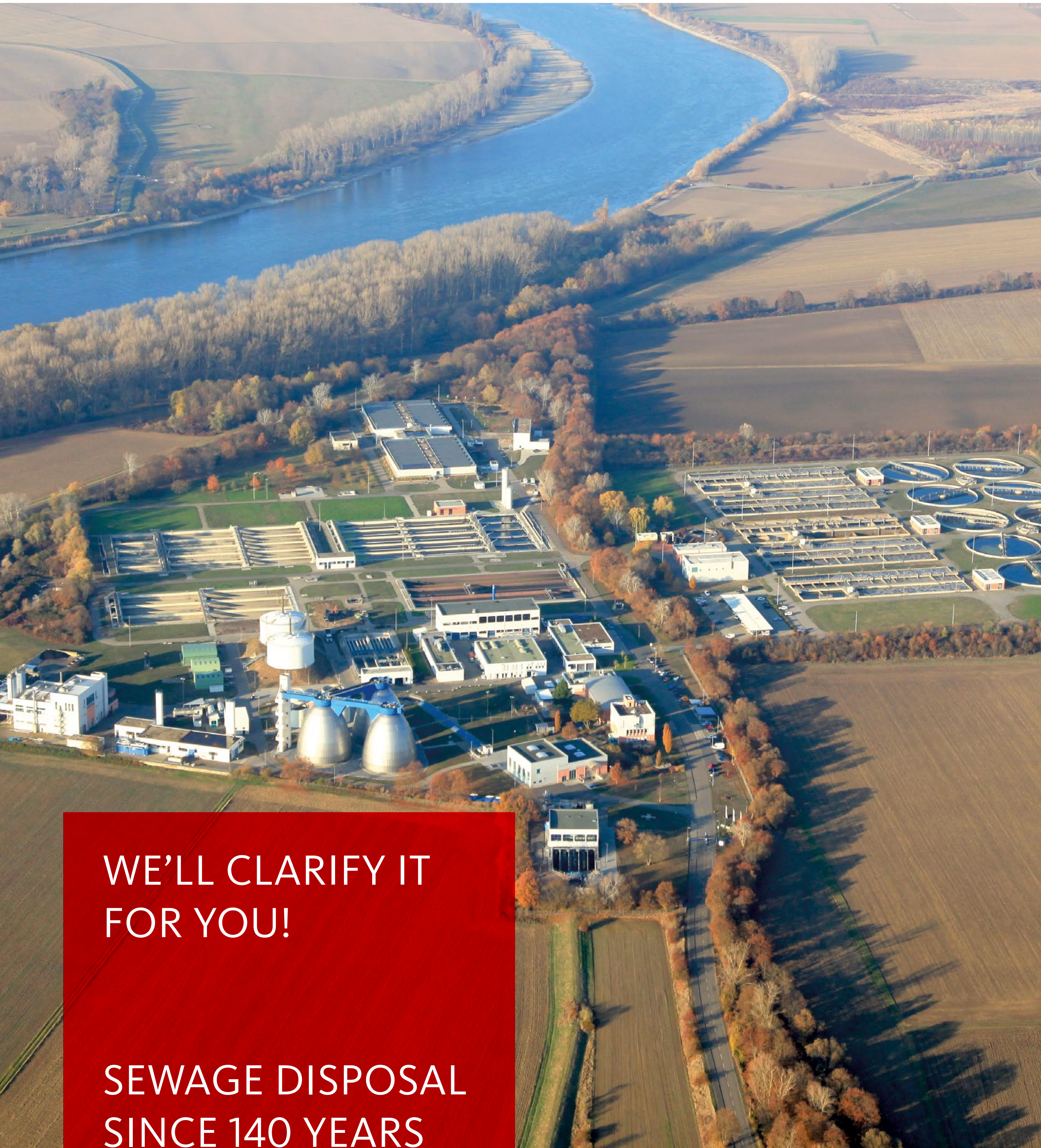


WE’LL CLARIFY IT FOR YOU!

SEWAGE DISPOSAL SINCE 140 YEARS IN **MANNHEIM²**

EBS **MANNHEIM²**
Stadtentwässerung

CONTENTS

INTRODUCTION

Alexander Mauritz
Manager of the Eigenbetrieb
Stadtentwässerung (EBS)

The state of our environment is a decisive factor in our quality of life. Alongside clean air, healthy soil and diversity of species, clean water is an essential. The Eigenbetrieb Stadtentwässerung (EBS) – an owner-operated municipal enterprise – see itself as a skilled provider of services to the local community and, as such, makes a significant contribution to environmental protection and water pollution control. Employing 250 people, it is commissioned to collect and treat wastewater and to return the purified water to circulation. This demands precise use of resources, technology and knowledge. Our highest priorities are to avoid health hazards, prevent water pollution and protect the environment.

One significant challenge is climate change, the consequences of which are already being felt. As a certified owner-operated municipal enterprise (to the ISO 9001 and 14001 environmental and quality standards), we feel we are geared up for our future responsibilities. Climatic changes, scarcity of resources and demographic changes are three challenges that currently dominate the environmental policy debate in the water management industry. The EBS is using its scope for action to find solutions now, before the authorities impose stricter regulation.

Examples of this include the powdered activated carbon system for eliminating traces of harmful substances and our replacement of the sewage sludge drying system which runs solely on surplus heat from combined heat and power systems. It is an important component of EBS's energy concept. Cutting-edge pilot projects on the use of wastewater heat for heating and cooling have been implemented in the new administration and operations building in Käfertaler Straße and at the Ochsenpferch pumping station. Another high-profile example is the Marchivum (Mannheim's city archive), where the converted wartime bunker at Ochsenpferch is also heated with wastewater heat. Wastewater energy systems offer an alternative to fossil fuels and make considerable savings with respect to the greenhouse gas CO_2.

We are also working on the use of biogas for electricity generation. The on-demand availability of power and heat will be essential to allow the Mannheim wastewater treatment plant to be self-sufficient in energy in the near future. As a wastewater operation financed by charges we naturally also have a duty towards Mannheim's citizens to maintain the wastewater facilities and invest prudently in the future, whilst balancing the two factors of climate and environmental protection and cost-effectiveness.

