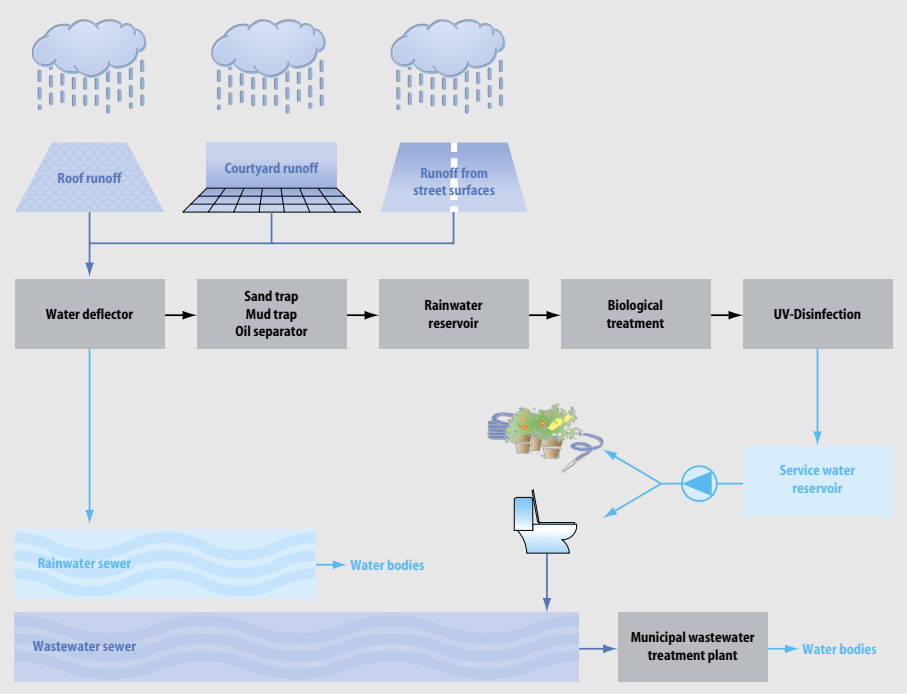
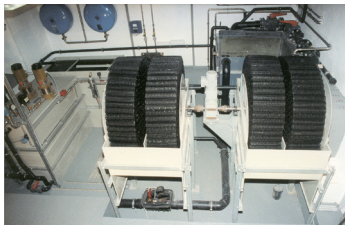
Berlin

Senatsverwaltung
für Stadtentwicklung





Innovative Water Concepts

Service Water Utilisation in Buildings

Imprint

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Berlin 2007

We thank the owners and operators of the herein introduced plants for their kind support.

Contents

Foreword

Due to the high demand, the brochure "Innovative Water Concepts – Service Water Utilisation in Buildings" is made available as a PDF-file in an abridged version in the German and English languages and can be accessed at the website of the Berlin Senate Department for Urban Development: www.stadtentwicklung.berlin.de

In many public and private buildings, plants for service water utilisation have been and are being operated as rainwater harvesting and greywater recycling facilities. The application areas are manifold: for toilet flushing and cooling purposes but also for washing and cleaning systems, rainwater as well as treated greywater can be utilised.

The application of innovative, environmental technologies in building design concepts exhibits a great potential in reducing the running costs and therefore, is becoming increasingly an important location and export factor. Based on a series of developments and evaluations from several pilot projects, Berlin has won considerable knowledge in this field. Specific targets at the service water quality have become internationally known as the "Berlin quality targets".

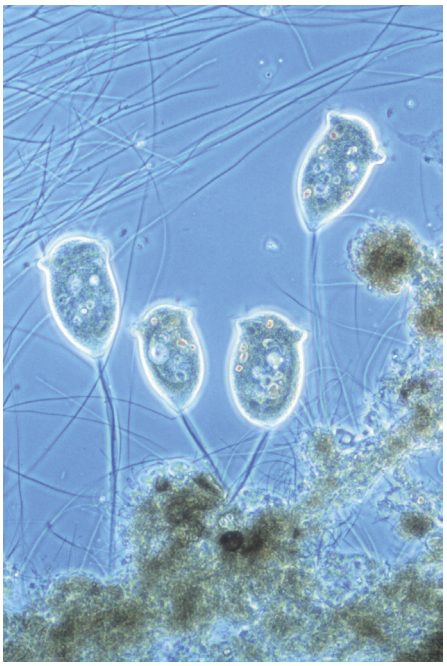
With the brochure "Innovative Water Concepts – Service Water Utilisation in Buildings", the Berlin Senate Department for Urban Development has published for the second time information on service water utilisation in buildings. The objective is to provide interested home owners, planners and plant operators with the extensive experience that has been gained from these pilot projects to use as a work tool for the planning, construction, operation, maintenance and monitoring of these plants.

The entire brochure, an expanded new edition of the brochure "Service Water Utilisation in Buildings", which has been released in 1995 is available in the German language under the following address:

Senatsverwaltung für Stadtentwicklung
Info-Center
Am Köllnischen Park 3
10179 Berlin

E-Mail: info-center@senstadt.verwalt-berlin.de

The unit price for the brochure is 15 Euro plus 1.5 Euro for mailing expenses.



"Water is needed in all aspects of life. The general objective is to make certain that adequate supplies of water of good quality are maintained for the entire population of this planet, while preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combating vectors of water-related diseases. Innovative technologies, including the improvement of indigenous technologies, are needed to fully utilise limited water resources and to safeguard those resources against pollution."
(Agenda 21, Chapter 18.2)

All countries, especially the industrial nations, are requested to safeguard the water resources and to develop and apply the corresponding technologies.

In Germany, water resources and water quality exhibit a higly variable distribution. In the new Federal States for example, there exist regions with less rainfall than on the arid Mediterranean Island of Crete. In metropolitan areas where water consumption is very high, drinking water must also be made available from treated, polluted surface water. As a result, more pollutants are continuously being detected in drinking water (e.g. pharmaceutical residues) which are of considerable health and ecological significance and a cause of much dispute among researchers. However, nowadays it has become widely accepted that not all household applications necessarily require a drinking water quality. Numerous scientific investigations have shown that service water plants that have been planned, constructed and operated in conform to standards pose no increased risk on the human health.

The utilisation of service water and rainwater in cities where a high demand for water exists is of particular interest. In practice, new water concepts have been already established and have found wide international acceptance and recognition. Representative objects are the Greywater Project in Berlin-Kreuzberg (70 persons), where for the first time in Germany a high-quality service water was made available for reuse, and the Rainwater Project in Berlin-Lankwitz where in addition to roof runoff, polluted rainwater from street runoffs is also used for toilet flushing following a simple treatment. Both systems operate with no hygienic risk or comfort loss. The benefits of such projects lie not only in the potential of saving water but also in the relief of the strain on surface waters bodies, into which rainwater is usually discharged either untreated or inadequately treated.

The experience from the Berlin water projects has shown that when administrators, investors, planners, executing firms, end-users and researchers all co-operate in a responsible manner, there are eligible chances that the environmental problems may be successfully encountered within the context of the Agenda 21.

Professor Henning Rüden
Technical University of Berlin
Working Group Environmental Hygiene

The advantages of service water* utilisation over the conventional centralised drinking water supply and wastewater systems are ecological as well as economical. It is an answer to the frequently expressed consumer wish for a low-priced service water intended for applications that do not require the stringent use of high-quality drinking water. In this context, drinking water should be preferentially won from anthropogenic non-polluted sources.

Especially in metropolitan areas, significantly more water is being continuously extracted from the underground than groundwater can be naturally built through the process of infiltration. A conservative attitude in dealing with the resource is an important target. The activities of the Berlin Senate Department are targeted at reducing the groundwater withdrawal rate in order not to exceed the natural groundwater recharge rate.

Since a drinking water quality is not required for every household application, service water utilisation in addition to the application of water-saving fittings are very effective instruments for the conservation of the scarce, high-quality groundwater resources and the reduction in the amount of resulting wastewater. With this, drinking water treatment and wastewater disposal are associated with a reduced energy and chemical consumption as well as sludge formation. Therefore, a reduction in the drinking water consumption is required in order to guarantee that the future drinking water supply will originate predominantly from non-polluted, deep groundwater sources.

Based on the enormous pollution potential rainwater discharges in Berlin have, it is necessary to control these runoffs. "An integral part of the complex of measures within the framework of the wastewater disposal scheme is the reduction of the nutrient input in order to diminish algal development in surface waters to reach the water quality class II" (1). In many water bodies, a sharp drop in the oxygen concentration is measured several times a year following intensive rain periods thus leading to regular fish death (1).

Every cubic metre of rain which is not being discharged into the combined sewer due to service water utilisation will lead to decreased wastewater discharges into the receiving surface water bodies, especially following strong storm events. However, where a separate sewerage system is available, a reduced pollution load on the water bodies is also expected.

In numerous publications, the State of Berlin strongly advocates the utilisation of treated rainwater and greywater for sectors in which drinking water quality is not stringently required (2, 3, 4, 5, 17).

Water Costs in Berlin

In Berlin, the costs for the water supply system rose from 1.21 Euro (1986) to 4.37 Euro (1996) per cubic metre. Since 1996, a stagnation in the water price has been recorded. Since 1 January 2000, 1.89 Euro are charged per cubic metre of drinking water and 1.97 Euro per cubic metre of disposed wastewater. Added to that is the rainwater fee of 1.29 Euro per square metre sealed surface area (updated January 2003) which was introduced on 1 January 2000, provided the surface area is connected to a municipal sewerage system and independent whether the system is a separate or a combined one.

