A Multi-Objective Optimization Tool for Green Infrastructure Planning

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Introduction
Sustainable urban planning requires the consideration of both community needs and environmental impacts. Green infrastructure or low impact development (LID) can reduce combined sewer overflows (CSOs) while providing other community benefits. To distribute LIDs efficiently, the Buffalo Sewer Authority and University at Buffalo are developing a new multi-objective Stormwater Management Model (SWMM) optimization tool. The tool, OSTRICH-SWMM, was applied in case studies regarding the placement of rain barrels (RBs) in Buffalo catchments.

OSTRICH, the Optimization Software Toolkit for Research Involving Computational Heuristics
- Model independent
- Wide variety of single and multi-objective optimization (MOO) algorithms

SWMM
- Dynamic rainfall-runoff simulation model commonly used to model LIDs
- Full Buffalo sewer system model is being developed and calibrated (Fig. 1)

OSTRICH-SWMM
- Python package that links OSTRICH operations with SWMM inputs/outputs
- Adds new LIDs to the SWMM input
- Adjusts the original subcatchment’s area and percent impervious
- Parses the binary SWMM output file
- Produces the optimal arrangement of LIDs that will minimize the number of CSO events (NCSO), the total CSO flow volume (FVOL), or any other objective defined in OSTRICH

Rain Barrel Case Study
OSTRICH-SWMM was used to optimize the distribution of 75 gal (284 L) RBs in a submodel extracted from the full Buffalo SWMM model. This submodel has 163 subcatchments contributing to one CSO outfall (Fig. 3). Without LIDs, 29 CSO events occur at this outfall during the typical rainfall year 1993.

Example Multi-Objective Optimization (MOO) Problem
Minimize NCSO and COST
Subject to: \( g = \sum_{i=0}^{n} \max(RB) - NRB = 0 \)
Where \( COST' = 150 \sum_{i=0}^{n} NRB \)
\( n \) = number of subcatchments, \( NRB \) = number of RB in each subcatchment, and \( \max RB \) = maximum NRB for each subcatchment

Optimization Algorithm
The Pareto Archived Dynamically Dimensioned Search (PADDS) was used to find the optimal RB arrangement. PADDS is a type of continuous global optimization that uses a neighborhood search and an archive of non-dominated solutions to produce a Pareto front.

Case Study Results

Conclusion
- Implementing RBs with downspout disconnections in urban areas can effectively reduce NCSO and/or FVOL
- The continued development of OSTRICH-SWMM as a MOO tool shows promise
- Future work will involve adding more types of LIDs to OSTRICH-SWMM

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