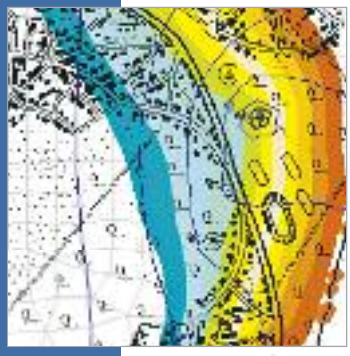
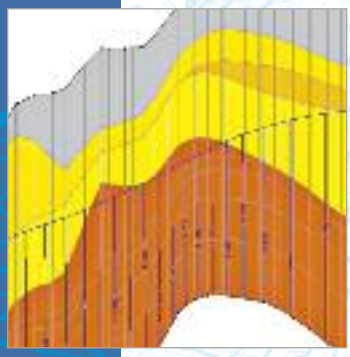
delta h
Ingenieurgesellschaft



Your Specialist for Water System Modelling



Streams: The interaction between surface water and groundwater is an important element of effective and holistic water management.

Sustainable solutions for complex planning tasks.

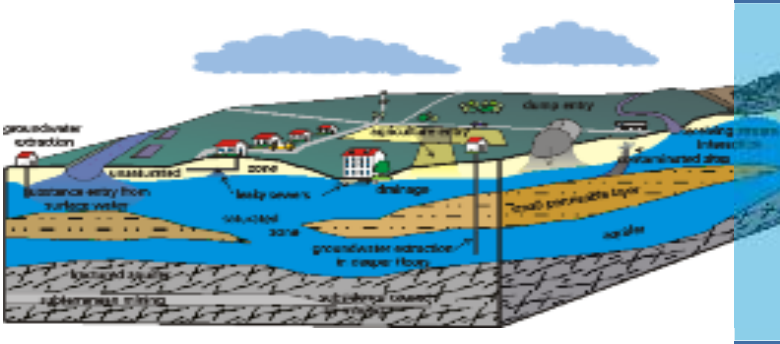
For many years, the engineering company delta h has been the competent specialist for professional water system modelling for their customers.

Whether you require individual strategies, complete projects or official expert opinions:

Our experienced team of experts will develop environmental numerical simulation models for any hydrological and hydrogeological requirements relating to groundwater, seepage water, surface water or geothermal water.

We plan and advise on projects in the following areas:

- (Coal)Mining
- Water supply and water management
- Building projects
- Groundwater redevelopment
- Geothermal energy



Schematical representation:
Different physical processes and effects in and on the groundwater system.

The latest modelling software for your success.

Highest precision is our ambition. Hence our experts rely on the groundwater flow, mass transport and heat transport models of our company-owned **software system SPRING** proven in many projects. We thus guarantee that you will receive precise details on the actual situation and the planned interventions in the groundwater situation in your project area. This ranges from calculating all relevant hydrogeological and hydraulic parameters in the model area to the evaluation of groundwater levels, flow velocities, pollutant concentrations or temperatures.

Practice-oriented research and software development.

In order to be able to offer professional and practice-oriented modelling solutions for the constantly increasing project requirements, we constantly develop our **software SPRING** further, attaching great importance to close cooperation with renowned partners in research and development.

For you, that means: Qualified planning data based on state-of-the-art technology and science.

Large-scale digital terrain model: Up-to-date planning data at a glance.

Good reasons for cooperation.

Whoever is responsible for complex projects needs especially one thing – Confidence in the efficiency and professional know-how of his partners. Three good reasons why you can rely on us 100%.

25 years of experience.

Developed from the interdisciplinary study group "Groundwater models" of the Ruhr University of Bochum, we have more than 25 years of practical experience in the special field of water system modelling. This gives you the security that you need for your project.

Global know-how.

Our trained geologists, mathematicians and engineers have the necessary know-how and are able to provide suitable methods for solving challenging hydrological and geological tasks. This guarantees highest precision in work and cost efficiency for your projects.

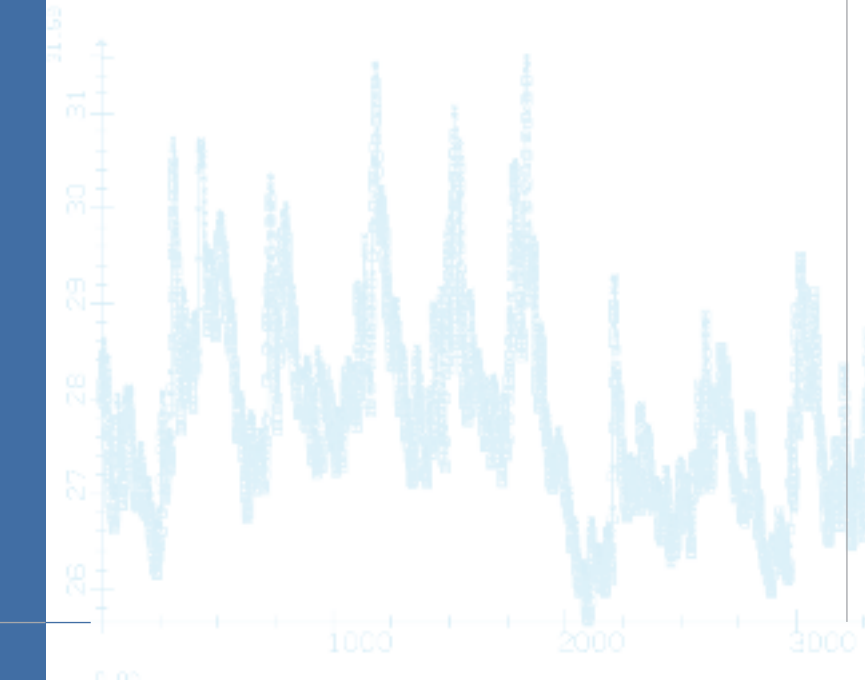
Modern software system.

