CITY OF TAMPERE

THE CITY OF TAMPERE GREEN FACTOR METHOD

Calculation tool instructions

Contents

INTRODUCTION

The goal of the City of Tampere green factor method is to increase the volume of urban green and natural stormwater management in the densifying urban structure. The method was developed based on the calculation tool of the City of Helsinki green factor method, which was modified by means of interviews, steering group work, exemplary and model yards, and a workshop. A separate final report (2019) has been prepared of the City of Tampere green factor method, which contains additional information on the development of the tool. In autumn 2021, both the green factor Excel tool and the text of the instructions for use were updated. In spring 2023 the tool's stormwater calculation functionality was improved and a separate category for vegetated roofs was added to the green factor tool. Based on the changes the user manual was updated too.

The City of Tampere introduced the green factor method to be used more widely in town plans suitable for green factor calculation from the beginning of the year 2020. The use of the method is decided at the initial meetings of the town planning process.

The final report (2019) of the Tampere green factor method includes, among other things, information on the process of creating the method, green factor calculations for sample yards, and model yard plans. (in Finnish: Tampereen viherkerroin, loppuraportti) https://data.tampere.fi/data/fi/dataset/tampereen-viherkerroin

Weighted area

The green factor method deals with the weighted area of the yard. What does this mean?

The green factor method measures the green efficiency of a block or plot, i.e. the weighted (scored) amount of green in relation to the area of the block or plot. The green factor method provides alternative solutions for increasing urban green and managing stormwater. The calculation is performed in an Excel-based spreadsheet, in which the data of the block or plot is entered, as well as the quantities and areas of the various elements, such as trees to be planted and stormwater solutions.

$$\text{Green factor} = \frac{\text{scored area}}{\text{total lot area}}$$

Green factor target value

The target values for the green factor used in Tampere are defined according to land use as follows:

Residential areas	0,8
Services and office building areas	0,7
Trade and commercial building areas	0,6
Industrial and logistics building areas	0,5

Furthermore, the current state of the site, e.g. groundwater status, does have an effect on the target level. The green factor tool automatically calculates the target level.

The green factor target level can also be changed manually. The target level to be set manually is selected in case the town plan specifies a target level to be used in the area, other than the one automatically determined by the tool. When a yard plan is prepared during the phase of creating the town plan, a non-automatic target value may be chosen if the planner finds it to be justified based on the specific site premises. The appropriate target value is then determined during the city planning process.

In Finland, the green factor method is used in several different cities. The objectives, emphasis and functionality of the tools are partly different in different cities. More information on the weightings of the Tampere tool is provided in Chapter 2.3 Additional information: weighting.

The operating model of the green factor method in the City of Tampere

The use of the method is decided at the initial meetings of the town planning process. In the town planning phase, a general yard plan and a rough green factor calculation are made, the target level and how to reach it are reviewed.

The use of the green factor is regulated by the instructions included in the town plan: the plans attached to the building permit application must show that the plan of the parcel or in some cases of a whole block meets the target green factor level, defined according to the land use.

At the building permit stage, the yard plan and green factor calculation are prepared at the detail level of an implementation plan. A stormwater plan should be done in connection with planning the yard, both at the town planning and building permit stages.

Yards that are in joint use of a whole city block including several plots, are in principle calculated on a plot-by-plot basis. Depending on the individual case, the green factor can nevertheless be calculated for the whole block or for

several plots at a time, provided that the entire block or area is included in the same urban plan.

In addition to the green factor level, the tool also checks compliance with stormwater regulations at the zoning/town planning stage and building permit stage. The default required stormwater detention volume is 1,1 m^3 per 100 m^2 of impervious surface. The town plan, the city's stormwater expert or the town planner can define a different value. Based on the required stormwater detention volume the tool calculates the amount of stormwater that must be detained on the plot.

Content of yard plan

The legend in the yard plan image must show the number of square meters of the yard elements (XX m^2) and the number of pieces (XX pcs) used in the calculation of the green factor.

Yards or parts of the yard located on the ground level, deck yards and vegetated roofs should be distinguished from each other in the plan, for example, by using different colours. Shadows are added to the buildings, so that the deck yards and vegetated roof areas are clearly stand out in the plan. In addition, the plan may include, for example, the altitude of different parts of the yard. Underground stormwater detention systems can be marked on the plan using, for example, a red dashed line.

It is recommended to add plan-related comments to the "Author's comments" field on the Green Factor "Score" worksheet, especially if the plan includes special solutions. In addition, the "Green factor" worksheet of the tool includes space for additional information. Filling in the additional information columns is optional (see Figure 10 section h, page 11).

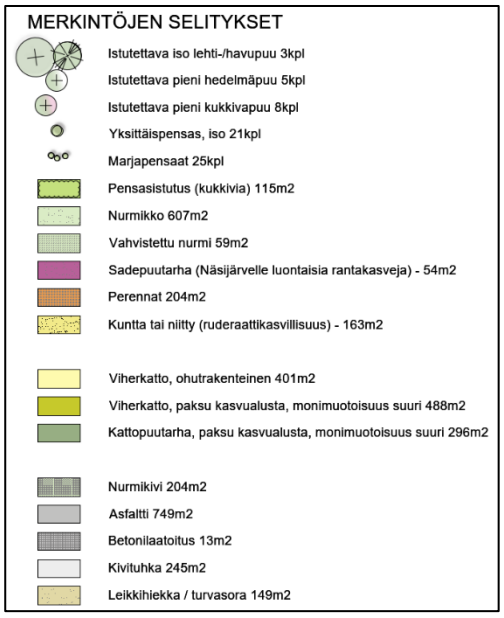


Figure 1. Number of square meters and pieces of elements in the plan legend (extract from the plan of the model yard located in the district center of Hiedanranta, Tampere)

<u>General plan level yard plan at the town plan stage</u>

The calculation of the town plan phase is more general than the calculation of the building permit phase, but it must also consider the rescue routes and the location of seating areas and maintenance areas of the yard. The accuracy should be appropriate for the town plan phase. The plan must also consider minimum distances plantings and stormwater management structures should be placed from buildings and plot boundaries (see also RT-cards: RT 103006 and RT 89-1101), the feasible placement of possible stormwater management structures as well as realistic stormwater runoff and overflow routes and directions.

The entire Excel spreadsheet is filled out and handed over to the city's town planning department along with the yard design at a general level. PDF printouts from the following Excel worksheets must be included:

- Specifications
- Green factor
- Score

The yard plan and Excel printouts are combined into one pdf file and are part of the town plan material.

Note: The print settings in the Green Factor Excel file are suitable for pdf printing of the above worksheets. Printing on paper may require changes to the print settings.

<u>Implementation level plan at the building permit stage</u>

The yard plan at the building plan level includes the structures of the yard, vegetation (including species and quantities in pieces or square meters), specifications of the building materials used, levelling, furniture and equipment, rescue routes and rescue areas as well as possible stormwater management structures.

The points mentioned above concerning the general plan stage must also be considered during the building permit phase. PDF printouts of the Excel spreadsheet are attached to the permit application.

1 The use and structure of the tool

The functionality of the Excel-based tool is based on macros (an .xlsm file), but its functionality is also ensured while macros are disabled. To make use of the tool's full functionality, macros must be allowed when the tool is opened. To accept the use of macros, click on "Enable Content", see Figure 2. Macros enable, for example, a smooth navigation between the worksheets with one click of a mouse (e.g. Start, Instructions, Next, and Previous). Alternatively, the worksheets can be navigated by clicking on the desired worksheet at the bottom bar of the workbook. The workbook also includes locked cells and areas, marked in light grey, that do not need to be edited in basic level use.

