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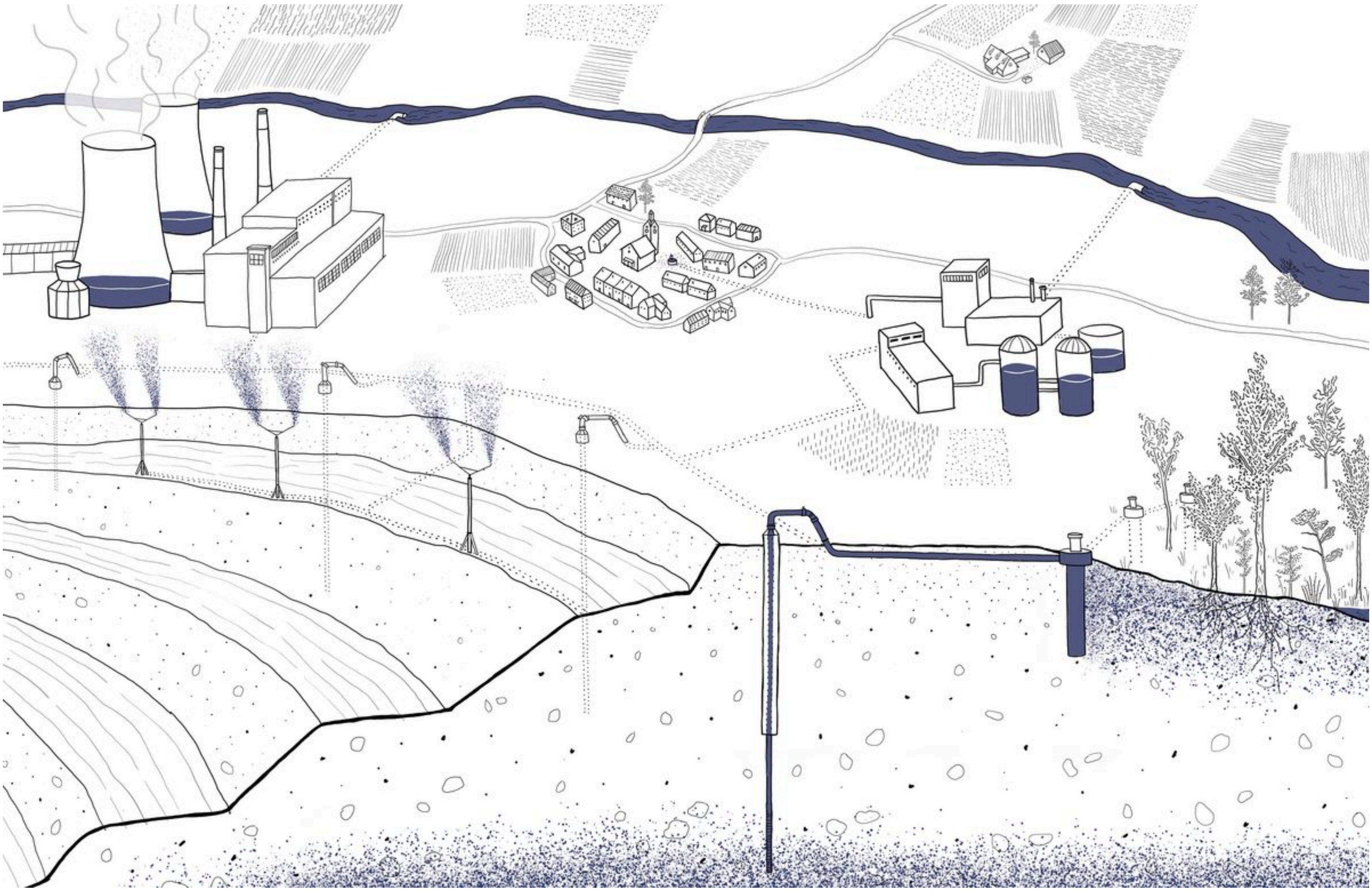
Power to the People
Fall 2022

Energy and Water

Eternity Burdens of Groundwater Exploitation

Nora Hauser, Leonie Mischler, and Andela Pejic



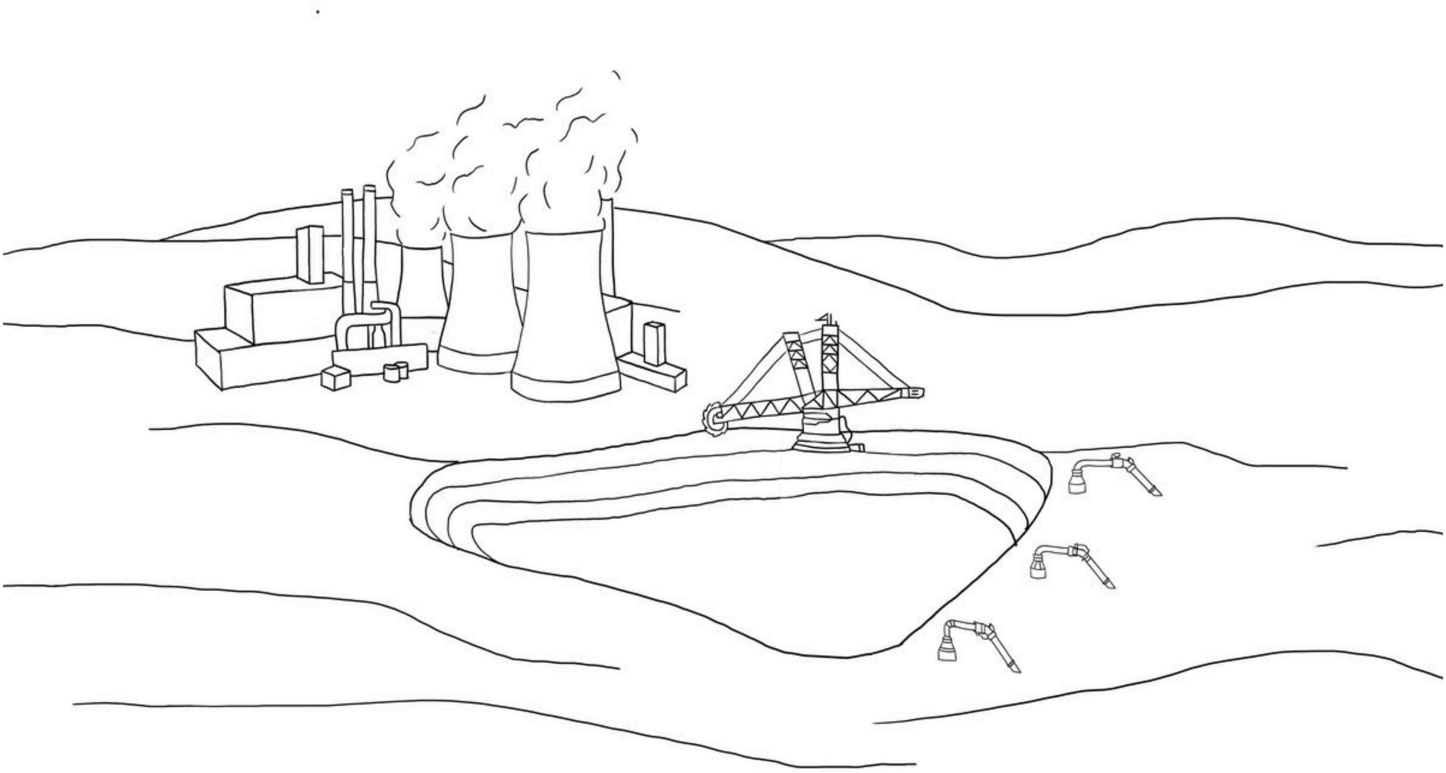
The brown coal mining in the Rheinische Revier has transformed the physical fabric of the region substantially since 1950. While the three open mining pits – Inden, Hambach and Garzweiler – are visible indicators for these transformation processes in the landscape, others are far more invisible, such as the alterations in the groundwater system.

RWE currently operates a complex water infrastructure pumping away groundwater to extract brown coal. This groundwater lowering cannot be limited to the open pit but influences the region beyond Germany's borders. Half of the pumped groundwater is used by RWE as service water for brown coal mining, as substitute drinking water for the communes or as infiltration in groundwater-dependent wetlands. The lowering of groundwater in the region causes problems such as drying up of wetlands, ground lowering and lacking groundwater in public water supply facilities. Unlike other groundwater users, RWE was exempt from the water extraction fee until 2011, which meant that this exploitation of the natural resource groundwater also generated a financial profit of 25 million Euros annually since 1950.

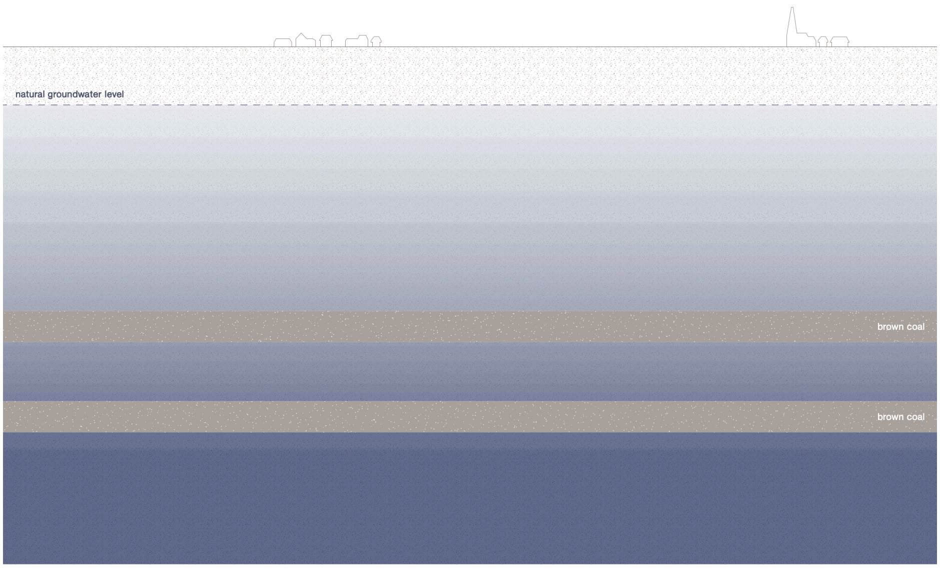
With the decision of the Bundestag to end brown coal mining in North Rhine-Westphalia by 2030 many questions remain open: how will the future look like, who decides in the future and who will pay the price.

RWE has a clear vision of transforming the three open pit mines into lakes, which should act as leisure activity and recreation area for locals and attract tourist into the region. Their scenarios give the impression that RWE will leave the landscape in good condition and all the issues caused by brown coal mining will be history by 2090. Problems such as flooding, toxic groundwater and water shortage due to climate change are not being addressed in these future scenarios. According to its own information, RWE has set aside only 165 million Euros to deal with the water management consequences after brown coal mining ends until groundwater levels are restored to its original level in 2380. Considering the time span and the financial resources set aside, there is a risk that future costs will be passed on to the taxpayer. RWE must therefore be obliged to pay an appropriate amount into a fund to be set up under public law. The damages caused by RWE are no longer consequential damages by brown coal mining, but need to be addressed as eternal burdens. In any event, the decisive factor in the future will not be the hasty vision of a lake as a recreational destination and a real-estate opportunity, but the inclusive and participatory process of healing the territory and the landscape and meeting the needs of all its inhabitants.

How Brown Coal Mining Steals Our Groundwater



RWE operates a complex water management network which pumps away groundwater constantly to extract brown coal in the open pit mines of the Rheinische Revier. Groundwater is pumped to the surface where one third of it is used as service water in their own brown coal facilities. The groundwater lowering cannot be limited to the open pit mines and their immediate surroundings: instead, a large-scale drawdown funnel is created, which alters the groundwater throughout the entire area.



GROUNDWATER SUMP IN THE OPEN PIT MINING CONTEXT OVER TIME.















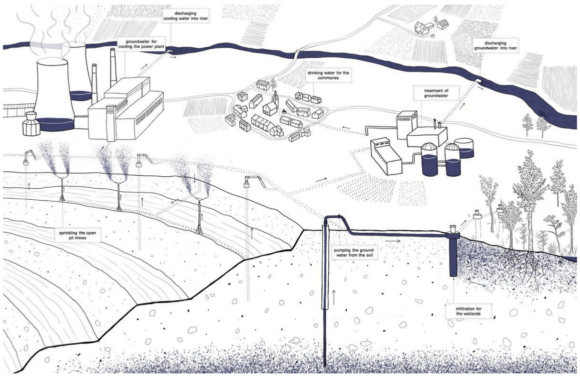
JR 1587


SERIES OF PHOTOGRAPHS SHOWING
THE VISIBLE INFRASTRUCTURE
CONNECTED TO THE PUMPING SYSTEM.