Our **software SPRING** proven in numerous projects guarantees you precise numerical simulations in complex projects of flow, mass and heat transport. If necessary, we will, of course, also develop individual program solutions.

In short: We guarantee the success of your project. This you can count on!

Anthropogenic effects change natural systems:
A lake formed by mine subsidence becomes a new biotope.

Mining - Effective safety for man and environment.



Controlling the groundwater is of essential importance in coalmining problems.

Reason: The resulting mine subsidence decreases the ground surface level more than the groundwater – This results in water-logged areas.
In general this will require extensive dewatering measures - for example drainage systems, wells or sheet piles - in order to protect man, agriculture and buildings sustainably from water logging and prevent extensive damage. Raising the ground level may also provide an adequate protection.

delta h - Your strong partner.

We will support you in detecting the impact of mine subsidence on the groundwater situation in your area under investigation. We will develop solutions for you and analyse the effectiveness of the measures planned. Always with a view to preventing adverse effects of coal mining in terms of water management, ecology and costs – today and in the future.

For example, as part of this approach, we will optimize the pumping and delivery rates of necessary pumping stations. We thus help you to sustainably minimize the "everlasting cost".

Effective Planning: High-resolution digital terrain models allow true-to-detail representation of the depths of the water level.

Pumping measure: Pumping groundwater into a body of water to prevent water logging.

Problems in draining surface water: Ground level subsidence results in run-off problems.

Overview of our services.

- Compiling environmental compatibility studies (e.g. in framework operation plan procedures)
- Prediction of the groundwater situation influenced by ground level subsidence
- Groundwater monitoring (to accompany coal mining)
- Hydraulic engineering planning
- Water planning
- Interaction between surface water and groundwater
- Long-term effect of flooding
- Flooding of a coal mine
- Groundwater quality
- Flood protection
- Creation of digital terrain models

Seepage reservoir: groundwater recharge through infiltrating bank filtrate.

Water Supply and Water Management – Optimal use of valuable groundwater.

Depending on local conditions, waterworks for drinking water supply show great differences regarding their capacities or technologies for water catchment.

But they all have one goal in common: a drinking water supply which corresponds to the strict legal standards of the Drinking Water Ordinance.

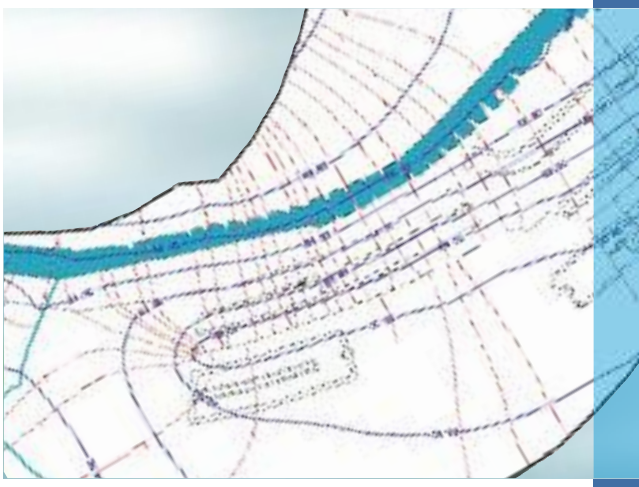
delta h – Your strong Partner.

Our qualified team of experts supports you when you are planning a water-catchment plant. It does not matter whether you need a definition of a groundwater basin or important information on the origin of the pumped water and its quality: Using our numerical simulation models we will analyse for you the interactions between water economy, ecology, agriculture and urban areas and show you possible solutions. This allows you to use the valuable resource “groundwater” optimally and protect it environmentally at the same time.

Efficient water catchment: Pump installation of groundwater catchment in a waterworks.

Overview of our services.

- Design of water catchment plants
- Quality management
- Value
- Evaluation of resources
- Calculation of bank filtrate rates
- Water balancing
- Considerations regarding catchment areas
- Analysis of fluid lines
- Well capacity
- Groundwater recharge (infiltration basins)
- Measures for hazard prevention



Precise predictions: Calculation of flow lines for delimiting and representing catchment areas and determining travel times.

Weir for regulating the water level of the river: Effect on the proportion of bank filtrate of a water catchment.

Clearly arranged: 3D block diagram of a finite element mesh in the area of a drinking water catchment plant on the Rhine.

