Workshop

AquaNES QMRA-tool: a webtool for quantitative microbial risk assessment of water reuse applications

Patrick W.M.H. Smeets, KWR Watercycle Research Institute, Nieuwegein, The Netherlands; Ulf Miehe, Kompetenzzentrum Wasser Berlin (KWB), Berlin, Germany

Summary

It is important to determine the microbial safety of reused water to prevent spreading of diseases. Quantitative Microbial Risk Assessment provides a methodology to assess health risks from water reuse. This workshop introduces a free, web-based QMRA tool for both beginners and experienced users that uses state of the art scientific knowledge and approaches developed in the Horizon2020 project AquaNES. The workshop will make potential end-users aware of this tool, but also provide feedback for the developers of the tool for user-driven improvements of the tool.

Objectives

Goal of the tool is to make QMRA more accessible to those responsible for safe water reuse. In this workshop, we want to make potential end-users familiar with the tool. More importantly, we want to discuss possible applications and case studies for the tool. We also want to collect feedback on clarity of the tool, any missing features or other improvements.

Rationale

Microbial safety of reused water is important to prevent spreading of diseases. Due to high prevalence of pathogens in wastewater and their fate in treatment processes for reuse, monitoring of *E. coli* or other fecal indicators is insufficient to assess the actual level of risk from using reclaimed water. Therefore, Quantitative Microbial Risk Assessment (QMRA) is applied to assess health risks from water reuse. However, QMRA can be challenging, as existing guidelines and tools have often been developed from a scientific point of view. Thus QMRA is often perceived as complicated, data hungry and requiring a lot of expertise. To make QMRA more accessible for practitioners, the AquaNES QMRA webtool was developed. The user can start at a generic level, performing a risk assessment for their system without the need for local data or scientific knowledge. By selecting a generic source water type (e.g. sewage or river water), water treatment processes (e.g. filtration and/or UV disinfection) and water application (e.g. drinking or irrigation of leafy crops), the health risk from exposure is calculated using the latest scientific knowledge. The outcome can be compared to local or international health based targets. Once familiar with the QMRA approach the user can perform more advanced assessments, get insight in the scientific data behind the tool or upload their own data. Thus, the generic risk assessment can be refined to the local situation and different scenarios can be tested.

Outcome

The workshop participants will become aware of the need for risk assessment of pathogens at water reuse sites and the limitations of using fecal indicators only. They will learn the basics of QMRA and be introduced to the tool. They will be offered the opportunity to be actively involved in the QMRA community of practice. For the organizers this is an opportunity to receive end-user feedback, identify case studies and build a community of practice for QMRA for water reuse.

Tentative Schedule

After a short introduction of microbial health risk in water reuse and the role of QMRA we will demonstrate the tool. Next the workshop participants can experiment with the tool themselves if they bring their own computer. We will assist and answer questions walking around, while users can also ask questions through a message board. After centrally discussing the questions on the message board we will ask participants to respond to the following questions, both by microphone and message board:

- What water reuse application would you use the tool for?
- What question would you ask the tool?
- What are strong points of the current tool?
- What could be improved?
- Do you want to participate in a community of practice (CoP) for QMRA in water reuse?
- What can you contribute to the tool?

1 RISK ASSESSMENT — 2 SOURCE — 3 TREATMENT — 4 USE — 5 SUMMARY — 6 EXPOSURE & RISK

NQIA current

Description: Current TANQIA WWTP
User: Patrick Smeets

esult

io can be compared to two commonly applied health based targets (WHO GDWQ 2011):
risk of infection or
Adjusted Life Years (DALY)
infection exceeds the health target of 1 infection per 10,000 people per year for Bacteria
risk exceeds the health target of 1 microDALY per person per year for Bacteria

watershare AquaNES « Back

AquaNES QMRA tool Workshop

Infection risk per person per year

(Red line is the health based target)

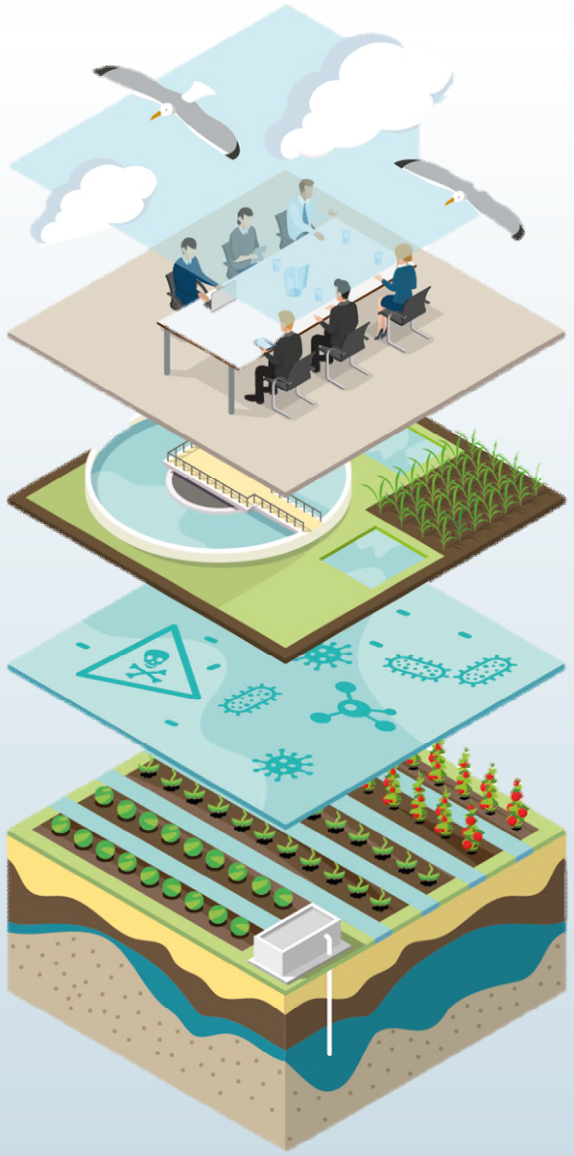
Patrick Smeets (KWR), Ulf Miehe (KWB)

16 June 2019,

IWA Water Reuse Conference, Berlin


WHY WASTE WATER?
OVER 80% OF OUR WASTEWATER FLOWS BACK TO NATURE UNTREATED.
REDUCE: improve wastewater treatment to reduce
pollutants entering the ecosystem.
REUSE: treat and use wastewater for green space
irrigation and municipal cleaning.
UN WATER
22 MARCH
WORLD
WATER
DAY

