European Commission

JRC TECHNICAL REPORTS

Level(s) indicator 5.3: Sustainable drainage

User manual: Introductory briefing, instructions and guidance
(Publication version 1.1)

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January 2021




European Commission
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How to cite: Donatello S., Dodd N. & Cordella M., 2021. Level(s) indicator 5.3: Sustainable drainage user manual: Introductory briefing, instructions and guidance (Publication version 1.1)

Title

Level(s) indicator 5.3: Sustainable drainage user manual: Introductory briefing, instructions and guidance (Publication version 1.1)

Abstract

Developed as a common EU framework of core indicators for assessing the sustainability of office and residential buildings, Level(s) can be applied from the very earliest stages of conceptual design through to the projected end of life of the building. As well as environmental performance, which is the main focus, it also enables other important related performance aspects to be assessed using indicators and tools for health and comfort, life cycle cost and potential future risks to performance.

Level(s) aims to provide a common language of sustainability for buildings. This common language should enable actions to be taken at building level that can make a clear contribution to broader European environmental policy objectives. It is structured as follows:

1. Macro-objectives: An overarching set of 6 macro-objectives for the Level(s) framework that contribute to EU and Member State policy objectives in areas such as energy, material use, waste management, water and indoor air quality.
2. Core Indicators: A set of 16 common indicators, together with a simplified Life Cycle Assessment (LCA) methodology, that can be used to measure the performance of buildings and their contribution to each macro-objective.

In addition, the Level(s) framework aims to promote life cycle thinking. It guides users from an initial focus on individual aspects of building performance towards a more holistic perspective, with the aim of wider European use of Life Cycle Assessment (LCA) and Life Cycle Cost Assessment (LCCA) methods.

Contents

Level(s) documentation structure

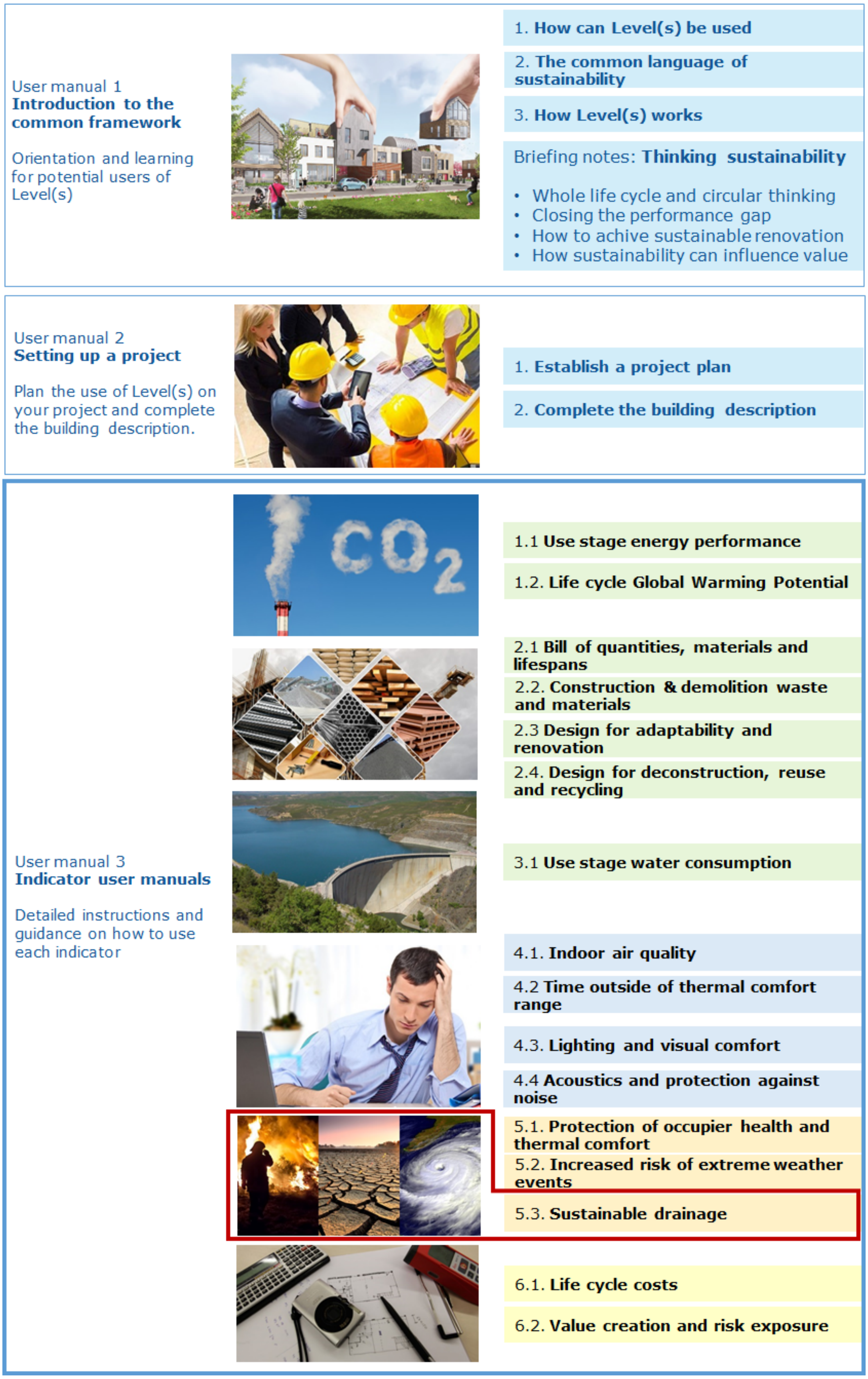

Figure 1. The Level(s) document structure

How this indicator user manual works

Level(s) is a framework of core indicators of sustainability that can be applied to building projects in order to report on and improve their performance. The supporting documentation has been designed to be accessible to all the actors that may be involved in this process.

