

# Inovatívne metódy geotechnického monitoringu na stavbách v SR a v zahraničí

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# Minimizing Risks with Testing and Monitoring

- Prior to construction, design stage
- During construction, realisation
- After completion of construction, permanent monitoring

# Testing and Monitoring at different project stages



Exploration



Deep excavation Alptransit Lötschberg



Gabcikovo

# Demand for Monitoring and Testing is growing

- Higher demand of security and safety
- Economic design requires better control of the behaviour of the structure
- Development of new instruments and improvement of measuring procedures
- Automated measurements and data visualisation

# From manual to automated reading



Manual Inclinator reading



Data acquisition GEOMONITOR 2



# Tasks of the Instrumentation and Testing

- **Prior construction: Geotechnical and hydrogeological data for the design**
- **During construction: Monitoring to compare predicted interaction between structure and sub ground, survey of adjacent buildings**
- **After construction: Long term behaviour for safety reasons**

# Automated control of Dams



Concrete arch dam Valle di Lei, Switzerland

# Bases for Planing and Design of testing procedures and measurements

- **Assessment of the possible amount of damage**
- **Assessment of the probability of occurrence**
- **Assessment of the combined effect of possibility and probability**

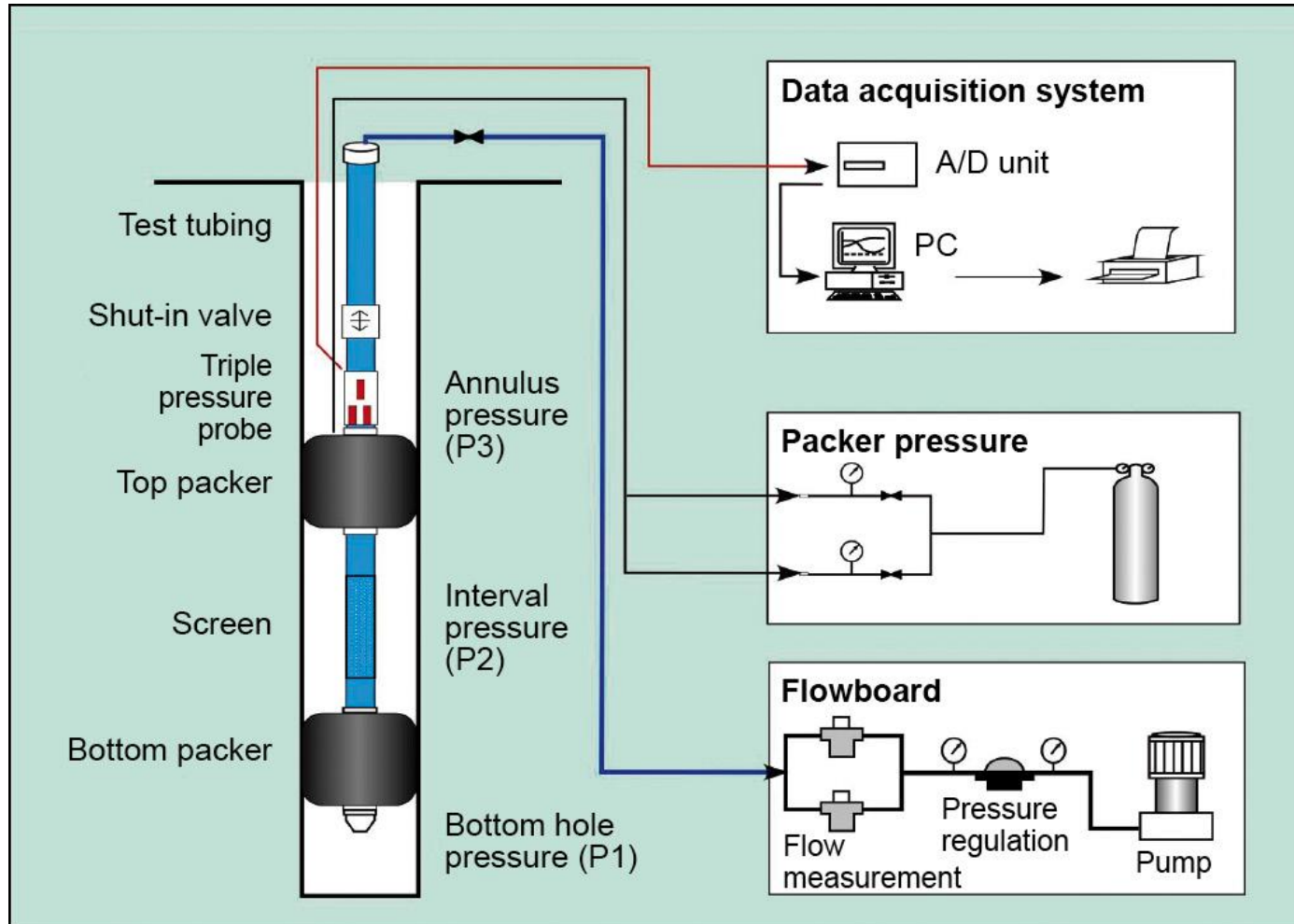
(K.Kovari, M.Bosshard)



# Field Tests in Tunnelling prior to Construction

- **Hydrogeological in situ tests**
- **Hydrogeological Instrumentation with Multiple Packer Systems**
- **Geomechanical testing**

