The methodology for the calculation of one single process step forms the basis of all kind of Water Footprint accounts. The Water Footprints of products, nations or businesses are the sum of the Water Footprint of the processes associated with product, nation or business. The relation between the different sorts of Water Footprints is as follows:
1. The Water Footprint of a product = the sum of the Water Footprints of the process steps taken to produce the product (considering the whole production and supply chain).
2. The Water Footprint of a consumer = the sum of the Water Footprints of all products consumed by the consumer.
3. The Water Footprint of a community = the sum of the Water Footprints of its members.
4. The Water Footprint of national consumption = the sum of the Water Footprints of its inhabitants.
5. The Water Footprint of a business = the sum of the Water Footprints of the final products that the business produces.
6. The Water Footprint within a geographically delineated area (e.g. a municipality, province, state, nation, catchment or river basin) = the sum of the process Water Footprints of all processes taking place in the area.

Water Footprint of a process step

The total Water Footprint of a single process step of is the sum of the green, blue and grey components

\[ W_{Proc} = W_{Proc\ green} + W_{Proc\ blue} + W_{Proc\ Grey} \]

The blue Water Footprint component of a process is calculated as:

\[ W_{proc,\ blue} = Blue\ Water\ Evaporation + Blue\ Water\ Incorporation + Lost\ Returnflow \]
The term ‘consumptive water use’ refers to one of the following four cases: water evaporates; water is incorporated into the product; water does not return to the same catchment area, e.g. it is returned to another catchment area or the sea; water does not return in the same period, e.g. it is withdrawn in a scarce period and returned in a wet period.

The green Water Footprint is the volume of rainwater consumed during the production process. This is particularly relevant for agricultural and forestry products (products based on crops or wood), where it refers to the total rainwater evapotranspiration (from fields and plantations) plus the water incorporated into the harvested crop or wood. The green Water Footprint in a process step is equal to:

\[ WF_{proc,\text{green}} = \text{GreenWaterEvaporation} + \text{GreenWaterIncorporation} \]

The grey Water Footprint is calculated by dividing the pollutant load \( (L, \text{in mass/time}) \) by the difference between the ambient water quality standard for that pollutant (the maximum acceptable concentration \( c_{\text{max}}, \text{in mass/volume} \)) and its natural concentration in the receiving water body \( (c_{\text{nat}}, \text{in mass/volume}) \).

\[ WF_{proc,\text{grey}} = \frac{L}{c_{\text{max}} - c_{\text{nat}}} \]

The critical load \( (L_{\text{crit}}, \text{in mass/time}) \) is the load of pollutants that will fully consume the assimilation capacity of the receiving water body. It can be calculated by multiplying the runoff of the water body \( (R, \text{in volume/time}) \) by the difference between the maximum acceptable and natural concentration:

\[ L_{\text{crit}} = R \times (c_{\text{max}} - c_{\text{nat}}) \]
In the case that pollutants are part of an effluent discharged into a water body, the pollutant load can be calculated as the effluent volume (Effl, in volume/time) multiplied by the difference between the concentration of the pollutant in the effluent (cefll, in mass/volume) and its natural concentration in the receiving water body (cnat, in mass/volume). The grey Water Footprint can then be calculated as follows:

\[ WF_{proc.grey} = \frac{L}{c_{max} - c_{nat}} = \frac{Effl \times (c_{effl} - c_{nat})}{c_{max} - c_{nat}} \]

For thermal pollution, the grey Water Footprint is now calculated as the difference between the temperature of an effluent flow and the receiving water body (oC) times the effluent volume (volume/time) divided by the maximum acceptable temperature increase (oC).

\[ WF_{proc.grey} = \frac{Effl \times \Delta T_{effl}}{\Delta T_{max}} = \frac{Effl \times (T_{effl} - T_{nat})}{T_{max} - T_{nat}} \]

The grey Water Footprint is determined by the pollutant that is most critical, i.e. the one that is associated with the largest pollutant-specific grey Water Footprint

