



HIGHWAY FACTORS

GROUP CHAIRMAN'S FACTUAL REPORT

FATAL MULTI-VEHICLE REAR-END ACCIDENT IN A WORK ZONE

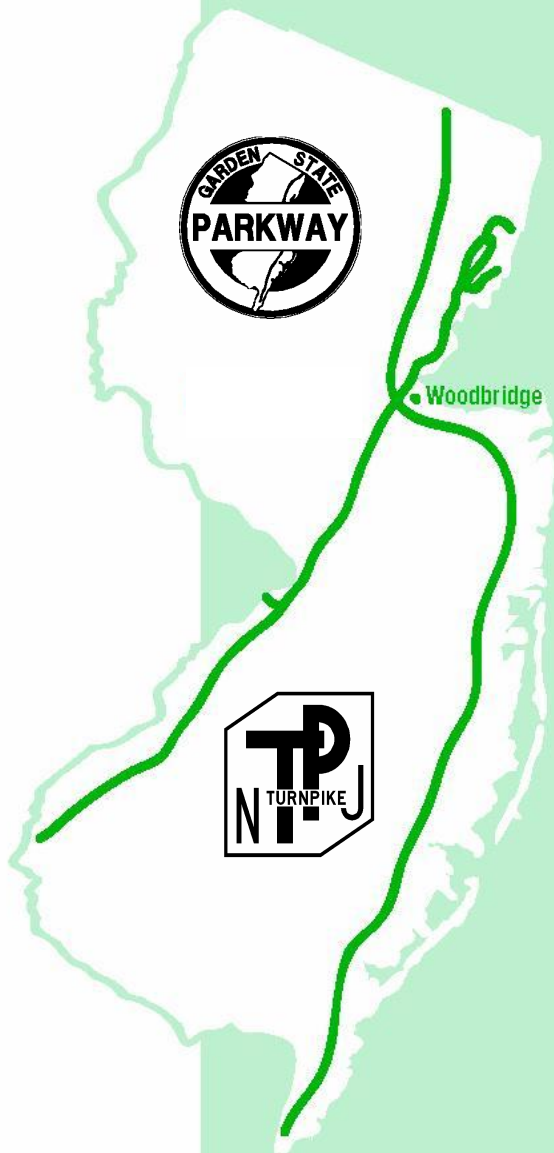
CRANBURY, NEW JERSEY

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ATTACHMENT 5, NEW JERSEY TURNPIKE AUTHORITY ROAD USER COST
MANUAL

(45) PAGES

**NEW JERSEY TURNPIKE AUTHORITY
GARDEN STATE PARKWAY
NEW JERSEY TURNPIKE**



**ROAD USER COST
MANUAL**

**(Including
Road User Cost
Worksheet and
Lane Occupancy
Charge Worksheet)**

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New Jersey Turnpike Authority Road User Cost Manual

Executive Summary

The New Jersey Turnpike Authority (Authority) has issued the Road User Cost Manual to document the process by which the Authority evaluates the impacts of work zones with lane or shoulder closures as costs to the users of the Authority's roadways. Road user costs are the combination of vehicle operating costs and the time costs that the traveling public experiences by traveling through a work zone, especially when there are delays approaching the work zone. One of the principal reasons to assess road user costs is to determine the Lane Occupancy Charges to be assessed to contractors when a short-term work zone lane closure is in place outside of approved hours. This Manual may also be used as a guideline to evaluate options for long-term closures prior to work zone installation. The organization of this Manual follows the process by which road user costs are determined:

- The first step in determining road user costs is to identify the roadway segment(s) affected by the work zone, including shoulder and lane closure tapers and closures.
- The roadway and work zone capacities and the hourly traffic volumes through the work zone are determined by which of the roadway segments affected by the work zone is the most restrictive (highest volumes relative to capacity).
- Once hourly volumes and capacities are known, each of the applicable user cost components are calculated according to the number of vehicles affected by each component on a per-hour basis.

The procedures described in the Road User Cost Manual are implemented in the Authority's Road User Cost Worksheet and the Lane Occupancy Charge Worksheet, which use the same calculations but have different interfaces. The Worksheets calculate the road user costs based on the volumes and capacities that are inputted and calculated, automatically determining if there will be queuing and associated costs during each hour or fraction thereof. The final output of the Road User Cost Worksheet is a single value reflecting the total road user cost for the given scenario. The final output of the Lane Occupancy Charge Worksheet is a table of Lane Occupancy Charges reflecting assessments against contractors when a lane closure remains in place outside approved hours.

The Road User Cost Worksheet allows the Authority and consulting engineers to perform a detailed evaluation of work zone and other conditions where a lane or shoulder is closed. As an example, the Road User Cost Worksheet may be used to compare costs between construction staging alternatives during earlier design phases of a project to analyze the effects of each staging alternative on roadway patrons. The Road User Cost Worksheet may also be used in conjunction with the Lane Occupancy Charge Worksheet as a supporting document that shows all calculations.

The Lane Occupancy Charge Worksheet, available at the Authority's website, is a single page that allows design engineers to perform a simple assessment of Lane Occupancy Charges for a contract. The support information in this Manual is not necessary to conduct simple analyses and assessments that can be performed in the Lane Occupancy Charge Worksheet. The Instructions that accompany the Lane Occupancy Charge Worksheet should be sufficient for most, if not all, contract work to determine Lane Occupancy Charges.

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I. Introduction

The New Jersey Turnpike Authority (Authority) serves a pivotal role for the State of New Jersey in managing, operating and maintaining the New Jersey Turnpike and Garden State Parkway, two vitally important north-south freeways. Both the Turnpike and Parkway are in continuous operation twenty-four hours a day, seven days a week, and are among the most heavily traveled roadways in the state. Keeping these roadways in operation is important to the economy and quality of life of the State, the Authority and the motoring public that utilizes these facilities.

Short-term lane and shoulder closures are permitted during the hours established in the most current Lane and Shoulder Closure Tables issued by the Authority or during any superseding hours issued by the Authority's Operations Department. Closures are limited by major events, holidays, inclement weather and other non-traffic related factors. Queuing approaching the work zone may also result in the closure being removed until the queue dissipates. The presence of a shoulder or lane closure outside of approved hours can cause unnecessary delays and queuing for the traveling public. Depending on the location, even a fifteen-minute delay in picking up a work zone can cause delays and queuing that take hours to dissipate, which is reflected in the Lane Occupancy Charges that may be assessed to contractors.

A. Purpose and Use of the Road User Cost Manual

The Authority has issued the Road User Cost Manual to document the process by which the Authority evaluates the impacts of work zones with lane or shoulder closures as costs to the users of the Authority's roadways. Road user costs are the combination of vehicle operating costs and the time costs that the traveling public experiences by traveling through a work zone, especially when there are delays approaching the work zone. One of the principal reasons to assess road user costs is to determine the Lane Occupancy Charges to be assessed to contractors when a short-term work zone lane closure is in place outside of approved hours. This Manual may also be used as a guideline to evaluate options for long-term closures prior to work zone installation. The organization of this Manual follows the process by which road user costs are determined:

- The first step in determining road user costs is to identify the roadway segment(s) affected by the work zone, including shoulder and lane closure tapers and closures.
- The roadway and work zone capacities and the hourly traffic volumes through the work zone are determined by which of the roadway segments affected by the work zone is the most restrictive (highest volumes relative to capacity).
- Once hourly volumes and capacities are known, each of the applicable user cost components are calculated according to the number of vehicles affected by each component on a per-hour basis.

Section II of this Manual describes free-flow and work zone roadway characteristics and their effects on the calculation of road user costs. Section III describes processing traffic volume data for road user cost calculation. Section IV describes the seven components that are combined to determine the road user cost. Section V describes the assessment of Lane Occupancy Charges based on the road user cost.

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This Manual directly incorporates the road user cost methodology considered good practice by the FHWA¹ in evaluating the impacts of work zones on roadway users. In applying the procedures described in this Manual, note that no two highways or two segments of the same highway have the exact same characteristics. Roadway capacity, free-flow speed, potential queue lengths and queue travel times for a given roadway segment may vary from the estimated or theoretical values from day to day or even between different hours of the same day. Factors affecting actual traffic characteristics include, but are not limited to, weather, police activity, vehicles on the shoulder and driver mix (recreational or commuter). These different factors cannot be predicted in advance and sometimes their actual effect on traffic is unknown even after the fact, so it should be understood that the methodology and results from using this Manual will approach, but not perfectly replicate, real-world conditions. However, this Manual uses industry standards and guidelines developed by recognized standard sources, providing an important basis for comparative evaluations of traffic conditions.

Throughout this Manual, the term “pcephpl” stands for “passenger car equivalents per hour per lane,” which is a measure of traffic volume. The concept of using passenger car equivalents (pce) allows comparison of two traffic streams with different percentages of trucks and other heavy vehicles. According to the methodology of the Highway Capacity Manual 2000² (HCM2000), converting each heavy vehicle to an equivalent number of cars in pce allows evaluation of the actual impact that vehicle has on traffic.

B. Road User Cost and Lane Occupancy Charge Worksheets

The procedures described in the Road User Cost Manual are implemented in the Authority’s Road User Cost Worksheet and the Lane Occupancy Charge Worksheet, which use the same calculations but have different interfaces. The Worksheets calculate the road user costs based on the volumes and capacities that are inputted and calculated, automatically determining if there will be queuing and associated costs during each hour or fraction thereof.

The Road User Cost Worksheet, included in Appendix A, allows the Authority and its consulting engineers to perform a detailed evaluation of work zone and other conditions where a lane or shoulder is closed. As an example, the Road User Cost Worksheet may be used to compare costs between construction staging alternatives during earlier design phases of a project to analyze the effects of each staging alternative on roadway patrons. The Road User Cost Worksheet may also be used in conjunction with the Lane Occupancy Charge Worksheet as a supporting document that shows all calculations. The final output of the Road User Cost Worksheet is a single value reflecting the total road user cost for the given scenario.

The Lane Occupancy Charge Worksheet, included in Appendix B and available at the Authority’s website, is a single page that allows design engineers to perform a simple assessment of Lane

¹ “Life-Cycle Cost Analysis in Pavement Design.” Federal Highway Administration, Publication No. FHWA-SA-98-079, Pavement Division Interim Technical Bulletin, September 1998.

² “Highway Capacity Manual 2000.” Transportation Research Board, 2000.

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Occupancy Charges for a contract. The support information in this Manual is not necessary to conduct simple analyses and assessments that can be performed in the Lane Occupancy Charge Worksheet. The Instructions that accompany the Lane Occupancy Charge Worksheet should be sufficient for most, if not all, contract work to determine Lane Occupancy Charges. The final output of the Lane Occupancy Charge Worksheet is a table of Lane Occupancy Charges reflecting assessments against contractors when a lane closure remains in place outside approved hours.

II. Capacity Calculations

A. Free-Flow Speed and Capacity

As explained in the Introduction, the free-flow speeds and capacities described in this Manual and used in the Road User Cost and Lane Occupancy Charge Worksheets are theoretical values that represent the average of a range of conditions. Different factors may affect the actual roadway capacity during different months and seasons, different days or even different hours of the same day. Weather, police activity, vehicles on the shoulder and driver mix (recreational or commuter) are just some of the factors that would affect the theoretical capacities described in this Section. These different factors cannot be predicted in advance and sometimes their actual effect on traffic is unknown even after the fact, so the methodology of this Manual does not involve daily, monthly or seasonal adjustments to capacity and flow rate values.