# Hydro Test Equipment



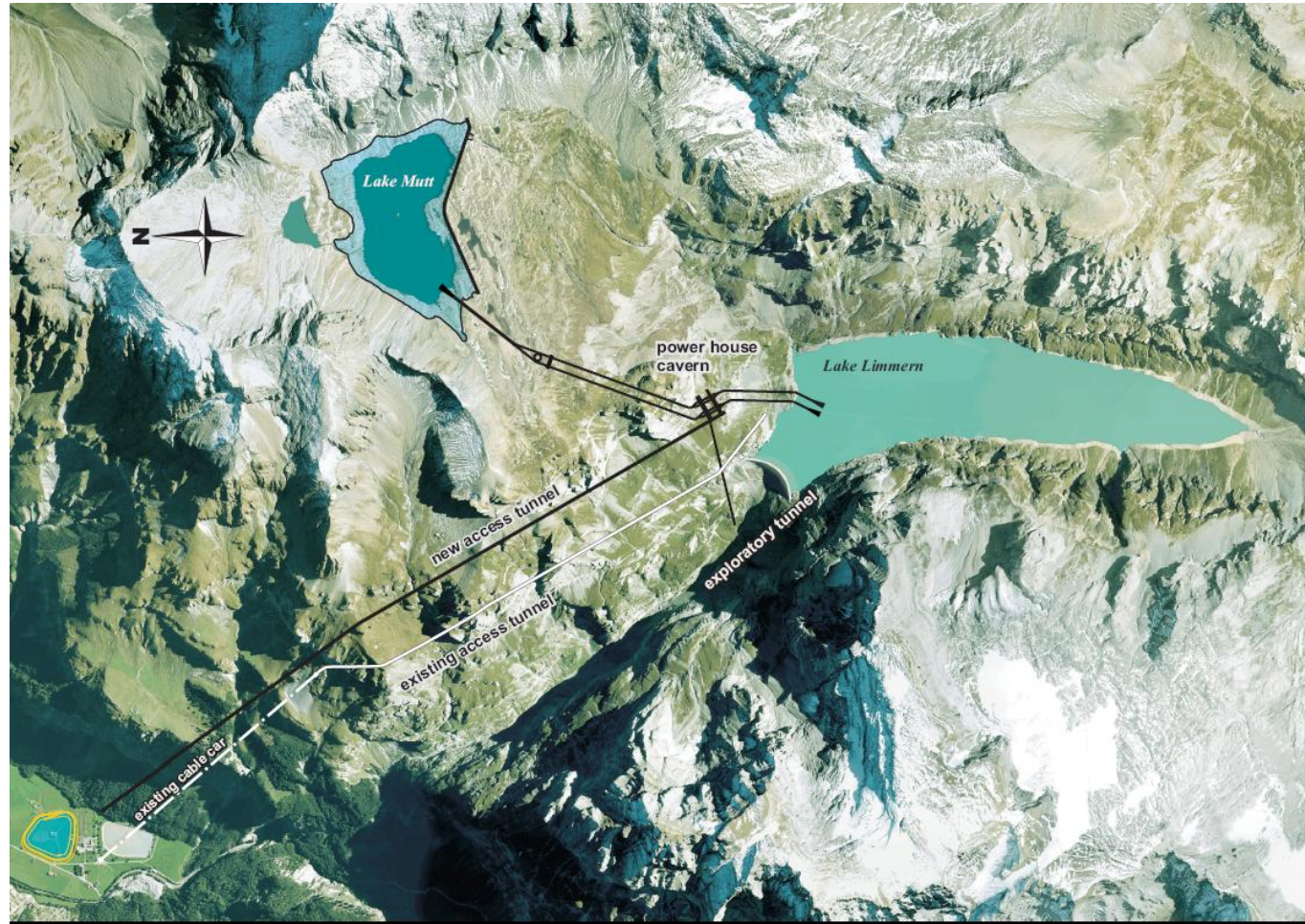
# Pump Storage Plant Linth Limmern



The sites are not always easy accessible



# Pump Storage Plant Linth Limmern





# Pump Storage Linth Limmern



Hydrogeological tests in the abutment of the Lake Mutt

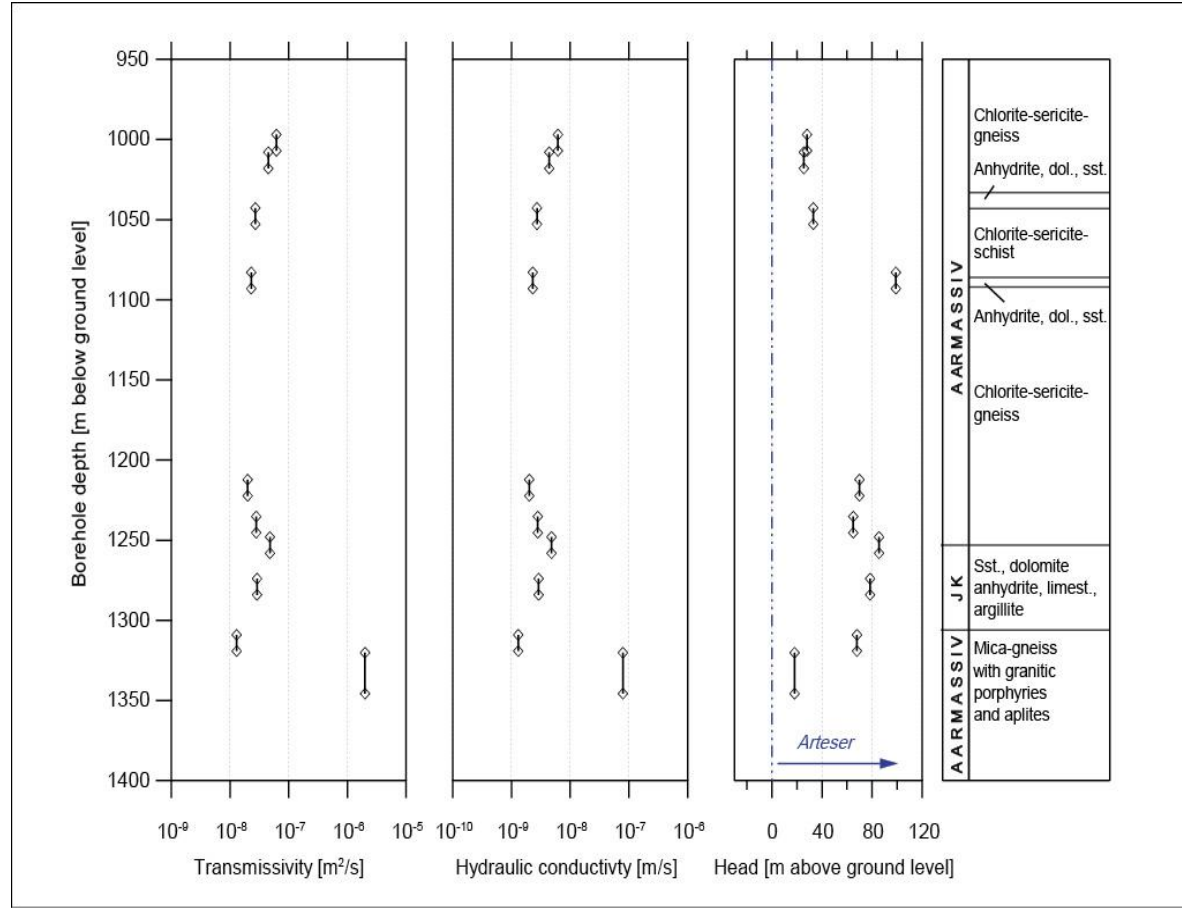


# Pump Storage Scheme Linth Limmern



Hydro tests underground to explore ground water conditions for the turbine cavern