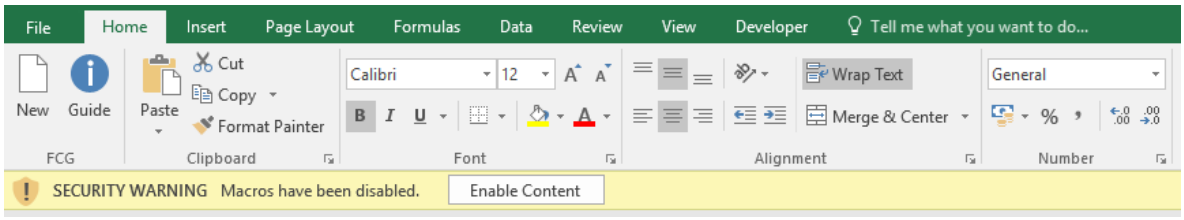


Figure 2. Click on "Enable Content" to enable macros.

The tool includes seven worksheets – Instructions, Specifications, Green factor, Score, Additional information, Surface materials and iWater stormwater solutions.

The Instructions worksheet contains important information regarding the use of the workbook, as well as descriptions of its contents and the concepts used. It is recommended that new users, in particular, start the use of the tool by reading the instructions. In calculations, the Specifications and the Green factor worksheets are filled in. The Additional information worksheet contains information on the elements and their scoring. The Surface materials worksheet provides examples for the four different material categories used within the tool. The seventh worksheet, iWater worksheet (prepared by Aalto University), contains detailed descriptions of the various stormwater solutions, which can be used in the tools.

2 The three-phased green factor calculation

2.1 Phase 1: Specifications

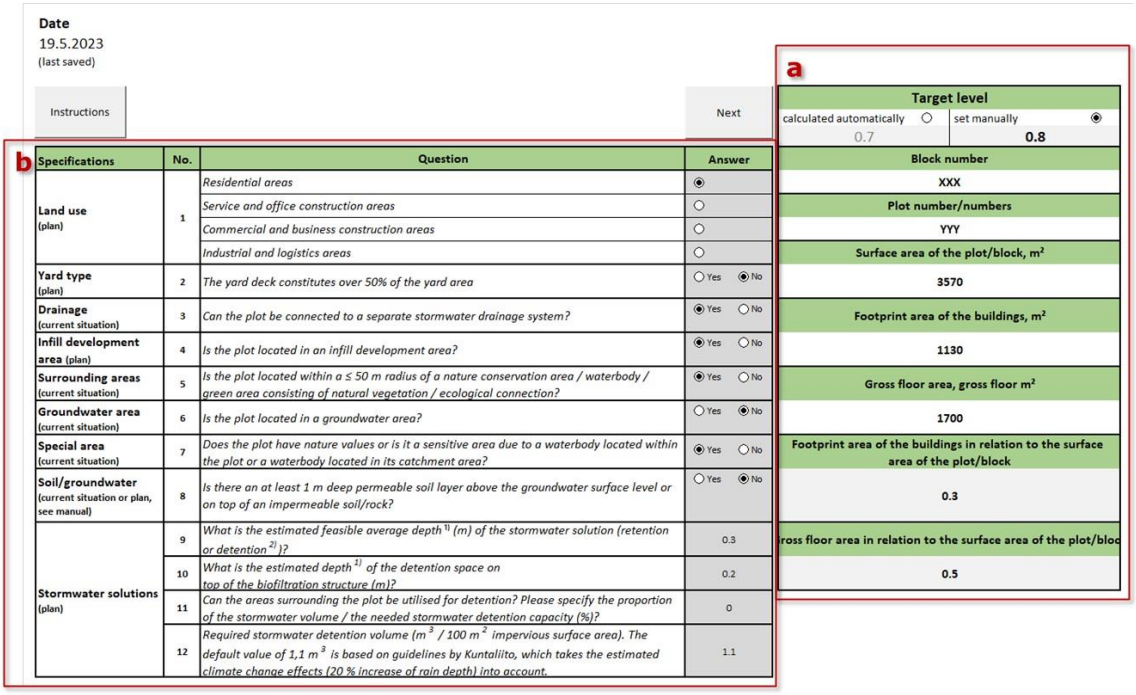


Figure 3. The "Specifications" worksheet. The basic data is shown on the right (section a) and the Specifications are shown on the left (section b) of the worksheet.

The yard planner can check the specific information required to fill in the "Specifications" worksheet from the Oskari service at https://kartat.tampere.fi/oskari/ (soil, bedrock, groundwater areas, sensitive water bodies, nature reserves, …). In Oskari there is information on 5) Surrounding areas, 6) Groundwater area, 7) Special area and 8) Soil / groundwater.

At the beginning of green factor calculation projects at the town plan stage, an initial meeting is held where the information on the "Specifications" worksheet is reviewed. In the construction permit phase, the material of the town plan is used as basic information, including the green factor "Specifications" worksheet and stormwater surveys.

The calculation is started by filling in the basic data and restrictions of the plot on the Specifications worksheet. First, the empty (white) fields on the right are filled in (see Figure 3, section a), i.e. the block and plot numbers, the surface area of the plot/block (m2), the footprint area of buildings (m2), and the gross floor area (gross floor m2). Surface area data is essential initial data for the correct operation of the table. Automatic calculation is selected as the target level calculation method. When the automatic calculation method is selected, the target level depends on the selections made in the Specifications section, such as land use and groundwater data.

The "Specifications" worksheet handles basic information and limitations of both the initial situation (current situation) and the situation of the constructed outcome (plan). Whether the information is related to the current situation or to the plan is indicated in parentheses next to the headings in the Excel spreadsheet.

In urban infill projects, the information on the "Specifications" worksheet is filled according to the current situation of the site, including the buildings, yard elements and possible deck structures that will be preserved on the site. In this case, the situation of the plot before the original construction is not considered.

In some cases, the design solution may change the input data entered on the "Specifications" worksheet, so that the answer must be given according to the plan instead of the current situation. Examples of such cases are given in section 8 Soil/groundwater and in the box on page 9.

The following data is entered in the left-side table of the Specifications worksheet (Figure 3, section b):

1. Land use (plan): This selection has a direct impact on the target level. The target level is 0.8 in Residential areas, 0.7 in Service and office construction, 0.6 in Commercial and business construction, and 0.5 in Industrial and logistics areas. The land use of the plot may change during the planning process. In this case the target level must be reset accordingly. If the land use is mixed (e.g. residential and business construction), the target level is selected based on the main use of the plot or block. The recommendation to increase the use of aboveground (natural) stormwater management structures will apply to all forms of land use. In addition, it is recommended that a qualitative stormwater management solution be added to industrial areas.

2. Yard type (plan): If a yard deck covers over 50% of the yard area on the plot or in the courtyard, the tool recommends a significant increase in the surface area of vegetated roofs. The recommendation to use vegetated roofs is given because the yard deck significantly restricts the use of other stormwater management solutions. In addition, it is recommended that a green wall, climbers, and large trees be added. The yard deck does not automatically mean that there cannot be a sufficiently thick (i.e. over one metre) layer of soil on top of it; however, the goal is that the yard areas are either partly founded on a natural foundation bed, which enables the infiltration of stormwater, or at least part of the yard deck is reserved for plantings and has an at least one metre thick layer of permeable soil (a suitable substrate for large trees).

Deck yard and vegetated roof

The **deck yard** is usually a yard (or part of the yard) on the street level or, for example, on top of the ground floor, covered with vegetation, under which there is a garage or other use that prevents contact with the topsoil layer and the deeper layers of the soil. In the Tampere green factor tool, deck yards are basically calculated in the same way as regular yards, which means by counting **elements**. The elements are listed on the "Green Factor" worksheet. Elements are calculated by area (e.g. lawn) or piece (e.g. trees). The building or part of a building under the deck is not included in the building area on the "Specifications" worksheet of the calculation tool. The target level for the green factor is the same regardless of whether it is a deck yard site or a regular yard, as the deck yard can also be green (question 2 on the "Specifications" worksheet does not affect the target level).

