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CLOSURE AND AFTERCARE REGIME FOR LANDFILLS BELOW THE WATER TABLE

1. Introduction

The German landfill "Halle-Lochau" is located in a former open cast mining site (Fig. 1). This open cast area is situated approximately 5 km southeast of Halle, a city of 238.000 inhabitants in eastern Germany.

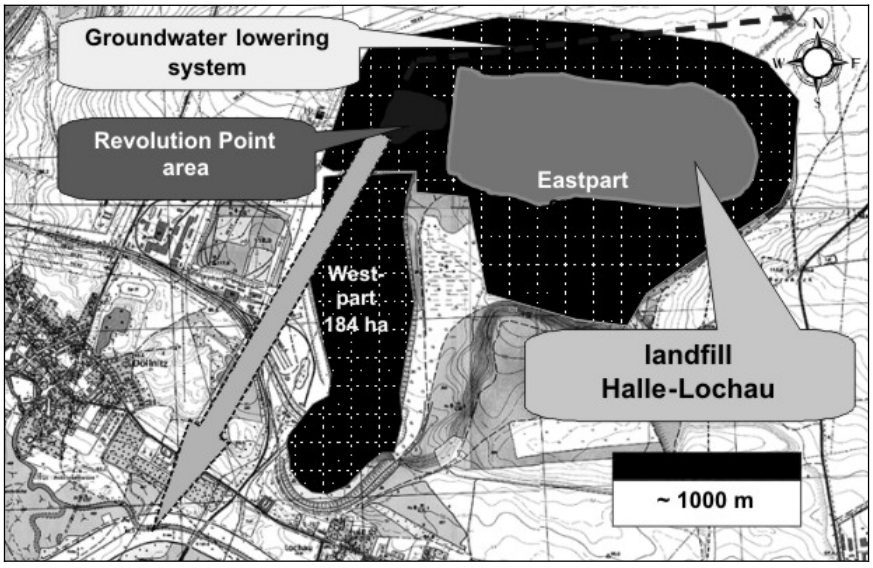

Fig. 1. Overview of the landfill "Halle-Lochau"

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Landfill Operation started in 1976. At the end of 2004 the tipping area was app. 81.5 ha and the filled volume of the landfill was app. 17 Mio. m^3. The height of the landfill is thought to be about 20 m or even more.

The landfill Halle-Lochau possesses special features particularly in regard to the hydro-geological conditions, since it was constructed in a worked-out open cut. The discontinuation of active de-watering to lower the ground water table(pump out facility) is also connected with the foreseeable closure of the landfill for good. The ground water table will rise again and the landfill body will come into contact with the ground water. There are no technical guidelines that equally take into account sustainability and environmental protection for the closure and after-care of such subaquatic (old-) landfills.

For this reason, the company Abfallwirtschaft GmbH Halle-Lochau was mandated by the Federal Ministry of Education and Research and the Ministry of Environment of the state of Saxony-Anhalt, to find solutions that are effective in the long run, economically feasible and ecologically sensible, within the framework of a research project. The project involved analysis, assessment and engineering technical classification of local conditions and of the processes going on during closure and after-care, so that these solutions could in turn become the foundations for the standard regulations needed for the closure of subaquatic landfills and for the removal of legal deficits if necessary. The title of the research and development project is “Investigations for the sustained closure of landfills that were constructed in worked-out open cuts of brown coal mining, considering the example of the landfill Halle-Lochau”.

2. Problems of Landfills Below the Water Table

To explain the problems we face it is necessary to show the effects and functions of the ground water lowering system. To prevent groundwater flowing into the landfill area, the groundwater level is maintained at a lowered level. Because of the groundwater control the pressure gradient of all groundwater will be maintained in the direction of the landfill. By establishing and maintaining this situation of an inwards gradient direction to the landfill pollution of the groundwater can be prevented.

The EU regulations state that landfills below the groundwater level should not be in operation after 2009. Special German regulations shorten this operational period to 2005. The laws do not include special measures to protect the environment for the closure and aftercare regime of below water table landfills.

One technical solution for such landfills could be controlling the groundwater level for an indeterminate period of time. But this strategy does not fulfill the principles of environmental sustainability and minimized operational aftercare. That is why the groundwater lowering operation ideally should end during or at the end of the closure period of the landfill before starting the aftercare regime.

