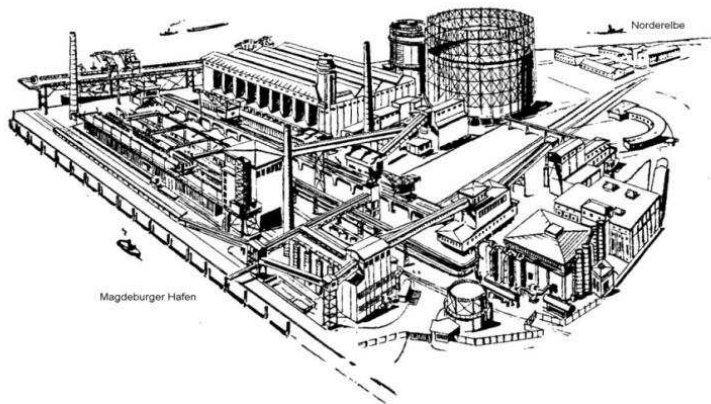


Clean-up of the Grasbrook Gasworks in Hamburg's HafenCity

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In HafenCity, Hamburg's city development project, the Overseas Quarter is to be realised by 2009 as the largest and most important measure and will cover a surface area of approximately 10 hectares. Here, covering an area of nearly 7 hectares, are the former premises of the oldest gasworks in Hamburg. The Grasbrook Gasworks was built in 1844 (!) and operated up until 1976 with many modifications. Now this area is to be cleaned up by means of soil excavation (approx. 195,000 m³). Here, there are a multitude of various boundary conditions that must be observed.



1: Overview of Grasbrook Gas Coking Plant



2: Model Overview, 2003

After the gasworks closed, the aboveground buildings and production facilities were abandoned. At the beginning of the eighties, in preparation for use by the company CELLPAP, the terrain was raised from +5.0 m above sea level to about +7.0 m above sea level to be storm tide proof. It was also sealed with a driveable surface and a large 150 m x 200 m warehouse and many lightweight construction buildings were built on the site. In the forefront of the planned reuse, the company moved in 2002 and the buildings were removed.

Presently, part of the Grasbrook area is being actively used during the summer season by international shipping companies as a temporary cruise terminal. The area is owned by the Free and Hanseatic City of Hamburg; however the property will be managed, marketed, and sold as a separate estate by the city-owned Hafencity Hamburg Corporation.



3: Present Condition of the Area, 2003

Historical Development

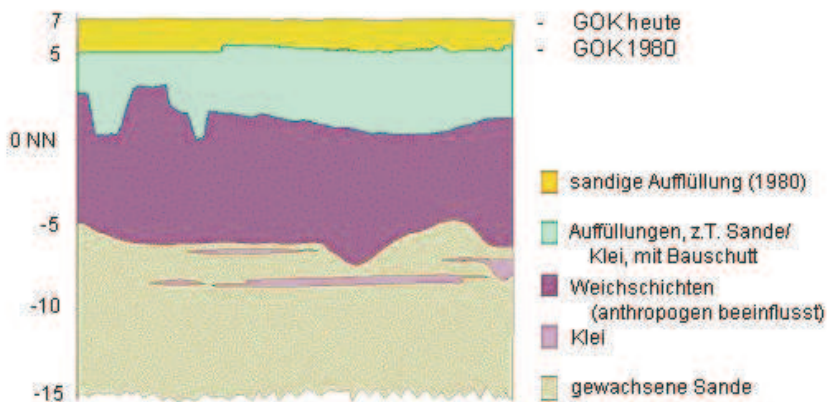
The area at Grasbrookhafen that is to be cleaned up lies in the region of the former Elbe island called "Grosser Grasbrook", which was used as a livestock pasture up until 1796 and partly also as a source of sand. Originally, the ground elevation was between 0.5 m and 1.8 m above sea level and therefore it was in the tidal area of the Elbe River. In order to make it possible to use the site for industrial purposes, a tremendous amount of landfill was necessary first, before the Grasbrook Gasworks could be put into operation in September 1846. The "Englische Gas Compagnie" built the gasworks and operated it for the next 30 years. The know-how of hard coal distillation and gasworks technology mainly originated in England and was sold from there to the rest of Europe until the middle/end of the 19th century. In April 1874, the gasworks became the property of the City of Hamburg, which leased its operation to a private contractor. Hamburg Gasworks managed operations from 1924 until the gasworks facility was abandoned in 1977. The gasworks was bombed in the Second World War, and the large gas tanks as well as a large part of the installations were destroyed. In 1951, gas production was resumed. It can be assumed that when the gasworks facilities were torn down in the mid seventies, the site was cleared to the ground surface level, or alternatively in some areas to approximately 1.0 m at the most, below the ground surface level at that time (sea level +5.0 m). In all likelihood, all underground plant