Figure 4. Deck yard, Ratina, Tampere, photo: Ida Tammi 2018

Rules for calculating the deck yard

- The passageways on deck yards are calculated in the same way as if they were located in a ground-level yard.
- Deck yard elements cannot be counted as vegetated roofs, even though the structural courses of a roof garden often correspond to the substrate used for vegetated roofs. This is because the construction below the deck is not counted as a building in the green factor calculation.

Vegetated roofs are roof surfaces covered with vegetation. The "Green Factor" worksheet of the tool includes three elements for different vegetated roofs, whose unit is **square meters**: Roof garden (thickness of substrate 20-100 cm), meadow / dry meadow roof and hay roof (15-30 cm) and stonecrops roof (6-8 cm). Corridors on a vegetated roof (plant-free surfaces) are not included in the surface area of vegetated roof elements.

Degree of detail when planning vegetated roofs

Less detailed vegetated roof plans at the town planning stage can be specified more detailed during the building permit stage.

In case the vegetated roof is not planned in detail, a vegetated roof element can be calculated for the entire surface, without any additional elements. In this case, also passageways not specified in more detail are included in the total surface area of the vegetated roof.

If the vegetated roof is planned more precise, in addition the value of the individual elements (e.g. trees, shrubs) in the vegetated roof can be added to the value calculated as an area. In this case, passageways and other non-vegetated surfaces are not included in the total surface area of the vegetated roof.

Substrate depth of vegetated roofs

The deck yard or vegetated roof substrate can be from a few centimetres to a meter thick, sometimes it can be thicker. The vegetated roof elements of the Green Factor tool take the thickness of the substrate into account. For example the runoff coefficient of the meadow roof element is 0,4 and the runoff coefficient of the meadow element is 0,2.

Rules for calculating a vegetated roof

- **Passageways** on vegetable roofs are calculated as impervious roofs, regardless of their surface material. This means that they must be completely excluded from the vegetated roof's surface area, because the green factor tool automatically calculates all roof surfaces as being impervious.

- In addition to **vegetated roof** surface elements, **vegetation elements defined per piece** can be assigned to a vegetated roof, if the depth of the substrate allows it. However, **elements with a default surface area**, such as bushes (mass plantings, ground covering shrubs) or perennials **cannot be placed separately on vegetated roofs**, as they are already included in the vegetated roof element's surface area. In addition, bonus elements can be placed on vegetated roofs. Adding individual elements to a vegetated roof requires the plan to be accurate. Only then passageways and recreational areas can be defined separately as impervious surfaces.

Figure 5. Vegetated roof, "Vihreistä Vihrein", Jätkäsaari district, Helsinki; photo: Ida Tammi, 2018

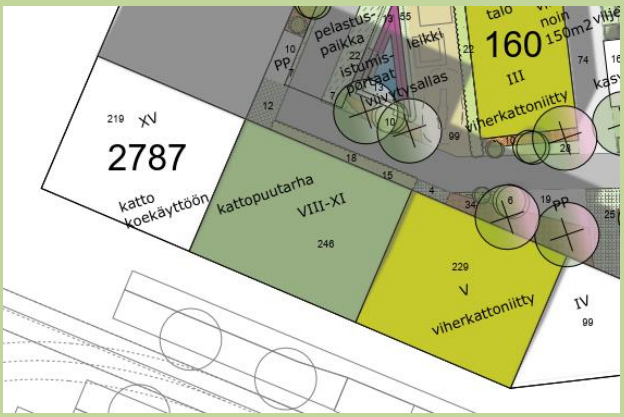


Figure 6. The plan for the vegetated roofs of the model yard in the center of Hiedanranta, Tampere, is not detailed. The values for the different vegetated roof types have been calculated for the entire roof area. (map excerpt)

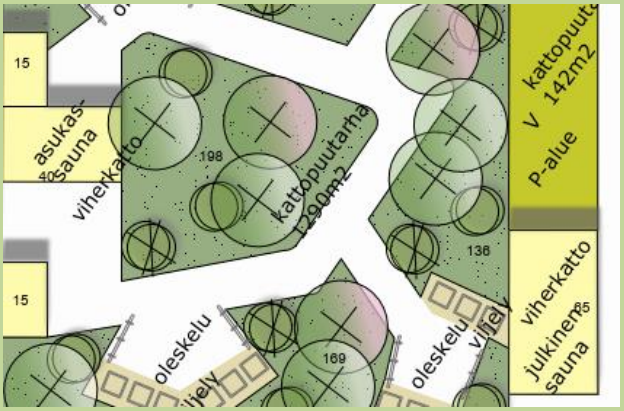


Figure 7. The vegetated roof of the 5-storey car park in Tampere Lielahti model yard have been designed with changing level of detail: some parts more accurately, other parts less detailed. The values of the vegetated roofs have been calculated according to the elements and the corridors have been excluded from the calculation in case they are distinguished in the plan. The more precisely designed part of the roof has trees, large bushes, planting boxes and climbers assigned as separate elements (map excerpt)

3. Drainage (current situation): If the plot cannot be connected to a separate stormwater drainage system, the table reminds that at least one significant stormwater detention solution must be added.

4. Infill development area (plan): Infill development refers to an area within an existing built-up community structure, such as a plot or block of land, that is going to (re)developed. If the plot or the block is located in an infill development area, it is recommended that at least one stormwater management structure be added and any trees that are felled be replaced with new trees.

5. Surrounding areas (current situation): If there is a nature conservation area /waterbody/ ecological corridor within a maximum of 50 m radius of the plot, this must be observed in the planning e.g. by preserving the current vegetation or by planting new vegetation that supports the connection to the nature conservation area /waterbody/ ecological corridor.

6. Groundwater area (current situation): If the plot or the block is located in a groundwater area, 0.1 is added to the target level. It is recommended that only clean water led from the roof be infiltrated, if possible. It is also recommended that qualitative stormwater management solutions be added. The plan and related stormwater survey specify the methods in more detail.

7. Special area (current situation): If there are nature values on the plot or in the block, or the plot or the block is linked to a sensitive area via its waterbody or the catchment area of its waterbody, 0.1 is added to the target level. See the planning specification or contact the planner for further information regarding the sensitivity of the plot/block and its surrounding nature and waterbodies.

8. Soil/groundwater (current situation/plan): If the groundwater surface level or an impermeable surface, such as rock or clay, is very close to the ground surface, stormwater cannot be infiltrated. In addition, trees cannot be planted on a bare rock surface, for example. When NO is selected, the green factor target level is reduced by 0.2. A yard deck does not automatically mean that the soil layer on top of it is insufficient (less than one metre thick), see section 2 Yard type

Soil and groundwater: Why does the soil type have an effect on the Green Factor?
The soil type and thickness of the water-permeable layer affects the target level of the Green Factor. In yards with a layer of permeable soil of less than 1 meter, conditions do not allow rainwater to be infiltrated into the soil in the same way as in yards with a sufficiently thick soil layer. Also vegetation cannot develop to its full potential.

Item 8 on the ”Specifications” worksheet normally relates to the current situation, before implementation of the plan. However, if, for example, the level of the soil surface changes so significantly during the planning process, that the proportion of areas where the soil layer is thicker than one meter becomes sufficient (at least half of the plot surface), the question can be answered according to the situation after the implementation of the plan.