Water reuse, many aspects to consider



Sustainability

Legislation and regulations

Water treatment technologies

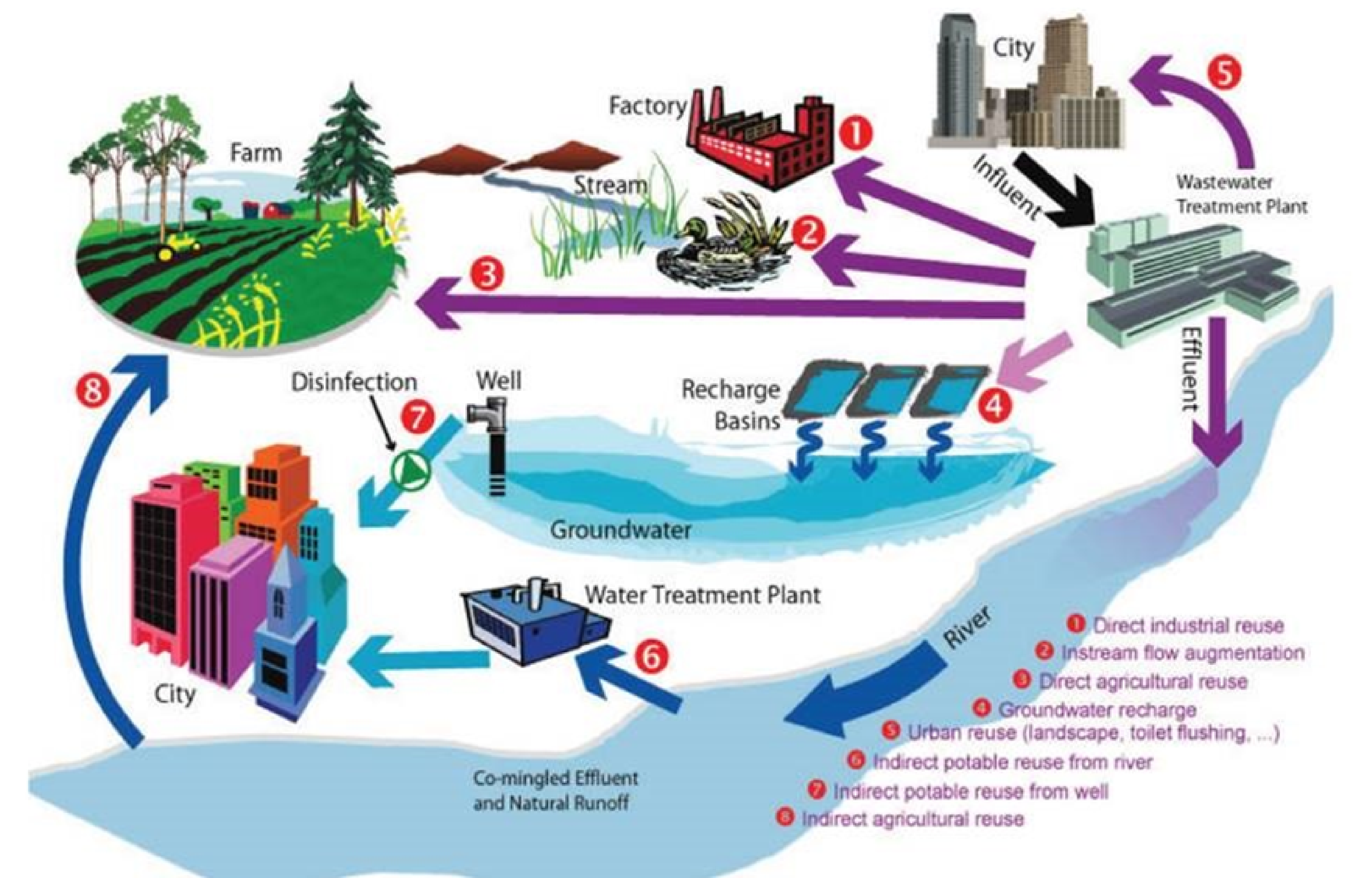
Health and safety

Reuse application

Matching availability and demand

Experience through de facto indirect potable reuse

QMRA to quantify microbial risk for decision support

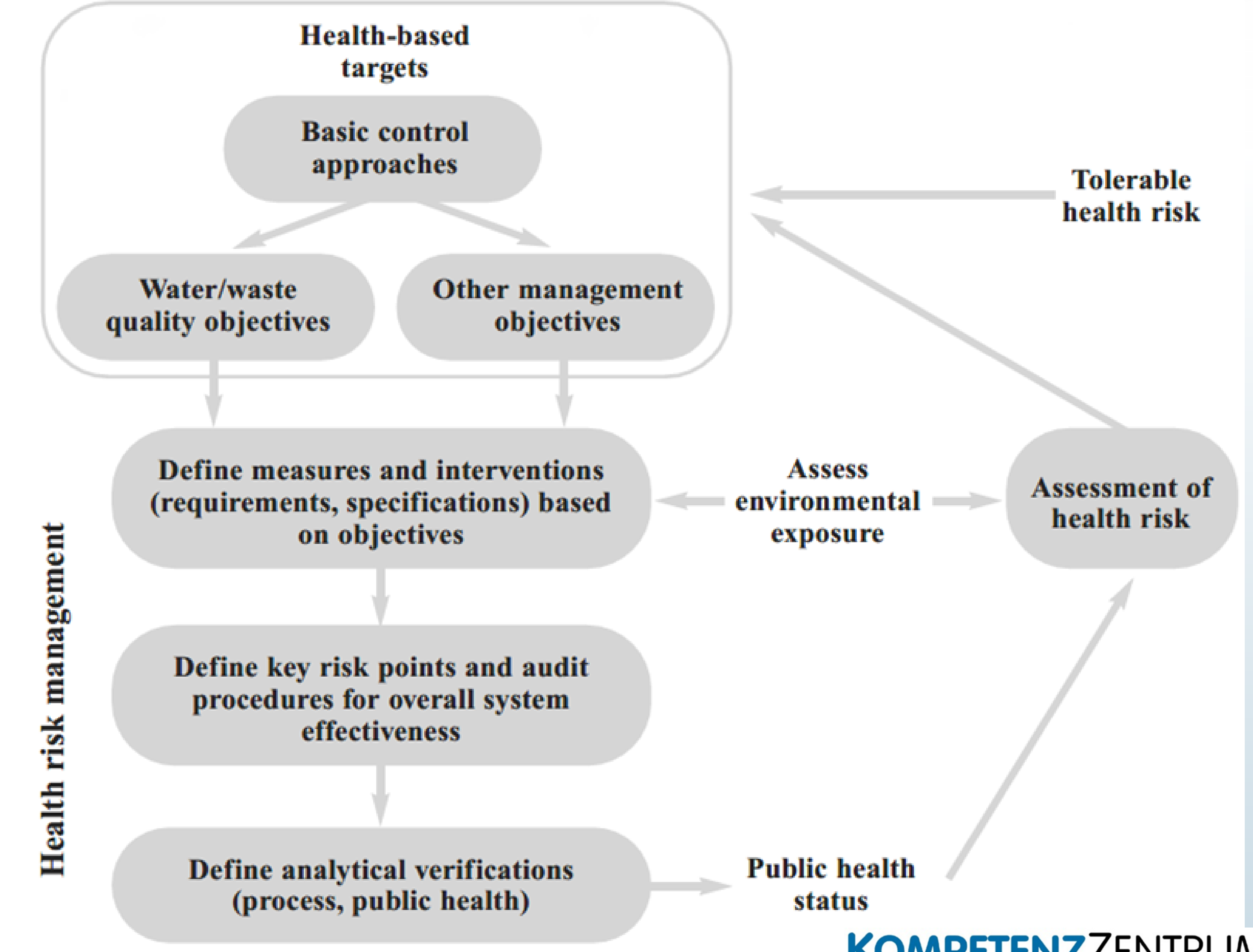


http://www.water.ca.gov/recycling

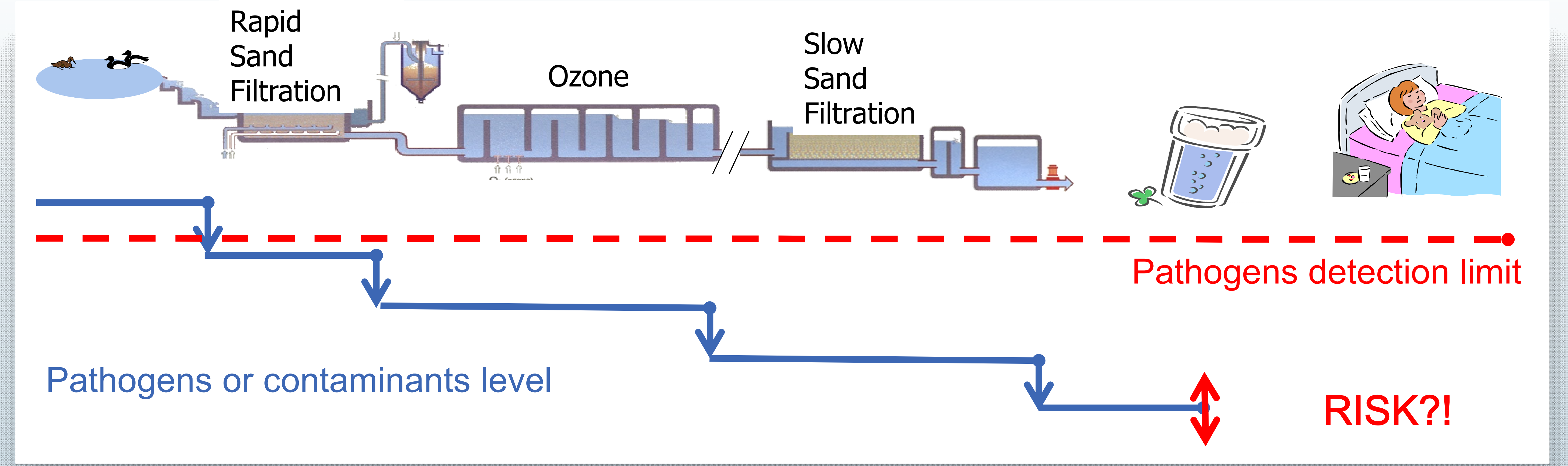
Health based targets

Stockholm framework

Bartam, Fewtrell and Stenström 2001



Drinking water QMRA

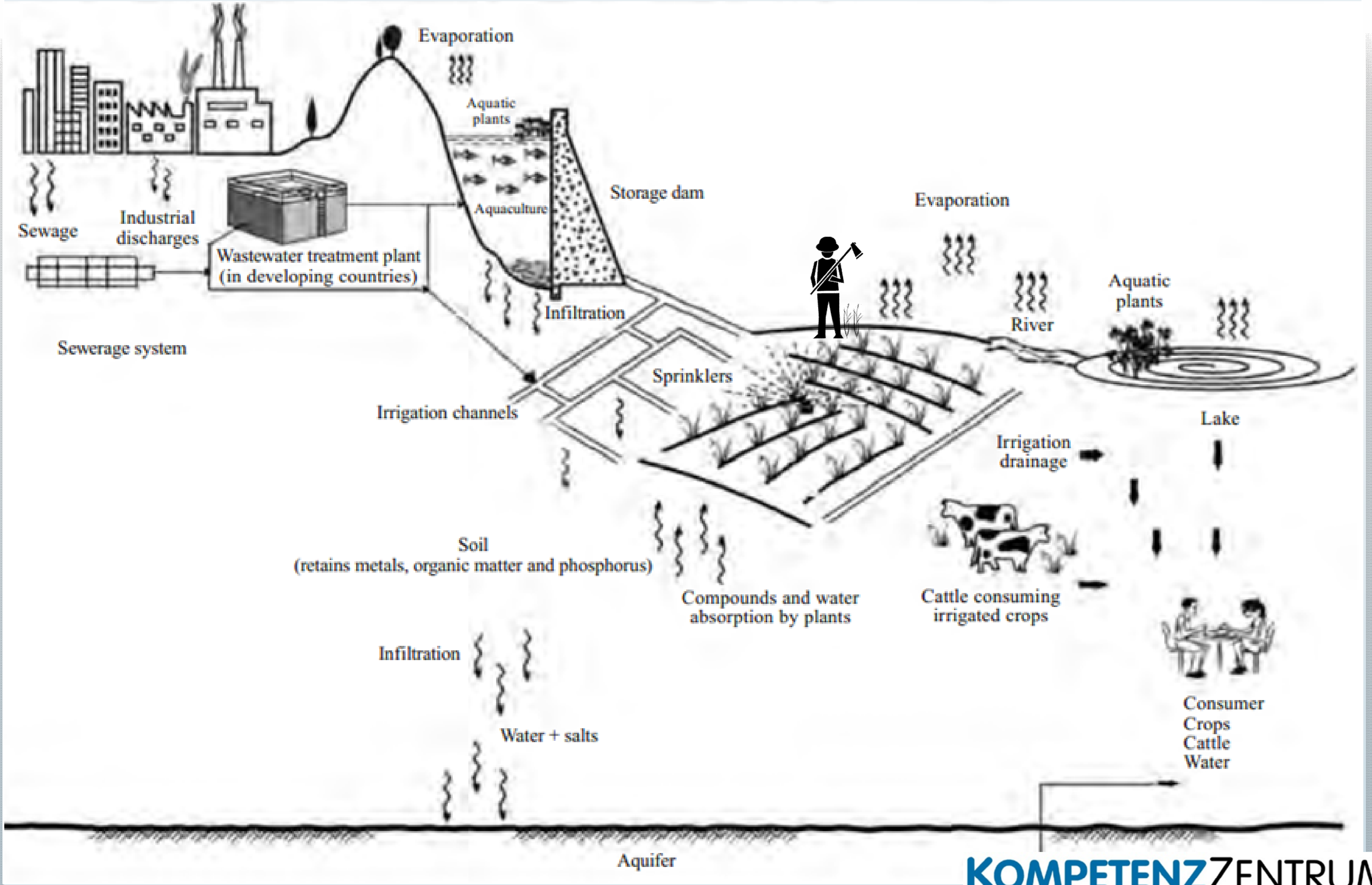


Reuse: different sources, treatments, exposure routes

Intended use
- groundwater recharge
- irrigation
- domestic
- drinking

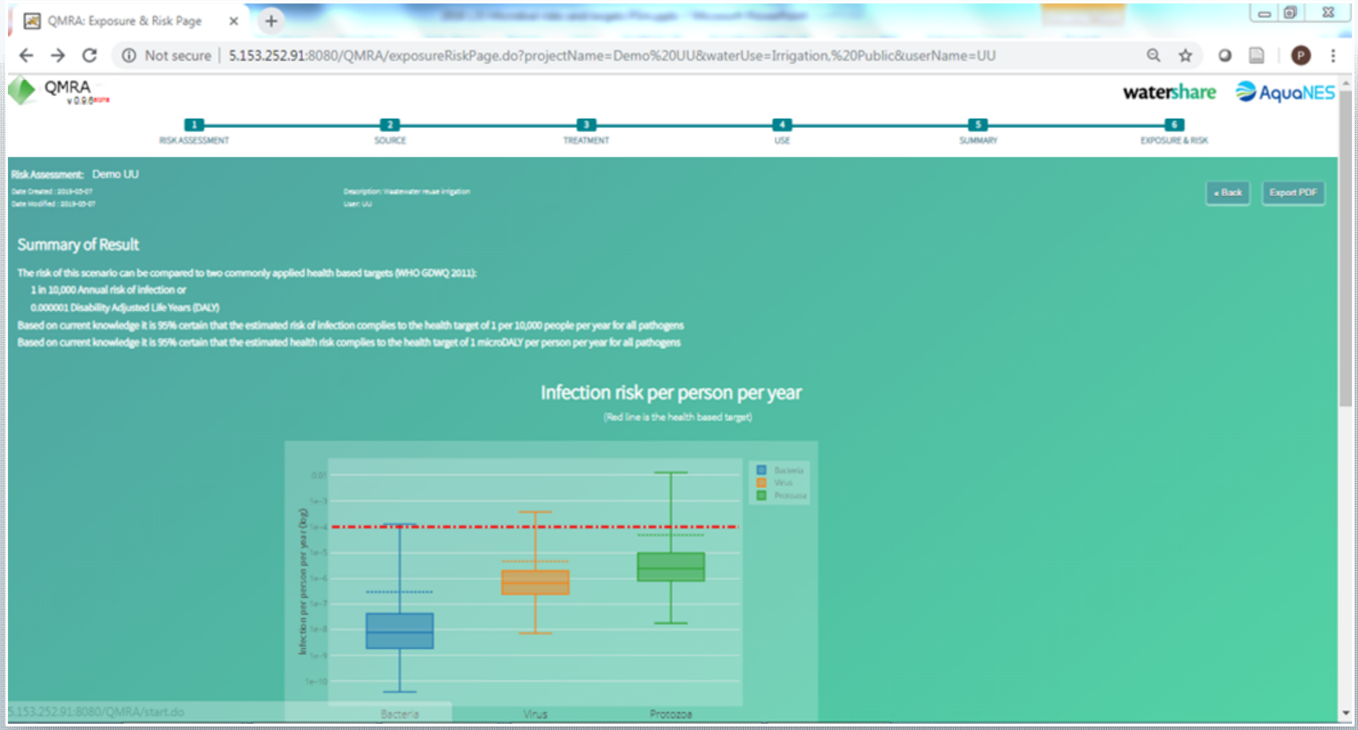
Method of application
- drip vs spray
- toilet vs gardening

Exposure:
- consumers
- workers
- public
- environment



AquaNES QMRA tool

- Transparant, science based QMRA tool
- User friendly, interactive calculation of risk
- Based on guideline information (data)
- Including guidance for user
- Introduction to QMRA
- Option for user data input
- Decision support by testing scenarios

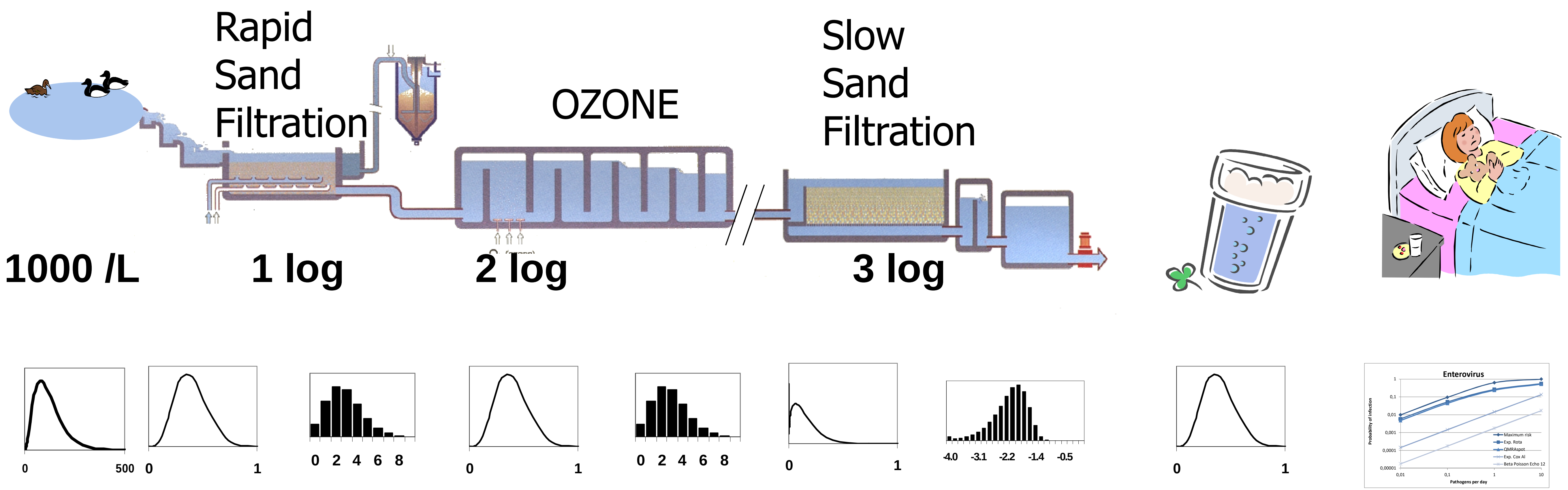


SCREENSHOT OF AQUANES QMRA TOOL

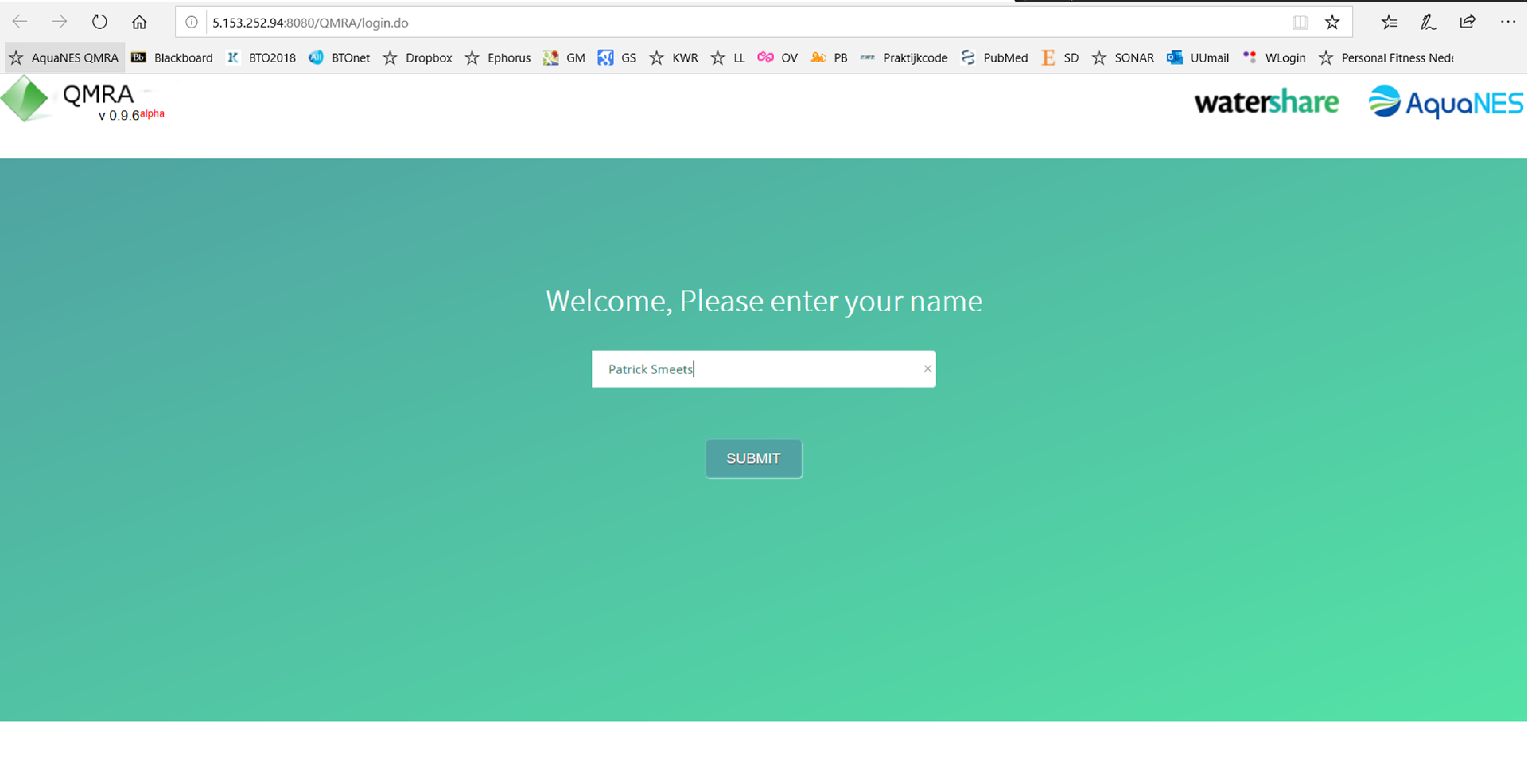
AquaNES tool intended for first stage of risk assessment

