Data collection frequency	Annually; at minimum, before and after NBS implementation
Level of expertise required	Moderate – ability to evaluate the accuracy of measurements is required (in case of equipment malfunction)
Synergies with other indicators	Direct relation to *Height of flood peak* and *Time to flood peak* indicators
Connection with SDGs	SDG 6 Clean water and sanitation, SDG 11 Sustainable cities and communities
Opportunities for participatory data collection	No opportunities identified
Additional information	
References	Adkins, G.B. (2006). Flow Measurement Devices. Utah Division of Water Rights, Utah. Armson, D., Stringer, P. & Ennos, A.R. (2013). The effect of street trees and amenity grass on -urban surface water runoff in Manchester, UK. Urban Forestry & Urban Greening, 12, 282-286. Stovin, V., Vesuviano, G. & Kasmin, H. (2012). The hydrological performance of a green roof test bed under UK climatic conditions. Journal of Hydrology, 414-415, 148-161

3.13.2 Curve Number method

Project Name: UNaLab (Grant Agreement no. 730052), CLEVER Cities (Grant Agreement no. 776604) and GROW GREEN (Grant Agreement no. 730283)

Author/s and affiliations: Laura Wendling[1], Ville Rinta-Hiiro[1], Maria Dubovik[1], Arto Laikari[1], Johannes Jermakka[1], Zarrin Fatima[1], Malin zu-Castell Rüdenhausen[1], Peter Roebeling[2], Ricardo Martins[2], Rita Mendonça[2], Maddalen Mendizabal[3]

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Runoff coefficient – Curve Number	**Water Management**
Description and justification	The extent of impermeable surfaces in urban areas is continually increasing as cities develop and expand, due to the construction of buildings, roads, streets, parking lots, etc. A significant consequence is greater runoff in urban areas, which can also lead to flooding. Many factors are

	affecting the quantity of surface runoff, including soil characteristics, land use and vegetative cover, hillslope, and storm properties such as rainfall duration, amount, and intensity (Sitterson et al. 2017). In general, surface runoff is generated in two ways (Yang, Li, Sun & Ni, 2014): through saturation excess, where runoff is generated when the soil becomes saturated (for example after a lengthy period of rainfall); or, through infiltration excess, where runoff is generated when the rainfall intensity exceeds the infiltration rate of water into the soil (for example during a heavy precipitation event when rain falls more rapidly than it can infiltrate the soil).
Definition	Runoff in relation to precipitation quantity (mm)
Strengths and weaknesses	+ The most widely used modelling method to estimate runoff from rainfall + Particularly useful for comparing pre- and post-development peak rates, volumes, and hydrographs - Curve number varies due to differences in rainfall intensity and duration, total rainfall, soil moisture conditions, cover density, stage of growth, and temperature
Measurement procedure and tool	USDA Curve Number – Taking into account losses (interception, infiltration and storage) as well as antecedent moisture conditions – runoff is estimated for storm events. Published Curve Numbers (CN) can be used in the equation. CN values are function of soil, hydrological conditions and landcover (can be weighted). Widely used worldwide. Soil Conservation Service (1972). Used in context of NBS (Gill et al, 2007). Steps to produce the value for the storm runoff include: 1. Determine the value of *CN* for the specific cover type, hydrologic condition, and hydrologic soil group, using Table 9-1 in the USDA National Engineering Handbook (2004). 2. Determine the value for *S* based on the *CN* value, using Table 10-1 in the USDA National Engineering Handbook (2004) or equation for the *CN*. 3. Determine the runoff (*Q*) either using the graphical solution or tables provided by the USDA National Engineering Handbook (2004). For the determination, values for rainfall and *CN* are needed. Other possibility to determine the runoff is to use the runoff equation where values for rainfall and *S* are needed. The curve number equation to estimate runoff from rainfall is:

	$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \quad P > I_a$ $Q = 0 \quad P \le I_a$ Where Q is depth of runoff (in), P is depth of rainfall (in), I_a is initial abstraction (in), and S is maximum potential retention (in). The initial abstraction (I_a) consists mainly of interception, infiltration during early parts of a storm, and surface depression storage. The initial abstraction can be determined from rainfall-runoff events for small watersheds. However, estimation of the initial abstraction is not easy and I_a has been assumed to be a function of the maximum potential retention (S). An empirical relationship between I_a and S has been expressed as (USDA, 2004): $I_a = 0.2S$ With this relationship, the original runoff equation can be written in a more simplified form: $Q = \frac{(P - 0.2S)^2}{P + 0.8S} \quad P > I_a$ The runoff based on curve number can be determined based on graphs or tables provided by USDA (2004). The parameter CN is a transformation of potential maximum retention, S (in mm): $CN = \frac{1000}{10 + \frac{S}{25.4}}$
Scale of measurement	District scale to metropolitan area scale
Data source	
Required data	Hydrologic soil group (HSG), land use/cover, hydrologic surface condition and antecedent moisture condition
Data input type	Quantitative
Data collection frequency	Annually; at minimum, before and after NBS implementation
Level of expertise required	High – requires ability to execute the calculations, use the graphical solutions and evaluate the results

Synergies with other indicators	Direct relation to *Height of flood peak* and *Time to flood peak* indicators
Connection with SDGs	SDG 6 Clean water and sanitation, SDG 11 Sustainable cities and communities
Opportunities for participatory data collection	No opportunities identified
Additional information	
References	United States Department of Agriculture (USDA). (2004). National Engineering Handbook Part 630 Hydrology. Washington, D.C.: United States Department of Agriculture, Natural Resources Conservation Service. Retrieved from https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/manage/hydrology/?cid=STELPRDB1043063

3.13.3 Rational method

Project Name: UNaLab (Grant Agreement no. 730052), CLEVER Cities (Grant Agreement no. 776604) and GROW GREEN (Grant Agreement no. 730283)

Author/s and affiliations: Laura Wendling[1], Ville Rinta-Hiiro[1], Maria Dubovik[1], Arto Laikari[1], Johannes Jermakka[1], Zarrin Fatima[1], Malin zu-Castell Rüdenhausen[1], Peter Roebeling[2], Ricardo Martins[2], Rita Mendonça[2], Maddalen Mendizabal[3]

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Runoff coefficient – Rational method	Water Management
Description and justification	The extent of impermeable surfaces in urban areas is continually increasing as cities develop and expand, due to the construction of buildings, roads, streets, parking lots, etc. A significant consequence is greater runoff in urban areas, which can also lead to flooding. Many factors are affecting the quantity of surface runoff, including soil characteristics, land use and vegetative cover, hillslope, and storm properties such as rainfall duration, amount, and intensity (Sitterson et al. 2017). In general, surface runoff is generated in two ways (Yang, Li, Sun & Ni, 2014): through saturation excess, where runoff is generated when the soil becomes saturated (for example after a lengthy period of rainfall); or, through infiltration excess, where runoff is generated when the rainfall intensity exceeds the infiltration rate of water into the soil (for example during a