

02.11 Water Conservation Districts and Groundwater Use (Edition 1995)

Overview

The drinking water needs of Berlin are met primarily by groundwater. The drinking water supply is managed by the **Berlin Public Water Companies**. Water supplies are partially obtained as bank filtered water: surface waters filter through the soil and are withdrawn by extraction wells near the banks). Some surface water are diverted into groundwater recharge plants to percolate into groundwater, which will then be withdrawn for use.

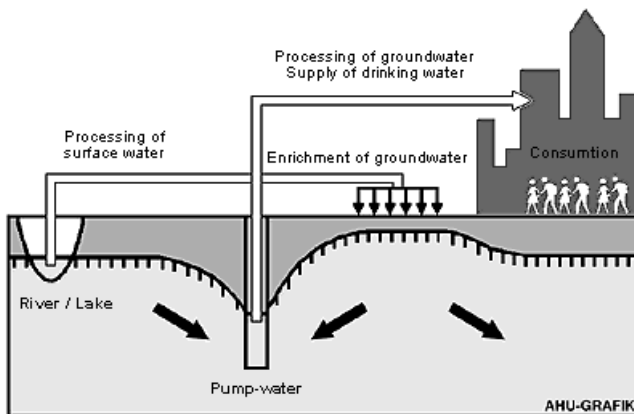
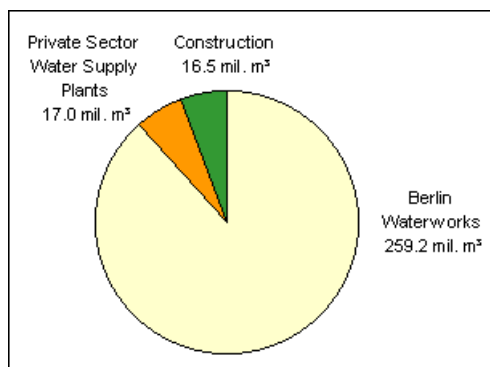


Fig. 1: Principles of Groundwater Production (AHU 1991)

There is also a number of smaller production plants, the **private sector water supply plants**, which withdraw groundwater for private sector purposes, mostly industrial, or withdraw groundwater for public facilities.

Construction increased considerably after the unification of Berlin in 1990. **Groundwater retention** is practiced during construction when groundwater is withdrawn. This occurs according to construction activity at various locations and in variable amounts. Especially deep and/or large construction projects use the trough construction method which spares groundwater. This method requires the withdrawal only of small remainders of water.

Drinking water is supplied by 12 waterworks of the Berlin Public Water Companies. Production at the Riemeisterfenn Waterwork was temporarily discontinued in March, 1995. The Berlin Public Water Companies withdraws water from 1,200 groundwater extraction wells. The waterwork wells are safeguarded as water conservation districts to protect water from pollution; certain activities and uses are forbidden in these areas.



*Fig. 2: Groundwater Withdrawal Amounts in Berlin According to Use in 1995 (including Stolpe Waterwork)
 Statements for groundwater recharge at construction sites refer to the calendar year; statements for raw water extraction refer to the water management year Nov. 1994 to Oct. 1995.*

West Berlin

There were 7 waterworks in the **western part of the city** in 1995. The Riemeisterfenn and Spandau Waterworks were protected by the Allied (U.S./French/British Occupation Authorities) Water Conservation Zone Ordinance of 1946. The 5 other drinking water conservation districts were determined by the Water Balance Law (Wasserhaushaltsgesetz - WHG), the Berlin Water Law (Berliner Wassergesetz - BWG) and the respective regulations for determination of water conservation districts for the waterworks in Kladow, Beelitzhof, Tiefwerder, Jungfernheide and Tegel. A regulatory draft for the Spandau drinking water conservation district exists (cf. Tab. 1).

