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Technical Memorandum

To: Jessica Wilson and Ross Bintner, City of Edina
From: Sarah Stratton and Cory Anderson, Barr Engineering Co.
Subject: Appendix E - Imperviousness Sensitivity Analysis
Date: March 30, 2020
Project: Edina Flood Risk Reduction Strategy Support (23271728.00)

Executive Summary

Barr was asked to review model-predicted flood impacts in the focal geography of the Morningside neighborhood, and to review the sensitivity of those impacts to the magnitude of imperviousness (the hard surfaces that prohibit water infiltration). For reference, the impervious area that is directly connected to the storm sewer system in the Morningside neighborhood is estimated to be about 25% of the total land area, in aggregate (Figure 1). The directly connected imperviousness is the portion of the watershed that is impervious and routes flow directly to an outlet (catch basin, pond, depression, outlet, etc.). Some prominent examples of this type of imperviousness in a low-density residential neighborhood tend to be streets, parking lots, driveways, water bodies (i.e., Weber Pond), portions of roofs with gutters and downspouts directed to impervious surfaces such as a driveway, etc.

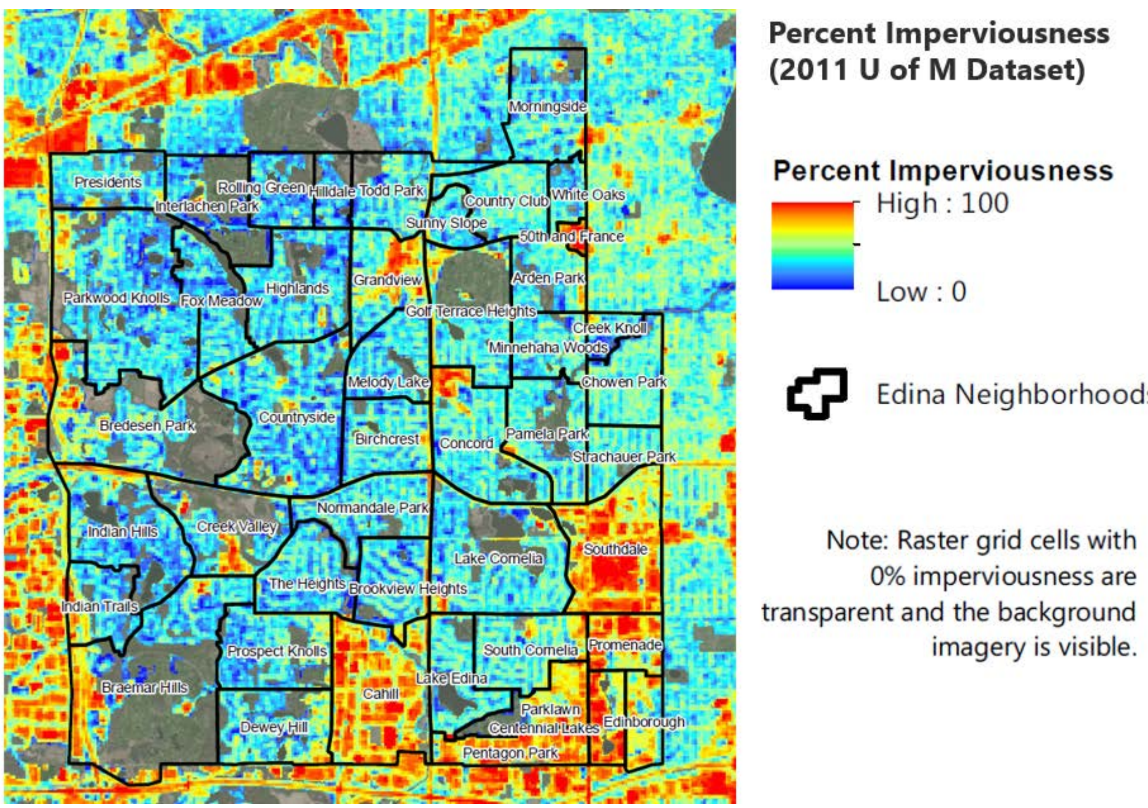

Figure 1 Imperviousness raster data set from the University of Minnesota. The Morningside neighborhood is in the northeast corner.

