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Development of Uniform Standards for Allowable Lane Closure

FINAL REPORT

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16. Abstract

Procedures for determining allowable lane closure hours to perform maintenance, construction, resurfacing, regional permit and major access permit work on the state highway system were evaluated. The current process involves the collection of traffic volumes, consultation with local authorities and the reliance on previous knowledge of the roadway to develop allowable lane closing hours. This is an ad-hoc process that lacks uniformity and does not make use of traffic engineering basics to assess the impacts of lane closures. Thus, there is a need to develop a process for determining and modifying lane closures that will have uniformity and take into account effects on productivity and traffic delay. The major goals of this study include the development of a uniform process for lane closures that takes into account the impact of lane closure on traffic and productivity, and the adoption of this uniform process throughout the NJDOT.

The QuickZone lane closure tool was selected for use with long term lane closures that require traffic diversion to alternate routes. The RILCA software was selected for analyzing the impacts of short-term lane closures.

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INTRODUCTION

In this study, procedures for determining allowable lane closure hours to perform maintenance, construction, resurfacing, regional permit, and major access permit work on the state highway system were evaluated. The current process to develop allowable lane closing hours that is being conducted by the NJDOT involves the collection of traffic volumes, consultation with local authorities and the reliance on previous knowledge of the roadway. This is an ad-hoc process that lacks uniformity and does not make use of traffic engineering basics to assess the impacts of lane closures. Thus, there is a need to develop a process for determining and modifying lane closures that will have uniformity and take into account effects on productivity and traffic delay.

The two major goals of this project are:

1. Develop a uniform process for lane closures that takes into account the impact of lane closure on traffic and productivity.
2. Adopt this uniform process for use throughout the NJDOT.

Various tools that are available to planners and engineers to address work zones are illustrated in Figure 1. The spectrum described here includes ten available tools that could be used to address the "soft cost" of roadway construction projects. Each of the ten tools is placed on a continuum from simple to complex. Simpler tools include the categories of sketch planning and analytic while more complex tools include regional travel demand models (TDM) and general-purpose traffic simulations.

Before selecting a specific work zone-modeling tool, there are five model selection criteria that should be considered: functionality, results, time, training and cost. Choosing a tool is generally a tradeoff among these five criteria. Functionality (the capability to represent specific work zone attributes) and results (precision of analysis) are the two main critical criteria. If the tool cannot analyze a specific situation or provide the necessary results to the precision or accuracy required, it would not be useful regardless of the cost, training or time applied. In some instances, such as a project currently in the construction phase, it may be critical that results be provided in a timely manner. The time required to rapidly assemble the required data and calibrate a simulation tool is generally much longer than the time and resources required for utilizing a sketch-planning tool. The need for timeliness must be balanced against the ability of the sketch-planning tool to provide a precise solution accurately reflecting the problem under study.

Finally, the training associated with a particular tool should be considered. Simulation tools often require a high level of expertise only found in a few individuals or consultants. On the other hand, many of the sketch planning and analytic tools are more accessible and can be mastered by a broad range of staff within a short period of time.

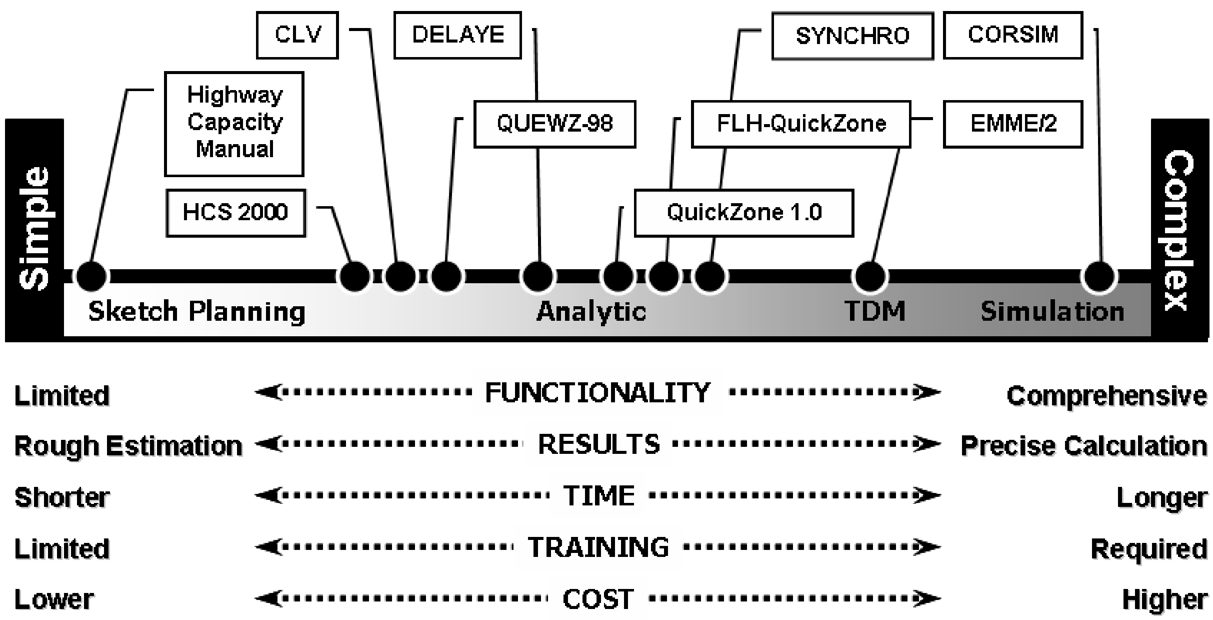


Figure 1. Work zone modeling spectrum [(1)]

In order to decide which tool to select for work zone analysis, a panel of experts was assembled, which included a number of NJDOT engineers involved in lane closure decision making. The specifics of the lane closure tools, the lane closure algorithm, and the available traffic count data were discussed. The panel decided that for short term lane closures, the Rutgers Interactive Lane Closure Application (RILCA) tool was to be utilized. For long term lane closures, QuickZone lane closure tool was selected. The panel agreed that only freeway lane closures will be considered in this project. RILCA is an easy to use analytical lane closure tool, and with its precision it falls between QuickZone and SYNCHRO in the chart shown in Figure 1.

QuickZone represents one set of tradeoffs among these five criteria and is appropriate for the type of work zone analyses that are generally conducted by NJDOT. QuickZone is an analytic tool that has more functionality specific to the analysis of work zones compared to HCS 2000, but is not as detailed as CORSIM or other traffic simulation tools. The results of QuickZone are calculated on a link-by-link and hour-by-hour basis. This type of time-based granularity is similar to other simple lane-closure impacts analysis tools like QUEWZ-98. However, QuickZone performs this level of analysis for one or many interacting work zones, and estimates impacts over time, taking into account changes in traffic control and travel demand that can vary day-to-day, week-to-week, or phase-to-phase. This flexibility makes QuickZone a good choice when many different work plans (often spanning two or more construction seasons) must be evaluated. Often, results from QuickZone can be obtained in less than one minute for typical networks once the data has been entered.

On the other hand, simulation programs can directly represent a wider range of work zone attributes, require significant more time and resource investment to build and analyze.

Below are several facts that warrant the decision of choosing QuickZone for this project:

1. QuickZone, developed by Noblis, Inc. (formerly Mitretek) with FHWA funding, is recommended by the FHWA as one of several tools to determine work zone delays. (2)
2. QuickZone considers traffic engineering parameters specified in the Highway Capacity Manual such as volume, truck percentage, lane width, etc.

3. As demonstrated in Figure 2, QuickZone is widely used by other State and local DOTs in the USA and thus it is well tested and validated. Current FHWA partners using QuickZone include Maryland State Highway Administration, Central Federal Lands Highway Division, Pennsylvania DOT, Ohio DOT, Wisconsin DOT, Washington DOT, Utah DOT, North Carolina DOT.

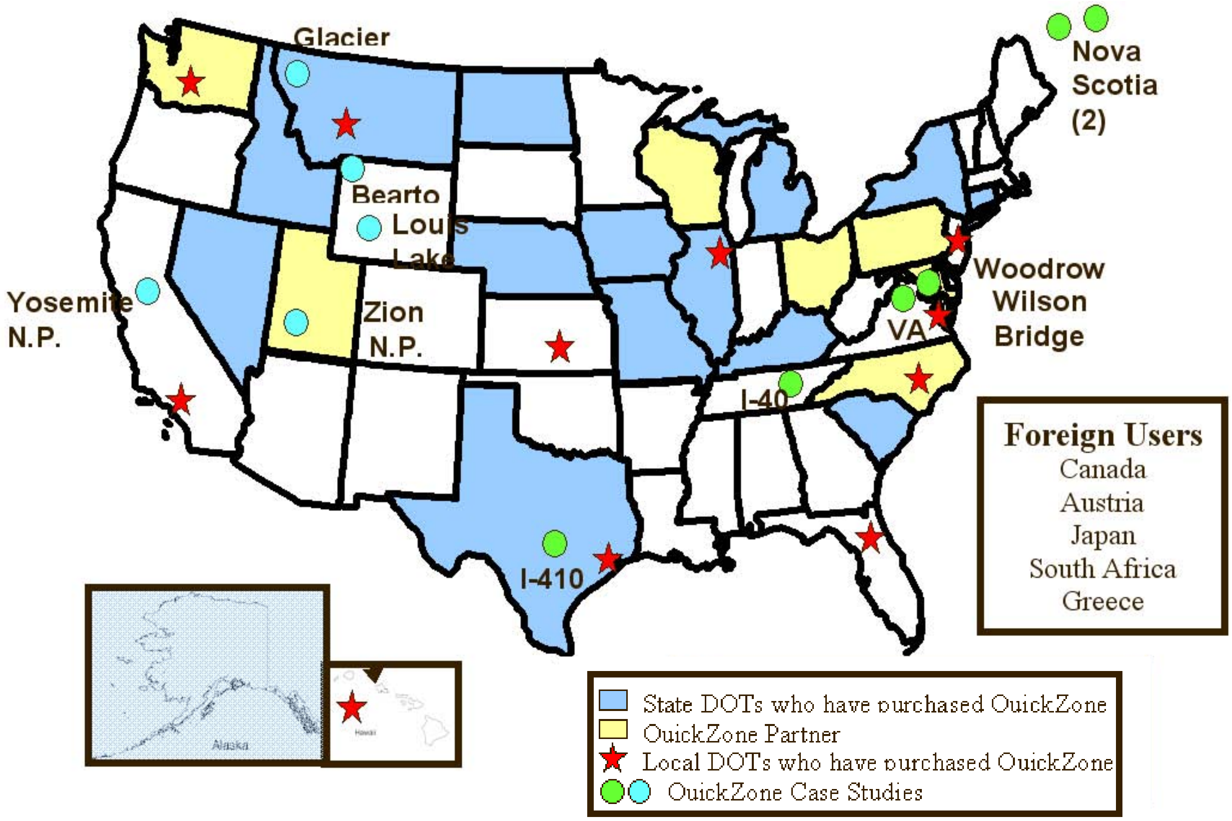


Figure 2. Various states where QuickZone is used [(1)]

4. QuickZone program is well tested and virtually free of bugs. FHWA has identified QuickZone as one of its key "ready to deploy" technologies. This presents a great advantage given the application-oriented nature of this project. In many cases, just debugging a new program might require several months of professional effort.
5. Data requirements for QuickZone are well established and flexible enough to accommodate projects with minimal available data as well as projects that have a wealth of detailed data.

6. QuickZone is a well-tested benefit/cost estimation module satisfying one of the main objectives of this study.
7. QuickZone is user friendly and does not require special expertise. Users of common spreadsheets are already familiar with its primary user interfaces. This makes it a perfect tool for wide-use by NJDOT's staff.

RILCA is an interactive computer tool developed for NJDOT for planning work zone lane closures. RILCA is aimed at providing engineers with a computerized and easy tool for determining allowable lane closure hours on NJ freeways.

RILCA was developed using ArcView GIS software package as the main development environment. The GIS map of the NJ freeways and its surrounding network is displayed using ArcView and various analysis and visualization options are provided for planning of lane closure hours. The tool has the geometric details of NJ freeways. It provides users the following applications:

- Volume information on selected links at a given time period on any given date.
- Link characteristics (such as number of lanes, AADT, milepost, link length).
- A function that generates lane closure schedule for selected link based on the hourly volume data processed by the Rutgers Intelligent Transportation Systems (RITS) team.
- A simple visualization function that shows the extent of expected delays as a result of lane closure and possibility of spill back onto the upstream links all in the form of link colors.
- Integrated lane closure cost estimation function.

The developed tool provides the NJDOT with a simple and interactive way to navigate visually along the freeways and gather link and volume information and estimate the impact of lane closure scenarios at selected locations.

LITERATURE REVIEW

The literature review focused on the methods used to measure capacity and the factors that affect capacity at work zone areas. The literature review also focused on the analysis tools developed to assess the traffic impacts at work zones in various States.

Existing Guidelines for Measuring Capacity at Work Zones

Several studies were found to address the estimation of remaining capacity at work zones based on several factors such as ratio of heavy vehicles, number of lanes closed and intensity of work zone activity, etc. Table 1 summarizes several studies on work zone capacity:

Table 1. Studies on work zone capacity

Study	Year	Location	# of Work Zones	Length of Study	Capacity at Work Zone
Krammes and Lopez	1992	Texas	33	4 years	1600 pcphpl
Dixon et al.	1996	North Carolina	24	9 months	1440 pcphpl
Yi	1999	Indiana	4	19 months	1258-1689 pcphpl
Maze et al.	2000	Iowa	1	19 days	1400-1600 pcphpl
Al-Kaisy et al.	2000	Ontario	2	3 days	1750-2150 pcphpl
Kim et al.	2001	Maryland	12	Not reported	1228-1790 pcphpl
Schnell et l.	2002	Ohio	4	Not reported	866-2982 vphpl
Al-Kaisy, Hall	2003	Ontario	6	Different for sites	1853-2252 pcphpl
Sarasua et al.	2004	South Carolina	23	1 year	1460 pcphpl
Benekohal et al.	2004	Illinois	11	1 day	597-1294 vphpl
Lee et al.	2008	Wisconsin	8	4 months	1134-2643 pcphpl
Heaslip et al.	2008	Florida, Massachusetts	2	7 and 10 days	1245-1992 vphpl

Research by Krammes and Lopez (2) developed capacity values for short-term freeway work zone lane closures using data collected at 33 work zone sites in Texas between 1987 and 1991 for three to one, two to one, four to two and five to three work zone lane configurations. This study recommended a base capacity value of 1,600 passenger cars per hour per lane (pcphpl) for all short-term freeway lane closure configurations. Several adjustments were made to the base capacity value including adjustments for intensity of work activity, effect of heavy vehicles, and presence of ramps when applying to specific work zone location.

