QUANTITATIVE MICROBIAL RISK ASSESSMENT

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Quantitative Microbial Risk Assessment (QMRA) for Potable Water Reuse

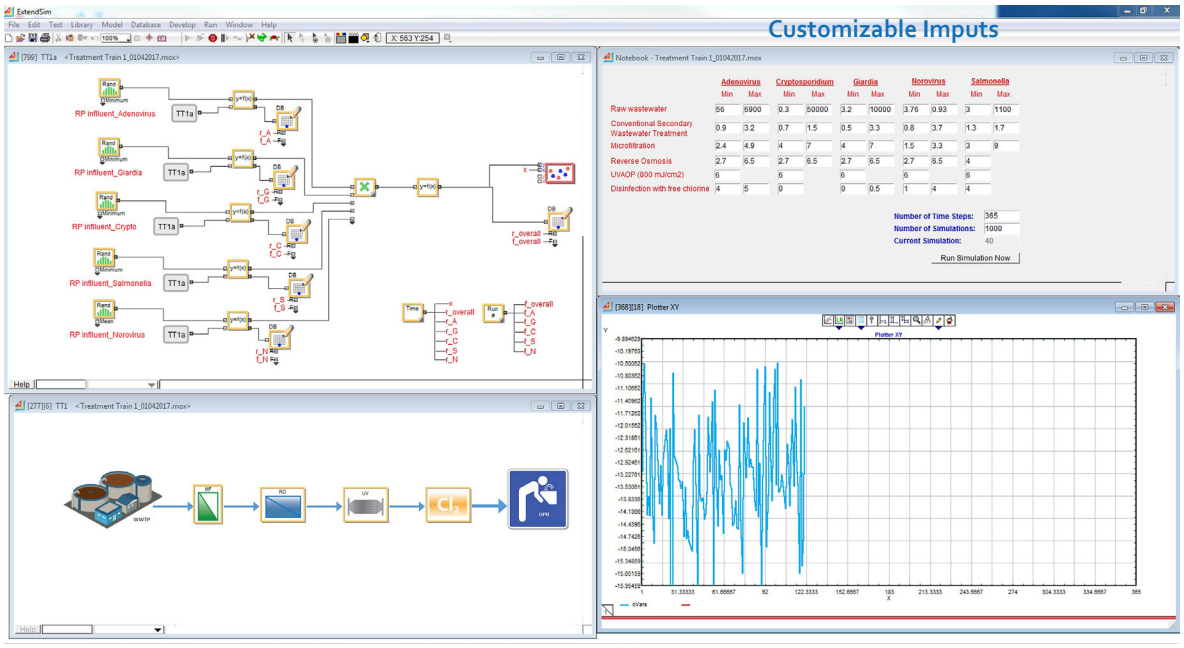
For potable water reuse projects, the target pollutants can be broken into three bins; chemical pollutants, salt, and pathogens. Of those three, the regulatory industry understands that pathogens present the greatest acute risk to human health. Regulators nationally have set a hard risk target for pathogens that results in <1 infection per 10,000 people per year, and requires multiple barriers of pathogen treatment to meet that standard.

The remaining issue and regulatory concern for the purification of wastewater for potable use is the variability of performance for each treatment process, and the combined removal performance of pathogens in the process train. The solution is the use of extensive treatment process data and Quantitative Microbial Risk Assessment (QMRA) to document the robust nature of different purification trains and the resulting final risk to the water consumer. The State of California's Expert Panel for DPR has stated that QMRA should be considered as one of several select criteria for DPR system analysis and permitting.

To this end, Carollo has developed a QMRA tool, combining the power of a state-of-the-art statistical Monte Carlo Analysis in Carollo's Blue Plan-it® (BPI) Decision Support System. The methodology, inputs, and results from the first QMRA analysis for DPR conducted by Soller, et al. (2016) were used to develop and validate the tool.

Based on a client-customized DPR treatment scenario, the tool characterizes risks associated with pathogens (*Adenovirus, Cryptosporidium, Giardia, Norovirus, Salmonella,* and others), and demonstrates the effectiveness of various advanced treatment technologies (ultrafiltration, reverse osmosis, ozonation, biological active filtration, ultraviolet disinfection, advanced oxidation, and others).

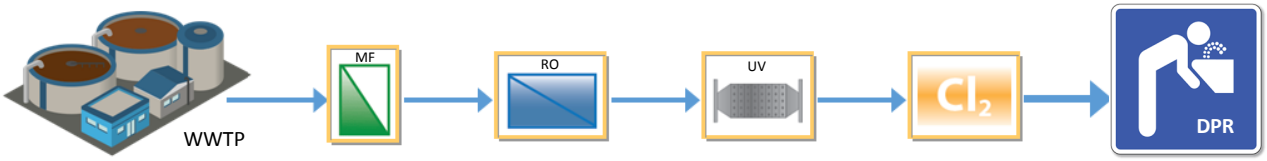
Blue Plan-it®
Monte Carlo Simulation



Using state-of-the-art Monte Carlo Analysis and computer simulation technology, Carollo's BPI Decision Support System provides a powerful engine for QMRA.