components such as caverns and pipelines are still there – and filled with production residue. From 1979, the property was rented to the company CELLPAP as a warehousing and reloading area for paper and containers. In the forefront of the planned reuse as the Overseas Quarter, this company was moved and the buildings removed.

Geology and Hydrogeology

Due to being raised artificially, the ground surface level of the gasworks lies between 4.5 m and 5.5 m above sea level. At the beginning of the eighties, the terrain was raised once again by ca. 2.0 m, and today it is safe against storm tides at 6.0 m to 7.2 m above sea level. Starting with the ground surface level below the sealing layer, the general ground stratification in the area under investigation can be described as follows:

The **anthropogenic fill** (sand, perimarine clay, glacial till and weathered glacial till, foundation remnants, construction rubble, layers of tar, mud and gyttja with layers of sand) had a thickness of between 3.6 m and 8.7 m at the beginning of the eighties (level of the gasworks terrain). After raising the terrain for the CELLPAP terminal, today's backfill thickness is a maximum of 12 m. The material used at the beginning of the eighties to raise the terrain was unpolluted dredged sand. The approximately 3.1 m to 7.0 m thick **soft layers** that exist throughout, consist of perimarine clay with sandy intermediate layers. However, it is to be expected that this geological barrier will have some imperfections due to the extended industrial use with deeply founded buildings. Under this is peat and gyttja (organic mud), with locally occurring layers of a lower perimarine clay. **Sand and gravel** (with interspersed clay and peat) below the soft layers form the upper aquifer and exist with a thickness of 13 m to 16 m. The bottom of this aquifer is formed by **tertiary micaceous clay**.



4: Geological Cross-Section

The following are determinant for the **hydrogeological situation** in the area under investigation: The near-surface **perched water horizon**, which formed in the anthropogenic fill to various extents and thicknesses, is only moving towards the Elbe at a negligible rate. The **upper aquifer** is subject to the tidal influence of the Elbe due to the “island location” of the area under investigation and the immediate proximity of

the port basin and the Norderelbe. Due to the overlay with water damming soft layers, the groundwater in the upper aquifer is under pressure. It has not been possible to determine a clear, constant direction of flow for the groundwater.

Clean-up Measures that have been performed

In the eighties, two procedures were undertaken to clean-up the subsurface of the former gasworks site by replacing the soil. After underground contamination was established during the demolition work in 1981, the first soil replacement took place with 5500 m³ of soil in a major part of the gasworks site. During the course of demolition work on the 200,000 m³ gasholder (telescope gas container), approximately 25,000 m³ of contaminated soil as well as foundations were removed and brought to a waste disposal site between 1984 and 1986. The clean-up area was filled with clean sand. There should still be some local underground contamination remaining in the area of the former gasholder. There is no specific documentation for these clean-up measures. At that time, no additional measures were taken.

Investigation and Description of the Contamination

In spring/summer 2001, "Historical Research" was conducted for the purpose of making a detailed inventory of the original buildings and it paid special attention to the structural engineering and pollutant related procedures and techniques in gasworks. Based on the results of the research, a contaminant investigation was conducted from September to November 2001 to establish the extent of the damage. Due to numerous drilling obstacles, this was only achieved to a very limited extent, so that a comprehensive and certain description of the underground contaminant situation was not possible. Out of approximately 150 small drill holes, 75% were abandoned due to obstacles, and even 90% at greater depths. For investigations of the deeper ground stratification, eight additional dry drilling holes were sunk in selected areas of the property, down to a maximum depth of 11 m below the surface of the ground. In order to eliminate drilling obstacles that occurred in the dry drilling holes, special drilling tools such as drilling bits and rock core bits were used.

