Staatstoezicht op de Mijnen
Ministerie van Economische Zaken en Klimaat

The legacy of coal mining in Limburg

Coal mining and lagging effects of mining

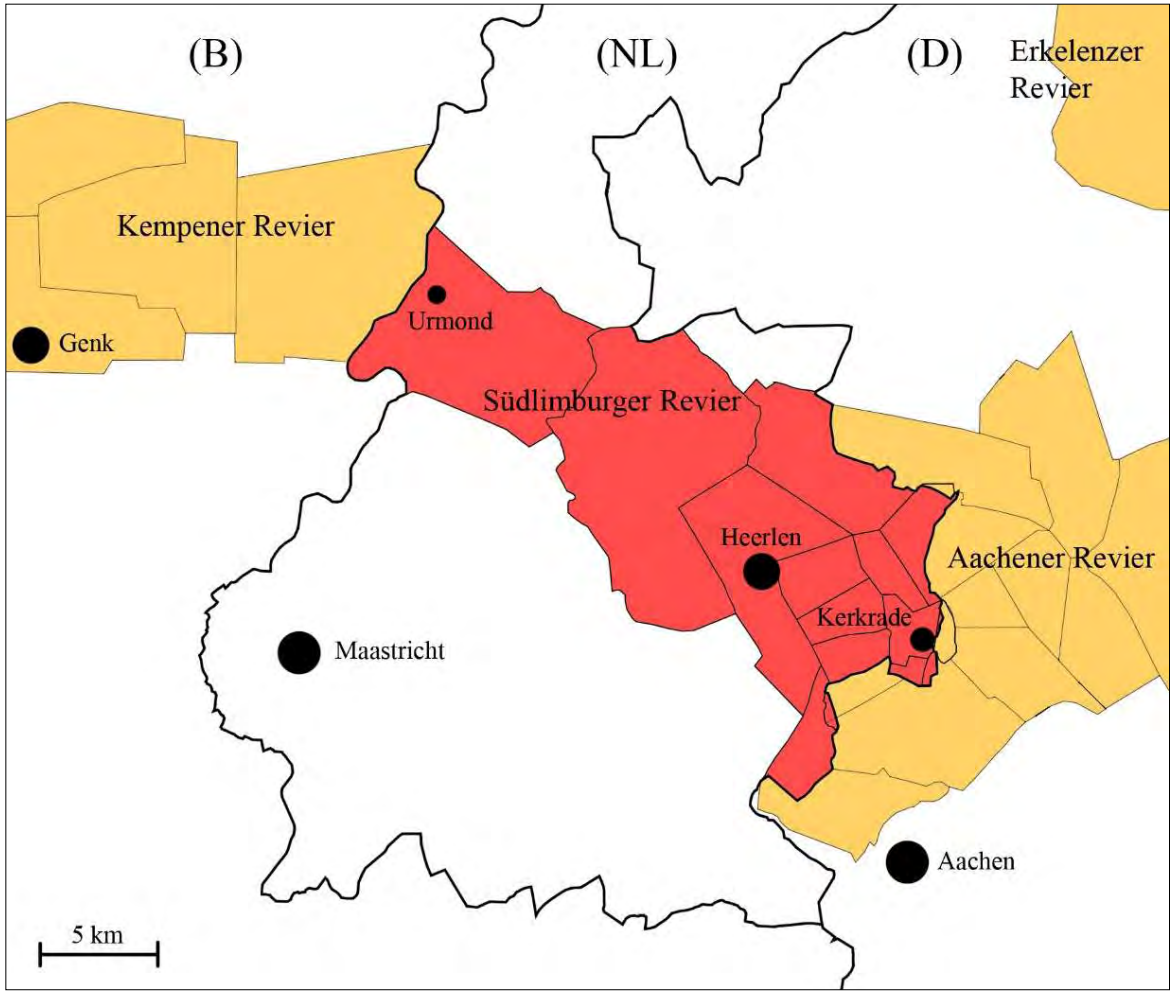
Management of post mining risks, ‘monitoring and control’