The calculation of the rainwater fee for rainwater harvesting systems is estimated on basis of the frequency of overflow into the municipal sewer. If no connection to the sewer exists, no rainwater fee will be charged.

Systems which are designed according to the generally acknowledged rule of technology and which overflow several times a year (normal case), are granted a lump reduction in the rainwater fee of 10%. For this purpose, an informal application should be sent to the Berliner Wasserbetriebe (Berlin Water Undertaking). In case of rare overflow events (less than once a year), a 100% fee exemption may be achieved.

* Service water (according to DIN 4046):
Water for use in trade, industry, agriculture or other similar purposes with different quality characteristics, whereby, drinking water quality may be included.

The table below shows the annual running costs for water from four different four-person households (A, B, C, D) in Berlin.

The economic efficiency of service water utilisation systems is dependent on diverse factors in addition to the strongly fluctuating local water costs and their future development.

Experience shows that service water utilisation is mostly cost-effective there where new properties are connected, new houses built or extensive redevelopment work is planned. In this case, a second pipe system can be installed for a probable service water utilisation in the future.

Principally, the saving potential is highest there where plenty of water can be substituted with service water year round. The figure shows that with similar investment costs for each measure (approx. 5,000 Euro), the saving potential in the energy sector is significantly lower than that of a greywater recycling system even if the system merely treats the water from showers and bath tubs for use in toilet flushing.

Requirements for Service Water Utilisation Systems

The following four criteria are to be regarded as general requirements for service water utilisation systems, and as such, should be guaranteed by the manufacturer. Moreover, the corresponding statutory regulations which are listed in the Drinking Water Ordinance (6) should be stringently maintained.

■ **Hygienic Safety**
Service water utilisation should not become a source of hygienic risk. This can be guaranteed taking into consideration the state-of-the-art.

■ **No Comfort Loss**
Odour nuisances, deposits on sanitary ceramics as well as clogging of fittings should be excluded.

■ **Environmental Tolerance**
The use of chemicals, especially chlorine-containing compounds for disinfection, and/or a high energy demand are basically rejected.

■ **Acceptable Costs**
Costs for energy, maintenance, monitoring and repair of the systems should lie below the drinking water and wastewater costs, and investment costs should amortise.

Drinking Water Ordinance
Based on the Drinking Water Ordinance and its causal text (7), the following can be deduced:

■ Service water utilisation is recommended for toilet flushing, gardening, outdoor irrigation and for cleaning purposes for which no stringent hygienic standards are required.

In the Drinking Water Ordinance Section 3, No. 1a, the term "water for human use" is defined. For the above mentioned applications no drinking water quality is required, whereas, a drinking water quality is demanded for all intended uses in which the water quality may directly or indirectly influence the health of the consumer (e.g. in kitchen area).

■ The decision to use service water and rainwater also for laundry activities lies solely by the consumer and is as such a personal responsibility.

In rented residential buildings, the Ordinance provides the consumer with the option of using drinking water or service water for laundry activities. This entails that in addition to the service water connection, a drinking water connection to the washing machine must be also made available.

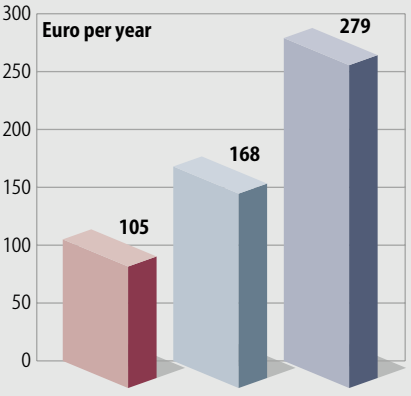
■ Since 1 January 2003 all service water systems, in addition to the already existing ones, must be reported to the health authorities. This applies for the construction as well as the start-up and shut-down of these systems (Section 13, Paragraph 1 & 3). For notification purposes, Annex 2 can be used (compare p. 30).

■ **Annual running costs for water in Berlin (Four-person households)**
Roof and connected sealed surface area: 120 m² (Updated: November 2002)

Household	Applied measure				Impacts		
	Water-saving fittings	Rainwater utilisation[1] (WC, garden, laundry)	Greywater utilisation[2] (WC)	Rainwater infiltration	Drinking water / wastewater (in litre per person and day)	Fee-relevant roof surfaces (in m²)	Annual running costs (in Euro)
A	⊖	⊖	⊖	⊖	140/140	120	**938**
B	⊕	⊖	⊖	⊖	100/100	120	**712**
C	⊕	⊕	⊖	⊕	50/100	0	**426**
D	⊕	⊖	⊕	⊕	65/65	0	**367**

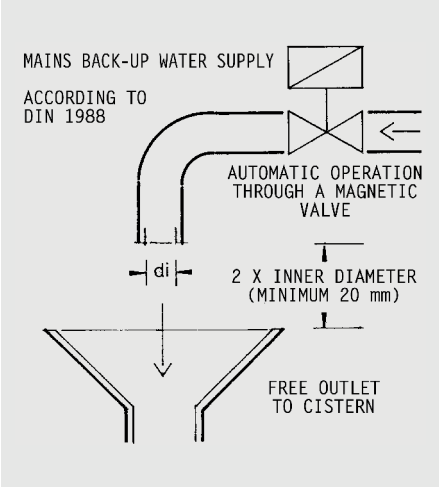
1) Without connection to the sewer
2) **Greywater** is part of the household wastewater which is free from faecal material. For technical reasons, the high-load kitchen wastewater is usually not utilised.

■ **A comparison of the annual savings from different ecological building measures**



■ Solar system for water heating
■ Standard low-energy-house instead of WschVO 95
■ Shower and bath water recycling of 35 litre per person and day

Based on: 3.86 Euro/m³ drinking water and wastewater; 0.35 Euro/l fuel oil or natural gas; single-family household with 6 persons.



A diagram for mains back-up water supply (left)

Materials used to label pipelines and extraction points of the service water network

■ It should be guaranteed that service water pipelines are not connected to those of the drinking water network.

Pipelines and extraction points are to be labelled permanently in accordance with the valid regulations (Section 17, Paragraph 2). The health authorities examine the service water utilisation plants in schools, kindergarten, hospitals, restaurants and other public facilities (Section 18, Paragraph 1) for cross connections with the drinking water network paying thereof special attention to the required pipeline labelling. Inspection of all other systems takes place only in individual cases which are subject to justification.

Technical Regulations

The DIN 1989 Rainwater Harvesting Systems – Part 1: Planning, Construction, Operation and Maintenance exists since April 2002 (8). It also includes normative references on further applicable standards. For greywater recycling systems, the Technical Note H 201 has been worked out by the Association for Rainwater Harvesting and Water Utilisation (fbr) for greywater recycling systems in households and the public/industrial sector (9).

Berlin Projects

Selected examples on service water utilisation

Since the 70s and in the course of a growing environmental awareness in Germany, a rediscovery of service water utilisation took place, whereby, plant parts were individually compiled and assembled. Professional system components for the use, retarded discharge and infiltration of rainwater became first available in 1990. The first factory-prefabricated rainwater systems consisted of 1000-litre plastic cellar tanks with a float switch, a mains back-up system, a suction pump and a press switch which have been all compactly pre-assembled. The volume of the reservoir could be optionally enlarged by coupling to extension tanks.

Meanwhile, rainwater utilisation abandoned the image of greenery handcraft at the latest since Sony and DaimlerChrysler utilised rainwater for toilet flushing at their headquarters at Potsdamer Platz in Berlin. In addition, the Association of German Chambers of Industry and Commerce which moved into its new domicile in Mühlendamm together with the Federation of the German Industries and the Confederation of the German Employers' Associations, store rainwater as water reserve for fire-fighting and toilet flushing. Similarly, this takes place at the Association of German Cities and Towns in Ernst-Reuter-Haus. Three motives play a role here:

- The demand for an effective on-site rainwater retention in order to relieve the strain on the combined sewer and the receiving water body
- Lowering of the running costs
- A prestige gain through the application of environmental technology.

Two outstanding service water concepts were realised and tested for the first time in Berlin.

- Exemplary for extended rainwater utilisation is the project in Berlin Lüdecke-Strasse (compare p. 14). In this project, the overall precipitation including rainwater from roof and street surfaces is collected, treated and eventually used for toilet flushing by 200 tenants.

- The first successful greywater recycling project was realised in Block 103 in Berlin-Kreuzberg (compare p. 16). Within this ecological urban model scheme, a greywater recycling plant was developed for the first time in 1988 as an operator model (16). This technology which was developed by the Technical University of Berlin and a small handicraft business also proved its success in a following project in a four-star hotel in Offenbach (400 beds). Greywater recycling plants "Made in Berlin" have been also exported to Denmark and China.

The following selected projects demonstrate greywater and rainwater plants in some residential and public buildings in Berlin.

