Texas A&M Transportation Institute

PROJECT SUMMARY

Texas Department of Transportation

0-6980: Update Rainfall Coefficients with 2018 NOAA Atlas 14 Rainfall Data

Background

Hydraulic engineering is essential for managing floods around transportation infrastructure. Unmanaged, flooding can cause long-term damage to roads and other transportation structures, impact traveler mobility, and cause accidents.

The hydraulic design process requires accurate, location-specific data on the intensity, duration, and frequency of storms. Hydraulic design uses the concept of a *design storm*, defined by its expected probability of occurrence (e.g., 1 in 100 years) and duration. Hydraulic models are then used to translate design storm rainfall intensity into surface runoff, and to design structures to accommodate this runoff to prevent flooding. This approach enables hydraulic engineers to balance the cost of implementing hydraulic structures against the level of flood protection they provide.

What the Researchers Did

Researchers used National Oceanic Atmospheric Administration (NOAA) Atlas 14 data to update an existing Texas Department of Transportation (TxDOT) hydraulic design tool. NOAA Atlas 14 data describe rainfall frequency, intensity, and duration. The Atlas 14 data were used to update and redevelop a tool (EBDLKUP-2019) that enables design engineers to estimate a location-specific rainfall intensity for a storm of a specified duration and annual exceedance probability (Figure 1). This rainfall intensity is used in hydraulic models to estimate peak storm runoff.

EBDLKUP-2019 is a Microsoft Excel® tool that uses a formula to predict rainfall intensity I for a specified return frequency and storm duration (t_c) at a specified location:

$$\mathbf{I} = \frac{\boldsymbol{b}}{(\boldsymbol{t_c} + \boldsymbol{d})^{\boldsymbol{e}}}$$

The parameters *e, b,* and *d* were obtained by fitting this equation to Atlas 14 data extracted for rainfall zones across the state. The equation translates the Atlas 14 data to a functional form more useful for hydraulic design. EBDLKUP-2019 has inbuilt databases that store all the data (i.e., *ebd* coefficients) required to predict rainfall intensity for any location across the state.

The project investigated variation in rainfall patterns across the state to determine an appropriate spatial resolution for EBDLKUP-2019. Researchers developed an algorithm to subdivide counties based on rainfall patterns to achieve a target spatial accuracy. This algorithm was used to derive a statewide map of rainfall zones that balances the tradeoff between prediction accuracy and the need for a simple, accountable hydraulic design process.

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Texas A&M Transportation Institute

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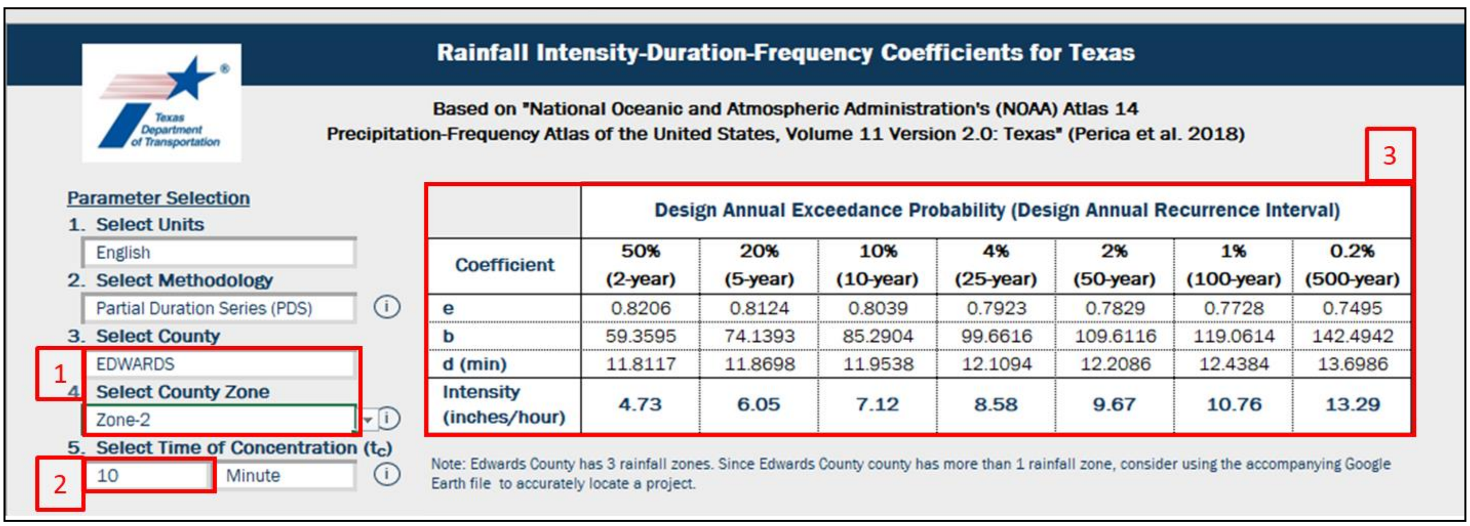
What They Found

Researchers found:

- Atlas 14 shows differences in the patterns of storm intensity, duration, and frequency compared to TxDOT's current *ebd* coefficients. The new Atlas 14–derived *ebd* coefficients will improve the accuracy of hydraulic design across the state.
- For most counties in Texas (224), a single rainfall zone provides a spatial prediction error of less than 10 percent. Nineteen of the remaining counties were subdivided into three or fewer rainfall zones, each with spatial errors less than 10 percent. Eleven topographically diverse counties were divided into rainfall zones with spatial errors less than 20 percent.
- Researchers assembled a statewide map of county and subcounty rainfall zones for use in EBDLKUP-2019. Although the addition of new rainfall zones required changes to the design of the tool, it remains easy to use. Maps embedded within EBDLKUP-2019 and a custom Google Earth™ kml file are used to help engineers locate projects.

What This Means

This project incrementally improves TxDOT's hydraulic design by incorporating latest available rainfall data into the design process. Atlas 14–derived *ebd* coefficients will enable more effective hydraulic design across Texas and ensure new hydraulic structures attain the level of flood protection outlined in national and state hydraulic design standards.



Coefficient	Design Annual Exceedance Probability (Design Annual Recurrence Interval)						
	50% (2-year)	20% (5-year)	10% (10-year)	4% (25-year)	2% (50-year)	1% (100-year)	0.2% (500-year)
e	0.8206	0.8124	0.8039	0.7923	0.7829	0.7728	0.7495
b	59.3595	74.1393	85.2904	99.6616	109.6116	119.0614	142.4942
d (min)	11.8117	11.8698	11.9538	12.1094	12.2086	12.4384	13.6986
Intensity (inches/hour)	4.73	6.05	7.12	8.58	9.67	10.76	13.29

Figure 1. User Interface of EBDLKUP-2019. An Engineer Enters (1) the Project Location by County and a Rainfall Zone and (2) the Duration of the Design Storm, and (3) the Results Show Predicted Storm Intensity for Seven Frequencies. Other Inputs Control the Methodology Used to Determine Rainfall Intensity and Measurement Units.

For More Information

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