Hydroplaning

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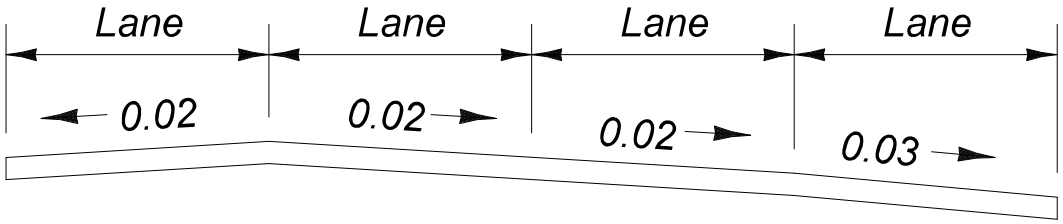
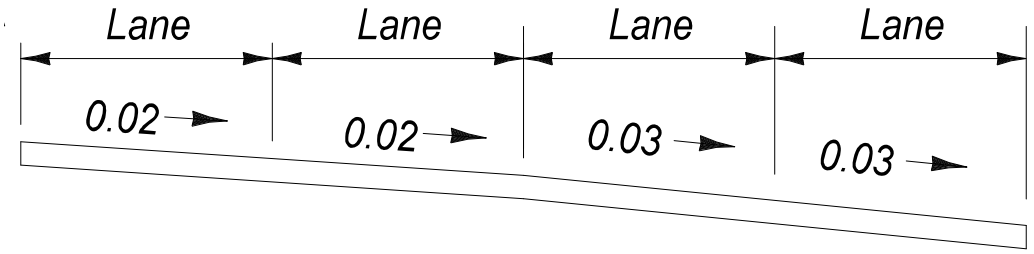
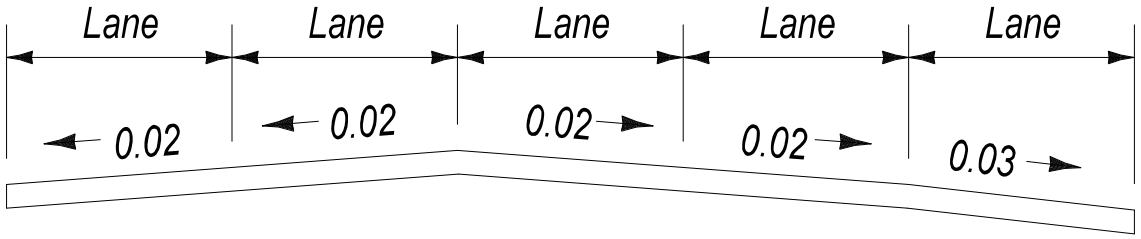
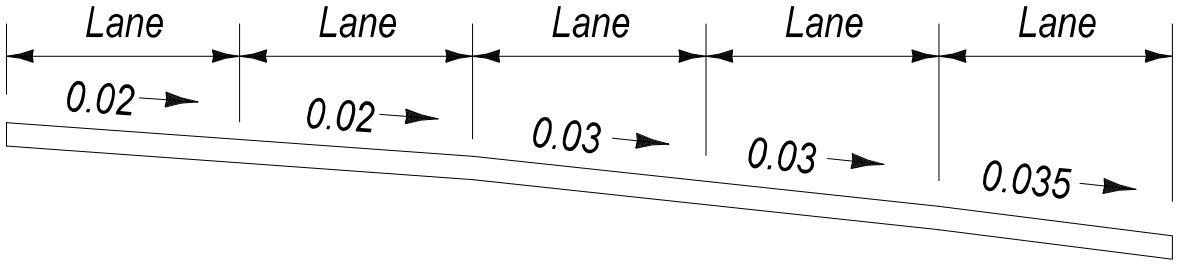
An Important Decision…