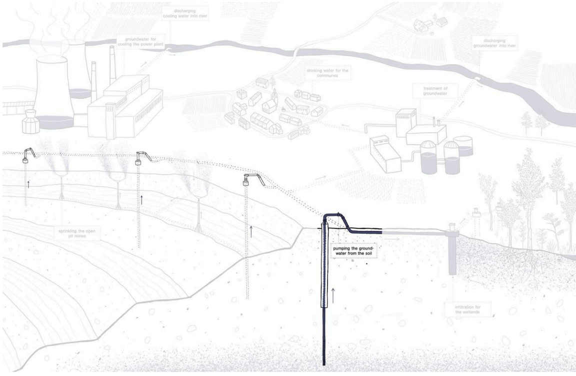
VISIBLE PUMPING SYSTEM AND OBSERVABLE
IMMEDIATE USE OF PUMPED GROUNDWATER.

https://youtu.be/CKc0mEqIbkk

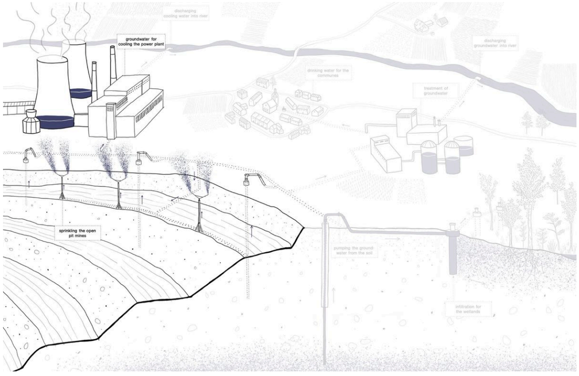
Brown coal can only be extracted in open mining pits due to the loose surface layers in the Rheinische Revier. RWE must lower the groundwater level by pumping groundwater constantly to the surface, therefore preventing water from entering the three mining pits of Inden, Hambach and Garzweiler.



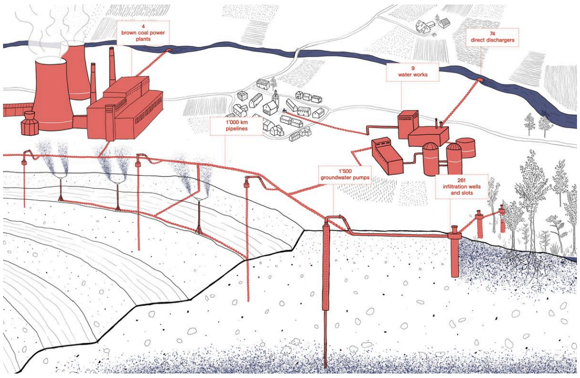
SCHEME OF GROUNDWATER MANAGEMENT IN THE ENVIRONMENT OF OPEN MINING PIT.



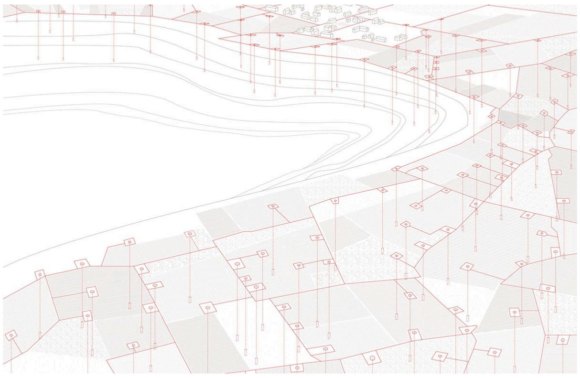
FOCUSING THE PUMPING SYSTEM.



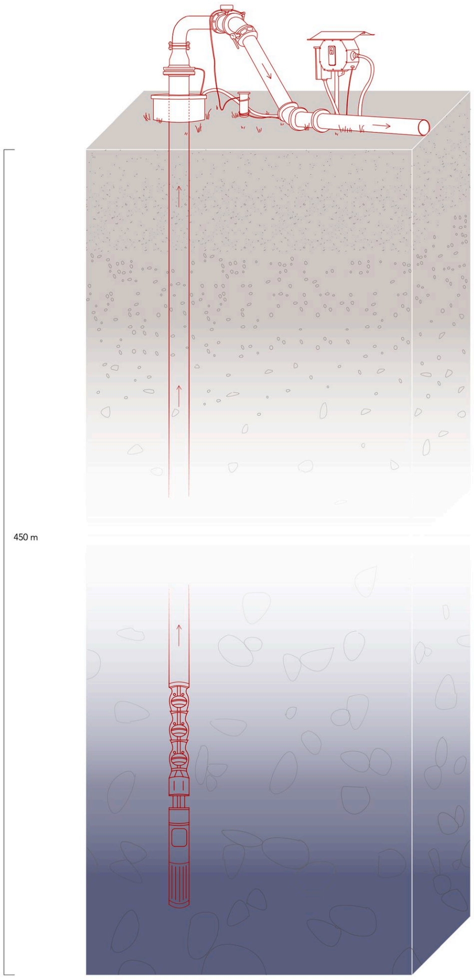
FOCUSING THE IMMEDIATE USE.



FOCUSING THE POWER OF RWE AND HIGHLIGHTING OWNERSHIP.



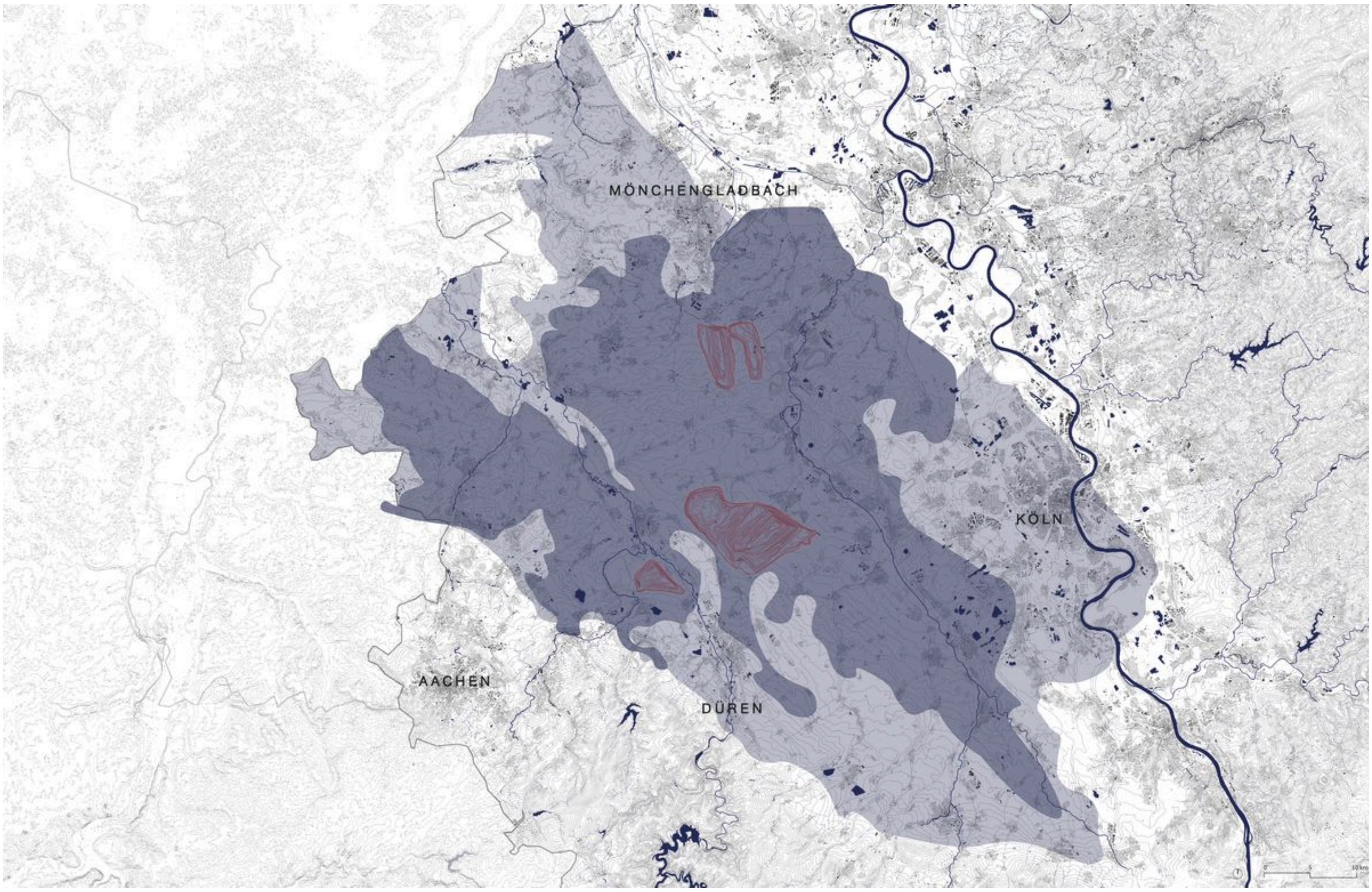
PUMPING LOCATIONS COMBINED WITH THE CONNECTING NETWORK NEXT TO THE OPEN MINING PIT.



CONNECTION OF THE PUMP ABOVE THE GROUND AND THE SUMP PIPE SUBSOIL.

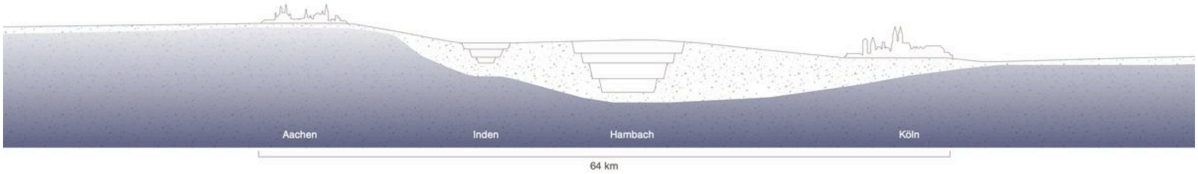
Groundwater is pumped away constantly with the help of a dense grid consisting of 1’500 pumps, which are located around the three open mining pits. The pumped groundwater is then transported by an underground pipeline network to one of the surrounding nine water works, where it is purified to drinking water quality. One third of the purified water is then distributed to the brown coal power plants, where it is either used as cooling water or as service water in the open mining pits, such as water sprinkler system to prevent dust pollution around the pits. Less than one third of the purified groundwater is used as compensation water for public water supply facilities or as infiltration water for wetlands. The remaining water is discharges into the river and streams in the region, thus ensuring the ecological balance of the rivers.

Since 1950, RWE has removed 580 million cubic meters groundwater every year. An amount 235 times higher than the annual private water consumption of inhabitants in the entire region of North Rhine-Westphalia.



GROUNDWATER INFLUENCE IN THE BROWN COAL MINING AREA (2021).
Source: Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein--Westfalen (LANUV).

- Groundwater lowering in the upper groundwater table 1600 km2
- Groundwater lowering in all groundwater levels 3300 km2
- Brown coal mining



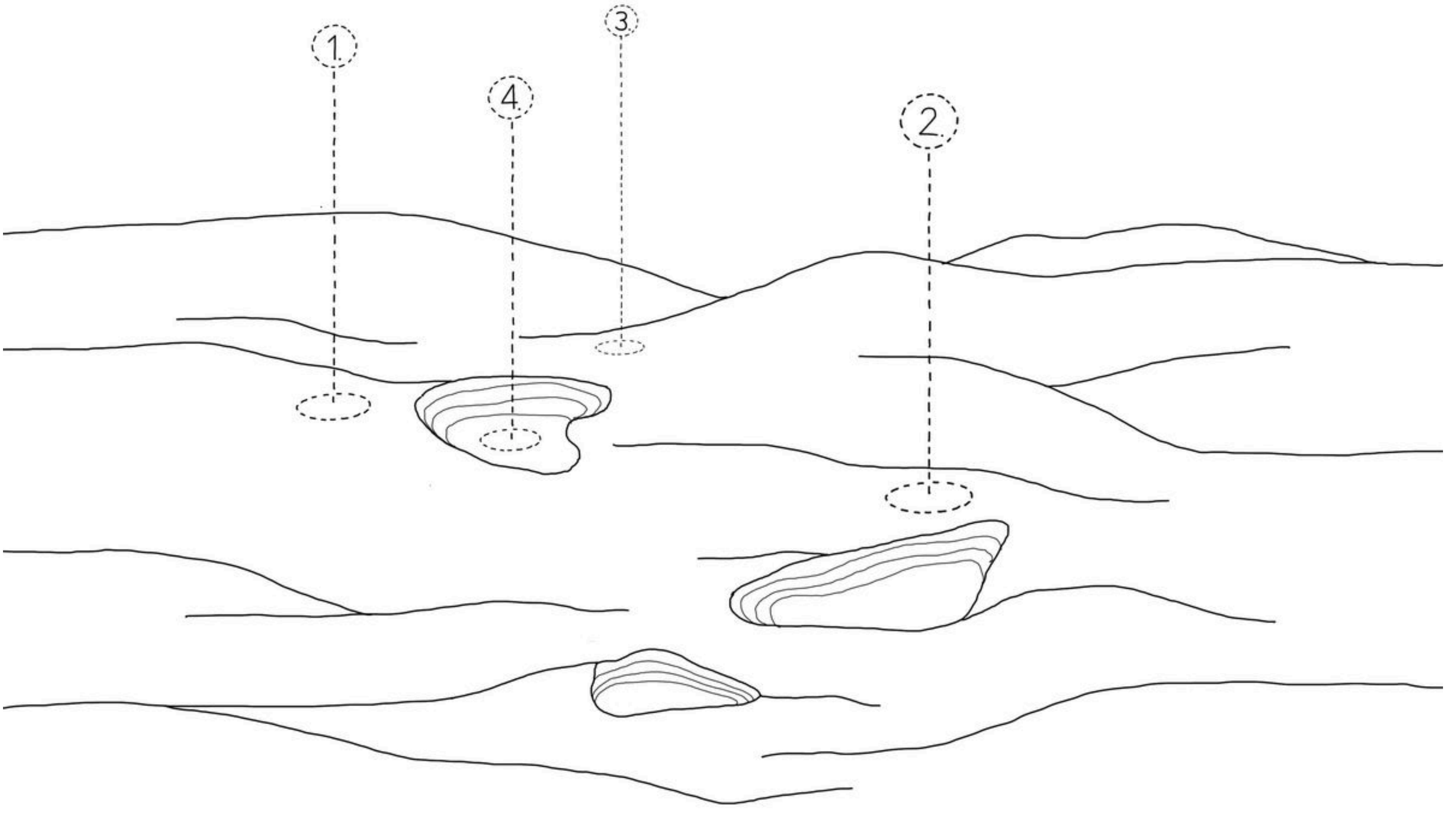
SCHEMATIC SECTION SHOWING THE LARGE IMPACT
OF GROUNDWATER LOWERING IN THE REGION.

