

## 02.19 Expected Highest Groundwater Level (EHGL) (Edition 2018)

### Overview

The level of the groundwater surface and the groundwater piezometric surface is relevant to various issues in water management, ecology and structural engineering. This is especially true for its maximal value, the largest value that the groundwater level can reach, which is primarily needed in designing buildings. This value is indispensable as a basis for planning and for designing the waterproofing of a building against water under pressure or for dimensioning its foundations.

The maximal value is usually determined on the basis of long-term observations of the groundwater level. Currently, at around 2000 groundwater measuring points in the city of Berlin groundwater levels (observation well levels) are being measured and represented in the form of groundwater hydrographs (see for example Figure 1). The maximal value of such a hydrograph is referred to as the **highest groundwater level**, abbreviated **HGL**. Thus, the HGL is a value measured in the past.

Groundwater hydrographs from three measuring points in the glacial valley: The highest groundwater level (HGL) was measured at different times: MP 137: 1975, MP 5476: 2002 and MP 8979: 2011.

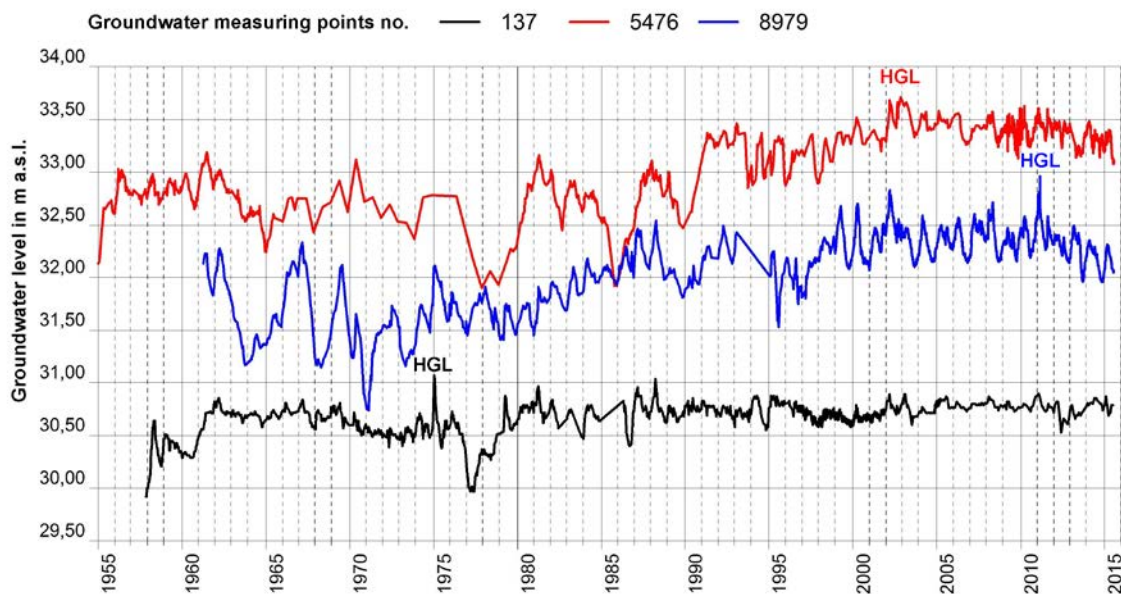


Fig. 1: Groundwater hydrographs from three measuring points in the glacial valley: The highest groundwater level (HGL) was measured at different times: MP 137: 1975, MP 5476: 2002 and MP 8979: 2011

If there is no groundwater measuring point with a sufficiently long observation history at a location at which the highest groundwater level is needed, this value can be approximately determined by interpolation from the highest groundwater levels of neighbouring measuring points. Such an interpolated value is also referred to as an HGL. If a highest groundwater level is stated in groundwater information provided by the Berlin Senate Department, the method of determining the specified HGL is set forth in detail.

In many cases, knowing the highest groundwater level that occurred in the past is very useful but not always fully satisfactory or sufficient. For instance, if the HGL is to be used for dimensioning the waterproofing of a building against water under pressure, this value observed in the past must of course also not be exceeded in the future, i.e. within the useful life of the building, and must occur only in extremely wet situations. If the observed history of the groundwater level is essentially determined by natural causes (seasonal differences in new groundwater formation, alternation of years with low

and high precipitation), it can be assumed to behave similarly in the future. This also applies in the case of anthropogenic interventions with consequences for the groundwater surface, if these are permanent and will thus not change in the future.

The groundwater conditions have not been natural in large parts of Berlin for a long time. The level of the **groundwater surface is subject to artificial influence** due to both permanent and temporary interventions into the groundwater balance.

The **permanent measures** include:

- rainwater sewerage, which may have the effect of reducing new groundwater formation and thus lowering the groundwater level;
- decentralised rainwater disposal in percolation facilities, which may locally raise the groundwater surface, depending on the precipitation events;
- drainages and ditches that were intentionally used to lower the groundwater level locally;
- hydrological construction measures (impoundments, shore revetments, straightening of watercourses), which may lead both to a rise and to a drop in the groundwater level;
- structures protruding into the groundwater, with the effect of groundwater afflux in the direction of inflow and lowering in the direction of outflow.

The **temporary measures** and those that may vary considerably in duration include:

- groundwater extractions for the public and private water supply and for keeping water out of construction pits or for remediation, which lower the groundwater surface;
- groundwater replenishments for increasing groundwater availability for the public water supply, which raise the groundwater level in the vicinity of the replenishment facilities;
- reinfiltration of extracted groundwater, e.g. in the context of groundwater preservation measures for construction purposes, which also raise the groundwater surface – usually only locally.

This multitude of possible artificial measures that affect the groundwater illustrates that in some cases it is difficult even for specialists to judge whether and to what extent an observed (= measured) highest groundwater level (HGL) is anthropogenically influenced and whether such a value can also be used in dealing with the future.

