Green Rest	
423		Mode			Rate		Rate	
424		Rate			740		740	
425	**Schedules:** 1	**Entry:** 2						
426		Setting			ATMS		Field	
427		Time			05:30		05:30	06:00
428		Days of Week			M,T,W,Th,F		M,T,W,Th,F	
429		Lanes			1,2		1,2	
430		Action			Traffic Responsive		Traffic Responsive	
431		Mode			Rate		Rate	
432		Rate			740		740	
433	**Schedules:** 1	**Entry:** 3						
434		Setting			ATMS		Field	
435		Time			09:00		09:00	
436		Days of Week			M,T,W,Th,F		M,T,W,Th,F	
437		Lanes			1,2		1,2	
438		Action			Green Rest		Green Rest	
439		Mode			Rate		Rate	
440		Rate			900		900	
441	**Schedules:** 1	**Entry:** 4						
442		Setting			ATMS		Field	Delete this Schedule Entry, Friday metering to start at same time (14:30) as metering for other weekdays
443		Time			12:00		12:00	
444		Days of Week			F		F	
445		Lanes			1,2		1,2	
446		Action			Traffic Responsive		Traffic Responsive	
447		Mode			Rate		Rate	
448		Rate			740		740	
449	**Schedules:** 1	**Entry:** 5						
450		Setting			ATMS		Field	
451		Time			14:00		14:00	14:30
452		Days of Week			M,T,W,Th,F		M,T,W,Th,F	
453		Lanes			1,2		1,2	
454		Action			Traffic Responsive		Traffic Responsive	
455		Mode			Rate		Rate	
456		Rate			740		740	
457	**Schedules:** 1	**Entry:** 6						

Time-of-Day Settings: Spreadsheet Adjustment Example

Appendix G

Ramp Meter Recommendations Form

RAMP METER RECOMMENDATIONS FORM

Ramp Meter

Timings

☐ No Changes

☐ Increased Red Times

☐ Decreased Red Times

☐ Other _____

Thresholds

☐ No Changes

☐ Modified Based On Current Freeway Conditions

☐ Other _____

AM Time-of-Day Schedule

Current Schedule

Recommended Schedule

Recommendations Based on Criteria:

Yes	No				
☐	☐	V/C Ratio	< 0.65	0.65-0.70	> 0.70
☐	☐	Downstream Bottleneck	< 1 Mile	1-2 Miles	> 2 Miles
☐	☐	Speed Reduction	< 10 MPH	10-15 MPH	> 15 MPH
☐	☐	Platooning			
☐	☐	Ramp Diversion			
☐	☐	Observation			
☐	☐	Ramp Acceleration Length			
☐	☐	Ramp Volume			
☐	☐	Other _____			

PM Time-of-Day Schedule

Current Schedule

Recommended Schedule

Recommendations Based on Criteria:

Yes	No				
☐	☐	V/C Ratio	< 0.65	0.65-0.70	> 0.70
☐	☐	Downstream Bottleneck	< 1 Mile	1-2 Miles	> 2 Miles
☐	☐	Speed Reduction	< 10 MPH	10-15 MPH	> 15 MPH
☐	☐	Platooning			
☐	☐	Ramp Diversion			
☐	☐	Observation			
☐	☐	Ramp Acceleration Length			
☐	☐	Ramp Volume			
☐	☐	Other_____			

Notes:

Questions:

Appendix H

Ramp Meter Retiming Review Form

Ramp Meter Retiming Review Form

(Observed ramp for minimum of 30 minutes. Ramp can be observed in the field or via cameras if possible.)

RM # _____ Location _____ Direction _____

Date _____ Time _____ Observed by _____

Weather Conditions _____ Pavement Conditions _____

Ramp Conditions

Did ramp begin metering during must/may period? Yes No

If no, did it begin metering at the scheduled time? Yes No

Do vehicles at the stop bar activate the green indication properly?

SOV Lane: Yes No N/A SOV Lane: Yes No N/A

HOV Lane: Yes No N/A

If no, explain problem.

_____

Is the ramp meter discharging vehicles appropriately for given freeway volume and speed? Yes No

If no, the ramp is discharging vehicles: too fast too slow

What is the ramp queue length: 0-3 cars ½ ramp ¾ ramp ramp full spilling onto side street

Is the ramp meter cycling? Yes No

Freeway Conditions

Freeway volume: Light Moderate Congested

Freeway average speed: 0-20mph 20-40mph 40-60mph

Recommendations for Improvement

_____

_____

****

Reviewed By: _____ Date: _____

Action Taken: _____

_____

Appendix I

Ramp Meter Retiming Process Checklist

Ramp Meter Retiming Process Checklist

This form will guide you through the ramp meter retiming process. Please write your initials and date in the space provided as each task is completed. The section of the Procedure Manual for each item is indicated in *italics*.

_____ Collect RM Background Information
(Section 3.1)

_____ Data Collection and Validation
(Section 3.2)

_____ Perform RM Inspection and Fill Out RM Field Inspection Report
(Section 3.3)

_____ Download Traffic Data and Complete RM Retiming Spreadsheet
(Sections 3.4 and 3.5)

_____ Develop Data and Complete RM Retiming Spreadsheet
(Sections 3.4 and 3.5)

_____ Develop Proposed Threshold and Time-of-Day Settings. Submit to WisDOT RM Operations Engineer.
(Section 3.5)

_____ Prepare Controller Settings Sheets and Ramp Meter Recommendations Forms
(Section 3.6)

_____ Hold Review and Acceptance Meeting with WisDOT TMC Staff
(Section 3.6)

_____ Enter New Timings into Ramp Meter Controller Program and Download to Controller
(Section 3.7)

_____ Observe RM with New Timings and Communicate Findings with WisDOT.
(Section 3.8)

_____ Complete Documentation Summarizing Changes to RM
(Section 3.9)

Appendix J

Queue Data Collection Template

Intersection Queuing Field Data Collection

Intersection:_____ Approach:_____

Observer: _____ Date: _____

Start Time:_____ (one sheet per 15-minutes)

