

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

Marion Großcurth, Monika Osten, Dr Ralf Kilger

In the HafenCity (Hamburg's city development project), the Overseas Quarter will be completed by 2009, as the largest and most important element. It will cover a surface area of approximately 10 hectares. The largest part of the site is the former premises of the oldest gasworks in Hamburg, which covered an area of nearly 7 hectares. The Grasbrook Gasworks (No.1: photo) was built in 1844 and operated, with many modifications, until 1976. The site had to be decontaminated by excavating the soil (approx. 300,000 m³) and either treating or dumping it. Besides the usual subtasks of such a clean-up measure, other specific tasks had to be completed during construction. There were many external circumstances that had to be observed, such as: separation of contaminated soil into 27 assignment classes, soil sample analyses, bomb disposal, safety and emission control, odour- and dust exposure, obstacles, measurement, documentation, conservation of evidence, cruise terminal activities and public relations. The execution of clean-up measures to avert dangers started in January 2004. It was completed by the autumn of 2005. Site decontamination was absolutely imperative for the development plan of the Overseas Quarter in HafenCity. In addition, the station "Overseas Centre", on the new underground line, will be built there.

In November 2005 the remediation of the gasworks Grasbrook was completed successfully with the exception of some minor contamination remaining in the subsoil. Although we are experienced in the remediation of contaminated sites, the target to complete the measure by spring 2005 at a cost of €17M was not met. What are the reasons and could we have foreseen and avoided them?

Historical Development

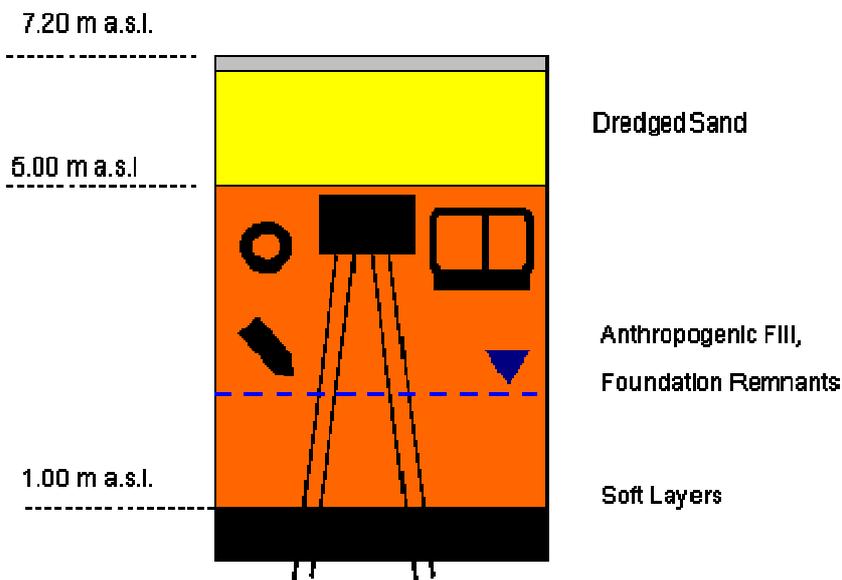
The area at Grasbrookhafen that had to be decontaminated lies in the region of the former Elbe island called "Grosser Grasbrook", which was used as a livestock pasture up until 1796 and partly also as a source of sand. Originally, the ground elevation was below the high water level of the Elbe River. In order to make it possible to use the site for industrial purposes, a tremendous amount of landfill, to raise the surface, was necessary before the Grasbrook Gasworks could be brought into operation in September 1846. 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. After 130 years of use the gasworks was decommissioned, abandoned and demolished above the surface in 1976. Until 2001, the property was used as a terminal.



No. 1: gasworks Grasbrook in the year 1930, view down the Elbe River

Geology and Hydrogeology

The ground surface level of the former gasworks was built up, to between 4.5 m and 5.5 m above sea level. At the beginning of the 1980s, the terrain was raised once again by an additional ca. 2.0 m, to make it safe against storm tides, so that it is now lying 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 is described in diagram No.2.



