

Aarhus Water

**WATER SUPPLY AND WASTEWATER PURIFICATION
IN AARHUS IN WORDS AND PICTURES**



***CLEAN WATER
FOR ENJOYMENT,
FUN AND LIFE***



Aarhus Water

Fact: Without water there would be no life. Water is the most precious liquid in the world – and it must be a pleasure to drink.

Water is also an important source of fun and activity. Our streams, lakes and sea offer the inhabitants in the Aarhus area a host of things to do. Therefore – not least out of respect for the environment – the wastewater we return to nature must be clean.

Aarhus Water counts about 250 committed employees who work together to put consumers first and do their utmost to ensure they are among the best and most efficient in the Danish water supply and waste water treatment sector.

Aarhus Water is one of the country's leading companies in the water industry and we work with the entire lifecycle of water – from the time consumers turn on the tap for a drink of fresh water – until the purified waste water from households and industries is returned to nature.

Aarhus Water supplies consumers in Aarhus Municipality with some of Denmark's most palatable water – and we supply them with a lot of it.

We produce about 16 million cubic metres of clean, fresh drinking water annually – corresponding to 85 per cent of the total water supply in the municipality.

We obtain the water with the help of groundwater extraction from about 100 wells in the municipality. We then treat it at our ten waterworks and finally supply consumers with clean, inexpensive drinking water from 12 elevated storage tanks via 1,500 kilometres of water mains.

We purify between 30 and 35 million cubic metres of water a year at ten high-tech waste water treatment plants by means of effective, environmentally sound methods that remove such impurities as nitrogen, organic matter and phosphorus. The purified waste water is then returned to nature and the water cycle can begin again.

This brochure provides insight into how we at Aarhus Water work to ensure clean water for enjoyment, fun and life for the benefit of consumers in Aarhus Municipality.

DID YOU KNOW THAT...

***EVERY SINGLE INHABITANT OF AARHUS MUNICIPALITY
USES AN AVERAGE OF 115 LITRES OF WATER A DAY?***

Drinking water

Life-giving groundwater

Water supply in Aarhus

The public water supply in Aarhus Municipality was established in 1872 and until 1902 the water came from Aarhus River. The company then changed to groundwater extraction and today Aarhus Water extracts drinking water from just under 100 groundwater wells.

Extracting groundwater

The wells are between 30 and 140 metres deep – most of them are between 60 and 80 metres deep. All wells are surrounded by a ten-metre protection zone and a 300-metre hygiene zone within which there must be no percolation of wastewater.

Extraction is carried out on the basis of a groundwater plan administered by Aarhus Municipality. The plan lays down guidelines for how the groundwater must be distributed between waterworks, agriculture and nature.

Water is vital so we must make sure that there is sufficient clean water for people and nature. We have excellent groundwater resources in the Aarhus area but the wells are spread around outside the city to relieve the impact on reserves – and to minimise the risk of pollution.

We pump up about 16 million cubic metres of water a year at Aarhus Water. To ensure that we pump up no more water than the groundwater reserves can provide, we monitor the water level at the individual wells continually. This way we can be sure of a sustainable supply.

Water treatment at the waterworks

We lead the groundwater from the wells to our ten waterworks where it is treated before we send the drinking water out to consumers. Thanks to the good quality of the groundwater in the municipality water treatment is quite simple and solely involves aeration and filtering through sand filters.

Aeration is carried out by leading the water over an aeration staircase or through a chamber where air is blown through the water. This will cause gasses – including hydrogen sulphide – to be blown out of the water and cause iron and manganese to oxidise. This oxidation is very important because iron and manganese are turned into solids that can be trapped in the sand filters.

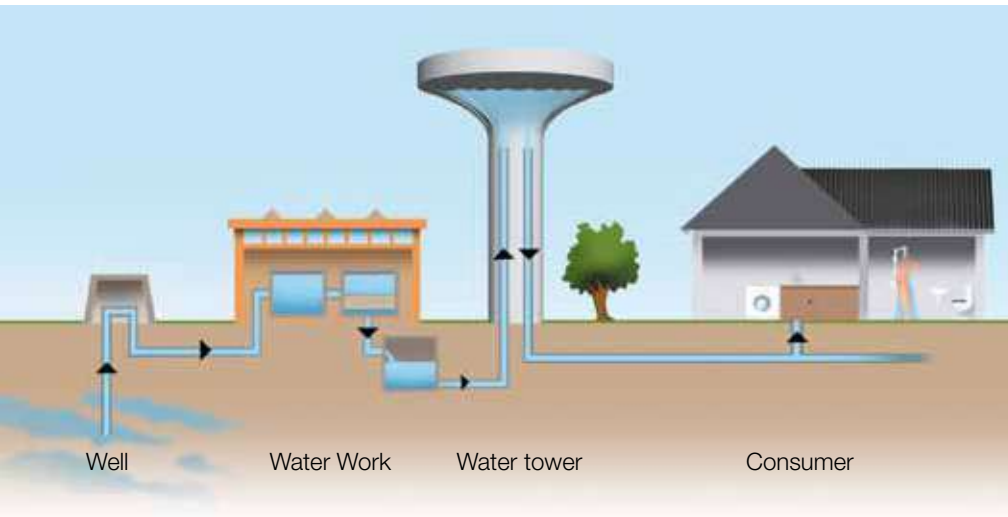
The sand filters are essentially thick layers of sand. When the water is led through the sand filters, iron and manganese attach themselves to the grains and are thus removed from the water.



