ROAD USERS LIQUIDATED DAMAGES WORKSHEET
GUIDEBOOK

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Prepared for

pennsylvania
DEPARTMENT OF TRANSPORTATION

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Purpose and Scope

The purpose of this guidebook is to provide basic information on the content and use of the Road Users Liquidated Damages (RULD) worksheet. This guidebook does not address matters of policy nor application regarding RULDs.

This guidebook was written for worksheet version 2.9 and may or may not be relevant and applicable to either older or more recent versions.

List of Abbreviations

AADT	annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
ADT	average daily traffic
a-ps / mile	access points per mile
BLS	Bureau of Labor Statistics
CT	combination truck
FFS	free-flow speed
FHWA	Federal Highway Administration
HCM (HCM2010)	Highway Capacity Manual
HERT-ST	Highway Economic Requirements System – State Version
#N/A	Excel error code
NCHRP	National Cooperative Highway Research Program
PC	passenger car
pcphpl	passenger cars per hour per lane
PennDOT	Pennsylvania Department of Transportation
RULD	road users liquidated damages
RV	recreational vehicle
SU	single-unit truck
TPG	PennDOT traffic pattern group
veh	vehicles
vphpl	vehicles per hours per lane

List of Definitions

Access-Point Density	*FROM HCM2010: The total number of access points on both sides of the roadway, divided by the length of the segment. "An intersection or driveway should only be included in the count if it influences traffic flow. Access points that go unnoticed by drivers, or with little activity, should not be used to determine access-point density."*
Annual Average Daily Traffic	The typical daily traffic on a road segment for all the days in a week, over a one-year period.
Average Daily Traffic	The total traffic volume on a road segment counted over a period of days divided by the number of count days.
Average Stop / Red Duration	The average time a queued vehicle is stopped and waiting for either a SLOW or green-light signal at a work zone using either flagging or a temporary signal, respectively, to control 2-way/1-lane traffic
Base Free-Flow Speed	This HCM2010 factor is used to determine a beginning point for calculating the free-flow speed. The base free-flow speed is adjusted based on roadway characteristic factors such as lane width, lateral clearance, access-point density, and total ramp density.
Base Work Zone Speed	The base work zone speed is adjusted based on roadway characteristic factors lane width and lateral clearance to calculate the free-flow speed of traffic through the work-zone.
Base Year	The year in which the worksheet was last updated and the year to which all monetary values are initially set. This will most often be the current year.

Combination Truck	These vehicles will have an AASHTO symbol WB. Includes any articulated vehicle with a separate tractor and trailer.
Construction Year	The year in which the work zone will be in place. All monetary values will be inflated from the Base Year to the Construction Year.
Construction Year Volume	The assumed ADT or AADT of the project roadway during the year in which the work zone traffic patterns will be in place. If ADT is entered, a Monthly Factor input should be provided. If AADT is entered, the Monthly Factor should remain as "no factor".
Contract Amount	The contracted cost of the project.
County	The county within Pennsylvania where the project will take place.
Demand Arriving	The number of vehicles approaching the work zone on the project roadway for that hour, based on the hourly distribution percentages.
Demand Serviced	The number of vehicles from the Demand Total that were able to traverse the work zone, based on the work zone capacity.
Demand Total	The sum of the Demand Arriving for that hour and the Remaining Queue from the previous hour.
Design Speed	The speed used by engineers when designing the roadway; often 10 mph greater than the posted speed limit.
Directional Split	*FROM HCM2010: The proportion of traffic moving in the peak direction of travel on a given roadway during the peak hour.*
District	The engineering district within Pennsylvania where the project will take place.
Divided (Median Type)	For a multilane highway where the opposing directions of traffic are separated, such as by a concrete barrier or grass divider.

Ending Time of Work Zone	The final hour the work zone traffic patterns will be in place when calculating hourly RULDs. For calculating daily RULDs, this value can be left blank or entered as “All Day”.
Free-Flow Speed	The average speed at which vehicles are traveling on the project roadway. This may be measured in the field or calculated either externally or within the worksheet using the base free-flow speed factors. For most instances, this value will be near the posted speed limit.
Freeway	*FROM HCM2010: A fully access-controlled, divided highway with a minimum of two lanes (and frequently more) in each direction.* For this worksheet, assumed to be any roadway from TPG 1 or 2.
Functional Classification	Categories for roadways based on size, function, and location. See PennDOT Publication 13M Figure 1.1 for list and definitions.
HCM2010	Highway Capacity Manual, Transportation Research Board of the National Academics, December 2010.
HCM Roadway Type	One of three roadway classifications defined by HCM2010. This worksheet translates each PennDOT Functional Classifications into HCM Roadway Type in order to use HCM2010 methodology for calculating free-flow speed and capacity. These translations are shown in the worksheet on the blue ‘Tables’ tab in table 1B.
Lane Width	The width of the travel lane.
Left-Side Lateral Clearance	Distance from the outside edge of the leftmost travel lane of a multilane divided highway to the nearest fixed obstruction.

