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Wismut

Landscapes designed and preserved

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Foreword

For almost 25 years, the federally-owned Wismut GmbH has been successfully remediating the legacies left behind by former uranium ore mining operations in Saxony and Thuringia. With German reunification in 1990, the Federal Republic of Germany assumed the sole social and financial responsibility for these operations and has provided funds totaling some 6 billion euros.

Environmental impacts in the former mining regions have significantly decreased. The remedial activities have mitigated environmental damage and reshaped natural landscapes for the benefit of the people and their region. Remediated areas are used primarily for forestry and agricultural purposes, for tourism and economic development. The accomplishments of Wismut GmbH are at the same time an internationally recognized reference project for the rehabilitation of radioactively contaminated industrial sites.

This brochure portrays the initial situation and the results achieved thus far in mine decommissioning and remediating former mining areas to prepare them for future reuse. In addition, it provides an overview of the tasks ahead. The presentation of this report is also a token of gratitude to the staff of Wismut GmbH, to their partners and to everybody else involved in the Project for their achievements.

Federal Ministry for Economic Affairs and Energy

1. Wismut uranium ore mining operations in Saxony and Thuringia

The legacies left behind by uranium ore mining were generated by more than 40 years of mining and processing of uranium ore in East Germany. As early as 1946, the then Sachsenerz Bergwerke AG started uranium mining from abandoned mine dumps, adits, and mine pits, under supervision of units of the Soviet military. To cover reparation claims, the mining companies operating in the Soviet occupation zone were transferred into Soviet ownership. Thus, the Soviet stock company Wismut was founded in 1947. The goal of the undertaking was to provide uranium for the nuclear armament programme of the Soviet Union. A large workforce, conscripted from across the Soviet zone of occupation, was forced to work in the uranium mines. Uranium mining and processing during that period was characterised by bad working conditions, complete disregard for nature and the environment, and insensitive encroachments on population centres. Whole areas were confiscated and turned into prohibited zones: Wismut became a state within a state.

In 1954 the German Democratic Republic (GDR) received a stake in what had been a purely Soviet stock company up to that time. The company was converted into the Soviet-German stock company SDAG Wismut, with both partners holding 50 percent of the shares. The basis for this change was an agreement concluded between the governments of the USSR and the GDR of August 22, 1953. This agreement was renewed in 1962 and was extended in 1975.

Annual uranium production peaked in 1967 at a rate of 7,100 tonnes. In 1990, production was still at some 3,000 tonnes of uranium. By the end of uranium ore mining on December 31, 1990, Wismut had produced a total of some 231,000 tonnes of uranium, ranking the GDR as the world's fourth largest uranium producer after the USSR, the United States and Canada.

Following German reunification, the Federal Republic of Germany and the Soviet Union signed a transition agreement on October 9, 1990 under the provisions of which SDAG Wismut ceased its operation on January 1, 1991. This put an end to uranium ore mining in Saxony and Thuringia.

In 1990, the environmental situation in the mining districts was characterised by enormous environmental degradation affecting a total surface area of some 3,700 hectares, including radioactively contaminated mine dumps, tailings ponds, and plant areas located within a densely populated region. Past mining activities had marked the mine and mill sites of Ronneburg, Seelingstädt, Crossen, Schlema, Pöhla, Königstein, and Dresden-Gittersee with their legacy of devastation. Uranium mining operations had released radioactive materials into the atmosphere, into soils, and into the hydrosphere. More than 300 million cubic metres of waste rock material had been brought to the surface and dumped in 48 waste rock piles. Processing uranium ore to yellowcake had generated more than 160 million cubic metres of tailings sludges containing residual levels of uranium and other contaminants. This situation made it imperative to initiate immediate action in 1990 to eliminate hazardous risks, to close mines and pits, and to clean-up and rehabilitate production sites.

Parking lot and pit shafts against a background of waste rock piles at Schlema (c. 1965)

The national Wismut GmbH – a federal responsibility

Under the terms of German unification, ownership of 50 percent of the shareholdings of the binational company SDAG Wismut passed to the Federal Republic of Germany. Under the terms of the German-Soviet intergovernmental agreement of May 16, 1991, the Soviet shareholdings were also transferred to the German side. As a consequence thereof, the Federal Republic of Germany assumed responsibility for the company as a whole. On December 20, 1991, with the coming into force of the Wismut Act of December 12, 1991, the company SDAG Wismut was changed into Wismut GmbH, a company under German corporate law. Site decommissioning and rehabilitation of uranium production legacies were defined as and remain the company's key mission and corporate purpose. The Federal Republic of Germany is its

Bad Schlema spa park (2014)

only shareholder, represented by the Federal Ministry for Economic Affairs and Energy.

Following the usual practice in countries with planned economies, the SDAG Wismut company had not set aside any financial reserves for future decommissioning and rehabilitation work. As a consequence, the federal government had to allocate sufficient funds for the Wismut GmbH company to fulfil its mission.

The legal framework for the decommissioning and rehabilitation work is set forth in the Wismut Act and other relevant regulations, laws and ordinances contained in German mining and radiation protection legislation in particular as well as in German soil protection and water legislation. Furthermore, under the provisions of the German unification treaty, two former GDR regulations containing specific provisions on the decommissioning of uranium mines (Nuclear Safety and Radiological Protection Ordinance and Mine Dump Ordinance) continue to be applied. Moreover, the German Commission on Radiological Protection has issued a number of radiological protection principles concerning the release of contaminated areas, waste rock piles, buildings, and materials originating from uranium ore mining. These principles are taken into consideration when assessing the need to remediate areas and facilities.

From mining to remediation company

A priority task to be addressed in the early 1990s was the restructuring of the company from a mining company oriented toward the maximum production of uranium operated under the conditions of a planned economy into a modern private sector remediation company. On January 1, 1992, the numerous affiliated mine support activities of SDAG Wismut were split from the newly founded Wismut GmbH and privatised during the mid-1990s.

When uranium mining was terminated at the end of 1990, there were no ready concepts or plans available to initiate the required pending remediation measures. For this reason, remedial concepts for all fields of activity had to be developed at short notice. A prerequisite for the development of remedial concepts was the assessment of the existing environmental impacts and the establishment of an environmental database. The need for environmental restoration and the definition of concrete remediation goals were derived from the analysis of these data. This meant in particular that the various options and alternatives had to be submitted to a thorough and comprehensive assessment in terms of their ecological, economic and social aspects. This optimisation process also comprised considerations regarding the long-term stability and follow-up costs of the various options. Trade-offs between the varied interests were conducted in close cooperation with the relevant State supervising authorities and through dialogue with municipal and district representatives of the affected areas.

The decision-making process had to acknowledge that a good many of the remediation operations were indeed intervention measures which have the capacity to mitigate environmental damage but cannot undo environmental impacts altogether. In the end, concepts were worked out through constructive cooperation with the regulatory bodies of the Free States of Saxony and Thuringia which built a safe and generally recognised basis for future remediation planning by Wismut GmbH. First site-specific remedial concepts were finalised by August 1991 and then continuously updated in accordance with growing expertise and know-how. They provide the basis for concrete design and planning of the various remediation measures as well as for the annual work programmes. All work projects are submitted by Wismut GmbH to the competent authorities of the Free States of Saxony and Thuringia for approval and licensing.

The multitude and diversity of tasks to be addressed in developing remedial concepts required the pooling of international technical and scientific expertise and the involvement of a great number of German and foreign experts.

Organisation and corporate structure

Following assumption of responsibility for the Wismut company by the federal government in 1990, the mining company needed restructuring. In the transition period leading to the founding of Wismut GmbH, the German side had already assumed managerial leadership as agreed during German-Soviet negotiations. For that period, the Federal Ministry of Economics and Technology had appointed an advisory board to act as an interim supervisory board. Upon the foundation of Wismut GmbH, the executive officers and a supervisory board were appointed. Until 2009, the shareholders and employees each had six representatives sitting on the supervisory board, equally represented in compliance with the 1976 Co-determination Act. Since 2009, the supervisory board has nine members in accordance with the One-Third Employee Representation Act.

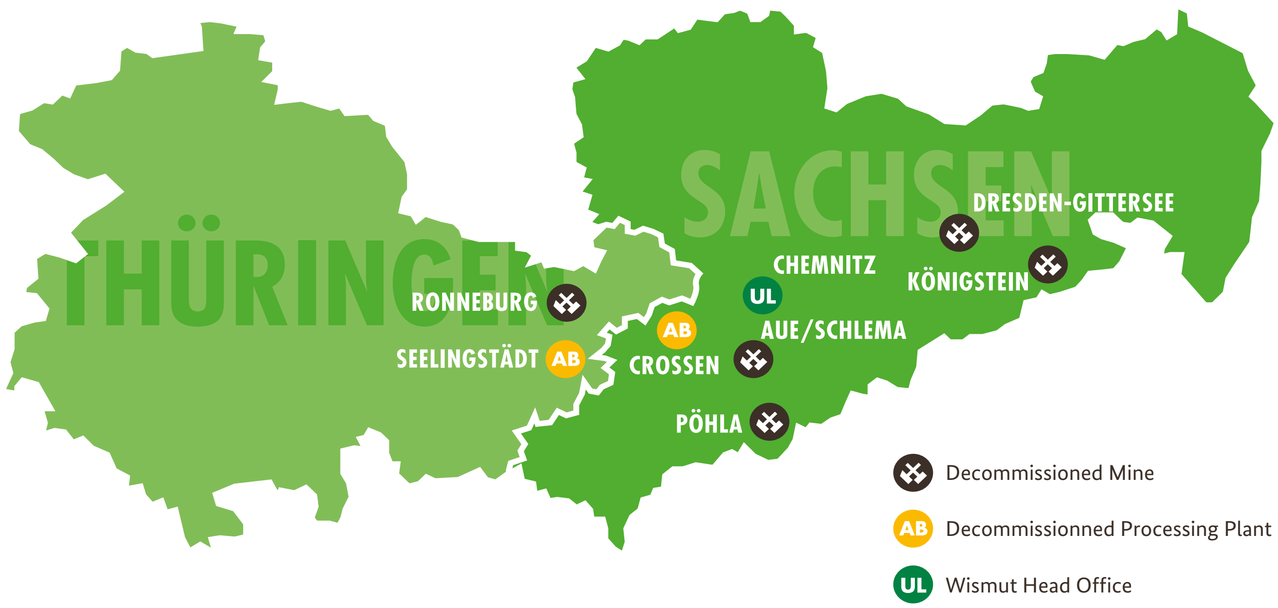
Today, Wismut GmbH comprises the head office based in Chemnitz, and seven rehabilitation units in Saxony and Thuringia. The corporate structure has been continuously adapted to the progress in remediation in a bid to conduct remedial processes in a cost-effective manner.

Funding

With German unification the federal government has not only assumed sole social responsibility for the remediation of the legacies left behind by uranium ore mining in Saxony and Thuringia but has also taken on sole responsibility for financing the enormous tasks. Wismut GmbH is an institutional donee funded by the federal government. To complete the environmental restoration programme, the federal government has earmarked 7.1 billion euros, around 6.0 billion of which had been spent by the end of 2014 – 3.2 billion in Thuringia and 2.8 billion in Saxony. Funding needs are established on the basis of the company's annual work plans, which are adopted as part of the federal budget by the German parliament.

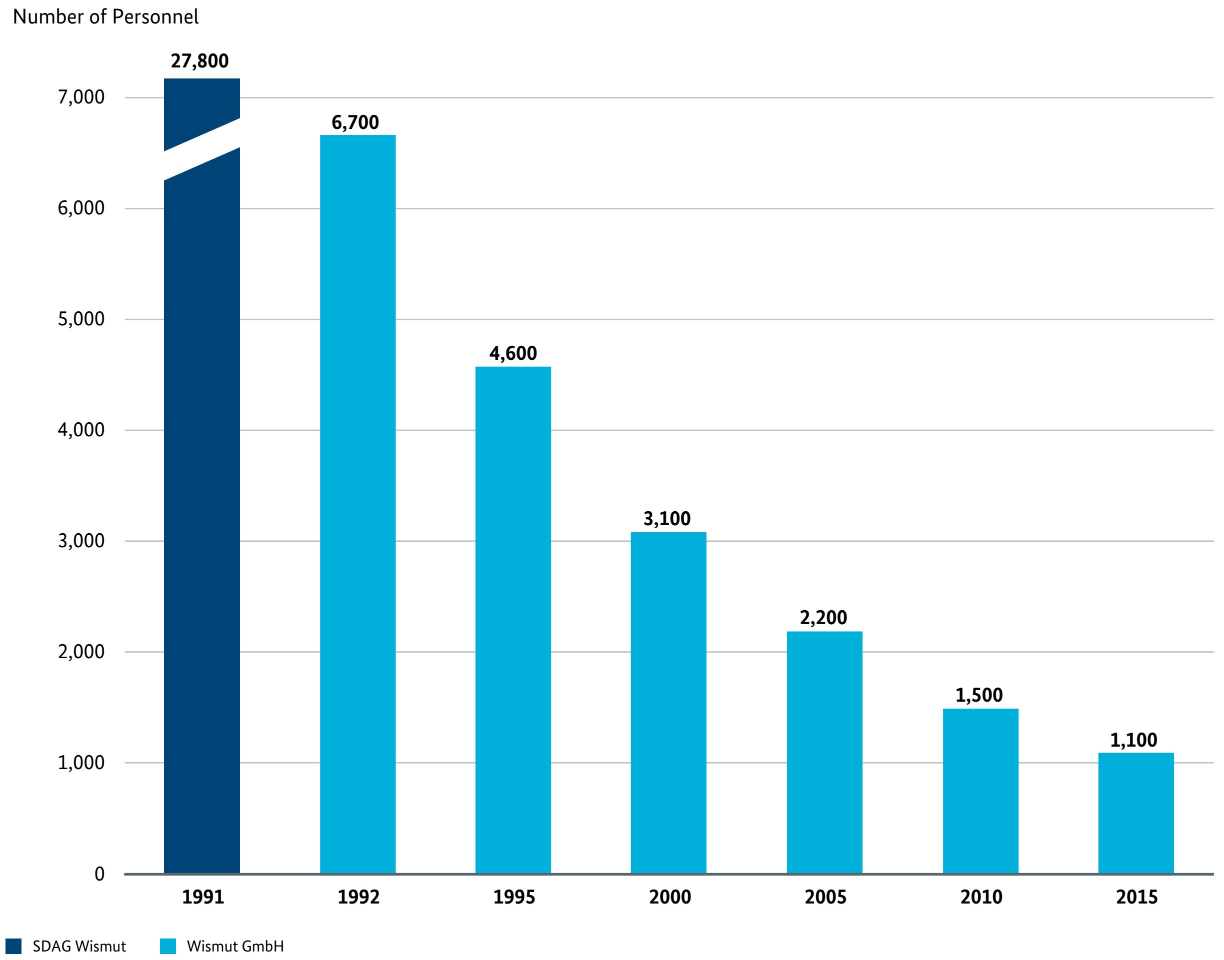
Workforce development

One of the major problems to be addressed during the early years following the termination of uranium ore mining was to adapt and size the workforce to meet the challenge of the forthcoming remedial action. At the time when uranium ore mining and processing ceased, Wismut's workforce totalled almost 28,000 employees. Numerous jobs were lost during the initial years. Setting up two employment promotion schemes made it possible to streamline the production workforce in a socially acceptable manner. Close to 11,000 employees registered with those schemes and joined various employee development and job conversion training programmes.



Wismut sites

Workforce development 1991 through 2015



Source: Wismut GmbH

Following the spin-off of mine support and auxiliary units on January 1, 1992, Wismut GmbH still had some 6,700 employees on its payroll. In 2015 some 1,100 remain. That such drastic staff cuts could be carried out in a socially acceptable manner using various tools (employment promotion schemes, semi-retirement, and miners' insurance compensatory payments) is a remarkable achievement made possible by good understanding among the parties involved, i.e. the Federal Ministry of Economics and Technology as owner, the supervisory board, management, staff, and the labour union.

The main goals set for workforce development – to ensure the completion of remedial tasks in a good and workmanlike manner by experienced Wismut staff and to achieve socially acceptable workforce reduction – have been fulfilled.

Managerial tasks funded by the federal budget encompass decommissioning and rehabilitation projects, employment promotion schemes, redundancy programmes and other personnel policy regulations for a socially acceptable staff reduction as well as extensive educational opportunities for some 1,500 young people who have received training in a variety of trades.

Wismut as an economic factor

For some 25 years now, Wismut GmbH has been making a major contribution to shaping improved living conditions and to the economic stabilisation of the former mining regions. Rehabilitation of areas is an important prerequisite to attract investors and ensure sustainable development. Achievements so far include the establishment of forest and grassland areas for recreational use, the reactivation of tourism, the attraction of new investors and the installation of a solar park. By implementing this environmental restoration project, Wismut and the subcontracted local firms make a major contribution to employment and job creation in the region. So far, Wismut GmbH has awarded third-party contracts totalling some 2.2 billion euros, including around 1.1 billion euros in Saxony and around 0.7 billion euros in Thuringia. These contracts usually cover the purchase of materials and equipment, the supply of energy, of raw materials and fuels and the purchase of engineering and construction services.

Favourable urban development following comprehensive rehabilitation of mining legacies is outstandingly exemplified by the community of Bad Schlema in Saxony which has

Industrial zone and forestry established on former Paitzdorf mine area (2013)

regained its former title as a spa town. Successful reclamation of former mining sites is also manifest in East Thuringia where the "New Ronneburg Landscape" of the BUGA 2007 National Horticultural Exhibition was to a large extent made up of areas rehabilitated by Wismut GmbH.