Aarhus River, c.1900.

DID YOU KNOW THAT...

ALL WATERWORKS ARE UNMANNED? THEY ARE MONITORED BY MODERN TECHNOLOGY DAY AND NIGHT.



The filtered water is then led into huge tanks from where it is pumped into the pipeline network and on to consumers.

The individual waterworks treat between 200 and 750 cubic metres of water an hour and together this amounts to a total of 4,800 cubic metres an hour. Every single inhabitant of Aarhus Municipality uses about 41 cubic metres of water for domestic purposes each year, so the figure above corresponds to the annual water consumption of about 117 people every hour.

Waterworks operation

Aarhus Water monitors its wells, waterworks and pipeline network 24 hours a day to ensure optimum water supplies are provided and to enable us to remedy faults as quickly as possible. All ten waterworks are unmanned and are controlled automatically by an electronic control, regulation and monitoring system. Day-to-day monitoring is operated from a 24-hour operating centre. In addition Aarhus Water employs operating technicians who inspect the waterworks every day and we have an emergency team on standby 24 hours a day.

A well cabin under construction at a groundwater well.



Groundwater aeration with the help of air bubbles.



Filtering groundwater. Sand filters trap iron and manganese.



Clean, healthy water on tap

The pipeline network

Drinking water is distributed to consumers from the ten waterworks through a network extending more than 1500 kilometres, a series of elevated storage tanks, a water tower and a number of pumping stations. Every year we establish an average of 26 kilometres of pipeline network – 15 kilometres of replacement or renovation and 11 kilometres of new pipes. The old cast iron pipes are most frequently replaced because they account for most leaks.

The pipeline network is divided into transmission pipes, distribution pipes and supply pipes and thus constitutes a graded structure comprising a number of sections.

Transmission pipes are the motorways of the pipeline network. They rapidly transport the water between waterworks, the water tower and the elevated storage tanks via distribution wells located in the sections. The goal is for the transmission pipes to have no direct connections with consumers.

Distribution pipes lead the water around the sections.

They can be compared to the main roads of the pipeline and they ensure reliable supplies within the sections.

Supply pipes lead the water from the distribution pipes to consumers. Aarhus Water supplies water to property boundaries after which the owner of the property in question is responsible for leading it into the property via an underground pipe.

Pipeline network reliability

The division of the pipeline network into sections is ongoing and was implemented to ensure greater reliability of supplies and bet-

ter water monitoring. The sections are kept separate from each other and most of them are supplied via two connections. There is a distribution well containing measuring equipment to monitor operations at the inlet to each section of these pipes.

Our goal is to install 80 distribution wells in the pipeline network in step with its division into sections. The measuring equipment in the distribution manholes registers pressure, water flow and temperature on an ongoing basis. The measurements are collected at a monitoring station and the data are sent on via the mobile phone network to a central data collection system. This allows rapid registration of pressure, water flow and temperature so we can immediately react if operating problems arise in the pipeline network. In addition, we also use the data collection system for leakage monitoring, which will allow us to rapidly discover any leakages and thus avoid unnecessary water loss.

Model of the pipeline network

The operating data we obtain on the pipeline network and from the control, registration and monitoring system are used to construct a model of the network.

The model can simulate supply conditions throughout the pipeline network – i.e. water pressure, the flow in the pipes and the direction the water flows in. The pipeline model is a central part of the operational control, monitoring and simulation of any pollution. In case of pollution, it is important to know which areas are affected, where the pollution comes from and how the pipeline network can be flushed out. The model can also be used to plan new pipe installations, locate leaks, and so on.