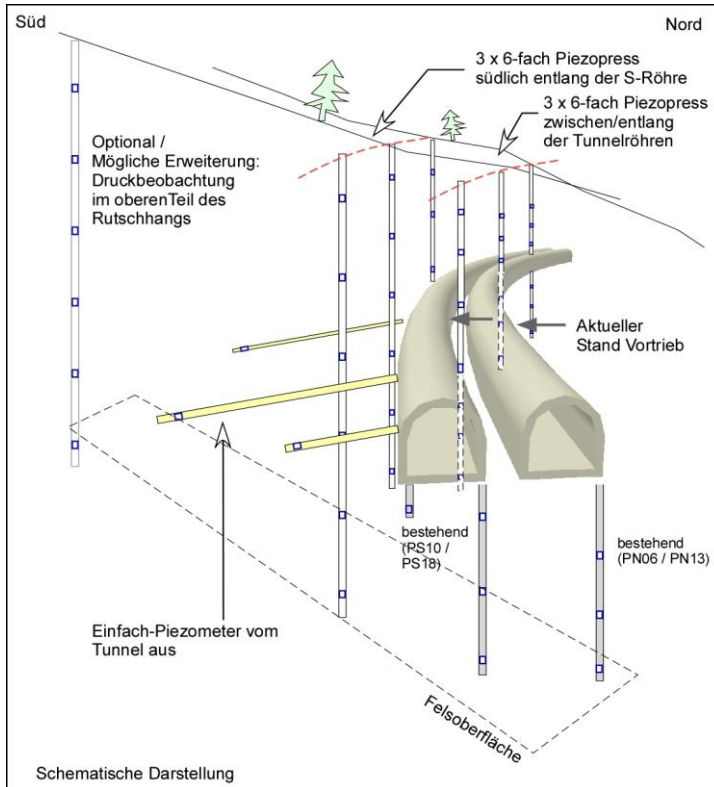
# Hydro Tests for Alptransit Lötschberg, Switzerland



Transmissivity, permeability and formation water pressure in a 1400 m deep borehole  
 Head varying between 20 to 100 m above ground level

# Multiple Packer System

## Pore Water Pressure distribution

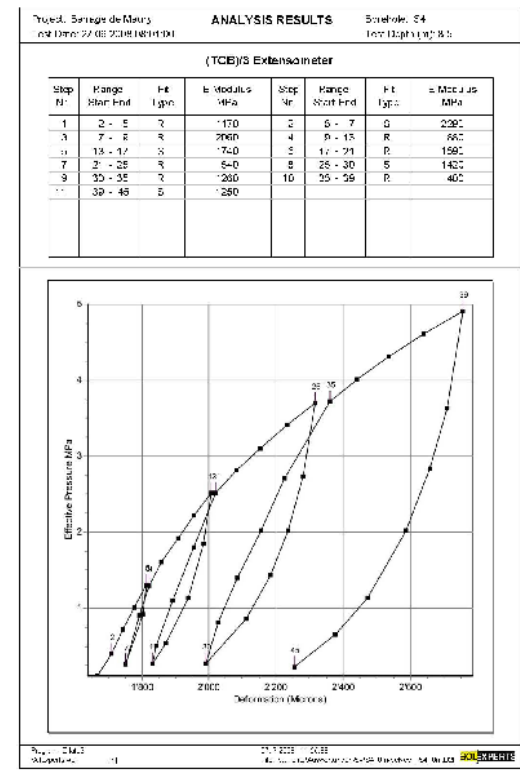
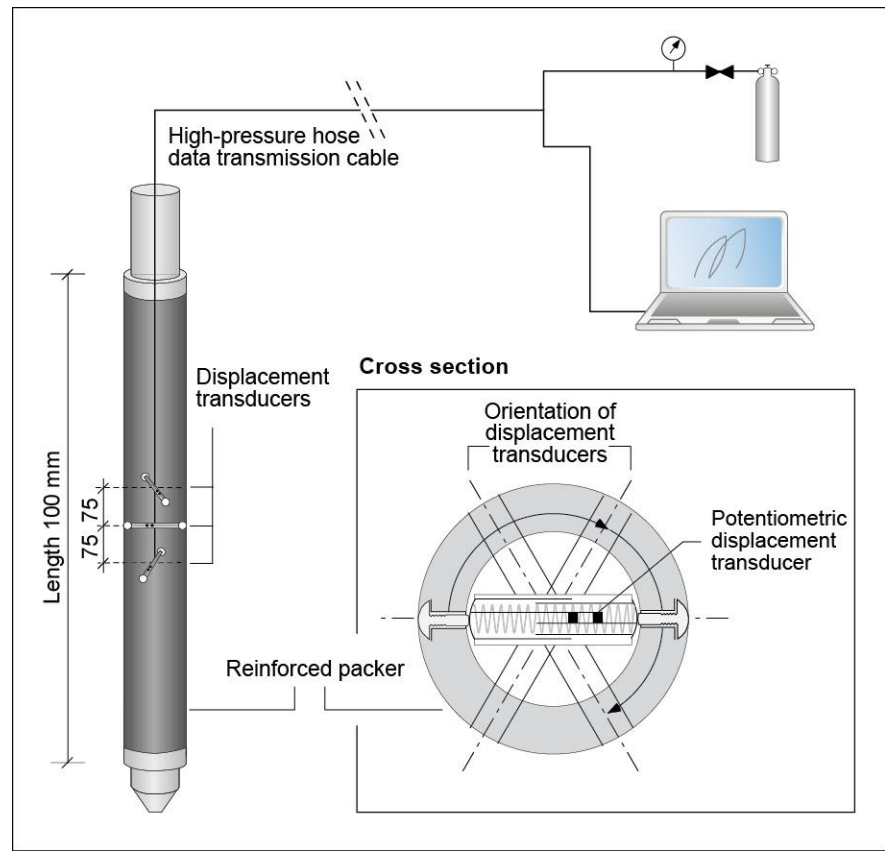


Riedberg Tunnel, Switzerland, monitoring unstable slope



Swiss Precision Geomonitoring

# Geomechanical Testing, Deformation Modulus



Dilatometer, probe diameters, 92, 96, 118, 142, 152, 216mm

V-Modulus 1200 MPa, E-Modulus 2100 MPa





# Large Scale Test in Foundation Engineering

## Determination of the soil structure interaction prior to construction

- Pile load test, interaction between pile and soil
- Embankment loading test on compressible soils