Level (Terrain)	*FROM HCM2010: Any combination of grades and horizontal and vertical alignment that permits heavy vehicles to maintain the same speed as passenger cars, typically containing short grades of no more than 2%.* For this worksheet, the terrain refers to the topography of the project roadway only; not the detours.
Long-Term Operations	The work zone traffic patterns are in place for 24 or more consecutive hours.
Median Type	For multilane highways, the type of division (if any) between the opposing lanes of traffic.
Monthly Factor	A factor used to adjust average daily traffic (ADT) into annual average daily traffic (AADT) based on the month in which the traffic data was collected. From PennDOT Pub 601 Table 355.
Mountainous (Terrain)	*FROM HCM2010: Any combination of grades and horizontal and vertical alignment that caused heavy vehicles to operate at crawl speed for significant distance or at frequent intervals.* For this worksheet, the terrain refers to the topography of the project roadway only; not the detours.
Multilane Highway	*FROM HCM2010: A highway with at least two lanes for the exclusive use of traffic in each direction, with no control or partial control of access, but that may have periodic interruptions to flow at signalized intersections no closer than 2 miles.* For this worksheet, assumed to be any roadway from TPG 3 or 4.
Number of Lanes	The number of through travel lanes on the roadway by direction.

Passenger Car	*FROM AASHTO Greenbook: The passenger-car class includes passenger cars of all sizes, sport/utility vehicles, minivans, vans, and pick-up trucks.* These vehicles will have an AASHTO symbol P.
Percent Combination	The percentage of the Percent Trucks that is classified as combination trucks.
Percent Recreational Vehicles	The percentage of the total AADT that are classified as recreational vehicles.
Percent Single-Unit	The percentage of the Percent Trucks that are classified as single-unit trucks.
Percent Trucks	The percentage of the total AADT that are classified as either single-unit trucks or combination trucks.
Queue	Vehicles that must wait at a stop to access the work zone due to a traffic demand that exceeds the available capacity of the work zone.
Queue End	The total length of the queue from the beginning of the work zone, determined by the product of the Remaining Queue for that hour and the average length and spacing of vehicles in the queue.
Recreational Vehicle	*FROM AASHTO Greenbook: Recreational vehicles include motor homes, cars with camper trailers, cars with boat trailers, motor homes with boat trailers, and motor homes pulling cars.* These vehicles will have an AASHTO symbol MH, P/T, P/B, or MH/B.
Remaining Queue	The difference between the Demand Total and the Demand Serviced for that hour, representing the number of vehicles that are queued at the end of the hour.
Right-Side Lateral Clearance	Distance from the outside edge of the rightmost travel lane to the nearest fixed obstruction.

Road Users Cost	Users Costs are the additional monetary cost to the public caused by a work zone beyond that which would be incurred under normal driving conditions. These are not RULDs since they occur during the contract's scheduled dates and/or times.
Road Users Liquidated Damages	RULDs are the additional monetary cost to the public caused by unscheduled work zones beyond that which would be incurred under normal driving conditions. These values can be used to recover unnecessary costs incurred by the public caused by the contractor mainting work zone traffic control beyond the dates and/or times specified in the contract.
Roadway Capacity	*FROM HCM2010:* The maximum sustainable hourly flow rate at which persons or vehicles reasonably can be expected to traverse a point or a uniform section of a lane or roadway during a given time period under prevailing roadway, environmental, traffic, and control conditions.
Rolling (Terrain)	*FROM HCM2010: Any combination of grades and horizontal or vertical alignment that caused heavy vehicles ro reduce their speed substantially below that of passenger cars but that does not cause heavy vehicles to operate at crawl speeds for any significant length of time or at frequent intervals.* For this worksheet, the terrain refers to the topography of the project roadway only; not the detours.
Route	The PennDOT route designation of the roadway on which the work zone will be placed.

Rural Interstate and Other Limited Access Freeways	A PennDOT functional classification. See PennDOT Publication 13M Figure 1.1 for definition.
Rural Local Roads	A PennDOT functional classification. See PennDOT Publication 13M Figure 1.1 for definition.
Rural Major Collectors	A PennDOT functional classification. See PennDOT Publication 13M Figure 1.1 for definition.
Rural Minor Arterials	A PennDOT functional classification. See PennDOT Publication 13M Figure 1.1 for definition.
Rural Minor Collectors	A PennDOT functional classification. See PennDOT Publication 13M Figure 1.1 for definition.
Rural Principal Arterials	A PennDOT functional classification. See PennDOT Publication 13M Figure 1.1 for definition.
Section	The PennDOT section designation of the route of the roadway on which the work zone will be placed.
Short-Term Operations	The work zone traffic patterns are in place for less than 24 consecutive hours.
Single-Unit Truck	These vehicles will have an AASHTO symbol SU. Includes commercial delivery vehicles and other large vehicles that are not articulated. For this worksheet, buses should be considered to be Single-Unit Trucks.
Speed Limit	The posted speed limit of the roadway.
Starting Time of Work Zone	The first hour in which the work zone traffic patterns will be in place when calculating hourly RULDs. For calculating daily RULDs, this value can be left blank or entered as “All Day”.
Terrain	A subjective description of the topography of the roadway based on the degree and prevalence of changes in the horizontal and vertical alignment.