	Stage	Goal	Information
1	Initial risk assessment	Could safety be achieved?	Standards guidelines
2	Design/built evaluation	Could design, equipment and operation achieve safety?	Equipment data, PID's operation and monitoring plan
3	Validation	Does the system (or parts) achieve performace?	Challenge testing Water quality testing
4	Verification	Is the installed system performing as expected?	Water quality monitoring (indicators)
5	Operational monitoring	Is the system operating within specifications?	Operational monitoring (equipment+condition+WQ)
6	Audit	Is the SSP executed?	Records, interviews, inspections

Steps of QMRA (drinking water example)



Monte Carlo simulation to combine uncerainties at each step


5.153.252.94:8080/QMRA/login.do
AquaNES QMRA
Blackboard
BTO2018
BTOnet
Dropbox
Ephorus
GM
GS
KWR
LL
OV
PB
Praktijkcode
PubMed
SD
SONAR
UUmail
WLogin
Personal Fitness Nede
QMRA
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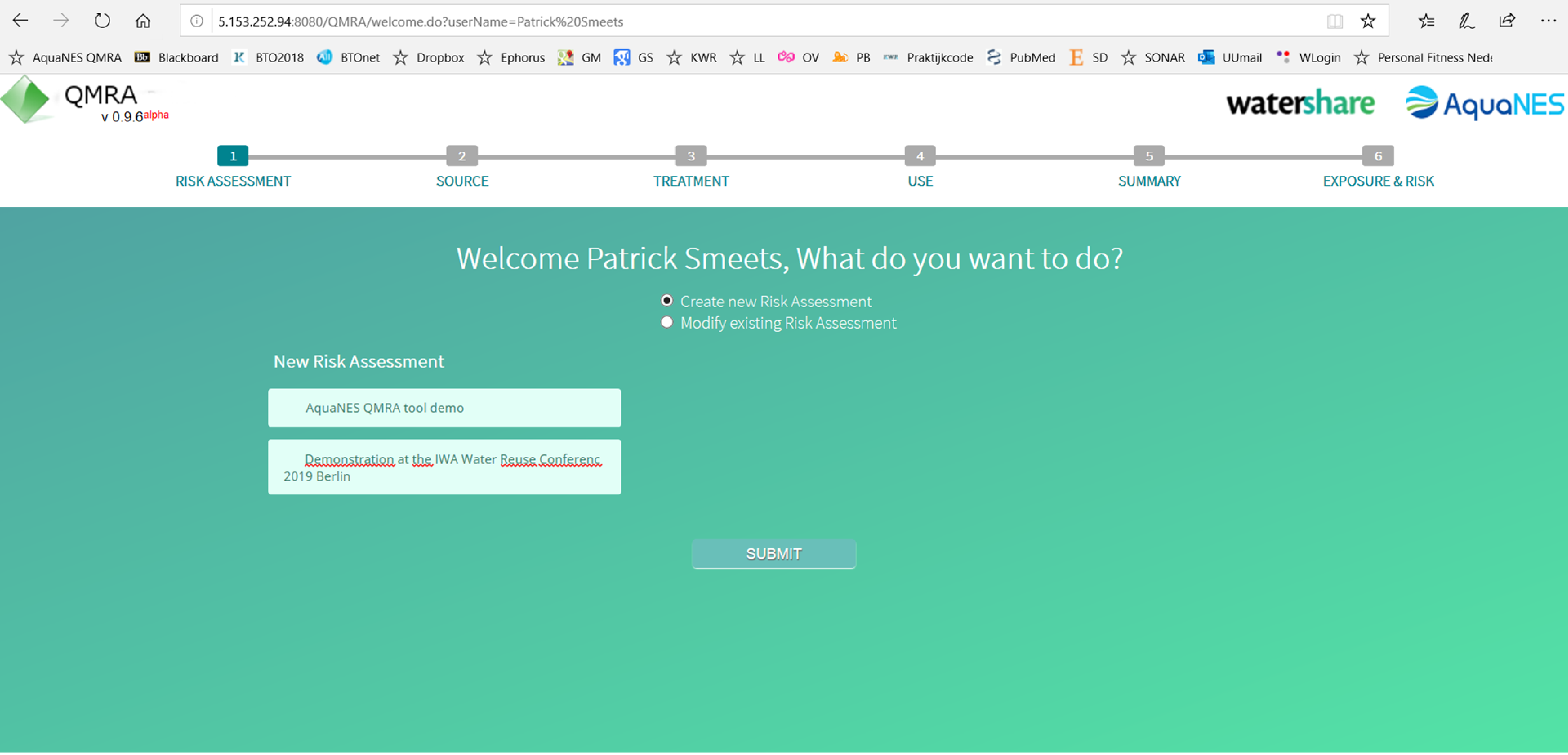
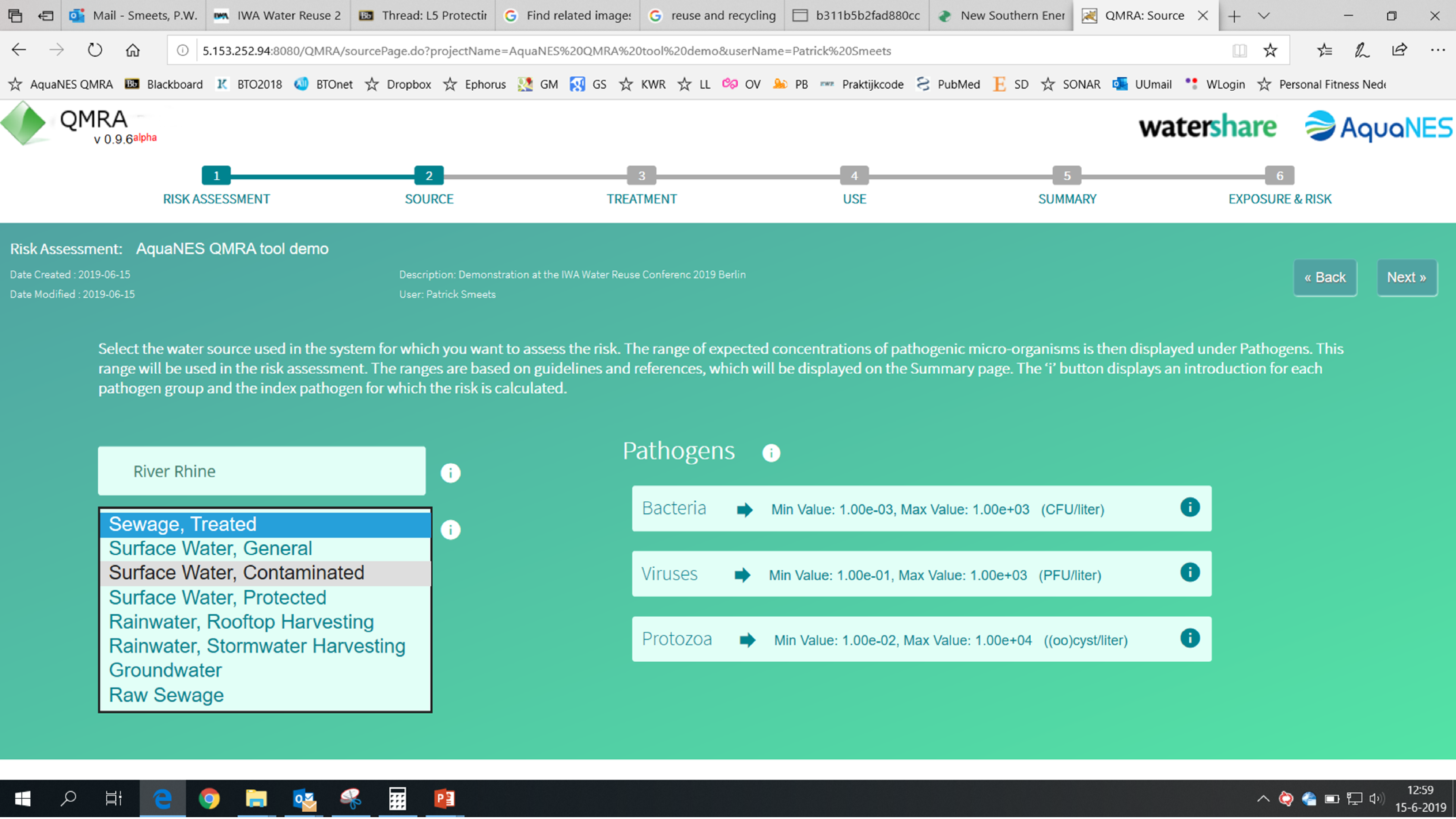
watershare
AquaNES
Welcome, Please enter your name
Patrick Smeets
SUBMIT


5.153.252.94:8080/QMRA/welcome.do?userName=Patrick%20Smeets
AquaNES QMRA
Blackboard
BTO2018
BTOnet
Dropbox
Ephorus
GM
GS
KWR
LL
OV
PB
Praktijkcode
PubMed
SD
SONAR
UUmail
WLogin
Personal Fitness Ned
QMRA
v 0.9.6alpha
watershare
AquaNES
1 RISK ASSESSMENT
2 SOURCE
3 TREATMENT
4 USE
5 SUMMARY
6 EXPOSURE & RISK
Welcome Patrick Smeets, What do you want to do?
Create new Risk Assessment
Modify existing Risk Assessment
New Risk Assessment
AquaNES QMRA tool demo
Demonstration at the IWA Water Reuse Conferenc 2019 Berlin
SUBMIT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1 RISK ASSESSMENT
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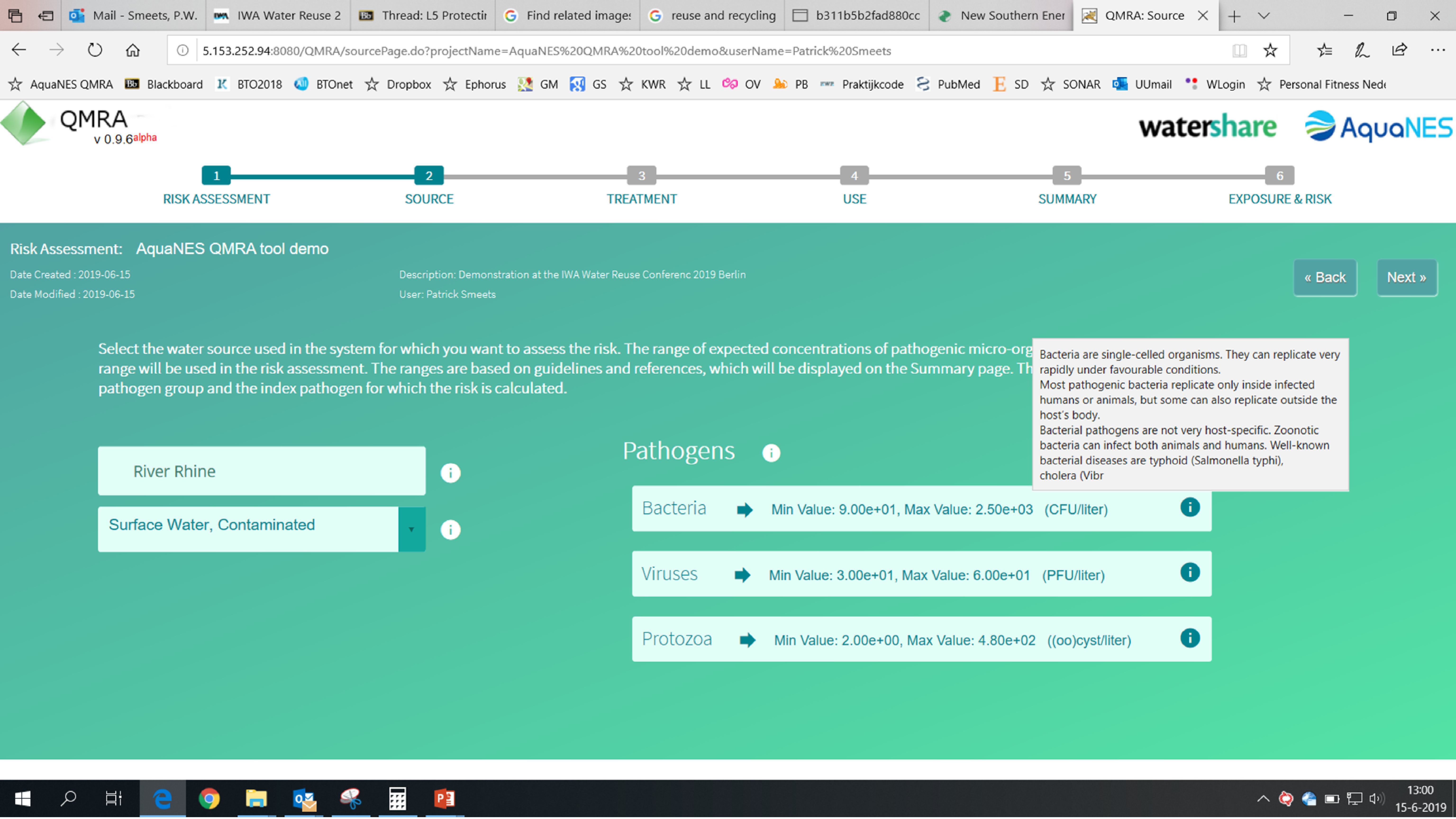
6 EXPOSURE & RISK
Risk Assessment: AquaNES QMRA tool demo
Date Created : 2019-06-15
Date Modified : 2019-06-15
Description: Demonstration at the IWA Water Reuse Conferenc 2019 Berlin
User: Patrick Smeets
« Back
Next »
Select the water source used in the system for which you want to assess the risk. The range of expected concentrations of pathogenic micro-organisms is then displayed under Pathogens. This range will be used in the risk assessment. The ranges are based on guidelines and references, which will be displayed on the Summary page. The 'i' button displays an introduction for each pathogen group and the index pathogen for which the risk is calculated.
River Rhine
Sewage, Treated
Surface Water, General
Surface Water, Contaminated
Surface Water, Protected
Rainwater, Rooftop Harvesting
Rainwater, Stormwater Harvesting
Groundwater
Raw Sewage
Pathogens
Bacteria Min Value: 1.00e-03, Max Value: 1.00e+03 (CFU/liter)
Viruses Min Value: 1.00e-01, Max Value: 1.00e+03 (PFU/liter)
Protozoa Min Value: 1.00e-02, Max Value: 1.00e+04 ((oo)cyst/liter)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range will be used in the risk assessment. The ranges are based on guidelines and references, which will be displayed on the Summary page. Th
pathogen group and the index pathogen for which the risk is calculated.
Bacteria are single-celled organisms. They can replicate very rapidly under favourable conditions.
Most pathogenic bacteria replicate only inside infected humans or animals, but some can also replicate outside the host's body.
Bacterial pathogens are not very host-specific. Zoonotic bacteria can infect both animals and humans. Well-known bacterial diseases are typhoid (Salmonella typhi), cholera (Vibr
River Rhine
Surface Water, Contaminated
Pathogens
Bacteria Min Value: 9.00e+01, Max Value: 2.50e+03 (CFU/liter)
Viruses Min Value: 3.00e+01, Max Value: 6.00e+01 (PFU/liter)
Protozoa Min Value: 2.00e+00, Max Value: 4.80e+02 ((oo)cyst/liter)
13:00
15-6-2019

