2020 WEBINAR SERIES

RPUG Road Profile Users' Group

Splash, Spray and Hydroplaning 101

Gerardo Flintsch, Virginia Tech

Contents

1. Introduction
2. Water accumulation on the pavement
3. Splash and Spray
4. Hydroplaning
5. Final Thoughts

1. Introduction

Road Evolution

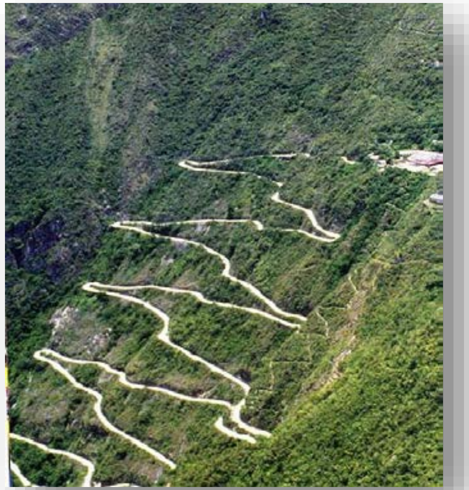
1st Generation ⇒ Track

2nd Generation ⇒ Paved road

3rd Generation ⇒ Smooth road (comfort)

4th Generation ⇒ Highway (safe & efficient)

5th Generation ⇒ Smart, Sustainable and Resilient roads & highways



https://www.outlookindia.com/newswire/story/ancient-inca-roads-win-world-heritage-status/845860

http://www.romeacrosseurope.com/?p=5417#sthash.ocgeu6wg.dpbs

Paving Pennsylvania Avenue (1870's)

Virginia Smart Road (1999)

Adapted from the FEHRL Concept for FOREVER OPEN ROAD
Redefining Road Transport for the 21st Century
FEHRL's Flagship Programme

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What is the function of the Road?

What does the use want/expect?

- ✓ **Mobility**
- ✓ **Access**
- ✓ **Safety**
- ✓ **Comfort**
- ✓ Fast & Reliable Travel
- ✓ Energy Efficient
- ✓ Low pollution / Low noise
- ✓ Renewable …

⟺

Economic Development

Social Equity

Environmental Protection

⇗ **Sustainable Infrastructure**

⇗ **Focus on the User**

→ **Level of Service (Performance)**

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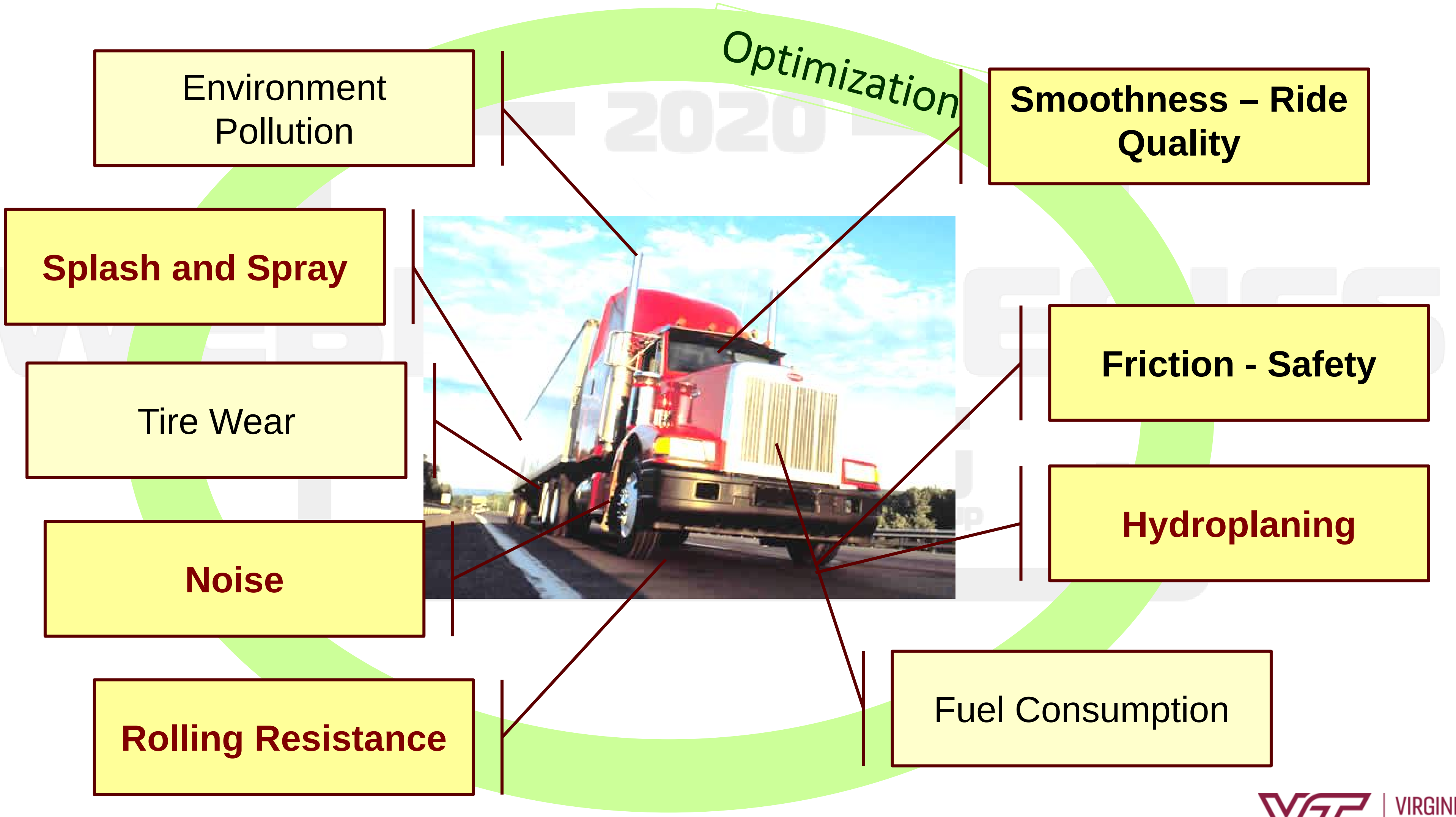
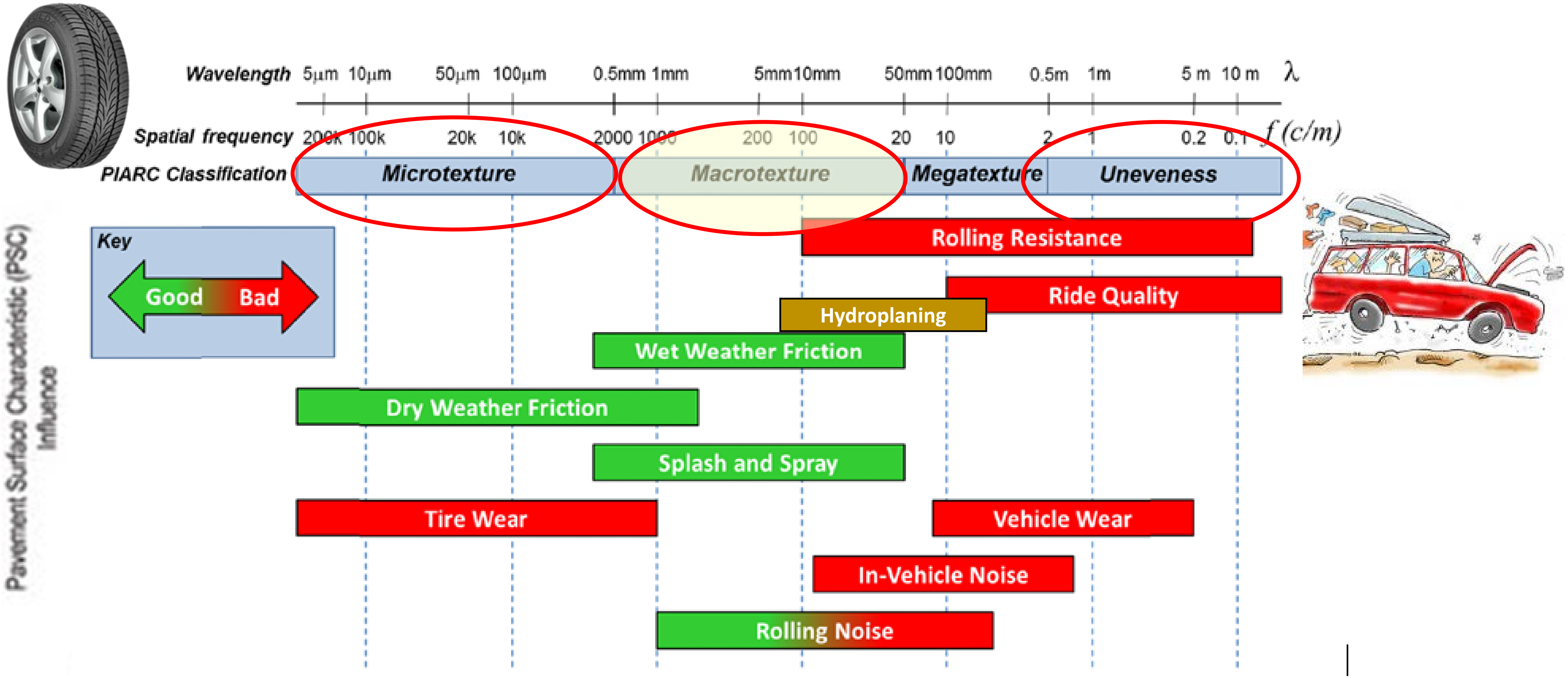
Vehicle (Tire) / Road (Pavement) Interaction



Pavement Texture – PIARC Classification and Impact on Pavement Vehicle Interaction



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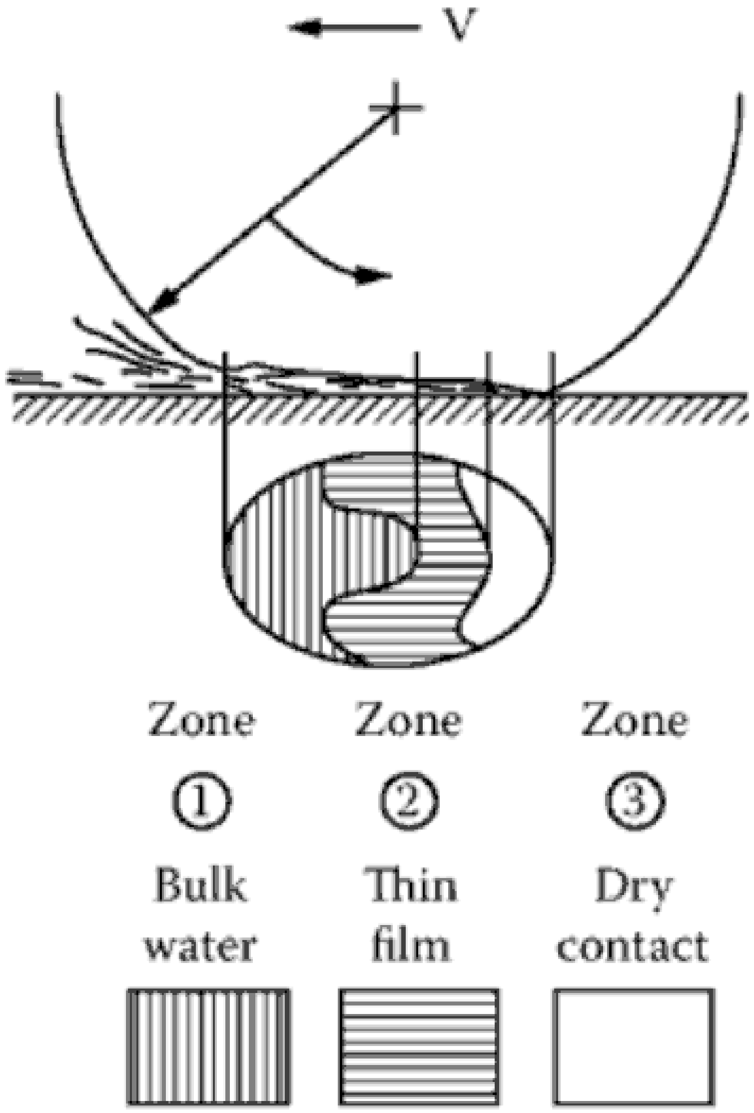
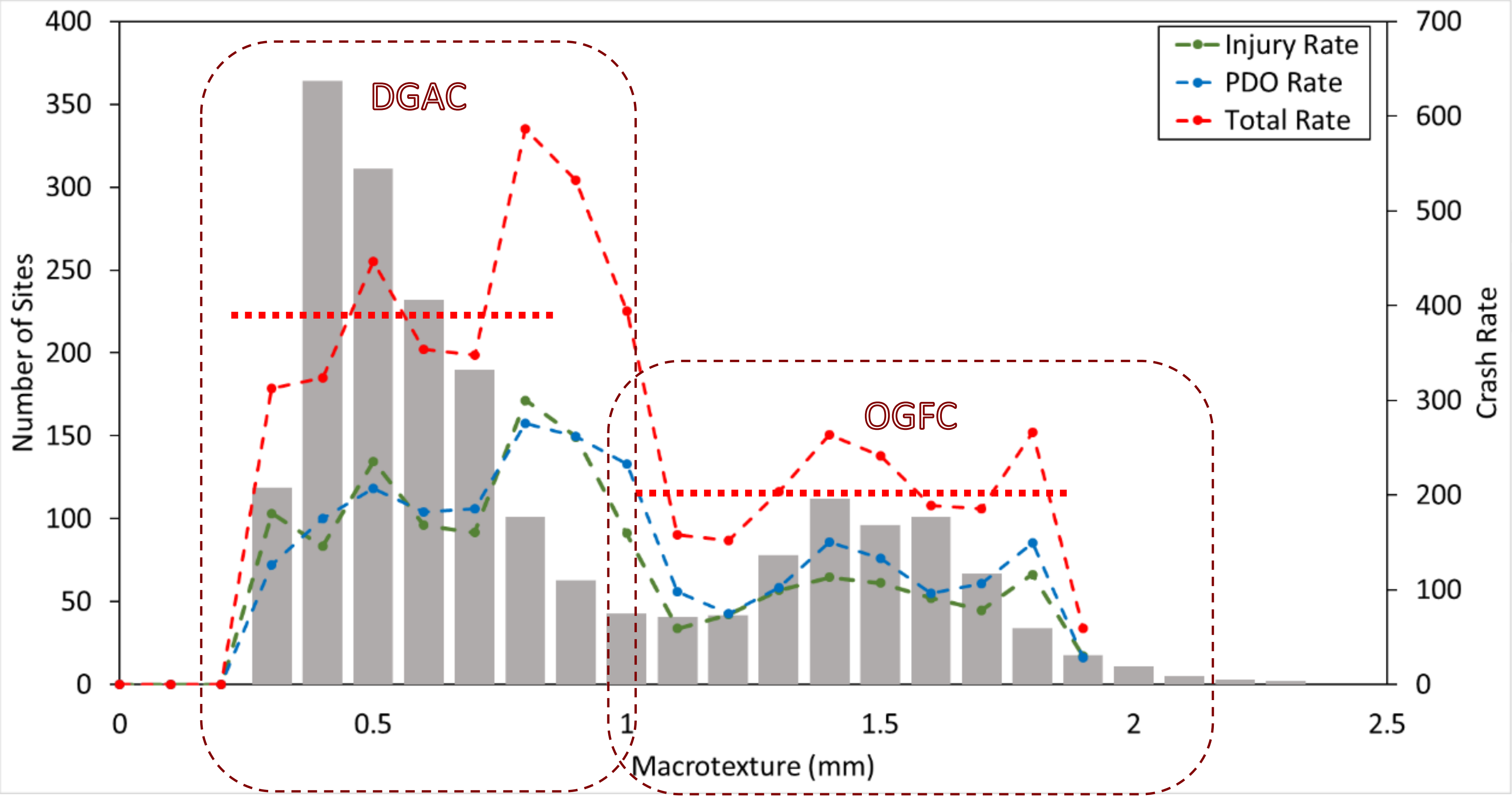


Smith, R. (2008). *Analyzing Friction in the Design of Rubber Products and Their Paired Surfaces.* London: CRC Press

Tire/Pavement Interface – Three Zone Concept

1. Macrotexture
2. Microtexture
3. Dry Contact

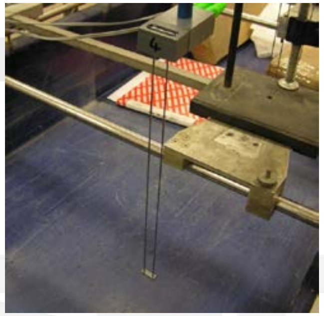
Example of the Effect of Texture on Crash Rate



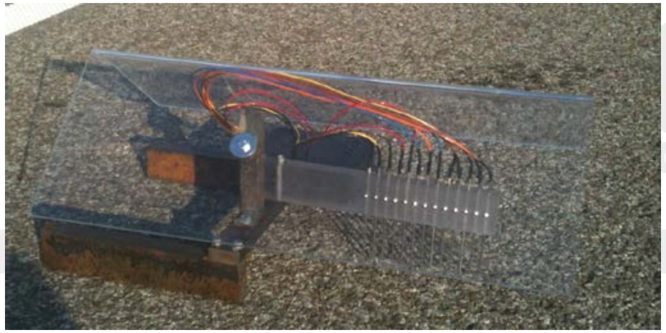
2. Water Accumulation

Measuring/Predicting Water Film Thickness

- ✓ Lab Measurements



- ✓ Field Measurements



https://www.lufft.com/products/road-runway-sensors-292/marwis-umb-mobile-advanced-road-weather-information-sensor-2308/

- ✓ Modeling

Examples of Water Accumulation Models

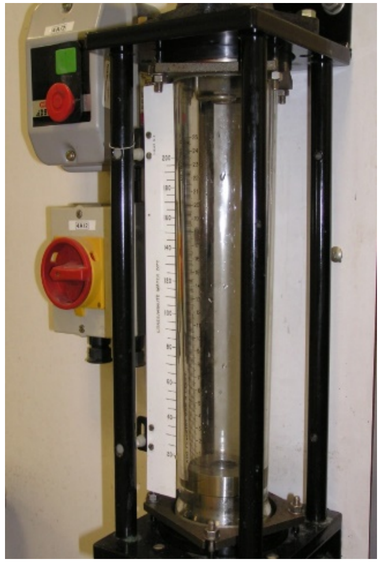
Table 1. Overview of previous and current models.