International Cooperation and Exploitation of Remedial Know-How and Expertise

From the outset of the remediation project, a priority was placed on making sure that the Wismut project drew on and benefited from the international expertise and experience that other countries – such as the United States and Canada – had gained in the remediation of uranium mining legacies. In the course of the ongoing remedial process – including decommissioning, remediation and preparation for reuse – Wismut staff have acquired vast scientific and technical know-how and developed state-of-the-art remedial technologies of their own in dealing with radioactive mining legacies. Since the mid-1990s, demand for the company's experience and the technical expertise has been growing from external, mainly international clients. Marketing of the know-how was initially assured by the corporate unity Wismut-Consult and since 2002 is performed by the wholly-owned subsidiary WISUTEC Umwelttechnik GmbH, which was privatised in 2010.

The Wismut environmental restoration project has emerged as a significant international reference project for the clean-up of radioactive legacies. Wismut GmbH has presented its comprehensive expertise and experience at a multitude of seminars, congresses, and workshops at the national and international levels, and the company itself has also organised a number of international forums for exchanging experienc e on major issues of mine rehabilitation. Prominent partners in these efforts included the U.S. Department of Energy (DOE) as well as institutions and firms from Canada and Australia. These exchanges were subsequently joined by Eastern European and CIS countries which, like Wismut, were in the process of decommissioning their uranium industries. This network of mine operators, remediation companies, regulators, and experts has established itself as the "Uranium Mining and Remediation Exchange Group (UMREG)" and organises topical symposia at regular intervals. Since 2009, these meetings have been held in Vienna under the auspices of the International Atomic Energy Agency (IAEA).

2. Remediation goals and concepts

Wismut GmbH has been conducting the remediation of the legacies of uranium ore mining left behind in Saxony and Thuringia since 1990. This clean-up work is aimed at removing the hazards generated by uranium ore mining and its legacies or at least diminishing such risks to an acceptable residual level and at restoring an environment that is ecologically largely intact and fit for reuse in compliance with the provisions of the Federal Mining Act. This is an indispensable prerequisite for the economic revival of the regions affected by Wismut mining operations.

In an initial phase, concepts had to be worked out for the remediation of the mining legacies. The concept-building process had to identify solutions which were both ecologically effective and sustainable for the remediation of mines, waste rock piles, and tailings management areas as well as for the treatment of contaminated waters generated during and past remedial operations. What would happen to plant buildings, production facilities, and plant areas was also up for decision.

Mine remediation concept

The remediation concept for the mines at the Ronneburg, Schlema-Alberoda, Pöhla, Königstein, and Dresden-Gittersee sites calls for the **flooding of the mines**. Shutting off the pumps which dewatered the mines during operation will allow natural inflow of groundwater into the mines. Prior to initiating the flooding process, oils, greases, and chemicals will be removed from the mines with a view to minimising subsequent contaminant release via the aquatic pathway. In a next step, mine workings of low rock mechanical stability – and in particular near-surface cavities – will be backfilled with self-hardening material to prevent surface subsidence and ensuing mine damage. Backfill materials consist of a mixture of sands, water, and cement or power plant fly ashes. Shafts and adit openings are safely sealed and plugged with concrete. In the meantime, mine flooding at the Pöhla, Schlema-Alberoda, Dresden-Gittersee and Ronneburg sites is complete. Flooding of the Königstein mine is not yet terminated.

Beerwalde waste rock pile, Ronneburg site (2014)

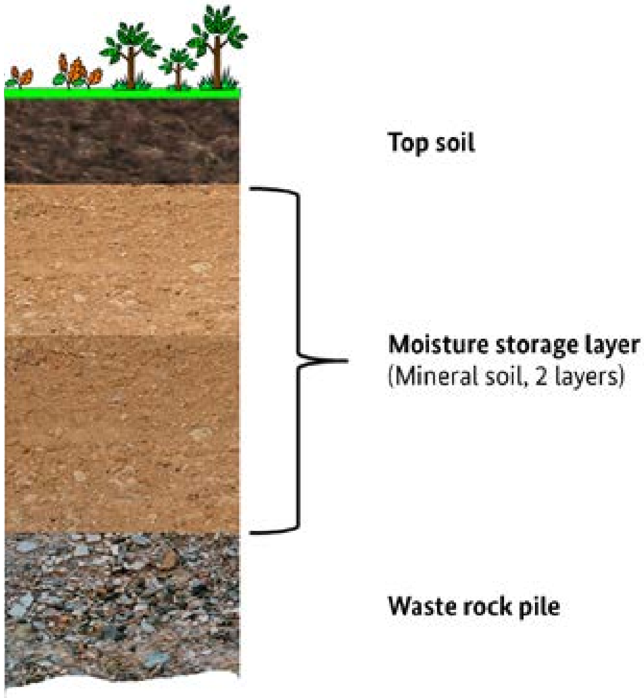
Mine dump remediation concepts

Waste rock and overburden stockpiled in mine dumps of Wismut resulted from the development of the various ore deposits. Given their levels of naturally occurring radionuclides, their resulting specific activity is generally within a range that requires remediation for compliance with radiation protection legislation. Moreover, the waste rock material contains heavy metals which may be relatively easily mobilised such as e.g. iron, nickel, and copper, which have to be prevented as far as possible from reaching groundwater and surface water. In addition, slopes of many waste rock piles were too steep, and there was a real risk of slope failure. Safe remediation of the waste rock piles is therefore required under mining, radiation protection and water legislation.

At Wismut waste rock pile remediation follows two different approaches: the concept of **relocation** whereby several waste rock piles are excavated and moved to a single location and the concept of **remediation in situ** whereby the waste rock piles are remediated in place. Which of the two concepts is followed in a given case is determined by site-specific conditions, cost-benefit considerations, and public acceptance issues.

All but two smaller waste rock piles located to the south of the A4 federal motorway at the Ronneburg site were relocated into the worked-out Lichtenberg open pit mine, while the Drosen and Korbußen waste rock piles located to the north of the motorway were banked against the Beerwalde waste rock pile. At the majority of waste rock pile sites in Saxony relocation was not feasible for lack of space or economic considerations. For this reason, these waste rock piles were almost without exception remediated in situ. Mine dumps which contain waste rock and overburden materials suitable for capping purposes at tailings management areas constitute an exceptional case, and they are either in part or entirely relocated for placement atop tailings management areas.

The basic remedial concept applicable to all waste rock piles provides for enhancing long-term slope stability and covering the piles with mineral and vegetation supporting soils. The cover has a number of functions to fulfil. It has to reduce infiltration of precipitation into the waste rock pile body in order to minimise the volume of contaminant-bearing seepage waters. Furthermore, the cover shall prevent direct contact with the waste rock material and diminish the environmental impact of radioactive releases from rock to a level within the natural background range. Finally, the waste rock pile cover must support vegetation growth.



Standard two-layer mine dump cover exemplified by the case of the Schlema site

In order to achieve the above mentioned goals, Wismut has designed a number of site-specific cover options. Their topmost element is a topsoil layer followed by mineral soils acting as a moisture storage layer. Depending on conditions at the site, the cover may comprise a bottommost additional sealing layer made of clayey material. Grass seeding follows immediately after completion of the cover. This primary seeding serves as a protection against erosion and stabilises the newly established topsoil layer.

Both landscape features newly constructed by the relocation of waste rock piles and piles remediated in situ have to be provided with farm roads and draining ditches for collection and discharge of surface runoff. The concept for the reuse of reclaimed waste rock pile surfaces recommends the establishment of a forest and meadow landscape. The basic principle underlying the landscaping of remediated waste rock piles provides for their contours and vegetation to blend in with the surrounding scenery.

Interim covering of tailings

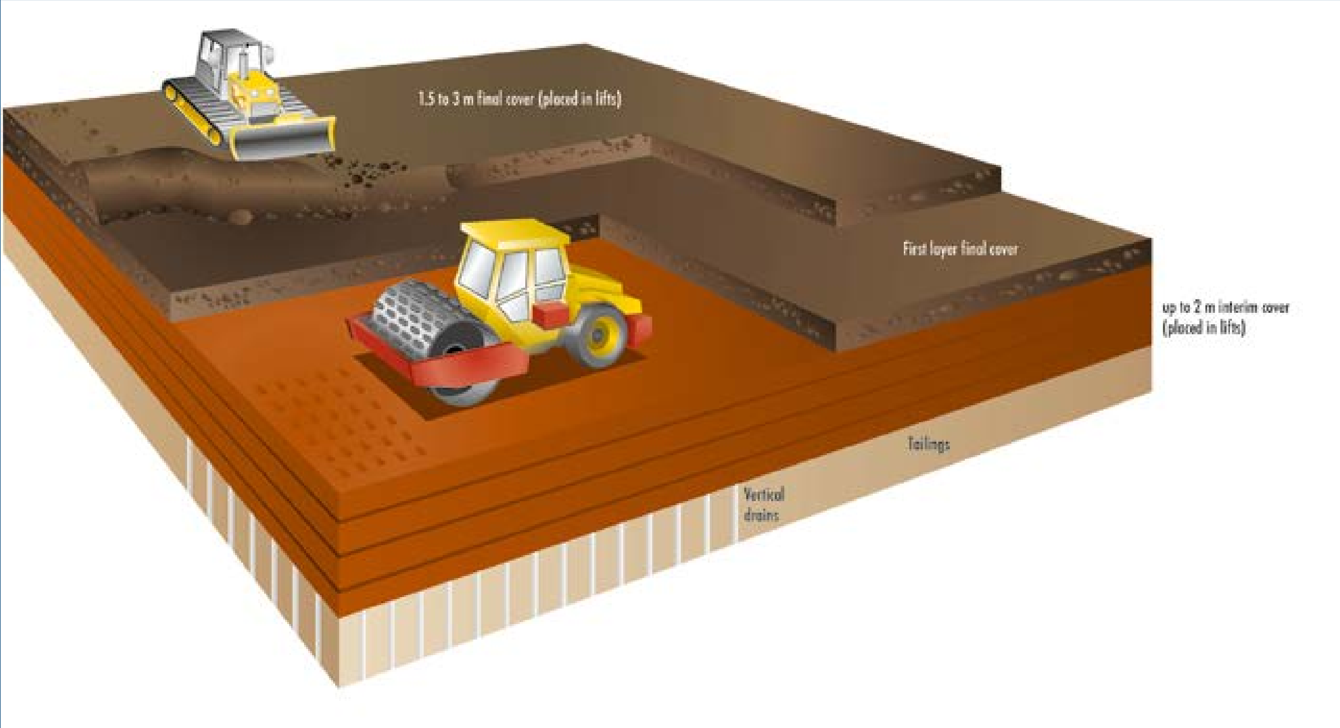
Tailings management facility remediation concept

Residues generated during the processing of uranium ores at Seelingstädt and Crossen – aka tailings – were deposited as slurries into the Culmitzsch, Trünzig, and Helmsdorf/Dänkritz tailings management facilities. Design of suitable stabilisation strategies was not an easy thing to do since there was no experience available in Germany or abroad on how to address tailings pond remediation of that order of magnitude. Scientific investigations and studies as well as pilot-scale tests had to be performed before informed decision-making was feasible. In developing promising remedial strategies, Wismut also sought the advice and expertise of foreign experts. In the end, in cooperation with the regulatory bodies and their consultants, "dry" in situ remediation of the tailings was identified as the preferred option, since it presented the optimum trade-off between environmental benefit and costs. Based on this option, the remedial concept provides for the in situ remediation of all three tailings management sites involving the removal of the supernatant water and the capping of the tailings ponds with soil materials.

To a large extent the technology of cover building had to be developed by Wismut itself. In a first step following the removal of the supernatant water, a circa 1.5 m thick **interim cover** was placed on top of the exposed tailings surface. As a rule, and this applies in particular to zones of fine-grained tailings, permeable waste rock, sand or gravel are used to build the interim cover.

Covering the clayey-silty fine-grained tailings was a formidable challenge. In contrast to the solid sandy-grained tailings of the beach areas, here the low load-bearing capacity of the subsoil did not allow a straightforward placement of the cover material. In order to build a load-bearing surface for follow-up operations, the exposed fine-grained tailings were covered with geotextile and geogrid materials. The geotextile primary capping provides sufficient load-bearing capacity for the operation of low-weight equipment used to stitch up to 5 metres long wicks (aka vertical drains) into the tailings. It also serves as a support pad for the placement of the interim cover. The superimposed load of the interim cover squeezes some of the pore water out of the fine-grained tailings; the expelled pore water rises along the vertical drains into the interim cover from where it runs by gravity flow to the lowest point of the pond surface for collection and pumping. The interim cover gradually evolves into a load-bearing surface suitable for future remedial action.

The next remedial step to follow is **contouring**. Dam slopes are flattened wherever required for stability or erosions protection reasons. The profile of plateau areas is regraded in a way to allow natural surface run-off. Given that deep fine-grained tailings sludges in particular will drain very slowly over extended periods of time under the applied superimposed load, so-called deep-reaching vertical drains are driven up to 30 metres down into the tailings in order to enhance settlement that comes along with drainage. Basically, settlements and deformations should have faded away for the most part before the final cover is put in place.



Schematic diagram of final cover placement on tailings pond

Eventually, the contoured surfaces are capped with 1.5 m to 3 metres of **final cover**. Its primary goal is to reduce the infiltration of precipitation into the tailings in order to minimise the generation of contaminant-bearing seepage. Final covers of tailings management areas basically feature an identical sequence of layers, namely recultivation and storage layer and infiltration barrier which may vary in thickness or compaction depending on the properties of the tailings material. Landscape planning for the reuse of covered tailings facilities provides for afforestation of sub-areas as well as for the creation of open grassland areas.

Concept for the handling of industrial buildings and facilities

After termination of uranium production there was no further use for most industrial buildings and facilities. Only few units are still being used for ongoing remedial work. These units will also be dismantled and demolished once remediation is completed. The concept for **dismantling and demolition** stipulates that radioactively or chemically contaminated scrap and demolition rubble shall be disposed of within tailings management areas and waste rock piles. Uncontaminated and decontaminated scrap is recycled. In contrast, uncontaminated demolition rubble is used for road construction purposes on reclaimed Wismut areas.

Concept for the reuse of rehabilitated areas

Areas which are contaminated or otherwise affected by mining activities and which are the responsibility of Wismut have to be prepared for reuse in compliance with the Federal Mining Act. This does not compellingly imply, however, that the proper shaping of the ground surface would tantamount to the restoration of pre-mining conditions. In practice, the development of concepts for the reuse of individual areas at Wismut is guided by existing regional land development and zoning plans. The actual

Afforestation area on Trünzig TMF, Seligstädt site (2014) need for remediation of an area is determined by the degree of the established contamination and the type of envisaged reuse. The release of areas for housing development, for industrial, commercial, agricultural or forestry reuse is primarily subject to compliance with the criteria recommended in the radiological protection principles issued by the German Commission on Radiological Protection.

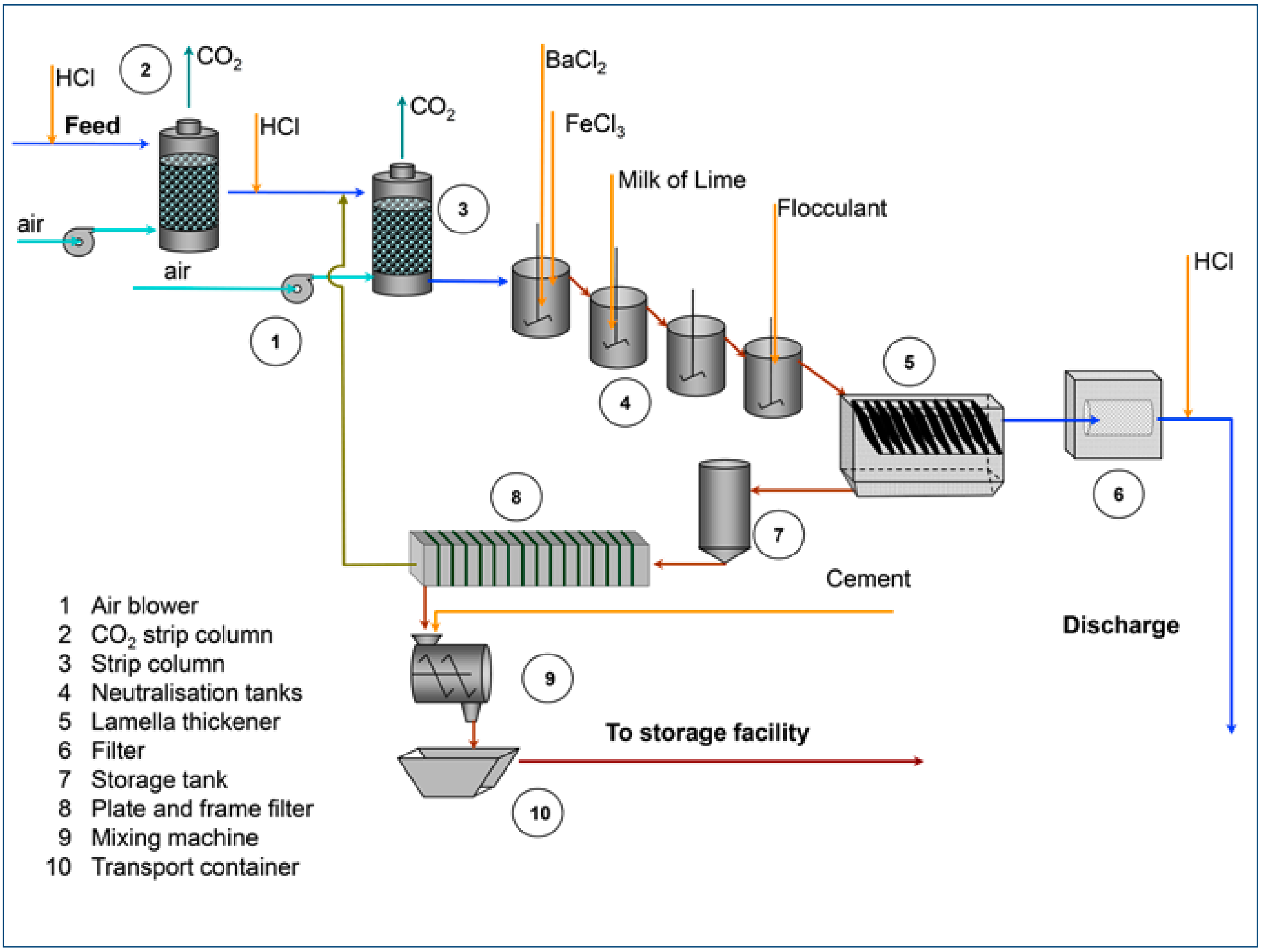
In accordance with regional land development and zoning plans, forests or green spaces are the preferred types of reuse for the vast majority of areas rehabilitated by Wismut. Only a few remediated plant areas are eligible for commercial or industrial reuse.