In order to further increase the quality of the HGL value and to make it more readily available to the user, a map has been developed that directly specifies the “**expected highest groundwater level**”, abbreviated “**EHGL**”. This is defined as follows:

**The expected highest groundwater level (EHGL) is the maximal one that can arise due to weather effects. It can occur after extremely wet periods if the groundwater level in the vicinity is neither lowered nor raised by artificial interventions.**

According to this definition, this is a groundwater level that is not exceeded according to current knowledge after very heavy precipitation events under the following geohydraulic conditions: the natural conditions (e.g. water permeability of the subsoil) on the one hand and the permanently artificially modified conditions (e.g. impoundments of the watercourses) on the other hand.

Higher groundwater levels than the EHGL can principally occur, but only as a result of further artificial interventions. Of course, such interventions (e.g. discharges into the groundwater) are not predictable in the long term. However, they do not need to be taken into account for most questions, as they require permission or approval from the water authorities.

The definition of the expected highest groundwater level thus essentially corresponds to the definition of the “design groundwater level” (*Bemessungsgrundwasserstand*) for waterproofing of buildings according to the BWK guidelines, Bulletin BWK-M8 (2009; BWK Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau e.V.).

The term “expected highest groundwater level” is being used here instead of the term “design groundwater level” because the EHGL map is made available also for other questions besides that of the required waterproofing for buildings.

In this context, it is also noted that the responsibility of determining design groundwater levels for construction measures principally lies with the constructor or their specialised planner or surveyor. As this is sometimes not, or only with disproportionate effort, possible for individuals solely on the basis of

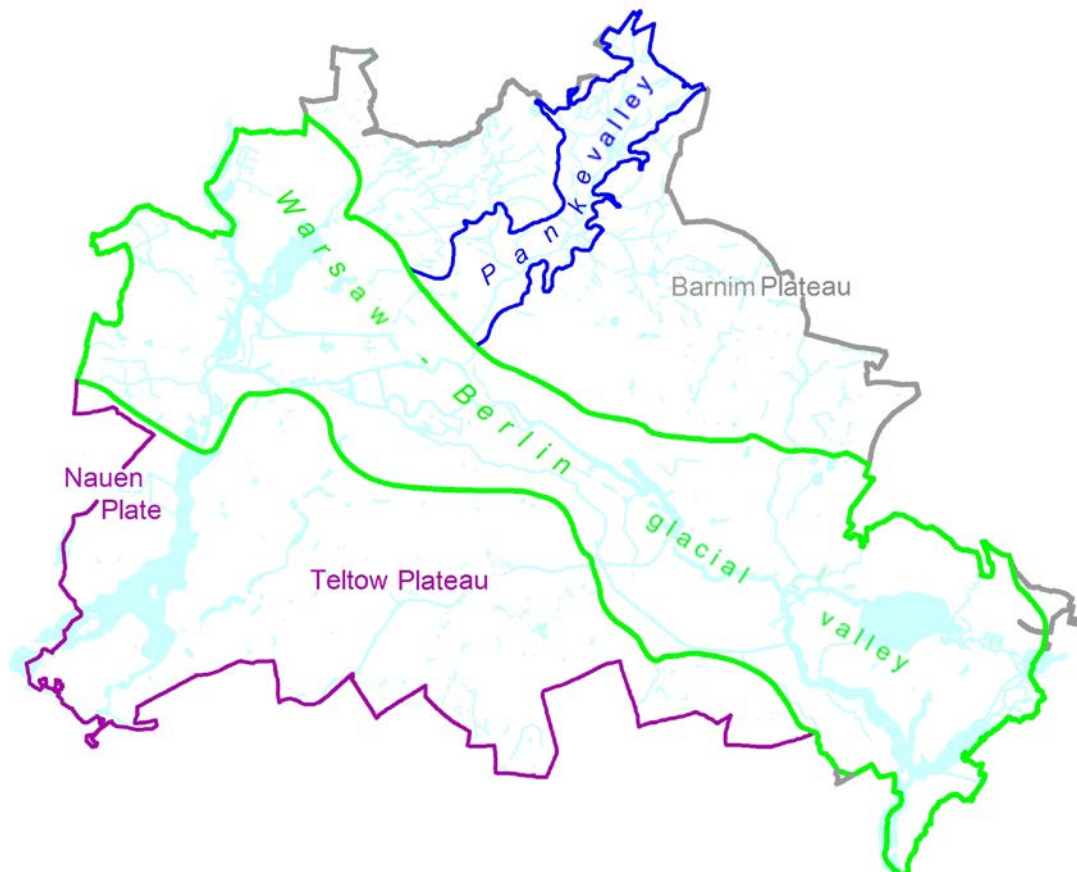
groundwater investigations at the construction site or in the immediate vicinity, due to the overarching complex and strongly anthropogenically influenced groundwater conditions in Berlin, the State of Berlin provides information on the groundwater level as a service to the citizen in the context of its groundwater advice.

The Geological Survey working group ("*Landesgeologie*") of the Senate Department for the Environment, Transport and Climate Protection has been providing information on the groundwater for decades, including the highest groundwater level (HGL), which is determined by specialists on the basis of the available groundwater level data. As the HGL, according to its definition (see above), is not necessarily an uninfluenced groundwater level, the aim is to develop a map of the EHGL, which is more meaningful for questions directed towards the future (e.g. waterproofing of buildings), for the entire city area. Accessing the map through the Internet allows the user to read off the EHGL for the respective site. Thus, waiting periods that were caused by the written inquiry can be avoided.

Currently, the EHGL map has been completed for three areas of Berlin (see Figure 2).