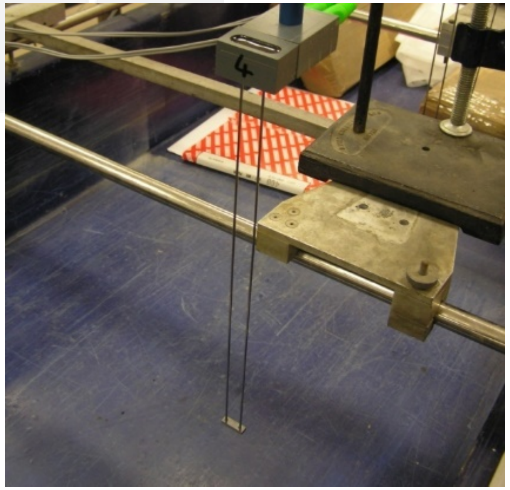
Models	Input	Description	Functions
TXDOT (1971)	Cross slope Macrotexture Rain intensity	1D empirical equations	$d = 3.38\times10^{-3}(\frac{1}{T})^{-0.11}L^{0.43}I^{0.59}(\frac{1}{S})^{0.42} - T$
PAVDRN (1997)	Cross slope Draining length Pavement Permeability Rain intensity	1D wave equations based on kinematic approximation conservation of mass and momentum	$WFT = (\frac{n\times L\times I}{36.1\times S_x^{0.5}}) - MTD$
TXDOT (2008)	Cross slope Draining length Longitudinal slope Rain intensity	2D wave equations based on Navier-Stokes equation	$\frac{\partial H}{\partial t} + \frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y} - r = 0$ $\frac{\partial q_x}{\partial t} + \frac{\partial}{\partial x}\left(\frac{q_x^2}{h}\right) + \frac{\partial}{\partial y}\left(\frac{q_x q_y}{h}\right) + gh\left(\frac{\partial h}{\partial x} + S_{fx} - S_{ex}\right) = 0$ $\frac{\partial q_y}{\partial t} + \frac{\partial}{\partial y}\left(\frac{q_y^2}{h}\right) + \frac{\partial}{\partial x}\left(\frac{q_x q_y}{h}\right) + gh\left(\frac{\partial h}{\partial y} + S_{fy} - S_{ey}\right) = 0$
NCHRP 15-55	Cross slope Draining length Longitudinal slope Macrotexture Pavement characteristics Rain intensity	3D full Navier-Stokes equations	$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u_x)}{\partial x} + \frac{\partial(\rho u_y)}{\partial y} + \frac{\partial(\rho u_z)}{\partial z} = 0$ $\frac{\partial(\rho u_x)}{\partial t} + \frac{\partial(\rho u_x^2)}{\partial x} + \frac{\partial(\rho u_x u_y)}{\partial y} + \frac{\partial(\rho u_x u_z)}{\partial z} + \frac{\partial P}{\partial x} + \rho g_x = \frac{\partial \bar{\bar{\tau}}_{xx}}{\partial x} + \frac{\partial \bar{\bar{\tau}}_{xy}}{\partial y} + \frac{\partial \bar{\bar{\tau}}_{xz}}{\partial z}$ $\frac{\partial(\rho u_y)}{\partial t} + \frac{\partial(\rho u_x u_y)}{\partial x} + \frac{\partial(\rho u_y^2)}{\partial y} + \frac{\partial(\rho u_y u_z)}{\partial z} + \frac{\partial P}{\partial y} + \rho g_y = \frac{\partial \bar{\bar{\tau}}_{xy}}{\partial x} + \frac{\partial \bar{\bar{\tau}}_{yy}}{\partial y} + \frac{\partial \bar{\bar{\tau}}_{yz}}{\partial z}$ $\frac{\partial(\rho u_z)}{\partial t} + \frac{\partial(\rho u_x u_z)}{\partial x} + \frac{\partial(\rho u_y u_z)}{\partial y} + \frac{\partial(\rho u_z^2)}{\partial z} + \frac{\partial P}{\partial z} + \rho g_z = \frac{\partial \bar{\tau}_{xz}}{\partial x} + \frac{\partial \bar{\bar{\tau}}_{yz}}{\partial y} + \frac{\partial \bar{\tau}_{zz}}{\partial z}$

Splash–Spray Assessment Tool Development Program Water Film Thickness Model

1. Lab Work

Material	Texture (mm)
Stone Mastic Asphalt	0.549
Asphaltic Concrete	0.633
Porous Asphalt	1.644
Tined Concrete	1.011
Smooth Concrete	0.208
Perspex	0.001





2. Generic Formula

$$d = k\,T^{w}(LI)^{y}S^{z}$$

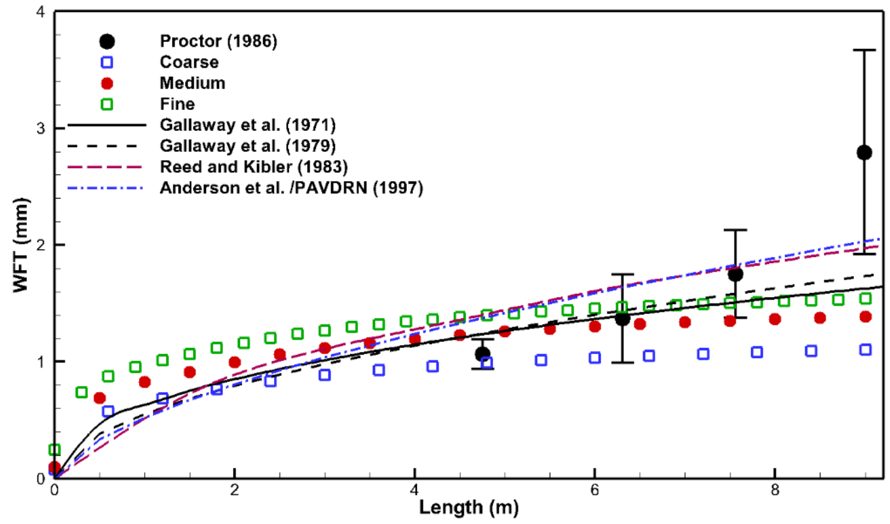
3. Calibrated Formula

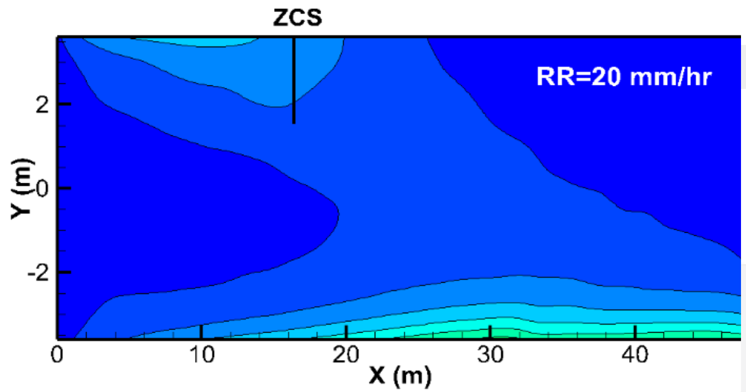
$$d = 6x10^{-4}\,T^{0.09}\,(LI)^{0.6}\,S^{-0.33}$$

d = Water depth (m)
T= texture (mm)
L = drainage length (m)
I = rainfall intensity (m/h)
S =slope
w, x, y, z, w, k = regression coefficients
(k incorporates Manning's coefficient)

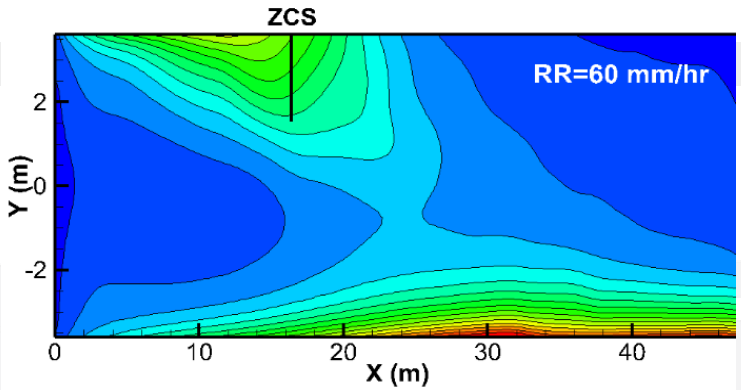
NCHRP 15-55 3D Water Accumulation Model

Validation work with Reed at al. (1989) and 1-D correlations.

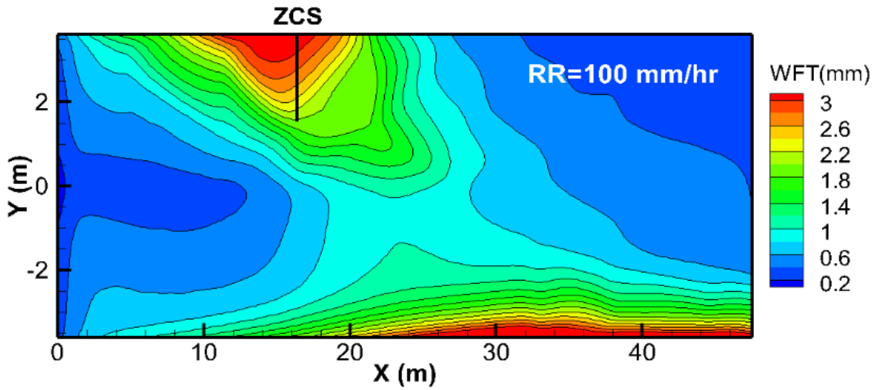




(a) Base case with 20 mm/h

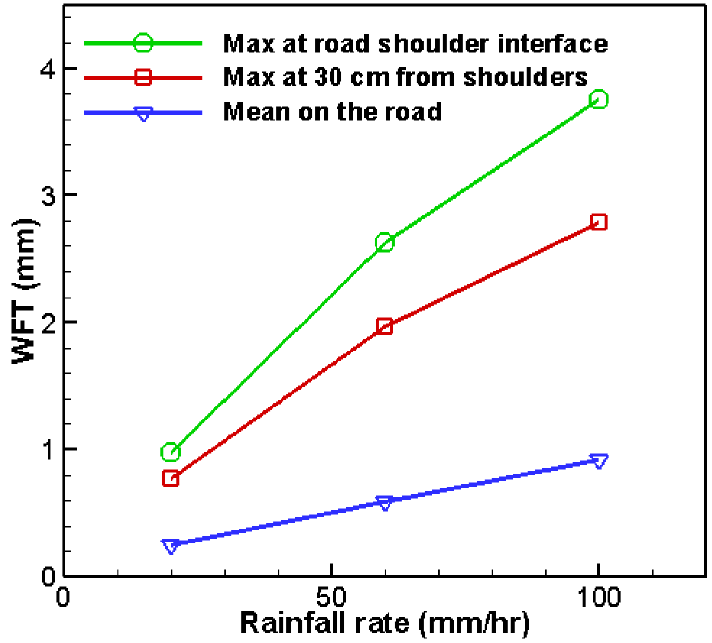


(b) Case 2 with 60 mm/h



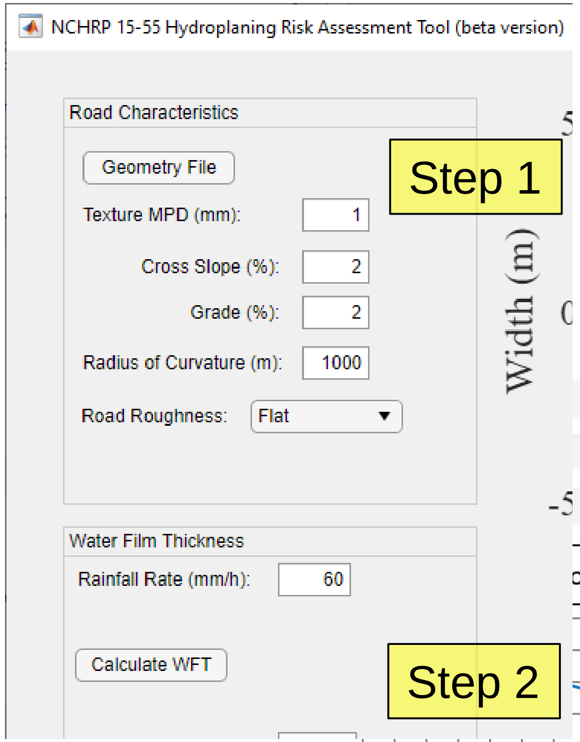
(c) Case 3 with 100 mm/h

WFT distribution on pavement with different rainfall rate

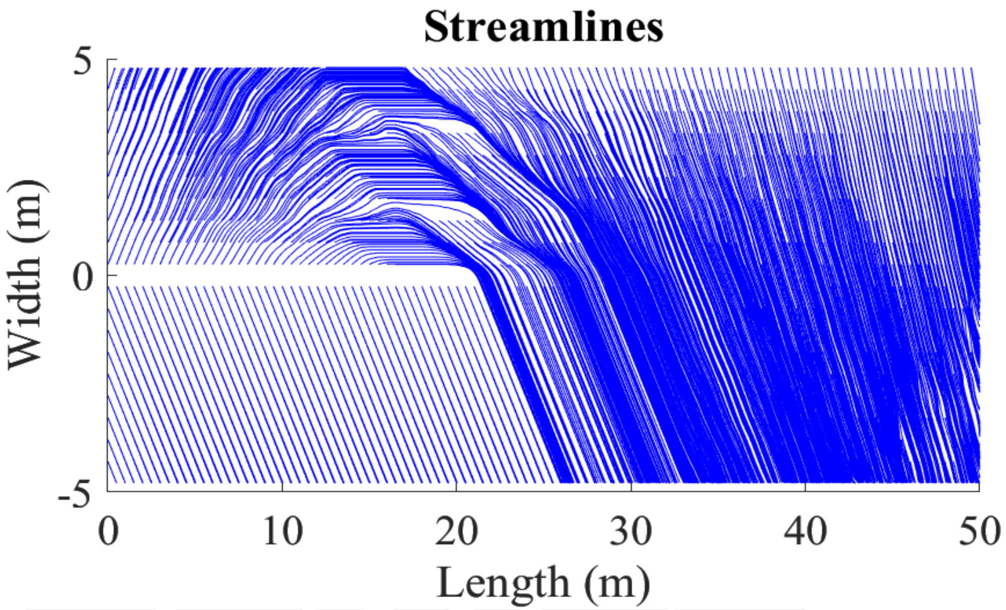


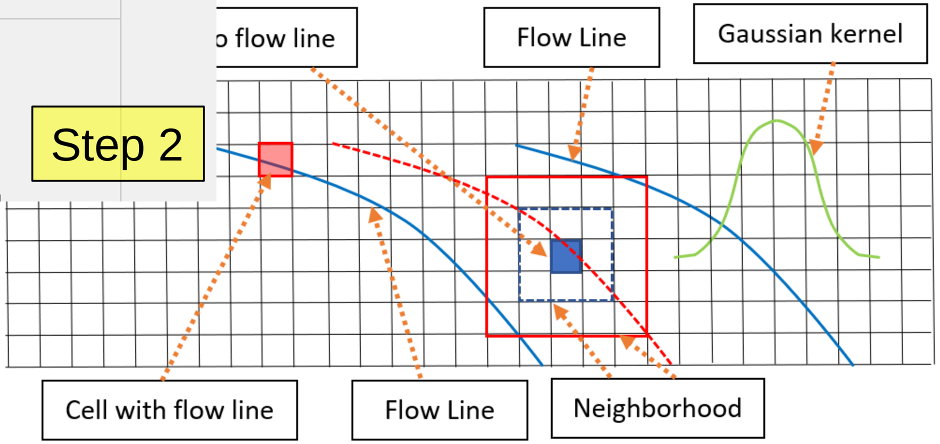
INSTITUTE

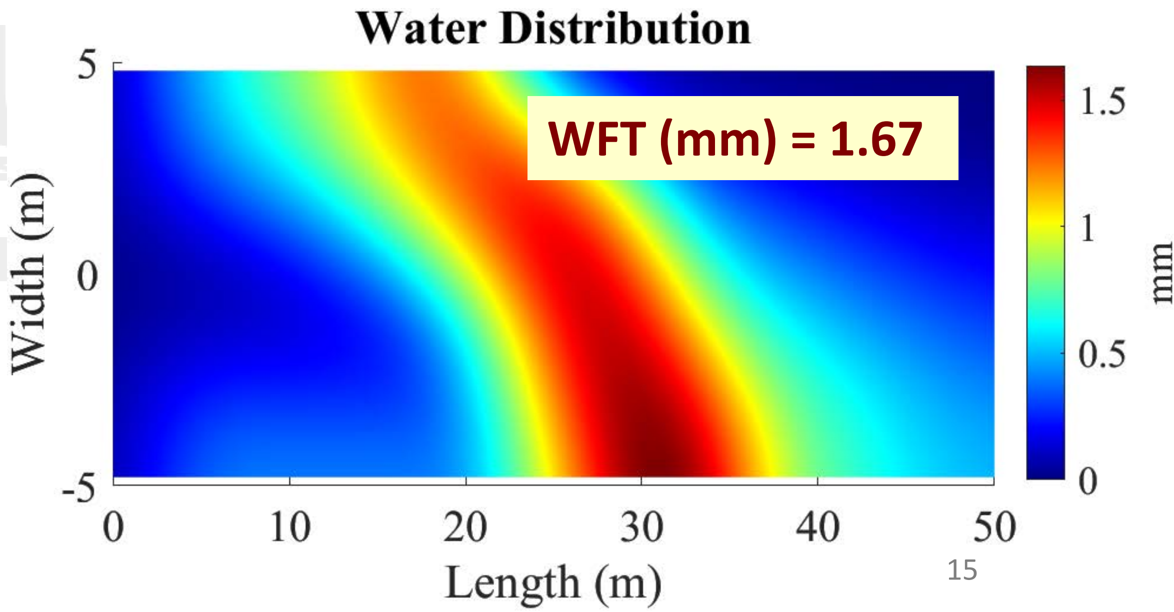
NCHRP 15-55 Hydroplaning Risk Assessment Tool Simplified Water Model



- ✓ Modified Gallaway Equation
- ✓ Gaussian Kernel Smoothing







Recent FHWA / USDoE / Argonne Reports

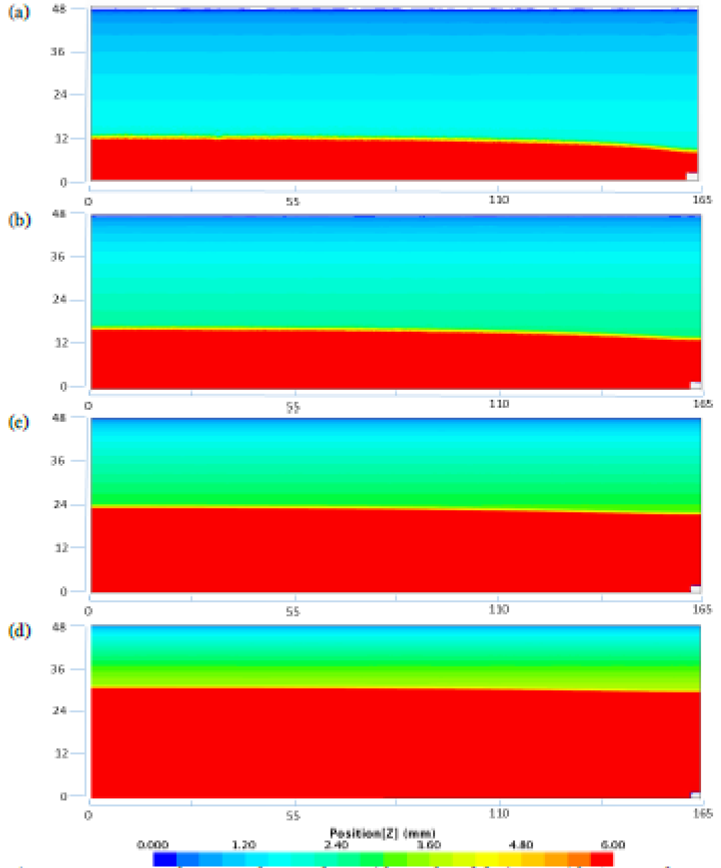
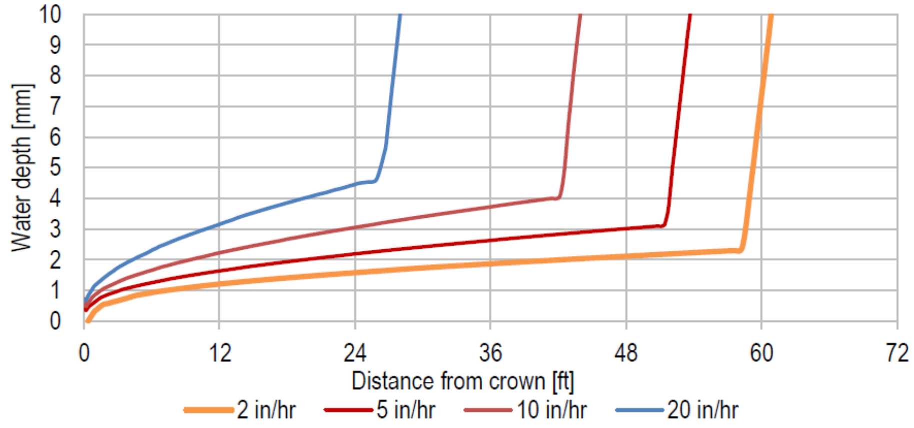


Figure 5-13: Water surface on a 4 lane roadway with a curb and drainage, with 1% cross slope, no longitudinal slope, and at rain intensity (a) 2 in/hr, (b) 5 in/hr, (c) 10 in/hr, and (d) 20 in/hr (curb overflow). The length scale of the computational domain is in feet.