The concept for the remediation of waste rock pile footprints, plant areas and roadways and railbeds basically stipulates that all ground contamination be removed. On cleaned-up areas, foundations of demolished buildings and facilities are removed down to a minimum depth of 1.5 metres below ground level.

Concept for the handling of contaminated waters

Radioactively and chemically contaminated waters have to be treated in water treatment plants before being eligible for discharge into receiving streams. Both during controlled mine flooding and after its completion, **flood waters** will daylight which are contaminated with uranium, radium, heavy metals, and arsenic. The same is true of **supernatant and pore waters** which have to be removed by pumping for tailings dewatering purposes, and also of **seepage** from covered tailings management facilities.

Wismut operates six water treatment plants. They use a flowsheet of precipitation with lime. By addition of milk of lime, barium chloride, and iron chloride heavy metals, uranium, radium, and arsenic are removed from the feed water as a low solubility precipitate. Water treatment residues are hydraulically immobilised by the addition of specific aggregates before their disposal in engineered cells in waste rock piles and tailings management facilities.



Flowsheet of the Seelingstädt water treatment plant using the lime precipitation process

3. Engineering services, licensing process, monitoring

Comprehensive planning work is required to translate remediation concepts into actual remedial action. Such planning is in many cases based on detailed **engineering services** which, for the most part, also serve to underpin licence applications. The broad variety of remedial goals is reflected in the range of engineering branches and supporting applied natural sciences involved: mining, geotechnics, soil mechanics, mine surveying, civil engineering including statical calculation, chemical engineering, process engineering, plant construction, electrical engineering, measurement and control systems engineering, transportation, hydraulics, road construction, energy supply, logistics, forestry and radiological protection. Science applications comprise geology, hydrogeology, radioecology, and meteorology. Mathematical modelling is used to assess the impact of various remedial options on water, air and soil quality as well as radiation exposure of the population.

Initially, these engineering services were aimed at

- The development of various remedial options,
- Performing technical feasibility studies, and
- Investigating the efficiency and sustainability of the proposed remedial options.

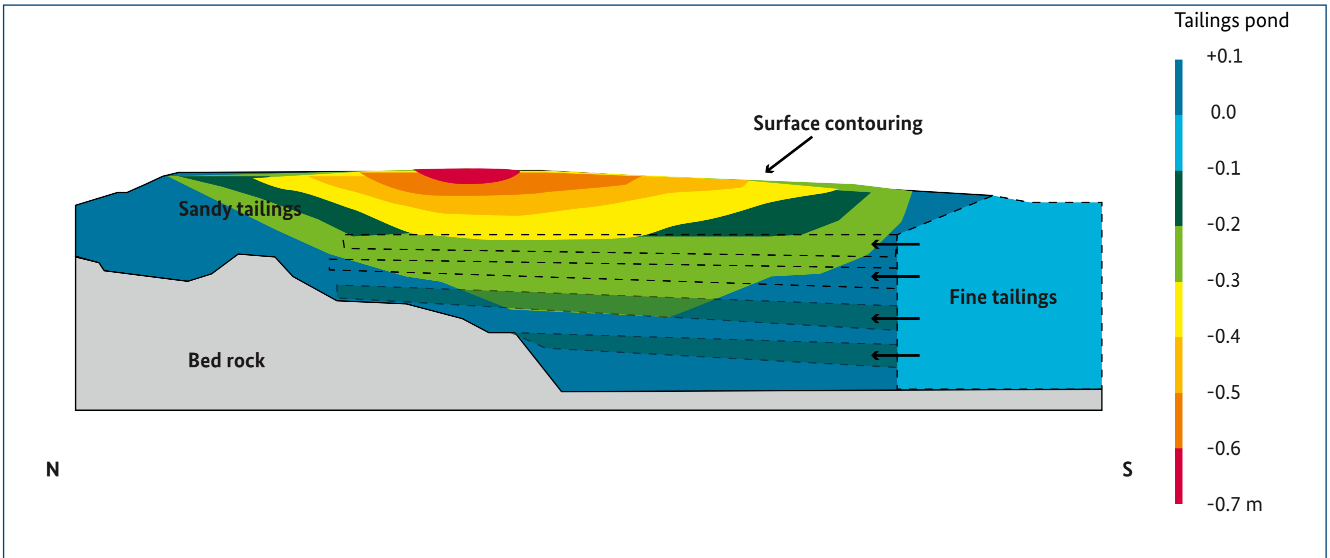
The findings served as a basis in the process of choosing a preferred option which in addition to technical feasibility would also comply with requirements regarding

- Safe working conditions and protection of the public during the execution of the required remedial operations,
- Total rehabilitation expenditure including follow-up long-term care and maintenance tasks, and
- Public acceptance.

Moreover, engineering services served as a basis for optimising work processes and enhancing quality control.

Engineering services not available at Wismut are contracted out to recognised specialised firms to profit from their expertise.

Already at the time when active mining operations ceased, Wismut began to broaden its mining engineering know-how by establishing contact with internationally operating engineering firms in the field of mine remediation with a view to integrating the state-of-the-art know-how into its conceptual planning work. In the meantime, Wismut's mine remediation know-how is in demand nationally and internationally. A case in point is Wismut's cooperation with the Czech company DIAMO in remediating the aban-



Numerical settlement computation for the contouring of the Culmitzsch TMF

Mobile measuring station for radon and dust

doned in situ leach mines of Stráž pod Ralskem and Königstein and optimising treatment options for effluents from flooded uranium mines. In Hungary, the Mecsek-Öko company successfully completed the rehabilitation of uranium mining legacies using Wismut know-how and expertise. Over a period of ten years, Wismut GmbH has been providing expert opinion on the remediation of the tailings management facilities at the Žirovski Vrh site in Slovenia.

Briefing of **regulatory agencies** early on in the engineering planning stage has turned out to be conducive to speeding up the licensing process, as it allows an informed discussion of technical and legal issues with the experts of the licensing authorities in Saxony and Thuringia.

Starting in 1990, Wismut has submitted more than 9,000 licence applications. Some 4,200 licences were granted in Saxony, approximately 4,700 in Thuringia and around 60 licences were awarded for clean-ups across State borders. Almost half of the licences were granted under the provisions of the mining legislation, and about 1,300 permits each were awarded under the provisions of radiological protection and water legislation.

Coordination of remediation planning with municipalities in the area is of particular importance. To the extent possible, reclamation at Wismut sites has to take local and regional land use planning into consideration. To this end, local government representatives and Wismut GmbH meet at regular intervals.

Project support is provided by a consultant acting on behalf of the BMWi and who is mandated to assess the implementation of decommissioning and remediation measures for solid practice and cost efficiency. The Hanover-based Federal Institute for Geosciences and Natural Resources (BGR)

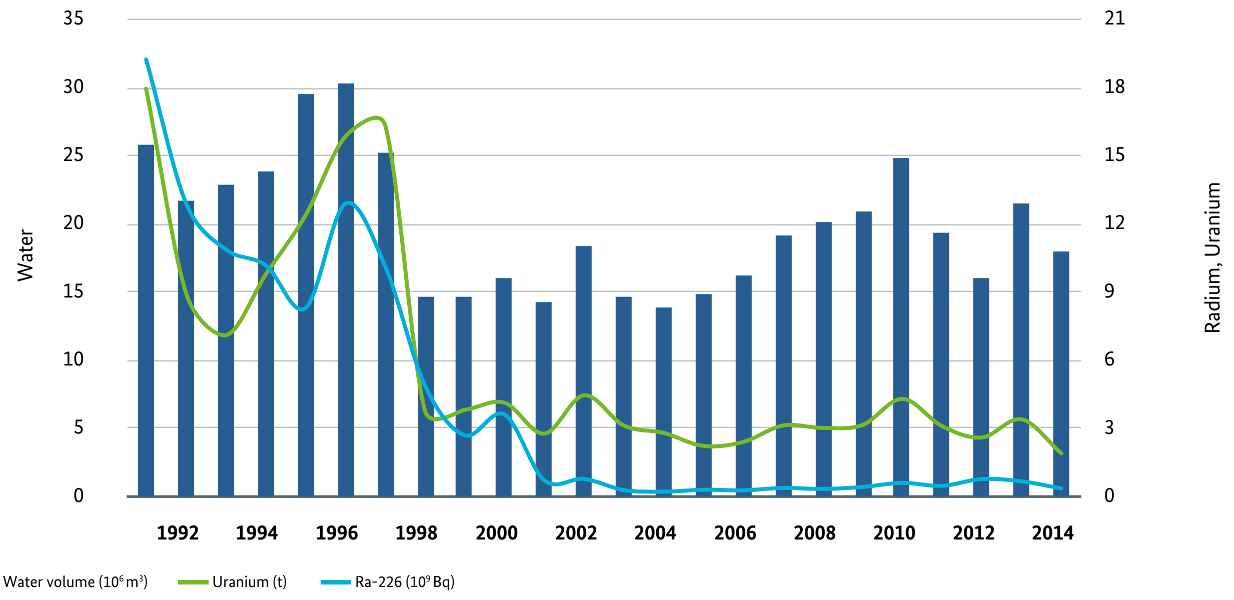
Flood water sampling at the Schlema-Alberoda site

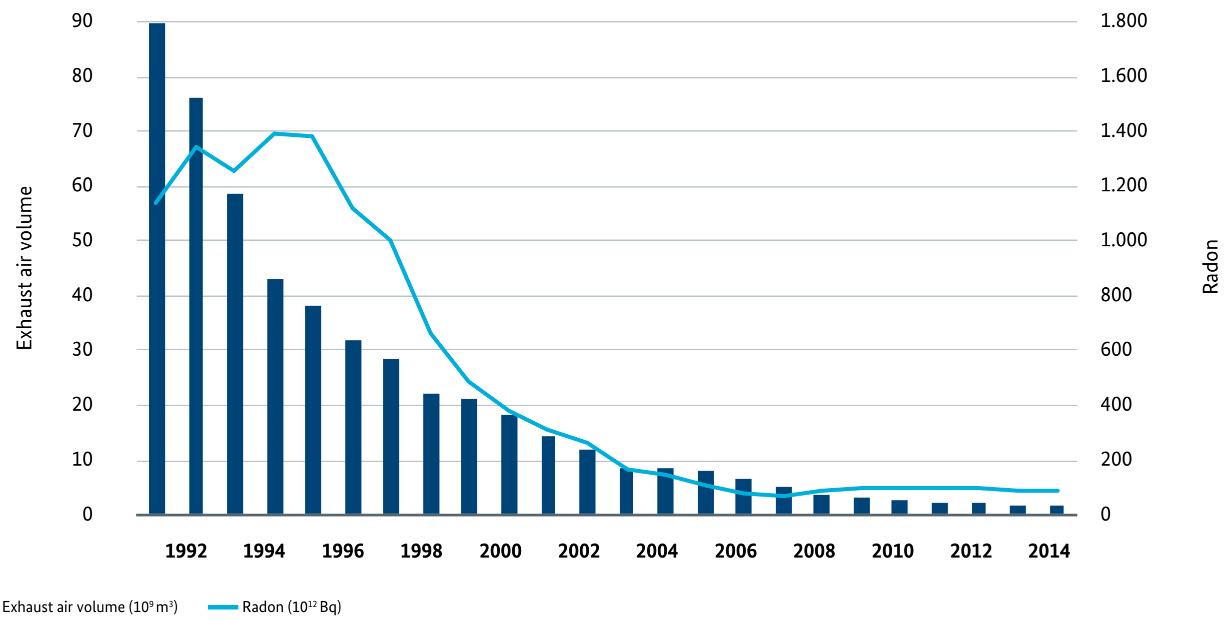
has been performing this task since 2012. The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) exercises federal supervision over licensing under radiological protection legislation of the Free States of Saxony and Thuringia. In this respect, the BMUB utilises the expertise of the Federal Office for Radiation Protection (BfS) and consultants.

Impacts and results of remediation activities are registered by a comprehensive **monitoring system**. Monitoring comprises radioactive and non-radioactive substances in water, soil and air. In addition, meteorological data are collected and soil physical parameters established from cover systems of waste rock piles and tailings management areas to compare their evolution with engineering and model calculation forecasts. Based on monitoring results, changes in environmental impacts occurring in the course of remediation are recorded, recorded data are stored in data banks, and the findings are documented in reports submitted to the regulators and the public. In this way, compliance with legal and regulatory standards and legislation is documented and the remedial success made obvious

By the end of 2014, Wismut operated a total of some 1,800 measuring stations. These stations monitor the atmosphere (radon, dust, long-lived radionuclides, both dust-borne and in precipitated dust) as well as receiving streams and groundwater (radionuclides, heavy metals, further contaminants).

Evolution of releases via the atmospheric and aquatic pathways





Source: Wismut GmbH

Other measuring networks are operated to register potential movements at ground surface which could be caused by the collapse of underground cavities and mine flooding. Soil and biomass sampling is conducted to track contamination by radionuclides or other contaminants.

The number of required measuring stations will decrease with further progress of remedial work and the transition of reclaimed objects into the post-remedial phase and long-term tasks. At the end, only measuring stations will remain active which are required for key measuring networks. These networks are designed to meet the needs of long-term post-remediation monitoring. Besides groundwater measuring points they also comprise measuring stations for surface water and seepage to ensure long-term hydrological and hydrochemical monitoring of individual objects or groups of objects. Any measuring station not eligible for integration into the key measuring networks for the aquatic pathway shall be gradually placed out of service. Depending on remedial progress at the various sites, this process will continue for several years and will certainly only be completed following the full remediation of the Culmitzsch tailings management site after 2028.

Measurement results registered to date demonstrate a significant improvement of environmental quality.

Environmental monitoring point m-150, Aue site

4. Remediation sites

Ronneburg

Initial situation

When uranium mining was terminated on December 31, 1990, the Ronneburg site comprised the mining units of Schmirchau, Paitzdorf, Beerwalde, and Drosen. The Schmirchau mining unit also comprised the Reust mine and the worked-out Lichtenberg open pit, and the Beerwalde unit also comprised the Korbußen mine. In 1991/92, these units were gradually merged to form the Ronneburg Rehabilitation Unit as from January 1, 1993.

When uranium mining was terminated, the legacies left behind at the Ronneburg site comprised the mining sites including a total of 38 major shafts, 3 adits, mine drifts of a total length of 1,043 kilometres having open mine workings of 26.7 million cubic metres, as well as the residual Lichtenberg open pit with a residual volume of 84 million cubic metres. Approximately 188 million cubic metres of waste rock and overburden were scattered among 16 mine dumps. Plant areas including waste rock pile footprints and the surface of the residual Lichtenberg open pit extended over an area of 1,670 hectares. The groundwater depression cone due to mining operations extended over more than 50 square kilometres.

Remediation concepts

Following approval by the regulatory bodies, remediation of mining legacies in the Ronneburg mining district was implemented on the basis of the subsequent concepts:

- **Mines:** Removal of substances with the potential to pollute the incoming groundwater and flooding up to natural groundwater levels.
- **Buildings and Structures:** Complete dismantling and demolition.
- **Lichtenberg Open Pit Mine:** Backfilling with waste rock material.
- **Waste Rock Piles:** Relocation and concentration at two locations, one to the north and one to the south of the A4 federal motorway.
- **Operation Areas:** Preparation for reuse of former mining areas predominantly for agricultural and forestry purposes as well as for industrial and commercial reuse.
- **Contaminated Waters:** Capture of all daylighting contaminated waters and treatment to reach compliance with authorised discharge limits.

Conical piles and plant area Ronneburg site before remediation (1991)

Remediation achievements

Flooding of underground mines

Flooding of the mining fields located to the north and south of the motorway of the Ronneburg mining district represented a major challenge. Elaborate preparatory work, both scientific and technical, was required to assess the impacts of mine flooding on rock stability and on aquifers and surface water bodies located downstream of the mines.

The preparatory studies revealed that prior to flooding the mines all pit shafts and near-surface mine workings (down to a depth of 100 metres) had to be backfilled with cohesive stowing material in order to preclude future surface subsidence. Identical precautions had to be taken with regard to mining cavities near protective pillars as well as beneath the town of Ronneburg. Mine workings at the Beerwalde and Drosen units had also to be backfilled in order to protect aquifers located north of a geological fault zone ("Crimmitschau fault"). Underground remedial work initiated in 1991 was completed in 2000. Approximately 5.8 million cubic metres of mining cavities were backfilled.

Once mine workings and pit shafts had been remediated and backfilled by 1998, overall flooding of mining fields located south of the motorway was initiated. Flooding of mining fields located north of the motorway commenced in 2000. In essence, all mine workings located in the northern sector are completely flooded. In the years to come, the southern part of the mining field will require further measures to be taken prior to complete flooding.

Modelling of anticipated flood behaviour for the mining districts located north and south of the motorway had revealed very early on that groundwater resurgence would very probably result in groundwater emergence in the Gessental valley and that this groundwater would be contaminated by rock contact in the flooded mine workings. Preparing for such a scenario, Wismut established a groundwater collection system on the bottom of the Gessental valley and along the north-western edge of the Lichtenberg open pit mine. Zones along the Posterstein Sprotte and Beerwalde Sprotte creeks were identified as further potential discharge areas.

