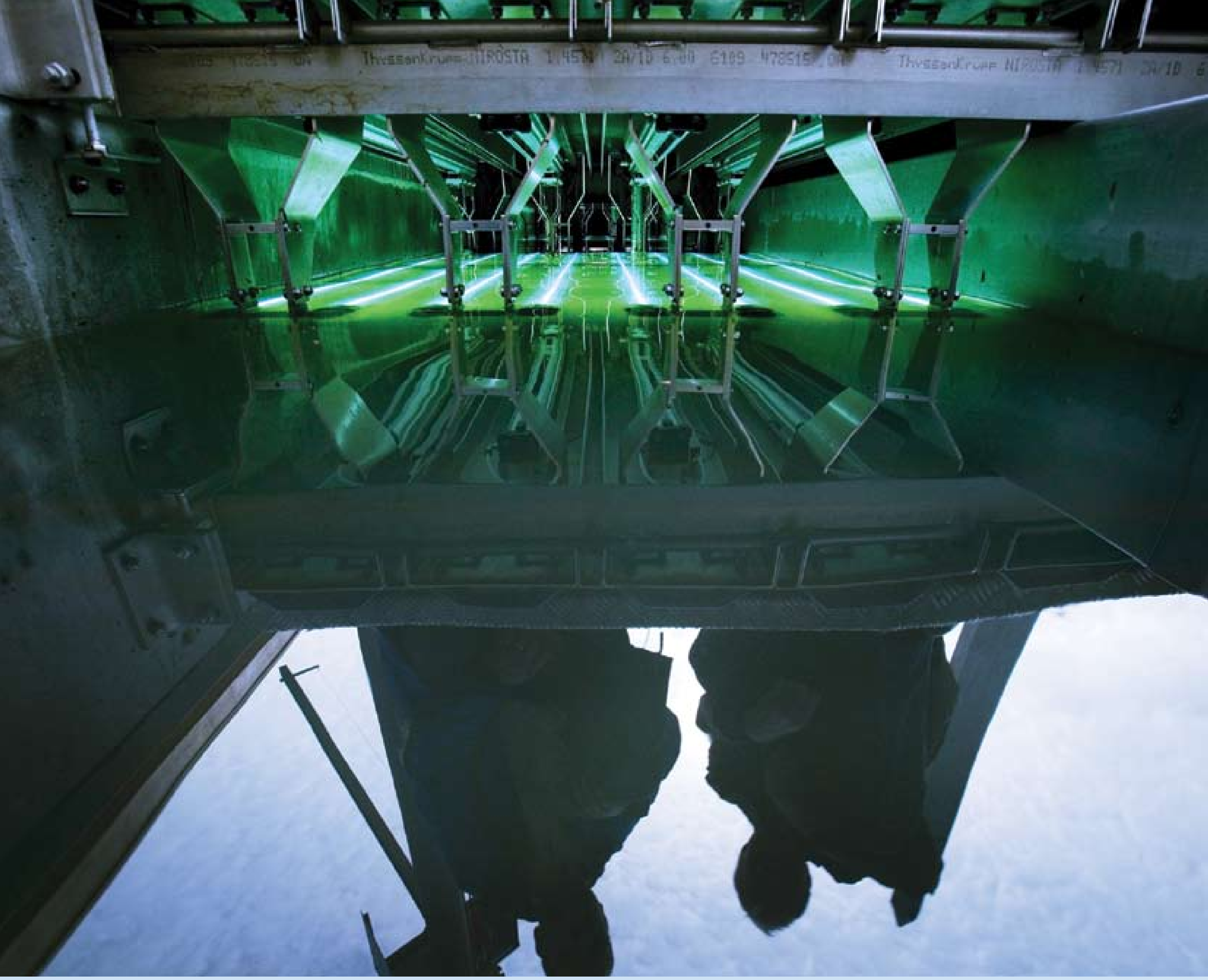


Innovative technologies for local treatment of combined sewage

The implementation of the European Water Framework Directive calls for new and innovative approaches to handling urban wet weather discharges. The EU LIFE project LOTWATER has tested a number of innovative technologies both technically and economically.

The project is supported through the EU LIFE-programme

LOTWATER
www.cowiprojects.dk/lotwater

Dissemination of project results has been a key priority throughout the project. During the 10th International Conference on Urban Drainage university professors, water company professionals, consultants and contractors made a site visit to the Copenhagen facility.