- In geological terms, these are the area of the Berlin glacial valley and the area of the Panke valley. Both are characterised in that near the surface their subsoil is composed predominantly of sands with high water conductivity and the groundwater surface is generally not deep below ground (depths to groundwater of a few metres, sometimes even less than one metre) (SenStadtUm).
- Furthermore, the EHGL map was developed for the areas connecting to the glacial valley in the South, i.e. the Teltow Plateau and the Nauen Plate west of the Havel. In the eastern part, the plateau is covered by relatively thick boulder marl or boulder clay of the ground moraine, which are also partly responsible for confined groundwater conditions. The western part is predominantly characterised by thick sand sequences. Boulder marl and meltwater sands are equally represented in the Nauen Plate area. South of the glacial valley, the area is characterised by groundwater surface levels found at depths that are usually much greater than 10 m, in some parts of the Grunewald and on the Wannsee peninsula even greater than 20 m. By contrast, surface waters, such as the Havel and the Grunewald lakes, but also the Rudower Fließ area, the southern part of Lichtenrade and the former Karolinenhöhe sewage farms feature low depths to groundwater.

A map on groundwater levels titled "Expected highest groundwater level (EHGL) (Edition 2018)" is published here covering all three areas, using different methods.



*Fig. 2: Area of validity of the EHGL map for the glacial valley, the Panke valley, as well as the Teltow Plateau and the Nauen Plate*

## Statistical Base

The EHGL maps for the Berlin glacial valley, the Teltow Plateau and the Nauen Plate, which were developed using numerical groundwater flow models (see Methodology), have an extraordinarily comprehensive statistical base.

Sixty [geological sections](#) from the State Geological Service were available for capturing the hydrogeological structure of the main aquifer in the Berlin glacial valley. They were supplemented by evaluating numerous deeper **boreholes** from the database of the State Geological Service.

The configuration data of over 1,300 **groundwater measuring points** and their groundwater level data were used for calibrating and verifying the groundwater models. Moreover, information on the **groundwater withdrawals** of all Berlin waterworks, on **groundwater replenishments** and on other groundwater extractions (unwatering, private water supply plants, remediation) was available.

The surface waters, which are the recipients for the groundwater, determine essential hydraulic conditions. A multitude of data – mostly **gauge heights** – and information on the state of development of the water bodies was used in this regard.

The data for new groundwater formation were implemented into the model from the map of the Environmental Atlas (SenStadtUm 2012).

The hydrographs of about 2,200 groundwater measuring points were evaluated for the Berlin glacial valley area and of about 1,100 for the Teltow Plateau and the Nauen Plate areas, in order to check the plausibility of the computed EHGL map.

Moreover, a very comprehensive pool of further hydrogeological, water management, geographical and historical sources of information was available.

The hydrographs of about 150 further groundwater measuring points were evaluated to develop the EHGL map for the Panke valley. Comprehensive data on the geology of the Panke valley aquifer that are available to the Senate Department were also used. Gauge heights were available for the Panke and some of its tributaries.

## Methodology

The current map was developed in individual sections corresponding to the different geological units of Berlin, in the following order:

1. Glacial valley
2. Panke valley
3. Teltow Plateau and Nauen Plate,

whereby different methodologies were applied in part.

### Glacial valley

For the area of the **Berlin glacial valley**, the EHGL map was developed using a numerical **groundwater flow model**. This was necessary because due to the long-standing and sometimes strong anthropogenic influence on the groundwater surface, the computation of such a map is not possible solely on the basis of measured groundwater levels in the sense of the above EHGL definition.

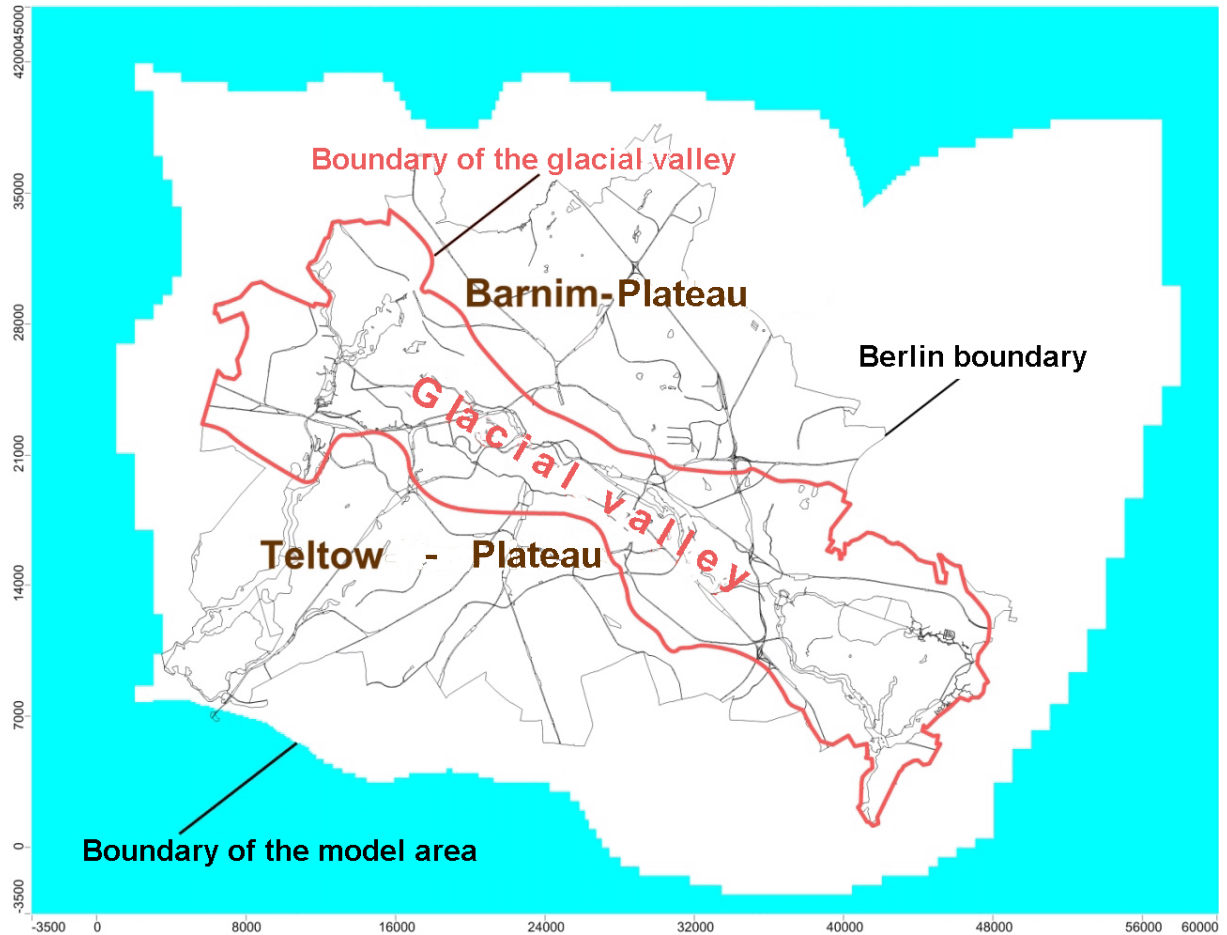
A numerical model allows the spatially discrete simulation of groundwater levels under given geohydraulic conditions. These include new groundwater formation, which is inter alia a function of precipitation, and the water levels of the surface waters. Both are subject to natural and also artificially induced fluctuations. For example, in our climate area new groundwater formation occurs mainly in the winter half year, with the result that the highest groundwater levels within a year usually occur in the spring. Often, relatively high water levels of the surface waters (here the Spree, the Havel and their tributaries) during this time further contribute to the high groundwater levels. Particularly high groundwater levels are observed when the amount of precipitation lies significantly above the long-