Heinrich-Roller Primary School

District
Pankow

Address
Heinrich-Roller-Str. 18
10405 Berlin

Contact person
District Council Pankow
10407 Berlin
Tel. (030) 42 40-41 00
Lindner@ba-pankow.verwalt-berlin.de

www.berlin.de/ba-pankow

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Sanitärsystemtechnik
(Planning)
Building Authority Prenzlauer Berg
(Project contractor, building management)
Berlin Senate Department
for Urban Development
(Partial funding)
S.T.E.R.N. GmbH
(Authorised project representative)

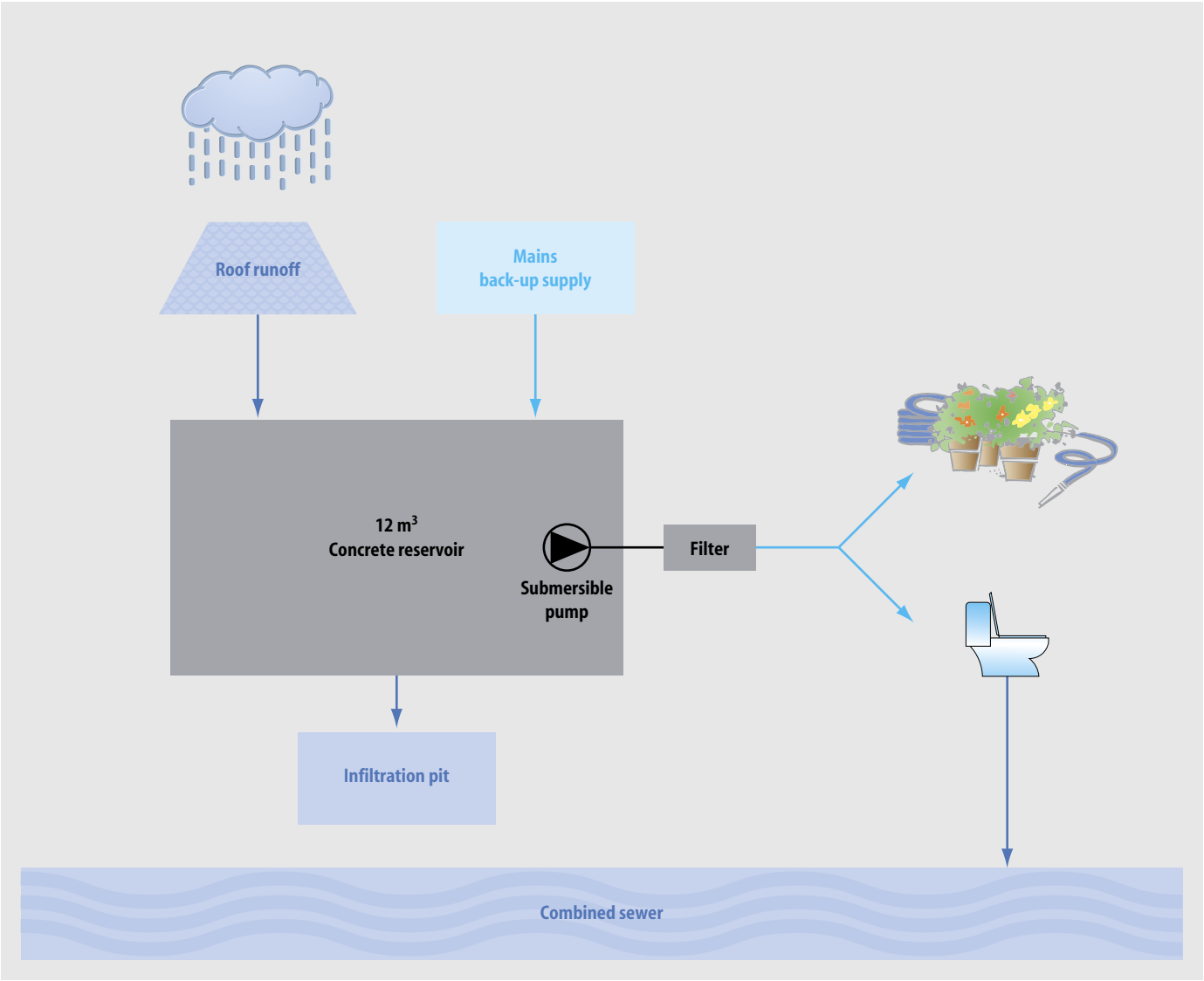
The Heinrich-Roller Primary School, a Wilhelminian style building standing under monumental protection, comprises two school buildings and one gymnasium, whereby the larger part of the classrooms and special field rooms as well as teachers' room, secretariat and auditorium are found in the rear and larger building. Within the scope of realising an ecological overall concept, the three newly constructed sanitary tracts lying above each other were furnished with different fittings for toilet and urinal flushing (service water) as well as for washbasins (drinking water). By using impulse counters for the single points of consumption, the consumption rates of the urinals, toilets and washbasins can be collected separately for each floor. The data files are regularly collected on a PC found in the secretariat and subsequently evaluated. For demonstration purposes, the amount of water saved and the current reservoir fill level can be viewed by the students on an information board.

Service water utilisation
Service water for toilet and urinal flushing is made available from the rainwater reservoir (12 m³) by means of three submersible pumps following filtration. All roof runoffs from the rear building (ca. 565 m²) are collected excluding the roof of the newly built sanitary tracts which has been extensively planted (ca. 75 m²). The overflow from the cistern is infiltrated over a pit.

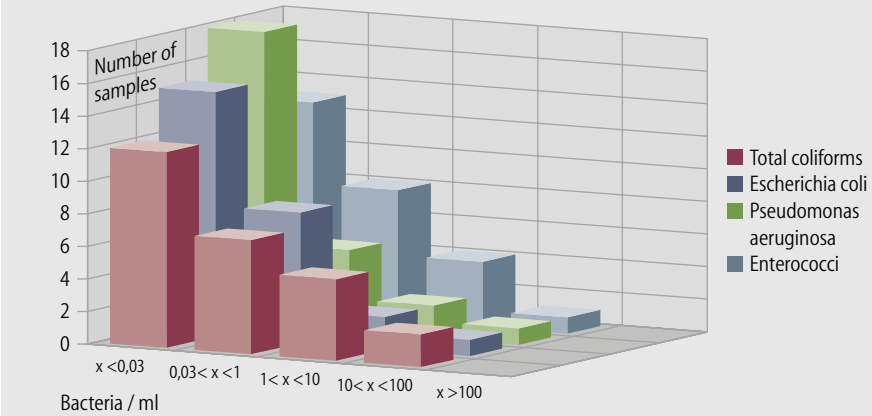
Investigation results

Service water demand	ca. 300 m³/year
Savings in drinking water	ca. 140 m³/year
Demand met by service water use	43%
Rainwater utilisation	67%

Within the scope of the scientific research that accompanied this project, the water concept and the service water quality were investigated in 1998/99 over a period of 15 months. The tested physical, chemical and microbiological parameters demonstrated only a low pollution load of the service water. In very few cases, the limits of the Berlin target values for the microbiological parameters were exceeded (compare Table on p. 21). Water supply is



Results of the hygienic-microbiological investigations



Plant Data

Start-up of operation	1996
Supply area	27 toilets, 12 urinals over 3 floors, one outdoor tap connection
Connected roof surfaces	ca. 565 m²
Roof material	Roof tiles
Storage capacity	12 m³ subsurface concrete reservoir (ring form)
Filter	No pre-filtration, automatic back-washable filter in the pressure pipeline
Booster station	Three submersible pumps with a 50-litre pressure-compensation vessel
Overflow	Infiltration pit

highly secured due the installed triplicate pump system. By infiltrating the overflow, the rainwater fee for the connected roof surfaces which is being charged in Berlin since 1 January 2000 is saved completely.

GSW Housing Settlement in Lankwitz

District
Steglitz-Zehlendorf

Address
Lüdeckestrasse 1
12249 Berlin

Contact Person
GSW
Kochstrasse 22
10969 Berlin
Tel. (030) 2534-1322
klaus.wisniewski@gsw.de

www.gsw.de

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Baufrösche Stadt- und Bauplanungs GmbH
(Architects)
Berlin Senate Department
for Urban Development
(Partial funding)
Nolde & Partner and the Technical University of Berlin (TUB)
(Research)

