Instructions

Extended HSM1 Predictive Method Spreadsheets v.9

(Updated HSM Spreadsheets originally developed by Dr. Karen Dixon, Oregon State University for NCHRP 17-38)

Prepared for

Alabama DOT & Virginia DOT & WSDOT

Updated August, 2016 (v.9)

***NOTE:** The extended spreadsheets were originally developed by a team at CH2M HILL and further development took place at WSDOT. The teams used the original spreadsheets developed by Dr. Karen Dixon.

For any questions about the extended spreadsheets, please contact Ida van Schalkwyk at vanschi@wsdot.wa.gov

The Extended Spreadsheets

There are four extended spreadsheet files available for use. Prior to use, please review this set of instructions carefully. The most recent version of the spreadsheets are available at http://safetyperformance.org/tools/.

Chapter 10 of the HSM (2010): Rural two-lane two-way highways

- *HSM Rural 2-Lane Roads_V9_081416.xlsm* – this file allows the user to estimate the predicted average crash frequency for a rural two-lane two way roadway project; or the expected average crash frequency for a rural two-lane two way roadway project; and, if so desired, a multiyear analysis with a fixed linear traffic volume growth.

Chapter 11 of the HSM (2010): Rural multilane highways

- *HSM Rural Multilane Roads_V9_081416.xlsm* – this file allows the user to estimate the predicted average crash frequency for a rural multilane roadway project; or the expected average crash frequency for a rural multilane roadway project; and, if so desired, a multiyear analysis with a fixed linear traffic volume growth with predicted average crash frequency or predicted and expected average crash frequency.

Chapter 12 of the HSM (2010): Urban and Suburban Arterials

- *HSM Urban_Suburban Arterials_V9_081416_PredOnly.xlsm* – this file allows the user to estimate the predicted average crash frequency for an urban or suburban arterial project.
- *HSM Urban_Suburban Arterials_V9_081416_PredExpected.xlsm* – this file allows the user to estimate the predicted and expected average crash frequency for an urban or suburban arterial project; and, if so desired, a multiyear analysis of predicted and expected average crash frequency given a fixed linear traffic volume growth.

DISCLAIMER

These Highway Safety Manual (HSM) predictive analysis spreadsheet tools were developed for training purposes only. The spreadsheets are believed to be functioning correctly, but are provided without any guarantee of accuracy or completeness. No business decisions should be made based on results of these analysis tools without first validating their accuracy and completeness. Any person, organization, firm, corporation or other entity using these analysis tools does so at their own risk, and assumes all legal liability and responsibility arising out of its use and the user(s) agrees to indemnify and hold harmless VDOT, ALDOT, and any individual or entity involved with or contributing to the development or update of the predictive method spreadsheets, and for those providing access to these tools, from any damages, losses or claims by any person, organization, firm, corporation, or other entity from the use of this tool.

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The user of this tool acknowledges that these spreadsheets were developed from information contained in AASHTO Highway Safety Manual, 2010, and should be familiar with the concepts and procedures outlined therein

when using this spreadsheet analysis tool.

ACKNOWLEDGEMENTS

During 2009 and 2010, Dr. Karen Dixon, Principal Investigator of NCHRP 17-38[1], developed three spreadsheets in a volunteer effort to support training efforts on the first edition of the HSM. The extended Highway Safety Manual (HSM) predictive analysis spreadsheets represent updates to these three spreadsheets. The update was funded through a partnership between the Alabama Department of Transportation and Virginia Department of Transportation. These agencies are releasing these tools for use by other individuals and agencies to support the implementation of the HSM across the nation.

The extended spreadsheets were developed in 2011 by Kate Bradbury and Ida van Schalkwyk; with support from Josh Johnson, Richard Storm, Tegan Enloe and Jacqueline Dowds-Bennett (CH2M HILL). Since then, the spreadsheets were further updated and modified by WSDOT staff.

CONTACT

For enquiries regarding the original HSM spreadsheets developed by Karen Dixon (available at http://www.highwaysafetymanual.org/documents/NCHRP-1738_XLS.zip), please contact Karen at k-dixon@ttimail.tamu.edu. For enquiries about the expanded spreadsheets, please contact Ida van Schalkwyk at vanschi@wsdot.wa.gov.

Acronyms and Abbreviations

AASHTO	–	American Association of State Highway Transportation Officials
ALDOT	–	Alabama Department of Transportation
HSM	–	Highway Safety Manual
OSU	–	Oregon State University
VDOT	–	Virginia Department of Transportation

[1] *The NCHRP 17-38 training materials is now available as NCHRP Report 715, Highway Safety Manual Training Materials - http://www.trb.org/Main/Blurbs/167185.aspx.*

Background to the Extended Spreadsheet Tool

During 2009 and 2010, a number of training courses related to the Highway Safety Manual occurred. Some of this this training was completed as part of a National Cooperative Highway Research Program (NCHRP 17-38). This project was led by Dr. Karen Dixon from Oregon State University. As part of the ongoing training activities, the course was refined to incorporate changes based on feedback from the participants of the pilot training courses.

It was apparent that the AASHTO HSM Part C Predictive Method Worksheets (provided on pages p.12-108 through 12-122 of Volume 2 of the HSM) were challenging to complete, time consuming and had a high potential for errors given the relative inexperience of the class participants. To improve the learning environment and support implementation of the HSM, Dr. Dixon developed automated spreadsheets for each chapter in Part C.

These spreadsheets are seeing increased usage across the country as states continue to implement the HSM. Given the time savings and improved quality the spreadsheets provide, response and use of the tools have been significant and positive. In April 2011, VDOT realized that enhancement to the tools could increase the learning experience and project development usage.

In particular, VDOT initiated discussion related to an extended version of the spreadsheets that would:

a) Eliminate the need for user manipulation of *Site Total* worksheet to perform the site-specific EB method,
b) Create an automated report that summarizes the results of the analysis in table, graphic, and text format, and
c) Perform a multi-year analysis.

Subsequently, VDOT and ALDOT collaborated on the development of the extended spreadsheets. During August 2011, work on the extended spreadsheets was initiated as part of a HSM training contract with the Alabama University Transportation Center. CH2M HILL completed Version 3 of the extended spreadsheets in October 2011.

The extended spreadsheets are official products of a project funded by the Alabama Department of Transportation through the Alabama University Transportation Center. The State of Alabama has released the spreadsheets to the industry at no cost and as is. A primary motivation for this public release is the state and national commitment of ALDOT to the goal of reducing the likelihood and severity of crashes on public roadways. ALDOT also recognizes that the original NCHRP 17-38 spreadsheets and training were jointly funded and developed through the efforts of a number of individuals and states. The work developed under contract with the University Transportation Center builds upon the existing efforts of Dr. Karen Dixon.

From 2013 through 2016 WSDOT staff has been updating and modifying the spreadsheets to add to the functionality of the spreadsheets.

Users should carefully review the disclaimer prior to the use of the spreadsheets. The extended spreadsheets will require the user to read, understand, and accept the disclaimer and the HSM Predictive Methods chapters (Chapters 10 to 12, 18 and 19) before the spreadsheets can be used.

A disclaimer is included in the footer of each printed page of the worksheets as a default (and can be changed by the user): *Federal law 23 USC § 409 prohibits the discovery or admission into evidence of "reports, surveys, schedules, lists, or data" compiled or collected for the purpose of highway safety improvement projects that might qualify for federal safety improvement funding*.

Assumptions

The assumption is made that the user of the spreadsheets (original and expanded) is familiar with the HSM predictive method, the particular chapter in the HSM and is using the spreadsheets alongside the HSM. The selection of appropriate values for use in the worksheets requires familiarity with the HSM and the development and the use of the information contained therein. The spreadsheets are intended to reduce input and analysis time by automating the predictive method calculations.

Each of the Safety Performance Functions (SPFs) in the HSM has a valid volume range. In the case of the multi-year analysis, it is presumed that the user will only use the spreadsheet across valid volume ranges, i.e. the extended spreadsheets will not provide any indication to the user that the volume ranges were exceeded.

Functionality of the Original Worksheets

The original spreadsheets developed by Dr. Dixon present a spreadsheet for each chapter in Part C of the HSM, with the following worksheets:

- Instructions - Provides instructions for the spreadsheet (and a description of the intent of the spreadsheets)
- Intersection Tables – Worksheet with intersection-related tables (for the particular Part C chapter) that incorporates default values from Part C of the HSM and the functionality to provide locally-derived values for use with the spreadsheet.
- Segment Tables - Worksheet with intersection-related tables (for the particular Part C chapter) that incorporates default values from Part C of the HSM and the functionality to provide locally-derived values for use with the spreadsheet.
- Intersection 1, Segment 1, etc. – Part C worksheet sets 1 and 2 for calculating the predicted average crash frequency for the particular project element across different severity levels.
- Site Total – Analysis for site-specific EB analysis using results from the intersection and segment worksheets (predicted average crash frequency for each of the project elements). This analysis requires observed crash history (in annual average values) for each segment and intersection in the project. The associated HSM worksheets are 3A and 3B.
- Project Total – Analysis for project-specific EB analysis using results from the intersection and segment worksheets. This analysis allows the user to use a project-wide EB analysis using a combined observed crash history across all project elements (only recommended for locations where the historic crash data cannot be summarized by segment and intersection). The associated HSM worksheets are Worksheets 4A and 4B.
- Construction – A sheet with tables that allow for pull-down menus in the analysis of the HSM worksheets.