term mean in several consecutive years. The highest groundwater level is expected to occur in such extreme wet periods.

Beginning in 2003, a numerical groundwater flow model was developed, which, in the long term, is to be available for the entire area of Berlin for addressing questions of water management at the state level. By 2008, this model had reached a state in which it could be used to create an EHGL map for the area of the Berlin glacial valley, which was subsequently used by the Senate Department's specialists for groundwater advice and was thus subject to a rigorous practical test.

The development of the EHGL map for the Berlin glacial valley is described in Limberg, Hörmann & Verleger (2010) and is summarised here:

The numerical model, for which the software system MODFLOW was used, is designed to encompass the entire area of Berlin (Figure 3).



*Fig. 3: Area of the groundwater flow model for developing the EHGL map for the Berlin glacial valley*

The area of the Berlin glacial valley is vertically divided into several model layers, of which the uppermost represents the – here usually unconfined – main aquifer, whose highest groundwater level is to be calculated.

Horizontally, the model is divided into rectangular cells. The cell size varies between 50 x 50 and 100 x 100 metres.

Further modelling occurred in the following steps:

- **Model calibration**  
After the known or estimated geohydraulic conditions (recipient levels, groundwater extractions, groundwater discharges, etc.) had been specified, the model was essentially calibrated by varying a given distribution of the water conductivity using hydraulically stationary calculations. The mean values of the data with respect to groundwater use and the groundwater levels of the year 2004 were selected for this purpose. The year 2004 may be regarded as climatically average.
- **Model verification**

Model verification here refers to a test of the model as to whether it can sufficiently accurately represent a known load situation of the groundwater different from the calibration period (e.g. altered groundwater extractions) with respect to the actually observed groundwater heights. In this case, the groundwater levels for the year 2001, which differ from the year 2004 in particular with respect to the distribution of groundwater withdrawal, were calculated using the model. The deviations of the groundwater levels calculated from the observed ones using the model were assessed as relatively small. Thus, the model has passed a significant test of quality.

- **Model simulation of the expected highest groundwater level and plausibility test**

After verification, different model simulations for calculating the highest groundwater level were performed. This required three kinds of hydraulic conditions to be correspondingly varied together. Those that underlie the model calibration and also the verification are valid for climatically average years and a certain groundwater load. The three conditions are:

- *the groundwater use*

According to the EHGL definition, neither groundwater extractions nor discharges into the groundwater occur in this scenario. This is true both for the waterworks and for other extractions, such as for personal water supply, remediation or construction.

