Risk assessment case study – Bergen, Norway

Executive summary

Introduction

The report provides an overview of the application and results of a risk and vulnerability analysis (RVA) of Bergen's water supply system covering all elements from source to tap (i.e. catchment, source, treatment plant, and distribution).

This is one of six case studies carried out in within WA 4 with the aim to: (i) apply and evaluate the applicability of different methods for risk analysis and to some extent risk evaluation of drinking water systems; and (ii) provide end-users with clear examples of how the risk analysis methods can be applied and what requirements exist.

Importance

Risk assessments providing relevant and informative results to assist decision-makers are essential for an efficient risk management. The World Health Organization concludes in their Water Safety Plan document that the most effective way to guarantee safe drinking water to consumers is an integrated risk management approach, including the entire drinking water system from source to tap. However, guidance on methods and tools to assist water utilities in managing risks is lacking. This report describes one type of advanced risk assessment method and an example of its application.

Approach

The applied method is based on a Coarse Risk Analysis combined with a more detailed analysis for some elements. The analysis covers all elements from source to tap (i.e. catchment, source, treatment plant, and distribution). The analysis gives an overview of the risk-picture for the water supply system.

Results

The main conclusion is that the flexible and redundant water system of Bergen, where 5 independent waterworks feed water into the same system, reduces the consequences from many of the undesired events which might happen. This puts Bergen in a unique situation compared to many other water companies in Norway. However, resulting from the analysis, we have identified new possible risk reducing measures for all elements in the water supply system which will improve the safety of the system to an even higher level. Within the project, a new procedure for assessing the strength of the hygienic barriers, represented by the water treatment step and the disinfection step, has been developed.

More information

The results of this work are presented in the report "Risk assessment case study – Bergen, Norway".

Deliverable number: D 4.1.5b

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TKI Categorisation

Classification									
Supply Chain		**Process Chain**		**Process Chain (cont'd)**		**Water Quality**		**Water Quantity (cont'd)**	
Source		**Raw water storage**		**Sludge treatment**		**Legislation/regulation**		- Leakage	
- Catchment	x	- Supply reservoir		- Settlement		- Raw water (source)		- Recycle	
- Groundwater		- Bankside storage		- Thickening		- Treated water			
- Surface water	x	**Pretreatment**		- Dewatering		**Chemical**		**Risk Management / Consumers**	
- Spring water		- Screening		- Disposal		- Organic compounds			
- Storm water		- Microstraining		**Chemical dosing**		- Inorganic compounds		**Risk analysis**	
- Brackish/seawater		**Primary treatment**		- pH adjustment		- Disinfection by-products		- Hazard identification	x
- Wastewater		- Sedimentation		- Coagulant		- Corrosion		- Risk estimation	x
Raw water storage		- Rapid filtration		- Polyelectrolyte		- Scaling		**Risk evaluation**	
- Supply reservoir		- Slow sand filtration		- Disinfectant		- Chlorine decay		- Risk tolerability decision	
- Bankside storage		- Bank filtration		- Lead/plumbosolvency		**Microbiological**		- Analysis of options	x
Water treatment		- Dune infiltration		**Control/instrumentation**		- Viruses		**Risk reduction / control**	
- Pretreatment		**Secondary treatment**		- Flow		- Parasites		- Risk reduction options	x
- Primary treatment		- Coagulation/flocculation	x	- Pressure		- Bacteria		- Decision making	
- Secondary treatment		- Sedimentation		- pH		- Fungi		- Implementation	
- Sludge treatment		- Filtration		- Chlorine		**Aesthetic**		- Monitoring	
Treated water storage		- Dissolved air flotation(DAF)		- Dosing		- Hardness / alkalinity		**Risk Communication**	
- Service reservoir		- Ion exchange		- Telemetry		- pH		- Communication strategies	
Distribution		- Membrane treatment		**Analysis**		- Turbidity		- Potential pitfalls	
- Pumps	x	- Adsorption		- Chemical		- Colour		- Proven techniques	
- Supply pipe / main	x	- Disinfection	x	- Microbiological		- Taste		**Trust**	
Tap (Customer)		- Dechlorination		- Physical		- Odour		- In water safety/quality	x
- Supply (service) pipe		**Treated water storage**						- In security of supply	
- Internal plumbing		- Service reservoir				**Water Quantity**		- In suppliers	
- Internal storage		**Distribution**	x					- In regulations and	

								regulators	
		- Disinfection				**Source**		**Willingness-to-pay/acceptance**	
		- Lead/plumbosolvency				- Source management		- For safety	
		- Manganese control				- Alternative source(s)		- For improved taste/odour	
		- Biofilm control				**Management**		- For infrastructure	
		Tap (Customer)				- Water balance		- For security of supply	
		- Point-of-entry (POE)				- Demand/supply trend(s)			
		- Point-of-use (POU)				- Demand reduction			

TKI Categorisation (continued)

Contains		**Constraints**		**Meta data**					
Report	x	Low cost		*Author(s)*					
Database		Simple technology		*Organisation(s)*					
Spreadsheet		No/low skill requirement		*Contact name*					
Model	x	No/low energy requirement		*Contact email*					
Research	x	No/low chemical requirement		*Quality controller name*					
Literature review		No/low sludge production		*Quality controller organisation*					
Trend analysis		Rural location		Source					
Case study / demonstration	x	Developing world location		*Date prepared*					
Financial / organisational				Date submitted (TKI)					
Methodology	x			Date revised (TKI)					
Legislation / regulation									
Benchmarking									