Barr tested the sensitivity by modifying the stormwater model so that the imperviousness of the entire contributing drainage area was increased, decreased, and even lowered all the way to 0%, which reflects a pre-development condition. This sensitivity test was also completed for a range of storm events, from the 20%-annual-chance storm event (5-year storm) to the 1%-annual-chance storm event (100-year storm). As expected, the imperviousness sensitivity test showed that less impervious area generates less stormwater runoff and more impervious area generates more stormwater runoff. However, the magnitude of the runoff changes generated by adjusting imperviousness were not as impactful as may have been expected.

For reference, in the Weber Pond subwatershed, the 1%-annual-chance storm event (100-year storm) flood level would need to be reduced by just over 4 feet in order to remove the 5 lowest homes from potential structural impacts from flood inundation. Based on Barr's imperviousness analysis, reducing or increasing impervious area by half (50%) tends to cause the peak water level to decrease or increase by up to approximately half a foot. This effect is more significant for small storm events, and less so for larger storm events. While affecting the flood level by half a foot may seem like a big gain, this change removed one impacted home at most from the flood inundation area around Weber Pond. Again, to achieve even this low level of impact, the entire contributing area (all of the Morningside neighborhood) would be required to reduce imperviousness by half (i.e., road widths are cut in half, driveway widths are cut in half, roof area cut in half and/or downspouts

Imperviousness Sensitivity Analysis Details

The sensitivity analysis focused on design storm events (NOAA Atlas 14, MSE3 temporal distribution) rather than an observed historical event(s). Modeled design storm events included the 5-year (3.59 inches), 10-year (4.29 inches), 50-year (6.39 inches), and 100-year events (7.49 inches), all 24-hour durations (i.e., for a 100-year storm event, 7.49 inches fall over a 24-hour period of time).

Imperviousness parameter values were adjusted relative to "base case" values from the stormwater model. In general, the "base case" imperviousness parameter values were adjusted to +50%, +25%, -25%, -50%, and finally a "low" case to attempt to significantly reduce runoff. The range of values for each of the sensitivity cases is listed in Table 1. Most of the Morningside neighborhood is "low density residential"; for simplicity, only the values for this land use type is presented in Table 1. All other land use types, with varying imperviousness were similarly adjusted upward and downward for this sensitivity analysis.

Table 1 Imperviousness parameter values for the sensitivity analysis

Parameter	Low Case	-50%	-25%	0% (Base)	+25%	+50%
Directly Connected Percent Impervious[1]	0% [2]	~13%	~19%	~25%	~31%	~38%

1) Only the value for "low density residential" is shown here, as this covers most of the model area. All land use types were similarly modified for each of the sensitivity cases (-50%, -25%, etc.)

Subwatersheds in the Morningside neighborhood are shown in Figure 2.