Number of Vehicles in Queue (worst lane, last veh traveling under ~5 mph):

	Left SOV Lane	Right SOV Lane	HOV Lane
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____
6	_____	_____	_____
7	_____	_____	_____
8	_____	_____	_____
9	_____	_____	_____
10	_____	_____	_____
11	_____	_____	_____
12	_____	_____	_____
13	_____	_____	_____
14	_____	_____	_____
15	_____	_____	_____
16	_____	_____	_____
17	_____	_____	_____
18	_____	_____	_____

For Queues > 18 veh, record number: _____

Appendix K

Detector Data Retrieval QA/QC User Guide

Detector Data Retrieval QAQC User Guide

September 30, 2020

1. Introduction

Traffic detector data quality is a critical part of quality assurance (QA) to data users. Data validity tests are a key component in any archived data management systems (ADMS) to ensure the provision of quality traffic data to support informed decision-making in traffic operations, planning, and other traffic management activities. Three data test options include

- Detector Preview-detailed data quality flagging
- Quick Mode-check data quality for several days, months or years
- DataStats (or Data Summary Report)-statistics for volume speed occupancy detector data

As an integral part of the VSPOC suite, the VSPOC Data QAQC tool includes comprehensive data summary statistics, quality validity rules, procedures, thresholds and criteria, and a systematic flagging system. The VSPOC data quality tests are accessed through the “Preview Detectors” button, the “Quick Mode” checkbox, and the “DataStats” button in the General Detector Data Retrieval application, as highlighted in Figure 1.

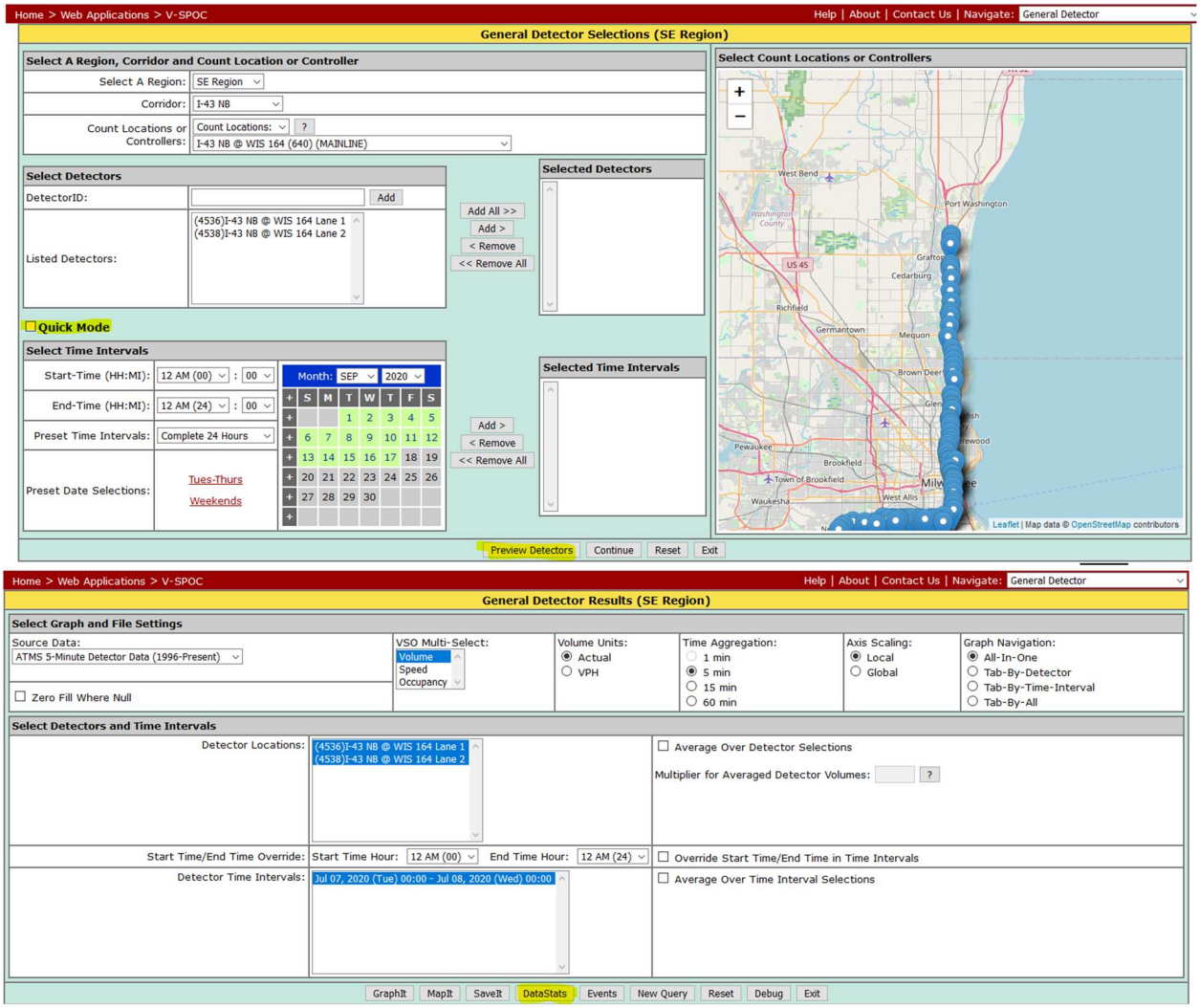


Figure 1 New VSPOC QAQC Functions

DISCLAIMER

The Preview Detectors and Quick Mode tests are available for detector data on and after Jan 1, 2020. Test results are applicable to freeway mainline detectors, not to detection on freeway ramps and local highways.

2. Preview Detectors and Quick Mode Tests

Data quality tests available through Quick Mode and Preview Detectors include ten tests and are described in detail in this section; units are: Speed (SP) in *mile/hour*, Volume (V) in *vehicle/lane/hour*, Occupancy (OC) in *percentage*; and time interval for data is 5 minutes.