**Calculation of the green, blue and grey Water Footprint of growing a crop or tree**

The agricultural and forestry sectors are major water consuming sectors, products that involve agriculture or forestry in their production system will often have a significant Water Footprint.
The green component in the process Water Footprint of growing a crop or tree (WF\textsubscript{proc,green}, m\textsuperscript{3}/ton) is calculated as the green component in crop water use (CWU\textsubscript{green}, m\textsuperscript{3}/ha) divided by the crop yield (Y, ton/ha). The blue component (WF\textsubscript{proc,blue}, m\textsuperscript{3}/ton) is calculated in a similar way:

\[
WF_{\text{proc,green}} = \frac{CWU_{\text{green}}}{Y}
\]

\[
WF_{\text{proc,blue}} = \frac{CWU_{\text{blue}}}{Y}
\]

The grey component in the Water Footprint of growing a crop or tree (WF\textsubscript{proc,grey}, m\textsuperscript{3}/ton) is calculated as the chemical application rate per hectare (AR, kg/ha) times the leaching fraction (\(\alpha\)) divided by the maximum acceptable concentration (c\textsubscript{max}, kg/m\textsuperscript{3}) minus the natural concentration for the pollutant considered (c\textsubscript{nat}, kg/m\textsuperscript{3}) and then divided by the crop yield (Y, ton/ha).

\[
WF_{\text{proc,grey}} = \frac{(\alpha \times AR)/(c_{\text{max}} - c_{\text{nat}})}{Y}
\]

The green and blue components in crop water use (CWU, m\textsuperscript{3}/ha) are calculated by accumulation of daily evapotranspiration (ET, mm/day) over the complete growing period:

\[
CWU_{\text{green}} = 10 \times \sum_{d=1}^{\text{lp}} ET_{\text{green}}
\]

\[
CWU_{\text{blue}} = 10 \times \sum_{d=1}^{\text{lp}} ET_{\text{blue}}
\]
in which ETgreen represents green water evapotranspiration and ETblue blue water evapotranspiration. The factor 10 is meant to convert water depths in mm into water volumes per land surface in m³/ha. The summation is done over the period from the day of planting (day 1) to the day of harvest (lgp stands for length of growing period in days).

**Water Footprint of a product**

The Water Footprint of a product can be calculated in two alternative ways: with the chain-summation approach or the step-wise accumulative approach.

The chain-summation approach

This can only be applied in the case where a production system produces only one output product. In this particular case, the Water Footprints that can be associated with the various process steps in the production system can all be fully attributed to the product that results from the system.

In this simple production system, the Water Footprint of product p (volume/mass) is equal to the sum of the relevant process Water Footprints divided by the production quantity of product p:

\[
WF_{prod}[p] = \frac{\sum_{s=1}^{k} WF_{proc}[s]}{P[p]}
\]

in which WFproc[s] is the process Water Footprint of process step s (volume/time), and P[p] the production quantity of product p (mass/time).
The step-wise accumulative approach

This approach is a generic way of calculating the Water Footprint of a product based on the Water Footprints of the input products that were necessary in the last processing step to produce that product and the process Water Footprint of that processing step. The Water Footprint of output product $p$ is calculated as:

$$WF_{\text{prod}}[p] = \left(WF_{\text{proc}}[p] + \sum_{i=1}^{y} \frac{WF_{\text{prod}}[i]}{f_{p}[p,i]} \right) \times f_{v}[p]$$

in which $WF_{\text{prod}}[p]$ is the Water Footprint (volume/mass) of output product $p$, $WF_{\text{prod}}[i]$ the Water Footprint of input product $i$ and $WF_{\text{proc}}[p]$ the process Water Footprint of the processing step that transforms the $y$ input products into the $z$ output products, expressed in water use per unit of processed product $p$ (volume/mass). Parameter $f_{p}[p,i]$ is a so-called ‘product fraction‘ and parameter $f_{v}[p]$ is a ‘value fraction‘.