Urban drainage goes back a long way in Mannheim. Here, the technical pioneering spirit, willingness to innovate and environmental awareness have gone hand-in-hand over many generations, creating the principles and values on which we base our work today.

In this brochure, we also provide an overview of the historical and current developments in Mannheim's urban drainage; from construction of the first main sewer in the city centre through to our "lighthouse projects" such as the 4th purification stage at the treatment plant.

I very much hope that this brochure will encourage the local population and our client (the Mannheim municipal council) to learn and understand more about their urban drainage system. Not least so that we can continue to work together and meet our objectives in the future.

MANNHEIM'S URBAN DRAINAGE SYSTEM

The Eigenbetrieb Stadtentwässerung (EBS) is a modern municipal service provider. Its core tasks include collecting untreated wastewater and rainwater from around the city, treating (purifying) it and then discharging the treated water into the Rhine's receiving water course. We do this using the best engineering practices and in compliance with all statutory requirements. Our highest priorities are to avoid health hazards, prevent water pollution and protect the environment.

EBS is based in two locations. The central wastewater treatment plant is located in Mannheim North, while the sewerage operations depot and the administration building are located in Käfertaler Straße.

Monitoring the sewer cleaning

Checking the video recordings in the camera vehicle

The newly constructed administration and staff facilities building is a prime example of sustainable municipal construction. It has a wastewater heat pumping system for heating and cooling. Green roofs provide evaporation and filter the rainwater, which percolates underground via a French drain system. The building was awarded the EU "Green building label". With all of this innovative technology, the new building rates as 33 percent below the requirements of the Energy Saving Ordinance (EnEv 2009).

Work on the urban drainage system – not an everyday job

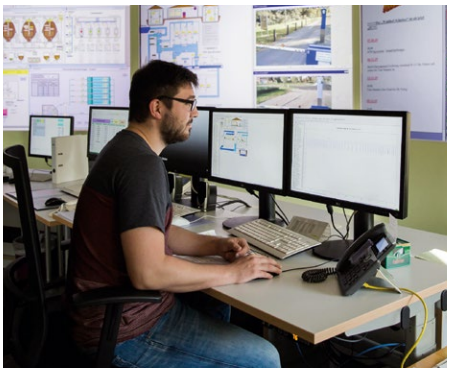
Day after day, EBS employees keep the wastewater flowing through Mannheim's underground system, make sure that there are no leaks from the sewers and keep the machinery and equipment at the treatment plant and in the pumping stations in good working order. This work places many demands on our personnel. The urban drainage field not only requires traditional roles such as treatment system or pump attendant and sewer specialist; electricians, instrumentation and control technicians, industrial mechanics, system operators, engineers, sewer renovation consultants, chemical engineers and laboratory staff are all needed as well. The training of our new recruits is particularly important for our operation. As they train to become a specialists in wastewater technology or pipe, sewer and industrial service technician, six young men and women follow a wide and varied training programme ending with a professional qualification.

Compliance with the work safety regulations is mandatory for all work in the sewers, pumping stations, stormwater tanks and on systems in the treatment plant. This includes, for example, fall protection when entering the shaft, plus wearing personal protective equipment. The multi-gas detector ensures safety when working underground: it sounds the alarm immediately when dangerous gases build up in the sewer or pump sump. Regular training on technical and safety-related topics are essential for professional work. Our field staff attend theoretical training courses on safety and health protection at the workplace and regularly carry out practical training in accident prevention and rescue.

For quality and the environment – processes on the test bench

In 2002, a quality and environmental management system (QEM) was introduced to comply with the stringent requirements of the German environment and health and safety acts while, at the same time, meeting the economic demands of a municipal waste management organisation. Based on the ISO 9001 quality standard and the ISO 14001 environmental standard, it provides EBS with guidelines concerning the environment, employees, IT security and its customers and business associates. The most important procedures and workflows are documented, and goals and actions are defined on an annual basis. External experts and internal auditors regularly check compliance with standards, legislation and our own specifications. They also determine whether we have met our own goals. We have achieved this certification every year since 2003, demonstrating the long-term effectiveness of our urban drainage management system.

One important component of the QEM system is the continuous improvement process. In some areas, we award prizes for outstanding ideas submitted by employees to improve operational or administrative workflows. Implementing these staff suggestions generally results in considerable savings in terms of costs or resources or improved safety at work.



Operator in the central control room at the treatment plant

Industrial mechanic working on the universal milling machine

Trainee carrying out checks on the digestion tower roof

WASTEWATER COLLECTION

From Mannheim to Copenhagen

Mannheim's public sewer system, which has developed over a 140-year period, is one of the city's largest urban infrastructure assets. In EBS's area of responsibility there are some 832 km of sewers, which is roughly the distance from Mannheim to Copenhagen. But this doesn't include domestic connection pipes since, according to the local wastewater regulations, the entire length of pipe as far as the connection to the city sewer belongs to the property owner. Most of Mannheim has a combined sewer system, i.e. wastewater and rainwater are collected together.

The sewer pipe cross-sections range between 0.30 and 3.40 m. The age distribution varies considerably. The oldest sewers in the city originate from the 1890s or even earlier; most of these are made from brick. Nearly half of the sewers are less than 50 years old.

The sewer system is made from various types of material. Vitrified clay is used for smaller sewers with a diameter of 30-80 cm. This material has been in use for decades, so glazed clay pipes are the most frequently encountered material in the sewer system (418 km in length). Nearly one third of the sewers are made from concrete.

Preparing to survey the sewer with a camera

Cleaning the sewer camera

Cleaning team preparing for work at the open sewer maintenance shaft

Sewer cleaning with high pressure jets

In previous years, larger sewers and main sewers were often made from masonry. There are some 100 km of these. More recent materials, such as glass fibre-reinforced plastic pipes, measure around 29 km in length.

High pressure jetting

Due to its topographical position in the upper Rhine valley, there are very few gradients in Mannheim. It is not only wastewater and rainwater that reaches the sewage system via sinks, toilets and gullies; sand, food waste, personal hygiene items and other wastes are also carried along. In periods of little rain, these substances then accumulate and become lodged in the sewer bed. As a consequence, the pipes must be regularly flushed to keep the sewer system in good working order at all times. The sewer operation has six high pressure suction/flusher vehicles. These combination vehicles clean the wastewater pipes with a high-pressure jet flusher at up to 180 bar pressure. Fresh water is primarily used for flushing. Three flusher vehicles have a special arrangement that allows them to extract and filter wastewater from the sewer for cleaning the pipes. Not only does this save drinking water, but it also avoids time-consuming trips to the hydrant. The filter residues, which mainly consist of contaminated sand, are taken to the treatment plant.