Sustainable building project: Effective groundwater drainage through sheet piles in a body of water.

Building project – Intelligent and safe planning of groundwater drainage.

The role of groundwater drainage is of particular importance in complex projects such as tunnel and channel constructions or building an underground car park. This affects not only safety, but also cost planning.

Especially the factor of "groundwater drainage" should be an integral part in the run-up to planning.

delta h – Your strong Partner.

That's where we come into play. We will establish, especially for your local groundwater situation, a suitable unsteady groundwater or building drainage. For example: We will compare the groundwater level differences between the current and planned states, calculating the effects on the groundwater inflow and runoff areas.
This will give you maximum safety in your planning and allow you to exclude settling phenomena or hydraulic shear failure right from the beginning.

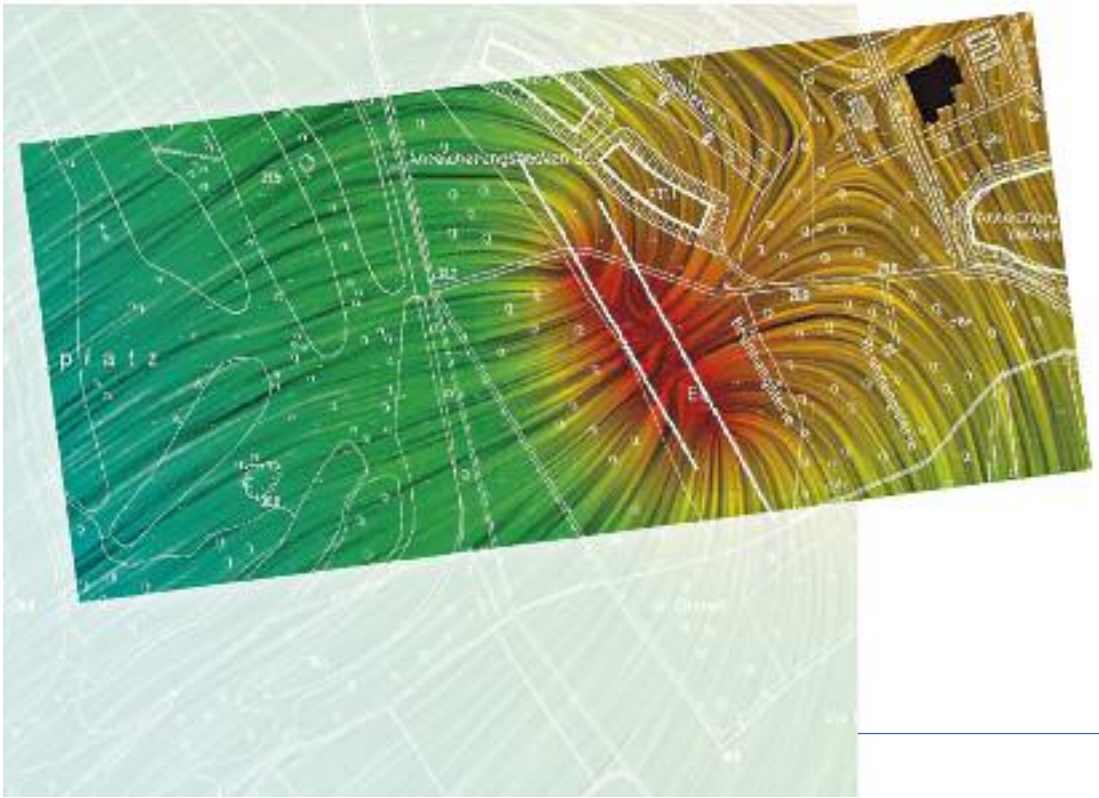
Building a “city lake”: Groundwater monitoring as important element of the construction stage.