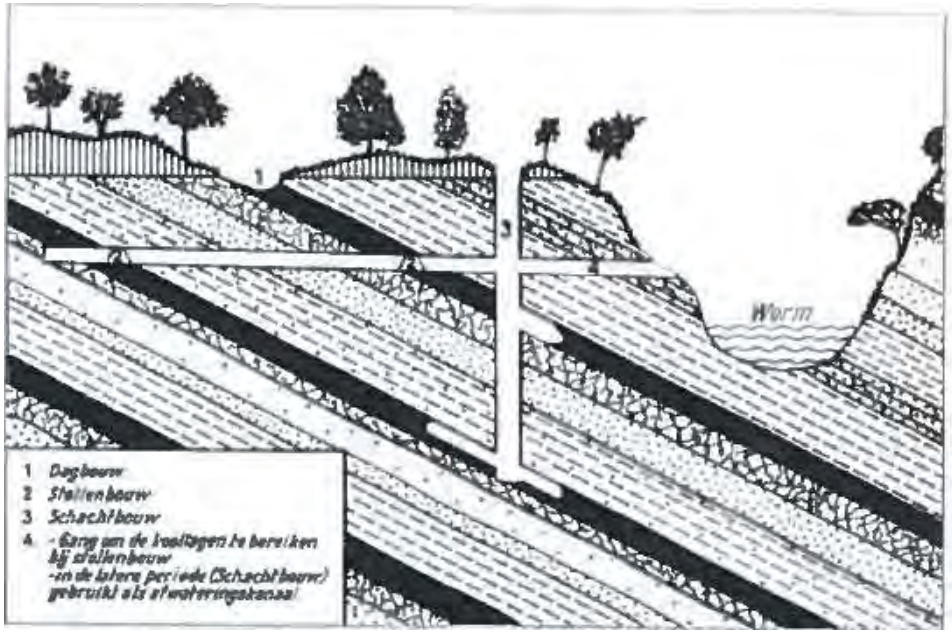
Lessons learned

Sustainable Post-Mining

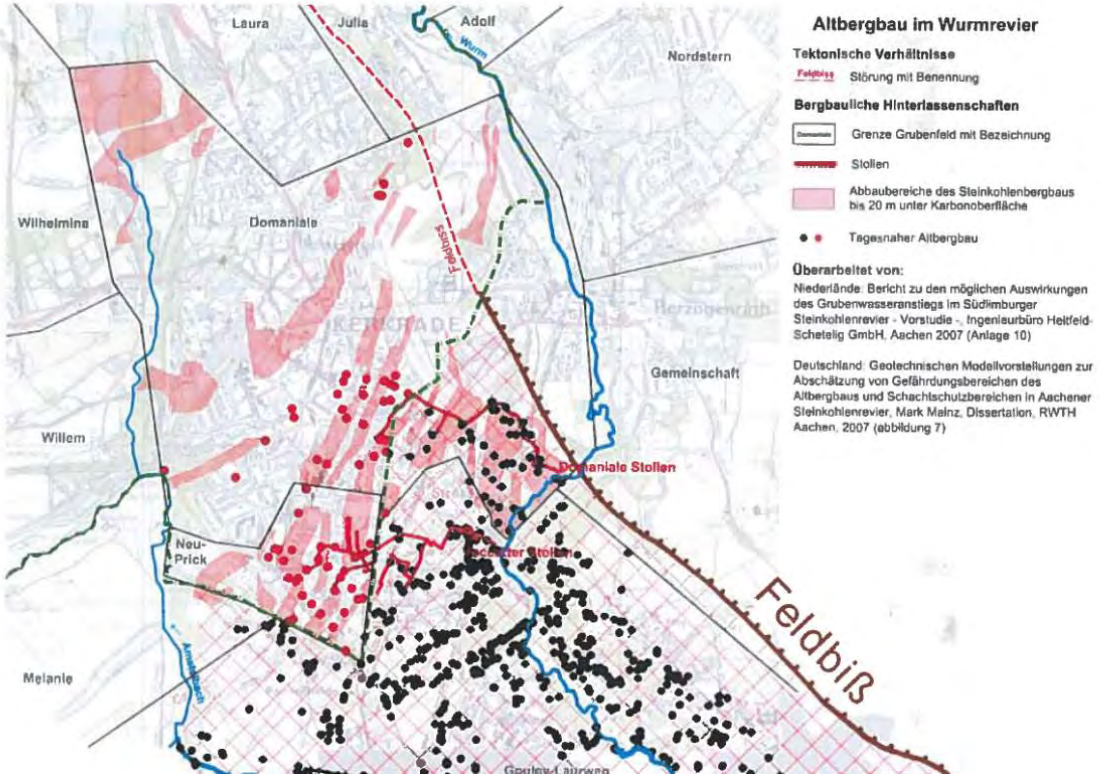
Delft, 15 nov. 2019
Ir. J.P.A.Roest

Coal mining South Limburg





Coal mining since 1113 AD

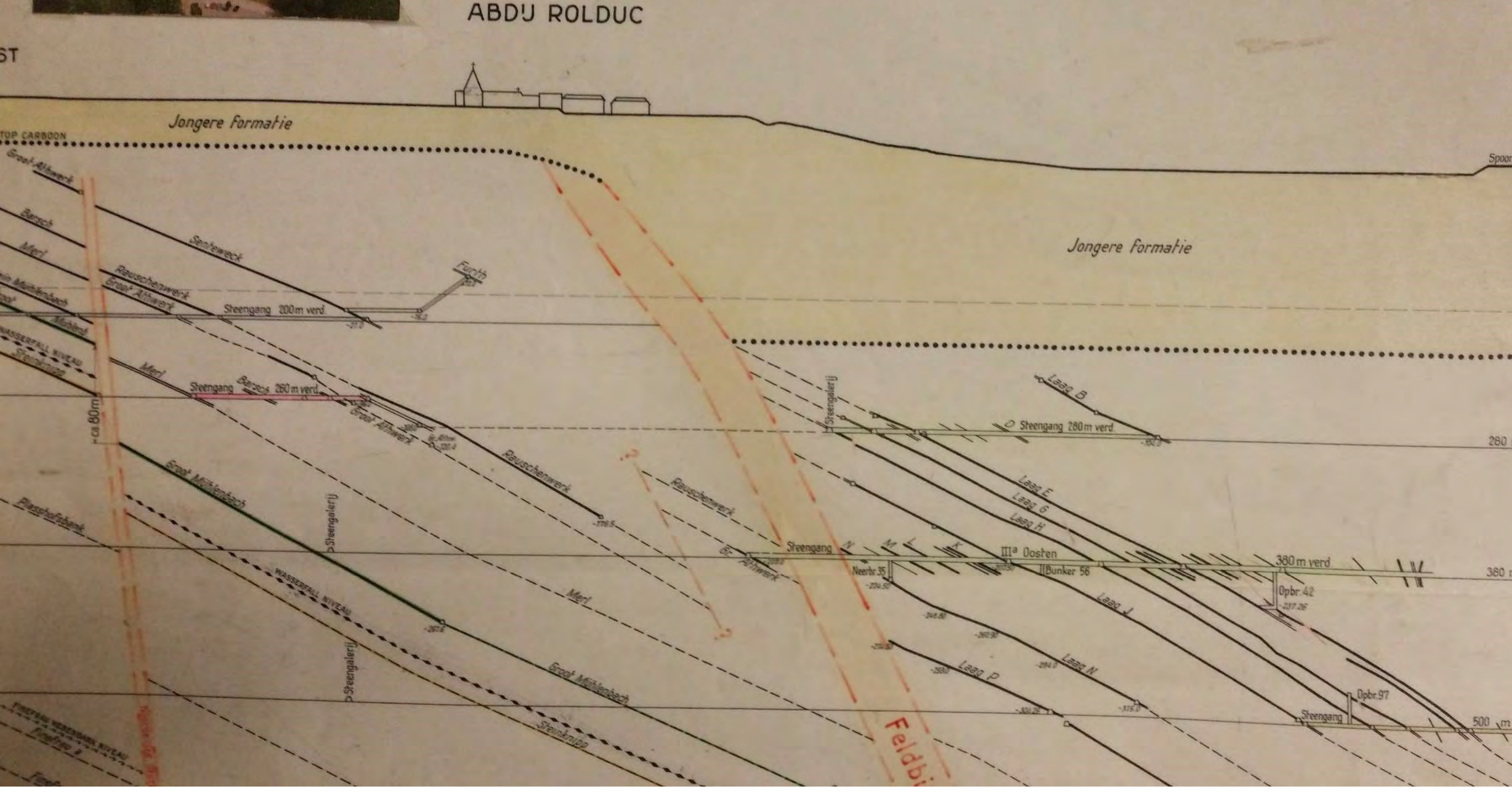

Laura
Julia
Adolf
Wurm
Nordstern
Wilhelmina
Domaniale
Feldbiß
Gemeinschaft
Willem
Domaniale Stollen
Neu-
Prick
Melanie
Feldbiß
Altbergbau im Wurmrevier
Tektonische Verhältnisse
Störung mit Benennung
Bergbauliche Hinterlassenschaften
Grenze Grubenfeld mit Bezeichnung
Stollen
Abbaubereiche des Steinkohlenbergbaus bis 20 m unter Karbonoberfläche
Tagesnaher Altbergbau
Überarbeitet von:
Niederlände: Bericht zu den möglichen Auswirkungen des Grubenwasseranstiegs im Südlimburger Steinkohlenrevier - Vorstudie -, Ingenieurbüro Heitfeld-Schetelig GmbH, Aachen 2007 (Anlage 10)
Deutschland: Geotechnischen Modellvorstellungen zur Abschätzung von Gefährdungsbereichen des Altbergbaus und Schachtschutzbereichen in Aachener Steinkohlenrevier, Mark Mainz, Dissertation, RWTH Aachen, 2007 (abbildung 7)