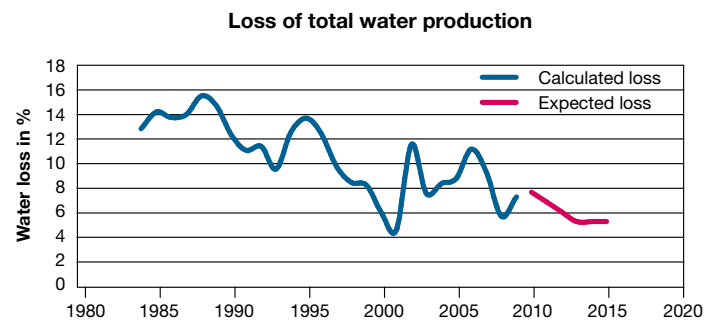
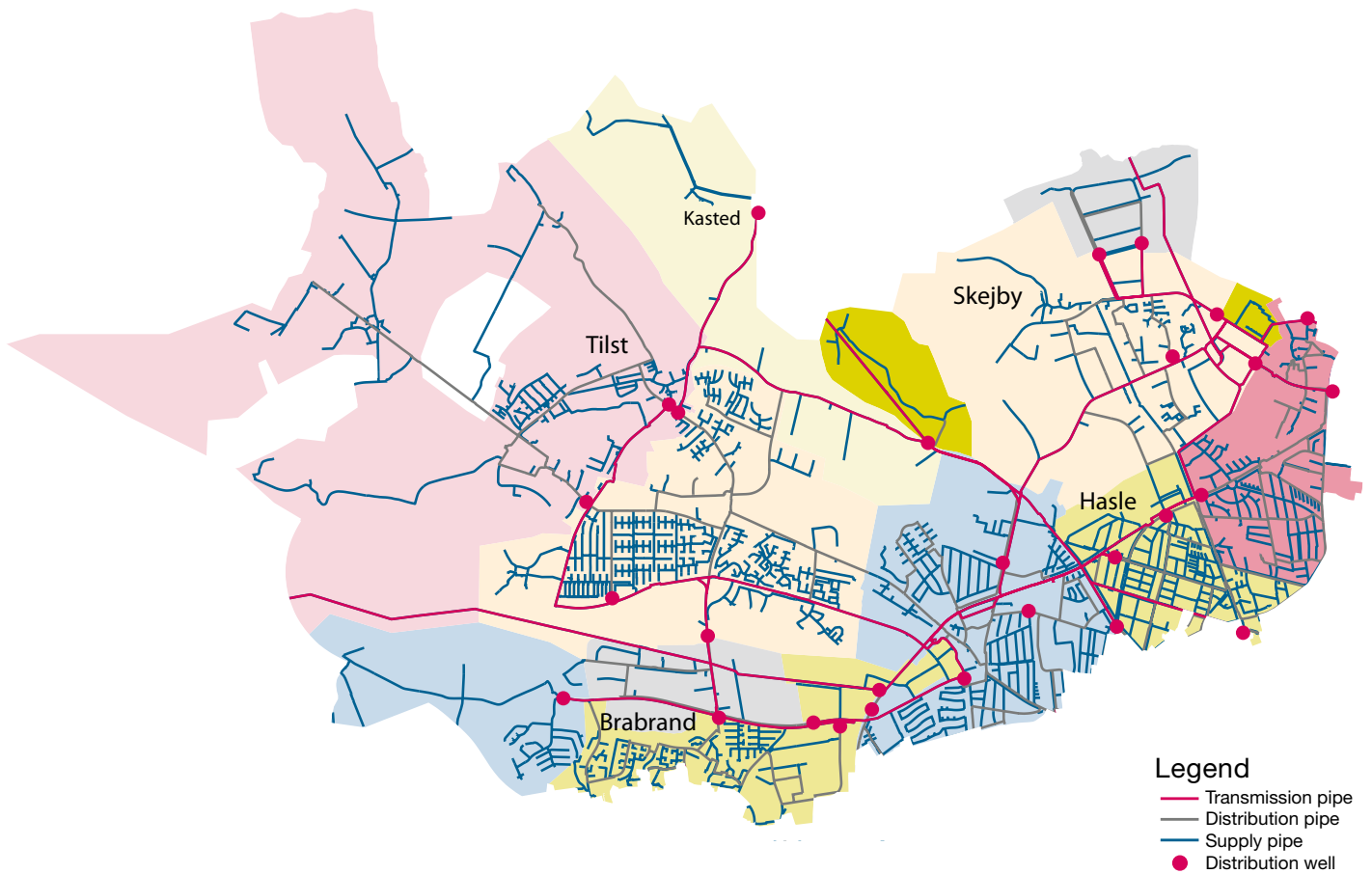
Among other methods, leaks in the pipeline are discovered with the help of ultrasonic leak detection, which involves 'listening' to the pipes.

New pipelines are placed in the ground.



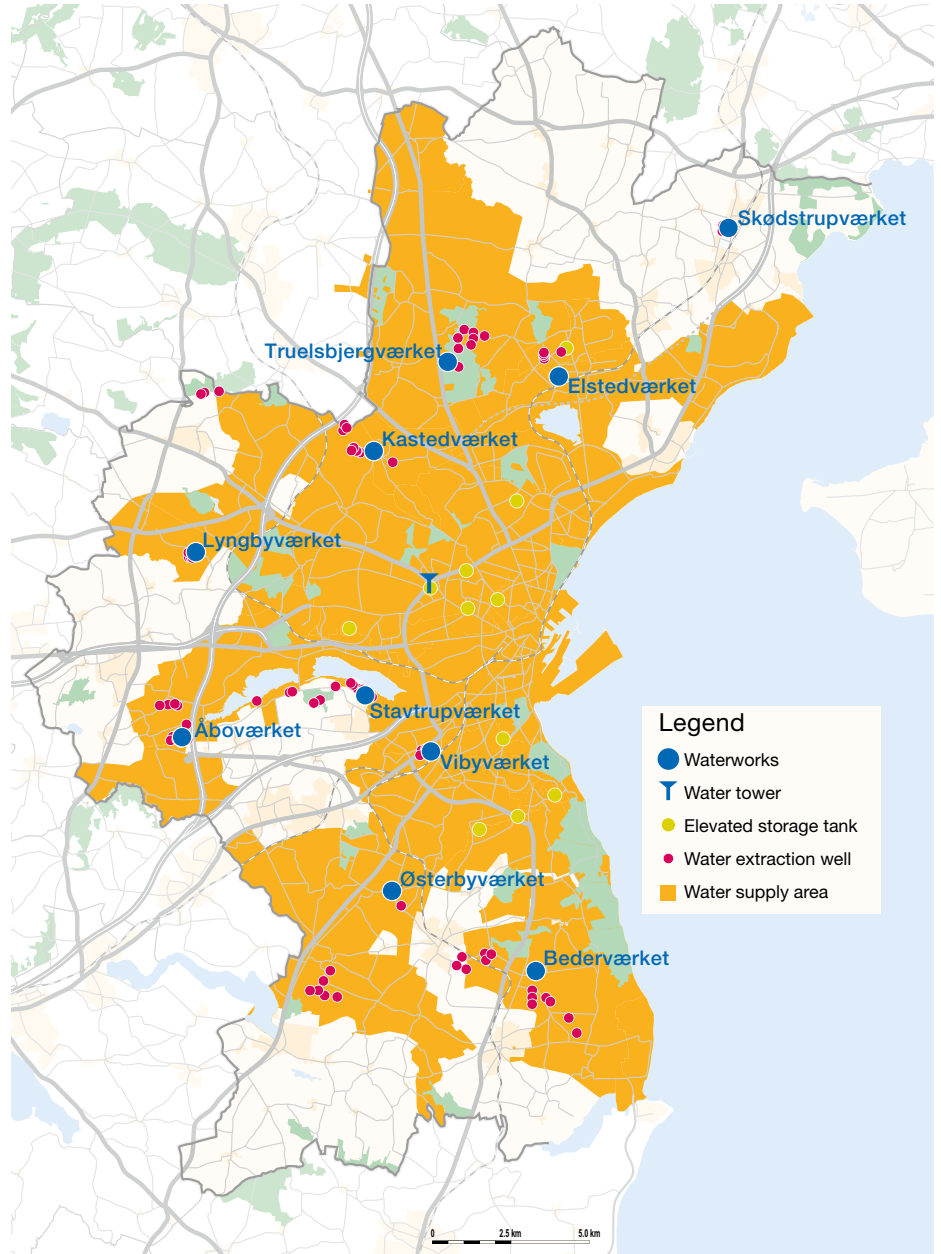
Distribution well.