If you are new to the assessment of building sustainability, we recommend reading the **first part of the Level(s) user manual**. This will provide you with an introduction to the basic concepts behind Level(s) and how you can apply it to a building project.

If you haven't yet set up your building project to use Level(s), including completing the project plan and the building description, then we recommend reading the **second part of the Level(s) user manual**.

This indicator user manual forms part of the third part of the Level(s) user manual where you will find instructions on how to use the indicators themselves. It is designed to help you apply your chosen indicator to a building project. It will help you to do this in the following way:

- **Introductory briefing:** This section provides an overview of the indicator, including:
  - ✓ why you may wish to measure performance with it,
  - ✓ what it measures,
  - ✓ at which stages in a project it can be used,
  - ✓ the unit of measurement, and
  - ✓ the relevant calculation method and reference standards.
- **Instructions on how to use the indicators at each level**: This section provides:
  - ✓ step by step instructions for each level,
  - ✓ what is needed to make an assessment,
  - ✓ a design concept checklist (at Level 1), and
  - ✓ the reporting formats.

  The instructions often refer to the guidance and further information section, which can be found after the instructions.
- **Guidance and further information for using the indicator**: This section provides more background information and guidance to support you in following specific steps in the instructions, including the design concepts introduced at Level 1 and the practical steps to calculate or measure performance at Levels 2 and 3. They are all cross-referenced to specific instruction steps at either level 1, 2 or 3.

This indicator user manual is structured so that once you are familiar with using the indicator and you know how to work with it, you may no longer need to refer to the guidance and background information, but only work directly with the instructions at the level of your choice.

Technical terms and definitions used

Term	Definition
Flood risk	The combination of the probability of a flood event and of the potential adverse consequences for human health, the environment, cultural heritage and economic activity associated with a flood event.
Fluvial flooding	Flooding caused by a river. It occurs when excessive rainfall and/or snow melt in the catchment area exceeds the river capacity.
Nature-based solutions (NBS)	Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions.
Natural water retention measures (NWRM)	Multi-functional measures that aim to protect and manage water resources and address water-related challenges by restoring or maintaining ecosystems as well as natural features and characteristics of water bodies using natural means and processes.
Pluvial flooding	Flooding caused by an extreme rainfall event or sudden release of water from other sources that is independent of an overflowing water body (e.g. a river). It occurs when the drainage system is unable to convey water away from the site quickly enough.
Sustainable (urban) drainage systems	(Also referred to as SuDS for short) are a collection of water management practices that aim to align modern drainage systems with natural water processes.
Urban Heat Island (UHI)	An urban area which is significant warmer than surrounding rural areas. Multiple factors can contribute to the UHI effect.

Introductory briefing

Note for users: This indicator only has instructions and guidance for using the indicator at **Level 1** at this moment. For those who wish to work at **Level 2 and 3,** it provides some initial information about possible units of calculation and measurement, as well as reference standards that could be used.

Why measure performance with this indicator?

Widespread urbanisation, and the buildings associated with it, has increased flood risk due to the loss of greenfield sites and thus the possibility of water to soak into the ground. However, with some creative thinking, sustainable drainage systems can mitigate or even over-compensate for this increased risk of flooding caused by urbanisation.

There is a common aspect between indicators 5.2 and 5.3 since both of them concern the relationship between building/plot area design and flood events/risk. The key differences are:

- Indicator 5.2 is about how to make the building more resilient and resistant to extreme weather events **when they occur** (including the three main types of flooding: fluvial, pluvial and coastal).
- Indicator 5.3 is about how to use the building design and plot area to **reduce the chances** of pluvial flood events in the local area and fluvial flood events downstream **from occurring in the first place**.

Traditionally, the default design solution for drainage engineers has been to convey storm water rapidly away from the site to be drained. This solution has worked well for decades in many places. In areas subjected to major variations in population (e.g. summer tourism) the mains sewerage system has to be sized for peak loads but ends up with very low flow velocities during the winter. A common solution to this problem is to divert storm water drainage into the sewers (creating "*combined sewers*"), which provide the extra flow needed during the wetter winter months. However, there are several major problems with rapid storm drainage and combined sewer systems today.

1. The drainage capacity of storm drains and combined sewers cannot be easily increased, but the impermeable areas that feed these drains have increased substantially with urban development. As the margins between actual hydraulic loadings and design capacities of drainage systems continue to reduce, the risk of pluvial flooding in the surrounding area increases for a given storm event.
2. A lot of rapidly draining areas upstream will create a large peak flowrate in the river downstream for a given storm event – thus increasing the risk of fluvial flooding downstream.
3. A lot of rapidly draining areas linked to combined sewers will result in larger peak flowrates in the sewer for a given storm event – thus increasing the risk of sewers backing up and overflowing onto streets.
4. Increases in average sea and land temperatures via climate change is being linked to increasing intensities of storm events in many parts of Europe – translating into an increased risk of both pluvial and fluvial flooding.