Intent and Functionality of the Extended Spreadsheets

Intent of the Extended Spreadsheets

The intent of the extended spreadsheets is to: automate the manipulation needed in the original spreadsheets; add standard reports that present results in tabular, graphical and text formats; and add multi-year analysis all without creating a stand-alone software tool where the user enters information and the results are presented as an automated process. By having access to the individual project element worksheets, the analyst is able to identify how CMFs change with changes to project elements along with changes in predicted and expected crash frequencies. This allows for the development of a greater understanding during the training process and ease of use for testing the impact of adjustments to cross section characteristics or signalization on anticipated safety performance. The extended spreadsheets include an additional worksheet, the *Report* worksheet, that summarizes analysis results for reports and further reduces the time associated with processing analysis results.

Functionality of the Extended Spreadsheets

The extended HSM spreadsheets build upon the original HSM spreadsheets developed by Dr. Dixon. Functionality was added to the extended spreadsheets using macros within Microsoft Excel 2007. The list below presents the changes made to the original spreadsheets (modification to existing worksheets, changes in process, and addition of worksheets and functionality). Note that there are still three separate spreadsheets, one for each chapter in Part C of the HSM: Chapter 10 for two-lane two-way rural highways, Chapter 11 for rural multilane highways and Chapter 12 for urban and suburban arterials.

- The user starts the analysis on a *Project Information* worksheet.
  a) First the user enters all the general project information (the spreadsheet macros automatically completes this information on each of the project element worksheets, the *Site Total* worksheet, and the *Report* worksheet).
  b) Second the user identifies the following elements in the project analysis:
     - the number of segments in the project,
     - the number of intersections in the project,
     - whether a multiyear analysis will be performed (yes/no), and
     - whether the analysis includes the calculation of the predicted average crash frequency or both the predicted and expected average crash frequency.
  c) A macro (push button) then uses information in (b) to automatically generate a table of project elements.
  d) The user completes information for each of the project elements (basic location information) and indicates whether the intersections (if there are any) are signalized or unsignalized
  e) A macro (push button) then uses information from (d) to automatically generate a worksheet for each project element.
- Worksheet Table 1A for each project element
  a) The user enters observed crash history by severity and collision type (where applicable for the particular chapter and analysis goals) on Worksheet Table 1A for each project element using project-element specific information.
  b) Table 1A is used to collect project element-specific conditions for calculating the predicted average crash frequency. The table consists of three columns: description, base conditions and site conditions. The user enters element-specific information in the site conditions column. The table is wide: to view the full table the user typically has to either zoom out to view the entire table (which would render the text unreadable) or scroll to the right (the description column is no longer visible). Table 1A was modified,

presenting the description first, then site conditions and lastly the base conditions: allowing the user to view the description and the site conditions columns on the same screen without scrolling.

c) The worksheet contains various additional features to prevent common input errors. For example, it prevents the user from entering information for a STOP controlled intersection when a signalized intersection is being analyzed (and vice versa); the worksheet also limits the selection of approaches for signalization etc. to the total number of legs of the intersection, etc.

d) In the Urban Arterial Intersection worksheet (Chapter 12),
   - The user selects whether pedestrian volumes are known or estimated (after selecting the intersection type). When the user selects known, the user can enter an actual numeric value, otherwise, the user will be presented with a drop-down menu that represents the default values presented in the HSM.
   - The number of bus stops and alcohol sales establishments are presented in a drop down menu consistent with the tables in the HSM.

- After the user has completed all the individual worksheets for each of the elements in a project, a push button activates a macro that automatically generates the *Site Total* and *Report* worksheets.
  a) In the original set of spreadsheets the *Site* Total worksheet was set up for a project with two segments and two intersections. If a project had a different number and combination of project elements, the user had to manipulate the *Site Total* worksheet (create physical linkages between the *Site Total* worksheet rows for each project element). This manipulation was time consuming and the risk of errors in the analysis is high. The expanded set of spreadsheets automatically generates a *Site Total* worksheet where project element information (including observed crash history) is already linked, i.e. no user manipulation is necessary.
  b) The spreadsheets only provide for a *Site Total* analysis – crash data are available by segment and intersection for most states. The *Project Total* worksheet was a common cause of confusion among users and is no longer included in the set of spreadsheets.
  c) Worksheet 3C of Chapter 12 (Urban and Suburban Arterials) was modified to support improved user understanding. The changes were driven by user questions and concerns.
  d) A *Report* worksheet summarizes results from each of the project element worksheets, as well as the *Site Total w*orksheet in tabular, graphical and text format. The *Report* worksheet is a new addition to the set of spreadsheets and is not included in the HSM.
  e) The *Report* worksheet does not require any input from the user. All of the content Is automatically generated.
- If the user has selected to perform a multi-year analysis on the *Project Information* worksheet, a worksheet titled *Multi-year Analysis Inputs* will automatically be generated once the *Project Information* worksheet is completed. The user enters the base year for the analysis (same as the analysis year entered on the *Project Information* sheet), the anticipated traffic growth, and the number of years for the analysis. A macro (activated with a push button) will perform the multiyear analysis and automatically generate an additional worksheet: the *Multi-Year Analysis Report* worksheet (similar in format to the *Report* worksheet).
- The Intersection Tables, Segment Tables, and Construction worksheets are hidden (the user can unhide them if needed; and local values can be inserted into the intersection tables and segment tables once available).
- Once the analysis is completed, none of the macros can be re-used. Changes to the individual project element worksheet input tables will automatically update the *Site Total* worksheet and the *Report* worksheet. The multi-year analysis will not update and cannot be re-generated.

The following sections provide a more detailed description of the steps involved in performing a predicted analysis in the HSM using the extended HSM training spreadsheets. The description includes tips and detailed information for the various processes.

User Instructions

Color Legend

Required user input data

Required user input data restricted to dropdown values

Automatically updated information based on previous user input data

User work space (notes, comments, etc.)

Basic Steps

Task 1. Create a Project File by opening the original chapter spreadsheet and saving it with a new filename.

Task 2. Enter the project information on the *Project Information* worksheet and select analysis options: multi-year analysis, and calculation of the predicted and/or expected average crash frequencies. For the urban and suburban predictive chapter two files are available depending on whether the user wants to only calculate the predicted average crash frequencies or whether the user wants to calculate both the predicted and expected average crash frequency.

Task 3. Complete the element table on the *Project Information* worksheet.

Task 4. Enter the required information for each element (worksheets presented for each segment and intersection in the project).

Task 5. Generate the EB analysis results and analysis report for predictive analysis (predicted average crash frequency and expected average crash frequency if applicable).

Task 6. Review analysis report and the discussion of results.

<u>If applicable:</u>

Task 7. Enter multi-year analysis information.

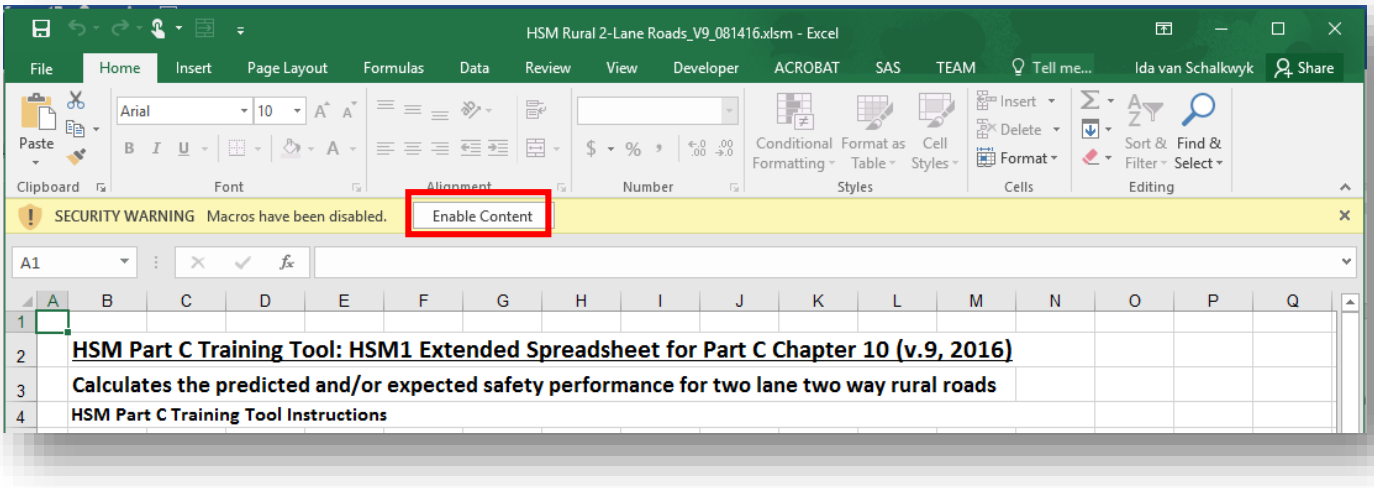
Task 8. Generate and review multi-year report.