- **NVSPOC (missing records)**

Definition: Combined speed, volume and occupancy records in selected data with "null" results.
Example:

Volume	Speed	Occupancy	Calculation	NVSPOC
			All are "null" or no values	0
	60	0.04	volume is "null"	0
404		0.045	speed is "null"	0
360	70		occupancy is "null"	0
48	60	70	No "null" values	1

- **HiLo_Rnge (univariate range)**

Definition: Records with data below zero, speeds greater than 100 mph, volume over 3,100 vph, or occupancy greater than 100% in selected data.

Volume	Speed	Occupancy	Calculation	HiLo_Rnge
500	110	0.06	speed >100	0
4000	50	0.07	volume>3,100	0
1200	45	1.5	occupancy>100%	0
3200	105	1.5	volume>3100, or speed>100	0
1200	60	0.09	All values within ranges	1

- **VOC_ZMPH (positive volume or occupancy with zero speed)**

Definition: Records with zero speed and non-zero volume or occupancy in selected data.
Example:

Volume	Speed	Occupancy	Calculation	VOC_ZMPH
360	0	0.6	Speed is 0, but the volume is 360 or the occupancy is 0.6	0
360	0		Speed is 0, but volume is 360	null
0	0	0	no speed, no volume, no occupancy	1

- **SPOC_ZVPH (positive speed or occupancy with zero volume)**

Definition: Records with zero volume and non-zero speed or occupancy in selected data.
Example:

Volume	Speed	Occupancy	Calculation	SPOC_ZVPH
0	80	0.6	volume is 0, but speed is 80 or occupancy is 0.6	0
0		0.6	volume is 0, but occupancy is 0.6	0
0	70		volume is 0, but speed is 70	null

0	70	0.2	volume is 0, but speed is 70 or occupancy is 0.2	0

- **VSP_ZOCC (positive speed or volume with zero occupancy)**

Definition: Records with zero occupancy and non-zero speed or volume in selected data.
Example:

Volume	Speed	Occupancy	Calculation	VSP_ZOCC
0	80	0	occupancy is 0, but speed is 80	0
600	50	0	occupancy is 0, but speed is 50 or volume is 600	0
	50	0	occupancy is 0, but speed is 50	null
450		0	occupancy is 0, but volume is 450	0

- **SPOCFUNC (infeasible speed in congestion)**

Definition: Records with speed out of range which is defined as 95% confidence interval for corresponding density based on occupancy data in selected data.
Example:

Volume	Speed	Occupancy	Calculation	SPOCFUNC
0	80	0.11	*Step 1:* occupancy>10% and 600/(occupancy+.00001) +3=57.55 189/(occupancy+.00001) -5=12.18 *Step 2:* speed,80 > 57.55	0
600	50	0.06	*Step 1:* occupancy <10%	1
450	30	0.11	*Step 1:* occupancy>10% and 600/(occupancy+.00001) +3=57.55 189/(occupancy+.00001) -5=12.18 *Step 2: 12.18<speed* < 57.55	1

- **CHG_V (abrupt change in volume)**

Definition: Selected data records with volume difference exceeding 450 vph from the individual preceding and following records in time.

Example:

Timestamp	Volume	Speed	Occupancy	Calculation	CHG_V
00:00	200	50	0.06	Insufficient input	
00:05	650	40	0.4	Step 1: volumes are not "null" for timestamps 00:00,00:05 or 00:10 Step 2: volume change = 650 - (170+200)/2 = 465 Step 2: |465| = 465 is greater than 450	0
00:10	170	60	0.6	Step 1: volumes are not "null" for timestamps 00:05,00:10 or 00:15 Step 2: volume change = 170-(650+180)/2 = 245	1

				Step 2: |245| = 245 is less than 450	
00:15	180			Step 1: volume is "null" for timestamp 00:20	null
00:20		65	0.6	Insufficient input	null

- **CHG_SP (abrupt change in speed)**

Definition: Selected data records with speed difference exceeding 12 mph from the individual preceding and following records in time.
Example:

Timestamp	Volume	Speed	Occupancy	Calculation	CHG_SP
00:00	300	50	0.06	Insufficient input	
00:05	410	40	0.4	Step 1: speeds are not "null" for time stamps 00:00,00:05 or 00:10 Step 1: speed change = 40 - (60+50)/2 = -15 Step 2: |-15| = 15 is greater than 12	0
00:10	375	60	0.6	Step 1: speeds are not "null" for time stamps 00:05,00:10 or 00:15 Step 1: speed change = 60 - (40+58)/2 = 11 Step 2: |11| = 11 is less than 12	1
00:15	360	58		Step 1: speed is "null" for timestamp 00:20	null
00:20	300		0.04	Insufficient input	null

- **STK_OC (non-zero (Occupancy) stuck)**

Definition: Records with a non-zero occupancy value repeating for more than three consecutive five-minute reporting intervals.
Example:

Timestamp	Volume	Speed	Occupancy	Calculation	STK_OC
00:00	325	40	0.11	Insufficient input	null
00:05	345	45	0.12	Insufficient input	null
00:10	300	43	0.13	Insufficient input	null
00:15	350	49	0.09	Insufficient input	null
00:20	310	55	0.17	Insufficient input	null
00:25	400	44	0.12	Insufficient input	null
00:30	450	46	0.12	step 1:1%<occupancy<100% step 2: number of "0.12" occupancy between timestamps 00:00 and 00.60[excluding 00:30] is 4 step 3: 4>3	0

00:35	480	49	0.08	step 1: 1%<occupancy<100% step 2: number of "0.08" occupancy between timestamps 00:05 and 00.65[excluding 00:35] is 0 step 3: 0<3	1
00:40	475	42	0.11	step 1: 1%<occupancy<100% step 2: number of "0.11" occupancy between timestamps 00:10 and 00.70[excluding 00:40] is 1 step 3: 1<3	1
00:45	410	51	0.12	Insufficient input	null
00:50	390	54		Insufficient input	null
00:55	400	49	0.12	Insufficient input	null
00:60	380	55	0.14	Insufficient input	null
00:65	395	51	0.14	Insufficient input	null
00:70	385	56	0.11	Insufficient input	null

