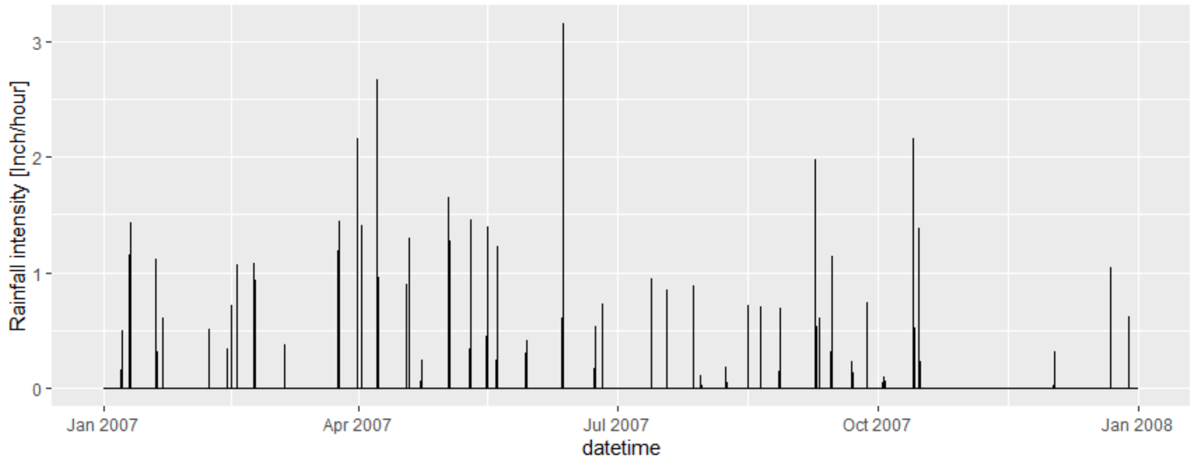
Toolbox for optimizing bioretention cell surface and drainage areas

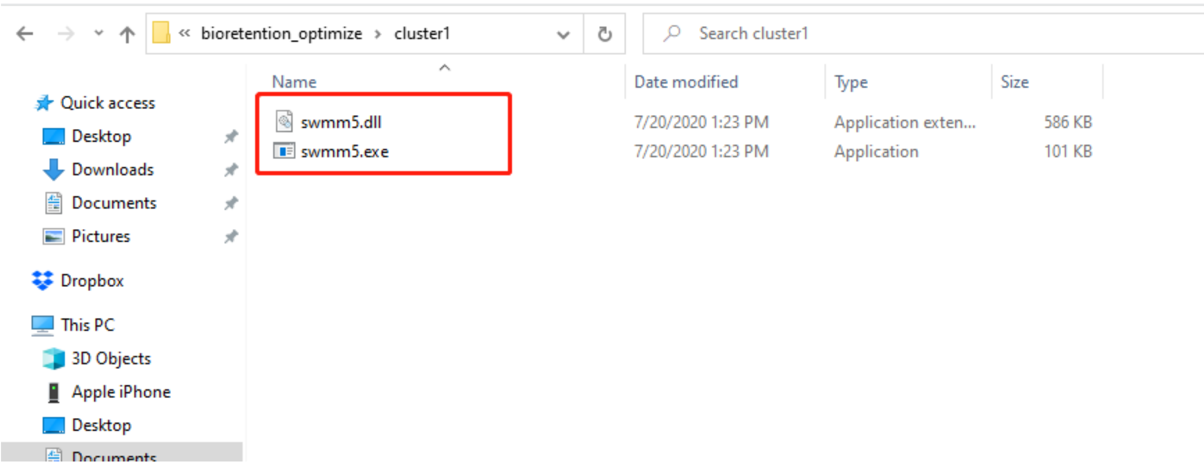
This document explains the code used in the paper "Optimizing surface and contributing areas of bioretention cells for stormwater runoff quality and quantity management" (https://doi.org/10.1016/j.jenvman.2017.11.064).

The code works on the Windows platform. EPA SWMM build 5.1.015 is used for modeling the hydrological processes of bioretention cells (https://www.epa.gov/water-research/storm-water-management-model-swmm).