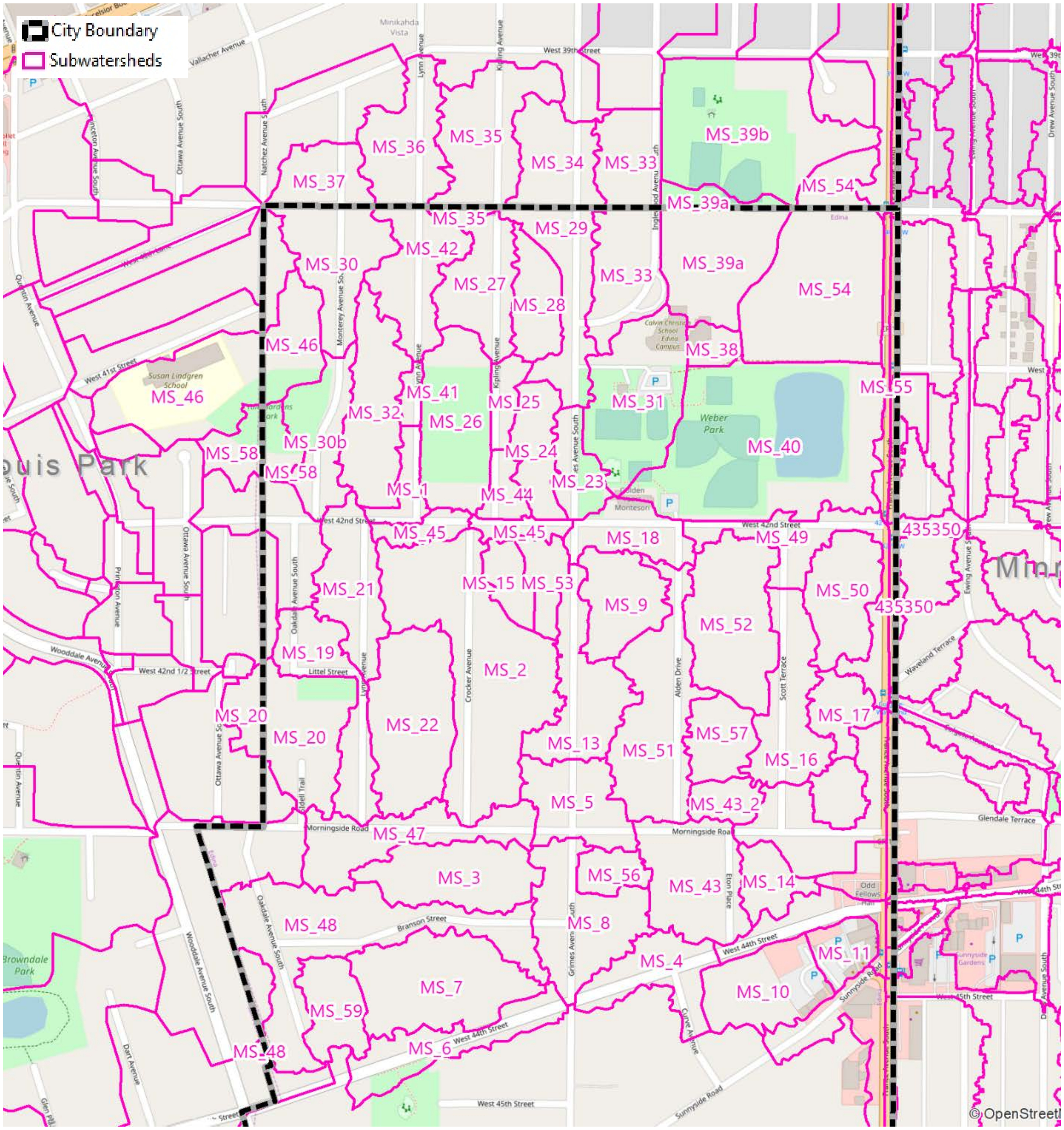

Figure 2 Map showing subwatershed divides in and around the Morningside neighborhood

The directly connected impervious percentage tends to have an impact up to ±0.5 feet for the ±50% change in the base value. Example graphs are included that show the results for Weber Pond (MS_40, Figure 3), for the low area between Lynn Avenue and Kipling Avenue, north of West 42nd Street (MS_26, Figure 4), and for a landlocked subwatershed (MS_22) between Lynn Avenue and Crocker Avenue, south of West 42nd Street (Figure 5).

In these figures, the horizontal, maroon-dashed lines represent approximate low elevations based on structure footprints for the five lowest homes around Weber Pond. They may or may not represent actual low entry elevations of these homes. However, they give a good representation of the home elevations and how close they are to the flood levels.