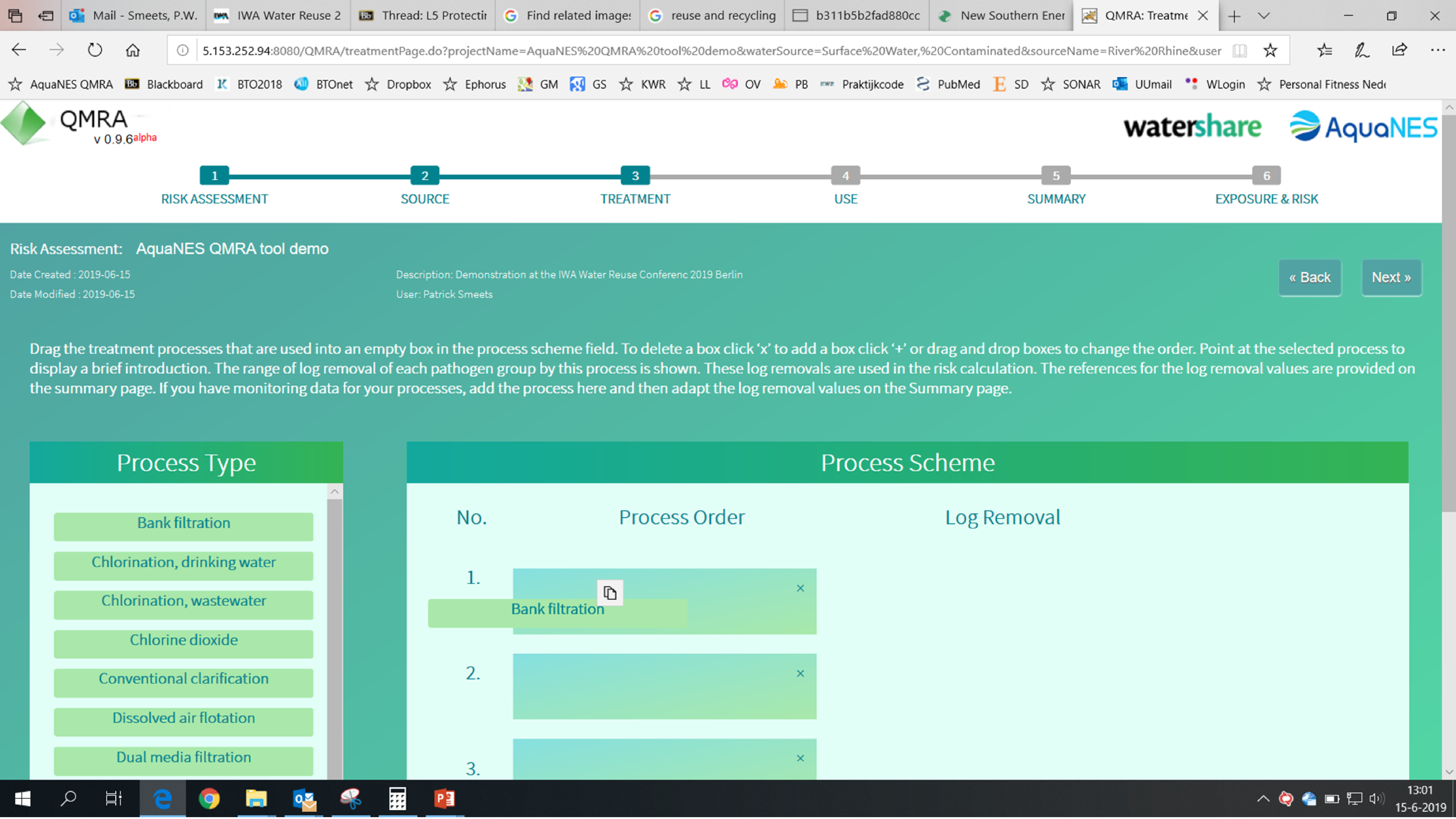
Data: WHO GDWQ and others

Table 7.6 Example occurrence of selected indicators and pathogens in faeces, wastewater and raw water (local data will vary)

Microbe	Number per gram of faeces	Number per litre in untreated wastewater	Number per litre in raw water
Faecal coliforms (*E. coli* and *Klebsiella*)	10^7 (mostly non-pathogenic)	10^6–10^{10}	100–100 000
Campylobacter spp.	10^6	100–10^6	100–10 000
Vibrio cholerae[a]	10^6	100–10^6	100–10^8
Enteroviruses	10^6	1–1000	0.01–10
Rotaviruses	10^9	50–5000	0.01–100
Cryptosporidium	10^7	1–10 000	0–1000
Giardia intestinalis	10^7	1–10 000	0–1000

[a] *Vibrio* can grow in the aquatic environment.

Sources: Feachem et al. (1983); Stelzer (1988); Jones, Betaieb & Telford (1990); Stampi et al. (1992); Koenraad et al. (1994); Gerba et al. (1996); AWWA (1999); Maier, Pepper & Gerba (2000); Metcalf & Eddy, Inc. (2003); Bitton (2005); Lodder & de Roda Husman (2005); Schijven & de Roda Husman (2006); Masini et al. (2007); Rutjes et al. (2009); Lodder et al. (2010)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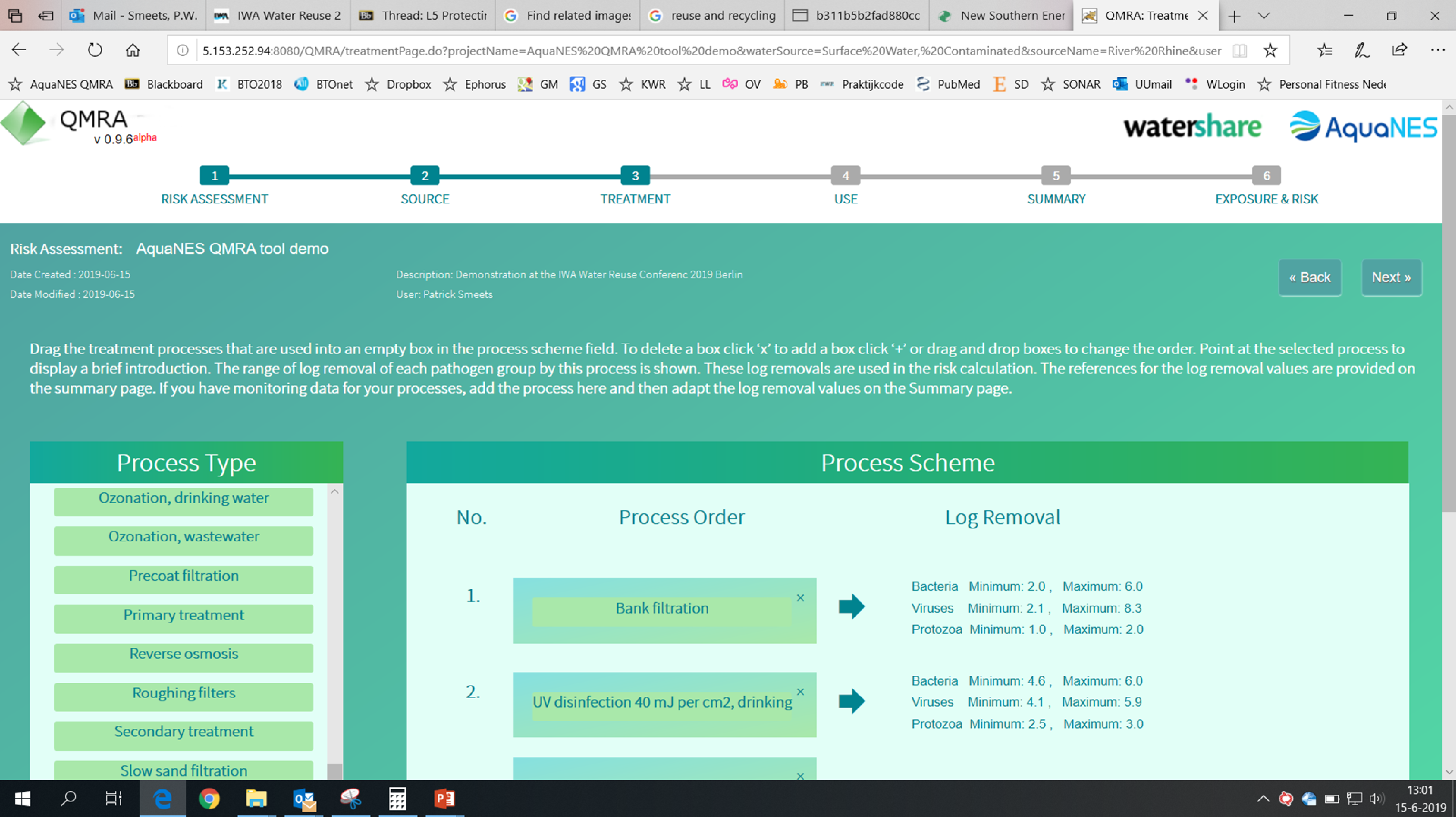
Drag the treatment processes that are used into an empty box in the process scheme field. To delete a box click 'x' to add a box click '+' or drag and drop boxes to change the order. Point at the selected process to display a brief introduction. The range of log removal of each pathogen group by this process is shown. These log removals are used in the risk calculation. The references for the log removal values are provided on the summary page. If you have monitoring data for your processes, add the process here and then adapt the log removal values on the Summary page.
Process Type
Bank filtration
Chlorination, drinking water
Chlorination, wastewater
Chlorine dioxide
Conventional clarification
Dissolved air flotation
Dual media filtration
Process Scheme
No.
Process Order
Log Removal
1.
Bank filtration
2.
3.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AquaNES
1 RISK ASSESSMENT
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5 SUMMARY
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Risk Assessment: AquaNES QMRA tool demo
Date Created : 2019-06-15
Date Modified : 2019-06-15
Description: Demonstration at the IWA Water Reuse Conferenc 2019 Berlin
User: Patrick Smeets
« Back
Next »
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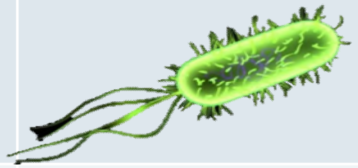
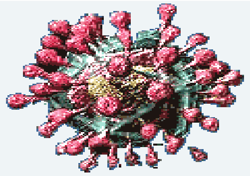
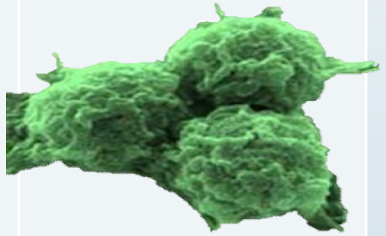
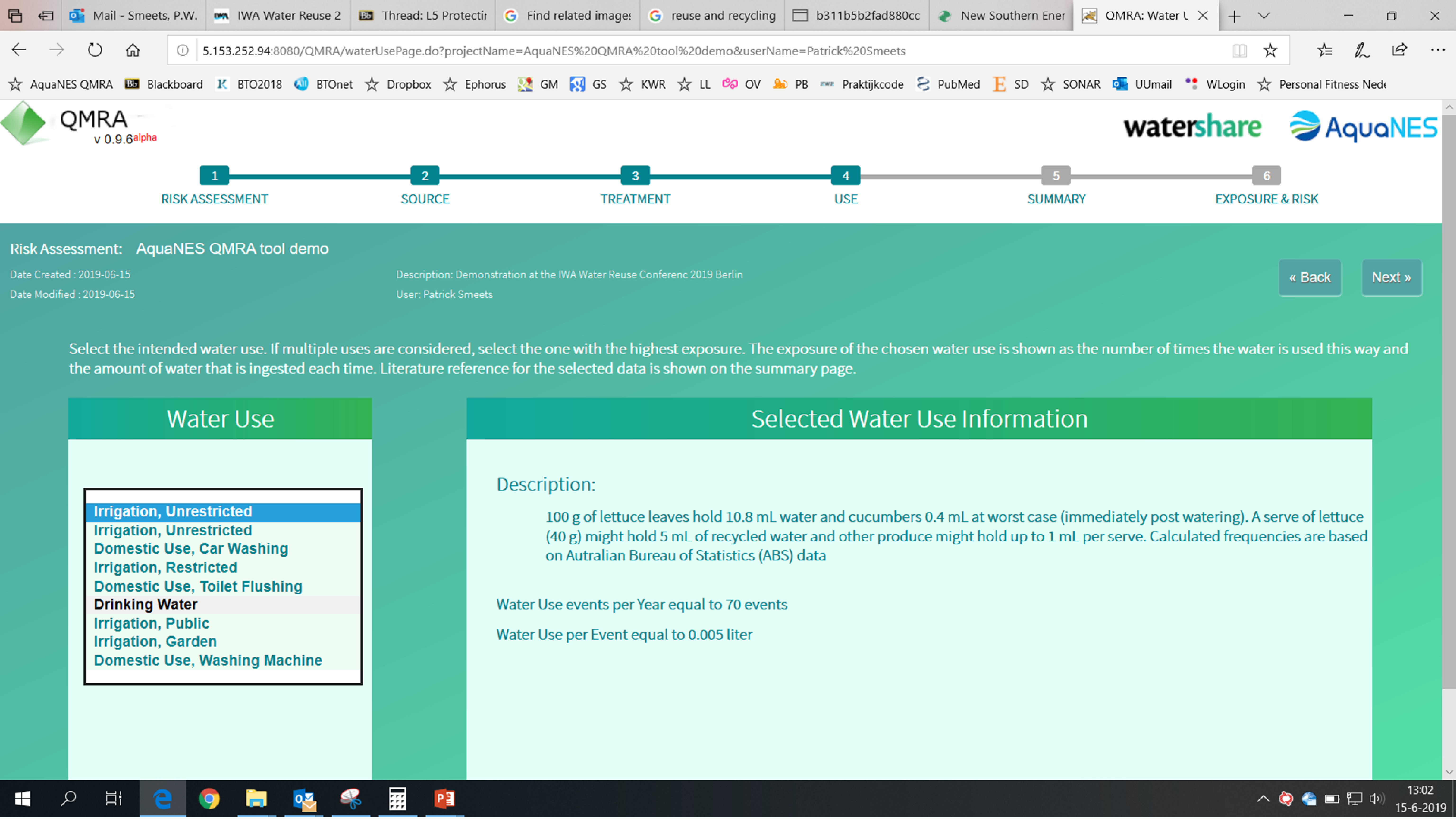
Process Type
Ozonation, drinking water
Ozonation, wastewater
Precoat filtration
Primary treatment
Reverse osmosis
Roughing filters
Secondary treatment
Slow sand filtration
Process Scheme
No.
Process Order
Log Removal
1.
Bank filtration
Bacteria Minimum: 2.0 , Maximum: 6.0
Viruses Minimum: 2.1 , Maximum: 8.3
Protozoa Minimum: 1.0 , Maximum: 2.0
2.
UV disinfection 40 mJ per cm2, drinking
Bacteria Minimum: 4.6 , Maximum: 6.0
Viruses Minimum: 4.1 , Maximum: 5.9
Protozoa Minimum: 2.5 , Maximum: 3.0
13:01
15-6-2019

