Urban Hydrology and Ecology Restoration – Feasibility Modeling

City of Austin Watershed Protection Department

Introduction

Large portions of Austin, TX were developed before adequate stormwater regulations were in place. As a result, streams in these areas have degraded significantly and exhibit higher erosion, more flooding and lower aquatic life scores. Modeling efforts have demonstrated that these issues will be mitigated through improved development regulations but this does nothing to address existing problems. The City maintains a program to build traditional regional stormwater controls in areas without existing controls but land is often unavailable or prohibitively expensive for cost-effective retrofits.

To address this problem, the City is considering implementing the Urban Hydrology and Ecology Restoration project (UHER) using distributed controls in partnership with private land owners primarily in the form of rainwater cisterns and rain gardens. Partners will be encouraged to join this program through public education. The goal of the project is to move the hydrology of the streams closer to an undeveloped state to help restore stream ecology and function. The primary metrics of success will be increased baseflow and reduced flashiness.

Objectives

The primary objectives of this project were:

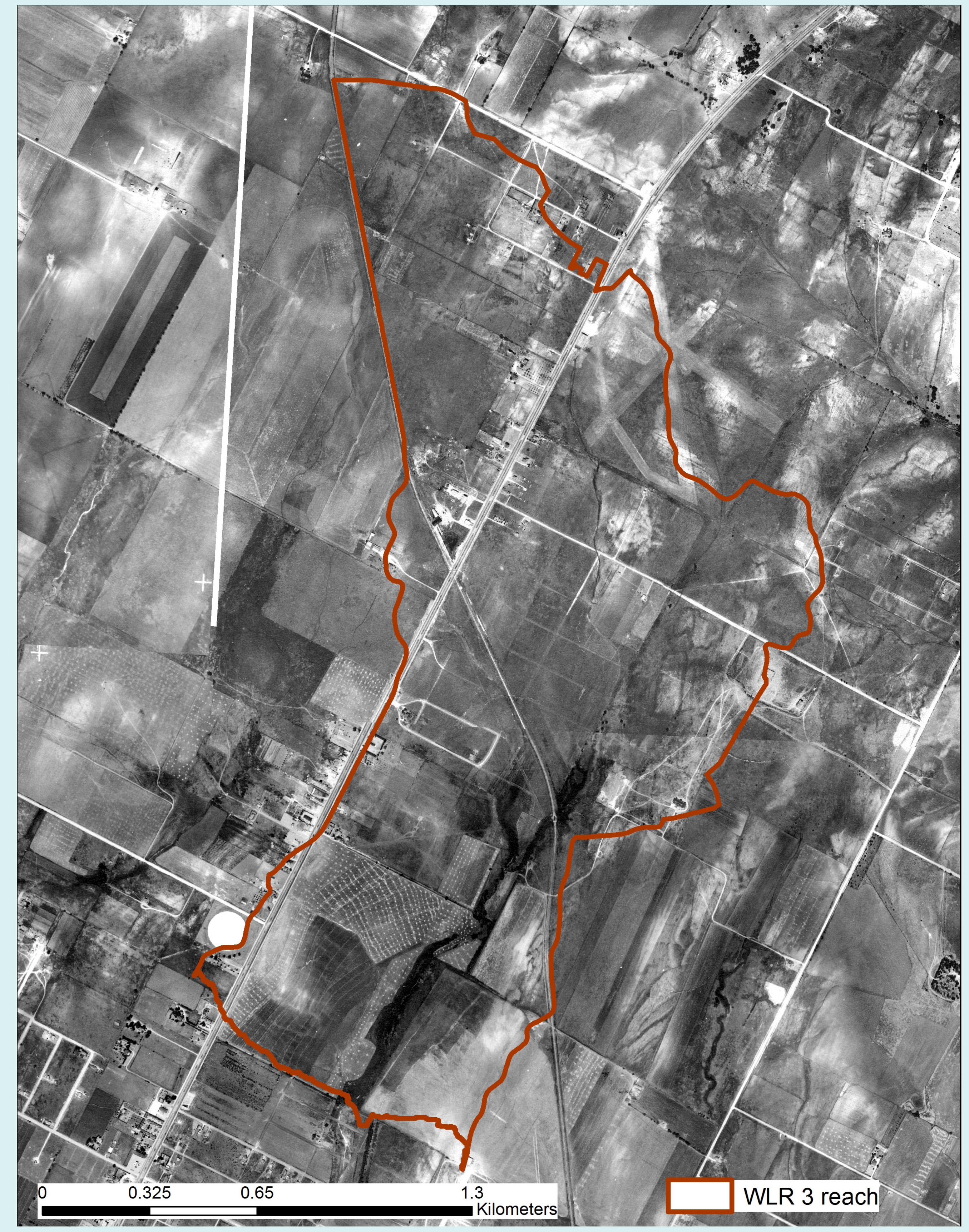
- Determine the current hydrologic state of the upper Waller Creek watershed.
- Determine the hydrologic state of the watershed under different levels of effective impervious cover.
- Determine if widespread implementation of decentralized controls will shift the hydrologic state of the watershed to a lower effective impervious cover condition.