The water catchment system is a combination of horizontal and vertical drainage installations. Groundwater intercepted by this collection system drains to a pump station located in the Gessental valley from where it is pumped via an approx. four kilometres long pressure pipeline to the Ronneburg water treatment plant.

Dismantling and demolition of structures and facilities

The termination of uranium ore mining made the mine hoisting complexes consisting of 19 pit shafts as well as 19 mine ventilation shafts redundant. For the associated ore bins and conveyors, ore loading and transportation facilities, substations, transformer stations, power grid for electric supply, boiler houses, distribution stations, steam pipe networks for heat supply, pumping stations, water storage tanks, waste water treatment plants, piping systems for drinking water and process water supply as well as sewage management, repair shops and storage houses as

Residual Lichtenberg open pit, Ronneburg site (1992)

Schmirchau Height atop former residual Lichtenberg open pit, Ronneburg site (2013)

well as administrative buildings, kitchen buildings and staff restaurants and sanitary facilities there was no further use at the Ronneburg site. Starting in 1991, facilities and buildings were dismantled and demolished. To date, only the administrative buildings, repair shops, and storage houses of the former Lichtenberg mine are still in use. In the meantime, unused facilities and buildings of the former vast mining district are gone.

By the end of 2014, dismantling and demolition of structures and buildings had generated some 70,000 tonnes of scrap and 285,000 cubic metres of demolition rubble. Radioactively contaminated scrap as well as radioactively and chemically contaminated demolition rubble were disposed of in the residual Lichtenberg open pit. Uncontaminated or decontaminated scrap was sold.

Waste rock pile remediation and backfilling of open pit mine

Waste rock pile remediation at the Ronneburg site was completed in 2008. Except for the Beerwalde mine waste rock pile and waste rock pile #381 and two piles already present in the Lichtenberg worked-out open pit mine (inside dump and what is known as Schmirchau balcony), all other low-grade ore, waste rock and overburden piles were completely dug up and removed. The material contained in the waste rock piles located south of the motorway was used to backfill the worked-out Lichtenberg open pit mine. The Drosen and Korbußen waste rock piles located north of the motorway were dug up and banked against the Beerwalde waste rock pile (Table 1).

Relocation of waste rock material into the worked-out Lichtenberg open pit mine resolved several problems in one go. On the one hand, the worked-out open pit mine was backfilled, which otherwise would have filled up with radioactively and chemically contaminated groundwater in the wake of mine flooding. On the other, there was waste rock at some locations which contained up to 5 per cent of pyrite which forms acid when reacting with atmospheric oxygen and water. To avoid the need to intercept and treat acid drainage for decades to come, pyrite-laden waste rock had to be concentrated at a single location and disposed of in a way that would preclude pyrite from coming into contact with atmospheric oxygen. Placing waste rock with elevated acid generation potential at the bottom of the open pit mine has met this requirement in an ideal manner since the backfilled material will for the most part be submerged below the groundwater table once flooding is completed. Groundwater provides efficient protection against air access.

The available pit volume of 84 million cubic metres was too small to accommodate the total volume of 132 million cubic metres made up of relocated waste rock (Table 1), excavated contaminated soil and rubble from the demolition of buildings and structures. The surplus material was used to build up a mound atop the backfilled open pit. In commemoration of the Schmirchau community which had to make way for the development of the open pit mine, the mound is called "Schmirchau Height". This landscape feature and the reclaimed Nordhalde footprint in the Gessental valley were integrated as the "New Ronneburg Landscape" into the grounds of the 2007 National Horticultural Exhibition.

The Lichtenberg fill body is being provided with a final cover of 1.6 metre thickness of which 96 per cent was completed by the end of 2014. A small area within the fill body will be left open to accommodate excavated contaminated soil from area remediation. Forests and green spaces are the intended reuse options for this 221-hectare area. By the end of 2014, afforestation had been completed on 106 hectares. A network of logging roads and hiking trails totalling 20 kilometres will be established for forest management and tourism development around the "Schmirchau Height". By the end of 2014, 18.5 kilometres of that network were completed.

The rationale behind excavating and banking the Drosen and Korbußen waste rock piles against the Beerwalde pile was similar to that for relocating the waste rock piles into the worked-out Lichtenberg open pit, namely to concentrate the waste rock material of the three piles located north of the motorway in a single location. This approach was more cost-effective than to remediate the three piles individually in situ.

The final cover of the Beerwalde waste rock pile consists of a 0.40 metre infiltration barrier and a 1.5 metre moisture storage layer on top. Vegetation of the newly created landscape feature completed the remediation of the Beerwalde waste rock pile in 2003. Since then, young forest plantations have been growing vigorously.

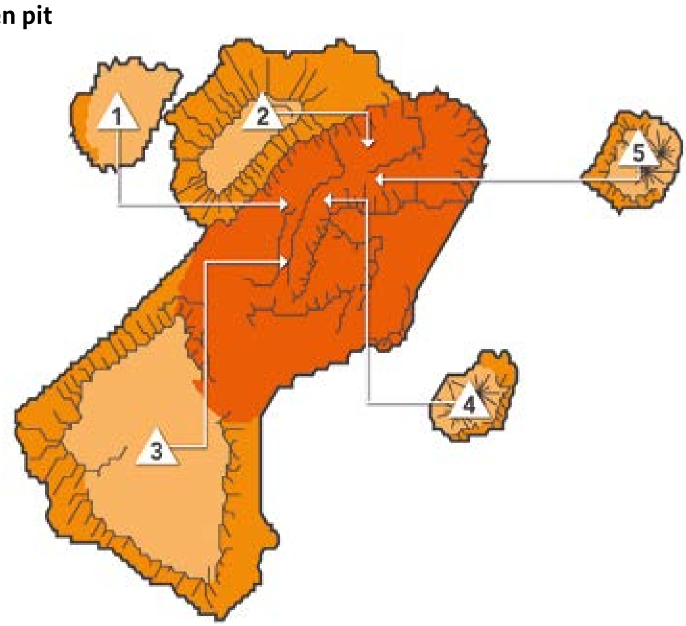
Excavating and moving waste rock piles at the Ronneburg site involved off-highway equipment. At the peak level of activity, a fleet worth some 45 million euros of up to 75 massive earthmoving machines including dump trucks, excavators, shovels, and dozers excavated and moved up to 40,000 cubic metres of waste rock material a day.

Operation areas and waste rock pile footprints

In 1992, an area of approximately 1,520 hectares at the Ronneburg site was owned by Wismut GmbH. This property was for the most part composed of operation areas of the former mining units as well as of waste rock footprints and roadways and railtracks. Of that total, some 1,100 hectares were in need of remediation. These sites either had an elevated natural radioactivity or were contaminated with heavy metals and hydrocarbons or showed multiple contaminations by two or three of the above types of contaminants. Depending on concentration levels of the hydrocarbons, the contaminated soil excavated during ground remediation was either integrated into the fill body of the Lichtenberg open pit or disposed of at the Lichtenberg disposal cell for materials with multiple contamination operated by Wismut. Given that large quantities of soil with multiple contamination were excavated from 1997 through 2001, Wismut established a biological treatment unit at Ronneburg where hydrocarbon decomposition was performed by bacterial oxidation.

Waste rock relocation into Lichtenberg open pit

- **Gessen heap leach pile** (1)
  Relocation: 1990 – 1995
  Volume: 7.6 Mm³
- **Nordhalde waste rock pile** (2)
  Relocation: 1998–2003
  Volume: 31.3 Mm³
- **Absetzerhalde waste rock pile** (3)
  Relocation: 1993–2006
  Volume: 70.1 Mm3³
- **Reust conical waste rock piles** (4)
  Relocation: 2004–2007
  Volume: 6.4 Mm³
- **Paitzdorf conical waste rock piles** (5)
  Relocation: 2005–2006
  Volume: 8.0 Mm³

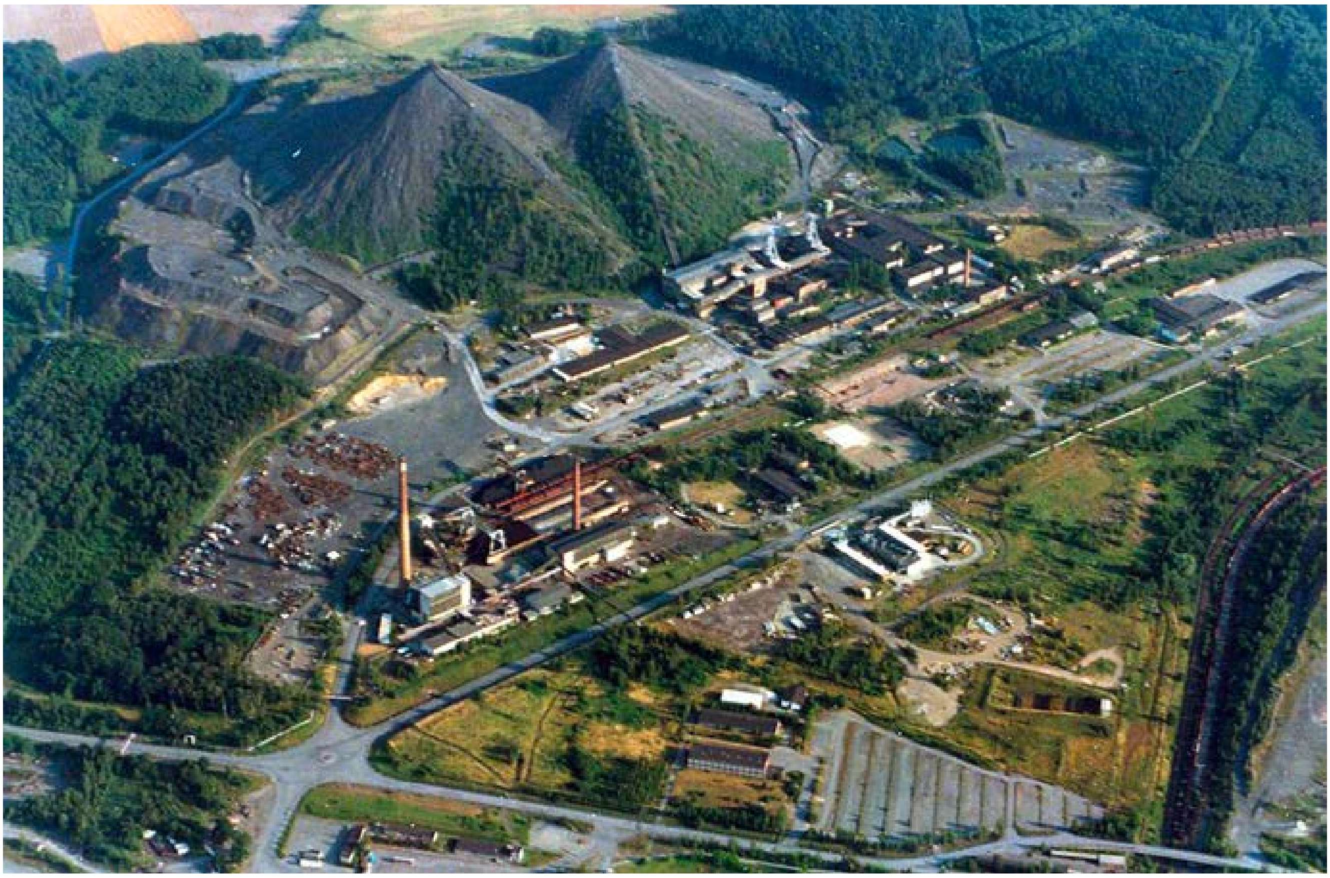


Relocation scheme for waste rock piles south of A4 federal motorway at Ronneburg

Shift change during waste rock pile relocation into Lichtenberg open pit mine (1998)

Table 1: Waste rock pile remediation at the Ronneburg site

Remediation option	Volume in Mm^3	Relocation period
Remediation in situ		
Beerwalde waste rock pile (plus Drosen and Korbußen waste rock piles)	9.0	
Waste rock pile #381	0.8	
Total	**9.8**	
Relocation into worked-out Lichtenberg open pit		
Absetzerhalde waste rock pile	70.1	1993–2006
Nordhalde waste rock pile	31.3	1998–2003
Paitzdorf conical piles	8.0	2006
Gessenhalde waste rock pile	7.6	1990–1995
Reust conical piles	6.4	2004–2007
Waste rock pile #370	1.4	2003
Waste rock pile #4	1.1	2006–2007
Waste rock pile #377	0.4	2004
Diabashalde waste rock pile	0.2	2002
Ronneburg dam	0.1	2007–2008
Total	**126.6**	
Relocation to Beerwalde mine waste rock pile		
Drosen waste rock pile	4.0	1997–1999
Korbußen waste rock pile	0.5	2000–2001
Total	**4.5**	



Conical waste rock piles at Reust mine site before remediation, Ronneburg site (1991)

To date, some 900 hectares of former plant areas, roadways and railtracks as well as waste rock pile footprints have been reclaimed. Remaining remedial works at the Absetzerhalde footprint will for the most part be completed by 2020.

In line with regional land development planning for Eastern Thuringia the reclaimed areas will be turned into forests and green spaces for the most part. Operation areas of the former Beerwalde, Schmirchau, and Paitzdorf mining units were reclaimed for commercial and industrial reuse. Installation of two photovoltaic plants at the site of the former Schmirchau mining unit and at the footprint of the former Reust waste rock pile is a case in point. Under the motto "Resurrektion Aurora" an open-air museum depicting the history of uranium mining by Wismut as well as a sculpture park were inaugurated at the site of the former Drosen mining unit on the occasion of the National Horticultural Exhibition in 2007.

Collection and treatment of contaminated waters

In August 2006, the groundwater had risen to the level of the collection system established in the Gessental valley. Parallel to the groundwater rise the volume of intercepted groundwater has risen from less than 20 cubic metres per hour at the beginning to a volume in excess of roughly 800 cubic metres per hour. Previously unknown hydraulic shortcuts caused the emergence of contaminated groundwater in the Gessental valley at sites located outside the sphere of influence of the collection system where the system hence failed to intercept them. Locally emerging water is currently intercepted in near-surface drainages and catchment ditches and then pumped to the Ronneburg water treatment plant as well. In 2008 and 2009, contaminated groundwater emerged as predicted also along the Postersteiner Sprotte and Beerwalder Sprotte creeks. Here as well, water collection systems are being dynamically adjusted in view of the latest findings. The collected water is piped to a water treatment plant.

To terminate the temporary catchment measures in the Gessental valley, the existing groundwater collection system will have to be enhanced. This in turn will require the lowering of the flood water level by about 25 metres. However, before proceeding with this plan, the capacity of the Ronneburg water treatment plant had to be expanded to treat 750 cubic metres per hour. The upgraded plant has been on stream since the autumn of 2011.

The Ronneburg water treatment plant is using lime precipitation to treat the contaminated waters. Immobilised water treatment residues are disposed within the Lichtenberg fill body. Treated waters are discharged into the Wipse streamlet from where they reach the Weiße Elster River. Since its commissioning, the plant has treated some 50.6 million

Photovoltaic plants atop Reust reclaimed mine dumps and operational areas, Ronneburg site (2012)

cubic metres of contaminated surface runoff and groundwater. Capital costs for the construction of the water treatment plant including the feeder pipe amounted to 17 million euros. Upgrading of the plant required an additional 5 million euros.

Outlook

Remedial operations at the Ronneburg site will for the most part be completed by 2018. Outstanding work to be completed by that date involves mainly area remediation projects. With the progress of remediation repair shops, storage houses, administrative buildings, associated roadways and railtracks as well as a number of water storage ponds are being demolished. Subsequent to this work, the cleared areas will be returned to nature.

Long-term tasks to be accomplished after remediation is complete will include water treatment, monitoring as well as care and maintenance duties. The time period during which water treatment will be required cannot be specified at the present time.

Seelingstädt

Initial situation

At the time when ore processing was terminated at the end of 1990, the Seelingstädt site comprised the Seelingstädt mill as well as the two tailings management areas of Culmitzsch and Trünzig. Commissioned in 1960, the Seelingstädt mill was Wismut's largest and most advanced processing site. The mill processed a total of 110 million tonnes of ore coming for the most part from Ronneburg, but for some time also from the Aue district as well as from Königstein and Dresden-Gittersee. The site of the mill was chosen for its proximity to the two worked-out open pit mines of Culmitzsch and Trünzig which could be used to accommodate the processing residues.

The Seelingstädt processing facility occupied an area of 83 hectares. Of that total some 25 per cent were built-up. In addition to ore processing facilities, the premises also contained a sulphuric acid plant and an industrial power plant. In total, there were more than 300 buildings. Depending on the type of ore, the Seelingstädt mill either used an acid (sulphuric acid) or alkaline (sodium carbonate) flowsheet.

The ore processing residues, also known as tailings, were discharged into the Trünzig tailings management facility from 1960 through 1967 and into the Culmitzsch tailings management facility from 1967 till the end of ore processing in 1991. Due to the process technology, each facility was divided by a dyke into two ponds for a separate storage of residues from the acid and alkaline leaching process.

The Trünzig and Culmitzsch tailings management facilities covered a total surface of about 350 hectares and contained some 104 million cubic metres of tailings (Table 2). In 1992, the volume of supernatant water in the ponds amounted to some 2.4 million cubic metres.

Both tailings ponds are bounded by dams and overburden dumps. The dumps were piled up during the development of the Culmitzsch and Trünzig as well as of the Sorge-Settendorf and Gauern open pit mines. Out of a total of 9 overburden dumps, only the Waldhalde, Jashalde, Lokhalde and Südwesthalde waste rock piles with an overall volume of 55 million cubic metres are still owned by Wismut in 1991 (Table 3).