Camera inspection

The Baden-Württemberg self-monitoring ordinance requires EBS to regularly check the condition of its wastewater treatment facilities and the sewer system. All sewers are checked for possible damage at legally-specified intervals to ensure that wastewater does not seep out of leaking pipes and into the ground, thus contaminating the groundwater.

Since 1986, this has been done using the camera. EBS has two vehicles containing the latest TV and IT equipment in constant deployment. Mobile TV cameras are used to survey the condition of the sewer and record it on video. The results are stored in a digital sewer database. Any damage identified is classified from 0 to 4 according to the size and extent of the damage.

Remote control sewer camera in use

In 2018, over 90 percent of the sewers were surveyed using the TV camera, while around 6 percent were actually inspected in person. It is essential to record the condition of the sewers by surveying and inspection to ensure that the sewer system is operating safely.

Sewer repair

In those sewers that can be inspected in person, minor damage is repaired by EBS's construction crew. For limited localised damage in smaller sewers, EBS commissions a construction company to repair the pipe by excavating an open trench. Holes and cracks in the pipe are sealed from the outside. The classification of the damage determines whether the sewer needs to be replaced or whether an inline repair will be sufficient.

WASTEWATER COLLECTION

Introducing a plastic pipe into the main sewer using the lining/reinforcement method

In this case, a needle felt or glass fibre hose is pulled into the sewer in order to reinforce and seal the inner walls. This allows pipes to be laid without digging up the street.

Land drainage

The hygiene conditions for Mannheim's population have improved fundamentally since the first sewers were built around 140 years ago. As early as 1930, 95.5 percent of all households were connected to the public sewer system. Today this figure has risen to 99.9 percent. According to the wastewater regulations of the City of Mannheim, it is the property owner who is responsible for leaks in and the proper functioning of private drainage systems as far as the connection to the city sewer. And according to the Baden-Württemberg Water Resources Act, the principle applies that contamination of the groundwater must be prevented. However this requires the entire sewer system (public sewers as well as pipes on private land) to be watertight and in a good state of repair. While the public sewer system is regularly cleaned, surveyed and repaired, this is not always the case with private sewers. Not only do urban drainage specialists advise and inform citizens, businesses and commercial operations on how to repair and leak test private wastewater pipes; they also provide information on backflow prevention, flood protection and the statutory regulations. The country-wide network of the German Association for Water Management, Wastewater and Waste offers more detailed information at: www.geanetz-bw.de.

Round shaft with connected sewers in the open trench

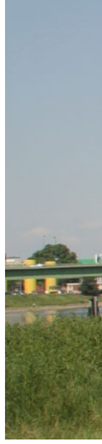
Backflow prevention and flood protection

During very heavy rainfall, the sewer system can be temporarily overloaded and it is difficult to remove the sheer volume of water that collects. If the water stands on the road, it can penetrate into lower-lying house doors, basement windows or garage entrances. The consequences are considerable damage to buildings and household contents.

"Backflow" is the term used when the water level in the sewer system rises up to the top of the pipe. According to Mannheim's wastewater regulations the backflow level is the road surface. Suitable backflow prevention devices such as backflow traps or sewage lifting systems need to be installed to ensure that wastewater does not flow back through domestic connecting pipes and into toilets, washbasins or inlets to basement spaces due to the unusually high water level.

The property owner can also implement structural measures to protect the home against flooding due to extreme rain events. One measure would be to raise the top edge of the basement window well or garage entrance. The best time to protect the property is at the planning stage. Another preventive measure is to unseal surfaces on the property by removing asphalt, concrete or interlocking pavers to allow the rainwater to percolate into the ground.

SEWER SYSTEM PLAN



WASTEWATER COLLECTION

With climate change in mind – decentralised rainwater infiltration

Mannheim has experienced many storms with heavy rainfall in recent years. For example, on both 1 and 7 June 2018, almost 50 litres of rain fell per square metre within just two hours. In some city districts such as Seckenheim, Rheinau or Käfertal, roads and basements were flooded due to blocked gullies.

There would be little point in constructing larger wastewater sewers as this would demand significant investment and would increase odour nuisance in periods of dry weather. In residential areas the sewers are designed for a 3-year rainfall event as required by law. The Water Resources Act also requires local infiltration or direct diversion of the rainwater into a watercourse.

In contrast to the conventional principle of diverting the rainwater as quickly as possible via the sewer system, decentralised infiltration aims to maintain the water cycle. This builds up new groundwater and promotes transpiration by plants and the soil.

Since 2011, EBS has been implementing measures for decentralised rainwater infiltration. The most recent example is the road drainage in the form of deep beds on the site of the old Taylor Barracks. In a residential area in the Gartenstadt district, rainwater infiltrates via a central ditch.

Pumping stations and storage sewers

Mannheim's topographical position means that a large number of pumping stations are needed to quickly pump the wastewater to the treatment plant. They pump the wastewater up a few metres to create sufficient head that it can then flow freely downhill to the treatment plant. EBS currently has 39 pumping stations and maintains 32 lifting stations on behalf of the Street Operations department of the Stadtraumservice owner-operated municipal enterprise.

In periods of heavy rainfall, 28 retention basins with a total storage capacity of 170,000 m^3 ensure that there is no flooding within the urban area. The rainwater is held temporarily in the storage sewers, and then fed into the main sewer system. In extreme rainfall events, if the volume of water exceeds the capacity of the storage sewers, the rainwater is mechanically cleaned and then flows through the stormwater outfall structures into the Rhine and Neckar receiving water courses.

Hidden industrial monument – the Ochsenpferch pumping station

Mannheim's oldest and largest wastewater lifting station is the Oschsenpferch pumping station. It was built between 1902 and 1904 to the plans drawn up by the then Head of the Public Works Department, Richard Perrey. Located between Neckar and the industrial port, the structure (which is protected as an historic monument) contains some very high-tech equipment – a lifting station controlled by an electronic process control system.