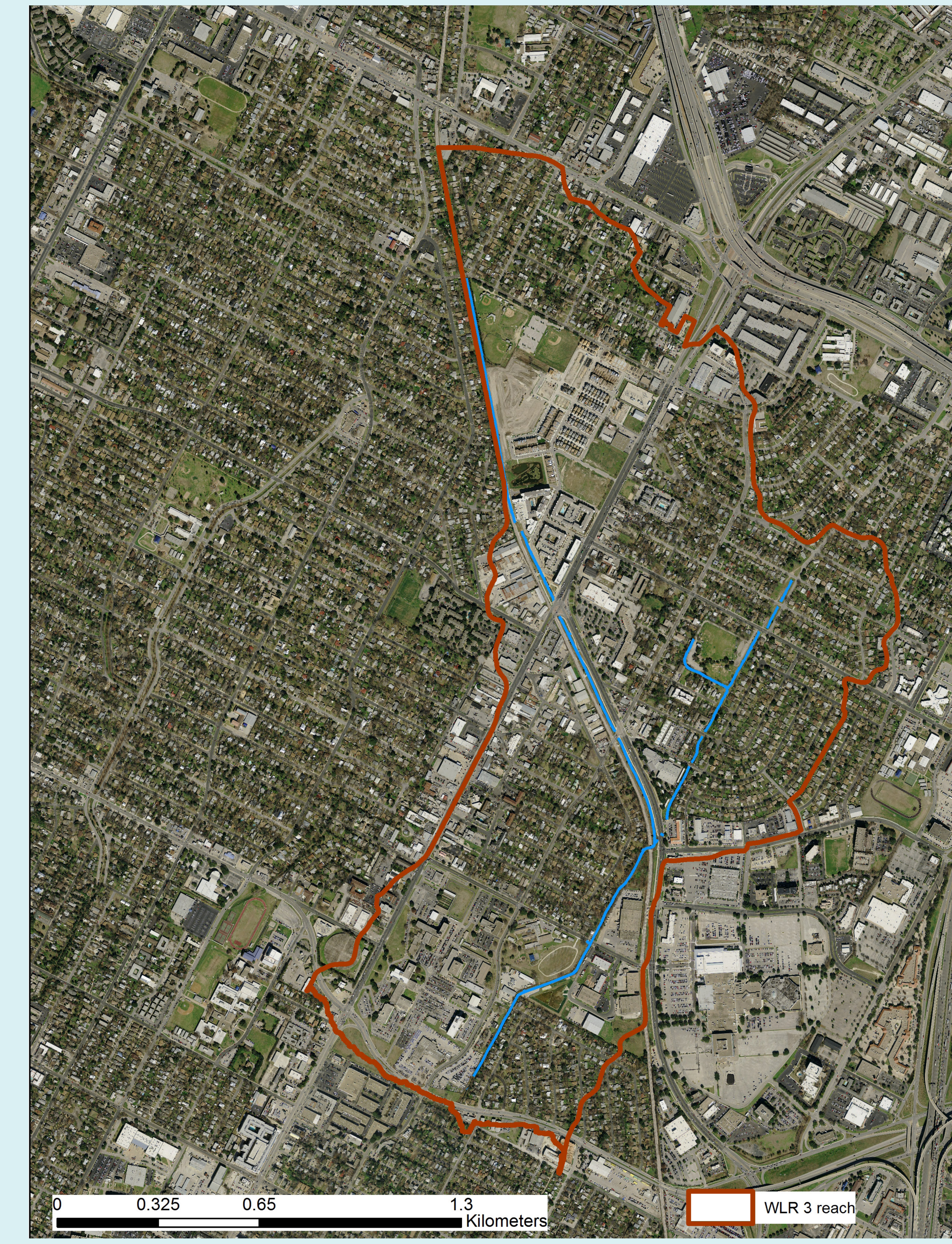
Methodology

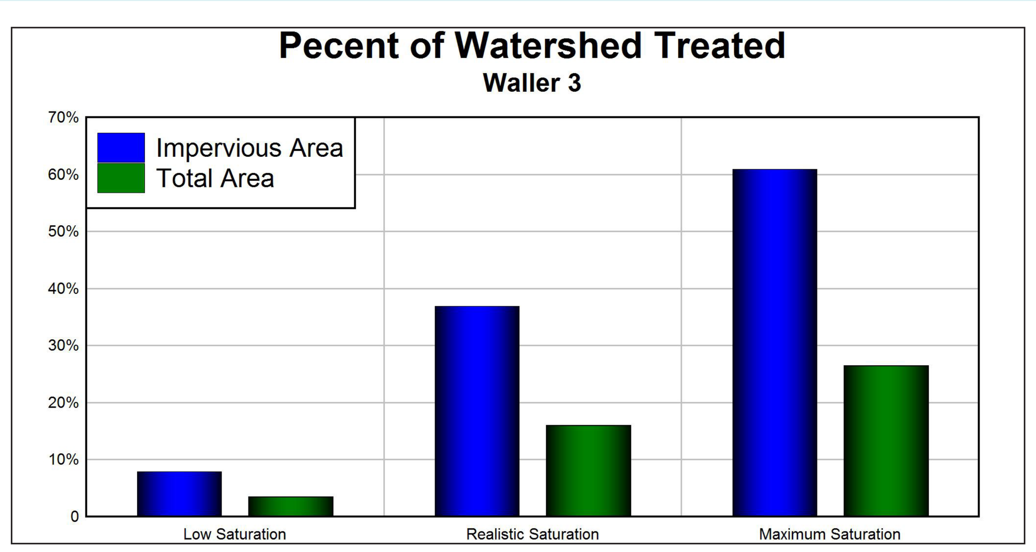
A SWAT model for Upper Waller Creek was developed using 2003 land use data and calibrated using USGS gage data. Flow was simulated for 26 years (1989-2015) based on the 2003 land use. Nine hydrologic metrics were computed to characterize the current hydrologic state.

The land use in the model was modified to create eight uniform levels of impervious cover (IC). These were used to simulate effective impervious cover. The models were rune for the same time periods and the same hydrologic metrics were computed.