From page 13-12 of the HCM2000, judged to be applicable to most segments of the Turnpike and Parkway as described below, the freeway Base Free-Flow Speed (BFFS) is 70 mph to 75 mph. Some quantitative deductions from the BFFS, varying on a segment by segment basis, are cited in Exhibits 23-4 through 23-7 of the HCM2000:

- Exhibit 23-4: Deduct 1.9 mph for 11-foot lanes and 6.6 mph for 10-foot lanes;
- Exhibit 23-5: Deduct approximately 1-3 mph for reduced right shoulder clearance (less than 6 feet) depending on the number of lanes and the lateral clearance;
- Exhibit 23-6: Deduct 1.5 mph for each freeway lane less than 5 per direction in urban areas (up to a 4.5 mph deduction for 2 lanes per direction, for example);
- Exhibit 23-7: Deduct 1.25 mph for each increase in interchange density of 0.25 per mile above a base of 0.5 per mile.

Note that some freeway segments have other attributes (such as traffic turbulence) that are not necessarily accounted for in the deductions given in the HCM2000.

The capacities applied to each freeway segment of the NJ Turnpike and Garden State Parkway are sourced from Exhibit 23-2, page 23-4 of the HCM2000². Capacity is related to the free-flow speed, which is calculated from the BFFS. There are three non-work zone freeway capacity values incorporated into the methodology of the Road User Cost and Lane Occupancy Charge Worksheets:

- Freeway segments with close to ideal conditions of lane width, lateral clearance, etc. These segments are located in rural and suburban areas and often have a posted speed limit of 65 mph. Because there is little deviation from ideal conditions, the free-flow speed would be 70-75 mph, which yields a capacity of 2,400 pcephpl.
- Freeway segments with some deviation from ideal conditions of lane width, lateral clearance, etc. Most of these segments are located in suburban and urban areas and often have a posted speed limit of 55 mph. The deductions in BFFS for these segments range

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from 5-10 mph, which results in a free-flow speed of approximately 65 mph that yields a capacity of 2,350 pcephpl.

- Freeway segments with much deviation from ideal conditions characterized by lane width and/or lateral clearance restrictions, more closely spaced interchanges and/or traffic issues with merging and weaving. These segments are located in suburban and urban areas and have a posted speed limit of 50-55 mph. The deductions in BFFS for these segments may be as high as 15 mph, which results in a free-flow speed of 55-60 mph. This range of free-flow speeds yields a capacity of 2,250-2,300 pcephpl, the average of which is 2,280 pcephpl.

The assignment of the three capacity values to freeway segments of the NJ Turnpike and Garden State Parkway is listed in Table II-1. In this table, “NBHCE” is the Newark Bay – Hudson County Extension of the Turnpike, part of Route I-78 east of Turnpike Interchange 14. The per-lane capacity is multiplied by the number of lanes when there is no work zone to obtain the overall roadway capacity with no work zone.

Table II-1. Turnpike and Parkway Freeway Segment Capacities Based on Free-Flow Speed

	Segment	Capacity with No Work Zone
New Jersey Turnpike	Mainline (MP 0-106)	2,400 pcephpl
	Easterly Alignment (MP E106-E117)	2,400 pcephpl
	Westerly Alignment (MP W106-W117)	2,400 pcephpl
	Northerly I-95 (MP 117-122)	2,350 pcephpl
	Pearl Harbor Memorial Turnpike Extension (MP 0-6)	2,400 pcephpl
	NBHCE, Interchange 14 to 14A (MP N0.0-N3.3)	2,280 pcephpl
	NBHCE, Interchange 14A to 14B (MP N3.3-N5.4)	2,350 pcephpl
	NBHCE, Interchange 14B to end (MP N5.4-N8.3)	2,280 pcephpl
Garden State Parkway	Interchange 0 to 80 (MP 0-81)	2,350 pcephpl
	Interchange 80 to 91 (MP 81-93)	2,280 pcephpl
	Interchange 91 to Express/Local Split (MP 93-104)	2,350 pcephpl
	Express Lanes (MP 104-125)	2,400 pcephpl
	Local Lanes (MP 104-125)	2,350 pcephpl
	Express/Local Split to Interchange 129 (MP 125-129)	2,350 pcephpl
	Interchange 129 to 163 (MP 129-163)	2,280 pcephpl
	Interchange 163 to New York (MP 163-172)	2,400 pcephpl

Capacities are based on Exhibit 23-2, page 23-4 of the HCM2000².

1. Passenger Car Equivalency

On level segments or downgrades, each truck is considered to be equivalent to 2.0 passenger cars when converting demand volumes from vehicles per hour (where each truck or car is counted once) to passenger car equivalents per hour (where each truck is counted twice and each car is counted once). This reflects observed operations in work

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zones³ and the operational experience of the Authority regarding the performance of heavy vehicles on the NJ Turnpike. Note that heavy vehicles (Turnpike Toll Classes 3-6 and B3) are roughly 10% of all non-passenger vehicles (all except Toll Class 1) on the Turnpike based on data from February 2006 to March 2007 obtained from the Authority.

When there is an upgrade, trucks operate more slowly and therefore have a greater impact on capacity on upgrades compared to level segments or downgrades. On certain freeway segments, such as (but not limited to) between Interchanges 15E and 15W (Passaic River Bridges) and the NBHCE between Interchanges 14 and 14A (Newark Bay Bridge), there are upgrades of approximately 3% with lengths of at least ½ mile. Trucks operate more slowly on upgrades than on level segments or downgrades, so they are considered equivalent to 2.5 passenger cars instead of 2.0 passenger cars, consistent with the methodology of the HCM2000.

B. Work Zone Capacity

The work zone is defined from the beginning of the first taper to the last traffic control device placed, excluding the “End Work Area” sign. Work zones may either be long-term or short-term, corresponding to FHWA definitions in Section 6G.02 of the Manual on Uniform Traffic Control Devices (MUTCD), 2009 Edition:

- Long-term work zones, typically delineated with fixed traffic control devices such as barriers, are those that occupy a location for more than 72 hours (“Long-Term Stationary” by MUTCD definition).
- Short-term work zones, typically delineated with portable traffic control devices such as cones, are those that occupy a location for up to 72 hours at a time (“Intermediate-Term Stationary” and “Short-Term Stationary” by MUTCD definition).

The MUTCD also defines “Short Duration” and “Mobile” work, but these types of work are only performed for the minimum duration where required and therefore may not be subject to a road user cost analysis.

The functional difference between long-term and short-term work zones is that long-term work zones typically remain in place for weeks or even months with little variation due to the time and cost involved in placing or removing barrier. Short-term work zones may be periodically picked up based on traffic volume, observed queues, incident response, weather or one of many other reasons. When a lane is temporarily closed within a long-term work zone, for example to deliver materials or move barrier, it is considered a separate short-term work zone. The Authority generally does not permit long-term lane closures, excluding some High-Intensity Construction Cycles (HICCs), so the Road User Cost Worksheet does not have an option to select “long-term lane closure” as a work zone type. The Lane Occupancy Charge Worksheet is only used for (short-term) lane closures, so the option to change the work zone type is not available.

³ Al-Kaisy, Ahmed, and Fred Hall. “Guidelines for Estimating Capacity at Freeway Reconstruction Zones.” *ASCE Journal of Transportation Engineering*, September/October 2003.

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For consistency with the estimates of free-flow speed in *Section II.A – Free-Flow Speed and Capacity* that are 5 to 10 mph above the posted speed limit, the effective work zone speed is calculated as 5 mph above the posted work zone speed limit, but no higher than the free-flow speed when no work zone is present. The effective work zone speed is used to determine the travel time through the work zone for calculating the added costs of traversing the work zone compared to when there is no work zone. Based on the relation between free-flow speed and capacity noted in Exhibit 23-2 of the HCM2000², every 1 mph in free-flow speed equates to 10 pcephpl in capacity between 55 mph and 70 mph. The per-lane work zone capacity is multiplied by the number of open lanes when the work zone is in place to obtain the overall work zone roadway capacity.

1. Variable Operational Considerations

The base capacity for a given work zone is subject to several variables that can occur at each work zone area. Adjustment factors have been incorporated into the road user cost analysis to account for the factors listed below.

Weekend Factor:

Driver characteristics have been shown in several industry studies to vary depending upon trip purpose and time of the week. The effects of driver characteristics differ based on the type of roadway, regional tendencies, urban / suburban / rural location and other factors. The capacity within a work zone is already reduced in part due to drivers' unfamiliarity or heightened discomfort caused by the work zone itself, which may already be addressed by other factors. To account for this, the Road User Cost Manual reduces the base "non-work zone" capacity threshold, which is reflected in the estimated queue dissipation rate, but does not reduce the work zone capacity directly. To account for different traffic mixes by season and by roadway, the related capacity reductions for normal (non-work zone) operations are as follows:

1. All weekdays – No reduction
2. All winter weekends – 10% reduction from weekday capacity
3. Summer weekends on the Turnpike and on the Parkway north of Interchange 129 – 10% reduction from weekday capacity
4. Summer weekends on the Parkway south of Interchange 129 – 15% reduction from weekday capacity due to predominantly recreational traffic mix

Note that the weekend factor is applied from 12:00 pm Friday until 12:00 pm Monday during the Summer season and only on Saturday and Sunday otherwise.

Nighttime Factor:

Driver characteristics have been shown in industry studies to vary during nighttime hours, particularly on roadways without overhead lighting. Based on these studies, a

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capacity reduction factor of 4% is applied during nighttime hours, reducing capacity for both normal (non-work zone) operations and work zone operations.

Ramp Junction Factor:

Roadway operations have been shown in many industry studies to be less efficient in close proximity to freeway interchanges due to increased lane changing, weaving and merging, resulting in a capacity reduction due to turbulence. This Manual establishes a ramp junction factor by dividing 2,200 pcephpl by the normal (non-work zone) per-lane roadway capacity, resulting in a 4% to 8% reduction in capacity per lane depending upon the normal roadway capacity. The reduction factor is applied to two active lanes of traffic within the work zone (representing the lanes involved in the ramp junction) and to two lanes of traffic under normal (non-work zone) conditions in the following circumstances:

- Apply the ramp junction factor if there is an off ramp within the work zone or up to 1,000 feet downstream of the end of the work zone.
- Apply the ramp junction factor if there is an on ramp within the work zone or up to 1,000 feet upstream of the beginning of the work zone.
- Use engineering judgment to determine whether to apply the ramp junction factor if there is an off ramp up to 1,000 feet upstream of the beginning of the work zone or if there is an on ramp up to 1,000 feet downstream of the end of the work zone.

Lane Width Factor:

Industry studies have estimated that when lane widths are reduced from 11 feet or greater in the non-work zone condition to less than 11 feet within the work zone, there is a reduction in roadway capacity (compared to the non-work zone condition) of 9%. Allowance for lane width reductions below 11 feet when the non-work zone lane width is 11 feet or greater has been incorporated into the road user cost methodology.

Length of Work Zone Factor:

The length of the work zone also has a theoretical impact on work zone capacity. The length of work zone factor is approximately 1.8% per mile of work zone, with a maximum value of 5.5% for work zones of 3 miles in length or greater, reflecting work zone lengths typically employed by the Authority.

Work Intensity Factor:

Industry research has shown that low and medium intensity work has little impact on work zone capacity. However, there is a measurable impact from high intensity work or a visible police presence (i.e., with flashing lights) at the work zone. High intensity work is defined as work zone activity that is plainly visible to drivers in adjacent lanes and is identified as being potentially distracting based on engineering judgment. The Road User Cost and Lane Occupancy Charge Worksheets include an input for High Intensity Work,

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which results in a 5.7% reduction in work zone capacity. If the work zone is located behind a concrete construction barrier and uses glare screens to shield activity from passing drivers, this reduction may not apply. Conversely, police presence with flashing lights located within 12 feet of the traveled way may constitute “high intensity” activity even if the work itself is of low or medium intensity.

2. Long-Term Work Zone with a Shoulder Closure

Highway capacity research supports the premise that the capacity of a long-term work zone with a shoulder closure is lower than the capacity of the same freeway segment with no closure due to the physical features of the work zone and the characteristics of the work being performed. Factors that affect capacity include, but are not limited to:

- Type and visibility of work being performed;
- Driver population (commuters, vacationers, etc.);
- Lane width and lateral clearance to obstructions or barrier;
- Weather and ambient light;
- Presence of police vehicles or other vehicles with flashing lights;
- Signing and striping approaching and through the work zone.