Rainwater infiltration in a deep bed on the Taylor Barracks site

Rainwater infiltration ditch at the Am Hochwald construction site

There are four contaminated water pumps which can operate continuously, pumping up to 6,200 litres of contaminated water per second from the southern districts and Feudenheim towards the treatment plan in Mannheim North.
In periods of heavy rainfall and flooding, two rainwater pumps with an output of 4,200 litres per second switch on automatically to prevent extensive flooding throughout the southern part of the city.

Richard Perrey (1866-1937)

Energy-efficient and climate-neutral: heat from wastewater

In 2011, the Ochsenpferch pumping station became the first public building to be heated with heat from the wastewater sewer. A heat exchanger in the inlet sewer extracts heat from the waste water. The average temperature of the wastewater is 17 °C; the heat is used to heat the pump hall. Thanks to several thousand litres of heating oil saved per year and public funding from the Baden-Württemberg state government, the new heating system had paid for itself by 2018.

There is massive potential for using wastewater heat for heating and cooling purposes. For example, heat exchangers can be installed in wastewater sewers beneath residential areas and business parks, and not just in pumping stations.

EBS also uses climate-neutral wastewater heat for its new administrative building in Käfertaler Straße. Here, a heat exchanger was integrated into the sewer in the summer of 2013 and now serves to heat and cool the building. For the peak heating load, the building was connected into the district heating system, while an additional cooling system on the roof kicks in when extra cooling power is needed. In 2016, the largest of the wartime "high-rise" air-raid shelters, the Ochsenpferch Hochbunker, was converted by the GBG Mannheim Housing Association to create a new home for the city's archives, the "Marchivum". This imposing structure with its 2 metre thick concrete walls protected up to 7,500 people against bombing raids during the 2nd World War. The municipal building is also heated and cooled with wastewater heat. When the heat exchanger was installed in the main collector sewer beneath Dammstraße, EBS carried out important preliminary work and supported the Mannheim housing association with its technical knowledge.

The Ochsenpferch pumping station

Heat exchanger in the inlet sewer to the Ochsenpferch pumping station

WASTEWATER TREATMENT

Aerial picture of the treatment plant in 2019

The Mannheim wastewater treatment plant

EBS's central treatment plant is designed for 725,000 population equivalents; it purifies the wastewater from Mannheim's homes, industries and businesses. It is located in a conservation area roughly 500 metres from the Rhine and 3 km as the crow flies from the Mannheim-Sandhofen town centre.

The wastewater treatment

Every day, 87,000 m³ waste water enters the treatment plant's inlet sewer on average, which is roughly equivalent to the content of 17 swimming pools. Inside the incoming pumping station, up to five screw conveyors lift the masses of water 6 metres; it then flows freely down to the circular flow diverters and cleaning stations. Using the very latest technology, it then spends 24 hours passing through a sophisticated purification method made up of four stages before the treated and filtered water is routed into the Rhine.

Nature as a role model

In the treatment plant, the wastewater is handled as though it were natural stream of running water: calm zones of water alternate with bubbling sections, it flows as a waterfall over weirs and bacteria polish off the contaminants. The difference from a natural watercourse is that the purification process occurs under controlled conditions within 24 hours with the addition of oxygen. It would not be possible in nature to treat such large volumes of water in such a short time.

In the **mechanical treatment stage**, solids are removed from the wastewater by coarse and fine screens in the screening house, then the screened material is drained and disposed of in the waste incineration unit. Every year roughly 570 tonnes of screened material is generated, corresponding to the content of 38,000 rubbish bags. Sand and grease are then separated using scrapers in the sand trap and aerated grease trap. The washed sand is sent to the Mannheim landfill site as a covering layer, while oil and grease joins the sewage sludge in the digester. Finally, any remaining solids are removed from the wastewater in the preliminary clarifier.

The **biological wastewater treatment** takes place in the five activated sludge tanks where various types of micro-organism remove the nutrients (phosphorus and nitrogen) and carbon dissolved in the wastewater under controlled technical conditions (addition or removal of oxygen). Under certain conditions, iron salts are also added to precipitate out phosphates. The smallest dirt particles settle out as sludge flocs in the secondary clarifier. In the 4th purification stage, the powdered activated carbon system, organic trace substances such as pharmaceutical residues, X-ray contrast agents, industrial or household chemicals are removed from the wastewater using powdered activated carbon. The final biological treatment stage is filtration. Here any remaining suspended particles are retained by different layers (anthracite, quartz sand and granulated activated charcoal). The purified wastewater flows into the Rhine.

The sludge treatment

The starting material for the sludge treatment is the fresh sludge from the preliminary clarifier and the surplus sludge from the biological treatment stage. Both have a high water content of 95 percent to 99 percent. The sludge is concentrated and reduced to one tenth of the original amount by removing the sludgy water. It then passes to the digester where it remains for up to 40 days, producing biogas under the exclusion of air and at a constant 36 °C. The sewage sludge is then dewatered and dried at a temperature of up to 500 °C. The water content of the residual sludge is just 5 percent. Most of the dried sewage sludge pellets (roughly 8,000 tonnes per year) are used in the cement industry, for generating heat and as a material.

Dewatered sewage sludge

WASTEWATER TREATMENT

Replacement of the sludge drying plant

After more than 20 years, the sludge drying plant is getting old; the heating installations are outdated and use far too much energy. To allow the new drying system to be constructed without shutting down operations, the two old drying lines will be replaced one after the other with three new belt dryers. Operating one old drum dryer and one new belt dryer in parallel will allow the full volume of sewage sludge to be dried continuously during the conversion phase.

Belt dryer in the converted sludge drying plant

Preventive water pollution control – removal of trace substances with powdered activated carbon

There is increasing public debate concerning amount of organic micropollutants in the wastewater. These are primarily pharmaceutical residues that people throw away; they find their way into the domestic wastewater and cannot be totally removed at the treatment plant. These stable and poorly degradable active substances pass into the water cycle via the rivers and have been found in drinking water sources for decades. The trace substances include synthetic hormones, painkillers, X-ray contrast agents and antibiotics, which could lead to resistance being developed by pathogens.

Powdered activated carbon system with two activated charcoal silos

Since July 2016, the EBS treatment plant has contained Europe's first large-scale system for removing trace substances from the wastewater. The use of powdered activated carbon to eliminate trace substances is a new technical process that is being used for the first time on an industrial scale for one partial wastewater flow. Scientific monitoring is provided by the Biberach Technical College.