- **RPT ZVPH (repeating zero (volume))**

Definition: Records with volume=0 vehicles during multiple reporting intervals. Daytime hours, nighttime hours, and historic volumes determine results.
Example:

Revised version:

Timestamp	Volume	Speed	Occupancy	Calculation	RPT ZVPH
0:00	24	40	0.11	Insufficient input	null
0:05	0	45	0.12	Insufficient input	null
0:10	0	43	0.13	Insufficient input	null
0:15	12	49	0.09	Insufficient input	null
0:20	12	55	0.17	step 1: volume>0	1
0:25	24	44	0.12	step 1: volume>0	1
0:30	0	46	0.12	step :1 volume is 0, night-time avg volume is 9.2[all records] step2: number(n) of "0" volume between timestamp 0:10 and 0.50 is 3[excluding timestamp 00:30] step 3: for avg volume 9.2, j is 2, step 4: n>j	0

0:35	0	49	0.08	step :1 volume is 0, avg volume is 9.2[all records] step2: number(n) of "0" volume between timestamp 0:15 and 0.55 is 2[excluding timestamp 00:35] step 3: for avg volume 9.2, j is 2 step 4: n=j	1
0:40	12	42	0.11	step 1: volume>0	1
0:45	24	51	0.12	Insufficient input	null
0:50	0	54	0.16	Insufficient input	null
0:55	60	49	0.12	Insufficient input	null
0:60	36	55	0.14	Insufficient input	null

3. QAQC Preview Detectors Function

The Preview Detectors function helps specify good data with detailed flagging information in a specified range of time and space, as an enhancement to the current data retrieval tool.

1. Select detectors and time/date in the Detector Selection window
2. Click the "Preview Detectors" at the bottom of the window, as highlighted in Figure 2.

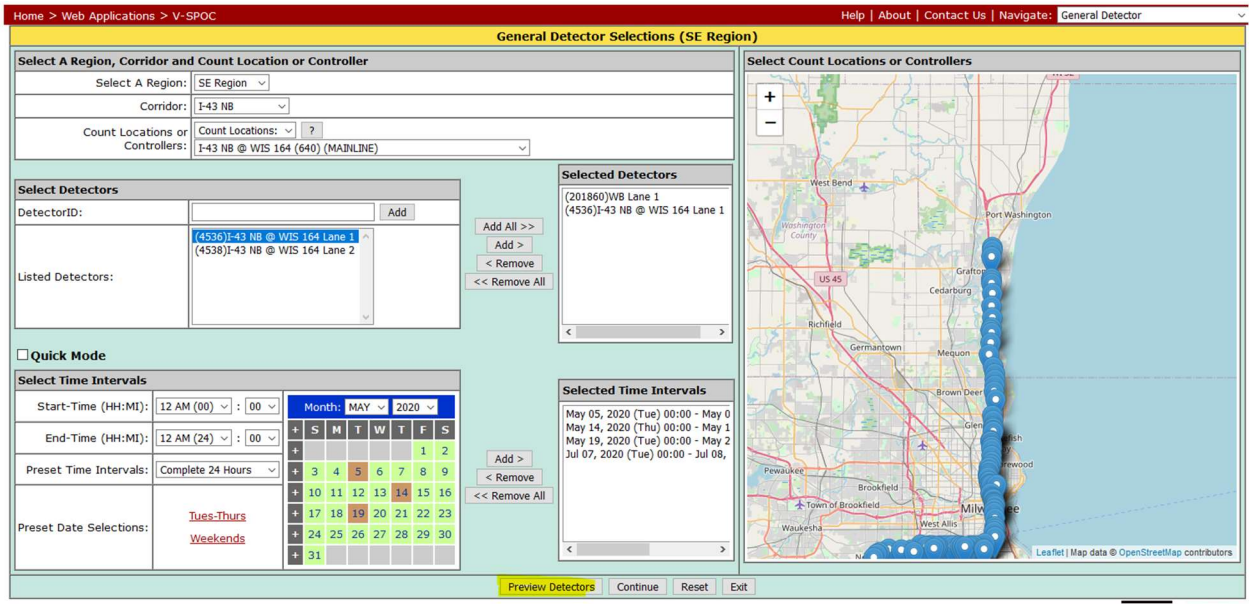


Figure 2 Preview Detectors

A Pop-up window shows the data quality results for each test, "Show details" provides the full test definition, as shown in Figure 3.

Preview Detectors QAQC Test Descriptions

Detector Data Quality Tests		
☑	Test ID	Test Name
☑	NVSPOC	**Missing Records** Show details
☑	HiLo_Rnge	**Univariate Range** Show details
☑	VOC_ZMPH	**Positive Volume or Occupancy with Zero Speed** Show details
☑	SPOC_ZVPH	**Positive Speed or Occupancy with Zero Volume** Show details
☑	VSP_ZOCC	**Positive Speed or Volume with Zero Occupancy** Show details
☑	SPOCFUNC	**Infeasible Speed by Occupancy Regime** Show details
☑	CHG_V	**Abrupt Change in Volume** Show details **Definition:** Selected data records with volume difference exceeding 450 vph from the individual preceding and following records in time. **Formula:** If $\lvert\Delta V_t\rvert > \Delta V_{max}$, then flag. Where ΔV_{max} is the threshold value determined by the distribution of $\lvert\Delta V_t\rvert$. ΔV_t is the change in volume at time t and formulated as $\left(V_t - \frac{V_{t-1}+V_{t+1}}{2}\right)$, where V_{t-1}, V_t, and V_{t+1} are the volumes at time
☑	CHG_SP	**Abrupt Change in Speed** Show details
☑	STK_OC	**Non-Zero (Occupancy) Stuck** Show details
☑	RPT_ZVPH	**Repeating Zero (Volume)** Show details

Data Quality Results (% of Good Records in Available Data)