Table 7.7 Reductions of bacteria, viruses and protozoa achieved by water treatment technologies at drinking-water treatment plants for large communities

Treatment process	Enteric pathogen group	Minimum removal (LRV)	Maximum removal (LRV)	Notes
Pretreatment				
Roughing filters	Bacteria	0.2	2.3	Depends on filter medium, coagulant
Storage reservoirs	Bacteria	0.7	2.2	Residence time > 40 days
	Protozoa	1.4	2.3	Residence time 160 days
Bank filtration	Viruses	> 2.1	8.3	Depends on travel distance, soil type, pumping rate, pH, ionic strength
	Bacteria	2	> 6	
	Protozoa	> 1	> 2	
Coagulation, flocculation and sedimentation				
Conventional clarification	Viruses	0.1	3.4	Depends on coagulation conditions
	Bacteria	0.2	2	
	Protozoa	1	2	
High-rate clarification	Protozoa	> 2	2.8	Depends on use of appropriate blanket polymer

Indicator organisms for pathogen reduction by treatment

Index pathogen	Indicator	Characteristics	
Indicators *E. coli, TherTolColi*	E. coli	Bacteria, high numbers in feces, Recent fecal contamination	
Viruses *enterovirus*	Phages	Very small (25 nm), hard to filter, variable resistance against UV, Cl_2	
Bacteria *Campylobacter*	E. coli	Bacteria, high numbers in feces, Easily removed by treatment	
Protozoa *Cryptosporidium* *Giardia*	SSRC	Very persistent, not affected by chlorine, but sensitive to UV	
Helminths (worms) *Ascaris*	Crypto?	Very persistent, especially in agriculture. No dose-response	


QMRA
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1 RISK ASSESSMENT
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Date Created : 2019-06-15
Date Modified : 2019-06-15
Description: Demonstration at the IWA Water Reuse Conferenc 2019 Berlin
User: Patrick Smeets
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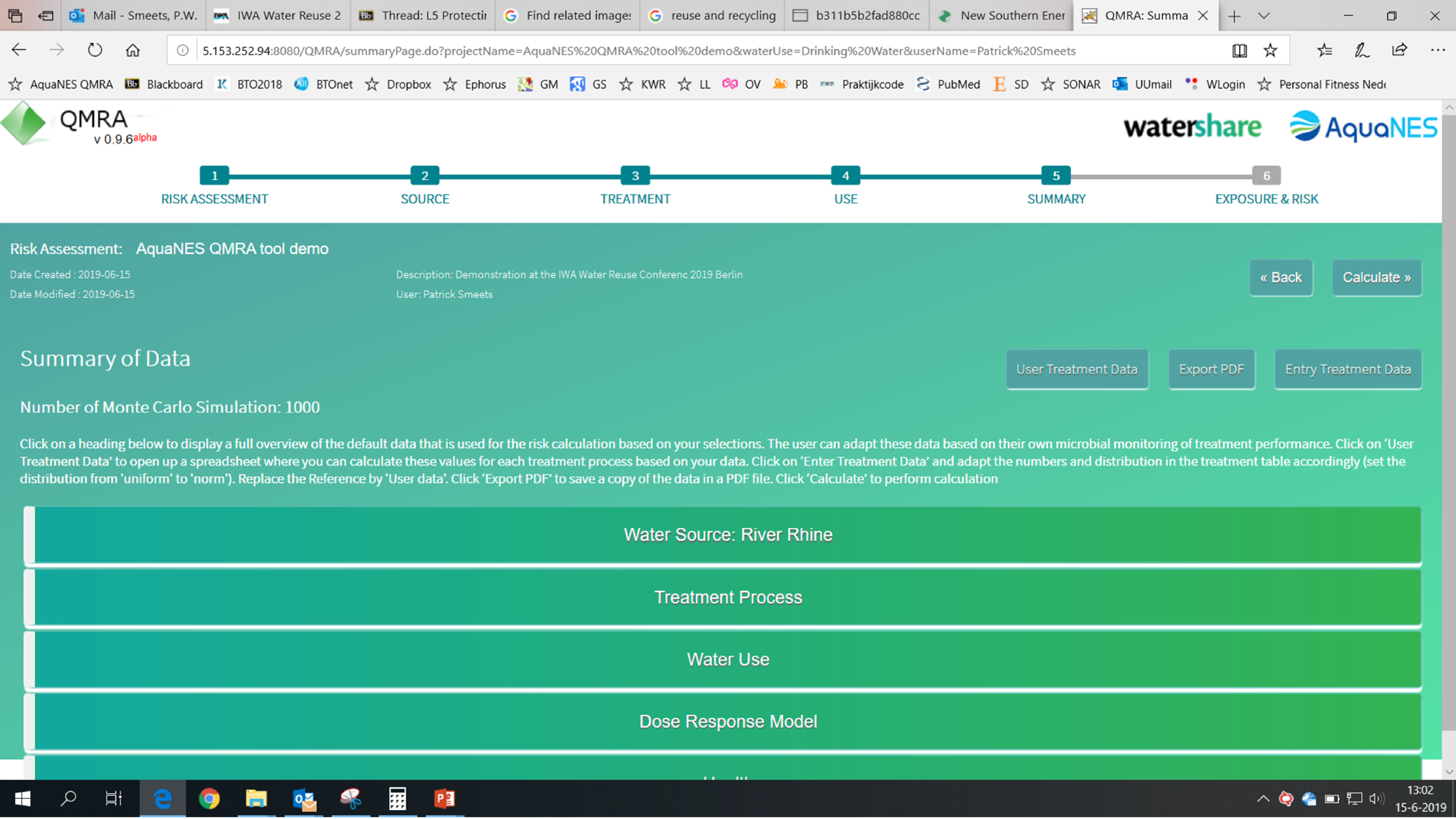
Next »
Select the intended water use. If multiple uses are considered, select the one with the highest exposure. The exposure of the chosen water use is shown as the number of times the water is used this way and the amount of water that is ingested each time. Literature reference for the selected data is shown on the summary page.
Water Use
Irrigation, Unrestricted
Irrigation, Unrestricted
Domestic Use, Car Washing
Irrigation, Restricted
Domestic Use, Toilet Flushing
Drinking Water
Irrigation, Public
Irrigation, Garden
Domestic Use, Washing Machine
Selected Water Use Information
Description:
100 g of lettuce leaves hold 10.8 mL water and cucumbers 0.4 mL at worst case (immediately post watering). A serve of lettuce (40 g) might hold 5 mL of recycled water and other produce might hold up to 1 mL per serve. Calculated frequencies are based on Autralian Bureau of Statistics (ABS) data
Water Use events per Year equal to 70 events
Water Use per Event equal to 0.005 liter



5.153.252.94:8080/QMRA/summaryPage.do?projectName=AquaNES%20QMRA%20tool%20demo&waterUse=Drinking%20Water&userName=Patrick%20Smeets
QMRA
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Date Created : 2019-06-15
Date Modified : 2019-06-15
Description: Demonstration at the IWA Water Reuse Conferenc 2019 Berlin
User: Patrick Smeets
« Back
Calculate »
Summary of Data
User Treatment Data
Export PDF
Entry Treatment Data
Number of Monte Carlo Simulation: 1000
Click on a heading below to display a full overview of the default data that is used for the risk calculation based on your selections. The user can adapt these data based on their own microbial monitoring of treatment performance. Click on 'User Treatment Data' to open up a spreadsheet where you can calculate these values for each treatment process based on your data. Click on 'Enter Treatment Data' and adapt the numbers and distribution in the treatment table accordingly (set the distribution from 'uniform' to 'norm'). Replace the Reference by 'User data'. Click 'Export PDF' to save a copy of the data in a PDF file. Click 'Calculate' to perform calculation
Water Source: River Rhine
Treatment Process
Water Use
Dose Response Model
13:02
15-6-2019

Number of Monte Carlo Simulation: 1000

Click on a heading below to display a full overview of the default data that is used for the risk calculation based on your selections. The user can adapt these data based on their own microbial monitoring of treatment performance. Click on 'User Treatment Data' to open up a spreadsheet where you can calculate these values for each treatment process based on your data. Click on 'Enter Treatment Data' and adapt the numbers and distribution in the treatment table accordingly (set the distribution from 'uniform' to 'norm'). Replace the Reference by 'User data'. Click 'Export PDF' to save a copy of the data in a PDF file. Click 'Calculate' to perform calculation

Water Source: River Rhine

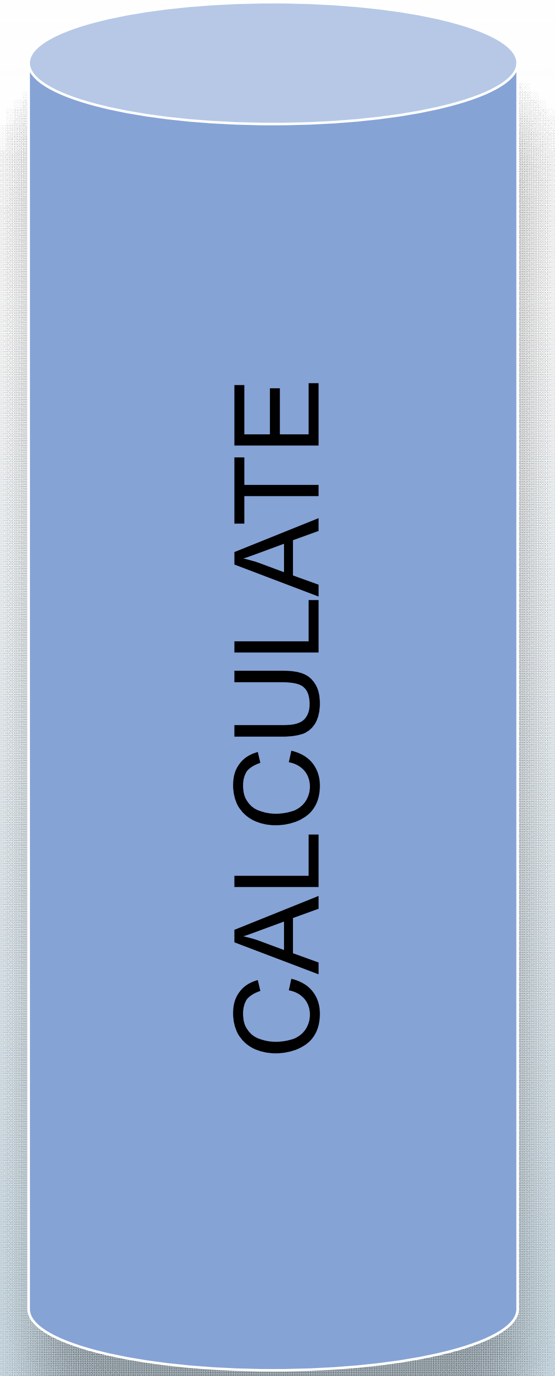
Surface Water, Contaminated	Bacteria	Viruses	Protozoa
Pathogen	Campylobacter jejuni	Rotavirus	Cryptosporidium parvum and Cryptosporidium hominis
Minimum Concentration	90.0	30.0	2.0
Maximum Concentration	2500.0	60.0	480.0
Distribution Shape	log10_norm	log10_norm	log10_norm
Reference	WHO GDWQ (2004)	WHO GDWQ (2004)	WHO GDWQ (2004)