It must be assumed that massive underground obstacles will be encountered across the entire site. Tanks and pits were apparently filled and/or pushed in. Furthermore, one must anticipate subterranean cavities such as tar pits and tanks, which most likely hold contaminated residues.

The ground survey in the area of the Grasbrook Gasworks revealed the contaminants shown in Table 1 with aromatic hydrocarbons (BTEX), benzene, polycyclic aromatic hydrocarbons (PAH), and cyanide.

Contaminat	Concentration (mg/kg)
BTEX	6 – 240
Benzene	1.6 – 150
PAH	60 – 56,000
proportion of benzopyrene	2.9 – 1300
Cyanide	105 – 850

Table 1: Contaminant Concentration in the Soil

Both in the perched water and the groundwater (upper aquifer), there were some concentrations of pollutants in the area of the gasworks site including benzene, PAH, cyanide, and ammonium in orders of magnitude that were relevant to the clean-up.

During the course of planning and preparing for the clean-up, three excavator diggings were made in October 2002 down to a maximum depth of 1.0 m below sea level to investigate detailed questions about excavation pit water (effect of the tide on the excavation pit and pollution) and pollutant concentration in the open air in the vicinity of the excavation pit and the stockpile respectively. The results of analysing the samples of solids substantiate the results of the investigation so far for parameters that are relevant to the clean-up. They show a strongly fluctuating contamination matrix with close coexistence of highly and slightly contaminated parts of the ground.

Subdividing the Clean-up Area

Like all former gasworks, the underground is extremely contaminated with contaminants that are typical of gasworks. We are dealing in particular with organic contaminants such as creosotes, benzene, and PAH. The contamination requires a clean-up of the highly contaminated areas of the property before its reuse in order to prevent any danger to the groundwater. Taking into consideration the historical development and the property use and the range of buildings on the former gasworks site respectively, there are the following main subdivisions of the 69,000 m² area under investigation:

Area A (12,000 m²): gas purification, gas extraction, with production of other chemical basic materials, therefore it is the most polluted down to a depth of +1 m above sea level, and even down to 1.0 m below sea level in some locations.

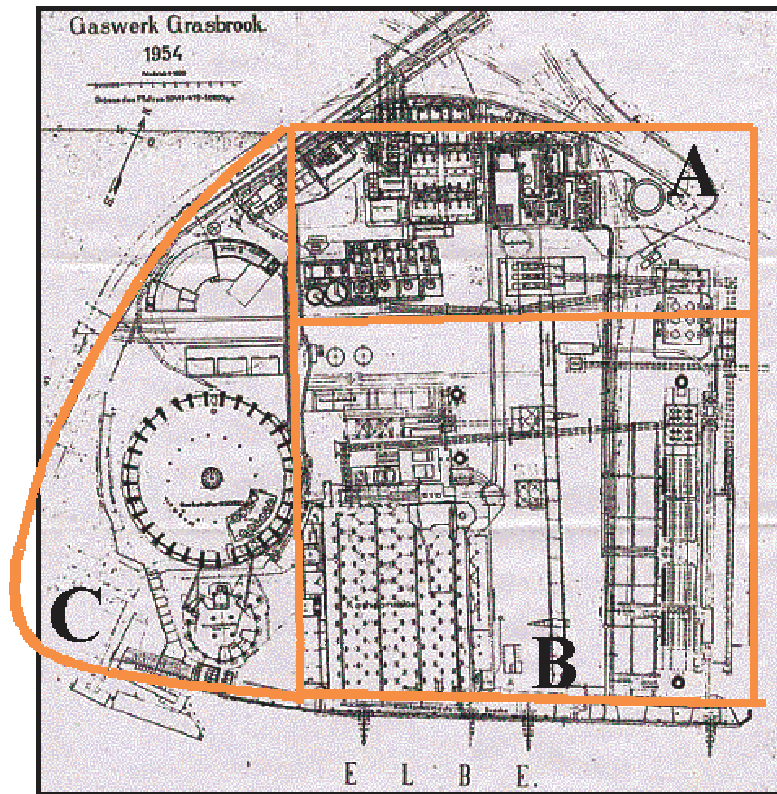
Area B (27,000 m²): coal silos and ovens, higher levels of pollution down to a depth of ca. +3 m above sea level.