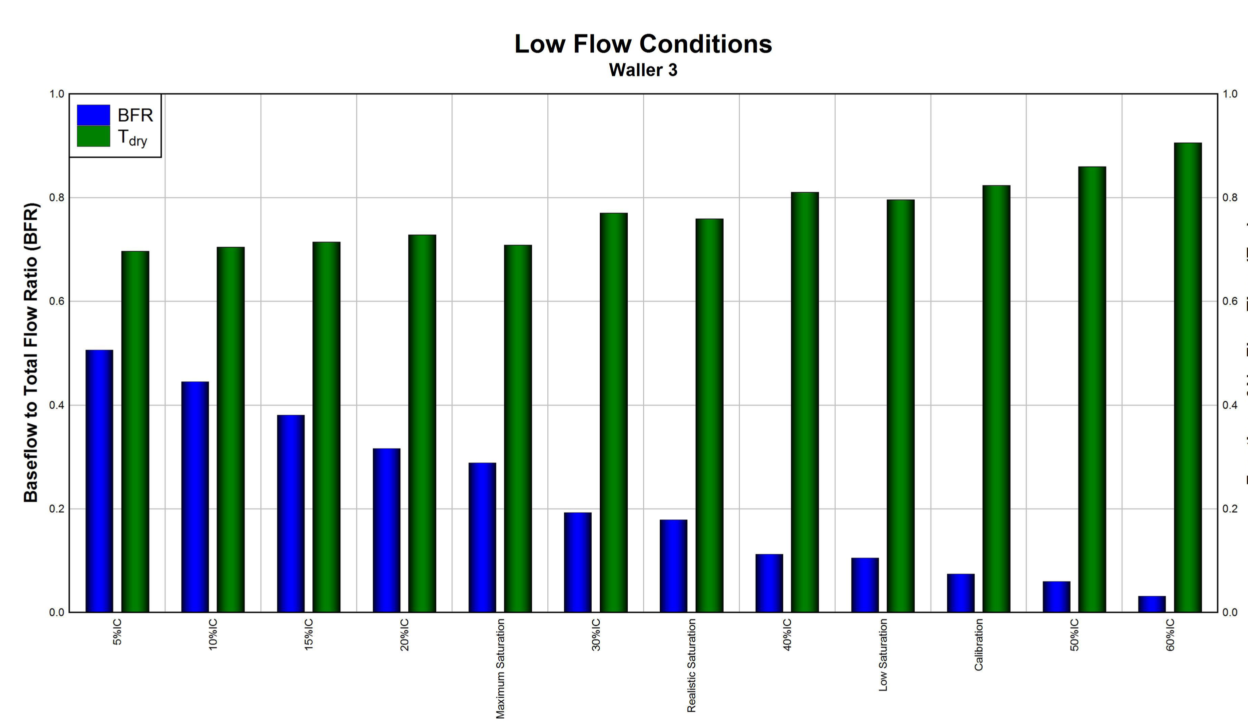
Three different levels of distributed control implementation were applied to the calibrated model; low, realistic and maximum. These models were run for the same time period and the same hydrologic metrics were computed.