Bavaria's Environment Agency (LFU Bayern) has investigated the effectiveness of the powdered activated carbon system using 20 male rainbow trout. The "fish monitoring" provided clear results: the powdered activated carbon process is able to remove more than 80 percent of the hormonally active trace substances from the wastewater.

WASTEWATER CHEMISTRY DEPARTMENT

The Wastewater Chemistry department plays a particularly important role in quality assurance for wastewater purification. Its remit is the analytical monitoring of the treatment plant and indirect dischargers (the industries and businesses in Mannheim that discharge their wastewater into the public sewer system).

It guarantees compliance with the statutory requirements, such as the Water Resources Act, the wastewater ordinance and self-monitoring ordinance from the Baden-Württemberg Water Act and the provisions of the permit under the German water legislation.

Expert body for the water management industry
As a recognised expert body for the water management industry, the Water Chemistry department is able to monitor the threshold values at the treatment plant under its own responsibility. The process parameters determined every day, such as total organic carbon (TOC), inorganic nitrogen (N_{inorg}) and total phosphorus (P_{tot}), etc. are sent on a monthly basis to the competent monitoring authority – the Karlsruhe Regional Council (RC).

Other tasks include analytical testing of the online measuring equipment, constant analytical monitoring of the sludges in the treatment plant and goods inwards inspections for operating materials.

The Wastewater Chemistry department is also commissioned by the Karlsruhe RC to sample and analyse the wastewater from industrial operations in Mannheim in order to monitor their compliance with the thresholds specified in the applicable water regulations.

Indirect discharger checks
To ensure that the purification effect of the treatment plant is not impaired by increased loads or contaminants such as greases, oils, heavy metals or bacterial toxins (e.g. cyanides), the Wastewater Chemistry department regularly takes expert random samples from industries and businesses and analyses them in its own laboratory. A severe pollution surcharge is imposed if above-average nutrient input is identified (TOC, TN_b, P_{tot}). The limits and calculation methods are defined in the wastewater regulations. The data is documented in the indirect discharger land register.

By combining this with the data from the measuring probes in the pumping station, the Wastewater Chemistry department is able to detect possible disruptions in the treatment plant caused by indirect dischargers at an early stage. They can then be traced and appropriate measures taken in collaboration with the Process Engineering department.

The EBS is in good contact with the relevant operations that discharge into the sewer system and their employees. They can then be given comprehensive advice on reducing pollution, cutting down on wastewater and other wastewater treatment strategies (e.g. delivering wastewater containing fats directly to the treatment plant, rather than illegally discharging it into the sewer). In this way, some companies have been able to avoid discharging bio-hazard pollutants.

Checking the purification stage using wastewater samples

Taking samples at the manhole of an indirect discharger

RENEWABLE ENERGIES IN THE TREATMENT PLANT

Operating a wastewater treatment plant is very energy-intensive. It is responsible for around 20 percent of municipal power consumption. Lots of electrical energy is needed to purify the 30 million m³ of wastewater that arrives at the treatment plant every year from across the whole of Mannheim; most of this is used to pump air into the activated sludge tanks in the biological treatment stage and for driving other pumps, motors and generators. Thermal energy (heat) is also needed for drying the sludge and heating the digestion towers. The treatment plant's annual power consumption is roughly 23 million kWh of electricity and around 29 million kWh thermal energy from biogas.

EBS has implemented many different measures to gradually meet its ambitious target of supplying 100 percent of its power and heat requirements with energy it has generated itself.

Power and heat from sewage sludge

Since the treatment plant was commissioned in 1973 it has generated biogas in the digestion towers from the pretreated sewage sludge. All of the roughly 9 million m³ of biogas per year is currently used to generate power and heat in the treatment plant. One third of the gas is used to fuel the hot gas generator in the sludge dryer; the remaining two thirds is converted into heat and electricity via gas Otto engines in the combined heat and power (CHP) system. In the future, all the biogas will be used via the CHP system which will mean that almost all the power and heat needed to heat the rooms, digesters and sludge drying plant will be produced in-house from biogas.

Power consumption follows different patterns to heat requirements, so it will still be necessary to build a thermal energy store. The CHP system produces power and heat at the same time, so it can only produce electricity to cover ongoing needs with the aid of a thermal store. If there is insufficient heat in periods of low power consumption, the heat buffered in the store can be used. And if the electricity generation produces too much heat, this will be fed into the thermal energy store, rather than cooling down and being lost outdoors. This means that the EBS does not waste any valuable energy.

Increased operational reliability with biogas motors

The gas motors in the combined heat and power system (CHP system) also act as an emergency power supply as the flow of wastewater through the treatment plant needs to be maintained during sustained power outages. Additional operational reliability is provided by the "turbo gas compressor". This is an air compressor operated with biogas. In the event of a power cut it maintains the aeration that is vital for the biological stage.

Generation and storage of biogas in digesters and gas holders

Gas motor in a container-housed CHP system

Combined heat and power system in containers

Waterwheel in the outflow to the Rhine

Expansion of the cofermentation facility
One important component in increasing biogas production is known as "cofermentation". In this process, product residues from the food industry or other readily degradable organic substances are combined with the sewage sludge in the digesters. The augmented digestion processes greatly increase the yield of biogas.

The use of 9 million m³ of biogas in the sludge dryer, the CHP system and the turbo gas compressor brings a total CO_2 saving of 30,000 tonnes per year.

Solar energy and water power
The use of decentralised energy potentials in the treatment plant also created the opportunity to try out innovative ideas. One example of this is the PV system on the filtration plant. The filter tanks used to be left open but, due to the algae formation in the summer months, a cover was needed. A new covered area measuring 2,300 m² is now put to good use housing solar modules for generating electricity. In the first year of operation, the photovoltaic system produced around 255,000 kWh solar power which is fed into the network of the local electricity supplier for the subsidised feed-in tariff.

One prime example of the combination of engineering and craft skills is the construction of a waterwheel which generates electrical energy from water power in the fall of the treated wastewater flow. This is a "Zuppinger wheel" with curved paddles enabling it to cope with changing water levels, in contrast to turbines. It is more than 80 percent efficient. The waterwheel was planned, dimensioned and constructed within the company and has run perfectly since it was brought into operation. It generates around 60,000 kWh of electricity per year (corresponding to the power consumption of 14 four-person households) which is fed into our own network.