# Pile Load Test

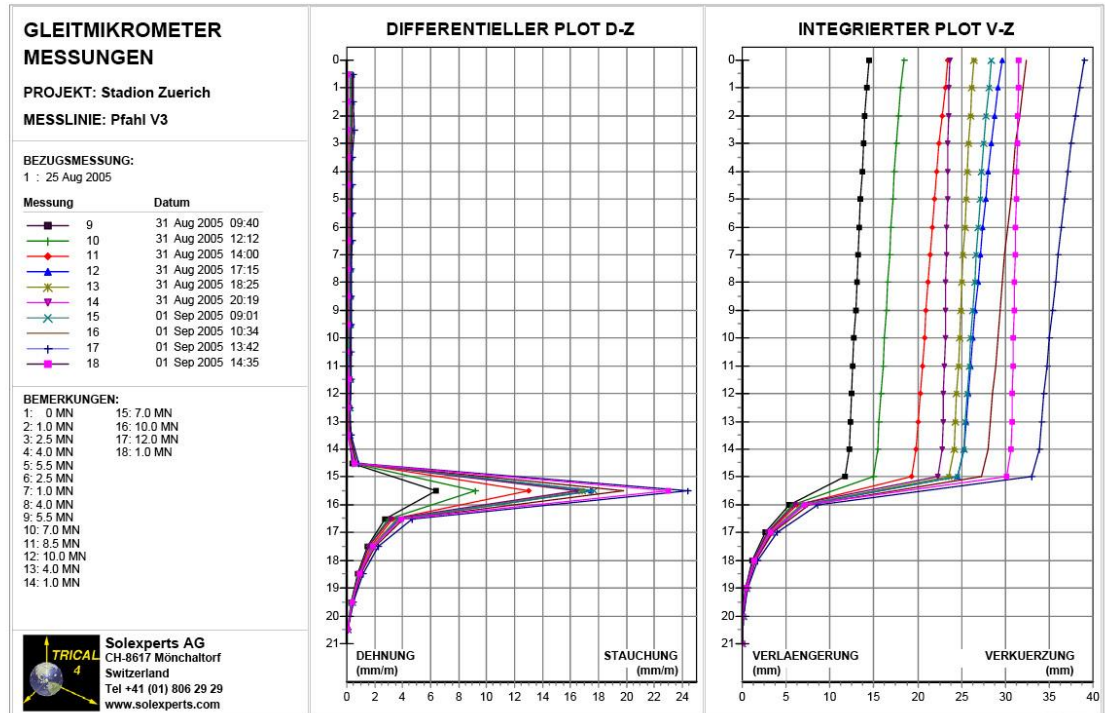


Stadium Hardturm, Zürich, pile diameter 1.20m length 15.0 m  
measurement of strain distribution with Sliding Micrometer

# Measurement of Strain within the Pile, Sliding Micrometer

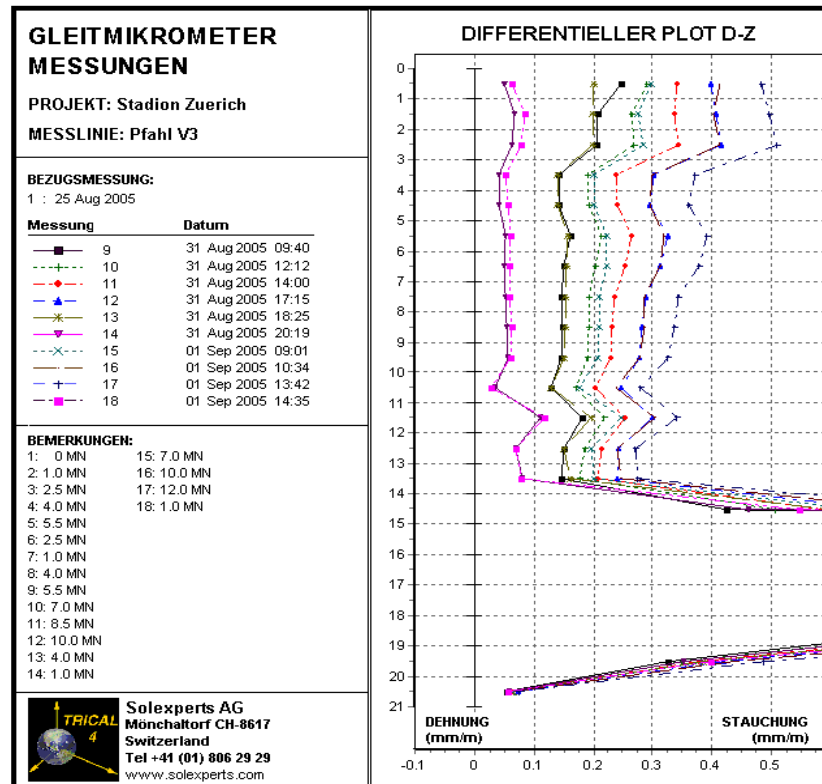


Sliding Micrometer



Differential and integrated displacements  
At load of 1200 to 0.33mm/m over the length of 15.0 m

# Sliding Micrometer, differential displacement along Pile



Strain distribution to the depth of 15 m (pile) showing small scatter (homogenous) concrete but low mobilisation of friction