Independent industry studies have estimated the average capacity of a long-term work zone with a shoulder closure based on these sources is 2,070 pcephpl. Because these studies examined highways in urban areas that may have some deviations from ideal conditions of lane width, lateral clearance, etc., this work zone capacity corresponds to a non-work zone freeway capacity of 2,350 pcephpl (65 mph free-flow speed). This average capacity is proportionally extended to freeway segments with different capacities and free-flow speeds as shown in Table II-2 and Figure II-1.

3. Short-Term Work Zone with a Shoulder Closure

From the observations and operational experience of the Authority, short-term shoulder closures with traffic cones are not significantly different from long-term shoulder closures with barriers until traffic flow starts to become turbulent as volumes approach capacity. Capacity may decrease by as much as 10% due to driver unfamiliarity with the short-term closure, potential impacts such as a displaced cone, increased visibility of work area activities and other factors specifically affecting short-term closures. Therefore, the capacity of a short-term shoulder closure is assumed to be 10% less than the capacity of a long-term closure, yielding the results shown in Table II-2 and Figure II-1.

4. Short-Term Work Zone with a Lane Closure

Independent industry studies have estimated the capacity of short-term work zones with lane closures. The average capacity of a short-term work zone with a lane closure based

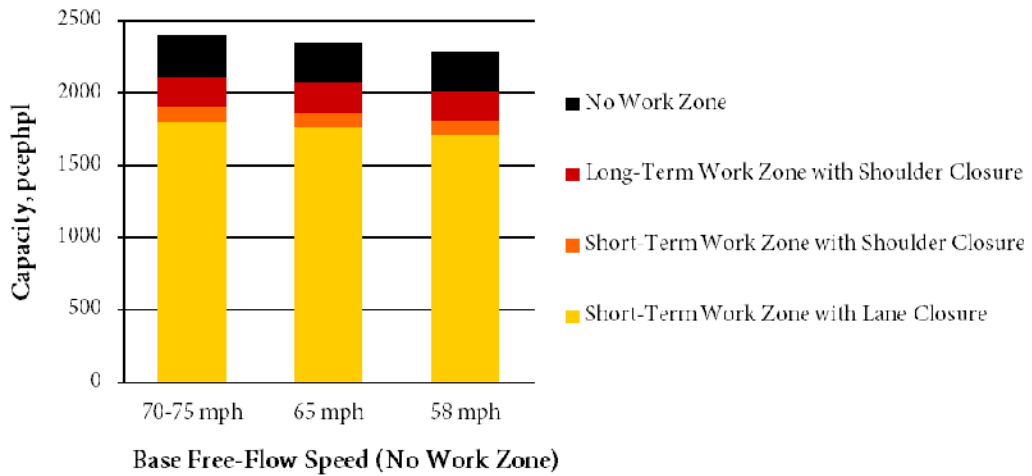
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on these sources is 1,760 pcephpl. Because these studies examined several different highways with unknown characteristics, there may be some deviations from ideal conditions of lane width, lateral clearance, etc. Due to these potential deviations, this work zone capacity corresponds to a non-work zone freeway capacity of 2,350 pcephpl (65 mph free-flow speed). This average capacity is proportionally extended to freeway segments with different capacities and free-flow speeds as shown in Table II-2 and Figure II-1.

Table II-2. Work Zone and Non-Work Zone Capacities Based on Free-Flow Speed

Free-Flow Speed	Capacity (passenger car equivalents per hour per lane, pcephpl)			
	Non- Work Zone	Long-Term Work Zone with Shoulder Closure	Short-Term Work Zone with: Shoulder Closure Lane Closure	
70-75 mph	2,400	2,110	1,900	1,800
65 mph	2,350	2,070	1,860	1,760
58 mph	2,280	2,010	1,810	1,710

Figure II-1. Work Zone and Non-Work Zone Capacities Based on Free-Flow Speed



C. Queue Discharge Capacity

As shown in Exhibit 13-4 of the HCM2000², traffic exiting a queue flows at the queue discharge capacity, which is less than the non-work zone freeway capacity when there is no queue. Queues cannot dissipate until demand volumes drop below the queue discharge capacity. For a stop-and-go queue, this rate of dissipation has been noted by the FHWA¹ to be approximately 20% less than

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the freeway capacity when there is no queue. Page 6-7 of the 1994 Highway Capacity Manual⁴ says, “Various observations of freeway queue departure rates range from as low as 1,500 pcephpl to as high as 2,000 pcephpl,” which is lower than the freeway capacities shown in Table II-1 by 10% to 35%. To represent the average properties of queue discharge, a queue discharge capacity reduction of 20% is used for road user cost calculations.

Whether or not there is a work zone in place, the per-lane queue discharge capacity is calculated as 80% of the per-lane roadway capacity with no work zone. When there is no work zone, the overall roadway queue discharge capacity is calculated as the per-lane queue discharge capacity multiplied by the normal (non-work zone) number of lanes. However, when there is a work zone in place, the per-lane work zone capacity must also be accounted for. Within a work zone, the overall roadway queue discharge capacity is calculated as the number of lanes in the work zone multiplied by the lesser of the per-lane queue discharge capacity and per-lane work zone capacity. This reflects that the lowest capacity on a roadway is the one that governs traffic flow.

⁴ “Highway Capacity Manual.” Transportation Research Board, 1994.

III. Traffic Demand Volumes

Hourly traffic volumes for the NJ Turnpike and Garden State Parkway roadways and ramps must be obtained from the most recent year of available data. Hourly volume data may be available from the following sources:

- Authority link volume information based on toll transactions and/or estimated ramp volumes;
- Recent or current traffic study for this project location;
- Another reliable source approved by the Authority.

If hourly volume data cannot be obtained as a monthly or seasonal average, the data must be normalized to the season during which the work zone will be in place. The Authority must approve the source of the data and the methodology to normalize the data before it is used in the Road User Cost Worksheet or Lane Occupancy Charge Worksheet. Hourly volume data should be obtained in terms of passenger car equivalents (pce) per hour so that volumes can be compared to roadway capacity. Hourly volume data that is in terms of vehicles per hour must be converted to pce per hour as described in this Section.

The process of calculating road user costs requires truck volumes or percentages. Truck data should be obtained on an hourly basis for the greatest accuracy in calculating road user costs. The use of daily, monthly, seasonal or yearly truck percentages should be avoided as they typically do not reflect the greater percentages of trucks during weekdays compared to weekends and the greater percentages of trucks during overnight hours compared to midday (and especially weekday peak) hours. It is preferred to use truck volume or percentage data from the same source as hourly volume data unless otherwise approved by the Authority. Note that the Garden State Parkway permits commercial vehicles south of Interchange 105, so there may be low (typically less than 5%) but non-zero truck volumes on the freeway and ramps.

Certain sections of the Turnpike and Parkway have parallel roadways (Inner and Outer, Express and Local). Hourly volume data may be available for each roadway or for the total of both roadways in each direction. In the latter case, the Authority will provide and/or approve the methodology for dividing traffic between two parallel roadways; no diversions between parallel roadways shall be assumed unless approved by the Authority. The calculation of road user costs is to be performed only for traffic on roadways with closed shoulders and/or lanes, not for parallel roadways.

When using the Lane Occupancy Charge Worksheet (see Appendix B) to calculate Lane Occupancy Charge assessments, the Design Engineer should select the appropriate volumes for the Worksheet using the following guidelines:

- Select the highest monthly or seasonal hourly volumes that fall within the anticipated duration of the lane closure. Only one month or season of hourly volumes should be used for each contract.
- Weekdays (Monday through Friday) and weekends (Saturday and Sunday) have different vehicle mixes, travel patterns and allowable lane closure hours. Complete separate Lane Occupancy Charge Worksheets for weekday work and for weekend work.
- For either weekday or weekend analysis, choose one day of hourly volumes, and the associated truck volumes or percentages, according to one of the following metrics, based on engineering judgment of volume data analysis and subject to acceptance by the Authority:

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- Use volumes and percentages from the highest-volume day within the work period
- Use the average volumes and percentages from Tuesday-Thursday, Monday-Friday or Saturday-Sunday
- Use volumes and percentages from a representative day within the work period
- If there are two lane closures anticipated to be scheduled on the same day or if two days have different allowable closure hours, complete a separate Worksheet for each case. Do not complete a separate Worksheet for a change in lane closure configuration unless the new lane closure is in a different location with different approaching traffic volumes.
- After completing the appropriate Worksheets, select the one with the highest Lane Occupancy Charges. Note that two or more Worksheets may appear to have the highest charges for certain intervals, in which case engineering judgment should be applied. Insert the selected table at the end of Section 102.17 of the Supplementary Specifications, including, if applicable, the additional charge for every 15 minutes late after a 2 hour delay in picking up.

A. Conversion from Vehicles to Passenger Car Equivalents

If traffic volumes are only available in units of vehicles per hour, volumes must be converted to pce per hour using truck volumes or percentages. The assumptions in Table III-1 are built into the Road User Cost and Lane Occupancy Charge Worksheets as default daily values, but should only be used if no truck volume information is available and must be approved by the Authority. Note that truck percentages vary according to time of day, day of week and month, so it is recommended to use actual truck volumes or percentages whenever available.

Table III-1. Approximate Daily Truck Percentages by Roadway
(Source: Year 2009 NJ Turnpike Authority roadway link volumes)

Facility	Roadway Segment	Daily Truck Percentage of Total Volume (vphpl)	
Parkway	Interchange 0 to 105 (MP 0-105)	2%	
Parkway	Int. 105 to New York (MP 105-172)	0%	
Turnpike	Mainline	Int. 1 to 8A (MP 0-73)	13%
	PHMTE*	Entire length (MP 0-6)	14%
	Inner/Outer Roadways	Entire length (MP 73-106)	2-roadway operation: 0% Inner, 21% Outer 1-roadway operation: 11%
	NBHCE**	Int. 14 to 14A (MP N0.0-N3.3)	6%
	NBHCE**	Int. 14A to end (MP N3.3-N8.3)	3%
	Easterly	Entire length (MP E106-E117)	10%
	Westerly	Entire length (MP W106-W117)	13%
	Northerly I-95	Entire length (MP 117-122)	15%***

* PHMTE = Pearl Harbor Memorial Turnpike Extension (I-95).

** NBHCE = Newark Bay – Hudson County Extension (I-78).

*** This is an estimated percentage; use measured truck volumes whenever available.

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To convert from vehicles per hour to pce per hour, the passenger car volume is assumed to be the total volume minus the truck volume. The hourly truck volume is multiplied by the appropriate passenger car equivalency factor as discussed in *Section II.A – Free-Flow Speed and Capacity*. The factored truck volume is added back to the passenger car volume to obtain units of pce per hour. Again note that that actual truck percentages vary according to time of day, day of week and month, especially on the Turnpike.

B. Determination of Passenger Car and Truck Volumes

Hourly traffic volumes are converted into volumes by vehicle type (Passenger Car, Single-Unit Truck, Truck with Trailer) to calculate road user costs. “Passenger Car” is defined as FHWA⁵ Classes 1-3, “Single-Unit Truck” is defined as Classes 4-7 and “Truck with Trailer” is defined as Classes 8-13. If vehicle data is available by the Authority’s toll classes, use Toll Classes 2, 3, B2 and B3 for Single-Unit Truck and Toll Classes 4, 5 and 6 for Truck with Trailer.