Some slope sections of the Waldhalde and Südwesthalde waste rock piles have to be flattened to achieve lasting slope stability. Material at other parts of the Waldhalde waste rock pile must either be covered or relocated for compliance with radiation protection regulations.

Seelingstädt processing plant, heat and power plant, Seelingstädt site (1991)

Table 2: Parameters of Culmitzsch and Trünzig tailings management facilities (1990)

		Culmitzsch	Trünzig
Tailings area	ha	**234**	**115**
Pond A	ha	158	67
Pond B	ha	76	48
Tailings volume	Mm^3	**85**	**19**
Pond A	Mm^3	61	13
Pond B	Mm^3	24	6
Solids	Mt	**91**	**19**
Pond A	Mt	64	13
Pond B	Mt	27	6
Maximum tailings thickness			
Pond A	m	72	30
Pond B	m	68	24
Volume supernatant water	Mm^3	**2.4**	**0.08**
Pond A	Mm^3	2.1	0
Pond B	Mm^3	0.3	0.08
Maximum water depth			
Pond A	m	7.9	0
Pond B	m	2.4	2.3

Remediation goals/concepts

Following approval by the licensing authorities, remediation of legacies at the Seelingstädt site was conducted on the basis of the subsequent concepts:

- **Plant Facilities and Buildings:** Except for the laboratory building, dismantling and demolition of all other structures.
- **Tailings Management Facilities:** Removal of supernatant water, followed by interim cover placement, contouring, placement of final cover on tailings; vegetation and afforestation of covered tailings.
- **Overburden Dumps:** Flattening of low-stability slopes, relocation of low-grade ore from the Waldhalde waste rock pile, and some excavation of material to be used for recontouring and final cover placement on both tailings management areas. Afforestation of newly recontoured dumps to be left in place.

Trünzig tailings management facility, Seelingstädt site (1991)

Table 3: Parameters of overburden dumps at Seelingstädt (1990)

	Footprint area ha	Max. height above footprint m	Volume Mm^3
Lokhalde waste rock pile	81	23	16
Waldhalde waste rock pile	73	36	21
Jashalde waste rock pile	22	23	4
Südwesthalde waste rock pile	42	41	14
Total			**55**

- **Areas:** Rehabilitation of former plant premises and of Lokhalde waste rock pile footprint for reuse as forests and green spaces.

- **Contaminated Waters:** Treatment of contaminated supernatant waters as well as contaminated seepage and runoff intercepted near tailings management areas in Seelingstädt water treatment plant. Treatment of seepage will have to continue until compliance with discharge standards.

Remediation achievements

Plant facilities and buildings

Dismantling and demolition of plant facilities were for the most part carried out from 1997 to 2003. Demolition work generated some 60,000 tonnes of scrap and 230,000 tonnes of demolition rubble.

Contaminated demolition rubble was crushed and used to build interim covers on tailings management areas. Uncontaminated rubble was also used to build roadways across tailings management areas.

Scrap from buildings and facilities where verifiably no radioactive materials were handled, e.g. the sulphuric acid plant and the industrial power plant, were directly recycled, certified by a declaration of plausibility. Steel scrap from radiation protection areas, on the other hand, had to be measured for total alpha surface activity using a procedure specifically designed for Wismut applications. In case of surface activity levels below the release standard of 0.5 becquerels per square centimetre the scrap was released for smelting. It was possible to recycle large quantities of contaminated steel scrap after decontamination by sand blasting. Decontamination waste and unusable contaminated scrap were disposed of in engineered cells at the Culmitzsch tailings management facility and plugged with concrete.

An unpolluted sector of the former plant premises was sold and is now used for commercial purposes. The laboratory and pilot-test building is the only surviving structure on the remaining premises. Also still in operation is the

Trünzig tailings management facility, Seelingstädt site (2014)

Culmitzsch tailings management facility, Seelingstädt site (2014)

unloading station of the Wismut branch line which is used for the supply of sand and gravel from the Starkenberg open pit destined for the interim cover of the Culmitzsch tailings management facility as well as topsoil destined for the recultivation of the reclaimed plant premises.

Tailings management facilities

Initial remediation work at the Culmitzsch and Trünzig tailings management facilities began as early as 1990 and 1991, respectively, when interim covers were placed on exposed tailings beaches in order to eliminate immediate risks and reduce contaminant dispersal by windblown dust. In the period that followed, supernatant water was removed and the areas exposed due to the falling water level were then gradually capped with an interim cover.

Placement of interim covers on ponds A and B of the Trünzig tailings management facility was completed in 1995 and 2001, respectively. The interim cover on pond B of the Culmitzsch tailings management facility was completed in 2006. Full interim cover on pond A (Culmitzsch) is slated for 2016; some 99 per cent is presently in place. Building the interim cover of the Trünzig tailings management facility consumed some 1.1 million cubic metres of earthen material, for the main part excavated during the renaturalisation of the Finkenbach valley which during production times was used as a dumping ground for overburden material. Some 3.5 million cubic metres of sand, gravel, and material excavated from the Lokhalde waste rock pile were needed to complete the interim cover on the larger Culmitzsch tailings management facility.

Recontouring of dam and plateau sections at the Trünzig tailings management facility started in 2001. Final cover placement across the entire facility was nearly completed in 2014. The gently undulated plateau area was designed in a way to allow surface run-off from pond A to discharge towards the Culmitzsch lowland and from pond B towards the Finkenbach valley. Contouring and final cover building at Trünzig tailings management facility used up some 6.5 million cubic metres of overburden material.

Contouring work on the Culmitzsch tailings management facility began in 2007 by flattening the Norddamm for stability reasons. Forestry roads were built on the berms of the recontoured Norddamm and the adjacent Jashalde waste rock pile as well as along the toe of the Norddamm. To collect surface run-off riprap channels and ditches were constructed. Work on the Norddamm is completed. Contouring work is under way on pond B. Süddamm and pond A are slated to follow in a couple of years.

According to current planning, contouring and final covering of the entire tailings management facility is to be completed by 2028. In addition to the 9 million cubic metres already used up, some 17 million cubic metres more of overburden material will have to be moved to the Culmitzsch tailings management facility for contouring and cover building purposes.

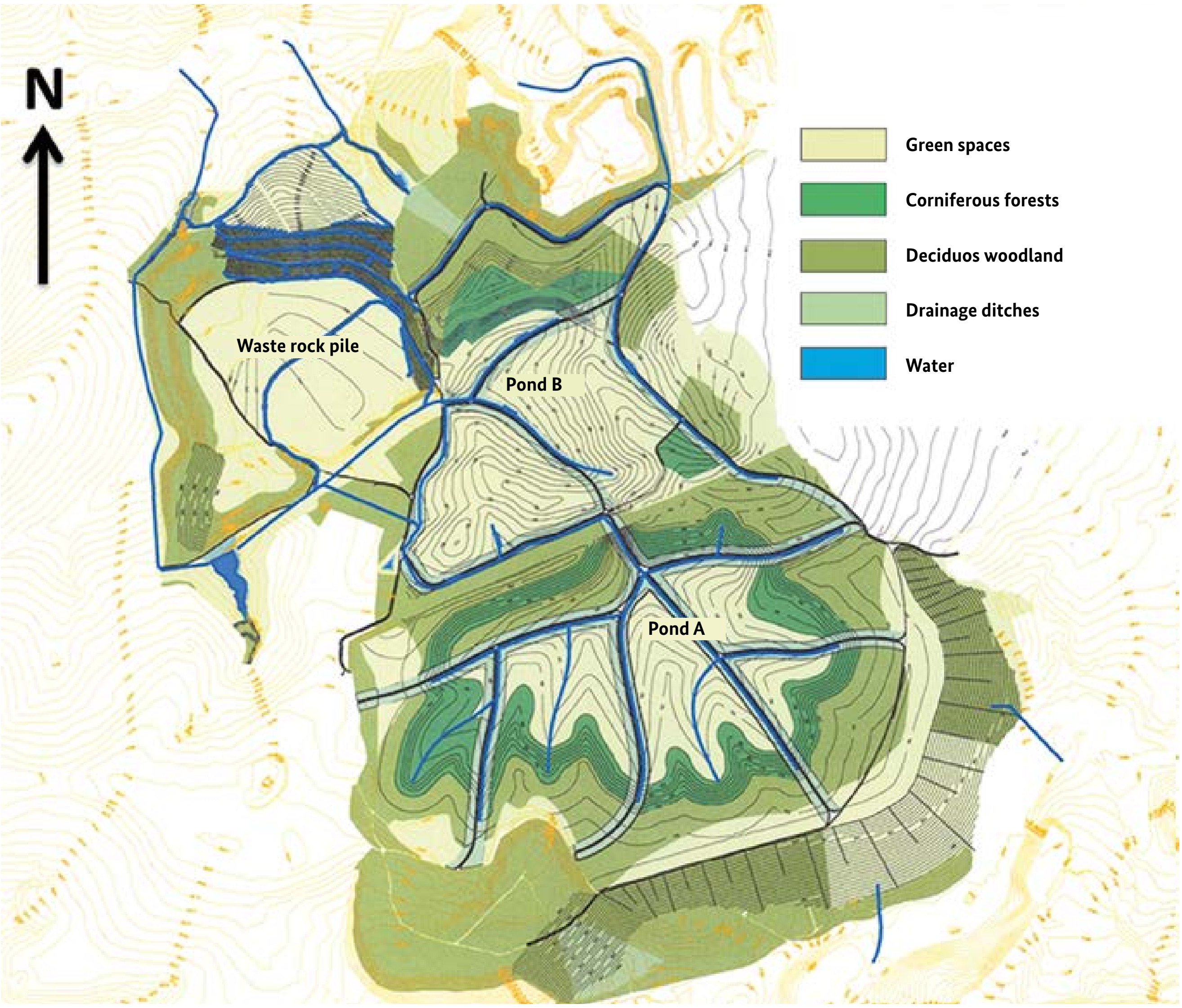
In the end, the plateau section of the Culmitzsch tailings management facility is to emerge as a slightly undulating landscape which discharges its run-off towards the north. The reclaimed areas are to be afforested for the main part with coniferous and deciduous trees to form mixed woodland. Partial areas along the external dams and the pond centres are designed as green spaces.

Overburden dumps

Material needed for contouring and final cover building at the Trünzig and Culmitzsch tailings management facilities is being provided by the complete excavation of the Lokhalde waste rock pile and the partial excavation of the Waldhalde and Südwesthalde waste rock piles. Material from a nearby opencast gravel and sand mine is also being used.

Excavation of the Waldhalde waste rock pile began in July 2008. In an initial step the dump slope is flattened. For that purpose, dumped material is removed from bottom right up to the top. The excavated material is used for contouring the Culmitzsch tailings management facility. Some 4.8 million cubic metres of dumped material were excavated from the Waldhalde waste rock pile and moved to the Culmitzsch tailings management facility for contouring by the end of 2014. Before contouring is completed by 2024, an additional volume of some 1.5 million cubic metres is slated for excavation and removal.

One slope of the Südwesthalde waste rock pile is also considered to lack long-term stability in its present state. In 2018 it shall be flattened by the excavation and removal of 100,000 cubic metres of material which will for the main part be used for building the final cover across the ponds of the Culmitzsch tailings management facility.



Reuse concept for Culmitzsch tailings management facility, Seelingstädt site

Seelingstädt water treatment plant (2011)

Following completion of the measures aimed at enhancing slope stability and providing cover materials, forests will be restored on the Waldhalde and Südwesthalde waste rock piles.

Areas

Contaminated areas within the cleared plant premises of the Seelingstädt mill were rehabilitated by soil replacement. A similar approach will be used at the cleared footprints of the Lokhalde, Waldhalde, and Südwesthalde waste rock piles.

The excavated contaminated soil from plant area remediation is integrated into the Culmitzsch tailings management facility.

Remediation of the areas of the former plant premises is almost complete; out of a total of 83 hectares, 77 hectares were reclaimed by the end of 2014. Completion of remaining work will take until 2024, because items up for demolition like the retention ponds, factory roads, parking spaces, and the railway unloading facility will be needed up to that point to conduct final remedial operations.

Collection and treatment of contaminated waters

Seepage collected by rows of wells and deep drains located around the Trünzig and Culmitzsch tailings management areas as well as the remaining supernatant water from Culmitzsch A are merged in a storage and homogenisation basin and then pumped to the Seelingstädt water treatment plant.

At the beginning, supernatant water and seepage were treated in the former uranium ore processing facility at the Seelingstädt site. In 2000, a new water treatment plant was erected next to the Culmitzsch tailings management facility; that plant went on stream in 2001. It has a design capacity of 300 cubic metres per hour and uses a lime precipitation flowsheet. Water treatment residues are immobilised and stored in an engineered disposal cell within the perimeter of the Culmitzsch B tailings management facility. The treated waters are discharged into the Culmitzschbach creek from where they reach the Weiße Elster River.

Since it came on stream, the new plant has treated some 59 million cubic metres of contaminated waters from the Trünzig and Culmitzsch tailings management facilities. Investment expenditure for the construction of the Seelingstädt water treatment plant was in the order of 8 million euros.

Outlook

After completion of remedial operations, forests and green spaces established on the covered Trünzig and Culmitzsch tailings management facilities as well as the renaturalised plant premises and dump footprints will have to be managed, i. e. post-remedial care and maintenance will have to be provided. Further long-term tasks are water treatment and monitoring. Seepage levels from the Trünzig and Culmitzsch tailings management facilities may drop over time; but the seepage flow will never dry up completely; and seepage quality will not comply with standards for direct discharge into the Culmitzschbach creek for an extended period of time. As a consequence, water treatment will have to be continued for a very long period of time.

Crossen/Helmsdorf

Initial situation

The Crossen processing plant was established in 1950 on the premises of the Leonhardt paper factory. Processing of uranium ores ceased already at the end of 1989 due to economic considerations.

Since the Zwickauer Mulde River was running right through the 21 hectares plant premises, the site was cut into two distinct areas. The 17 hectares area on the right bank of the Mulde River was densely built-up and comprised the factory buildings of the processing plant, while the ore discharge and storage facilities were on the left bank of the Mulde River.

The Crossen plant processed for the most part ores from mines in the Ore Mountains and from the Ronneburg district as well as – until 1960 – from open pit mines near Seelingstädt. Until 1980, wet chemical as well as radiometric sorting and gravitational concentration methods were used for ore processing. Later, only the hydrometallurgical process was used. In total, some 74 million tonnes of ore were milled and 77,000 tonnes of uranium produced in Crossen.

Residues of the hydrometallurgical process were disposed as slurries in the Helmsdorf, Dänkritz I and Dänkritz II tailings management facilities. The 3 tailings management facilities cover a total area of some 227 hectares and contain approximately 51 million cubic metres of tailings (Table 4).

The Helmsdorf tailings management facility was established by the damming of two valley locations. It was operational from 1958 to the shutdown of ore processing in 1989.

The Dänkritz I and Dänkritz II tailings management facilities were established in the early 1950s at the site of two abandoned gravel pits located north of the Helmsdorf tailings management facility. When the latter was commissioned in 1958 the two Dänkritz sites were closed. In 1990, the Dänkritz II tailings management facility was no longer owned by Wismut GmbH and is not part of the company's remediation mandate. The site is a candidate for the remediation programme of Wismut stewardship sites in Saxony.

The discarded waste rock from the radiometric and gravitational ore processing was dumped on the Crossen waste rock pile. At the time when production was terminated, some 3.2 million cubic metres of residues had accumulated on an area of 22 hectares, including approximately 0.5 million cubic metres of tailings from hydrometallurgical processing during the early years of operation until 1952.

Remediation goals/concepts

Remediation of the legacies left behind at the Crossen site was implemented on the basis of the subsequent concepts:

Crossen ore processing plant (1991)

Table 4: Parameters of Helmsdorf and Dänkritz tailings management facilities (Status 1990)

		Helmsdorf	Dänkritz I	Dänkritz II	Total
Tailings area	ha	200	20	7	**227**
Water cover	ha	116	12	3	**131**
Volume supernatant water	Mm^3	5	0.25	0.05	**5.3**
Tailings volume	Mm^3	45	5	1	**51**
Solids	Mt	50	7	1	**58**
Maximum tailings thickness	m	55	23	19	
Maximum water depth	m	14	2	2	

- **Plant Facilities and Buildings:** complete dismantling and demolition of all structures.
- **Helmsdorf and Dänkritz I Tailings Management Facilities:** Removal of supernatant water, followed by interim cover building, contouring and final covering of the tailings; vegetating for erosion protection and afforestation of covered tailings areas.
- **Crossen Waste Rock Pile:** Complete relocation to the Helmsdorf tailings management facility and use of the waste rock for interim cover and contouring purposes.
- **Operation Areas:** Rehabilitation of the former plant premises and of the Crossen waste rock pile footprint, design as alluvial landscape and flood retention area.
- **Contaminated Waters:** Treatment of contaminated supernatant waters and of seepage collected near tailings management facilities in the Helmsdorf water treatment plant. Seepage treatment to be continued until compliance with discharge standards.

Remediation achievements

Plant facilities and buildings

Most of the buildings dated from the 19th century and were beyond repair, so any reuse was ruled out from the outset. Therefore, facilities and buildings were completely demolished.

Remediated Crossen plant area (2013)

Helmsdorf and Dänkritz I tailings management areas, Crossen site (2014)

Dismantling of some technical equipment had begun as early as 1989. Dismantling and demolition of large and complex equipment was contracted to specialised firms. Dismantling and demolition of all above-ground buildings and facilities was accomplished by 2006.