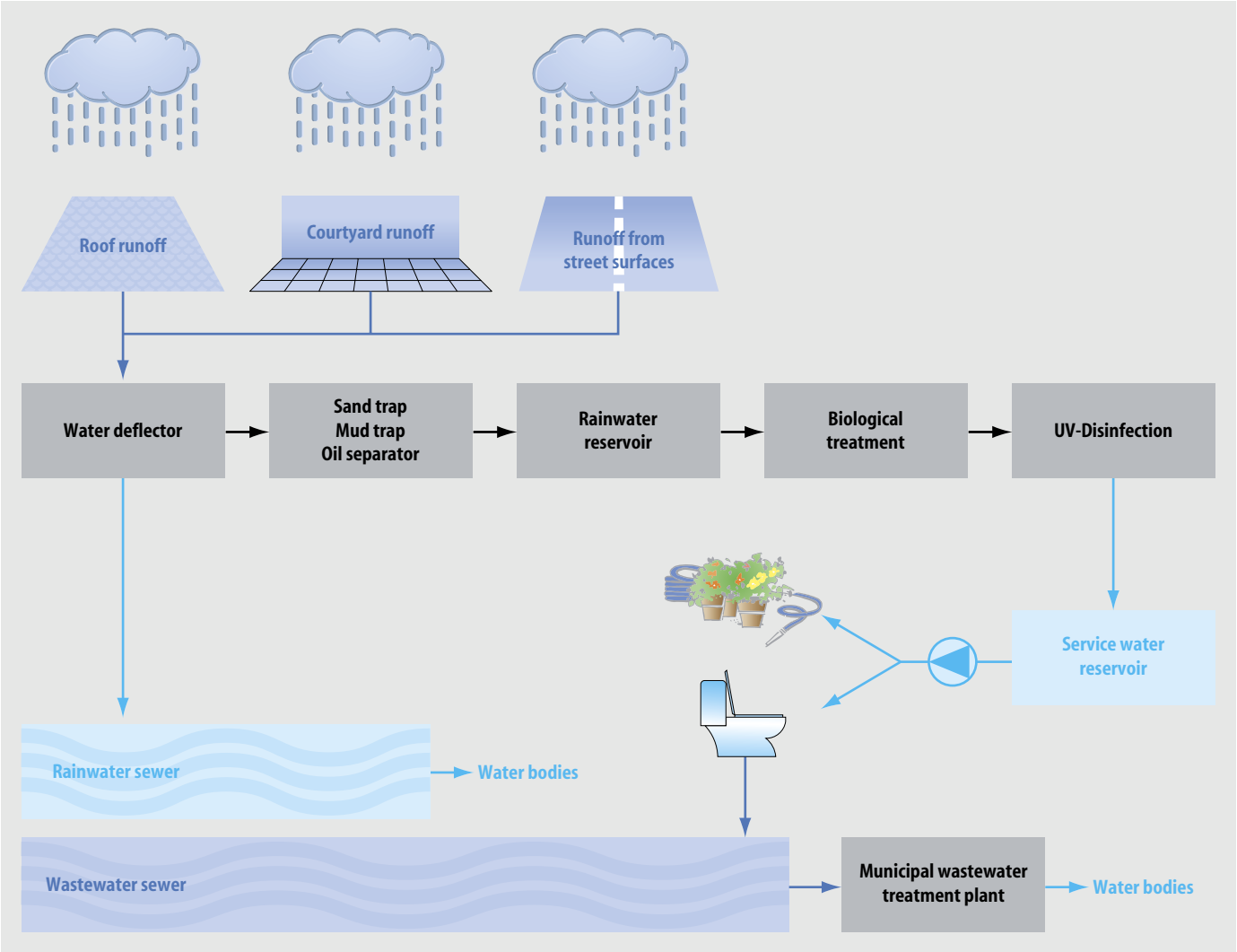
The small housing settlement established in 1952/53 was redeveloped in 1995 and additional units were newly built. Thus, a dense and compact residential area emerged as a result of an increase in the housing units. The complete housing technology was renewed and furnished with water-saving sanitary technology. The existing wastewater and rainwater sewers were retained and the new buildings connected to them. Due to the heavy sealing and the unfavourable infiltration conditions, a decision was made to probe a new technique of rainwater harvesting. The rainwater utilisation plant which was completed in 1999 is probably the first plant world-wide in which the first-flush entering the rainwater reservoir originates mainly from the strongly polluted rainwater draining from the public paved street surfaces. In March 2000, the second pipeline network was tested by dyeing the service water. After ensuring that no cross-connections existed to the drinking water network, about 200 tenants are being supplied today with service water for toilet flushing and lawn irrigation.

Service water utilisation
Rainwater from the rainwater sewer is directed to the rainwater reservoir after passing through a grit chamber (mud and sand trap) acting also as an oil separator. Following a biological treatment and an UV disinfection, the service water is used for toilet flushing and lawn irrigation.

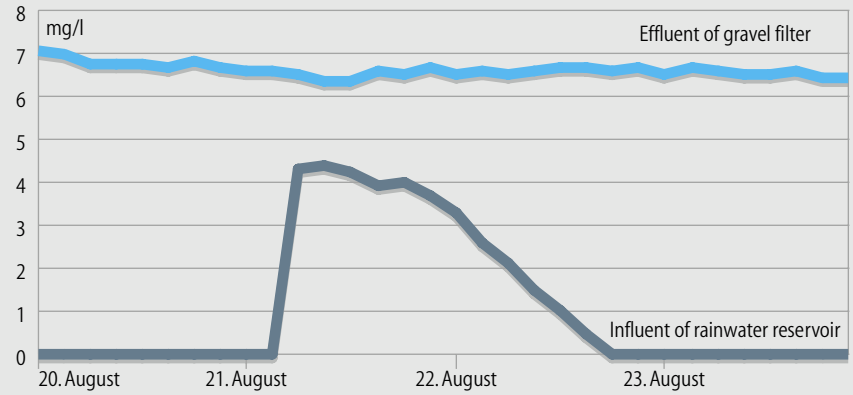
Operational experience / Investigation results

Service water demand	ca. 3,450 m³/year
Savings in drinking water	ca. 2,650 m³/year
Demand met by service water use	ca. 77%
Energy demand	0.85 kWh/m³

Within the scope of an accompanying scientific research which started in 1999, the work group "Environmental Hygiene" of the Technical University of Berlin investigated among others the service water quality of the above system. The plant was found to be failsafe and it was accepted widely by the tenants.



Change in the oxygen concentration during rainfall



Plant Data

Start-up of operation	2000
Supply area	All toilets in 80 residential apartments and 6 small trade units
Connected surface	ca. 7,325 m² roof surface and 4,450 m² traffic surface
Roof material	Flat roofs made of fibre-cement, corrugated panels and surfaces partly mounted with gravel
Traffic surfaces	1,458 m² of concrete road and partially sealed surfaces
Reservoir	190 m³ concrete reservoir underneath the cellar
Treatment	Grit chamber with oil separator, two-stage gravel filter and eventual UV-disinfection
Booster station	Three multi-stage pump and a 200-litre pressure-compensation vessel
Overflow	The overflow is found outside the reservoir in the rainwater sewer

Every time rainwater enters the reservoir, it carries with it dissolved oxygen in addition to pollutants (see measured values of 21 August). As a result of the microbiological activities, oxygen in the system is readily consumed. The same effect causes regular fish death in Berlin water bodies. As a result of the biological rainwater treatment, the effluent of the gravel filter is always poor in pollutants, clear and non-toxic to fish. Due to its high oxygen content it is also storable.

Although polluted rainwater from paved street surfaces is directed into the reservoir, the hygienic-microbiological as well as the chemical-physical parameters of all tested service water samples were clearly below those of Berlin target values. Energy consumption for the treatment and distribution of service water is considerably low with a total of 0.85 kWh/m³.

Greywater Recycling Plant in Block 103

District
Friedrichshain-Kreuzberg

Address
Manteufffelstrasse 40/41
10997 Berlin

Contact person
Lokus GmbH
Silbersteinstrasse 97
12051 Berlin
phone (030) 625 31 67
lokus@t-online.de

www.graywater.com

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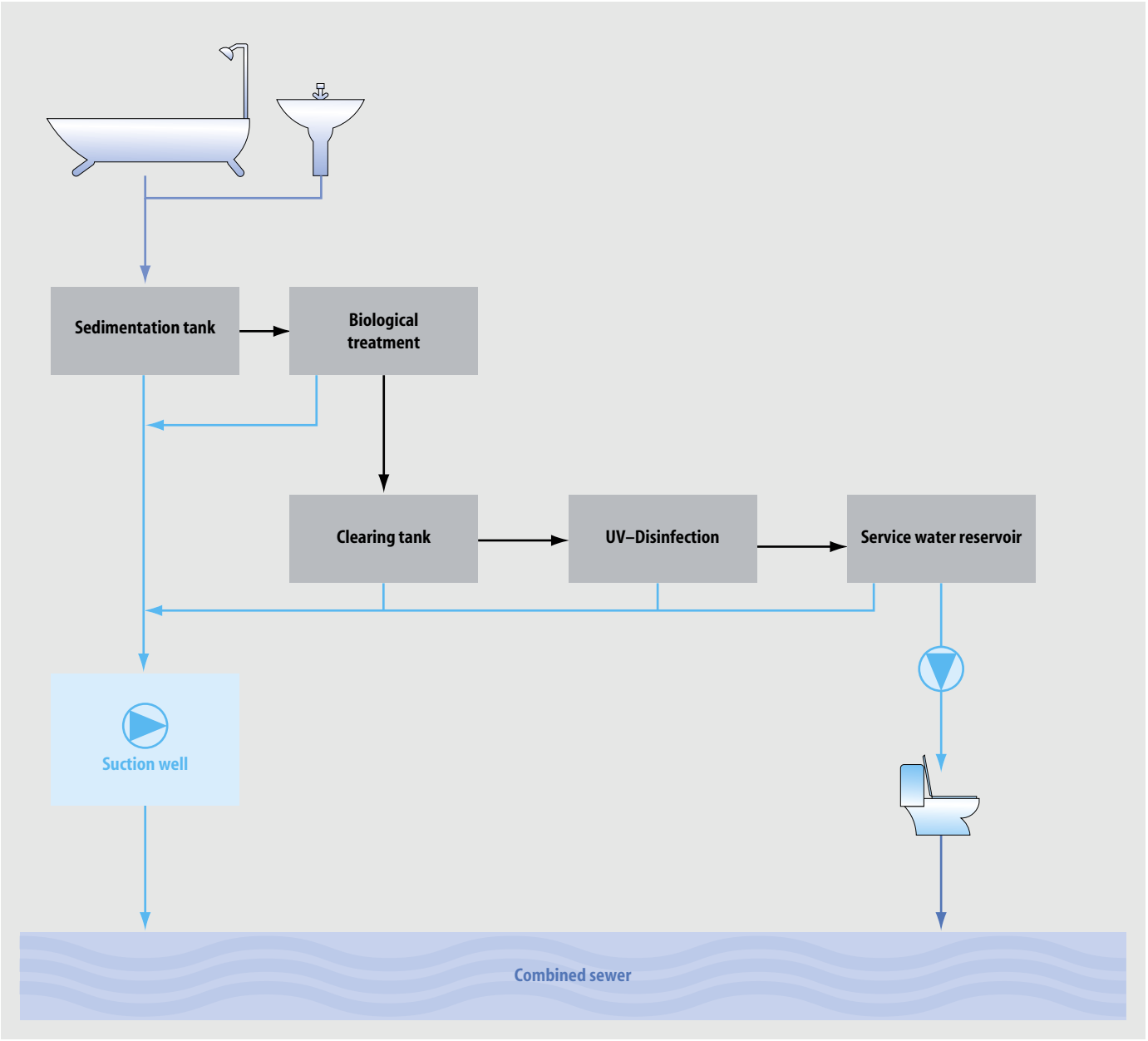
(Planning)
Berlin Senate Department for Urban Development
(Partial funding)
Co-operative Society Luisenstadt e.G.
(Proprietor)
TU Berlin
(Research)
STATTBAU GmbH and S.T.E.R.N. GmbH
(Authorised project representative)

Block 103 in Berlin-Kreuzberg is an old building block that has been saved from demolition in 1981. This project is one of the most comprehensive model projects in experimental urban development that has been initiated and funded by the Federal Government and the State of Berlin. Houses and courtyards were rehabilitated according to new standards giving rise to a wide interest both at home and abroad especially where greywater recycling is concerned. The plants were intensely researched and based on the investigation results they were optimised up to 1997. Subsequently, the Co-operative Society Luisenstadt concluded an operator contract with a sanitary handicraft business. Based on this contract, the owner was no more responsible for the operation of the greywater plant and the tenants received their water for toilet flushing for about 50 Cents per cubic metre less than what they would eventually pay for the same amount of water coming from the local water company. Based on the collected experience, similar projects were realised nation-wide and the positive results of the Berlin plants were reconfirmed in these new projects.