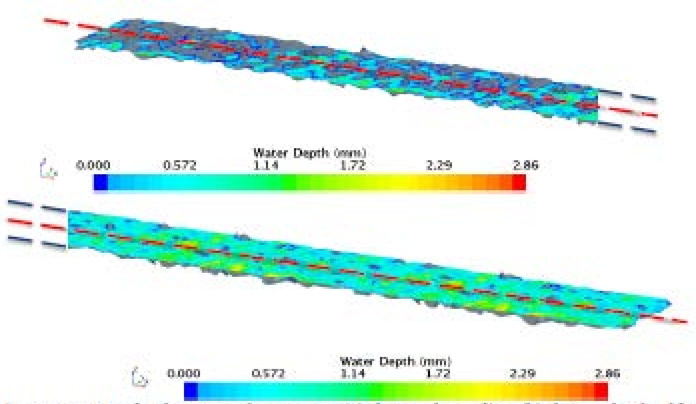
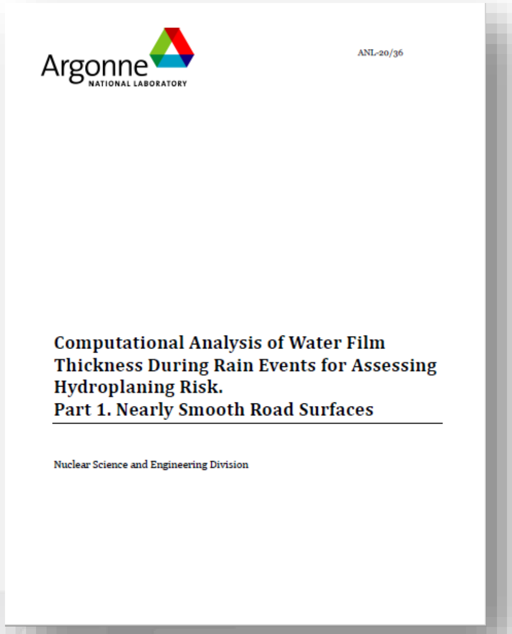


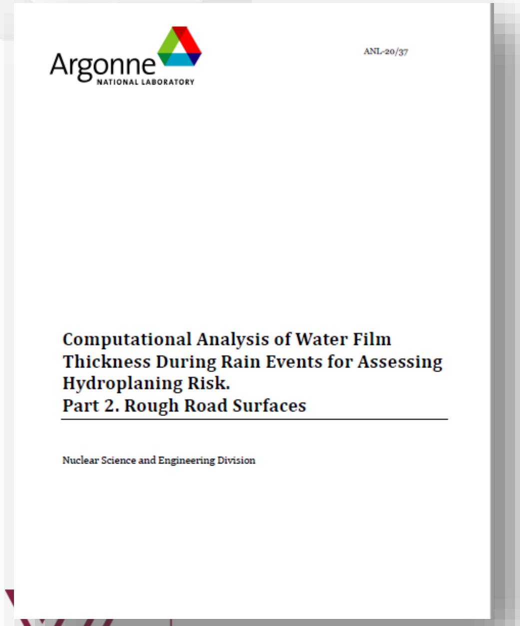
Figure 5-3: Water depth on a rough pavement, (a) close to the median, (b) close to the shoulder. Rainfall intensity 2 in/hr, slope 2%.


Argonne NATIONAL LABORATORY

ANL-20/36

Computational Analysis of Water Film Thickness During Rain Events for Assessing Hydroplaning Risk.
Part 1. Nearly Smooth Road Surfaces

Nuclear Science and Engineering Division


Argonne NATIONAL LABORATORY

ANL-20/37

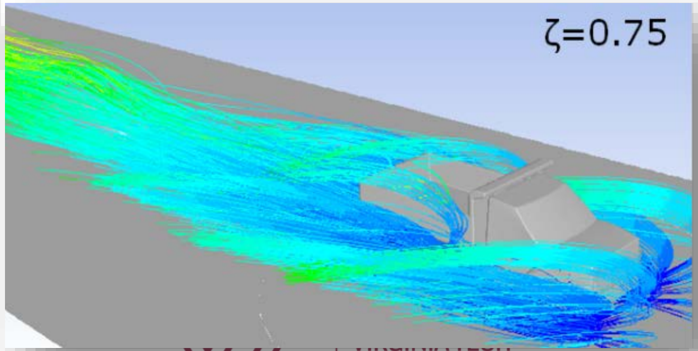
Computational Analysis of Water Film Thickness During Rain Events for Assessing Hydroplaning Risk.
Part 2. Rough Road Surfaces

Nuclear Science and Engineering Division

3. Splash and Spray

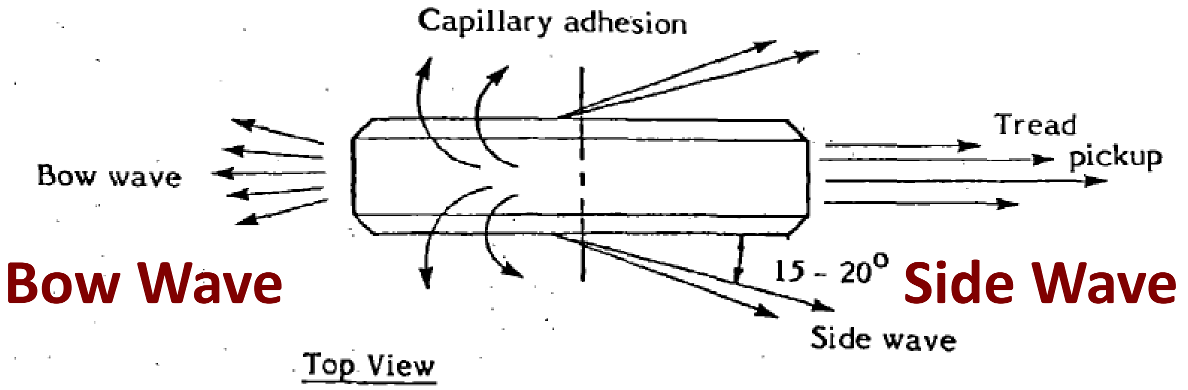
Splash & Spray

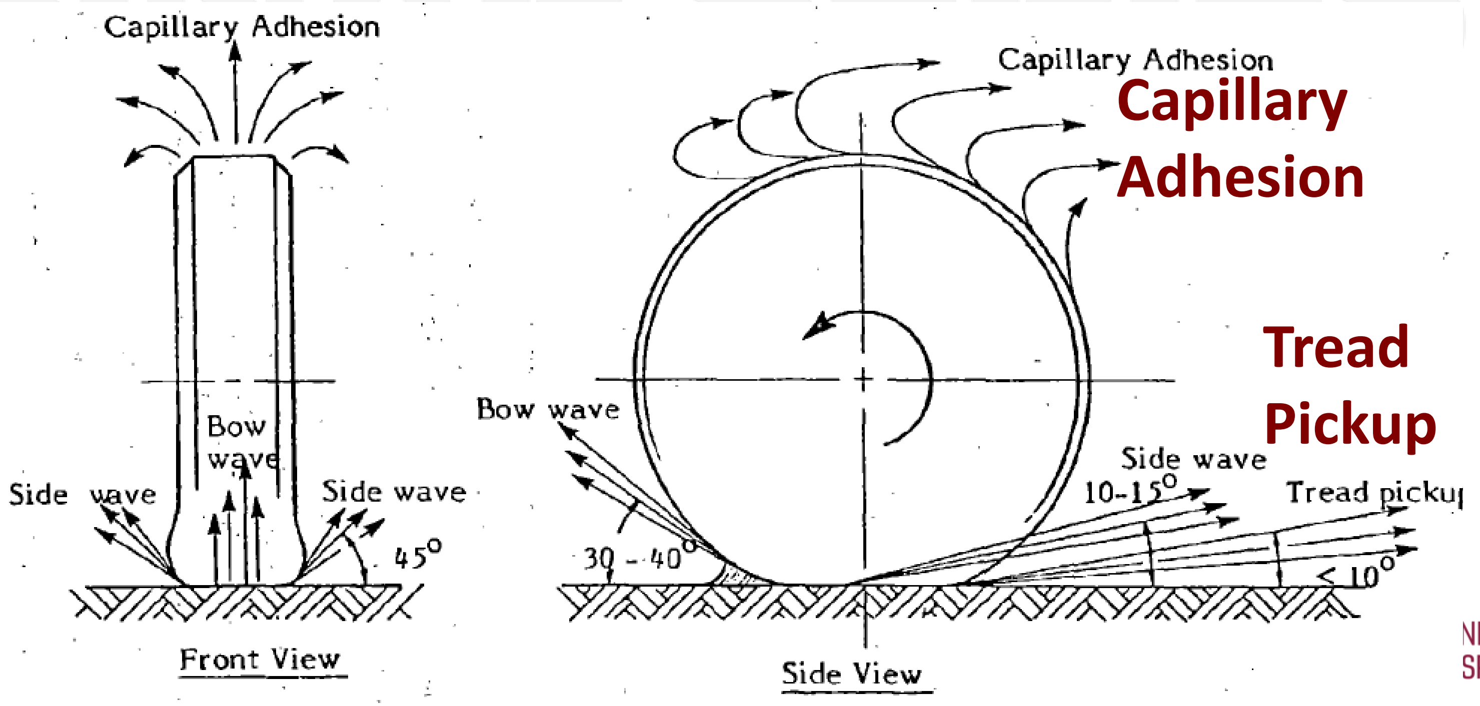
- ✓ Splash: "the mechanical action of a vehicle's tire forcing water out of its path. Splash is generally defined as water drops greater than 1.0 mm (0.04 inches) in diameter, which follow a ballistic path away from the tire."
- ✓ Spray: being formed "when water droplets, generally less than 0.5 mm (0.02 inches) in diameter and suspended in the air, are formed after water has impacted a smooth surface and been atomized."



Splash & Spray (cont.)

Weir, D. H., Strange, J. F., & Heffley, R. K. (1978). *Reduction of Adverse Aerodynamic Effects of Large Trucks - FHWA-RD-79-84.* Washington, D.C.: FHWA.





Factors affecting Splash and Spray

- Surface Geometry
  - Gradient
  - Cross-slope
  - Number and with of the lanes
- Pavement Macrotexture
- Surface Type
  - Permeable vs non-permeable
- Location or Rain Intensity
  - Intensity
  - Rain duration
- Tire
  - Width
  - Tread grooved proportion
  - Tread depth
- Speed

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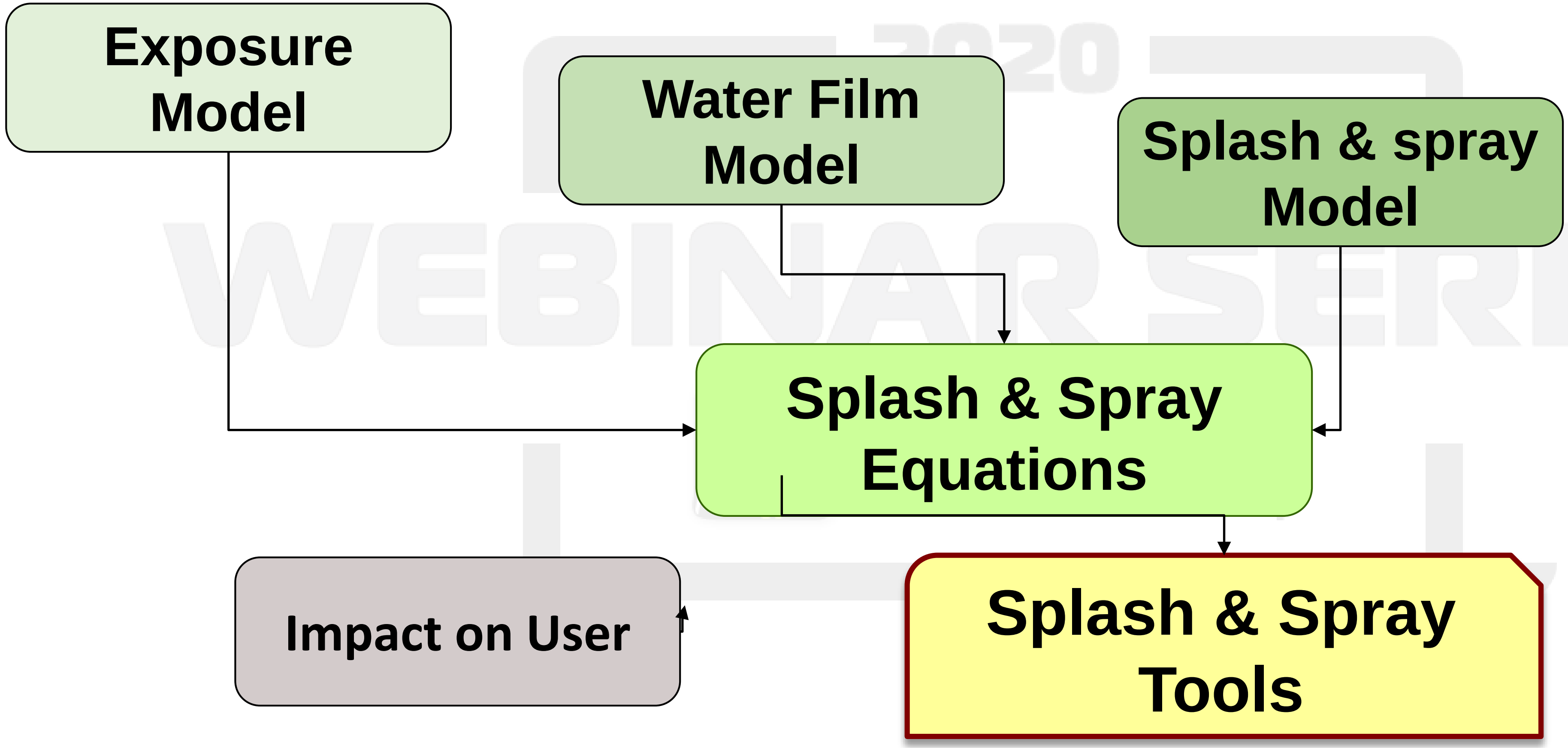
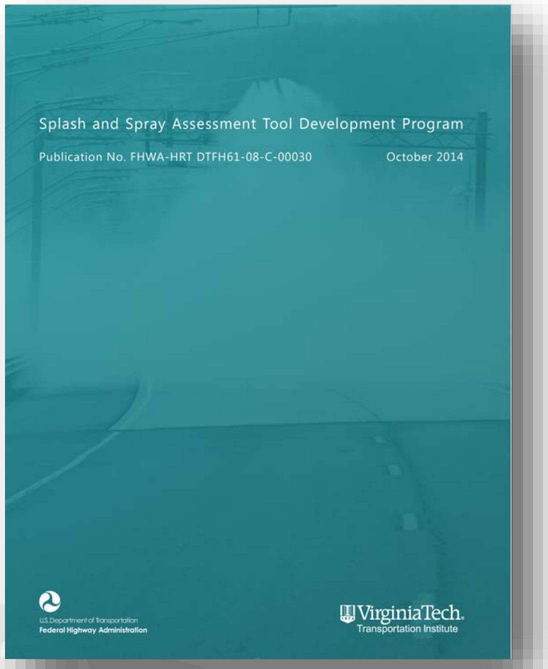
Splash–Spray Assessment Tool Development Program

FHWA DTFH61-08-R-00029





Flintsch, G.W., Tang, L., Katicha, S.W., de León, E., Viner, H., Dunford, A., Nesnas, K., Coyle, F., Sanders, P., Gibbons, R., Williams, B., Hargreaves D., Parry, T., McGhee, K., Larson, R.M., and Smith K. (2014), *Splash and Spray Assessment Tool Development Program,* Final Report, 2014, DTFH61-08-C-00030.

https://vtechworks.lib.vt.edu/handle/10919/50550

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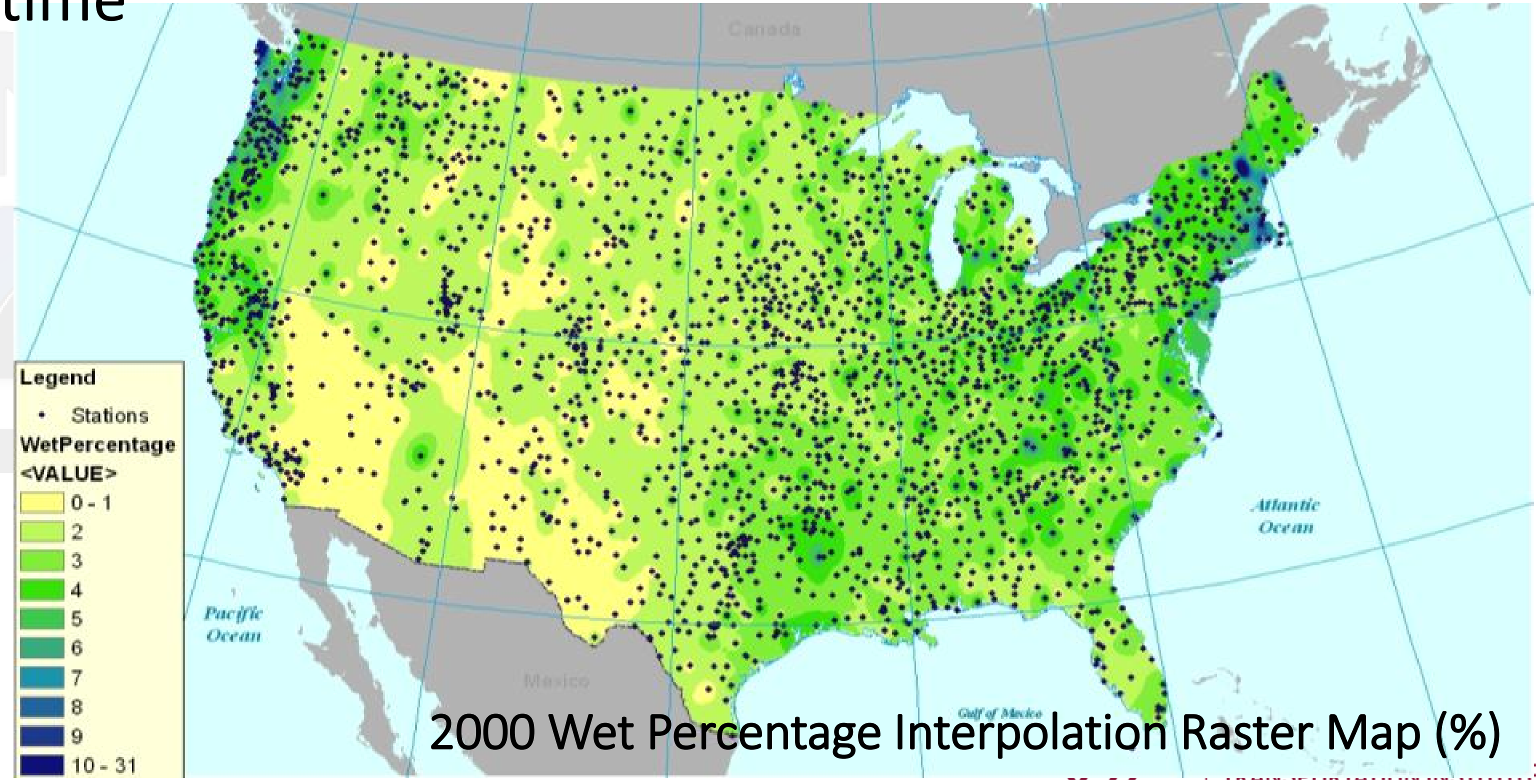
Exposure Model

✓ Builds on CalTrans project (Huang et al. 2008) which updated the California Wet Percentage Time tables.