Scope and objectives

Traditional design of combined sewer overflows is known to have detrimental effects sometimes preventing surface waters from having a good status. Implementation of the Water Framework Directive highlights the need to bridge the gab between discharge permits and water quality in surface waters resulting from combined sewer discharges. Combined sewer overflows to surface waters are frequent in urban areas and therefore they constitute an important factor when it comes to ensuring the implementation of the Water Framework Directive on the river basin level.

The project objective is to quantify and verify the efficiency of new concepts for local treatment of combined sewage and to quantify and verify the positive impact on the receiving surface waters at three facilities. Based on the results, cost-efficiency is calculated for the novel technologies relative to more traditional ways of minimizing the impact from urban combined sewer systems.

The demonstration facilities are based on technologies that have proved to be useful for treatment of other types of wastewater. Full scale studies of these technologies have not previously been carried out in relation to combined sewer overflows. The objective of the current project, covering demonstration facilities in Copenhagen, Odense and Aarhus, is to test these technologies with respect to treatment efficiency and environmental impact.

Cost-efficiency and the Water Framework Directive

The implementation of the Water Framework Directive will ensure that almost all surface waters in Europe will achieve good ecological status. This ambitious plan calls for a number of initiatives aimed at all types of emissions. Emissions from wet weather discharges are an important source of pollution, sometimes preventing water bodies from achieving good ecological status. However, reducing this source of pollution is often expensive compared to actions toward other sources of pollution. The LOTWATER project studies novel technologies that may reduce these costs and minimize pollution. This will enable a more cost-efficient implementation of the directive.

Bathing waters in downtown Copenhagen are popular. Copyright Polfoto.

In Copenhagen the objective is bathing water quality in a coastal water area.

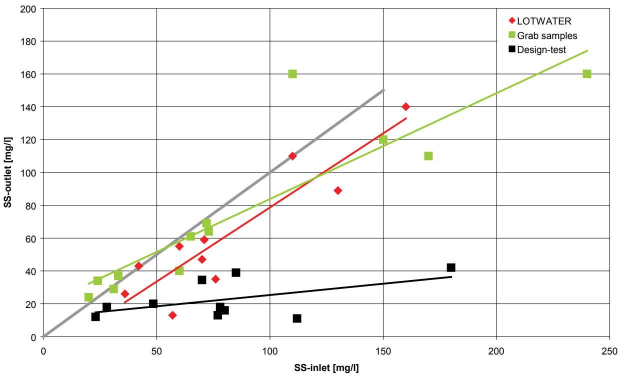
Copenhagen
– demonstration facility with emissions to marine water

The Copenhagen demonstration facility is the most advanced facility covered by the project. Here, the objective was to treat 1800 m^3/h of combined sewage with an emission to the marine water that complies with the requirements of the Bathing Water Directive, i.e. 500 *E. coli*/100 ml. If this objective is met, the plant will be the first of its kind and the method will be highly relevant in relation to large catchments in big cities located near bathing waters.

The demonstration facility consists of a mechanical treatment step and a microbiological treatment step. The mechanical treatment step is needed to ensure the efficiency of the microbiological treatment step. The mechanical treatment consists of a 2 mm screen, followed by two filters with a 100 µm and 20 µm mesh, respectively. The microbiological treatment step consists of a UV-disinfection unit.

Drum and disc filters from the Copenhagen demonstration facility. The sampling unit is shown in the foreground. The water runs by gravity through both filters and the UV-station.

The plant should be evaluated according to the following criteria:
1) The ability to remove suspended solids rapidly, efficiently and without interruptions
2) The ability to remove *E. coli*



Summary of results:
- Filters have a quick start and operation is stable
- Filters remove more suspended solids than a traditional basin using the same space
- The UV disinfection unit works well after being warmed up. Some samples contained less than 1 *E. coli* pr 100 ml.
- Based on experience from the project it is possible to design a plant with emissions that comply with the Bathing Water Directive.

The plant is one of the reasons why the bathing water quality in the Svanemøllebugten has improved.

During design of the facility pilot-scale tests indicated very high treatment efficiency of the drum filter. The full scale tests have shown lower treatment efficiency.