- *the height of the recipient for the groundwater*

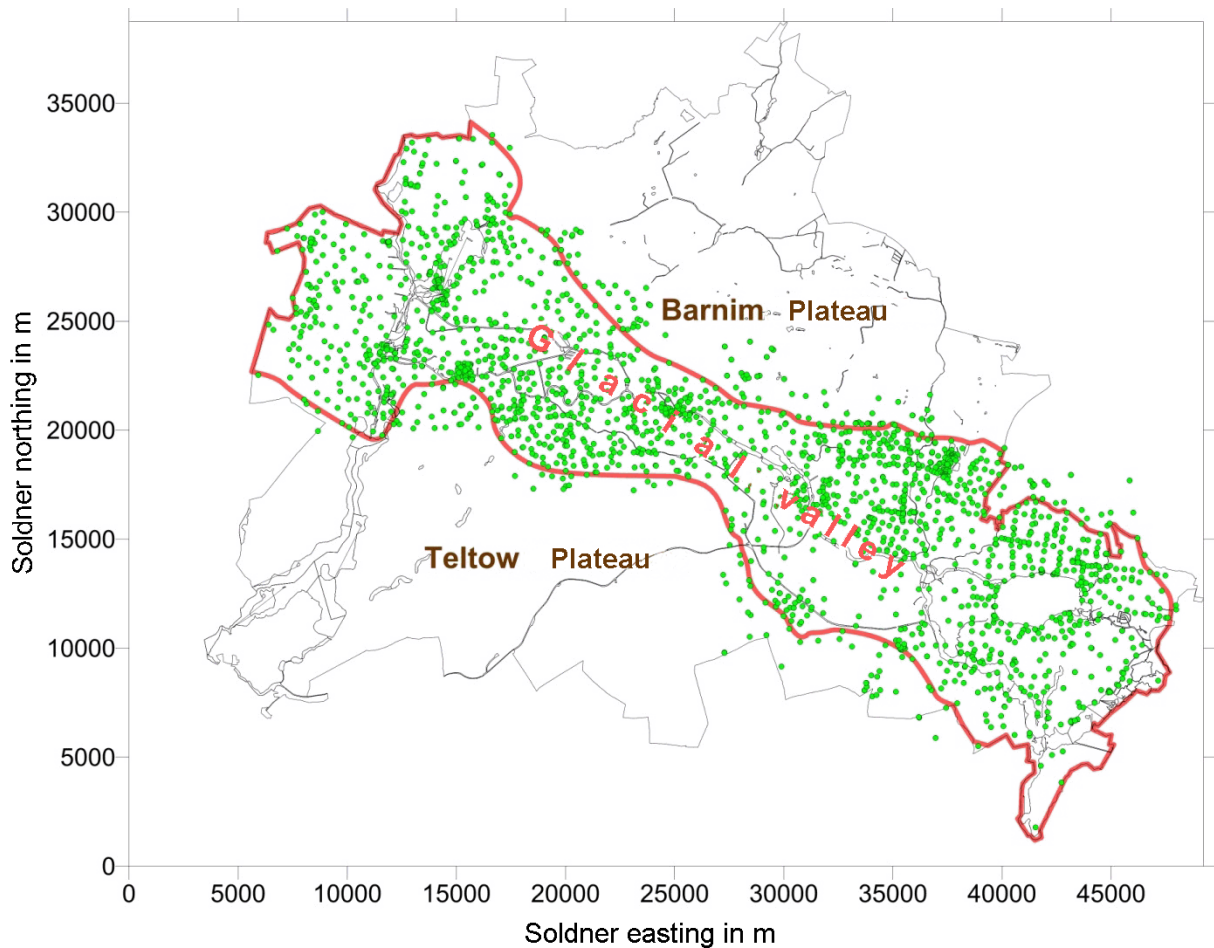
The water levels of the receiving waters for the so-called HGL case were defined through evaluation of the gauge heights.

- *the new groundwater formation*

When the highest groundwater level occurs, the new groundwater formation must lie significantly above the long-term mean. Some orientating model simulations with subsequent plausibility tests using selected measured groundwater levels were performed to obtain an estimate. As a result, the new groundwater formation was set at up to 15 % above the long-term annual mean for the HGL case, depending on its spatially differentiated level.

The completion of this preliminary EHGL map was followed by an intensive plausibility test using the data from about 2,200 groundwater measuring points and a multitude of further data and information (for the locations of the groundwater measuring points used for the plausibility test, see Fig. 4). Only minor modifications of the map were subsequently required.

These modifications included the introduction of the representation of so-called **riparian strips** along some of the surface waters. In these areas, which are separately designated on the map, EHGL values are stipulated that were not immediately calculated using the large-scale groundwater flow model. This was necessary because in some riparian areas, strong short-term increases in the recipient heights can lead to a rise in the groundwater surface close to the shore, which cannot be covered with sufficient certainty by the map derived from a hydraulically stationary calculation. Separate EHGL values were also established for individual areas in which the map calculated using the model may show too uncertain values due to a relatively low model discretisation, e.g. in the vicinity of locks and in some riparian areas on Tegel Lake. These EHGL values were determined based on measured maximal gauge heights of the surface waters, and in some cases approximative hydraulically non-stationary calculations.



*Fig. 4: Location of the groundwater measuring points used for the plausibility test of the EHGL map*

The methodology of the EHGL map also includes its ongoing review, particularly after very high groundwater levels are observed. After completion of the map, such extremely high groundwater levels were registered in the period from 2008 to 2011. The map passed the test using these groundwater level data very successfully. Only marginal changes were subsequently carried out. The published map is now set up such that the HGL which is definitive at a given measuring point, i.e. which is to be regarded as uninfluenced, lies at least 10 cm below the EHGL shown.

## Panke valley

The EHGL map in the area of the Panke valley was originally going to be developed using the same methodology as for that of the glacial valley, i.e. using a numerical groundwater simulation model. Thus, a separate groundwater model was first created for this area, which is principally available for questions of water management and has already been used. However, in preparing this model, it became apparent that the required hydrological and hydrogeological data are relatively sparse in some areas. The calculation of a preliminary EHGL map and its critical evaluation led to the assessment that in these areas the model does not yet fulfil the particularly high-quality requirements to be placed on an EHGL model.

As the anthropogenic influence on the groundwater in the Panke valley is relatively small, in contrast to the Berlin glacial valley, more directly measured HGL values can be taken into account in developing the EHGL map in this case. The EHGL map for the area of the Panke valley includes not only the Panke valley in the narrow sense, as designated on the geological map of Berlin, but also a small adjacent part of the glacial valley. This is a transition area between the two geological units, which hydrogeologically rather belongs to the Panke valley with its relatively shallow uppermost aquifer.

The methodological approach is described in Hörmann & Verleger (2016) and is summarised here as follows:

## 1. Hydrograph analysis

All hydrographs of the 135 groundwater measuring points from the Senate Department's archive that are installed in the Panke valley aquifer (GWL 1.2 according to the aquifer nomenclature of Limberg & Thierbach 2002) were checked for suitability for the present purpose. This included in particular an assessment of the groundwater levels with respect to a possible artificial influence and potential data errors. The essential result of this investigation was that the groundwater levels are significantly more often and usually also more strongly influenced before 1990 than afterwards. An essential cause for this is the operation of the sewage farms in the northern part of the Panke valley, which was ended in the 1980s and locally caused a significant rise in the groundwater level. The highest groundwater levels measured during operation of the sewage farms are not expected highest groundwater levels. As a result of this hydrograph analysis, only measurements since 1990 have been used to determine EHGL values.