Greywater recycling
Greywater treatment follows sedimentation, biological treatment and UV disinfection. A sedimentation tank acts as a buffer reservoir supplied with an outlet device for sludge removal. Biological treatment follows in a four-stage cascade of Rotating Biological Contactors (RBC) to which a clearing tank is connected for sedimentation of the biomass. Due to hygienic considerations, the treated greywater is disinfected with UV light before it is stored in the service water tank. The distribution of service water follows over a two-pump system and a pressure vessel.

Operational experience / Investigation results

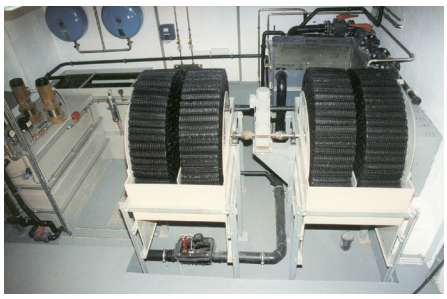
Service water demand	ca. 1.5 – 2.5 m³/day
Total residence time	1 day
Energy demand	ca. 2.15 kWh/m³
Mains back-up supply	less than 10 %



Plant Data

Start-up of operation	1989 / Reconstruction 1998
Greywater sources	Bath tubs and showers (from about 60 persons)
Service water utilisation	Toilet flushing (for about 60 persons)
Greywater network	Cast iron pipes
Service water network	Plastic (PE)
Reservoirs	Plastic (PP)
Treatment	Rotating Biological Contactors (RBC)
Booster station	Two high-pressure rotary pumps and two pressure compensation vessels (50 litre each)
Overflow	Suction well with connection to the combined sewer

The service water is visually clear and fulfils the Berlin quality requirements for service water regarding hygiene as well as the chemical-physical parameters. Due to the extensively automated system technology, the greywater plant is failsafe since many years and requires only minimal maintenance expenditure.



Plant based in the cellar: Back right are the retention and sedimentation tanks, in the foreground the four-stage Rotating Biological Contactors. Back left (underneath the two blue pressure vessels) are the clearing tank and the UV unit. Front left are the service water tank and the two rotary pumps.

Reducing the drinking water consumption
When service water utilisation is considered during planning, drinking water saving measures (usually cost-effective) should be exhausted to a large extent. These measures include:

- User information on consumer behaviour Installation of water-saving facilities and fittings:
  - 6-Liter, alternatively, 3-liter toilet flushing tanks or vacuum toilets
  - Flow regulators for fittings (e.g. 9 l/min for showers and 3 l/min for handwash basins)
- Consumption-dependent water billing (if required water metres can be installed)
- Use of water-saving household appliances (e.g. washing machines, dishwashers).

Using service water
Rainwater and greywater are the preferred sources for service water. While rainwater flow is discontinuous and therefore a large rainwater storage tank is required, greywater recycling systems are more compact due to the continuous flow of greywater. Other possible resources of service water such as drainage water, well and surface water in addition to faecal wastewater are not the topic of this brochure.

The cited literature on page 28 provides guidance during the planning of service water plants and to the applicable technology.

Space requirement and treatment expenditure of favoured service water resources

	Space requirement	Treatment expenditure
Precipitation from roof surfaces	high	low
Precipitation from impervious surfaces (e.g. traffic surfaces)	high	medium to high
Greywater from bath tubs and showers (alternatively handwash basins and washing machines)	low	high

Planning Aspects

Infrastructure and load relief effects
On which infrastructure will the planned service water utilisation have its impacts? Which load relief effects will result?

- Drinking water supply
- Water supply for fire fighting
- Sewerage system
- Municipal rainwater retention system
- Wastewater treatment plants
- Receiving water body/water bodies

Factors influencing an economic efficiency evaluation

- Investments taking into account the second pipeline installation
- Maintenance and operation of the system
- Savings made in the connection costs to the available infrastructure
- Reduction in the drinking water and wastewater costs
- Reduction in the rainwater drainage fees
- Other savings (e.g. lower chemical consumption during water processing in industry).

Likewise to be taken into consideration:

- The additional space requirement for the service water system in competition with other uses
- Provision of the proper space (if necessary, provide installations for humidity as well as for aeration and ventilation)
- The energy demand for service water utilsation systems. This should lie below those of the existing centralised drinking water supply and wastewater disposal systems. The energy requirement for greywater treatment including service water distribution should not exceed 2 kWh/m³. For rainwater harvesting systems undergoing no treatment, the energy demand should lie below 1 kWh/m³
- Chemicals should not be used for the treatment and disinfection of service water
- The legal duty to notify the health authorities and the drinking water suppliers (see Annex 2)

- System planners and operators should inform themselves on modified billing modalities by the water suppliers and wastewater undertakings. In Berlin, the installation of additional water metres for rainwater harvesting systems is required.

Quantitative Considerations

Prior to the planning of a service water utilisation system, an assessment of the water quantities involved in the planned object should be made. In doing so, the following questions should be answered:

Drinking water demand
- How much drinking water is expected to be utilised in the planned object?
- Are seasonal fluctuations expected to occur?

Service water demand
- How high is the saving potential for the following application areas as a result of service water utilisation?
- Toilet flushing, urinal flushing
- Irrigation (e.g. garden, facades, green roofs)
- Cleaning purposes (e.g. car wash systems, courtyard cleaning)
- Laundry
- Cooling purposes

Generated water quantities
- Rainwater quantities (taking into consideration the seasonal distribution at the planned site; for larger plants, simulation programmes should be applied)
- Greywater quantities (possibly highly variable dependent on user's behaviour)

Amount of wastewater discharges into the separate or combined sewer systems
- How high is the total amount of wastewater?
- Would an infiltration of the remaining rainwater result in further cost savings?
- Can a connection to the sewer be abandoned?

In case of a connection to the sewer, a cost optimisation calculation is recommended which includes the reduced rainwater fee.

Selection Criteria for Service Water Resources

Rainwater from roof runoff
- For rainwater utilisation without previous treatment, slightly polluted, smooth roof surfaces are mostly suitable.
- Problem roofs (e.g. preferred resting place for birds) should not be connected to the rainwater utilisation system except following an appropriate treatment of the rainwater.
- Uncoated metal and some bitumen roofs result in an increased load of heavy metals or problematic organic compounds (e.g. PAH).
- With planted roofs, significantly less rainwater will be available for utilisation. Choosing a suitable substrate and planting the roof surface will contribute to a negligible foreign matter entry into the cistern. However, a colouration of the water is possible.
- Water quantities entering the storage tank should be maximised.
- Overflow discharges from the storage tank should be infiltrated in order to possibly achieve a complete load relief of the sewer. Infiltration of rainwater from non-metallic roof surfaces requires no permission (14), whereas, rainwater from non-coated metallic roof surfaces should not be infiltrated.
- Many consumers can be supplied with service water without the need for large amounts of drinking water as a mains back-up supply. When using larger systems, a computer-based simulation is recommended.

Rainwater from traffic surfaces

Dependent on the case at hand, properly designed treatment stages should be installed. A simple filtration of the water is insufficient. As is the case with greywater recycling, biological treatment stages followed by UV disinfection appear to be suitable. However, little experience exists so far on the treatment of polluted rainwater for use as service water in buildings.

Greywater

Greywater resources are evaluated differently dependent on the source.
- Wastewater from showers and baths are least polluted, however, those are sometimes insufficient water resources to cover the total demand for toilet flushing.
- Drains from handwash basins usually cause no problems.
- Drains from washing machines (laundry) increase the waste load and as such the treatment expenditure. A connection of washing machines to the greywater system is recommended when other sources are insufficient, whereby a more economic efficiency of the system can be achieved.
- The heavy waste load from kitchen wastewater necessitates a higher treatment and maintenance expenditure. As long as it is not necessary to include kitchen wastewater, one should abstain from discharging it into the greywater system.

Further possible greywater resources in trade/industry are:
- Clear rinse water from restaurants for the

Quality targets for service water

Quality targets	Assessment criteria / Justification		
Nearly free from suspended material, nearly odourless, colourless and clear	For proper functioning of fittings and no comfort loss to the user		
Oxygen-rich	> 50 % saturation for a longer storage period of the service water		
Low BOD[1]	BOD_7 below 5 mg/l to guarantee that the service water has been extensively treated		
Hygienically/microbiologically sound[2]	Total coliforms	0/0.01 ml	(< 100/ml)
	Escherichia coli	0/ 0.1 ml	(< 10/ml)
	Pseudomonas aeruginosa	0/ 1.0 ml	(< 1/ml)

1) The BOD_7 (Biological Oxygen Demand measured over a period of 7 days) is a suitable parameter which gives information on the available biodegradable organic matter in water. For technical reasons, the Total Organic Carbon (TOC) or the Chemical Oxygen Demand (COD) can be also considered as suitable parameters.