A study by Dixon et al.[3] estimated work zone capacity values for rural and urban freeways in North Carolina This study found that intensity of work zone activity and type of study site, i.e., rural or urban, had strong affects on work zone capacity. This study found that for two to one lane operation in rural sites with heavy work intensity, capacity was 1,210 vehicles per hour per lane in the activity area, where as in urban area with same lane operations under moderate and heavy work zone intensity, activity area capacity were 1,560 vehicles per hour per lane and 1,490 passenger cars per hour lane, respectively. This study reported an activity area capacity of 1,440 passenger cars per hour per lane for moderate work intensity in urban sites.

Jiang [4] assessed vehicle speeds and queue-discharge rates at work zones In addition to traffic capacity. The traffic data collected from four different work zones on Indiana four-lane freeways used. Low vehicle speeds and fluctuating traffic flow rates are indication of congestion at work zones. Therefore, work zone capacity was defined as the traffic flow rate just before a sharp speed drop, followed by a sustained period of low vehicle speed and fluctuating traffic flow rate. Study results indicated that capacity at work zones varied between 1,258 and 1,689 passenger cars per hour per lane, and also heavy vehicle ratio has effect on the capacity.

Al-Kaisy and his colleagues [5] investigated freeway capacity at a reconstruction site with long-term lane closures. They also considered the effect of some important control and extraneous variables such as temporal variation, grade, day of week, and weather conditions. They used data from a construction site on Gardiner Expressway in Ontario at each direction. Normal three lane configuration was reduced to two at the construction zone in each direction and approximate length of work site in each direction was 1,640 feet. As a result of the study, they found that the capacity varied within a wide range between 1,750 and 2,150 pcphpl and with mean values of 1943. Later, Al-Kaisy and Hall [(6)] added for different construction site in Ontario to this data. Individual investigations were used to estimate a base capacity for freeway reconstruction sites and determine the effect of important factors including heavy vehicles, driver population, rain, site configuration, and work zone activity. A generic work zone capacity model (R^2=0.63) was created for freeway reconstruction sites using a base capacity value of 2,000 passenger cars per hour per lane for reconstruction sites under favorable conditions with heavy vehicles and driver population exhibiting the effect on capacity.

Maze et al. [(7)] investigated a work zone on a rural interstate highway (I-80) at Iowa, to measure the volume of vehicles that can pass through a work zone lane closure prior to and during congested operations and to understand driver behavior at a work zone. They collected data for 19 days on the work zone. To find maximum capacity at the work zone, the average volume of the ten highest volumes immediately before and after the queue is taken. They found that the capacity at the work zone varies between 1,400 to 1,600 pcphpl.

Kim et al. [(8)] developed a new methodology to estimate capacity for freeway work zones that examined various independent factors that contribute to capacity reduction in work zones. Data were collected at 12 work zone sites with lane closures on four normal lanes in one direction, mainly after the peak hour during daylight and night. A multiple regression model was developed to estimate capacity on work zones for establishing a functional relationship between work zone capacity and several key independent factors including number of closed lanes, proportion of heavy vehicles, grade, and intensity of work activity. The stepwise regression analysis of the proposed model was promising with a R^2 value of 0.993. Model results were also compared with existing capacity models using the root mean square (RMS) error, and showed the new capacity estimation model is better than the others, which exclude key independent factors affecting work zone capacity.

Schell et al. [9] studied feasibility of commercially available traffic simulation and prediction tools at work zones for Ohio Department of Transportation. The simulation and prediction tools used in the study include HCS, Synchro ,CORSIM ,NetSim and QueWZ92.They collected field data from 4 different work zones (2 interstate and 2 state) at highways in Ohio. The values obtained from the field data are compared with the outputs of each tool. They found that although they are visually appealing, simulation packages: Synchro and CORSIM have inaccuracies in prediction of queue lengths. In the study, it is reported that none of the tools except QueWZ92 and ODOT Spreadsheet are designed for modeling work zones operating at or above capacity.

Karim and Adeli [10] developed an adaptive computational model for estimating the work zone capacity and queue length and delay. In their model, they proposed various factors that affect the capacity such as the number of lanes, number of open lanes, work zone layout, length, lane width, percentage of trucks, grade, speed, work intensity, darkness factor and the proximity of ramps. A radial-basis function neural network model was developed to learn the mapping from quantifiable and non-quantifiable factors describing the work zone traffic control problem to the associated work zone capacity.

Ullman and Dudek [11] developed a theoretical approach for estimating queue length during short-term road work on urban freeways. They argued that although the traditional approaches, basically macroscopic work zone analysis tools, work well for rural and suburban work zones, they may severely overestimate traffic queues. This is mainly due to entrance and exit ramps are spaced relatively far apart whereas in urban areas the ramps are closely spaced which enable users to take many diversion opportunities and routes. Their model is based on macroscopic fluid-flow analogies of traffic and consideration of the freeway corridor as a section of permeable pipe. This model also calibrated to represent the magnitude of traffic queues at work zones on freeways in Texas.

Sarasua et al. [12] investigated various factors affecting capacity of short-term lane closures for Interstate work zones in South Carolina. In this research, they were developed to assess current practices for short-term work zone closures on the Interstate system and they distributed this survey to transportation agencies in all states, Puerto Rico, and the District of Columbia. Although eleven surveys were returned to them, they provide information especially about threshold lane volume used by agencies. Below table shows the formally adopted threshold lane volume by agencies:

Table 2. Threshold lane volumes adopted by DOTs

State	Threshold Lane Volume
Connecticut	1,500 to 1,800 vphpl
Missouri	1,240 vphpl
Nevada	1,375 to 1400 vphpl (7% trucks)
Oregon	1,400 to 1,600 pcphpl
South Carolina	800 vphpl
Washington	1,350 vphpl
Wisconsin	1,600 (rural) and 2,000 pcphpl (urban)

Later, they collected the field data (flow, speed and queue length) at 23 work zone sites, which had 2, 3 or 4 lane roads and different lanes were closed at each site, for one year. Then, using the passenger car equivalent flow and speed data, they developed a model which can estimate the capacity at work zones based on vehicle make up, number of lanes open at the work zone and work zone intensity.

Adeli [13] conducted a study to model work zone capacity using a case-based reasoning model for freeway work zone traffic management that considered work zone layout, traffic demand, work characteristics, traffic control measures, and mobility impacts. An adaptive computational model was created for estimating work zone capacity, queue length and delay.

Benekohal et al. [14] presented a methodology for estimating speed and capacity in freeway work zones. The underlying principle of this methodology is that operating factors in work zones, which include work intensity, lane width, lateral clearance, and other factors, cause motorists to reduce their speed. Video data were collected for 11 two-to-one work zone lane closures on interstates in Illinois including eight long-term and three short-term sites. Work zone intensity was quantified and correlated with consequent speed reduction using field data for long-term work zones and driver survey data for short-term work zones. Based on these relationships an anticipated work zone operating speed can be computed using a speed-flow relationship developed from project data.

Lee et al. [15] developed a tool to predict delays and queues for short-term lane closures. In order to evaluate and enhance their tool, they collected field data which contains information about traffic flow and queuing patterns during work zone operations on selected urban freeways. The field data showed that capacity of roadway changes between 1,134 pcphpl and 2,643 pcphpl depending on number of lanes closed, intensity of work zone activity.

Study by Heaslip et al. [16] proposed an enhanced methodology for assessing capacity at work zones. They investigated the impact of driver behavior at work zones and they found that driver behavior influences flow quality when drivers encounters to changing roadway conditions and lane configurations. For this study, the data collected from two highways, one in Florida for ten days and the other in Massachusetts for seven days. The observations showed that the average capacity is 1,992 vphpl for Florida site whereas 1,245 vphpl for Massachusetts site. Later, based on the field observations they calculated the driver behavior factor which is based on assessment of tendencies such as driver familiarity, driver adaptability, driver aggressiveness, and driver accommodation tendencies that are unique for different demographic groups.

Work Zone Traffic Impacts Assessment Tools

Several tools are available for estimating the effects of various transportation projects. These tools vary in level of complexity, and each tool offers different capabilities. Some tools were designed specifically for work zone applications. Other traffic analysis tools, although not designed specifically for work zones, can be used for to analyze work zone situations. This section includes information on both of these types of tools.

Highway Capacity Manual (HCM) 1994

HCM reports the range of observed capacities and the corresponding average capacities of freeway work zones in Texas. It demonstrates graphically how to estimate the number of vehicles in the queue and the queue length. The procedure requires low input data requirement and ease of use. However the capacity values are outdated, since the capacity charts were determined for work zones in Texas that were conducted before 1982.

Highway Capacity Manual (HCM) 2000

For short-term work zones, HCM 2000 suggests a base capacity value of 1,600 pcphpl that was obtained from work zone studies conducted in Texas. The manual suggests applying adjustment factors for intensity of work zones, the percentage of heavy vehicles and the presences of ramps in the vicinity of the work zone.

The advantage of HCM 2000 is the low input data requirement, ease of use and quick output capabilities. However, the manual does not provide any approach for estimating queue lengths. Also, the capacity values and the adjustment factors may not apply to all work zones. Also the effects of traffic diversion cannot be obtained due to the simplistic nature of the inputs.

Spreadsheet Models

Several Department of Transportation (DOT) offices adopt spreadsheet-based tools for estimating the impacts of work zones. The spreadsheets estimate delay and queue lengths as the main output values using the graphical procedures explained in the HCM. Calculations are usually carried in MS Excel. For example, NJDOT uses these tools, where the inputs include traffic demand for each hour, the number of open lanes, roadway capacity, percentage of trucks, the work zone layout (24). These tools require very few inputs and give quick results. However, they too cannot account for the effects of traffic diversion, therefore overestimate the duration of delay and queue lengths.

DELAY Enhanced 1.2

DELAY Enhanced 1.2 is an application developed by FHWA's Utah division to estimate the traffic impacts of incidents. The model is applicable to work zones as well. The tool uses the same deterministic queuing model used by the other available tools. It requires minimal input data, presents results quickly. The program has the disadvantage of all the HCM-based models.

QUEWZ

Queue and User Cost Evaluation of Work Zones (QUEWZ) was developed by the Texas Transportation Institute. This tool can estimate the capacity of the work zone when work activity is present using the HCM2000 model for short-term work zone capacity. It also has a speed-volume relationship. It estimates the queue length and queue delay using arrival departure plots. QUEWZ can estimate the work zone capacity, average speed, average queue length, travel time costs for a given lane closure schedule at a work zone. It calculates the queue lengths based on the methodology given in HCM 1994. The tool needs slightly more input data as compared to the earlier methods. It is easy to use and to obtain results quickly. It also has a simplistic diversion algorithm.

QuickZone

QuickZone, developed by Noblis (formerly Mitretek) using FHWA funding, is referenced in the FHWA guidelines as one of several suggested tools to determine work zone delays [1]. QuickZone is coded as a program within MS Excel. The program considers traffic engineering parameters as specified in the Highway Capacity Manual such as volume, truck percentage, lane width, etc. It has been widely used by other State and local DOTs in the USA and thus it is well tested and validated. Current partners of FHWA using QuickZone are Maryland SHA, CFLHD, Pennsylvania DOT, Ohio DOT, Wisconsin DOT, Washington DOT, Utah DOT, North Carolina DOT. Data requirements for QuickZone are well established and flexible enough to accommodate projects with minimal available data as well as projects that have a wealth of detailed data. It is comprehensive and highly detailed. It incorporates various factors that have impacts on traffic delays at work zones.

QuickZone provides analysis options to estimate work zone delays and user costs for different demand patterns and for temporal (seasonal, weekly, daily) and spatial variations of work zone configurations. It can quantify corridor delay resulting from capacity decreases in work zones; identify the impact on delay of alternative construction phasing plans; and support tradeoff analyses between construction costs and delay costs. Work zone impacts and costs are estimated for an average day of work, which can then be amortized to get an estimate of average annual costs based on a user-specified life-cycle for the improvement. It can assess the impact of delay-mitigation strategies, such as alternate routing, signal re-timing, lane widening, and ramp metering. In addition to estimating work zone delays and user costs, QuickZone also provides a sketch-planning analysis of travel behavioral changes in response to work zones. QuickZone also supports the calculation of work-completion incentives.

Microscopic Simulation Tools

Microscopic simulation models simulate the movement of individual vehicles, based on theories of car following and lane-changing. Typically, vehicles enter a transportation network using a statistical distribution of arrivals (a stochastic process), and are tracked through the network over small time intervals (e.g., one second or fraction of a second). Typically, upon entry, each vehicle is assigned a destination, a vehicle type, and a driver type. In many microscopic simulation models, the traffic operational characteristics of each vehicle are influenced by vertical grade, horizontal curvature, and super-elevation, based on relationships developed in prior research. Computer time and storage requirements for microscopic models are large, usually limiting the network size and the number of simulation runs that can be completed. Examples of microscopic simulation models include Traffic Software Integrated System/Corridor Simulation (TSIS/CORSIM), INTEGRATION, SimTraffic, Wide Area Traffic Simulation (WATSim), VISSIM, and Parallel Microscopic Traffic Simulator (PARAMICS).

Figure 1 shows the spectrum of the analysis tool described above. It includes ten tools currently available that could be used to address the “soft cost” of roadway construction projects. Each of these tools is placed on a continuum from simple to complex. Simpler tools include the categories of sketch planning and analytic while more complex tools include regional travel demand models (TDM) and general-purpose traffic simulations.