## 2. Determining the EHGL values

The highest groundwater level (HGL) was extracted for every single groundwater measuring point that was recognized as suitable. To determine the EHGL, an increment was added to the HGL:

$$\text{EHGL} = \text{HGL} + \text{increment}$$

The increment was determined based on various considerations for estimating the reliability of the recording of highest groundwater levels. In particular, the frequency of measurements and the duration of the observation of the groundwater measuring points were taken into account. The minimum increment added to the HGL is 0.3 m. This value applies to measuring points that capture the period from 2007 to 2012 well through frequent measurements. In Berlin, the highest groundwater levels under the currently prevailing geohydraulic conditions (cf. EHGL definition) were generally observed in this period (see example Fig. 5).

HGL values from groundwater measuring points that do not capture the time of generally high groundwater levels and/or have a lower measuring frequency were incremented by 0.5 m or 0.7 m.

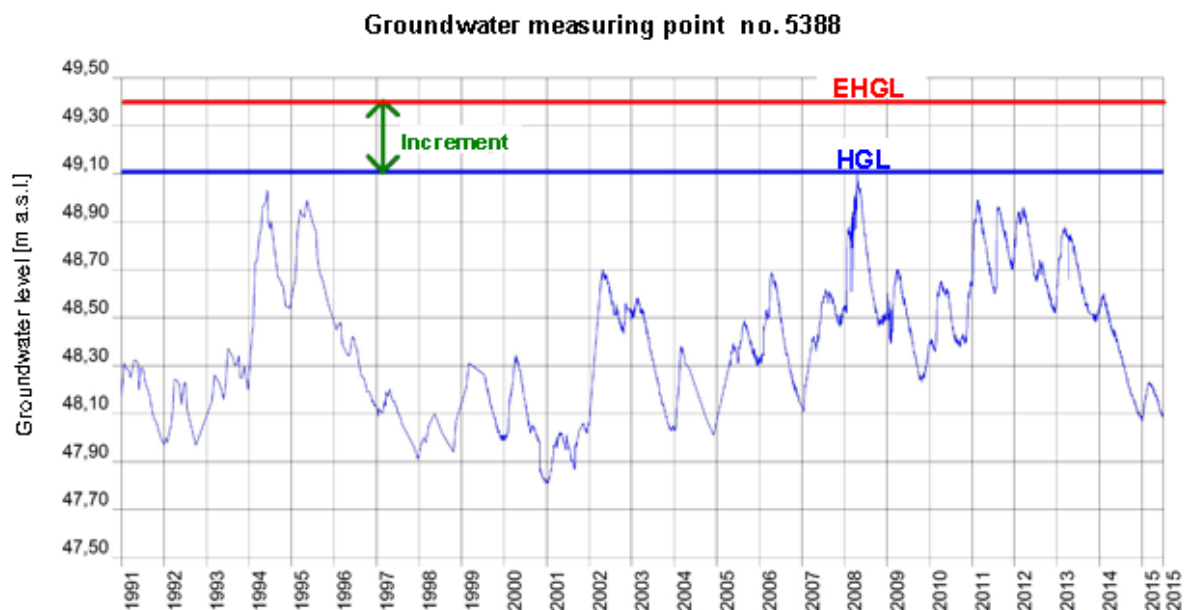


Fig. 5: Example of a hydrograph from the Panke valley with HGL, EHGL and increment

## 3. Calculation of the EHGL map

On the basis of 105 suitable groundwater measuring points and their EHGL values as sample values, the distribution of the EHGL was calculated using the software system SURFER, without taking bodies of water into account, and was represented in the form of lines of equal EHGL. The calculation method is the same as the one used for the current [groundwater levels map](#) (Hannappel, Hörmann & Limberg 2007).

The following general remarks are in order:

Since the EHGL map is being made available for different applications, the expected highest groundwater levels include **no application-specific blanket safety margins, as are required e.g. in**



**the regulations relevant for the construction of buildings.** The increments added to the HGL (0.3 to 0.7 m, see Methodology), which are partly differentiated for the area of the Panke valley, were chosen solely due to the different quality of capture of highest groundwater levels and the relatively large natural amplitude of the groundwater graph, compared to the glacial valley. In the glacial valley, the values shown in the EHGL map lie **at least 0.1 m above the highest measured groundwater levels assessed as significant.** However, the EHGL predominantly lies much further above the HGL, on the scale of metres in the area of the cone of depression of the Berlin waterworks.

Thus, the estimates of the EHGL have been determined with computational methods on the basis of comprehensive data and a multitude of further information, and according to current knowledge they are on the “safe side” – in the sense that in all likelihood they will not be exceeded. The consequence, on the other hand, is that they may not necessarily occur with the full height specified.

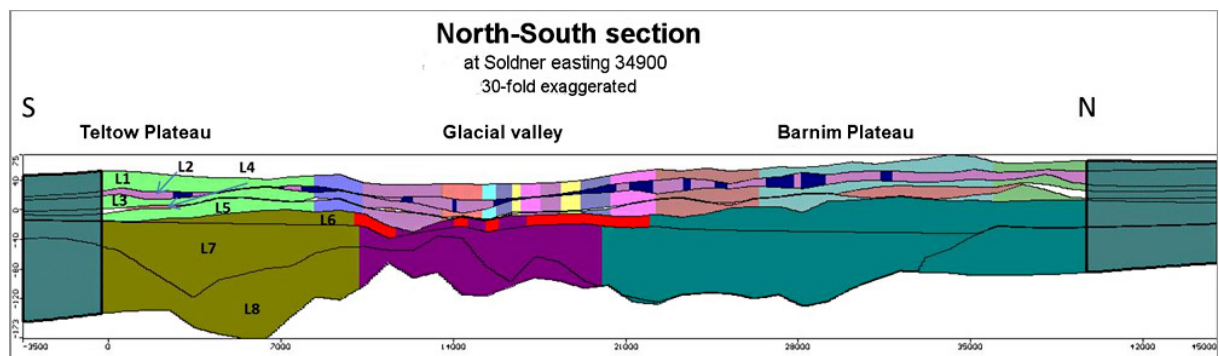
The methodology of the development of the map also includes ongoing review, i.e. comparison with the current groundwater levels. A comprehensive test of the map, which is based on the data up to 2007, was carried out in 2013, after extremely high groundwater levels had been registered in Berlin in 2008 and 2011. **The result was that even in these times of very strong precipitation the EHGL values were not exceeded.**

## Teltow Plateau and Nauen Plate

The development of an EHGL map for the areas of the Teltow Plateau and the Nauen Plate began in 2013. In 2017, it was completed for these two hydrogeological units and is published here for the first time together with the EHGL maps for the glacial valley and the Panke valley.