What issues need to be addressed in the soil / groundwater question and where can the necessary information be found?
- It is a recommended to discuss this topic at the initial meeting of the city planning process.
- Information can be retrieved, for example, from the Oskari map service at https://kartat.tampere.fi/oskari/ (bedrock surface, soil / groundwater data)
- Current stormwater situation and its assessment using existing stormwater surveys or consulting a stormwater expert.

Item 8 has to be answered positively, in case at least more than half of the yard has more than a meter of permeable soil. In addition to the size of the area in question, when answering the question, one must take into account e.g. whether the area is in one piece or divided, where the area is located on the plot and whether it is possible to connect it to the stormwater system. So, well over half of the yard must be an area that can be used to infiltrate rainwater.

1 m of soil can be on top of the yard deck. Note! soil layers that are located under buildings cannot be considered. Canopies do also qualify as buildings in the Green Factor calculation.

Example: The yard of an urban infill site is largely asphalt. The proportion of the yard with contact to the soil top layer is less than 10% and will be preserved. A parking garage will be built under the asphalted yard. The plan is to have a deck yard garden on top of the parking garage. The substrate of the deck yard is max. 60 cm thick. Although there is more than 1 m of permeable soil in the area with no deck, question 8 is answered negatively. The Green factor target level decreases, because the possibility of water infiltration to the soil in the section of the yard that has topsoil contact is very small, both from the point of view of the current situation and in the plan.

Example: On top of the parking garage in the example above, a deck yard is built with a substrate thickness and permeable soil layer thickness of at least 1 m. In this case, the plan is the basis for answering the question, because the situation was improved. The answer to the question is “yes”. As a result, the Green Factor target level rises.

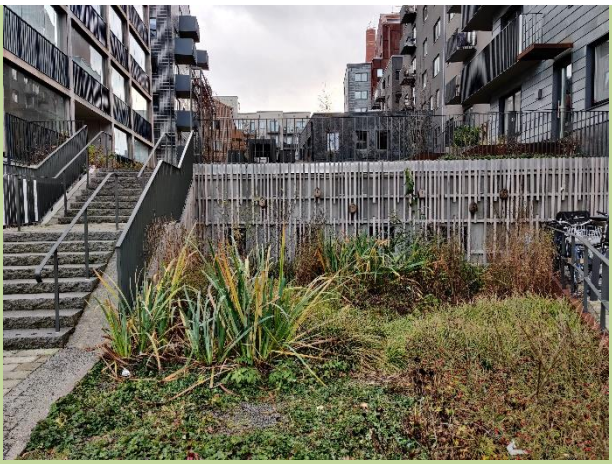


Figure 8. Only a small proportion of this yard has a connection to the topsoil layer. There are insect hotels attached to the wall, which can be calculated as bonus elements in the Green Factor calculation. Norra Djurgårdsstaden district, Stockholm; photo: Taina Tuominen, 2021

Example: At a new development site, about 40% of the yard is covered with bedrock. The bedrock forms the highest part of the yard and the rest of the yard is not divided into smaller parts. On the other side of the yard, a deck yard garden with a layer of less than 1 m of permeable soil is planned on top of a garage. The deck yard area makes up for just under 50% of the whole yard. In this case, the starting point for answering question 8, is the current state of the plot, where, despite the rocks, it is very possible to infiltrate stormwater to the soil. Although the planned deck solution worsens the situation, the Green Factor target level is not lowered.

Example: Based on the municipal engineering plans, stormwater management plans and green master plans prepared during the city planning phase, the general leveling of the plot will rise well above the current ground level and the permeable soil layer will increase to more than one meter. In this case the planned situation is the basis for answering question 8.

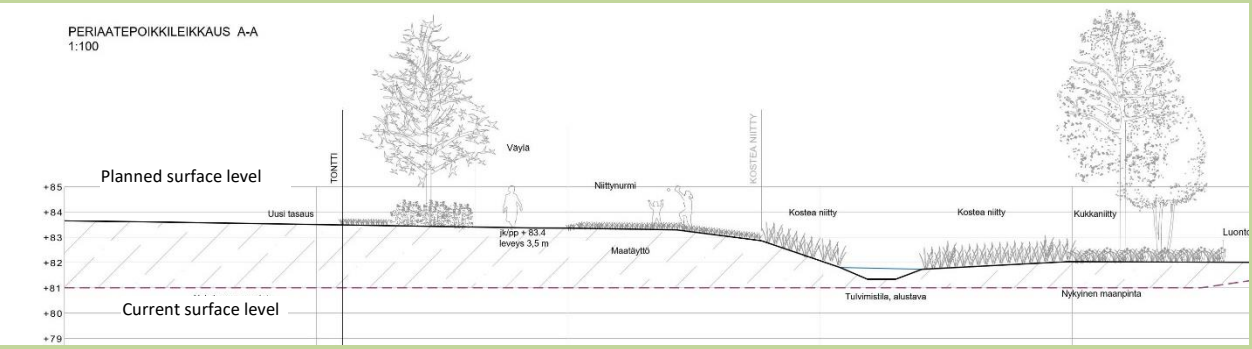


Figure 9. Cross section. A surface level is planned, that is clearly higher than the current surface level. Image: City of Tampere

9. and 10. Stormwater solutions (plan): These selections have a direct impact on calculating the stormwater detention capacity of the plot. An average depth is estimated for the aboveground stormwater solutions. The table calculates the detention capacity of the stormwater solutions based on this and the surface area specified on the Green factor worksheet. The average depth of the stormwater solution varies depending on the steepness of the ramp. See the bottom of the worksheet for further instructions on how to calculate the average depth. The recommended maximum water depth of a detention depression or a detention basin located on top of a biofiltration structure is, on average, 30–40 cm.

11. Is it possible to utilise the areas surrounding the plot for detention? (current situation) If so, which proportion (%) of the stormwater volume / required detention capacity is directed outside the plot/block?: The stormwater of the plot/block can be led outside the plot/block, e.g. into a centralised stormwater wetland located in a park area, when this is the

common intent of the City. A suitable percentage is selected manually, based e.g. on a stormwater survey.

12. Required stormwater detention volume: This selection directly affects the site's needed stormwater detention capacity. The volumes' unit is m^3 / 100 m^2 of impervious surface. 1 m^3 corresponds to 10 mm of precipitation. The default required stormwater detention volume is 1,1 m^3. During the town planning stage, the city's stormwater expert or town planner can define a different value.

Once the basic data and specifications have been filled in, the green factor tool calculates the target level. The needed stormwater detention capacity and the capacity of the presented stormwater solutions is calculated in phase 2 of the calculation. Use the Next button or the worksheet icon at the bottom of the view to proceed to the next phase, which is the Green factor worksheet. Recommendations can be verified on the Score worksheet before filling in the required information on the Green factor worksheet.

Required stormwater detention volume
The default value of 1,1 m^3 is based on the stormwater guidelines of Kuntaliitto (Suomen Kuntaliitto ry, 2012) for a regular once-in-five-years 10-minute rain event with an intensity of 180 l/s*ha and a corresponding rain depth of about 11 mm. The guidelines are taking the expected climate change effects into account (based on earlier studies, the amount of rainfall will increase approximately 20 % by the year 2100). According to statistical studies, approximately 85-90% of the future rain events in Finland will be 11 mm or less.

In the previous version the default required stormwater detention volume was 1 m^3 for each 100 m^2 of impervious surface and 10 mm rain depth respectively.