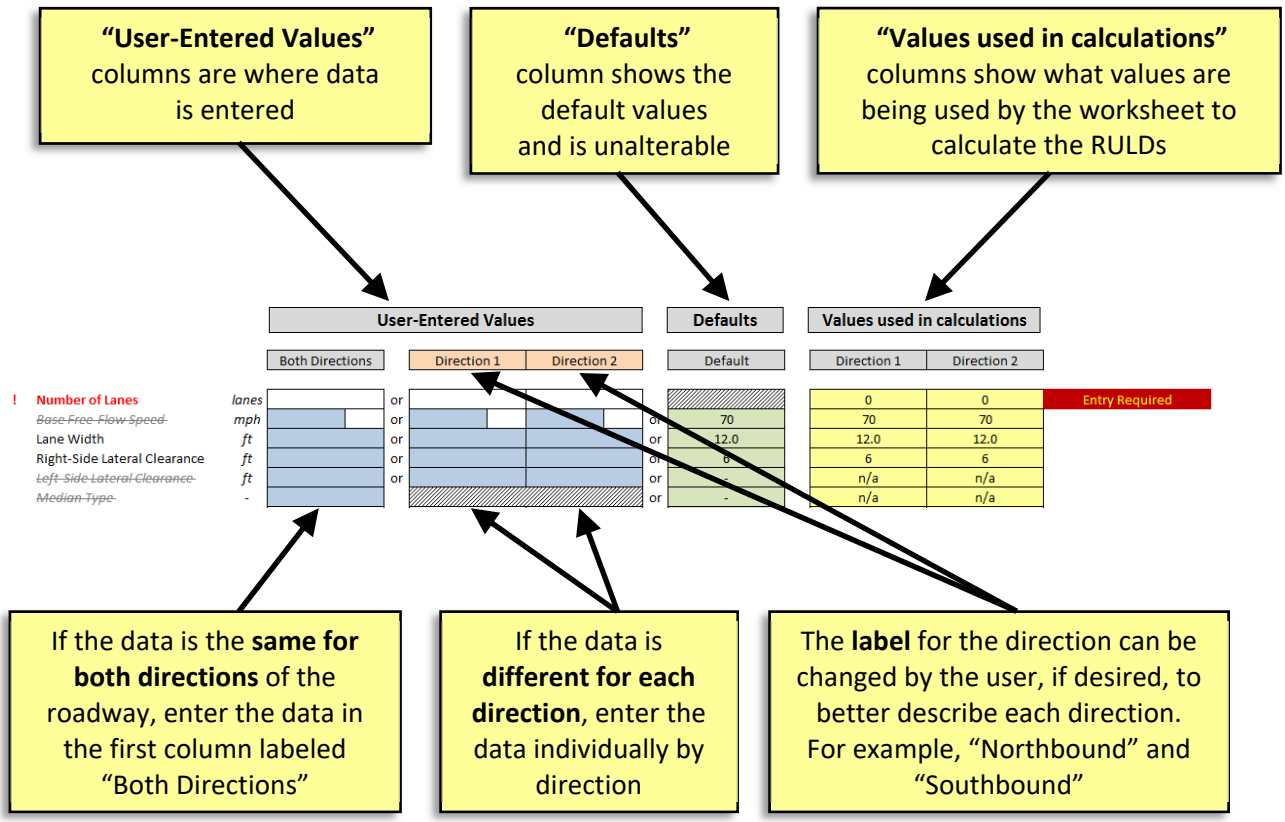
Total Inflation	The Yearly Inflation applied from the Base Year to the Construction Year. This value is used to calculate the future inflated monetary values.
Total Ramp Density	*FROM HCM2010:* The average number of on-ramp, off-ramp, major merge, and major diverge junctions per mile. It applies to a 6-mile segment of freeway facility, 3-miles upstream and 3-miles downstream of the midpoint of the study segment.
Traffic Pattern Group	PennDOT categories for roadways based on functional classification, geographic area, and urban/rural characterstics. The user-entered functional classification is translated into a traffic pattern group, from which default values are established based on the Pennsylvania Traffic Data report (PUB 601 (8-12)).
Two-Lane Highway	*FROM HCM2010: A roadway with a two-lane cross section, one lane for each direction of flow, on which passing maneuvers must be made in the opposing lane.* For this worksheet, assumed to be any roadway from TPG 5, 7, or 9.
Two-Way Left-Turn Lane (Median Type)	For a multilane highway, the opposing directions of traffic are separated by only a two-way left-turn lane used to access driveways along the corridor.
Undivided (Median Type)	For a multilane highway, the opposing directions of traffic are separated only by a double-yellow centerline.
Urban Collectors	A PennDOT functional classification. See Publication 13M Figure 1.1 for definition.
Urban Interstate and Other Limited Access Freeways	A PennDOT functional classification. See Publication 13M Figure 1.1 for definition.
Urban Local Roads	A PennDOT functional classification. See Publication 13M Figure 1.1 for definition.

Urban Minor Arterials	A PennDOT functional classification. See Publication 13M Figure 1.1 for definition.
Urban Principal Arterials	A PennDOT functional classification. See Publication 13M Figure 1.1 for definition.
Work Intensity	A user-entered description of the scale and proximity of road work to the travelled way used to approximate the resulting reduction in speed of work zone traffic flow. For more information, see the “Inputs” section of this guidebook.
Work Zone Capacity	The capacity of the roadway through the work zone.
Work Zone Duration	The number of calendar days that the work zone traffic patterns will be in place. This number does not affect the RULD calculations but will affect the User Costs, which are provided on the Summary page for information. This number may be different from the contract or working days.
Work Zone Speed	The average speed at which vehicles are traveling through the work zone. This may be measured in the field or calculated either externally or within the worksheet using the base work zone speed factors. For most instances, this value will be near the posted work zone speed limit.
Work Zone Length	The distance from the beginning of the work zone traffic control to the end of the work zone traffic control measured along the travel lanes of the affected roadway.
Yearly Inflation	The average annual monetary inflation.