☑	Detector ID	Detector Description	Date	Time Interval	NVSPOC	HiLo_Rnge	VOC_ZMPH	SPOC_ZVPH	VSP_ZOCC	SPOCFUNC	CHG_V	CHG_SP	STK_OC	RPT_ZVPH
☑	4536	I-43 NB @ WIS 164 Lane 1	JUN 02, 2020 (TUE)	00:00 - 24:00	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	35.76 %	100.0 %	90.91 %	100.0 %	92.86 %
☑	201860	WB Lane 1	JUN 02, 2020 (TUE)	00:00 - 24:00	82.29 %	100.0 %	99.58 %	100.0 %	84.39 %	100.0 %	100.0 %	85.84 %	100.0 %	96.96 %
☑	4536	I-43 NB @ WIS 164 Lane 1	JUN 03, 2020 (WED)	00:00 - 24:00	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	0.0 %
☑	201860	WB Lane 1	JUN 03, 2020 (WED)	00:00 - 24:00	100.0 %	100.0 %	100.0 %	100.0 %	87.85 %	100.0 %	100.0 %	87.76 %	100.0 %	96.43 %

Download Results | Download Hourly Test Results

Figure 3 Test Description

The table "Data Quality Results (% of Good Records in Available Data)," shows the percentage of 5-min data that has "**passed**" each test in the selected time interval and detectors. In other words, the percentage of "good" records among the available data (excluding the ones fail in Missing Records), which is color-coded: Red for less than 50%, Orange for 50% - 75%, Yellow for 75% - 85%, and Green for larger than 85%.

Test result columns can be hidden by unchecking the box in the left column next to the Test ID as shown in Figure 4. Unchecking the box in the left column next to Detector ID will exclude the results for that detector/date combination from the Download Results and Download Hourly Results files.

Preview Detectors QAQC Test Descriptions

Detector Data Quality Tests		
☑	Test ID	Test Name
☑	NVSPOC	**Missing Records** Show details
☐	HiLo_Rnge	**Univariate Range** Show details
☑	VOC_ZMPH	**Positive Volume or Occupancy with Zero Speed** Show details
☑	SPOC_ZVPH	**Positive Speed or Occupancy with Zero Volume** Show details
☑	VSP_ZOCC	**Positive Speed or Volume with Zero Occupancy** Show details
☑	SPOCFUNC	**Infeasible Speed by Occupancy Regime** Show details
☐	CHG_V	**Abrupt Change in Volume** Show details
☑	CHG_SP	**Abrupt Change in Speed** Show details
☑	STK_OC	**Non-Zero (Occupancy) Stuck** Show details
☑	RPT_ZVPH	**Repeating Zero (Volume)** Show details

Data Quality Results (% of Good Records in Available Data)

☑	Detector ID	Detector Description	Date	Time Interval	NVSPOC	VOC_ZMPH	SPOC_ZVPH	VSP_ZOCC	SPOCFUNC	CHG_SP	STK_OC	RPT_ZVPH
☑	4536	I-43 NB @ WIS 164 Lane 1	JUN 02, 2020 (TUE)	00:00 - 24:00	100.0 %	100.0 %	100.0 %	100.0 %	35.76 %	90.91 %	100.0 %	92.86 %
☑	201860	WB Lane 1	JUN 02, 2020 (TUE)	00:00 - 24:00	82.29 %	99.58 %	100.0 %	84.39 %	100.0 %	85.84 %	100.0 %	96.96 %
☑	4536	I-43 NB @ WIS 164 Lane 1	JUN 03, 2020 (WED)	00:00 - 24:00	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	0.0 %
☑	201860	WB Lane 1	JUN 03, 2020 (WED)	00:00 - 24:00	100.0 %	100.0 %	100.0 %	87.85 %	100.0 %	87.76 %	100.0 %	96.43 %

Download Results | Download Hourly Test Results

Figure 4 QAQC Test Results

"Download Results" provides the displayed results in a CSV file for further analysis, as shown in Figure 5.

Region	Detector ID	Detector Description	Date	Time Interval	NVSPOC	HiLo_Rnge	VOC_ZMPH	SPOC_ZVPH	VSP_ZOCC	SPOCFUNC	CHG_V	CHG_SP	STK_OC	RPT ZVPH
					Missing Records	Univariate Range	Positive Volume or Occupancy with Zero Speed	Positive Speed or Occupancy with Zero Volume	Positive Speed or Volume with Zero Occupancy	Infeasible Speed by Occupancy Regime	Abrupt Change in Volume	Abrupt Change in Speed	Non-Zero (Occupancy) Stuck	Repeating Zero (Volume)
SE	4536	I-43 NB @ WIS 164 Lane 1	JUN 02, 2020 (TUE)	00:00 - 24:00	100	100	100	100	100	35.76	100	90.91	100	92.86
SE	201860	WB Lane 1	JUN 02, 2020 (TUE)	00:00 - 24:00	82.29	100	99.58	100	84.39	100	100	85.84	100	96.96
SE	4536	I-43 NB @ WIS 164 Lane 1	JUN 03, 2020 (WED)	00:00 - 24:00	100	100	100	100	100	100	100	100	100	0
SE	201860	WB Lane 1	JUN 03, 2020 (WED)	00:00 - 24:00	100	100	100	100	87.85	100	100	87.76	100	96.43

Figure 5 Data Format of Download Results

"Download Hourly Test Results" provides the hourly average results in a CSV file for further analysis, as shown in Figure 6.