No. 2: general ground stratification

Published in "Proceedings of the International Symposium and Exhibition on the Redevelopment of Manufactured Gas Plant Sites, 4 – 6 April 2006, Reading, UK, GMP-Meeting 2006"

Investigation and Description of the Contamination

Before the project to investigate the subterranean conditions started, historical research was necessary to obtain location information. In spring/summer 2001 a detailed inventory of the original buildings was compiled, with special attention being paid 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 detailed description of the underground contaminant situation was not possible. Both in the perched water and the groundwater, there were 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 decontamination. The results, from analysing the samples of solids, substantiate the results of the investigation in parameters that are relevant to the decontamination. They showed a strongly fluctuating contamination matrix with close coexistence of highly and slightly contaminated parts of the ground (for details see No. 3 table).

Clean-up Areas

The level of contamination detected necessitated a clean-up of the most contaminated areas of the property before its reuse, to prevent any danger to the groundwater. Taking into consideration the historical development, the property use and the range of buildings on the former gasworks site, the following main subdivisions of the 69,000 m² area were investigated.

Area A: (12,000 m²): gas purification, gas extraction, with production of other chemical basic materials. Determined to be the most polluted part to a depth of +1 m above sea level, and to 1.0 m below sea level in some locations; 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: (27,000 m²): coal silos and ovens, higher levels of pollution to a depth of ca. +3 m above sea level; ca. 115,000 m³ soil excavation, or alternatively replacement, to a depth of 3 m above sea level; optionally to 1.0 m below sea level to remove hot spots.

Area C: (18,000 m²): large above-ground gasholders; here the soil was already replaced in the eighties when the gasholders were abandoned; there should be no soil replacement necessary but probably some remaining local underground contamination in the area of the former gasholder. Unfortunately, there is no specific documentation for those clean-up measures.

Altogether, there was a volume of soil to move in the order of magnitude of 195,000 m³ or 330,000 t. This included approximately 110,000 m³ or 190,000 t of excavated soil that was classified as contaminated and had to be disposed of or 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, could be reused. In spite of extensive investigation procedures, it was not possible to estimate the actual volume to be expected, classified into the various assignment classes of TR LAGA (special technical German rules), and the type of anthropogenic fill material.

Published in "Proceedings of the International Symposium and Exhibition on the Redevelopment of Manufactured Gas Plant Sites, 4 – 6 April 2006, Reading, UK, GMP-Meeting 2006"

	investigation	execution
BTEX	6 to 240	5,800
Benzene	1.6 to 150	1,400
PAH	60 to 56,000	100,000
Proportion of Benzopyrene	2.9 to 1,300	4,370
Cyanide	105 to 850	1,300

No. 3: Contaminant concentration in the soil in mg/kg

Excavation Task and Soil Handling

The property is a central and prominent development area of the HafenCity and the project was 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. Due to the heterogeneity of the soil, the inhomogeneous distribution of the contaminants, and the pending marketing and reconstruction, the only clean-up alternative that could be taken into consideration was soil replacement.

During excavation work, we were mainly dealing with contaminated material and it was very unlikely that work could proceed uninterrupted because of batch separation, suspicion of historical explosive ordnance, obstacles, sample taking, and the accompanying measurement work. Therefore, a discontinuous volume of material was to be expected. With the reduced daily output per excavator, with a mean value of only approximately 300 m³ to 400 m³ of solid material per workday, at least three excavators were used simultaneously. 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, a volume of material of roughly 260,000 m³ had to be moved. That meant an average daily output of ca. 900 m³.

Additional Issues

During the remediation process, we realized that the contamination reached a deeper level.

In addition, the expectation that area A would be the most polluted did not come true. There were no hot spots in areas A and B. Finally, excavation down to the clay was necessary for the whole site (sea level).

During the remediation work, we learned of the precise course of the Overseas Quarter boundary. Two excavation digs, in May 2005, showed that the remediation had to be expanded, towards area C (4,000 m²) because of the contamination and the expected location of the planned buildings. Table No.4 shows the result of this measure.