The lowering of the groundwater level is measurable far beyond the perimeter of the open-cast mines. The widespread drawdown funnel area is measured to be around 3,300 square kilometres, equivalent to about 460,000 football fields. It extends beyond the country's borders. Problems such as drying up of wetlands, ground lowering and lacking groundwater in public water supply facilities can be directly linked to RWE's groundwater lowering.

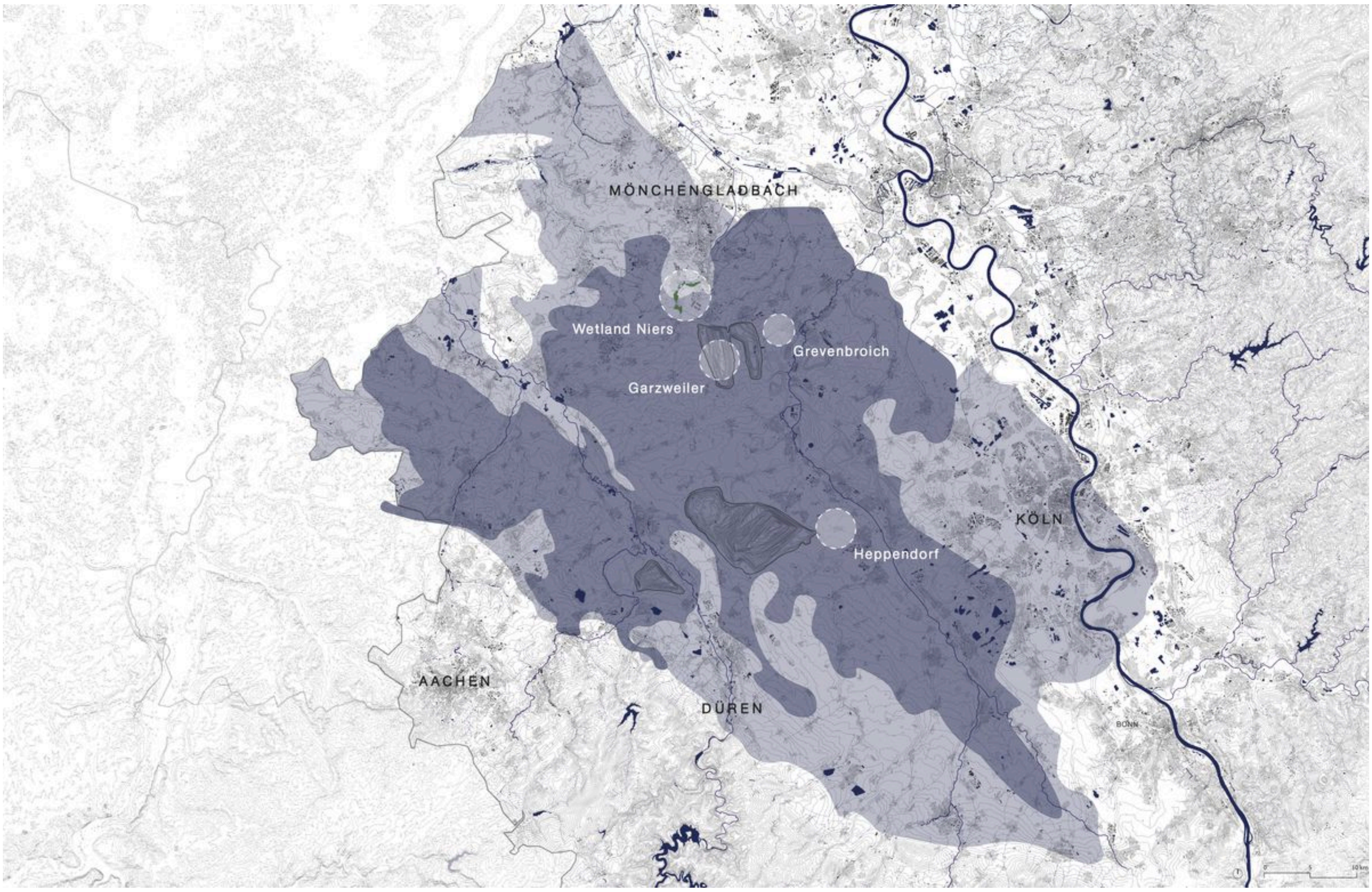
Unlike other groundwater users, RWE was exempt from the water extraction fee until 2011, which meant that this exploitation of the natural resource groundwater also generated a financial profit of 25 million Euros annually since 1950.

RWE is legally obliged to compensate where groundwater is lacking. Numerous infiltrations and direct discharges of water in the area between the open-cast mine and the wetlands ensure that the groundwater level in the wetlands worth protecting is maintained, thereby ensuring their ecological value, and preventing them from drying out. Public water supply facilities receive compensation in form of direct water supply by RWE. Vegetation in the region for the most part depends on loess, which absorbs rainwater and then stores it in the soil. Due to compensation, RWE claims that for the public water supply and vegetation in the region there is no harm by groundwater lowering.

Large-Scale Problems of Groundwater Lowering: Four Case Studies



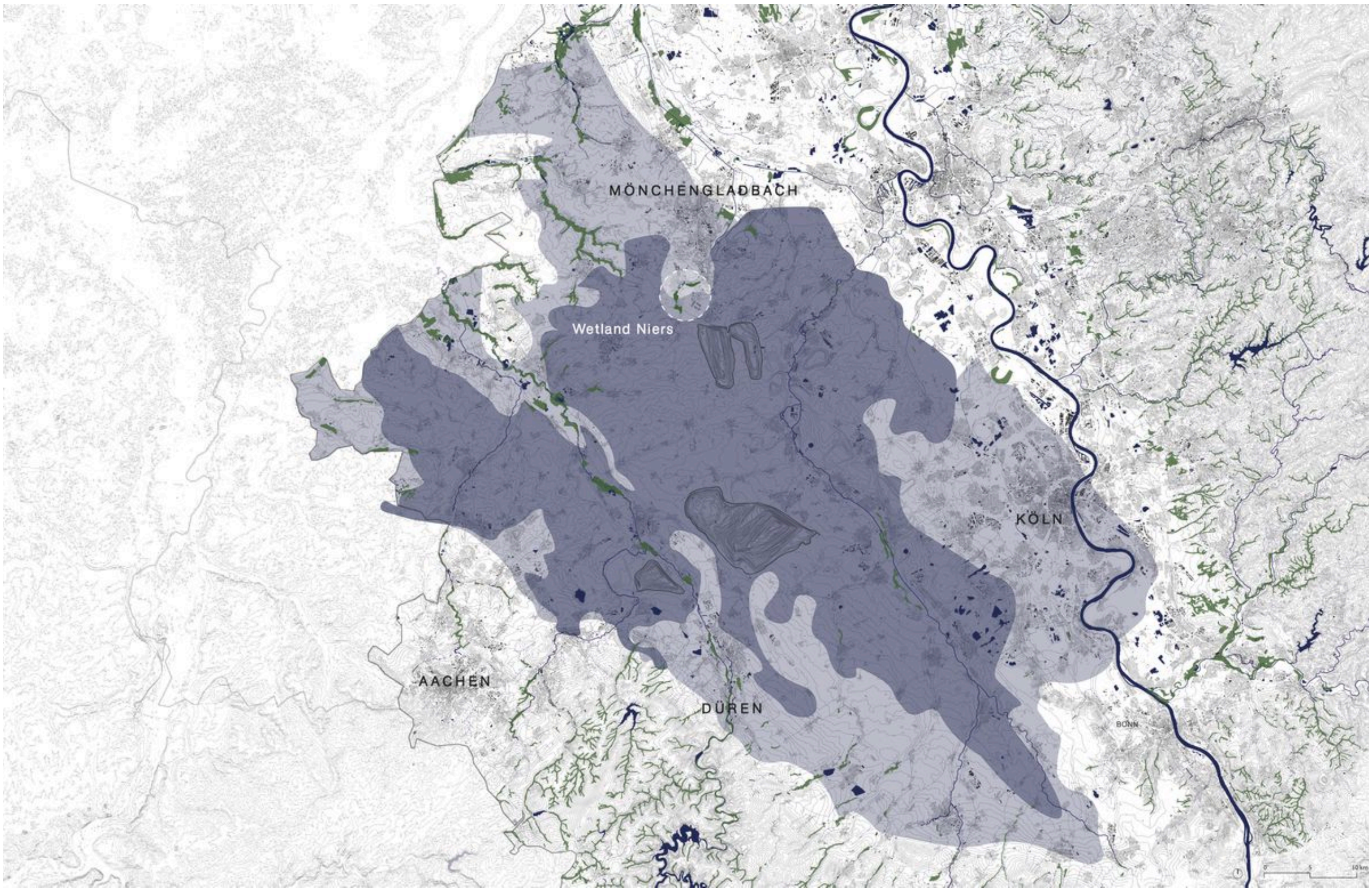
To accomplish a deeper understanding of the region and its problems caused by brown coal mining four case studies are elaborated. It becomes visible how groundwater lowering around the open mining pits causes problems across the territory of the Rheinische Revier.



FOUR CASE STUDIES AFFECTED BY GROUNDWATER LOWERING.

- Groundwater lowering in the upper groundwater table 1600 km2
- Groundwater lowering in all groundwater levels 3300 km2

Case Study Wetland Niers



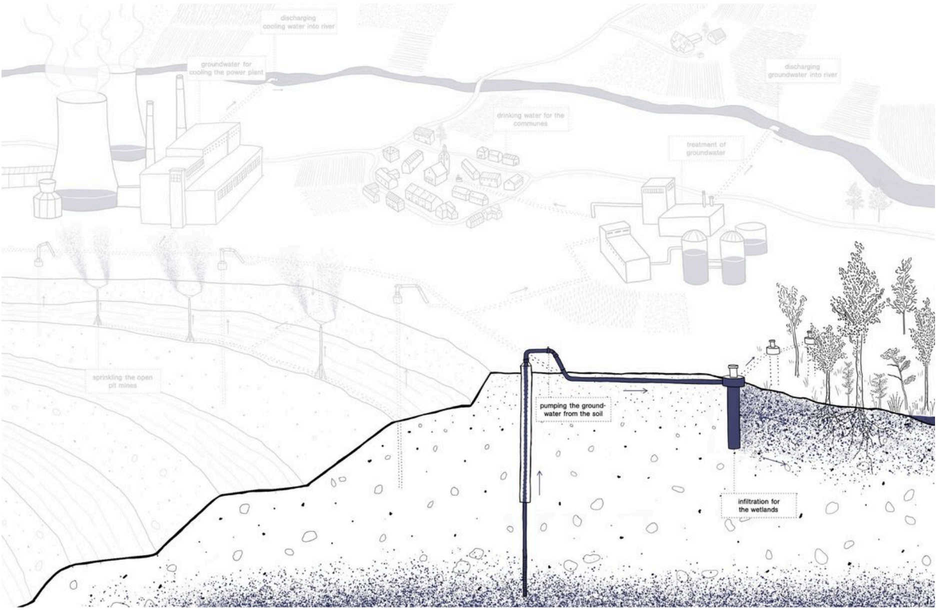
WETLAND NIERS: DEPENDENT ON GROUNDWATER.

- Groundwater dependent wetland
- Groundwater lowering in the upper groundwater table 1600 km2
- Groundwater lowering in all groundwater levels 3300 km2

Wetlands are among the most diverse ecosystems because they are home to a variety of flora and fauna. When wetlands grow, they filter carbon dioxide from the atmosphere. 500 times more C02 is stored in wetlands than in forests or oceans, making them an effective CO2 storage. Therefore, wetlands are very important for ecology and climate protection, making them worthy of special protection.