Treatment Process

Treatment Process	Order	Data	Bacteria	Viruses	Protozoa
Bank filtration	1	Minimum Log Removal	2.0	2.1	1.0
		Maximum Log Removal	6.0	8.3	2.0

Calculation, practical limitations

- Works best in Chrome or Firefox
- One calculation at a time, only when you have the calculation-token
- Maximum of 7 treatment steps



QMRA
v 0.9.6alpha

1 RISK ASSESSMENT — 2 SOURCE — 3 TREATMENT

Risk Assessment: AquaNES QMRA tool demo

Date Created : 2019-06-15

Date Modified : 2019-06-15

Description: Demonstration at the IWA Water Reuse Conferenc 2019 Berlin

User: Patrick Smeets

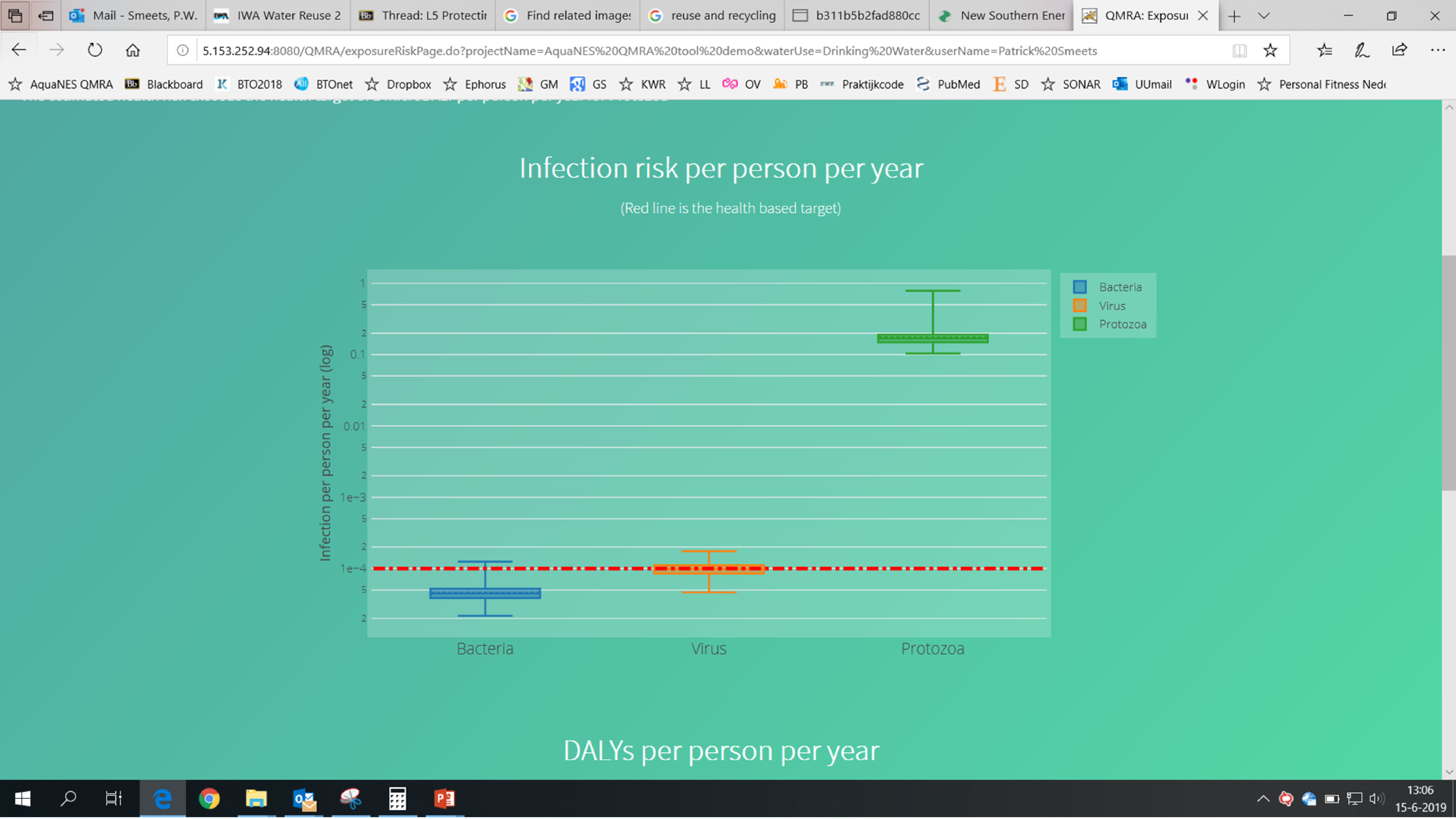
Summary of Result

The risk of this scenario can be compared to two commonly applied health based targets (WHO GDWQ 2011):

- 1 in 10,000 Annual risk of infection or
- 0.000001 Disability Adjusted Life Years (DALY)

The estimated risk of infection exceeds the health target of 1 infection per 10,000 people per year for Protozoa

The estimated health risk exceeds the health target of 1 microDALY per person per year for Protozoa



5.153.252.94:8080/QMRA/exposureRiskPage.do?projectName=AquaNES%20QMRA%20tool%20demo&waterUse=Drinking%20Water&userName=Patrick%20Smeets
Infection risk per person per year
(Red line is the health based target)
Infection per person per year (log)
1
0.1
0.01
1e−3
1e−4
Bacteria
Virus
Protozoa
DALYs per person per year

Result Table

Bacteria Risk Assessment

Data	Number/log10	Mean	5%	50%	95%
Source Concentration	N/l	474.93	426.43	472.85	525.20
Bank filtration	log10	4.0	2.2	4.0	5.8
UV disinfection 40 mJ per cm2, drinking	log10	5.3	4.67	5.3	5.93
Total Treatment	log10	9.3	9.12	9.3	9.47
DALY per Year	/person/year	6.37E-8	4.26E-8	6.14E-8	9.15E-8
Exposure per Year	number/person/year	0.00233	0.00156	0.00225	0.00335
Infection Risk per Year	/person/year	4.61E-5	3.09E-5	4.45E-5	6.63E-5
Ingestion per Event	liter/event	1.0	1.0	1.0	1.0
Events per year	number/year	365	365	365	365

Virus Risk Assessment

User data input

E28

Input in AquanNES QMRA tool Summary page

Treatment process

Treatment process	Order	Data	Bacteria	Viruses	Protozoa
Bank filtration	1	Minimum log removal	0,9	1,8	2,1
		Maximum log removal	1,7	2,7	2,6
		Distribution	norm	norm	norm
		Reference	User input	User input	User input

USER DATA INPUT

Monitoring data summary of log concentrations (calculated or entered by user)

Mean	5,8	4,5	5,7	3,4	4,7	2,4
StDev	0,3	0,3	0,3	0,5	0,3	0,1
N	8	10	11	11	11	11

Monitoring data (replace by user data)

bacteria		Viruses		Protozoa	
inflow concentration	outflow concentration	inflow concentration	outflow concentration	inflow concentration	outflow concentration
#/l	#/l	#/l	#/l	#/l	#/l
2,5E+05	1,0E+04	2,5E+05	1,0E+03	2,5E+04	1,0E+02
3,0E+05	2,0E+05	3,0E+05	2,0E+03	3,0E+04	2,0E+02
9,0E+05	2,5E+04	9,0E+05	2,5E+03	9,0E+04	2,5E+02
3,0E+05	2,5E+04	2,5E+05	2,5E+04	3,0E+04	2,5E+02
9,0E+05	2,5E+04	3,0E+05	2,5E+04	9,0E+04	2,5E+02
9,0E+05	2,5E+04	9,0E+05	1,0E+03	3,0E+04	2,5E+02
9,0E+05	2,5E+04	2,5E+05	2,0E+03	9,0E+04	2,5E+02
9,0E+05	2,5E+04	3,0E+05	2,5E+03	3,0E+04	2,6E+02
	20001	9,0E+05	1,0E+03	9,0E+04	2,6E+02
	42131	9,0E+05	2,0E+03	3,0E+04	2,6E+02
		9,0E+05	2,5E+03	9,0E+04	2,6E+02

Summary of Data

User Treatment Data | Export PDF | Entry Treatment Data

Number of Monte Carlo Simulation: 1000

Click on a heading below to display a full overview of the default data that is used for the risk calculation based on your selections. The user can adapt these data based on their own microbial monitoring of treatment performance. Click on 'User Treatment Data' to open up a spreadsheet where you can calculate these values for each treatment process based on your data. Click on 'Enter Treatment Data' and adapt the numbers and distribution in the treatment table accordingly (set the distribution from 'uniform' to 'norm'). Replace the Reference by 'User data'. Click 'Export PDF' to save a copy of the data in a PDF file. Click 'Calculate' to perform calculation

Water Source: River Rhine

Treatment Process

Treatment Process	Order	Data	Bacteria	Viruses	Protozoa
Bank filtration	1	Minimum Log Removal	2.0	2.1	1.0
		Maximum Log Removal	6.0	8.3	2.0
		Distribution	uniform	uniform	uniform
		Reference	WHO (2011): Drinking water guideline, Table 7.7	WHO (2011): Drinking water guideline, Table 7.7	WHO (2011): Drinking water guideline, Table 7.7
UV disinfection 40 mJ per cm2, drinking	2	Minimum Log Removal	4.6	4.1	2.5
		Maximum Log Removal	6.0	5.9	3.0
		Distribution	uniform	uniform	uniform
		Reference	Hijnen et al. (2006)	Hijnen et al. (2006)	Hijnen et al. (2006)

13:08 15-6-2019

Summary of Data

User Treatment Data | Export PDF | Entry Treatment Data

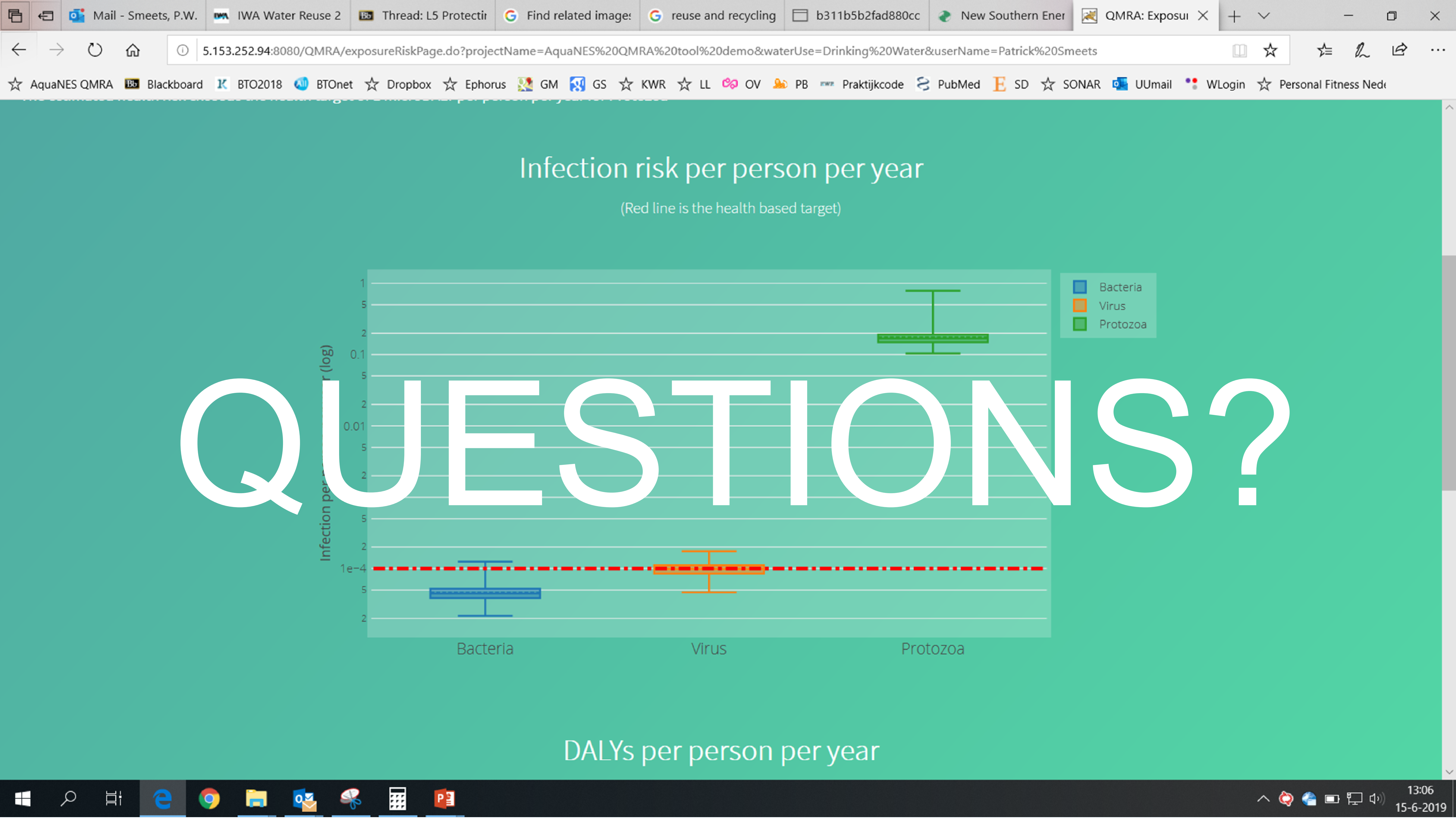
Number of Monte Carlo Simulation: 1000

Click on a heading below to display a full overview of the default data that is used for the risk calculation based on your selections. The user can adapt these data based on their own microbial monitoring of treatment performance. Click on 'User Treatment Data' to open up a spreadsheet where you can calculate these values for each treatment process based on your data. Click on 'Enter Treatment Data' and adapt the numbers and distribution in the treatment table accordingly (set the distribution from 'uniform' to 'norm'). Replace the Reference by 'User data'. Click 'Export PDF' to save a copy of the data in a PDF file. Click 'Calculate' to perform calculation

Water Source: River Rhine

Treatment Process

Treatment Process	Order	Data	Bacteria	Viruses	Protozoa
Bank filtration	1	Minimum Log Removal	4.0	2.1	1.0
		Maximum Log Removal	5.0	8.3	2.0
		Distribution	Norm	uniform	uniform
		Reference	User data	WHO (2011): Drinking water guideline, Table 7.7	WHO (2011): Drinking water guideline, Table 7.7
UV disinfection 40 mJ per cm2, drinking	2	Minimum Log Removal	4.6	4.1	2.5
		Maximum Log Removal	6.0	5.9	3.0
		Distribution	uniform	uniform	uniform
		Reference	Hijnen et al. (2006)	Hijnen et al. (2006)	Hijnen et al. (2006)



Infection risk per person per year
(Red line is the health based target)
Bacteria
Virus
Protozoa
1e−4
0.01
0.1
1
Bacteria
Virus
Protozoa
QUESTIONS?
DALYs per person per year

Try it yourself ☺

https://tinyurl.com/AquaNES-QMRA

1 Execute the example yourself

- 1a Standard data
- 1b User data
- Is the tool user friendly?
- Tips for improvements?