*Table 1. Intensities [l/s*ha] for rain events covering areas of about 1 km², including climate change effects (Hulevesiopas p. 210 table 15-7, Suomen Kuntaliitto ry, 2012).*

Average intensity (l/s*ha)

	Rain duration								
Return period	5 min	10 min	15 min	30 min	1 h	3 h	6 h	12 h	24 h
1/1 a	140	96	94	60	40	22	13	8,3	5,0
1/2 a	200	144	120	73	50	25	16	10,0	6,0
1/3 a	220	156	133	86	56,4	28	17	10,6	6,2
1/5 a	260	180	146	100	64	30	19	11,6	7,0
1/10 a	280	216	187	120	77	36	23	13,1	8,3

2.2 Phase 2: Green factor calculation

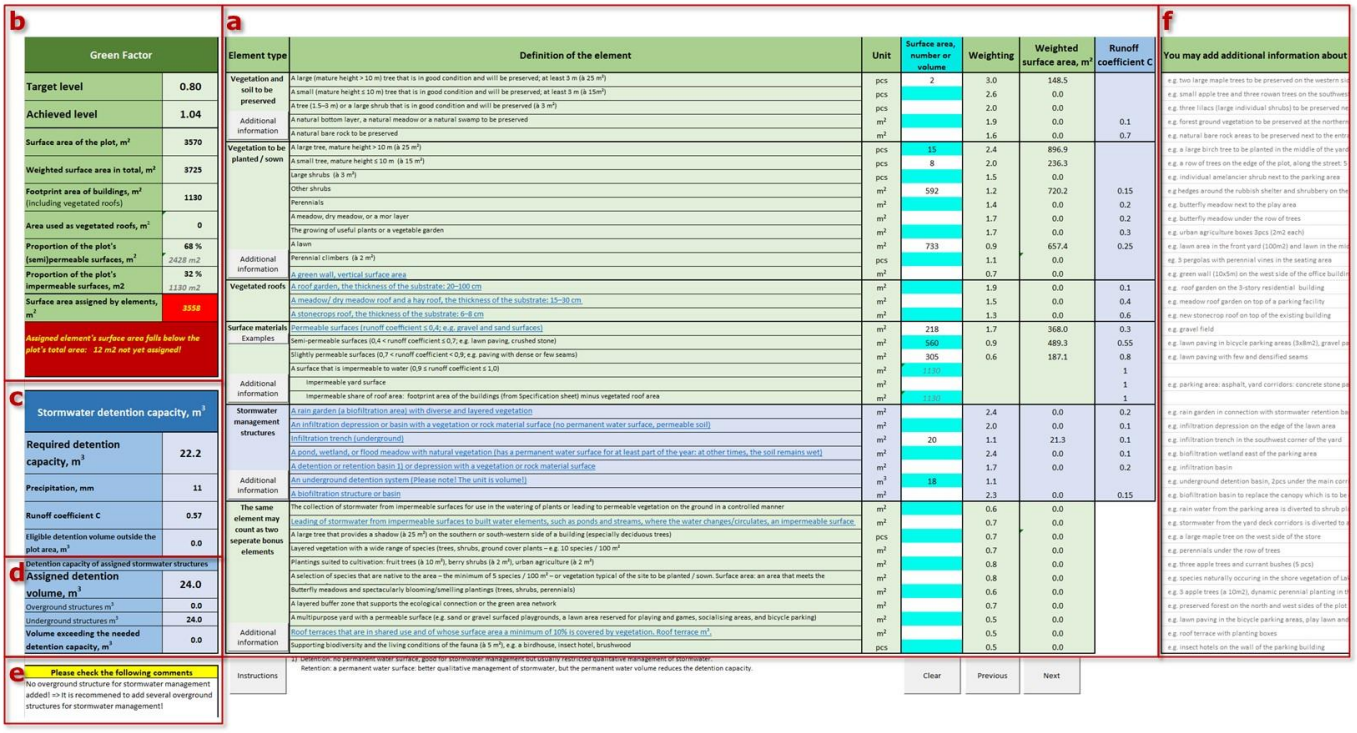


Figure 10. The "Green factor" worksheet

The elements of the Green factor worksheet fall into six groups (see Figure 10, section a):

- vegetation and soil to be preserved
- vegetation to be planted/sown
- vegetated roofs
- surface materials
- stormwater management structures and
- bonus elements

If possible, at least one element should be chosen from each element group, except for the bonus elements. Please observe the unit (surface area, number, or volume) when filling in the number of the elements.

While filling the element list the tool automatically checks if certain recommendations and preconditions remain unmet. These are shown in Figure 10, sections b, d and d).

Impermeable surfaces can be completely excluded from the calculation because the green factor tool automatically calculates all surfaces as impermeable surfaces that have not otherwise been calculated as Green Factor elements.

Elements outside the plot cannot be included in the calculation, even if they shade or otherwise affect the yard conditions of the plot. One exception is stormwater detention outside of the plot (see item 11 on the "Specification" worksheet).

Scored areas

Based on the selections, the table calculates weighted surface areas, their combined total, and the target level achieved. These are shown in the table in the upper left corner of the "Green factor" worksheet (Figure 10, section b).Additionally, the total coverage area of all buildings, the total area of the vegetated roofs and the proportions of the plot's (partially) permeable and impervious surface are presented for revision in the tool. The tool automatically checks and reports, if the total surface area of the assigned square-meters does not correspond to (exceeds or falls below) the plot's total surface area or if proportion of plant roofs exceeds the coverage area of the buildings the coverage area of the plot's buildings.

Example: layered vegetation
In the Tampere Green Factor tool, the area of layered vegetation is calculated twice (or multiple times). For example, if there is perennial and shrub planting under a tree, the square meters of the tree and shrub and perennial planting and their individual weightings are calculated. Within the stormwater calculation the same yard cannot be calculated multiple times.

The units of the elements of the green factor calculation are square meters or pieces (the unit of the underground detention system is a cubic meters). The number of pieces is also converted to square meters in the calculation (for example, the area a large tree affects is 25 m^2). In the Green Factor calculation, scored areas are also used for overlapping elements.

Vegetation

Vegetation elements are listed in the Green Factor worksheet in two categories: vegetation and soil to be preserved and vegetation to be planted/sown.

Vegetation elements have different weights for the green factor calculation. The most valuable ones are trees, that can be preserved or planted. Vegetation elements, which are assigned as pieces have no effect on the calculation of the plot's average runoff coefficient, although trees and bushes can practically reduce the amount of stormwater, e.g. via evapotranspiration effects.

What is a "large tree", a "small tree" and a "big shrub" and "other shrubs"?

A large-sized tree (to be preserved or planted) is a tree that is more than 10 m tall when fully grown. In addition to the species, the possible height of the tree is affected by the growth conditions, such as the depth of the substrate, the growing space, the light supply, etc. Large tree species are for example maple and birch. The area of influence of large trees in Green Factor calculation is 25 m2. This means that the tool calculates the weighted area of large trees by multiplying the weight by 25m2 and the number of trees. The weight of a large tree to be planted is 2,4. Often the area of influence of a tree is the same as the canopy size when viewed from above, but the canopy size of a column-shaped tree, for example, can be smaller.

A small tree is a tree that is less than 10 m tall in the Green Factor calculation. Small tree species are for example rowan and fruit trees, such as apple and cherry trees.

Large shrubs are solitary shrubs with an area of effect of about 3 m2 each. Large shrubs are for example lilacs and rowans. A large shrub should have enough space to reach a canopy size of 3m2. Shrubs that are planted too close to another cannot be counted as large shrubs. If the shrubs have been planted close to each other or in the case of a hedge or low shrub planting, they should be counted according to the planting area as the element "other shrubs". Other shrubs include for example meadowsweets and yew.

Trees planted on deck yards or roof gardens are counted as small trees, because trees on decks and roofs do not usually grow large.

Green wall or perennial climbers?

A **green wall** means that the vegetation is, in one way or another, integrated into the façade of the building. Green walls can be completely detached from the ground and their actual impact on stormwater management is difficult to assess, although a functioning green wall is likely to retain, absorb and evaporate water. In the Tampere Green Factor tool, a runoff coefficient for a green wall is currently not taken into account. The weighting of the green wall element is 0,7. In the calculation of the Green Factor, choosing the green wall element, one can best take into account, the vertical surface area of the wall covered by even high vegetation.

