Pittsburgh Water & Sewer Authority

APPENDIX B
SWMM LID SENSITIVITY ANALYSIS

Prior to the PWSA City-Wide Green Infrastructure Assessment, a modeling sensitivity analysis using the SWMM Low Impact Development (LID) tool was conducted within the A-22 Sewershed. The following sensitivity analysis was originally part of previous study called the Shadyside/A-22 Flooding Assessment. The Shadyside/A-22 Flooding Assessment served as modeling "test bed" for many of the approaches carried forward as part of the larger City-Wide GI Assessment including the Arc Hydro Analysis and the SWMM LID approaches. The SWMM LID tool sensitivity analysis was performed using a subset of SWMM subcatchments in the A22 sewershed. The findings herein are expected to be consistent and scalable when modelled as part of full City-Wide Green Infrastructure Assessment within other sewersheds throughout the City.

The subcatchments selected for the sensitivity analysis were located within the Shadyside neighborhood of the City of Pittsburgh. The primary reason these subcatchments were selected was due to their proximity to a historical basement and street flooding complaint area. Figure 1 shows the subcatchments in the Shadyside area used for the SWMM LID Tool sensitivity analysis.

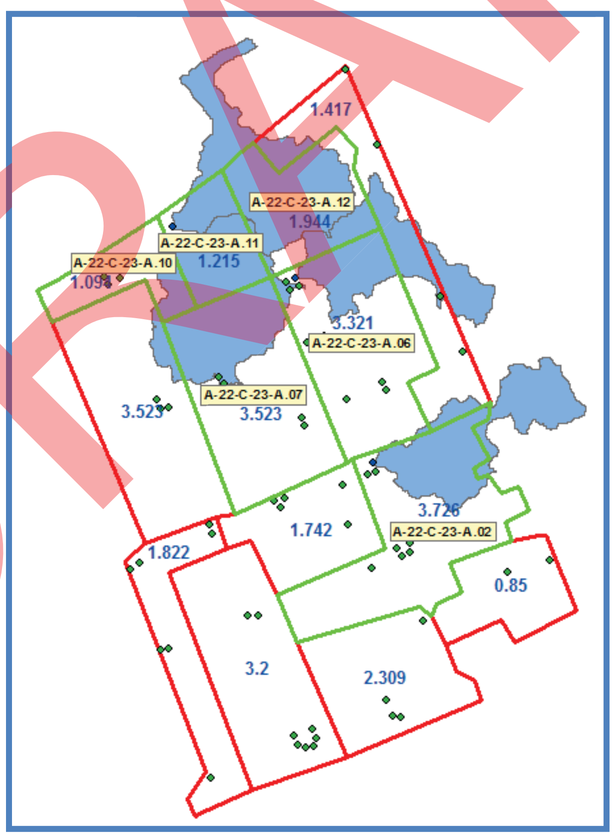

Figure 1: Subcatchments Selected for the SWMM LID Tool Sensitivity Analysis (Subcatchments shown in green – SWMM LID BMP areas shown in blue)

The SWMM LID Tool allows for the simulation of various GI technologies including rain gardens, infiltration trenches, bioinfiltration, bioswales, and rain barrels/cisterns directly within the hydraulic model. Each GI technology within the LID Tool has varying functional components based on the technology simulated. For this study all GI was simulated using rock filled infiltration trenches. Infiltration trenches were selected since this GI type allows for the high rate transfer of runoff to a subsurface storage facility. Infiltration trenches within the SWMM LID Tool provide the ability to quickly transfer high rate runoff to a subsurface storage layer allowing for the necessary detention of the peak flows, whereas the other GI technologies within SWMM LID Tool do not offer this capability.