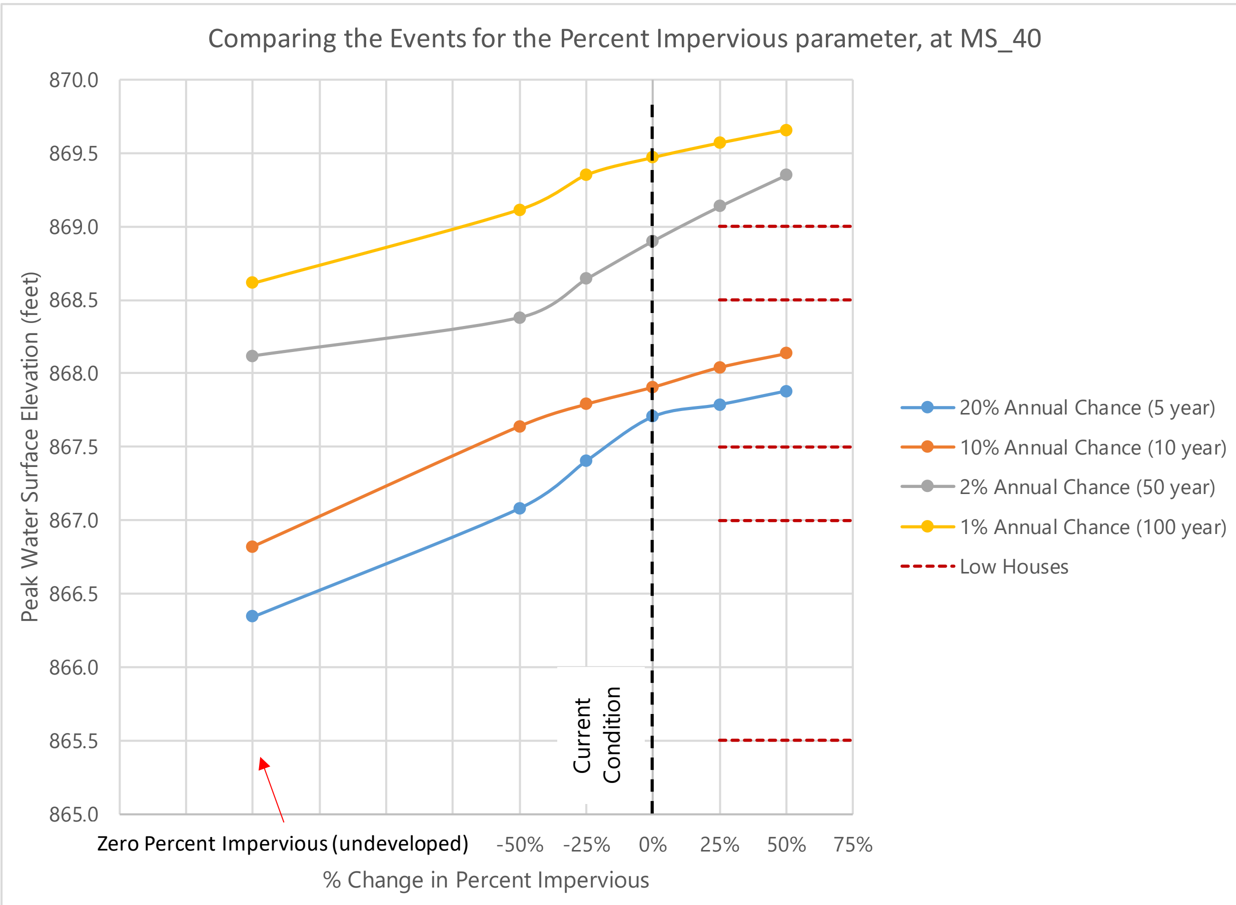

Figure 3 Sensitivity analysis results showing peak flood levels in Weber Pond (subwatershed MS_40) for a range of imperviousness and a range of storm events.