This means the ground water level will return to its natural position. Figure 2 shows the resulting situation for the landfill “Halle-Lochau” if the groundwater control operation would be stopped at the same time as landfill operations in 2005 without any additional measures.

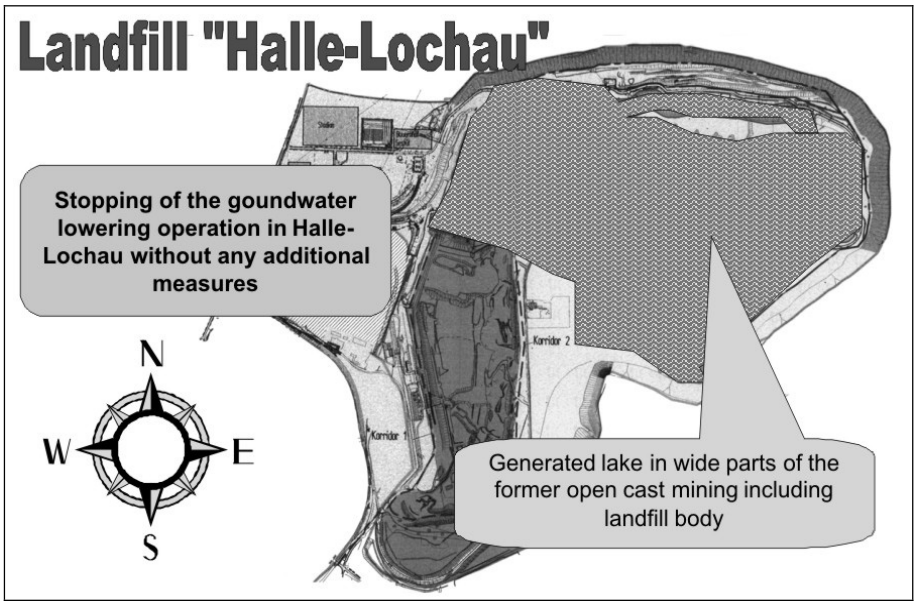

Fig. 2. Worst case scenario of cessation of the groundwater control, without any additional measures

A lake with an average depth of 50 m would be generated in the former mining area. As a result, a part of the landfill waste body would be below the water table causing pollution migration into the surrounding soil.

Because the aim of any landfill technology is to cause no harm to human beings and the environment, additional measures must be deployed to prevent such pollution. This is necessary to make sure that the landfill will meet ecological standards for any use after closure.

3. Results of the Investigations

Taking into account the conditions and current situation of the landfill the following options have been developed for the final design of the closed landfill, presented also in the Figure 3.

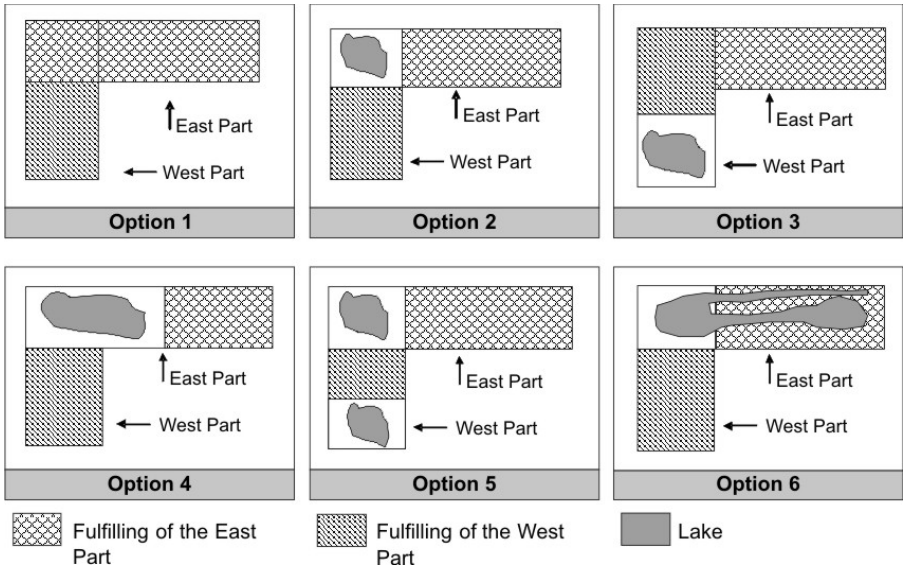

Fig. 3. Developed options for the final design of the landfill "Halle-Lochau"

Option 1: Completely infilling the mining area.