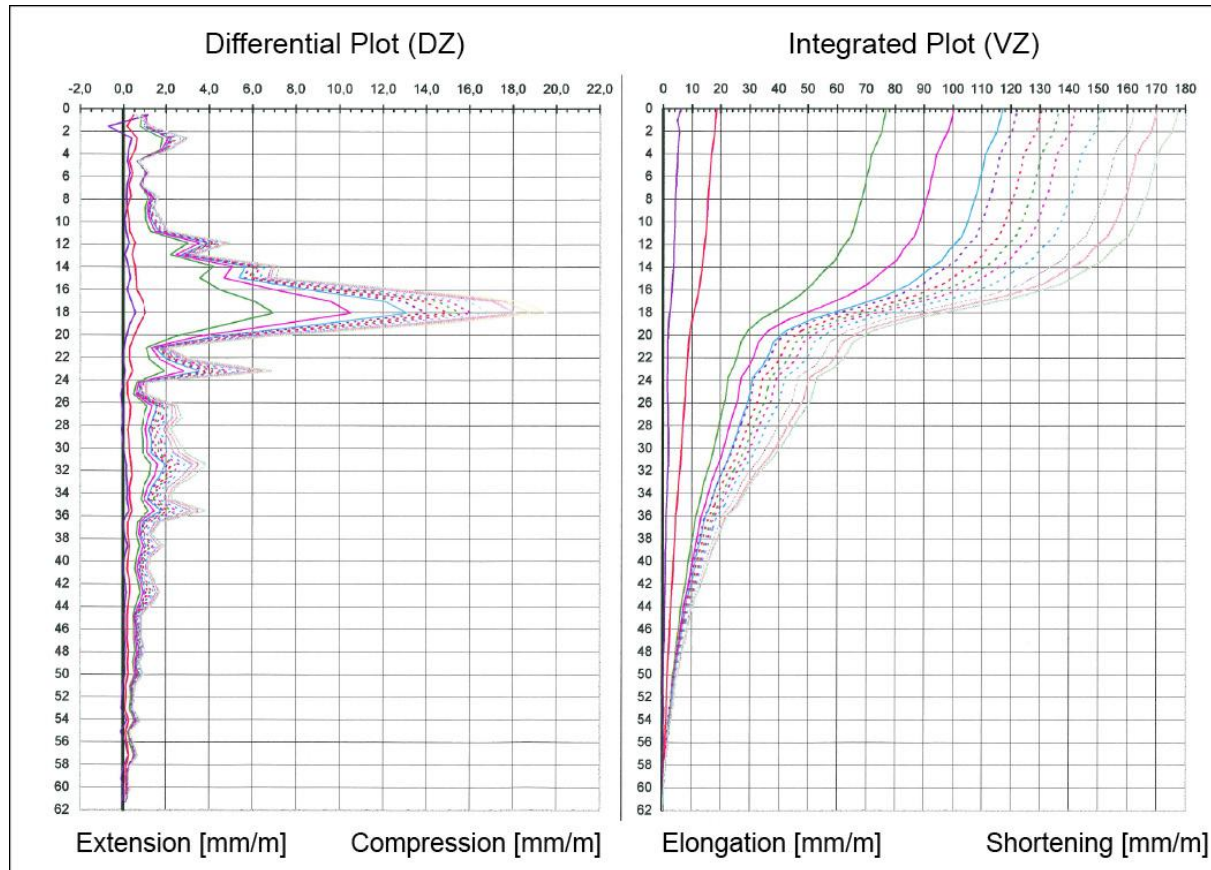
# Embankment Loading test on soft soil



Loading test Bocca di Lido, Venezia, Italy



# Distribution of settlement under embankment load



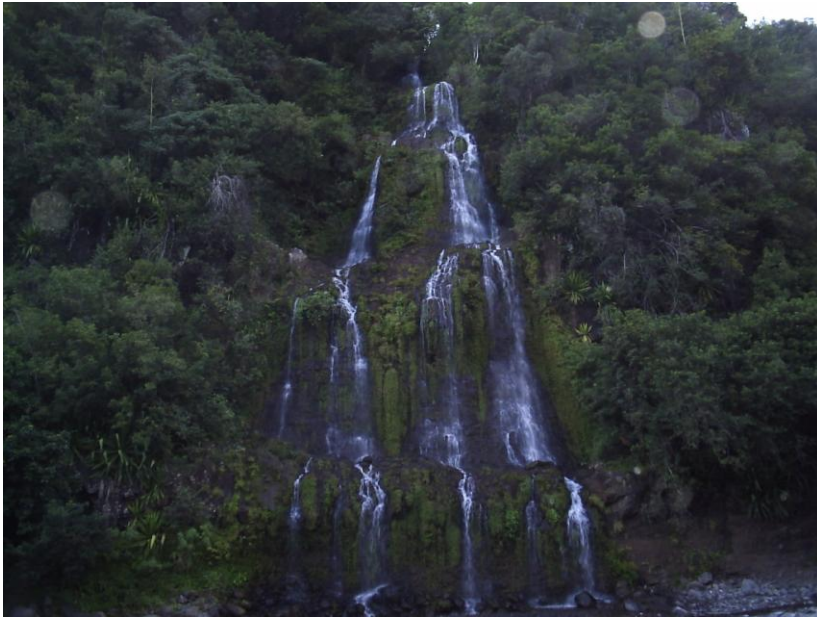
Displacement distribution along a measuring line of 62 m showing soft soil between 14 and 15 m



# Advance Tunnelling Exploration

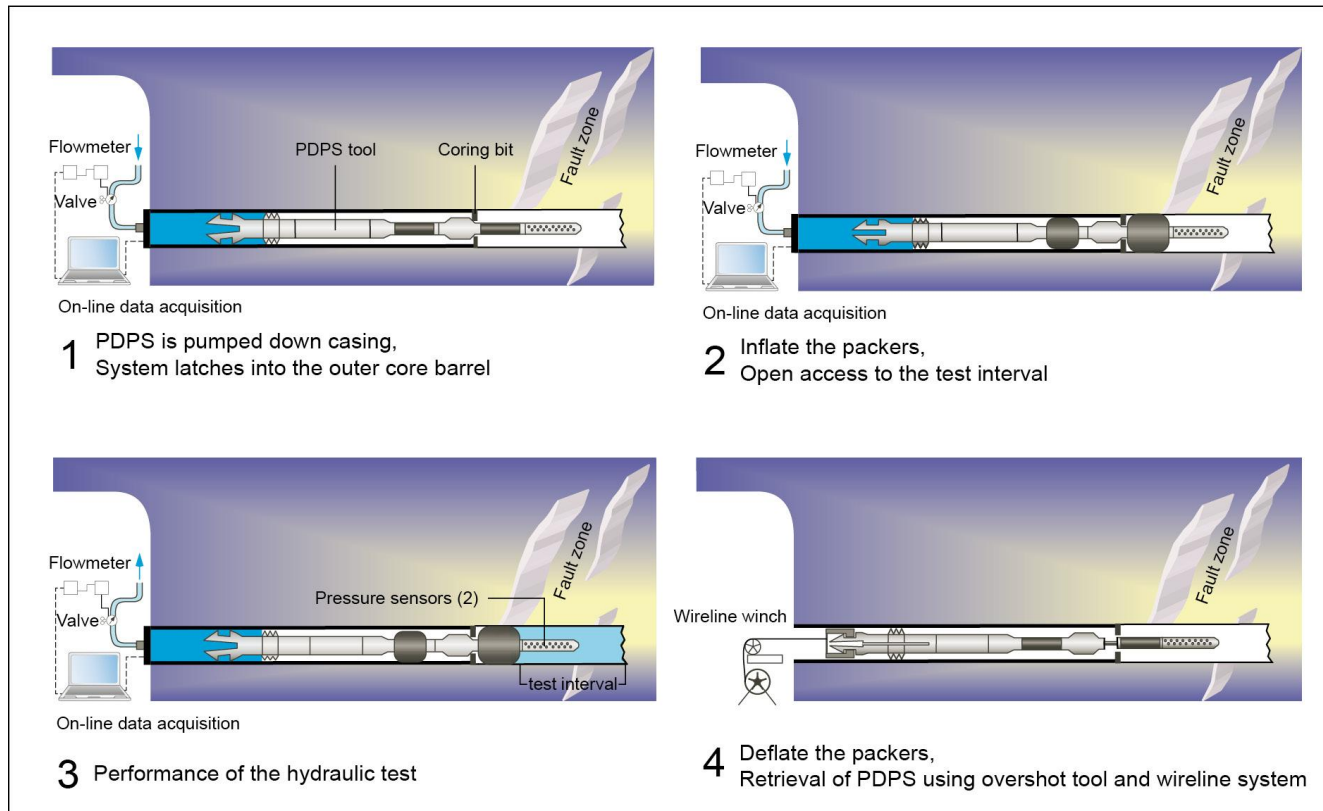
- Hydrogeological investigation in advance of the tunnel face with Pump Down Packer System (PDPS).
- Geomechanical investigation in advance of the tunnel face with Reverse Head Extensometer (MRHX)