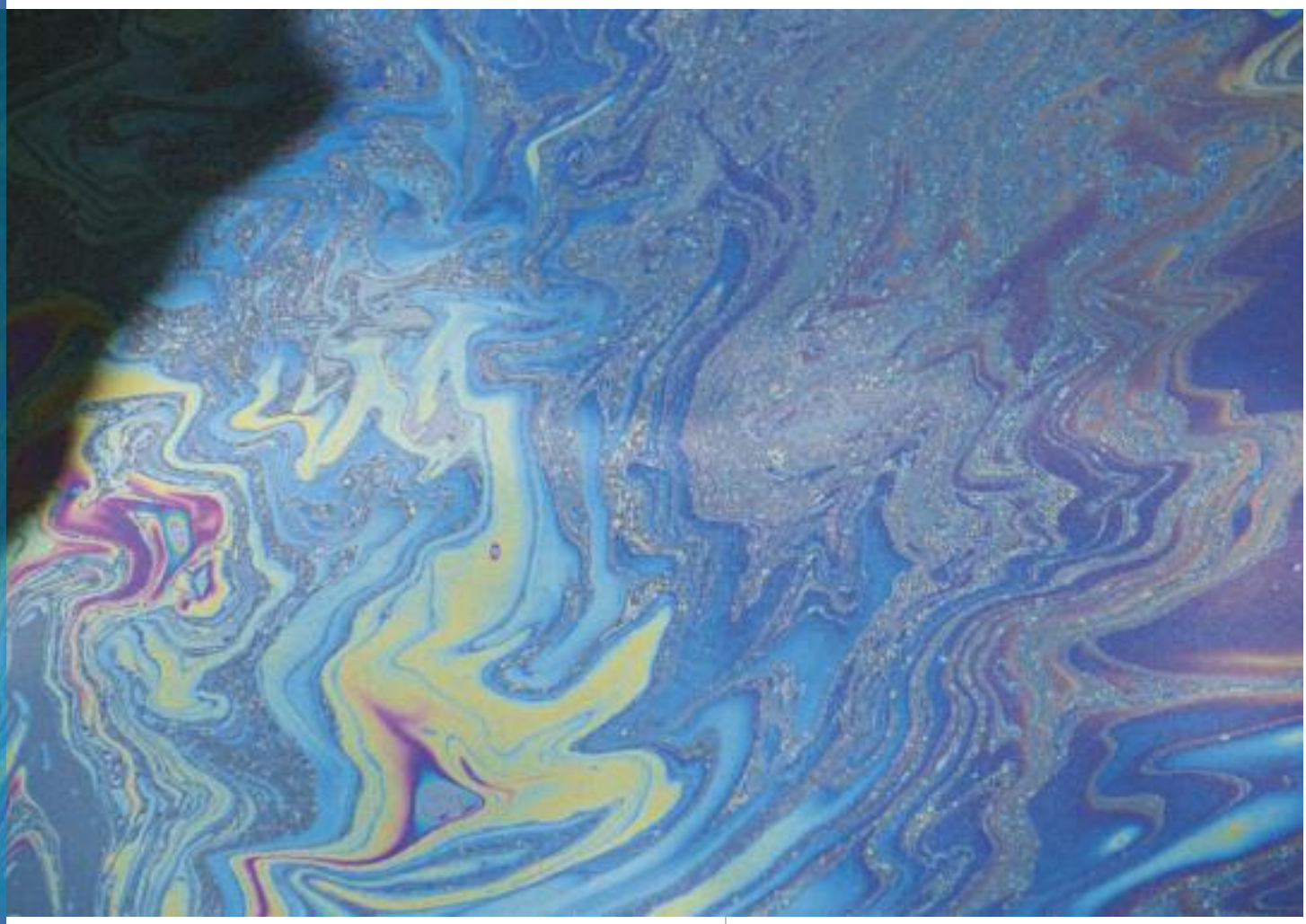
Overview of our services.

- Water management
- Groundwater monitoring
- Considerations regarding catchment areas
- Determination and analysis of groundwater quality
- Water balancing
- Analysis of fluid lines
- Creation of digital terrain models

Lignite opencast mining in South-East Europe: large-scale groundwater drainage.

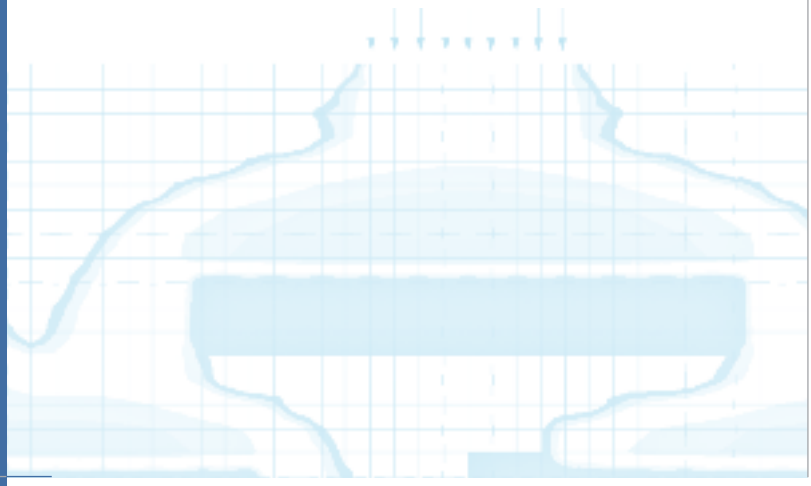
Detailed overview: Representation of the flow conditions after planning and building a process-controlled horizontal well.





Contaminated groundwater: Deposition of the oil phase on the water surface.

Groundwater redevelopment – Environmentally compatible restoration of contaminated areas.



Groundwater is one of the most valuable goods in the hydrological circle and must therefore be protected.

This makes it all the more important to select an environmentally compatible and economical decontamination method when environmental pollution or existing waste deposits are involved – for example near landfills or former industrial areas.

delta h – Your strong Partner.