The vertical area of **perennial climber** elements in the Green Factor calculation is 2 m2, a piece, regardless of the height, the weighting of the climbers is 1,1. Individual perennial vines are counted as perennial climber elements. If the climbers are to be counted as green wall elements, the façade, structure and plantings must be organized in a way, that the vegetation actually forms a uniform green wall surface.

Figure 11. Methods of counting perennial climbers and green walls

Bonus elements

Bonus elements can be used to increase the Green Factor. However, other Green Factor elements are more important than bonus elements. Using bonus elements alone, one cannot achieve a high Green Factor.

The same element (e.g. the same tree) can be counted twice as a bonus element in the Tampere tool (e.g. 1 x flowering planting and 1 x fruit tree). In this way i.e. a variety of ecosystem services is added.

Bonus elements do not have an effect on the stormwater calculation.

Runoff coefficient

The tool automatically calculates the average runoff coefficient of the plot based on the assigned elements (Figure 10, section c).

The runoff coefficient describes the proportion of precipitation (rain water) that generates surface runoff within a defined catchment area (in this case the plot or block) by taking into account various types of losses caused e.g. by evaporation, depression storage, infiltration and other retention effects. The runoff coefficient depends, among other things, on the material of the ground surface and its permeability. The runoff coefficient is 0, if the surface is fully permeable (e.g. a forest on a sandy soil), and 1, if the surface is fully impermeable (e.g. a roof).

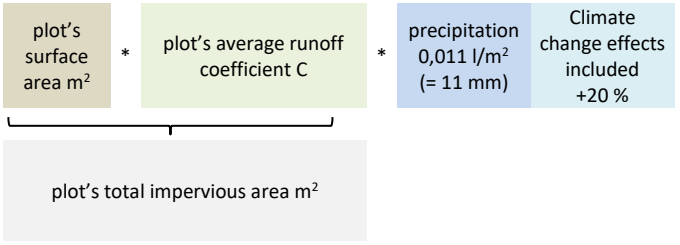
The runoff coefficients assigned to each element have been determined by using various sources. For example, surface materials are divided into four different groups according to their average runoff coefficient: permeable, semipermeable, slightly permeable and impermeable / impervious. A brief list of example surface materials of each group can be found in the tool's worksheet "Surface materials" and in Table 2. There are no national norms for runoff coefficients, but runoff coefficient values have been specified for the most common land use types in various publications. A more detailed list including thresholds and average values for runoff coefficients from literature is attached to this document.. The vegetated roof types, substrate thicknesses, and the runoff coefficients of various vegetated roof types have been taken from the guidelines for vegetated roofs (RT card 85-11203 on Vegetated roofs and deck yards from 2016, Building Information Ltd). Whilst vegetated roofs cannot be used to meet the required detention capacity, they reduce the volume of stormwater on the plot or city block by using runoff coefficients less than 1.

The use of the Green Factor tool does not replace a stormwater survey and a stormwater plan prepared by a stormwater expert. The stormwater solutions selected for the green factor must fulfil the requirements of any plan regulations.

Stormwater detention capacity (Figure 10, section c).

The tool automatically calculates the following values:

- **Required stormwater detention capacity** (m^3) is the volume that needs to be provided on the plot to detain stormwater. It is calculated as follows:



- **Precipitation (rain depth, mm)** is calculated based on the required (relative) stormwater detention volume specified in the "Specifications" worksheet (chapter 2.1, item 12). By default, it should include the predicted effects of the climate change and is calculated as follows: 180 l/s*ha * 10 min * 0,006 (unit conversion factor) ≈ 11 mm (Figure 10, section c).

- **Average runoff coefficient C** is calculated automatically within the "Green factor" worksheet based on all assigned element's surface area and their average runoff coefficients (Figure 10, section c).

- **Eligible detention volume outside the plot area (m^3)** is specified in the "Specifications" worksheet (chapter 2.1, item 11). The default value is zero.

- **Achieved detention volume (m3)** is calculated automatically based on the chosen stormwater solution elements within the "Green factor" worksheet and the assigned average storage depths in the "Specifications" worksheet. The volumes are additionally calculated separately for over- and underground structures. Depending on both the required and assigned detention volumes the tools checks and automatically calculates a potential shortage of detention volume (Figure 10, section d).

Stormwater management structures

Vegetation elements, which are assigned in m^2 (e.g. perennials), may not be added on top of stormwater management structures / solutions. An exception is the "underground detention system", which can be covered with suitable vegetation depending on the required substrate depth (for example vegetation, with deep roots, should be avoided on top of underground structure with a shallow cover of substrate. The “infiltration trench” element is an underground structure that additionally requires space on the surface, that must not be assigned by other elements.

Overground storage tanks (e.g. for irrigation purposes) can be assigned as follows: the surface area covered by the tank is added as an impervious surface area in the yard (m^2) and the storage volume is added as "underground detention system" (m^3).

Examples of stormwater management structures (iWater Toolsheet, Aalto University) can be accessed through links (blue texts) contained on the Green factor worksheet. On the Green factor worksheet, only the surface area and volume of Element types that have a white or turquoise background as well as a black font colour can be specified and edited. The only exceptions are the "A surface that is impermeable to water” and “Impermeable share of roof area” fields, which the tool calculates automatically. Where required, inserted values can be deleted by using the “Clear” button.

It is recommended that the “Next” button be selected once all data has been entered in the table in order for the software to ensure that certain preconditions are met. If no changes are needed, the tool will go to the Score worksheet.

What is a permeable, slightly permeable, semi-permeable and impermeable surface material?

For the sake of certainty, higher values of runoff coefficients have been used in the Tampere Green Factor tool than the mean values of runoff coefficients used in the source literature. The amount of stormwater calculated using the tool and the required detention capacity are preliminary estimates, and the surface material groups contain different materials with varying runoff coefficients. Using higher runoff coefficients ensures that the amount of stormwater calculated with the tool is not too small. Underestimating the amount may lead to difficulties in achieving sufficient capacity at a later design stage.

Permeable surface materials in the Green Factor calculation include for instance uncompacted gravel and sand, which have an average runoff coefficient of 0,4 or less. In the Green factor worksheet permeable surface materials’ average runoff coefficient is the lowest of all surface materials: 0,3 and the green factor weight is the largest of all surface materials with a value of 1,7.

Semi-permeable surface materials include, for example, grass pavers or (self-binding) gravel/stone dust pavements with average runoff coefficients ranging from 0,4 to 0,7. In the Green factor worksheet all semi-permeable surfaces have an average runoff coefficient of 0,55 and their green factor weight is 0,9.

There are different types of grass and gravel pavement solutions, and their runoff coefficient varies depending on the width of the seams / joints. Studies have shown that permeable concrete pavers and permeable asphalt may be comparable to permeable surface materials (see https://projectsites.vtt.fi/sites/class/www.vtt.fi/sites/class/en/ publications.html). However, it has been found that the permeability of these surface materials may change over time because small particles can cause clogging of the pavement’s pores. However, this issue has not yet been thoroughly investigated, and therefore permeable concrete and asphalt are recommended to be calculated as semi-permeable surfaces.

Slightly permeable surfaces include for instance paving with few and / or densified seams and joints, whose average runoff coefficients range from 0,7 to less than 0,9. In the Green factor worksheet all slightly permeable surfaces have an average runoff coefficient of 0,8 and a green factor weight of 0,6.