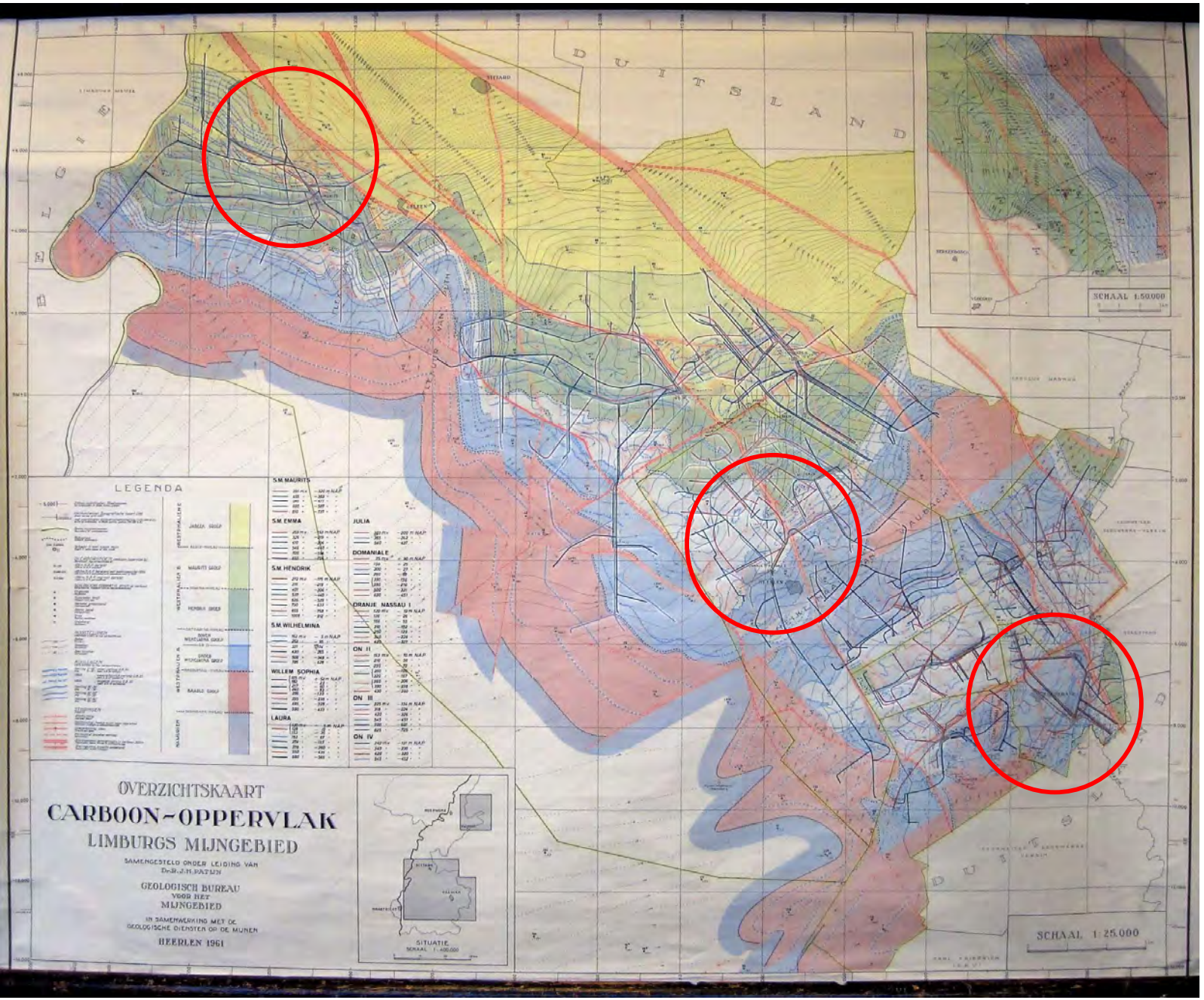
Profiel

Steengang III^a Oosten 380 m verdieping

Volgens profiellijn A - B

Schaal 1:2000





Domaniale 1847-1969

Oranje Nassau I 1899-1974

Maurits 1923-1967

Neue Furth, famous for its *Pumpenkunst*

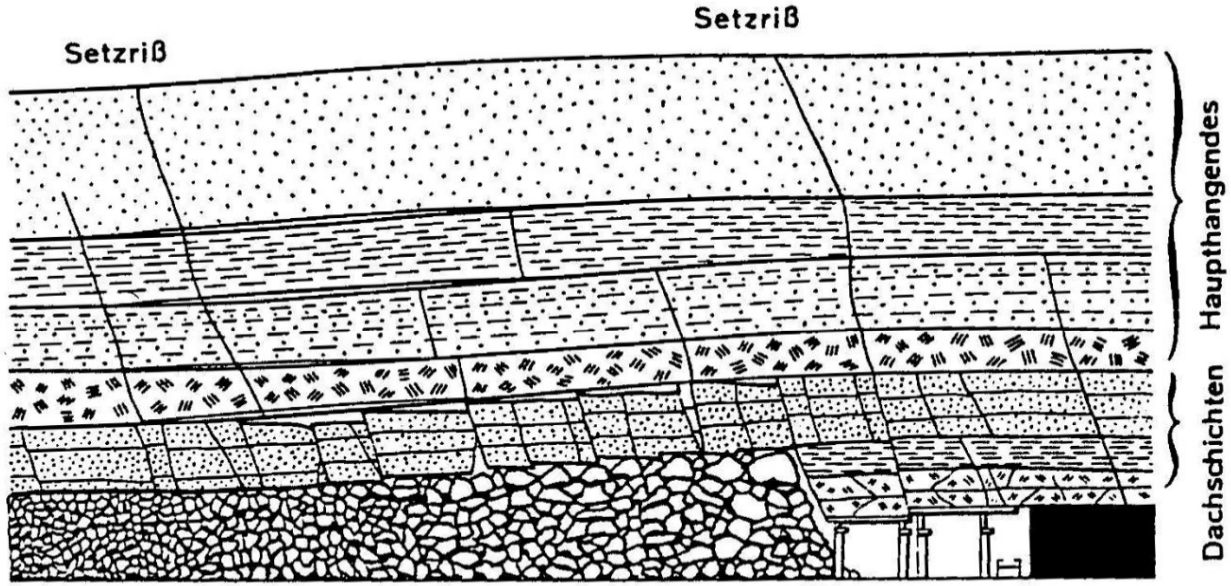


Bild 23: Die Bruchverformung der unteren Hangendschichten beim Strebbruchbau (Kratzsch)

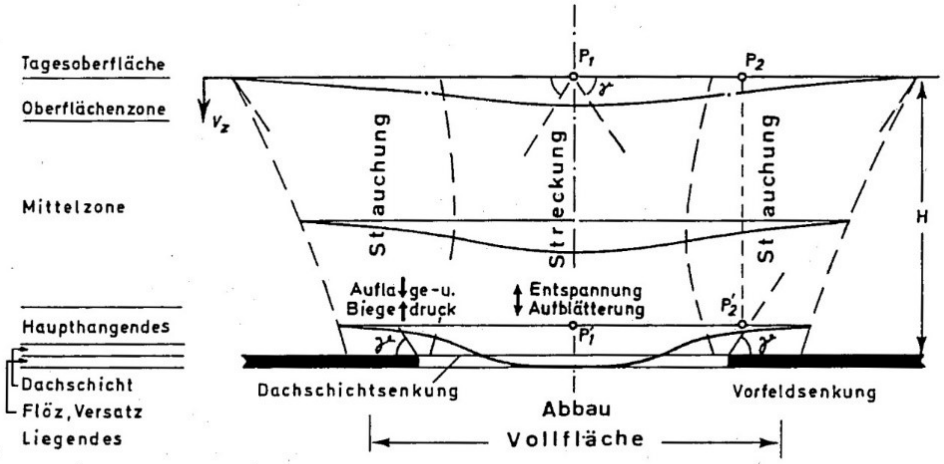
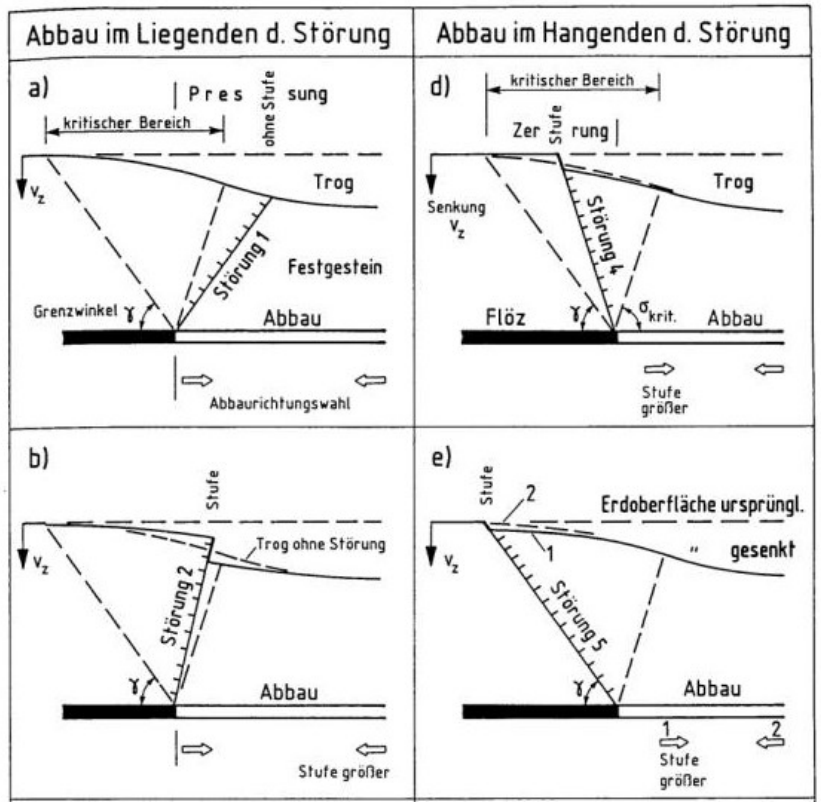


Bild 41: Die lotrechte Verformung eines unterbauten Gebirgskörpers bei flacher Lagerung (Abbauteilfläche)