Wetlands can dry out due to the lowering of groundwater caused by RWE. If the wetlands disappear, CO2 is released into the atmosphere and important ecosystems are destroyed. Areas for wetlands in North Rhine-Westphalia shrank by more than a fifth from 2016 until 2020.

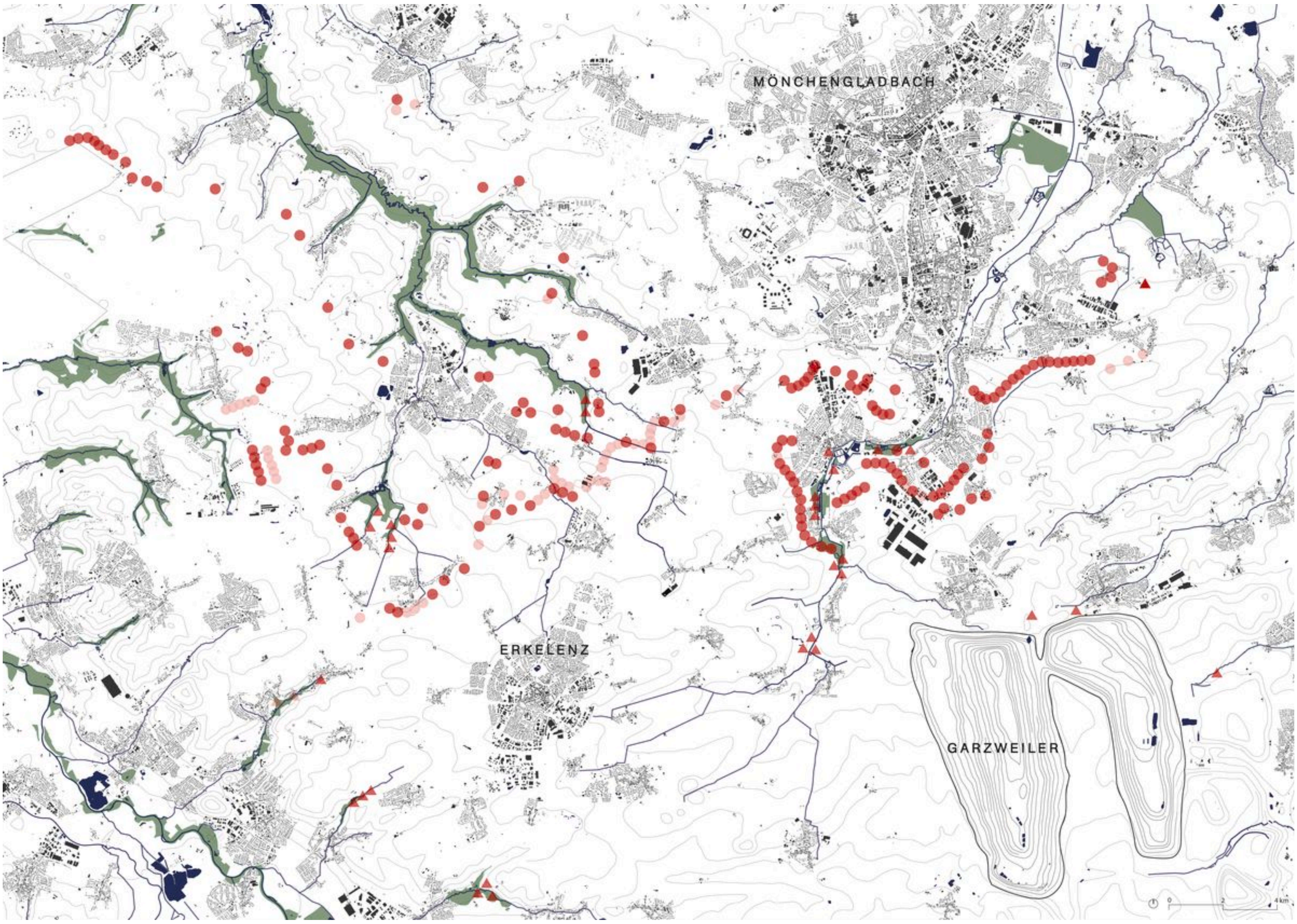
FOOTAGE FROM THE WETLAND NIERS AND A NEARBY INFILTRATION UNIT.
https://youtu.be/foAIQZa1Y5c



INFILTRATION OF WETLANDS.

281 infiltrations wells and 74 direct discharges of water in the area between the open-pit mine and the wetlands reinsure the natural groundwater level in the wetlands and thus prevent the drying up of the wetlands.

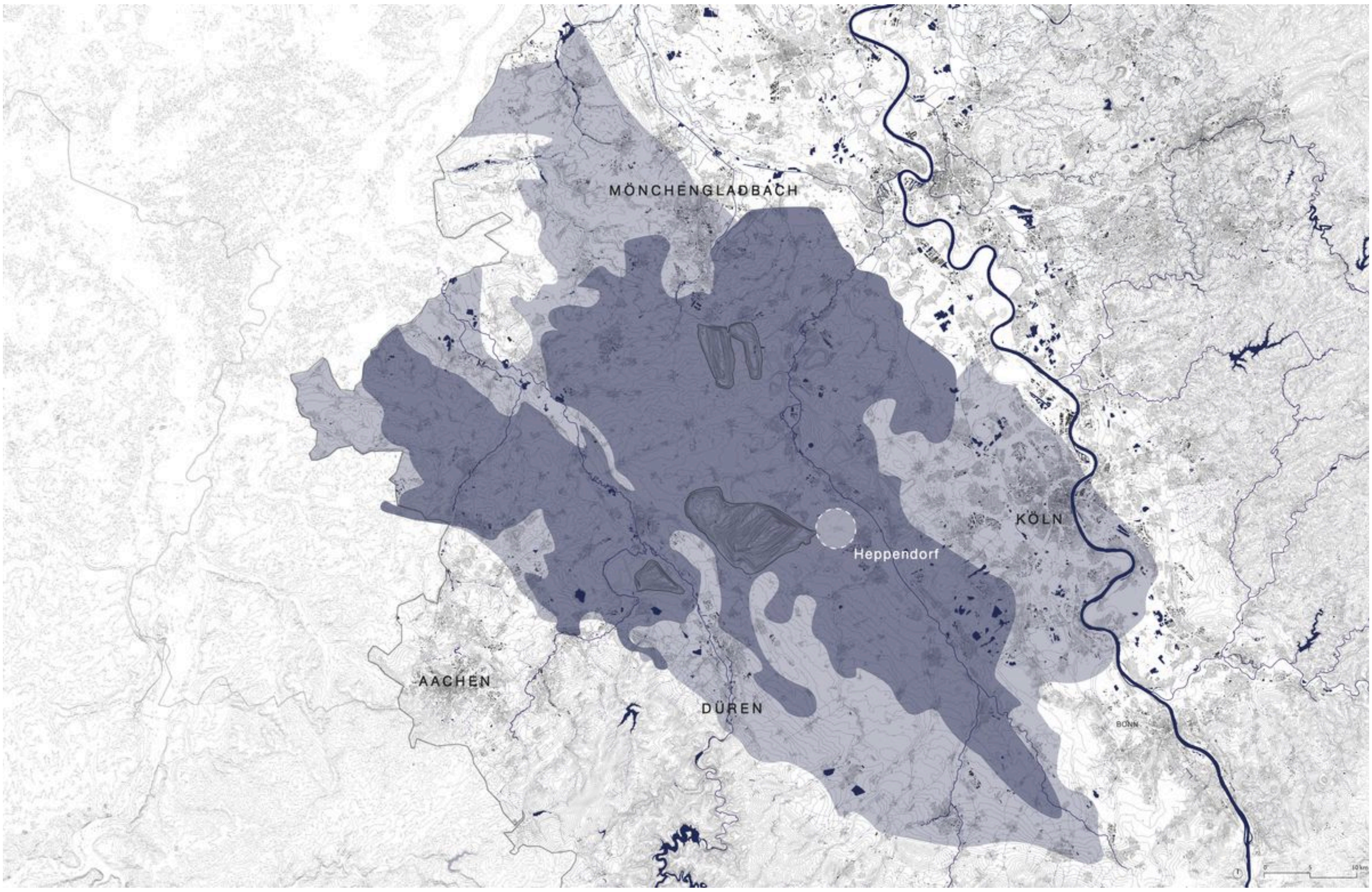
100 Mio. cubic meter water – equivalent to approximately 666 Mio. filled bathtubs – of the pumped groundwater is used for wetlands every year. This is one of RWE's compensations which they are legally obliged to do.



INFILTRATION BY RWE IN THE REGION OF MÖNCHENGLADBACH.
Source: Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein--Westfalen (LANUV).

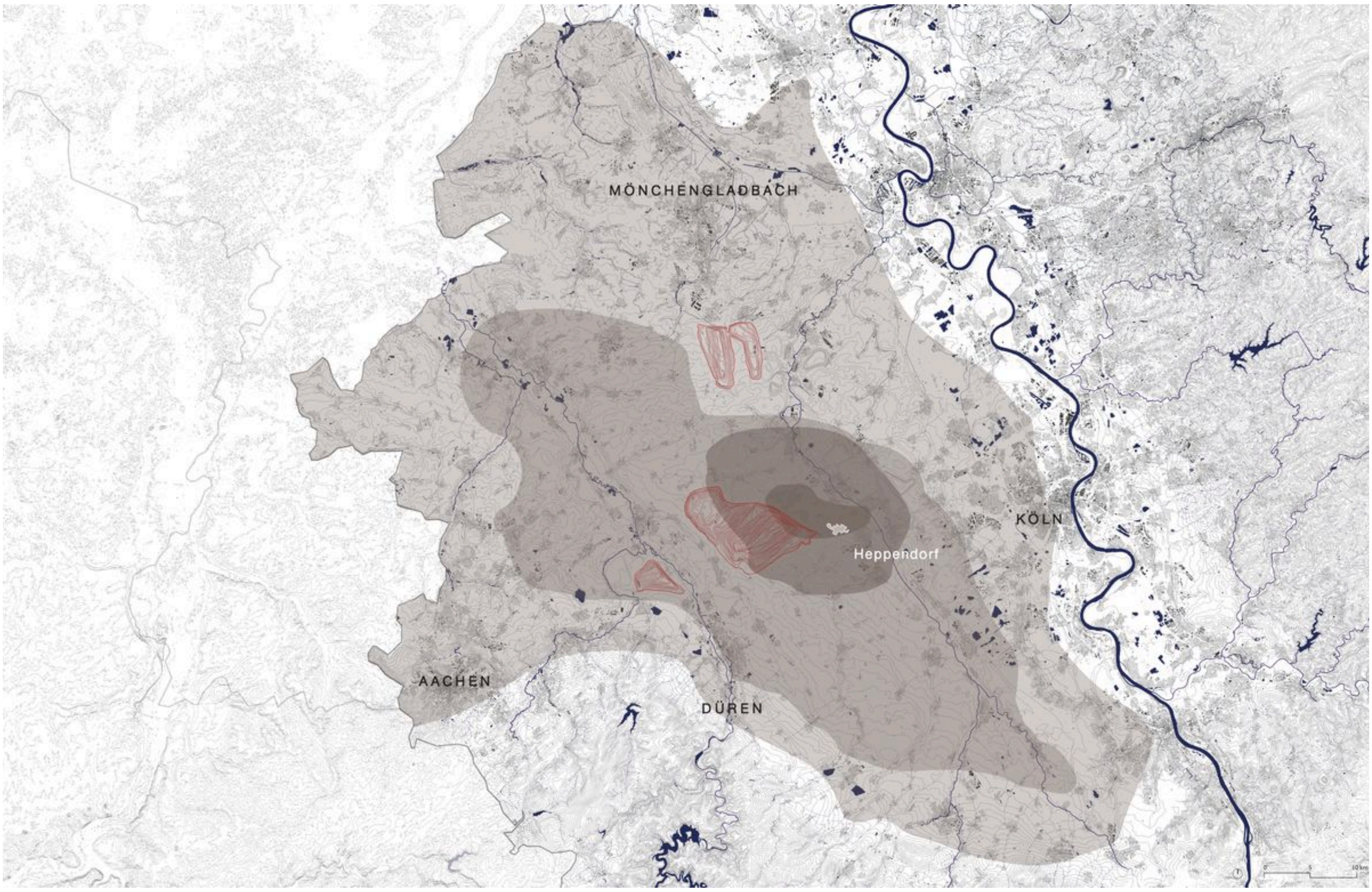
Groundwater dependent wetland
Infiltration in operation
Infiltration in planning
Direct dischargee in operation
Direct discharge in planning

Case Study Heppendorf



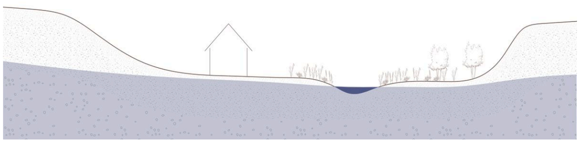
HEPPENDORF: AFFECTED BY SOIL LOWERING.