Worksheet Limitations

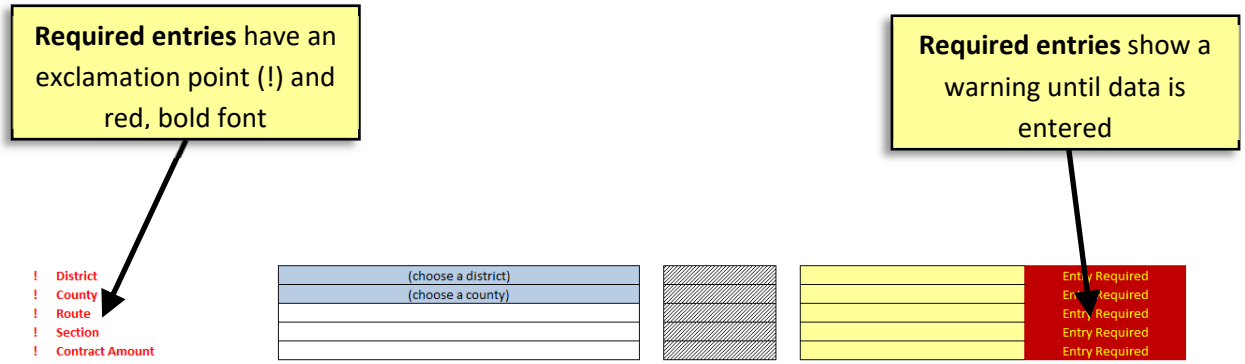
- ⊗ This worksheet is designed for stationary work zones on roadways without traffic control devices. Complex traffic situations such as signalized corridors, ramps, and weaving, cannot be modeled with this worksheet and should instead be evaluated with standard traffic engineering software such as HCS or Synchro.
- ⊗ Mobile work zones were not considered in the development of this worksheet.
- ⊗ The effect of intersection traffic control along the main roadway are not directly considered in this worksheet.
- ⊗ Pedestrian and bicycle user costs and liquidated damages were not considered in the development of this worksheet.
- ⊗ The queue approaching and within the work zone at the Starting Time is assumed to be zero.
- ⊗ Queue dissipation is considered but will not be fully calculated if the queue remains past the 24th hour.
- ⊗ The HCM methodology is used for determining work zone capacity.
- ⊗ To simplify the spreadsheet for users, assumptions have been made to translate PennDOT Functional Classifications into PennDOT Traffic Pattern Groups and HCM Roadway Types.
- ⊗ Due to limits in the HCM methodology, the spreadsheet cannot calculate lane reductions if the existing number of lanes in one direction is greater than 4.
- ⊗ This worksheet uses only English units and cannot accommodate or convert to or from metric.

Using and Understanding the Columns



- When entering data, use either the 'Both Directions' or by-directional columns, but not both.
- Before finishing, check the yellow 'Values used in calculations' cells to verify that the worksheet is using the correct values. If the correct values are not being used, review the user-entered values and overrides.

Required Fields



- Only a few fields in this worksheet require user input, but they must be completed for the worksheet to function.
- The remaining fields are optional, but may be used if project-specific information is available. The worksheet will assume a default value for all optional fields that are left blank.

Note that in the Roadway Information section, some fields are not available depending on the HCM Roadway Type being used. These are marked with gray, strikethrough font (~~*example font*~~).

Explanation of Colored Tabs

While this worksheet contains many tabs (individual sheets shown along the bottom of the viewing window), most contain internal calculations and do not require user entry.

Users enter values on the INPUT tab and then print results from the REPORT and SUMMARY tabs. The OVERRIDES tab may be used if information is available. All other tabs are for information only.

INSTRUCTIONS	(yellow)	INFORMATION - This tab contains basic instructions for the user on how to enter and retrieve data from the worksheet. *Users cannot alter this tab.*
INPUT	(white)	**USER TAB** – This tab is for entering all of project data to be used in calculations.
OVERRIDES	(red)	**USER TAB** – This tab is to provide project-specific overrides not available on the INPUT tab, if available and desired.
REPORT	(green)	**USER TAB** – This tab is formatted for printing and displays all the input and output values necessary for checking and creating back-up.
SUMMARY	(purple)	**USER TAB** – This tab is formatted for printing and displays only critical input and output values necessary for review and approval.
LISTS	(blue)	REFERENCE – This tab shows all lists used to create pull-down menus. *Users cannot alter this tab.*
TABLES	(blue)	REFERENCE – This tab shows all of the tables and external values used in the calculations. *Users cannot alter this tab.*
REFERENCES	(blue)	REFERENCE – This tab lists all of the external documents used to create and compile this worksheet. *Users cannot alter this tab.*