DID	Detector Description	Date	Day of Week	NVSPOC	HiLo_Rnge	VOC_ZMPH	SPOC_ZVPH	VSP_ZOCC	SPOCFUNC	CHG_V	CHG_SP	STK_OC	RPT ZVPH
				Missing Records	Univariate Range	Positive Volume or Occupancy with Zero Speed	Positive Speed or Occupancy with Zero Volume	Positive Speed or Volume with Zero Occupancy	Infeasible Speed by Occupancy Regime	Abrupt Change in Volume	Abrupt Change in Speed	Non-Zero (Occupancy) Stuck	Repeating Zero (Volume)
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 0:00	Tue	100	100	100	100	100	100	100	45.45	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 1:00	Tue	100	100	100	100	100	100	100	33.33	100	91.67
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 2:00	Tue	100	100	100	100	100	100	100	41.67	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 3:00	Tue	100	100	100	100	100	100	100	75	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 4:00	Tue	100	100	100	100	100	66.67	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 5:00	Tue	100	100	100	100	100	0	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 6:00	Tue	100	100	100	100	100	0	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 7:00	Tue	100	100	100	100	100	0	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 8:00	Tue	100	100	100	100	100	0	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 9:00	Tue	100	100	100	100	100	0	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 10:00	Tue	100	100	100	100	100	0	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 11:00	Tue	100	100	100	100	100	0	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 12:00	Tue	100	100	100	100	100	0	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 13:00	Tue	100	100	100	100	100	0	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 14:00	Tue	100	100	100	100	100	0	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 15:00	Tue	100	100	100	100	100	0	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 16:00	Tue	100	100	100	100	100	0	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 17:00	Tue	100	100	100	100	100	8.33	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 18:00	Tue	100	100	100	100	100	25	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 19:00	Tue	100	100	100	100	100	16.67	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 20:00	Tue	100	100	100	100	100	58.33	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 21:00	Tue	100	100	100	100	100	91.67	100	100	100	100
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 22:00	Tue	100	100	100	100	100	91.67	100	83.33	100	8.33
4536	I-43 NB @ WIS 164 Lane 1	6/2/2020 23:00	Tue	100	100	100	100	100	100	100	100	100	0
4536	I-43 NB @ WIS 164 Lane 1	6/3/2020 0:00	Wed	100	100	100	100	100	100	100	100	100	0
4536	I-43 NB @ WIS 164 Lane 1	6/3/2020 1:00	Wed	100	100	100	100	100	100	100	100	100	0
4536	I-43 NB @ WIS 164 Lane 1	6/3/2020 2:00	Wed	100	100	100	100	100	100	100	100	100	0
4536	I-43 NB @ WIS 164 Lane 1	6/3/2020 3:00	Wed	100	100	100	100	100	100	100	100	100	0
4536	I-43 NB @ WIS 164 Lane 1	6/3/2020 4:00	Wed	100	100	100	100	100	100	100	100	100	0

Figure 6 Data Format of Download Hourly Test Results

4. Quick Mode Function

Quick Mode helps identify potential data quality issues in a wide range of time and space. Specifically, users can pick multiple years, months, and days of the week to look at the daily average quality. To switch to the Quick Find mode, just click the checkbox as in Figure 7.

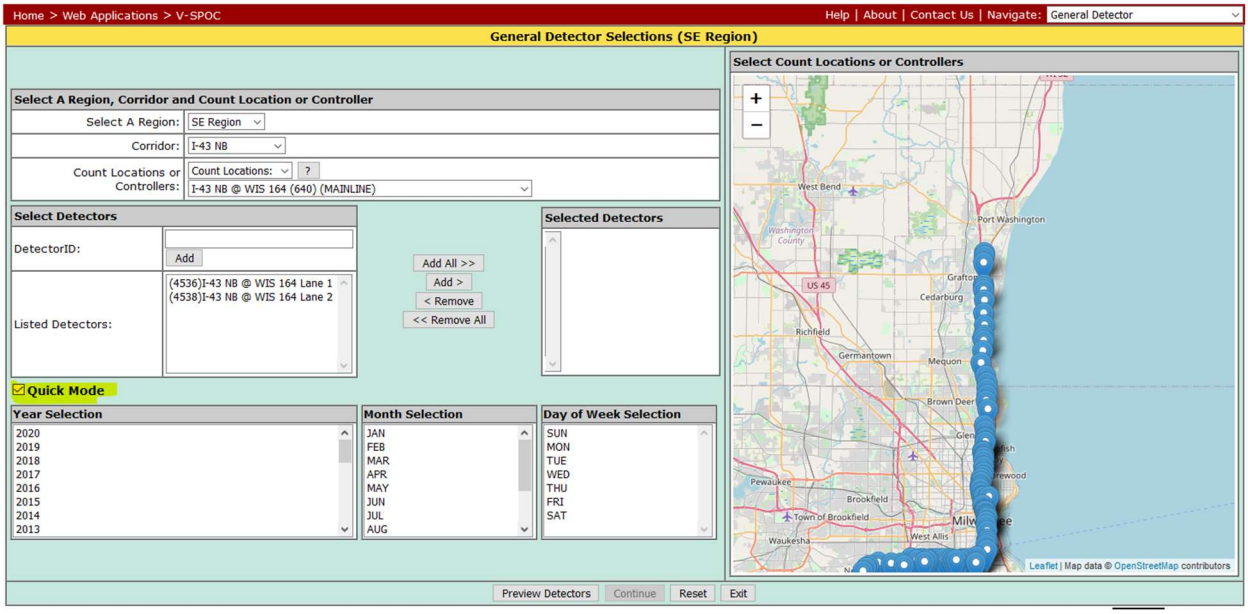


Figure 7 Quick Mode

One example is that a user is looking for a Tuesday, Wednesday and a Thursday with good data in May and July from predetermined detectors. First, add detectors. Next, choose year, month, and day of week (multiple selections are possible).