A more sustainable alternative to traditional drainage systems has emerged in the last 10-15 years and these can link seamlessly with other sustainability goals, such as rainwater harvesting (see Levels(s) indicator 3.1) or habitat creation. Level(s) indicator 5.3 aims to inform readers about what sustainable drainage systems are, how they can be incorporated into building designs or renovation activities and the benefits they can deliver.

What does it measure?

Indicator 5.3 focuses on the quantities of stormwater that will fall on the plot area, where it will be directed, how quickly it will leave the drainage system and reach the natural watercourse and what exactly are the different components of the drainage system. At Level 1, the only Level presented for this indicator at this stage, a procedure is set out for how to consider different options for sustainable drainage systems in the conceptual design of the building and plot area.

At what stage of a project?

The stages at which an assessment can be made reflect the three 'levels'. Only Level 1 is currently available, but the intention for Levels 2 and 3 is also outlined for future reference.

Level	Activities related to the use of indicator 5.3
1. Conceptual design (following design principles)	✓ information is provided to prompt discussion and decision making for the project about aspects that will influence pluvial flood risk directly at the site and that will indirectly influence fluvial flood risk downstream. The overall performance requirements of the drainage system should be agreed with planning authorities at this stage.
2. Detailed design and construction (based on calculations, simulations and drawings)	✓ *Prior to commencement of works on site and during the detailed design stage, the performance of the system shall be modelled against relevant design storms to estimate performance. The final design shall be adapted accordingly to meet any additional performance requirements or spatial constraints.*
3. In-use performance (based on commissioning, testing and metering)	✓ *The actual performance of the drainage system will be monitored by measuring runoff rates from the discharge point(s) and how closely water levels approach overflow points during real rainfall events and later determining how this compares to the predicted performance under an equivalent design storm determined in Level 2 estimations.*

Unit of measurement

There are a number of different units that could be involved with the Level 1 aspects for indicator 5.3. For example, the inputs of rainfall to the system (based on meteorological data in mm/unit time, total plot area (m2), total green space created (m2 or % of total plot area) or the total stormwater retention capacity onsite (m3).

Thinking ahead to possible approaches for Levels 2 and 3 in a future version, modelling of the drainage system with rainfall data could allow the drainage system to be defined in terms of the maximum storm event it is predicted to withstand without overflowing (e.g. a 1 in 200 year event of 2 hours duration) and how close it gets to the performance of a greenfield site in terms of runoff rate (L/s) for the same design storm event.

System boundary

In terms of physical boundaries, implementing sustainable drainage systems will consist of trenches, piping and other components that are external to the building envelope. Depending on the nature of the surrounding area, sustainable drainage systems may extend beyond the building plot area and take advantage of publicly owned land that has no use value but which can provide valuable stormwater retention capacity (e.g. roadsides and centres of roundabouts).

In terms of boundaries for life cycle impacts within the EN 15978 framework (illustrated in Figure 4 of User manual 1), environmental benefits can be expected in the A1-A5 stages (product manufacture, transport and installation) by fully or partially substituting "*hard-engineered*" materials (e.g. concrete, asphalt and hard paving) with "*soft engineered*" materials (e.g. pervious concrete, loose aggregate filled trenches and vegetated areas). However, vegetated systems will require higher maintenance efforts, that would be reflected in the EN 15978 life cycle stages B3 and B4 stages during the building use stage. In cases where rainwater is harvested by the drainage system for use, benefits would be shown in life cycle stage B7 (use stage water consumption).

Scope

In principle, the indicator is designed to be applied for a single building project, which may in itself consist of one or more buildings. However, indicator 5.3 could also be applied in a standalone renovation project for a broader area, where the existing drainage system for areas prone to pluvial flooding is overhauled.

Calculation method and reference standards

The Level 1 procedure is generally aligned with the concepts of sustainable drainage systems outlined in the SuDS Manual published by CIRIA[1].

Although Levels 2 and 3 are not available yet, it is foreseen that:

- *for Level 2, reference will be necessary to standard approaches for defining design storms from rainfall data and for relevant approaches to hydraulic modelling of water flows through drainage systems.*
- *for Level 3, a standard approach for remotely monitoring flow rates from discharge points will be required*

[1] Woods Ballard et al., 2015. The SuDS manual. C753, CIRIA. See: www.ciria.org

Instructions on how to use the indicators at each level

Instructions for Level 1

L1.1. The purpose of Level 1

The focus of Level 1 is to set out the steps to take during the conceptual design stage in order to embrace sustainable drainage options as much as possible. This includes an awareness of both the risk of flooding at the building and the possible effect of the building itself on flood risk in surrounding and downstream areas.

L1.2. Step-by step instructions

These instructions should be read in conjunction with the accompanying Level 1 technical guidance and supporting information (see page 13).