Truck percentages should be separated for Single-Unit Truck and Truck with Trailer if this data is available. If separate truck percentages are not available, a single truck percentage per hour can be used. The default values in Table III-1 are used if no source is available, but the use of default values should be avoided, especially on the Turnpike where trucks are a significant percentage of the overall vehicle mix. When a single truck percentage per hour or the default value is used, assume that 90% of trucks are Single-Unit and 10% of trucks are Truck with Trailer to determine road user costs. These approximate percentages are based on Turnpike volumes obtained from February 2006 to March 2007 and may not accurately reflect the actual truck percentages at a given location and time.

The Worksheet converts the hourly traffic volume in pce per hour to demand in vehicles per hour. To do so, it subtracts the percentages of Single-Unit Truck and Truck with Trailer (or the single, combined percentage) from 100% to obtain passenger car percentage. The truck percentage(s) are multiplied by the passenger car equivalency factor (described in *Section II.A.1 – Passenger Car Equivalency*) and added back to the passenger car percentage to obtain the overall pce per vehicle factor. The traffic volume in pce per hour may be divided by that factor to obtain volumes in vehicles per hour, which can then be split into truck and car volumes using the truck percentage(s).

The functionality of the Road User Cost and Lane Occupancy Charge Worksheets is to divide the hourly volumes into quarter-hourly volumes for determining delays, queues and road user costs to the nearest 15 minutes. There is no provision for the use of Peak Hour Factor (PHF) because to calculate the PHF for all ¼ hour intervals would result in overestimation of hourly volumes and thus invalid estimation of road user costs. Calculating the PHF for only one ¼ hour interval per hour of data is also not supported because it cannot be predicted which ¼ hour interval will experience the highest volume.

⁵ “FHWA Vehicle Classification.” Federal Highway Administration, 2011: <https://www.fhwa.dot.gov/policy/ohpi/vehclass.htm>

C. Queuing

Queuing occurs when approaching demand exceeds roadway capacity. If there is no queue at the beginning of the $\frac{1}{4}$ hour and approaching traffic demand is less than the capacity of the roadway (including all applicable reduction factors), then there will be no queuing during the $\frac{1}{4}$ hour. Otherwise, there will be queuing during the $\frac{1}{4}$ hour and the roadway capacity will be equal to the queue discharge capacity, calculated as described in *Section II.C – Queue Discharge Capacity*. Note that for calculation purposes, if a queue exists for any part of a $\frac{1}{4}$ hour, the roadway capacity during the entire $\frac{1}{4}$ hour is considered to be equal to the queue discharge capacity. This does not affect road user cost calculations because the demand for the remainder of the $\frac{1}{4}$ hour is less than the queue discharge capacity, or else the queue would not have dissipated.

Assuming there is a queue, the number of vehicles that will enter or travel the queue during the $\frac{1}{4}$ hour being analyzed is determined according to the following steps:

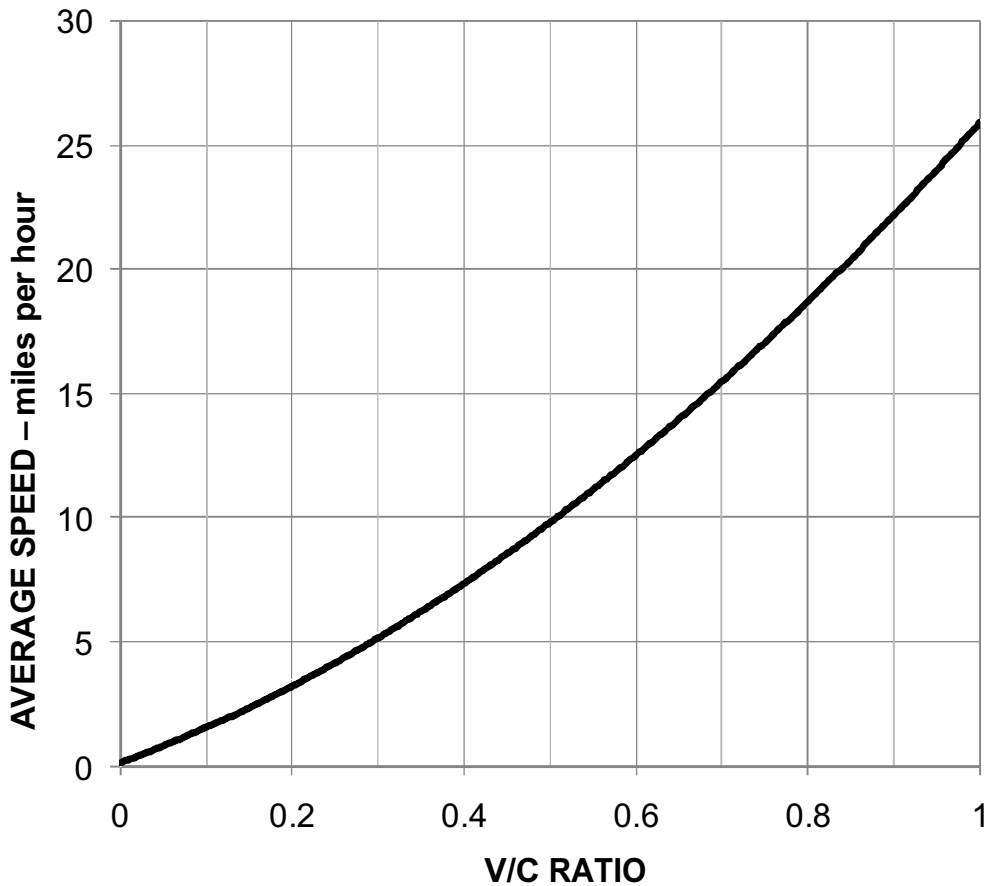
- If the demand exceeds the capacity of the roadway, there will be added queued vehicles, defined as the difference between demand and capacity. The queue at the end of the $\frac{1}{4}$ hour will be equal to the number of vehicles in the queue at the beginning of the $\frac{1}{4}$ hour (if any) plus the added queued vehicles.
- If the demand is less than the capacity of the roadway, there will be no added queued vehicles. The difference between demand and capacity is the reserve capacity of the roadway. If the number of vehicles in the queue at the beginning of the $\frac{1}{4}$ hour is less than the reserve capacity, the queue will dissipate. Otherwise, the queue at the end of the $\frac{1}{4}$ hour will be equal to the number of vehicles in the queue at the beginning of the $\frac{1}{4}$ hour minus the reserve capacity.
- The average queued vehicles are calculated as the average of the number of vehicles in the queue at the beginning of the $\frac{1}{4}$ hour and number of vehicles in the queue at the end of the $\frac{1}{4}$ hour.
- The number of vehicles traveling the queue is calculated for the purpose of road user cost assessment on a per-vehicle basis. If there is a queue at the end of the $\frac{1}{4}$ hour, this number is equal to the queue discharge capacity, calculated as described in *Section II.C – Queue Discharge Capacity*. If the queue dissipates during the $\frac{1}{4}$ hour, the number of vehicles traveling the queue is determined according to these steps:
 - Calculate the total queue demand as the number of queued vehicles at the beginning of the $\frac{1}{4}$ hour plus approaching demand.
 - Calculate the fraction of the $\frac{1}{4}$ hour with queuing as the number of queued vehicles at the beginning of the $\frac{1}{4}$ hour divided by the reserve capacity defined above.
 - Calculate the number of arriving vehicles that will travel the queue as the approaching demand multiplied by the fraction of the $\frac{1}{4}$ hour with queuing.
 - The number of vehicles traveling the queue is equal to the number of queued vehicles at the beginning of the $\frac{1}{4}$ hour added to the number of arriving vehicles that will travel the queue.

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Once the number of vehicles entering or traveling the queue is known, the speed traveled by the queued vehicles is estimated using Figure III-1. Figure III-1 has been adapted from previous editions of the Highway Capacity Manual, as cited by FHWA¹, to estimate the speed at which vehicles travel within a queue. Separate speeds are estimated for work zone and non-work zone conditions if the queue discharge capacity, calculated as described in *Section II.C – Queue Discharge Capacity*, is lower when there is a work zone.

When performing queue speed estimation, the horizontal axis of Figure III-1 is taken as the Queue V/C Ratio. The Queue V/C Ratio is calculated as the actual roadway capacity (i.e., the queue discharge capacity) divided by the free-flow roadway capacity when there is no queue or work zone. For example, the Queue V/C Ratio would be 0.80 when there is queuing but no work zone. The queue speed is then read from the vertical axis using the curve shown in the Figure.

Figure III-1. Vehicle Speed in Queue Conditions According to V/C Ratio



Next, the queue density and approaching demand density are calculated, yielding the queue length and queue delay. Queue density is calculated as the number of vehicles that travel the queue (pce per hour) divided by the average queue speed (miles per hour) to yield a density in pce per mile. Queue density reflects the following trends:

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- Given a certain volume traveling the queue, traffic moves more slowly as density increases.
- Given a certain queue speed, a denser queue means that more vehicles will travel the queue in a given time interval.

The approaching demand density applies to vehicles that have not yet entered the queue. It is calculated as the vehicle demand (pce per hour) divided by the average approach speed (miles per hour), which is assumed to be the free-flow speed, to yield a density in pce per mile. Based on FHWA¹ methodology, the average queue length during a ¼-hour period is calculated as the average number of queued vehicles divided by the difference between queue density and approaching demand density. For any reasonable range of traffic volumes, queue density will be higher than demand density, so the queue length should never be calculated as less than zero.

Finally, queue delay is calculated as the difference in travel time when there is a queue (queue length divided by queue speed) compared to when there is not (queue length divided by free-flow speed). This is the delay experienced by each vehicle as it passes through the queue compared to if there were no queue.

IV. Road User Costs

Road user costs are an unavoidable feature of work zones. Work zone road user costs represent the combination of vehicle operating costs (VOC) and delay costs to highway users traveling through work zones. As described by the FHWA¹, user costs account for the effects of timing, duration, frequency, scope and characteristics of the work zone, volume and operating characteristics of the traffic affected, and the unit VOC and delay costs. They are based on unit costs for each component of VOC and delay costs factored to the current year, multiplied by the number of units (such as vehicle-hours). These are the seven components of user costs defined by the FHWA¹:

Free-flow work zone conditions

- Speed change VOC
- Speed change delay cost
- Reduced speed delay cost (also applicable to queued/stopped work zone conditions)

Queued / stopped work zone conditions

- Stopping VOC
- Stopping delay cost
- Queue delay cost
- Idling VOC

It is desirable to minimize the occurrence of queuing in work zones. When traffic volumes exceed roadway capacity, queuing will occur and the higher-cost components of user cost are calculated according to the methodology of this Manual for the duration of queuing. The Authority's Lane Closure and Shoulder Closure Tables have been developed using a methodology that reduces the possibility of a queue forming through a short-term approved work zone. However, long-term work zone shoulder closures and lane shifts are usually designed to be left in place, even if volumes indicate that queues will form periodically. Features of the work zone that may affect user costs and/or the possibility of queuing include length (distance), lane width and lateral clearance, duration and types of closures and posted speed limits.

The procedures described in this Manual and the calculation models that are implemented in the Road User Cost and Lane Occupancy Charge Worksheets assume that traffic will not voluntarily divert from the work zone roadway to an alternate facility. Alternate facilities do not provide the same functionality or familiarity as the NJ Turnpike and Garden State Parkway. When traffic diverts, there are effects on the road user costs of the diverting traffic and incremental costs to other roadway users on the alternate facility that are not always known or able to be calculated. The calculation models also do not include the costs incurred by the Authority for engineering, inspection, administration, etc. due to the work zone being in place outside of approved hours.

For some work zones, the Authority may elect to operate Variable Message Signs (VMS) and/or Changeable Message Signs (CMS) to rebalance traffic when there are two roadways past the work zone (e.g. Inner/Outer Roadways, Easterly/Westerly Alignments, etc.). At the Authority's discretion, the volume inputs to the Road User Cost Worksheet or the Lane Occupancy Charge Worksheet may be adjusted to incorporate the effects of rebalanced traffic, but the Worksheet user should not assume any rebalancing or diversions unless otherwise directed by the Authority.