Heppendorf is a village in four kilometres proximity to the Hambach brown coal mining pit. Due to the lowering of the groundwater and the associated loss of volume, the soil level in Heppendorf has dropped by more than two meters since RWE began its mining operations. The movement of the soil leads to so-called mining subsidence damages, which include cracks in the foundations and walls of buildings, causing water damage inside.

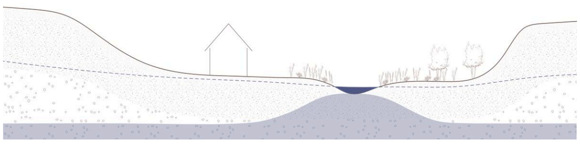


SOIL LOWERING IN THE BROWN COAL MINING AREA (1977-2013).
Source: Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen (LANUV)
[https://www.lanuv.nrw.de/fileadmin/lanuvpubl/3_fachberichte/LANUV-Fachbericht_88.pdf].

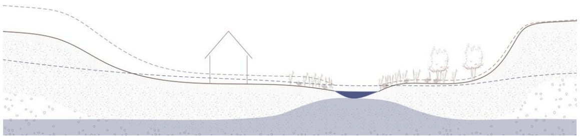
- 2.0 m
- 1.0 m
- 0.1 m
- < 0.1 m
- Brown coal mining: 200-450 m



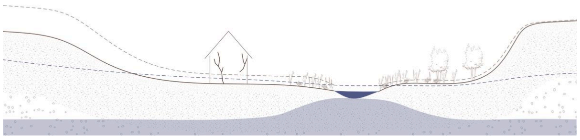
PRE-MINING: NATURAL GROUNDWATER DEPOSITS IN THE SOIL.



ACTIVE MINING: LOWERED GROUNDWATER TO ENABLE OPEN PIT MINING



ACTIVE MINING: LOWERED SOIL DUE TO A LOSS OF VOLUME IN THE SUBSURFACE LAYERS.



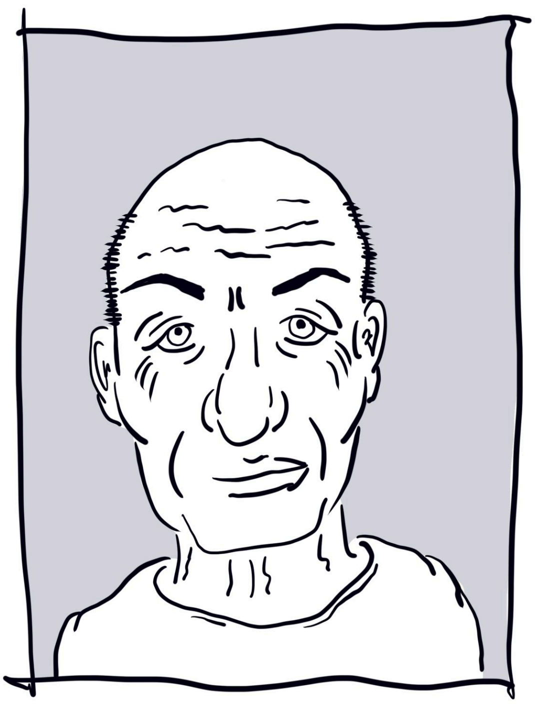
POST MINING: GROUNDWATER-DEPENDENT WETLANDS WITH MANDATORY INFILTRATION MEASURES TO PREVENT DESICCATION.

The process of the soil lowering in the territory is in the best case slow and even and therefore harmless for most buildings. However, the ground can also lower unevenly if there are geological features that cause it. In this case, damages to the built environment can occur. There are some indications that allow a rough distinction to be made between mining damage and other building damage. Mining damage usually starts where the ground moves, i.e. from the foundation.

Many inhabitants of Heppendorf reported of cracks on their houses, water damages or dust pollution. RWE claims that these damages cannot directly be linked to the brown coal mining and the groundwater lowering in the region. Therefore, no compensation was ever paid, and the costs remained with the residents of Heppendorf.

“There was once a town hall meeting because of all the cracks in the walls of the houses.”

“I had to refill my garden with soil three times already."



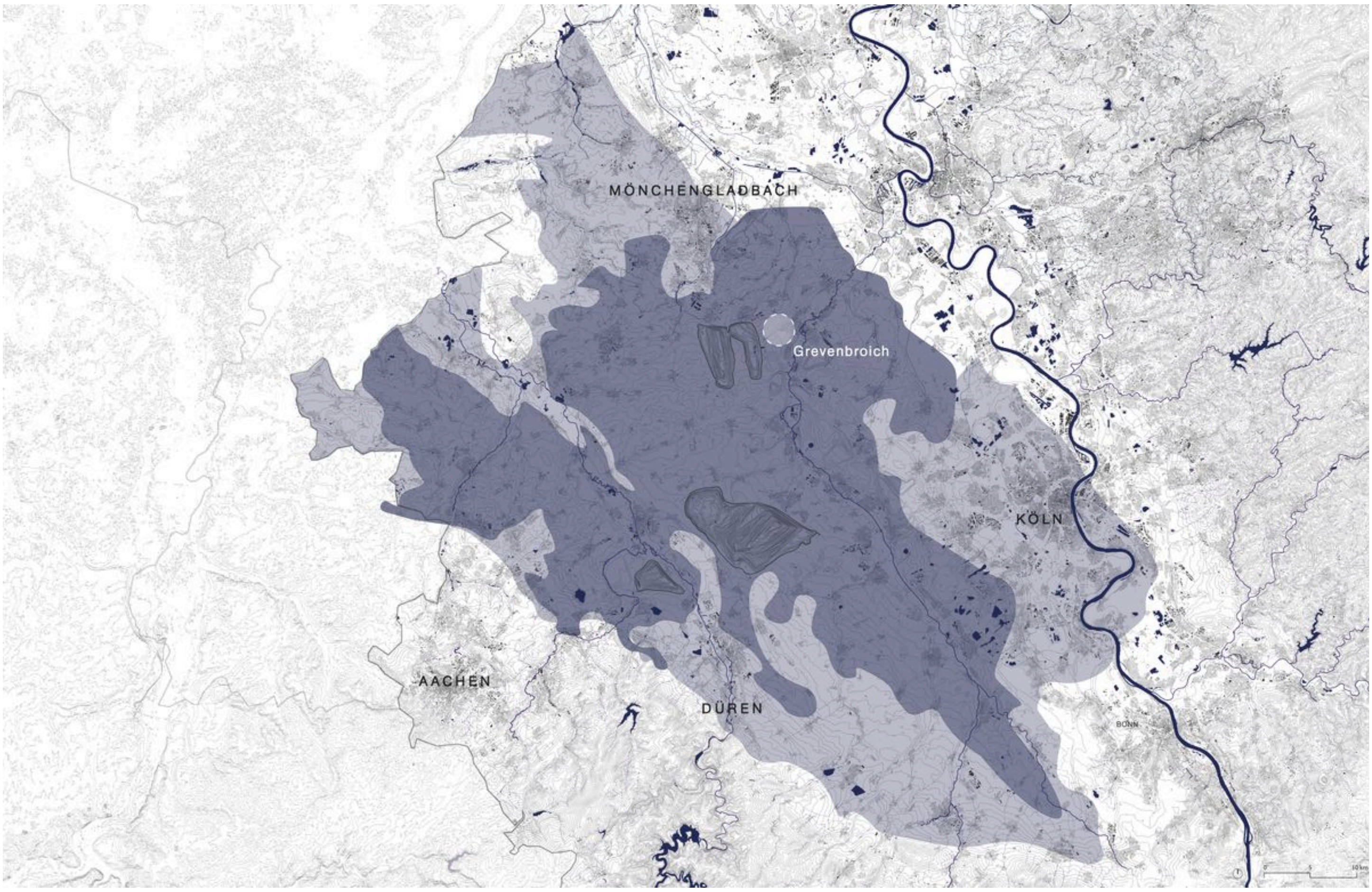
“My daughter works for RWE, there are no problems in our village."

“No one received any compensation from RWE.”

“In our basement we had several cracks in the walls which led to water damage.”

“RWE didn’t ask us before, so they don’t have to ask us now."

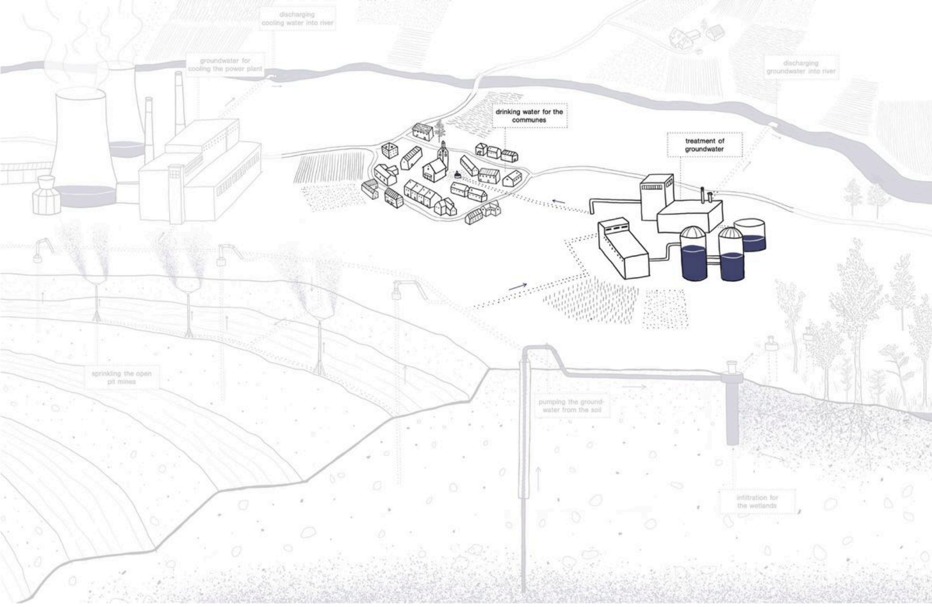
Case Study Grevenbroich



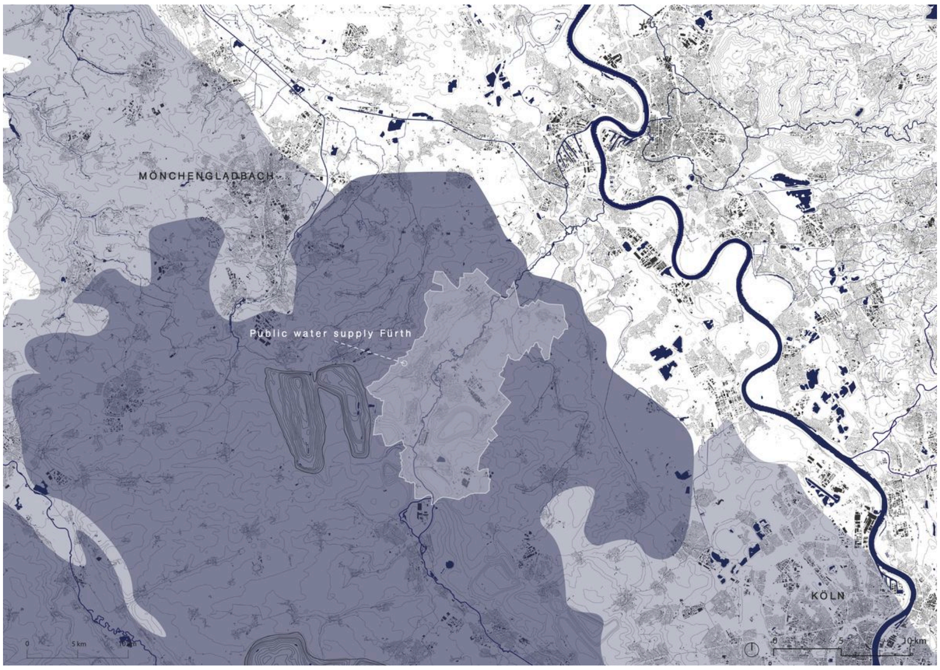
GREVENBROICH: DEPENDENT ON WATER SUPPLY BY RWE.

Grevenbroich is a large district town in North Rhine-Westphalia, within 13 kilometres proximity to the brown coal mine Garzweiler. In 1973 the Fürth waterwork, which is the public water supply facility in Grevenbroich, felt dry due to groundwater lowering by brown coal mining and was therefore replaced by RWE. The waterwork was newly supplied with pumped-up groundwater from the open mining pit and supplies until today 62'000 residents with drinking water.

Every year approximately 6,3 Mio. cubic meter are supplied by RWE as compensation water into the Fürth water supply facility. Communes are dependent on RWE, otherwise there would be water shortage and the water supply would not be secured. This compensation gives RWE power over drinking water and thus thousands of inhabitants in the Rhenish Revier.