The method used to develop this map is essentially the same as that used for the glacial valley map, i.e. the map was created based on a numerical groundwater flow model. As was the case for the glacial valley, the use of a simulation model was required here because of the long-standing anthropogenic influence on the groundwater levels, especially by the Beelitzhof, Tiefwerder and Kladow waterworks. The main differences are listed below:

The existent four-layer groundwater model for Berlin was used for further vertical differentiation. The model is now divided into eight layers. This was necessary to accommodate the hydrogeological layer structure of the Teltow Plateau and the Nauen Plate that is considerably more complex than that of the glacial valley. Figure 6 shows a North-South section through the model, as it currently exists for the entire Berlin area. The model layers L 1 to L 6 represent the main aquifer, which is locally differentiated into the aquifers GWL 2.1, GWL 2.2 and GWL 2.3, which are hydraulically separated from each other – especially in the plateau areas – by layers of boulder marl with low water conductivity.



*Fig. 6: Section of the numerical groundwater flow model for the State of Berlin*

The year 2001 was used for calibration and the year 2004 for verification, based on their advantageous data on the observed groundwater levels.

As for the glacial valley area, the EHGL simulation was carried out following the calibration and verification process. Data from about 1,100 groundwater measuring points was used to implement the plausibility test and a required recalibration of the EHGL model.

Based on the plausibility test of the Teltow Plateau and the Nauen Plate map, identifying riparian strips separately along individual bodies of water turned out to be superfluous here, in contrast to the glacial

valley. Essentially only a small area on the Nauen Plate west of Kladow was subsequently modified on the model-calculated map, i.e. where a hydrogeological anomaly was taken into account by indicating areas with the same EHGL values based on the highest groundwater levels observed.

## Map description

The EHGL map for the Berlin glacial valley, the Panke valley as well as the Teltow Plateau and the Nauen Plate (2018) covers about three quarters of the area of the State of Berlin. The expected highest groundwater level is represented by lines of equal height in metres above sea level. The difference in height between groundwater isolines is 0.1 m. Thus, the map shows the distribution of the observation well levels in the EHGL case. In the areas of the glacial valley and the Panke valley, the uppermost groundwater is predominantly unconfined, in the area of the plateaus it is confined or covered. It is evident from the course of the contour lines that the Spree and the Havel and their tributaries form the receiving waters for the groundwater close to the surface. The groundwater flow direction lies perpendicular to the contour lines from the higher to the lower level. The EHGL varies between about 58.7 m above sea level in the northern Panke valley on the state border and 30.1 m above sea level where the Lower Havel exists the state area in the southeast. The closer clustering of the contour lines in the Panke valley, the Teltow Plateau and the Nauen Plate shows that the height gradient of the groundwater is larger here than in the glacial valley, as expected. Thus, the course of the EHGL isolines shows a plausible picture for the case that neither groundwater extractions nor artificial groundwater replenishments occur. In particular, this map provides realistic EHGL values in the area of the large cones of depression of the Berlin waterworks, which could hitherto only be estimated very roughly without the groundwater levels calculated using the model (cf. current [groundwater levels maps](#), on which the cones of depression are visible).

On the digital map, the EHGL value for a certain location can be displayed on screen by a mouse click.

In the vicinity of the shores of the Spree, the upper Havel and Tegel Lake, there are lateral riparian strips (see also Methodology). These areas are marked with different colours according to the EHGL value and can also be queried with a mouse click.

Thus, the user receives an EHGL value for his respective question in a simple manner.

### **The following should be noted:**

The map value applies to the groundwater level of the uppermost aquifer. In the area of the glacial and Panke valley, the uppermost aquifer is predominantly unconfined. Thus, the map value generally specifies the height of the groundwater surface here, which is for instance relevant for dimensioning waterproofing for buildings.

However, in some places – more often in the plateau areas – overlying layers with low water conductivity, such as boulder clay and boulder marl, clay, silt and organic soils, cause the groundwater to be confined (e.g. in the area of a boulder marl “island” in Charlottenburg designated on the map). In these cases, the map does not specify the height of the groundwater surface, but rather that of the piezometric surface of the confined groundwater.

**In these cases, shallow groundwater (in the sense of the groundwater definition of DIN 4049) may form – possibly only temporarily – above the confining layers. This so-called stratum water is also water under pressure in a constructional sense and must be taken into account in corresponding contexts.**

Due to the scale and the rather heterogeneous individual sedimentation conditions, the two possible deviations from the usual hydrogeological configuration that were mentioned are not, or not completely, representable in the Geological Outline provided. However, they can be recognized in the framework of a subsoil expertise, which is principally required for construction activity. In addition, in concrete cases the strata-log sheets from the database of the [State Geological Service](#) can be accessed on the Internet [only in German].

It should also be noted that the EHGL may lie above ground level. In this case, the formation of groundwater ponds cannot be excluded.

Near surface waters, in addition to high groundwater levels, short-term local flooding may occur, which cannot be inferred from the EHGL map. Information in this regard is available under [Hochwasser](#) [floods, only in German].

The [current groundwater level](#) can be accessed for the month of May on the Internet.

Should the current groundwater level at a certain location lie only slightly below the value of the EHGL map, or even above, which is very unlikely in the glacial valley but cannot be entirely excluded, this may be due to the different statistical basis of the maps. In these cases, more detailed information may be requested from the Berlin Groundwater Service.