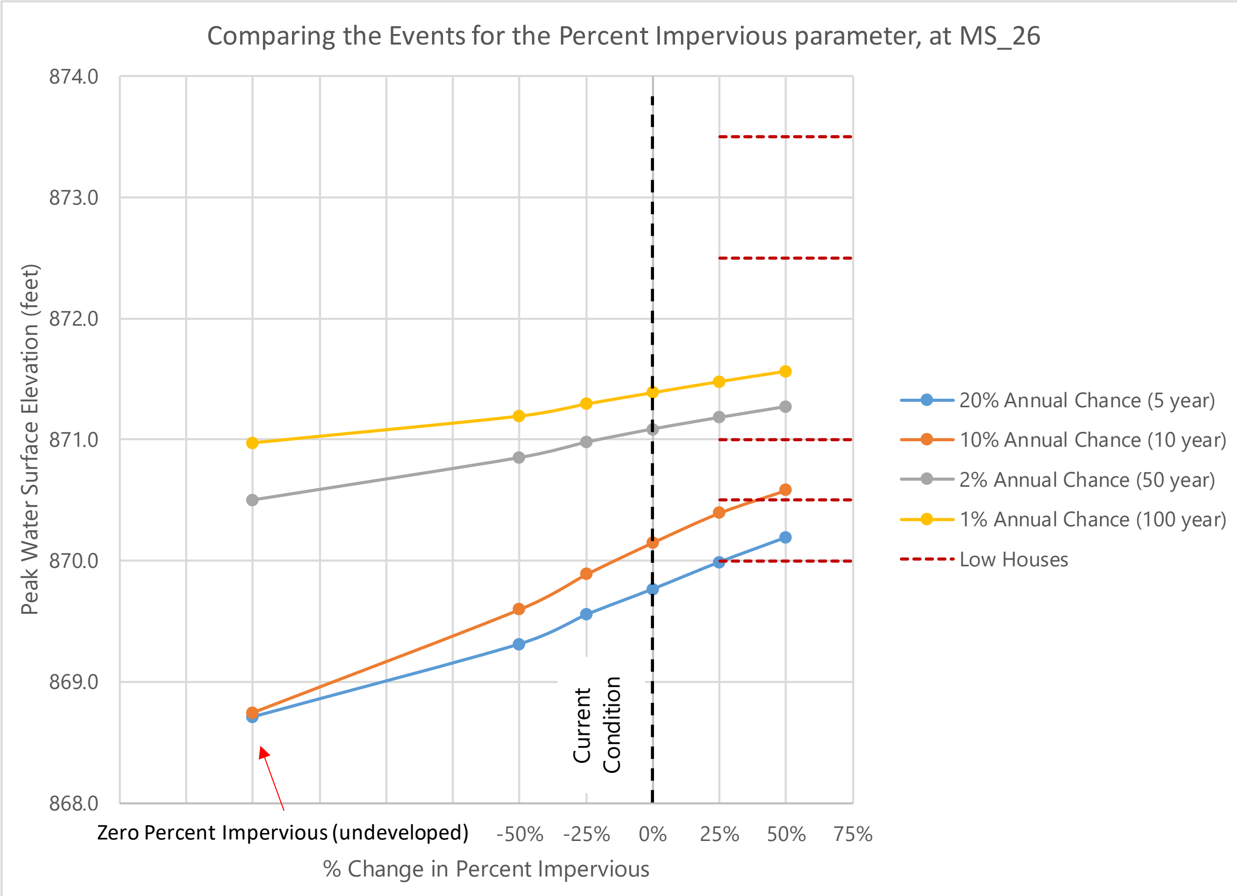

Figure 4 Sensitivity analysis results showing peak flood levels in MS_26 for a range of imperviousness and a range of storm events.