The product fraction of an output product $p$ that is processed from an input product $i$ ($f_{p}[p,i]$ mass/mass) is defined as the quantity of the output product ($w[p]$ mass) obtained per quantity of input product ($w[i]$ mass):

$$f_{p}[p,i] = \frac{w[p]}{w[i]}$$

The value fraction of an output product $p$ ($f_{v}[p]$ monetary unit/monetary unit) is defined as the ratio of the market value of this
product to the aggregated market value of all the outputs products (p=1 to z) obtained from the input products:

\[
\frac{f_v[p]}{z} = \frac{\sum_{p=1}^{z} (\text{price}[p] \times w[p])}{\sum_{p=1}^{z} (\text{price}[p] \times w[p])}
\]

in which price\(\text{[p]}\) refers to the price of product \(p\) (monetary unit/mass).

**Water Footprint of national consumption**

The Water Footprint of the consumers in a nation (WF\(\text{cons, nat}\)) has two components: the internal Water Footprint and the external Water Footprint.

\[
WF_{\text{cons, nat}} = WF_{\text{cons, nat, int}} + WF_{\text{cons, nat, ext}}
\]

The internal Water Footprint of national consumption (WF\(\text{cons, nat, int}\)) is defined as the use of domestic water resources to produce goods and services consumed by the national population. It is the sum of the Water Footprint within the nation (WF\(\text{area, nat}\)) minus the volume of virtual-water export to other nations insofar as related to the export of products produced with domestic water resources (Ve,d):

\[
WF_{\text{cons, nat, int}} = WF_{\text{area, nat}} - Ve,d
\]

The external Water Footprint of national consumption (WF\(\text{cons, nat, ext}\)) is defined as the volume of water resources used in other nations to produce goods and services consumed by the population in the nation considered. It is equal to the virtual-water
import into the nation (Vi) minus the volume of virtual-water export to other nations as a result of re-export of imported products (Ve,r):

$$WF_{cons,nat,ext} = V_i - V_{e,r}$$

The virtual-water export (Ve) from a nation consists of exported water of domestic origin (Ve,d) and re-exported water of foreign origin (Ve,r):

$$V_e = V_{e,d} + V_{e,r}$$

The virtual-water import into a nation will partly be consumed, thus constituting the external Water Footprint of national consumption (WFcons,nat,ext), and partly be reexported (Ve,r)

$$V_i = WF_{cons,nat,ext} + V_{e,r}$$

The sum of Vi and WFarea,nat is equal to the sum of Ve and WFcons,nat. This sum is called the virtual-water budget (Vb) of a nation.

$$V_b = V_i + WF_{area,nat} = V_e + WF_{cons,nat}$$
Calculation of business Water Footprint

The Water Footprint of a business unit (WFbus, volume/time) is calculated by adding the operational Water Footprint of the business unit and its supply-chain Water Footprint:

\[ WF_{bus} = WF_{bus, oper} + WF_{bus, sup} \]

Both components consist of a Water Footprint that can be directly associated with the production of the product in the business unit and an overhead Water Footprint:

\[ WF_{bus, oper} = WF_{bus, oper, inputs} + WF_{bus, oper, overhead} \]
\[ WF_{bus, sup} = WF_{bus, sup, inputs} + WF_{bus, sup, overhead} \]

The operational Water Footprint is the amount of freshwater used at a specific business unit, i.e. the direct freshwater use. The supply-chain Water Footprint is the amount of freshwater used to produce all the goods and services that form the input of production at the specific business unit, i.e. the indirect freshwater use. The overhead Water Footprint is defined as the Water Footprint pertaining to the general activities for running a business and to the general goods and services consumed by the business. The term ‘overhead Water Footprint’ is used to identify water consumption that is necessary for the continued functioning of the business but that does not directly relate to the production of one particular product.