VALUES	(black)	CALCULATIONS – This tab organizes and lists all of the initial values based on the INPUT tab. *Users cannot alter this tab.*
VOLUMES	(black)	CALCULATIONS - This tab calculates and displays traffic volumes by direction, path, class, and hour. *Users cannot alter this tab.*
DELAY	(black)	CALCULATIONS - This tab calculates and displays the delay by direction, path, and class. *Users cannot alter this tab.*
QUEUING	(black)	CALCULATIONS - This tab calculates and displays the number of vehicles in the queue and their delay by direction and hour. *Users cannot alter this tab.*
COSTS	(black)	CALCULATIONS - This tab calculates and displays the unit costs by direction, class, and scenario. *Users cannot alter this tab.*
CALCULATIONS	(black)	CALCULATIONS - This tab displays the final RULD outputs by direction, path, and hour. *Users cannot alter this tab.*
UPDATER	(orange)	UPDATES - This tab will be used annually by PennDOT Central Office to update monetary and traffic defaults used in the spreadsheet. *Users cannot alter this tab.*

Inputting and Calculating RULDs

It is assumed that those using or supervising the use of this worksheet have general transportation engineering experience and previous specific experience calculating road users liquidated damages (RULD) for PennDOT.

Always verify that the most-recent version of the RULD worksheet is being used by comparing the version number on the INSTRUCTIONS tab with the number listed in the PennDOT Toolbox. If a more recent version is available, download the new file before calculating RULDs.

1. Begin by entering project data into the white INPUT tab.
    a. Enter project-specific values into the white, blue, and red cells, as available and desired.
        i. Items that are listed in **bold red** with an exclamation point (**!**) are required for all projects. The spreadsheet will not function properly unless these values are entered.
        ii. Items that are listed in ~~*strikethrough gray*~~ and italized are not available for that roadway classification
        iii. All other items are available but not required. If left blank, default values are used.
    b. Review the values to be used in calculations in the right-most (yellow-shaded) column.
2. Check the red OVERRIDES tab to determine if any project-specific overrides are applicable.
3. Review the calculated RULD totals on the green REPORT and purple SUMMARY tabs.
    a. Confirm that no error warnings are presented at the top of the REPORT or SUMMARY tab. If an error exists, return to the "INPUT" tab to find and correct it.
    b. Note the final answer presented in **bold** on the SUMMARY tab, labeled as either "Total Daily RULD" or "Total Hourly RULD."
4. Print the green REPORT tab for checking and back-up.
5. Print the purple SUMMARY tab for review and approval.
6. Include printed copies of the REPORT and SUMMARY tabs in the Project Development Checklist.

Inputs

- The following tables explain each item on the white INPUT tab. The left column lists the name of the item and the right column provides information on that item.
- All items shown in **bold, red** are required for the worksheet to calculate RULDs.
- Other values are available for use but are not required. If these optional items are not assigned project-specific values, the worksheet will assume default values.

PROJECT INFORMATION	This **required** section is used to enter administrative data used to identify the project location.
Project Name	This optional field can be used to enter a project name which will appear on the Report and Summary print-outs to aid in identifying the calculations.
Scenario Description	This optional field can be used to enter a scenario name which will appear on the Report and Summary print-outs to aid in identifying the calculations.
! District	This **required** field identifies the district in which the project will take place.
! County	This **required** field identifies the county in which the project will take place.
! Route	This **required** field identifies the route on which the project will take place.
! Section	This **required** field identifies the section of the route where the project will take place.
! Contract Amount	This **required** field identifies the contract amount for the project.

NOTE – If a route/section number is not available, a street name can be entered instead.

MONETARY INFORMATION	This section can be used to override values affecting the future construction year and inflation values.
Base Year	This value represents the current year from which unit prices will be inflated. This value cannot be altered.
Construction Year	This field identifies the year in which the work zone traffic control will be in place and is used to inflate unit prices. By default, the construction year is the same as the base year.
Yearly Inflation	This override field can be used to adjust the yearly inflation value. This value is then used in calculating the overall inflation from the base year to the construction year.
Total Inflation	This override field can be used to adjust the overall inflation value. This value is used as the overall inflation at the construction year.

NOTE - The yearly inflation is used to calculate the overall inflation. If values are entered for both overrides, the overall inflation takes priority.

ROADWAY INFORMATION	This section is used to enter data regarding the project roadway in its existing condition.
! PennDOT Functional Classification	This **required** field identifies the PennDOT classification of the roadway on which the project will take place. The classification is used to determine the applicable HCM Roadway Type and to set default values for hourly distribution of traffic and truck percentages.
HCM Roadway Type	This override field can be used to change the HCM Roadway Type to be used in calculations. By default, the HCM Roadway Type will be selected based on the PennDOT Classification. Changing this field affects which inputs are required and/or available in the rest of the Roadway Information section and affects the free-flow speed and roadway capacity calculations.
Terrain	This field can be used to identify the type of terrain of the roadway in the area of the work zone. By default, the terrain is assumed to be Level. Changing this field affects the passenger car equivalents.
! Number of Lanes	This **required** field quantifies the number of existing lanes of the roadway on which the work zone will be placed.
! Base Free-Flow Speed *(n/a for "Freeway" Roadway Type)*	This **required** field is the initial speed of the roadway used in calculations. It will be reduced to the actual free-flow speed based on the following inputs within this section, in accordance with HCM2010. The entry cells have two components: the blue pull-down box is used to identify the input as either the 'Design Speed' or 'Speed Limit'; the white box is used to enter the value. This item can be overridden by using the 'Free-Flow Speed' field below.
Lane Width	This field can be used to quantify the width of the existing lanes. By default, all lanes are assumed to be 12.0-ft wide. If the existing width varies, use an average. If the existing width is outside the range given in the worksheet, use the closest value. This value affects the calculation of the free-flow speed.
Right-Side Lateral Clearance	This field can be used to quantify the width of the right shoulder. This value affects the calculation of the free-flow speed. By default, the right shoulder is assumed to be equal to or greater than 6.0-ft. If the existing width varies, use an average. If the existing width is outside the range given in the worksheet, use the closest value.