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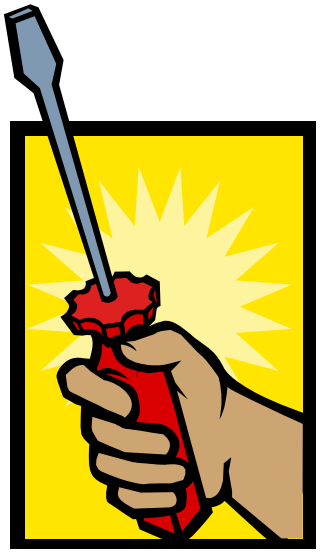
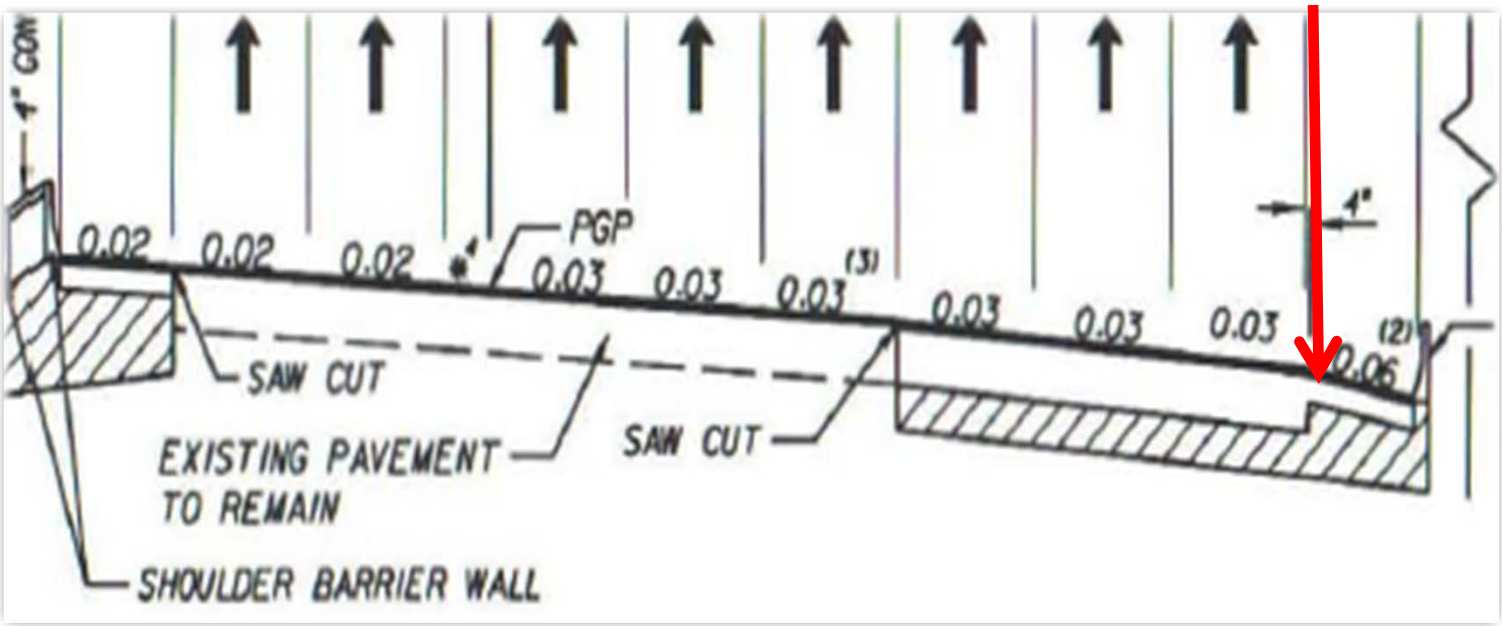
Hydroplaning Analysis Procedure



- NEW Design Guidance
- NEW Software Program
- NEW PPM Typical Sections

Currently… **Design Variation**

- Roadways exceeding the maximum allowable travel lanes with a cross slope in one direction