QMRA Case Study for DPR

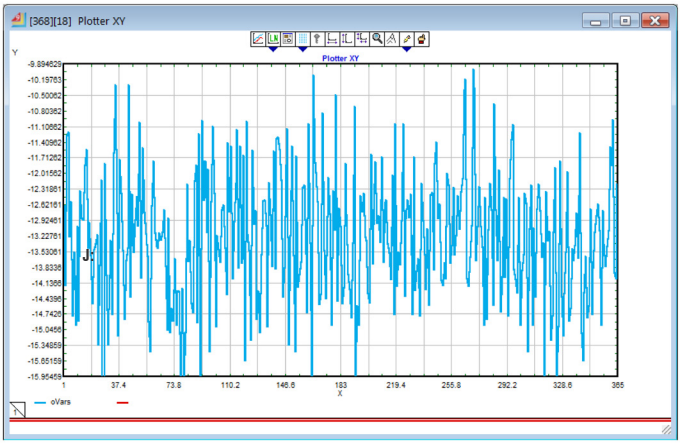
Step 1. Develop DPR Treatment Trains and Microbe Concentration Inputs



Train 1a UV AOP, Dose = 900mJ/cm² and Train 1b UV Disinfection, Dose = 20 mJ/cm².

Step 2. Simulate Daily Risks Using Monte Carlo Techniques

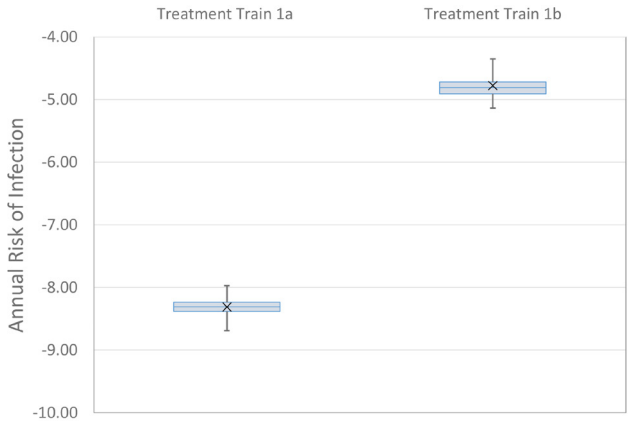
Carollo's QMRA tool leveraged available peer-reviewed data and a previously published statistical approach (Soller, et al., 2016) to estimate daily and annual infection risks associated with consuming product water from various DPR treatment trains.



1,000 risk simulations in under two minutes.

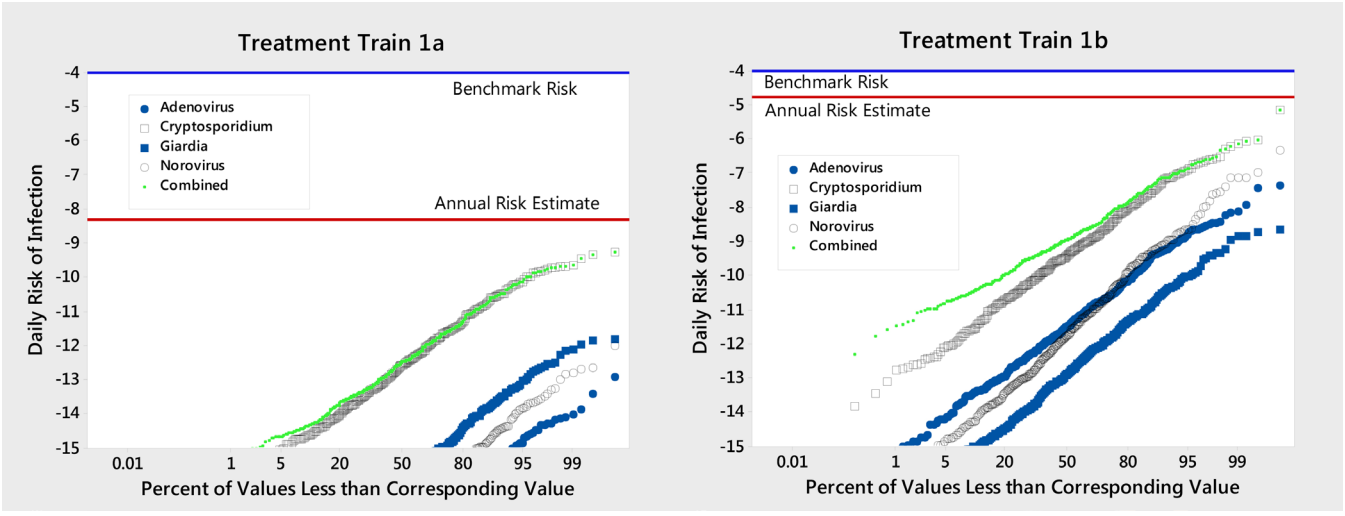
Step 4. Sum Risks Over All Organisms

Confirming the results and findings from Soller, et al., (2016), the analysis illustrated some important conclusions for implementation of DPR, including that the organism that drives the overall risk is a function of many parameters, including incoming concentrations and the treatment processes applied, and may change based on different source water and treatment scenarios.



Risk for Train 1a is much lower than Train 1b.

Step 3. Determine Cumulative Daily Risk of Infection Over a Year



Cumulative risk graphs illustrate the relative contribution of individual pathogens to the overall risk for each train.

Reference: Soller, J., S. Eftim, I. Warren, S. Nappier, 2016. *Microbial Risk Analysis*, in press.