Designing Stormwater Management Facilities to Minimize Downstream Watercourse Impacts

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The sizing of stormwater management facilities across North America largely relies on event-based hydrologic modeling methods, which target specific rainfall characteristics, namely:

- Peak rainfall intensities expressed according to a return period (e.g., X-year storm event) generate peak flows that affect the conveyance capacity of collection systems (e.g., pipes, ditches, and culverts); and
- Total rainfall volumes expressed according to a unit-area depth (e.g., Y-inch storm event) generate runoff volumes that affect the storage capacity of detention facilities (e.g., ponds and LID facilities).

The basis for engineering design standards prescribed by local governments and regulatory agencies often assumes that the statistical properties of intense rainfall events are similar to those of the resulting runoff from land surfaces. Such event-based methods cannot be used to evaluate flow duration impacts, or runoff volume/pollutant load reductions on an average annual basis; continuous hydrologic simulation is required. Further, even though stormwater facilities may acheive the design objectives for flood control and quality treatment, there are a number of downstream impact considerations that also need to be factored into the design, including geomorphology, hydrogeology, in-stream water chemistry, and aquatic/terrestrial resources.

An analysis of continuous simulation results can be used to quantify downstream impacts, particularly through identifying exceedance/deficit durations with respect to threshold values of runoff hydrograph ordinates (e.g., flow, depth, or velocity). In California, a regulatory permitting process has been adopted for identifying potential hydrograph modification (known as "hydromodification") based on flow-duration curves that indicate geomorphologic changes due to development.

This paper summarizes a new methodology for determining flow duration exceedances and quantifying the level of flow duration control compared to pre-development conditions. The methodology is demonstrated for case studies that illustrate the design of facilities that either mimic natural hydrology or minimize downstream impacts compared to existing conditions.