Dismantling and demolition work generated 26,500 tonnes of scrap and 62,300 cubic metres of demolition rubble; of that total, 21,000 tonnes and 49,000 cubic metres, respectively, were contaminated. Radioactively or chemically contaminated scrap and demolition rubble were first dumped at the Crossen operation area for interim storage and subsequently moved to the Helmsdorf tailings management facility. At Helmsdorf the rubble was used for interim covering purposes and the scrap was disposed in engineered cells within the covered tailings beach areas. Uncontaminated scrap was sold, the rubble for the most part used for roadwork on Wismut sites.

Helmsdorf and Dänkritz I tailings management facilities

In order to mitigate immediate risks, interim action undertaken immediately after termination of production focused on covering exposed sandy tailings to prevent windblown dust. Moreover, seepage collection systems were extended.

Remediation work in the proper sense began in 1996 after commissioning of the new water treatment plant at the Helmsdorf site, where the pumped away supernatant water could be treated and hence the water level in the Helmsdorf tailings facility could be gradually lowered. During the following years the exposed tailings areas were capped with an interim cover.

By the end of 2014, some 200 hectares had been capped with 1.5 metre interim cover; this effort had consumed 2.9 million cubic metres of waste rock and sand and gravel. The interim cover is now complete.

Work began in 2002 at the Helmsdorf tailings management facility to establish a final contour designed as an undulating landscape of hills and swales. This involved the slope flattening and partial excavation of embankment dams. Since 2005, the contoured areas are in the process of being capped with a final cover of 1.5 metre of mineral soil. The plateau relief is designed to allow discharge of surface run-off towards the Wüster Grund dam and towards Oberrothenbach. A minor portion of the run-off will discharge towards the Zinnbach creek, just like the run-off from the Dänkritz I tailings management facility where contouring and cover placement were completed in 2007.

Contouring and final cover placement at the Helmsdorf and Dänkritz I sites are to be completed by 2019. Some 7.8 million cubic metres of material have been used for this purpose to date. An additional volume of 1.2 million cubic metres will be required to complete the task.

The reclaimed area shall be used for forestry and grassland purposes.

Crossen waste rock pile

Nearly 97 per cent of the Crossen waste rock pile has already been relocated to the Helmsdorf/Dänkritz I tailings management facilities. Excavation of the remaining waste rock material and of the soil from footprint remediation is to be terminated by 2017.

Since 1997, haulage of waste rock and crushed demolition rubble to the Helmsdorf tailings management facility has been conducted by pipe conveyor over a distance of 1.8 kilometres, which minimises environmental impacts as opposed to truck haulage on public roads.

Areas

Initiated in 2003, remediation of plant premises of the former Crossen uranium ore processing unit was completed by 2008. Contaminated soil was excavated and replaced by unpolluted earthen materials. Generated as a result of remediation work were 294,000 cubic metres of contaminated fill and excavated soil, 115,000 cubic metres of contaminated demolition rubble, and more than 3,000 cubic metres of multiple contaminated materials. On balance, nearly 268,000 cubic metres of uncontaminated soil materials were needed as replacement. The area is now vegetated and blends in with the floodplain landscape of the Zwickauer Mulde River.

Following removal of contaminations identified in the ground, the 22 hectares footprint of the Crossen waste rock pile, located immediately along the Zwickauer Mulde River, is to be turned into green space and shall serve as a polder for flood control. Remediation of the footprint and dismantling of the pipe conveyor are to be completed by 2018.

Collection and treatment of contaminated waters

Until 1995, supernatant water and seepage were treated in an existing treatment plant. In 1995, the Helmsdorf water treatment plant was the first of the state-of-the-art treatment plants of Wismut GmbH to come on stream. The plant had a design capacity of 250 cubic metres per hour. In the early years, it used a highly complex process to remove uranium, radium, and nonradioactive contaminants separately from supernatant and seepage waters. Three different treatment sludges were immobilised separately and disposed at a licensed location within the Helmsdorf tailings management facility. In order to simplify the process and for cost reasons, precipitation with lime was introduced in 2002. Presently, the two-line facility has a design capacity of 200 cubic metres per hour. Immobilised residue sludges continue to be disposed at the Helmsdorf tailings management facility. Treated waters are discharged to the Zwickauer Mulde River.

Pipe conveyor, Crossen site (1996)

Construction costs for the Helmsdorf water treatment plant were in the order of some 20 million euros. Since it came on stream, the Helmsdorf water treatment plant has processed some 25 million cubic metres of contaminated supernatant and seepage water from the Helmsdorf and Dänkritz I tailings management facilities.

Outlook

After completion of remedial operations, the covered areas of the Helmsdorf and Dänkritz I tailings management facilities which will be used for the most part for silvicultural purposes, will have to be managed, i.e. post-remedial care and maintenance will have to be provided. Further long-term tasks are water treatment and monitoring. Seepage from the Helmsdorf and Dänkritz I tailings management facilities may drop over time, but the seepage flow will never dry up completely, and seepage quality will not comply with standards for direct discharge into the Zwickauer Mulde River for an extended period of time. As a consequence, water treatment will have to be continued for a very long period of time.

Königstein

Initial situation

Prospecting for uranium in Upper Cretaceous sandstones of the Elbe rift valley southeast of Dresden began in the early 1960s. In 1963, the Königstein deposit was discovered. Mine development commenced as early as 1964 and eventually comprised 5 pit shafts and 7 ventilation raises as well as headings, extraction drifts, and cross-cuts on 4 levels. The surface area affected by mining operations extends over approximately 6 square kilometres near the localities of Königstein, Bielatal, Langenhennersdorf and Struppen.

Systematic operations commenced in 1967 using conventional underground mining methods.

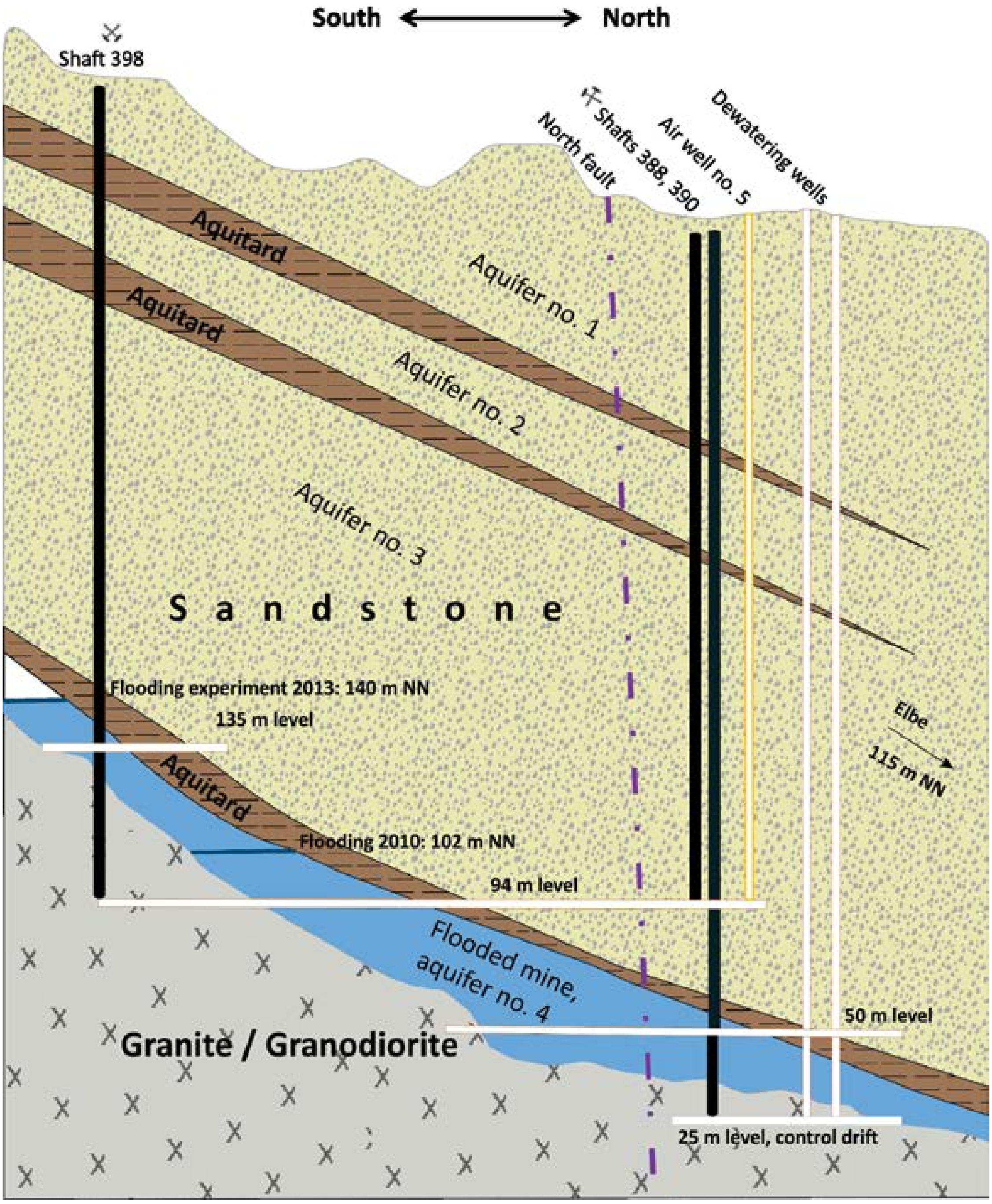
A total rock volume of some 9 million cubic metres including about 5 million cubic metres of ore was mined by conventional mining. The ore was hauled by ropeway to the Rottwerndorf loading station and then by rail to the central ore processing facility at Seelingstädt. Waste rock from mine development and conventional ore mining was moved to the Schüsselgrund waste rock pile.

Following development of an in situ leach technology, the mine shifted to full in situ leaching of uranium in 1984 as a response to decreasing ore grades.

Königstein plant area (1994)

Leaching of the ore was performed with groundwater to which sulphuric acid had been added. This liquor leached the uranium from the underground rock, and hence rock extraction was no longer required. By 1990, more than 55 million tonnes of sandstone had come into contact with the leach liquor. When mining was terminated, a portion of the liquor remained locked in the sandstone as pore water. Uranium was also extracted from ore at 8 leach pads as some ore had initially to be removed from underground in order to prepare for the in situ leach operation. Pregnant liquor from underground leaching and from the heap leach operation was piped to an above-ground ion exchange unit which produced a liquid uranium concentrate as an interim product for final processing at Seelingstädt. Residues from this process as well as the leached rock were moved to the Schüsselgrundhalde waste rock pile.

When uranium production was terminated in 1990, the mine had produced about 18,000 tonnes of uranium, of that total some 70 per cent by conventional mining and 30 per cent by in situ leaching.



Königstein mine, schematic vertical profile, flood water level as of January 2013 (not to scale)

Demolition of shaft complex #388/390, Königstein site (2014)

Cover placement work at Schüsselgrund waste rock pile, Königstein site (2014)

Remediation goals/concepts

Its location within the "Sächsische Schweiz" Protected Landscape Area and its vicinity to the Elbe River make the Königstein site stand out among the other remediation sites of Wismut GmbH.

Above-ground remediation is characterised by the requirement to blend the area affected by mining into the "Sächsische Schweiz" Protected Landscape Area and to control contaminant release from above-ground springs and wells. The remedial concept specifies in this respect that radioactively contaminated facilities and buildings unfit for further use be demolished and radioactive areas excavated. In addition to contaminated material from ground excavation, water treatment residues are to be moved to the Schüsselgrund waste rock pile.

Clean-up goals for the Schüsselgrund waste rock pilefocus for the most part on the reduction of precipitation infiltration into groundwater, of radon exhalation and of gamma radiation exposure. To this end, the mine dump is being regraded to enhance geotechnical stability, capped and vegetated. In its final state, the dump will comply with the requirements of the surrounding Protected Landscape Area.

In addition to the requirement of remediating and cleaning up the above-ground legacies such as ore handling grounds, heap leach pads, buildings, plant areas, and the Schüsselgrund waste rock pile, the task to minimise contaminant release in the wake of flooding the mine workings presents an enormous challenge.

The **mine flooding** concept of 1991 was based on the awareness that flooding immediately after mine shutdown would entail too high environmental risks. Uncontrolled flooding of the mine would have allowed the residual uranium and other metals to dissolve and rise from the deposit located in the fourth aquifer to the overlying third aquifer and then discharge to the Elbe River.

With this scenario in mind, the option calling for monitored and controlled flooding involving construction of control drifts and water treatment in an above-ground facility was given preference over all other remedial approaches. Therefore, remedial emphasis was focussed on:

- Removing substances from underground with the potential to pollute the incoming groundwater (grease, oil, etc.),
- Operation of control drifts aimed at preventing discharge of contaminated water, and allowing direct monitoring and sampling of flood water,
- Attenuation of sulphuric acid concentration of leach solutions,
- Removal of easily soluble uranium and other heavy metals, and
- Sealing of mine perforations between the 3rd and 4th aquifer to minimise water rise into 3rd aquifer during flooding.

Remediation achievements

While the slope of the Schüsselgrund waste rock pile is already capped with 1 metre of mineral soil to reduce radon exhalation and infiltration of precipitation as well as to promote vegetation, precipitation continues to infiltrate the mine dump by the uncapped plateau area. Contaminated seepage is intercepted by a drainage system and piped to the flood water treatment unit. A rainwater retention pond established at the toe of the mine dump receives uncontaminated run-off from reclaimed slope areas for discharge to the receiving stream.

The Schüsselgrund waste rock pile will continue to receive any radioactively contaminated material from the clean-up

Groundwater sampling, Königstein site (2013)

of the Königstein site. In 2009 alkaline material was tilled into the top layer of the entire uncapped plateau area. Precipitation is supposed to take up and carry the alkalinity inside the dump and aid in the neutralisation of the dump's acidic pore water. The final covering of the Schüsselgrund waste rock pile started in 2010.

In the meantime, off-site plant areas like the Rottwerndorf ore loading station have been cleaned up.

Establishment of underground control drifts designed to intercept contaminated flood water was completed in 1994. After experimental flooding conducted over several years, flooding of the Königstein mine was initiated in 2001. Since then, natural inflow and controlled addition of groundwater have gradually raised the water level in the initially open control drifts.

To continue flood control after mine closure it was necessary to connect the flooded control drifts which functioned as horizontal wells to the water treatment plant. To this end, two 300 metres deep wells were drilled at a cost totalling about 8 million euros.

While the underground mine was prepared for flooding, a water treatment unit was built to treat contaminated mine water. Investment expenditure for this unit was in the order of around 15 million euros. Since coming onstream in 2000 the plant has treated some 53 million cubic metres of flood water.

Impacts due to remedial operations are recorded and documented as part of the environmental monitoring programme. Environmental surveillance at the Königstein site comprises long-term monitoring of flood water and mine dump seepage as potential sources of contaminant release and of their impact on groundwater and surface water bodies. Moreover, a flood-related monitoring system was established to monitor and control the flood process. Monitoring also extends to the release of airborne particles.

Concentration levels of trace elements and uranium in the flood water have significantly decreased as a result of the multi-year flushing of the sandstone in the underground mine.

Immission measurements conducted in the Elbe River show that there is no environmentally relevant impact on the Elbe due to discharge of treated water from the Königstein site.

The flood monitoring network monitors the rise of the groundwater level in the third and fourth aquifer, the void subject to flooding, and the groundwater quality during and after flooding of the Königstein mine. Monitoring emphasis is on areas of zones of potential flood water rise to the third aquifer as well as on discharge areas of the third and fourth aquifer along the northern and western edges of the mine.

Due to the continued shrinking of the volume of open mine workings, there is a steady decrease of radon exhalation from the Königstein mine. There is no record of any significant radiological exposure to the public via the atmospheric pathway.

Outlook

With the plugging and sealing of pit shafts #388/390 at the end of 2012, mine closeout and pull-out of the mine were completed. Since January 2013, the flood water has been kept at a level of 139.5 metres a.s.l. Wismut intends to let the flooding continue to the natural level of groundwater rise. The licensing procedure was initiated in December 2011. Pending the final decision in the licensing process, the flood water has to be kept below the approved level of 140 metres a.s.l.

Dresden-Gittersee

Initial situation

The Dresden-Gittersee site of Wismut is located within a historic coal mining district where hard coal was mined from 1542 through 1967. After the uranium content of the coal had been established in 1946, coal was also mined for its uranium content from 1947 till 1955. In the 1950's, Wismut temporarily took over hard coal mining operations from VEB Steinkohlenwerk Freital, later renamed as VEB Steinkohlenwerk "Willi Agatz". Following complete take-over by Wismut in 1968, the uranium-bearing coal deposit was exclusively mined for uranium.

The uranium deposit extends across the mining fields of Gittersee, Bannewitz, and Heidenschanze. Abandoned in 1958, the Heidenschanze mining field was not included in uranium mining operations starting in 1968 for economic reasons, but remained hydraulically connected to the other mining fields.

The mined uranium-bearing coal was first hauled to Freital-Döhlen and Dresden-Coschütz for processing. Afterwards, the ore was transported by rail to Crossen or Seelingstädt for processing.

When mining operations were terminated in 1989, about 4 million tonnes of uranium-bearing coal had been mined, creating mine workings of some 2 million cubic metres and extending over a surface area of 210 hectares. In the course of time, a considerable portion of the mine workings has caved in or subsided. From 1949 through 1989 about 3,700 tonnes of uranium were produced.

Remediation goals/concepts

Remediation and clean-up work began in 1990, shortly after mining was terminated. This work was based on preliminary studies conducted already in 1988 on mine workings rehabilitation. Termination of mining operations was followed by a systematic recording of contaminated areas, investigations of the hydrogeological regime, of groundwater quality in the vicinity of plant areas and mine dumps, and the sampling of receiving streams.

In line with the results and findings of those preliminary activities, the proposed **above-ground rehabilitation works** encompassed the demolition and dismantlement of above-ground facilities and buildings, clean-up of areas contaminated by the mining of uranium ore and the remediation in situ of the Gittersee and Marienschacht waste rock piles by contouring and capping with a multiple layer cover.