1. Familiarise the design team with the concept of sustainable drainage, its different components and how they can be linked together.
2. Consult relevant authorities responsible for flood risk and flood hazard mapping in the region. Request access to maps for the development site and surrounding area.
3. Gather information from local authorities and utilities about the existing drainage network in the area surrounding the site. Check if there is any history of pluvial flooding or that the site may be at risk of pluvial flooding (if not already covered by the maps in step 2). Decide if the drainage system should link to surrounding areas as well or not.
4. Discuss potential performance metrics for the drainage system with the local authority. One example would be to define a non-overflow situation for a modelled design storm of a fixed return period and duration (e.g. 1 in X year storm of Y hours duration). A fixed % margin could be added for climate change (e.g. +20%). Note that the less probable and longer design storm durations that a system is designed to cope with, the larger and more robust the drainage system will need to be for a given site.
5. Consider other objectives that could be linked to the sustainable drainage system (e.g. retention of water for irrigation during summer, creation of green space, wildlife habitat etc.
6. Define the outline design and layout of the sustainable drainage system, the approximate retention capacities needed, how water would be conveyed to the storage areas and discharge points and what maintenance would be needed. Depending on space constraints on site and in the surrounding area, the system may extend well beyond the building plot boundary.

L1.3. Who should be involved and when?

For the conceptual design (Level 1), the main actors would be the local planning authorities, the regional water utility, drainage engineers with experience in sustainable drainage, the concept architect and the prospective building owner or investor. When proceeding to the detailed design, other specialists would be expected to become involved, such as landscape architects, ecologists, highway engineers, hydraulic modellers (also with knowledge of projected future changes in rainfall patterns with climate change) and the contractor.

L1.4. Checklist of relevant design concepts

The following relevant design concepts have been identified from best practice and literature reviewed by the Joint Research Centre.

Level 1 design concept	Brief description
1. Familiarise the core design team with the concept of sustainable drainage, its different components and how these can be linked together.	There is a wealth of literature available on the subject of sustainable drainage system thanks to work over the last 10-15 years. Some specific reference materials are recommended in the guidance section for consultation.

Level 1 design concept	Brief description
2. Assess the potential flood risk at the site.	Identify and contact the relevant authorities. Consider historical rainfall data and consult available flood risk maps for the local area (fluvial, pluvial and, if relevant, coastal). For the specific site, consider the current drainage system in the surrounding area (e.g. age, combined/non-combined etc.), the vertical drop to nearest discharge points, the extent of urbanisation in recent years and any concerns with pluvial flooding in recent years.
3. Consult relevant professionals and organisations at the beginning of the design process.	Gather urban planners, landscape architects, the concept architect, drainage engineers, the road authority and any other relevant parties around the table in order to collectively consider design and environmental aspects. This way, potential conflicts of interest can be flagged up and the roles, rights and responsibilities can be clearly understood before the design is completed and before the works begin.
4. Define the outline design and layout of the sustainable drainage system.	It is important here to define where storm water would be collected, where it would runoff to by gravity and how the runoff is conveyed to the ultimate discharge point(s). Overflows should also be clearly defined. At this stage it should be clearly agreed who takes ownership and responsibility for maintenance of the different components of the sustainable drainage system (i.e. the local authority or the building owner or a combination of both).
5. Assess the costs and benefits of sustainable drainage system.	Costs aspects should be determined by materials, works, landscaping and maintenance. Consideration could also be given to less tangible cost aspects such as increasing the risk of vector borne diseases (e.g. mosquitos) if the system includes a permanent pond where previously there was no permanent water in the immediate area. Benefits should focus on the four main pillars of sustainable drainage, which are: (i) water quantity; (ii) water quality; (iii) amenity value and (iv) biodiversity. Other benefits are also possible, including reduction of potable water demand (in cases where rainwater is harvesting for human uses) and the reduction of the urban heat island effect, thanks to evaporative cooling of standing water or evapotranspiration by vegetation.

L1.5. Reporting format

To complete the reporting format for Level 1 you should answer yes or no for each of the design concepts that you have addressed and then provide a brief descriptions of the measures or decisions taken for each one.

Sustainable drainage design concept	Addressed? *(yes/no)*	How has it been incorporated into the building project? *(provide a brief description)*
1. Familiarising the core design team with sustainable drainage systems	Yes	*The core design team has been provided with a number of reports and case studies about the design and implementation of SuDS. A training webinar has also been arranged to cover all the basics of these systems and allow for further Q&A.*
2. Assess the potential flood risk onsite.	Yes	*The site is not proximate to any natural watercourse and is not highlighted in any flood risk maps. However, the development activity will convert some 3000m2 of greenfield plot area to impervious surface and the site lies uphill of a highly urbanised area at the riverside. Consequently, attempts to minimise runoff rates from the building site are prioritised in order to decrease pluvial flood risk downhill and fluvial flood risk downstream.*
3. Consult relevant professionals and organisations at the beginning of the process.	Yes	*Local planning authorities have been consulted to explore any synergies with existing drainage systems and infrastructure for the surrounding area and to discuss the potential use of low-development value public land for stormwater retention capacity.*

Sustainable drainage design concept	Addressed? *(yes/no)*	How has it been incorporated into the building project? *(provide a brief description)*
5. Assess the costs and benefits of adaptation actions.	Yes	*A cost estimate for the standard drainage installation will be obtained for comparison with the finally agreed SuDS installation. Maintenance costs of Y € per year are estimated for the upkeep of vegetated areas in grass swales and seeded retention ponds.* *Savings of X € per year are estimated due to projected rainfall harvesting of Z m3 of rainwater per year. The system is predicted to be able to withstand a 1 in 200 year storm event of 24 hour duration, which is well beyond minimum design requirements set by the planning authority (1 in 100 year storm event of 12 hours duration). The system will provide 500m2 of green space (70% offsite) and 100m2 of permanent pond surface (offsite). It is planned to introduce 45 different plant species into the system and have an island area in the middle of the pond.* *The filtration action of the SuDS system in infiltration trenches and grass swales and the sedimentation action of the retention pond will remove particulate pollutants from the storm water before it reaches the natural watercourse.*

Guidance and further information for using the indicator

For using level 1

In this section of the manual, additional background guidance and explanations are provided for key concepts introduced in Level 1, namely:

- L1.4. Checklist concept 1: Familiarise the design team with sustainable drainage systems
- L1.4. Checklist concept 2: Assessing flood risk at the site
- L1.4. Checklist concept 5: Assess the costs and benefits of sustainable drainage

L1.4. Checklist concept 1: Familiarise the design team with sustainable drainage systems.