Our methods of modelling help you select a redevelopment method which exactly fits the toxic condition and the groundwater situation of your project. This starts with the description and determination of the groundwater situation and includes the prediction of the impacts to be expected of:

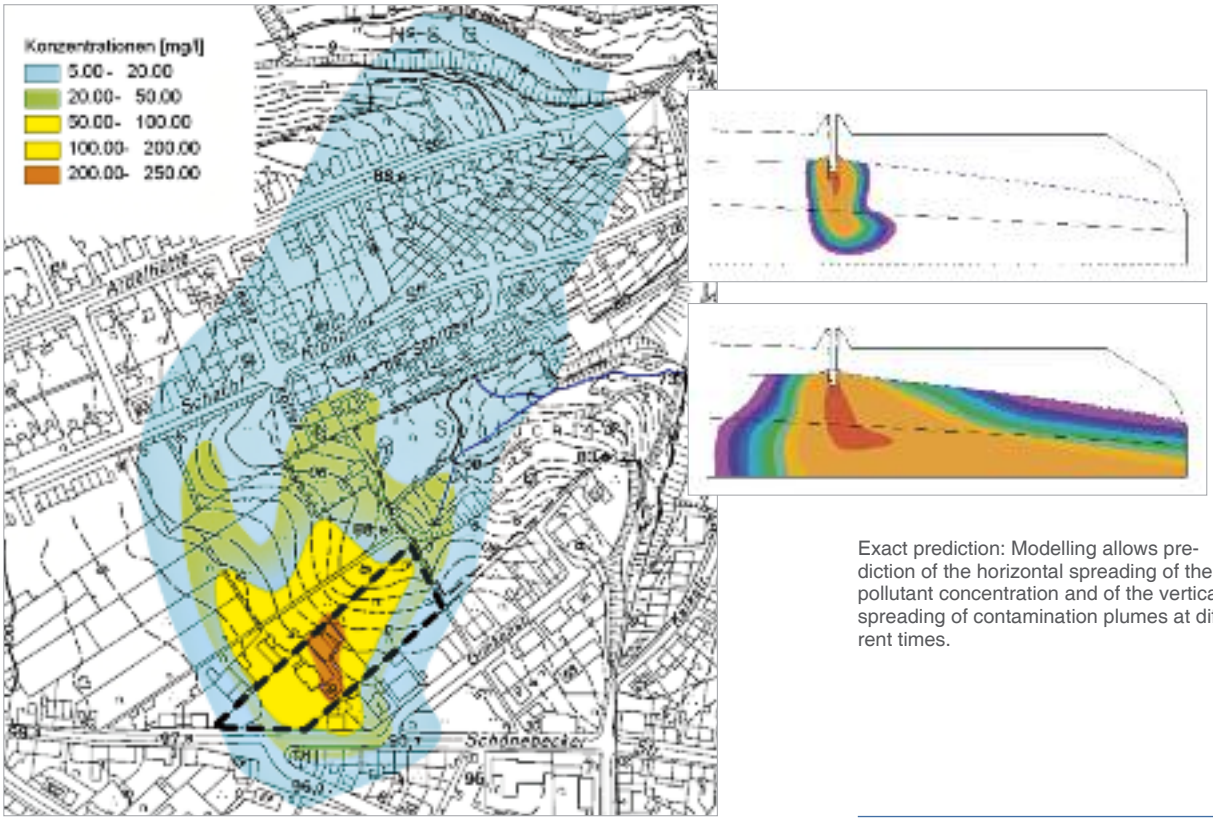
We provide you with all data important for your planning and assist you in the definition of the hazard assessment and the redevelopment method.

Danger to nature and man: Contaminated surface water.