Table 3 shows the summary of the survey conducted by the Virginia Transportation Research Council in 2006 regarding the current practices used by nineteen states for assessing the traffic impacts at work zones. Table 4 shows the current practices performed by ten more states compiled by Edara and Cottrell [17]. The most common tool for determining the capacity at work zone bottlenecks appears to be the experience of the DOT staff. For the estimation of traffic impacts, HCM- based tools and spreadsheets are the most popular among DOTs.

Table 3. Responses from State DOTs regarding current practices for assessing work zone traffic impacts [17]

State	Tools Used for Estimating Capacity	Tools Used for Estimating Traffic Impacts: Queues and Delays
Colorado	Guidelines in the "Lane Closure Policy" document	Synchro/Sim Traffic and HCS
Delaware	HCM	Delaware Transportation Model, HCS, Synchro, CORSIM
Florida	Chapter 10 of FDOT's Plan Preparation Manual and HCS 2000	Chapter 10 of FDOT's Plan Preparation Manual and HCS 2000
Hawaii	HCM	• HCM and experience • QuickZone in the future
Kansas	None Experience, if any	None
Kentucky	Experience, no formal procedure	• No formal procedure • Rare use of CORSIM
Maine	Experience and HCM 1994	• Spreadsheet and Synchro/SimTraffic for partial closures • TRIPS (Travel Demand Model) for full closures of bridges or highways
Massachusetts	Start with base capacity value and apply adjustment factors for lane widths, truck percentages, grades, etc. (similar to HCM)	• Spreadsheet model (BASICQUE) based on 'Planning and Scheduling Work Zone Traffic Control' publication of FHWA (Chapter 2, page 15), published in 1981 • Also use QuickZone, TRANPLAN for complex projects
Montana	No estimation	HCM, if used
Nevada	HCM 2000	• Currently Synchro, CORSIM, HCM • QuickZone in the future
New Jersey	HCM 1994	Spreadsheet based on HCM
Ohio	QUEWZ-98	Ohio DOT Spreadsheet
Oregon	• Currently experience • Actual traffic counts in future	• Currently CORSIM • Aim to develop graph from CORSIM results and validate it with field data
Rhode Island	HCM 1997	• Mostly HCM and experience • Occasionally QuickZone
Tennessee	Mix of actual traffic counts and HCM procedures	Web-based Queue/Delay Prediction Model under development
Texas	QUEWZ	QUEWZ and CORSIM
Washington	Mix of actual traffic counts and HCM procedures	• Primarily QUEWZ • Limited use of QuickZone
Wisconsin	Experience and literature	Mainly spreadsheet based on HCM, but occasionally CORSIM and QuickZone
Wyoming	HCM and Synchro	HCM and Synchro

Table 4. Current practices for assessing work zone traffic impacts in selected DOTs [17]

State	Tools Used for Estimating Capacity	Tools Used for Estimating Traffic Impacts: Queues and Delays
Alabama		Oklahoma DOT Spreadsheet
Arizona		(QUEWZ)
Arkansas		(QUEWZ)
California	Experience and HCM	Spreadsheet based on HCM
Illinois	(HCS 2000, SIG/Cinema, HCM, and QUEWZ)	(HCS 2000, SIG/Cinema, HCM-based Spreadsheet, QuickZone, and QUEWZ)
Indiana	(Past data, HCM)	(QUEWZ, QuickZone, Synchro, CORSIM)
Maryland	MD-QuickZone (modified QuickZone) using HCM Value or University of Maryland Model or any user defined value	MD-QuickZone (modified QuickZone)
Oklahoma		Spreadsheet based on HCM
Pennsylvania		Actively using QuickZone
Utah		DELAY Software for small projects, MINUTP (comprehensive planning model) for large projects

Indiana Department of Transportation (INDOT) developed interstate highways lane closure policy to eliminate or reduce delays caused by the work zones. This policy applies to all individual contractors. With this policy, INDOT is required to accept some increases in project costs. The cost increases in order to comply with the policy may include permanent lane additions and/or bridge widening or the use of accelerated construction methods and materials.

INDOT lane closure policy encourages the use of a microscopic simulation model for the modeling of work zone queues.

The following thresholds are used for the evaluation of project queue lengths as determined by the computer model [18]:

1. For queues less than 1.0 mile, the work zone impacts are acceptable.

2. For queues greater than 1.0 mile and less than 1.5 miles, the work zone impacts are acceptable if the queue exceeds 1.0 mile for two hours or less. Additional advanced work zone warning signs are required where queues are expected.
3. For queues longer than 1.0 mile for more than two hours or longer than 1.5 miles for any period of time, the work zone impacts are unacceptable.

California Department of Transportation (CALTRANS) requires Transportation Management Plans (TMP) including contingency plans for all construction, maintenance, encroachment permit, planned emergency restoration, or other activities on the State highway system [(19)]. These TMPs are considered early, during the project initiation or planning state. TMPs are expected to minimize project related traffic delay and accidents. The work zone delay policy includes the following two criteria:

1. Major lane closures are expected to result in significant traffic impacts despite the implementation of TMPs. However, there are no specifications of the magnitude of the traffic impacts.
2. Significant traffic impact is considered as 30 minutes above normal recurring traffic delay, or the delay threshold set by the District Traffic Manager, whichever is less.

CALTRANS uses PARAMICS micro simulation software to determine the traffic impacts of various lane closure scenarios before the implementation of each project. Two ongoing projects funded by CALTRANS, I-710 in Long Beach, and I-15 in San Bernardino have illustrated the benefits of using PARAMICS as part of the traffic analysis for construction delays. In addition to the impressive visualization capabilities offered by the graphical user interface, the traffic simulation software provides a powerful analysis tool to quickly and accurately evaluate a large number of freeway reconstruction scenarios and associated traffic management plans

British Columbia Ministry of Transportation uses the following policy for the acceptable delays caused by lane closures [(20)]:

1. Minor Delays: Less than 2 minutes in duration; for occasional interruption due to construction activities. These delays shall be coordinated with available breaks in the traffic flow.
2. Major Delays: Maximum 10 minutes in duration; for occasional interruption of traffic for construction activities, between 2 a.m. and 4 a.m. only. Activities that are anticipated to require Major Delays shall be indicated in a Traffic Control Plan; as well, traffic control measures to be deployed for these activities shall be specified in the Traffic Control Plan.

Acceptable delays are approved by the District Highway Manager and only considered outside peak hours.

Ohio Department of Transportation (ODOT) employs QUEWZ modeling tool to estimate the traffic impacts of work zones. ODOT uses the following criteria for the acceptable delay caused by lane closures (21):

1. For queues less than 0.75 miles, the work zone impacts are acceptable.
2. For queues greater than 0.75 miles and less than 1.5 miles, the work zone impacts are acceptable if the queue exceeds 0.75 miles for two hours or less. Where queues are expected to exceed 0.75 miles for any period of time, additional advanced work zone warning signing should be specified.
3. For queues longer than 0.75 miles for more than two hours or longer than 1.5 miles for any period of time, the work zone impacts are unacceptable. Alternate strategies shall be considered per the provisions of this policy.
4. A vehicle will be considered part of a queue if its average operating speed is approximately 10 mph or less.

New Jersey Turnpike Authority follows the following guidelines during the short-term work zones on New Jersey Turnpike network.

- Define the length and the number of lanes in the closure.
- Define dates and times of closure.

- Define the roadway section (Route and mileposts) where lane closure will take place.
- Define the location of the lane closure in term of mileposts (taper to open roadway).
- Develop a 24-hourly volume (including truck percentage) for a typical weekday for the lane closure area.
- Compute volume/capacity ratio (v/c) for each hour during a typical weekday without closure.
- Use lane capacity at 1,800 vehicles per hour (truck equivalency of 2.0).
- Compute queuing and delays for vehicles approaching the lane closure area (Road User Cost Manual spreadsheet – see reference 10).
- Do not allow lane closure if the queue is longer than 0.25 miles.
- Provision should be made to identify traffic patterns on weekends (additional recreational traffic) if lane closure is planned for weekends.
- It is recommended that lane closure area be limited to 3 miles at a time.
- There should not be another lane closure on the same roadway in an area less than two miles from another closure area.
- Lane closure hours could be cancelled or modified during adverse weather forecast for the following conditions:
    - Snow accumulation of more than 2 inches
    - Low visibility less than ¼ of a mile due to fog
    - Heavy winds with gusts of 20 MPH or more
    - Heavy rain that could cause flooding problems

Lane closure hours could be cancelled or modified if major accidents or incidents occurred resulting in lane closure in an area less than 2 miles from the planned lane closure.

SOFTWARE FOR LONG TERM LANE CLOSURES: QUICKZONE

It is important to briefly describe QuickZone, since it is the centerpiece of delay and cost / estimation methodology for this study.

QuickZone provides an easy-to-use, easy-to-learn tool that utilizes software interfaces that are familiar to the users of spreadsheet applications. QuickZone is a Microsoft Excel-based application. The use of Excel obviates the need to develop a customized user interface from scratch, and the workbook application may be distributed free without royalties or license from Microsoft. The prospective QuickZone analyst need only have Excel97 or higher running on a Windows-based PC with minimal memory and processing speed requirements. In order to accomplish the goal of less than three minutes to analyze the data and produce delay profiles over the project duration, the following system requirements are needed: 1) PC running Microsoft Windows 95 or higher with monitor, mouse and keyboard and 2) Microsoft Excel 97 or later. For larger networks we recommend processor speeds of at least 500 MHz.

In addition to the system requirements, it is recommended that display settings of the computer monitor be set at a minimum resolution of 800 x 600. All of the QuickZone worksheets and the code modules have been password-protected to ensure that the user does not overwrite key system elements. It is recommended that the QuickZone program be opened after the Excel program has been started (File/Open…) to help with the computer and memory resources that QuickZone requires. Finally, when opening the QuickZone program, users must ensure to enable macros within Excel; otherwise, the QuickZone program will not work. (Note: for those reluctant to open Microsoft Excel macros due to virus threat, it is recommended that you satisfy yourself that the application is virus-free prior to use; however, the developer and distributor have been scrupulous in verifying the absence of viruses in the macros.) The QuickZone development and validation timeline is given in Figure 3.

Validation of QuickZone

As shown in Figure 3, QuickZone went through several development cycles and have been improved over time. One of the main advantages of this relatively long development cycle is the fact that QuickZone was used by many agencies for real projects and extensively validated. An important aspect of developing any new modeling tool is validating the results against real-world conditions. For example, a customized version of the software developed for application in Federal Lands projects, FLH-QuickZone, the validation effort focused on the new features customized for FLH application, in particular the ability to accurately predict queue length and delays under 2-way, 1-lane operations.

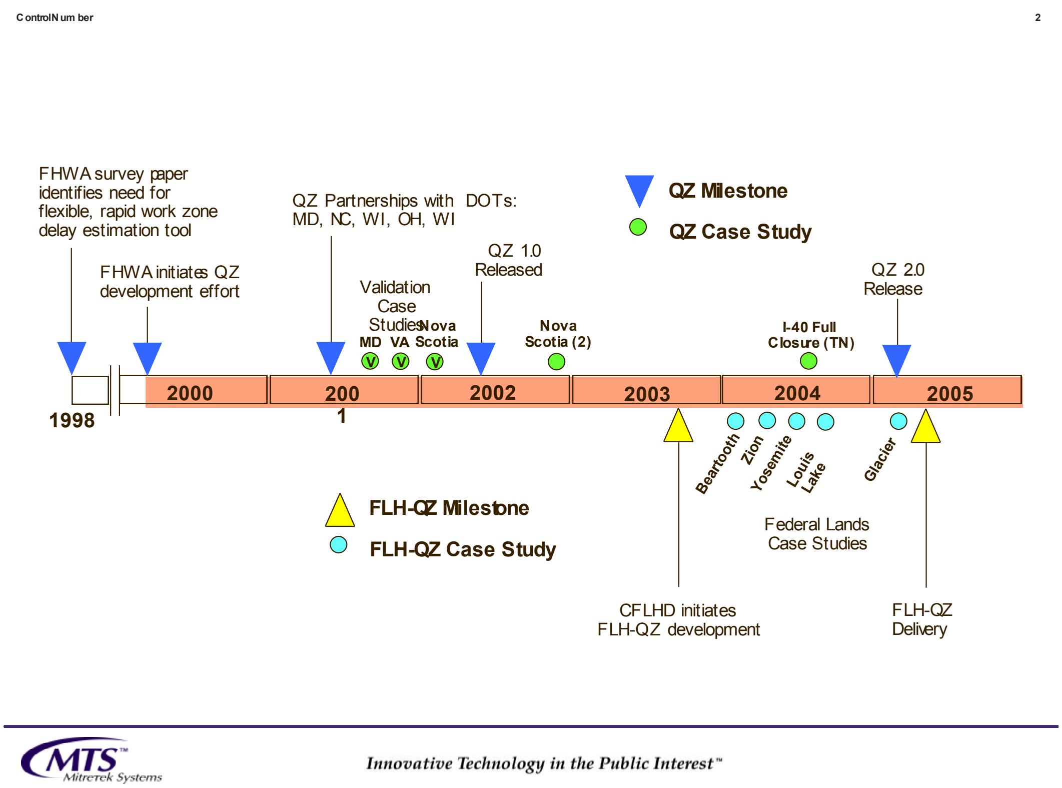


Figure 3. QuickZone development timeline

FLH-QuickZone was validated based on queue length, flow and delay data collected in conjunction with NPS staff at Glacier National Park. In August 2005, the NPS collected data at a current work zone operation along the Going-to-the-Sun-Road in Glacier National Park. Two three-hour data collection events were undertaken at the direction of

NPS staff using summer students, with the goal of validating key FLH-QuickZone parameters such as work zone capacity and work zone speed. The data collection activity also monitored delays and queue length development to verify the outputs of FLH-QuickZone for the GTSR analysis.

Initial estimates were made on certain input parameters such as demand, jam density and roadway capacity. Initial results of FLH-QuickZone (primarily queue length) using these parameters tended to overstate delays and queue lengths because the assumptions about work zone operations were more conservative than those implemented in the field. Once these input parameters were adjusted to more accurately reflect work zone operations (that is, input parameters were better calibrated), user delay and queue length estimates generated by FLH-QuickZone were within 5 percent of actual conditions; consistent with other QuickZone validation efforts in urban settings.