The design team should be aware of why sustainable drainage systems (SuDS) are important, what components and options it actually consists of and how these can be put together.

First of all, it is worth considering what happens to storm water after it hits the ground, and how this differs depending on the nature of the ground surface and the drainage system.

During storm events in any particular river catchment, water that hits an impermeable area is rapidly conveyed via the drainage system to the river whereas storm water hitting a greenfield site infiltrates into the ground and, only once the ground is saturated, it would flow across the vegetated surface towards the river or be trapped in natural depressions in the surface topography. The result is that for a given storm event, there is a higher and more concentrated peak flow in watercourses fed by impermeable areas compared to those fed by greenfield areas.

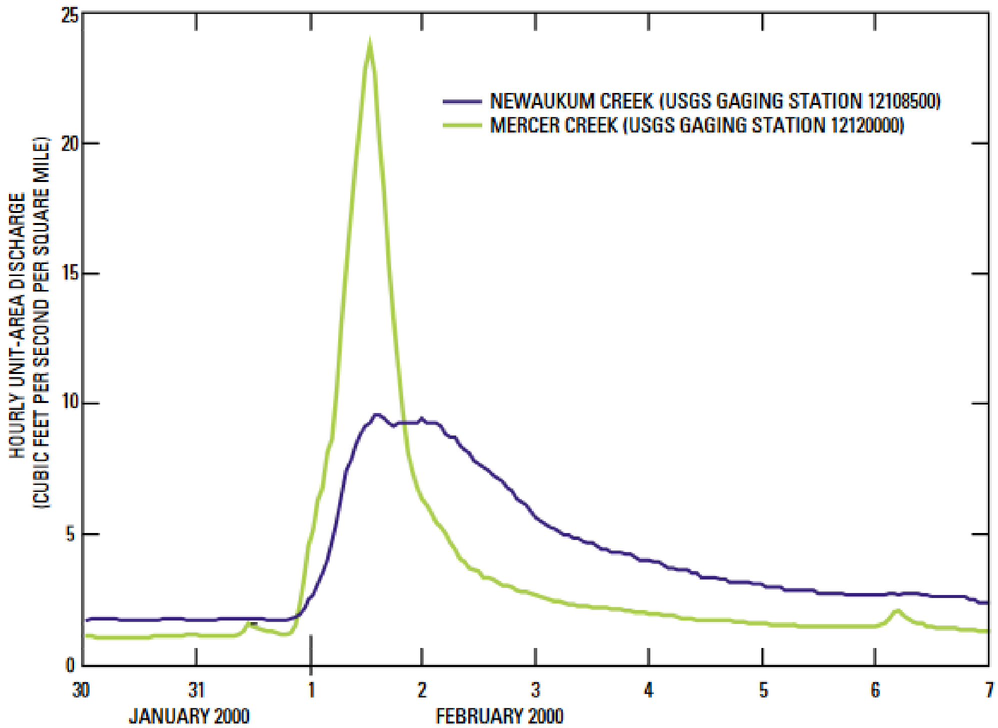

Figure 2. Specific runoff rates in an urban stream (green) and a rural stream (purple) that are located in the same area (Konrad, 2003[2]).

The aim of indicator 5.3 is to reduce the risk of flooding by controlling the runoff rate of storm water to levels that are closer to those of an equivalent greenfield site. However, this is only one of the four main benefits that SuDS can deliver.

[2] Konrad CP., 2003. USGS Fact Sheet FS-076-03. Effects of urban development on floods.