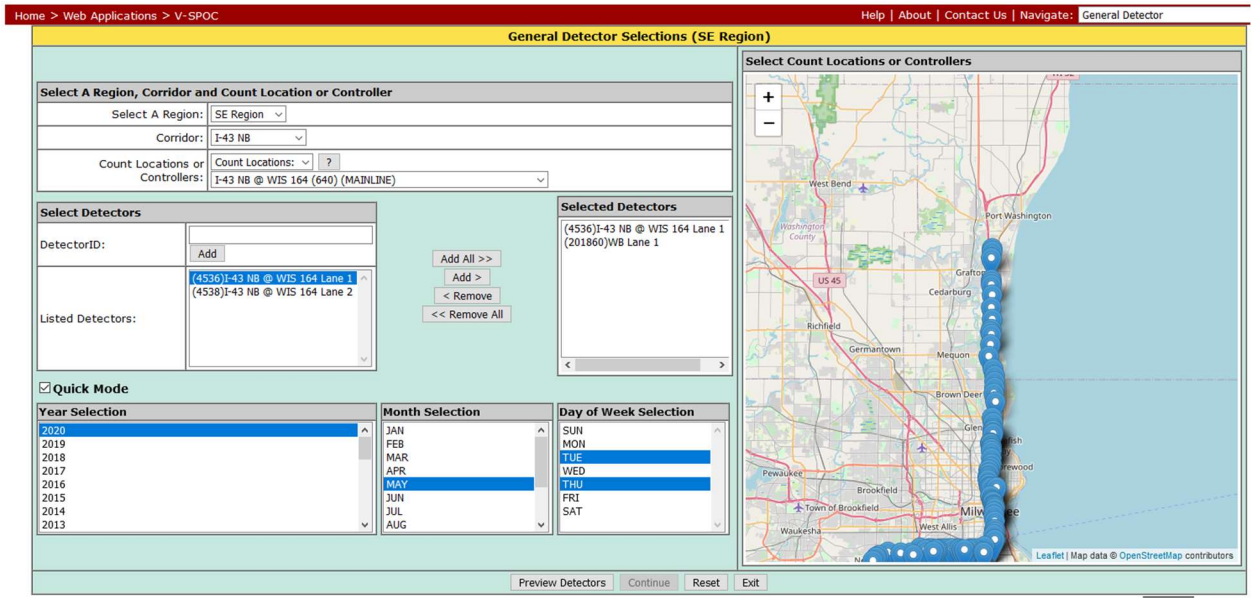
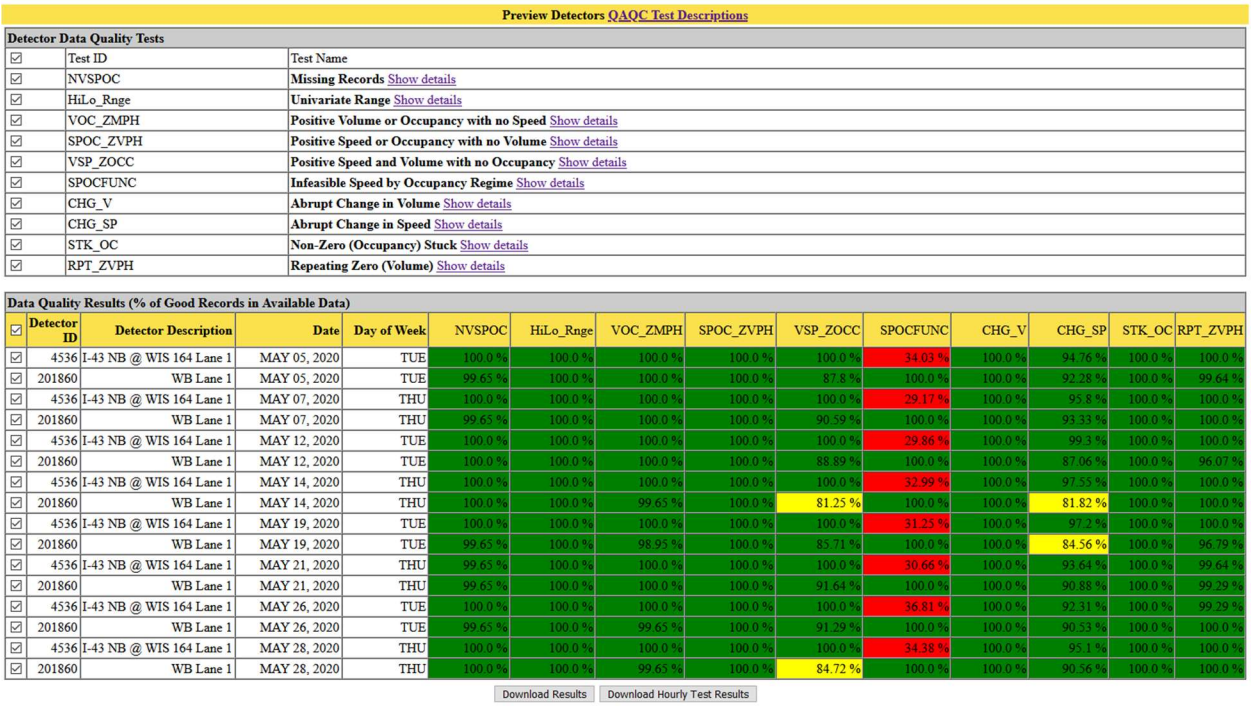


Figure 8 Quick Mode Functions

Click “Preview Detectors” for a pop-up window, as shown in Figure 9. Users can download the data for further analysis. Uncheck Quick Mode before using Continue to retrieve data.



Preview Detectors QAQC Test Descriptions

Detector Data Quality Tests

	Test ID	Test Name
☑	NVSPOC	**Missing Records** Show details
☑	HiLo_Rnge	**Univariate Range** Show details
☑	VOC_ZMPH	**Positive Volume or Occupancy with no Speed** Show details
☑	SPOC_ZVPH	**Positive Speed or Occupancy with no Volume** Show details
☑	VSP_ZOCC	**Positive Speed and Volume with no Occupancy** Show details
☑	SPOCFUNC	**Infeasible Speed by Occupancy Regime** Show details
☑	CHG_V	**Abrupt Change in Volume** Show details
☑	CHG_SP	**Abrupt Change in Speed** Show details
☑	STK_OC	**Non-Zero (Occupancy) Stuck** Show details
☑	RPT_ZVPH	**Repeating Zero (Volume)** Show details

Data Quality Results (% of Good Records in Available Data)