Option 2: Generating a lake in the Revolution Point area by partly filling the landfill and completely filling of the coal ash landfill.

Option 3: Completely infilling the landfill (East Section) and part filling the coal ash landfill (West Section) by generating a lake in the West Section area.

Option 4: Transfer of part of the existing infilled household waste within the East Section from west to east to obtain a suitable final landform profile, and generating a lake between East and West Sections, whilst filling the West Section to the final level.

Option 5: Complete infilling of the East Section by using sealing materials and generating a lake at the Revolution Point, partly infilling the West Section and generating a second separate lake in the southern end of the Western Section.

Option 6: Closure of the landfill in 2005 in the East Section and infilling the West part, so that large parts of the household landfill will in the future be below the water table and lakes will be generated in the landfill area including at the Revolution Point.

These developed options were investigated and compared in the next step of the research project. The increase of the groundwater level induced by the end of the present groundwater lowering is a common feature of all options. Therefore a lake will be generated if the ground water control system is stopped in most of these options (option No. 2–6). It was investigated what kind of substances will be released during flooding. The quantity and concentration of landfill pollutants was estimated, as well their zones of influences and the mechanism of their effect on the environment.

The results of these investigations and model calculations are summarized in Table 1.

TABLE 1

Results of the model calculations for different options

Option for closure of the landfill Halle-Lochau	Final concentration* of pollutants at the end of the aftercare regime [mg/l]			Other important restrictions
	NH4–N	CSB	AOX	
1	3.1	21.7	0.03	Very high need for additional material to infill all remaining parts of the landfill area — this amount is not available
2	33.0	144.5	0.08	Additional measures are necessary
3	4.5	25.8	0.03	Very high need for additional material to infill all remaining parts of the landfill area — this amount is not available
4	59.2	209.3	0.07	Additional risks resulting from the necessary transfer of old landfill parts (e.g. asbestos waste); additional measures are necessary
5	30.6	125.9	0.08	Additional measures are necessary
6	45.8	204.8	0.07	Additional pollution by diffusion on the very large contact area must be taken into account; additional measures are necessary

* concentration in the flow directed to the nearby river

As shown in Table 1 the most promising options to date are No. 1 and 3, but the very large amount of additional material is not available for the landfill “Halle-Lochau”. The second-best alternative options are No. 2 and 5. The contact area between lake and landfill will be minimized in these options. The need for additional material to infill the remaining parts after landfill closure is also reduced.

But it can also be seen that additional measures should be realized for further reduction of pollution from the landfill. In result of model calculations of different possible measures and their investigation the lake was designed to have minimized contact with the landfill body using a special underwater sealing system constructed of non permeable waste materials. The stability of the slopes especially in the zones of incoming groundwater and shorelines was proved because of the changed hydraulic conditions when a lake will be developed.

The final proposed water level in the lake will ensure inflowing ground water from surrounding area collects in this lake and will be directed to the nearby river without pumping.

The landfill body will be partially inertisized by stimulating landfill gas development. This landfill gas will be collected and burned after landfill closure. Leachate will be used to adjust optimal water content and to stimulate microbiological reduction of pollutants in the landfill body. During this time the sealing systems of the lake as well as landfill surface will be constructed using suitable materials and waste. At the end of gas generation the area will be flooded to generate the lake and to start the aftercare regime. Residual pollution from the landfill body will be directed to the lake but will not affect the good ecological status of this lake.

As a result of all these measures a large reduction in pollution from the landfill can be achieved. Table 2 shows the results of the corresponding model calculations.

TABLE 2
Results of the model calculations for additional measures to reduce pollution in option No. 2

Option and measures for closure of the landfill Halle-Lochau	Final concentration of pollutants in the flow directed to the nearby river at the end of the aftercare [mg/l]		
	NH4–N	CSB	AOX
Option No. 2 without additional measures	33.0	144.5	0.08
Option No. 2 with additional measures (e.g. underwater sealing system, inertization of the landfill body by stimulation gas development, landfill surface design)	2.63	25.16	0.04
Highest permitted value	5	90	0.1

As an important question the resulting ratio for costs and benefits was also be examined as a main topic. It was shown that the preferred solution has the best results in the costs-benefits correlation of all investigated options.