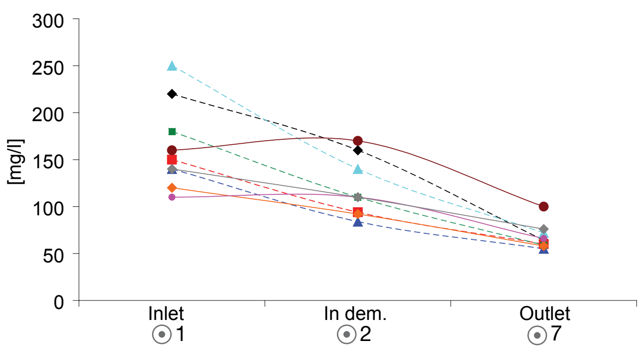
The Odense Rriver flows into the Odense Fjord which is one of the pilot river catchments in the coordinated strategy for implementation of the Water Framework Directive.

Odense
– demonstration facility with emissions to a large water course

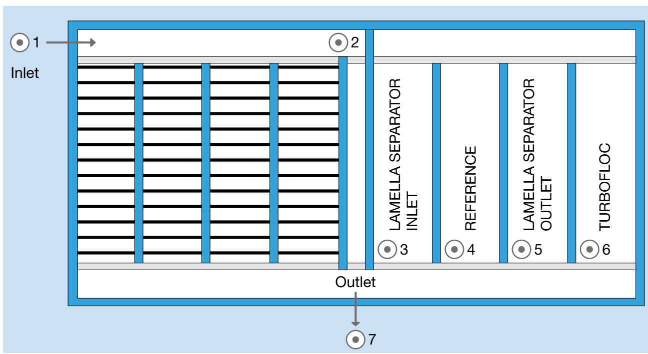
The facility in Odense is an optimization of an existing detention volume in Odense located at the inlet to the treatment plant. The volume is 7200 m^3. Prior to the optimization the emissions from the facility contained relatively high concentrations. Therefore, it was the objective to optimize flow patterns in the detention volume and test a total of four enhanced clarification technologies. The turbofloc and lamella separators were selected because they have shown good performance with respect to enhancement of removal of particles from water.

Summary of results:
- The optimization of flow patterns has worked at least as well as anticipated.
- Installation of the lamella separator at the outlet gave the most efficient removal of suspended solids.
- The tank with scrapers and sludge pit was as efficient as installing the lamella separator at the inlet and the Turbo-floc.

Discharge from the facility is one of 66 points of discharge to Odense River in the Odense city area. Nevertheless, the measurements in the river indicate that the concentration of *E. coli* is lower than before the facility was optimized.

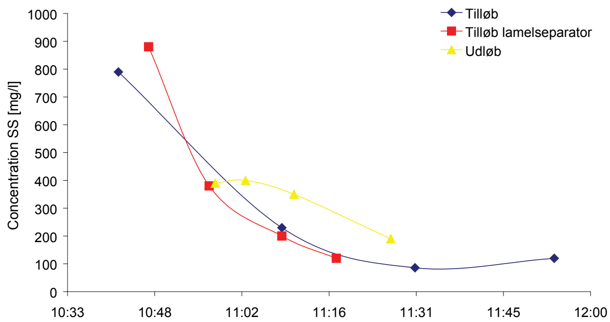


Plan plot of the optimized detention pond at the Odense facility. Before the optimization the facility consisted of 8 identical channels.



Measurements of the removal of suspended solids throughout the facility. The removal of pollutants is due to the reduction in concentration as well as to the retainment of the polluted water.

The Silistria Stream is a small water course in a popular recreational area south of Aarhus. Achieving good ecological status is important - not least to the many people visiting the forrest every day



The event mean concentration is clearly lower at the outlet than at the inlet. The main reason is the change in concentration througout the event. The lamella separator does not appear to remove particles during the actual discharge.

	Upstream (150 m)	Downstream (50 m)	Downstream (350 m)
Before	4-5	5	5
After	3-5	5	5-6

Measurements of biological index throughout the measurement period. The increase in the index is significant and should be ascribed to the installation of the demonstration facility.