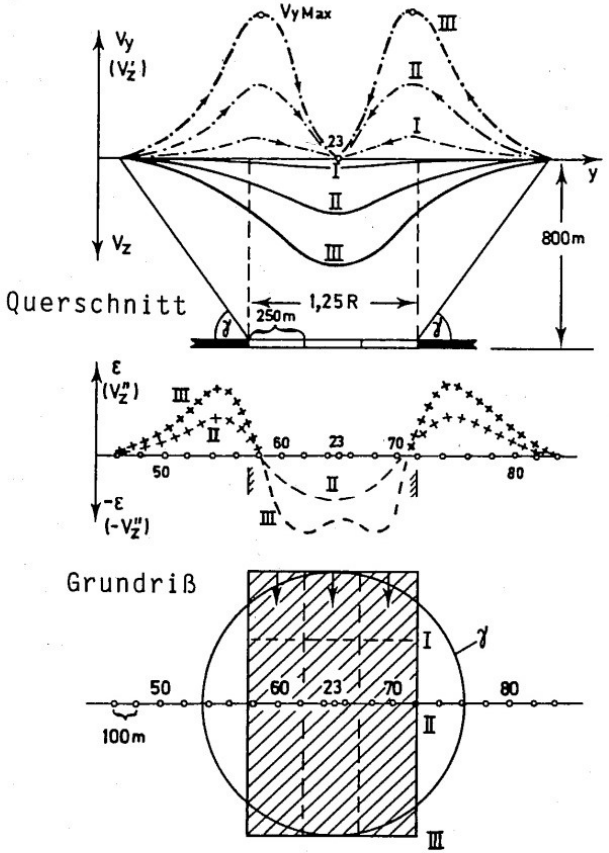


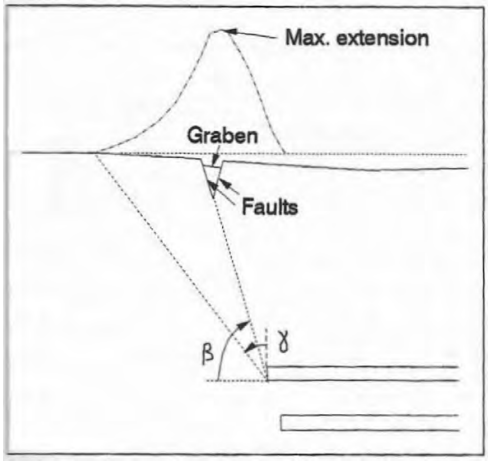
Bild 66: Die Bodenbewegung parallel zur Abbaufront (Endstand der Bewegung) entlang der Linie 50-80 in Abhängigkeit von den Lagen I, II und III der Abbaufront dreier gleichlaufender Streben. Oben: Kurven der Verschiebung v_y (oder Schieflage v'_z) und Senkung v_z der Bodenpunkte. Mitte: Kurven der Zerrung $+\varepsilon$ (oder konvexen Krümmung v''_z) und Pressung $-\varepsilon$ (oder konkaven Krümmung $-v''_z$). Unten: Grundrißplan mit Vollflächenkreis

Kratzsch, 1984

Example of damage due to coal production

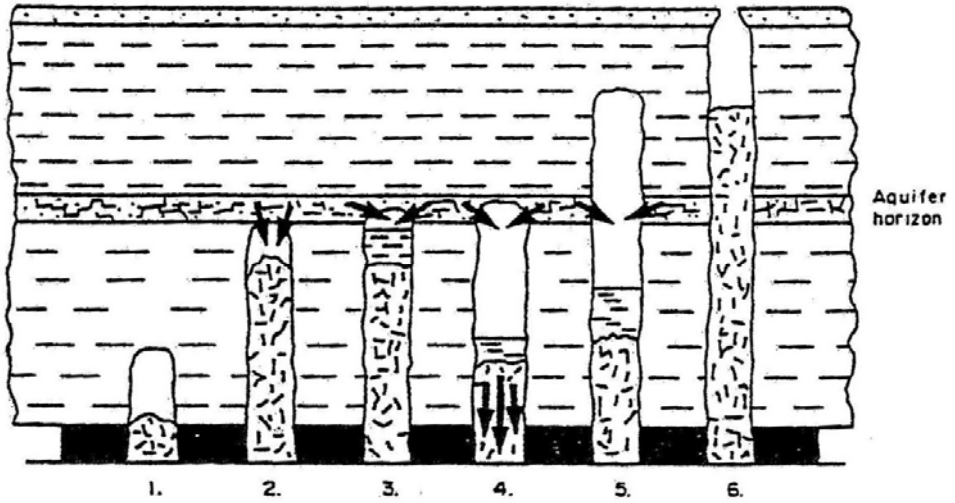
Example of a surface step during coal production