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A. User Cost Factors

The road user cost factors presented in this Section are current to Year 2009, the last full year that the transportation component of the Consumer Price Index (CPI) is available. Road user cost factors for the current year are calculated by multiplying the Year 2009 cost factors by a scaling factor. The scaling factor is calculated by dividing the CPI transportation component of the most recent available year by the CPI transportation component of the base year (2009).

- The CPI transportation component during the base year of 2009 was 179,252.

The most recent available CPI transportation component may be found on the US Bureau of Labor Statistics website⁶. The most recent full year should be used, because the transportation component is not typically available for the most recent month or half-year. Also, monthly or half-yearly values may change significantly by the end of the year, as explained by the Bureau of Labor Statistics. The Year 2009 CPI is the basis for Year 2010 user costs, so when calculating costs for the current year, it is appropriate to use the CPI of the most recent full year.

Road user cost factors are provided for three vehicle categories:

- Passenger cars, representing FHWA Classes 1-3;
- Single-unit trucks, representing FHWA Classes 4-7;
- Trucks with trailers, representing FHWA Classes 8-13.

The Year 2009 updated values for value of time are shown in Table IV-1, based on the most recent studies included in FHWA¹ Table 2.12. These values are repeated in Table 1 of the Road User Cost Worksheet (see Appendix A). Table 2 of the Road User Cost Worksheet uses the most recent available CPI transportation component to scale these values to the current year.

Table IV-1. Values of Time (2009 Dollars)

	<i>From MicroBENCOST</i>	<i>From HERS model</i>	Average Value of Time
Passenger cars	\$13.37 / vehicle-hour	\$16.82 / vehicle-hour	\$15.10 / vehicle-hour
Single-unit trucks	\$20.52 / vehicle-hour	\$30.57 / vehicle-hour	\$25.55 / vehicle-hour
Trucks with trailers	\$29.38 / vehicle-hour	\$36.81 / vehicle-hour	\$33.10 / vehicle-hour

Note that if a work zone is in place for any part of a 15-minute interval (¼ hour), the Road User Cost and Lane Occupancy Charge Worksheets are designed to calculate costs for the entire 15-minute interval, which reflects the Authority’s standard procedure for road user cost and Lane Occupancy Charge calculation.

⁶ “Consumer Price Index.” U.S. Bureau of Labor Statistics, 2011: <http://www.bls.gov/cpi/#tables>

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1. Speed Change and Stopping VOC and Delay Costs

Speed change VOC and delay costs are calculated based on the difference in free-flow speed and work zone speed for vehicles approaching a work zone when there is no queuing. There is no speed change VOC or delay if work zone speed is equal to the free-flow speed. When there is queuing, regardless of the presence of a work zone, stopping VOC and delays are calculated instead of speed change VOC and delays because queues are characterized by frequent stops and starts. The definition of a stopping VOC or delay is the cost (in dollars or hours) of stopping from a given initial speed and then returning to that speed.

Table IV-2 shows the stopping VOC as of Year 2009 and vehicle delays in units per 1,000 vehicle stops. The source of these values is given under FHWA¹ Table 2.2. Operating costs and delays in

Table IV-2 for trucks operating at 65-70 mph and faster have been extrapolated from the available data.

Table IV-2. Stopping Vehicle Operating Costs (2009 Dollars) and Delays

Initial Speed (mph)	Vehicle Operating Costs, \$/1,000 Stops			Delays, Hours/1,000 Stops		
	Passenger Car	Single-Unit Truck	Truck with Trailer	Passenger Car	Single-Unit Truck	Truck with Trailer
5	\$3.39	\$11.62	\$42.21	1.02	0.73	1.10
10	\$11.09	\$26.00	\$97.27	1.51	1.47	2.27
15	\$19.02	\$42.54	\$163.14	2.00	2.20	3.48
20	\$27.29	\$60.75	\$238.57	2.49	2.93	4.76
25	\$35.99	\$80.30	\$322.03	2.98	3.67	6.10
30	\$45.31	\$100.72	\$411.99	3.46	4.40	7.56
35	\$55.31	\$121.60	\$506.92	3.94	5.13	9.19
40	\$66.16	\$143.07	\$605.30	4.42	5.87	11.09
45	\$77.91	\$163.29	\$705.63	4.90	6.60	13.39
50	\$90.77	\$183.22	\$806.39	5.37	7.33	16.37
55	\$104.78	\$201.96	\$906.01	5.84	8.07	20.72
60	\$120.12	\$224.66	\$1002.95	6.31	8.80	27.94
65	\$136.85	\$245.84	\$1095.85	6.78	9.53	37.25
70	\$155.16	\$263.73	\$1183.07	7.25	10.27	50.31
75	\$175.14	\$281.83	\$1263.11	7.71	11.00	67.91
80	\$196.89	\$298.76	\$1334.47	8.17	11.73	91.06

For each vehicle type, the speed change VOC/1,000 stops is calculated as the VOC/1,000 stops of the initial speed minus the VOC/1,000 stops of the final speed in

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Table IV-2, factored to current year costs. The stopping VOC/1,000 stops is simply the VOC/1,000 stops of the initial speed. The overall speed change or stopping VOC is obtained by multiplying by the number of approaching vehicles of that type divided by 1,000. The values are then summed for all vehicle types and multiplied by the cost factor for the current year.

For each vehicle type, the speed change delay (hours per 1,000 stops) is calculated as the stopping delay of the initial speed minus the stopping delay of the final speed in Table IV-2. Note that delay values are not factored to the current year because they do not represent a dollar value. The stopping delay (hours per 1,000 stops) is simply the stopping delay of the initial speed. The overall speed change or stopping delay is obtained by multiplying by the number of approaching vehicles of that type divided by 1,000. The delay is multiplied by the average value of time given in Table IV-1, factored to current year costs, to obtain the speed change or stopping delay cost value. The values are then summed for all vehicle types and multiplied by the cost factor for the current year.

If there is queuing for part of a $\frac{1}{4}$ -hour period, stopping VOC and delay are calculated for the part of the $\frac{1}{4}$ hour when there is queuing. Speed change VOC and delay are calculated for the part of the $\frac{1}{4}$ hour when there is no queuing only if the work zone is still in place. The fraction of the $\frac{1}{4}$ hour with queuing is calculated as the number of queued vehicles at the beginning of the $\frac{1}{4}$ hour divided by the reserve capacity (defined in *Section III.C – Queuing*).

The values in

Table IV-2 are repeated in Table 3 of the Road User Cost Worksheet (see Appendix A) for speeds of 35 mph or greater. Entries for 58 mph and 72 mph have been interpolated in the Worksheet to correspond to the estimated free-flow speeds of certain roadway segments (72 mph is used as an intermediate speed between 70 and 75 mph). The Worksheet uses the most recent available CPI transportation component to scale VOC values to the current year.

2. Reduced Speed Delay Cost

This cost is calculated for all vehicles traveling through the work zone, whether or not there is a queue. The number of vehicles traveling the work zone is calculated as follows:

- When there is no work zone, this is equal to zero.
- When there is a work zone with queuing at the end of the $\frac{1}{4}$ hour, this is equal to the roadway capacity discussed in *Section II.B – Work Zone Capacity*.
- When there is a work zone with no queuing at the end of the $\frac{1}{4}$ hour, this is equal to the approaching demand plus any queued vehicles at the beginning of the $\frac{1}{4}$ hour.

Reduced speed delay costs are calculated on a $\frac{1}{4}$ -hourly basis for each vehicle type:

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- Determine the time taken to traverse the work zone at free-flow speeds (length of work zone divided by free-flow speed).
- Determine the time taken to traverse the work zone at work zone speeds (length of work zone divided by work zone speed); work zone speed is discussed in *Section II.B – Work Zone Capacity*.
- The reduced speed delay is the difference in travel time (per vehicle) when there is a work zone compared to when there is not, multiplied by the number of vehicles traveling the work zone for each vehicle type.
- Multiply the overall reduced speed delay by the Average Value of Time found in Table IV-1, factored to current year costs, to obtain reduced speed delay costs for each vehicle type.

3. Queue Delay Cost and Idling VOC

When there is queuing, queue length and queue delay are calculated as described in *Section III.C – Queuing*. Queue delay cost is calculated on a ¼-hourly basis by multiplying the average queue delay (per vehicle) by the average value of time in Table IV-3, factored to current year costs. Idling VOC is similarly calculated by multiplying the average queue delay (per vehicle) by the idling cost in Table IV-3, factored to current year costs. These values are repeated in Table 1 of the Road User Cost Worksheet (see Appendix A). Table 2 of the Road User Cost Worksheet uses the most recent available CPI transportation component to scale these values to the current year.

Table IV-3. Value of Time when Queued (2009 Dollars)

	Average Value of Time (from Table IV-1)	Idling Cost
Passenger cars	\$15.10 / vehicle-hour	\$0.87 / vehicle-hour
Single-unit trucks	\$25.55 / vehicle-hour	\$0.96 / vehicle-hour
Trucks with trailers	\$33.10 / vehicle-hour	\$1.04 / vehicle-hour

If there is queuing for part of a ¼-hour period, queue delay cost and idling VOC are calculated for the part of the ¼ hour when there is queuing. The fraction of the ¼ hour with queuing is calculated as the number of queued vehicles at the beginning of the ¼ hour divided by the reserve capacity (defined in *Section III.C – Queuing*).

4. Detour Delays and VOC

When a detour is instituted for a work zone during a ramp or roadway closure, vehicles travel additional time and distance between the start and end points of the detour. Detour VOC and delay costs are calculated for the additional length of the detour and the additional time to travel the detour compared to the normal length and travel time on the closed ramp or roadway. If queuing is predicted, queue delay cost and idling VOC are calculated based on queue length and speed traveled by queued vehicles.

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Consult the Authority when determining road user costs associated with a detour due to a ramp closure or a road closure in areas where there is no parallel Authority roadway (Inner / Outer, Express / Local, etc.). In these cases, a detailed study may be undertaken to determine the volume constraints and speed characteristics of the detour route.

V. Assessment of Lane Occupancy Charges

While road user costs may factor into work zone-related decisions, Lane Occupancy Charges are only assessed when work zones remain in place outside the allowable time limits, according to the provisions of the contract. These charges reflect the costs experienced by road users and act as an incentive to adhere to the specified times that a work zone may be in place. For the length of time that a work zone is in place when the roadway is supposed to be clear of all work, the user costs associated with free-flow work zone conditions are evaluated as charges assessed against the responsible party. For the length of time that queuing occurs as a result of the work zone remaining in place outside the allowable time limits, even after the work zone has been picked up, the user costs associated with queued work zone conditions are evaluated as additional Lane Occupancy Charges assessed against the responsible party.

The Lane Occupancy Charge Worksheet is included in Appendix B. To determine which costs should be assessed as Lane Occupancy Charges, the Worksheet should be filled out assuming that the work zone is only in place during approved hours. The Worksheet automatically calculates the total road user cost of the work zone in 15-minute increments if it is left in place beyond approved hours. If the actual work zone is in place for more than 2 hours beyond the approved hours, the differential amount assessed during the previous 15-minute interval (from 106-120 minutes late) is repeatedly assessed every 15 minutes until the work zone is removed or \$20,000 is reached. Note that this amount is not the total assessment for a work zone that is 106-120 minutes late picking up, only the additional charge compared to a work zone that is 90-105 minutes late picking up.

Lane Occupancy Charges that may be assessed are the difference of the actual work zone costs for the entire day minus the approved work zone costs for the entire day up to the maximum of \$20,000. This process accounts for existing conditions where volumes are greater than the theoretical roadway capacity even without a work zone in place, so that parties are not assessed Lane Occupancy Charges for costs they do not incur.