Aarhus

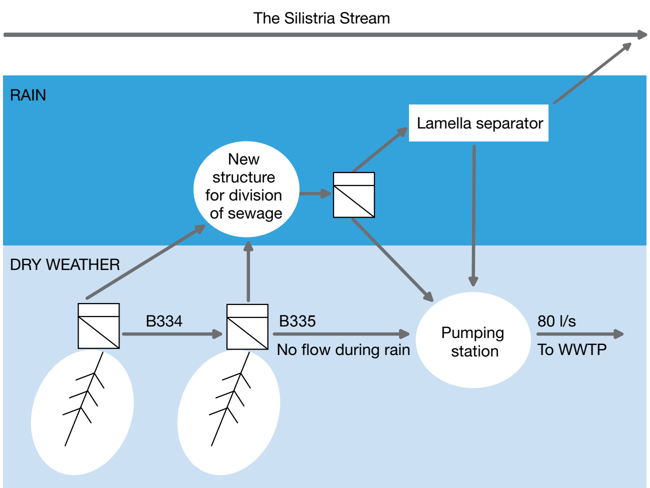
– demonstration facility with emissions to a small water course

The facility in Aarhus represents a typical small catchment and the corresponding small water course. This setup is typical for most discharges. The solution must be simple and relatively cheap in order to be recommendable as a general guideline.

The actual facility consists of two small catchments. The reason for combining the catchments is that monitoring at the stream would be disturbed if only one catchment was treated.

Summary of results:

- The ecological status of the surface water has clearly improved. The improvement is due to the installation of the demonstration facility.
- The measurements indicate that the main reason for the improved surface water is the reduction in the number and size of discharges.



Installation of the lamella separator in the structure. The left structure is the overflow structure while the right structure is for the installation of the lamella separator.

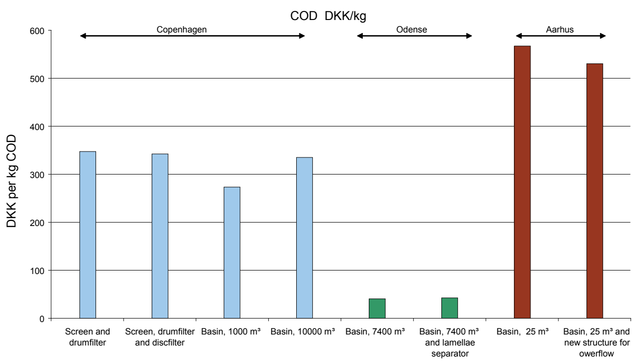
All results have been reviewed by the scientific review team. Here some of the team members are inspecting the demonstration facility in Odense.

Cost-efficiency of demonstration facilities

The results of the cost-efficiency calculations form part of the basis for the conclusions stated for each location. The cost-efficiency calculations can be summarized as follows:

- When increased treatment is a moderate requirement hydraulic optimization of existing detention volumes is highly cost-efficient. In this case, installation of lamella separators at the outlet is also cost-efficient relative to construction of extra volume.
- Filters are cost-efficient with respect to removal of suspended solids when compared to large detention volumes.
- Construction of UV-disinfection is cost-efficient at large catchments compared to traditional volumes.
- Local conditions are of paramount importance. The actual calculation of cost-efficiency relies heavily on local characteristics such as size of the catchment and availability of space.

The importance of the local conditions is illustrated in the figure below. The actual cost of removing one kg of organic matter varies highly between the different sites.



Cost-efficiency calculations for the different facilities yield very different results. This is an indication that local circumstances are very important when choosing the best technology for a specific site.

Transfer of results to other locations

The novel technologies are cost-efficient when installed at large catchments. For catchment sizes below 25 connected paved areas the construction of detention volume is generally still cost-efficient. Two of the three facilities studied in the project are installed at large catchments and these facilities are cost-efficient.

A number of novel technologies have been tested during the project. Below the conclusions are discussed by technology.

Screens

Screens are normally installed to prevent aesthetic pollution rather than *E. coli* and suspended solids. They do not retain much of the macro-pollution.

In the current project the screens were installed to prevent malfunction of the fine filters. This objective was achieved.

Filters

The filters proved to be stable during operation. Installation of filters are cost-efficient at very large catchments.
Relative to the space required for the this type of technology, the filters offer the highest efficiency in terms of removal of pollutants.

If the treatment efficiency of the filters can be improved to the level registered during the pilot tests the method will also be cost-efficient at smaller catchments.