See roof and damage pattern



Surface step, Bekendam

Example of a sinkhole



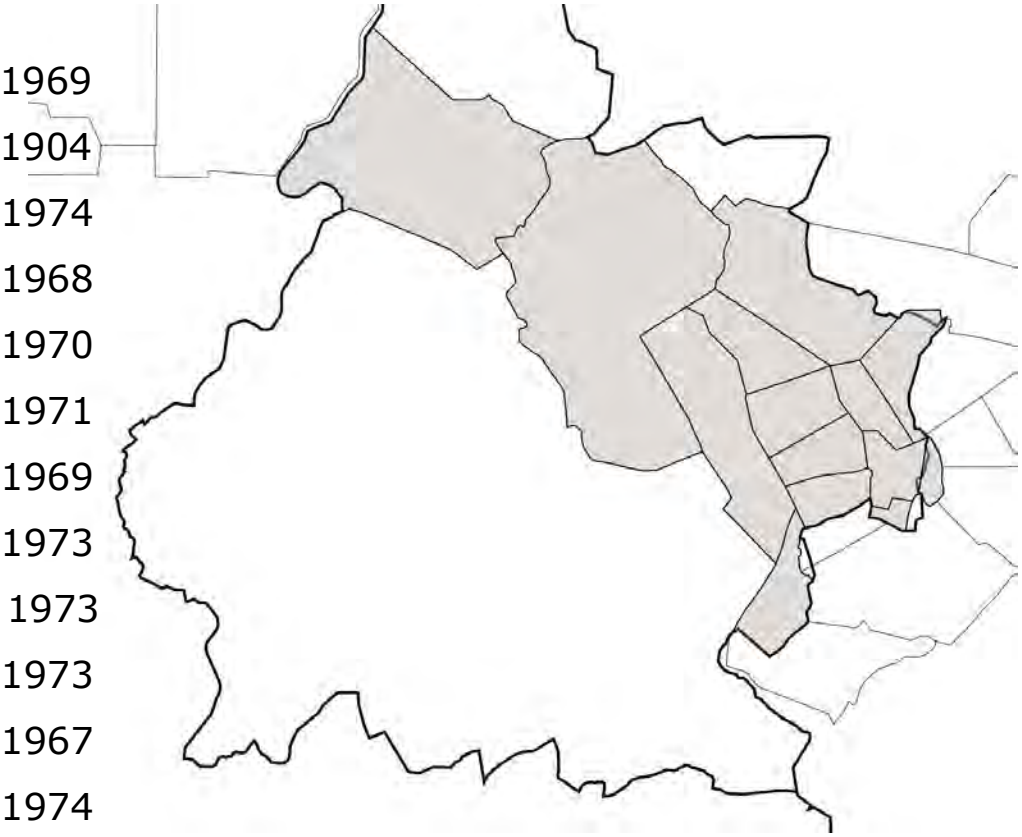
Sinkhole development stages

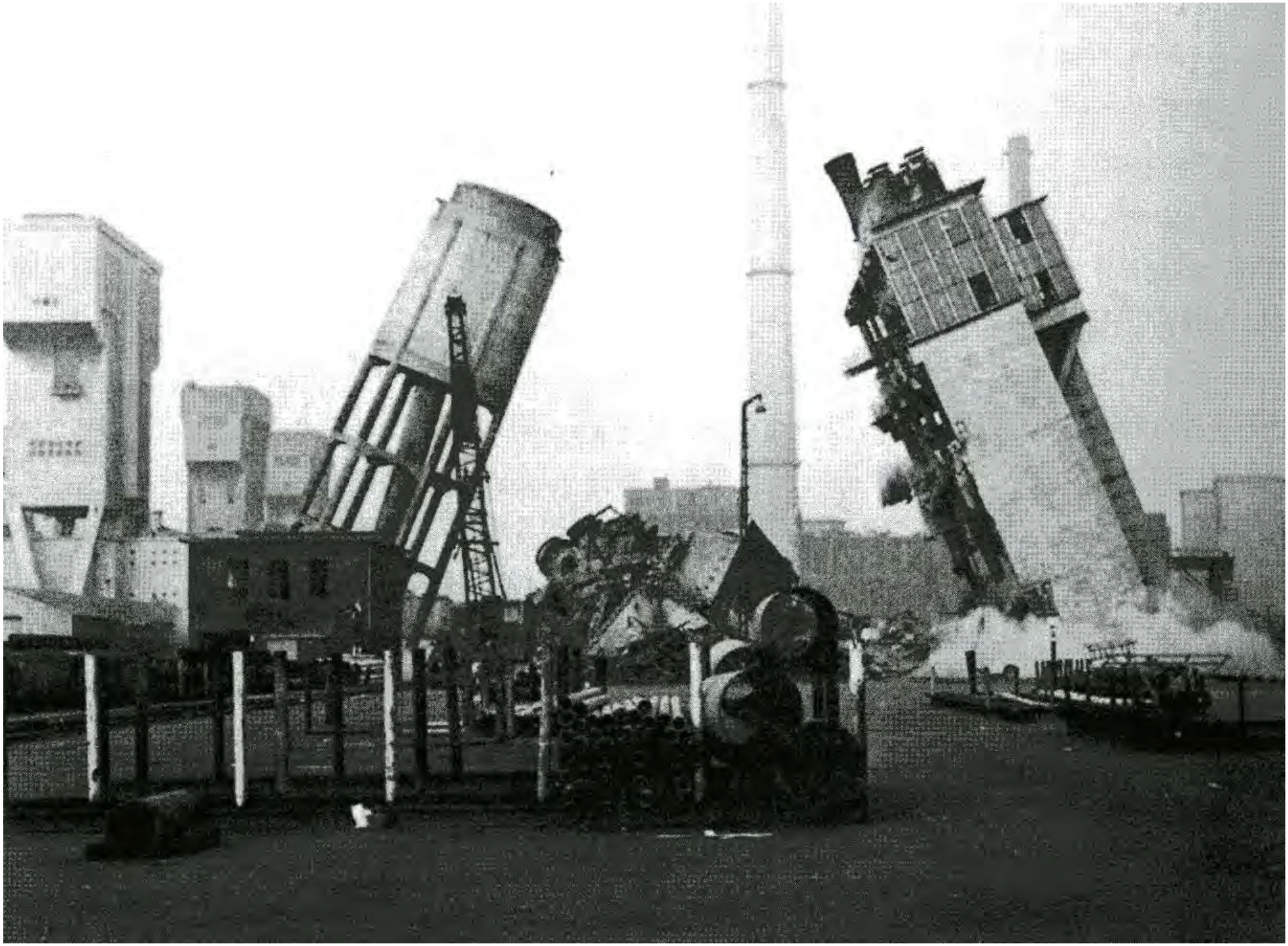
1. Early stage in development.
2. Chimney taps aquifer horizon and allows water to drain into cavity.
3. Build-up of water pressure by ponding can promote instability of plug of caved rock and result in flowing into mine
4. Caved mass flows into adjoining mine rooms.
5. Chimney continues caving due to increased available space for broken rock.
6. Sinkhole can emerge at surface from considerable depths (greater than 10 H).

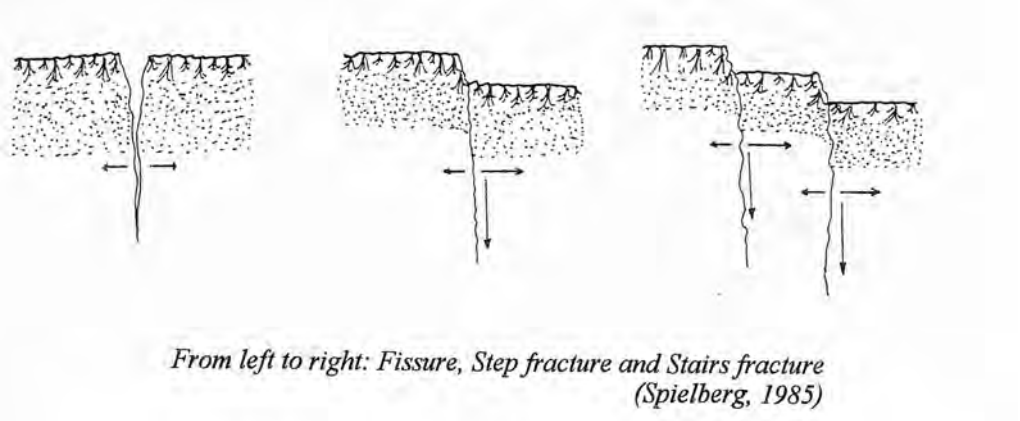
Influence of collapse chimney intercepting an overlying aquifer and changing the potential caving height above a collapsed mine junction (after Whittaker [38])

Coal production

Domaniale:	XI	- 1969
Neuprick:	XI	- 1904
Oranje Nassau I:	1899	- 1974
Laura:	1901	- 1968
Willem-Sophia:	1902	- 1970
Oranje Nassau II:	1904	- 1971
SM Wilhelmina:	1906	- 1969
SM Emma:	1911	- 1973
Oranje Nassau III:	1914	- 1973
SM Hendrik:	1918	- 1973
SM Maurits:	1923	- 1967
Julia:	1926	- 1974







From left to right: Fissure, Step fracture and Stairs fracture (Spielberg, 1985)

ISSN: 1386-5072

The Registration and Analysis of Engineering Geological and Hydro-geological Data in the Field of an Instability Zone in the Ruhr District

Memoir of the Centre of Engineering Geology in the Netherlands, no.134

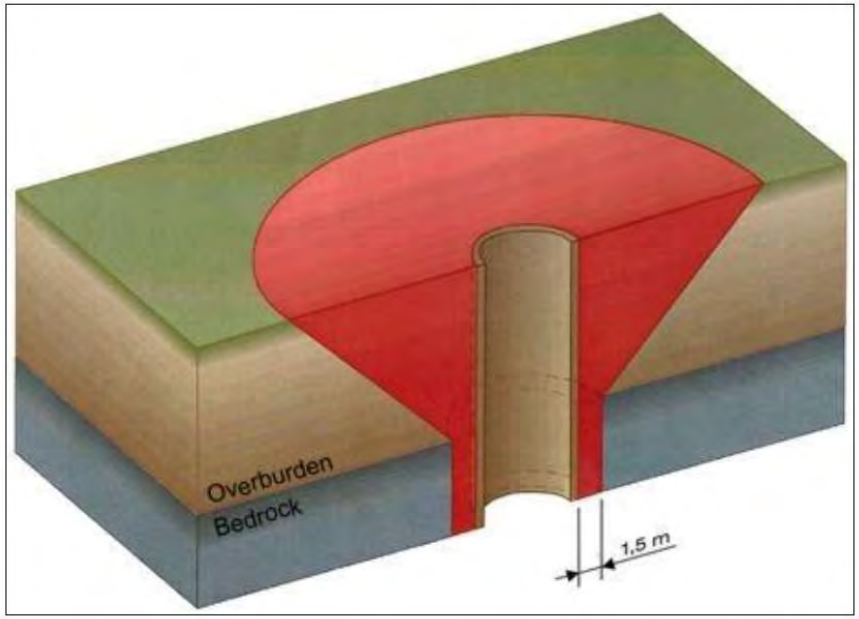
D.I. Post

Confidential

TU Delft
Delft University of Technology

Faculty of Applied Earth Sciences
Section Engineering Geology

Remediation shafts in Germany (Domaniale mine)



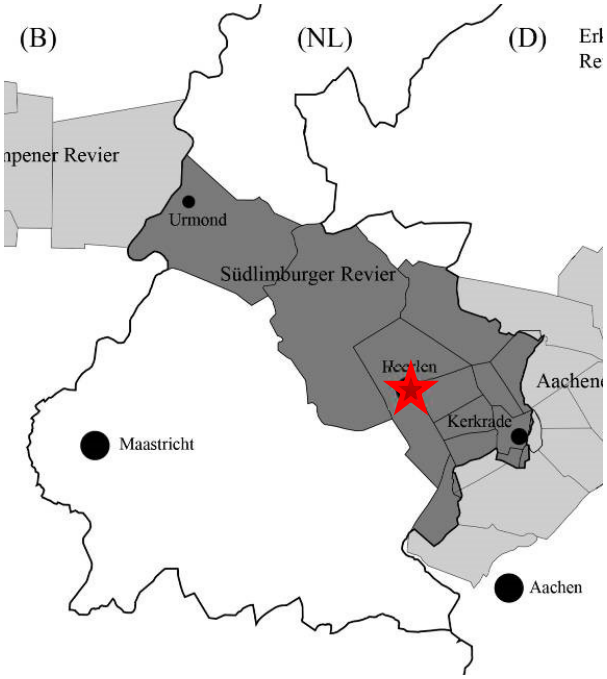
1: Schematic profile of the Shaft-Protection-Zone of a vertical mine shaft