# Advance Hydrogeological Tests



La Réunion, France, volcanic rock with dykes, large inflow of water

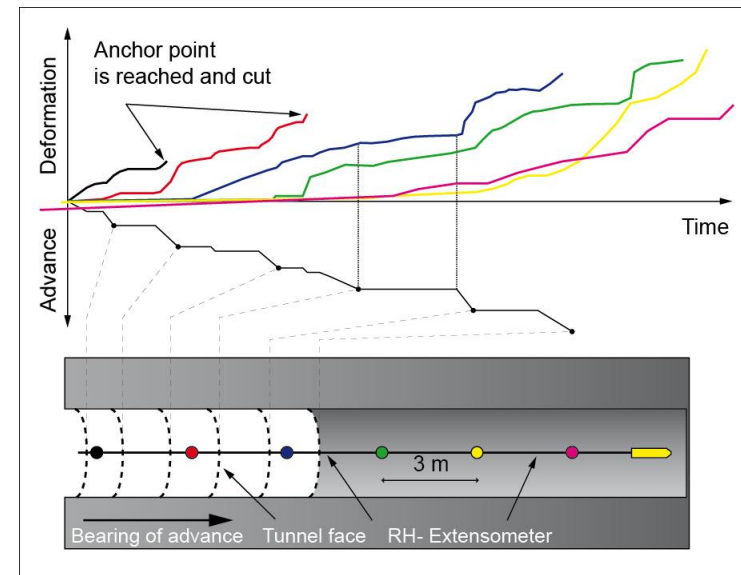
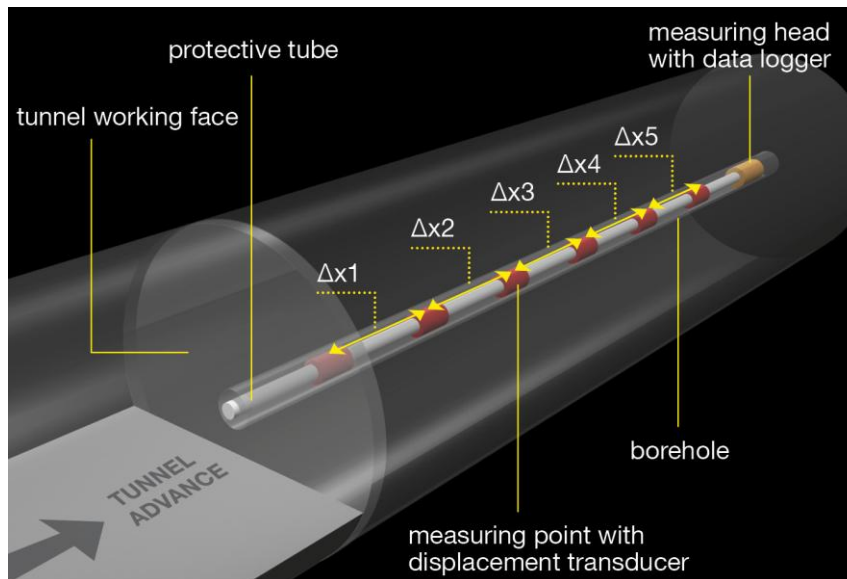
# Advance Hydrogeological Test with PDPS