Tab. 1: Waterworks of the Berlin Public Water Companies and Statutory Framework for the Water Conservation District Designation	
Statutory Framework	Waterworks
Water Conservation District pursuant to Berlin Water Law (BWG) in concurrence with the Water Balance Law (WHG)	Beelitzhof Tiefwerder Jungfernheide Tegel Kladow
Water Conservation District according to Water Authority Directive for the Provisional Protection of Berlin Conservation Districts and Reserved Areas	Buch Friedrichshagen Köpenick Altglienicke (not currently producing) Johannisthal Wuhlheide Kaulsdorf Friedrichsfelde (closed down) Eichwalde Erkner Staaken (West-Staaken) Parts of the Water Conservation Districts Eichwalde, Erkner, and Staaken (West-Staaken) are situated in Berlin and in Brandenburg.
Water Conservation Zone after assumption of Allied Ordinances	Spandau Riemeisterfenn (not currently producing) Teufelssee (closed down)
Brandenburg Water Law (BbgWG) 1994	Stolpe

Tab. 1: Waterworks of the Berlin Public Water Companies and Statutory Framework for Water Conservation Districts

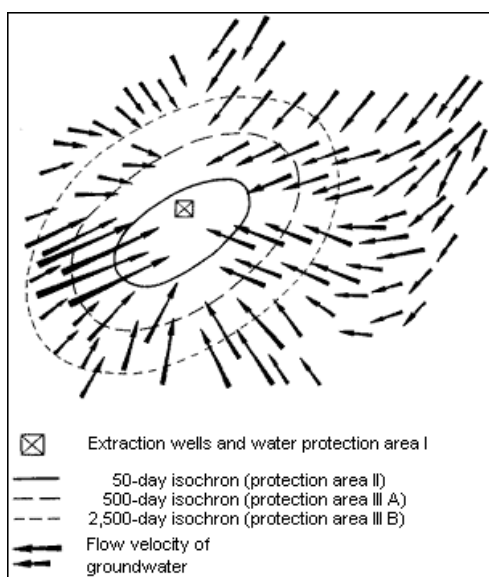
Water conservation zones in areas regulated by Section 4 of the **Magistral Ordinances** of 8 October 1946 were determined use limitations. This ordinance proceeded from an order of the Allied Commandant of Berlin, valid for all Berlin. The conservation zones are divided into a narrow conservation zone with a radius of 100 m around extraction wells, and into a wider conservation zone with a radius of 500 m. The Spandau Waterwork is still protected by this ordinance. This ordinance will be replaced by a water conservation district regulation according to the Berlin Water Laws in the next few years.

Water conservation districts in the western part of the city are determined by Section 19 of the **Water Balance Law** (Wasserhaushaltsgesetz - WHG) or Section 22 of the **Berlin Water Law** (Berliner Wassergesetz -BWG). They are divided into 3 conservation zones with differing protection status; certain actions are forbidden or permissible with limitations. The borders of conservation districts and descriptions of limitations of use are defined in the regulations for each area.

The area size of the conservation zones is measured according to the DVGW Regulatory Rules "Guidelines for Drinking Water Conservation Districts" (DVGW-Regelwerk "Richtlinien für

Trinkwasserschutzgebiete"). The areal extent of Zone I is generally at least 10 m surrounding the extraction well. Zone II reaches from the border of Zone I to a line at which groundwater requires 50 days to seep into the extraction well feed area. Zone III comprises the area from the outer border of Zone II and the border of the subterranean water catchment area. If the catchment area is larger than 2 km, a subdivision into Conservation Zone III A and III B is possible. Local hydrogeological conditions must be considered in the determination of conservation districts; a universal pattern may not be applied.

The rigid radius drawn around the extraction well does not take into account the differing hydrological and geological conditions in the catchment areas of the individual water withdrawal sites. The water conservation districts of Tegel and Jungfernheide were redefined on 31 August 1995. Their borders were determined by different criteria, according to the **isochronic concept** (cf. Fig. 3). The isochronic concept determines the size of water conservation districts and their geometric forms in hydraulic terms: from the flow time of water to the removal site. Lines of identical flow time are called isochrons. The determination of the isochrons, and thus the conservation district borders, proceed from hydrogeologic examinations of a given area. A regional groundwater flow model is developed for this area. The goal of the concept is to have sufficient time for damage control should soil (and/or groundwater) be contaminated. The determination of conservation district borders then follows under consideration of these isochrons, according to DVGW Regulatory Rules.



*Fig. 3: Example for Definition of a Water Protection Area According to the Isochronic Concept
The flow velocity of groundwater is indicated by the length of the arrows. The longer the arrow, the higher the flow velocity.*

Use limitations within conservation districts were supplemented and extended in the course of revising the Water Conservation District Regulations according to the isochronic concept.