2) During greywater treatment especially when more than one housing unit is connected, and when utilising runoff water from paved traffic surfaces, UV disinfection with a minimum dose of 250 – 400 J/m² should be carried out.

immediate use for toilet and urinal flushing
- Shower and bath wastewater in hotels and recreational facilities
- Rinse water from laundry
- Overflow water from swimming pools

Quality Targets

For service water use (in buildings), there exist no legally framed quality or monitoring requirements. However it is recommended to keep to the quality targets listed in the table above.

Taking into consideration the state-of-the-art in the planning, execution, operation and maintenance of the systems in addition to the recommendations listed in this brochure, these quality targets are usually achieved.

During the Expert Symposium "Hygienic Aspects of Rainwater Utilisation" held in Fulda on 21 October 1998 (10), the hygiene experts unanimously agreed that for toilet flushing no drinking water quality is required. Since the hygiene requirements for roof runoffs based on the EU Directive concerning the quality of bathing water (11) are usually maintained even without prior treatment, a routine testing of these systems which treat roof runoffs for the purpose of reuse for toilet and urinal flushing as well as for irrigation purposes is superfluous.

When other sources of roof runoff water are connected to a service water utilisation system in a building, an internal quality control is recommended in this case.

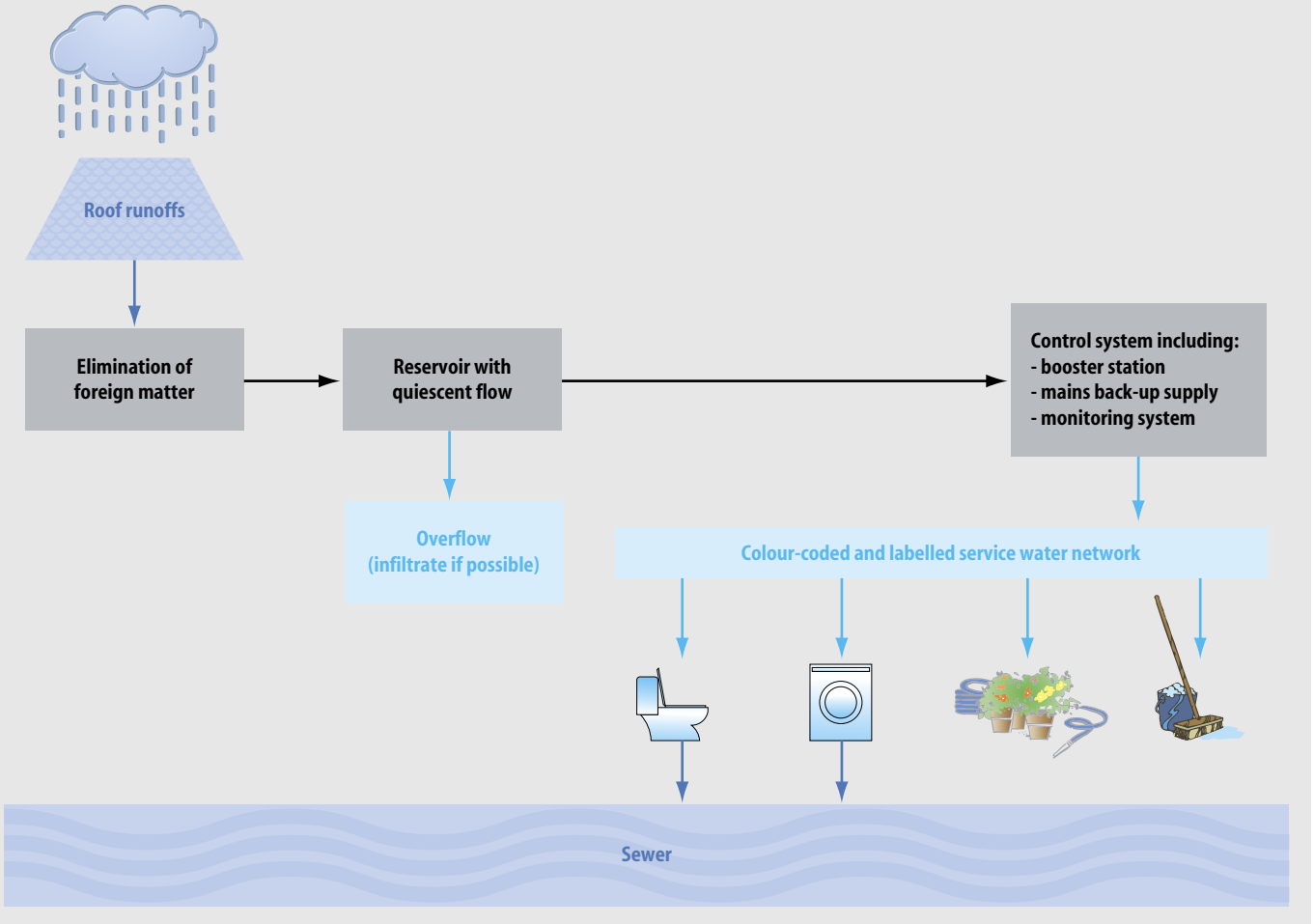
Construction of a Rainwater Harvesting System

Rainwater harvesting systems differ in their configuration especially in the location of the storage tank and the fate of the overflow during a filled volume. The cistern is not always placed above the backwater level. In addition, the overflow cannot be always infiltrated at a low cost according to the Worksheet ATV-DVWK-A 138 (12).

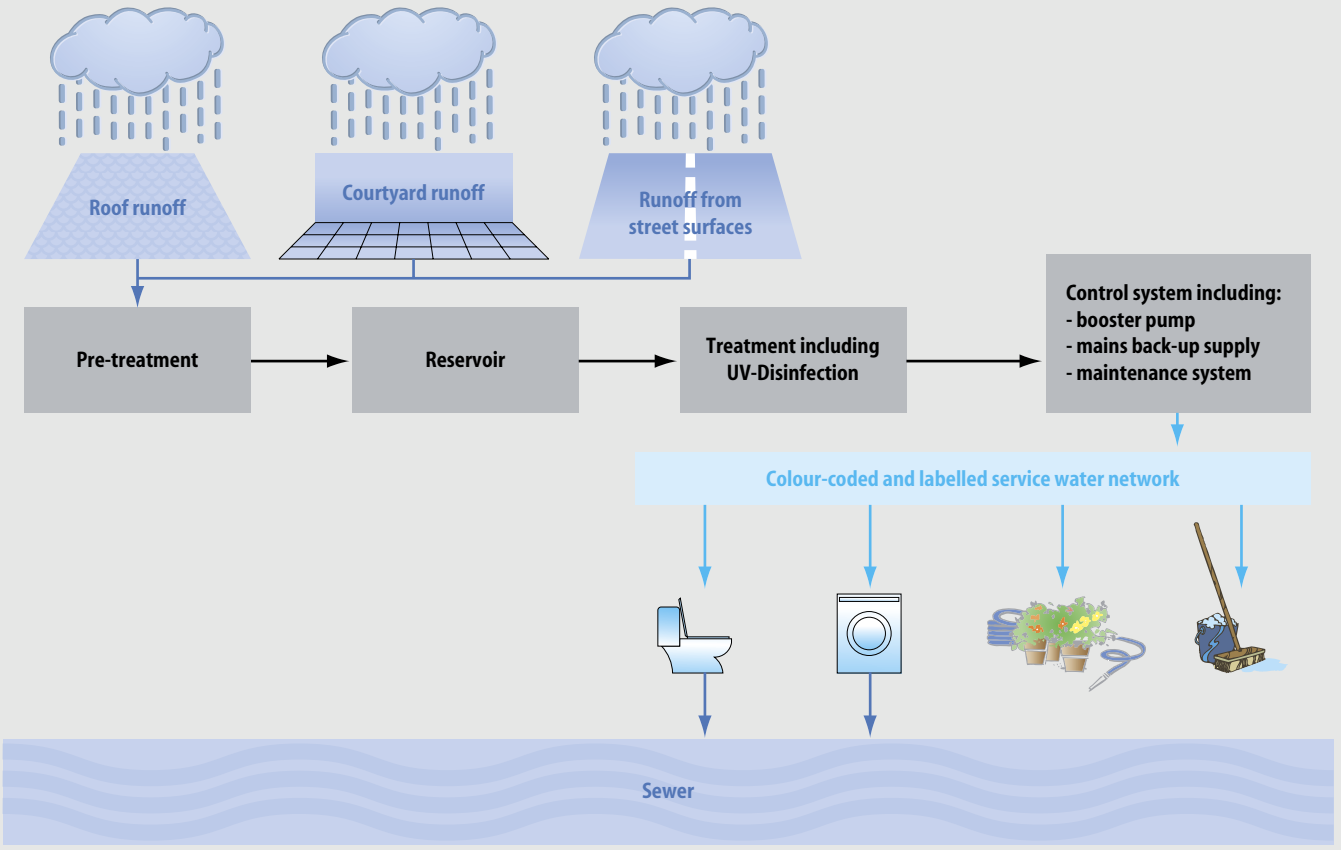
Rainwater from roof runoffs

- If required, rainwater is pre-treated using low-maintenance filters or sieves built into the inlet of the rainwater reservoir keeping water loss minimal.
- Surface or sub-surface water reservoirs are positioned such that rainwater is protected against strong warming, frost and light. The connection levels should be checked. With surface reservoirs, the maximum groundwater level as well as protection against buoyancy in addition to the trafficability and stability against earth thrust should be also checked.
- Water discharge into the rainwater reservoir should be carried out as a "quiescent flow".
- Service water withdrawal should be designed such that no solid material is sucked into the pipes.
- Mains back-up supply should follow only in a free outlet. Using short pipelines and regular, temporary opening of the drinking water supply line, stagnation effects can be avoided.
- Low-noise, durable and low-energy pumps are preferred for use and if necessary, noise control measures should be met. When using suction pumps, the supply line should be always placed in a rising position. Multiple pump system arrangements are indispensable for public institutions and larger buildings.
- During the construction of pressure compensation vessels, radial-flow variants are preferred.
- Service water pipelines, water taps and water metres should be labelled clearly and permanently.
- During infiltration of the excess rainwater or during reservoir overflow into the sewer, the backwater level should be observed. If necessary, wastewater pumps must be installed.
- If required, additional water metres should be installed such that only relevant consumption sites are included (13).