2 Try out for your own scenario

- What question do you want to answer?
- Does the tool provide decision support?
- Tips, requests, ideas for future developments

Maximum of 7 steps
Only calculate if you have the token

CALCULATE

Outlook

- Apply tool in projects (NextGen, Knowledge-impulse, WICE, …)

https://nextgenwater.eu/

Outlook

- Apply tool in projects (NextGen, Knowledge-impulse, WICE, …)
- Allow more user input (raw water pathogens, use scenarios)

Outlook

- Apply tool in projects (NextGen, Knowledge-impulse, WICE, …)
- Allow more user input (raw water, use scenarios)
- Adapt for discrepancies between guidelines

Default wastewater compositions

WHO

	Pathogens		
	Enteric bacteria (*Campylobacter*)	Enteric viruses (noroviruses)	Enteric protozoa (*Cryptosporidium*)
Default concentration (per litre) in source wastewater	7000	20 000	2700

Australian

	Pathogens		
	Enteric bacteria (*Campylobacter*)	Enteric viruses (noroviruses)	Enteric protozoa (*Cryptosporidium*)
Default concentration in wastewater (per litre)	7000	8000	2000

Californian Title 22

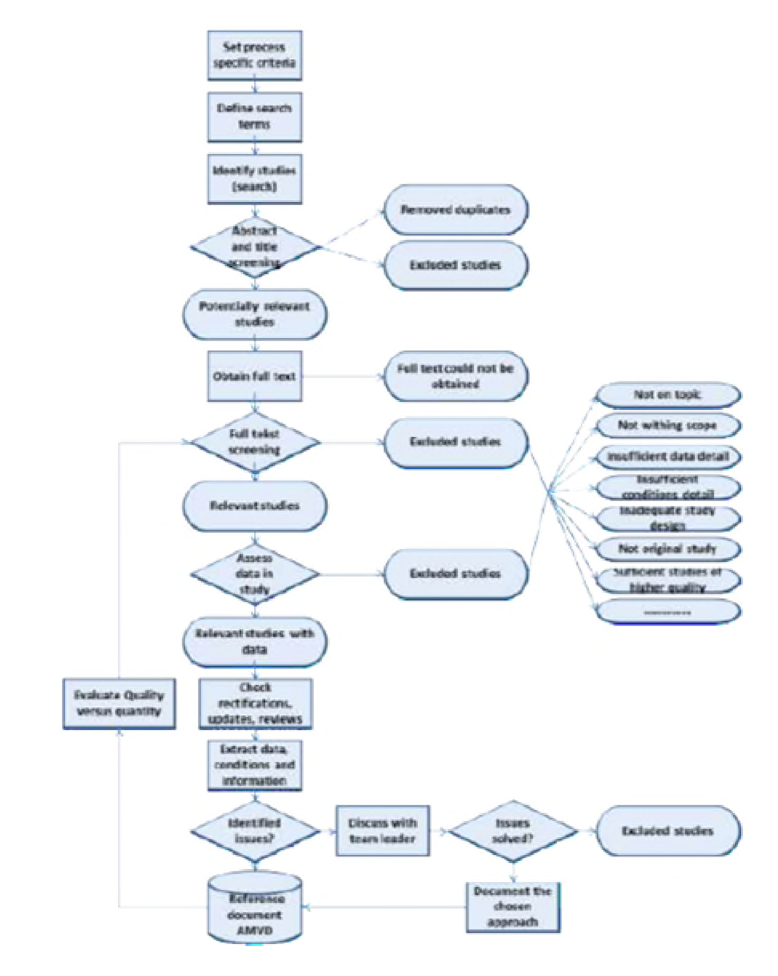
	Pathogens		
	Enteric viruses	*Cryptosporidium*	*Giardia*
Maximum wastewater concentration (per litre)	10^5	10^4	10^5
	100 000	10 000	100 000

Outlook

- Apply tool in projects (NextGen, Knowledge-impulse, WICE, …)
- Allow more user input (raw water, use scenarios)
- Adapt for discrepancies between guidelines
- Link to other tools

LRV literature database (transparent, evidence based)

rolling revision of LRV in literature (KWR, Colorado University, KWB)



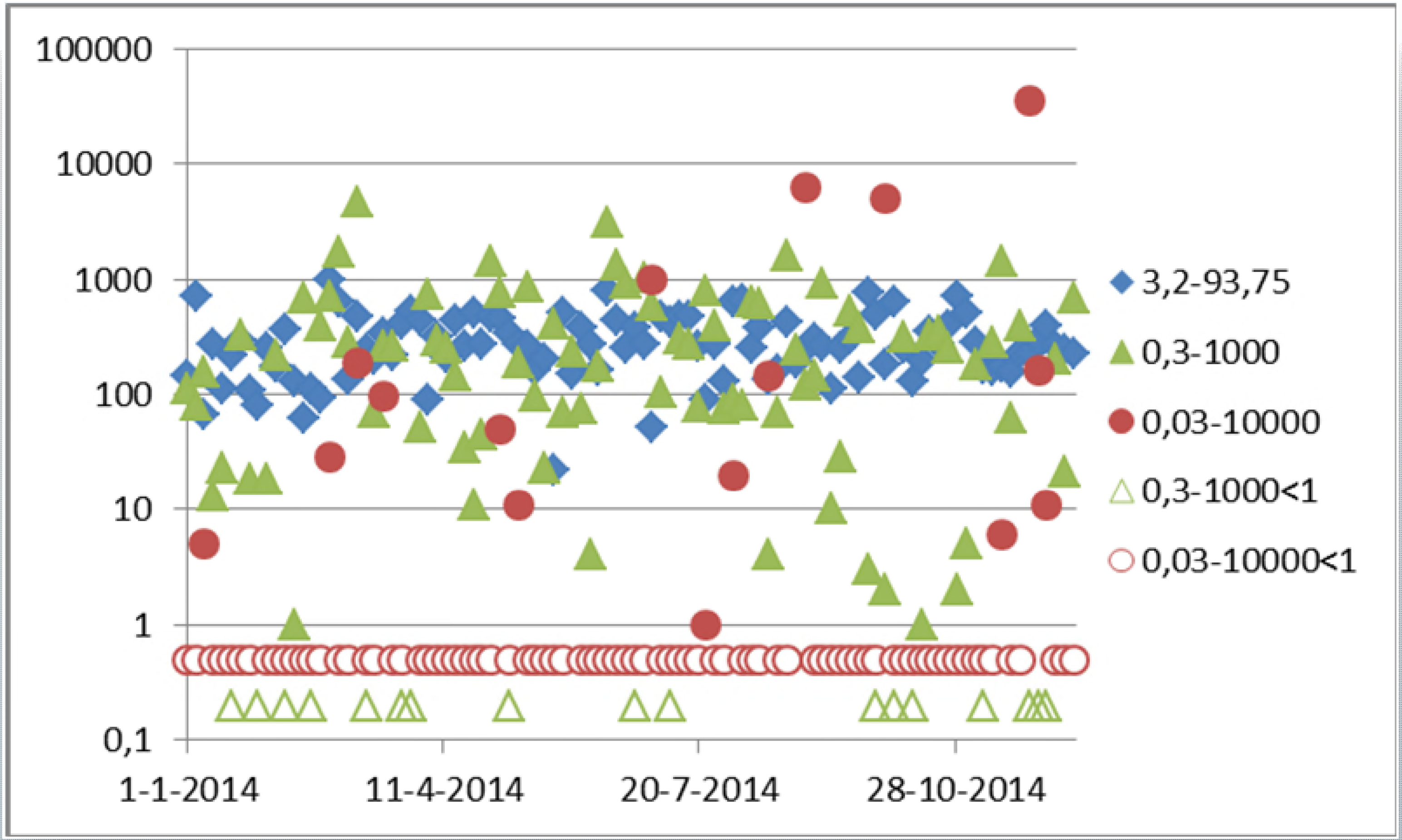
Figuur 2 Process scheme of data identification and selection.

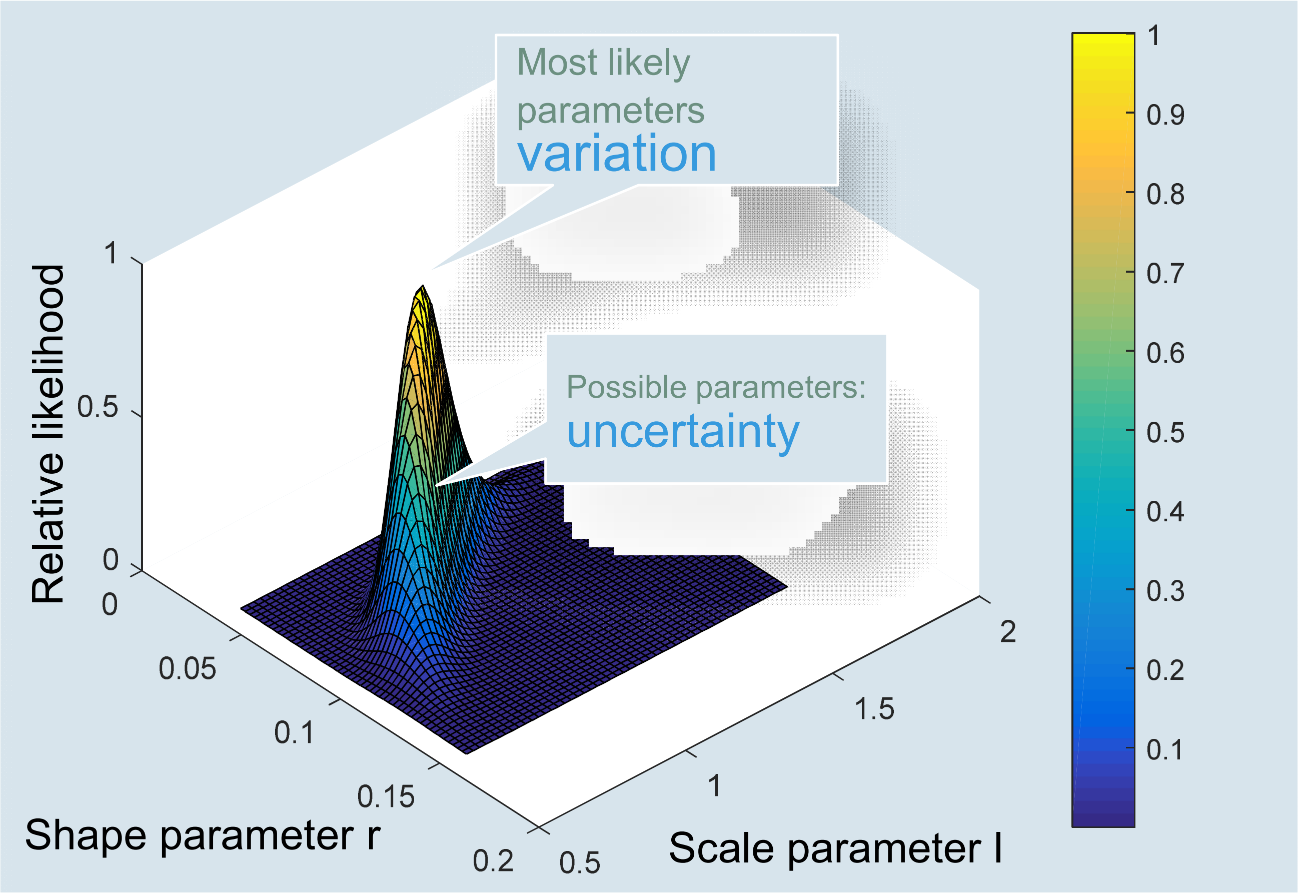
Outlook

- Apply tool in projects (NextGen, Knowledge-impulse, WICE, …)
- Allow more user input (raw water, use scenarios)
- Adapt for discrepancies between guidelines
- Link to other tools
- More advanced data analysis for user data