As of January 2005, there were more than 100 copies sold to over 75 different organizations plus seven partner states. Mitretek estimates 150+ users nationwide and even more worldwide. This user base has generated a wealth of information on applications and provided us with a pool to drawn on when deciding how to improve the model. In addition, FHWA has tracked a number of State DOT (green) and Federal lands (cyan) case studies where QuickZone has been successfully applied to a local work zone problem. In some of these case studies, data collection during the construction phase has helped to validate the queues and delays predicted by QuickZone.

Major QuickZone applications include:

1. Urban Freeway
   - Knoxville, TN: I-40, full closure analysis (green circle in Figure 2).
   - Maryland/Virginia Woodrow Wilson Bridge: I-95 (green circle in Figure 2).
2. Urban Arterial
   - Little Bras d’Or Bridge: Nova Scotia, Canada (green circle in Figure 2).

- Reeves Street: Nova Scotia, Canada green circle in Figure 2).

3. Rural High AADT
   - Yosemite National Park (cyan circle in Figure 2).
   - Zion National Park (cyan circle in Figure 2).
4. Rural Low AADT
   - Beartooth Highway (cyan circle in Figure 2).
   - Louis Lake Road (cyan circle in Figure 2).
5. Other Applications
   - Pennsylvania I-80.
   - ITS Technology Assessment.

These applications and the corresponding characteristics of the QuickZone models are given in Table 5.

Table 5. Study comparison matrix (http://quickzone.mitretek.org/updates/)

	AADT	Traffic Control Elements				QuickZone Network Model	Purpose		Objective (for use of QuickZone)	QuickZone Version
		Partial Closure	Full Closure	Flagging	Detour		Planning	Operations		
Urban Freeway										
Knoxville, TN: I-40	High	X	Long Duration		X	Large, Complex	X		Determine feasibility of full closures option for a congested urban freeway.	V 1.0 Summer 2004
Maryland/Virginia Woodrow Wilson Bridge: I-95	High	X				Medium, Complex		X Results of QuickZone verified in field.	Analyze additional construction staging strategies to maximize time for contractor in work zone without impacting motorists.	MD-QuickZone Fall 2001
Urban Arterial										
Little Bras d'Or Bridge: Nova Scotia, Canada	Medium			X		Small, Simple		X Results of QuickZone verified in field.	Determine feasible construction times to limit impact on motorists.	V 0.99 Beta Summer 2001
Reeves Street: Nova Scotia, Canada	Medium			X		Small, Simple		X Results of QuickZone verified in field.	Justify additional cost of night work by quantifying delays expected from planned daytime roadwork.	V 1.0 Winter 2002
Rural High AADT										
Yosemite National Park	High	X	Long Duration	X		Medium, Complex	X		Alternatives analysis comparing one-season and two-season construction phasing.	QuickZone-CFLHD Spring 2004
Zion National Park	High	X				Small, Simple	X		Analyze various construction staging scenarios.	QuickZone-CFLHD Spring 2004
Rural Low AADT										
Beartooth Highway	Low		Periodic	X		Large, Complex	X		Analyze overall construction impact on motorists resulting from multiple work zones.	QuickZone-CFLHD 2003 - 2004
Louis Lake Road	Low		Periodic	X	X	Large, Simple	X		Estimate economic loss and delays from a work zone with a lengthy detour.	QuickZone-CFLHD 2004

The utilization of QuickZone is not relegated to just one type of roadway facility or location. QuickZone can be used for multiple applications including:

- Rural or Urban.
- Big Projects/Small Projects.
- Operations and Planning.
- Freeway and Arterial.
- Single Work Zones to Projects with Multiple, Interacting Work Zones.
- Full and Partial Lane Closures, Flagging Operations, Periodic Full Closure.
- Projects with Good Detour Routes.
- Projects with No Detour Routes.

QuickZone has the capability to calculate user and economic costs resulting from construction activity. Conducting a cost analysis using QuickZone is optional and is not required in order to analyze queuing and delay impacts. Also, QuickZone will generate useable user and economic cost impacts by utilizing the default values within QuickZone. In order to conduct a detailed cost impact analysis, there are five categories of user and economic costs required: travel time delay costs, vehicle operating costs, inventory costs, economic costs, and other costs.

Detailed travel demand and other project data may not always be available for every project. QuickZone is designed to allow the inclusion of project-specific data when available and provide default values when data are not available. Each of these default values is based on the best available data.

In many cases, default values come from a document or report that is updated periodically, e.g., annually or every few years. The analyst should always ensure the most current references are used. For example, travel time cost is a function of the nationwide average hourly wage, which is available in a report entitled, “National Compensation Survey – Compensation Cost Trends,” which is published annually by the U.S. Department of Labor Statistics. QuickZone allows the user to check the reference of each default value and also to update its source information including the date it was last updated. A comment box is provided for each user and economic cost component for the analyst to record any notes for later reference. A brief description of User and Economic Cost resources is provided in Appendix of this report [2].

Within the User and Economic Cost Modules, the grayed out text boxes have figures that are either filled in automatically by QuickZone from default values or from inputs in other parts of the program. For example, within the Travel Time Delay Costs screen, percent of cars and trucks is input in the travel demand module; average vehicle occupancy is a default value that is unchangeable from this screen.

Travel Time Delay Costs

The only inputs required for delay costs are percent business trips vs. percent personal trips for cars, and percent local trips vs. percent intercity trips for personal trips. Percent of cars and trucks should already have been input in the travel demand module. If percent of cars and trucks has not yet been input before arriving at this screen, QuickZone will prompt the user to input these values first. Trip purpose and trip length can come from origin-destination surveys, or they can be estimated if such data collection is not possible. Details on how cost per hour of delay is calculated from these inputs are provided in the User Costs Literature Review. An abbreviated explanation will be available by the QuickZone user by clicking the “Help” button on the lower right of the input screen. The default values used in the cost calculations may be updated by selecting the “Update Default Values” button on the lower right of the input screen.

The calculation of delay costs, vehicle operating costs, and inventory costs, each rely on a set of default values. By selecting “Update Default Values” from the input screen, a form for viewing and updating the default values is shown. For delay costs, as shown above, the default values are average vehicle occupancy for business and personal trips, wage rate information, and wage rate multipliers. Source data for each value or calculation methodology is provided in a text box beside each set of default values. As new data become available, this source information can be updated and saved into the program for subsequent projects.

The input screen for vehicle operating costs does not actually need any additional input from the analyst beside the percentage of cars and trucks, which is input in the travel demand module, and the vehicle operating cost per mile for each vehicle type, which are default values.

Default values for vehicle-operating costs are cost per mile for trucks, light duty trucks/SUV's, and cars. The calculation of vehicle operating costs takes the breakdown of light duty trucks vs. cars, calculates a cost per mile for non-truck traffic, and applies it the percentage of cars in the traffic stream. It then takes the cost per mile for trucks and applies it to the percentage of trucks. The weighted average by vehicle mix (95% trucks, 5% cars in this example), gives a cost per vehicle-mile for all traffic demand. This is then applied to any traffic diverting to a detour. The total vehicle operating cost for the work zone is the cost per vehicle-mile times the volume taking the detour times the additional distance traveled on the detour compared with the work zone route.

Inventory Costs

Inventory costs apply to freight vehicles. Given that a truck's payload has value, there is a cost to it being delayed reaching its destination. This cost is the value of the payload amortized based on a discount rate. The inputs are average payload, average payload value, and discount rate. The default values used in QuickZone, which are based on the most recently available nationwide average freight statistics, may be changed to reflect region-specific or project-specific values. The discount rate is typically chosen to be the prime rate + 1% for this calculation. This value can be found in the Wall Street Journal or on any of a number of different financial web sites.

Economic Costs

Economic cost is proportional to the reduced traffic flow to affected businesses. Daily revenue in the area of reduced traffic flow due to the work zone is input here. Different values can be input for each month. This is to allow for projects where demand is highly seasonal, which includes most projects. This data should be collected as part of the environmental impact assessment. Sources will vary by the nature of the project and the types of businesses in the project area. For example, important inputs for national parks will be entrance fee and concessions revenue.

SOFTWARE FOR SHORT-TERM LANE CLOSURES: RILCA

RILCA is a GIS based interactive lane closure tool that is intended for short-term lane closures in this project. The complete list of the highways included in RILCA is as follows: I-278, I-78, I-280, HWY 24, I-76/I-676, NJ 3, Atlantic City Expressway, Palisades Interstate Parkway, NJ 19, NJ 29, NJ 440, NJ 495, HWY 287, I-195, I-95, I-80 and I-295.

This chapter describes how to use RILCA in detail.

Getting Started

<u>Opening GIS Software</u>

In order to open the GIS application, open (double-click) the shortcut icon named **Shortcut to NJ-RILCA.mxd** on your desktop (See Figure 4).

Figure 4. Shortcut to GIS Application

The shortcut is linked to the application file named **NJ-RILCA.mxd** located in the folder **C:\NJ-RILCA\Shape Files**. This shortcut opens the GIS application as shown in Figure 5. The map is composed of following layers of GIS shape files:

1. NJTPK _Highways.
2. counties.

These layers are listed on the left column of the GIS window under the **Layers** menu as shown in Figure 6.

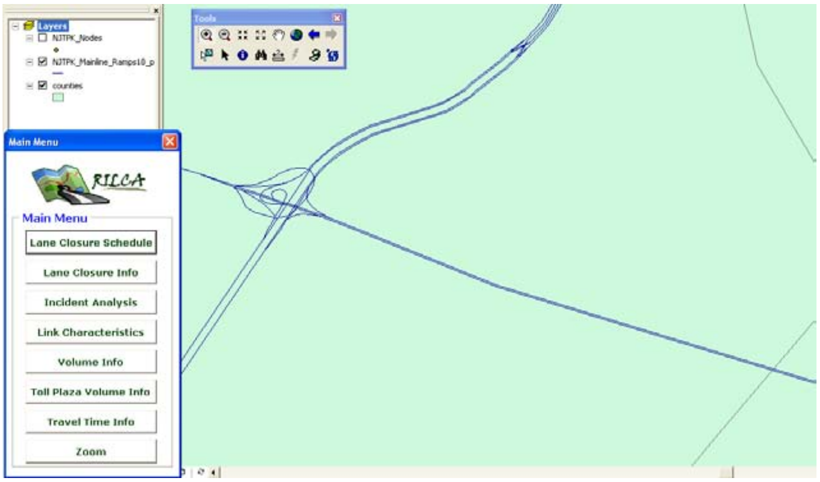


Figure 5. GIS application window

<u>Adding Missing Shape Files to the Document</u>

If any of the shape files are missing, follow the procedure shown below to add the corresponding shape files. For instance, if **Njnahighways** and **counties** shape files are missing in the **Layers** list will appear as shown in Figure 6.

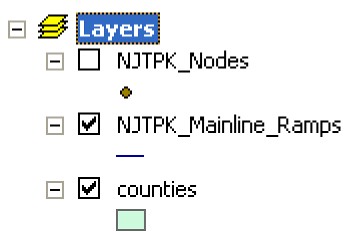


Figure 6. List of Shape files

1. Right-click on the Layers list and select the Add Data (see Figure 7)

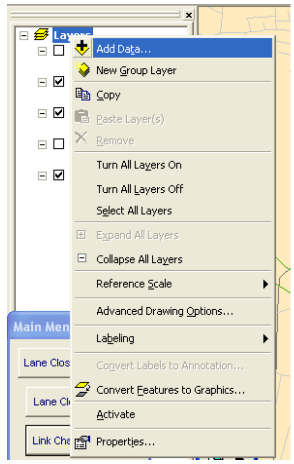


Figure 7. Add data to replace missing shape files

2. Then open the folder **C:\NJ-RILCA\Shape Files**, where the shape files are located (see Figure 8). The shape files have the extension ***.shp**.

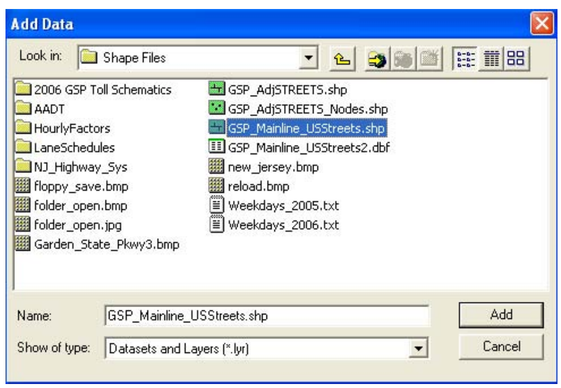


Figure 8. List of shape files in the main directory

3. In this folder all the shape files are present and the missing shape files can be selected and added to the document.

Please note that it is imperative to have the shape files in the same order. If they are present in a different order, the order can be adjusted by dragging (with the left mouse button held down) the shape file to the respective place.

Setting Selectable Layers

In order to set selectable layers in the main toolbar choose (see Figure 9).

1. Selection > Set Selectable Layers

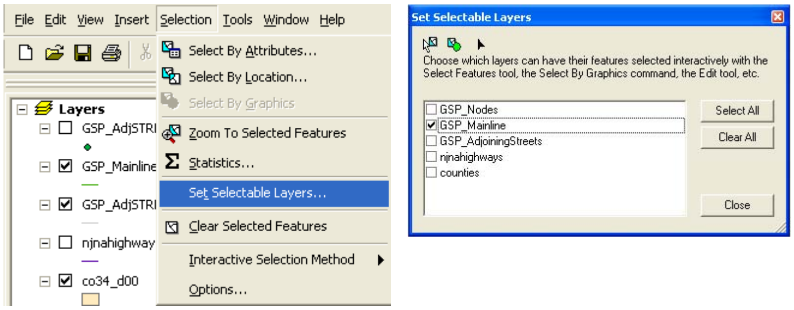


Figure 9. Setting Selectable Layers

2. Check the checkbox adjacent to the layer with name “NJTPK_Mainline_Ramps” and press “Close” button (see Figure 9).

After finishing the above changes, save the document, i.e. **File>Save**.