The cost assessment methodology does not provide for costs incurred by the Authority (as opposed to costs incurred by road users). Having work zones in place outside approved hours adds costs for engineering, inspection, operations and other administrative areas. The Authority's Maintenance and/or Operations Departments may provide additional Lane Occupancy Charges to be assessed per hour or per ¼ hour to recoup some or all of the Authority's costs, but no such costs shall be assumed unless directed by the Authority.

The single-day limit for Lane Occupancy Charges to be assessed is currently \$20,000, including any additional costs directed by the Authority. The Authority may change this amount, and it may be overridden by contract provisions. This limit will likely be assessed to a work zone that is late picking up when a queue forms due to the magnitude of queue-related costs. Lane Occupancy Charges when there is no queuing may or may not reach this limit. The calculated charges for contract work are shown in a table on the front of the Lane Occupancy Charge Worksheet, including additional charges for every 15 minutes late after 2 hours if applicable. This table should be included in Subsection 107.12 of the Authority's Supplementary Specifications. If more than one row of the table shows an assessment of \$20,000, only the rows up to and including the first row that shows \$20,000 need to be included in the Specifications.

VI. Road User Cost Worksheet

The Road User Cost Worksheet is included in Appendix A.

A. Inputs

Inputs that are in rows can be found at the top left of the Worksheet in Column F. Inputs that are in columns can be found starting in Row 32 of the Worksheet.

Select Roadway (Row 1) – Select the roadway from the drop-down menu. This will determine which roadway sections are available for selection in the next row.

Select Section (Row 2) – Select the roadway section from the drop-down menu. If the work zone spans multiple sections, choose the one with the most restrictive conditions based on demand volumes, roadway and work zone capacities and other work zone characteristics. As described in *Section II.A – Free-Flow Speed and Capacity* and shown in Table II-1, each roadway section has a particular non-work zone freeway capacity.

Number of Lanes When There Is No Work Zone (Row 3) – Enter the minimum number of freeway lanes in the work zone area, as defined in *Section II.B – Work Zone Capacity*, when the work zone is not in place.

Upgrade of at Least 3% Grade and ½ Mile Length (Row 4) – Select “Yes” if there is such an upgrade either within the work zone or within approximately 2 miles approaching the work zone. Confirm whether demand volumes already include the passenger car equivalency (pce) factor for trucks of 2.0 on level terrain and 2.5 on upgrades. The pce factor is discussed in *Section II.A.1 – Passenger Car Equivalency*.

Select Type of Work Zone (Row 5) – Select the work zone type from the drop-down menu. There is no option for “Long-term; lane closed” as explained in *Section II.B – Work Zone Capacity*. To analyze HICCs with lane closures, select “Short-term; lane closed.” The type of work zone selected determines the base per-lane work zone capacity as explained in *Sections II.B.2 through II.B.4*.

Select Day of First Hour of Data (Row 6) – Select the day that applies to the first 24 hours in the Volume Inputs. The selected day will determine whether the roadway capacity will be reduced by a weekend factor as discussed in *Section II.B.1 – Variable Operational Considerations*.

Is the Work Zone in Summer? (Row 7) – Separate analyses should be performed for Summer and non-Summer months, reflecting seasonal variations in traffic volumes. The selection of the season also affects the application of the weekend factor as described in *Section II.B.1 – Variable Operational Considerations*. Select “Yes” if the work zone to be analyzed will be installed during the indicated dates:

- May 1 to October 14: Garden State Parkway north of Interchange 129

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- May 15 to September 14: All other roadways

Ramp Merge or Diverge within 1000' of Work Zone (Row 8) – Select “Yes” to reduce roadway capacity by a ramp junction factor based on the criteria discussed in *Section II.B.1 – Variable Operational Considerations*.

Number of Lanes When Work Zone Is in Place (Row 9) – Enter the minimum number of open lanes in the work zone. Values entered into the Worksheet must follow these rules:

- If the work zone has a shoulder closure, the number of lanes must remain the same as when there is no work zone (Row 9 = Row 3).
- If the work zone has a lane closure, the number of lanes must be less than when there is no work zone (Row 9 < Row 3).
- The worksheet does not support zero values. If a ramp or roadway is to be closed, consult the Authority for detour cost calculations or analyze the work zone using a parallel, open roadway (e.g. if the Inner Roadway is closed, analyze the Outer Roadway with all traffic moved onto it).

Normal Lane Width, No Work Zone (Row 10) – Enter the minimum width of freeway lanes in the work zone area, as defined in *Section II.B – Work Zone Capacity*, when the work zone is not in place.

Lane Width in Work Zone (Row 11) – Enter the minimum lane width at any point in the work zone. The work zone lane width should not be greater than the normal lane width that was entered in Row 10. The normal and work zone lane widths are used to determine whether to apply a lane width factor as described in *Section II.B.1 – Variable Operational Considerations*.

Length of Work Zone (Row 12) – Enter the length of the work zone based on the definition in *Section II.B – Work Zone Capacity*. The length of work zone factor is applied to work zone roadway capacity as described in *Section II.B.1 – Variable Operational Considerations*. The work zone length also determines travel times through the work zone area with and without the work zone in place.

Does the Work Zone involve High Intensity Work? (Row 13) – Based on engineering judgment, select “Yes” if there is high intensity work as defined in *Section II.B.1 – Variable Operational Considerations*. This will apply a reduction factor to the work zone roadway capacity.

Posted Work Zone Speed Limit (Row 14) – Enter the lowest speed limit posted in the work zone. The posted speed limit is used to calculate the effective work zone speed as described in *Section II.B – Work Zone Capacity*.

Current Year CPI Transportation Component (Row 15) – As described in *Section IV.A – User Cost Factors*, see the US Bureau of Labor Statistics website⁶ for the most recent value. This value is divided by the Year 2009 CPI transportation component to obtain a scaling factor used to determine current year road user unit costs.

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Demand (pce per hour) (Column B) – The Worksheet is constructed to analyze a single day’s work zone(s). Typically, only the first 24 hours (12-1 am until 11p-12a) of traffic demand volumes need to be entered in the Worksheet. However, if queuing that occurs as a result of the work zone does not dissipate by the end of the 24-hour period, enter additional demand volumes up to 36 hours to reflect the true anticipated road user costs. Additional hours of demand volumes should also be entered if the ending hour of the approved work zone is at or near 12 am to ensure that queuing will be accounted for. Follow the procedures described in *Section III – Traffic Demand Volumes* to process raw demand volumes before inputting them into the Worksheet.

Single-Unit Truck % (Column C), Truck with Trailer % (Column D) – Enter percentages into these two columns, if available from the demand volume data, for each hour that there is vehicle demand. Values must be entered as a percentage or a decimal less than or equal to 1.00, not as a whole number. It is preferable to enter percentages into these two columns than in Column E, as described in *Section III.B – Determination of Passenger Car and Truck Volumes*.

Overall Truck % (Column E) – If Single-Unit Truck and Truck with Trailer percentages (Columns C and D) are not available, enter percentages into this column for each hour that there is vehicle demand. Values must be entered as a percentage or a decimal less than or equal to 1.00, not as a whole number. It is preferable to enter percentages into this column than to leave Columns C through E blank and use default values, as described in *Section III.B – Determination of Passenger Car and Truck Volumes*.

Work Zone (Columns F and I) – Select “YES” from the drop-down menu in Column F for any full or partial hour that the work zone is in place. After selecting values in Column F, if the approved or actual work zone is only in place for part of the hour, use the drop-down menu in Column I to more precisely select each ¼ hour interval that the work zone is in place.

B. Calculated Values

Calculated values that are in rows can be found at the top left of the Worksheet in Column F below the user inputs. Calculated values that are in columns can be found starting in Row 32 of the Worksheet to the right of the user volume inputs.

Per-Lane Roadway Capacity, No Work Zone (Row 16) – This value is dependent on the roadway and segment selected in Rows 1 and 2 of User Inputs, as described in *Section II.A – Free-Flow Speed and Capacity* and shown in Table II-1.

Estimated Free-Flow Speed (Row 17) – This value is dependent on the roadway and segment selected in Rows 1 and 2 of User Inputs. It correlates to the per-lane roadway capacity with no work zone that is shown in Row 16.

Passenger Car Equivalents per Truck (Row 18) – This value is dependent on the presence of an upgrade of at least 3% grade and ½ mile length if selected in Row 4 of User Inputs. The pce factor is discussed in *Section II.A.1 – Passenger Car Equivalency*.

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Merge/Diverge Area Reduction (Row 19) – This value is dependent on the presence of a ramp merge or diverge within 1000 feet of the work zone if selected in Row 8 of User Inputs. A ramp junction reduction factor is applied as described in *Section II.B.1 – Variable Operational Considerations*.

Base Per-Lane Roadway Capacity, Work Zone (Row 20) – This value is dependent on the non-work zone capacity of the roadway section, shown in Row 16 of Calculated Values, and the type of work zone selected in Row 5 of User Inputs. It is multiplied by the merge/diverge area reduction, if applicable, in Row 19 of Calculated Values. Each type of work zone has an associated reduction factor from the non-work zone capacity as described in *Sections II.B.2, II.B.3 and II.B.4*.

Work Zone Lane Width Reduction (Row 21) – This value is dependent on the normal (non-work zone) and work zone lane widths entered in Rows 10 and 11 of User Inputs. If the normal lane width is 11 feet or greater and the work zone lane width is less than 11 feet, a lane width reduction factor is applied as described in *Section II.B.1 – Variable Operational Considerations*.

Work Zone Length Reduction (Row 22) – This value is dependent on the work zone length entered in Row 12 of User Inputs. The length of work zone reduction factor is applied as described in *Section II.B.1 – Variable Operational Considerations*.

Work Intensity Reduction (Row 23) – This value is dependent on whether High Intensity Work is selected in Row 13 of User Inputs based on engineering judgment. If “YES” is selected in Row 13, a work intensity reduction factor of 5.7% is applied as described in *Section II.B.1 – Variable Operational Considerations*.

Final Per-Lane Roadway Capacity, Work Zone (Row 24) – This value is equivalent to the base work zone capacity (Row 21) multiplied by the reduction factors, if applicable, for length of work zone, lane width and work intensity in Rows 22, 23 and 24.

Effective Work Zone Speed (Row 25) – This value is dependent on the posted work zone speed limit entered in Row 14 of User Inputs, and is calculated as described in *Section II.B – Work Zone Capacity*.

Year 2009 CPI Transportation Component (Row 26) – This value is taken from the US Bureau of Labor Statistics website⁶ as described in *Section IV.A – User Cost Factors*. It is used as a baseline to scale road user cost unit values to the current year based on the Current Year CPI Transportation Component entered in Row 15 of User Inputs.

Cost Factor to Current Year (Row 27) – This value is equivalent to the Current Year CPI Transportation Component (Row 15) divided by that of Year 2009 (Row 26). It is used to scale Year 2009 value of time costs as described in *Section IV.A – User Cost Factors*.

Demand (pce per ¼ hour) (Column J) – These values are determined by dividing the hourly demand from Column B into ¼-hour intervals so that road user costs may be calculated for every 15 minutes that a work zone is in place. Peak hour factors are not applied to 15-minute volumes as explained in *Section III.B – Determination of Passenger Car and Truck Volumes*.

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Lanes Open (Column K) – Depending on whether the work zone is in place as shown in Column I of User Inputs, this is either the normal (no work zone) number of freeway lanes or the number of lanes in the work zone.

Roadway Capacity (pce per ¼ hour) (Column L) – Roadway capacity during a particular ¼ hour is calculated as follows:

- If there is queuing, the roadway capacity is equal to ¼ of the hourly queue discharge capacity as calculated in *Section II.C – Queue Discharge Capacity*.
- If there is no queuing and no work zone, the roadway capacity is equal to ¼ of the hourly per-lane roadway capacity with no work zone (Row 16 of Calculated Values) multiplied by the number of freeway lanes with no work zone (Row 3 of User Inputs).
- If there is no queuing and the work zone is in place, the roadway capacity is equal to ¼ of the hourly per-lane work zone capacity (Row 24 of Calculated Values) multiplied by the number of work zone lanes (Row 9 of User Inputs).