Proposed work for **underground remediation** included the rehabilitation of the mine workings by backfilling of pit shafts and controlled flooding of the mine workings. The flooding concept provided for the flood water to rise within the mine workings and be kept at a safe level from where it would discharge via the Tiefer Elbstolln tunnel to the Elbe River.

Plant area Dresden-Gittersee site before remediation (1992)

Plant area and waste rock pile at Dresden-Gittersee site (2007)

Preparations for flooding included:

- Removal of materials from the mine workings with the potential to pollute the incoming water, and in particular of hydrocarbons,
- Backfilling and safe plugging of pit shafts,
- Extension of the monitoring network between the Gittersee mine and the Tiefer Elbstolln tunnel to monitor flooding,
- Rehabilitation of the Tiefer Elbstolln tunnel which was built from 1817 to 1837 to dewater the 19th century coal mines but had lost a considerable portion of its hydraulic efficiency by 1.5 metre sludge deposition,
- Establishment of an alternative temporary water handling system by sinking a drainage well at each of the Gittersee/Bannewitz and Heidenschanze mining fields to provide for the case that insufficient flood water drainage via the Tiefer Elbstolln tunnel would require the construction of a water adit between the Gittersee mine and the Tiefer Elbstolln tunnel.

Remediation achievements

Except for some minor outstanding work, remedial work performed on the plant area was completed with the demolition of buildings and facilities and excavation of contaminated ground on an area of approximately 21 hectares. Excavated contaminated soil and demolition debris have been incorporated in the Marienschacht and Gittersee waste rock piles. Remediation of the Marienschacht waste rock pile including the plant area was completed in 1999. Remedial work comprised placement of a multiple layer cover and grass seeding of the entire surface area. The Marienschacht pit and its Malakoff head frame form an industrial monument. Together with its associated mine dump it constitutes a mining heritage ensemble. It currently houses the headquarters of Bergsicherung (Mine safety consultants) Freital.

The Gittersee waste rock pile was also rehabilitated in situ. Its capping with a multiple layer system was completed in 2006.

Natural discharge of the rising groundwater via the abandoned coal mines towards the Tiefer Elbstolln tunnel was less than predicted and required. As a result, the water level rose up to 180 metres a.s.l. This level of flood water rise caused surface damage as well as surface water emergences in residential areas of the town of Freital. As a consequence, the flood level was lowered by discharge via the discharge well provided for such an emergency and kept at around 115 metres a.s.l. in the Gittersee/Bannewitz mining field.

Water pumped from the Gittersee/Bannewitz mining field was treated in the water treatment plant located on the Gittersee waste rock pile and discharged in the Kaitzbach creek. Water treatment residues were incorporated in the Schüsselgrund waste rock pile at the Königstein site.

Marienschacht waste rock pile, Malakoff tower, Dresden-Gittersee site (2009)

In order to preclude renewed flood water rise and subsidence risks, the decision was taken in 2005, following regulatory approval, to develop a horizontal gallery running between the Tiefer Elbstolln tunnel and the Gittersee/Bannewitz mine over a total distance of around 2,900 metres. Flood water from the Gittersee/Bannewitz and Heidenschanze mining fields is to discharge via this gallery to the Tiefer Elbstolln tunnel and from there to the Elbe River without any risk to the public. Flood levels in the Gittersee mining field will be constantly kept at around 120 metres a.s.l. and in the Heidenschanze mining field at around 130 metres a.s.l.

Development of what is known as Wismut gallery began in 2007 in Freital-Potschappel at the site of the abandoned Osterberg quarry. From that point, the gallery was developed to the northwest in the direction of the Tiefer Elbstolln tunnel and to the southeast in the direction of pit shaft #3 of the Gittersee mining field located in Freital-Burgk.

Rock anchoring, bolting, meshing, and grouting were required to ensure safety and long-term stability in heavily fissured and water-bearing rock zones. Driving operations were successfully terminated in June 2014. Finishing touches will be completed in the course of 2015, and flood water will discharge by gravity flow into the Tiefer Elbstolln tunnel.

Outlook

It is a specific feature of the Dresden-Gittersee site that there are no waters with radionuclide levels requiring licensing under radiation protection legislation for discharge into receiving streams. Permanent safe discharge of waters from the flooded Dresden-Gittersee mine via the Wismut gallery towards the Tiefer Elbstolln tunnel will make pumping, treatment and discharge of flood water into the Kaitzbach creek redundant. Following completion of the gallery, it was possible to dismantle the water treatment plant in 2015. As a consequence, construction of the Wismut gallery not only mitigates environmental impacts but also has cost-saving aspects.

Inspection round, Wismut-Stolln (2015)

Bad Schlema

Initial situation

The Bad Schlema site is located in southwest Saxony, immediately north of the town of Aue. At this site, one of the world's largest "hydrothermal" uranium deposits was extracted from 1946 through 1990, with its lodes yielding approximately 80,000 tonnes of uranium. Mining operations affected areas within the townships of Oberschlema and Niederschlema as well as in the Aue suburb of Alberoda and extended to the boundaries of the towns of Schneeberg and Hartenstein.

Uranium ore mining in the Schneeberg-Schlema-Alberoda ore field followed upon mining operations for tin, iron, silver, bismuth, copper, cobalt, and nickel which have taken place in this district since the mid-15th century. Since the 19th century, uranium was mined as a by-product. This advance knowledge of uranium occurrence and of the use of radon-laden water in the Oberschlema spa launched prospecting for uranium in this area in 1945. Investigations began in the region of Oberschlema at the site of the Markus-Semmler-Stolln, a drainage gallery built in the 16th century to dewater the historic Oberschlema und Schneeberg mines. The gallery runs from the portal at the Zwickauer Mulde River along the entire Schlema valley and extends out under Schneeberg right up to Wolfgangmaßen.

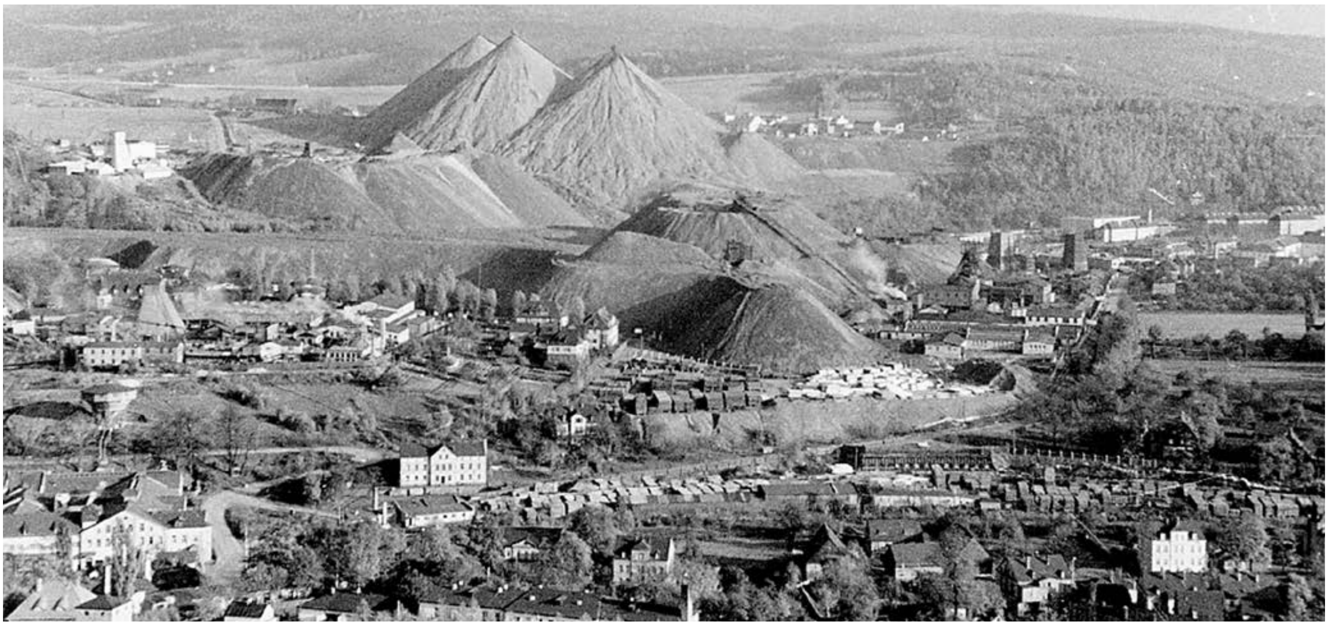
In 1946, near-surface mining started at numerous newly discovered lodes in the Oberschlema area. The subsequent development of the deposit down to a depth of 640 metres involved 30 pit shafts as well as several adits, blind shafts, and winzes. The Markus-Semmler-Stolln gallery was defined as 0-metre-level for surveying purposes. The horizontal development of the Oberschlema deposit comprised a total of 23 levels.

During the course of mining operations, an extended waste rock pile landscape emerged at the site of the historic Oberschlema radon spa. Apart from waste rock dumped right in the town's centre, a number of conical waste rock piles disturbed the local scenery. Mining operations also extended to the Silberbach valley and the Hammerberg. In an effort to redress the lack of dumping grounds available in the town area, a rail track was built to haul waste rock for dumping along the Hammerberg and Schafberg slopes. In the end, waste rock dumping was extended to the Borbachtal valley located within the boundary of the Wildbach community.

By the late 1950s, the Oberschlema deposit was exhausted. Abandoned pit shafts were for the most part backfilled with waste rock and to some extent subsequently plugged. Surface subsidence as well as near-surface mine voids were locally backfilled, but there was no systematic mine rehabilitation. As mining-induced surface cave-ins and subsidence continued to occur, larger portions of the Oberschlema town area had to be fenced off and subsequently degenerated into wasteland.

With the discovery of the larger and more fertile Niederschlema-Alberoda deposit, mining operations shifted to the lower Schlema valley and to the banks of the Zwickauer Mulde River. Mining in that district went down 1,800 metres below the level of the Markus-Semmler-Stolln gallery.

In the wake of these mining operations, large waste rock pile complexes were dumped on both sides of the Zwickauer Mulde River and along the town boundaries.



Schlema (1960)

Table 5: Mine dump remediation at the Schlema site

No.	Object	Mine dump volume (Mm³)	Remedial option	End of substantial remediation work
1	Waste rock pile Schacht 38alt/Lilo 9	0.56	Remediation in situ	2002
2	Waste rock pile Schacht 38neu/208	4.90	Remediation in situ	2007
3	Waste rock pile Schacht 13b	0.45	Remediation in situ	2002
4	Hammerberg waste rock pile	2.40	Remediation in situ	2006
5	Waste rock pile Schacht 66/207	4.06	Remediation in situ	2014
6	Waste rock pile Schacht 371/II	3.72	Remediation in situ	2025
7	Waste rock pile Schacht 371/I	9.39	Remediation in situ	2025
8	Waste rock pile Schacht 310	0.54	Remediation in situ	2021
9	Waste pile Schacht 366/plant area 186/366/383	7.48	Remediation in situ	2008
10	Waste rock pile Schacht 208W	0.06	Remediation in situ	1995
11	Embankment dam Borbachtal tailings pond	1.25	Remediation in situ	2002
12	Waste rock pile Schacht 8	0.05	Remediation in situ	1998
13	Waste rock pile/plant area Schacht 12/259/309	1.92	Remediation in situ	2018
14	Waste rock pile Blaufarbenwerk/Schacht 13	0.03	Excavation and relocation	2001
15	Waste rock pile/plant area Schacht 373	0.11	Remediation in situ	2007
16	Waste rock pile Schacht 382	4.21	Remediation in situ	2014
17	Waste rock pile Großschurf 1/plant area site 250	0.03	Excavation and relocation	1999
18	Waste rock pile Schacht 372	0.10	Remediation in situ	2008
19	Waste rock pile 312	1.23	Remediation in situ	2006
20	Waste rock pile 382 West	3.25	Remediation in situ	2010
21	Waste rock pile Schacht 250	1.04	Excavation and relocation	1992

Physical processing of the mined uranium ore was initially conducted in the Blue Colour Factory at Oberschlema with residues being discharged into the newly established tailings pond in the Borbach valley. From the mid-1950s, radiometric sorting was conducted at pit shaft #371 and hydrometallurgical processing at the Crossen processing plant.

In the1960s during active mining, pilot-scale projects were initiated with a view to conducting purposeful remediation of the waste rock piles involving contouring and afforestation. This, however, resulted only in modest corrections to the waste rock pile landscape.

In the end, mining operations extended over an area of approximately 22 square kilometres and created underground mine openings on 62 levels with a total mined volume of around 41 million cubic metres that were developed by means of more than 54 pit shafts, numerous blind shafts, and a few adits. Of that total, 8 pit shafts including 4 ventilation shafts, and 10 blind shafts were still in operation after mine shutdown. Horizontal headings totalled 4,200 kilometres. When remedial work started, 176 kilometres of headings on 7 levels were still in use. Mining waste had been dumped on 42 waste rock piles covering an area of 311 hectares. Wismut GmbH has responsibility for the reclamation of 21 of these waste rock piles, which contain a total of approximately 47 million cubic meters.

The plant areas associated with the Aue mining unit extended over 111 hectares. Apart from mine pits, mine support and auxiliary units included repair shops, storage and supply complexes, the radiometric sorting unit, ore loading facilities, and tailings pond in the Borbach valley. Handling of uranium ores had caused widespread radioactive contamination of plant areas and technical facilities as well as locally elevated levels of arsenic and heavy metals.

Remediation goals/concepts

The remediation objectives were as follows:

- Removal of technical substances with the potential to pollute incoming groundwater, followed by mine flooding and adjustment of mine ventilation to rising flood water levels,
- Erection and operation of water treatment plants to reduce contaminant levels in mine waters prior to discharge into receiving streams, and

- Protection of ground surface against subsidence events by backfilling of near-surface mine voids.

Above-ground remedial action was aimed at restoring to profitable reuse the areas affected by uranium mining operations.

In detail, the above-ground remediation programme was focussed on the following activities:

- Remediation of waste rock piles and preparation for their gradual return to profitable use on the basis of agreed reuse concepts,
- Demolition and dismantling of buildings and facilities unfit for future use, and
- Rehabilitation of plant areas.

In essence, the remediation concept for the waste rock piles provided for their rehabilitation in situ including regrading for long-term stability as well as capping and vegetation.

Remediation achievements

By the end of 2014, 55 pit shafts had been backfilled, sealed, and plugged to ensure long-term stability. In order to protect the ground surface against subsidence, 239,300 cubic metres of near-surface mine voids were backfilled in the Schlema-Alberoda area. A major remedial focus was the safeguarding and backfilling in the large subsidence area in Oberschlema, now turned into a spa park. Another important task was the establishment of stable and long-lasting mine ventilation. For this purpose mine workings on the Markus-Semmler level were upgraded and the ventilation shaft #382 was equipped with new mine fans.

Flooding of the mine began as early as 1991 when mine water pumping was shut off. The mine is now almost completely flooded. The residual void of around 0.5 million cubic metres remaining below the Markus-Semmler level will be used as a buffer storage facility to compensate for peak inflow levels or temporary shutdown of the water treatment plant. The plant which was built at a cost of approximately 15 million euros in 1998 had treated some 94 million cubic metres of contaminated mine water by the end of 2014.

Operation of the water treatment plant will permanently ensure that no contaminated flood water will emerge. The flood water level may be lowered or raised as needed. Residues from the water treatment process will be moved to waste rock pile #371 where they are incorporated and covered. Seepage from waste rock pile #371 is piped to the mine and treated together with the flood water in the Schlema-Alberoda water treatment plant.

In the immediate vicinity of Oberschlema and in Alberoda, the waste rock pile landscape has been completely recultivated. Remedial work is still underway at the sites of waste rock piles #309, #310, and #371. At the other waste rock piles, post-remedial maintenance and long-term tasks are performed in order to ensure long-term remedial success. The focus is on grass mowing and grazing, maintenance of ditches and culverts, and forest tending.

Schlema subsidence area, spa park (1960)

Bad Schlema spa park (2014)

In the vicinity of waste rock piles, remedial progress is significantly reflected by diminished radon concentrations in ambient air. Many sites have reached compliance with radiation protection standards. At some locations work is continuing to further improve the situation.

Surveying and geomechanical monitoring provides evidence of flooding-induced ground movements which, however, are negligible in comparison to mining-induced movements. To replace a deformed and long-term inoperative section of the Markus-Semmler water-adit, a by-pass of 1,200 metres length had to be developed. Completely developed by 2014, the by-pass will be commissioned in the course of 2015.

Outlook

Underground remedial work still to be accomplished will focus on the Markus-Semmler level in the Oberschlema mining field where further refurbishing of drifts is required to complete the establishment of a stable and long-lasting mine ventilation.

As a constant drop of contaminant levels in the flood water is to be expected but will take some time to reach compliance standards, operation of the water treatment plant will have to continue for an extended period of time.

Waste rock pile #38 neu/#208, pit shaft #382, Borbachtal tailings pond, Schlema site (1992)

Waste rock pile #38 neu/#208 and embankment dam Borbachtal tailings pond, Schlema site (2013)

Pit shaft #366, waste rock pile #366, Schlema site (1991)

The focus of waste rock pile remediation during forthcoming years will be on waste rock complex #371 where integration of contaminated soil and rubble from area remediation and demolition of buildings as well as of immobilised water treatment residues will continue. Cover building operations will be completed by 2024 except for the engineered area where immobilised residues are to be integrated.

Final contouring and capping of the remaining remotely located waste rock piles #309 and #310 are to be completed by 2018. Depending on remedial progress, follow-up work on the reclaimed areas will include care as well as post-remedial and long-term tasks. These works are required to ensure long-term remedial success.