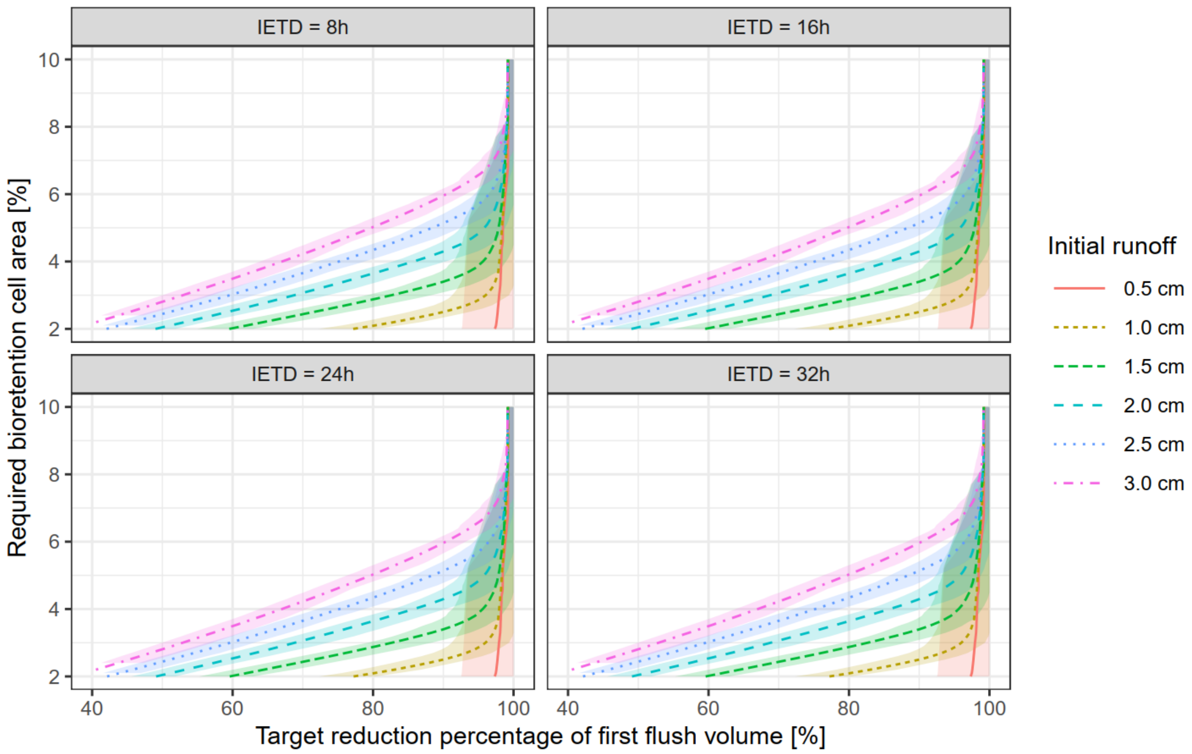
1. "generate_rainfall.R" contains the code to generate random rainfall time series. The rainfalls are considered as a superposition of some "base rainfalls" with varying peak intensity, duration, and occurring time. The rainfall generation process is controlled by a few parameters. The randomly-generated rainfalls are stored at the "./data" folder. The following figure shows an example of a randomly generated storm for a year.