Task 1. Create a Project File

1.1 If Excel Macros are not enabled, a *Security Warning* will show above the equation window in Excel. Click "Options…" button on message bar. Check "Enable this content" option and click OK.

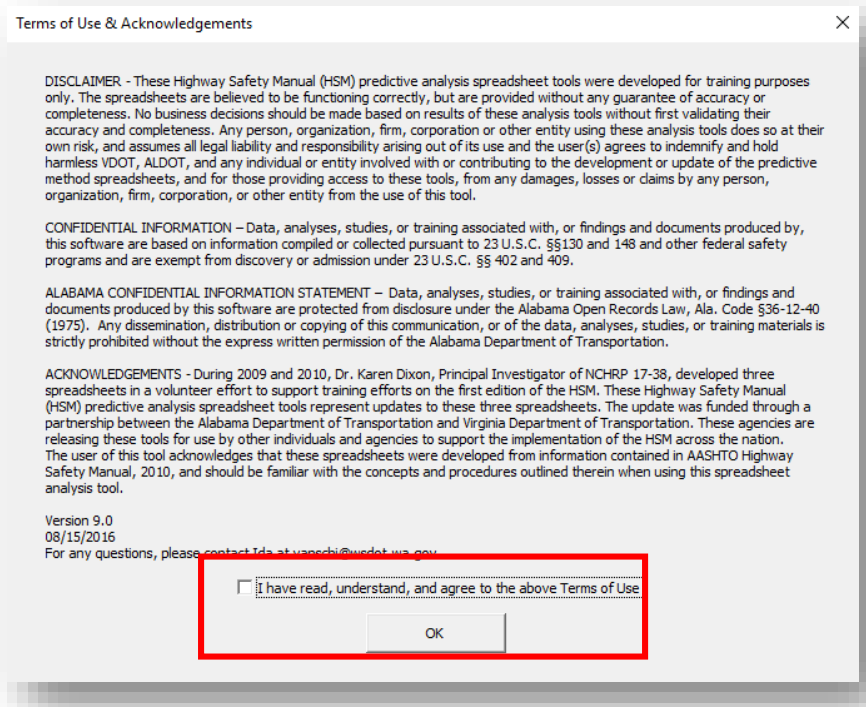
For more information about enabling macros, refer to Microsoft Help.

EXHIBIT 1: Enable Macros Procedure in Microsoft Excel



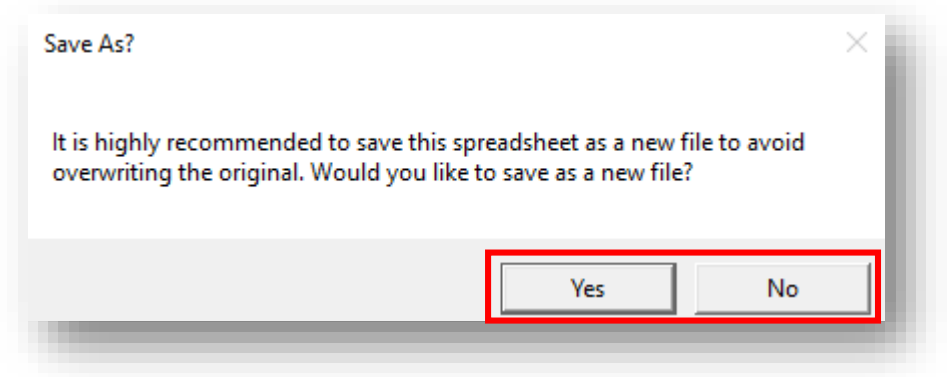
1.2 Read the terms of use, confidential information, and acknowledgements. Check the box if you understand and agree and click OK. If the user does not agree to the terms of use the user will not be able to use the spreadsheets.

EXHIBIT 2: Extended Spreadsheet Disclaimer



1.3 The spreadsheet then presents a *Save As?* prompt. If you are starting a new project, select *Yes* and save the file as a new project file. If you are opening an existing analysis that was completed, select *No*.

EXHIBIT 3: Save Spreadsheet As Prompt



1.4 The spreadsheet opens on the *Instructions* worksheet. Please read all instructions before proceeding.

QUICK TIP

The extended spreadsheets use various macros – <u>these macros can only be executed once</u>. In other words, once you have clicked on any button the macro will no longer perform the function as intended and likely to result in run-time errors.

Task 2. Enter Project Information

2.1 Navigate to the *Project Information* worksheet.

2.2 Complete the General Information Table on the *Project Information* worksheet.

Consult the color guidelines for information regarding the different types of inputs required. Be sure to enter the desired number of segments and intersections as well as select the appropriate option from the multiple year analysis and predicted/expected crashes drop downs. This information (except for the drop downs) can be changed at any time and will update automatically.

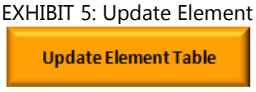
EXHIBIT 4: General Information Inputs on the *Project Information* Sheet

	A	B	C	D	F
1	PROJECT SAFETY PERFORMANCE ANALYSIS INPUT SHEET - RURAL 2-LANE ROADS				
2	General Information				
3	Project Name	Project Name		Contact Email	Email
4	Project Description	Project Description		Contact Phone	(123) 456-7891
5	Reference Number	Route & Project Name		Date Performed	08/15/16
6	Analyst	First and Last Name		Analysis Year	2016
7	Agency/Company	WSDOT		Multiple Year Analysis?	Yes
11	# of Segments in Analysis	1		Predicted/expected crashes	Predicted & Expected
12	# of Intersections in Analysis	1		Crash history (years)	5

2.3 Click the "Update Element Table" button to populate the *Element Table* on the *Project Information* worksheet.

*Note that **once this button is clicked, NO NEW SEGMENTS OR INTERSECTIONS CAN BE ADDED TO THE ANALYSIS.** The button will be disabled and the table cannot be updated again.*

EXHIBIT 5: Update Element Table Button and Element Table on the *Project Information* Sheet



Task 3. Complete the Element Table

3.1 Complete the location-specific information for each project element: Route, Location Description, and Jurisdiction. For intersections, also select whether or not the intersection is signalized.

All of the element information (except for Signalized/Unsignalized or Divided/Undivided) can be changed at any time. All of the inputs will update automatically if changed.

EXHIBIT 6: Element Table on the *Project Information* Sheet

	A	B	C	D	F
1	PROJECT SAFETY PERFORMANCE ANALYSIS INPUT SHEET - RURAL 2-LANE ROADS				
2	General Information				
3	Project Name	Project Name		Contact Email	Email
4	Project Description	Project Description		Contact Phone	(123) 456-7891
5	Reference Number	Route & Project Name		Date Performed	08/15/16
6	Analyst	First and Last Name		Analysis Year	2016
7	Agency/Company	WSDOT		Multiple Year Analysis?	Yes
11	# of Segments in Analysis	1		Predicted/expected crashes	Predicted & Expected
12	# of Intersections in Analysis	1		Crash history (years)	5 >=2
13					
14		LOCATION INFORMATION			INTERSECTIONS ONLY
15	INDIVIDUAL PROJECT ELEMENTS	Route	Location Description	JURISDICTION	Signalized or Unsignalized?
16					
17	SEGMENTS				
18	Segment 1				-
19	INTERSECTIONS				
20	Intersection 1				
21					Signalized
22					Unsignalized

3.2 Once all of the information has been entered, click the "Proceed to 1st Element" button.

Only general information (not needed for actual calculations) will update automatically once 'Proceed to 1st Element' has been clicked.