In the document the following options are present in the Main Menu present along the left edge of the document (as shown in Figure 10):

1. Zoom.
2. Link Characteristics.
3. Volume Info.
4. Lane Closure Info.
5. Incident Analysis.
6. Lane Closure Schedule.

Figure 10. Main menu

If the main menu is not visible, it can be activated using the RILCA button in the Menu bar located in the RILCA main window or using the shortcut in the **Tools** toolbar .

Application Features

<u>Zoom to Mile Post</u>

The window corresponding to the **Zoom to Mile Post** option is open automatically as the GIS tool is opened. If this window is not visible, it can be activated using the **Zoom to MP** button on the main menu (See Figure 10). Enter the milepost of the link that has to be selected in the textbox and press **Zoom** button. The link with the milepost entered is zoomed to in the map and selected and highlighted.

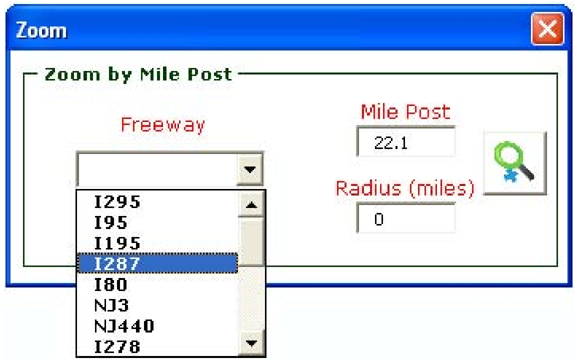


Figure 11. Zoom to MP

<u>Navigating</u>

The entire network can be viewed by clicking on the "Full Extent" icon in the **Tools** toolbar 

In order to zoom in a desired location in the network, select the "Zoom In" tool in the **Tools** toolbar and create a rectangle using the cursor around the target location in the map (See Figure 12).

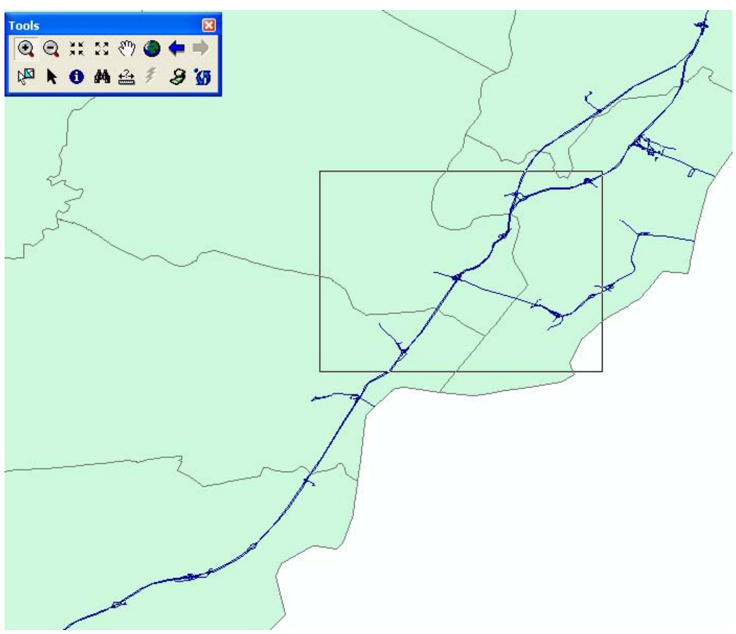


Figure 12. Zooming in the network

In order to navigate in the network, select the “Pan” tool in the **Tools** toolbar  and drag the window in the desired direction. “Go Back to Previous Extent” and “Go to Next Extent” tools can be use to select undo or redo the zooming actions. 

Link Selection

For all the other options in the Main Menu a link has to be selected. The following procedure is to be followed to select a link:

1. In the **Tools** toolbar, choose the “Select Features” tool, as shown in Figure 13.
2. Select the appropriate link using the mouse by clicking on the link. The selected link is highlighted after selection.

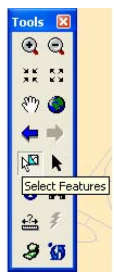


Figure 13. Select features icon in toolbar

Link Characteristics

After the selection of the link (using the procedure described above), press the **Link Characteristics** button in the **Main Menu** window. After selecting the time and the year information, the link characteristics are displayed in a tabular form on the screen. The link characteristics table includes (See Figure 14):

1. Milepost of the link.
2. Number of lanes.
3. Link Length.

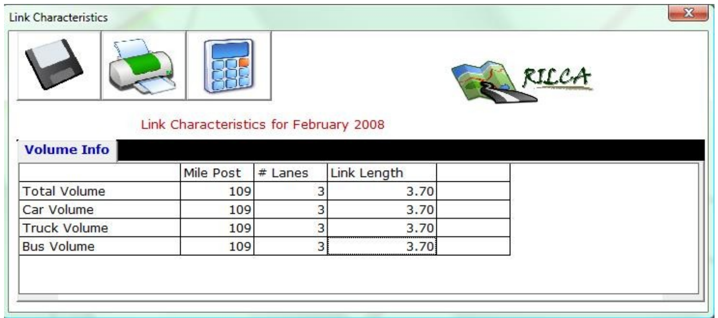


Figure 14. Link characteristics table

The columns of the table show the direction of each section (northbound or southbound) and whether the section is a part of the express or local sections, or cars only or cars/trucks lanes.

<u>Volume Info</u>

The volume information of a selected link can be obtained for a selected day, month, year and time period using the **Volume Info** button in the **Main Menu** window.

1. Select the link using the procedure described in the *Link Selection* section.
2. Press the **Volume Info** button.
3. “Input Scenario Info” window appears in which the day, month, year and the time period can be selected. Select the day, month, year and the time period for which the volume info is required (See Figure 15).
4. Press the **Continue** button.

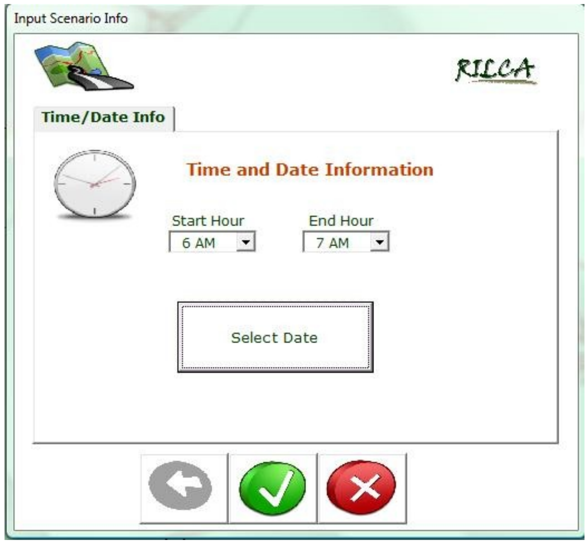


Figure 15. Input Scenario Info window

5. The outputs are displayed in a tabular form in the **Volume Info** table. The following features are displayed in the table as shown in Figure 16:

a. Milepost.

b. Number of lanes.

c. Hourly volume.

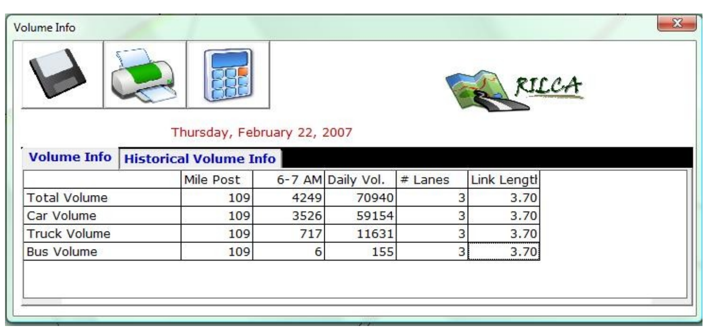
d. Time period.

e. Date (month, day and year).

f. Link length.

g. Daily and monthly volume.

h. Historical information.



	Mile Post	6-7 AM	Daily Vol.	# Lanes	Link Lengtl
Total Volume	109	4249	70940	3	3.70
Car Volume	109	3526	59154	3	3.70
Truck Volume	109	717	11631	3	3.70
Bus Volume	109	6	155	3	3.70

Figure 16. Volume Info table

The columns of the table show the direction of each section (northbound or southbound) and whether the section is a part of the car only or cars/trucks sections.

The hourly volume and time period are displayed consecutively for each hour in the time period selected.

Lane Closure Schedule

A schedule for the minimum number of lanes to be open on a roadway section can be generated using the **Lane Closure Schedule** button in the **Main Menu** window. These schedules are generated using the Annual Average Daily Traffic (AADT) data for the selected day. Lane closure schedules can be generated for a selected day or a week starting with a selected day for each month. An annual percentage increase in traffic can also be entered as an input to obtain the schedules for the future traffic demand.

The threshold traffic volume per lane involved in the decision of minimum number of lanes to be open is 1,600 vehicle per hour per lane (vphpl). In other words, if the traffic volume per lane exceeds 1,600 vphpl due to a lane closure, then the lane closure is not warranted for. This process is performed iteratively for all the lanes of the selected link over the selected time horizon. It should be mentioned that these capacity values can be easily changed by the user.

The generation of the Lane Closure schedules involves the following steps (see Figure 17):

1. Select the link using the procedure described in the Selection of Links section.
2. Press the “Lane Closure Schedule” button on the Main Menu.
3. The Input Scenario Info Menu appears from which the following options can be chosen:
    a. Type of schedule to be generated (Daily or Weekly schedule).
    b. Date i.e. day, month and year.
    c. Lane closure information (Northbound or southbound). The information can be selected by checking the appropriate checkbox.

d. Percentage increase in volume.

4. Press the Continue button to view the Lane Closure Schedule for the selected scenario.

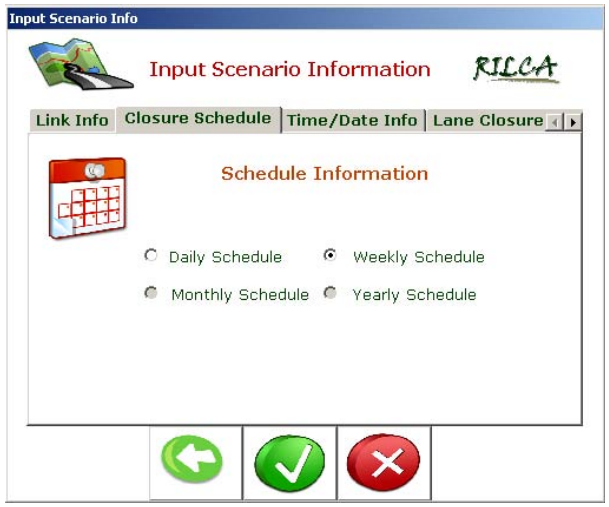
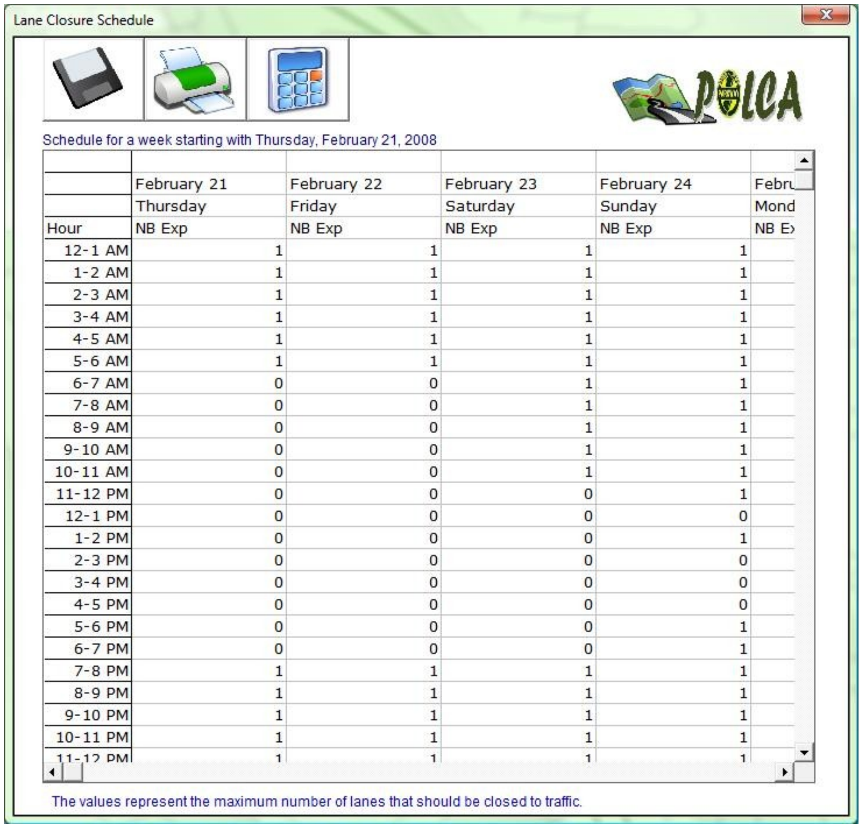


Figure 17. Input Scenario Info window for lane closure schedule

In the **Lane Closure Schedule** is displayed in a tabular form as shown in Figure 18. The table includes the following information:

1. Date.
2. Day of the week.
3. Hour.
4. Maximum number of lanes that can be closed, for each hour, on each day without getting any queues.



Lane Closure Schedule

Schedule for a week starting with Thursday, February 21, 2008

	February 21	February 22	February 23	February 24	Febru
	Thursday	Friday	Saturday	Sunday	Mond
Hour	NB Exp	NB Exp	NB Exp	NB Exp	NB E>
12-1 AM	1	1	1	1	
1-2 AM	1	1	1	1	
2-3 AM	1	1	1	1	
3-4 AM	1	1	1	1	
4-5 AM	1	1	1	1	
5-6 AM	1	1	1	1	
6-7 AM	0	0	1	1	
7-8 AM	0	0	1	1	
8-9 AM	0	0	1	1	
9-10 AM	0	0	1	1	
10-11 AM	0	0	1	1	
11-12 PM	0	0	0	1	
12-1 PM	0	0	0	0	
1-2 PM	0	0	0	1	
2-3 PM	0	0	0	0	
3-4 PM	0	0	0	0	
4-5 PM	0	0	0	0	
5-6 PM	0	0	0	1	
6-7 PM	0	0	0	1	
7-8 PM	1	1	1	1	
8-9 PM	1	1	1	1	
9-10 PM	1	1	1	1	
10-11 PM	1	1	1	1	
11-12 PM	1	1	1	1	

The values represent the maximum number of lanes that should be closed to traffic.