East Berlin

Water conservation districts in East Berlin were defined under GDR law. The legal basis is the Water Law of the GDR in its 3rd Implementation Ordinance (Durchführungsverordnung) of 2 July 1982 in regard to conservation and reserved areas. The East Berlin conservation districts were enacted at the 14th Berlin city council meeting on 19 October 1984.

The GDR determined **reserved areas** for future water supply production, where no groundwater was withdrawn. Special use limits were in force in these areas, as given in the Water Law of the GDR or in TGL 43271 of September 1984.

The border between West Berlin and the GDR was an unnatural border in the definition of water conservation districts and against the given geological and morphological conditions of the area. Conservation districts were forced to end at the political border. The new definition of drinking water conservation districts can finally resolve this problem properly.

The 5 waterworks located in the eastern part of Berlin will be protected until a final new definition of water conservation districts is made according to Federal German law by 1999. This protection takes place

under Berlin Water Law by a directive of the Water Authority Directive for the Provisional Protection of Berlin Conservation Districts or Reserved Areas of the Waterworks, dated 11 October 1993, latest revision 27 February 1996. Use restrictions under this directive are similar.

Water conservation districts in the surrounding areas of Berlin are defined according to GDR law. New demarcations and changes of conservation districts, as well as changes in protective status or area size are to occur after the passage of drinking water conservation district ordinances for each waterwork according to the Water Law of the State of Brandenburg. An ordinance determining the water conservation district for the Stolpe Waterwork in Brandenburg is being prepared according to the Brandenburg Water Law (Brandenburger Wassergesetz - BbgWG) of 13 July 1994.

Use Restrictions in Water Conservation Districts

Water conservation districts have protective zone categories with differentiated **use restrictions**.

Conservation Zone I prohibits all activities except for those measures required for water supply purposes.

Conservation Zone II prohibits:

- the erection or alteration of constructed facilities (residential buildings, industrial facilities, streets) with the exception of alterations in buildings;
- the erection and operation of facilities for dealing with substances harmful to water and the transportation of substances harmful to water through pipelines;
- the discharge of waste water and non-purified rain water into surface waters;
- the use of fertilizers, insecticides, herbicides and pesticides;
- the removal of water and solid materials from the subsoil and from openings in the earth.

Conservation Zone III prohibits:

- the discharge of waste water into the subsoil with the exception of the spraying or seepage of rain water through the topsoil;
- activities which enable the penetration of pollutants into surface waters, the subsoil or groundwater; in particular the dismantling and repair of motor vehicles, including the changing of oil on unstabilized soil;
- the erection, rebuilding, extension or basic alteration of buildings, unless there is a complete and proper waste water drainage by sealed pipelines into public waste water facilities, or the collection of drainage in permanently sealed pits with proper disposal;
- the erection and operation of dumps for waste harmful to water and/or waste disposal facilities which require planning approval;
- the construction of gravel pits, the placement and storage of materials harmful to water directly on the subsoil, particularly for the construction of streets, canals, and paths; with the exception of small improvements with no danger of contamination;
- the construction or extension of drains for dewatering the subsoil.

The protective regulations of Conservation Zone III apply to the narrow Conservation Zone II and for the captation area (Zone I). The protective regulations for the narrow Conservation Zone II apply to the captation area (Zone I).

The prohibitions of Conservation Zone III as well as two prohibitions of Conservation Zone II apply to the Plänterwald and Gosener Wiesen reserved areas. These areas are part of the conservation district of the Johannisthal Waterwork and/or the Friedrichshagen Waterwork.

There is also a number of smaller groundwater supply facilities in the private sector, usually for industrial purposes, or commissioned by public facilities. Water is withdrawn and treated in these **private sector water supply plants** by users themselves. These plants are usually established and run by industrial and commercial operations, but also by public institutions such as hospitals and swimming facilities. The groundwater they withdraw is used as drinking, operating, and cooling water, and to water plants, lawns and meadows. Both the Berlin Public Water Companies, private sector water supply plants require official permits or special approval with specified use considerations and restrictions. These are mandated by the Berlin Water Balance Law or the Berlin Water Law. There are no conservation zones for private sector plants.