Construction of a service water plant for utilisation of roof runoffs



Construction of a service water plant for utilisation of roof runoffs and runoffs from paved traffic surfaces



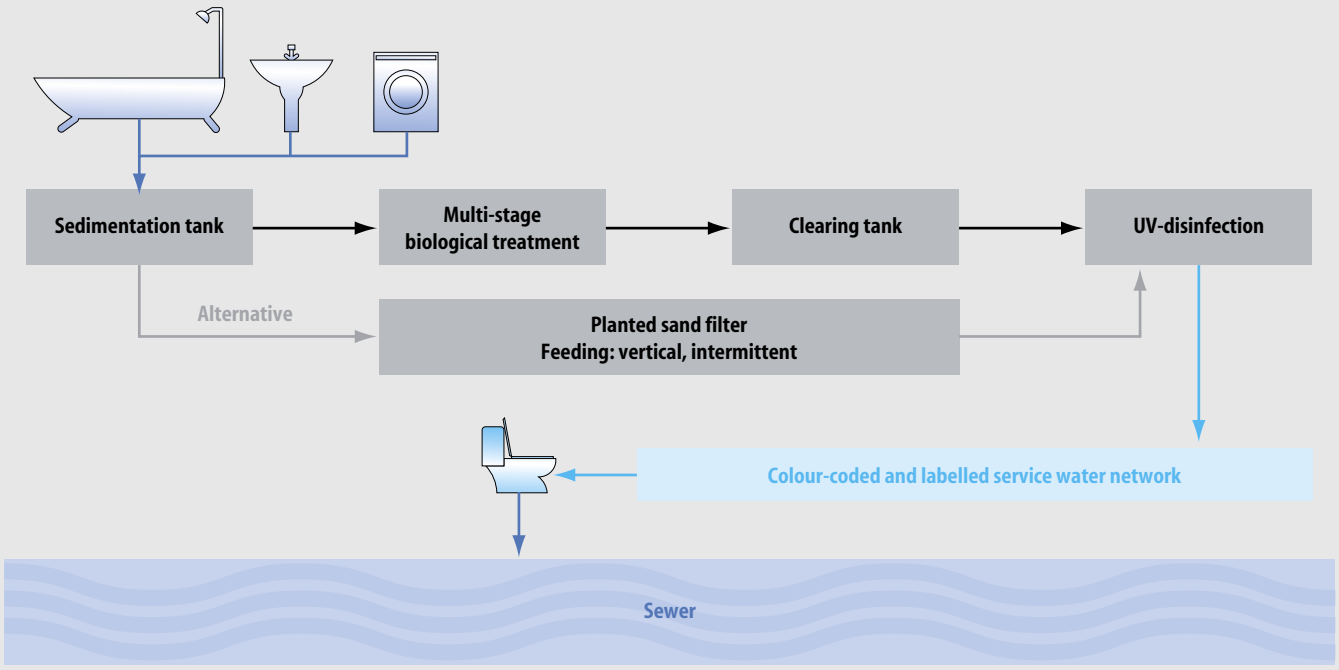
- Withdrawal sites for irrigation purposes are installed in front of the service water metre.

Rainwater discharges from paved surfaces

In addition to the recommendations given for roof runoffs, the following aspects should be also considered when treating heavily polluted rainwater:

- An adequately dimensioned treatment plant is indispensable.
- The selection of site and the degree of pollution of the connected surfaces, for example through dust, abrasion, fuel residues and dog droppings, determine the treatment expenditure.
- An intermittently-fed, planted substrate filter followed by UV disinfection and connected to a monitoring system has proved to be very efficient.

Construction of a greywater recycling system



Construction of a Greywater Recycling System

Similar to rainwater harvesting systems, there are different configurations which cannot be considered here in details. Contrary to rainwater utilisation from roof runoffs, treatment of greywater is necessary in every case. Water quality requirements which apply usually to small wastewater treatment plants are inadequate for the purpose of service water utilisation. In order to keep the maintenance expenditure as low as possible, contaminants in form of hair, fat and problematic wastewater fractions should be removed in a pre-treatment stage.

Greywater utilisation in buildings

An adequately dimensioned treatment plant for greywater processing is indispensable.

In the practice, multi-stage, biological treatment plants consisting of sedimentation and final clarification stages in addition to a UV disinfection stage and a monitoring facility have shown best results. This is achieved as:

- multi-stage Rotating Biological Contactors (RBC)
- multi-stage fluidised bed reactor
- vertical-flow, planted soil filter

At the present time, it is advised against using:

- a trickling filter filled with lava stones (based on the conventional design)
- exclusively horizontally-fed soil filters
- systems with a polishing pond installed prior to the service water tank

Greywater utilisation in dwellings (flats)

- The utilisation of wastewater from own shower and bath tub is regarded less critical than the utilisation of wastewater originating from the same sources from a larger community. Treatment plants are in both cases indispensable. However, it is recommended that the quality requirements listed on page 21 should be guaranteed by the manufacturer.
- Sole aeration of the greywater tank is insufficient
- Biological treatment stages such as planted soil filters and compact treatment systems using a fluidised bed have proved their efficiency.

Certain important factors should be considered and clarified at an early stage. In addition to the legal requirements which should be fulfilled in all cases, the responsibilities and liabilities for the maintenance and operation of these plants could, if necessary, be clarified in an operator contract.

Funding possibilities

In Berlin, general funding for service water utilisation plants is not available. Nevertheless, a request for funding possibilities should be made at the Investment Bank of Berlin (IBB) and the responsible Senate departments especially for the commercial sector.

Building permission

Building Law is Federal Law. The procedural handling of a project conforms with the regulations of the respective Federal Building Law. The exemption of certain constructional works or other systems from building control procedures can be regulated through special statutory regulations ("Exemption Regulation").

In addition, projects which require no permission must conform completely with all substantial regulations that may come into consideration (according to all Federal Building Laws). In this case, service water utilisation plants are arranged, produced and maintained such that they are safe to operate and will cause no risk or nuisance.

Service water utilisation is not explicitly mentioned in Berlin Laws. However, the basic principle holds that rainwater remains on the property and no legal claim exists for its drainage.

The following Berlin Laws and Regulations also apply to service water utilisation.
In the broadest sense, water supply systems, to which components of a service water system also count, require no permission if they are designed for a water demand of less than 20 m³/day (Section 38, Paragraph 1 of the Berlin Water Law[1]). According to Section 40, Paragraph 2 of the Berlin Building Law (BauOBln[2]), a mandatory connection to the public sewer does not apply when retention or infiltration measures are laid down in a land-use plan or otherwise designed or approved.
Wastewater and rainwater plants do not require a building permission according to Section 55, Paragraph 2 (BauOBln2) in connection with Section 56, Paragraph 1, No. 3 b, c and d.
The construction of the plants is not subject to a preventive control by the building inspection authorities.

Consent of the water authorities

Utilisation of rainwater
Basically, the utilisation of rainwater is advocated and supported and as far as the water authorities are concerned requires no permission. In general, drainage of the reservoir overflow is also permit-free only if it is dealing with a broad infiltration over the vegetation zone of the existing site. Directed infiltration using troughs or underground facilities such as infiltration ditches and pits and in the area surrounding the reservoir, requires a permission from the water authorities (5). The obligation to obtain a permission is for systems outside water protection areas into which only slightly polluted rainwater is discharged and which are not considered as contaminated sites, has been cancelled through the enactment of the "Rainwater Exemption Regulation" (14). A connection to a sewer of the Berliner Wasserbetriebe requires also a permission from the water authorities for an indirect discharge when the drained water is contaminated, as is the case with traffic surfaces and metal roofs.

Utilisation of greywater
Generally, no consent is required for greywater utilisation. However, the infiltration of treated greywater requires the approval of the water authorities. In water protection areas, overflow discharge with subsequent infiltration is prohibited.

Anmerkungen:
1 BWG vom 3. März 1989 (GVBl S. 605 u. ff) zuletzt geändert durch Artikel LV des Gesetzes vom 16. Juli 2001 (GVBl Nr. 29, S. 260)
2 Bauordnung für Berlin, letzte Änderung vom 16. Juli 2001

Information of the local water undertaking

- According to Section 3 (meeting water requirements) of the AVBWasserV (15)
  - the customer is entitled to a part exemption from the mandatory connection and use fees,
  - the customer is obliged to inform the water undertaking (exception is garden irrigation from rainwater tank).
- With rainwater utilisation plants, the reduction of or exemption from the rainwater discharge fees should be applied for.