Hydraulic optimization of detention volumes

Hydraulic optimization of detention volumes is highly recommendable and should be incorporated into all new detention volumes. Optimization of detention volumes can also be recommended when the pollution load has to be reduced moderately relative to the existing situation.

Lamella separators

Installation of lamella separators in existing detention volumes can be recommended when the pollution load has to be be reduced moderately relative to the existing situation and hydraulic optimization is not sufficient.

Turbo-floc

The Turbo floc technology has proved to be efficient when used on water with sludge. The measurements indicate that this technology cannot be transferred to sedimentation on combined sewage.

UV-disinfection.

Disinfection by means of UV-light has proved to be cost-efficient when applied to very large catchments.

Calculated unit costs for reducing emissions from combined sewage from a standard catchment with a connected paved area of 25 hectares. This type of catchment represents a typical large catchment. High initial costs are associated with the technologies studied. Therefore, the filters and UV-disinfection units will become more and more competitive as size of the catchment is increased.

Technology for reduction of emissions	SS [€/kg]	*E. coli* [€/10^{12} *E. coli*]
Detention volume, 25% reduction of SS (170 m³)	20	
Detention volume, 50% reduction of SS (480 m³)	20	
Detention volume, 75% reduction of SS (1300 m³)	30	
Screen and drum filter, 77% reduction of SS (pilot-scale results)	50	
Screen and filters, 86% reduction of SS (pilot-scale results)	80	
Screen and drum filter, 32% reduction of SS (full scale results)	140	
Screen and filters, 45% reduction of SS (full scale results)	150	
Detention volume, 99.5% reduction of *E. coli* (7400 m³)		1600
Screen, filters, and UV-disinfection, 85% reduction of *E. coli* (full scale results)		1800
Screen, filters, and UV-disinfection, 99.5% reduction of *E. coli* (pilot scale results)		1500

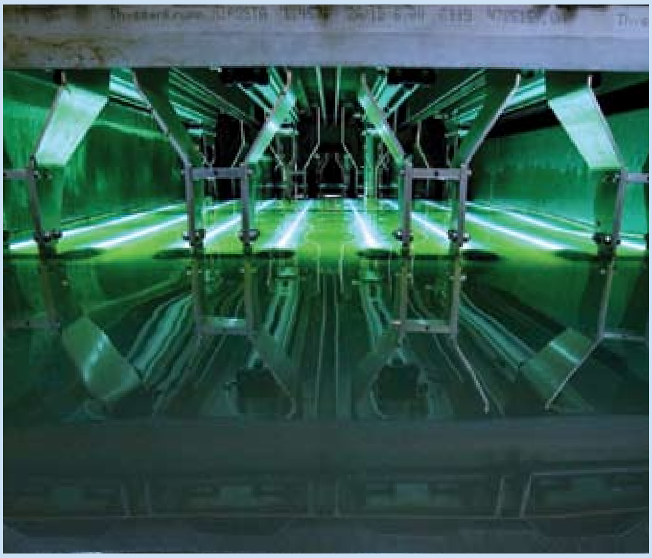
The project results are documented through a number of reports and papers. The most important ones are listed below. The reports can also be found at:
www.cowiprojects.dk/lotwater

Reports:

- *Monitoring of treatment efficiency and achievement of environmental goals. Sampling manual. May 2004*
- *Monitoring of treatment efficiency and achievement of environmental goals. (Report and appendix). December 2006*
- *Vurdering af omkostningseffektiviteten for demonstrationsprojekterne (Report and appendix). March 2007.*
- *Documentation of design for each of the facilities. October 2005 - February 2006.*

Articles:

- *Enhanced local treatment of combined sewer overflows enabling the implementation of the Water Framework Directive. NOVATECH, France, juni 2004.*
- *Construction and testing of a CSO treating combined sewage to bathing water quality standards. 10 International Conference on Urban Drainage, Copenhagen. August 2005.*
- *Full scale testing of enhanced local treatment of CSOs enabling a cost-efficient implementation of the EU Water Framework Directive. 10 International Conference on Urban Drainage, Copenhagen. August 2005.*
- *Enhanced local treatment of combined sewer overflows enabling the implementation of the Water Framework Directive. NOVATECH, France, juni 2007.*



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