Figure 18. Lane Closure Schedule Output

The columns of the table show the direction of each section (northbound or southbound) and whether the section is a part of the express or local sections or cars only or cars/trucks lanes. The schedule generated can be saved as an MS Excel document (see Figure 19) using the “Save File” button on the Lane Closure Schedule display form .

The default folder or directory for the lane closure schedules is the **C:\NJ-RILCA\Shape Files\Output** directory within the main directory **C:\NJ-RILCA\Shape Files.**

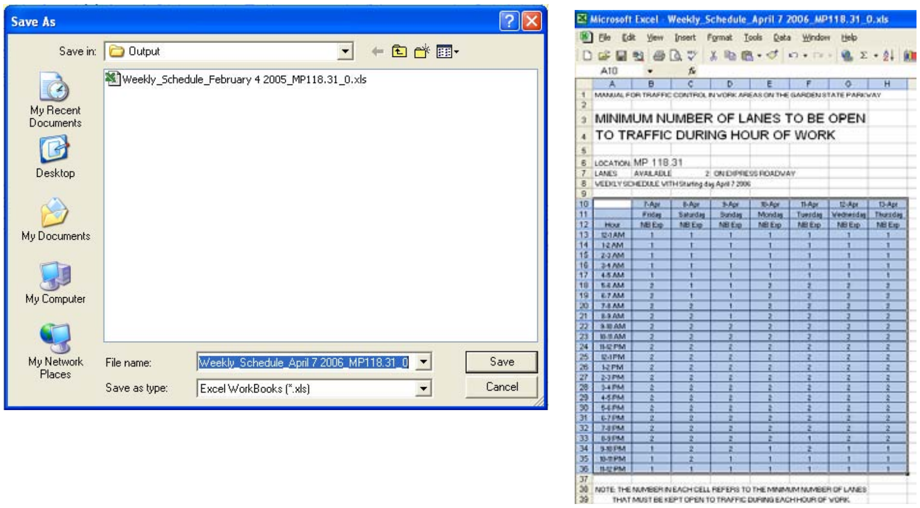


Figure 19. Lane Closure Schedule - Save File

Lane Closure Info

The Lane Closure Info option can be used to generate the delays and queues resulting from a particular lane closure scenario. The estimation of delay and queue due to lane closure is based on the Road User Cost Model developed by Urban Engineers, Inc.

The steps involved in the **Lane Closure Info** option are (see Figure 20):

1. Select the link using the procedure described in the *Selection of Links* section
2. Press the **Lane Closure Info** button on the **Main Menu** window
3. The **Input Scenario Info** window appears from which:
    a. The following options can be chosen from **Time/Date Info** tab:
        i. Start and End hours for the lane closure scenario.
        ii. Date i.e. day, month and year.
    b. Lane closure information can be entered in the **Lane Closure Info** tab:
        i. Northbound or southbound.
        ii. Express or local sections or cars only or cars/trucks lanes in the case of dual-dual roadway section. The information can be selected by checking the appropriate checkbox.
        iii. Configuration of Lane Closure: “Exterior”, if the lane is adjacent to median or curb and “Middle” if otherwise.
    c. Percentage increase in volume.
    d. The following parameters can be changed by the user in the **Other Parameters** tab:
        i. Lane Width of the roadway.
        ii. Average length of the vehicle (for queue length calculations).

iii. Average gap between vehicles in queuing conditions.
iv. Capacity per lane under Normal and Work Zone conditions.

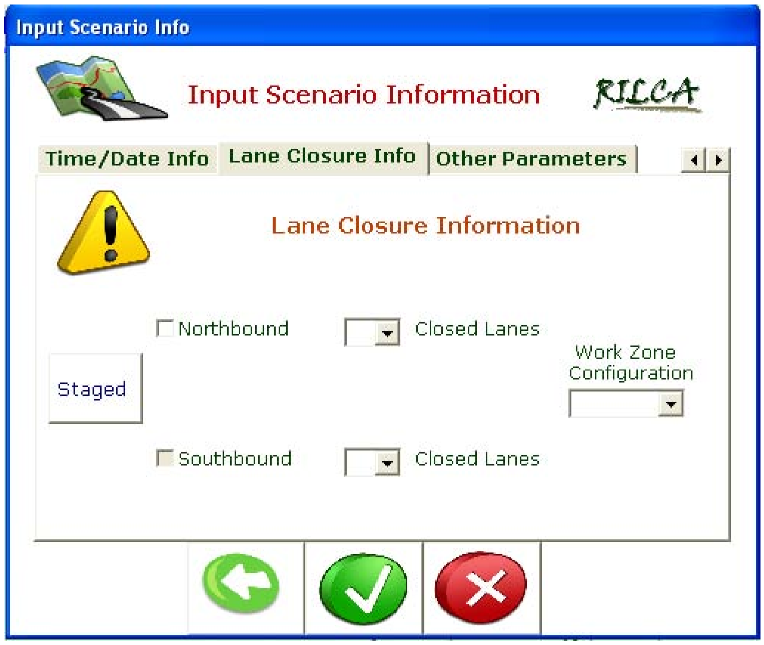


Figure 20. Input Scenario Info for Lane Closure Info

4. In order to analyze the cases where there are different number of lanes closed during selected period of lane closure, there is a **Staged Lane Closure** option. The **Staged Lane Closure** option can be accessed from the **Lane Closure Information** tab, through the "**Staged**" button.

5. Press "**Staged**" button

6. Staged Lane Closure window open where the number of lanes to be closed within each hour of the analysis period can be entered (as shown in Figure 21)

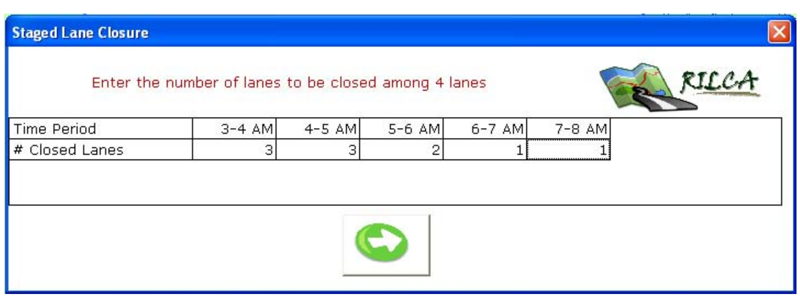


Figure 21. Staged Lane Closure Info

7. Press the **Continue** button to complete the other relevant information for the Lane Closure **Input Scenario Information**.

8. Press the **Continue** button to view the output for the selected scenario.

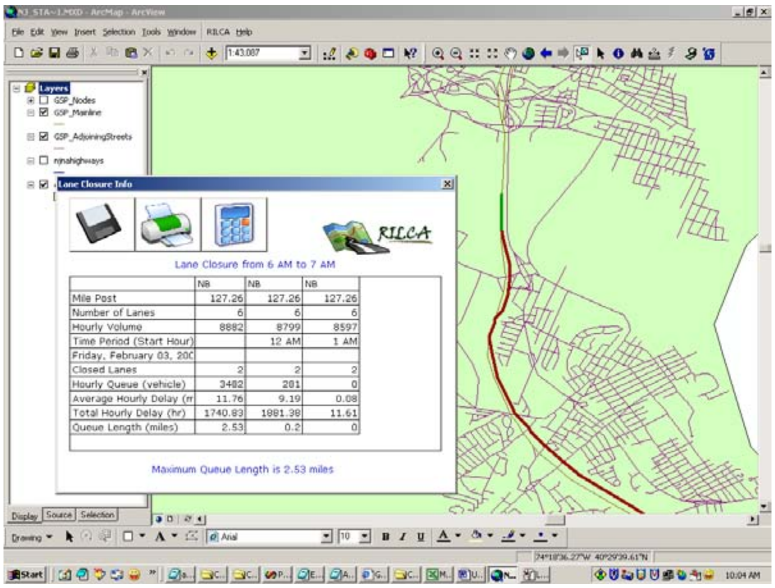


Figure 22. Lane Closure Info table

The output of the **Lane Closure Info** option involves (see Figure 22):

1. Mile post of the selected link
2. Number of lanes on the selected link..
3. Hourly volume for each hour in the selected scenario.
4. Selected time period and date of the scenario.
5. Number of closed lanes.
6. Level of Service (based on the HCM procedure for work zone studies).
7. Minimum number of lanes to be open.
8. Hourly Queue (vehicles).
9. Average Hourly Delay (hr/vehicle).
10. Total Hourly Delay (hrs).
11. Queue Length (miles).

The columns of the table show the direction of each section (northbound or southbound) and whether the section is a part of the express or local or cars only or cars/trucks sections.

In addition to the above outputs, the maximum spill over of the queue is highlighted on the map. In order to clear the highlighting from the display, the refresh button  must to be used. The case of any spill over of the queue from the time period of the work zone operation is also considered. The corresponding delays and queue lengths for the other hours are also displayed.

Notes:

1. Users are advised to save their output files in the **Output** subfolder in the main directory **C:\NJ-RILCA\Shape Files**.
2. Users are advised to save their output files using different file names when creating lane closure schedule at the same link for various scenarios.

Incident Analysis

The **Incident Analysis** option can be used to generate the delays and queues resulting from a particular occurrence of an incident. The estimation of delay and queue due to lane closure is based on the Road User Cost Model developed by Urban Engineers, Inc.

The steps involved in the **Incident Analysis** option are (see Figure 23):

1. Select the link using the procedure described in the *Selection of Links* section.
2. Press the **Incident Analysis** button on the **Main Menu** window.
3. The **Input Scenario Info** window appears from which:
    a. The following options can be chosen from **Time/Date Info** tab:
        i. Start hour of the incident scenario.
        ii. Date i.e. day, month and year.
        iii. Duration of the incident in minutes.
    b. Lane information can be entered in the **Incident Info** tab:
        i. Northbound or southbound.

ii. Express or local sections or cars only or cars/trucks lanes in the case of dual-dual roadway section. The information can be selected by checking the appropriate checkbox.

c. Percentage increase in volume.

d. The following parameters can be changed by the user in the **Other Parameters** tab:

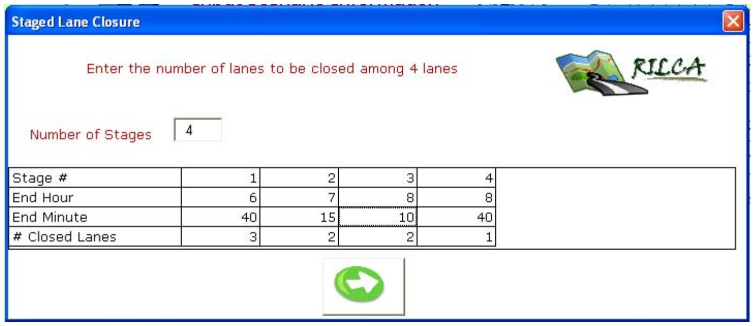
   i. Lane Width of the roadway.
   ii. Average length of the vehicle (for queue length calculations).
   iii. Average gap between vehicles in queuing conditions.
   iv. Capacity per lane under Normal and Incident conditions.

Figure 23. Input Scenario Info for Incident Analysis

4. In order to analyze the cases where there can be different number of lanes closed during selected period of lane closure, there is a **Staged Lane Closure** option. The **Staged Lane Closure** option can be accessed from the **Lane Closure Information** tab, through the "**Staged**" button.

5. Press "**Staged**" button.

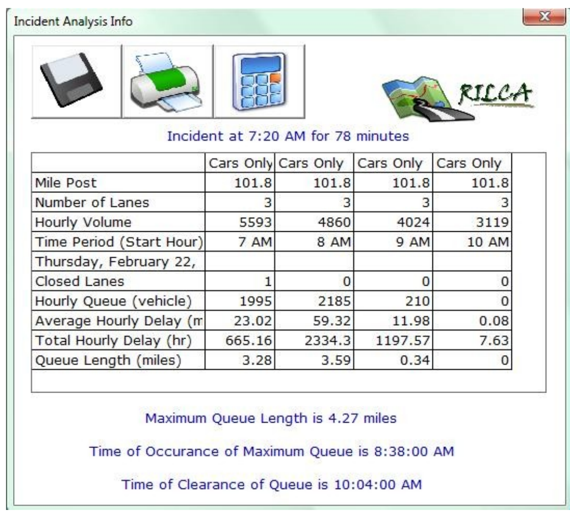
6. **Staged Lane Closure** window open where the number of stages and number of lanes to be closed within each stage within the analysis period can be entered (as shown in Figure 24).



Stage #	1	2	3	4
End Hour	6	7	8	8
End Minute	40	15	10	40
# Closed Lanes	3	2	2	1

Figure 24. Staged Lane Closure Info for Incidents

7. Press the Continue button to complete the other relevant information for the Lane Closure Input Scenario Information.
8. Press the **Continue** button to view the output for the selected scenario.



	Cars Only	Cars Only	Cars Only	Cars Only
Mile Post	101.8	101.8	101.8	101.8
Number of Lanes	3	3	3	3
Hourly Volume	5593	4860	4024	3119
Time Period (Start Hour)	7 AM	8 AM	9 AM	10 AM
Thursday, February 22,				
Closed Lanes	1	0	0	0
Hourly Queue (vehicle)	1995	2185	210	0
Average Hourly Delay (m	23.02	59.32	11.98	0.08
Total Hourly Delay (hr)	665.16	2334.3	1197.57	7.63
Queue Length (miles)	3.28	3.59	0.34	0

Figure 25. Incident Analysis table

The output of the **Incident Analysis** option involves (see Figure 25):

1. Start time and duration of the incident.
2. Mile post of the selected link.
3. Number of lanes on the selected link.
4. Hourly volume for each hour in the selected scenario.
5. Selected time period and date of the scenario.
6. Number of closed lanes.
7. Hourly Queue (vehicles).
8. Average Hourly Delay (hr/vehicle).
9. Total Hourly Delay (hrs).

