# Rainfall Variability & Credit Fungibility: Evaluating the Hydrologic Robustness of Stormwater Retention Credit Programs

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Stormwater runoff in urban areas generates significant negative externalities, including localized flooding and water quality degradation. In response, municipalities have increasingly adopted market-based mechanisms, including stormwater volume credit trading programs, to permit developers to meet regulatory retention requirements by purchasing off-site runoff reduction credits. These programs are designed to internalize stormwater externalities by allocating mitigation to the less expensive locations, improving economic efficiency while maintaining hydrologic performance.

Despite their growing adoption, the efficacy of stormwater volume credit trading remains uncertain. Most programs rely on modeled runoff reductions based on standardized design storms or long-term average rainfall assumptions. However, urban precipitation exhibits substantial spatial and temporal variability. This variability challenges the assumption that stormwater retention credits are fully fungible across space and time. If rainfall heterogeneity affects runoff generation unevenly, credits generated in one location may not reliably offset impacts elsewhere, potentially undermining environmental outcomes.

This study evaluates the hydrologic robustness of the Washington D.C. Stormwater Retention Credit Trading Program under spatially and temporally variable rainfall conditions. Using NOAA Atlas-14 Point Precipitation Frequency Estimates as a baseline for regulatory design storms, the analysis compares modeled retention performance under Atlas assumptions with runoff outcomes derived from high-resolution rainfall variability scenarios. The study assesses how rainfall heterogeneity affects offset reliability at the sewershed scale.

By linking environmental economics with urban hydrology, this research examines whether rainfall variability introduces uncertainty into stormwater credit markets. If precipitation patterns differ meaningfully from Atlas-based design assumptions, credits generated in one location may not consistently offset hydrologic impacts elsewhere. This has implications for credit fungibility and the credibility of market-based stormwater compliance tools.

As municipalities increasingly rely on decentralized green infrastructure and market-based compliance mechanisms to meet stormwater regulations, understanding the limits of credit fungibility is critical. This research provides evidence to inform the design of stormwater trading programs that are not only economically efficient, but also hydrologically reliable in a changing climate.

Keywords: Stormwater credit trading, Credit fungibility, Urban hydrology, Environmental economics, Rainfall spatial variability

 