Statistical Base

The demarcation of **water conservation districts and zones** and the location of **wells and well galleries** followed the large-scale maps of the Berlin Public Water Companies and the Berlin Department of Urban Development, Environmental Protection and Technology. Amounts withdrawn by waterwork wells or well galleries and groundwater recharge plants are set by the Public Water Companies. The location and withdrawal amounts of **private sector water supply plants** are taken from the databank of the Work Group Water Management Bases (Arbeitsgruppe Wasserwirtschaftliche Grundlagen) of the Berlin Department of Urban Development, Environmental Protection and Technology.

The withdrawal amounts of private sector water supply plants and of waterworks or well galleries are based on the **water management year** November - October (Wasserwirtschaftsjahr - WWJ). Figures for Berlin Public Water Companies facilities and private sector water supply plants correspond to the 1995 water management year; for the Brandenburg waterworks, water management year 1993. Groundwater recharge plant quantities refer to calendar year 1995.

Water processing at the **Teufelsee** Waterwork was ended in 1970; at the Friedrichsfelde Waterwork in 1993. The Köpenick Waterwork has only processed drinking water since 1988. Its production is included in the raw water production of the Friedrichshagen Waterwork. No water is being produced from the waterwork wells at Altglienicke and Riemeisterfenn or from the partial gallery at **Nikolassee** (Beelitzhof Waterwork).

The withdrawal amounts for the Brandenburg waterworks were made available by the State of Brandenburg Ministry for the Environment, Conservation, and Regional Planning. The delineation of **Brandenburg waterworks** protection areas was made available by water supply operators themselves.

Methodology

Depicted for Berlin are the private sector water supply plants registered with the Berlin government. Single wells on private property which decentrally serve domestic water consumption are generally not depicted. None could be depicted for the state of Brandenburg because data was not available.

Raw water withdrawals from groundwater are depicted. Portions of groundwater withdrawn by the Jungfernheide Waterwork (water management year 1995, 4.1 mil. m³) serve internal operating purposes, or are used to protect other wells (groundwater restoration) against threats to their quality. This water was purified and discharged into the Spree river and was not available for drinking water supplies. The Johannisthal Waterwork produced 5.9 mil. m³ of groundwater from the protection wells of the Alte Königsheide and the Teltow canal galleries in calendar year 1995; this raw water was purified in percolation basins and discharged into the Teltow canal. Gallery A of the Friedrichshagen Waterwork produced 840,760 m³ from May, 1995 to the end of the year; this water was discharged to the Münchenhofe (Brandenburg) clarification plant, processed and discharged through the Erpe into the Spree river. 157,680 m³ of groundwater withdrawn by a Gallery I well of the Friedrichshagen Waterwork in 1995 was discharged into the Krumme Lake biotope and was not available to drinking water supplies.

The selected map scale of 1 : 50,000 does not allow Berlin Public Water Companies wells to be depicted individually, but only as **well gallery**. The depiction of Conservation Zone II in the former West Berlin and the captation zone (Zone I) are also missing.

Private sector water supply plants are depicted with current **production** amounts. Not all facilities need water for drinking water purposes. Facilities which must have **drinking water quality** are indicated.

Map Description

Berlin Public Water Companies waterworks (except the Buch Waterwork) are located in the Warsaw-Berlin pleistocene watercourse or the Havel channel. Private sector water supply plants are located throughout the city.

The **Stolpe** Waterwork is located in Brandenburg. It is operated by the Berlin Public Water Companies and serves the drinking water supply of Berlin and a few nearby communities in the state of Brandenburg. The conservation districts of the **Staaken**, **Eichwalde** and **Erkner** Waterworks, which serve communities in the vicinity of Berlin, are located both inside and outside Berlin. These conservation districts are maintained under the Water Authority Directive for Provisional Protection of Berlin Conservation Districts, or under a Brandenburg ordinance.

Two **reserved areas** for future drinking water supplies were defined in Berlin: Plänterwald and Gosener Wiesen. They are located in direct vicinity to Conservation Zone II in existing water conservation districts.