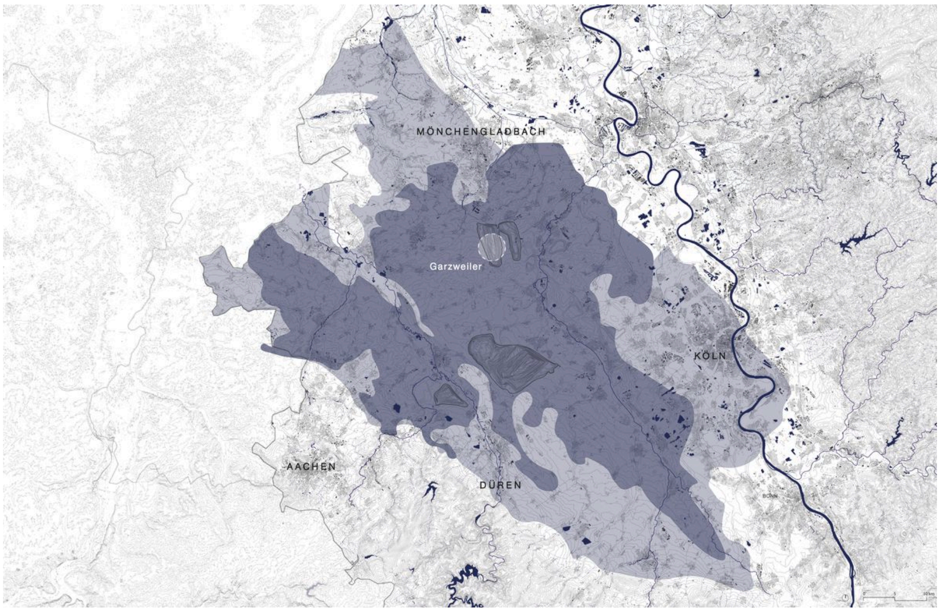


WATER COMPENSATION BY RWE TO COMMUNES.



SERVICE AREA OF WATER SUPPLY FÜRTH IN
OVERLAY TO GROUNDWATER INFLUENCE.
Source: GWG Grevenbroich GmbH [https://www.gwg-grevenbroich.de/fileadmin/user_upload/gwg-grevenbroich.de/Dokumente/GWG_Versorgungsgebiet_Trinkwasser.pdf].

Case Study Garzweiler



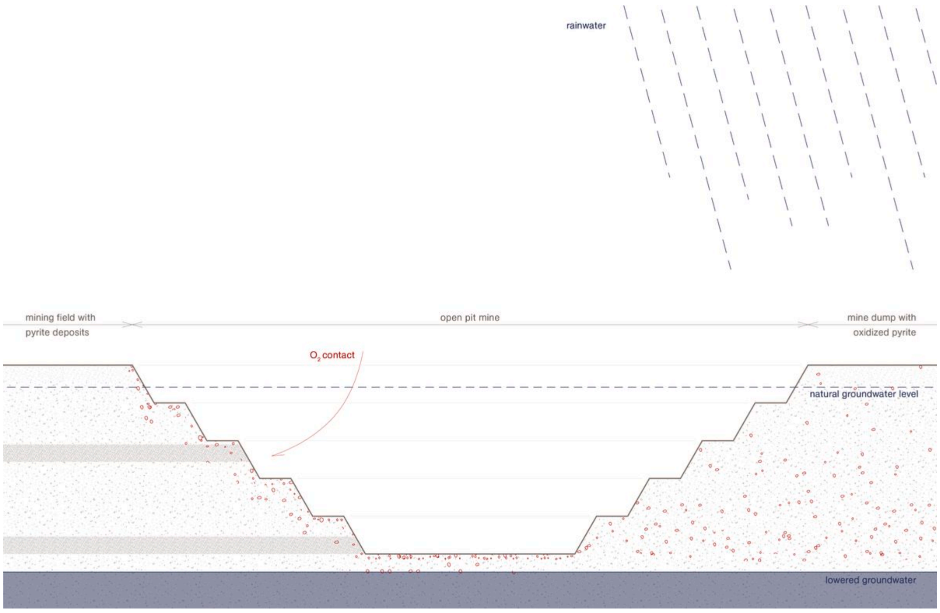
GARZWEILER: PYRIT PROBLEM IN THE OPEN MINING PIT.

Garzweiler is one of the three brown coal open pits in the Rheinische Revier. It covers an area of 35 square kilometres, equivalent to 4,902 football fields.

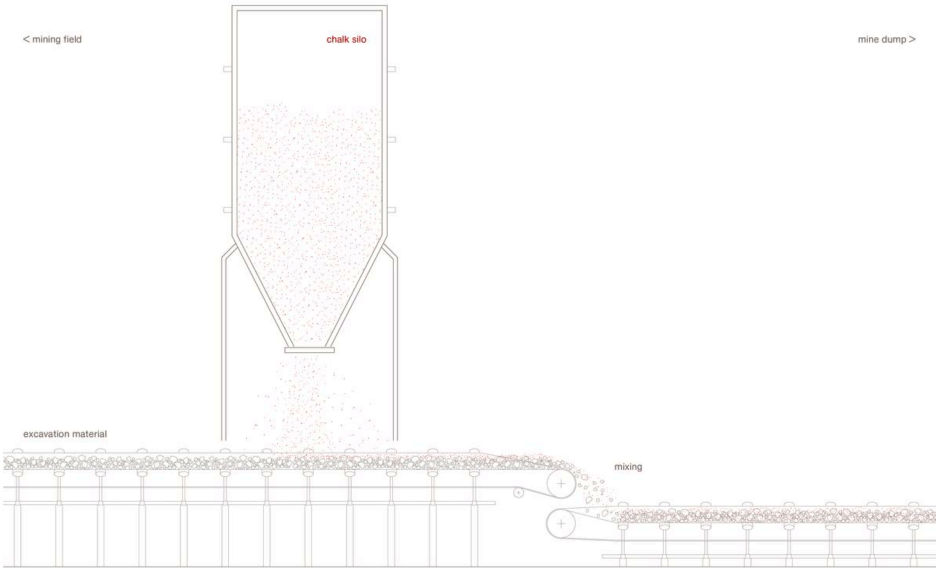
The brown coal mining pit works in one direction. Brown coal is being extracted from one end of the open mine and the dump material is being disposed on the other side. During this process the pyrite (iron disulphide) contained in the brown coal by-products is exposed to atmospheric oxygen and oxidised. Significant amounts of acid, iron and sulphate are released and stored in the soil.

To minimise the material discharge from the inner dump various measures were investigated. These range from “dump management”, i.e. dumping the acidification-sensitive masses under oxygen exclusion if possible, to the addition of power plant ash and chalk as an acid buffer.
Ultimately, these measures could only lead to one-third reduction in groundwater acidification, resulting in two-thirds of the acidification potential.

So far, pollutant discharge has been limited to a few sites due to large-scale groundwater lowering. However, with the flooding of the remaining holes and the groundwater rebound, the toxic discharge from the inner dumps will begin.

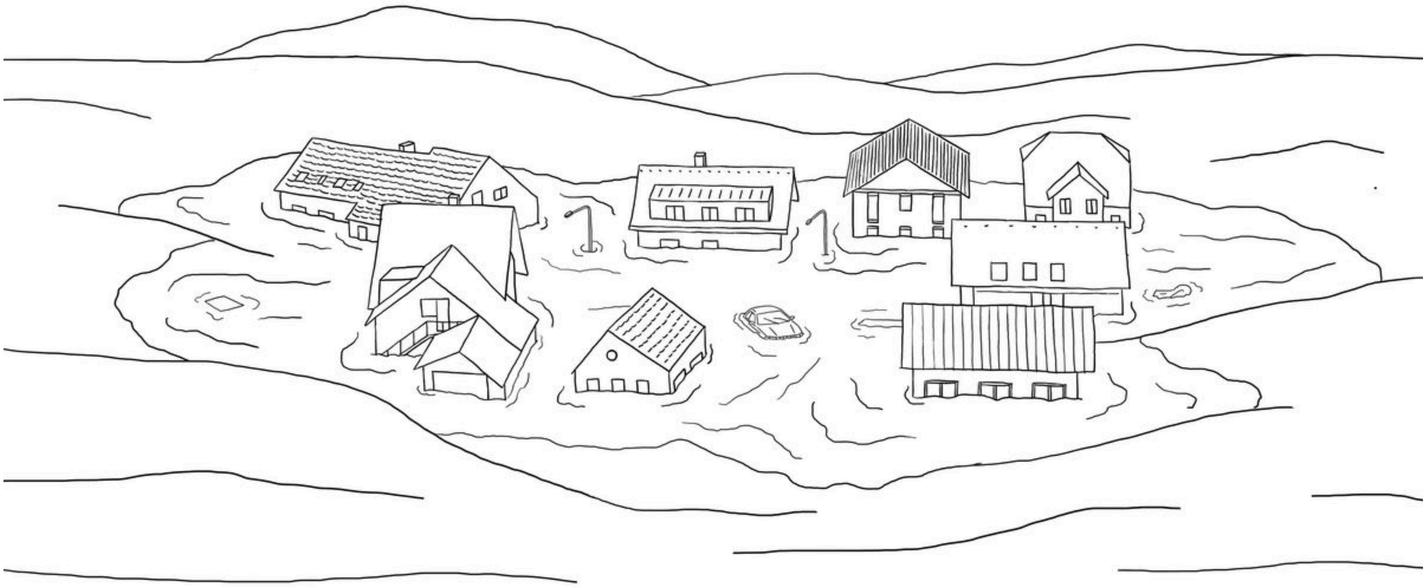


ACIDIFICATION: OXIDIZED PYRITE DISTRIBUTION IN THE OPEN MINING PIT.

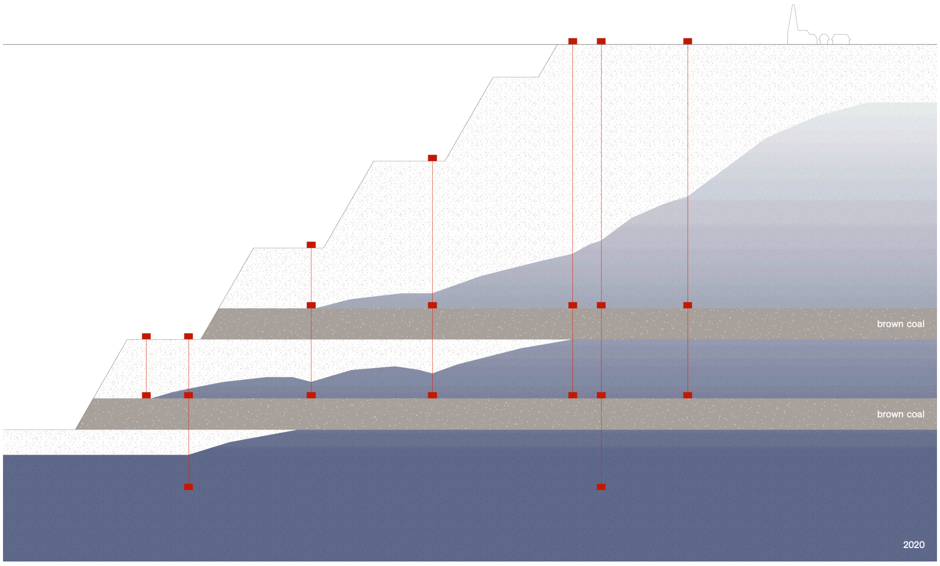


CONVEYOR BELT WITH EXCAVATED MATERIAL IS BEING
MIXED WITH CHALK FROM A SILO TO REDUCE ACIDIFICATION

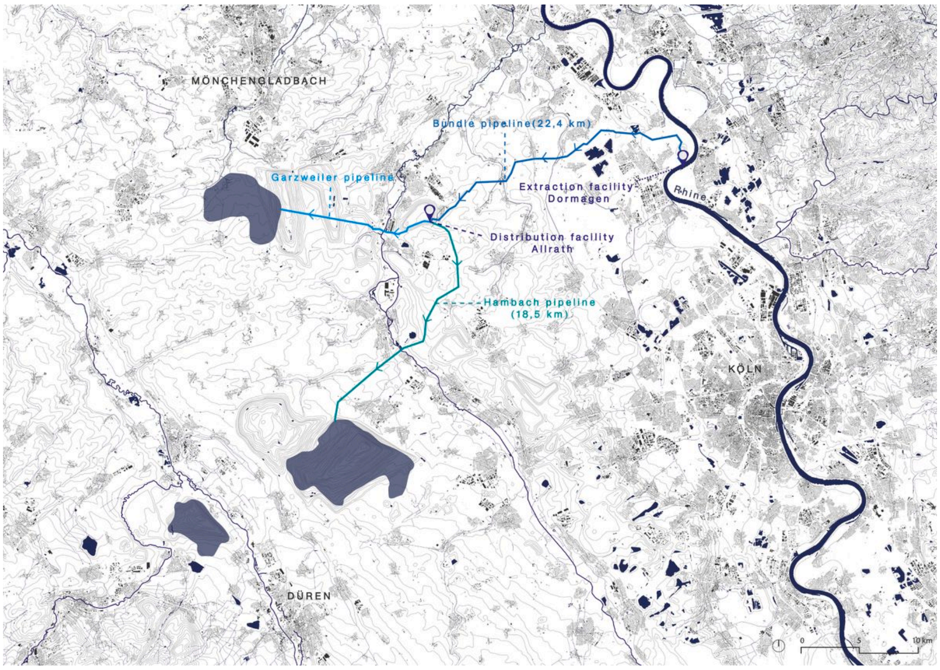
The Echo of Mining: Prolonged Disruptions of the Hydrological Cycle



In 2030, brown coal extraction in the Rheinische Revier will end as part of the German coal phase-out. RWE will then stop all activities related to brown coal, thus groundwater in the region will rise slowly. Natural groundwater levels should be achieved by 2090 according to RWE. Until then the 7’250 hectares of brown mining pits – approximately 9,944 football fields – will be transform into recreational lakes. Future problems such as flooding, toxic groundwater, and water shortage due to climate change are not being addressed in these future scenarios. Other eternal burdens to the water system such as infiltration of wetlands or who will pay for them in the future are not issued by RWE.