Area C (18,000 m²): large above-ground gasholders; here, the soil was already replaced in the eighties when the gasholders were abandoned.

The stability of the **quay wall edging strip** (10,000 m²) must be maintained including the grouted anchoring with a width of 20 m.

Safety edge strip (2000 m²) along the northern border of the clean-up site property with a width of 5 m.

According to the results of the "Historical Research", gas purification was located in Area A, the coal silos and ovens in Area B, and the large above-ground gasholders in Area C. This generalised summary of the area utilisation – marked by many modification phases – remained unchanged for close to the entire time that the gasworks was in operation.



5: Site Plan of the Area Subdivision

Clean-up Procedure

The property is a central and prominent development area of HafenCity and is under time pressure due to the planned marketing and the inevitably related construction measures. Independent of the current usage concepts that are still being discussed for the Overseas Quarter, the master plan envisions large-area construction here, which requires at least 2-floor underground garages. It has been established that “in situ” or alternatively hydraulic or any other alternative clean-up methods don’t come into question due to the heterogeneity of the soil, the inhomogeneous distribution of the contaminants, and the pending marketing and reconstruction. Therefore, the only clean-up alternative that can be taken into consideration is soil replacement.

Scope of Clean-up

Taking into consideration the measures that are required for averting any danger, future use and ensuring comparativeness, the following scope of clean-up was established:

Area A: Ca. 75,000 m³ soil excavation, or alternatively replacement, down to a depth of 1.0 m above sea level; optionally down to 1.0 m below sea level to remove hot spots.

Area B: Ca. 115,000 m³ soil excavation, or alternatively replacement, down to a depth of 3 m above sea level; optionally down to 1.0 m below sea level to remove hot spots.

Area C: There will be no soil replacement in the above-mentioned safety strips along the quay wall structure.

Altogether, there will be a volume of soil to move in the order of magnitude of 195,000 m³, or alternatively 330,000 t. This includes approximately 110,000 m³, or alternatively 190,000 t of excavated soil that is classified as contaminated and which must be disposed of or alternatively treated. Only the upper filling sand, ca. 100,000 t, which was originally put in to raise the terrain to make it safe against storm tides, can be reused. In spite of extensive investigation procedures, it is still not possible to estimate the actual volume that is to be expected, classified into the various assignment classes of TR LAGA, and the type of anthropogenic fill material.

Performing the Clean-up

Besides the usual subtasks of such a clean-up measure like

- equipping the construction site
- excavation in an open pit and with the protection of pit lining boxes
- measures to guarantee occupational safety and emission control
- operation of a purification facility for excavation pit water
- material transport within the construction site and to the waste disposal sites
- backfilling the excavation pit
- establishing protection against flooding
- installation of drainage for the partially filled excavation pit

the following specific services must be performed during construction:

- rubble clearance and renaturalisation of subterranean plant components; it must be assumed that both massive and numerous obstacles will be encountered over the entire area in the form of relict construction matter from the former gasworks, load-bearing building elements from the former CELLPAP warehouse, and a variety of different types of plant components. Furthermore, cavities such as tar pits and cellars must be expected, which have been filled with waste material and which also may be filled with polluted production residue. Due to the hundred year history of utilisation, various types of pipes are to be expected in the excavation area;
- physical safeguarding measures for the excavation pit, which is up to 8 m deep and close to the Elbe.

The main plan is to excavate the soil in an open excavation pit. In Area A, soil excavation will be along the west, north, and east borders covering a total length of ca. 300 m and a width of 9 m with the protection of pit lining boxes. The use of pit lining boxes is necessary because of the depth of the excavation, the proximity of building construction at the edge, and the bordering Port Railway tracks. Although the excavation diggings that were performed indicated that no major drainage measures must be undertaken, one must still generally expect “water problems” so close to the Elbe.