Huinsch
323
Sch! W.I
Buiz.sch!
Sch! W.II
Opbr.343
Opbr.488
Steinkuil

Kerkrade

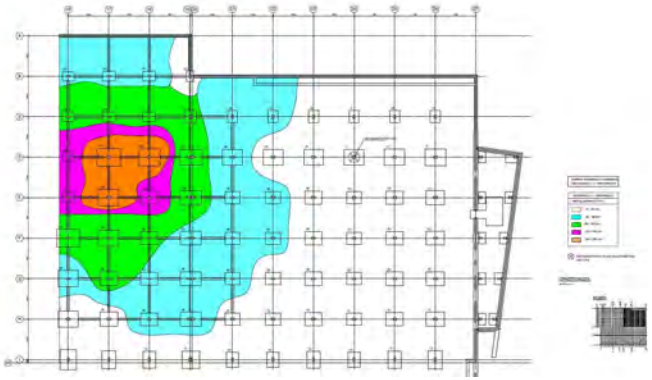

Huinsch
323
Sch! W.I
Buiz.sch!
Sch! W.II
Opbr.343

Signals shown before sinkhole shopping centre`t Loon, sept. 2011 Heerlen



Analyzing signals before sinkhole`t Loon, sept. 2011 Heerlen

Inclined pillars in garage



Subsidence pattern

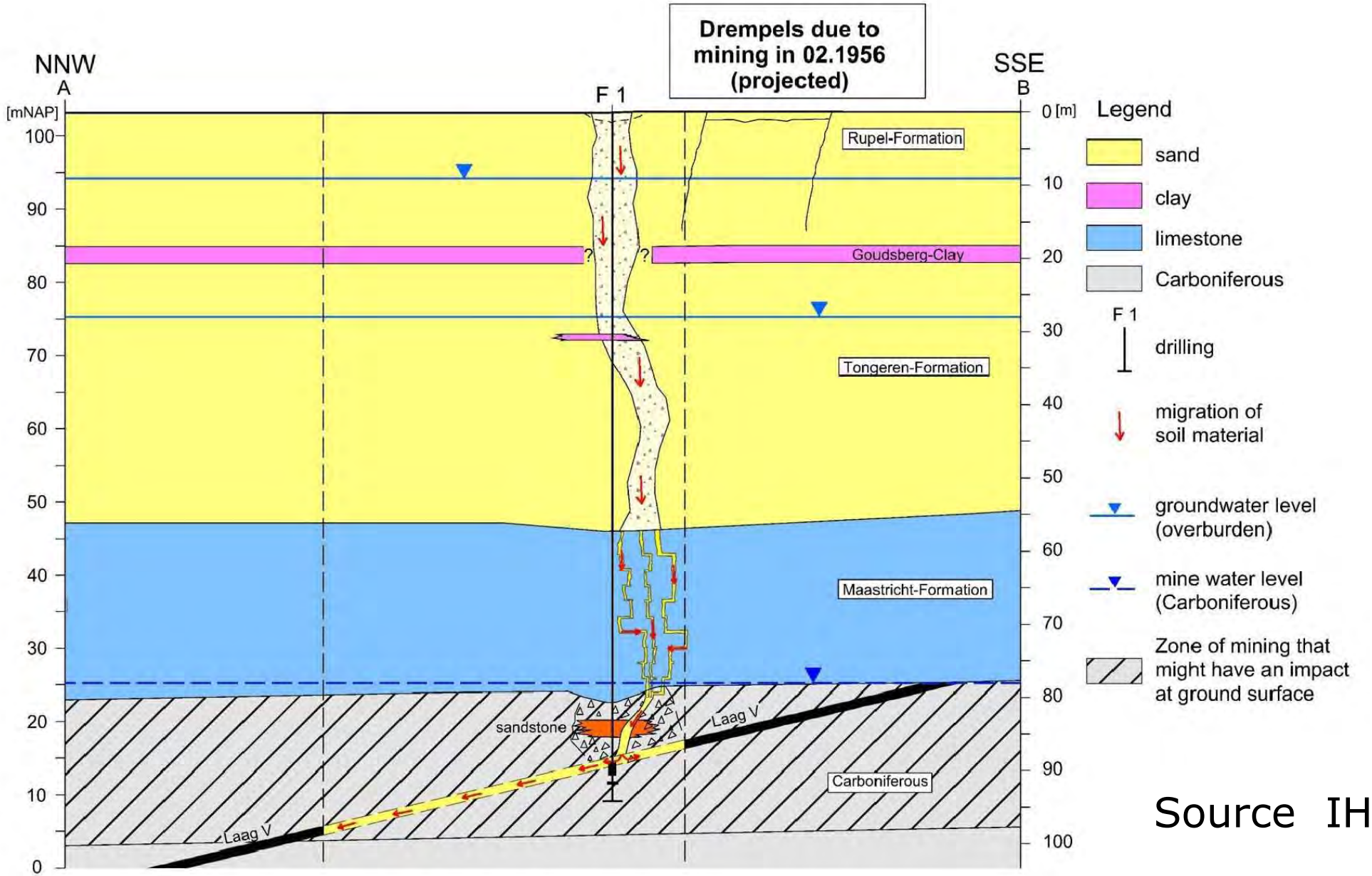
Analyzing mine maps at
'Regional historic centre Limburg'