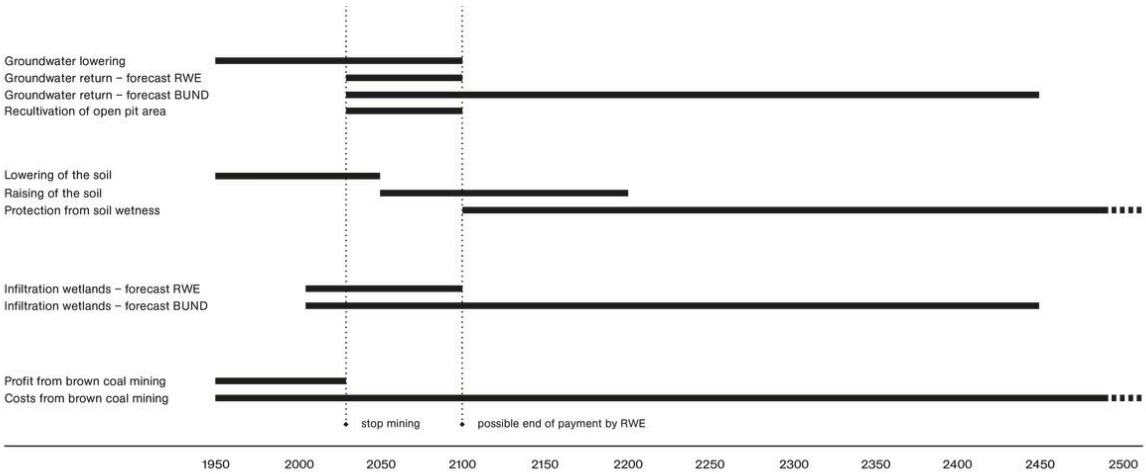
GROUNDWATER RETURN IN THE OPEN PIT MINING CONTEXT OVER TIME.



FUTURE VISON OF RWE.
Source: RWE AG [https://www.rwe.com/forschung-und-entwicklung/projektvorhaben/rheinwassertransportleitung/projekt].

The Bundestag has decided to end brown coal mining in North Rhine-Westphalia by 2030. From then on RWE will no longer extract brown coal in the Rheinische Revier. As a result, three gigantic residual holes with a surface of 7’250 hectares will remain.
The stop of mining will also lead to a stop of groundwater pumping and therefore the groundwater will naturally rise again and slowly fill the remaining holes with water.

RWE envisions this water landscape as a place where future generations can use the three lakes at Inden, Hambach and Garzweiler as recreation area, sailing area and bathing location. But the volume of the three lakes together are estimated to be 6,700 Mio. cubic metre, equalling one tenth of the size of Lake Constance and much deeper. Because of this enormous volumes of the lakes and the slow rate of groundwater recharge, the natural filling of the lakes would take hundreds of years. However, RWE wants to use a 45 kilometres long pipeline to carry Rhine water to the former open mining pits to speed up the filling of the lakes.
The question remains whether there will even be enough water in the Rhine for this process and how the impact of the withdrawn water will show in the territory.



WATER MANAGEMENT INTERVENTIONS ON THE TIMELINE:
JUXTAPOSITION OF INTERVENTION AND IMPACT.

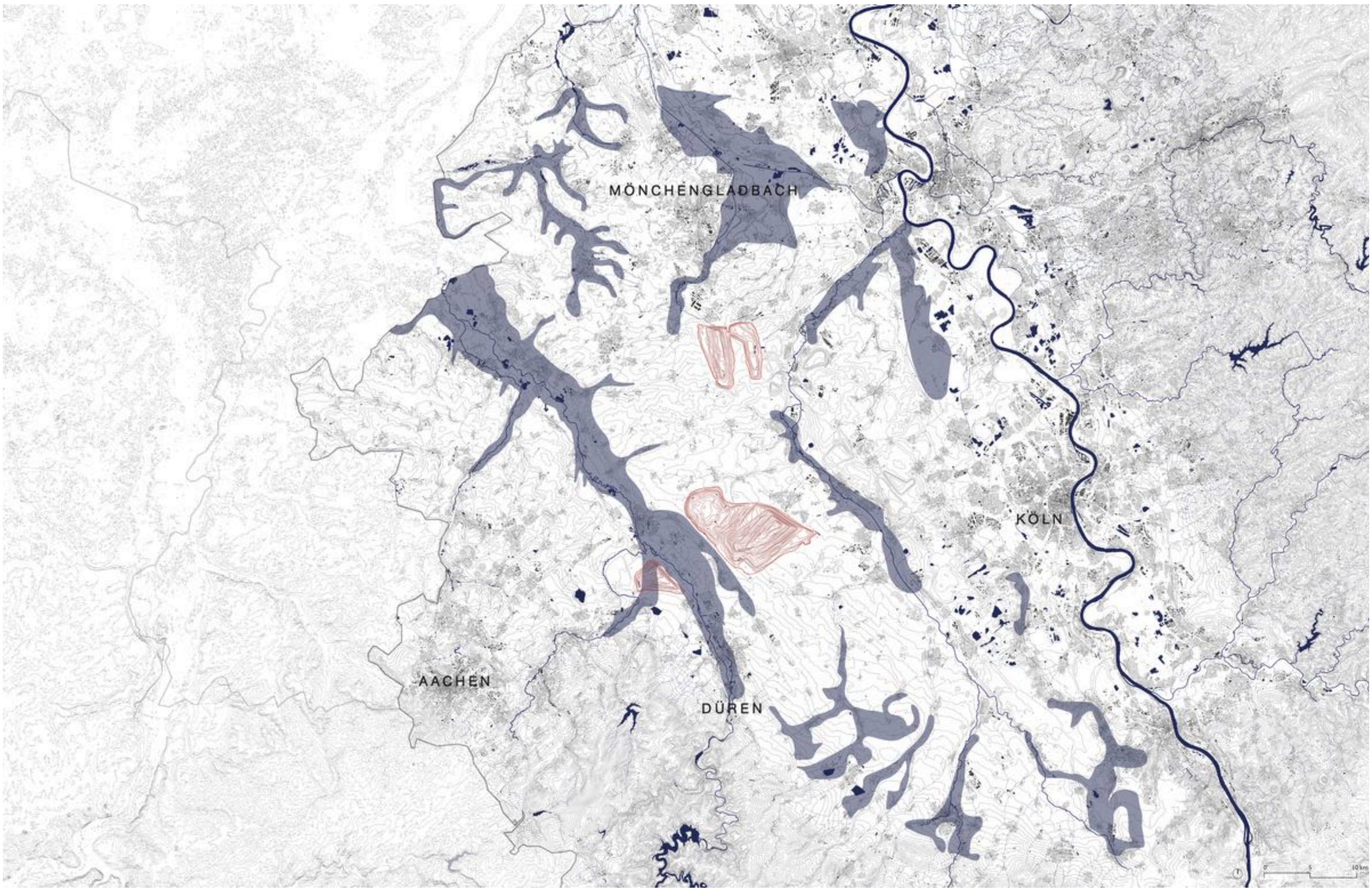
It is already known today, that problems such as soil wetness, water pollution and prolonged infiltration of wetlands will occur sooner or later and are closely linked to the slow rebound of groundwater. In order to ensure the stability of the open pit mines and to provide water for wetlands during the rise of the groundwater, some pumping of groundwater needs to be prolonged.
In addition, water shortages may occur in public water supply systems if RWE does not compensate for them during the long period that groundwater needs to rise.

RWE has set aside 165 Mio. Euro for these so-called follow-up costs of brown coal mining. With a timespan of over 350 years and the large-scale impact that the various problems will have, this amount seems to be insufficient. There is a risk that future costs will not be taken care of and will be passed on to the taxpayers. Therefore, the term follow-up costs should be changed to eternity costs, because problems will continue to occur in the future that cannot be foreseen today and it must be ensured that RWE, a company that has made profits for decades, has to pay for the burdens it has caused.

RESERVES FROM RWE	AMOUNT	TIMEFRAME
Recultivation of open pit areas	1,550 mio	2030–2085
Water management impacts	165 mio	2030–eternity
Pumping in the Erft region	0 mio	2030–eternity
Damage due to soil rebound	0 mio	2030–eternity
Unexpected problems	0 mio	2030–eternity
Acidification problem	0 mio	2030–eternity
In total	1,615 mio	

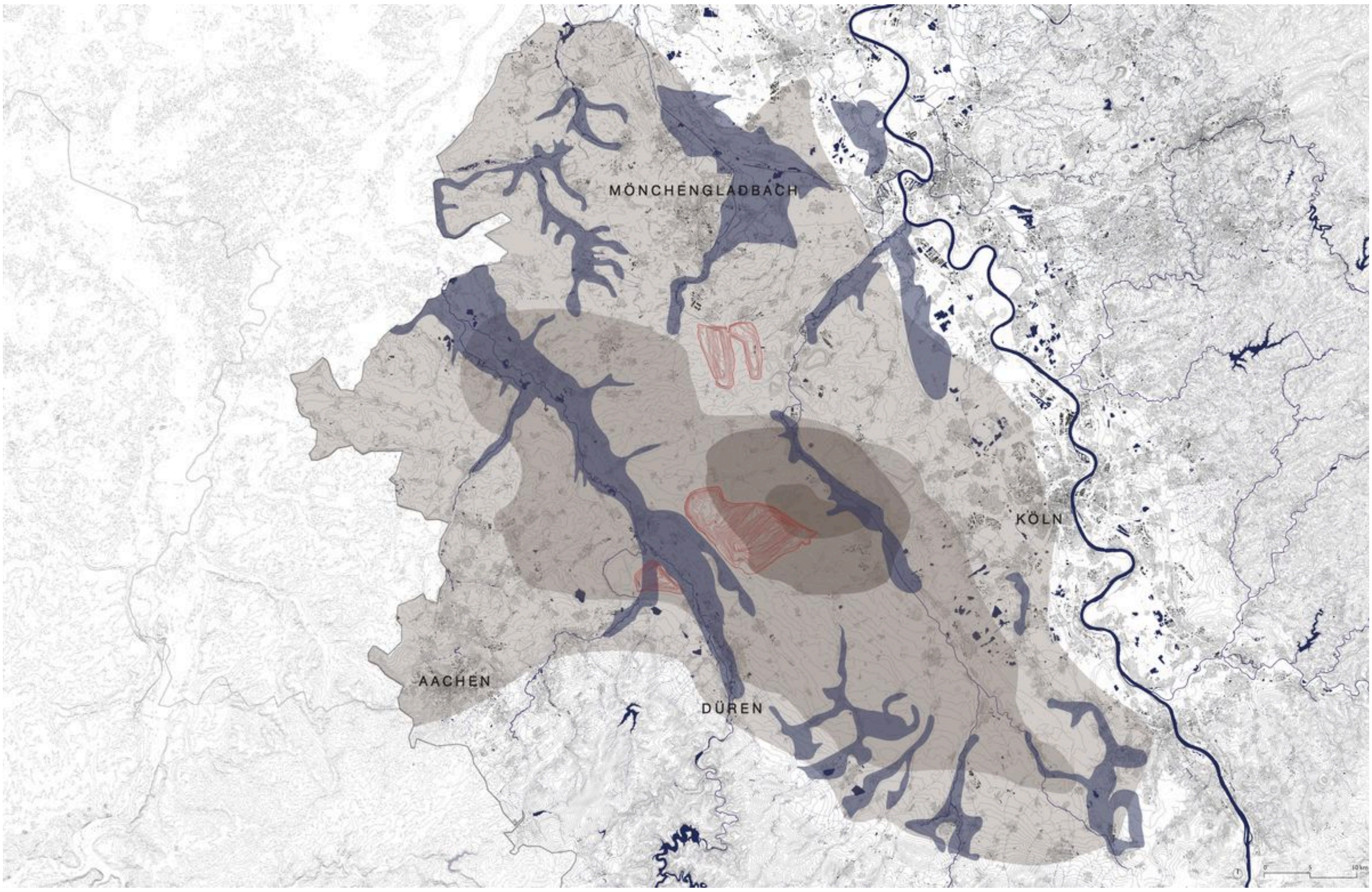
RWE'S MONEY RESERVES FOR FOLLOW-UP COSTS COMPARED TO THE AMOUNT OF MONEY THAT WOULD ACTUALLY BE NEEDED.