Elements of Hydroplaning Risk

Predicted Hydroplaning Speed

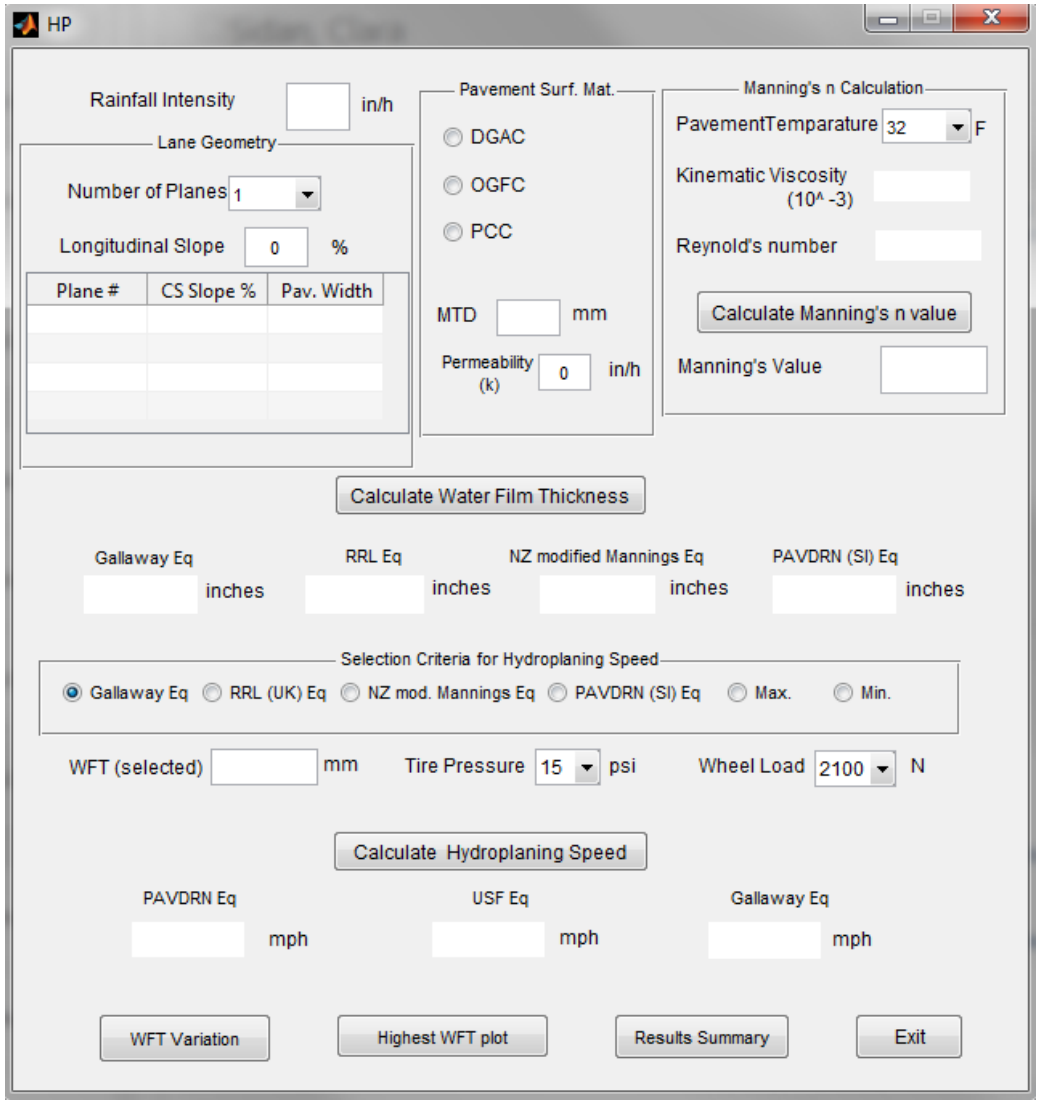
Expected Driver Speed

Rain
Pavement
Water Film Thickness

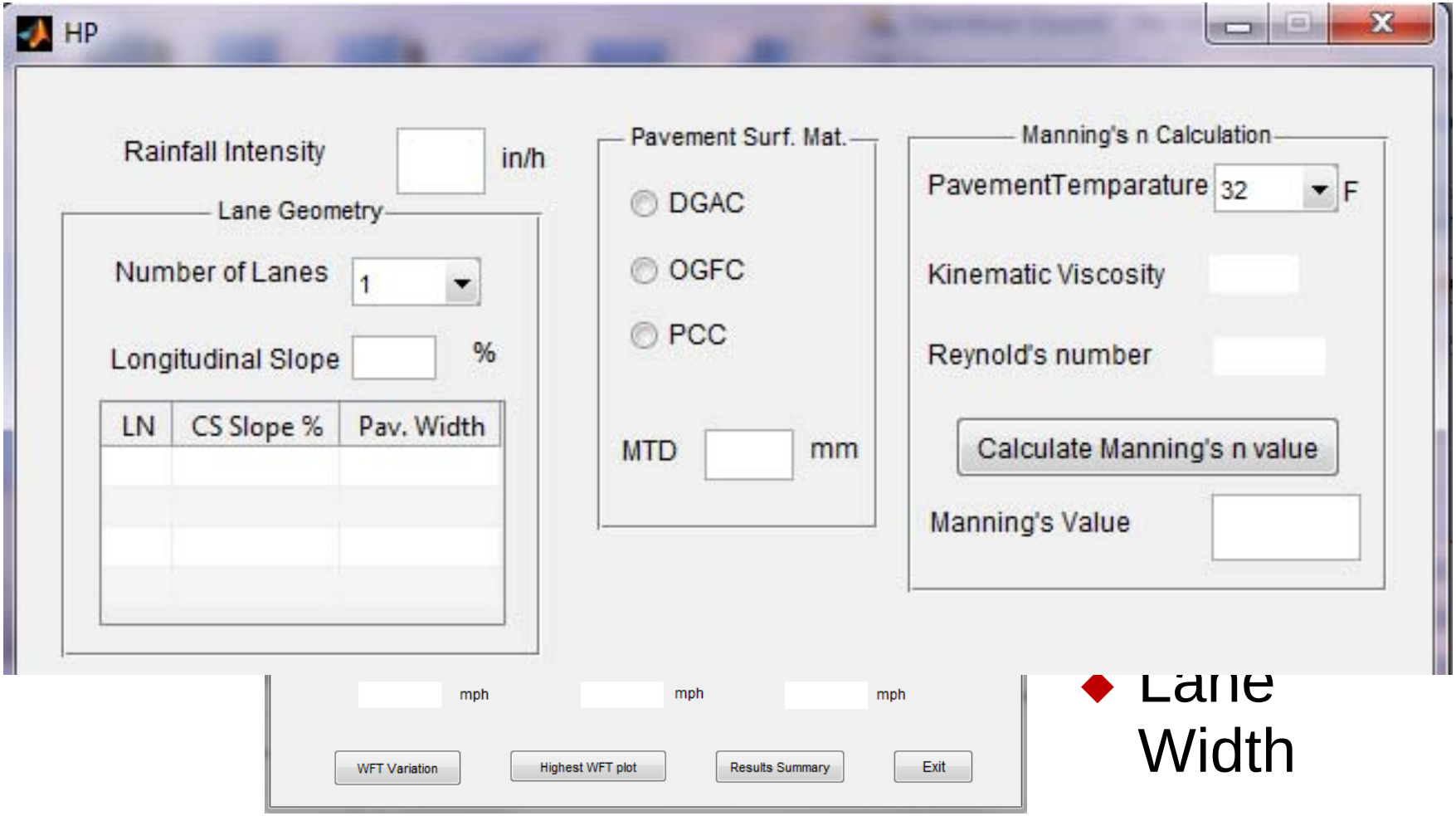
Design Speed
Driver Reaction

HP: Hydroplaning Speed Prediction Tool

- DOT & USF collaborated on Window-friendly program HP
- Predicts speed at which hydroplaning *could* occur.