Excavation Task and Soil Handling

It must be taken into account that during excavation work, we are mainly dealing with contaminated material and that it is very unlikely that work can proceed uninterrupted because of batch separation, suspicion of war material, obstacles, sample taking, and the accompanying measurement work. Therefore a discontinuous volume of mass must be expected. Taking these difficulty factors into consideration, one must assume that the daily output of the excavation equipment will be considerably reduced and the time and effort to remove and load each cubic metre of solid mass must be set very high. With this reduced daily output of each excavator, with a mean value of only approximately 300 m³ to 400 m³ of solid mass per workday, at least three excavators must be used at the same time. With a total of only 300 workdays of available time and an excavation volume of 195,000 m³ and a backfill volume of ca. 65,000 m³, from an earthmoving perspective, a volume of mass of roughly 260,000 m³ must be moved. This means an average daily output of ca. 900 m³. In order to meet the completion deadline with this difficult starting situation, and in order to compensate for working below capacity on some days, this requires the highest degree of flexibility and performance by the contractor.

Awarding the Contract

The construction works were awarded in a public tender by the Office for Remedial Action of the Hamburg Ministry of Environment and Health (former; now State Ministry of Urban Development and Environment), in the late autumn of 2003 in accordance with German tender norms for building (VOB/A). For the disposal services, a European-wide public competition was held in accordance with the German tender norms for procurement and services (VOL/A) with the quote request presently in progress and then the negotiations, because the volume, composition, and contaminant concentration of the excavation material could not be described adequately. In spite of extensive investigation procedures, it was still not possible to estimate the actual volume that is to be expected, classified into the various assignment classes of the German technical norms (TR LAGA), and the type of backfill material. Currently, the total cost is estimated to be approx. Euro 17 million.

Construction Supervision by the Bomb Disposal Squad

The old town region of Hamburg and the Grasbrook region were bombed intensively, especially during the air strikes in July 1943. More than 25 bomb craters are documented on the former gasworks site. The existing aerial photographs don't permit an advance analysis and localisation of duds due to high-density building construction and shadows on the aerial photographs. There is a strong suspicion of war materials on the former gasworks sight. As a result of the dangerous situation, the clean-up work will be constantly supervised by the war materials disposal service. Accordingly, the special requirements for the excavation and bracing work are extensive, and require a lot of time and money.

Cruise Terminal

When performing the clean-up measures, it is essential to have unrestricted, highly sensitive use of the existing wharfage as a docking area for cruise ships, in particular in the high season from March to October. It is not possible to have an exact forecast up to 2005 with regard to the level of activity. There were approximately 50 registrations for 2003, which represents ca. 75 days that are booked by cruise ships. One of the ships that will dock at Grasbrook in the summer of 2004 is the "Queen Mary II" with a length over all of 345 m and over 2500 passengers on board. The "MS Europa" will visit

Hamburg five times in 2004. Ground transportation will be taken care of in the shortest possible time by 50 – 60 busses. In addition, there will be many visitors, who will drop off or pick up passengers or who are simply onlookers. During this time, it is the construction site's duty to prevent noise pollution or inconveniencing the clearance operations of the cruise ships, or alternatively to reduce it to an unavoidable minimum.

Public Relations

Public relations are immensely important to this project. Together with HafenCity Hamburg Corporation the clean-up of the gasworks and the maritime Overseas Quarter is presented to the public. Near the entrance of the construction site is an information board for any interested parties. It includes presentation boards about the former gasworks and about carrying out the clean-up measures as well as an observation deck with a view over the construction site fence. Special exhibitions will be initiated in the HafenCity information centre "Kesselhaus". The name "Overseas Quarter" is the programme, and the development of the overall project forms the foundation of the communications and public relations work. It is intended to promote acceptance among the residents and cruise passengers for the construction work in this area that will continue for years.

Outlook

Execution of clean-up measures to avert dangers started in January 2004. It will prospectively be completed by the spring of 2005. This is absolutely imperative for the development plan of the Overseas Quarter in HafenCity. With approx. 240,000 m² of gross floor space, the Overseas Quarter with the maritime Adventure World will become the largest and most important element of HafenCity – at a prominent location at the end of the line connecting the Alster to the Elbe. In addition, the "Overseas Centre" station of the new underground line is to be realised here.

Even without the environment of the 2012 Olympics, which certainly would have been beneficial with the additional investment impulse, the HafenCity project is a city development measure that has a trendsetting character.



6: Future Vision

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