Waste rock pile #366 after completion of remedial work, Schlema site (2014)

Remediated Luchsbach waste rock pile, Pöhla Site (2010)

Pöhla

Initial situation

The Pöhla site is located in the Western Ore Mountains on the border with the Czech Republic. The surroundings of Pöhla contain many traces of historical mining; some of them date back to the 17th century. After 1945 Wismut started a number of mining developments in the area. Uranium mining conducted in the Pöhla area from 1967 through 1990 produced about 1,200 tonnes of uranium.

During prospecting for uranium mineralisation the Hämmerlein tin deposit and the Tellerhäuser tin-uranium deposit were developed by the Pöhla adit and vertical passageways. Mining operations created the spacious mine void of approximately 1 million cubic metres of the Pöhla mine. The adit portal was annexed to a vast plant area which included the Luchsbach waste rock pile. A radiometric ore sorting unit was erected at this site during the 1980s, but shut down after trial operation. As a consequence, the ore mined from the Pöhla-Tellerhäuser deposit was trucked to the sorting unit at mine shaft #371 of the Aue mining unit.

Plant facilities, Pöhla site (1991)

Water treatment plant at the Pöhla site (2014)

The smaller, separate Pöhla-Globenstein mine had been developed by prospect shaft #24 sunk as early as 1957. Despite most intense prospecting on three levels no mineable uranium mineralisation was detected. In 1989/90, the pit shaft was partly backfilled to ground level and plugged, and the mine was flooded.

On balance, the mining field extended over an area of about 5.5 square kilometres. Above-ground units and the associated pit openings, buildings, facilities, and mine dumps covered an area of 60 hectares. Of that total, the 4 mine dumps covered a footprint area of around 34 hectares. Their volume was about 2 million cubic metres.

Remediation goals/concepts

The following works had to be accomplished in order to ensure a sustainable reduction of contaminant release from the mine closed in 1990 and to blend the reclaimed former mining area into the surrounding landscape:

- Removal of technical substances from underground with the potential to pollute the incoming water,
- Backfilling of redundant near-surface vertical passageways and of adits, except for the main adit,
- Flooding of the mine until natural overflow occurs at the level of the main adit,
- Maintenance of the main adit to allow monitoring and discharge of contaminated flood water separately from unpolluted infiltration water,
- Erection and operation of a water treatment plant for flood water, and
- Remediation of mine dumps, the largest of which was the Luchsbach waste rock pile containing 1.8 million cubic metres of mine waste and covering an area of 26 hectares.

Remediation achievements

All above-ground facilities were either dismantled or demolished. The Luchsbach waste rock pile was regraded and capped with mineral soil. Construction of forest roads and drainage ditches as well as landscaping was terminated on and around the Luchsbach waste rock pile in 2008, ending substantial remediation work in this area.

After termination of required clean-up and demolition work in the Tellerhäuser area, flooding of the mine commenced in 1992. Flood water has to be treated in a water treatment plant for its radium, arsenic, and iron levels. Over time, uranium has decreased to low levels and does not henceforth need removal.

Outlook

Rehabilitation of the Luchsbach waste rock pile, of the Pöhla plant area and of the Schurf 24 waste rock pile has been completed. Post-remedial care and environmental monitoring have to be continued at these objects.

Final rehabilitation of the Pöhla mine will only be possible after water treatment is terminated. Given that flood water quality is improving at a very slow rate, treatment will be required over an extended period of time.

5. Stewardship sites

Stewardship site Annaberg-Buchholz, Drei Könige waste rock pile at beginning clean-up operation (2007)

These areas and facilities used for uranium mining operations by the predecessor Wismut Company had been returned for the most part in an unremediated state to local authorities or private parties in the early 1960s. For these legacies which are known as previously abandoned Wismut sites, Wismut GmbH has no remediation obligations under the provisions of the Wismut Act as these sites were neither property of Wismut GmbH on June 30, 1990 nor ceded to the company for unlimited and unrestricted use. A survey of these objects was established by the legacy inventory compiled by the Federal Office for Radiation Protection on behalf of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. This inventory documented a total area of approximately 1,500 square kilometres in Saxony, Saxony-Anhalt, and Thuringia. For Saxony alone, around 1,900 individual objects were identified.

This inventory served as the basis for an initial agreement concluded in 2001 between the federal government and the Free State of Saxony regarding seven priority rehabilitation projects at the sites of Johanngeorgenstadt, Breitenbrunn and their environs. For these priority projects the federal government and the Free State of Saxony provided financing totalling approximately 4.8 million euros.

In September 2003, the federal government and the Free State of Saxony, without prejudice to their respective legal positions, signed an administrative agreement expiring in 2012 and with a funding volume of 78 million euros regarding remediation of previously abandoned Wismut sites in Saxony. The aim is similar to the Wismut Project: mitigation of environmental damage in order to restore a

Stewardship site Annaberg-Buchholz, Drei Könige waste rock pile (2014)

Stewardship site Schneckenstein, pit shaft #241, central pit shaft in background (c. 1948)

wholesome and unimpaired environment for the benefit of the public in the affected former mining regions and provide impetus to positive regional development and economic revival. Following the signing of a supplemental administrative agreement on April 24, 2013 additional funds of 138 million euros have been made available until 2022. The federal government and the Free State of Saxony each contribute 50 per cent to these funds.

An advisory council on remediation was established to steer and control the rehabilitation of previously abandoned Wismut sites. Wismut GmbH is mandated with the proper conduction of the remedial projects. Wismut is also committed to award public contracts for a minimum of 50 per cent of the available funds to external firms with a view to providing positive impetus to regional development.

Remediation is conducted according to priorities on the basis of concepts for site remediation and clean-up which are coordinated with the communities affected. In addition to technical aspects (radiation protection issues, geomechanical long-term stability, soil and water protection), the assessment of required remedial action also takes the interests of regional and local development into account. Immediate measures are taken to eliminate risks and repair of recent surface subsidence is integrated into the remedial works.

With a view to achieving meaningful overall results, measures in which the scope of work exceeds the remediation of the actual stewardship site are implemented by means of third-party cost sharing. Co-financing has been provided by, for example, Deutsche Bahn AG (Zeche 20, Aue), the municipality of Dresden (Collmberg waste rock pile) and the Saxon Mining Office (mine workings stabilisation, Kirchplatz, Schneeberg).

The signing of the follow-up agreement of April 2013 provided the base for the smooth continuation of the remedial actions.

In the years to come, emphasis will be on the following tasks:

- Remediation of mine dumps and areas;
- Demolition of buildings and removal of constructional remains;
- Remediation of tailings management facilities;
- Plugging and sealing of surface openings and closeout of near-surface mining voids;
- Mine water management at stewardship sites;
- Corrective action at sites where land subsidence occurred recently.

Stewardship site Schneckenstein, waste rock pile #241 after remediation (2013)

In this context, the implementation of large-scale projects in particular has to be sped up and completed. Above-ground projects of that kind often require elaborate licensing, planning approval procedures and negotiation of various trade-offs with owners and users.

In 2015, 61 projects are either being continued, initiated or are in the design planning stage. These include the remediation of the southern part of waste rock pile #54 and the operation area of object #98 in Johanngeorgenstadt, decommissioning and closure of mining fields Schacht #44 and #48 in Wolkenstein as well as measures for water discharge via the Markus-Semmler gallery.

From 2003 to 2014 spending for these measures amounted to 104 million euros. 226 projects in 45 communities were successfully completed. The remediation of uranium mining legacies left behind in Saxony has returned areas in the affected communities to sustained use for industrial, agricultural and recreational purposes.

Subsidence repair at Dörfler Weg, Annaberg-Buchholz

6. Building confidence by providing excellence in remedial design and action

Open Day visitor group, Ronneburg site

Until 1990, the uranium ore mining company Wismut was a raw material supplier to the Soviet atomic weapons programme during the Cold War. For many decades, uranium ore mining in Saxony and Thuringia took place regardless of environmental or health concerns. The company became a state within the state. All activities were shrouded in utmost secrecy.

Due to decades of a policy of secrecy followed by SAG/SDAG Wismut, in 1990/91 Wismut GmbH was confronted with strong mistrust and reservations of the public, the media and the nascent regulatory authorities. At that time, the newly established remedial company was almost daily in the regional and nation-wide news, providing unfavourable headlines.

Therefore, trust had to be gained little by little through a purposeful and transparent information policy. By a multitude of measures, but first and foremost by successful remediation that was visible from the outside, broad public acceptance was gained over time.

Nowadays Wismut GmbH presents itself in numerous public outreach activities as an efficient remedial company. Municipalities, districts, public authorities, experts and environmental groups were involved in the development of remedial concepts, the identification of remediation goals and proposals for the reuse of reclaimed properties.

Locals were able to witness what happened on their doorstep. Information centres were established at remediation sites in Saxony and Thuringia. Every year, visitors turn out in their thousands to witness remedial progress at the various sites on the occasion of the traditional “Open Day”.

Wismut GmbH keeps the public regularly informed about remediation progress via the press and online; it maintains a worldwide dialogue with experts at national and international symposia. A number of Wismut’s outstanding remedial projects were presented on the occasion of the 2000 World Exposition EXPO 2000 and the National Horticultural Exhibition held in 2007 in Gera/Ronneburg.

Since 1991, more than 1.5 million visitors from Germany and abroad have been welcomed to remedial sites in Saxony and Thuringia. A particular form of paying tribute to remediation achievements and regional development was the Saxon State Award for Building Culture 2008 awarded jointly to Wismut GmbH and the spa town of Bad Schlema for their joint submission “From Death Valley to Spa Town”.

Meaningful public relations activities will continue to be a major component of the remedial efforts undertaken by Wismut GmbH.

Environmental reports of Wismut GmbH

7. The Wismut Heritage collections

Kurt Pesl: View of Ronneburg, 1983

The federally-owned Wismut GmbH is committed to documenting and preserving for future generations any facts and data on its former mining activities, the implementation of remedial works, environmental monitoring and the use of reclaimed areas. What is known as the Wismut heritage also encompasses the preservation of the history of uranium ore mining in Saxony and Thuringia including the various aspects of political significance, of mining traditions as well as the specific features of the Wismut Company such as the geological archives or the collections of works of art and the collection of mineral samples.

Evidence of the vast artistic and cultural activities of SDAG, some 4,200 works of art (paintings, drawings, graphic art among others) by 450 artists are owned by Wismut GmbH.

Artists working for SDAG Wismut came notably from the Academy of Visual Arts Leipzig, which established its reputation as the “Leipziger Schule”, and the Dresden University of Art. In addition, the collection also comprises works of artists from art colleges in Halle, Berlin, and Weimar. It also includes many works by amateur artists working in art clubs at Wismut. Other contributions were provided by artists from Armenia, Hungary, Bulgaria, Poland, and Russia.

The collection of ore deposit samples encompasses minerals, rocks and records from uranium ore mining operations in Saxony and Thuringia. The collection of minerals of the former Aue mining unit plus samples from the Schneeberg-Schlema-Alberoda and Pöhla-Tellerhäuser areas constitute the core of the collection. Other exhibition areas are dedicated to minor uranium deposits in the Ore Mountains and Vogtland regions such as Annaberg, Johanngeorgenstadt, Antonsthal and Zobes where mining operations ceased before 1965.

Wismut GmbH will continue to present to the public its collection of minerals, housed at mine shaft #371, the main shaft of the Schlema-Alberoda mining district, and its collection of works of art, ranking as the largest and most important of GDR corporate collections.

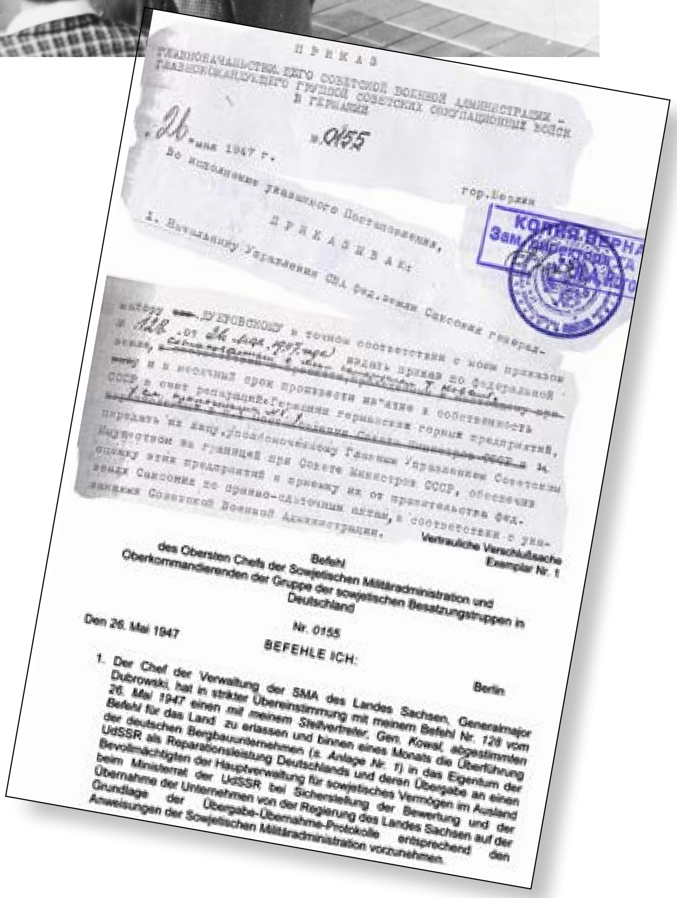
View of the collection of ore deposit samples of Wismut GmbH

8. Documentation on Wismut corporate history

May Day rally in the 1960s

In 2011, a two-volume collection of documents was published on the history of uranium ore mining by Wismut in Saxony and Thuringia and on rehabilitation results achieved after 1990 by Wismut GmbH. An international team of historians has scientifically investigated and documented the subject areas of politics, economics, environment, and social affairs. International comparative studies have been conducted with the aim of providing benchmarks for the classification and evaluation of Wismut corporate history, particularly with regard to the business regime, levels of sophistication of mining engineering, environmental concerns and radiological protection, safety standards, economic viability, and employee social benefits.

Financing was ensured by contributions from the Ministry for Economic Affairs and Energy, the Chemnitz University of Technology, the Gerda Henkel Foundation, the Friedrich Ebert Foundation, the Munich-based Institute of Contemporary History, and Wismut GmbH. The documentation "Uranium mining in the Cold war-era – the Wismut Company in the Soviet nuclear complex" constitutes an important work of reference on Wismut corporate history.



ПРИКАЗ

ГЛАВНОНАЧАЛЬСТВУЮЩЕГО СОВЕТСКОЙ ВОЕННОЙ АДМИНИСТРАЦИИ –
ГЛАВНОКОМАНДУЮЩЕГО ГРУППОЙ СОВЕТСКИХ ОККУПАЦИОННЫХ ВОЙСК
В ГЕРМАНИИ

26 мая 1947 г. № 0155

гор. Берлин

ПРИКАЗЫВАЮ:

Vertrauliche Verschlußsache
Exemplar Nr. 1

Befehl
des Obersten Chefs der Sowjetischen Militäradministration und
Oberkommandierenden der Gruppe der sowjetischen Besatzungstruppen in
Deutschland

Den 26. Mai 1947 Nr. 0155 Berlin

BEFEHLE ICH:

1. Der Chef der Verwaltung der SMA des Landes Sachsen, Generalmajor Dubrowski, hat in strikter Übereinstimmung mit meinem Befehl Nr. 128 vom 26. Mai 1947 einen mit meinem Stellvertreter, Gen. Kowal, abgestimmten Befehl für das Land zu erlassen und binnen eines Monats die Überführung der deutschen Bergbauunternehmen (s. Anlage Nr. 1) in das Eigentum der UdSSR als Reparationsleistung Deutschlands und deren Übergabe an einen Bevollmächtigten der Hauptverwaltung für sowjetisches Vermögen im Ausland beim Ministerrat der UdSSR bei Sicherstellung der Bewertung und der Übernahme der Unternehmen von der Regierung des Landes Sachsen auf der Grundlage der Übergabe-Übernahme-Protokolle entsprechend den Anweisungen der Sowjetischen Militäradministration vorzunehmen.

Order no. 155, Soviet Military Administration, 1945

9. Summary and outlook

New Ronneburg landscape and BUGA exhibition area

Since uranium ore mining was terminated and remedial operations started in 1991, remedial results achieved by Wismut GmbH in rehabilitating the legacies of former uranium ore mining operations have been clearly visible at all sites in Saxony and Thuringia. Apart from a few exceptions, a large number of remediation measures have been completed or are nearly finished. Environmental impacts in the affected areas have been significantly reduced by the remedial efforts.

Today, the rehabilitated areas once again have become habitats to a multitude of animals and plants. Wismut GmbH documents the process of biological recolonization and development by various ecological studies such as bio-monitoring.

The work completed so far has provided a sound basis for the accomplishment of future tasks. The federal government will continue to fund the effort. According to current levels of knowledge in 2015, it looks as though the substantial remediation work will be completed in 2028. Thereafter, long-term tasks will have to be performed at reclaimed objects such as landscape structures and rehabilitated mining fields. This includes in particular the collection and treatment of flood water and seepage, maintenance of covered areas of waste rock piles and tailings management facilities, the operation of a vast environmental monitoring system as well as mine inspection tasks. The time frame required for these efforts cannot be specified at the present time.

The rehabilitation and reuse of former mining fields has established the preconditions for economic development and job creation. Continued remediation at previously abandoned Wismut sites will provide local communities with new possibilities for the sustainable use of reclaimed mine land.

Main dam of the Helmsdorf tailings management facility

This brochure provides a general overview of the remediation work performed by Wismut GmbH, including its mission, goals, and achievements. In the annexed flyer, tables and graphs provide figures on key processes and developments of Wismut GmbH. For more complete information concerning the Wismut Project, please log onto the Wismut GmbH website at (www.wismut.de) or consult the extensive literature available on this subject.

www.bmwi.de