10. Queue Length at the end of each hour (miles).
11. Maximum queue length (miles).
12. Time of maximum queue length.
13. Time of Queue Clearance.

The columns of the table show the direction of each section (northbound or southbound) and whether the section is a part of the express or local sections or cars only or cars/trucks lanes.

In addition to the above outputs, the maximum spill over of the queue is highlighted on the map. In order to clear the highlighting from the display, the refresh button  must to be used. The case of any spill over of the queue from the time period of the work zone operation is also considered. The corresponding delays and queue lengths for the other hours are also displayed.

Note: If the volume data for the time period chosen is not available, then the volume of the most representative (same day from the previous year) is chosen for analysis.

DATA AVAILABILITY

In order to determine the allowable lane closure hours, using either QuickZone or RILCA, hourly traffic volume data are needed. NJDOT utilizes two methods to collect hourly traffic counts: (1) Automated Traffic Recorder (ATR) and (2) Continuous counting stations. ATRs are deployed on various locations on different highways in NJ, which usually collects hourly vehicles counts for three weekdays. Continuous counting stations utilize roadside radar detectors that record traffic continuously.

The traffic volume dataset can be reached via the NJDOT Web Site [22]. Traffic volume dataset of any given station on a highway can be reached via the Live Report Webpage that allows users to search traffic count reports. Figure 26 shows the main window of this interactive traffic data acquisition tool.

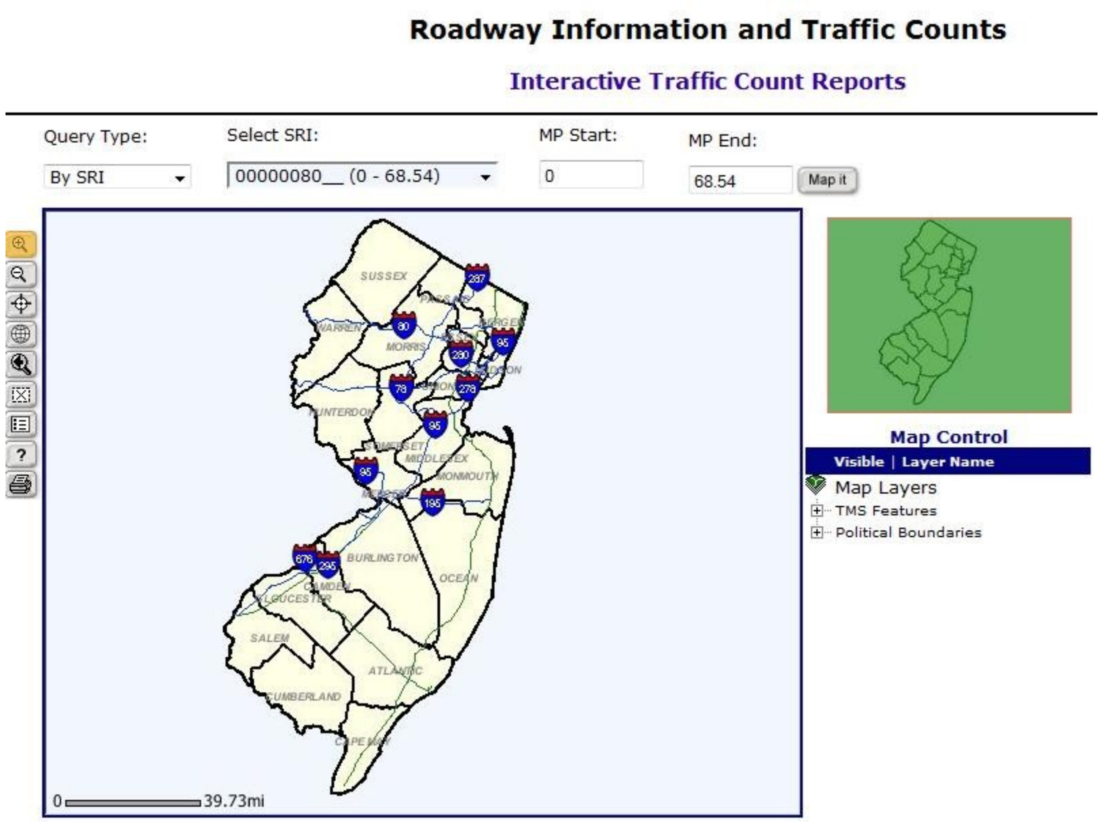


Figure 26. NJDOT live report webpage main window

Traffic count data can be retrieved based on SRI number, station ID or by county. The results are reported in a tabulated format with hyperlinks to PDF files of available traffic count reports of the traffic counting stations within the selected highway or county. An example report for I-287 is show in Figure 27.

Total stations selected: 33 | Total pages: 2 | 1-30 next

Station Number	Count Report	Year	Count Aadt	Station Location Details	Street	Route	Township	County	Comments
1-1-021	Morris_Harding_3219_7040.pdf	1/1/2002	78500	AT GLEN ALPIN RD CO 646 OVERPASS		00000287__	Harding Twp	Morris	hourly volume file
	1-1-021-cons-wrpt-2004_04_10_06.txt	1/1/2004		AT GLEN ALPIN RD CO 646 OVERPASS		00000287__	Harding Twp	Morris	
	1-1-47_98_sum.pdf	1/1/1998		BET NJ 24 & NJ 10		00000287__	Hanover Twp	Morris	
	1-1-47_98_StationHrVol.pdf	1/1/1998		BET NJ 24 & NJ 10		00000287__	Hanover Twp	Morris	
	1-1-47_98_consol.pdf	1/1/1998		BET NJ 24 & NJ 10		00000287__	Hanover Twp	Morris	
	1-1-47_99_sum.pdf	1/1/1999		BET NJ 24 & NJ 10		00000287__	Hanover Twp	Morris	
	1-1-47_99_StationHrVol.pdf	1/1/1999		BET NJ 24 & NJ 10		00000287__	Hanover Twp	Morris	
1-1-047	1-1-47_99_consol.pdf	1/1/1999		BET NJ 24 & NJ 10		00000287__	Hanover Twp	Morris	
	1-1-47_00_sum.pdf	1/1/2000		BET NJ 24 & NJ 10		00000287__	Hanover Twp	Morris	
	1-1-47_00_consol.pdf	1/1/2000		BET NJ 24 & NJ 10		00000287__	Hanover Twp	Morris	
	1-1-47_00_StationHrVol.pdf	1/1/2000		BET NJ 24 & NJ 10		00000287__	Hanover Twp	Morris	
	Morris_Hanover-Twp_1760_7075.pdf	1/1/2003	156251	BET NJ 24 & NJ 10		00000287__	Hanover Twp	Morris	Hourly Volume File
	Morris_Hanover-Twp_1760_7076.pdf	1/1/2003	156251	BET NJ 24 & NJ 10		00000287__	Hanover Twp	Morris	Monthly AADT Summary File
	1-1-48_98_consol.pdf	1/1/1998		BET RT 511 & I-80		00000287__	Parsippany-Troy Hills Twp	Morris	
	1-1-48_99_StationHrVol.pdf	1/1/1999		BET RT 511 & I-80		00000287__	Parsippany-Troy Hills Twp	Morris	
	1-1-48_99_consol.pdf	1/1/1999		BET RT 511 & I-80		00000287__	Parsippany-Troy Hills Twp	Morris	
1-1-048	1-1-48_99_sum.pdf	1/1/1999		BET RT 511 & I-80		00000287__	Parsippany-Troy Hills Twp	Morris	

Figure 27. Example interactive traffic count report

Continuous counting stations provide hourly traffic volume data for the entire year. This type of dataset is well suited for determining allowable lane closure hours, since lane closures take place at any given season at any given time. However, though continuous counting stations give very detailed traffic volume information, only a few number of NJ's highways are covered 100% by continuous counting stations. Most highways currently have ATRs and some continuous counting stations. As mentioned before ATRs provide 3 weekdays of traffic volume data for a given location in a highway. However, for accurate lane closure analysis, hourly volume for any given month and day is needed at a given location on a selected highway.

Therefore, it was decided that the available AADT information provided on the NJDOT Web Page would be used to convert AADT values to hourly volumes.

The annual consolidate report of each counting stations provides the AADT and seasonal factors as shown in Figure 28.

STATION ID 1-1-21
DIRECTION NORTH
(MAIN)

TRAFFIC COUNTING STATION INFORMATION
FOR PERMANENT STATIONS

ROUTE	I 287	STREET		FA SYSTEM	FAI	FUNC. CLASS.	11
MILEPOST	31.88	LOCATION	AT GLEN ALPIN RD,CO646 OVERPASS	FA SYS NUMBER	287	NO OF LANES	3
MAP SHEET NO	19	COUNTY	MORRIS	FED RURAL/URBAN	URBAN	LANE WIDTH	12
DATE STARTED	09/68	MUNICIPALITY	HARDING TWP.	JURISDICTION	STATE	CAPACITY	
PREVIOUS STA		ROADWAY TYPE	DIVIDED ROADWAY (FULL ACCESS CONTROL)			V/C RATIO	

TABLE - 1B AADT VARIATION BY YEARS

OPPOSITE DIRECTION : SOUTH

YEAR	A.A.D.T	PERCENTAGE VARIATION 2006	2005	2004	2003	2002	2001	2000	1999	1998	1997
2006	[redacted]										
2005		1.8									
2004		0.7	-1.1								
2003		2.6	0.8	1.9							
2002		-4.0	-5.7	-4.7	-6.4						
2001		2.0	0.2	1.2	-0.6	6.2					
2000		31.3	29.0	30.4	28.0	36.8	28.8				
1999		8.8	6.9	8.0	6.1	13.3	6.7	-17.2			
1998		19.0	16.9	18.2	16.0	23.9	16.7	-9.4	9.4		
1997		*	*	*	*	*	*	*	*	*	

STATION [redacted]GNATED AS URBAN BEING VERY CLOSE TO RURAL-URBAN BOUNDARY

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DIVISION OF DATA BASE GENERATION
BUREAU OF DATA RESOURCES

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YEAR 2006
STATION ID 1-1-21
DIRECTION NORTH
(MAIN)
FUNC. CLASS. 11

TABLE - 2 : ANNUAL AVERAGE SUMMARY FOR YEAR 2006

MAIN DIRECTION : NORTH

[redacted]ADT 50199

MONTH	DAILY AVERAGES MON	TUE	WED	THU	FRI	SAT	SUN	72 HOUR WEEK END TOTAL	3 DAY WEEK DAY (TUE-THU) FACTOR		WEEKEND FACTOR	GROUP/ PATTERN FACTOR
JANUARY	49450	51330	52690	54960	55960	32370	27430	114519	0.947	[redacted]	0.438	0.99
FEBRUARY	48530	53330	53670	55170	55450	30960	29420	108943	0.929		0.461	0.96
MARCH	53270	54100	54950	56420	57240	34870	31430	124702	0.910		0.403	0.95
APRIL	54880	54710	56510	57930	57850	34900	35210	127989	0.890		0.392	0.92
MAY	55390	56040	57110	58300	58050	37090	35450	126989	0.878		0.395	0.91
JUNE	56650	56840	57250	59320	59250	37110	37550	134797	0.868		0.372	0.89
JULY	56130	56670	56180	59220	58770	38890	36500	136151	0.875		0.369	0.90
AUGUST	56400	56670	58290	59780	59300	39040	37120	136896	0.862		0.367	0.90
SEPTEMBER	56640	56570	57690	59020	59450	38230	34570	125152	0.869		0.401	0.91
OCTOBER	56750	56800	57580	59680	60870	38010	35990	136952	0.865		0.367	0.91
NOVEMBER	55400	56630	56870	57490	59070	37070	34290	129551	0.881		0.387	0.91
DECEMBER	54540	52380	55020	55920	54050	35300	29520	118531	0.922		0.424	0.92

OPPOSITE DIRECTION : SOUTH

[redacted]ADT 49596

MONTH	DAILY AVERAGES MON	TUE	WED	THU	FRI	SAT	SUN	72 HOUR WEEK END TOTAL	3 DAY WEEK DAY (TUE-THU) FACTOR	MONTHLY (7 DAY) FACTOR	WEEKEND FACTOR	GROUP/ PATTERN FACTOR
JANUARY	48920	50480	51890	53640	54810	32770	27930	113410	0.954	1.083	0.437	0.99
FEBRUARY	47630	52170	52760	54110	54710	31500	29280	108041	0.936	1.078	0.459	0.96
MARCH	51110	52550	53090	51380	55910	34820	30940	120655	0.948	1.053	0.411	0.95
APRIL	52950	53050	55020	57140	56700	34140	32920	121588	0.901	1.015	0.408	0.92
MAY	53780	55150	56710	58350	58930	37820	34450	127480	0.874	0.977	0.389	0.91
JUNE	55150	60330	56610	58970	59870	38260	35740	133294	0.846	0.951	0.372	0.89
JULY	55470	56860	55830	58400	59380	40170	35520	135904	0.870	0.960	0.365	0.90
AUGUST	55970	56390	57790	58720	59640	41120	36490	136893	0.861	0.948	0.362	0.90
SEPTEMBER	54830	55590	56680	57780	58710	39230	34000	125664	0.875	0.973	0.395	0.91
OCTOBER	54930	55960	56880	58440	59910	39200	36540	136336	0.869	0.959	0.364	0.91
NOVEMBER	53710	55610	56240	56830	58390	38350	33680	126758	0.882	0.984	0.391	0.91
DECEMBER	52860	51120	54300	55270	54040	35890	29100	118560	0.926	1.044	0.418	0.92

Figure 28. Annual consolidated report

AADT information in the annual consolidated reports can be converted to hourly volumes as follows: Hourly Volume = AADT * k * d * h

Where, k is the seasonal factor that represents the variation of monthly ADT from the AADT value; d is the daily factor that represents the variation of daily traffic; h is the hourly factor. These seasonal, daily and hourly factors allow users to observe the effect of lane closures from one month to another. The use of an average traffic volume, such as AADT would be erroneous in the estimation of allowable lane closure hours since traffic counts change considerably from February to August for example. Similarly, lane closure hours change from a weekday to a weekend due to different hourly demand patterns. Therefore, the use of these factors is essential in estimating accurate lane closure hours.

