# Supporting Information

## Appendix S1 Datasets, Data Visualization and Reproducibility

Data were plotted in R using the `ggtern` package version 2.1.1 released to the CRAN repository on March 31, 2016 (Hamilton 2016). Full datasets and R scripts for plots and statistical analysis are available online at: <https://github.com/cgeger/WaterBudgetTriangle>. Water budget data are scant in the peer-reviewed literature for more conventional systems, including sewer conveyance networks, detention (dry) ponds and retention (wet) ponds. In this analysis, we show data visualizations for both individual studies and summaries from several review papers. Many prior analyses model peak discharge from retention (wet) and detention (dry) ponds, but few comprehensive water budgets partition evapotranspiration or permanent groundwater recharge in these systems. Water budget data available for conventional stormwater control structures come primarily from post-project monitoring reports compiled by engineering firms and government planning agencies.

It is also relatively uncommon for complete water budgets to be reported in the peer reviewed literature for individual LID systems. Most researchers studying GI systems solely measure runoff (Q), fewer measure percolation (I) and almost none report evaporation or transpiration (ET). Few studies report a closed water budget (all three loss pathways). The ecohydrology of natural wetlands has been an ongoing field of study for more than four decades, thus, water budget data are most readily available for natural and constructed wetlands. Complete water budget data for green roofs are numerous, owing to the fact that percolation is zero and ΔS approaches zero over long time scales. The most comprehensive reports of complete water budgets over months or years of monitoring are generally available through engineering reports and student theses or dissertations.

## Appendix S2 Discussion of additional systems reported in Tables 1 and 2

### S2.1 Sewered Watersheds versus Natural Hydrologic Function

Urban development and implementation of sewers fundamentally change the hydrologic budget of a watershed. Undeveloped watersheds generally evaporate about half or more of incoming precipitation, even in wet, energy-limited ecosystems such as coastal Maryland, Maine and Ontario (Jones et al. 2012). Jones et al. (2012) estimates that the most energy-limited systems, such as temperate wet rainforest in Washington State, evaporate about 20% of incoming precipitation. Water-limited systems often evaporate greater than 80% of incoming precipitation, even in low-temperature alpine or high-desert regions including Alaska, California and New Mexico. Annual continental-scale water balances from Rodell et al. (2015) estimate the average distribution of water budgets around 25 to 55% runoff, 40 to 70% ET and 2 to 10% contribution to groundwater flux (not including Antarctica, n = 6; Figure S5). An estimate for non-landscaped vegetation in semi-humid temperate climates is approximately Q = 10%, ET = 60%, I = 30% (Starke et al. 2010), supporting the concept that vegetated surface roughness plays a role in capturing and infiltrating runoff. In contrast, sewer networks in developed watersheds may discharge more than 75% (Q = 55 to 98%) of incoming precipitation into receiving waterways (Figure S4, yellow triangles). The hardscape development in urban sewered catchments reapportions evaporative losses primarily to runoff (compare Figures S4 and S5). Starke et al. (2010) report that increasing impervious surfaces from zero to a range of 10-20% can double the volume of runoff delivered to waterways. This level of hydrologic alteration often results in flow regimes that are outside ecological flow limits, contributing to urban stream syndrome and flooding (Walsh et al. 2005, Poff and Zimmerman 2010).

Estimated water budgets from exfiltration studies of catchment-scale sewersheds and individual sewer sections show very little loss to ET, but may exfiltrate up to half the conveyed volume of water to groundwater in very dry ecosystems (Figure S4). On average, water budgets for sewersheds in the literature report 88% runoff, 12% infiltration and 0% ET (n = 12). As expected, estimates for individual pipe sections tend to be a bit more leaky (i.e. infiltration is greater) than for entire sewersheds. Due to scant data and the complexity of urban water budgets, we have not presented case studies representing watershed-scale water budgets for urban watersheds; however, they are expected to plot near the lower vertex of the Water Budget Triangle. For reference, an urban watershed budget was developed for Baltimore by Bhaskar and Welty (2012).

### S2.2 Rainwater Harvesting: Rain Barrels and Cisterns

Two important variables affecting the effectiveness of long-term stormwater retention of cisterns and rain barrels are barrel volume and usage pattern. Undersized and under-used cisterns overflow more frequently (Q increases). Cistern sizing is based on regional climate, roof or collection area, expected demand (usage), as well as cost. Real and modeled water budget estimates for cisterns over a range of sizes (190 L to 900 m3) and climatic conditions (36.5 to 1092 mm rainfall) are shown in Figure S3. Some measurements estimate an initial loss on the roof of the capture structure (used to estimate ET) or include a first flush to eliminate particulates from harvested water (used to estimate Q).

### S2.3 Additional Uses of the Water Budget Triangle

The Water Budget Triangle can be used to visualize hysteresis of water budgets across seasonal time scales, and to clarify ranges of expected summer and winter performance. A time series of water budgets for the first five years following construction of the Everglades Nutrient Removal Project (ENRP) is shown in Figure S2 (Nungesser and Chimney 2006). The water budget for the constructed wetland shows a reduction in surface water runoff through improvements in operation and the maturation of vegetation. Increased infiltrative losses accounted for 80% of the decrease in surface discharge whereas the remaining 20% was associated with increased ET.