By using biogas, combined heat and power and electricity generation from solar energy and water power, roughly 80 percent of the treatment plant's energy requirements is covered by its own production. Once the new sludge drying plant is ready and the thermal energy store has been constructed, it will require almost no energy from external sources at all.

ADVICE AND INFORMATION

Billing centre employee talking to a customer

Customer advice
EBS is a municipal service provider. Its tasks include providing advice and information for residents, businesses and industry. EBS employees offer property owners, builders and architects technical advice on questions and applications for domestic connections or billing matters. At the invitation of residents' associations or organisations, sewer repair experts provide information about domestic connections, backflow prevention or structural flood protection measures on properties and in buildings.

Faults in the sewer system – complaint management
Blocked rainwater inlets, clattering manhole covers, rats and odour nuisance are frequent reasons for contacting EBS. Complaints from residents, municipal officials, the fire service or police are immediately forwarded to sewer operations employees. After talking to the caller, they drive to the location in order to determine the cause of the fault and, whenever possible, to eliminate it straight away. All the important data, including the action carried out, is recorded in an electronic customer service report.

Annual evaluation of these fault reports provides important information when specific faults occur frequently at particular locations. The resulting actions are, when necessary, also carried out in collaboration with other municipal service providers.

PR work and environmental education
Urban drainage mainly works in secret and underground. So there is a lot of interest in the guided tours that EBS regularly offers in the treatment plant and sewer system. EBS also participates in events and action days, such as the New Year reception, May Market, World Water Day or Open Monuments Day. Lots of visitors take the opportunity to discover the history of urban drainage and EBS's work at the EBS stand, at the historical entrance to the sewer system or in the Ochsenpferch pumping station. The urban drainage

team organises regular open door events at the treatment plant with lots of activities, tours and information on the topic of wastewater treatment.

“Wastewater adventure”

EBS’s PR work includes environmental education. School classes from Mannheim and the region take guided tours around the treatment plant all year round. They learn from experienced wastewater technicians how the sewage passes through mechanical and biological treatment stages and what the 4th purification stage – the powdered activated carbon system – has to do with our modern life. On site, the pupils learn all about Mannheim’s water cycle, the drainage of roads and properties and follow the route that their domestic waste water takes through the sewer system and treatment plant. The children also discuss the relationship between personal (consumer) behaviour and its effects on the environment. And during the summer children are taken on guided “Wastewater adventure” tours as part of Mannheim’s “Agenda Aktion” activity programme. The treatment plant and sewer system are used as “learning environments” where children and young people use all their senses to experience and observe how wastewater is collected, treated and purified using complex processes and high-tech equipment.

Guided tour at the treatment plant

Open sewer entrance in Mannheim’s Breite Straße

Tour of the Ochsenpferch pumping station on the Open Monuments Day

URBAN DRAINAGE IN THE PAST

From city moat to ring sewer

In the 17th and 18th centuries, the fortified city of Mannheim situated between the Rhine and Neckar rivers was frequently threatened by war, plagues and flooding. As in many other cities in those times, the living conditions for the inhabitants were miserable. “The water is so bad that my tea tastes as though I am drinking liquid stone. The moats give off a foul stink that is made worse by the four graveyards that are all inside the city”, wrote the poet Wilhelm Heinse when he visited the city in 1780. Up to the 19th century, foul water and rainwater flowed through courtyards and gutters into the open city moat which fed into the Rhine and Neckar through locks.

William H. Lindley (1853-1917)

Historical view of the City of Mannheim in 1869

Hygiene conditions did not improve until the first sewers and drainage systems were constructed. In 1877, the city moat was replaced by a concrete and brick sewer beneath the ring roads; a steam-driven pumping station routed the wastewater from the old Grabenstraße (behind the MVV-Hochhaus high-rise building) into the Neckar.

In 1890, the Mannheim City Council appointed the famous drainage expert and Frankfurt City Planner, William H. Lindley, to construct the sewer system for the city centre, and then for the adjacent districts. Industry was expanding and the population growing. This resulted in frenetic building activity, opening up new areas outside the ring (Schwetzingerstadt) and on the other side of the Neckar (Neckarstadt-West).

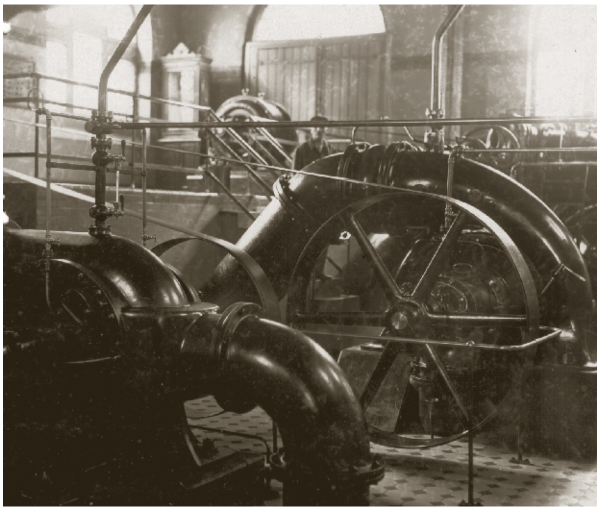
This was the start of the planned urban drainage system. Within just a few decades, an efficient sewer system was created, significantly improving the hygiene conditions and quality of life for the city's residents.

The Baden Water Act – The first steps to protect watercourses

Towards the end of the 19th century, increasing industrialisation lead to serious contamination of rivers and streams. As early as 1876, the Grand Ducal government passed the Baden Water Law which made the unauthorised discharge of sewage into the rivers a punishable offence for the first time.