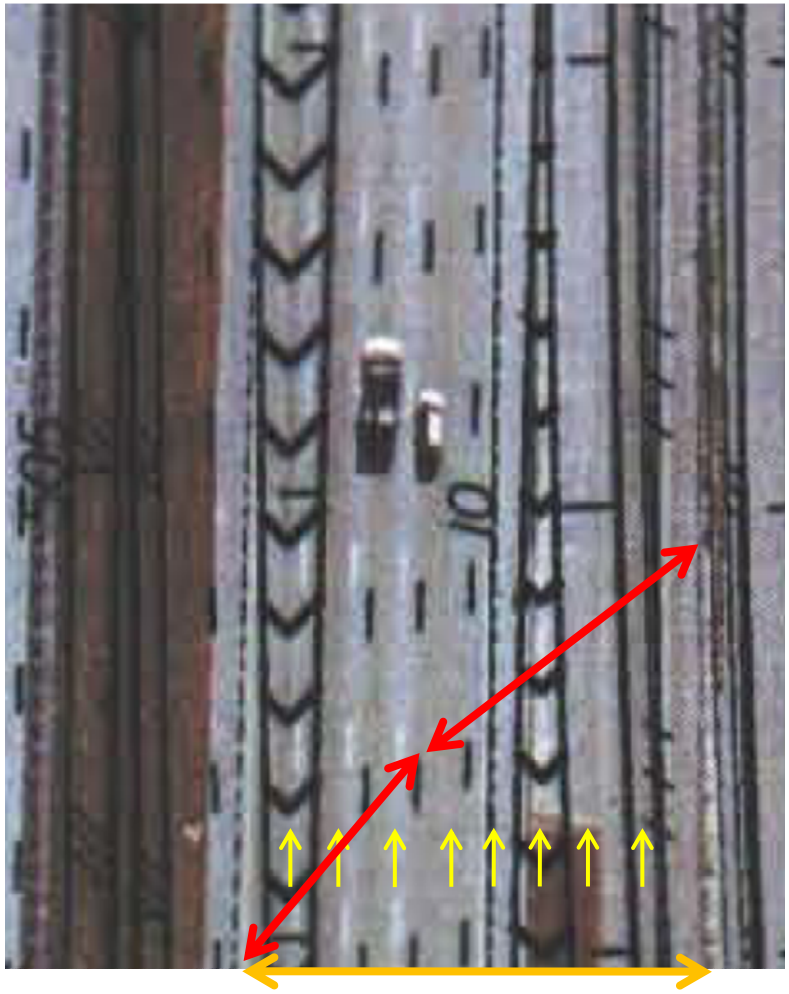
HP: User Defined Inputs



- Lane Width

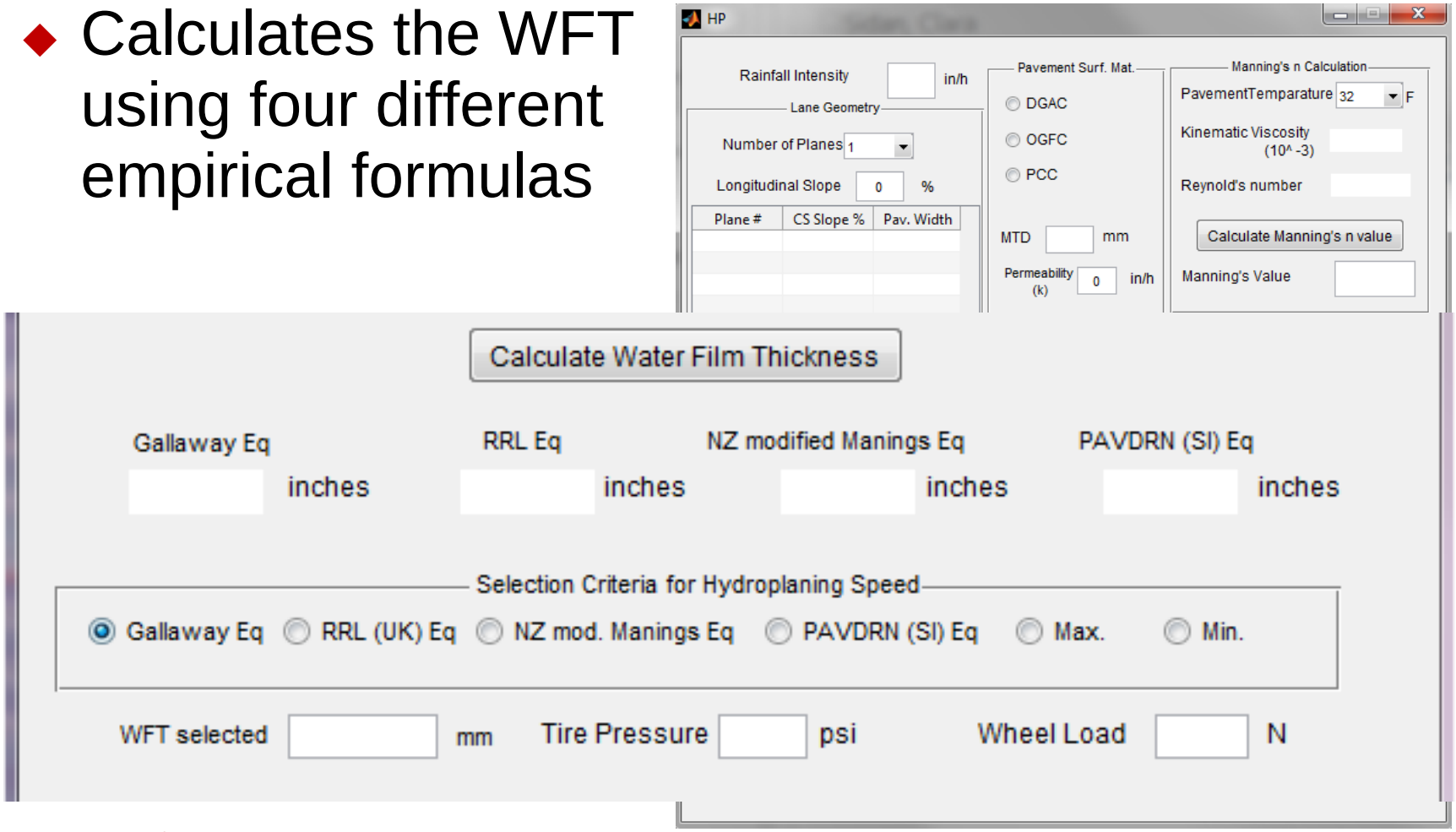
Longitudinal Slope

- WFT Increases Along Flow Path
- Greater upstream contributing area
- Increase S_L = Increase WFT



HP: Water Film Thickness

- Calculates the WFT using four different empirical formulas



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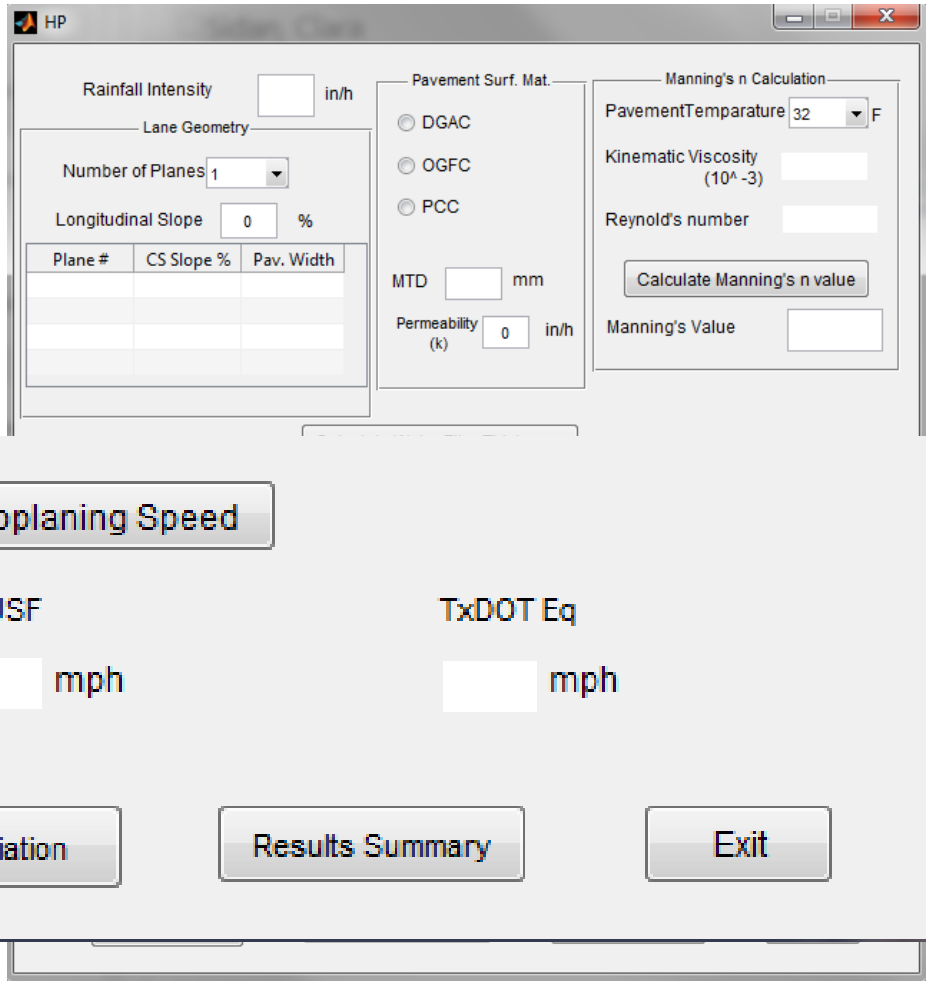
HP: Hydroplaning Speed

- Calculates the Hydroplaning Speed using three different empirical formulas



Which Equations Should I Use?

- USF - Relative Accuracies with Relation to Florida's Wet Weather Crash Data
- Florida's 1,347 Miles of Interstate System
- CARS, PCS, GIS, VPD & Police Reports; 2006-2011
- National Climactic Data Centre (NCDC)

