REDUCING HYDRAULIC LOADING TO WWTPS
WHAT IMPROVEMENTS IN WWTP PERFORMANCE?

A scenario analysis to assess the effects of hydraulic loading reduction on effluent quality, energy consumption and costs of WWTP operation

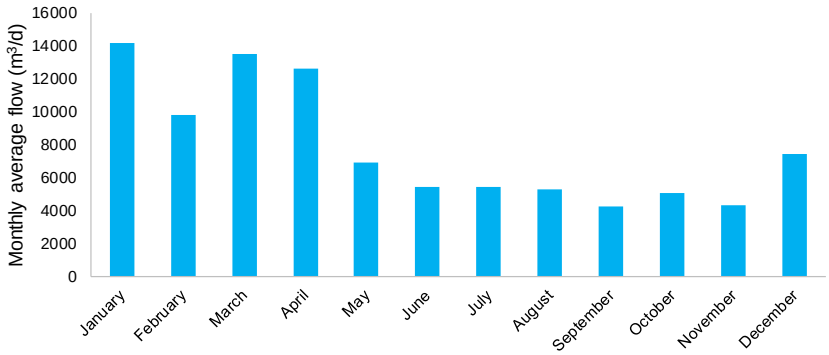
An increasing number of water utilities and municipalities, in Denmark and worldwide, are seeking a reduction of the hydraulic loading to WWTPs. While carrying significant investment (implementation of separate sewers, repair of sewer pipes), this can also bring considerable improvements in WWTP operation and related costs.

The simulation of WWTP operation in WEST under different influent quality and quantity scenarios, allowed to evaluate the effect of hydraulic loading reduction on effluent quality (COD, N, P), sludge production, energy consumption (pumping and aeration) and operational costs.

BACKGROUND AND STATUS OF RØNNE WWTP

Rønne WWTP is the major treatment facility on the island of Bornholm, Denmark. The WWTP receives wastewater from households and local industries through a combined sewer, and comprises preliminary treatment (screening, grit and fat removal) biological nutrient (N, P) removal with activated sludge and iron chloride dosing for chemical P removal. Wastage sludge undergoes dewatering with dosing lime and polymers.

The WWTP has traditionally been subject to significant variations in influent flow over the year, as a result of varying stormwater and infiltration contribution. Although an improvement of WWTP performance under reduced hydraulic loading conditions can be expected, an exact quantification of the effects of such reduction could be quantified based on simulation results from a WEST model of the WWTP.



Variation of monthly average influent flow to Rønne WWTP (year 2018).

CLIENT

- Bornholms Energi og Forsyning (BEOF)
- Bornholm Spildevand A/S

CHALLENGE

- High variability in hydraulic loading to WWTP
- Assessment of improved WWTP performance in case of future reduction of hydraulic loading

SOLUTION

- Development and calibration (yearly and monthly average performance) of a WWTP model in WEST.
- Scenario analysis to assess progressive reduction of hydraulic loading.

VALUE

- Description of WWTP performance under current typical scenario
- Determination of effects of hydraulic loading on WWTP operation in consideration of multiple objectives (effluent quality, sludge production, energy consumption)
- Estimation of potential improvements in WWTP performance and cost savings when implementing inflow reduction strategies

LOCATION / COUNTRY

Rønne, Denmark

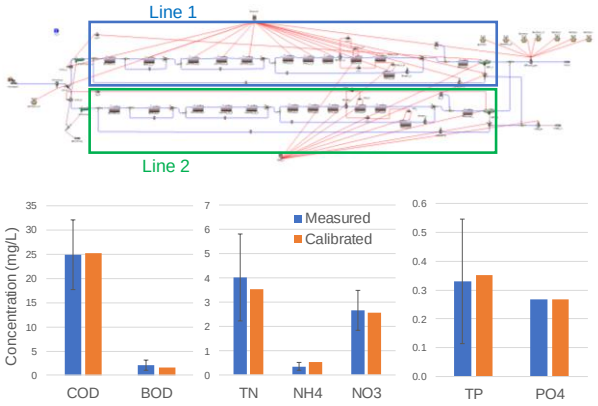
SOFTWARE USED

WEST

MODEL IMPLEMENTATION AND CALIBRATION

The layout of Rønne WWTP was set up in WEST, considering two separate lines for the biological treatment. Each of the two lines comprised a selector, two non-aerated tanks and a final tank with intermittent aeration. An internal recirculation within each (circular) tank was established to reproduce a typical mixing velocity.

The fractionation of influent COD, N and P was carried out based on 1-year measured data provided by operators, being was verified with independent measurements. The WWTP model was first calibrated against average concentrations of COD, N and P fractions and mixed liquor suspended solids in activated sludge reactors. The model was additionally verified with specific measured data from one month, representing WWTP operation under reduced hydraulic loading.



WEST layout implementation of Rønne WWTP and results of model calibration (average year 2018). © DHI

SCENARIO ANALYSIS

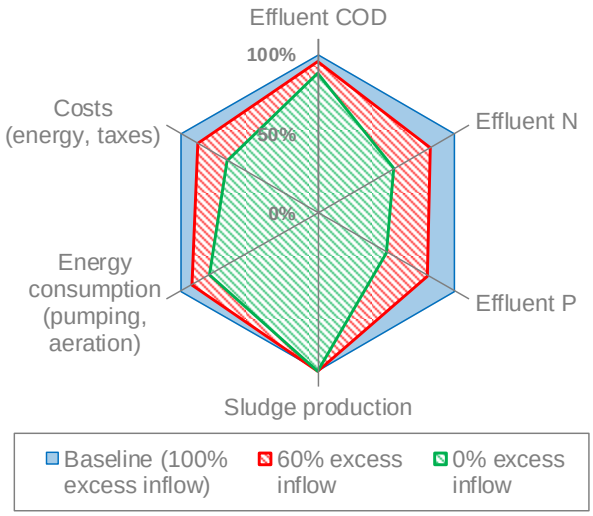
Following verification with available measured data, the WEST model was used to evaluate differences in WWTP performance under varying influent flows. The excess flow (stormwater, infiltration) to be reduced in the future was estimated to be approximately 3800 m^3/d.

A scenario analysis was carried out, where several hydraulic loading scenarios were considered:

- Baseline scenario (no reduction, 100% excess inflow)
- Progressive excess inflow reduction (80%, 60%, 40%, 20% excess inflow)
- Complete excess inflow reduction (0% excess inflow)

Results of the scenario analysis are here presented in terms of effluent quality, sludge production, energy consumption (pumping and aeration) and costs. A radar plot allowed to visualize changes in WWTP performance while considering multiple objectives.

A complete reduction of excess inflow was estimated to provide for considerable improvement in terms of effluent quality (-12% to -50% load), energy consumption (-418 kWh/d) and costs (-350,000 DKK/y).



Results of scenario analysis with increasing reduction of hydraulic loading to Rønne WWTP. © DHI

CONCLUSIONS AND FUTURE VALUE

Considering an excess hydraulic loading of up to 3800 m^3/d (accounting for 40% of average diurnal influent flow), it is estimated that every 20% step reduction of this excess flow will correspond to:

- 9%, 10% and 7% reduction in effluent BOD, N and P, respectively
- 4% reduction in energy consumption (pumping and aeration)
- 7% reduction in costs (effluent taxes, energy)

Upon complete reduction of the excess hydraulic overloading, savings in terms of reduced effluent taxes and energy have been estimated to be in the order of 350,000 DKK/y. These estimated savings can be used to define the most suitable strategy for hydraulic loading reduction, considering e.g., investment return time.

BENEFITS OF WEST