4. Developed Measures for the Closure of the Landfill “Halle-Lochau”

In application of option No. 2 (Fig. 4) the West Section is completely infilled with inert materials. Since uniform and sufficient height is not yet produced in the disposal areas at the end of the disposal phase of the landfill, the further emplacement of inert materials will take place as part of the closure operations. These additional masses served the purpose of geotechnical security of the landfill body and for settlement compensation. With the completion of these measures, prerequisites to begin with surface enclosures and recultivation

are also fulfilled. For this, the plan is to raise a water balance and restoration layer on the landfill body and to afforest it.

During the landfill closure phase, a further facility is constructed for the biochemical inertization of the emplaced wastes. For this purpose, the collected leachate is led back over a complex humidification system into the landfill body. As a result of this cycle, the setting of optimal humidity content is reached in the emplaced waste, which is an essential prerequisite for the biochemical decomposition of harmful substances. The decomposition products, mostly in gaseous state, are collected with the landfill gas and burnt in the gas utilization station. Thus, the old landfill body can be widely inertisized and mineralized in the closure phase.

The completion of the landfill closure phase and the active after-care can be anticipated around 20–30 years after the completion of the landfilling phase based on the current knowledge level. The landfill site then stays open to other possible after-uses without an environmental threat emanating from the earlier landfill or necessitating other special environmental protection measures. As after-use, commercial settlement as well as local recreation resources are conceivable in connection with the planned landfill afforestation.

The waters arising in the central area of the landfill in the future should be associated as a scenic lake in the sense of tourism and recreational activities with the layout of wooded and park areas in the region closer to the worked-out open cut (Fig. 4).

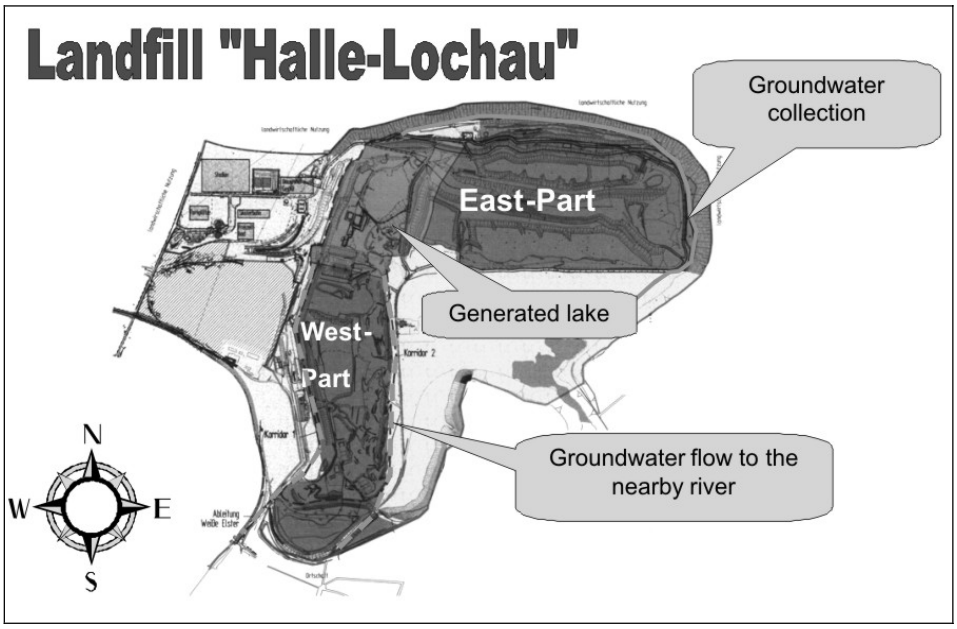

Fig. 4. Developed and optimized solution for closure and aftercare of the landfill “Halle-Lochau” (option No. 2)

5. Prospects

In the recent completing investigations of the research and development project legal restraints and possible social-ecological conflicts are considered because their solution will make sense for acceptance and realization of the results of the research and developing program.

The realization of the developed measures for the closure of the landfill “Halle-Lochau” began in June 2005. Because of the great importance for similar landfills the finance for a second stage of the RD-Project was announced by the German federal ministry for education and research. In this continuation the scientific support in the realization of the developed measures will be promoted.

The results of the research work are of significant importance to the operator which can also be adopted and adapted by other landfills with similar problems.