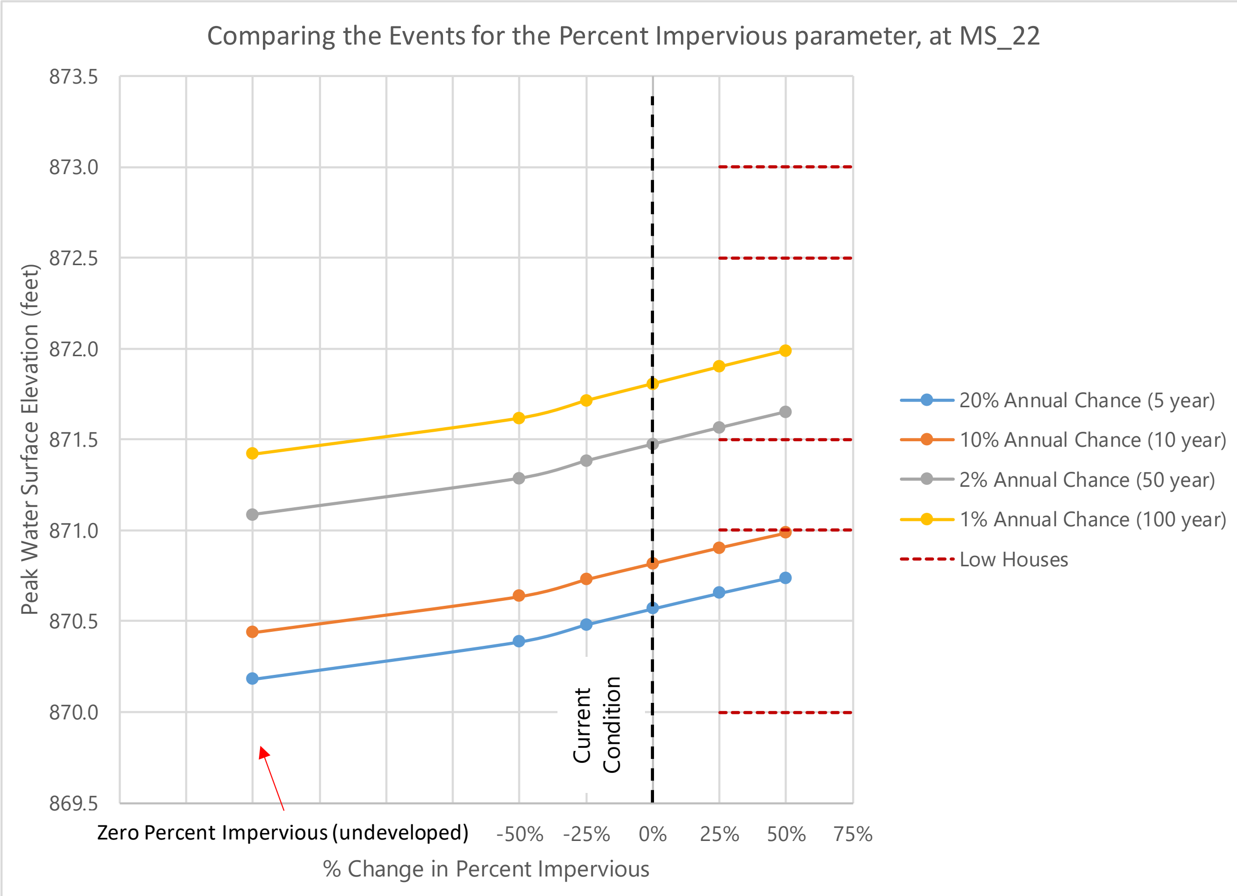

Figure 5 **Sensitivity analysis results showing peak flood levels in MS_22 (a landlocked subwatershed) for a range of imperviousness and a range of storm events.**

As mentioned previously, some prominent examples of directly connected imperviousness in a low-density residential neighborhood tend to be streets, parking lots, driveways, water bodies (i.e., Weber Pond), portions of roofs with gutters and downspouts directed to impervious surfaces such as a driveway, etc. To achieve a 50% decrease in this parameter, these portions of the watershed would need to decrease in area by 50%. In essence, this means driveway and street widths would be cut in half, half of the directly connected roof area would be rerouted to pervious surfaces, half of the parking spaces converted to pervious surfaces and/or routed to BMPs to offset the runoff, etc. Such changes over the entire watershed would be significant and require a coordinated effort from all parcels. This would produce a beneficial change in the peak flood level, but would generally be limited to a benefit of about half a foot or less in this neighborhood. For some homes adjacent to Weber Pond, for example, where the 100-year peak flood level is multiple feet above the suspected low entry elevations, the impacts to peak flood levels shown in Figure 3 due to changes in directly connected imperviousness do not change whether these homes are wet or dry during a large, intense storm event.

The results of the sensitivity analysis change depending on the storm event that is being modeled (e.g., 5-year versus 10-year). Trends and overall magnitudes do not change substantially from what is shown in the few example figures above. Other cases of interest (different storms, different subwatersheds, etc.) can be viewed in a companion Excel spreadsheet generated for the *Morningside XP-SWMM Modeling* technical memorandum (Barr, March 2020).

Finally, it is also important to remember that the results of the sensitivity analysis depend on the input storm itself. As described, this analysis used the NOAA Atlas 14, 24-hour design storm with a MSE3 temporal distribution. This storm is both significant in total precipitation depth and very intense in the middle part of the storm. Storms with high intensity near the beginning or near the end of the event may produce different results, as will storms with more moderate, consistent intensity. However, given that flood management within the City is currently informed by Atlas 14 storms with the MSE3 temporal distribution, this storm was used for the sensitivity analysis.