Key map of the water pipeline network in part of Aarhus.

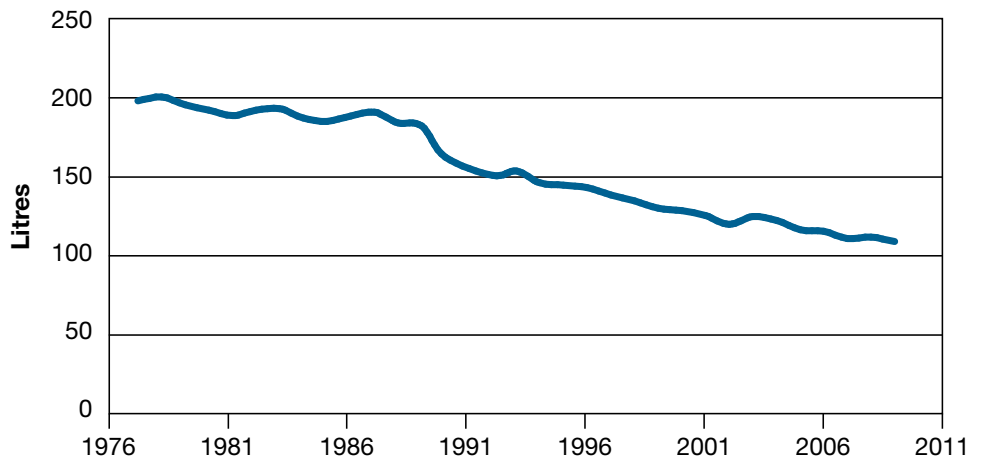


The curve shows the reduction in water loss as a consequence of our targeted efforts to trace and repair leaking pipelines.

DID YOU KNOW THAT...
DRINKING WATER FROM AARHUS WATER IS INEXPENSIVE AND AMONG SOME OF THE TASTIEST IN THE COUNTRY? 1 LITRE OF WATER COSTS 4 ØRE



Household consumption (litre/person/day)



Aarhus Water took more than 1,000 water samples in 2009 and performed more than 12,000 analyses of these samples.

Protecting water resources

Water quality

The drinking water consumers are supplied with is of very high quality as is shown by technical measurements and sampling. Aarhus Water monitors water quality thoroughly – from well to consumer – to make sure that any irregularities are discovered and traced rapidly. If you get your water from Aarhus Water you can see the water quality at your address at our website: www.aarhusvand.dk.

We check the quality of the water at wells, at waterworks, in storage tanks, in the pipeline system and at the consumer's address. The executive order on water quality lays down the substances our analyses must trace and the limit values for the individual substances. We also have our own laboratory at Aarhus Water where we perform in-house checks on the water.

Groundwater protection

Aarhus Water makes every effort to ensure that our groundwater is not contaminated with pesticides. Among other things, we offer financial subsidies and technical advice to farmers who are willingly changing to the pesticide-free cultivation of fields. The fields in interest are close to our extraction areas and in other critical areas where groundwater accumulates.

We offer subsidies for afforestation because wooded areas provide unique groundwater protection, as there is far less leaching of pesticides and nitrate beneath forests than beneath agricultural land.

We offer subsidies for concrete washing and filling stations where farmers can pour pesticides into sprays as this minimises the risk of spilled pesticides percolating into the groundwater. In addition, we offer to seal old wells and water wells free of charge as they act as drains from the surface to the groundwater reservoir. Sealing them, considerably reduces the risk of pesticides, for instance, seeping into the groundwater.

Water price in 2010 per cubic metre (1,000 litres)

Consumption price:	DKK 7.90
Groundwater fee for 'Natur og Miljø':	DKK 0.48
Drainage contribution:	DKK 20.98
State water charge:	DKK 5.00
State wastewater charge:	DKK 0.25
VAT:	DKK 8.65
Total price:	DKK 43.26

The price corresponds to 4 øre per litre of water.

Taking a water sample to be sent to the laboratory for analysis.



Afforestation provides excellent groundwater protection.



Washing and filling stations for pesticide sprays.