EXHIBIT 7: Example of completed *Project Safety Performance Analysis Input Sheet*

	A	B	C	D	F
1	PROJECT SAFETY PERFORMANCE ANALYSIS INPUT SHEET - RURAL 2-LANE ROADS				
2	**General Information**				
3	Project Name	Project Name		Contact Email	Email
4	Project Description	Project Description		Contact Phone	(123) 456-7891
5	Reference Number	Route & Project Name		Date Performed	08/15/16
6	Analyst	First and Last Name		Analysis Year	2016
7	Agency/Company	WSDOT		Multiple Year Analysis?	Yes
11	# of Segments in Analysis	1		Predicted/expected crashes	Predicted & Expected
12	# of Intersections in Analysis	1		Crash history (years)	5
13					
14	INDIVIDUAL PROJECT ELEMENTS	LOCATION INFORMATION			INTERSECTIONS ONLY
15		Route	Location Description	JURISDICTION	Signalized or Unsignalized?
16					
17	**SEGMENTS**				
18	Segment 1	SR 99	MP 2 to 5	South Eastern Region	-
19	**INTERSECTIONS**				
20	Intersection 1	SR 99	4-way STOP at Signal Way	South Eastern Region	Unsignalized

Task 4. Enter Required Information on Each Element Tab

4.1 On the current tab (either "Segment 1" or "Intersection 1"), enter all of the required information.

Project information will update automatically. Required inputs vary depending on the type of project (i.e. Urban/Suburban Arterial, Rural 2-Lane Road, Rural Multilane Road). An example of a rural two-lane two-way segment is shown. Element tabs may be for segments and/or intersections, depending on the project.

EXHIBIT 8: Example Element Input Table (e.g. *Segment 1*) – Worksheet 1A

1	Worksheet 1A -- General Information and Input Data for Rural Two-Lane Two-Way Roadway Segments												
2													
3	**General Information**					**Location Information**							
4	Analyst	First and Last Name				Roadway		SR 99					
5	Agency or Company	WSDOT				Roadway Section		MP 2 to 5					
6	Date Performed	08/15/16				Jurisdiction		South Eastern Region					
7	Segment for Analysis	Segment 1				Analysis Year		2016					
8	**Input Data**					**Site Conditions**					**Base Conditions**		
9	Length of segment, L (mi)					1.2					--		
10	AADT (veh/day)		$AADT_{MAX}$ =	17,800	(veh/day)	15,000					--		AADT OK
11	Lane width (ft)					11					12		
12	Shoulder width (ft)					Right Shld:	5	Left Shld:	4		6		
13	Shoulder type					Right Shld:	Paved	Left Shld:	Paved		Paved		
14	Length of horizontal curve (mi)					0.8					0		
15	Radius of curvature (ft)					800					0		Radius Value OK
16	Spiral transition curve (present/not present)					Present					Not Present		
17	Superelevation variance (ft/ft)					0.05					<0.01		
18	Grade (%)					5					0		
19	Driveway density (driveways/mile)					10					5		
20	Centerline rumble strips (present/not present)					Present					Not Present		
21	Passing lanes [present (1 lane) /present (2 lane) / not present)]					Not Present					Not Present		
22	Two-way left-turn lane (present/not present)					Present					Not Present		
23	Roadside hazard rating (1-7 scale)					6					3		
24	Segment lighting (present/not present)					Not Present					Not Present		
25	Auto speed enforcement (present/not present)					Not Present					Not Present		
26	Calibration Factor, Cr					1.00					1		
27	**Average Annual Crash History (3 or 5-yr average)**												
28	Segment crashes			KABC		Fatal and Injury Only		4.0			Next Element		*If inputs are complete, click for next element*
29				PDO		Property Damage Only		15.0					
30	NOTES: * AADT: It is important to remember that the AADT(major) = AADT(major approach1) + AADT(minor approach2) (refer to p.10-6 in Part C of the HSM)												
31													
32													

4.2 Review the table to confirm that all necessary information has been entered, then click the "Next Element" button. This includes Site Conditions and the Average Annual Crash History (3- or 5-year average).

All element inputs can be changed after this button is pushed. They will be updated automatically. For intersections, not all site conditions will apply to every intersection, depending on whether or not the intersection is signalized.

4.3 Repeat Steps 6 and 7 for all project elements (segments and intersections).

Each SPF was developed for a particular volume range. Refer to the HSM Part C (the TRB Highway Safety Performance Committee developed a quick reference for Part C that may be useful as well). The individual element worksheet will not perform the analysis if the volume threshold is exceeded.

Task 5. Generate Analysis Results and Report

5.1 After all inputs have been entered for all elements, click the "Generate Report" button on the final project element tab to run the analysis. This will redirect the page to the "Report" tab, which provides a summary of the analysis.

The final element tab may be a segment or an intersection depending on the project. Once this button is clicked, the report cannot be generated again. However, if any of the inputs need to be changed, they can be updated on each element tab and the report will update automatically based on the changes.

Task 6. Review Report and Discussion of Results

6.1 Review the report results (graph, table, and summary table) and discussion of safety performance analysis results.

Appendix A presents an example project, along with the HSM worksheets for each element and the analysis report.

Optional Analysis: Multi-Year Analysis

NOTE: Prior selection of option required in Task 2 to allow for multi-year analysis

Each SPF in Part C of the HSM was developed for a particular volume range. Refer to the HSM Part C (the TRB Highway Safety Performance Committee developed a quick reference for Part C that may be useful as well). The multi-year analysis will show results even if the volume range for one or more element are exceeded – the user should check each traffic volume with growth against the upper boundary of the SPF volume prior to analysis.

The multi-year analysis can only be performed once. **If the multi-year analysis is complete and the user updates information on one or more of the project element sheets, the information in the multi-year analysis will not update.**

*Task 7. Enter Multi-Year Analysis Information

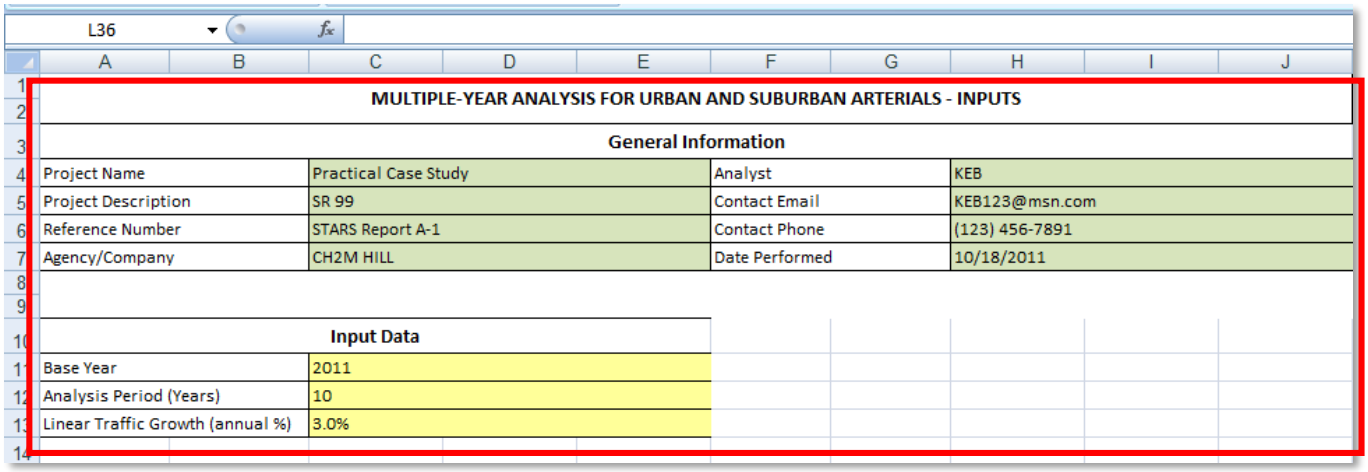
Task 7 and 8 are only necessary if a multi-year analysis is desired. In Task 2.2 the user identifies whether a multiple year analysis will be performed (selected from the drop down for *Multiple Year Analysis?* on the *Project Information* worksheet). If the user selected "Yes", Task 7 and 8 can be performed.

7.1 Select the *Multi-Year Analysis Inputs* worksheet.

7.2 Enter the required information: Base Year (must match year on *Project Information* tab), Analysis Period (Years), and Linear Traffic Growth Rate (annual %).

The Traffic Growth Rate is a linear growth rate per year (i.e. the volume increases by the same number of vehicles each year) and should be entered as a percent, not as a decimal. General information is automatically completed using information from the Project Information Worksheet.

EXHIBIT 9: Multiple-Year Analysis Inputs in the *Multi-Year Analysis Inputs* worksheet



MULTIPLE-YEAR ANALYSIS FOR URBAN AND SUBURBAN ARTERIALS - INPUTS			
General Information			
Project Name	Practical Case Study	Analyst	KEB
Project Description	SR 99	Contact Email	KEB123@msn.com
Reference Number	STARS Report A-1	Contact Phone	(123) 456-7891
Agency/Company	CH2M HILL	Date Performed	10/18/2011
Input Data			
Base Year	2011		
Analysis Period (Years)	10		
Linear Traffic Growth (annual %)	3.0%		

*Task 8. Generate and Review Multi-Year Report and Discussion

**Task 7 and 8 are only necessary if a multi-year analysis is desired.* In Task 2.2 the user identifies whether a multiple year analysis will be performed (selected from the drop down for *Multiple Year Analysis?* on the *Project Information* worksheet). If the user selected "Yes", Task 7 and 8 can be performed.