- Wet hours (for different thicknesses)
- Wet exposure = percentage time



2000 Wet Percentage Interpolation Raster Map (%)

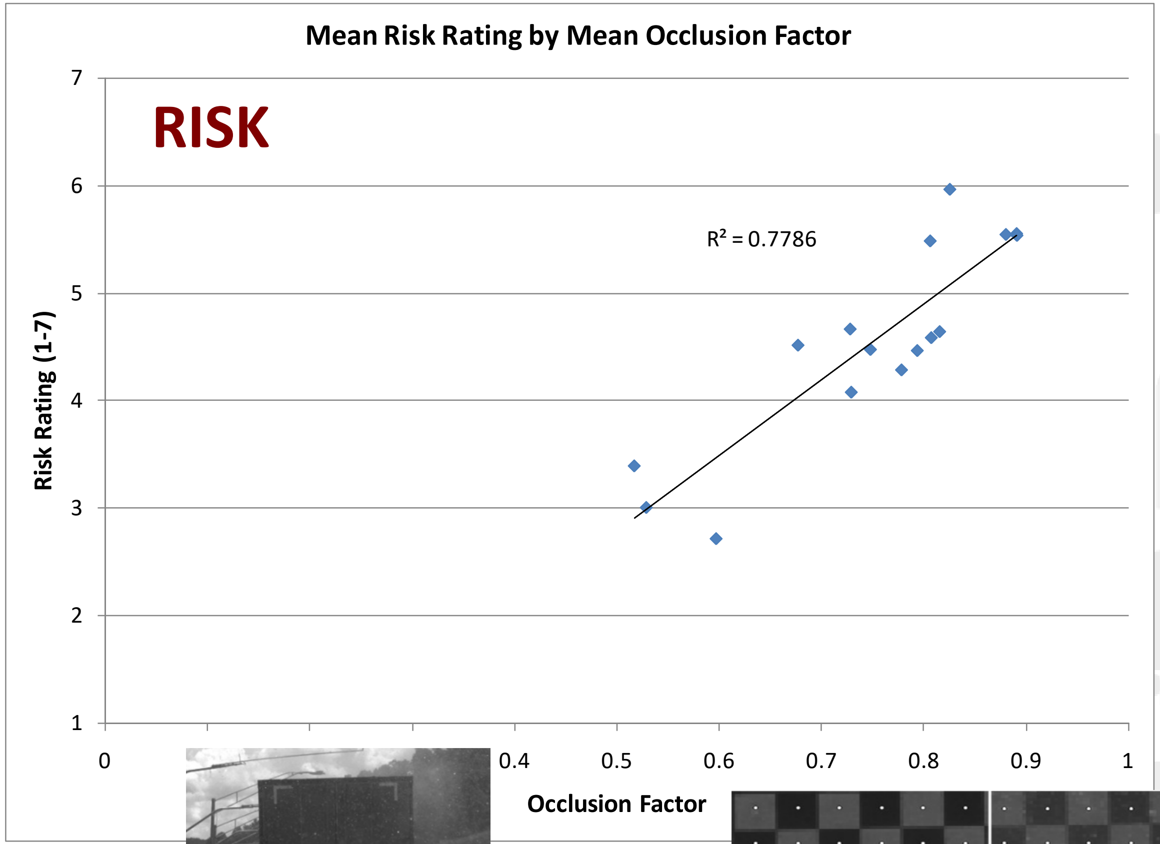
Tang, L., Flintsch, G.W., and Viner, H., (2012) "Exposure Model For Predicting Splash and Spray," *Proceedings of the 7th Symposium on Pavement Surface Characteristics* (SURF 2012), Sep. 18-21, 2013, Norfolk, VA.

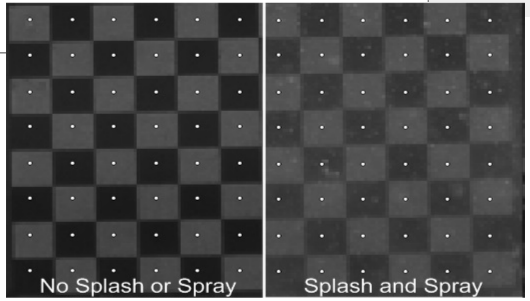
User Impact

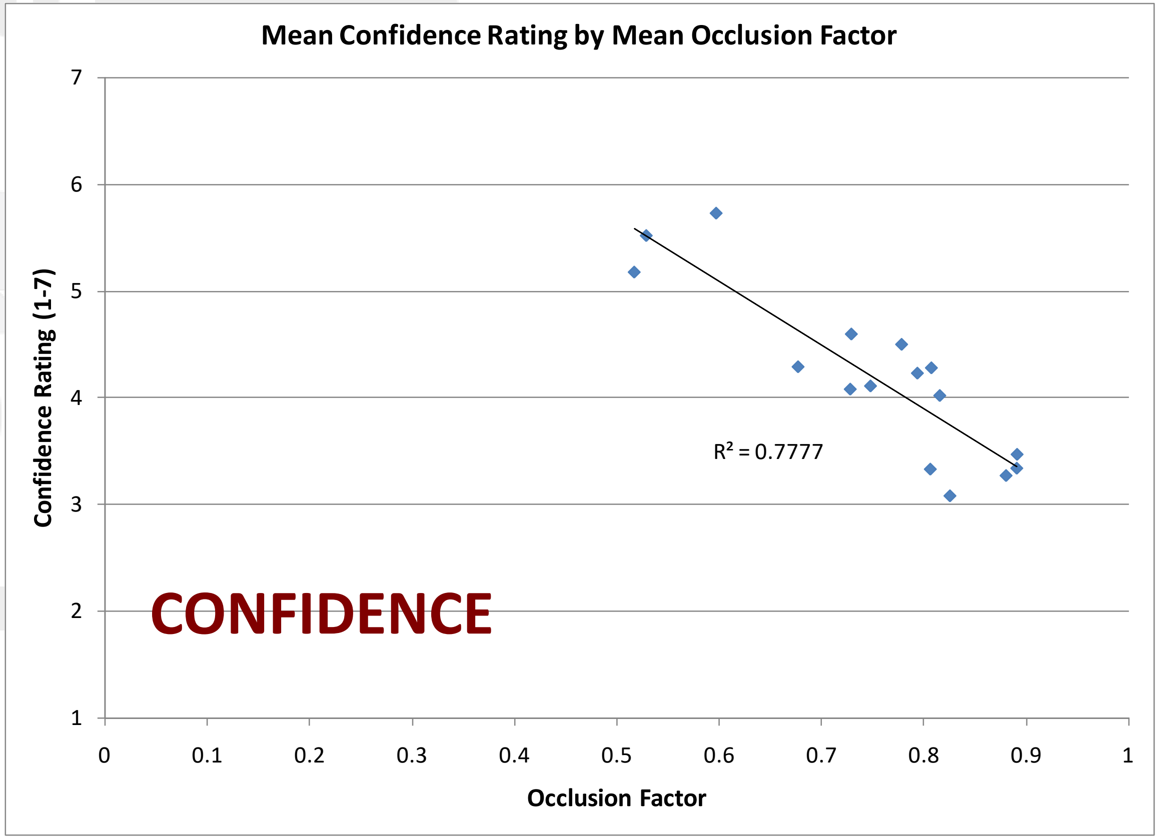
- ✓ Test under to a range of different controlled conditions
- ✓ Measure of splash and spray: **Occlusion Factor**
- ✓ Correlates with user responses (subjective ratings of obstruction, concentration, and risk and lower ratings for confidence and control)

Occlusion Factor = ratio of the mean luminance of the black squares to the mean luminance of the white squares

Occlusion Factor- Correlation with User Perceptions







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Splash and Spray Model

CDF Simulation

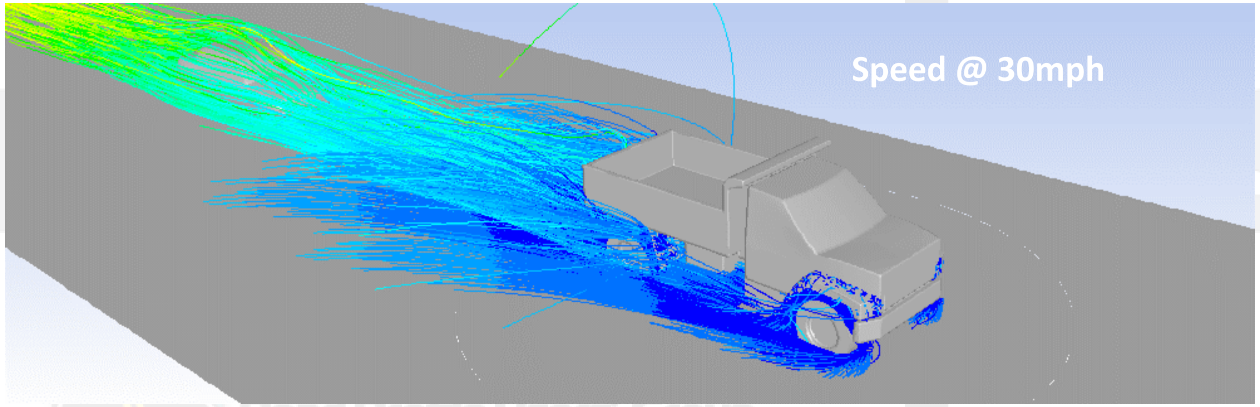
→Capillary Adhesion + Tread Pickups

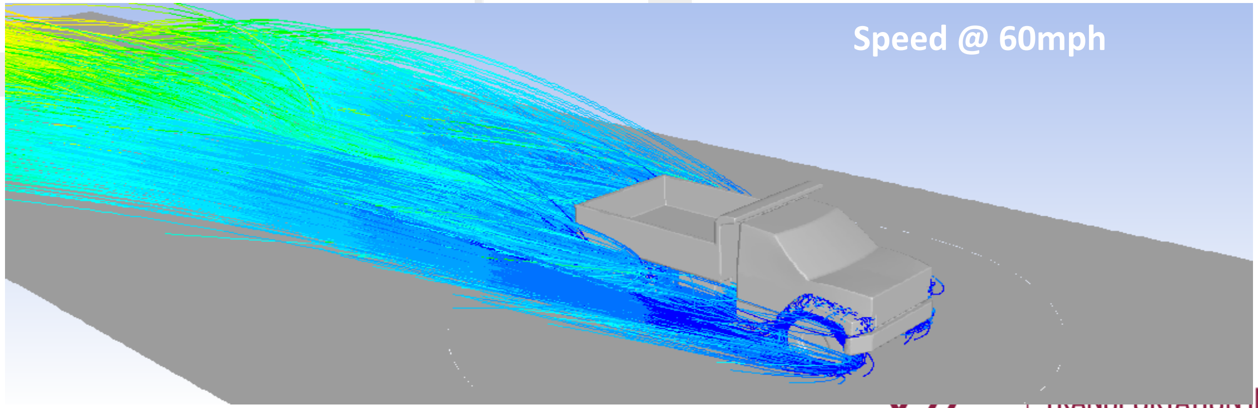
+ Bow wave

+ Side Wave

→Combined

→Used results to build the model





Splash–Spray Assessment Tool Development Program Products

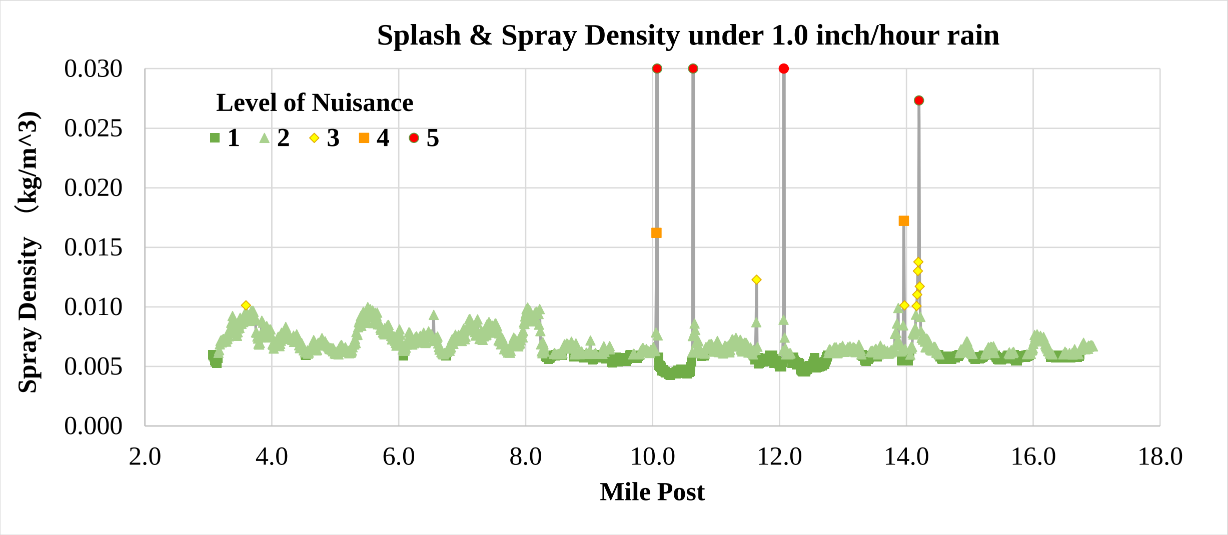
FHWA DTFH61-08-R-00029

1. Splash and Spray Assessment Tool Development Program Final Report

2. TechBrief: *Assessing Pavement Surface Splash and Spray Impact on Road Users*, FHWA-HRT-15-062

www.fhwa.dot.gov/pavement/pub_details.cfm?id=964

3. Splash and Spray Assessment Tool



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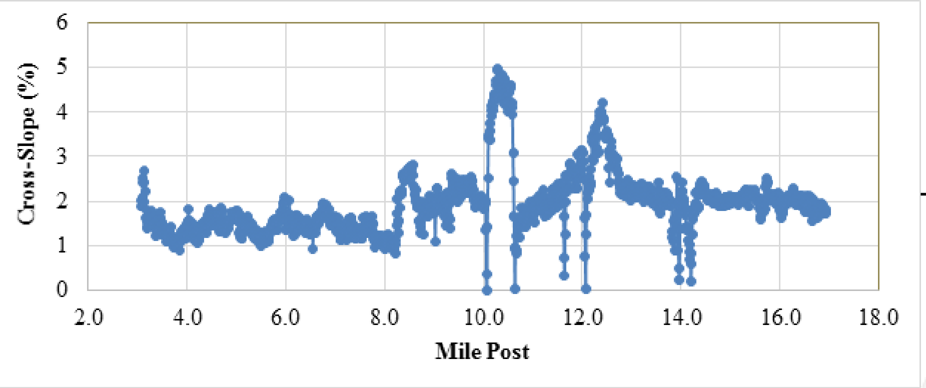
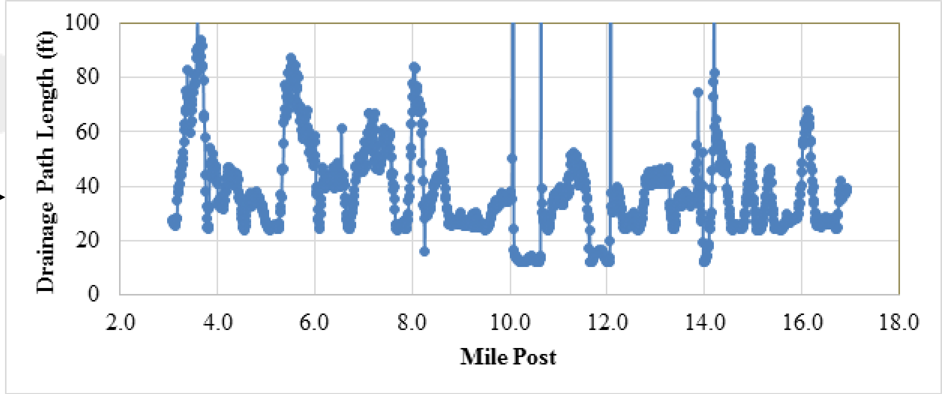
Spreadsheet Tool