Wastewater

Wastewater

Sewers were constructed in Denmark to promote hygiene and prevent diseases. The middle of the 19th century saw the tentative beginning of sewer construction in the form of establishing drains in some places and covering up some of the open pipes that led straight to the river or beaches. In 1909 Aarhus Municipality adopted a sewer plan with the introduction of water closets, cut-off sewer pipes along the coast and the river and the construction of a sewerage pumping station. This made it possible to lead sewage from WCs into the bay where it became sufficiently spread and diluted.

As the population of Aarhus grew, the composition of wastewater changed, which meant that it became an acute problem. A mechanical purification plant for wastewater was therefore built in the northern part of Aarhus in 1944. During the 80s and 90s the focus

on environmental impact increased and the demand for sanitation grew. From the beginning of the 1990s there was a transition to purifying wastewater not only mechanically, but also biologically and chemically in order to eliminate organic matter, nitrogen and phosphorus.

There is even more pressure on the sewer system today in Aarhus Municipality due to the growth of the population and an increase in industrial production and because there are more areas covered by asphalt, paving stones and roofs. These surfaces reduce the percolation of rainwater. Whereas this formerly ran into the ground, it now ends up in the sewers. There is also more precipitation today – including more frequent heavy rain – because of climate change. All of which makes heavier demands on our sewer system and waste water treatment plants.

DID YOU KNOW THAT...

**AARHUS WATER IS RESPONSIBLE FOR
2,350 KILOMETRES OF SEWERS?**

Establishment of sewers in Aarhus.



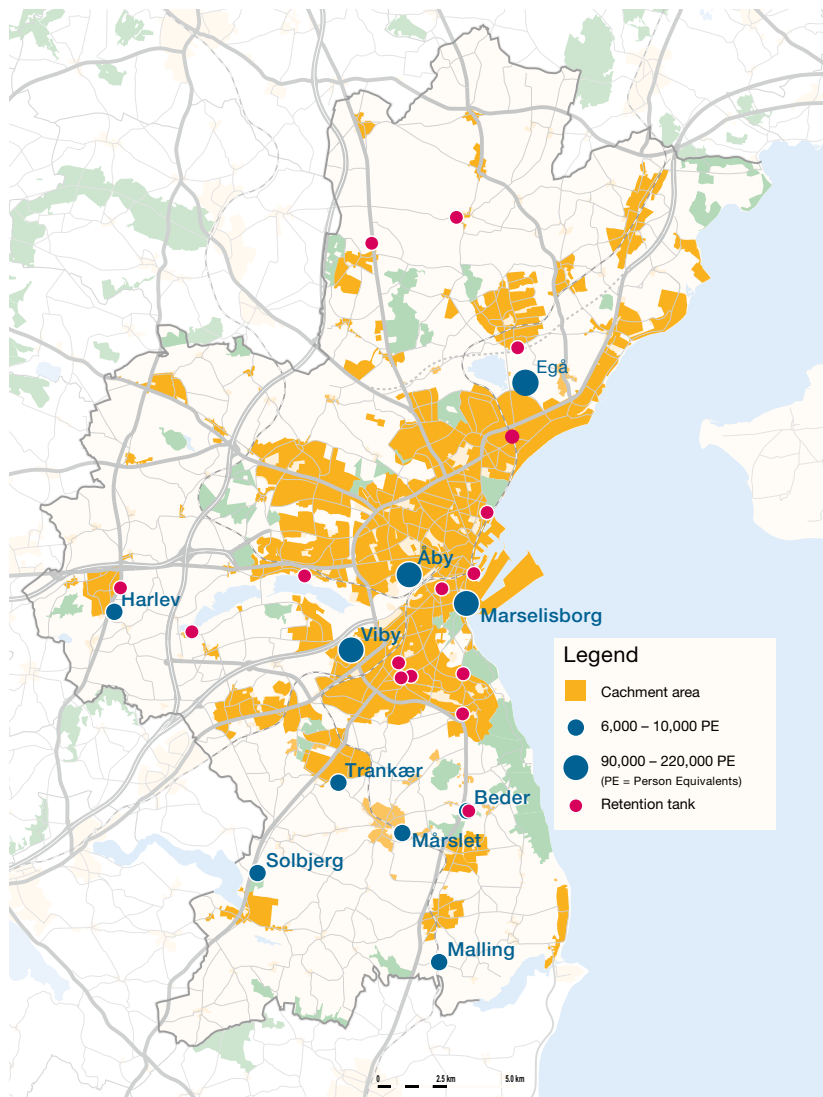
Clarification pond at Aaby Waste Water Treatment Plant.



Sand and fat separation ponds at Egaa Waste Water Treatment Plant.



List of waste water treatment plants in Aarhus.





A storm water pond at Tranbjerg being emptied of sludge and re-established as a recreational area.

Excavation in connection with sewer pipe replacement.



DID YOU KNOW THAT...

AARHUS WATER PURIFIES AND DRAINS OFF BETWEEN 30 AND 35 MILLION CUBIC METRES OF WASTEWATER A YEAR?

The sewer system

Aarhus Water is responsible for 2,350 kilometres of sewers. Every year we lay new pipes for housing development and we also renovates between 10-20 kilometres of sewer pipes a year. We expect a sewer pipe to be operational for 100 years on average.

A separate system and a common system

There are two kinds of sewer system: a separate system and a combined system. The separate sewer system leads sewage from households and industries through one pipeline to a waste water treatment plant, while stormwater (rainwater) is led through another pipeline to streams, lakes and the sea. The combined sewer system leads both sewage and stormwater through a single pipeline to a waste water treatment plant.