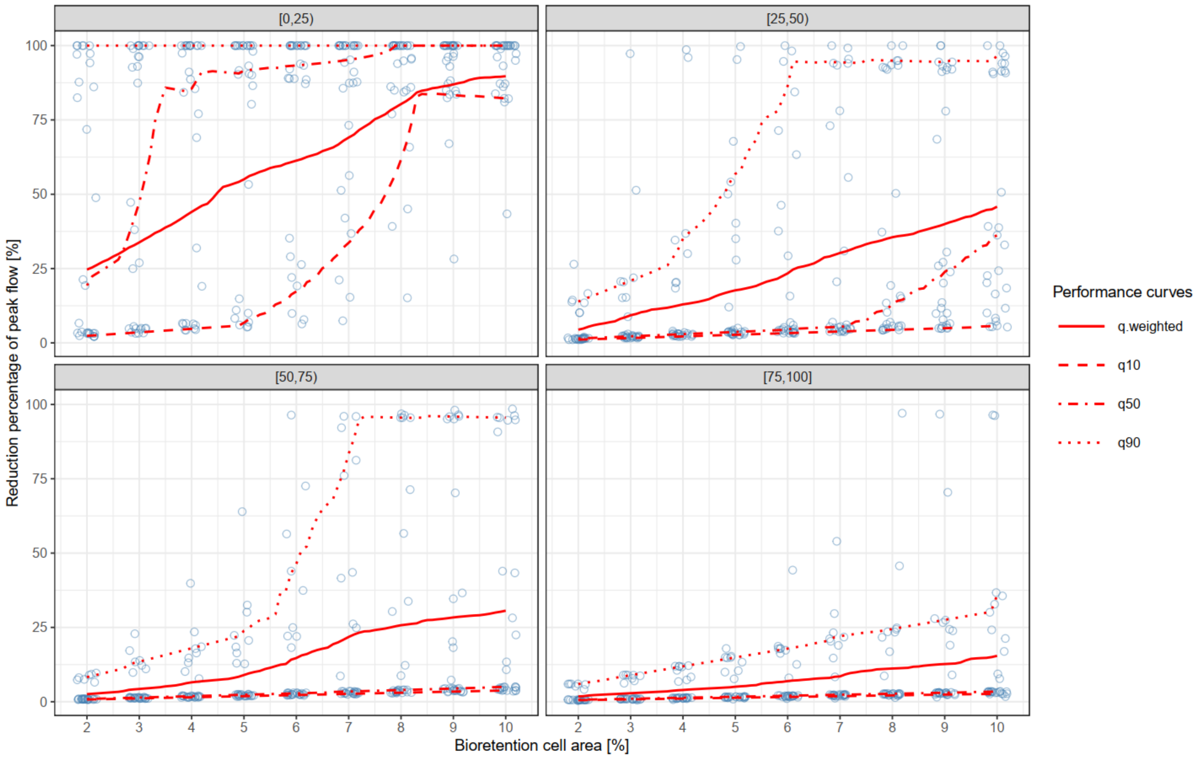
2. SWMM is used as the computational engine, and the simulations are taken place inside "cluster" folders. Thus, the "swmm5.dll" and "swmm5.exe" files should be copied to each cluster folder (shown as the figure below).