SOIL WETNESS



AREAS WITH LOW HEIGHT DIFFERENCE TO GROUNDWATER SURFACE.
Source: Bund für Umwelt und Naturschutz Deutschland (BUND) [https://www.bund-nrw.de/themen/braunkohle/hintergruende-und-publikationen/braunkohle-und-umwelt/braunkohle-und-wasser/vernaessungen-nach-tagebauende/].

≤ 3.0 m   Brown coal mining



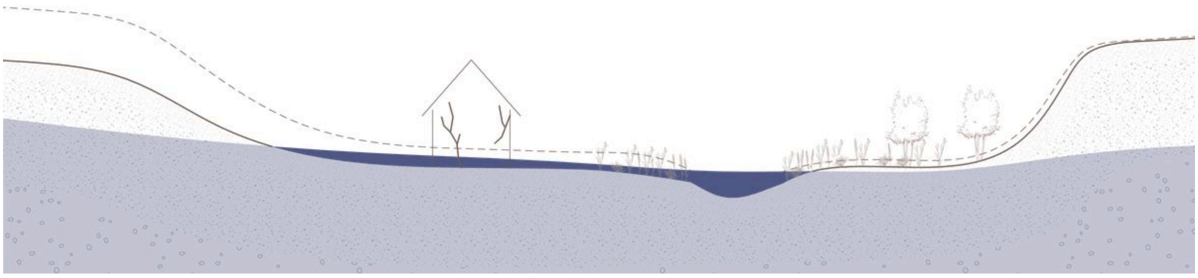
OVERLAY OF THE SOIL LOWERING AND LOW HEIGHT DIFFERENCE TO GROUNDWATER SURFACE.

- 2.0 m
- 1.0 m
- < 1.0 m
- < 0.1 m
- ≤ 3.0 m
- Brown coal mining

Depending on the extent of groundwater lowering by RWE and the nature of the soil, terrain lowering occurs. This process is not fully reversible even when the groundwater rises after the end of brown coal mining in 2030. In settlement areas this could lead to negative effects such as soil wetness or flooding.

7,5 meters ground lowering is expected around the Hambach open mining pit. Permanent swamping will be necessary after the end of brown coal mining so that settlements do not drown. Precise extension and regional distribution of the expected future waterlogging – up to the year 2200 – are not known.

An example from Korschenbroich shows the effects groundwater rise can have. Korschenbroich is a town located within 16 kilometres of Garzweiler. In parts of the urban areas, groundwater levels are naturally low, especially in the lowland areas. When groundwater levels are high, buildings in these areas are repeatedly damaged by waterlogging. About 3’100 houses in the Korschenbroich area would be affected, when the highest expected groundwater levels occur. The southern districts of Korschenbroich are currently still under the influence of groundwater pumping from the Garzweiler opencast lignite mine, which means that the maximum groundwater levels cannot currently occur. The groundwater levels here are up to 10 metres below the naturally expected groundwater level. Due to the progressive spatial shift of the lowest point of the opencast mine and thus of the pumping centre to the west, the mining influence will gradually weaken in the future, so that an increase in the number of people affected by high groundwater levels in the Korschenbroich area can be expected.



POST MINING: FLOODING AND HEAVY SOIL WETNESS IN ENDANGERED REGIONS DUE TO THE SOIL LOWERING.

WATER POLLUTION

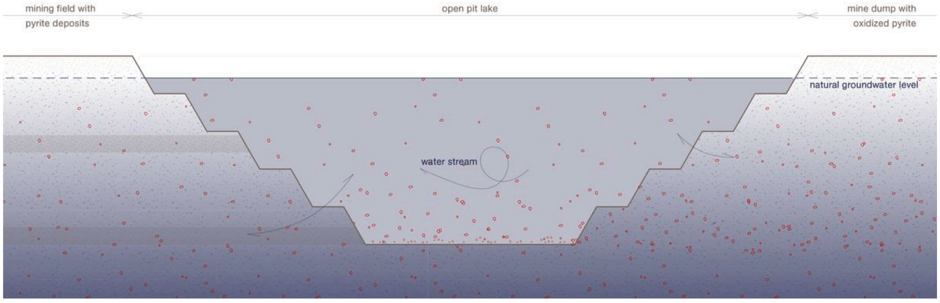
Iron sulfide oxidation in the soil

$$FeS_2(-1) + 7/2\ O_2 + H_2O > Fe^{2+} + 2\ S(+6)O_4^{2-} + 2H^+$$

The overburden acidifies by iron sulfine oxidation to soil pH values between five and two. Therefore storing storing acid, sulphates and other pollutants, which are easily soluble with water.

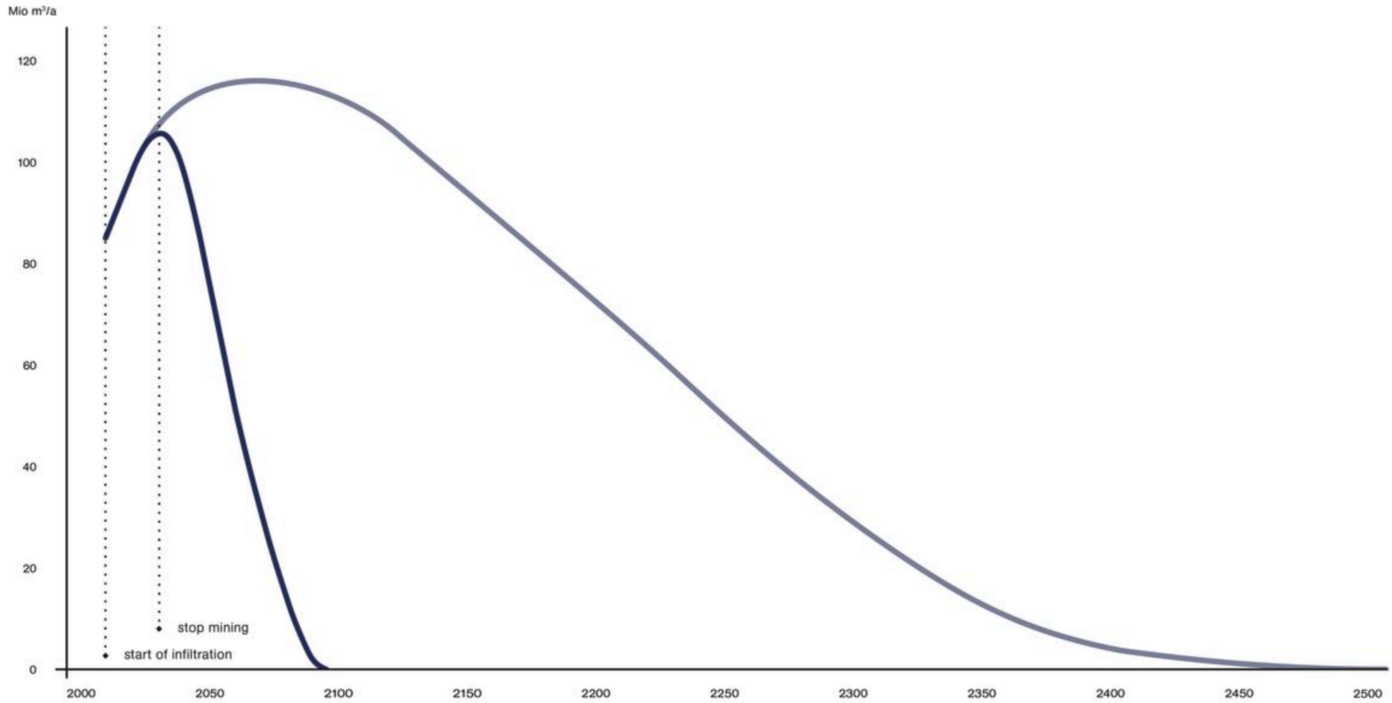
In the direct open-cast mining area, the natural geological floor structure is irretrievably destroyed. Resulting in unhindered spreading of pollutants. If rising groundwater flows through the dump body after the end of opencast mining, a steady stream of acid, iron and sulphate flows into the subsoil. Therefore, polluting the groundwater and surface waters in the region.

In the old Berrenrath brown coal dump near Kerpen-Türnich the groundwater has returned. Due to pyrite oxidation, highly mineralised water is leaking out. This water has highly elevated concentrations of iron, sulphate, and traces of potentially toxic metals such as nickel and arsenic. According to the Erftverband, 70 tonnes of iron sludge – approximately 7 medium duty trucks – have to be excavated from the surrounding area and dumped every year.



ACIDIFICATION: OXIDIZED PYRITE IS DISTRIBUTED IN THE WATER CYCLE.

ETERNAL INFILTRATION



AMOUNT OF INFILTRATION WATER AT OPEN PIT MINE GARZWEILER.

Forecast by RWE

Forecast based on groundwater return

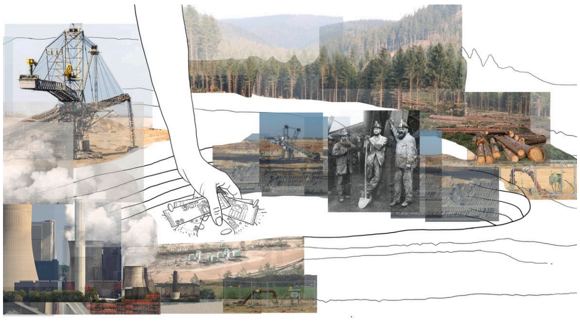
Until groundwater rebound after brown coal mining is complete, infiltration and support measures as well as substitute water supply must still be maintained. In some cases, there is not even enough water supply. As an example of this is the upper region of Garzweiler open mining pit. An alternative must be already found before brown coal mining ends for the affected area. Because there is not sufficient pumped groundwater available for these infiltrations.

Until 2030 a water transfer pipeline from the Rhine should be connected to the Garzweiler water distribution facility Grevenbroich. This external water supply should supply both the wetlands and surface waters of the northern Garzweiler area. From approximately 2050 on the remaining Garzweiler lake should also be filled with water from the Rhine.

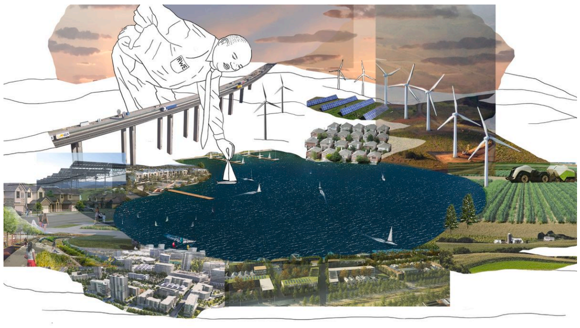
This example shows that not even enough water will be available by 2030 to cover the consequences of groundwater lowering. Without external supply, wetlands, water supply and surface waters are at risk of water shortage. This would lead to immense damage for ecosystems and the inhabitants of the Rheinische Revier.

Towards a Regenerative Landscape: Taking Back Control of the Water

Brown coal mining is part of the identity of Rheinische Revier territory. Water and its landscape have been exploited by RWE as a resource causing harm far beyond its region and time. The future must therefore focus on an inclusive and participatory process of healing the territory and meeting the needs of its inhabitants.



Brown coal mining has transformed the Rheinische Revier landscape and is now part of its identity. In 2030, lignite mining will come to an end and water may become the agent of landscape transformation.

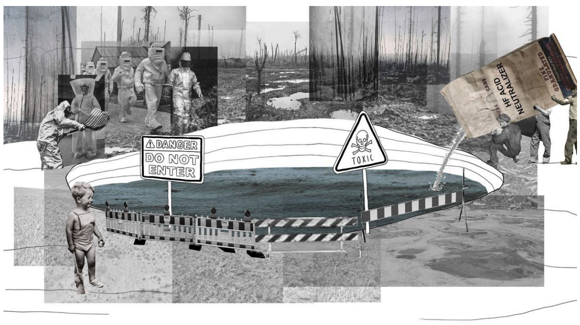


Although the future is uncertain, RWE promotes plans to convert pits into lakes, which will transform the landscape into a recreational attraction and will cause the partial privatisation of the lakeshores. Does society want this future?

The inhabitants of the region must become part of the decision-making processes, because they are the ones affected by the eternal burdens of lignite mining. How can this be achieved?

If the development process is inclusive, involving the inhabitants, the future landscape can contain more space for nature and biodiversity, such as wetlands.

Another kind of eternal burden is the derelict infrastructure which will be left behind. It can be transformed into cultural spaces, creating the opportunity for social diversity. Abandoned water sprinkler systems can be reused as fountains thus preserving the identity of the landscape as a contemporary witness of brown coal mining.



Besides opportunities, problems such as soil wetness, acidification of the groundwater and the drying up of the wetlands have already occurred, and there will be others in the future that cannot be foreseen at present. How to ensure that RWE, a company that has made profits for decades, will continue to pay the price for the burdens for which it is responsible in the unforeseeable future?

Climate change will have an impact on the water and the way water bodies and habitats are managed. How to deal with extreme weather events such as drought and floods? Will there be enough water in the future to fill up the new pit lakes?

In any event, the decisive factor will not be the hasty vision of a lake as a recreational destination and a real-estate opportunity, but the inclusive and participatory process of healing the territory and meeting the needs of all its inhabitants.

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