Impermeable surfaces include, for example, asphalt and concrete stone, that have a runoff factor of 0,9 – 1. In the Green factor worksheet, all slightly permeable surfaces have an average runoff coefficient of 1 and a green factor weight of 0. The total amount of impermeable surfaces is calculated as follows:

the coverage areas of all buildings (including yard canopies, the amount is filled in the “Specifications” tab)
+ impervious surface of the yard area
- the area of the green roof elements

All non-vegetated roof surfaces (not defined as green roof elements, field: "Impermeable share of roof area" in Green factor worksheet) as well as the all impervious yard surface area elements, are added together as a sum in field “a surface that is impermeable to water” of the Green factor sheet. Impermeable surfaces within the yard area (e.g. asphalt or concrete) must be entered into the table separately (manually!) after the spring 2023 update.

Passageways and other areas used for traffic on deck yards are calculated in the same way as passageways in ground-level yard. Passageways on vegetated roofs are calculated as impermeable roofs, regardless of their surface material. This means that the area of walkways on vegetated roofs must be completely excluded from the vegetated roof element’s area.

All buildings and canopies on the plot count as coverage area of buildings, i.e. also the canopies on the yard, up to the eaves. Balconies are also counted as part of the building, just like courtyard buildings and canopies. The area under the balconies can be used, for example, as a planting area, but in the Green factor tool, the area must not be calculated as an element other than a building.

Table 2 contains examples of different surface materials for each group.

Table 2. A list of surface material groups and example materials used in the Green factor tool

Group	Surface cover, pavement
Impermeable surfaces or paving	Roofs
	Asphalt, concrete
Slightly permeable surfaces or paving	Pavement with ≤ 15 % seams (e.g. concrete tiles)
	Compacted unbound pavement (e.g. gravel, sand, stone ash), slightly permeable structural courses
Semipermeable surfaces or paving	Permeable asphalt or concrete
	Pavement with > ~15 % seams (open paving patterns)
	Crushed stone, to some extent compacted (permeable structural courses)
	Safety covers, e.g. tiles from recycled rubber or plastic, semipermeable
	Gravel road or embankments
Permeable surfaces	Artificial turf (permeable structural courses)
	Safety covers, e.g. rubber mulch (permeable structural courses)
	Uncompacted sand
	Uncompacted crushed rock or stone
	Fields and passage ways made from uncompacted gravel

2.3 Additional information: weighting

Use the Additional information button at the bottom of the element type column on the Green factor worksheet to access the Additional information worksheet that provides a short description of the elements and their significance for different categories. The categories are Ecology, Functionality, Landscape value, Maintenance, and Stormwater. The weighting of the elements in relation to the categories and their weighted averages can be found on the Additional information worksheet. The Additional information worksheet can also be accessed from the bottom bar.

The scoring and weighting are based on the descriptions and weighting used in the Ilkka project and in the development of the City of Helsinki Green Factor Method. In case of Tampere, the weighting of the elements was specified based on expert surveys. The respondents represented various groups, such as land use planners (planners), landscape architects, the building control department, environmental experts, maintenance planners, and stormwater experts.

The significance of each element of the green factor calculation has been described for five different categories and their weighting has been specified. The element-specific weighting was tested and specified by means of test calculations implemented on model yards. The tool was also tested at workshops. The weighting cannot be changed by the user of the table. The Back button takes the user to the Green factor worksheet.

2.4 Phase 3: The score

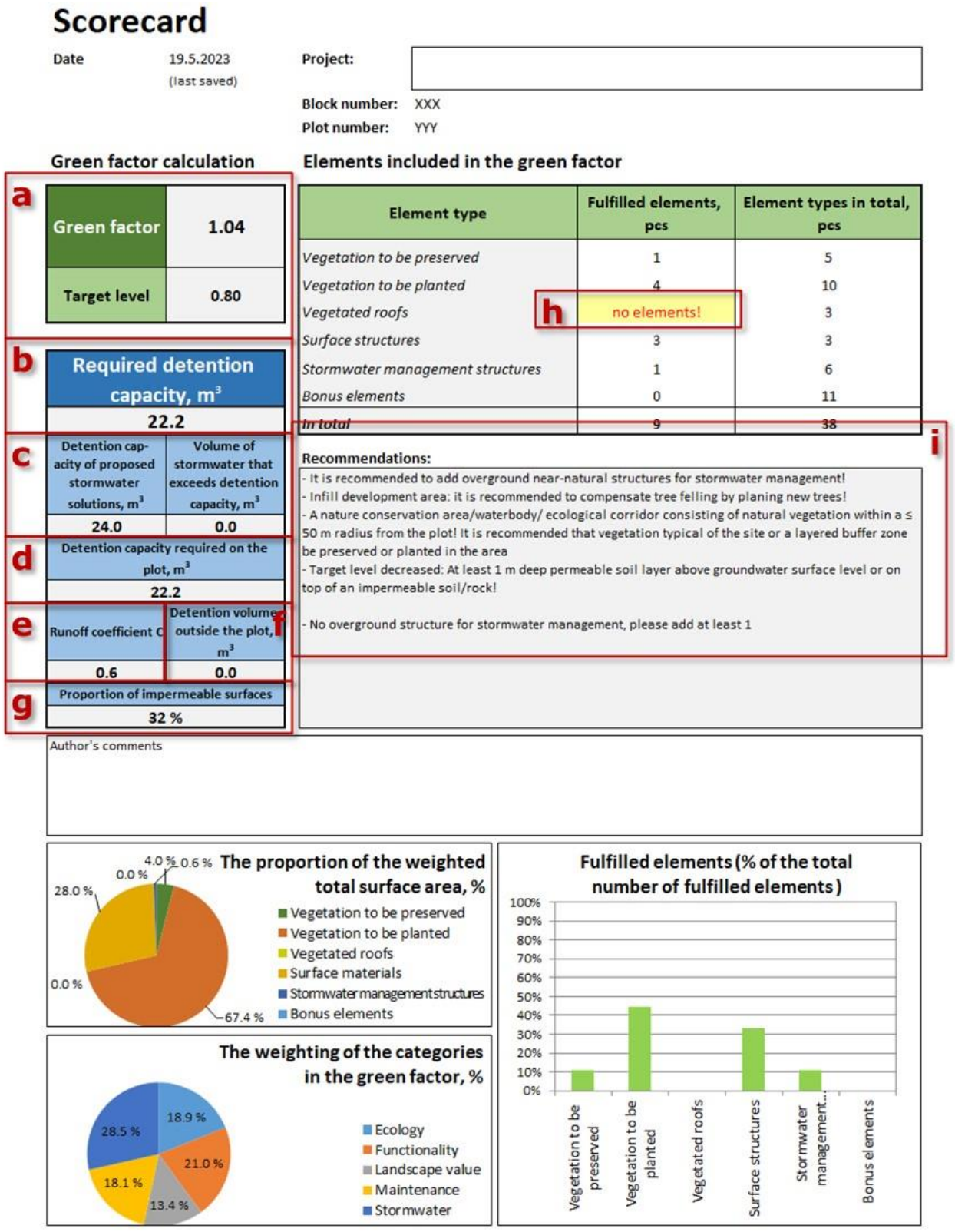


Figure 12. The "Score" worksheet.

The Score worksheet (Figure 12) contains a summary of the calculation. It can be printed in an A4 size. The scorecard contains the data in a numeric form, e.g. the achieved green factor and target level, and the element types used. The calculation data is also illustrated graphically.