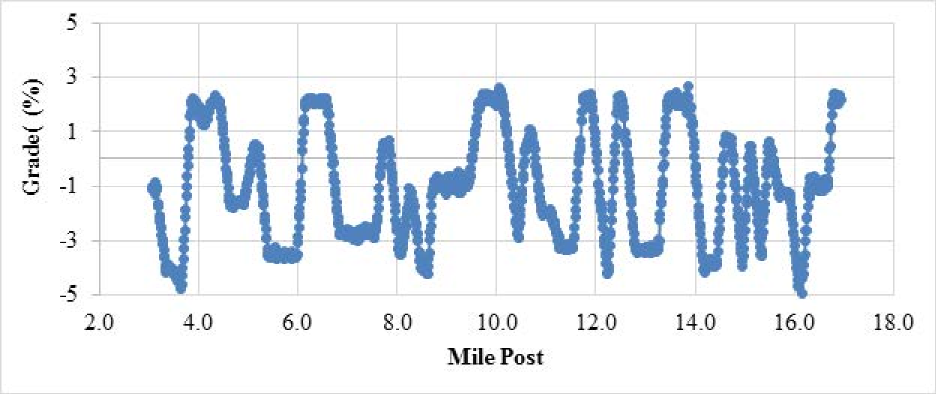
Pavement surface cross slope



Calculated drainage path

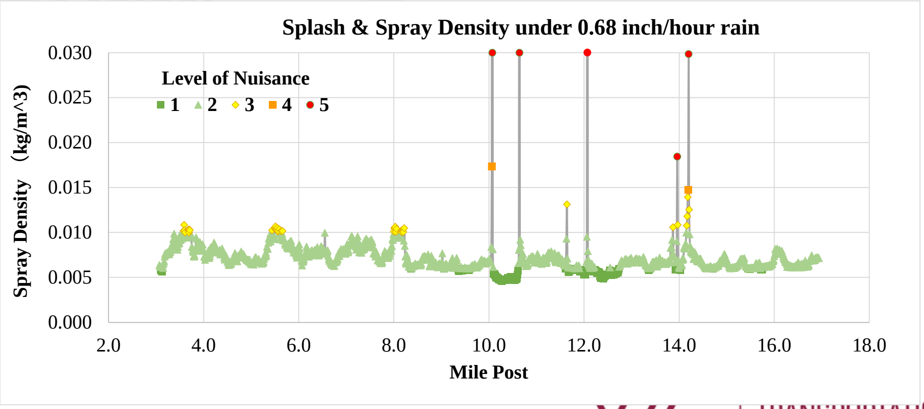


Longitudinal grade



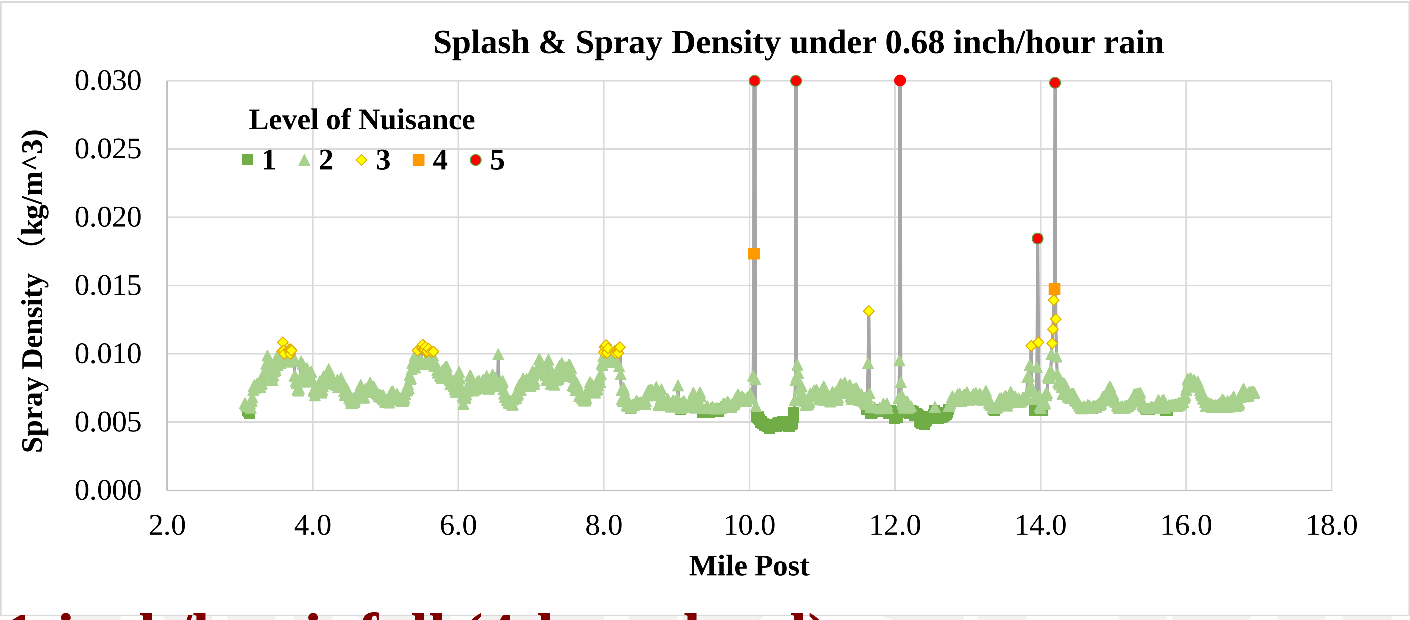
Precipitation

Spray Density

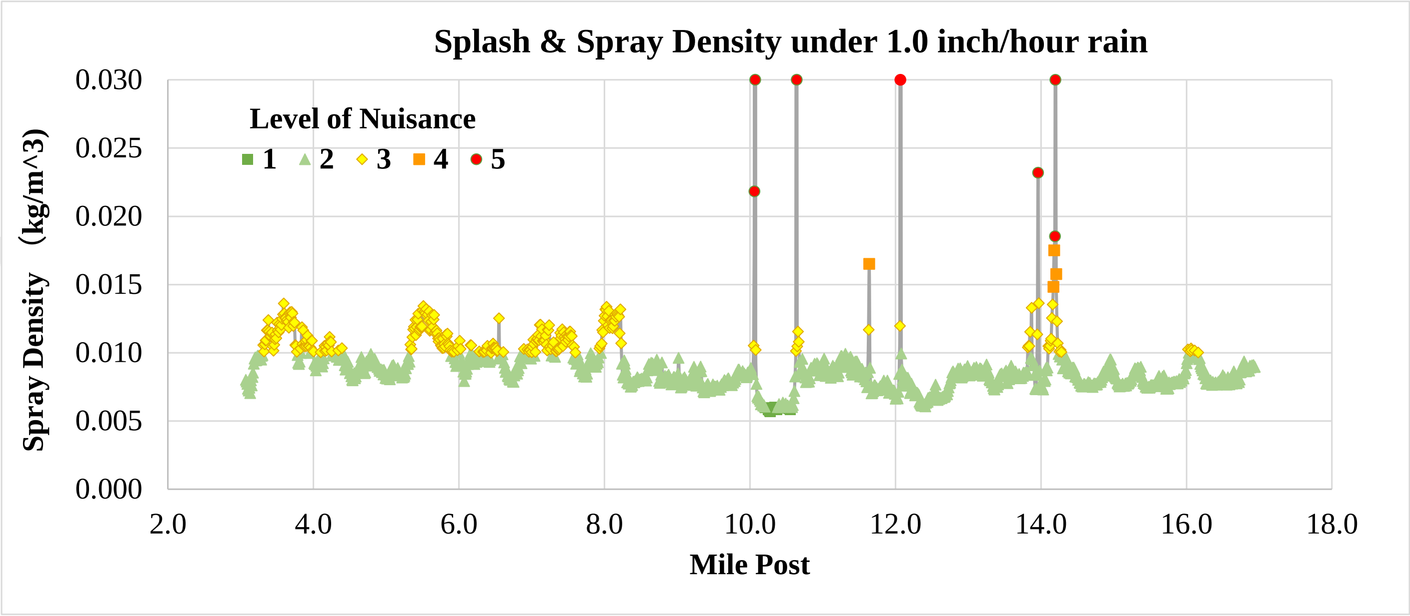


Example

0.68-inch/h rainfall (10-hour level) non-porous pavement



1-inch/h rainfall (4-hour level) non-porous pavement



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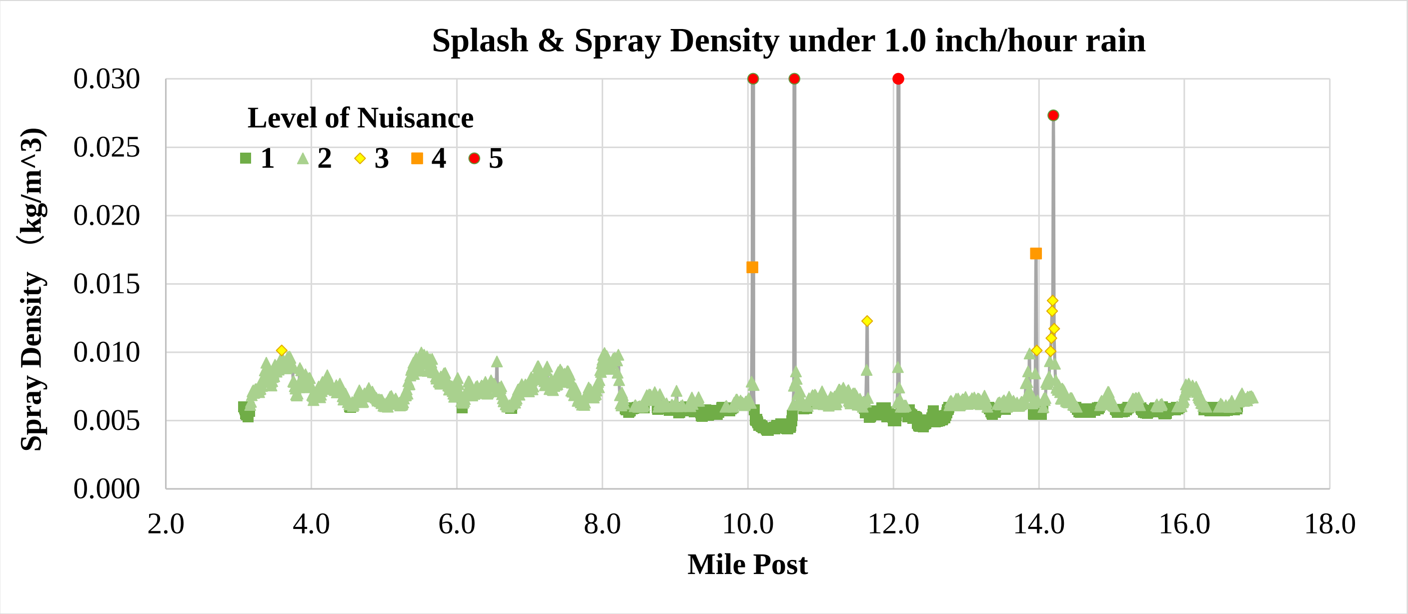
Case Study (cont.)

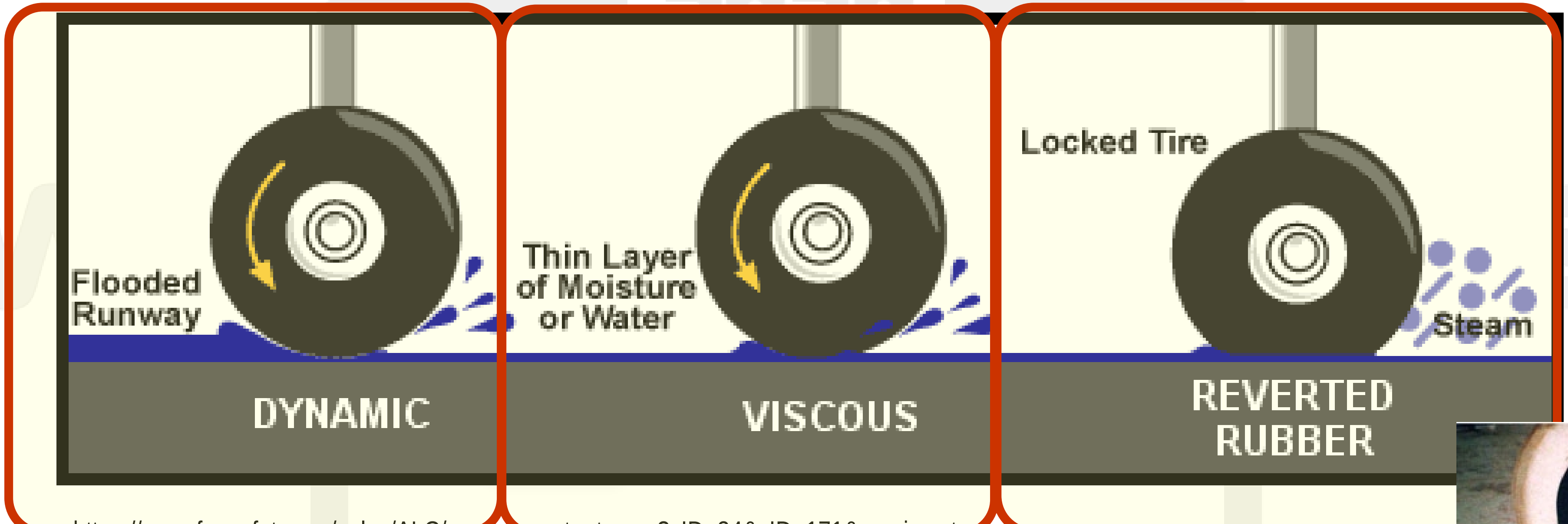
1-inch/h rainfall (4-hour level) porous pavement



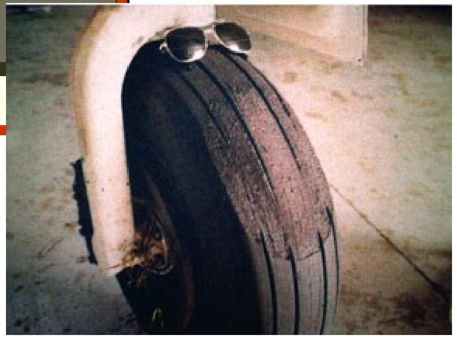
4. Hydroplaning

http://auto.howstuffworks.com/car-driving-safety/accidents-hazardous-conditions/hydroplaning.htm

Hydroplaning



https://www.faasafety.gov/gslac/ALC/course_content.aspx?cID=34&sID=171&preview=true



Traditional Hydroplaning Models: Hydroplaning Speed Prediction

- ✓ NASA:

$$v_p = 51.80 - 17.15(FAR) + 0.72p$$

$$v_p = 7.95\sqrt{p(FAR)^{-1}}$$

- ✓ TXDOT:

$$v_p = SD^{0.04} p^{0.3} (TD + 1)^{0.06} A$$

$$A = \max\left(3.507 + \frac{10.409}{WFT^{0.06}}, \left[\frac{28.952}{WFT^{0.06}} - 7.817\right] T^{0.14}\right)$$

- ✓ PAVDRN:

$$v_p = 26.04 WFT^{-0.259}$$

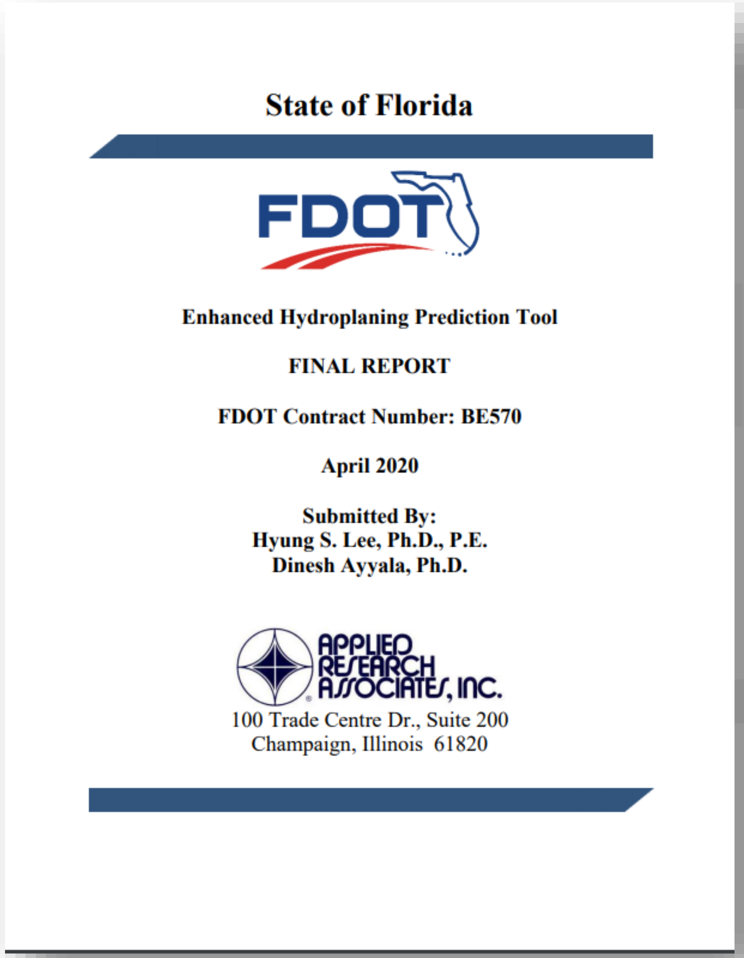
- ✓ USF:

$$v_p = WL^{0.2} p^{0.5} \left(\frac{0.82}{WFT^{0.06}} + 0.49\right)$$

Factors affecting Hydroplaning

- Roadway and Pavement
  - Pavement micro- and macrotexture
  - Cross-slope (including superelevation)
  - Longitudinal grade
  - Pavement width (number of lanes)
  - Roadway curvature
  - Rut depth
  - Depressions
- Environmental conditions
  - Rainfall intensity
  - Rainfall duration
  - Temperature
- Driver behavior
  - Speed
  - Acceleration or baking
  - Steering maneuver
- Vehicle conditions
  - Vehicle type
  - Vehicle (or axle) weight
  - Tire tread wear (tread depth)
  - Tire pressure
  - Tire tread design

Florida DOT Hydroplaning Tool



State of Florida

Enhanced Hydroplaning Prediction Tool

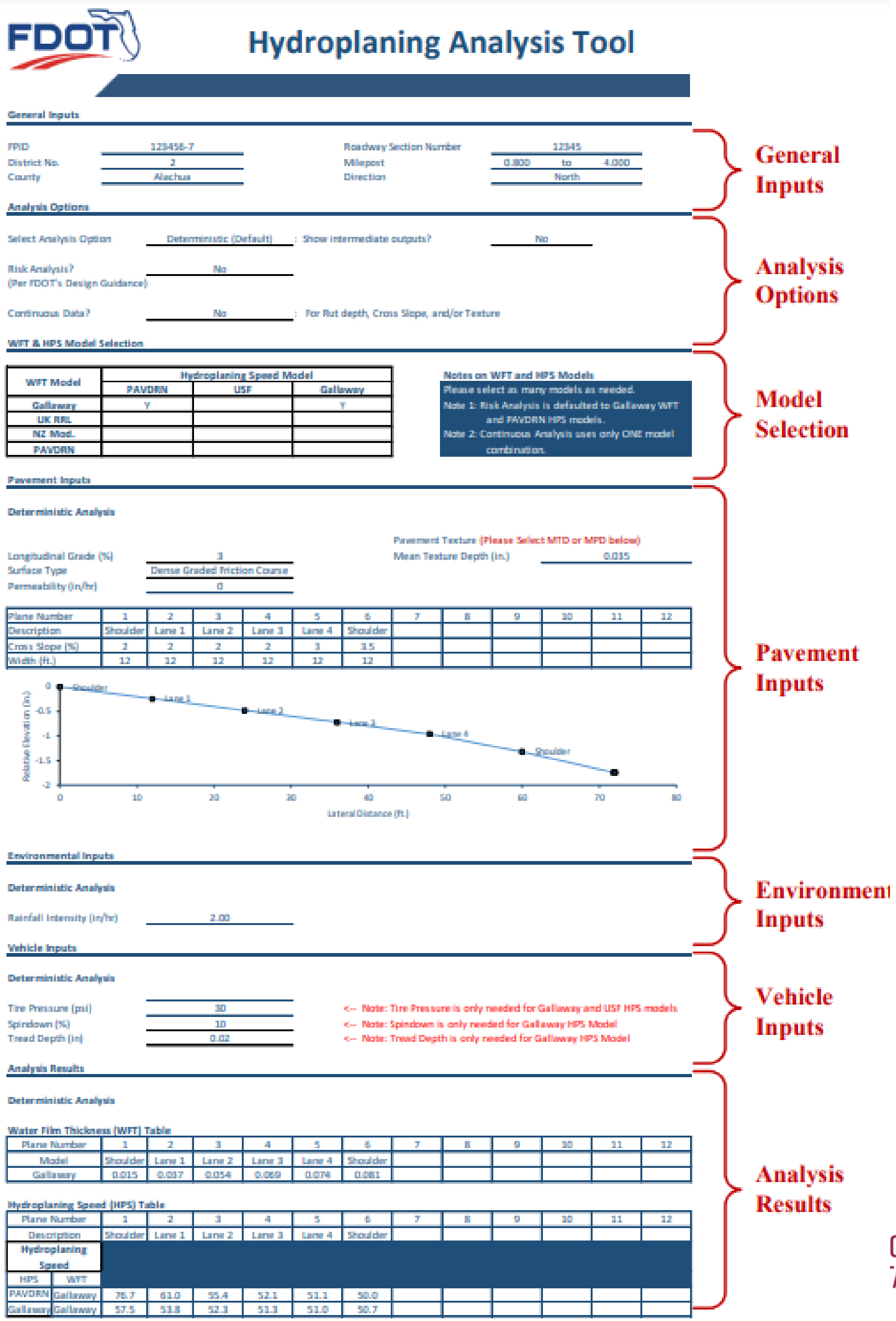
FINAL REPORT

FDOT Contract Number: BE570

April 2020

Submitted By:
Hyung S. Lee, Ph.D., P.E.
Dinesh Ayyala, Ph.D.