While, AADT information and seasonal factors can be obtained from the annual consolidated reports, hourly factors and daily factors need to be generated from the continuous counting station volume reports as shown in Figure 29.

However, there are several setbacks when one decides to generate hourly volumes for an entire roadway network. For example, the distribution of hourly factor, h, for weekdays and weekends are different due to the travel patterns of drivers. Therefore, for a complete picture of the hourly variation of traffic at a counting station, a whole week of volume data is necessary. However, only continuous counting stations provide such detailed information. This limitation of ATR data is valid for daily factors as well. Therefore, we have considered several assumptions while generating the hourly volumes for the freeways available in RILCA. These assumptions are listed as follows. For a traffic counting station of a given highway:

- If the station is ATR, then use the hourly factor, h, of the closest continuous counting station.
- If the station does not have the seasonal or daily factors, obtain it from the closest station.

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CONTROL STATION HOURLY VOLUME REPORT

ROUTE I 287 MILEPOST 31.88 COUNTY MORRIS STATION ID 1-1-21
COINC RT MUNIC. HARDING TWP. METER NO. 21112
STREET YEAR 2003
LOCATION AT GLEN ALPIN RD,CO646 OVERPASS

	MON	02/10	TUE	02/11	WED	02/12	THU	02/13	FRI	02/14	SAT	02/15	SUN	02/16
HOUR	N	S	N	S	N	S	N	S	N	S	N	S	N	S
0- 1	531	489	411	458	581	594	621	591	623	696	747	863	738	890
1- 2	365	301	319	350	375	415	402	353	435	451	459	669	413	606
2- 3	313	173	260	208	302	247	312	248	353	328	289	395	271	339
3- 4	235	130	175	206	260	215	246	198	278	244	226	290	188	182
4- 5	299	150	265	214	272	216	359	243	300	232	198	220	138	118
5- 6	388	243	402	291	387	282	416	290	402	311	160	201	81	113
6- 7	956	622	918	598	920	572	907	657	900	624	250	259	138	118
7- 8	3012	1878	2753	1825	2930	1763	2875	1907	2628	1770	471	461	265	214
8- 9	6344	3541	5939	3388	6154	3300	5781	3567	5712	3251	866	757	458	350
9-10	6262	3799	6115	3629	6418	3809	6627	3942	5840	3638	1286	1108	675	595
10-11	3643	2375	4556	3027	3808	2968	4309	2796	3975	2634	1495	1473	1106	1029
11-12	2203	1901	2521	2139	2552	2077	2487	2089	2665	2279	1732	1744	1648	1480
12-13	1974	1981	2240	2164	2148	2154	2309	2208	2531	2483	2047	2053	2097	1861
13-14	2045	2061	2116	2335	2050	2227	2309	2356	2739	2736	2044	2247	2132	2267
14-15	1785	2081	2029	2222	2138	2299	2387	2435	2687	2724	2047	2176	2154	2166
15-16	1910	2282	2378	2727	2249	2580	2563	2824	3031	3428	2038	2134	2031	2169
16-17	2291	2983	2861	3563	2833	3463	3062	3605	3481	4349	2043	2148	2049	2129
17-18	2953	4399	3358	4549	3461	4454	3698	4654	4183	5265	1981	2070	1912	2087
18-19	3079	5044	3862	5632	3812	5485	4032	5404	4219	5829	1929	1964	1359	1786
19-20	2327	3636	3150	4466	3171	4562	3306	4696	3502	4533	1755	1693	964	1460
20-21	1337	1967	1827	2577	1980	2643	2113	2793	2240	2717	1299	1363	681	1096
21-22	908	1214	1261	1798	1261	1859	1444	1870	1537	1805	1005	1079	467	928
22-23	684	962	1032	1462	1159	1498	1251	1684	1116	1578	963	986	327	534
23-24	649	641	896	949	898	1015	936	1160	877	1141	872	1020	238	409
TOTAL	46493	44853	51644	50777	52119	50697	54752	52570	56254	55046	28202	29373	22530	24926
10AM-6PM	18804	20063	22059	22726	21239	22222	23124	22967	25292	25898	15427	16045	15129	15188
WEATHER	( )		( )		( )		( )		( )		( )		( )	
HOLIDAY					LINCOLNS BDAY									

$h = 531/46{,}493$ hourly factor 0 a.m. -1 a.m. for Monday Northbound

$d = 46{,}493/(46{,}493 + 51{,}644 + 52{,}119 + 54{,}752 + 56{,}254 + 28{,}202 + 22{,}530)$ for Monday Northbound

Figure 29. Hourly volume data from continuous counting stations

- If the highway does not have any continuous counting stations, obtain hourly and daily factors from a closest highway that contains a continuous counting station.
- Weekdays (Monday-Friday) have the same hourly factor distributions; Weekends (Saturday and Sunday) have the same hourly factor distributions.
- There are only two daily factors that represent the change in daily traffic volume for weekdays and weekends. Therefore, the daily volume for any given weekday is the same. The same is valid for weekend volumes.
- Since traffic counting stations have AADT values obtained in various years, these values are converted for year 2008 using an annual traffic increase of 2%.

This proposed method of hourly volume generation results in faster processing of applications in RILCA. Furthermore, the AADT information and *k*, *h*, *d* values can be easily modified as new dataset is obtained.

TRAINING ACTIVITIES

QuickZone

Rutgers team, in cooperation with Noblis, held two QuickZone training classes.

The first QuickZone training session was held on March 11, 2008. There were 6 NJDOT engineers who attended the training. The training was held in the computer lab at NJDOT headquarters. The purpose of this training was to familiarize the NJDOT engineers with the application of QuickZone software for determining the allowable lane closure hours for relatively long-term lane closure projects. During this first session, a real world example - long term lane closure at Garden State Parkway (GSP) - was analyzed using QuickZone. The data were obtained from GSP link flow database.

The general consensus of the first training was that it was very informative; however, not long enough for attendees to learn the full functionality of the tool. Therefore, the second QuickZone training session was held on July 30 and 31, 2008. There were 13 NJDOT engineers that attended the training. As requested by the NJDOT staff this training session was more NJ specific and a real-world project oriented, hands-on training. The training was held in the computer lab at NJDOT headquarters. Tim Bourne was the coordinator of this event on the NJDOT side. Dennis Motiani opened the training session. There were two real world examples taken from the I-295 lane closure projects. The data used for the training were obtained using the hourly volume generation discussed in the previous section.

RILCA

Rutgers Team installed RILCA on the workstations of several NJDOT engineers as shown in Table 6. One-to-one training was provided to the NJDOT engineers at the time of software installation.

Table 6. RILCA users

Name	Date
Eddy Exantus	05/30/2008
Tiberiu Tajts	07/25/2008
Tim Bourne	07/25/2008
Maged Gabriel	07/25/2008
Mark Smith	07/28/2008
Mark Hauske	08/01/2008
Kantilal Patel	08/01/2008

Additional half-day hands-on RILCA workshop on NJ specific lane closure projects will be given to the NJDOT personnel. The training was held in NJDOT headquarters on October 24, 2008.

SUMMARY

The need for this project stems from the lack of a uniform process for determining allowable lane closure hours that is accepted and used throughout NJDOT. The current process is a time consuming task of finding hourly traffic volumes and it heavily relies on previous knowledge of the roadways. This ad-hoc process does not make use of traffic engineering basics for evaluating the impacts of lane closures. NJDOT operations would benefit highly from a computerized tool that can assist engineers in making quick and reliable decisions for work zone related lane closures, especially when the decision has to be made in a short period of time.

Several tools are available for estimating the effects of various transportation projects. These tools vary in level of complexity, and each tool offers different capabilities. Some tools were designed specifically for work zone applications. Other traffic analysis tools, although not designed specifically for work zones, can be used for to analyze work zone situations.

QuickZone was selected for long term lane closures that require traffic diversion to alternate routes. RILCA was selected for short-term lane closures.

QuickZone is developed by Noblis Inc. (formerly Mitretek) with FHWA funding is recommended in the FHWA guidelines as one of several tools to determine work zone delays [(1)]. It is coded as a program within MS Excel. QuickZone considers traffic engineering parameters as specified in the Highway Capacity Manual such as volume, truck percentage, lane width, etc. It has been widely used by other State and local DOTs in the USA and thus it is well tested and validated.

RILCA is an interactive computer tool developed for NJDOT for planning work zone lane closures. RILCA is aimed at providing engineers with a computerized and easy tool for determining allowable lane closure hours on NJ freeways.

RILCA was developed using ArcView GIS software package as the main development environment. The GIS map of the NJ freeways and its surrounding network is displayed using ArcView and various analysis and visualization options are provided for planning of lane closure hours. The tool has the geometric details of NJ freeways. It provides users the following applications:

- Volume information on selected links at a given time period on any given date.
- Link characteristics (such as number of lanes, AADT, milepost, link length).
- A function that generates lane closure schedule for selected link based on the hourly volume data processed by the Rutgers Intelligent Transportation Systems (RITS) team.
- A simple visualization function that shows the extent of expected delays as a result of lane closure and possibility of spill back onto the upstream links all in the form of link colors.
- Integrated lane closure cost estimation function.

In order to determine the allowable lane closure hours, using either QuickZone or RILCA, hourly traffic volume data are needed. RILCA is based on hourly volumes obtained by converting AADT information using seasonal, daily and hourly factors that are available online at the NJDOT Web Page [(22)]. This proposed method of hourly volume generation results in faster processing of applications in RILCA. Furthermore, the AADT information and seasonal, daily and hourly factors can be easily modified as new dataset is obtained.

Future Improvements

This research project main objective was to develop a uniform process for estimating the impact of lane closures on New Jersey highways. RILCA tool was thus developed for the NJDOT engineers and staff to estimate the impact of short -term lane closures quickly. RILCA stores the latest traffic volume data collected by the NJDOT along with the roadway geometry of the highways that are included in the program. Using this up-to-date information, users can then estimate the impact of lane closures and analyze the results using different assumptions of traffic volume, lane closure hours, and the number of closed lanes, all without having to look for specific volume and roadway information for each lane closure scenario.

During our follow-up interviews, current users of RILCA stated that they frequently use it as part of their day-to-day lane closure decision making process. During the workshops conducted by the research team and the one-on-one training and installation sessions, users of RILCA expressed their interest in including all NJDOT maintained highways in RILCA. However, given the short duration and budget constraints for this project, it was not possible to include all the highways maintained by NJDOT in RILCA.

Based on the feedback received from the users of RILCA, it is clear that it can become a very useful decision support tool for the NJDOT engineers and staff in their day-to-day operations if it is further improved with the additions suggested by the NJDOT.

The following improvements suggested by the users of RILCA can be made to enhance existing capabilities of the developed tool:

(1) Include all major highways maintained by the NJDOT in RILCA.

(2) Develop a simple and robust interface between the *Data Developments Traffic Counts database* and RILCA, which allows users to import updated traffic volumes to RILCA.

(3) Improve the QuickZone & RILCA interface to be able to deal with more complex work zone operations.

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APPENDIX: USER AND ECONOMIC COST IMPACT INPUTS

User and Economic Cost Impact Inputs

Cost	Input	Source	Description
Travel Time Cost	Hourly wage	U.S. Department of Labor Statistics (7)	Basis for travel time cost
	% of Hourly wage	Office of the Secretary of Transportation (4)	Multiplier for hourly wage
	Vehicle type (car/truck)	OST (4)	Basis for selection of hourly wage
	Trip length (local/intercity)	OST (4)	Basis for selection of hourly wage and % of hourly wage
	Trip purpose (business/personal)	OST (4), National Transportation Household Travel Survey (9)	Basis for % of hourly wage and average vehicle occupancy
Vehicle Operating Cost	Vehicle type (car/truck)	Minnesota Department of Transportation (11)	15.3¢-19.2¢ per mile for cars/SUVs, 43.4¢ per mile for trucks
Inventory Cost	Average payload (lbs.)	Bureau of Transportation Statistics, Commodity Flow Survey (15)	The average weight of cargo of all trucks passing through the work zone.
	Average payload value (dollars per lb.)	Bureau of Transportation Statistics, Commodity Flow Survey (15)	The average value of the cargo. Table 3 gives this value for different commodities, which can be used in cases where the predominant type of commodity is known. Note that these values apply to all modes of transport (truck, rail, ship, etc.)
	Discount rate (%)	Federal Reserve Board	Prime rate + 1% (4% as of 3/2004)
Economic Cost	Daily business revenue in area of reduced traffic flow due to work zone	Varies by project	Source will vary by project depending on the size of the commercial area affected and the types of businesses affected. These businesses should be identified and revenue figures gathered during the environmental impact assessment.
Other Costs	Varies by project	Varies by project	These are any costs that do not fit into another category. Example: If alternative parking facilities or shuttle buses are required to accommodate travelers due to construction activity, the associated costs should be included here.

User and Economic Cost Impact Selected Non-user Cost Inputs.

Cost	Input	Source	Description
Network-related input data	Pre-construction capacity	Highway Capacity Manual	
	Jam density	-	Default value is 120 veh/km/lane
	Free flow speed	Speed limit	Basis for delay calculations
	Detour route, length		
Traffic demand	Average daily traffic	Traffic study	Typically collected as part of environmental impact assessment
	Hourly demand K-factors	Traffic study	Good temporal demand distribution data exists for the Beartooth Highway project for use as default for projects where demand is highly seasonal and vacation-oriented.
	Seasonality of demand	Traffic study	Important for cases where traffic is highly seasonal. For summer vacation destinations, peak weekends in the summer may govern allowable construction impacts.
	Day of week demand patterns	Traffic study	Weekend traffic may be very different from weekday traffic.
	Percent of trucks	Traffic study	