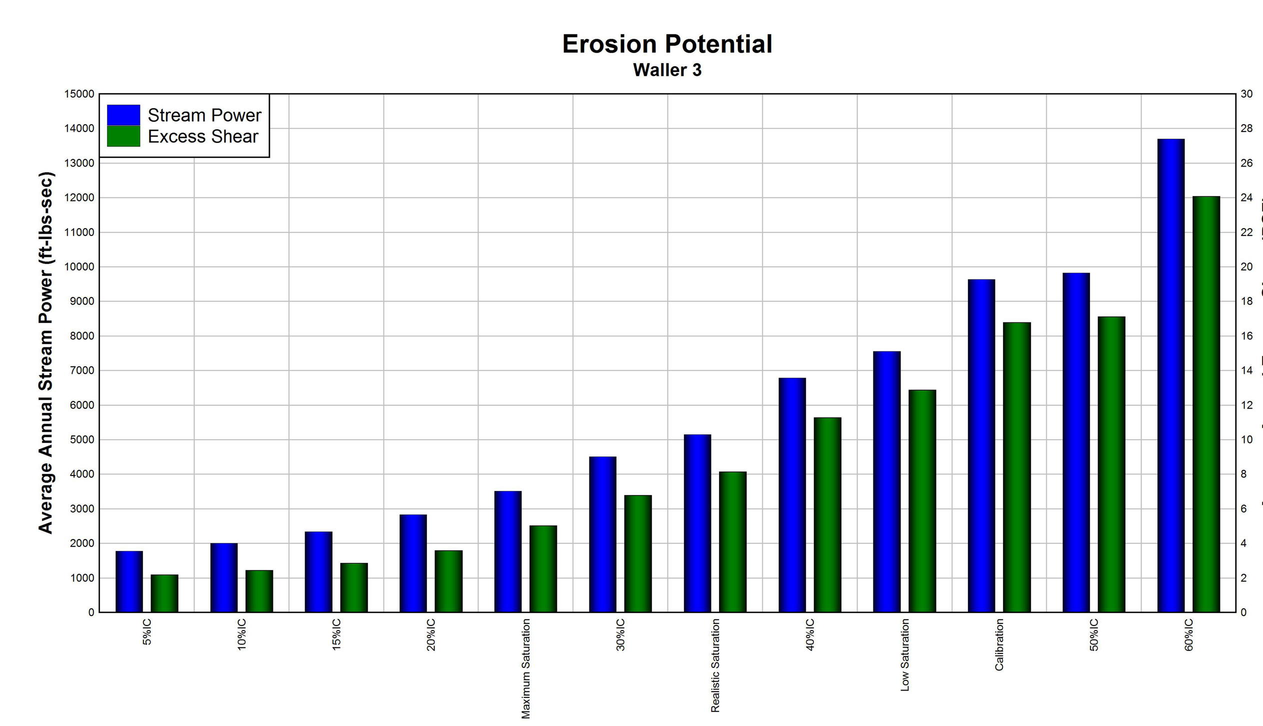


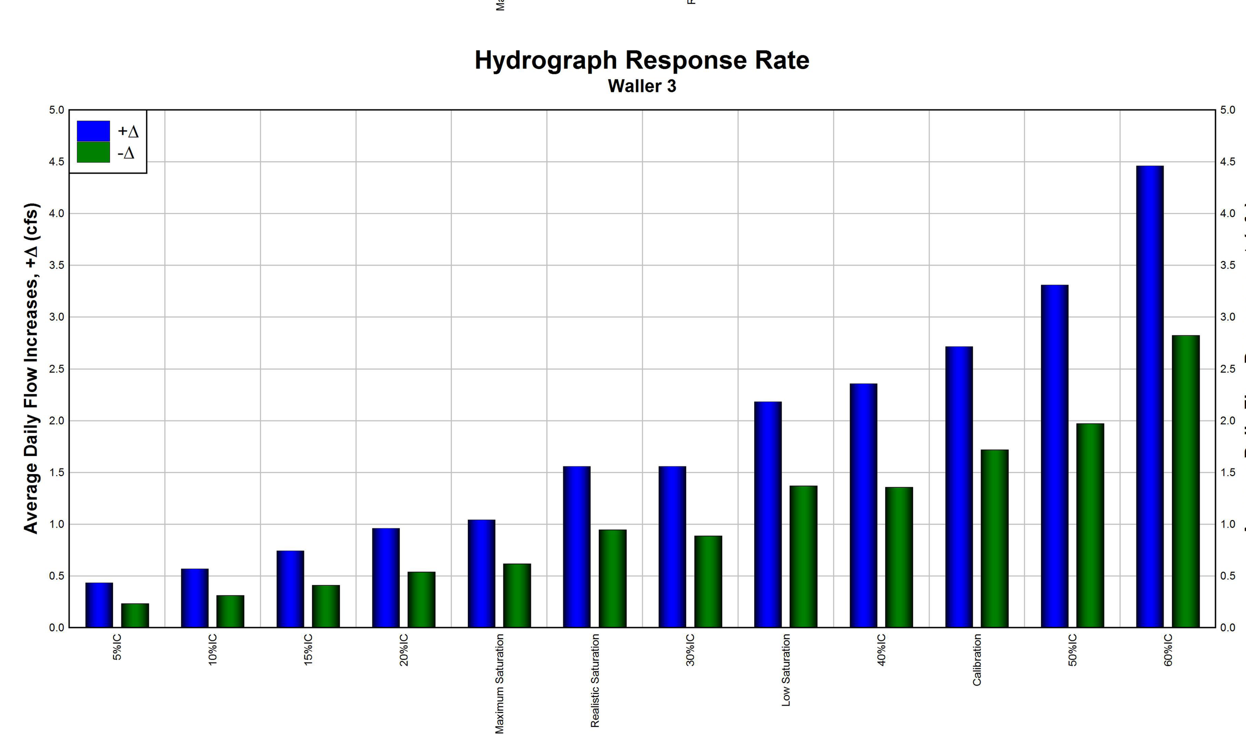


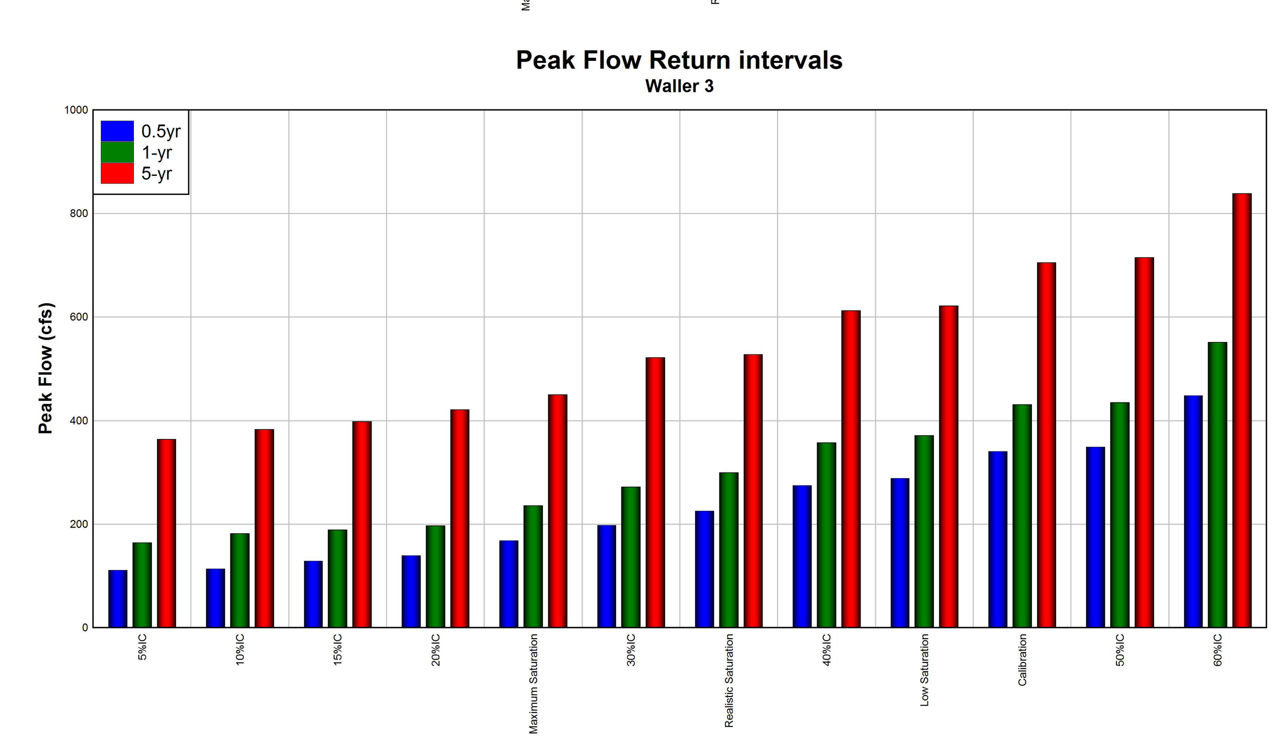


Hydrologic Variable	Units	Description
BFR	---	The ratio of storm flow to baseflow.
Tdry	---	The fraction of time the flow is less than 0.1 cfs
+Δ	cfs	The mean of all positive differences between consecutive daily values
-Δ	cfs	The mean of all negative differences between consecutive daily values
Stream Power	Ft-lbs/sec	The average annual stream power
Excess Shear	PSF	The average annual shear in excess of the critical shear, based on d50=16mm
0.5-yr	cfs	The peak flow rate associated with a 6-month return interval.
1-yr	cfs	The peak flow rate associated with a 1-yr return interval.
5Yr	cfs	The peak flow rate associated with a 5-yr return interval.









Results and Conclusions

The improvements to the SWAT model make it applicable for urban hydrologic simulation and it does a reasonable good job of simulating the existing conditions. As expected, increases in IC result in less baseflow and a flashier runoff. Erosion and peak flows also increase. Unexpectedly, the fraction of the time the creek is dry did not change greatly with increase IC up to 40% (~0.7 to 0.8). This is likely due to the small size of the watershed, would normally be dry for significant periods even in an undeveloped state, making this a poor metric for evaluation.

Low level implementation of cisterns and rain gardens had a marginal effect on the metrics, reducing the effective IC from ~45% to 40%. The realistic implementation scenario reduced the effective IC to roughly 30% while maximum saturation of cisterns and rain gardens resulted in an effective IC of ~20%.

The feasibility modeling demonstrated that wide spread implementation of decentralized controls could improve hydrology for aquatic life, reduce erosion potential and reduce the peak flows for frequent flood events. This may viable be a solution for urban retrofits in areas with limited opportunities of traditional centralized controls