The Score worksheet also includes data of stormwater volumes in a blue table. The topmost figure shows the estimated stormwater volume (Figure 12, section a) on the plot or in the block that should be detained. Based on the proportion of stormwater that can be detained outside the plot or block, the amount in m^3 is calculated and shown on the scorecard (Figure 12, section j). The runoff coefficient field includes an average of the runoff coefficient of the plot or the block (Figure 12, section b) and the proportion of impermeable surface on the plot (Figure 12, section c) is at the very bottom of the table. The final detention capacity needed on the plot or in the block is indicated in the middle of the table (Figure 12, section d). The table also specifies the detention capacity of the presented stormwater solutions (Figure 12, section e) and the volume of stormwater that exceeds the detention capacity (Figure 12, section f). The aim is that as large a proportion of the stormwater as possible could be detained on the plot or in the block. The detention capacity must meet the regulations of the local detailed plan.

The table warns the user, if the target level of the green factor is not met (Figure 12, section g). The table also notifies the user if certain elements are missing (Figure 12, section h). Depending on the selections and the elements, the internal inspection of the table lists any recommendations that must be observed in the planning.

Update history

Original version 25.8.2020
FCG Design and Engineering Ltd
Inspected by: Eeva Eitsi
Landscape Architect, MARK
Prepared by: Eric Wehner
Specialised Designer, M.Sc. (Tech.)

Updated version 22.12.2021
FCG Finnish Consulting Group Oy
Ida Tammi, Landscape Architect, MARK, MSc
Eric Wehner, Specialised Designer, MSc (Tech.)
Anni Westrup, Landscape Architect, MARK
Anna-Maria Rajala, Horticultural Planner, BSc
In the role of a sub-consultant:
Eeva Eitsi, expert, Landscape Architect, MARK

Updated version 26.052023
FCG Finnish Consulting Group Oy
Ida Tammi, Landscape Architect, MARK, MSc
Eric Wehner, Specialised Designer, MSc (Tech.)
Anna-Maria Rajala, Horticultural Planner, BSc

Appendix 1. Surface material runoff coefficients

Group	Type of cover or pavement	Min	Max	Ave-rage	Source
Standard roofs	Roofs	0,8	1,0	*0,9*	Hulevesiopas (Suomen Kuntaliitto ry, 2012, 183)
	Roofs			0,9	Suomen Kuntatekniikan yhdistys ry 2002, 120
	Roofs			1,0	RIL 126-2009, 55
	Roofs	0,9	1,0	*0,95*	DIN-standard, DIN 1986-100:2016-12
Vegetated roofs	Extensive, stonecrops roof, substrate layer 6-8 cm			0,6	RT cards, Building Information Ltd, RT 85-11203, 2016, 5
	Extensive or semi-intensive, (dry) meadow, substrate layer 15-20 cm			0,4	RT cards, Building Information Ltd, RT 85-11203, 2016, 5
	Extensive or semi-intensive, grass / turf, substrate layer 20-30 cm			0,4	RT cards, Building Information Ltd, RT 85-11203, 2016, 5
	Roof garden, intensive, substrate layer 20-100 cm			0,1	RT cards, Building Information Ltd, RT 85-11203, 2016, 5
	Extensive, slope > 5°	0,4	0,7	*0,55*	DIN-standard, DIN 1986-100:2016-12
	Intensive, substrate layer > 30 cm, slope ≤ 5°	0,3	0,5	*0,4*	DIN-standard, DIN 1986-100:2016-12
	Extensive, substrate layer > 10 cm, slope ≤ 5°	0,2	0,4	*0,3*	DIN-standard, DIN 1986-100:2016-12
	Extensive, substrate layer ≤ 10 cm, slope ≤ 5°	0,1	0,2	*0,15*	DIN-standard, DIN 1986-100:2016-12
Impermeable surfaces or pavements	Asphalt, concrete	0,7	0,9	*0,8*	Hulevesiopas (Suomen Kuntaliitto ry, 2012, 183)
	Asphalt, concrete			0,8	Suomen Kuntatekniikan yhdistys ry 2002, 120
	Asphalt	0,7	0,9	*0,8*	Liikennevirasto (Teiden ja ratojen kuivatuksen suunnittelu, 2013, 29)
	Asphalt, concrete (impervious surface)			1,0	RIL 126-2009, 55
	Asphalt, concrete	0,9	1,0	*0,95*	DIN-standard, DIN 1986-100:2016-12
Permeable concrete /asphalt	Permeable asphalt	0,1	0,55	*0,33*	Permanent BMPs (Brown and Caldwell, Caltrans)
	Permeable concrete	0,1	0,6	*0,35*	Permanent BMPs (Brown and Caldwell, Caltrans)
Semi-permeable paving, grass and gravel pavers	Pavers with sand joints			0,7	Suomen Kuntatekniikan yhdistys ry 2002, 120
	Pavers with narrow densified joints			0,8	Suomen Kuntatekniikan yhdistys ry 2002, 120
	Concrete pavers, proportion of joints ≤ 15%	0,7	0,9	*0,8*	DIN-standard, DIN 1986-100:2016-12
	Pavers, proportion of joints > 15%	0,6	0,7	*0,65*	DIN-standard, DIN 1986-100:2016-12
	Pavers, proportion of joints > ~50% (e.g. grass pavers with large gaps)	0,2	0,4	*0,3*	DIN-standard, DIN 1986-100:2016-12
Sportsfields, playgrounds	Artificial turf, well permeable			0.3	DIN-standardi, DIN 18035-3:2006–09
	Artificial safety covers, well permeable			0.3	DIN-standardi, DIN 18035-3:2006–09
	Safety covers, plastic or rubber, semi-permeable			0.6	DIN-standardi, DIN 18035-3:2006–09, DIN 1986-100:2016-12
Gravel, stone dust, crushed stone/rock	(self-binding) gravel/stone dust			0,5	Tuusulan kunnan rakennusvalvonnan hulevesien hallinnan suunnitteluohje (link)
	Gravel (road, embankments)	0,2	0,5	*0,35*	Hulevesiopas (Suomen Kuntaliitto ry, 2012, 183)
	Gravel surfaces	0,7	0,9	*0,8*	RIL 126-2009, 55
	Gravel road, in good condition			0,5	Suomen Kuntatekniikan yhdistys ry 2002, 120
	Gravel fields and lanes			0,3	Suomen Kuntatekniikan yhdistys ry 2002, 120
	Gravel, not densified	0,2	0,3	*0,25*	DIN-standard, DIN 1986-100:2016-12
	Crushed rock or stone	0,2	0,3	*0,25*	
Bare or rocky surface	Open uncovered land	0,3	0,5	*0,4*	Hulevesiopas (Suomen Kuntaliitto ry, 2012, 183)
	Rock, bare / flat			0,4	Suomen Kuntatekniikan yhdistys ry 2002, 120
Green areas	Grass-covered embankment			0,5	Suomen Kuntatekniikan yhdistys ry 2002, 120
	Grass, turf, lawns	0,1	0,4	*0,25*	Hulevesiopas (Suomen Kuntaliitto ry, 2012, 183)
	Grass, turf, unpaved surfaces			0,3	RIL 126-2009, 55
	Lawns			0,2	Suomen Kuntatekniikan yhdistys ry 2002, 120
	Parks, lawns, turf, gardens (even, flat)	0,1	0,2	*0,15*	DIN-standard, DIN 1986-100:2016-12
	Parks, lawns, turf, gardens (sloped)	0,2	0,3	*0,25*	DIN-standard, DIN 1986-100:2016-12
	Meadows, fields/acres, gardens	0,1	0,3	*0,2*	Hulevesiopas (Suomen Kuntaliitto ry, 2012, 183)
	Meadows, fields/acres, gardens			0,1	Suomen Kuntatekniikan yhdistys ry 2002, 120
Forest, woods	Forest / woods	0,1	0,1	*0,1*	Hulevesiopas (Suomen Kuntaliitto ry, 2012)
	Forest /woods on rocky terrain			0,15	Suomen Kuntatekniikan yhdistys ry 2002, 120