Combined sewerage therefore means that rainwater puts great pressure on waste water treatment plants. Heavy showers can easily lead to flooding in areas with common sewers. All newly-established sewer systems are therefore separate systems and we are working on major projects to convert old, combined sewer systems into separate systems.

Pumping stations

A pumping station is a small building equipped with a pump that pumps water through the sewer system. Pumping stations are used in places where it is not possible to give pipelines a sufficient gradient to allow water to flow under the force of gravity.

Today it is necessary to lead wastewater from households and industries to purifying plants over longer distances than previously because the population of Aarhus Municipality is growing, and we are in the process of shutting down smaller waste water treatment plants in favour of bigger and better plants. So we have built more pumping stations in recent years.



Pumping station.

Retention tanks

We use retention tanks in places with common sewer systems. They contain both rainwater and sewage and are covered for hygienic reasons. When there are heavy showers, rainwater and sewage are collected in these retention tank where the mixed wastewater remains until the sewer network and waste water treatment plants have the capacity to handle it. This prevents flooding in basements and for instance overflow.

Two kinds of tanks – storm water ponds and retention tanks

We build storm water ponds in areas with separate sewer systems. Stormwater ponds are small lakes that collect rainwater and allow it to gradually seep into rivers and the sea. When Aarhus Municipality plans new urban areas, rainwater ponds are often included in the plans out of respect for the environment and because lakes function as recreational areas.

Climate change has led to more violent downpours and they have stretched the capacity of our sewers and waste water treatment plants to the limit so we have had to build retention tanks to collect this water in. Without these tanks there would be overflows and the diluted sewage would flow into streams, lakes and sea without being purified.

Renovating sewer pipelines

Aarhus Water has been systematically renovating the sewer system, especially the combined areas, since 1988. There are several methods of renovating sewer pipelines, one of which is to dig up the existing pipeline and lay a new one. This is a laborious method, however, as excavations are an inconvenience so, wherever possible, we use what is known as No-Dig method which, as the name suggests, involves no excavation. This method is less of an irritation for local residents and there is no great expense for re-establishing pavements and roads.



Building a retention tank at Mølleparken.

Wastewater

– the advanced purifying process

Waste water treatment plants

At present, Aarhus Water operates four large and six smaller high-tech waste water treatment plants that together receive about 35 million cubic metres of wastewater a year.

Stages of purification

Wastewater goes through several different stages at a waste water treatment plant: mechanical, biological and chemical purification and finishing treatment. Mechanical purification involves the removal of bigger particles, while biological and chemical purification remove nitrogen, organic matter and phosphorus. Finishing treatment removes the remnants of pollution by leading the water through a sand filter.

Mechanical purification was the only method used until the beginning of the 80s. This meant that only visible particles were removed from the wastewater, but biological and chemical purification were introduced later due to pollution and the deoxygenation of lakes, rivers and the sea.

Mechanical purification

Wastewater is initially purified mechanically by being led into finely-meshed screens that trap such items as cotton buds, pieces of plastic and paper. The sorted material is called screenings.

This material is led into a press where it is pressed and dehydrated so that it can be taken to an incineration plant.

The wastewater then goes through a sand and fat separator where the sand is precipitated and the fat remains on the surface. The sand is taken to a controlled rubbish dump and the fat is put into a digester where it decomposes and is converted into biogas, which can be used to produce electricity.

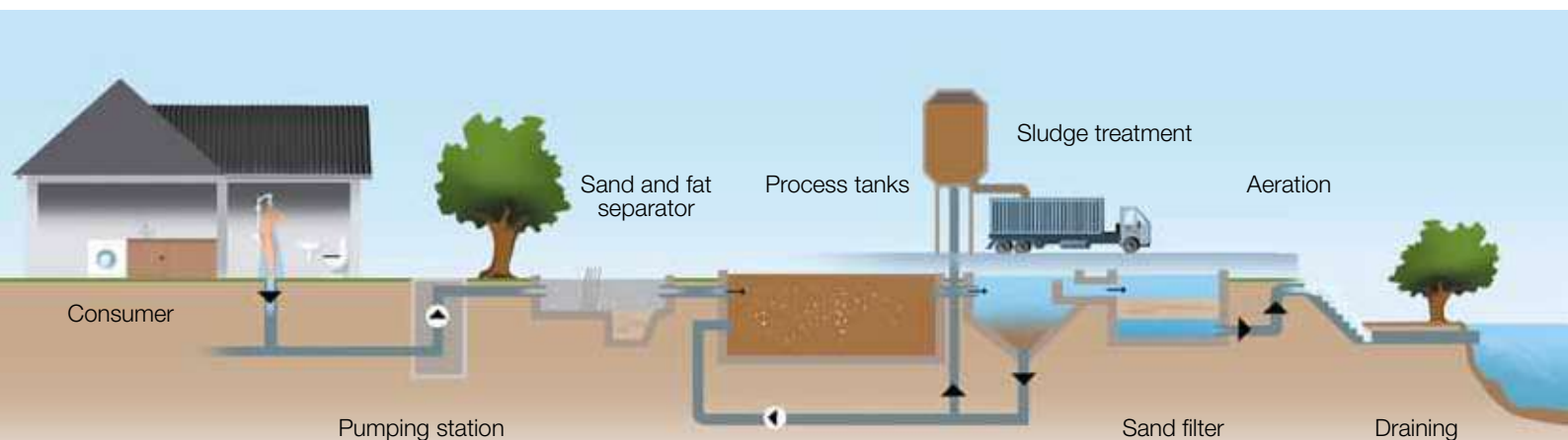
Mechanical purification is concluded at some purification plants by leading the wastewater into a precipitation tank to separate the particles that can be precipitated.