WFT: Galloway Equation

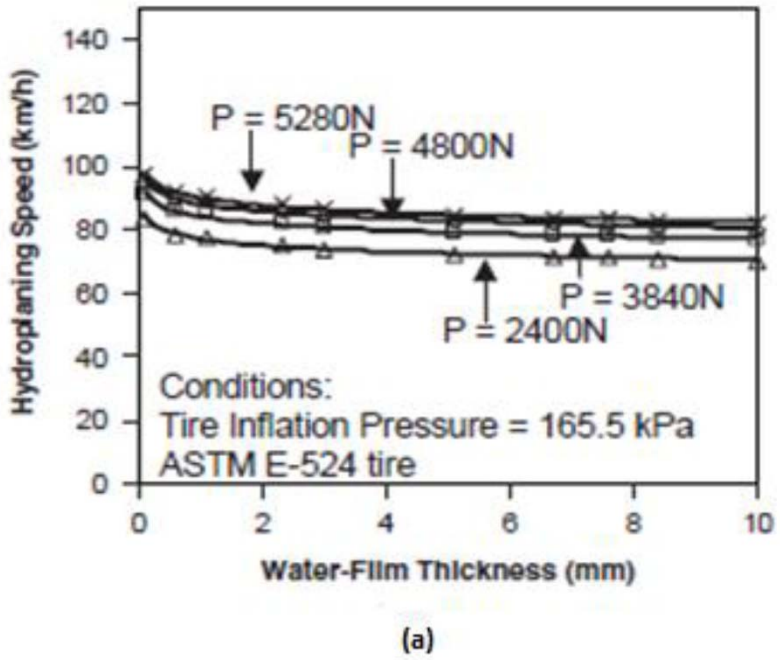
Hydroplaning Speed: PAVDRN

Assumptions

- PAVDRN Developed Through Testing
- Empirically Derived Formula
- ASTM E-524 Standard Tire Testing
  - ✓ Tire Pressure = 24 psi
  - ✓ Wheel Load = 4800 N
- Tire Tread Depth = 3/32 inches (TWI = 2/32”)

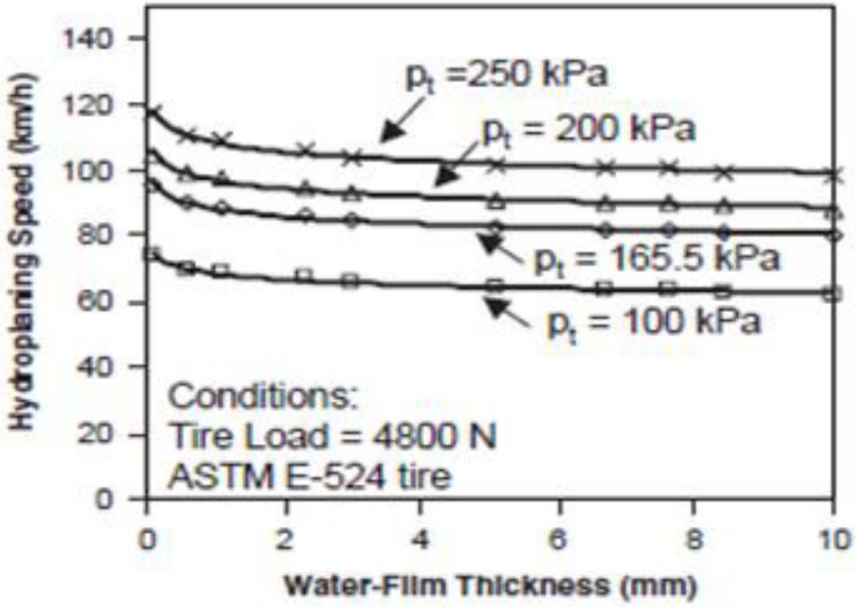
Hydroplaning Speeds Vary

Wheel Load



(a)

Tire Pressure



(b)

Analyzing the HP Results

- Gulf Coast University - *Evaluation of Driver Behavior to Hydroplaning in the State of Florida Using Drive Simulation*
  - ✓ PatrolSim: Driving Simulator at UCF
  - ✓ Driver Age, Gender

✓ Light rain (0.1-0.24in/hr) did not affect driver speed

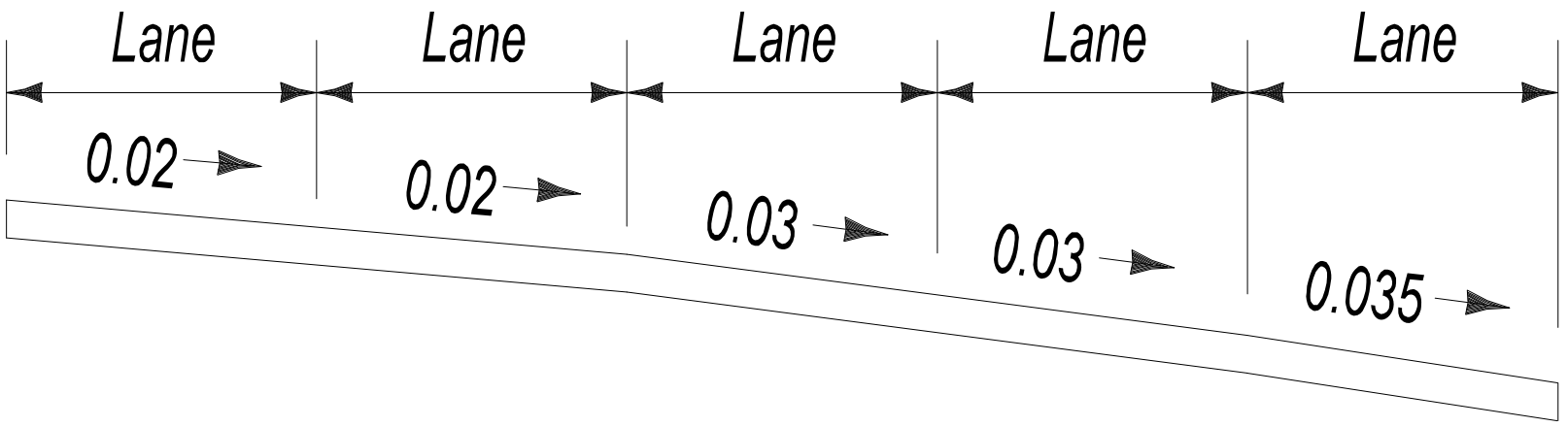
✓ Heavy rain (+0.24in/hr) reduced speed by 6-12mph