8.1 Once all of the information is complete, click the "Run Multi-Year Analysis" button to perform the analysis.

8.2 Review the multi-year summary report and discussion of the multi-year safety performance analysis results.

Appendix A: Example of Output from the Extended Spreadsheets

Project Information Sheet

PROJECT SAFETY PERFORMANCE ANALYSIS INPUT SHEET - RURAL 2-LANE ROADS				
General Information				
Project Name	Project Name		Contact Email	Email
Project Description	Project Description		Contact Phone	(123) 456-7891
Reference Number	Route & Project Name		Date Performed	08/15/16
Analyst	First and Last Name		Analysis Year	2016
Agency/Company	WSDOT		Multiple Year Analysis?	Yes
# of Segments in Analysis	1		Predicted/expected crashes	Predicted & Expected
# of Intersections in Analysis	1		Crash history (years)	5
INDIVIDUAL PROJECT ELEMENTS	LOCATION INFORMATION		JURISDICTION	INTERSECTIONS ONLY
	Route	Location Description		Signalized or Unsignalized?
SEGMENTS				
Segment 1	SR 99	MP 2 to 5	South Eastern Region	-
INTERSECTIONS				
Intersection 1	SR 99	4-way STOP at Signal Way	South Eastern Region	Unsignalized

Segment 1

Worksheet 1A -- General Information and Input Data for Rural Two-Lane Two-Way Roadway Segments

General Information		Location Information	
Analyst	First and Last Name	Roadway	SR 99
Agency or Company	WSDOT	Roadway Section	MP 2 to 5
Date Performed	08/15/16	Jurisdiction	South Eastern Region
Segment for Analysis	Segment 1	Analysis Year	2016

Input Data	Site Conditions	Base Conditions
Length of segment, L (mi)	1.2	--
AADT (veh/day) ($AADT_{MAX}$ = 17,800 (veh/day))	15,000	--
Lane width (ft)	11	12
Shoulder width (ft)	Right Shld: 5 Left Shld: 4	6
Shoulder type	Right Shld: Paved Left Shld: Paved	Paved
Length of horizontal curve (mi)	0.8	0
Radius of curvature (ft)	800	0
Spiral transition curve (present/not present)	Present	Not Present
Superelevation variance (ft/ft)	0.05	<0.01
Grade (%)	5	0
Driveway density (driveways/mile)	10	5
Centerline rumble strips (present/not present)	Present	Not Present
Passing lanes [present (1 lane) /present (2 lane) / not present)]	Not Present	Not Present
Two-way left-turn lane (present/not present)	Present	Not Present
Roadside hazard rating (1-7 scale)	6	3
Segment lighting (present/not present)	Not Present	Not Present
Auto speed enforcement (present/not present)	Not Present	Not Present
Calibration Factor, Cr	1.00	1

Average Annual Crash History (3 or 5-yr average)

Segment crashes	KABC	Fatal and Injury Only	4.0
	PDO	Property Damage Only	15.0

NOTES: * AADT: It is important to remember that the AADT(major) = AADT(major approach1) + AADT(minor approach2) (refer to p.10-6 in Part C of the HSM)

Next Element

Worksheet 1B -- Crash Modification Factors for Rural Two-Lane Two-Way Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
CMF for Lane Width	CMF for Shoulder Width and Type	CMF for Horizontal Curves	CMF for Super-elevation	CMF for Grades	CMF for Driveway Density	CMF for Centerline Rumble Strips	CMF for Passing Lanes	CMF for Two-Way Left-Turn Lane	CMF for Roadside Design	CMF for Lighting	CMF for Automated Speed Enforcemen	Combined CMF
CMF 1r	*CMF 2r*	*CMF 3r*	*CMF 4r*	*CMR 5r*	*CMF 6r*	*CMF 7r*	*CMF 8r*	*CMF 9r*	*CMF 10r*	*CMF 11r*	*CMF 12r*	*CMF comb*
from Equation 10-11	from Equation 10-12	from Equation 10-13	from Equations 10-14, 10-15, or 10-16	from Table 10-11	from Equation 10-17	from Section 10.7.1	from Section 10.7.1	from Equation 10-18 & 10-19	from Equation 10-20	from Equation 10-21	from Section 10.7.1	(1)x(2)x ... x(11)x(12)
1.03	1.07	1.07	1.15	1.10	1.03	1.00	1.00	0.93	1.22	1.00	1.00	1.742

Worksheet 1C -- Roadway Segment Crashes for Rural Two-Lane Two-Way Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crash Severity Level	**N spf rs**	**Overdispersion Parameter, k**	**Crash Severity Distribution**	**N spf rs by Severity Distribution**	**Combined CMFs**	**Calibration Factor, Cr**	**Predicted average crash frequency, N predicted rs (crashes/year)**
	from Equation 10-	from Equation 10-7	from Table 10-3 (proportion)	(2)TOTAL x (4)	(13) from Worksheet 1B		(5)x(6)x(7)
Total	4.809	0.20	1.000	4.809	1.74	1.00	8.377
Fatal and Injury (FI)	--	--	0.321	1.544	1.74	1.00	2.689
Property Damage Only (PDO)	--	--	0.679	3.265	1.74	1.00	5.688

Worksheet 1D -- Crashes by Severity Level and Collision Type for Rural Two-Lane Two-Way Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Collision Type	Proportion of Collision Type$_{TOTAL}$	N $_{predicted\ rs\ TOTAL}$ (crashes/year)	Proportion of Collision Type$_{FI}$	N $_{predicted\ rs\ FI}$ (crashes/year)	Proportion of Collision Type$_{PDO}$	N $_{predicted\ rs\ PDO}$ (crashes/year)
	from Table 10-4	(8)$_{TOTAL}$ from Worksheet 1C	from Table 10-4	(8)$_{FI}$ from Worksheet 1C	from Table 10-4	(8)$_{PDO}$ from Worksheet 1C
Total	1.000	8.377	1.000	2.689	1.000	5.688
		(2)x(3)$_{TOTAL}$		(4)x(5)$_{FI}$		(6)x(7)$_{PDO}$
SINGLE-VEHICLE						
Collision with animal	0.121	1.014	0.038	0.102	0.184	1.047
Collision with bicycle	0.002	0.017	0.004	0.011	0.001	0.006
Collision with pedestrian	0.003	0.025	0.007	0.019	0.001	0.006
Overturned	0.025	0.209	0.037	0.099	0.015	0.085
Ran off road	0.521	4.365	0.545	1.466	0.505	2.873
Other single-vehicle collision	0.021	0.176	0.007	0.019	0.029	0.165
Total single-vehicle crashes	0.693	5.805	0.638	1.716	0.735	4.181
MULTIPLE-VEHICLE						
Angle collision	0.085	0.712	0.100	0.269	0.072	0.410
Head-on collision	0.016	0.134	0.034	0.091	0.003	0.017
Rear-end collision	0.142	1.190	0.164	0.441	0.122	0.694
Sideswipe collision	0.037	0.310	0.038	0.102	0.038	0.216
Other multiple-vehicle collision	0.027	0.226	0.026	0.070	0.030	0.171
Total multiple-vehicle crashes	0.307	2.572	0.362	0.973	0.265	1.507

Worksheet 1E -- Summary Results for Rural Two-Lane Two-Way Roadway Segments

(1)	(2)	(3)	(4)	(5)
Crash severity level	Crash Severity Distribution (proportion) (4) from Worksheet 1C	Predicted average crash frequency (8) from Worksheet 1C	Roadway segment length (mi)	Crash rate (3)/(4)
Total	1.000	8.4	1.2	7.0
Fatal and Injury (FI)	0.321	2.7	1.2	2.2
Property Damage Only (PDO)	0.679	5.7	1.2	4.7

PROJECT ELEMENT RESULTS SUMMARY[1]

Summary for the project element	Total Crashes/yr (KABCO)			Fatal and Injury Crashes/yr (KABC)			Property Damage Only Crashes/yr (PDO)		
	Predicted average crash frequency $N_{predicted\ (KABCO)}$	Expected average crash frequency $N_{expected\ (KABCO)}$	Potential for Improvement	Predicted average crash frequency $N_{predicted\ (KABC)}$	Expected average crash frequency $N_{expected\ (KABC)}$	Potential for Improvement	Predicted average crash frequency $N_{predicted\ (O)}$	Expected average crash frequency $N_{expected\ (O)}$	Potential for Improvement
	8.4	17.9	9.5	2.7	5.7	3.0	5.7	12.1	6.4

Special Note: When the project element is not included in the analysis the results will all be zeros. In addition if only the analysis only includes determining the predicted average crash frequency (i.e. EB analysis is not carried out), the results will show zero values where EB results are usually displayed.