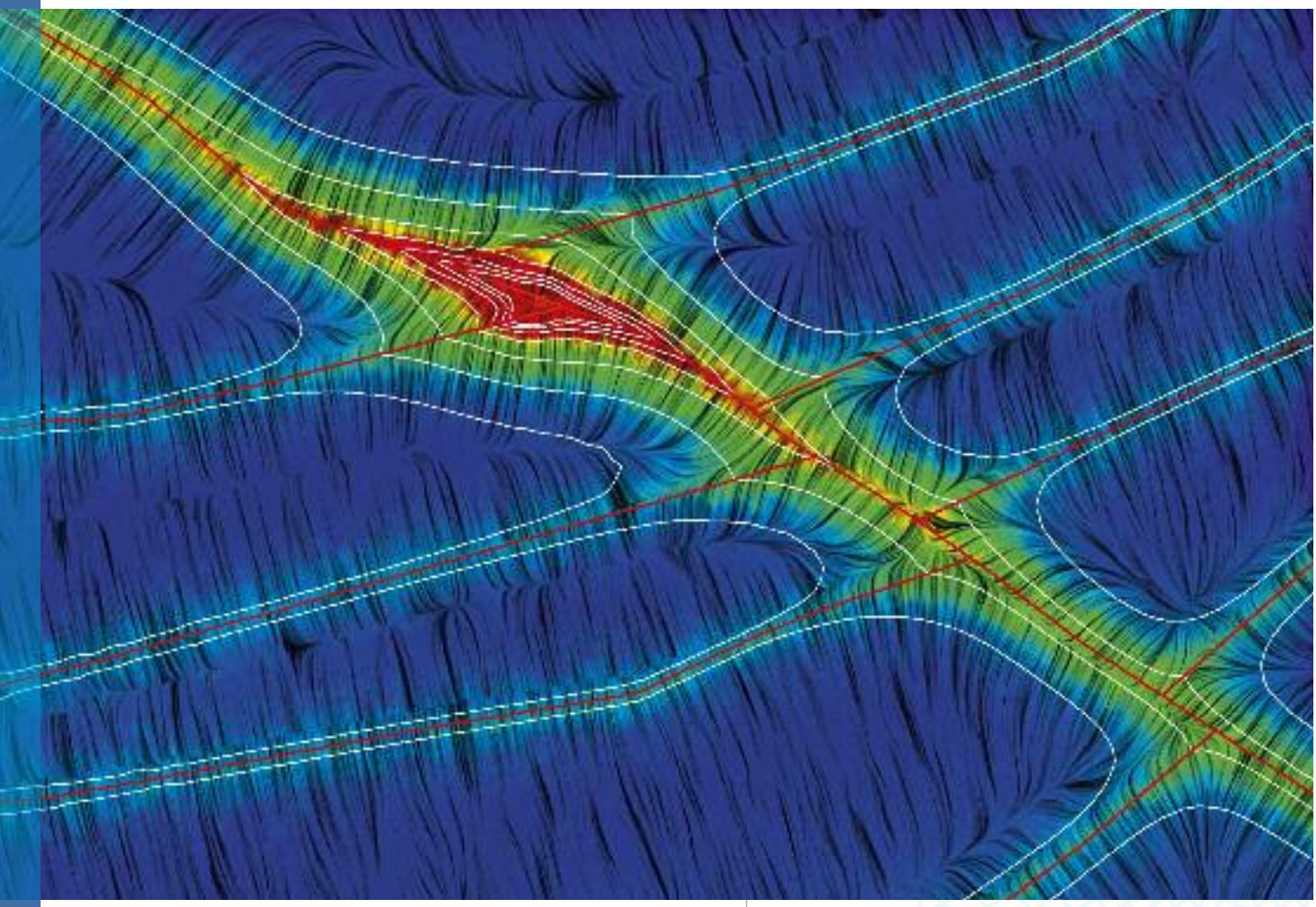
Overview of our services.

- Recommendation of suitable redevelopment methods
- Assessment of the Natural Attenuation
- Prediction of the spreading of pollutants
- Calculation of the reactive mass transport
- Water balancing
- Analysis of the fluid lines
- Prediction of seepage water
- Design of tracer tests

Redevelopment action required: Flooding and discharge of seepage water in a uranium mine.



Exact prediction: Modelling allows prediction of the horizontal spreading of the pollutant concentration and of the vertical spreading of contamination plumes at different times.



Geothermal energy in maximum depth in the south German Molasse basin (depths up to 5000 m below the surface): Representation of the temperatures in a fault zone as a result of the numerical calculation.

Geothermal energy – Cost-effective dimensioning of geothermal energy plants.

When planning major geothermal plants, considerable expenses are incurred for the required exploration measures right from the beginning. Because of dynamic criteria such as inhomogeneities of the underground or cyclic strains of the plant, the dimensioning of the plant is often not exactly predictable.

Consequence: The additional safety requirements for designing a geothermal plant are quite high – the costs will "explode".

delta h – Your strong Partner.

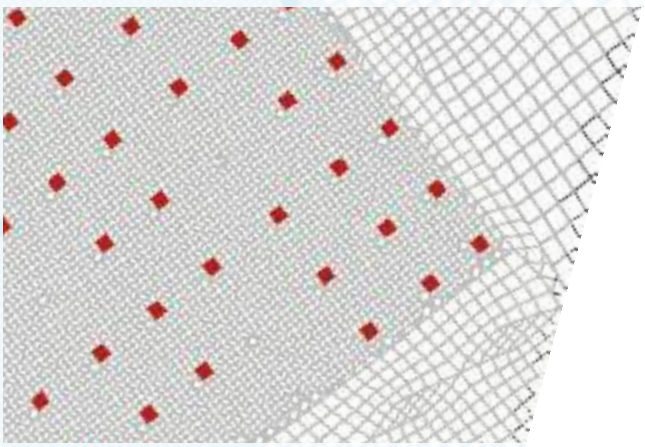
We help you plan your geothermal plant in detail, safely and holistically right from the beginning. This allows you to determine the costs as exactly as possible. Our simulation models give you reliable conclusions and predictions for the overall physical system.

Apart from the geothermal potential, we also analyse the impact of its later use on the groundwater situation
It goes without saying that we also plan and evaluate pumping tests.

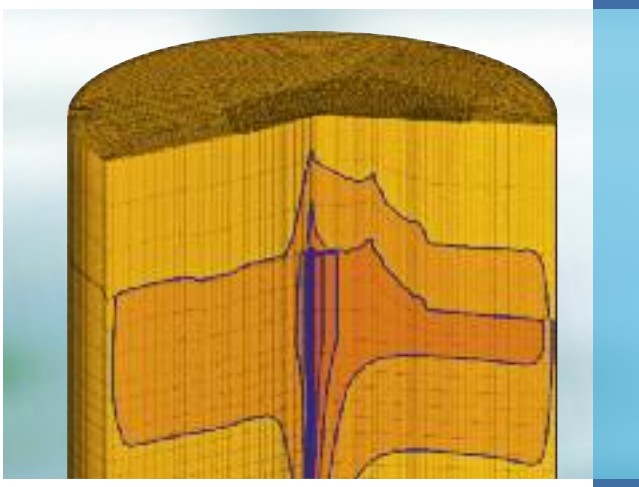
Overview of our services.