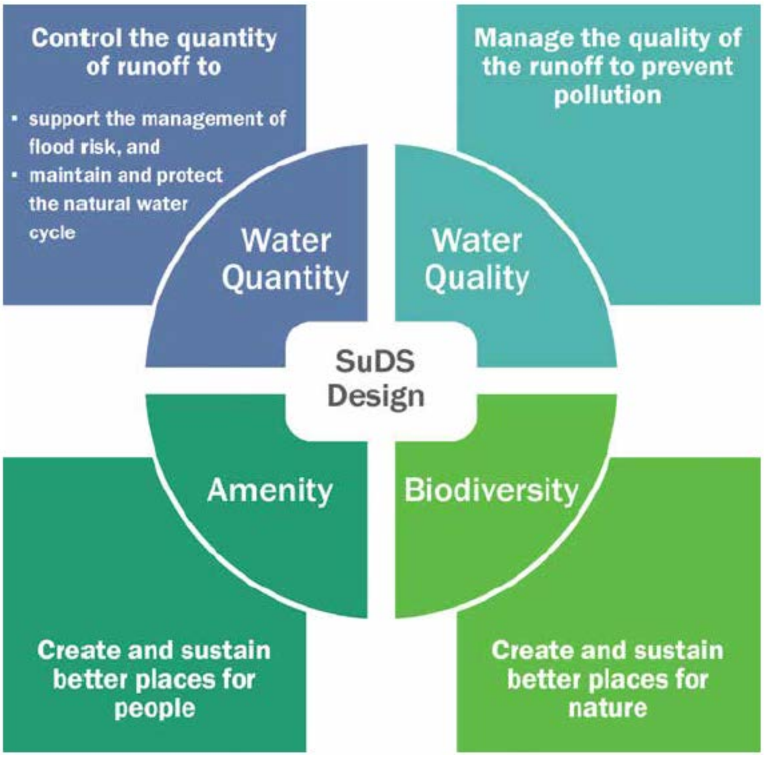

Figure 3. The 4 main benefits (or pillars) of SuDS. (Source: Woods Ballard et al., 2015l[3])

A SuDS design is composed of multiple components, each of which may be above or below ground, be hard-engineered, soft engineered or somewhere in-between and which may contribute to one or more of the four benefits illustrated above.

The components in the SuDS system will carry out one or more of the key 6 functions listed below.

Table 1. The six main functions of SuDS components (Source: Woods Ballard et al., 2015)[4]

Function	Description
1. Rainwater harvesting systems	Components that capture rainwater and facilitate its use within the building or local environment.
2. Pervious surfacing systems	Structural surfaces that allow water to penetrate, thus reducing the proportion of runoff that is conveyed to the drainage system, e.g. green roofs, pervious paving. Many of these systems also include some subsurface storage and treatment.
3. Infiltration systems	Components that facilitate the infiltration of water into the ground. These often include temporary storage zones to accommodate runoff volumes before slow release to the soil.
4. Conveyance systems	Components that convey flows to downstream storage systems. Where possible, these systems also provide flow and volume control and treatment, e.g. swales.
5. Storage systems	Components that control the flows and, where possible, volumes of runoff being discharged from the site, by storing water and releasing it slowly (attenuation). These systems may also provide further treatment of the runoff, e.g. ponds, wetlands and detention basins.
6. Treatment systems	Components that remove or facilitate the degradation of contaminants present in the runoff.

[3] Woods Ballard et al., 2015. The SuDS manual. C753, CIRIA. See: www.ciria.org

[4] Woods Ballard et al., 2015. The SuDS manual. C753, CIRIA. See: www.ciria.org

Finally, users should be aware of what are the main types of SuDS component. These are listed in the Table below.

Table 2. Different types of SuDS component (Source: Woods Ballard et al., 2015)

Component Type	Description
Rainwater harvesting system	Rainwater is collected from the roof of a building or from other paved surfaces in an over-ground or underground tank for use on site. Depending on its intended use, the system may include treatment elements. The system should include specific storage provision if it is to be used to manage runoff to a design standard.
Green roofs	A planted soil layer is constructed on the roof of a building to create a living surface. Water is stored in the soil layer and absorbed by vegetation. Blue roofs store water at roof level, without the use of vegetation.
Infiltration systems	These systems collect and store runoff allowing it to infiltrate into the ground. Overlying vegetation and underlying unsaturated soils can offer protection to groundwater from pollution risks.
Proprietary treatment systems	These subsurface and surface structures are designed to provide treatment of water through the removal of contaminants.
Filter strips	Runoff from an impermeable area is allowed to flow across a grassed or otherwise densely planted area to promote sedimentation and filtration.
Filter drains	Runoff is temporarily stored below the surface in a shallow trench filled with stone/gravel, providing attenuation, conveyance and treatment (via filtration).
Swales	A vegetated channel is used to convey and treat runoff (via filtration). These can be “wet”, where water is designed to remain permanently at the base of the swale, or “dry” where water is only present in the channel after rainfall events. It can be lined, or unlined to allow infiltration.
Bioretention systems	A shallow landscaped depression allows runoff to pond temporarily on the surface, before filtering through vegetation and underlying soils prior to collection or infiltration. In its simplest form it is often referred to as a rain garden. Engineered soils (gravel and sand layers) and enhanced vegetation can be used to improve treatment performance.
Trees	Trees can be planted within a range of infiltration SuDS components to improve their performance, as root growth and decomposition increase soil infiltration capacity. Alternatively they can be used as standalone features within soil-filled tree pits, tree planters or structural soils, collecting and storing runoff and providing treatment (via filtration and phytoremediation).
Pervious pavements	Runoff is allowed to soak through structural paving. This can be paving blocks with gaps between solid blocks, or porous paving where water filters through the block itself. Water can be stored in the sub-base and potentially allowed to infiltrate into the ground.
Attenuation storage tanks	Large, below-ground voided spaces can be used to temporarily store runoff before infiltration, controlled release or use. The storage structure is often constructed using geocellular or other modular storage systems, concrete tanks or oversized pipes.
Detention basins	During a rainfall event, runoff drains to a landscaped depression with an outlet that restricts flows, so that the basin fills and provides attenuation. Generally, basins are dry, except during and immediately following the rainfall event. If vegetated, runoff will be treated as it is conveyed and filtered across the base of the basin.
Ponds and wetlands	Features with a permanent pool of water can be used to provide both attenuation and treatment of runoff, where outflows are controlled and water levels are allowed to increase following rainfall. They can support emergent and submerged vegetation along their shoreline and in shallow, marshy zones, which enhances treatment processes and biodiversity.