Left-Side Lateral Clearance	This field can be used to quantify the width of the left shoulder. This value affects the calculation of the free-flow speed. By default, the left shoulder is assumed to be equal to or greater than 6.0-ft. If the existing width is outside the range given in the worksheet, use the closest value.
Median Type	This field can be used to identify the type of median, if any. This value affects the calculation of the free-flow speed.
Total Ramp Density *(n/a for "Multilane Highway" and "Two-Lane Highway" Roadway Types)*	This field can be used to quantify the number of on- and off-ramps within the work zone, measured from 3 miles downstream to 3 miles upstream, divided by the number of miles. This value affects the calculation of the free-flow speed.
Access Point Density	This field can be used to quantify the number of access points (driveways and side roads) within the work zone, divided by the number of miles. This value affects the calculation of the free-flow speed. An intersection or driveway should only be included if it influences traffic flow. Access points that go unnoticed by drivers, or with little activity, should not be used to determine access-point density.
Free-Flow Speed	This is the speed of traffic under existing conditions. This override field can be used to enter the measured free-flow speed of the traffic under existing conditions. By default, the free-flow speed is calculated using HCM 2010 methodology for the selected HCM Roadway Type and based on the previous values entered in this section. The free-flow speed affects the delay and the roadway capacity.
Roadway Capacity	This override field can be used to adjust the calculated capacity (per lane) of the roadway under existing conditions. By default, the roadway capacity is calculated using HCM 2010 methodology for the selected HCM Roadway Type and free-flow speed. The roadway capacity affects the development of overcapacity queuing.

TRAFFIC INFORMATION	This section is used to enter data regarding the existing traffic on the project roadway.
! Construction Year Volume	This **required** field is used to quantify the average daily traffic volume of the roadway at the construction year. This can be either the ADT or AADT value. o If ADT is entered, the Monthly Factor entry is to be used to adjust the values for time of year. o If AADT is entered, the Monthly Factor is to be left as "(no factor)" since the volume is already adjusted. *It is assumed that a growth factor will have been applied to existing traffic volumes prior to the use of this worksheet.*
Directional Split	This field can be used to enter the directional split (D-factor) of the roadway at the construction year. The value entered will be applied to the first direction and the remainder applied to the second direction.
Monthly Factor	This field can be used to adjust the average daily traffic (ADT)—entered as the Construction Year Traffic—into an average annual daily traffic (AADT) volume. If the value entered for the Construction Year Traffic is already an AADT, leave this field as "(no factor)".
Annual Average Daily Traffic	This calculated field adjusts the Construction Year Traffic according to the Monthly Factor, if any. This value cannot be directly altered or overridden.
Percent Trucks	This field can be used to enter the percentage of trucks within the traffic volume.
Percent Single-Unit	This override field can be used to adjust the breakdown of truck class within the 'Percent Trucks'. By default, the worksheet assumes the percentage of single-unit and combination trucks based on the functional classification. If project-specific information is available, these values can be overridden. This value affects the traffic volume by altering the number of vehicles by class.
Percent Combination	This calculated field determines the percentage of combination trucks based on the 'Percent Single-Unit' override. This value cannot be altered so as to ensure that the total of single-unit and combination trucks equals 100%.
Percent Recreational Vehicles	This field can be used to enter the percentage of recreational vehicles within the traffic volume.

WORK ZONE INFORMATION	This section is used to enter data regarding the proposed work zone on the project roadway.
! Work Zone Length	This **required** field is used to quantify the length of the work zone on the project roadway. This value should be measured from the beginning to the end of the work zone traffic pattern. If a detour is used, this value is the length of the closure (where vehicles leave and rejoin the project roadway). This value can be entered in units of miles (mi) or feet (ft) by selecting either option from the blue drop-down menu.
! Base Work Zone Speed	This **required** field is the initial speed of the work zone traffic used in calculations. It will be reduced to the actual free-flow speed based on the following inputs within this section. The entry cells have two components: the blue pull-down box is used to identify the input as either the 'Design Speed' or 'Speed Limit'; the white box is used to enter the value. This item can be overridden by using the 'Work Zone Speed' field below.
Number of Lanes	This field can be used to enter the number of lanes that remain open to traffic while the work zone is in place. By default, the worksheet assumes that all existing lanes remain open. For a full detour (road closed), leave this field blank.
Lane Width	This field can be used to quantify the width of the lanes while the work zone is in place. By default, all lanes are assumed to be existing width. This value affects the calculation of the work zone capacity.
Right-Side Lateral Clearance	This field can be used to quantify the width of the right shoulder within the work zone. This value affects the calculation of the free-flow speed. By default, the right shoulder is assumed to be equal to or greater than 6.0-ft. If the existing width varies, use an average. If the existing width is outside the range given in the worksheet, use the closest value.
Left-Side Lateral Clearance	This field can be used to quantify the width of the left shoulder within the work zone. This value affects the calculation of the free-flow speed. By default, the left shoulder is assumed to be equal to or greater than 6.0-ft. If the existing width is outside the range given in the worksheet, use the closest value.