Intersection 1

Worksheet 2A -- General Information and Input Data for Rural Two-Lane Two-Way Roadway Intersections

General Information		Location Information	
Analyst	First and Last Name	Roadway	SR 99
Agency or Company	WSDOT	Intersection	4-way STOP at Signal Way
Date Performed	08/15/16	Jurisdiction	South Eastern Region
Intersection	Intersection 1	Analysis Year	2016
Signalized/Unsignalized	Unsignalized		

Input Data		Site Conditions	Base Conditions
Intersection type (3ST, 4ST, 4SG)		4ST	--
$AADT_{major}$ (veh/day)	$AADT_{MAX}$ = 14,700 (veh/day)	14,000	--
$AADT_{minor}$ (veh/day)	$AADT_{MAX}$ = 3,500 (veh/day)	2,500	--
Intersection skew angle (degrees) [If 4ST, does skew differ for minor legs? Else, No.]		Skew for Leg 1 (All): 0 / Skew for Leg 2 (4ST only): 0	0
Number of signalized or uncontrolled approaches with a left-turn lane (0, 1, 2, 3, 4)		1	0
Number of signalized or uncontrolled approaches with a right-turn lane (0, 1, 2, 3, 4)		1	0
Intersection lighting (present/not present)		Not Present	Not Present
Calibration Factor, C_i		1.00	1.00

Average Annual Crash History (3 or 5-yr average)

Intersection crashes	KABC	Fatal and Injury Only	8.0
	PDO	Property Damage Only	78.0

NOTES: * AADT: It is important to remember that the AADT(major) = AADT(major approach1) + AADT(minor approach2) (refer to p.10-6 in Part C of the HSM)

Worksheet 2B -- Crash Modification Factors for Rural Two-Lane Two-Way Roadway Intersections

(1) CMF for Intersection Skew Angle CMF_{1i} from Equations 10-22 or 10-23	(2) CMF for Left-Turn Lanes CMF_{2i} from Table 10-13	(3) CMF for Right-Turn Lanes CMF_{3i} from Table 10-14	(4) CMF for Lighting CMF_{4i} from Equation 10-24	(5) Combined CMF CMF_{COMB} (1)*(2)*(3)*(4)
1.00	0.72	0.86	1.00	0.62

Worksheet 2C -- Intersection Crashes for Rural Two-Lane Two-Way Roadway Intersections

(1) Crash Severity Level	(2) $N_{spf\ 3ST,\ 4ST\ or\ 4SG}$ from Equations 10-8, 10-9, or 10-10	(3) Overdispersion Parameter, k from Section 10.6.2	(4) Crash Severity Distribution from Table 10-5	(5) $N_{spf\ 3ST,\ 4ST\ or\ 4SG}$ by Severity Distribution $(2)_{TOTAL}$ * (4)	(6) Combined CMFs from (5) of Worksheet 2B	(7) Calibration Factor, C_i	(8) Predicted average crash frequency, $N_{predicted\ int}$ (5)*(6)*(7)
Total	6.964	0.24	1.000	6.964	0.62	1.00	4.312
Fatal and Injury (FI)	--	--	0.431	3.001	0.62	1.00	1.859
Property Damage Only (PDO)	--	--	0.569	3.963	0.62	1.00	2.454

Worksheet 2D -- Crashes by Severity Level and Collision Type for Rural Two-Lane Two-Way Road Intersections

(1) Collision Type	(2) Proportion of Collision $Type_{(TOTAL)}$ from Table 10-6	(3) $N_{predicted\ int\ (TOTAL)}$ (crashes/year) $(8)_{TOTAL}$ from Worksheet 2C; $(2)x(3)_{TOTAL}$	(4) Proportion of $Collision\ Type_{(FI)}$ from Table 10-6	(5) $N_{predicted\ int\ (FI)}$ (crashes/year) $(8)_{FI}$ from Worksheet 2C; $(4)x(5)_{FI}$	(6) Proportion of $Collision\ Type_{(PDO)}$ from Table 10-6	(7) $N_{predicted\ int\ (PDO)}$ (crashes/year) $(8)_{PDO}$ from Worksheet 2C; $(6)x(7)_{PDO}$
Total	1.000	4.312	1.000	1.859	1.000	2.454
SINGLE-VEHICLE						
Collision with animal	0.010	0.043	0.006	0.011	0.014	0.034
Collision with bicycle	0.001	0.004	0.001	0.002	0.001	0.002
Collision with pedestrian	0.001	0.004	0.001	0.002	0.001	0.002
Overturned	0.005	0.022	0.006	0.011	0.004	0.010
Ran off road	0.122	0.526	0.094	0.175	0.144	0.353
Other single-vehicle collision	0.008	0.034	0.004	0.007	0.010	0.025
Total single-vehicle crashes	0.147	0.634	0.112	0.208	0.174	0.427
MULTIPLE-VEHICLE						
Angle collision	0.431	1.859	0.532	0.989	0.354	0.869
Head-on collision	0.040	0.172	0.060	0.112	0.025	0.061
Rear-end collision	0.242	1.044	0.210	0.390	0.266	0.653
Sideswipe collision	0.101	0.436	0.044	0.082	0.144	0.353
Other multiple-vehicle collision	0.039	0.168	0.042	0.078	0.037	0.091
Total multiple-vehicle crashes	0.853	3.678	0.888	1.650	0.826	2.027

Worksheet 2E -- Summary Results for Rural Two-Lane Two-Way Road Intersections

(1) Crash severity level	(2) Crash Severity Distribution (proportion) (4) from Worksheet 2C	(3) Predicted average crash frequency (crashes / year) (8) from Worksheet 2C
Total	1.000	4.3
Fatal and Injury (FI)	0.431	1.9
Property Damage Only (PDO)	0.569	2.5

PROJECT ELEMENT RESULTS SUMMARY[1]

Summary for the project element	Total Crashes/yr (KABCO)			Fatal and Injury Crashes/yr (KABC)			Property Damage Only Crashes/yr (PDO)		
	Predicted average crash frequency $N_{predicted\ (KABCO)}$	Expected average crash frequency $N_{expected\ (KABCO)}$	Potential for Improvement	Predicted average crash frequency $N_{predicted\ (KABC)}$	Expected average crash frequency $N_{expected\ (KABC)}$	Potential for Improvement	Predicted average crash frequency $N_{predicted\ (O)}$	Expected average crash frequency $N_{expected\ (O)}$	Potential for Improvement
	4.3	72.8	68.5	1.9	31.4	29.5	2.5	41.4	39.0

Special Note: When the project element is not included in the analysis the results will all be zeros. In addition if only the analysis only includes determining the predicted average crash frequency (i.e. EB analysis is not carried out), the results will show zero values where EB results are usually displayed.

Site Total (EB Analysis)

Worksheet 3A -- Predicted and Observed Crashes by Severity and Site Type Using the Site-Specific EB Method

(1)	(2)	(3)	(4)	(5)	(5)	(5)	(6)	(7)	(8)
Site type	**Predicted average crash frequency (crashes/year)**			**Observed crashes, $N_{observed}$ (crashes/year)**			**Overdispersion Parameter, k**	**Weighted adjustment, w**	**Expected average crash frequency, $N_{expected}$**
	$N_{predicted}$ (TOTAL)	$N_{predicted}$ (FI)	$N_{predicted}$ (PDO)	$N_{predicted}$ (TOTAL)	$N_{predicted}$ (FI)	$N_{predicted}$ (PDO)		Equation A-5 from Part C Appendix	Equation A-4 from Part C Appendix
ROADWAY SEGMENTS									
Segment 1	8.377	2.689	5.688	19.0	4.0	15.0	0.197	0.108	17.850
INTERSECTIONS									
Intersection 1	4.312	1.859	2.454	86.0	8.0	78.0	0.240	0.162	72.770
COMBINED (sum of column)	12.689	4.548	8.142	105	12	93	0.437	0.270	90.620