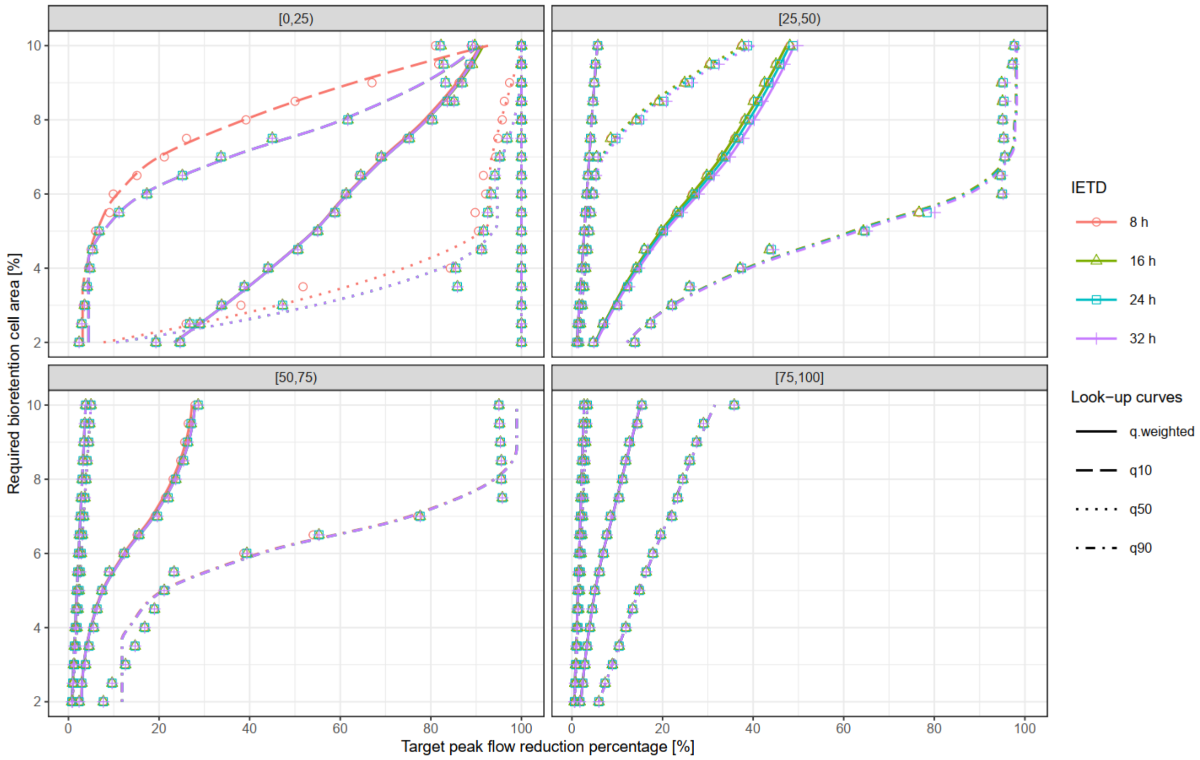


3. “main_controller.R” provides functions to write SWMM input files, execute SWMM simulations, and post-processing simulation results. The input files are stored insider the “input_files” folder, and the simulation results of each year are stored inside “results” folder. SWMM file modification is achieved with the help of the “swmmr” package, more specifically the “read_inp” and “write_inp” functions. The key function is the “run_swmm” function, which works together with “parLapply” function to allow SWMM simulations to be executed in parallel over different clusters. The results of each bioretention implementation scenario of each year are stored inside “results” folder, where “br**.rpt” are the SWMM report files, “ud**.txt” are the underdrain time series, “surf**.txt” are the surface runoff time series. The digits in the file name, denoted by i, correspond to different bioretention implementation scenarios, i.e., bioretention cells occupies $[(i-1)*0.1+2]\%$ of the impervious area.
4. “main_controller_none_lid.R” is similar to “main_controller.R”, and it is used for executing SWMM simulations of impervious catchments without bioretention cells. The simulation results of each year are stored inside the “results” folder. The report file is stored as “br0.rpt”. The surface runoff time series is stored as “surf0.txt”, and the underdrain flow time series is stored as “und0.txt”.
5. “first_flush_effect.R” provides functions to compute the effectiveness of bioretention cells in terms of first flush reduction. The evaluation result is stored as “figure4.pdf” and “Figure4.Rda” inside the “figures” folder. The equations used can be found in the paper mentioned at the beginning of this document.

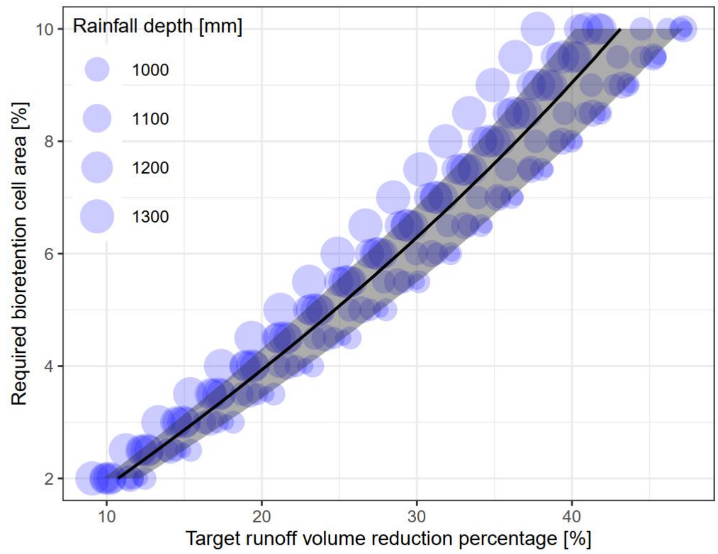


6. “peak_flow.R” provides functions to evaluate bioretention cells’ effectiveness in reducing peak flows of runoff events of different intensities. The results are stored as “figure5.pdf”, “figure6.pdf”, “Figure5.Rda” and “Figure6.Rda” inside the figures folder. The methods are explained in detail in the paper mentioned at the beginning of this document.