Biological purification

Biological purification is carried out in process tanks where organic matter, nitrogen and phosphorus are removed from the wastewater.

Removal of organic matter

Organic matter is removed at the plants with the help of activated sludge, which is part of the wastewater. Activated sludge chiefly comprises micro-organisms (bacteria and protozoans, etc). The bacteria break down the organic matter and incorporate it into the activated sludge. Once this process has been completed, the matter can be removed in the form of surplus sludge. The bacteria are thus a precondition for our ability to purify wastewater. This means it is important not to pour chemicals into washbasins and water closets as this can kill the bacteria and thereby prevent their purifying effect.



DID YOU KNOW THAT...

WASTEWATER IS NORMALLY RETAINED AT PURIFYING PLANTS BETWEEN 10-15 HOURS?

Purification output at Aarhus Water's purifying plants			
	2007	2008	2009
	"----- ton -----"		
Total organic matter to waste water treatment plant	14,822	16,830	15,095
Retained at purifying plant	13,930	16,068	14,354
Led out to rivers and the sea	892	762	741
Removed (%)	94	95	95
Total nitrogen to waste water treatment plant	1,204	1,483	1,323
Retained at purifying plant	1,039	1,374	1,182
Led out to rivers and the sea	165	109	141
Removed (%)	86	93	89
Total phosphorus to waste water treatment plant	242	259	213
Retained at purifying plant	231	251	206
Led out to rivers and the sea	11	7.97	6.84
Removed (%)	95	97	97

Development in purification output at our plants. The fluctuations from year to year are due to changes in industrial production.

An "Archimedes screw" is used to lift the water into the purifying plant.



Mechanical purification, where screens trap all bigger items.



Activated sludge comprises micro-organisms, including animalcules (seen here).



Removal of nitrogen

Biological purification converts organically-bound nitrogen into nitrate by mixing air with activated sludge and wastewater in tanks. The bacteria use the air to break down and convert organic matter into nitrate. This process is called nitrification. Groups of bacteria convert nitrate into free nitrogen under anaerobic conditions, so the oxygen supply to the waste water must be cut off. This forces the bacteria to use the oxygen bound in the nitrate and release gaseous nitrogen – in a process known as denitrification. This process can be observed by taking a close look into the tanks at a purification plant where it appears in the form of small air bubbles on the surface as gaseous nitrogen and carbon dioxide are released into the atmosphere. The process of alternately aerating/ not aerating wastewater is repeated several times to remove as much nitrogen as possible.

Removal of phosphorus

The phosphorus that is not removed by biological purification is usually removed in a separate process. This can be carried out with the help of biological phosphorus removal under anaerobic conditions in which the phosphorus becomes incorporated into the activated sludge. But this process is not always sufficiently effective, so chemical precipitation can be used as supplement. This involves adding chemicals (ferric chloride or ferric sulphate) to the wastewater. It is more economical and environmentally advantageous, however, to purify the wastewater biologically because it saves money and reduces the quantity of sludge.

Final clarification

Final clarification is carried out after biological and chemical purification. The water is led into a final clarification tank where the biological sludge and the chemically precipitated phosphorus

are allowed to precipitate. Most of the sludge that is precipitated is returned to the biological tanks as activated sludge and mixed with the incoming wastewater. The rest of the sludge is sent on for further treatment. The purified wastewater is pumped into a sand filter to remove the last impurities. Finally, the purified wastewater is aerated to increase its oxygen content before it is led off into rivers or the sea.

Wastewater sludge

Each year, 30,000 tonnes of sludge and about 7,500 tonnes of solids are removed from our purification plants. Until recently, all of the sludge was used as agricultural fertilizer where the content of plant nutrients could be of benefit. The possibility of burning the sludge or disposing of it in another way is now being looked into due to changes in incinerating charges and to protect groundwater from the undesirable effects of possibly harmful substances it could contain. Operating a purification plant is a very complex affair, but with the help of a control, regulation and monitoring plant, the individual processes can be monitored so accurately that we can achieve optimum operation and purification of wastewater.

Protecting nature

We will continue to work to protect nature in the future. We make every effort to ensure that purification plants are efficient enough to allow us to purify wastewater in the best possible way, and in combination with the enlargement of the sewer network and ponds, we can make sure we have as little impact on nature as possible. For instance, a new sand filter was installed at Marselisborg Waste Water Treatment Plant in 2009 that significantly reduces phosphorus emissions to Aarhus Bay, which means a cleaner aquatic environment in Aarhus.

There are strict demands on hygiene at our waste water treatment plants.



Biological purification with activated sludge.



The aeration staircase ensures sufficient oxygen in the water before it is led into rivers and sea.





DID YOU KNOW THAT...

**ON-LINE METERS AT PLANTS HELP TO CONTROL
THE PURIFICATION PROCESS EFFECTIVELY?**

Aarhus Water

Aarhus Water in brief

Aarhus Water A/S is an independent enterprise owned by Aarhus Municipality. Aarhus Water has a management board, a board of directors and an annual general meeting. Aarhus Water has 250 employees and a total annual turnover of DKK 550 million.

We supply 250,000 customers with water and produce 16 million cubic metres of drinking water a year.