Withdrawal Amounts

Amounts withdrawn by the Berlin Public Water Companies have risen ever since the beginning of public water supplies (cf. Tab. 2). A clear reduction of withdrawal amounts occurred after World War II. West Berlin withdrawal amounts steadied in the mid-70's. In East Berlin there was a continual increase until 1989 (cf. Fig. 4).

Tab. 2: Groundwater Withdrawals 1913, 1990 resp. 1989 and 1995					
	Groundwater Withdrawals (million m ³)				
	Pre-War Berlin 1913	Berlin 1989/90 ¹⁾²⁾	West Berlin 1989/90 ²⁾	East Berlin 1989/90 ¹⁾²⁾	Berlin 1995
Berlin Public Water Companies	73.9	324.0	191.6	132.4	259.2
Private sector water supply plants	20.0	41.6	24.3	17.3	17.0
Groundwater retention at construction sites	20.0	12.7	5.7	7.0	16.5
Total	113.9	378.3	221.6	156.7	292.7
Groundwater withdrawals per inhabitant (liters/day)	143.0	302.0	281.0	336.0	231.0

¹⁾ Including Stolpe Waterwork
²⁾ for Berlin Public Water Companies and population 1990, all other figures from 1989

Figures for withdrawal amounts of commercial and domestic water supply facilities in East Berlin contain only facilities with a permitted withdrawal amount of > 73,000 m³ per year. The figures are of raw water withdrawals. In 1989 resp. 1990 East Berlin figures refer to the calendar year; West Berlin figures to the water balance year. In 1995 figures for Berlin Public Water Companies refer to the water management year; for construction to the calendar year.

Tab. 2: Groundwater Withdrawals 1913, 1990 resp. 1989 and 1995

In 1989, the Berlin Public Water Companies (including Stolpe Waterwork) removed 358.4 mil. m³ of raw water from groundwater. In 1995, 259.2 mil. m³ of raw water were produced (including Stolpe Waterwork). The withdrawal volume of the Berlin Public Water Companies sank 23 % from 1989 to 1995 (cf. Fig. 4). Factors for reduced raw water production were: the closure of many industrial facilities in East Berlin; price structures of the waterworks (increased price for water); and improved technologies which enabled domestic consumers to reduce use.

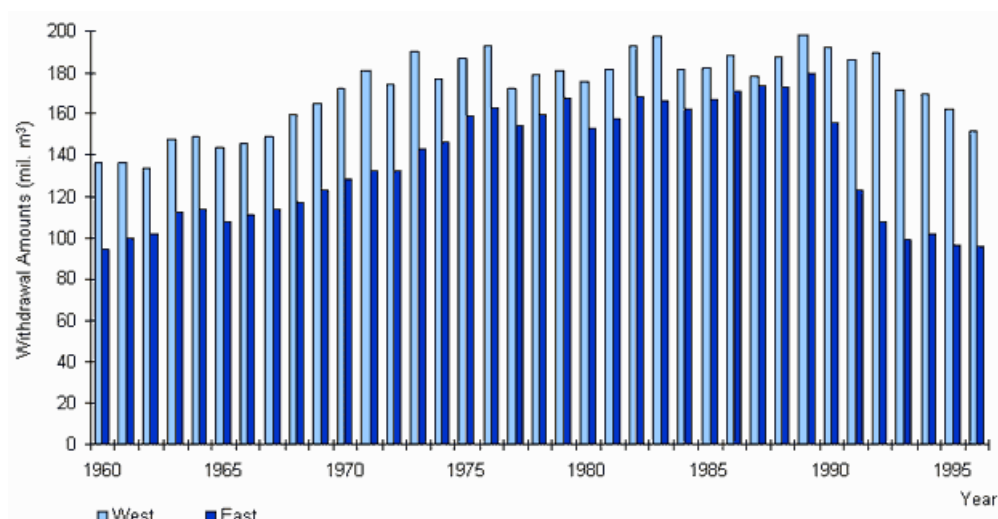


Fig. 4: Groundwater Withdrawal Amounts of the Berlin Public Water Companies 1960 - 1996
 Figures are for withdrawals of raw water and refer to (including Stolpe Waterwork) the water management year. The sum for 1973 includes 8.2 mil. m³ for filling Teufelssee lake in Grunewald. Figures include Jungfernheide Waterwork amounts mainly used for restoration of groundwater and not for the drinking water supply: 1990, 5.7 mil. m³; 1995, 4.1 mil. m³; 1996, 3.4 mil. m³. Figures for the Friedrichshagen Waterwork 1996 water management year include 1.8 mil. m³ from Gallery A which were discharged to the Münchehofe clarification plant; and 158,040 m³ of a Gallery I well discharged to the Krumme Lake biotope. This water was not used for the drinking water supply.