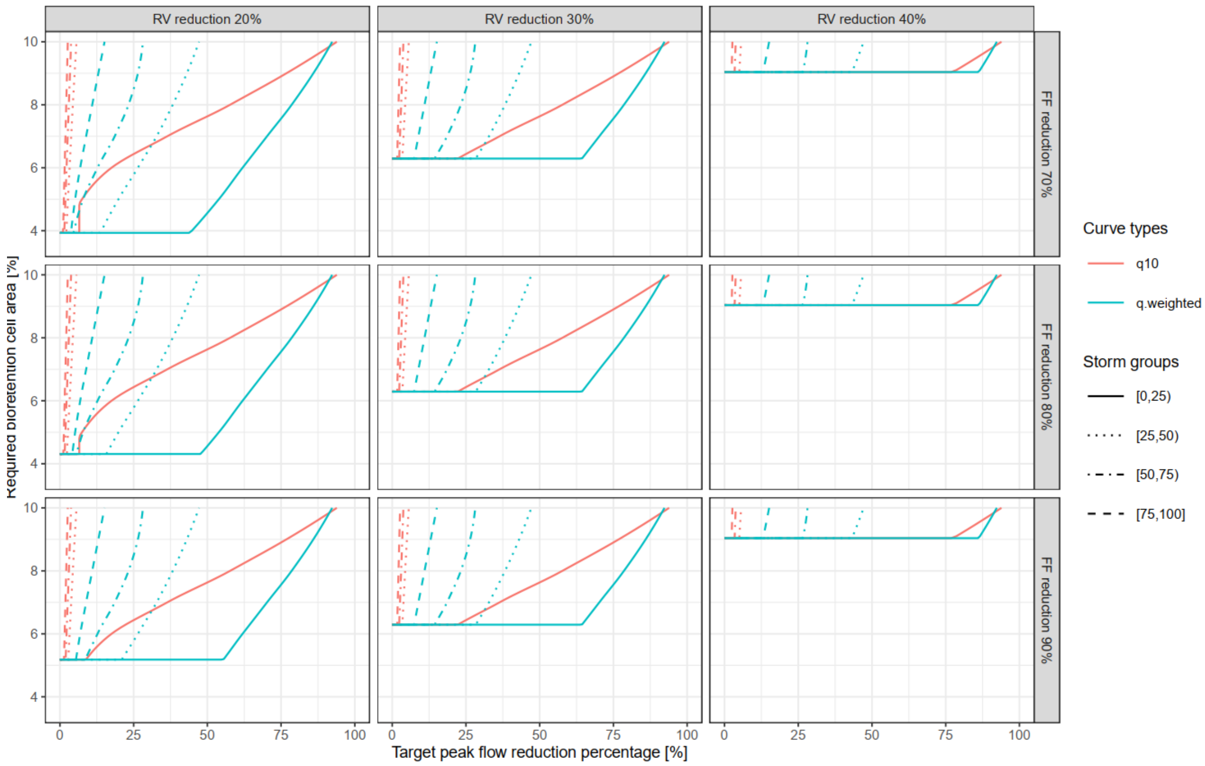




7. “surface_runoff.R” contains functions to calculate runoff volume reductions of bioretention cells of different surface areas in different years. The results are stored as “figure7.pdf” and “Figure7.Rda” inside the “figures” folder.



8. “performance curve.R” contains functions to derive look-up curves for determining the required surface areas of bioretention cells that simultaneously satisfy the first flush, peak flow, and runoff volume reduction requirements. The “modelr” package is used to fit many LOESS models that correspond to different stormwater management requirements. The data used to build the models are stored inside “figures/overall_results.csv”, which are derived from the evaluation result for individual requirements (first flush reduction, peak flow reduction, and runoff volume reduction). The results are stored as “figure8.pdf” and “figure8.Rda” inside the “figures” folder.



9. “Optimization.R” contains functions to determine the optimal bioretention cell surface areas under different management interests. The data inside “figures/overall_results.csv” are used

to fit LOESS models. An exhaustive search method is used to determine the optimal solution. The results are stored as “figure9.pdf” and “figure9.Rda” inside the “figures” folder. Please refer to the paper for more details.