We have at our disposal:

Nineteen wells fields
 About 100 water wells
 Ten waterworks
 Ten elevated storage tanks
 One water tower
 1,500 kilometres of pipeline network
 62,000 water meters

We supply water to and purify wastewater from 300,000 customers, which corresponds to about 35 million cubic metres of water a year.

We have at our disposal:

Ten wastewater treatment plants which will have been reduced to four by 2013
 130 pumping stations, a number that will be increased in the years to come
 2,300 kilometres of mains network
 78,000 laterals
 363 overflow structures
 Ten retention tanks
 225 separate stormwater ponds

Mission

The purpose of the company is to supply drinking water and provide wastewater treatment of high quality in terms of health

and the environment, while taking into account reliable supplies, nature and efficient operation in a manner that is transparent for consumers.

Vision

Aarhus Water wants to be Denmark's leading water company.

Aarhus Water will:

- Develop holistic solutions and commit to sustainability in relation to the overall water cycle
- Strive to utilise resources even better and achieve an even greater effect through our efforts
- Develop and renew the necessary production apparatus and build up know-how
- Do the utmost to satisfy our customers
- Create an attractive, competence-intensive workplace where employees can develop and thrive

Read more at www.aarhusvand.dk

Quality has pride of place

At Aarhus Water we constantly focus on ensuring high drinking water quality, respecting the environment as much as possible and providing our employees with a pleasant workplace.

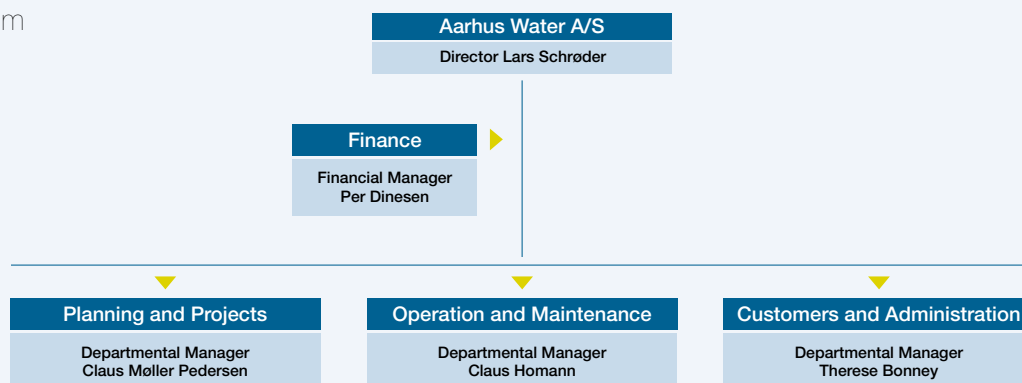
Specifically, our work is based on four areas:

- Drinking water quality
- Environmental management
- The working environment
- Energy management

Drinking water quality

In 2006 our management of drinking water quality was accredited in accordance with the ISO 22000 HACCP standard. We call it "Documented Drinking Water Quality". This means in practice that

Organogram



our management system has been approved as a suitable means of ensuring supplies of one of our core products – namely drinking water of the highest quality.

Environmental management

In the spring of 2008 we were also accredited in environmental management and the working environment. Our environmental management system was accredited in accordance with ISO 14001, which means that we purify and lead off wastewater efficiently and with the least possible impact on the environment. Environmental management also means that we take good care of our groundwater resources by protecting them against pollution, among other things.

The working environment

Our management system also focuses on employees by keeping close checks on the working environment in accordance with the DS/OHSAS 18001 standard. This means that we make sure that our employees work in a secure, physically and mentally developmental environment and that nobody is exposed to injury.

Energy management

Energy consumption at our facilities is high, but we also received energy accreditation in accordance with DS 2403 in the autumn of 2009 so that we can reduce this consumption.

Aarhus Water is one of the few utility companies in Denmark to have received accreditation in all four areas. Working on the basis of systematic, recurring accreditation helps to bring dynamism and development to the company and accreditation shows we are fully in control of the above-mentioned areas and can ensure that quality is given pride of place. And, in the final analysis, this benefits all customers.

DID YOU KNOW THAT...

***YOU CAN CHECK DRINKING WATER QUALITY
IN YOUR AREA AT WWW.AARHUSVAND.DK***

Aarhus Water's customer service performs casework and provides advice on technical inquiries from our customers and is responsible for balancing and invoicing their consumption of water and emissions of wastewater.

Visits

Aarhus Water receives about 3,000 visitors a year at waterworks and purifying plants. We are visited by pupils and students from primary schools and upper secondary schools and people from associations, interest groups, companies and the industry and prospective employees from all over Denmark.

We arrange the contents of visits based on the target group so that they range from teaching sessions about the entire water cycle to more technical matters at the individual plants.

We place great emphasis on talking about our work and will be pleased to arrange visits to our plants. We have chosen three waterworks and two purifying plants for this purpose.

*For more information about our visitors' service:
www.aarhusvand.dk.*





Denmark's leading water company

We work on the basis of the entire water cycle at Aarhus Water and take pride in supplying pure, cold water that tastes good. About 85% of the inhabitants of Aarhus Municipality receive their water from us.

We are also proud to be able to contribute to public health and a steadily improving aquatic environment by receiving and purifying wastewater from almost the entire municipality.

Sustainability, efficiency and development are key words at Aarhus Water – and we constantly focus on making a good workplace even better.

Our vision is to be Denmark's leading water company.

Publisher:

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Design og production:

Scanad

Printed by:

Jypa

Number of copies: 3,000
0810, 11069



aarhusvand