In 1989, **private sector water supply plants** removed 41.6 million m³ (17.3 million m³ of it in the eastern part of the city). In 1995, the 276 private sector water supply plants in Berlin removed 17.0 mil. m³ of groundwater. This water was used as drinking, operating, and cooling water, and for plants, lawns and green areas. The 49 plants which also remove for drinking water are specially monitored to maintain a water quality fit for human consumption. In 1995, the 10 private sector water supply plants in the eastern part of the city removed 1.16 mil. m³; the largest removers in the western part withdrew about 899,024 m³ a year. Production volumes of private sector water supply plants in the entire city are going down. Figure 5 shows the course of groundwater removals by private sector water supply plants in the western boroughs. There is a tendency to close such plants, primarily for economic reasons, and to take water from the public network.

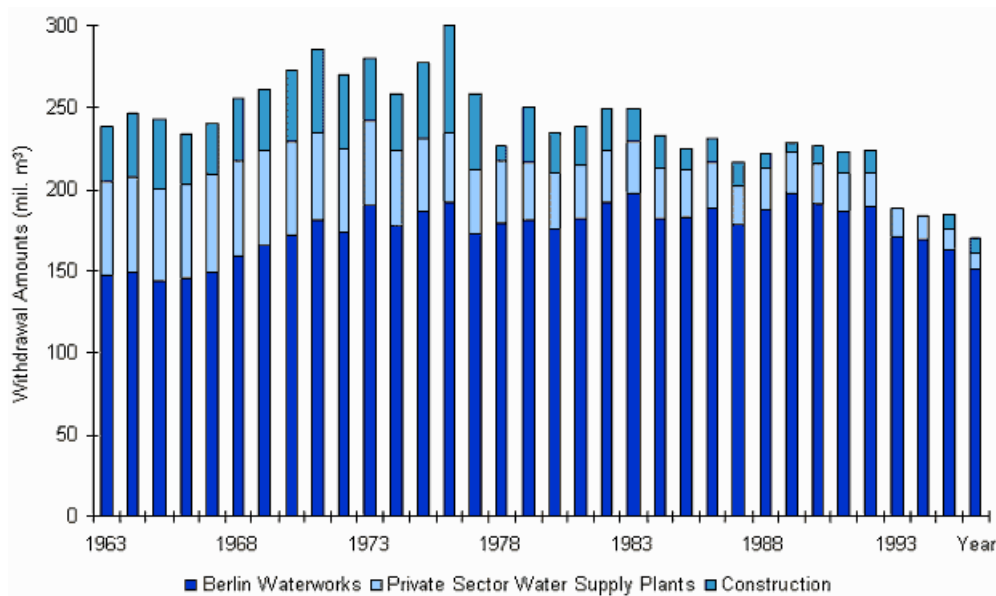


Fig. 5: Groundwater Withdrawal Amounts According to Use in West Berlin from 1963 - 1996
 Since 1987, construction groundwater retention for restoration and redevelopment measures have been included. The figures are for raw water withdrawals and refer to the water balance year.

In 1989, 12.7 mil. m³ of water was removed by **groundwater retention at construction sites**. In 1995, the total was 16.5 mil. m³; 7.3 mil. m³ at construction sites in the western part of the city, and 9.2 mil. m³ in the eastern part. The increase of groundwater removals is due to increased construction in Berlin since 1990.

Groundwater Balance

The goal of water management is to maintain a balanced **groundwater balance**. That means only so much groundwater should be removed as can be recharged. If removals exceed recharge, the groundwater reservoir will gradually empty; the groundwater level sinks. The West Berlin groundwater level sank strongly in 1950 - 1975, due to large withdrawal amounts of the Berlin Public Water Companies, private sector water supply plants, and groundwater retention at construction sites. The groundwater level has been rising since the mid-70's (cf. Map 02.07). This is caused by lesser withdrawal amounts of groundwater by private sector water supply plants, and by lesser groundwater removals, as well as groundwater returns, at construction sites.