APPLIED RESEARCH ASSOCIATES, INC.
100 Trade Centre Dr., Suite 200
Champaign, Illinois 61820



Hydroplaning Analysis Tool

General Inputs

FPID: 123456-7
District No.: 2
County: Alachua
Roadway Section Number: 12345
Milepost: 0.800 to 4.000
Direction: North

Analysis Options

Select Analysis Option: Deterministic (Default) : Show intermediate outputs? No

Risk Analysis? (Per FDOT's Design Guidance): No

Continuous Data?: No : For Rut depth, Cross Slope, and/or Texture

WFT & HPS Model Selection

WFT Model	Hydroplaning Speed Model		
	PAVDRN	USF	Gallaway
Gallaway	Y		Y
UK RRL			
NZ Mod.			
PAVDRN			

Notes on WFT and HPS Models
Please select as many models as needed.
Note 1: Risk Analysis is defaulted to Gallaway WFT and PAVDRN HPS models.
Note 2: Continuous Analysis uses only ONE model combination.

Pavement Inputs

Deterministic Analysis

Longitudinal Grade (%): 3
Surface Type: Dense Graded Friction Course
Permeability (in/hr): 0

Pavement Texture (Please Select MTD or MPD below)
Mean Texture Depth (in.): 0.035

Plane Number	1	2	3	4	5	6	7	8	9	10	11	12
Description	Shoulder	Lane 1	Lane 2	Lane 3	Lane 4	Shoulder						
Cross Slope (%)	2	2	2	2	3	3.5						
Width (ft.)	12	12	12	12	12	12						

Environmental Inputs

Deterministic Analysis

Rainfall Intensity (in/hr): 2.00

Vehicle Inputs

Deterministic Analysis

Tire Pressure (psi): 30 <-- Note: Tire Pressure is only needed for Gallaway and USF HPS models
Spindown (%): 10 <-- Note: Spindown is only needed for Gallaway HPS Model
Tread Depth (in): 0.02 <-- Note: Tread Depth is only needed for Gallaway HPS Model

Analysis Results

Deterministic Analysis

Water Film Thickness (WFT) Table

Plane Number	1	2	3	4	5	6	7	8	9	10	11	12
Model	Shoulder	Lane 1	Lane 2	Lane 3	Lane 4	Shoulder						
Gallaway	0.015	0.037	0.054	0.069	0.074	0.081						

Hydroplaning Speed (HPS) Table

Plane Number		1	2	3	4	5	6	7	8	9	10	11	12
Description		Shoulder	Lane 1	Lane 2	Lane 3	Lane 4	Shoulder						
Hydroplaning Speed													
HPS	WFT												
PAVDRN	Gallaway	76.7	61.0	55.4	52.1	51.1	50.0						
Gallaway	Gallaway	57.5	53.8	52.3	51.3	51.0	50.7						

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ATION INSTITUTE

Florida DOT Hydroplaning Tool (cont.)

WFT & HPS Model Selection

WFT Model	Hydroplaning Speed Model		
	PAVDRN	USF	Gallaway
Gallaway		Y	
UK RRL			
NZ Mod.		Y	
PAVDRN			Y

Notes on WFT and HPS Models

Please select as many models as needed.

Note 1: Risk Analysis is defaulted to Gallaway WFT and PAVDRN HPS models.

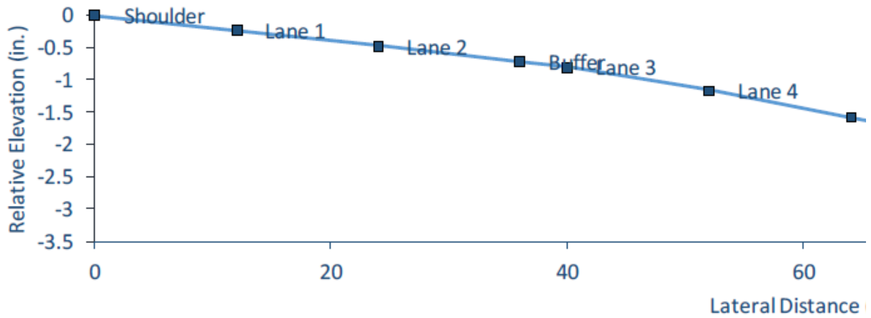
Note 2: Continuous Analysis uses only ONE model combination.

Pavement Inputs

Deterministic Analysis

Longitudinal Grade (%)	3
Surface Type	Open Graded Friction Course
Permeability (in/hr)	0

Plane Number	1	2	3	4	5	6
Description	Shoulder	Lane 1	Lane 2	Buffer	Lane 3	Lane 4
Cross Slope (%)	2	2	2	2	3	3.5
Width (ft.)	12	12	12	4	12	12



Water Film Thickness (WFT) Table (Units: in.)

Gallaway WFT

Plane Number	1	2	3	4	5	6				10	11	12
Model	Shoulder	Lane 1	Lane 2	Buffer	Lane 3	Lane 4						
Gallaway	-0.002	0.026	0.048	0.054	0.060	0.068	0.078	0.087	0.074			
UK RRL	-0.003	0.024	0.045	0.051	0.060	0.068	0.078	0.087	0.083			
NZ Mod.	-0.010	0.010	0.025	0.029	0.031	0.035	0.041	0.047	0.034			
PAVDRN	-0.013	0.000	0.008	0.011	0.012	0.014	0.020	0.024	0.017			

Hydroplaning Speed (HPS) Table (Units: mph)

PAVDRN HPS using Gallaway WFT

Plane Number		1	2	3	4	5	6	7	8	9	10	11	12
Description		Shoulder	Lane 1	Lane 2	Buffer	Lane 3	Lane 4	Gore	Ramp	Shoulder			
A Parameter													
WFT	Gallaway	0.00	19.34	18.45	18.27	18.11	17.96	17.76	17.60	17.82			
	UK RRL	0.00	19.44	18.54	18.36	18.13	17.95	17.76	17.60	17.67			
	NZ Mod.	0.00	20.79	19.41	19.17	19.07	18.91	18.67	18.47	18.93			
	PAVDRN	0.00	0.00	21.04	20.65	20.50	20.27	19.69	19.45	20.00			
Hydroplaning Speed													
HPS	WFT												
PAVDRN	Gallaway	999.0	67.1	57.3	55.4	53.9	52.3	50.5	49.0	51.1			
	UK RRL	999.0	68.3	58.3	56.4	54.1	52.2	50.4	49.0	49.6			
	NZ Mod.	999.0	85.8	67.9	65.2	64.0	62.2	59.6	57.5	62.4			
	PAVDRN	999.0	999.0	89.5	83.9	81.8	78.7	71.3	68.5	75.2			
USF	Gallaway	999.0	54.9	53.7	53.4	53.2	53.0	52.7	52.5	52.8			
	UK RRL	999.0	55.1	53.8	53.6	53.2	53.0	52.7	52.5	52.6			
	NZ Mod.	999.0	57.0	55.0	54.7	54.5	54.3	54.0	53.7	54.3			
	PAVDRN	999.0	999.0	57.3	56.8	56.6	56.2	55.4	55.1	55.9			
Gallaway	Gallaway	999.0	60.6	57.8	57.2	56.8	56.3	55.7	55.2	55.9			
	UK RRL	999.0	60.9	58.1	57.5	56.8	56.2	55.6	55.2	55.4			
	NZ Mod.	999.0	65.1	60.8	60.1	59.7	59.3	58.5	57.9	59.3			
	PAVDRN	999.0	999.0	65.9	64.7	64.2	63.5	61.7	61.0	62.7			

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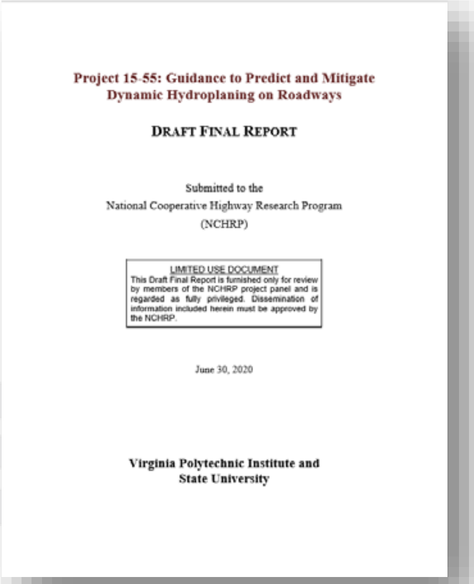
TRANSPORTATION RESEARCH BOARD

NCHRP 15-55: Guidance to Predict and Mitigate Dynamic Hydroplaning on Roadways

- ✓ Objective: To develop a comprehensive hydroplaning risk assessment tool that can be used by transportation agencies to help reduce the potential of hydroplaning.
  - Treating hydroplaning as a multidisciplinary and multi-scale problem
  - Solutions for areas with a high potential of hydroplaning based on a fundamental and meaningful understanding of the problem.


Project 15-55: Guidance to Predict and Mitigate Dynamic Hydroplaning on Roadways

DRAFT FINAL REPORT

Submitted to the
National Cooperative Highway Research Program
(NCHRP)

LIMITED USE DOCUMENT
This Draft Final Report is furnished only for review by members of the NCHRP project panel and is regarded as fully privileged. Dissemination of information included herein must be approved by the NCHRP.

June 30, 2020

Virginia Polytechnic Institute and State University

Flintsch, G.W., Ferris, J.B., Battaglia, F., Taheri, S., Katicha, S., Chen, L., Kang, Y., Nazari, A., de Leon Izeppi, E., Velez, K., Kibler, D., McGhee, K.K., Project 15-55: Guidance to Predict and Mitigate Dynamic Hydroplaning on Roadways, **Draft Final Report**, June 2020

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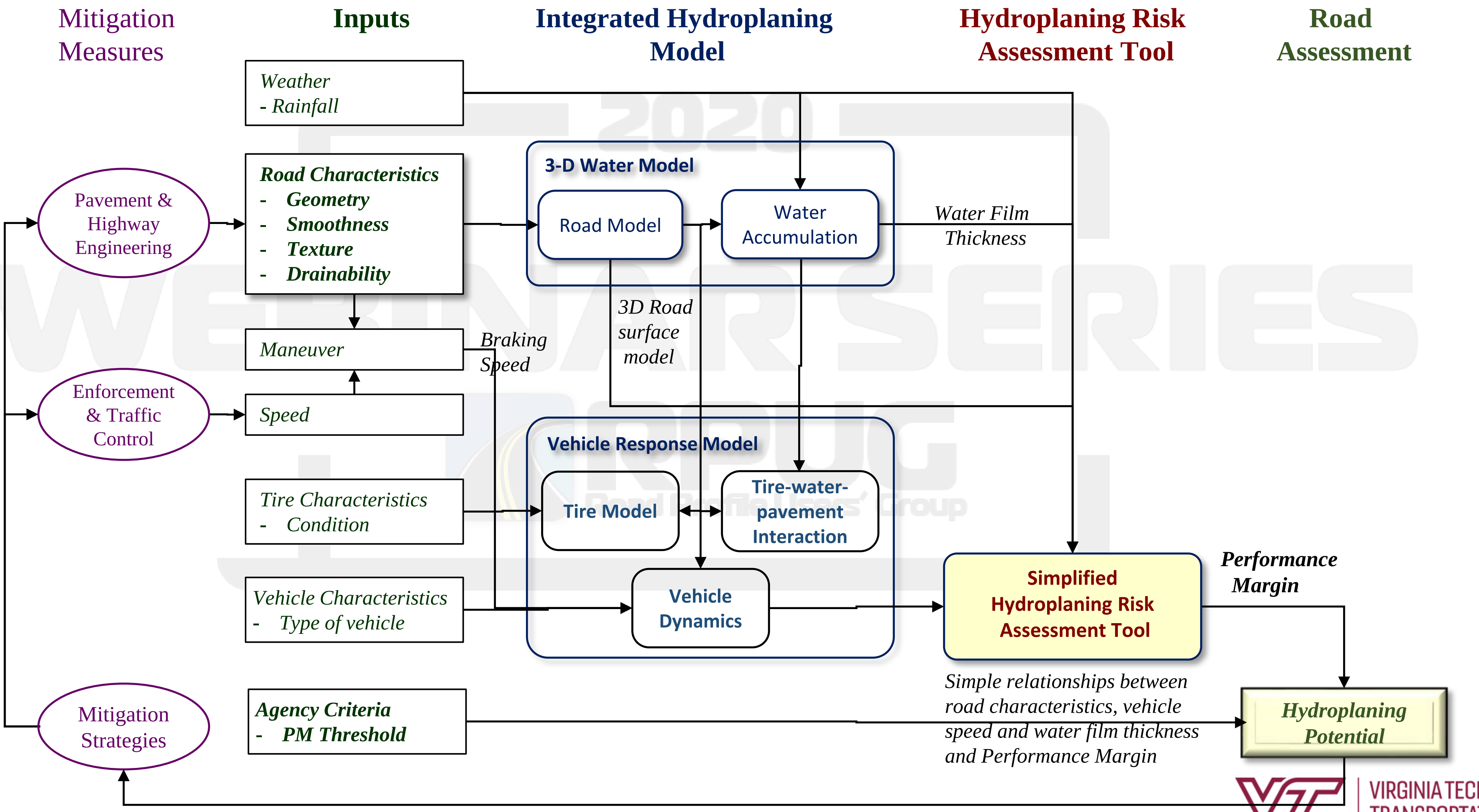
Research Approach Overview



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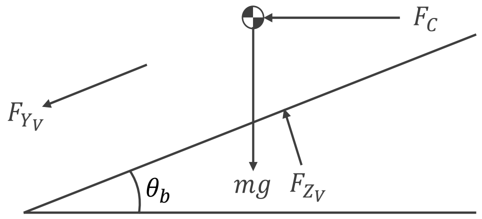
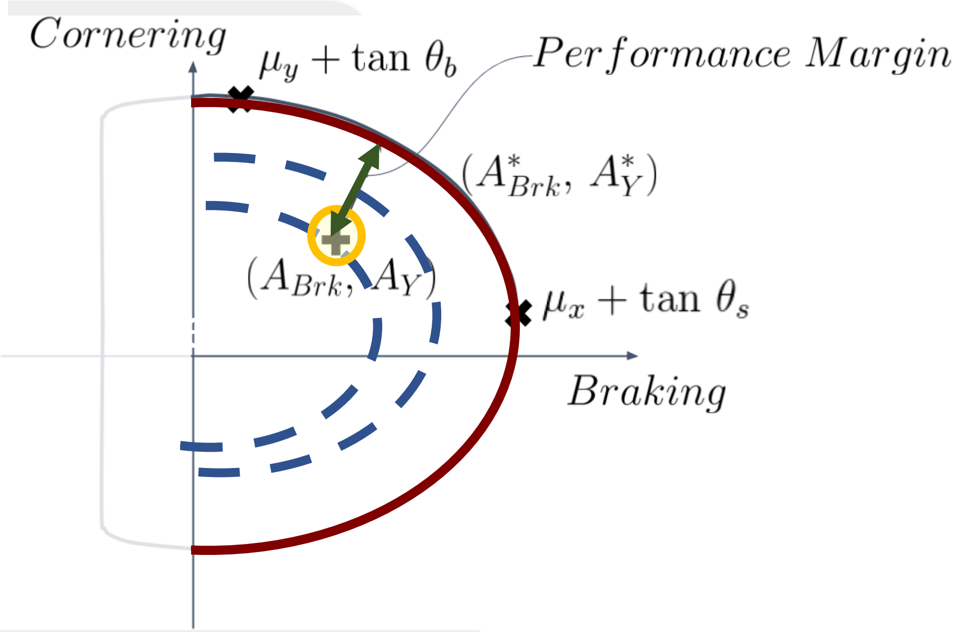
Hydroplaning Definition



- ✓ Based on vehicle handling capabilities
  - Performance margin (available fiction) dry
  - Required friction
  - Available fiction wet



- ✓ **Performance Margin**

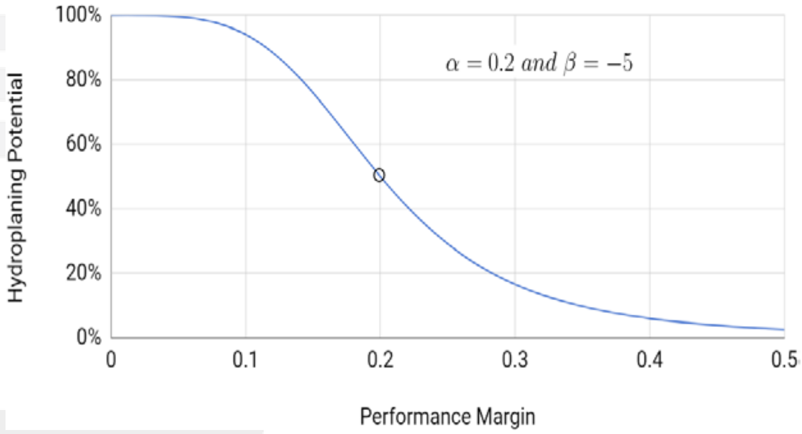
$$\frac{(A^*_{brk} - tan(\theta_s))^2}{\mu_X^2} + \frac{(A^*_Y - tan(\theta_b))^2}{\mu_Y^2} = 1$$