3 dec. 2011

3 dec. 2011

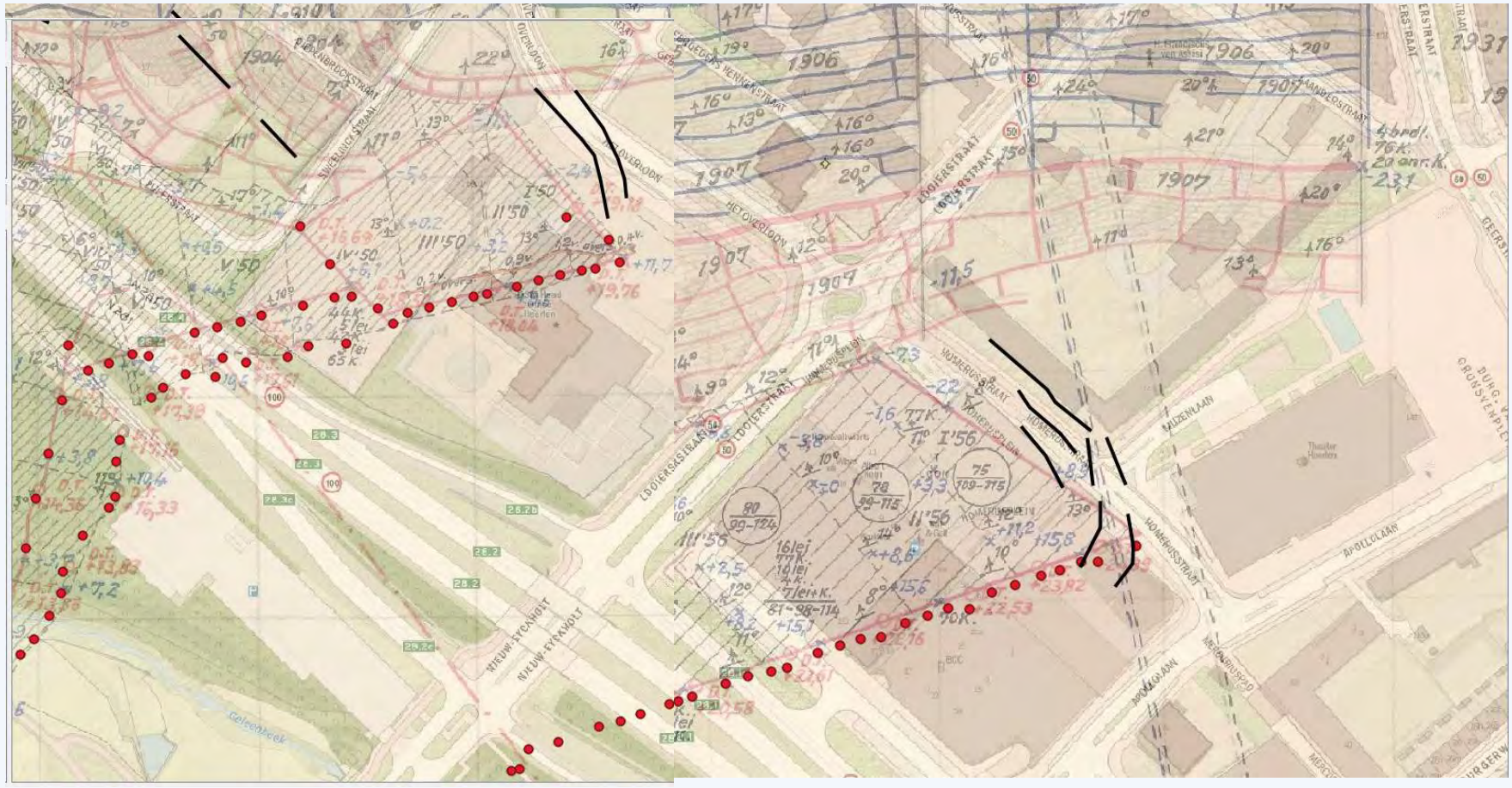
5 dec. 2011

Coal layer V - 1956


Drempels due to mining in 02.1956 (projected)
NNW
A
SSE
B
F 1
[mNAP]
100
90
80
70
60
50
40
30
20
10
0
0 [m]
10
20
30
40
50
60
70
80
90
100
Rupel-Formation
Goudsberg-Clay
Tongeren-Formation
Maastricht-Formation
Carboniferous
sandstone
Laag V
Laag V
?
?
Legend
sand
clay
limestone
Carboniferous
F 1
drilling
migration of soil material
groundwater level (overburden)
mine water level (Carboniferous)
Zone of mining that might have an impact at ground surface

Source IHS

During many years signals were visible of gradual settlement on a parking area



Left industrial mining coal layer IV ‘DSM building’ and right shopping centre ‘t Loon (+ upward drillings).

Lagging mining damage in the Netherlands? 2013

Recent signs of soil movement in the Zuid-Limburg coal district

(ISM-symposium-Markscheidewesen)

Ilse de Vent, Hans Roest

Staatstoezicht op de Mijnen, The Netherlands

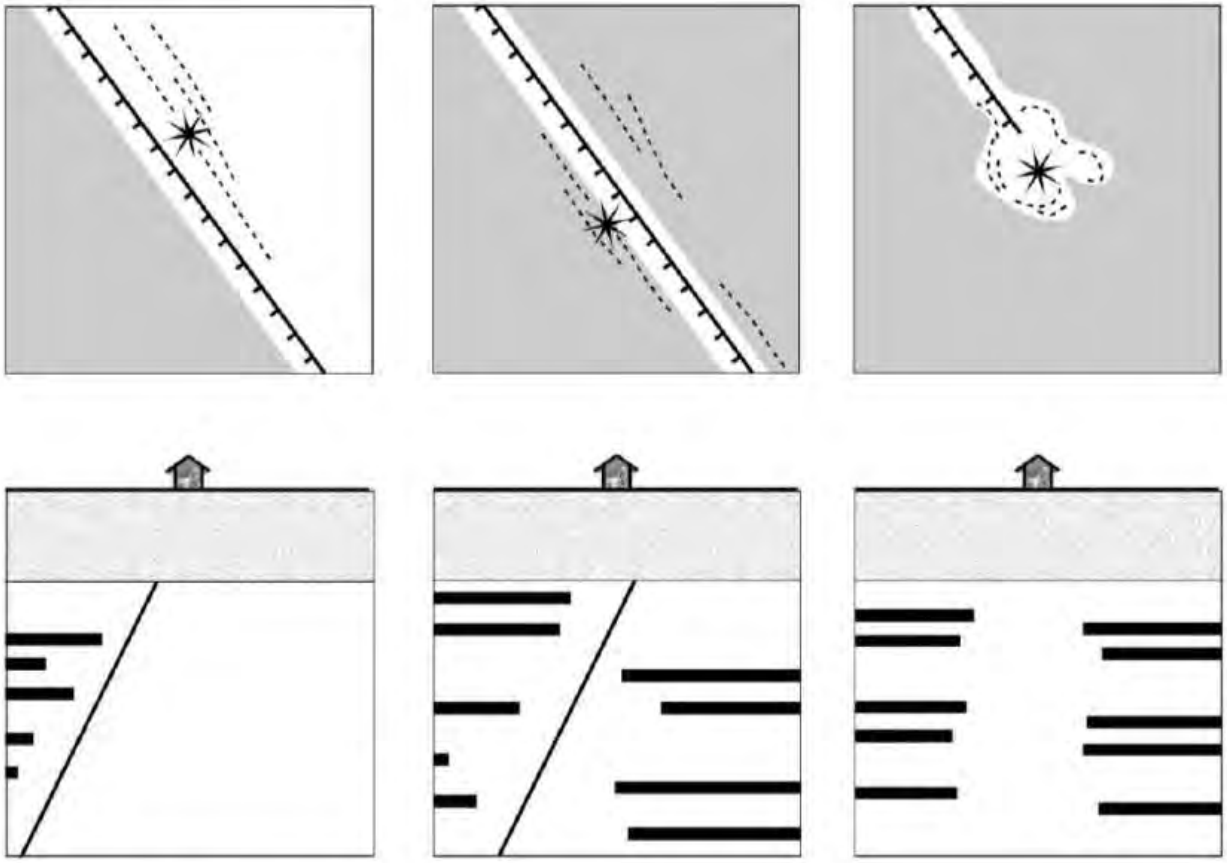
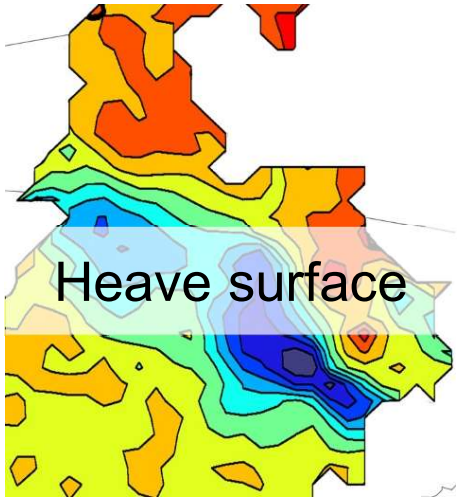
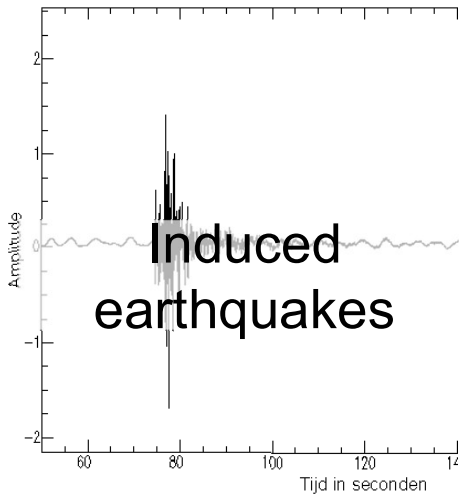
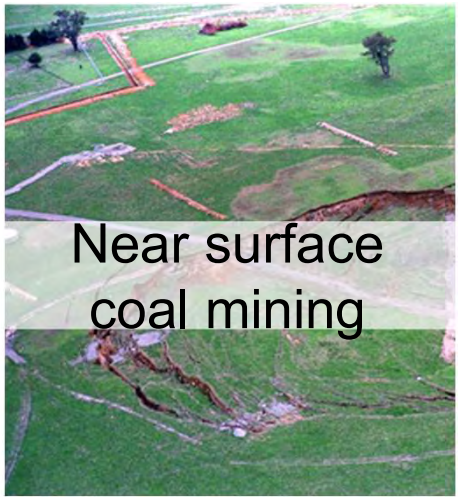


Figure 7: Three characteristic mining situations: one-sided mining (left), two-sided mining with a linear pillar in between (middle), and mining around a (quasi-) circular pillar (right).