## Pump Down Packer System

# Advance Geotechnical Investigation

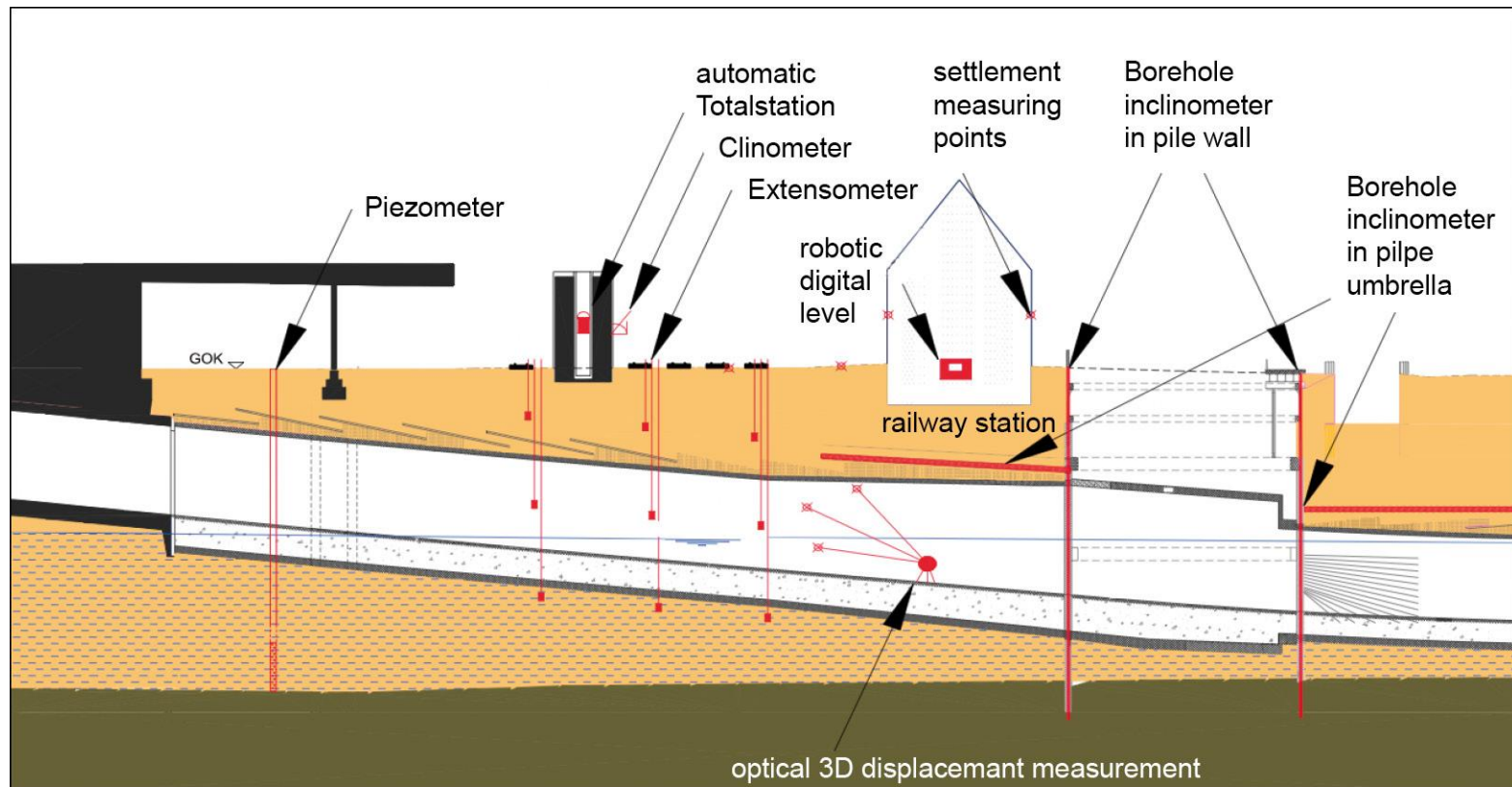
## Reverse head Extensometer MRHX



**Permanent displacement measurement ahead of the excavation (Extrusion)**  
**Installed from the tunnel face**

**Measuring results displacement vs. time**  
**Excavation advances, anchor cut**

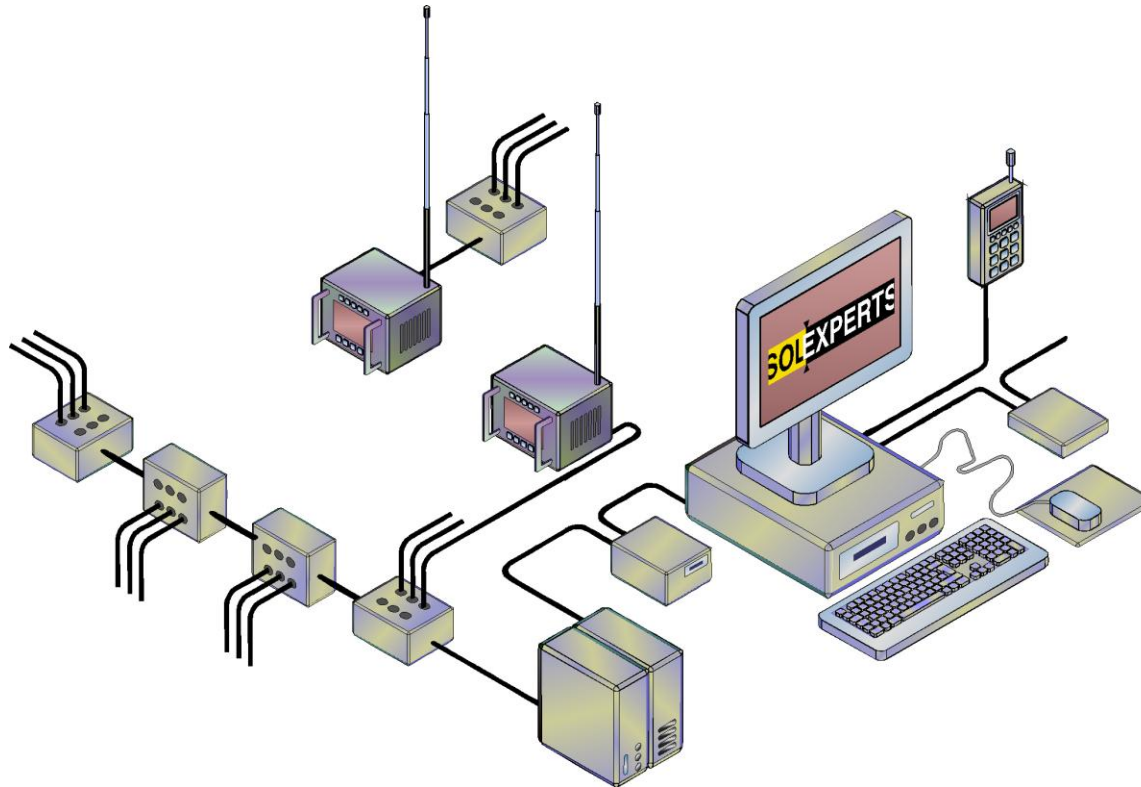
# Geotechnical Measurements and Monitoring of Structures and Soil Settlement



Basel, Luzernerring, Northern Bypass, Switzerland

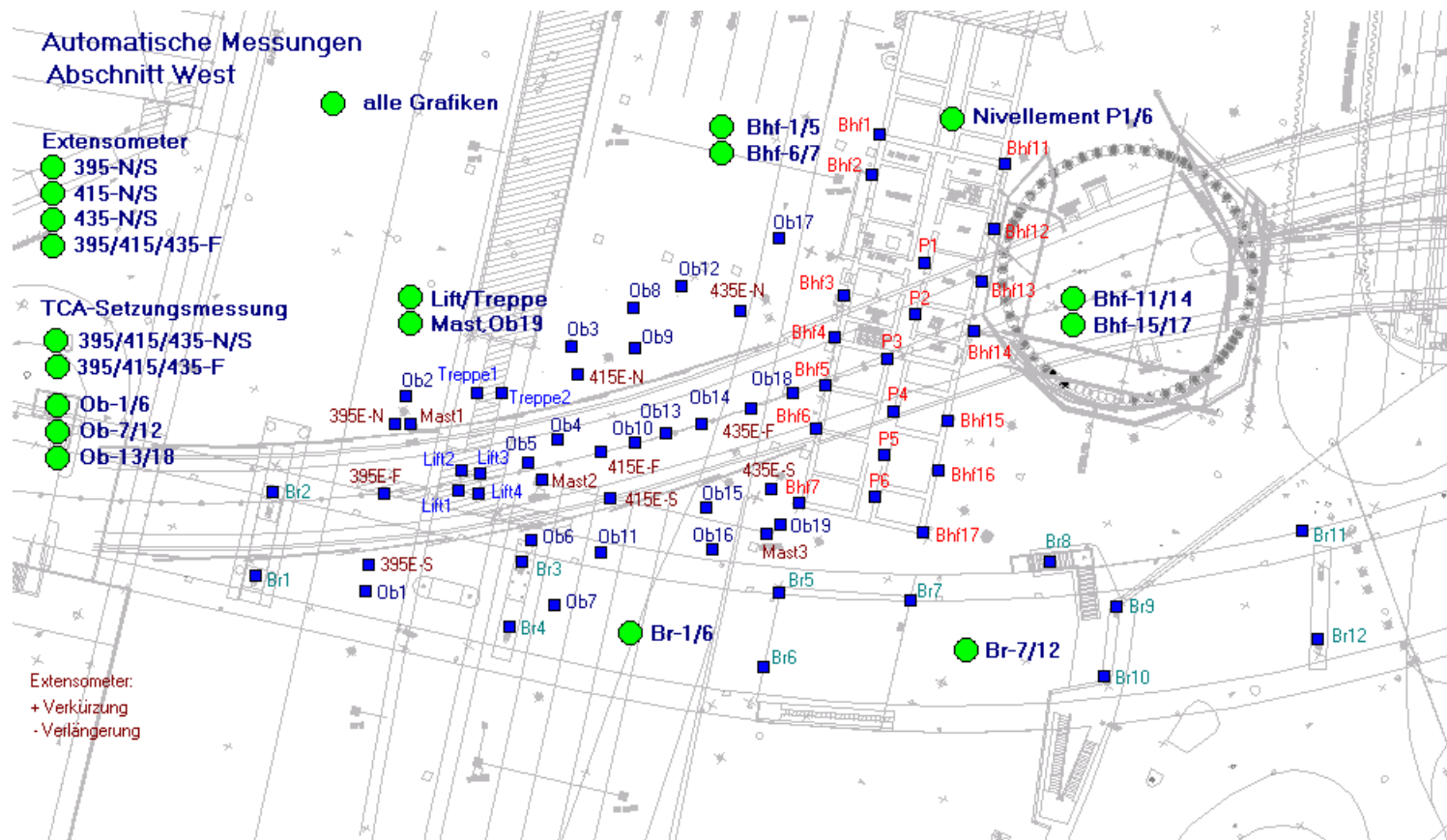


# Geomonitor 2, automatic data acquisition



Automatic reading of sensors with various signals (potentiometric, VW, digital etc.)