Hydroplaning Potential and Risk

- ✓ Not implemented in the tool

- ✓ Hydroplaning potential

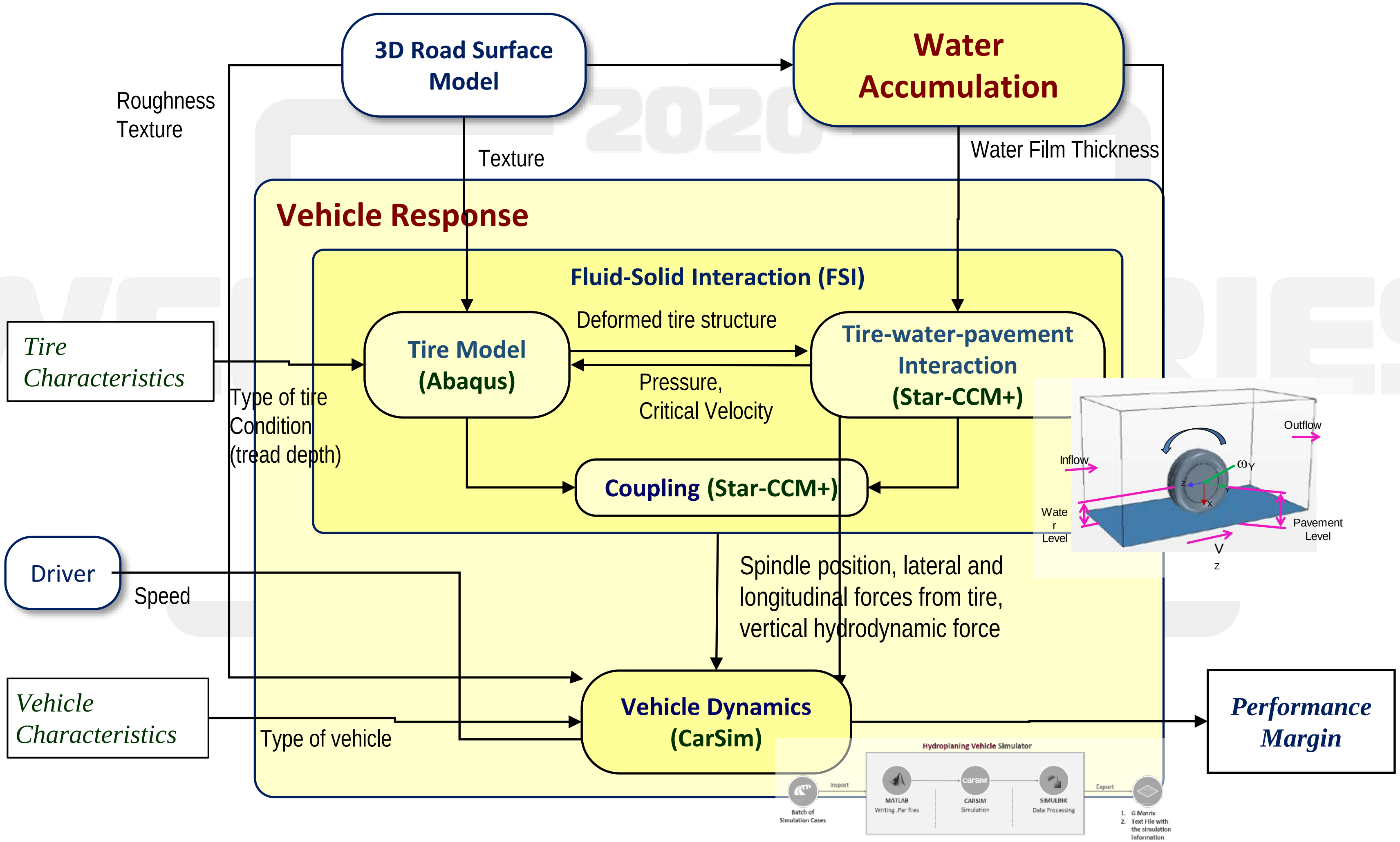
$$H_P = P(\mathrm{H}/\ V\ S\ W) = \left(1 + \left(\frac{PM}{\alpha}\right)^{-4\alpha\beta}\right)^{-1}$$



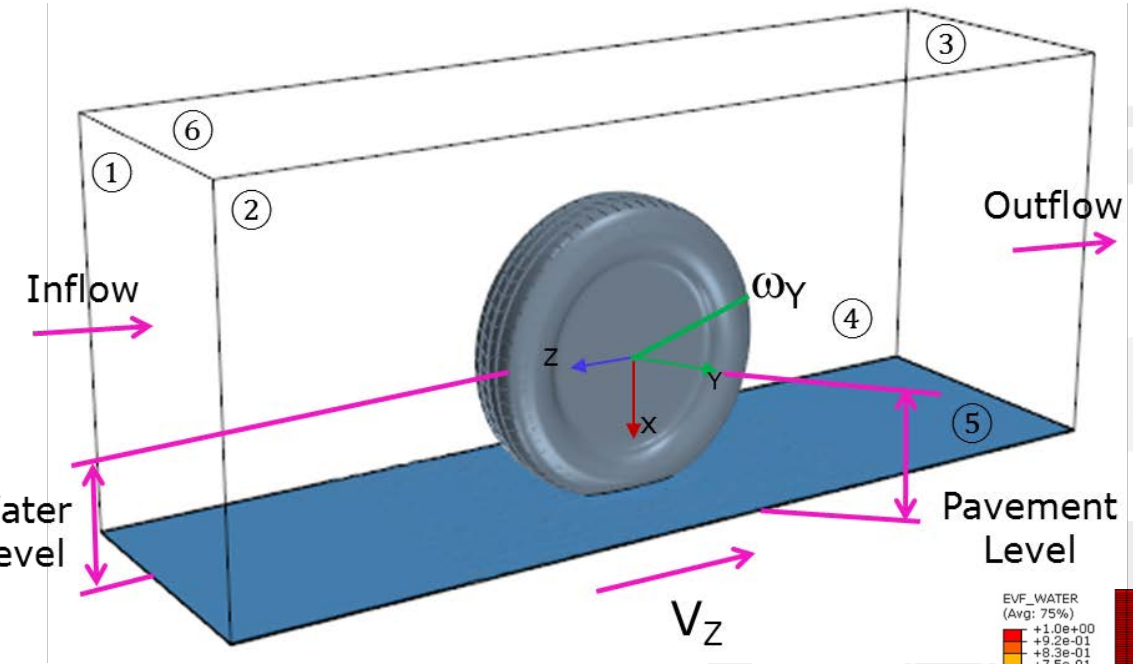
- ✓ Hydroplaning risk

$$H_R = P(H/\ S) = \sum_V \sum_W P(H\ /\ V\ W\ S))(P\ P(W)\ P\ (W/\ S))$$

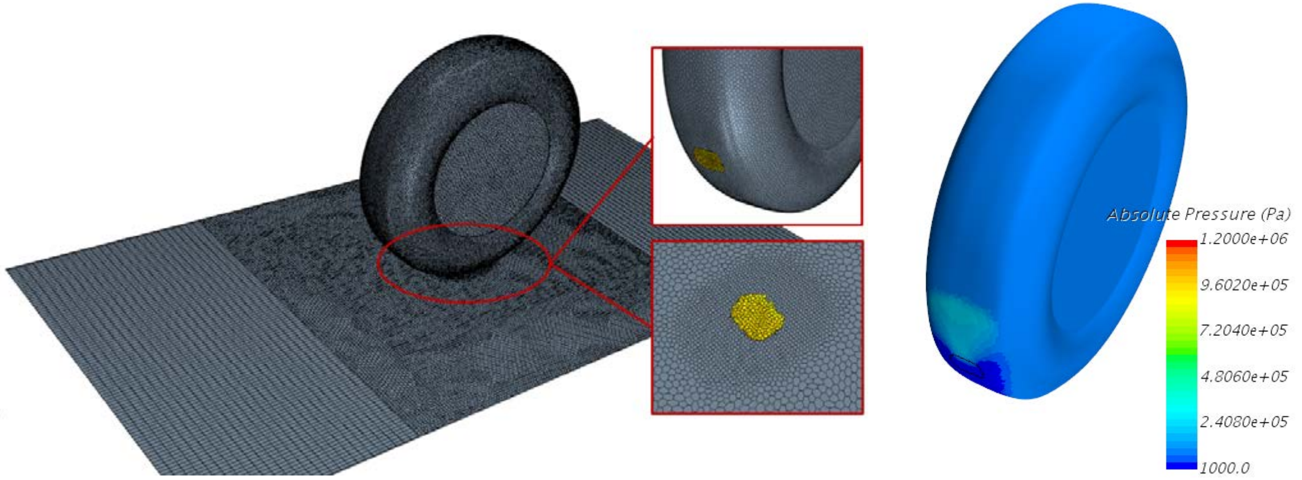
Integrated Hydroplaning Model

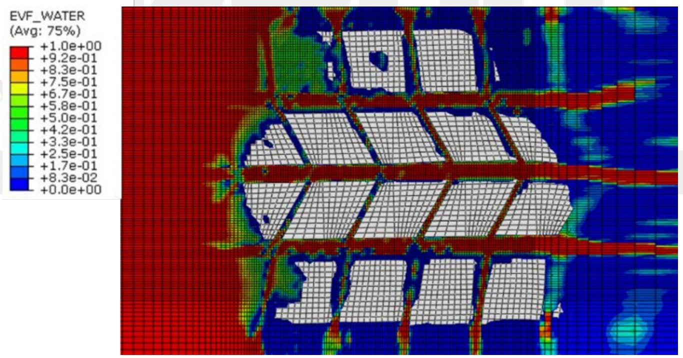


Tire-pavement-water Interaction Model



Bald tire mesh profile and pressure distribution on bald tire surface





Volume fraction of the water flowing in the tire pattern groove with 5-mm WFT at 40 mph.

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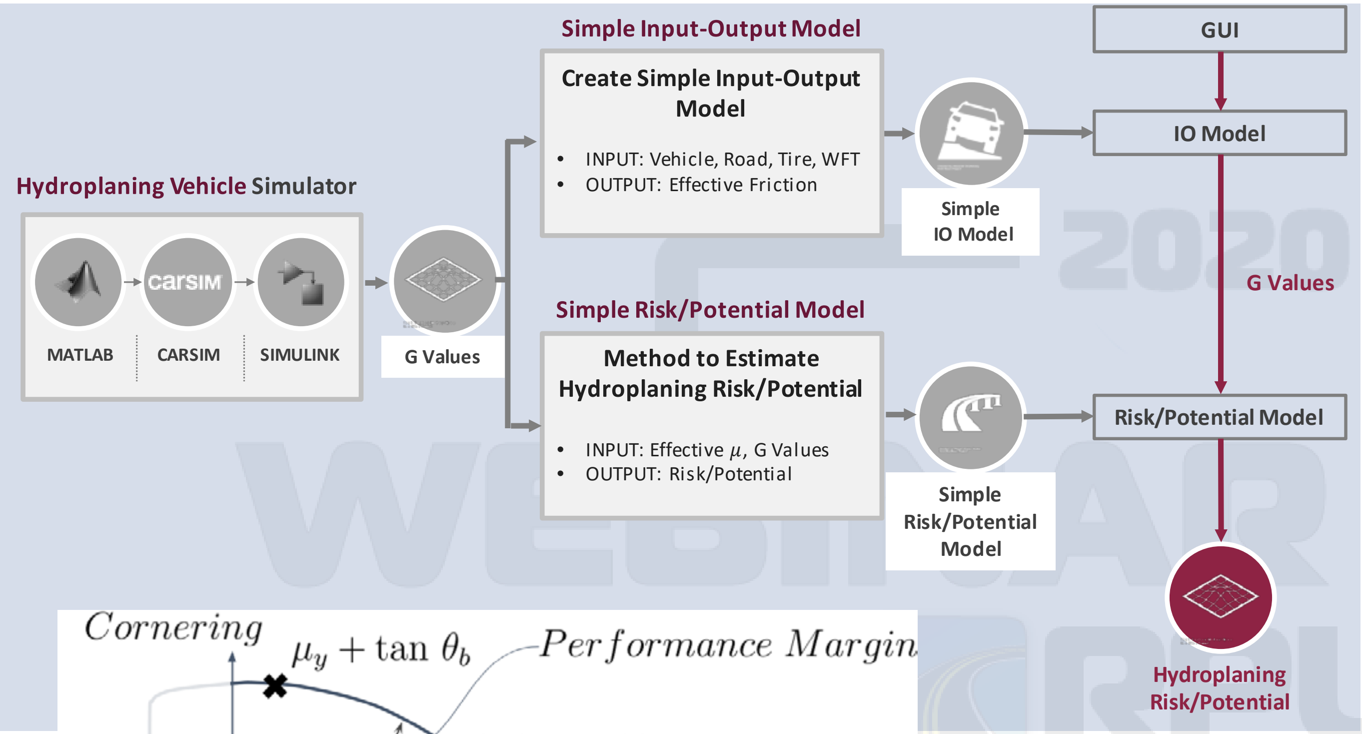
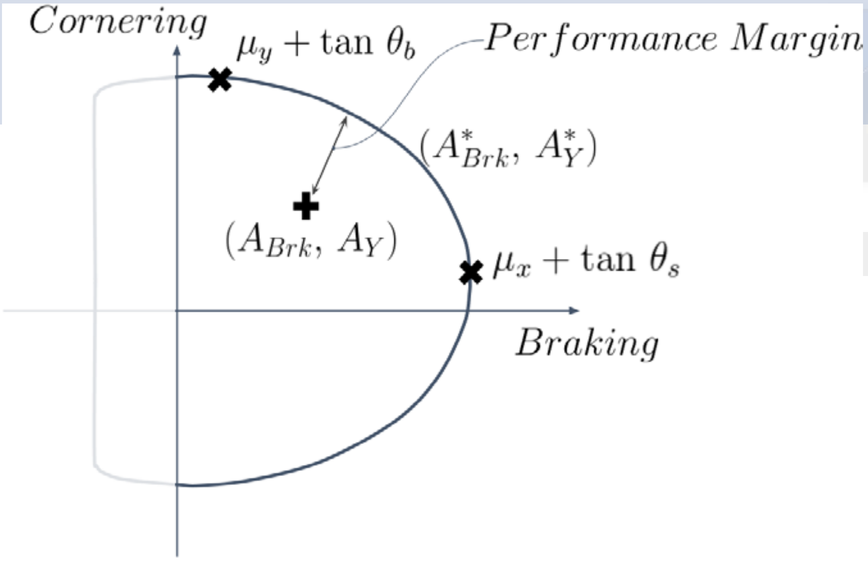
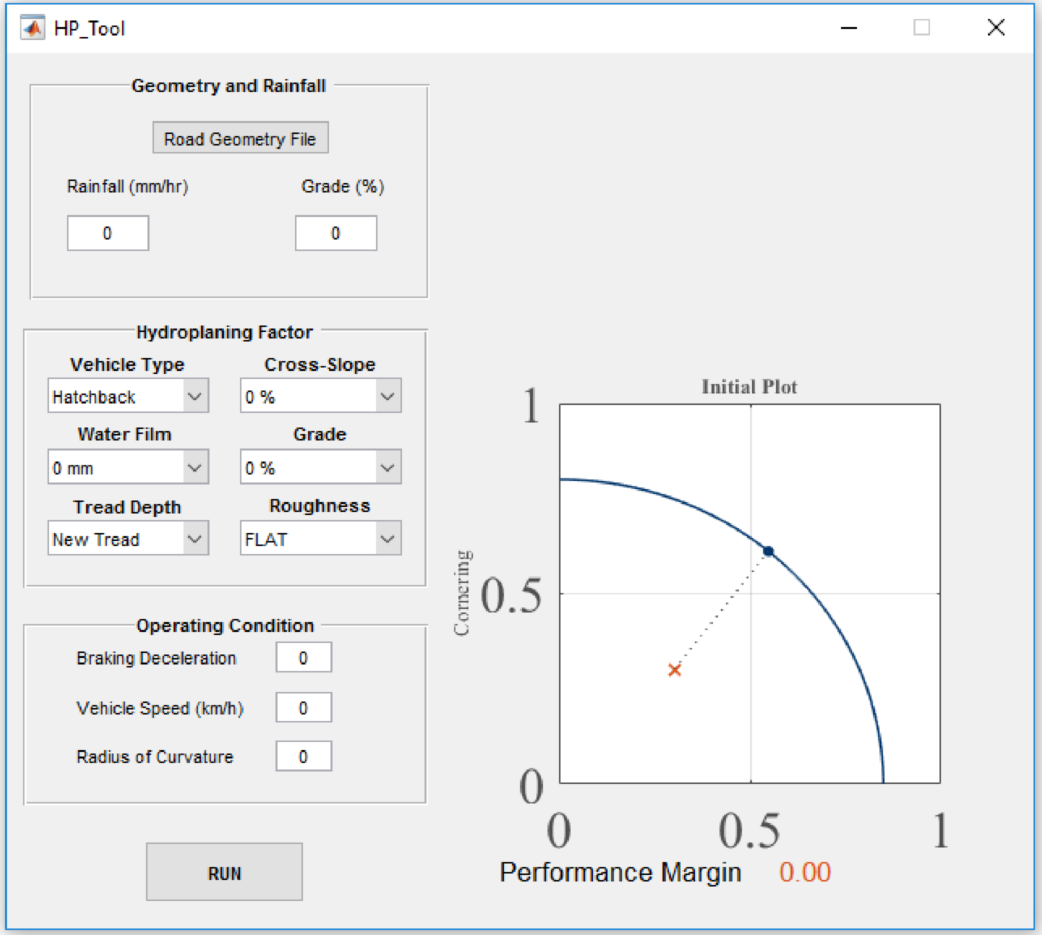
Vehicle Dynamics Model - Performance Margin