Using the infiltration trench as the standard GI technology within the SWMM LID Tool, the following modeling parameters were evaluated as part of the sensitivity analysis:

- GI Size (0.75, 1.0, 1.5, 2.0 inches) of runoff captured
- Infiltration Rate (0.05, 0.10, 0.25, 0.50 in/hour)
- GI Return Time (24, 36, 60, 72 hours)
- Underdrain Height Offset (0, 6, 8, 12 inches)

The parameters listed above were then run in singular independent simulations for the observed August 31, 2014 flooding rainfall event to observe the relative change in peak flow and runoff in comparison to the baseline scenario (existing conditions with no LID). This equated to a total of 32 independent SWMM LID Tool simulations within the sensitivity subcatchments. The results from this analysis are shown in Table 1. A key observation from each parameter is included in the Table.

From the results presented in Table 1, it was determined that the following parameters would be carried forward for the full SWMM LID tool within the entire A22 sewershed:

- GI Size (0.75, 1.0, 1.5, 2.0 inches) of runoff captured
- Infiltration Rate (set constant at 0.10 in/hour)
- GI Return Time (24 and 72 hours)
- Underdrain Height Offset (set constant at 6 inches)
- All GI in the full A22 simulations would be modeled using infiltration trenches in the SWMM LID Tool to provide for the needed storage, detention and slow release functionality.

TABLE 1
SENSITIVITY ANALYSIS RESULTS USING THE SWMM LID TOOL FOR AUGUST 31, 2014 OBSERVED RAINFALL EVENT

Model Simulation	Model Parameter Values	Total Runoff Volume (Gal)	Delta Total Runoff Volume (Gal)	Total Infiltration Volume (Gal)	Delta Total Infiltration Volume (Gal)	Peak Runoff Volume (MGD)	Delta Peak Runoff Volume (MGD)	Runoff Volume Delayed (Gal)	Delta Runoff Volume Delayed (Gal)	Key Observation From Analysis of Parameter
Existing Conditions		69,846		0		3.320		88		
GI Size (inches)	0.75	67,544	-2,302	2,302	+2,302	3.097	-0.222	17,490	+17,402	GI Size has influence on Runoff Volume, Infiltration, Peak Flow, and Delay
	1.00	66,798	-3,048	3,048	+3,048	2.150	-1.169	23,046	+22,958	
	1.25	66,074	-3,773	3,773	+3,773	0.998	-2.321	28,482	+28,394	
	2.00	64,046	-5,800	5,800	+5,800	0.084	-3.236	42,979	+42,891	
Infiltration Rate (in/hr) - Assuming GI Size of 0.75	0.05	67,544	-2,302	2,302	+2,302	3.097	-0.222	17,490	+17,402	Infiltration has influence on Runoff Volume and Infiltration. But not on Peak Runoff or Delay
	0.10	65,275	-4,571	4,571	+4,571	3.096	-0.224	18,282	+18,193	
	0.25	60,656	-9,190	9,190	+9,190	3.085	-0.235	19,873	+19,784	
	0.50	55,089	-14,757	14,757	+14,757	3.066	-0.254	22,473	+22,385	
GI Return Rate (hrs) - Assuming GI Size of 0.75	24	67,544	-2,302	2,302	+2,302	3.097	-0.222	17,490	+17,402	Return Rate does not have an influence on any of the results for the August 31 Design Storm
	36	66,607	-3,239	3,239	+3,239	3.103	-0.217	18,096	+18,008	
	60	66,607	-3,239	3,239	+3,239	3.103	-0.217	18,096	+18,008	
	72	64,027	-5,819	5,819	+5,819	3.108	-0.212	18,467	+18,379	
Underdrain Height (inches) - Assuming GI Size of 0.75	0	67,544	-2,302	2,302	+2,302	3.097	-0.222	17,490	+17,402	Underdrain Height has an influence on Total Runoff and Infiltration. But not on Peak Runoff or Delay
	6	65,463	-4,383	4,383	+4,383	3.104	-0.216	17,601	+17,513	
	8	53,963	-15,884	15,884	+15,884	3.072	-0.248	22,347	+22,259	
	12	53,041	-16,805	16,805	+16,805	3.074	-0.246	22,443	+22,354	

The full A22 sewershed with the impervious area of 270 acres retrofitted for SWMM LID was then simulated with various incremental GI design rainfall depths (in inches of rainfall over the contributing impervious drainage area) and detention times (in hours stored after a single rain event). The results were then used to determine the optimal GI design to maximize typical year CSO volume reduction. The results of the model simulations are shown in Table 2.