Worksheet 3B -- Site-Specific EB Method Summary Results

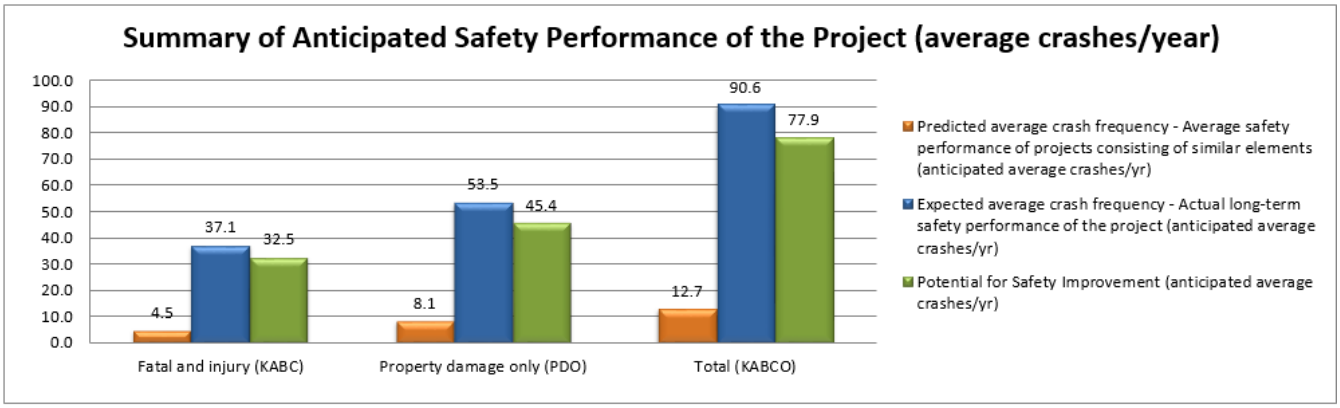
(1)	(2)	(3)
Crash severity level	$N_{predicted}$	$N_{expected}$
Total	$(2)_{COMB}$ from Worksheet 3A	$(8)_{COMB}$ from Worksheet 3A
	12.689	90.620
Fatal and Injury (FI)	$(3)_{COMB}$ from Worksheet 3A	$(3)_{TOTAL} * (2)_{FI} / (2)_{TOTAL}$
	4.548	32.477
Property Damage Only (PDO)	$(4)_{COMB}$ from Worksheet 3A	$(3)_{TOTAL} * (2)_{PDO} / (2)_{TOTAL}$
	8.142	58.144

Report

PROJECT SAFETY PERFORMANCE SUMMARY REPORT

General Information			
Project Name	Project Name		
Project Description	Project Description		
Reference Number	Route & Project Name		
Analyst	First and Last Name		
Agency/Company	WSDOT		
Contact Email	Email		
Contact Phone	(123) 456-7891		
Date Completed	08/15/16	Years of crash data incorporated into the analysis:	5

PROJECT SUMMARY



Project Element	Total Crashes/yr (KABCO)			Fatal and Injury Crashes/yr (KABC)			Property Damage Only Crashes/yr (PDO)		
	Predicted average crash frequency $N_{predicted\ (KABCO)}$	Expected average crash frequency $N_{expected\ (KABCO)}$	Potential for Improvement	Predicted average crash frequency $N_{predicted\ (KABC)}$	Expected average crash frequency $N_{expected\ (KABC)}$	Potential for Improvement	Predicted average crash frequency $N_{predicted\ (O)}$	Expected average crash frequency $N_{expected\ (O)}$	Potential for Improvement
INDIVIDUAL SEGMENTS									
Segment 1	8.4	17.9	9.5	2.7	5.7	3.0	5.7	12.1	6.4
INDIVIDUAL INTERSECTIONS									
Intersection 1	4.3	72.8	68.5	1.9	31.4	29.5	2.5	41.4	39.0
COMBINED (sum of column)	12.7	90.6	77.9	4.5	37.1	32.5	8.1	53.5	45.4

PROJECT SUMMARY -- Site-Specific EB Method Summary Results for Rural 2-Lane Roads

Crash severity level	$N_{predicted(PROJECT)}$ Predicted average crash frequency - Average safety performance of projects consisting of similar elements (anticipated average crashes/yr)	$N_{expected\ (PROJECT)}$ Expected average crash frequency - Actual long-term safety performance of the project (anticipated average crashes/yr)	$N_{potential\ for\ improvement\ (PROJECT)}$ Potential for Safety Improvement (anticipated average crashes/yr)
Fatal and injury (KABC)	4.5	37.1	32.5
Property damage only (PDO)	8.1	53.5	45.4
Total (KABCO)	12.7	90.6	77.9

HSM1 Extended Spreadsheet for Part C Chapter 10 v.9

Discussion of Results

Given the potential effects of project characteristics on safety performance, results indicate that:

1. It is anticipated that the project will, on average, experience 90.6 crashes per year (37.1 fatal and injury crashes per year; and 53.5 property damage only crashes per year).

2. A similar project is anticipated, on average, to experience 12.7 crashes per year (4.5 fatal and injury crashes per year; and 8.1 property damage only crashes per year).

3. It is anticipated the project has, on average, a potential for safety improvement of 77.9 crashes per year (32.5 fatal and injury crashes per year; and 45.4 property damage only crashes per year).

Multi-Year Analysis Inputs

MULTIPLE-YEAR ANALYSIS FOR RURAL 2-LANE ROADS - INPUTS

General Information			
Project Name	Project Name	Analyst	First and Last Name
Project Description	Project Description	Contact Email	Email
Reference Number	Route & Project Name	Contact Phone	(123) 456-7891
Agency/Company	WSDOT	Date Performed	8/15/2016

Input Data	
Base Year	2016
Analysis Period (Years)	20
Linear Traffic Growth (annual %)	4.0%

Multi-Year Analysis Summary

MULTIPLE-YEAR ANALYSIS SUMMARY FOR RURAL 2-LANE ROADS

General Information	
Base Year	2016
Analysis Period (Years)	20
Linear Traffic Growth Rate (annual %)	4.0%

20-Year Analysis Summary Report

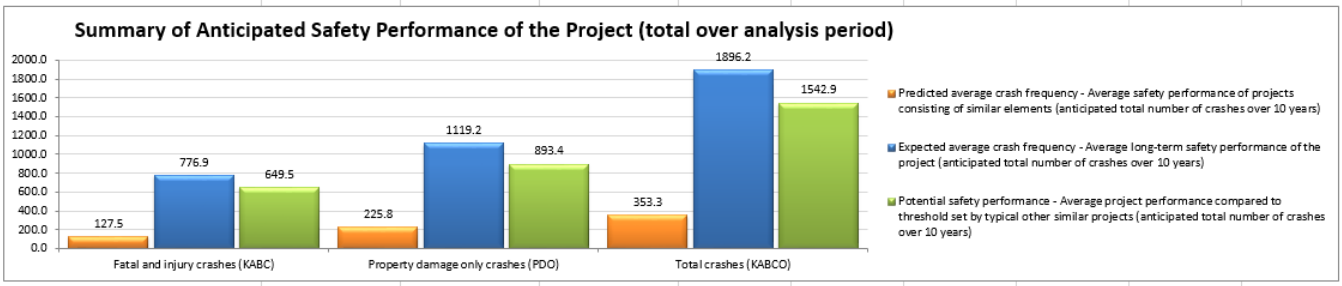
Analysis Year	Predicted Average Crash Frequency ($N_{predicted}$)			Expected Average Crash Frequency ($N_{expected}$)			Potential for Safety Improvement (crashes/yr)		
	KABC	*PDO*	*Total (KABCO)*	*KABC*	*PDO*	*Total (KABCO)*	*KABC*	*PDO*	*Total (KABCO)*
2016	4.5	8.1	12.7	37.1	53.5	90.6	32.5	45.4	77.9
2017	4.7	8.5	13.2	37.4	53.9	91.2	32.6	45.4	78.0
2018	4.9	8.8	13.7	37.6	54.2	91.8	32.7	45.4	78.1
2019	5.1	9.1	14.3	37.8	54.5	92.4	32.7	45.4	78.1
2020	5.3	9.5	14.8	38.0	54.8	92.9	32.7	45.4	78.1
2021	5.5	9.8	15.3	38.2	55.1	93.3	32.7	45.3	78.0
2022	5.7	10.1	15.8	38.4	55.4	93.8	32.7	45.2	78.0
2023	5.9	10.5	16.3	38.6	55.6	94.2	32.7	45.1	77.9
2024	6.1	10.8	16.9	38.8	55.8	94.6	32.7	45.0	77.7
2025	6.3	11.1	17.4	38.9	56.1	95.0	32.6	44.9	77.6
2026	6.5	11.5	17.9	39.1	56.3	95.3	32.6	44.8	77.4
2027	6.7	11.8	18.4	39.2	56.5	95.7	32.5	44.7	77.2
2028	6.9	12.1	19.0	39.3	56.6	96.0	32.5	44.5	77.0
2029	7.0	12.5	19.5	39.5	56.8	96.3	32.4	44.4	76.8
2030	7.2	12.8	20.0	39.6	57.0	96.6	32.3	44.2	76.5
2031	7.4	13.1	20.6	39.7	57.1	96.8	32.3	44.0	76.3
2032	7.6	13.5	21.1	39.8	57.3	97.1	32.2	43.8	76.0
2033	7.8	13.8	21.6	39.9	57.4	97.3	32.1	43.6	75.7
2034	8.0	14.1	22.1	40.0	57.6	97.6	32.0	43.4	75.4
2035	8.2	14.5	22.7	40.1	57.7	97.8	31.9	43.2	75.1
Total	127.5	225.8	353.3	776.9	1119.2	1896.2	649.5	893.4	1542.9