The roadway capacity is modified by a weekend reduction factor if it falls within a defined weekend period, as explained in *Section II.B.1 – Variable Operational Considerations*.

Demand (vehicles per ¼ hour) (Column M) – These values are converted from the values in Column J (pce per ¼ hour) using the heavy vehicle percentages in Columns C and D, Column E or the fixed default percentage as described in *Section III.B – Determination of Passenger Car and Truck Volumes*.

Single-Unit Trucks (Column N) – This is the demand in Column M multiplied by the percentage of Single-Unit Trucks. If a percentage has been entered in Column C, it is applied here. Otherwise, the percentage of Single-Unit Trucks is assumed to be half the overall percentage of trucks (either from Column E or from the default Worksheet value).

Trucks with Trailers (Column O) – This is the demand in Column M multiplied by the percentage of Trucks with Trailers. If a percentage has been entered in Column D, it is applied here. Otherwise, the percentage of Trucks with Trailers is assumed to be half the overall percentage of trucks (either from Column E or from the default Worksheet value).

Passenger Cars (Column P) – This is the remaining demand after subtracting the calculated truck volumes in Columns N and O from the demand in Column M.

Reduced Speed Delay (Column Q) – This is the delay experienced by each vehicle as it passes through the work zone, calculated as described in *Section IV.A.2 – Reduced Speed Delay Cost*.

Added Queued Vehicles (Column R) – This is the number of vehicles added to the queue length during a given ¼ hour if demand exceeds capacity. It is calculated as described in *Section III.C – Queuing*, and is equal to zero if demand is less than capacity.

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Queued Vehicles at End of ¼ Hour (Column S) – This is the number of vehicles remaining in the queue at the end of the ¼ hour, calculated as described in *Section III.C – Queuing*.

Average Queued Vehicles (Column T) – This is the average number of queued vehicles during the ¼ hour, calculated as described in *Section III.C – Queuing*.

Vehicles that Travel Work Zone (Column U) – This value is calculated as described in *Section IV.A.2 – Reduced Speed Delay Cost*.

Vehicles that Travel Queue (Column V) – The number of vehicles traveling the queue is calculated as described in *Section III.C – Queuing*.

Queue V/C Ratio (Column W) – This is the number of vehicles that are able to travel the queue in a given ¼ hour compared to free-flow conditions. It is used to determine average queue speed as described in *Section III.C – Queuing*.

Average Queue Speed (Column X) – This is calculated from the Queue V/C Ratio in Column W based on the equation fitted to Figure III-1 as described in *Section III.C – Queuing*.

Queue Density (Column Y) – The queue density is calculated as described in *Section III.C – Queuing*. To obtain the number of vehicles that travel the queue in pce per hour, Column V is multiplied by 4 because it is expressed in pce per ¼ hour.

Demand Density (Column Z) – The approaching demand density is calculated as described in *Section III.C – Queuing*. To obtain the vehicle demand in pce per hour, Column J is multiplied by 4 because it is expressed in pce per ¼ hour.

Average Queue Length (Column AA) – The average queue length is calculated as described in *Section III.C – Queuing*. If the Worksheet calculates a queue length less than zero, there is likely an error in volume input.

Average Queue Delay (Column AB) – The queue delay is calculated as described in *Section III.C – Queuing*.

Speed Change VOC (Column AC) – Speed change VOC is calculated for vehicles approaching a work zone when there is no queuing as described in *Section IV.A.1 – Speed Change and Stopping VOC and Delay Costs*. There is no speed change VOC calculated if work zone speed is equal to the free-flow speed or if there is queuing.

Speed Change Delay Cost (Column AD) – Speed change delay cost is calculated for vehicles approaching a work zone when there is no queuing as described in *Section IV.A.1 – Speed Change and Stopping VOC and Delay Costs*. There is no speed change delay cost calculated if work zone speed is equal to the free-flow speed or if there is queuing.

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Reduced Speed Delay Cost (Column AE) –Reduced speed delay cost is calculated based on the reduced speed delay (Column Q) for each vehicle that travels the work zone (Column U), as described in *Section IV.A.2 – Reduced Speed Delay Cost*.

Stopping VOC (Column AF) – Stopping VOC is calculated for vehicles when there is queuing, whether or not the work zone is in place, as described in *Section IV.A.1 – Speed Change and Stopping VOC and Delay Costs*.

Stopping Delay Cost (Column AG) – Stopping delay cost is calculated for vehicles when there is queuing, whether or not the work zone is in place, as described in *Section IV.A.1 – Speed Change and Stopping VOC and Delay Costs*.

Queue Delay Cost (Column AH) – Queue delay cost is calculated for vehicles when there is queuing, whether or not the work zone is in place, as described in *Section IV.A.3 – Queue Delay Cost and Idling VOC*.

Idling VOC (Column AI) – Idling VOC is calculated for vehicles when there is queuing, whether or not the work zone is in place, as described in *Section IV.A.3 – Queue Delay Cost and Idling VOC*.

C. Outputs

The Worksheet evaluates each of the seven components of user costs defined by the FHWA¹. The ¼-hourly costs in each column are summed to arrive at the daily cost for each category. The overall daily cost is computed as the sum of these seven daily costs and is given below the User Volume Inputs.

VII. Lane Occupancy Charge Worksheet

The Lane Occupancy Charge Worksheet is included in Appendix B.

A. Inputs

Inputs that are in rows can be found at the top left of the Worksheet in Column F. Inputs that are in columns can be found starting in Row 32 of the Worksheet.

Select Roadway (Row 1) – Select the roadway from the drop-down menu. This will determine which roadway sections are available for selection in the next row.

Select Section (Row 2) – Select the roadway section from the drop-down menu. If the work zone spans multiple sections, choose the one with the most restrictive conditions based on demand volumes, roadway and work zone capacities and other work zone characteristics. As described in *Section II.A – Free-Flow Speed and Capacity* and shown in Table II-1, each roadway section has a particular non-work zone freeway capacity.

Number of Lanes When There Is No Work Zone (Row 3) – Enter the minimum number of freeway lanes in the work zone area, as defined in *Section II.B – Work Zone Capacity*, when the work zone is not in place.

Upgrade of at Least 3% Grade and ½ Mile Length (Row 4) – Select “Yes” if there is such an upgrade either within the work zone or within approximately 2 miles approaching the work zone. Confirm whether demand volumes already include the passenger car equivalency (pce) factor for trucks of 2.0 on level terrain and 2.5 on upgrades. The pce factor is discussed in *Section II.A.1 – Passenger Car Equivalency*.

Select Begin and End Hours of Approved Work Zone (Row 5) – Select the beginning and ending hours from the drop-down menus in Columns F and I. If a lane is closed overnight (i.e., 12:00 am falls during the approved closure), select “12 AM” as the beginning hour. The ending hour will always be later than the beginning hour. The Lane Occupancy Charge Worksheet evaluates one lane closure at a time even if there are other approved lane closures during the day, because lane closures may be delayed or canceled if queuing remains from the prior lane closure. The input for the Lane Occupancy Charge Worksheet has been simplified because lane closures based on the NJTA Lane Closure Tables are approved in whole-hour increments.

Select Day of First Hour of Data (Row 6) – Select the day that applies to the first 24 hours in the Volume Inputs. The selected day will determine whether the roadway capacity will be reduced by a weekend factor as discussed in *Section II.B.1 – Variable Operational Considerations*.

Is the Work Zone in Summer? (Row 7) – Summer and non-Summer months experience seasonal variations in traffic volumes. The selection of the season also affects the application of the

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weekend factor as described in *Section II.B.1 – Variable Operational Considerations*. Select “Yes” if the work zone to be analyzed will be installed during the indicated dates:

- May 1 to October 14: Garden State Parkway north of Interchange 129
- May 15 to September 14: All other roadways

Ramp Merge or Diverge within 1000’ of Work Zone (Row 8) – Select “Yes” to reduce roadway capacity by a ramp junction factor based on the criteria discussed in *Section II.B.1 – Variable Operational Considerations*.

Number of Lanes When Work Zone Is in Place (Row 9) – Enter the minimum number of open lanes in the work zone. Values entered into the Worksheet must follow these rules:

- If the work zone has a shoulder closure, the number of lanes must remain the same as when there is no work zone (Row 9 = Row 3).
- If the work zone has a lane closure, the number of lanes must be less than when there is no work zone (Row 9 < Row 3).
- The worksheet does not support zero values. If a ramp or roadway is to be closed, consult the Authority for detour cost calculations or analyze the work zone using a parallel, open roadway (e.g. if the Inner Roadway is closed, analyze the Outer Roadway with all traffic moved onto it).

Normal Lane Width, No Work Zone (Row 10) – Enter the minimum width of freeway lanes in the work zone area, as defined in *Section II.B – Work Zone Capacity*, when the work zone is not in place.

Lane Width in Work Zone (Row 11) – Enter the minimum lane width at any point in the work zone. The work zone lane width should not be greater than the normal lane width that was entered in Row 10. The normal and work zone lane widths are used to determine whether to apply a lane width factor as described in *Section II.B.1 – Variable Operational Considerations*.

Length of Work Zone (Row 12) – Enter the length of the work zone based on the definition in *Section II.B – Work Zone Capacity*. The length of work zone factor is applied to work zone roadway capacity as described in *Section II.B.1 – Variable Operational Considerations*. The work zone length also determines travel times through the work zone area with and without the work zone in place.

Does the Work Zone involve High Intensity Work? (Row 13) – Based on engineering judgment, select “Yes” if there is high intensity work as defined in *Section II.B.1 – Variable Operational Considerations*. This will apply a reduction factor to the work zone roadway capacity.

Posted Work Zone Speed Limit (Row 14) – Enter the lowest speed limit posted in the work zone. The posted speed limit is used to calculate the effective work zone speed as described in *Section II.B – Work Zone Capacity*.

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Current Year CPI Transportation Component (Row 15) – As described in *Section IV.A – User Cost Factors*, see the US Bureau of Labor Statistics website⁶ for the most recent value. This value is divided by the Year 2009 CPI transportation component to obtain a scaling factor used to determine current year road user unit costs.

Demand (pce per hour) (Column B) – The Worksheet is constructed to analyze a single work zone on a single day. Typically, only the first 24 hours (12-1 am until 11p-12a) of traffic demand volumes need to be entered in the Worksheet. However, additional hours of demand volumes up to 36 hours should be entered if the ending hour of the approved work zone is at or near 12 am to ensure that queuing will be accounted for and to ensure proper completion of the Lane Occupancy Charge table. Follow the procedures described in *Section III – Traffic Demand Volumes* to process raw demand volumes before inputting them into the Worksheet.

Single-Unit Truck % (Column C), Truck with Trailer % (Column D) – Enter percentages into these two columns, if available from the demand volume data, for each hour that there is vehicle demand. Values must be entered as a percentage or a decimal less than or equal to 1.00, not as a whole number. It is preferable to enter percentages into these two columns than in Column E, as described in *Section III.B – Determination of Passenger Car and Truck Volumes*.

Overall Truck % (Column E) – If Single-Unit Truck and Truck with Trailer percentages (Columns C and D) are not available, enter percentages into this column for each hour that there is vehicle demand. Values must be entered as a percentage or a decimal less than or equal to 1.00, not as a whole number. It is preferable to enter percentages into this column than to leave Columns C through E blank and use default values, as described in *Section III.B – Determination of Passenger Car and Truck Volumes*.

B. Calculated Values

The functionality of the Lane Occupancy Charge Worksheet is to apply the user inputs to several Road User Cost Worksheets and tabulate the results. Therefore, the same calculations are performed as described in *Section VI.B – Calculated Values*, but are invisible to the Worksheet user.