In the Panke valley, in particular in its northern part, the groundwater measuring points are sometimes relatively far apart in view of the heterogeneity of the aquifer and the mostly large natural groundwater gradient. As a result, the EHGL map is more fraught with uncertainty here than in the area of the glacial valley. This also applies to areas in the immediate vicinity of surface waters (the Panke and its small tributaries). While this was accounted for by the abovementioned increments, localised deviations of the map value from an actually occurring highest groundwater level cannot be entirely excluded. If new investigations (drillings, groundwater level measurements) yield results in such areas that clearly contradict the EHGL value of the map (current groundwater level above the map value or within metres of it), the EHGL should be locally modified by an expert. In such cases, the Berlin Groundwater Service kindly requests to be notified.

The hydrogeological conditions in the area of the Teltow Plateau and the Nauen Plate are considerably more complicated than those in the glacial valley and the Panke valley. Therefore, the mathematical EHGL estimate, applying the method described above is fraught with somewhat higher uncertainties. To be on the safe side, the map was thus developed to indicate EHGL values that are rather on the high side compared to those that may actually occur. It was deemed a reasonable approach in construction planning. It should also be noted here that the probability of locally-occurring stratum water atop confined layers at heights above the indicated EHGL values is greater than in the glacial valley. Should you detect contradictions to the map in the framework of future investigations (e.g. a subsoil expertise), please also inform the above-mentioned authority. It is envisaged that the map will continue to be checked and possibly modified based on the results of the Berlin Groundwater Service and new scientific findings. The intent is to recognize and take into account possible changes in the hydrological conditions that cannot currently be foreseen (e.g. due to general changes in the climate) as soon as possible.

## Literature

- [1] **Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau e.V [Association of Engineers for Water, Waste and Land Management] (BWK) (2009):**  
BWK-Regelwerk, Merkblatt BWK-M8 [BWK guidelines, Bulletin BWK-M8]
- [2] **Hannappel, S., Hörmann, U. & Limberg, A. (2007):**  
Zeitnahe Erstellung digital verfügbarer Grundwassergleichenkarten im Rahmen des landesweiten Grundwassermanagements in Berlin [Short-term generation of digitally available groundwater level maps in the context of statewide groundwater management in Berlin].  
Hydrogeologie und Wasserbewirtschaftung, 51. Jahrg., 5, p. 215-222
- [3] **Hörmann, U., & Verleger, H. (2016):**  
Eine Karte des zu erwartenden höchsten Grundwasserstands für das Panketal in Berlin.  
Brandenburg. [A map of the expected highest groundwater level for the Panke valley in Berlin]  
Geowiss. Beitr. 23, 1/2, p. 3-9, Cottbus.  
[https://www.berlin.de/senuvk/umwelt/wasser/wasserrecht/pdf/hgw-artikel\\_panketal.pdf](https://www.berlin.de/senuvk/umwelt/wasser/wasserrecht/pdf/hgw-artikel_panketal.pdf) [only in German]
- [4] **Limberg, A. & J. Thierbach (2002):**  
Hydrostratigraphie von Berlin – Korrelation mit dem Norddeutschen Gliederungsschema [The hydrostratigraphy of Berlin – correlation with the North German structural scheme].  
Brandenburg. Geowiss. Beitr. 9, 1/2, p. 65-68, Kleinmachnow  
Internet:  
<https://www.berlin.de/senuvk/umwelt/wasser/wasserrecht/pdf/hydrostratigrafie2002.pdf> [only in German]
- [5] **Limberg, A., Hörmann, U., & Verleger, H. (2010):**  
Modellentwicklung zur Berechnung des höchsten Grundwasserstandes in Berlin [Model development for calculating the highest groundwater level in Berlin]. Brandenburg. Geowiss. Beitr. 17, 1/2, p. 23-37, Cottbus.  
Internet:  
<https://www.berlin.de/senuvk/umwelt/wasser/wasserrecht/pdf/hgw-artikel.pdf> [only in German]

- [6] **SenUVK (Berlin Senate Department for the Environment, Transport and Climate Protection):**  
 Geologie [Geology]  
 Internet: <https://www.berlin.de/senuvk/umwelt/wasser/geologie/> [only in German]
- [7] **SenUVK (Berlin Senate Department for the Environment, Transport and Climate Protection):**  
 Hochwasser [Floods]:  
 Internet: <https://www.berlin.de/senuvk/umwelt/wasser/hochwasser/de/hochwasser.shtml> [only in German]

## Maps

- [8] **SenStadt (Berlin Senate Department for Urban Development) (2007):**  
 Geological Outline 2007, Map 1.17, Edition 2013  
 Internet: <https://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/ei117.htm>
- [9] **SenStadtUm (Berlin Senate Department for Urban Development and the Environment) (2012):**  
 New Groundwater Formation 2012, Map 2.17, Edition 2013  
 Internet: <https://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/eib217.htm>
- [10] **SenStadtUm (Berlin Senate Department for Urban Development and the Environment) (2013):**  
 Geologische Schnitte [Geological sections]  
 Internet: [https://fbinter.stadt-berlin.de/fb/index.jsp?loginkey=showAreaSelection&mapId=wmsk\\_01\\_18\\_GeolSchnitte@senstadt&areaSelection=map](https://fbinter.stadt-berlin.de/fb/index.jsp?loginkey=showAreaSelection&mapId=wmsk_01_18_GeolSchnitte@senstadt&areaSelection=map) [only in German]
- [11] **SenStadtWohn (Berlin Senate Department for Urban Development and Housing):**  
 Depth to the Water Table (Depth to Groundwater), Map 2.07, various years.  
 Internet: [https://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/edin\\_207.htm](https://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/edin_207.htm)
- [12] **SenStadtWohn (Berlin Senate Department for Urban Development and Housing):**  
 Groundwater levels map, Map 2.12, various years.  
 Internet: [https://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/edin\\_212.htm](https://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/edin_212.htm)