For more detailed information and practical guidance, users of Level(s) that wish to report under indicator 5.3 are strongly recommended to consult the following reports (many of which are available as free downloads):

- Woods Ballard B., Wilson S., Udale-Clarke H., Illman S., Scott T., Ashley R., Kellagher R., 2015. The SuDS Manual. C753, CIRIA, London, UK (ISBN 978-0-86017-760-9). Go to www.ciria.org
- Strosser P., Delacámara G., Hanus A., Williams H., Jaritt N., 2015. A guide to support the selection, design and implementation of Natural Water Retention Measures in Europe - Capturing the multiple benefits of nature-based solutions. (ISBN 978-92-79-46060-9). Go to www.nwrm.eu/
- The 11 synthesis documents available here: http://nwrm.eu/implementing-nwrm/synthesis-documents
- Dickie S., Ions L., McKay G., Shaffer P., 2010. Planning for SuDS – making it happen, C687, CIRIA, London, UK (ISBN: 978-0-86017-687-9). Go to: www.ciria.org
- Digman C., Ashley R., Balmforth D., Stovin V., Glerum J., 2012. Retrofitting urban areas to effectively manage surface water, C713, CIRIA, London, UK (ISBN: 978-0-86017-715-9). Go to: www.ciria.org
- AECOM, 2013. Water, people, places. A guide for master planning SuDS into developments, prepared by the Lead Local Flood Authorities of the South East of England, AECOM, London, UK. Go to: http://tinyurl.com/npdsf63
- Graham A., Day J., Bray B., MacKenzie S., 2012. Sustainable drainage systems: maximising the potential for people and wildlife – A guide for local authorities and developers. The Royal Society for the Protection of Birds and Wildfowl & Wetlands Trust, UK. Go to: http://tinyurl.com/pzwwaaz

L1.4. Checklist concept 2: Assessing flood risk at the site.

The “Floods Directive”[5] sets out requirements for Member States to develop and maintain flood hazard maps and flood risk maps as part of developing flood risk management plans for river basins. For further information about flood risk and hazard maps in any given Member State, the relevant Competent Authority should be contacted, as per the list below.

Table 3. List of Competent Authorities for flood risk and flood hazard mapping (Source: DG ENV[6]).

Member State	Competent Authority name	Website
Austria	Federal Ministry of Sustainability and Tourism	www.bmnt.gv.at/
Belgium	Leefmilieu / Environment	www.health.belgium.be/
Bulgaria	Ministry of Environment and Water	www.moew.government.bg/
Croatia	Hrvatske Voda	www.voda.hr
Cyprus	Water Development Department	www.moa.gov.cy/moa/wdd/
Czech Republic	Ministry of the Environment	www.mzp.cz
Denmark	Danish Ministry of the Environment Danish Coastal Authority	www.mim.dk www.kyst.dk
Estonia	Ministry of the Environment	www.envir.ee

[5] Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks. (Text with EEA relevance) OJ L 288, 6.11.2007, p.27-34.

[6] See: https://ec.europa.eu/environment/water/flood_risk/links.htm

Member State	Competent Authority name	Website
Finland	Joint website of Finland's environmental administration	www.ymparisto.fi
France	Ministère de l'écologie, du développement durable et de l'énergie - DGALN/DEB	www.ecologique-solidaire.gouv.fr
Germany	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit	www.bmu.de
Greece	SPECIAL SECRETARIAT FOR WATER	www.ypeka.gr
Hungary	Ministry of Internal Affairs	www.kormany.hu/hu/belugyminiszterium
Ireland	The Commissioners of Public Works in Ireland	www.opw.ie
Italy	Ministero dell'Ambiente del Territorio e del Mare	www.minambiente.it
Latvia	Ministry of environmental protection and regional development	www.varam.lv
Lithuania	Ministry of Environment	http://am.lt
Luxembourg	Ministry for Home Affairs and the Greater Region	www.miat.public.lu
Malta	Malta Resources Authority	www.mra.org.mt
Netherlands	Ministry of Infrastructure and the Environment	www.rijksoverheid.nl/ministeries/ienm
Poland	Ministry of Marine Economy and Inland Navigation	www.gov.pl/gospodarkamorska
Portugal	Portuguese Water Institute	http://snirh.pt
Romania	Ministry of Environment and Climate Change	www.mmediu.ro
Slovakia	Ministry of Environment of the Slovak Republic	www.enviro.gov.sk
Slovenia	Ministry of Agriculture and the Environment	www.mko.gov.si
Spain	Ministry of Agriculture, Food and Environment	www.marm.es
Sweden	Swedish Civil Contingencies Agency	www.msb.se
UK	Secretary of State for Environment, Food and Rural Affairs	www.defra.gov.uk

A variety of different approaches have been taken to flood risk and flood hazard mapping and there is no universal style or format for these maps. When consulting maps for the specific area where the building will be located, it is useful to be aware of the different types of map that can be produced (see the purely hypothetical examples below).