☑	Detector ID	Detector Description	Date	Day of Week	NVSPOC	HiLo_Rnge	VOC_ZMPH	SPOC_ZVPH	VSP_ZOCC	SPOCFUNC	CHG_V	CHG_SP	STK_OC	RPT_ZVPH
☑	4536	I-43 NB @ WIS 164 Lane 1	MAY 05, 2020	TUE	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	34.03 %	100.0 %	94.76 %	100.0 %	100.0 %
☑	201860	WB Lane 1	MAY 05, 2020	TUE	99.65 %	100.0 %	100.0 %	100.0 %	87.8 %	100.0 %	100.0 %	92.28 %	100.0 %	99.64 %
☑	4536	I-43 NB @ WIS 164 Lane 1	MAY 07, 2020	THU	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	29.17 %	100.0 %	95.8 %	100.0 %	100.0 %
☑	201860	WB Lane 1	MAY 07, 2020	THU	99.65 %	100.0 %	100.0 %	100.0 %	90.59 %	100.0 %	100.0 %	93.33 %	100.0 %	100.0 %
☑	4536	I-43 NB @ WIS 164 Lane 1	MAY 12, 2020	TUE	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	29.86 %	100.0 %	99.3 %	100.0 %	100.0 %
☑	201860	WB Lane 1	MAY 12, 2020	TUE	100.0 %	100.0 %	100.0 %	100.0 %	88.89 %	100.0 %	100.0 %	87.06 %	100.0 %	96.07 %
☑	4536	I-43 NB @ WIS 164 Lane 1	MAY 14, 2020	THU	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	32.99 %	100.0 %	97.55 %	100.0 %	100.0 %
☑	201860	WB Lane 1	MAY 14, 2020	THU	100.0 %	100.0 %	99.65 %	100.0 %	81.25 %	100.0 %	100.0 %	81.82 %	100.0 %	100.0 %
☑	4536	I-43 NB @ WIS 164 Lane 1	MAY 19, 2020	TUE	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	31.25 %	100.0 %	97.2 %	100.0 %	100.0 %
☑	201860	WB Lane 1	MAY 19, 2020	TUE	99.65 %	100.0 %	98.95 %	100.0 %	85.71 %	100.0 %	100.0 %	84.56 %	100.0 %	96.79 %
☑	4536	I-43 NB @ WIS 164 Lane 1	MAY 21, 2020	THU	99.65 %	100.0 %	100.0 %	100.0 %	100.0 %	30.66 %	100.0 %	93.64 %	100.0 %	99.64 %
☑	201860	WB Lane 1	MAY 21, 2020	THU	99.65 %	100.0 %	100.0 %	100.0 %	91.64 %	100.0 %	100.0 %	90.88 %	100.0 %	99.29 %
☑	4536	I-43 NB @ WIS 164 Lane 1	MAY 26, 2020	TUE	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	36.81 %	100.0 %	92.31 %	100.0 %	99.29 %
☑	201860	WB Lane 1	MAY 26, 2020	TUE	99.65 %	100.0 %	99.65 %	100.0 %	91.29 %	100.0 %	100.0 %	90.53 %	100.0 %	100.0 %
☑	4536	I-43 NB @ WIS 164 Lane 1	MAY 28, 2020	THU	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	34.38 %	100.0 %	95.1 %	100.0 %	100.0 %
☑	201860	WB Lane 1	MAY 28, 2020	THU	100.0 %	100.0 %	99.65 %	100.0 %	84.72 %	100.0 %	100.0 %	90.56 %	100.0 %	100.0 %

Download Results | Download Hourly Test Results

Figure 9 Preview Detectors Pop-up Window

5. Data Statistics Report

The Data Statistics Report (DataStats) provides statistics of the selected detectors and dates, as shown in Figure 10, providing average, maximum, and percentage of null and zero values of volume, speed, and occupancy. DataStats, replacing the existing Quality Assurance Report (QAReport), includes all the data statistics previously provided but no data quality results since the new data QAQC test results are now superior to the quality tests in QAReport.

Data Statistics Report

Data Statistics Column Headers Legend	
DID	Detector ID
TIME INTERVAL	Time Interval
Avg VPH	Average Volume (VPH)
Avg MPH	Average Speed (MPH)
Avg OCC	Average Occupancy (%)
Max VPH	Maximum Volume (VPH)
Max MPH	Maximum Speed (MPH)
Max OCC	Maximum Occupancy (%)
NVPH	Percentage of null values for Volume
NMPH	Percentage of null values for Speed
NOCC	Percentage of null values for Occupancy
ZVPH	Percentage of zero values for Volume
ZMPH	Percentage of zero values for Speed
ZOCC	Percentage of zero values for Occupancy

Taken Over All Detector IDs and Time Intervals

DID	TIME INTERVAL	NVPH	ZVPH	Avg VPH	Max VPH
---	---	.0	1.8	226.3	888.0
DID	**TIME INTERVAL**	**NMPH**	**ZMPH**	**Avg MPH**	**Max MPH**
---	---	.0	1.8	71.4	80.2
DID	**TIME INTERVAL**	**NOCC**	**ZOCC**	**Avg OCC**	**Max OCC**
---	---	.0	1.8	19.6	69.0

Taken Over All Detector IDs

DID	TIME INTERVAL	NVPH	ZVPH	Avg VPH	Max VPH
---	05/05/2020 12:00AM - 05/06/2020 12:00AM	.0	1.7	216.9	816.0
---	05/07/2020 12:00AM - 05/08/2020 12:00AM	.0	1.9	235.8	888.0
DID	**TIME INTERVAL**	**NMPH**	**ZMPH**	**Avg MPH**	**Max MPH**
---	05/05/2020 12:00AM - 05/06/2020 12:00AM	.0	1.7	71.0	80.2
---	05/07/2020 12:00AM - 05/08/2020 12:00AM	.0	1.9	71.8	79.6
DID	**TIME INTERVAL**	**NOCC**	**ZOCC**	**Avg OCC**	**Max OCC**
---	05/05/2020 12:00AM - 05/06/2020 12:00AM	.0	1.7	19.1	63.2
---	05/07/2020 12:00AM - 05/08/2020 12:00AM	.0	1.9	20.0	69.0

Figure 10 DataStats Function