Multi-Year Analysis Results Report

MULTIPLE YEAR PROJECT SAFETY PERFORMANCE SUMMARY REPORT FOR RURAL 2-LANE ROADS

General Information	
Project Name	Project Name
Project Description	Project Description
Reference Number	Route & Project Name
Analyst	First and Last Name
Agency/Company	WSDOT
Contact Email	Email
Contact Phone	(123) 456-7891
Date Completed	08/15/16
Base Year	2016
Analysis Period (Years)	20
Linear Traffic Growth Rate (annual %)	4%

PROJECT SUMMARY



20-Year Analysis Summary Report

Analysis Year	Predicted Average Crash Frequency			Expected Average Crash Frequency			Potential for Safety Improvement		
	KABC	*PDO*	*Total (KABCO)*	*KABC*	*PDO*	*Total (KABCO)*	*KABC*	*PDO*	*Total (KABCO)*
2016	4.5	8.1	12.7	37.1	53.5	90.6	32.5	45.4	77.9
2017	4.7	8.5	13.2	37.4	53.9	91.2	32.6	45.4	78.0
2018	4.9	8.8	13.7	37.6	54.2	91.8	32.7	45.4	78.1
2019	5.1	9.1	14.3	37.8	54.5	92.4	32.7	45.4	78.1
2020	5.3	9.5	14.8	38.0	54.8	92.9	32.7	45.4	78.1
2021	5.5	9.8	15.3	38.2	55.1	93.3	32.7	45.3	78.0
2022	5.7	10.1	15.8	38.4	55.4	93.8	32.7	45.2	78.0
2023	5.9	10.5	16.3	38.6	55.6	94.2	32.7	45.1	77.9
2024	6.1	10.8	16.9	38.8	55.8	94.6	32.7	45.0	77.7
2025	6.3	11.1	17.4	38.9	56.1	95.0	32.6	44.9	77.6
2026	6.5	11.5	17.9	39.1	56.3	95.3	32.6	44.8	77.4
2027	6.7	11.8	18.4	39.2	56.5	95.7	32.5	44.7	77.2
2028	6.9	12.1	19.0	39.3	56.6	96.0	32.5	44.5	77.0
2029	7.0	12.5	19.5	39.5	56.8	96.3	32.4	44.4	76.8
2030	7.2	12.8	20.0	39.6	57.0	96.6	32.3	44.2	76.5
2031	7.4	13.1	20.6	39.7	57.1	96.8	32.3	44.0	76.3
2032	7.6	13.5	21.1	39.8	57.3	97.1	32.2	43.8	76.0
2033	7.8	13.8	21.6	39.9	57.4	97.3	32.1	43.6	75.7
2034	8.0	14.1	22.1	40.0	57.6	97.6	32.0	43.4	75.4
2035	8.2	14.5	22.7	40.1	57.7	97.8	31.9	43.2	75.1
Total	127.5	225.8	353.3	776.9	1119.2	1896.2	649.5	893.4	1542.9

PROJECT SUMMARY -- Site-Specific EB Method Summary Results for Rural 2-Lane Roads

Crash severity level	$N_{predicted(PROJECT)}$ Predicted average crash frequency - Average safety performance of projects consisting of similar elements (anticipated total number of crashes over 20 years)	$N_{expected\ (PROJECT)}$ Expected average crash frequency - Average long-term safety performance of the project (anticipated total number of crashes over 20 years)	$N_{potential\ for\ improvement\ (PROJECT)}$ Potential safety performance - Average project performance compared to threshold set by typical other similar projects (anticipated total number of crashes over 20 years)
Fatal and injury crashes (KABC)	127.5	776.9	649.5
Property damage only crashes (PDO)	225.8	1119.2	893.4
Total crashes (KABCO)	353.3	1896.2	1542.9

Discussion of Results

Given the potential effects of project characteristics on safety performance and assuming a 4 % growth in AADT over a 20 year analysis period with 2016 as the base year, results indicate that:

1. The project is anticipated, on average, to experience 1896.2 crashes over a 20 year analysis period (776.9 fatal and injury crashes; and 1119.2 property damage only crashes).

2. A similar project is anticipated, on average, to experience 353.3 crashes over a 20 year analysis period (127.5 fatal and injury crashes over 20 years; and 225.8 property damage only crashes over 20 years).

3. It is anticipated the project will have an average potential for safety improvement of 1542.9 crashes over a 20 year analysis period (649.5 fatal and injury crashes over 20 years; and 893.4 property damage only crashes over 20 years).

Appendix B: Modifications to Worksheet 3C in Chapter 12

Appendix B:
Modifications to Worksheet 3C in Chapter 12

Appendix B describes the changes made to Worksheet 3C of Chapter 12 (AASHTO HSM 2010). The purpose of the changes was to improve the understanding of headings of the results and assessment of the analysis results summarized in the HSM Worksheet 3C (p.12-119). Appendix A provides Worksheet 3C as part of the analysis worksheet printouts.

EXHIBIT 10: The original HSM Worksheet 3C

Worksheet 3C. Site-Specific EB Method Summary Results for Urban and Suburban Arterials

(1)	(2)	(3)	(4)	(5)	(6)
Crash Severity Level	$N_{predicted}$	N_{ped}	N_{bike}	$N_{expected\ (vehicle)}$	$N_{expected}$
Total	$(2)_{comb}$ Worksheet 3A	$(2)_{comb}$ Worksheet 3B	$(3)_{comb}$ Worksheet 3B	$(13)_{comb}$ Worksheet 3A	(3)+(4)+(5)
Fatal and injury (FI)	$(3)_{comb}$ Worksheet 3A	$(2)_{comb}$ Worksheet 3B	$(3)_{comb}$ Worksheet 3B	$(5)_{total}*(2)_{FI}/(2)_{total}$	(3)+(4)+(5)
Property damage only (PDO)	$(4)_{comb}$ Worksheet 3A	— 0.000	— 0.000	$(5)_{total}*(2)_{PDO}/(2)_{total}$	(3)+(4)+(5)

EXHIBIT 11: The updated HSM Worksheet 3C in the extended spreadsheets for the urban and suburban arterial predictive chapter

Worksheet 3C -- Site-Specific EB Method Summary Results for Urban and Suburban Arterials

(1)	(2)	(3)	(4)	(7)	(5)	(6)
Crash severity level	**N predicted(SV+MV)**	**N predicted(ped)**	**N predicted(bicycle)**	**N predicted(PROJECT)**	**N expected (VEHICLE)**	**N expected (PROJECT)**
Total	$(2)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	(2)+(3)+(4)	$(8)_{COMB}$ Worksheet 3A	(3)+(4)+(5)
Fatal and injury (FI)	$(3)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	(2)+(3)+(4)	$(5)_{TOTAL} * (2)_{FI} / (2)_{TOTAL}$	(3)+(4)+(5)
Property damage only (PDO)	$(4)_{COMB}$ from Worksheet 3A	--	--	(2)+(3)+(4)	$(5)_{TOTAL} * (2)_{PDO} / (2)_{TOTAL}$	(3)+(4)+(5)

i. Updated title for column (2) to $N_{predicted\ (MV+SV)}$. Column (2) in the extended Worksheet 3C represents the sum of the predicted average crashes for single vehicle and multi vehicle collisions. Users often incorrectly assume that $N_{predicted}$, the original column (2) in HSM Worksheet 3C on p.12-119), represents the value for the total number of predicted average crashes for the project when it merely represents the total predicted average crashes for single and multiple vehicle crashes (i.e. not including the predicted average crashes for vehicle-pedestrian or vehicle-bicycle crashes). The updated title clarifies the content of the column to users.

ii. Updated title for column (3) to $N_{predicted\ (ped)}$. Column (3) in the expanded spreadsheet represents the predicted average crash frequency for vehicle-pedestrian crashes. The updated title clarifies the content of the column to users.

iii. Updated title for column (4) to $N_{predicted\ (bicycle)}$. Column (4) in Worksheet 3C represents the predicted average crash frequency for vehicle-bicycle crashes. In addition, frequently asked questions from first-time HSM users indicated that the term “bike” does not necessarily mean “bicycle” to users. The updated title clarifies the content of the column to users.

iv. Column (5) still shows $N_{expected\ (VEHICLE)}$, the expected average multiple and single vehicle crashes.

v. Added a column (7) to show $N_{predicted\ (project)}$, the sum of all predicted average crash frequencies for the project (columns (2), (3) and (4) for total crashes and so forth). The updated title and contents of the column support an improved understanding of the results.

vi. Changed title and contents for

vii. Changed title for column (6). The updated column (6) represents the total average expected crash frequency for the project, expressed as $N_{expected\ (project)}$. Frequently asked questions indicate that users often incorrectly presume that column (5) represented the total expected average crash frequency for the project rather than just the sum of the expected average crash frequency for multiple vehicle and single vehicle crashes for the project. The updated title and contents of the column support an improved understanding of the results, and an easy comparison of the total predicted average crash frequency and the total expected average crash frequency for the project.