The Ochsenpferch pumping station in 1904

Floodwater pumping station in the old treatment plant



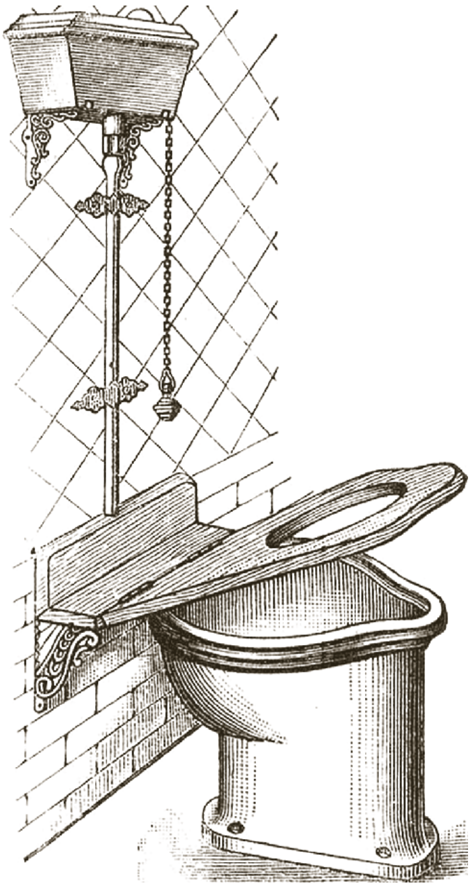
URBAN DRAINAGE IN THE PAST

In 1900, Mannheim's citizens' assembly approved around one million Marks for constructing further sewers and pumping stations and for draining sewage into the Rhine. The modern water closets (WC) were also to be connected to the sewer system. The cities downstream along the Rhine protested against Mannheim's plans as they feared contamination of their drinking water, which was drawn from the river. Farmers around Mannheim also joined the protest as they used the content of the septic tanks as a cheap fertiliser for tobacco farming. Finally a compromise solution was found to the dispute. The district government approved the sewage discharge into the Rhine, but also required the construction of a wastewater treatment plant. It was not until the mechanical treatment plant on Friesenheim Island, with its six sedimentation tanks, came into operation that faecal matter was permitted to be flushed away with the wastewater.

The first treatment plant on Friesenheim Island

In 1906, Mannheim-born Dr Karl Imhoff (1876-1965) developed the "Imhoff tank" in Essen. This enabled the settlement and digestion processes for sewage sludge to be separated within the same structure. It was a milestone in the treatment of sewage sludge.

Advertisement for a water closet in 1900



Karl Imhoff (1876-1965)

In Mannheim, the first domestic drainage ordinance of 1892 regulated the connection of private wastewater pipes to the city's sewer system. Five years later, sewer construction was transferred to the newly created Public Works Department. The success of this far-sighted decision by the City Council became clear a few decades later. In 1932, over 95 percent of all of Mannheim's households were already connected to the then 316 km long sewer system.

The costs of growth

In the period of reconstruction after the Second World War, wastewater treatment caused a lot of headaches for the city's administrators. One particular problem was the increase in daily water consumption. The volumes of rainwater in the sewers are also rising due to the large surface area that had been covered over. There was also severe contamination of the Rhine and Neckar receiving water courses. All of this meant that a comprehensive redevelopment concept was needed for urban drainage.

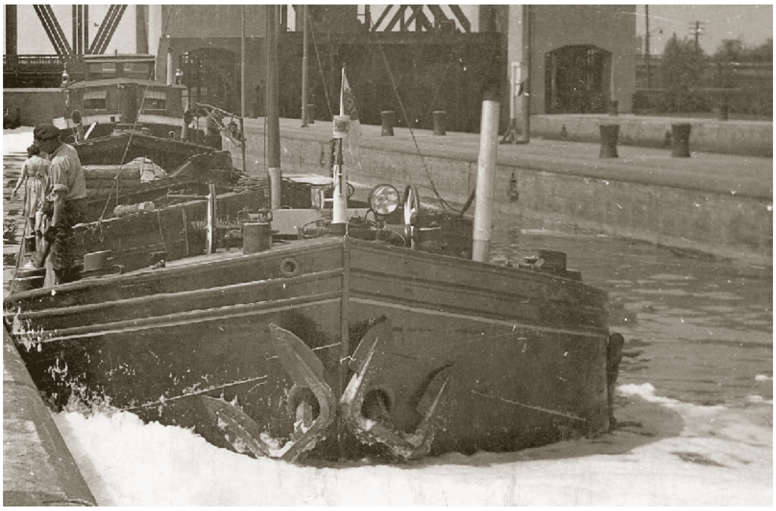
The difficult wastewater situation was relieved by the construction of the "Main Sewer North" and an auxiliary treatment plant for wastewater from the northern districts. But it was further exacerbated by the settlements for the American occupying force. The extension of the sewer system, the necessary development measures and the adaption of the wastewater systems to meet the increased demand amounted to 158 million Marks in a period of eight years.

There were still problems because of the inadequate rate of purification by the treatment plant on Friesenheim Island, which soon reached its capacity limits.

More stringent regulations to protect watercourses demanded further investment in improved technology and processes. A design for a modern treatment plant with mechanical and biological purification had existed for some time and had been assessed as "ripe for implementation" in 1944 by the surveyor Dr Karl Imhoff. But lack of financing prevented the construction project going ahead in the post-war years. Soon the planners concentrated on constructing a new, central treatment plant with biological wastewater and sludge treatment. This was located in a conservation area to the north of Sandhofen.

Lido on the curve of the Rhine at Neckarau around 1950

Mason working on the sewer bed lining in 1951



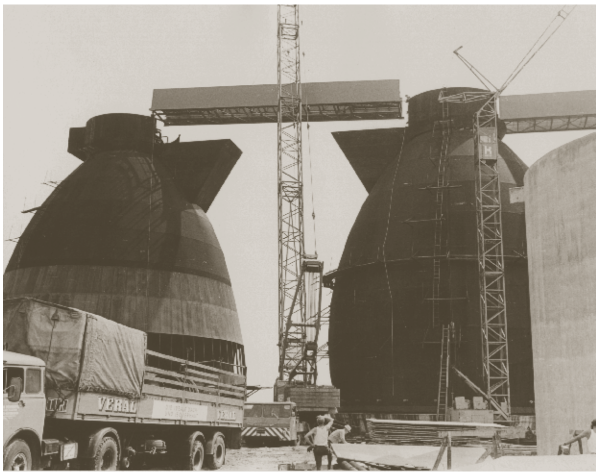
Foaming waters at the Mannheim-Feudenheim lock on the Neckar

URBAN DRAINAGE IN THE PAST

The new treatment plant

After ten years planning and construction, the new wastewater treatment plant came into service in 1973. Equipped with the technology needed to treat wastewater, such as incoming pumping station, screens, sand and grease trap, plus preliminary clarifier, activated sludge tanks and secondary clarifier, it also has extensive sludge treatment equipment. The discharge permit was approved until 1985. It was assumed that there would then be more stringent water pollution control conditions. Options for extending the plant for the expected increased wastewater volume were incorporated at the planning stage.

