Master Course Water Footprint Assessment
Calculation questions

Question 1
Various water balance components and the yield for one crop (one growing period) are given. Determine the green and blue water footprint per unit of product (cubic metre per ton).

Data:
Total gross irrigation = 1249 mm
Total net irrigation = 874 mm
Total irrigation losses = 375 mm
Total rainfall = 230 mm
Effective rainfall = 180 mm
Total rain loss = 50 mm
Actual water use by crop = 562 mm
Actual irrigation requirement = 382 mm
Yield = 50 t/ha

Question 2
Determine the grey water footprint per unit (ton) of product related to direct release of chemicals into a surface water body from a steel-processing company. Assume that the effluent volume is equal to the abstraction volume, i.e. there is no consumptive water use.

Data:
Effluent volume: Effl = 6×10^4 m^3/yr
Concentration of the pollutant in the effluent: c_{effl} = 20 mg/l
Actual concentration of the intake water: $c_{act} = c_{nat}$ = 2 mg/l
Maximum acceptable concentration: c_{max} = 3 mg/l
Annual production = 10,000 t/yr

Question 3
A soft drink is made of several ingredients. Determine the product water footprint (green, blue and grey) that is related to the sugar that is used to produce 0.5 litre of a particular soft drink. The sugar is derived from sugar beet. Note that the process water footprint is zero.

Data:
Amount of sugar used in the product: 50 g
Water footprint of the sugar beet: WF_{green} = 45 m^3/ton, WF_{blue} = 23 m^3/ton and WF_{grey} = 18 m^3/ton. One kg of sugar beet gives 150 g of sugar. The value of the derived sugar constitutes 89% of the total value obtained from the sugar beets. The other 11% of the value refers to the by-product of pulp and molasses, which are fed to animals.

Question 4
Determine the global average green, blue and grey water footprint of a chocolate bar that weighs 100 g. Assume that the chocolate bar consists of 40% cocoa paste, 20% cocoa butter and 40% cane sugar.

Data:
Water footprint of cocoa beans (global average):
WF_{green} = 19745 m^3/ton, WF_{blue} = 4 m^3/ton and WF_{grey} = 179 m^3/ton

Cocoa beans are first made into cocoa paste, with cocoa shells as rest product. About 97% of the total water footprint of cocoa beans is allocated to the cocoa paste that is derived from the beans; the rest is attributed to the by-products. One kilogram of cocoa beans gives about 800 gram of paste. Cocoa paste is separated into cocoa butter and cocoa powder. About 66% of the water footprint of cocoa paste is allocated to the cocoa butter and 34% to the cocoa powder (this attribution is done based on the relative value of the two products). One kilogram cocoa paste gives 470 gram cocoa butter and 530 gram cocoa powder.

Water footprint of sugar made from sugar cane (global average):
WF_{green} = 1176 m^3/ton, WF_{blue} = 481 m^3/ton and WF_{grey} = 107 m^3/ton

Question 5
Determine blue water scarcity WS_{blue} for each month of one year in the Guadalquivir river basin in Spain, which has an area of 56 955 km^2 and a population of 3 947 000. Assume that 80 per cent of the natural runoff R_{nat} must be reserved to meet the environmental flow requirements. Interpret the results regarding the severity of water scarcity in the river basin.

Data:

	January	**February**	**March**	**April**	**May**	**June**
R_{nat} (10^6 m^3/month)	677	1307	3140	1978	1055	1004
WF_{blue} (10^6 m^3/month)	7	34	124	190	280	689

	July	**August**	**September**	**October**	**November**	**December**
R_{nat} (10^6 m^3/month)	1111	955	481	186	65	160
WF_{blue} (10^6 m^3/month)	1098	940	460	162	34	11

Question 6
We consider the same case as in question 5. What is the actual runoff R_{act} in each month? Determine the water pollution level WPL given a constant grey water footprint for each month of 1000×10^6 m^3/month. Interpret the results regarding the severity of the WPL and discuss potential policy measures.