TABLE 2
A22 TYPICAL YEAR CSO REDUCTION FOR VARYING GI DESIGN DEPTH AND RETURN TIME USING 270 AC OF IMPERVIOUS AREA RETROFITTED FOR SWMM LID

GI Size (inches)	A22 Sewershed Typical Year CSO (MG) Existing Typical Year CSO Volume at A22 = 586.1 MG			
	24 Hour Return Time		72 Hour Return Time	
	CSO Discharge (MG)	CSO Reduction (MG)	CSO Discharge (MG)	CSO Reduction (MG)
0.75	476.4	109.7	462.7	123.4
1.00	469.8	116.3	452.8	133.3
1.50	452.2	133.9	429.8	156.3
2.00	428.1	158.0	416.1	170.0

Based on the results in Table 2, it was determined that 1.5-inch capture design detained for 72 hours was the optimum GI design size and was recommended to carry forward for future sewershed modeling analysis.

Analysis of the typical year rainfall and CSO activations at A-22 further confirm the 1.5-inch GI design. Figure 2, shows the 91 rainfall events during the typical year versus the modeled CSO volume activation at A-22. Capturing and detaining up to the 1.5-inch rainfall event would represent approximately 95.6% of the rainfall events in the typical year. Similar rainfall to CSO activations have also been observed in other sewersheds.

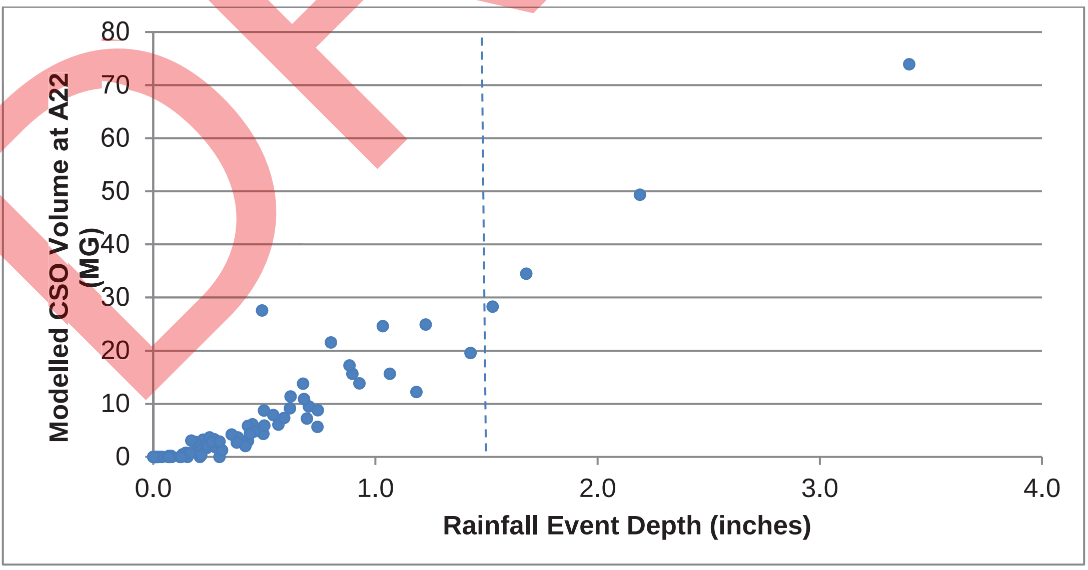

Figure 2: Relationship of Rainfall Event Size and CSO Volume at A22 (Existing Conditions)