Precautionary measures for water pollution control included rainwater treatment. Since 1978, rainwater overflow tanks have been constructed at the stormwater outfalls; they are still used as storage and purification tanks and reduce pressure on the sewer system.



The digestion towers of the new treatment plant during construction in 1971

Aerial picture of the completed treatment plant in July 1973

The “Töpfer decree” and its consequences
In the late 1980s, the extent of the environmental damage was becoming obvious. Increasing water pollution in the North Sea and the Baltic was manifested by blankets of toxic algae and the mass seal deaths. The pictures and reports in the media caused a great stir among the general public, ultimately leading to the “Töpfer decree”.

In it, the then environment minister, Klaus Töpfer, set out minimum requirements concerning the quality of the wastewater that is discharged into rivers. The introduction of the nutrients phosphorus and nitrogen was massively reduced, and the limits for other pollutants were made much stricter. To meet the new statutory requirements, the treatment plants needed to have new equipment retrofitted.

Extension of the treatment plant
The new statutory requirements with the more stringent discharge values (limits) for pollutants made further investment necessary to improve the performance of the Mannheim treatment plant.

A filtration system was added to the biological treatment stage in 1986. In the following decade, the screening house plus the sludge dewatering and drying unit were replaced. The effluent values have dropped sharply since the extended biological purification stages were successfully commissioned in the course of the treatment plant extension. This made an important contribution to sustainable water pollution control and also reduced the statutory wastewater levies which are determined by the level of pollution.

In the late 1990s, further extension of the treatment plant once again required considerable investment in order to meet the stringent conditions for discharging wastewater into public watercourses. At a total cost of DM 138 million, a new biological purification stage was created with five activated sludge tanks, ten secondary clarifiers, a blower station and a charging station.

Even the rainwater was no longer permitted to be routed untreated into the rivers as it was so polluted (acid rain). Between 1990 and 2005, numerous rainwater retention basins and storage sewers were created in Mannheim in response to the rainwater treatment report.

The goal of sustainable water pollution control is being pursued on an ongoing basis with a series of other projects. The commissioning of new or extension of existing pumping stations and rainwater overflow tanks to relieve the pressure on the affected districts during heavy rainfall events concluded the rainwater retention and treatment programme, resulting in a total storage volume of 185,000 m^3.

Sustainable water pollution control
Today, 30 years after the “Töpfer decree” and the systematic implementation of its 10-point programme, most rivers have good water quality. By working together on water pollution control, the national government, federal states, municipalities and industry have created a situation in which, today, the water quality in the Upper Rhine is as good as it was at the end of the 19th century. More than 30 fish species, including freshwater lamprey, rainbow trout and Atlantic salmon, are flourishing in the Rhine once more. The population’s increased environmental awareness, more stringent water regulations and technological progress have combined to set new standards in terms of wastewater treatment.

Rainwater overflow tank under construction in the city centre in 1997

A HISTORY OF URBAN DRAINAGE

1606	Frederick IV, Elector Palatine of the Rhine, founded the fortified city of Mannheim. Wastewater and rainwater flow from the squares into the defensive moats.
1808	After the fortifications fell into disrepair, the new city moat, running in a semi-circle around the eastern squares, discharged the wastewater into the Neckar river.
1876-1877	The ring sewer is created beneath the ring road as a replacement for the dilapidated city moat.
1888	The Käfertal waterworks is brought into service, giving Mannheim a central water supply.
1890	Frankfurt City Planner, William H. Lindley, is commissioned to construct the sewer system for the city centre.
1892	The first domestic drainage ordinance regulates the connection of private wastewater pipes to the city's sewer system.
1904-1905	The Ochsenpferch pumping station and the mechanical treatment plant on Friesenheim Island are brought into operation. A "sewer usage charge" is levied for the first time.
1930	95.5 percent of all Mannheim households are connected to the public sewer system.
1973	The new treatment plant with biological wastewater treatment is brought into service.
1978	The first rainwater retention tanks are constructed at the stormwater outfalls.
1986	The second biological purification stage (biofiltration) is brought into service in the treatment plant.
1996-1999	The sludge dryer, screening building and new biological stage are completed in the course of extending the treatment plant. The total cost is around 190 million DM.
1997	At the Public Works Office, the "Urban drainage department" is outsourced and the "Eigenbetrieb Stadtentwässerung" (an owner-operated municipal enterprise) is established.
2002-2003	The EBS introduces a quality and environmental management system.
2007	A photovoltaic system is created on the filtration tank cover. With a surface area of 2,300 m², it is one of Mannheim's largest PV systems.
2011	The construction of new rainwater infiltration systems on the public roads in the Gartenstadt district relieves the pressure on the sewer system in the event of heavy rainfall.
2011	The Ochsenpferch pumping station becomes the first public building in Mannheim to be heated with heat from the wastewater sewer.
2016	The 4th biological purification stage (the powdered activated carbon system) is brought into service in the treatment plant.

THE EBS IN FIGURES – 2018

General data

Drainage area	The city area of Mannheim
Surface area	145 km²
Number of residents	320,080
Connected residents	99.9 percent
Number of employees	250
Trainees	6

Waste water charges – from 1 January 2019

Wastewater charge	1.61 €/m³
Rainwater charge	0.83 €/m² per year

Wastewater collection

Drained areas	approx. 7,100 ha
Length of sewers in EBS's area of responsibility (combined sewer system)	832 km
Operational vehicles	
- Cleaning vehicles (suction/flusher vehicles, two with water recovery	6
- TV vehicles	2

Pumping stations and storage sewers

Rainwater overflow tanks (ROT)	8
Rainwater retention basins (RRB)	8
Storage sewers	12
Rainwater infiltration systems	2
Total retention volume	170,000 m³
Pumping stations	39
Lifting systems	32

Wastewater treatment and treatment plant

Population equivalents	725,000 PE
Incoming volume in dry weather	approx. 87,000 m³ per day

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