Predicted Driver Response

Intensity (in/hr)	Predicted Speed Reduction (mph)	Predicted Driver Speed (mph)
0.1	0	Design Speed
0.25	0	Design Speed
0.5	6	Design Speed - 6
1.0	8	Design Speed - 8
2.0	12	Design Speed - 12
3.0	*below hydroplaning speed*	
4.0	*below hydroplaning speed*	

Example

- Design Speed = 60mph
- Longitudinal Slope = 5%
- Open graded friction course



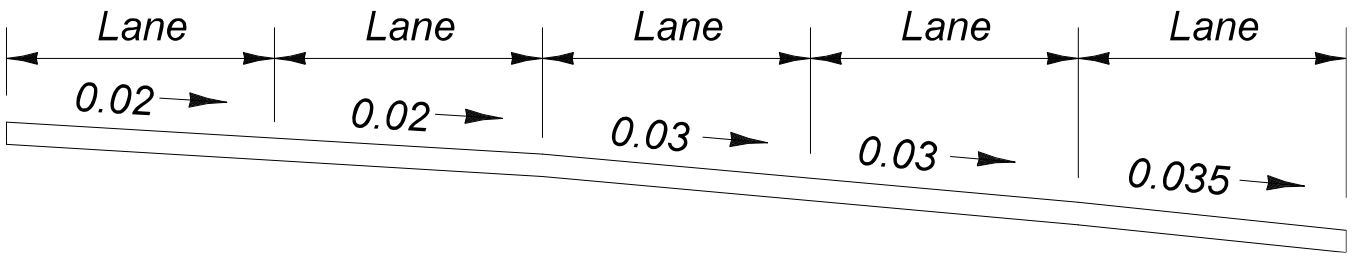
Potential Hydroplaning Speed: Example Design Speed = 60 mph

Cross Slope	0.02	0.02	0.02	0.03	0.03	0.035	Predicted Driver Speed
Rainfall Intensity i (in/hr)	Shoulder	Lane 1	Lane 2	Lane 3	Lane 4	Lane 5	
0.10	--					100 (n/a)	60
0.25	--					100 (n/a)	60
0.50	--					100 (n/a)	54
1.00	--					70	52
2.00	--					54	48
3.00	--					48	45
4.00	--					52	45

Potential Hydroplaning Speed: Example Design Speed = 70 mph

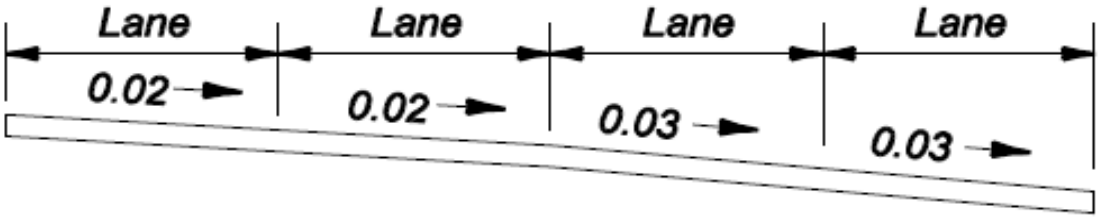
Cross Slope	0.02	0.02	0.02	0.03	0.03	0.035	Predicted Driver Speed
Rainfall Intensity i (in/hr)	Shoulder	Lane 1	Lane 2	Lane 3	Lane 4	Lane 5	
0.10	--					100 (n/a)	70
0.25	--					100 (n/a)	70
0.50	--					100 (n/a)	64
1.00	--					70	62
2.00	--					54	58
3.00	--					48	45
4.00	--					52	45

Potential Hydroplaning Speed: Example Design Speed = 65 mph



Cross Slope	0.02	0.02	0.02	0.03	0.03	0.035	Predicted Driver Speed
Rainfall Intensity i (in/hr)	Shoulder	Lane 1	Lane 2	Lane 3	Lane 4	Lane 5	
0.10	--					100 (n/a)	65
0.25	--					100 (n/a)	65
0.50	--					100 (n/a)	59
1.00	--					70	57
2.00	--					54	53
3.00	--					48	45
4.00	--					52	45

PPM Typical Section: Design Speed = 70 mph



Cross Slope	0.02	0.02	0.02	0.03	0.03	Predicted Driver Speed
Rainfall Intensity i (in/hr)	Shoulder	Lane 1	Lane 2	Lane 3	Lane 4	
0.10	--				100 (n/a)	70
0.25	--				100 (n/a)	70
0.50	--				100 (n/a)	64
1.00	--				73	62
2.00	--				55	58
3.00	--				49	45
4.00	--				52	45