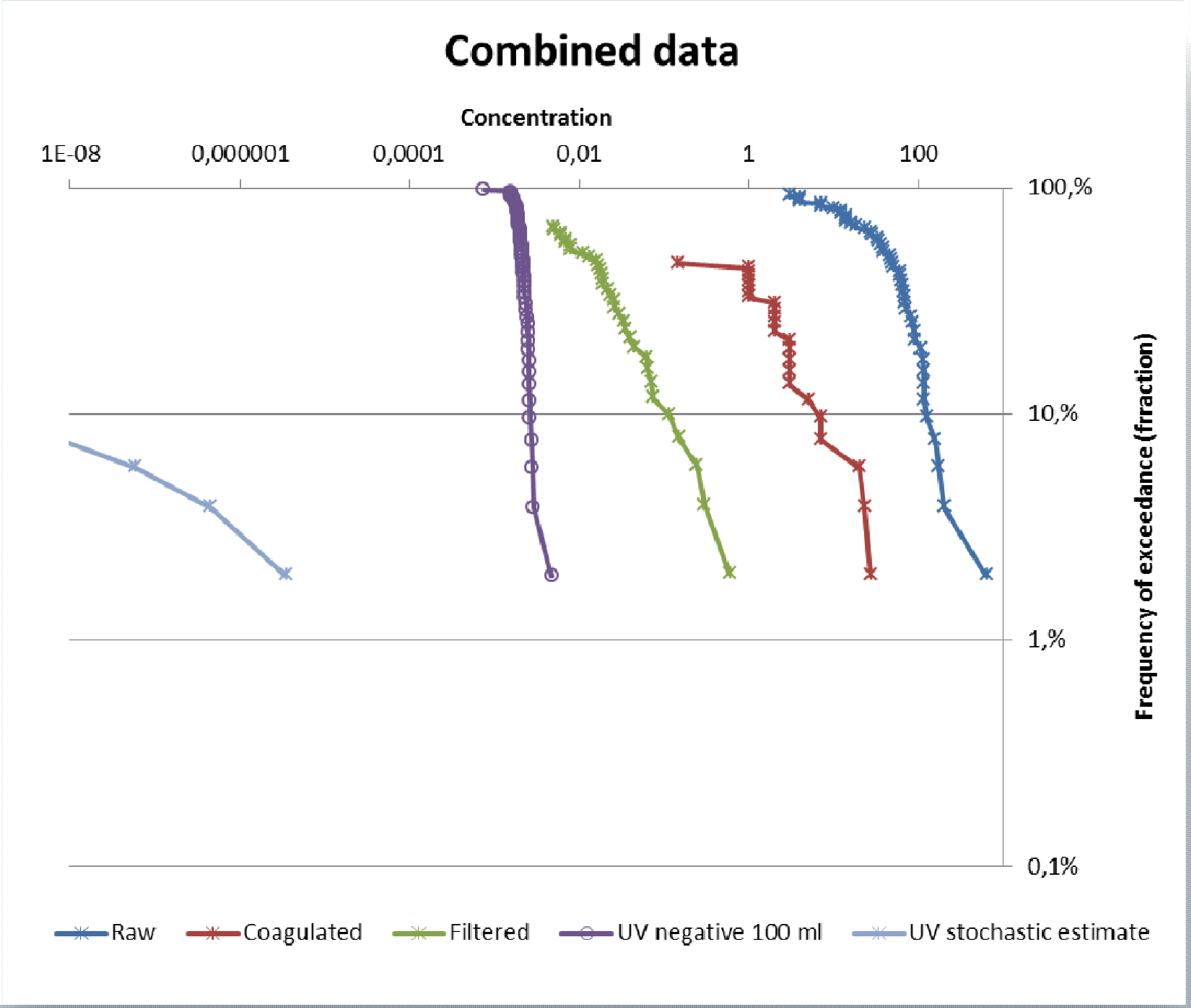
Stochastic analysis of variable data

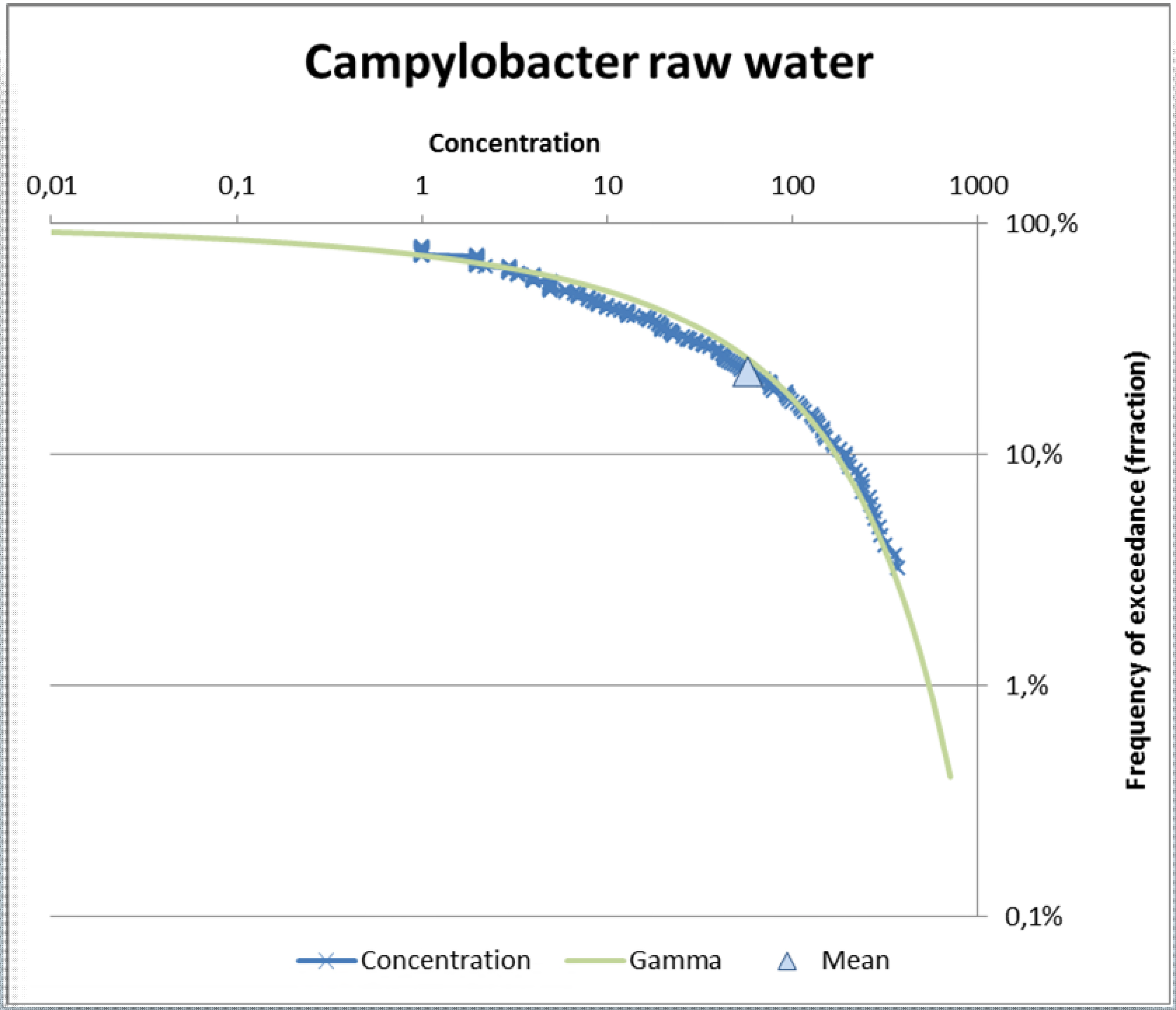
Separate uncertainty from variability: MH-MCMC, 2D MC QMRA





Stochastic analysis of variable data

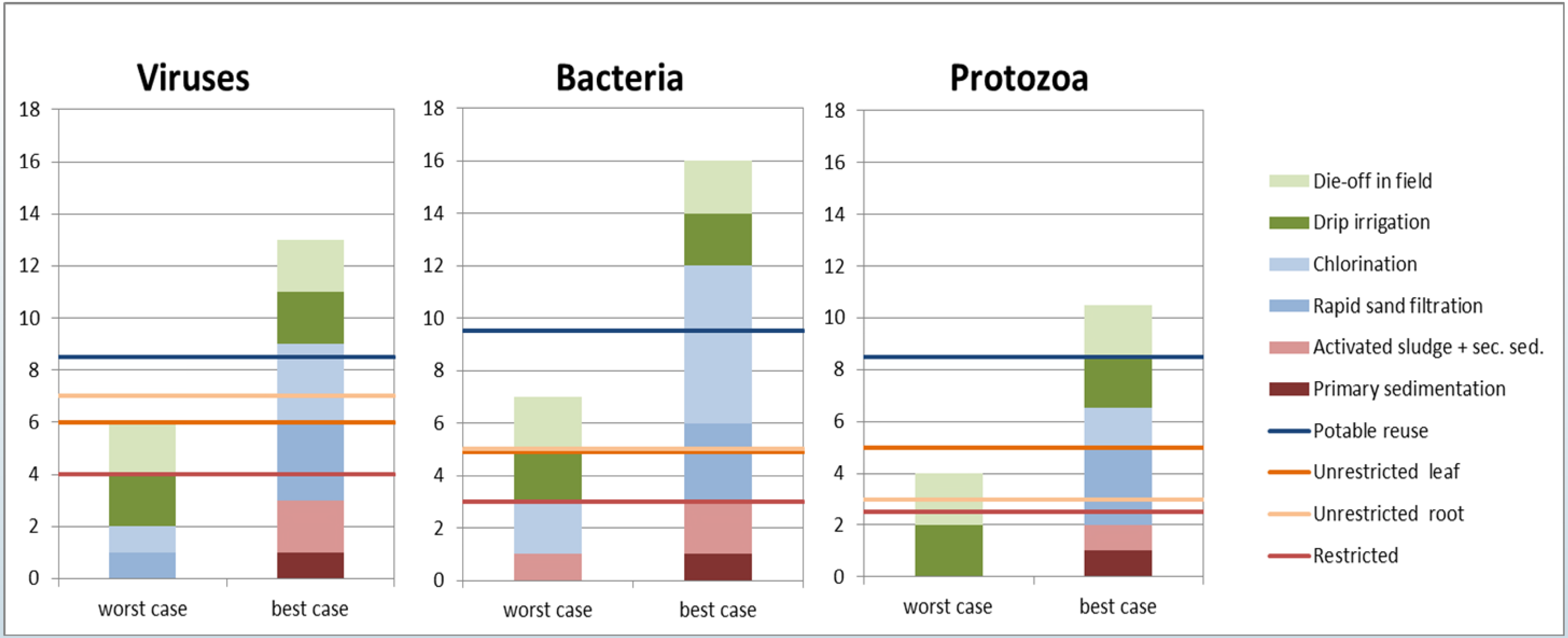




Outlook

- Apply tool in projects (NextGen, Knowledge-impulse, WICE, …)
- Allow more user input (raw water, use scenarios)
- Adapt for discrepancies between guidelines
- Link to other tools
- More advanced data analysis for user data
- Direct link to guideline approaches

Simple reuse scheme + drip irrigation



Outlook

- Apply tool in projects (NextGen, Knowledge-impulse, WICE, …)
- Allow more user input (raw water, use scenarios)
- Adapt for discrepancies between guidelines
- Link to other tools
- More advanced data analysis for user data
- Direct link to guideline approaches
- Embed in international networks

Embed in international networks

21

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KWR

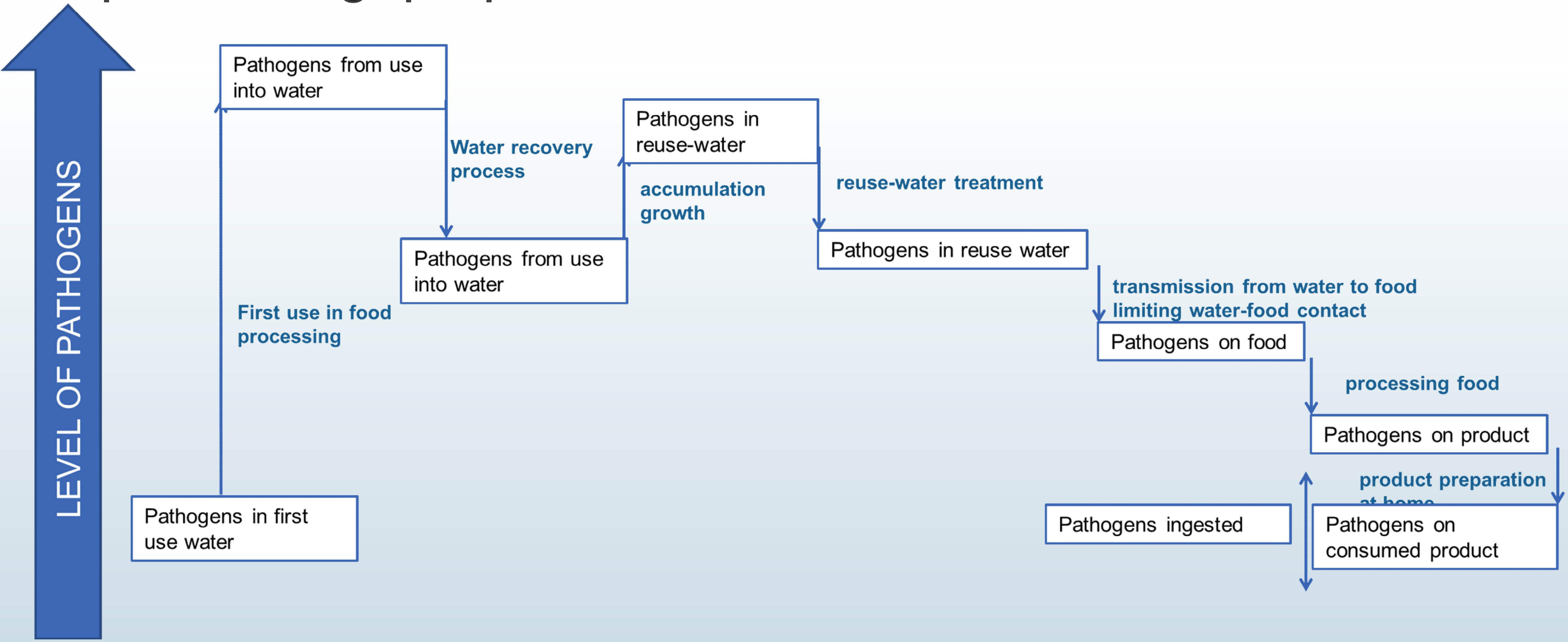
University of Colorado

Boulder | Colorado Springs | Denver | Anschutz Medical Campus

Outlook

- Apply tool in projects (NextGen, Knowledge-impulse, WICE, …)
- Allow more user input (raw water, use scenarios)
- Adapt for discrepancies between guidelines
- Link to other tools
- More advanced data analysis for user data
- Direct link to guideline approaches
- Embed in international networks
- Expand to Water in Food

Water reuse in food production: include food processing+preparation



Outlook

- Apply tool in projects (NextGen, Knowledge-impulse, WICE, …)
- Allow more user input (raw water, use scenarios)
- Adapt for discrepancies between guidelines
- Link to other tools
- More advanced data analysis for user data
- Direct link to guideline approaches
- Embed in international networks
- Water in food
- ……

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@KWR_Water

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