Informing the local public health department

According to the amended Drinking Water Ordinance that came into force on 1 January 2003, service water utilisation plants must be reported to the local public health department. This applies to the construction as well as the start-up and shut-down of the plants (Section 13, Paragraph 1 & 3). The public health departments examine service water utilisation plants in schools, kindergarten, hospitals, restaurants and other public facilities (Section 18, Paragraph 1) (6).

Technical regulations and notes

The most important technical regulation for rainwater utilisation plants is DIN 1989-1 (8). Point 2 includes several normative references such as:

- DIN 1986: Connections to the sewer are to be secured against backwater
- DIN 1988 Part 2 Paragraph 3.3.2: Labelling and safeguarding of withdrawal points which are supplied with service water; designation with "No Drinking Water " or "Service Water" and / or a corresponding symbol
- DIN 1988 Part 4 Paragraph 4.2.1: Mains back-up supply unit as a free outlet
- DIN 2403: Identification of the pipelines.

DIN 1988 is expected to be completely replaced with DIN EN 1717 in 2006.

Furthermore, two technical notes of the Association for Rainwater Harvesting and Water Utilisation (fbr) and one ATV-DVWK worksheet should be also referred to:

- fbr Technical Note H 201: Greywater recycling systems for households and the public and commercial sector (9)
- fbr Technical Note H 101: Combination of rainwater utilisation with rainwater infiltration
- ATV-DVWK Worksheet A 138: Planning, construction and operation of systems for rainwater infiltration (12).

For the purpose of connecting the washing machine to the service water network (private dwellings excluded), an optional connection to the drinking water network must be made available according to the Drinking Water Ordinance.

Operation, maintenance and monitoring

The responsibility for the operation of a service water plant lies solely by the operator. In the event of system damage and at the same time a verified cross-connection to the drinking water network, the operator is committed to supplying evidence which proves that the identified drinking water contamination is not a result of his defective service water plant.

According to the AVBWasserV Section 12 Paragraph 2, plant construction in addition to any major changes should be carried out only by installation firms which are registered in the directory of a water supply undertaking (15). The service water plant should be operated exclusively by responsible and assigned persons.

Directions for use and operation manuals as well as circuit and flow chart diagrams should be made available by the plant manufacturer or planner. They should give information on the following details:

- System function
- Operation of equipment
- Maintenance plan
- Safety regulations that should be taken into account particularly during maintenance
- Responsible person in case of breakdown events (firm, name, address, phone, facsimile and e-mail)
- Indicate the fact that the operator is eventually responsible for everything and if necessary can be held liable.

According to the Product Liability Law, the manufacturer is also held legally responsible in case of defective or incomplete directions for use.

In order to guarantee a safe and unobstructed operation, all possibly involved persons should be properly informed:

- User information (through rental agreement, announcement or letter)
- Information to technicians to announce the presence of a service water plant in the building
- Clear labelling of service water pipelines, shut-off valves and water metres.

Start-up of Operation

- The operator is advised to request for a completion certificate from the executing firm upon accomplishment of operation.
- Service water supply from greywater systems or plants treating rainwater from paved surfaces should take place only following a start-up period and a successful trial operation according to the manufacturer's instructions.
- Service water tap connections are to be secured against misuse either using a socket wrench or a lockable tap connection. Cross-connections should not exist to the drinking water network.
- Maintenance performance according to the maintenance manual and keeping an operation record book are strongly recommended (compare Annex 3). Furthermore, the local health department strongly advises to adhere to the quality targets listed on page 21 of this brochure and to document the investigation results when planning large systems supplying a third party.

Recommendations for larger systems

Especially for greywater systems and systems which treat rainwater from paved surfaces designed for multiple accommodation units:

- It should be demonstrated (at least once) that the system at hand is capable of fulfilling the established quality requirements following a deliberate contamination of the water (e.g. following inocculation with coliform bacteria at about 10^5 - 10^6 bacteria/ml measured in system influent).
- It is recommended to temporarily dye the service water (e.g. using a food pigment) during start-up of operation of larger systems or following the completion procedure in order to ensure that no cross-connections exist to the drinking water network (compare Annex 1).
- A control device should guarantee through automatic shutdown or diversion that no insufficiently treated or disinfected wast water enters the service water cycle.
- In the context of internal quality control, service water from greywater recycling systems with disinfection units and systems that treat runoff water from paved surfaces should be tested at least once a year for the already listed parameters by a qualified laboratory (compare page 21).
- A demonstrable high operational safety of the system engineering as well as a demonstrable low contamination potential of the treated service water justifies longer time intervals of the system internal quality control.

Taking into consideration the state-of-the-art during the planning and construction of service water systems, as well as the recommendations and quality targets listed in this publication, a health hazard for the consumer can be excluded provided the system is operated, maintained and used properly.

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Inspection of the service water pipelines for possible cross-connections with the drinking water network

To exclude improper connections, an inspection of the pipeline network should obligatorily take place whereby two methods are available for testing:

1) Shut-off of the drinking water main supply pipeline in the building
2) Dyeing of the service water

With a single-family household, it is usually easier to shut off the drinking water main supply pipeline for a short time. With larger projects this is usually not possible since either the interruption of the water supply is not desired or the inspection requires a longer period of time. In this case, temporary dyeing of the service water using a food pigment (e.g. blue pigment E 132) or potassium permanganate (red pigment) is recommended.

As to 1) Shut-off of the drinking water main supply pipeline in the building:

When the drinking water main supply pipeline is shut off
and the service water supply is turned on,
- water should not flow from any drinking water tap or other drinking water use site,
- all service water taps and use sites should be supplied with service water.

As to 2) dyeing of the service water:

The dyeing procedure should be only of a short duration, however, it should last so long until all tap and supply sites have been inspected. If service water is used exclusively for toilet flushing, the dyeing procedure can take place over a longer time period. If service water is to be used for the washing machine, only a small amount of the water should be dyed.

Approach:
- Immerse the suction hose of the pump or the whole submersible pump in dyed water during pipeline inspection
- Inject the dye into the pump and the pressure boiler
- Dye the whole content of the service water tank.

Potassium permanganate as well as E 132 are readily soluble in water and give a strong colouring at a concentration of 0.1 g/l (100 g/m3) (1:10,000). In a drinking water glass against a white background, one can reliably identify the colouring even at a 20-fold dilution (concentration 1:200,000).

Since dilution of the water can take place during cross-connections, it is recommended to dye the service water at a concentration between 1:10,000 and 1:40,000. One kilogram of the food pigment costs between 20 and 50 Euro and is sufficient for 40,000 litres.

Source: Nolde & Partner

Sender (Entrepreneur, Owner)
Surname, Name
Firm
Address
Post code / Place
(Code) Phone / Fax / e-mail

To the District Council

_____ **of Berlin**

- Health Department -

_____
Street, House Number

_____ **Berlin**
Post Code

1. With this I notify the following:

☐ The operation of an already existing plant
☐ Start-up of operation of a plant
☐ A repeated start-up of operation of a plant
☐ Shut-down of a plant

On _____
Date

Cistern capacity: _____ ca. m³

2. Plant location:

_____
Address

_____ Berlin
Post Code

_____
Building / Part of Building

_____
Kind-of-use of the building

3. Origin of the service water:

☐ Home wells
☐ Roof runoff
☐ Surface water
☐ Greywater
(from bath, shower, handwash basins, washing machine)
☐ Other:

_____

4. Source of the mains back-up water supply:

☐ Central drinking water supply
☐ Other:

_____

5. Drainage of the surplus service water takes place in / through:

☐ Separate sewerage system
☐ Combined sewerage system
☐ Infiltration
☐ Other:

_____

Announcement according to Section 13 Paragraph 3 of the Drinking Water Ordinance

- Utilisation of a Service Water Plant -

6. Contact person on site:

_____
(Title) Surname, Name

_____
Address

_____
Post Code / Place

_____
Phone / Fax

7. General information:

a) How many accommodation units will be supplied with service water? _____ Number

b) How many consumers will be supplied with service water? _____ ca. Number

c) What are the estimated generated annual quantities of service water? _____ ca. m³

d) Did you conclude a maintenance contract? ☐ Yes / ☐ No

e) What is being supplied with service water?
☐ Toilet
☐ Washing machine
☐ Garden irrigation
☐ Other:

_____

8. Have the following requirements been considered?

a) Was the plant installed by a certified skilled firm? ☐ Yes / ☐ No
(If yes, please enclose reference)

b) Are the pipelines clearly colour-coded and labelled and the withdrawal sites clearly designated with the inscription **"Service Water – No Drinking Water"** (Section 17, Paragraph 2 TrinkwV 2001)? ☐ Yes / ☐ No

c) Does the mains back-up water supply from drinking water take place exclusively as a free outlet? ☐ Yes / ☐ No

d) Is a maintenance plan available? ☐ Yes / ☐ No
(If yes, please enclose reference)

_____ _____
Place, Date Signature

Start-up of operation, briefing, inspection and maintenance

Protocol form

Project
Operator
Executing firm

	Start-up of operation	
1		
2		
3		
4		
5		
6		
7		
8		
9		

(Place, Date) Operator's signature

Signature of executing firm

	Inspection	**every .... months**	**carried out**	**carried out**
1				
2				
3				
4				
5				
6				
7				
8				
9				

	Maintenance	**every .... months**	**carried out**	**carried out**
1				
2				
3				
4				
5				
6				
7				
8				
9				

Executing firm

Signature of executing firm

Source: Klaus, König: das Handbuch der Regenwassertechnik,
Publisher: V.Wilo-Brain, Dortmund 2001. Compare Annex B DIN 1989-1 and Table 5 DIN 1989-1.