- Calculation of the effect of geothermal energy probes
- Geothermal energy of maximum depth
- Creation of geological models
- Considerations regarding catchment areas
- Design of geothermal locations
- Long-term predictions of the geothermal potential
- Preparation of geothermal expert opinions
- Planning of seepage plants (water from pumping tests)
- Planning and evaluation of pumping tests

Shown as element mesh: earth probe grid for cooling and/or heating buildings with geothermal energy near the surface.

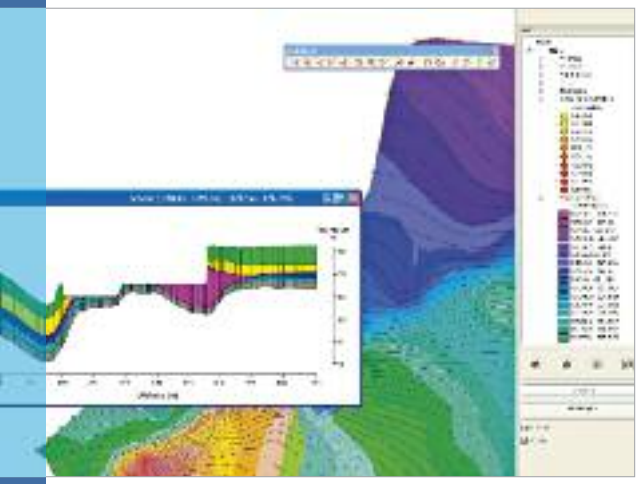


Exploration measure: drilling a geothermal well in maximum depth.

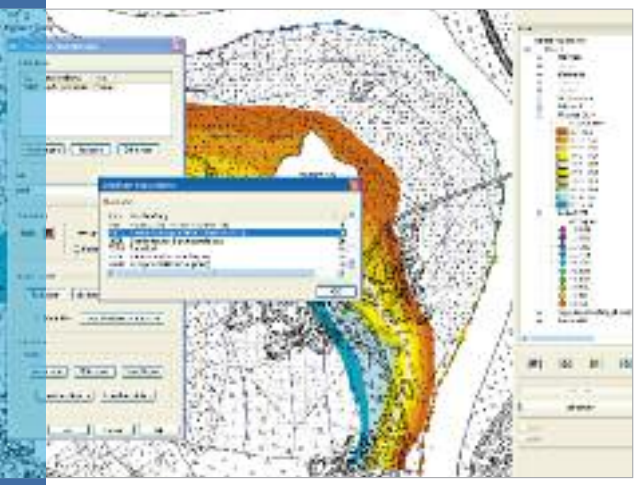


Section through a geothermal model: Exact representation of the element mesh and the calculated temperatures.

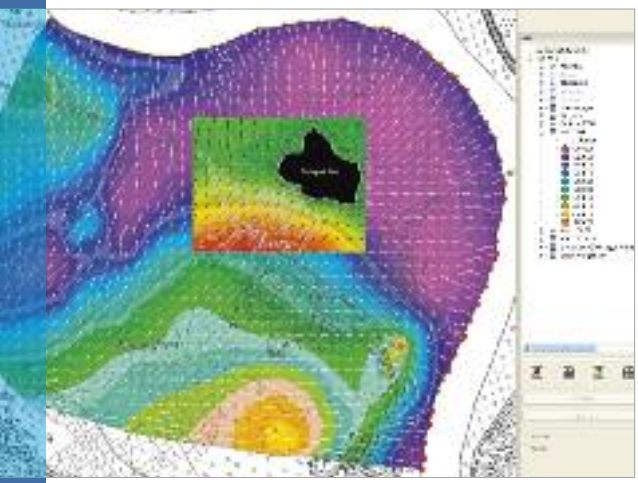
Using thermal sources for balneological purposes or public baths: Following the use of the thermal waters, their subsequent use must be decided.



User-friendly and clearly arranged visualization: Vertical section through an existing groundwater model.



Simple and accurate: Displaying and editing input data.



Flexible options: Horizontal representation of the model data.

SPRING – Accurate planning and simulation of water systems

Whether in the fields of mining, civil engineering, water supply, groundwater redevelopment or geothermal energy: In all our projects, we have been relying on our well established software system SPRING for many years. The program is based on a development of the Ruhr University of Bochum and calculates three-dimensional groundwater flow, surface-water, heat and mass transport models. Thus, – combined with the special know-how and the experience of our staff – SPRING is the best basis of your success.

Current state of science.

Through the permanent use at international academies, research institutions and in engineering companies SPRING is always at the current state of the art – and fulfils all qualifications for use in complex projects.

Marketing and training by delta h.