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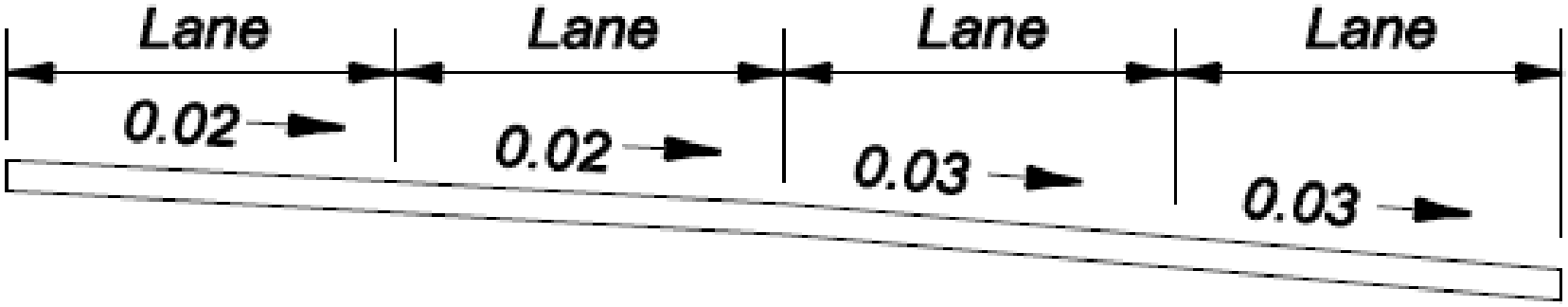
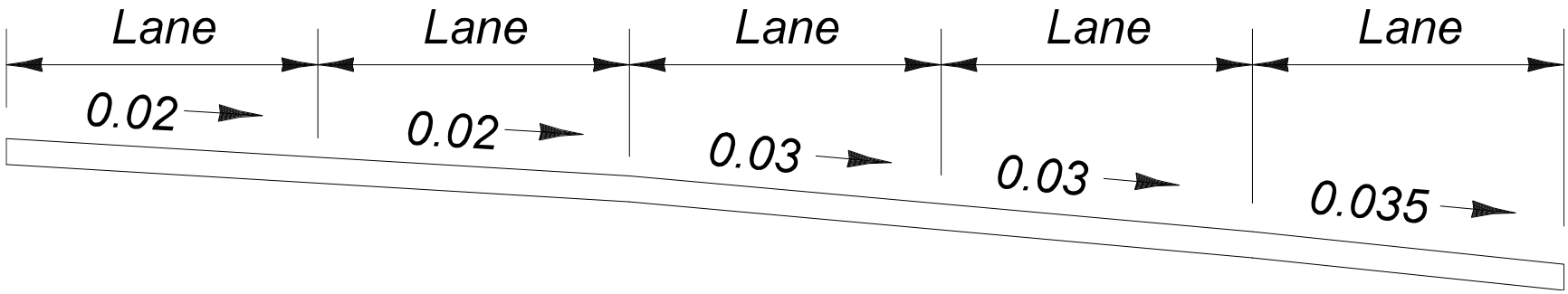
PPM Typical Section Modification

Design Speed ≤ 65 MPH
Longitudinal Slope ≤ 5%



Not just for curb & gutter sections

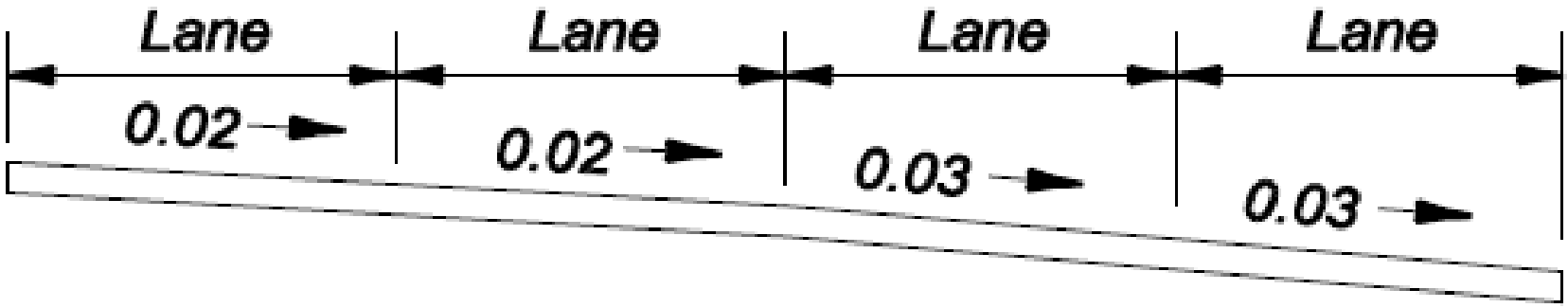
PPM Typical Section Modification



Design Speed ≤ 65 MPH

Longitudinal Slope ≤ 5%

LET'S TRY AN EXAMPLE IN THE HP PROGRAM…



Web Links:

- Roadway Design Bulletin

http://www.dot.state.fl.us/rddesign/Bulletin/Default.shtm

- Hydroplaning Tools

http://www.dot.state.fl.us/rddesign/Drainage/ManualsandHandbooks.shtm

QUESTIONS?

Don't forget to register/update your contact information in the Contact Mailer Database.

http://www.dot.state.fl.us/projectmanagementoffice/ContactDatabase.shtm

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