C. Outputs

The Worksheet first evaluates each of the seven components of user costs defined by the FHWA¹ for the approved work zone hours to determine the daily cost for each category. The overall daily cost of the approved work zone is computed as the sum of these seven daily costs. The Worksheet then evaluates the overall daily cost of a work zone that is picked up 1 to 15 minutes late, 16 to 30 minutes late, etc. until 120 minutes (2 hours) has been reached. The Lane Occupancy Charge is the difference between the overall daily cost of the approved work zone and the actual (picked up late) work zone, limited to a maximum of \$20,000.

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The table to the right of the volume inputs presents the Lane Occupancy Charges for a work zone that is picked up 1 to 15 minutes late, 16 to 30 minutes late, etc. until 120 minutes (2 hours) or the maximum assessment of \$20,000 has been reached. If the assessment for a work zone picked up 120 minutes late is less than \$20,000, an additional note appears that provides the additional cost to be assessed per 15 additional minutes late picking up until \$20,000 is reached. This cost is equal to the last incremental 15 minute charge, which is the difference between the charges for a work zone 106-120 minutes late picking up and a work zone 91-105 minutes late picking up.

The Lane Occupancy Charge table and all notes appearing beneath it are to be copied into the end of Section 107.12 of the Supplementary Specifications. The table and notes together constitute the contract Lane Occupancy Charges.

APPENDIX A

ROAD USER COST WORKSHEET

**NJ TURNPIKE AUTHORITY
ROAD USER COST WORKSHEET**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI
1	Select roadway: TURNPIKE																	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> Part I - User Inputs </div> <div style="border: 1px solid red; padding: 5px; display: inline-block; color: red;"> See the NJTA Road User Cost Manual, Section VI for instructions on how to use this Worksheet. </div> <div style="border: 1px solid black; padding: 5px; display: inline-block;"> Part II - Calculated Values </div>																	
2	Select section: Mainline (MP 0-73)																																		
3	Number of lanes when there is no work zone: 5																																		
4	Upgrade of at least 3% grade and 1/2 mile length: NO																																		
5	Select type of work zone: Short-term; lane closed																																		
6	Select day of first hour of data: Sunday																																		
7	Is the work zone in summer (May 15-September 14)? YES																																		
8	Ramp merge or diverge within 1000' of work zone: NO																																		
9	Number of lanes when work zone is in place: 4																																		
10	Normal lane width, no work zone (ft): 12																																		
11	Lane width in work zone (ft): 11																																		
12	Length of work zone (miles): 0.5																																		
13	Does the work zone involve High Intensity Work? YES																																		
14	Posted work zone speed limit (mph): 45																																		
15	Current year CPI transportation component: 179.252																																		
16	Per-lane roadway capacity, non-work zone: 2400 passenger car equivalents/hour/lane (pcephpl)																																		
17	Estimated free-flow speed (mph): 72																																		
18	Passenger car equivalents per truck: 2.0																																		
19	Merge/diverge area reduction (%): 0.0%																																		
20	Base per-lane roadway capacity, work zone: 1800 pcephpl																																		
21	Work zone lane width reduction (%): 0.0%																																		
22	Work zone length reduction (%): 0.9%																																		
23	Work intensity reduction (%): 5.7%																																		
24	Final per-lane roadway capacity, work zone: 1682 pcephpl																																		
25	Effective work zone speed (mph): 50																																		
26	Year 2009 CPI transportation component: 179.252																																		
27	Cost factor to current year: 1.000																																		

Year 2009 costs	Average value of time (per vehicle-hour)	Idling Cost (per vehicle-hour)
Passenger cars	\$15.10	\$0.87
Single-unit trucks	\$25.55	\$0.96
Trucks with trailers	\$33.10	\$1.04

Current year costs	Average value of time (per vehicle-hour)	Idling Cost (per vehicle-hour)
Passenger cars	\$15.10	\$0.87
Single-unit trucks	\$25.55	\$0.96
Trucks with trailers	\$33.10	\$1.04

Initial Speed (mph)	VOC / 1,000 Stops			Delays, hr / 1,000 Stops		
	Pass-enger Cars	Single Unit Trucks	Trucks with Trailers	Pass-enger Cars	Single Unit Trucks	Trucks with Trailers
35	\$55.31	\$121.60	\$506.92	3.94	5.13	9.19
40	\$66.16	\$143.07	\$605.30	4.42	5.87	11.09
45	\$77.91	\$163.29	\$705.63	4.90	6.60	13.39
50	\$90.77	\$183.22	\$806.39	5.37	7.33	16.37
55	\$104.78	\$201.96	\$906.01	5.84	8.07	20.72
58	\$113.82	\$216.74	\$964.59	6.11	7.77	24.80
60	\$120.12	\$224.66	\$1,002.95	6.31	8.80	27.94
65	\$136.85	\$245.84	\$1,095.85	6.78	9.53	37.25
70	\$155.16	\$263.73	\$1,183.07	7.25	10.27	50.31
72	\$162.95	\$271.10	\$1,216.03	7.45	10.56	56.75

PART IV - CALCULATIONS

28	PART III - USER VOLUME INPUTS							Units of vehicles per 1/4 hour				Units of passenger cars per 1/4 hour							PART V - ROAD USER COSTS															
	Hour	Demand (pce per hour)	Single-Unit Truck % (if known)	Truck with Trailer % (if known)	Overall truck %* (if known)	Work Zone	1/4 Hour	Work Zone	Demand (pce per 1/4 hour)	Lanes Open	Roadway Capacity (pce per 1/4 hour)	Demand (vehicles per 1/4 hour)	Single-Unit Trucks	Trucks with Trailers	Pass-enger Cars	Reduced Speed Delay (hr/veh)	Added Queued Vehicles	Queued Vehicles at End of 1/4 Hour	Average Queued Vehicles	Vehicles that Travel Work Zone	Vehicles that Travel Queue	Queue V/C Ratio	Average Queue Speed (mph)	Queue density (pce/mi)	Demand density (pce/mi)	Average Queue Length (mi)	Average Queue Delay (hr)	Speed Change VOC (work zone)	Speed Change Delay Cost (work zone)	Reduced Speed Delay Cost	Stopping Delay VOC (queuing)	Stopping Delay Cost (queuing)	Queue Delay Cost	Idling VOC (queuing)
32	12-1 am Sun	1			NO	12:00-12:15a	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
33	1-2	1			NO	12:15-12:30	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
34	2-3	1			NO	12:30-12:45	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
35	3-4	1			NO	12:45-1:00	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
36	4-5	1			NO	1:00-1:15	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
37	5-6	1			YES	1:15-1:30	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
38	6-7	1			YES	1:30-1:45	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
39	7-8	1			YES	1:45-2:00	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
40	8-9	1			YES	2:00-2:15	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
41	9-10	1			YES	2:15-2:30	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
42	10-11	1			NO	2:30-2:45	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
43	11a-12p	1			NO	2:45-3:00	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
44	12-1	1			NO	3:00-3:15	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
45	1-2	1			NO	3:15-3:30	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
46	2-3	1			NO	3:30-3:45	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
47	3-4	1			NO	3:45-4:00	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
48	4-5	1			NO	4:00-4:15	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
49	5-6	1			NO	4:15-4:30	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
50	6-7	1			NO	4:30-4:45	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
51	7-8	1			NO	4:45-5:00	NO	0	5	2592	0	0	0	0	0.000	0	0	0	0	0	0	0.86					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
52	8-9	1			NO	5:00-5:15	YES	0	4	1615	0	0	0	0	0.003	0	0	0	0	0	0	0.54					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
53	9-10	1			NO	5:15-5:30	YES	0	4	1615	0	0	0	0	0.003	0	0	0	0	0	0	0.54					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
54	10-11	1			NO	5:30-5:45	YES	0	4	1615	0	0	0	0	0.003	0	0	0	0	0	0	0.54					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
55	11p-12a	1			NO	5:45-6:00	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
56	12-1 am Mon				NO	6:00-6:15	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
57	1-2				NO	6:15-6:30	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
58	2-3				NO	6:30-6:45	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
59	3-4				NO	6:45-7:00	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
60	4-5				NO	7:00-7:15	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
61	5-6				NO	7:15-7:30	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
62	6-7				NO	7:30-7:45	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
63	7-8				NO	7:45-8:00	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
64	8-9				NO	8:00-8:15	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
65	9-10				NO	8:15-8:30	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
66	10-11				NO	8:30-8:45	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
67	11a-12p				NO	8:45-9:00	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
68						9:00-9:15	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0	
69	TOTAL ROAD USER COST FOR THIS SCENARIO: \$1						9:15-9:30	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56					\$0	\$0	\$0	\$0	\$0	\$0	\$0
70							9:30-9:45	YES	0	4	1682	0	0	0	0	0.003	0	0	0	0	0	0	0.56</											

APPENDIX B

LANE OCCUPANCY CHARGE WORKSHEET

NJ TURNPIKE AUTHORITY LANE OCCUPANCY CHARGE WORKSHEET

	A	B	C	D	E	F	G	H	I	J	K	L
1	Select roadway: TURNPIKE											
2	Select section: Mainline (MP 0-73)											
3	Number of lanes when there is no work zone: 3											
4	Upgrade of at least 3% grade and ½ mile length: NO											
5	Select begin and end hours of approved work zone: 12 AM to 9 AM											
6	Select day of first hour of data: Wednesday											
7	Is the work zone in summer (May 15-September 14)? NO											
8	Ramp merge or diverge within 1000' of work zone: NO											
9	Number of lanes when work zone is in place: 2											
10	Normal lane width, no work zone (ft): 12											
11	Lane width in work zone (ft): 11											
12	Length of work zone (miles): 3											
13	Does the work zone involve High Intensity Work? NO											
14	Posted work zone speed limit (mph): 45											
15	Current year CPI transportation component: 179.252											

**See the NJTA Road User
Cost Manual, Section VII
for instructions on how
to use this Worksheet.**

	Hour	Demand (pce per hour)	Single- Unit Truck % (if known)	Truck with Trailer % (if known)	Overall truck %* (if known)
17					
18	Hour				
19	12-1 am Wed	1707			8%
20	1-2	901			7%
21	2-3	620			10%
22	3-4	512			13%
23	4-5	523			15%
24	5-6	660			14%
25	6-7	934			10%
26	7-8	1480			7%
27	8-9	2257			6%
28	9-10	3235			4%
29	10-11	4091			3%
30	11a-12p	4462			3%
31	12-1	4621			3%
32	1-2	4631			3%
33	2-3	4633			3%
34	3-4	4565			3%
35	4-5	4557			3%
36	5-6	4459			3%
37	6-7	4231			3%
38	7-8	3923			4%
39	8-9	3654			4%
40	9-10	3308			5%
41	10-11	2754			6%
42	11p-12a	1887			6%
43	12-1 am Thu				
44	1-2				
45	2-3				
46	3-4				
47	4-5				
48	5-6				
49	6-7				
50	7-8				
51	8-9				
52	9-10				
53	10-11				
54	11a-12p				

INSERT TABLE AND NOTES IN SUPPLEMENTARY SPECIFICATIONS:

Pick Up Is Late By:	Lane Occupancy Charge Assessed:
1 to 15 minutes	\$500
16 to 30 minutes	\$700
31 to 45 minutes	\$1,000
46 to 60 minutes	\$1,300
61 to 75 minutes	\$2,400
76 to 90 minutes	\$4,600
91 to 105 minutes	\$7,800
106 to 120 minutes	\$12,800

Every 15 minutes late after 2 hours is an additional charge of \$5,000 to a maximum total daily charge of \$20,000.

Note that the charges above shall not be added together. The Lane Occupancy Charge to be assessed is the single value in the right-hand column corresponding to the lateness of work zone pick up found in the left-hand column.

* Preferred to use columns C and D instead.