We are exclusive distributor of the software SPRING and offer individual training sessions for our customers in all features and areas of use – also at their location, if they so desire. On individual request from our customers, it is also possible to include additional features.

Overview of important features.

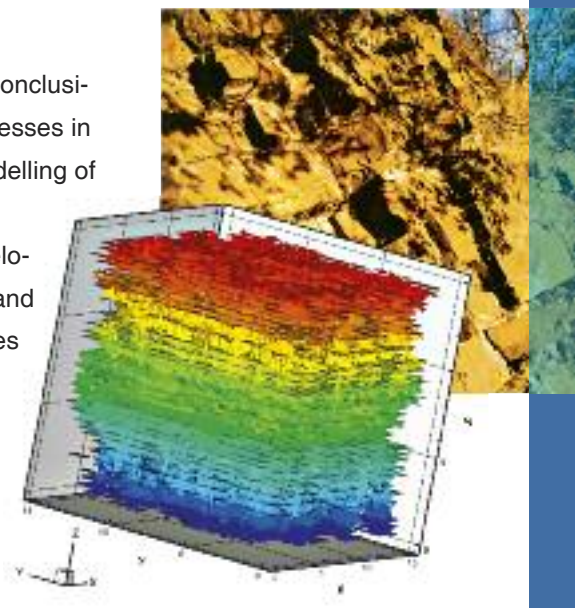
- Automatic calibration tools
- Stochastic calculation of fractures
- Reactive mass transport
- Exact copy of geological structures through tapering layers
- Flooding simulation through box models
- Special boundary conditions for geothermal calculations
- Groundwater recharge calculation based on a climatic moisture balance
- Water-system-related stream balancing
- Stochastic determination of catchment areas

Research – Ideal combination of science and practice.

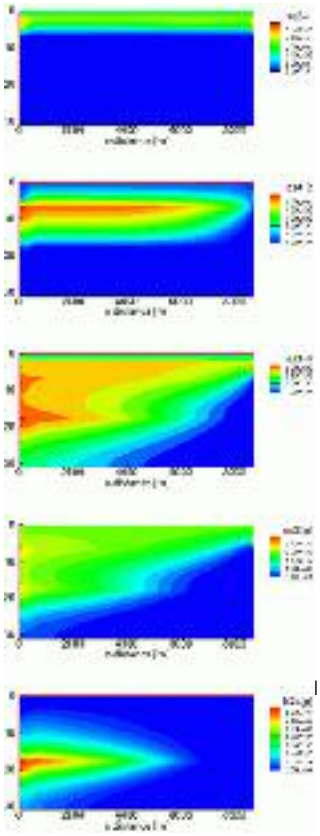
In our projects in the area of professional water system modelling, we aim to improve constantly - to the benefit our customers - and to achieve results with higher precision. This is why we attach great importance to the practice-oriented further development of our software system SPRING and to intensive scientific activity. This is demonstrated by two current examples of our research.

1. Calculating fractures

In order to be able to make precise conclusions on flow and mass transport processes in a fractured body of rock, precise modelling of the fractures themselves is required. Against this backdrop, we have developed a method to generate fractures and to integrate the calculation of fractures into our models.



Fracture systems: Reproduction of nature through stochastic generation of a model image.



2. Determination of the reactive mass transport.

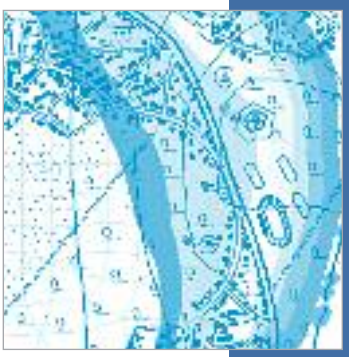
When non-conservative water ingredients enter the groundwater, models for calculating the transport and reaction processes that are simultaneously taking place in the groundwater are required. One of the models developed by us allows us to predict the temporal, spatial and geochemical development of the area under investigation. This allows us, for example in the case of redevelopment projects, to test and reliably predict planned interventions in the groundwater.

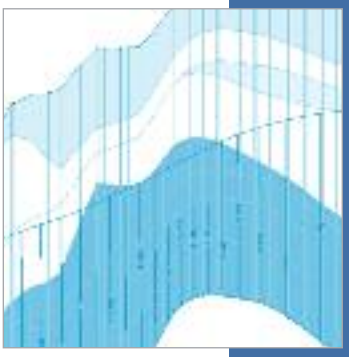
Geochemical reaction model

A selection of our references.

- Grundwasser und Geo-Forschung
- Emscher Genossenschaft
- Gelsenwasser AG
- GETEC
- DMT
- Lippe Verband
- Saarland Ministerium für Umwelt
- PORR
- EADS
- Ruhrverband
- SWK
- USGS
- ThyssenKrupp
- WISMUT
- GRS
- e·on
- RAG Deutsche Steinkohle

delta h
Ingenieurgesellschaft





delta h
Ingenieurgesellschaft mbH

Parkweg 67
58453 Witten, Germany

Telefon 0049·2302·91 406-0
Telefax 0049·2302·91 406-20

E-Mail dh@delta-h.de
Internet www.delta-h.de