Work Zone Intensity	This field can be used to describe the scale and the proximity to traffic of the construction activities. In general, construction activities that are smaller in scale or farther from the roadway are “LOW” intensity and activities that are larger in scale or closer to the roadway are “HIGH” intensity. For more detailed information, see the Illinois Center for Transportation “Queue and User’s Costs in Highway Work Zones” from September 2010 by Benekohal, Ramezani, and Avrenli. (ICT-10-075) To determine the intensity, add the number of workers (w, 0 to 10) and the number of large construction equipment (e, 0 to 5) and divide the sum by the lateral distance between the work activity and the edge of the concrete barrier facing the activity (p, 1-ft to 9-ft). For short-term work-zones, if the resultant of the (w+e)/p formula is less than 0.70, the intensity is LOW. If the resultant is greater than 2.60, the intensity is HIGH. Values between 0.70 and 2.60 inclusive are MODERATE. For long-term work-zones, if the resultant of the (w+e)/p formula is less than 1.00, the intensity is LOW. If the resultant is greater than 3.00, the intensity is HIGH. Values between 1.00 and 3.00 inclusive are MODERATE.
Starting Time of Work Zone	This field can be used to establish the first hour that the work zone will be in place for short-term operations. By default, the work zone is assumed to be in place All Day. If the same time is entered for the ‘Starting’ and ‘Ending’ values, the worksheet will default to ‘All Day’.
Ending Time of Work Zone	This field can be used to establish the final hour that the work zone will be in place for short-term operations. By default, the work zone is assumed to be in place All Day. If the same time is entered for the ‘Starting’ and ‘Ending’ values, the worksheet will default to ‘All Day’.
Work Zone Duration	This field can be used to establish the number of days that the work zone condition will be in place. This value represents the number of days that the work zone traffic patterns are in place, not necessarily the number of calendar or work days. This value affects the total road user cost as a result of the work zone delays, but does not affect the daily or hourly RULDs.

Work Zone Speed	This is the speed of traffic through the work zone. This override field can be used to enter the assumed or calculated speed of the traffic under work zone conditions. By default, the free-flow speed is calculated based on the previous values entered in this section. The work zone speed affects the delay and the work zone capacity.
Work Zone Capacity	This override field can be used to adjust the capacity of the work zone from the calculated value. By default, the worksheet determines the work zone capacity based on the roadway type, number of lanes closed, lane width, and type of operations (short-term or long-term) using values given in the HCM 2010.

FLAGGING / SIGNAL INFORMATION	This section can be used to enter data regarding the flagging or signal cycle length, if necessary.
Average Stop / Red Duration	This field can be used to enter the average stop / red time for either flagging or a temporary signal. This value affects the delay per vehicles used in calculations. If flagging is used, the stop duration is the time (in seconds) that the "STOP" sign is displayed to one direction of traffic. If a temporary signal is used, the red duration is the time (in seconds) that the red signal is displayed to one direction of traffic. The delay through the work zone itself is calculated based on information in the 'Work Zone Information' section. The flagging / signal input is only for additional delay caused by stopping.

ADDITIONAL DELAY	This section can be used if project conditions include significant miscellaneous delay that is not accounted for in the worksheet (such as work zones in heavy weaving areas). This section should be used sparingly.
Delay Per Vehicle	This field can be used to enter an additional, miscellaneous delay (not already accounted for in the worksheet) for all vehicles.
Passenger Cars	This override field can be used to enter an additional, miscellaneous delay (not already accounted for in the worksheet) for all passenger cars.
Single-Unit Trucks	This override field can be used to enter an additional, miscellaneous delay (not already accounted for in the worksheet) for all single-unit trucks.
Combination Trucks	This override field can be used to enter an additional, miscellaneous delay (not already accounted for in the worksheet) for all combination trucks.
Recreational Vehicles	This override field can be used to enter an additional, miscellaneous delay (not already accounted for in the worksheet) for all recreational vehicles.

DETOUR INFORMATION	This section can be used to enter vehicle, length, and speed information for up to three detour routes.
Orange Labels *"Primary Detour"* *"Secondary Detour"* *"Tertiary Detour"*	The customizable labels at the beginning of each detour sub-section can be used to rename the detour to a more descriptive name. The customizable labels under the "Segment" columns can be used to provide a brief description for each detour segment.
Percent of Vehicles Using Detour	This field can be used to enter the percentage of vehicles using each of up to 3 detours. If no value is entered, the delay cost from the detour will not be calculated, even if length and speed values have been entered. The sum of the percentages for the three detours must total 100% or less. Any percentage of vehicles not assigned to a detour is assumed to travel through the work zone. This allows for the calculation, if desired, of unofficial detours used by locals to avoid the work zone.