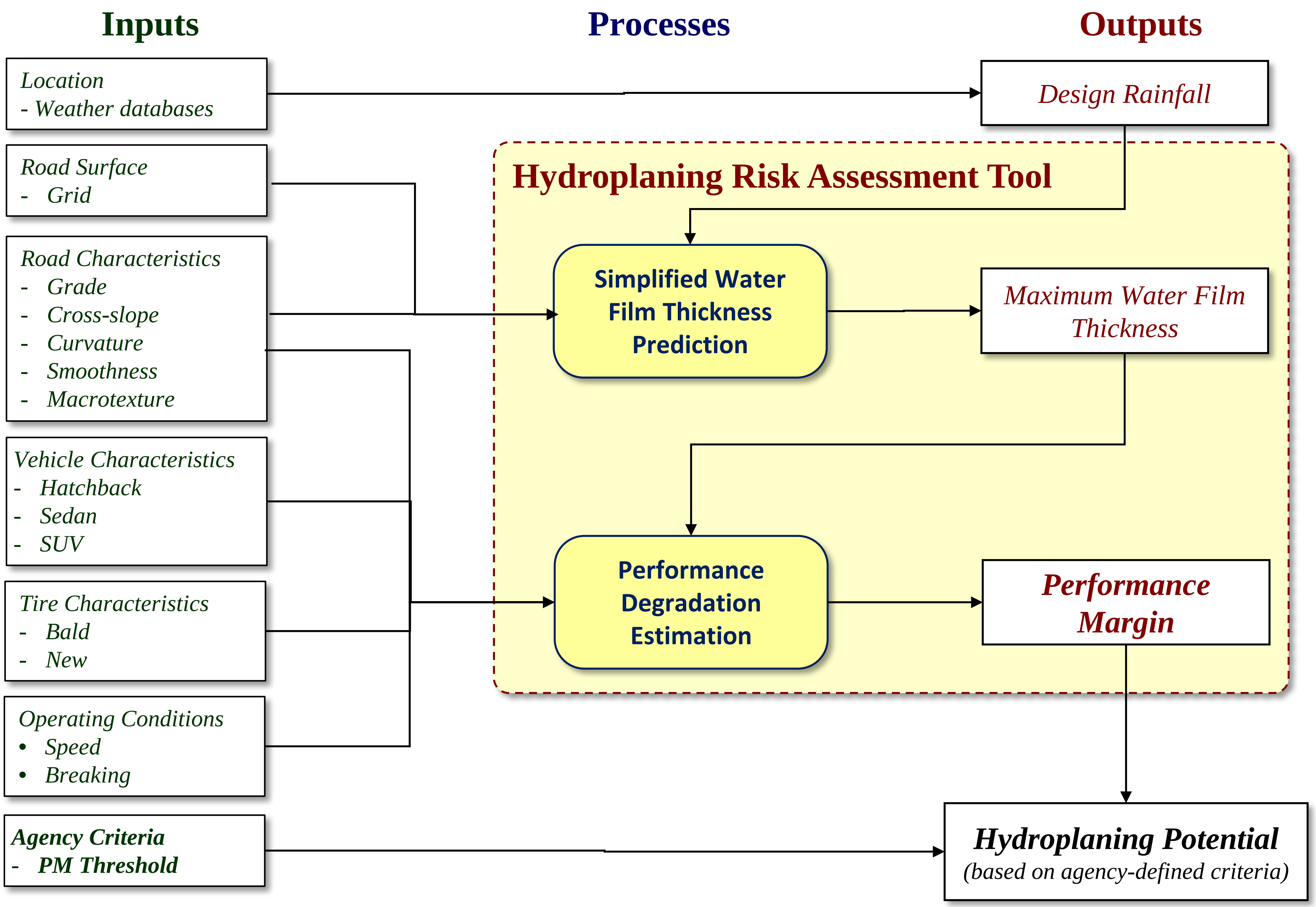


$$\frac{(A^*_{brk} - tan(\theta_s))^2}{\mu_X^2} + \frac{(A^*_Y - tan(\theta_b))^2}{\mu_Y^2} = 1$$

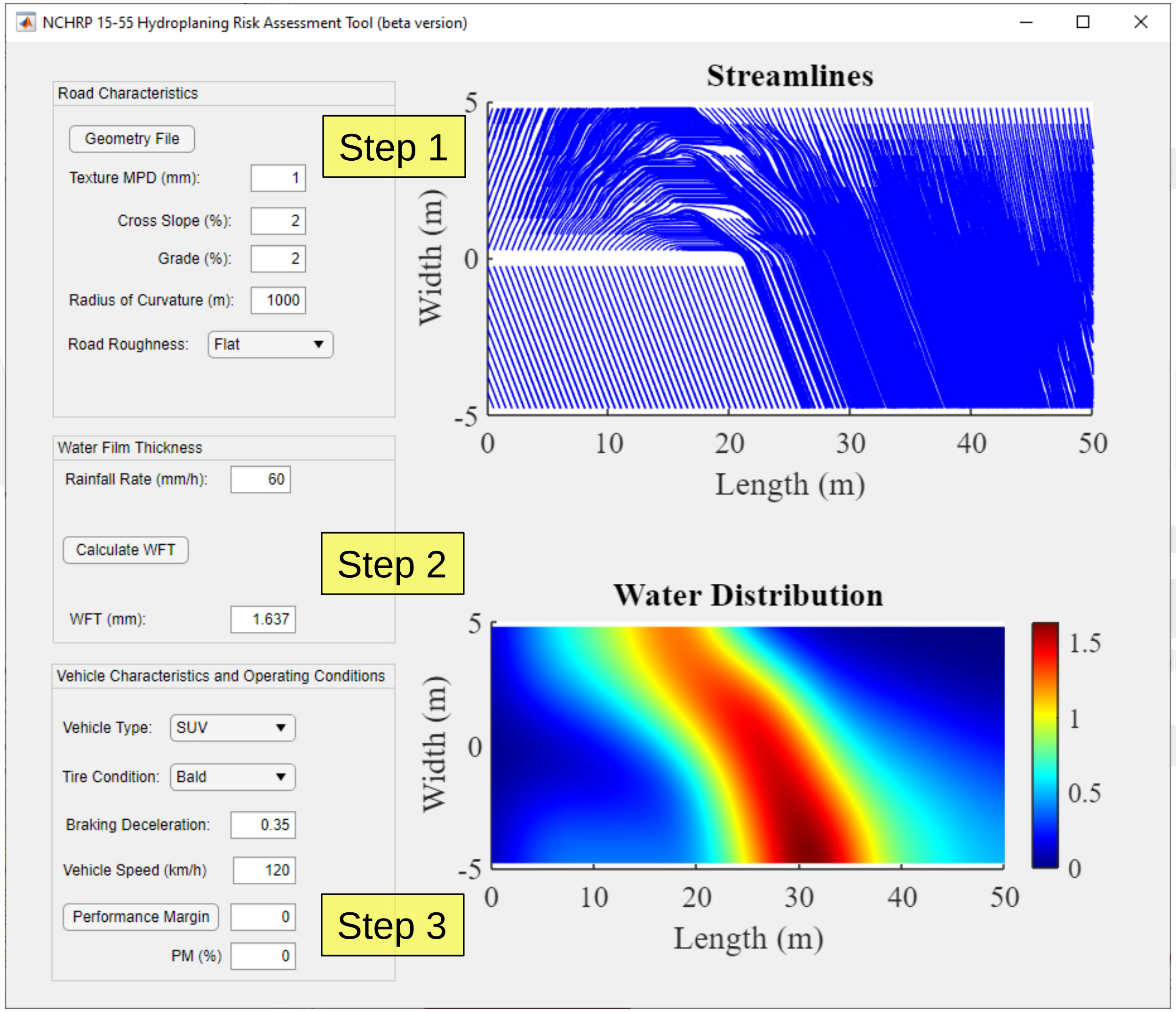




Hydroplaning Risk Assessment Tool

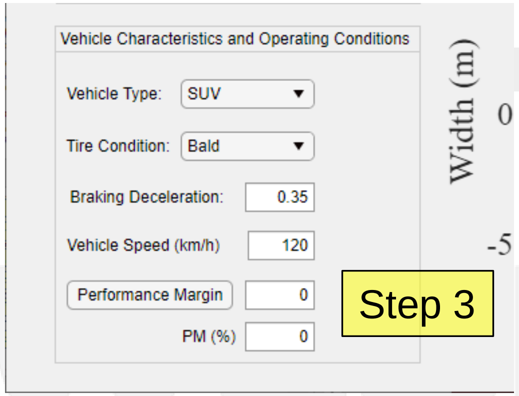


NCHRP 15-55 Tool – beta version

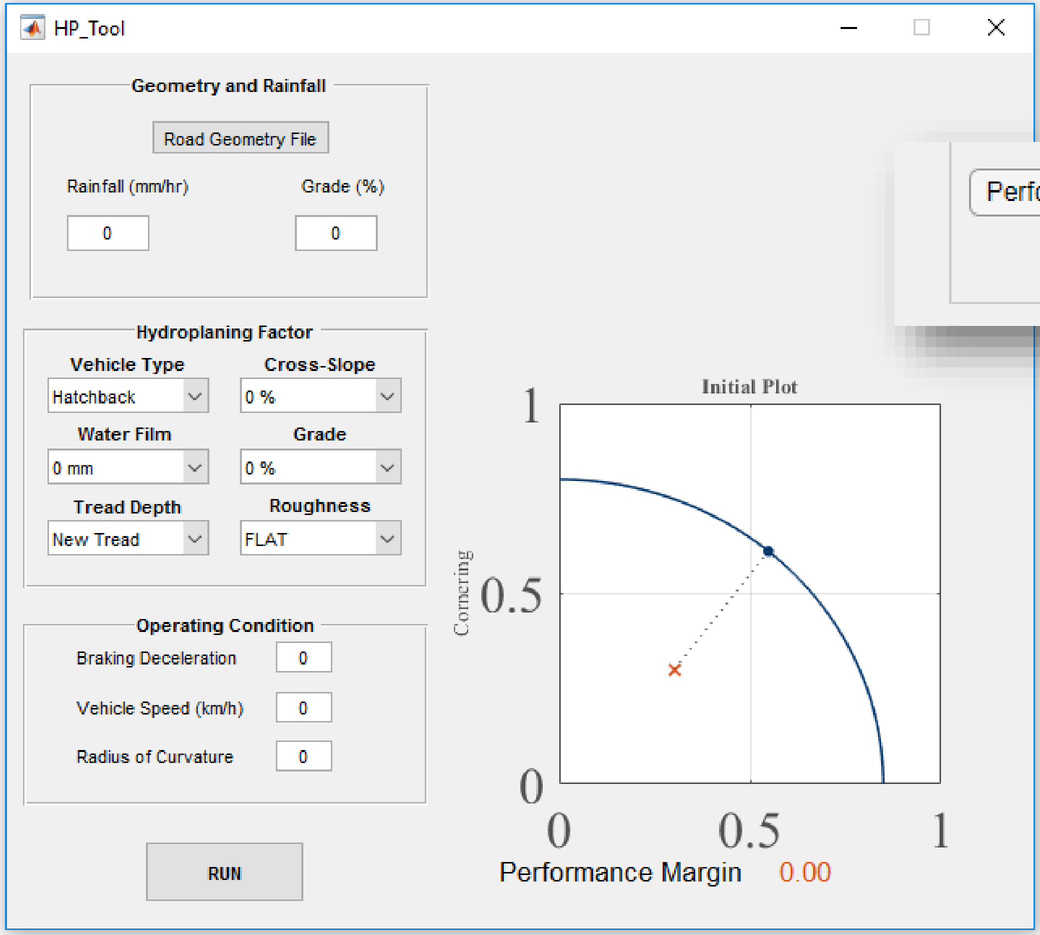


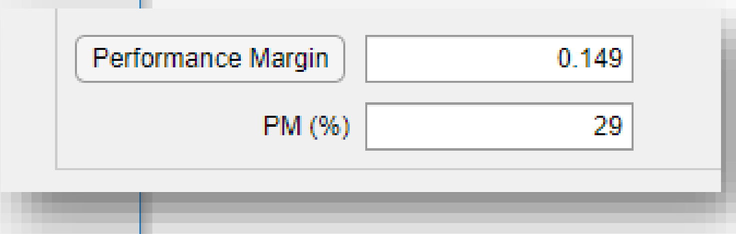
1. Select a file containing a prepared coarse grid for the alignment
2. Add the main surface characteristics and road geometric characteristics
3. Select the design speed and braking deceleration, design vehicle, and tire condition (or approve the default).

Performance Margin Calculation



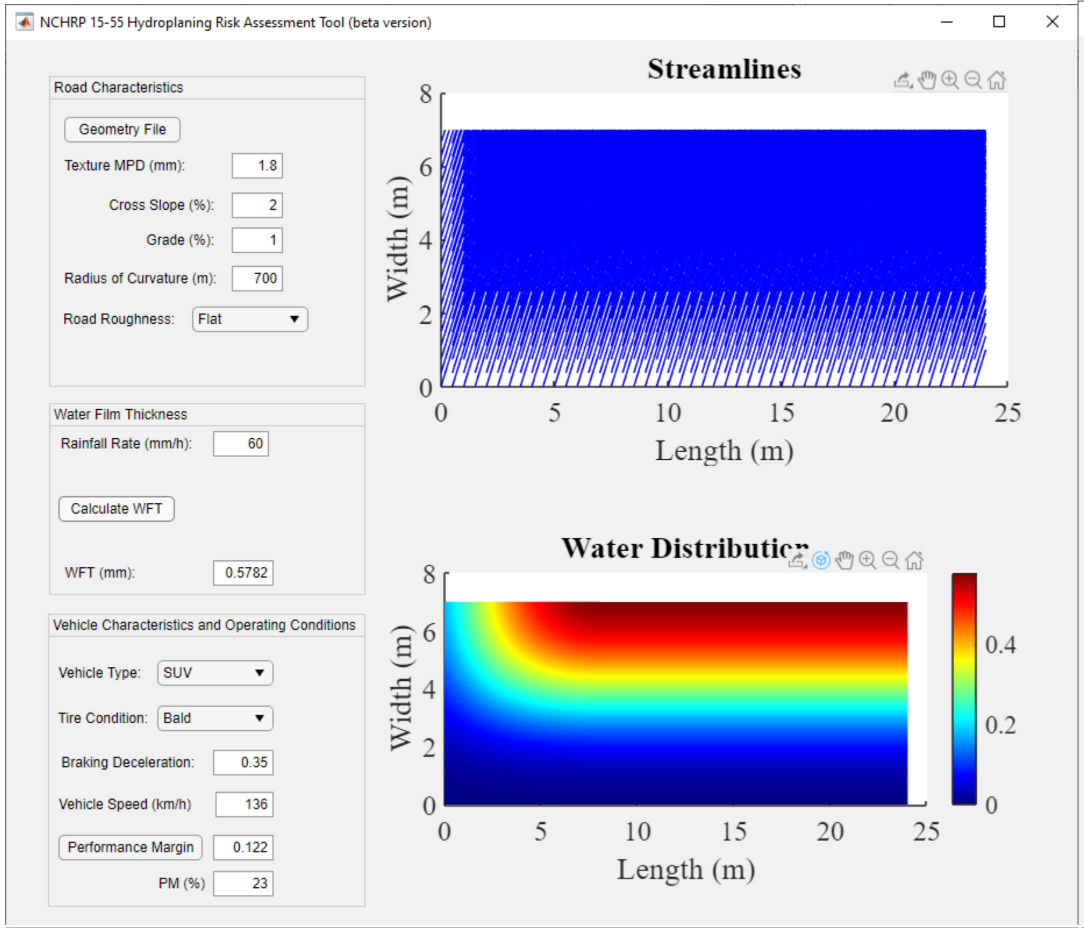
Step 3



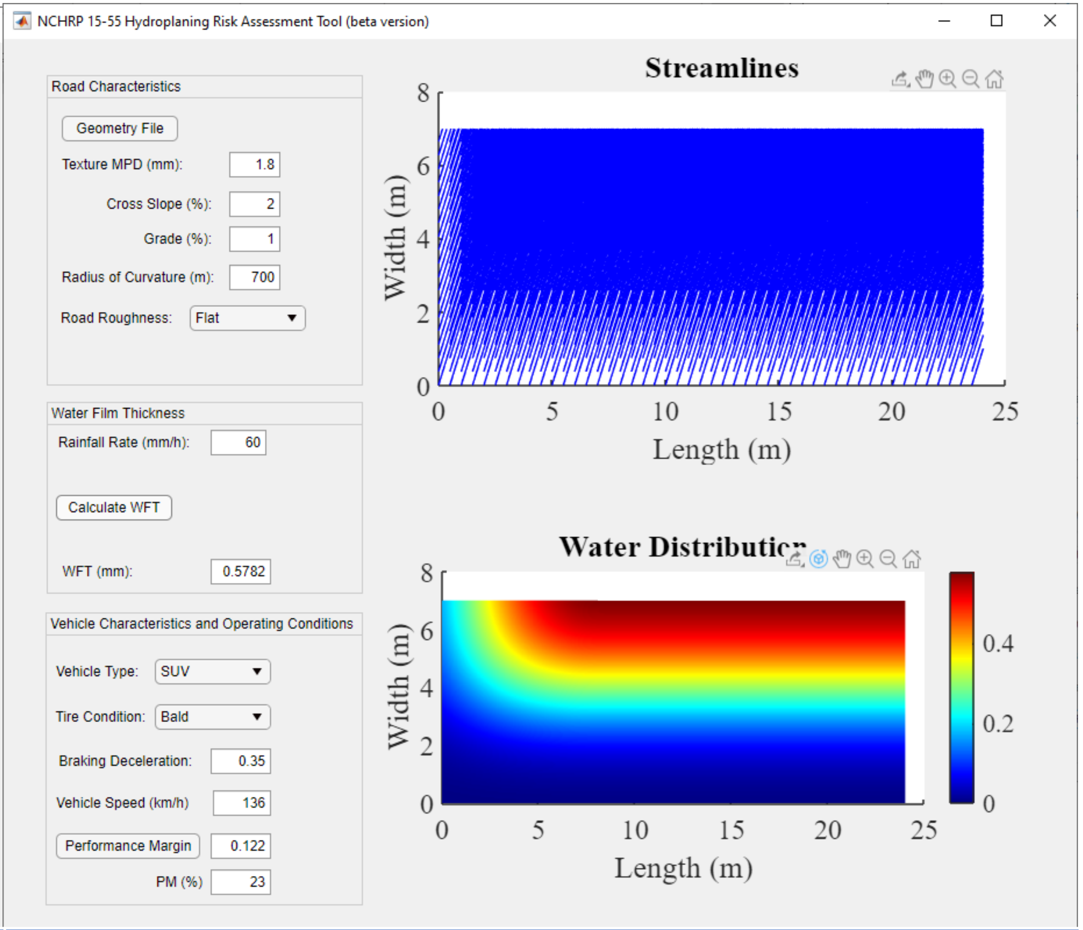


P= 0.15

Example – Effect of Macrotexture



MPD = 0.5 mm; WFT = 1.57 mm; $PM_{136km/h}$ = 0.098



MPD = 1.8 mm; WFT = 0.58mm; $PM_{136km/h}$ = 0.122

5. Final Thoughts

http://garak.wimp.com/images/thumbs/2014/06/66effb01da776d2c3fce3228eb28cb58_record_506_332.jpg

Final Thoughts

- ✓ There are many pavement-vehicle interactions that impact driving safety and comfort
- ✓ The accumulation on water on the pavement impact the vehicle performance and safety and the comfort of drivers
- ✓ **Splash and Spray** and **Hydroplaning** are two interactions that are difficult to measure directly
- ✓ However they can be modeled and the presentation presented a couple of simple tools to predict them
- ✓ These tools can be used to identify roadway sections in need for interventions and the potential impact of various treatments

VIRGINIA TECH

RPUG Road Profile Users' Group
The 101 Sessions

2020 WEBINAR SERIES
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Splash, Spray and Hydroplaning 101

Gerardo Flintsch, Virginia Tech

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