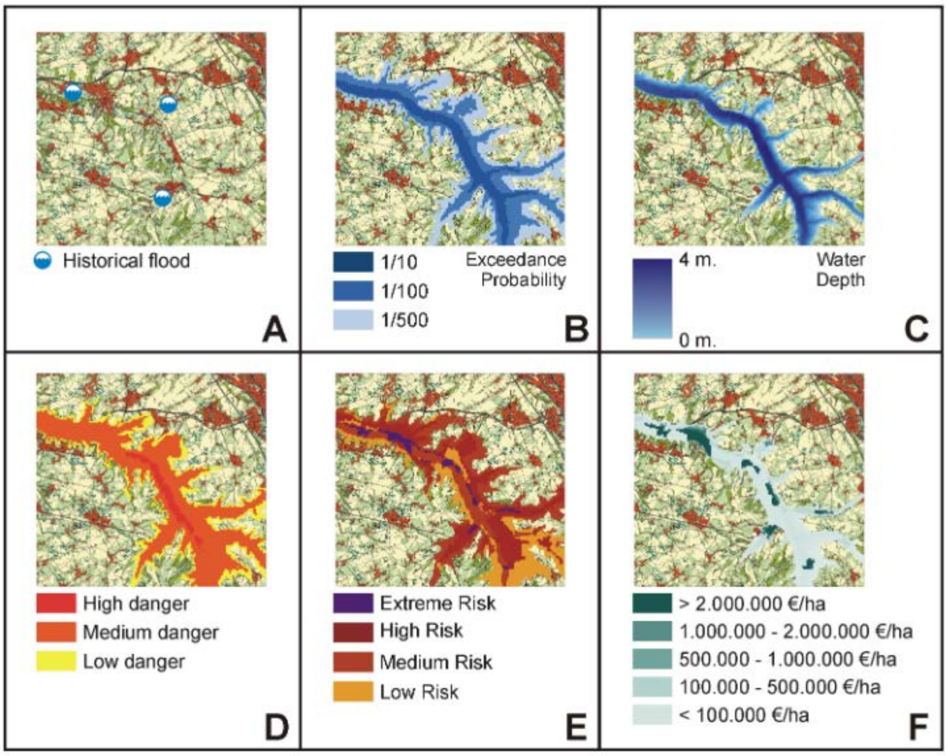

Figure 4. Different flood map types. (A) historical flood map; (B) flood extent map; (C) flood depth map; (D) flood danger map; (E) qualitative risk map; (F) quantitative risk (damage) map (Source: De Moel et al., 2009[7]).

The most common type of map is (B), flood extent maps. These maps are simple to generate and delineate the points which a real flood event reached or a hypothetical flood event would be predicted to reach. Flood extent maps would need to be supplemented with additional information in order to produce C, D, E or F type maps.

Users should be aware that flood maps with risk zones extending from existing rivers will most likely depict fluvial flood risks, however these are sometimes combined and shown with floods from other sources, therefore clarifications from the map provider should be sought. There are relatively few flood maps that show risk areas that are independent of natural watercourses (i.e. pluvial flood risk). To have a good understanding of pluvial flood risk, it is necessary to be aware of the local drainage infrastructure and other factors, for example:

- Are the storm drains are combined with the sewers?
- What is the maximum capacity of the storm sewers?
- Where are the bottlenecks and points of maximum blockage risk in the storm/combined sewer system?
- What longitudinal slopes are there in the sewers towards the discharge points?
- Where are the overflow points?
- How old is the core drainage system and how much recent urban development has taken place that feeds into the storm/combined drains?

These questions can best be answered by engineers from the regional water utility or officials from the local planning authority.

[7] De Moel H., Van Alphen J., Aerts JCJH., 2009. Flood maps in Europe – methods, availability and use. Natural Hazards and Earth System Sciences, 9, p. 289-301.

L1.4. Checklist concept 5: Assessing the potential costs and benefits of sustainable drainage

For more details about costs associated with sustainable drainage, the reader is referred to "Synthesis Document 5", available at www.nwrm.eu . The three main costs defined are:

- Financial costs: costs incurred during the design and implementation of the drainage system. Including upfront capital expenditure (the investments in equipment, infrastructures and other assets required throughout the lifespan of the NWRM); depreciation allowances (annualised cost of replacing the accounting value of existing assets in the future); maintenance expenditure (all the financial outflows required to preserve existing or new assets in good functioning); and the operational expenditure (those incurred to keep he NWRM running in an efficient manner on a daily basis).
- Opportunity costs: these can be broadly considered as the deviations from what the building owner wanted. For drainage systems, this would most often relate to the loss of available land area for a specific use (e.g. car parking or building floor space) that is instead solely occupied by the drainage system.
- Sunk costs: these are costs that cannot easily by recovered or diverted to other uses. These are especially relevant at the beginning of innovative projects. Sunk costs include all expenditure applied to research and development, consultancy, project designs, stakeholder engagement, bargaining processes and consensus building, etc. They tend to decrease throughout time as far as more projects are considered, the uncertainty about the biophysical impacts is reduced, more experience is gained and society progresses along its learning curve. Sunk costs are then higher for NWRM than for traditional and well established water management alternatives. These costs are rarely reported.

Care should be taken with cost comparisons of traditional and sustainable drainage systems because, depending on how the costs are constructed, different conclusions can be reached.

For more details about benefits associated with sustainable drainage, the reader is referred to "*Synthesis Document 4*", available at www.nwrm.eu . The main benefits associated with sustainable drainage systems are much harder to quantify and to monetize. Amenity value, the provision of habitat for wildlife, reduced flood risk (onsite and downstream) and various ecosystem services are all possible in cases where habitat and green space is incorporated into the drainage system.