Because of the contamination, a larger excavation mass accumulated. Due to this increased expenditure, the measure could not be completed without a delay. Failure to remove the contamination to a greater depth would inevitably have led to problems with the structural engineering work and investors, in

turn, would have faced construction shutdowns and additional costs as a result. Residual contamination remaining in the subsoil might not be relevant to remediation, but can cause additional costs for disposal during the excavation work for the underground-line. At least a 70 % performance increase was delivered which, due to favourable tender results, have led to additional costs of only 20 %.

Controlling external Issues

-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 did not permit an advance analysis and localisation of duds due to high-density building construction and shadows on the aerial photographs. There was a strong suspicion of historical explosive ordnance on the former gasworks site. As a result of the anticipated risk, the clean-up work was constantly supervised by the explosive ordnance disposal service. Accordingly, the special requirements for the excavation and bracing work were extensive, and required additional time and money. No explosive ordnance was found during the course of the remediation work. The EOD service found bunkers for the workers of the gasworks. The bombs were most likely removed in the early 1950`s during the general renewal of the gasworks. Unfortunately, there were no documentations of such activities.

-Restricted operations because of the Cruise Terminal

When performing the clean-up measures, it was essential to ensure unrestricted operation of the existing wharfage as a docking area for cruise ships, in particular in the high season from March to October. It was not possible to have an exact forecast of the level of activity up to 2005. There were approximately 50 registrations during construction time, which represents ca. 75 days that were reserved by cruise ships. During this time it was the construction site's duty to prevent noise pollution or inconvenience to the clearance operations of the cruise ships, or alternatively to reduce it to an unavoidable minimum. When a cruise ship had arrived the main works had to stop, i.e. the excavation in the contaminated layer was restricted because of safety reasons – had a bomb been found, the ship could not have been moved.

Conclusion

Execution of clean-up measures to remove contamination started in January 2004 and was completed in November 2005. The environmental clean-up costs amounted to a total of €20M because of unavoidable, additional decontamination measures and impact from external circumstances. An approximate €12M had to be spent for soil disposal, €7M for building costs and €1M for other costs. Better preparation and execution was not possible. In the review we concluded that we could not have done anything differently to avoid the schedule and cost overrun.

The State Ministry of Urban Development and Environment, Division for Remediation, is preparing the next gasworks remediation in Hamburg which is already planned for autumn 2006.

	target	result
area	40,000 m ²	44,000 m ²
excavation	190,000 m ³	300,000 m ³
backfill	70,000 m ³	150,000 m ³
daily output	900 m ³	approx. 900 m ³
mass volume	260,000 m ³	450,000 m ³
workdays	300	464
costs	€ 17 M	€ 20 M
costs per m ²	425 Euro/m ²	455 Euro/m ²

No. 4: output and costs

References

- [1] HafenCity Hamburg, Masterplan der GHS Gesellschaft für Hafen- und Standortentwicklung, März 2000 (siehe auch: <http://www.hafencity.com/>).
- [2] Osten, M.: „Sanierung Gaswerk Grasbrook in der HafenCity“ in „ITVA-Symposium –Revitalisierung von Verkehrsflächen: Element einer nachhaltigen Siedlungspolitik“, Hamburg 08. und 09. Mai 2003, pages 103 – 117.
- [3] Osten, M., Kilger, R.: [„Sanierung Gaswerk Grasbrook in der Hamburger HafenCity“](#), „TerraTech – WLB-Supplement für Altlasten und Bodenschutz“, pages TT 21 – TT 24 in „wlb – Wasser, Luft und Boden“ 9/2003.

Contact and Presenting Author:

Marion Großcurth
Free and Hanseatic City of Hamburg
State Ministry of Urban Development and Environment
Division for Remediation
Billstr. 84, 20539 Hamburg, Germany
Phone: +4940/42845-3486
Fax.: +4940/42845-3572
E Mail: Marion.Grosscurth@bsu.hamburg.de