Passenger Cars	This override field can be used to enter the percentage of passenger cars using each detour. This value represents the percentage of passenger cars in the total Average Daily Traffic, not the percentage of vehicles on the detour. The sum of the percentages for the three detours must total 100% or less.
Single-Unit Trucks	This override field can be used to enter the percentage of single-unit trucks using each detour. This value represents the percentage of single-unit trucks in the total Average Daily Traffic, not the percentage of vehicles on the detour. The sum of the percentages for the three detours must total 100% or less.
Combination Trucks	This override field can be used to enter the percentage of combination trucks using each detour. This value represents the percentage of combination trucks in the total Average Daily Traffic, not the percentage of vehicles on the detour. The sum of the percentages for the three detours must total 100% or less.
Recreational Vehicles	This override field can be used to enter the percentage of recreational vehicles using each detour. This value represents the percentage of recreational vehicles in the total Average Daily Traffic, not the percentage of vehicles on the detour. The sum of the percentages for the three detours must total 100% or less.
Blue Header *"No Detour"* *"Both Directions"* *"Direction 1"*	The blue drop-down header at the beginning of each detour's table **must** be used to notify the worksheet that a detour will be used. By default, the value is set to 'No Detour'. If the detour values to be entered is the same for both directions, select 'Both Directions' from the drop-down and enter values in only the left set of columns. If the detour values to be entered will be different for each direction, select 'Direction 1' from the drop-down and enter values in their respective columns. Note that if the directional name headers in the 'Roadway Information' section have been customized, these customized names will appear instead of 'Direction 1' and 'Direction 2'.

Segment Length	The first column of each detour table can be used to enter the length of each segment in either miles (mi) or feet (ft). A segment is considered to be a stretch of roadway with a uniform free-flow speed. This column must be used in conjunction with the Average Speed column. Do not enter data in this column for this segment if the Segment Delay column is used instead.
Average Speed	The second column of each detour table can be used to enter the average free-flow speed of each segment. If a measured free-flow speed is not available, enter the speed limit. This column must be used in conjunction with the Segment Length column. Do not enter data in this column for this segment if the Segment Delay column is used instead.
Segment Delay	The third column of each detour table can be used instead of the first two to enter a time delay for the segment. In this case, a segment is assumed to be an intersection or other similar point of delay. Do not enter data in this column for this segment if the first two columns are used instead.

Variable Detour Entries

* To create a Cars-Only or Trucks-Only detour, use the red override cells to set either "Passenger Cars" or "Single-Unit Trucks" and "Combination Trucks" to 100%. This will place the entire traffic volume of that class on that detour.

* To enter a detour with varying speed limits and intersections, break down the detour path into traveling segments and stopping segments. A traveling segment is a stretch of roadway with a uniform free-flow speed. A stopping segment is any place where a motorist is delayed by a stop, such as at an intersection. Enter either one traveling segment or one stopping segment per row. Enter the traveling segment information using the Segment Length and Average Speed columns. Enter the stopping segment information using the Segment Delay. The worksheet will automatically convert both types of entries into a uniform delay (in units of minutes). The orange labels under the "Segment" columns can be used to provide a brief description or identifier for each segment.

Overrides

- The red OVERRIDES tab allows the user to enter project-specific information for certain default values that are too cumbersome to present on the input tab.
- The only override currently available on the overrides tab is for Hourly Distribution of Total Daily Traffic, according to Functional Classification.
- The default values (from PennDOT Pub 601 Table 350) are displayed in the second column ("Default Values").
- If a project-specific override is available, enter the values by hour and direction into the red cells in columns 3 and 4.

NOTE – Override values will not be used unless they total 100.00. If the red-and-yellow "Total must equal 100.00" error warning is displayed at the bottom of the page, the default values will be used in the calculations. To remove this error, balance the override values so that each direction totals 100.00.

Output - Report

- The green REPORT tab presents all input and output values from the RULD calculations for checking and back-up. It is pre-formatted for printing.
- All input values are presented by direction and item. Next to each item is a small letter or symbol (d, c, U, #) that specifies how the value was acquired. This is to aid in checking and review by highlighting which values are default and which values are project-specific.
    - **d** = this is a default value
    - **c** = this is a calculated value
    - **U** = this is a user-entered, project-specific value
    - **#** = this is a user-entered, project-specific override value that has replaced a worksheet default value
- If input errors have not been resolved on the INPUT sheet, a **bold red warning** will be displayed at the top of the REPORT sheet indicating that the Input Tab contains errors. To remove this warning, return to the INPUT tab and address any red-and-yellow warnings that are shown in the right-most column.

Output - Summary

- The purple SUMMARY tab presents critical project information and bottom-line RULD results for review and approval. It is pre-formatted for printing.
- **The bold line labeled "Total Daily RULD" or "Total Hourly RULD" is the desired RULD answer.**
- The presentation of the bottom section will vary based on the use of detours.
    - If detours are not used, only the "User Costs for Project Duration" and "Total Daily RULD" lines will be shown
    - If detours are used, then the "RULD from Work Zone" line will be shown. Also shown will be one line for each detour, with both the monetary RULD cost and the length of the detour in miles.
- If input errors have not been resolved on the INPUT sheet, a **bold red warning** will be displayed at the top of the SUMMARY sheet indicating that the Input Tab contains errors. To remove this warning, return to the INPUT tab and address any red-and-yellow warnings that are shown in the right-most column.