# Web Davis, Data Visualisation, Section West



Basel, Luzernerring, view of the monitored area, with location of instruments

# Optical Instruments read by GEOMONITOR

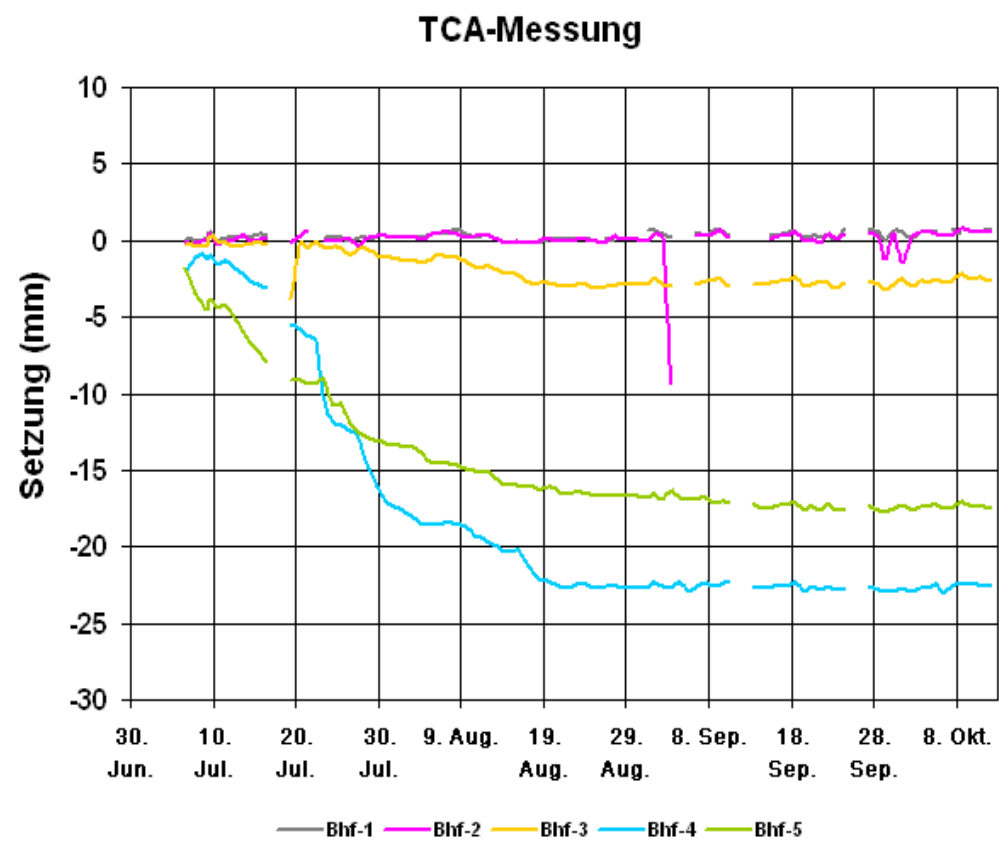


Theodolite



Digital Level, motorised

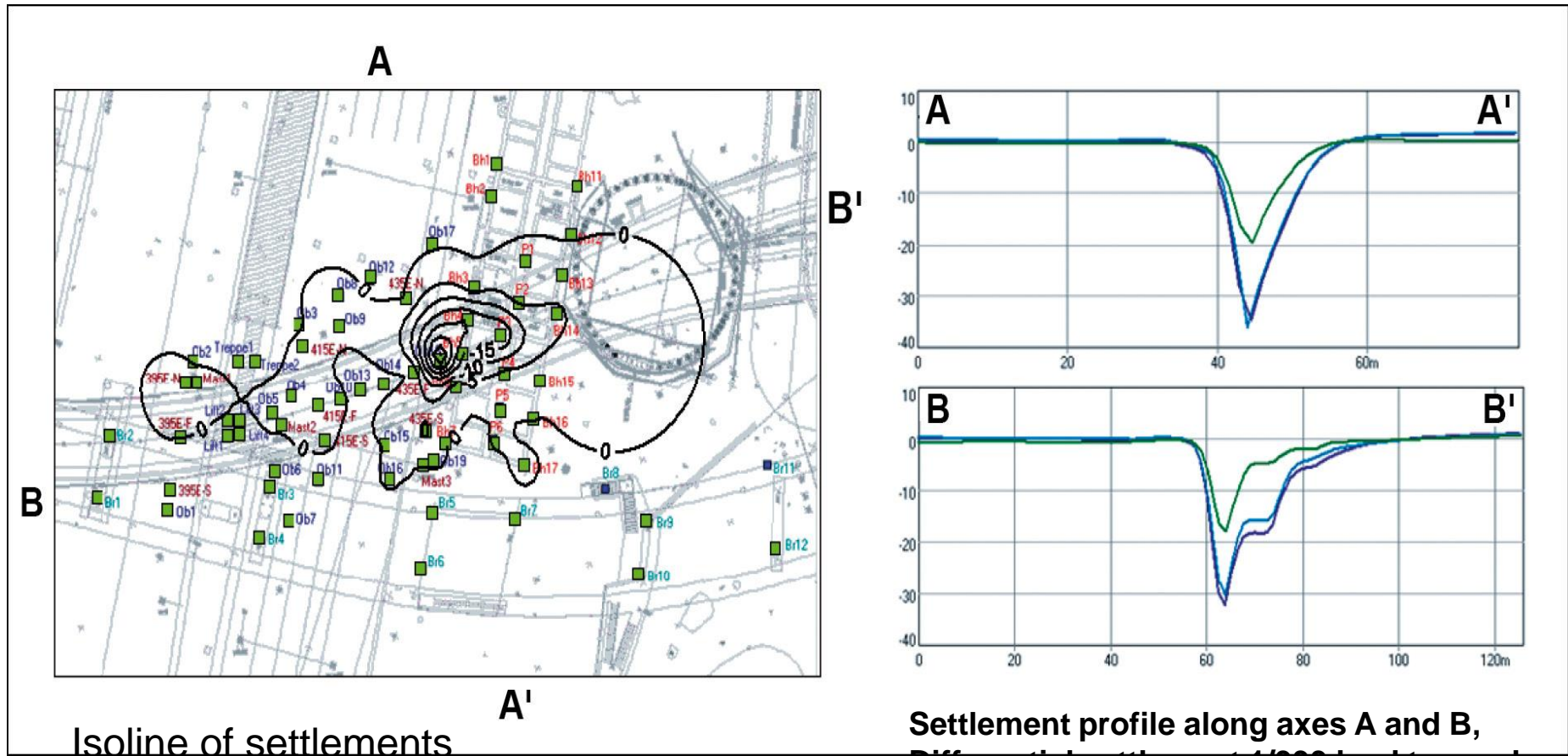
# Web Davis, Plot



Basel, Luzernerring, Settlement vs. time of the St. Jakob Station



# Basel, Luzernerring Settlements Presented with Web Davis



Isoline of settlements

Settlement profile along axes A and B, Differential settlement 1/333 lead to cracks in the railway station

# Installation and Instruction to the Client is important for the proper Function



Rokkasho, Japan, low and medium nuclear waste repository, installation of Multiple Packer System

**We can't avoid any risk but we can minimize it**



Thank you for your attention



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