The Public Water Companies established **groundwater recharge plants** in order to increase groundwater. These plants were necessary because precipitation and natural bank filtration from surface

waters were insufficient to compensate for and balance out groundwater removals. Surface water is discharged in the vicinity of groundwater removal wells, into shallow earthen basins, ponds, or pits. This water then percolates into the groundwater. Natural percolation basins include Kuhlake in the Spandau Forest and the Grunewald chain of lakes (Grunewaldseenkette), which are located in the catchment area of withdrawal wells.

The processing facilities of the Spandau Waterwork receive surface water from the Havel river, process it mechanically and chemically, and then discharge it for percolation at Kuhlake, Kreuzgraben, and the connected channel-pond system. After lake water from the Tegeler See is processed, it is discharged through micro-sieve facilities for percolation at Baumwerder island and at Saatwinkel. The Beelitzhof Waterwork purifies Havel river water in a phosphate elimination facility for discharge into the Schlachtensee lake. This water eventually enters the Grunewald lakes. In the area of the Stolpe Waterwork, Havel river water is dammed onto Havel meadows and percolates.

Groundwater recharge plants injected 57.3 mil. m³ of prepared surface water for percolation in 1995.

Besides "true" and **manmade recharged** groundwater, a considerable portion of water withdrawn by the Public Water Companies comes from **bank filtered** water. Wells in the vicinity of surface waters produce cones of depression, and water from the bank areas of the Havel, Dahme and Spree rivers flow into them. The proportion of bank filtered water in the total withdrawal amount of each well gallery depends on the distance of the well from the surface waters. An average of 50 % of the removals of the Berlin Public Water Companies has been assumed. Figure 6 depicts the origin of waters used by the public water supply, as well as a division of its uses. Water consumption from public water supplies per inhabitant in Berlin was 188 liters/day in 1995. Water consumption of Berlin households totalled 161 mil. m³; per inhabitant 128 l/d.

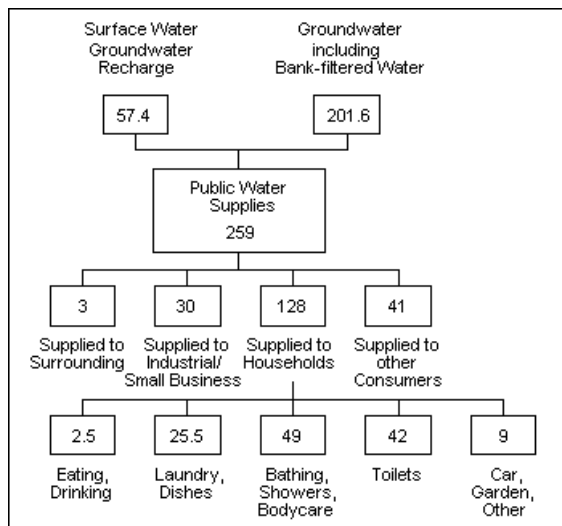


Fig. 6: Origin and Use of Water from Public Drinking Water Supplies in Berlin 1995 in million m³ per year (according to AHU 1991)

Increased sealing of soil surfaces and Berlin's rising population necessitate more water conservation and new methods of recharging groundwater both to maintain groundwater balance, and avoid use of drinking water supplies from distant areas. The groundwater recharge rate could be increased by near-natural percolation of rainwater over the topsoil zone, in lowlands, for example, as long as the rainwater isn't too polluted. Rainwater that would otherwise flow into the canalization could be separately collected and either directly discharged onto non-built-up surfaces, or discharged into artificial ponds to infiltrate the ground and percolate into groundwater. In this sense, measures to 'de-seal' surfaces would also contribute to an increased groundwater recharge.

In 1990, an ordinance providing for a **groundwater withdrawal fee** was adopted in the Berlin Water Law (Sec. 13a, Para. 1). This was intended as an economic incentive promote thrifty groundwater use. It allows Berlin to charge users a fee for the removal of groundwater, for the purpose of a more sparing use of groundwater. The resulting income should be applied to the protection of the quantity and quality of existing groundwater, particularly to ward off threats to groundwater, and to ameliorate damages.

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Maps

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