"project proposal na-ijlende effecten in Limburg" SodM, Ilse de Vent







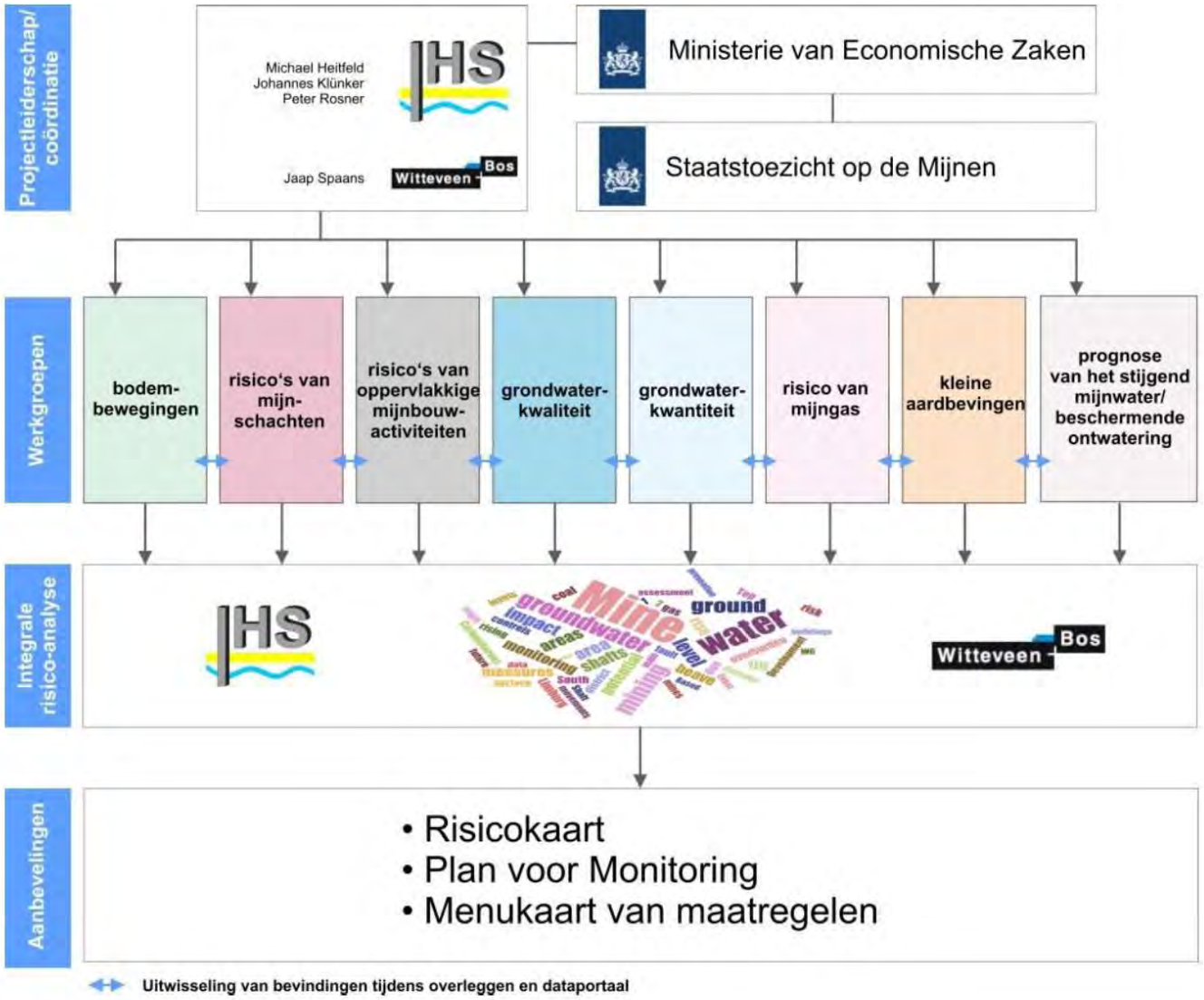
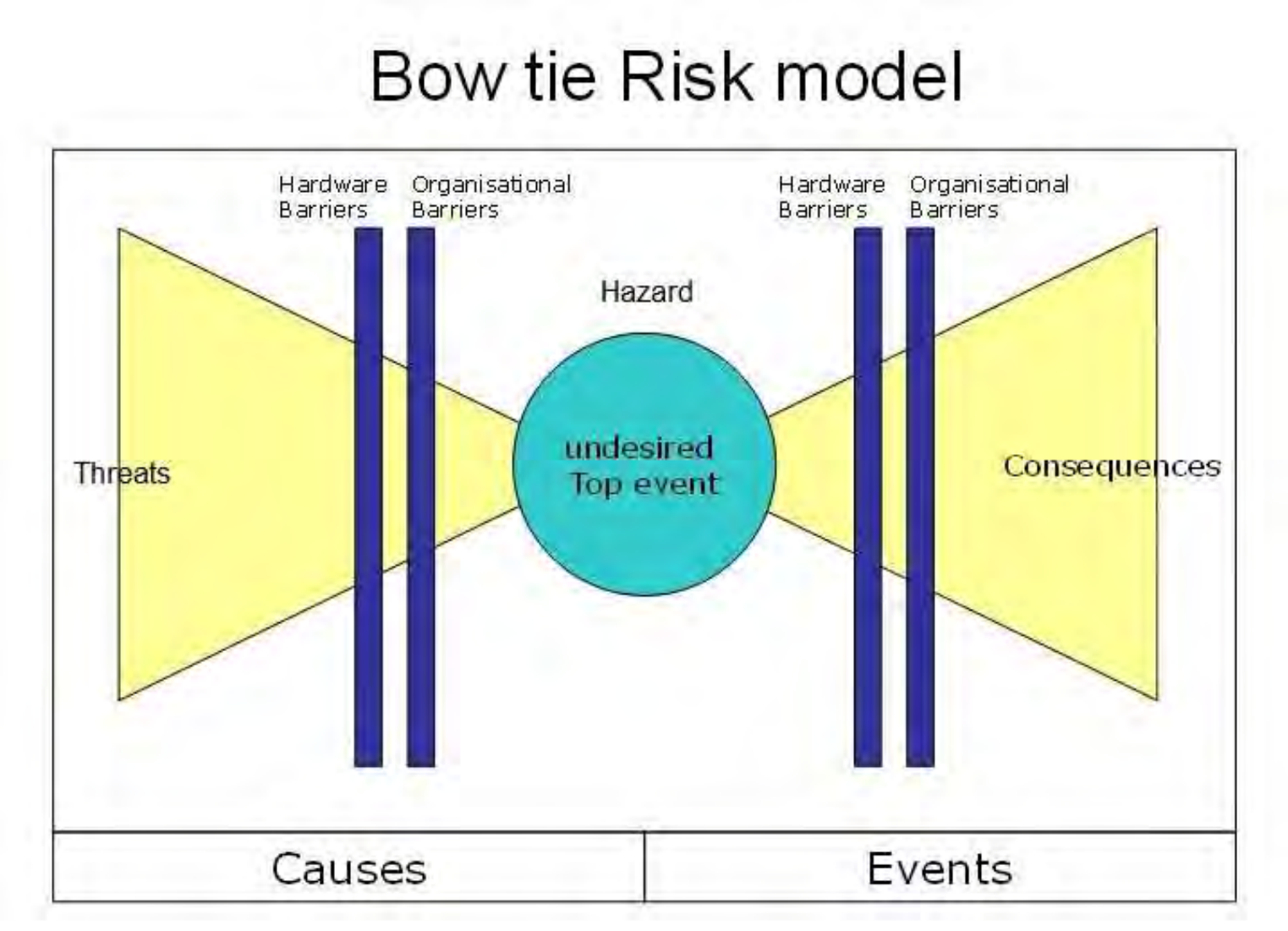


Fig. 1: Projectstructuur

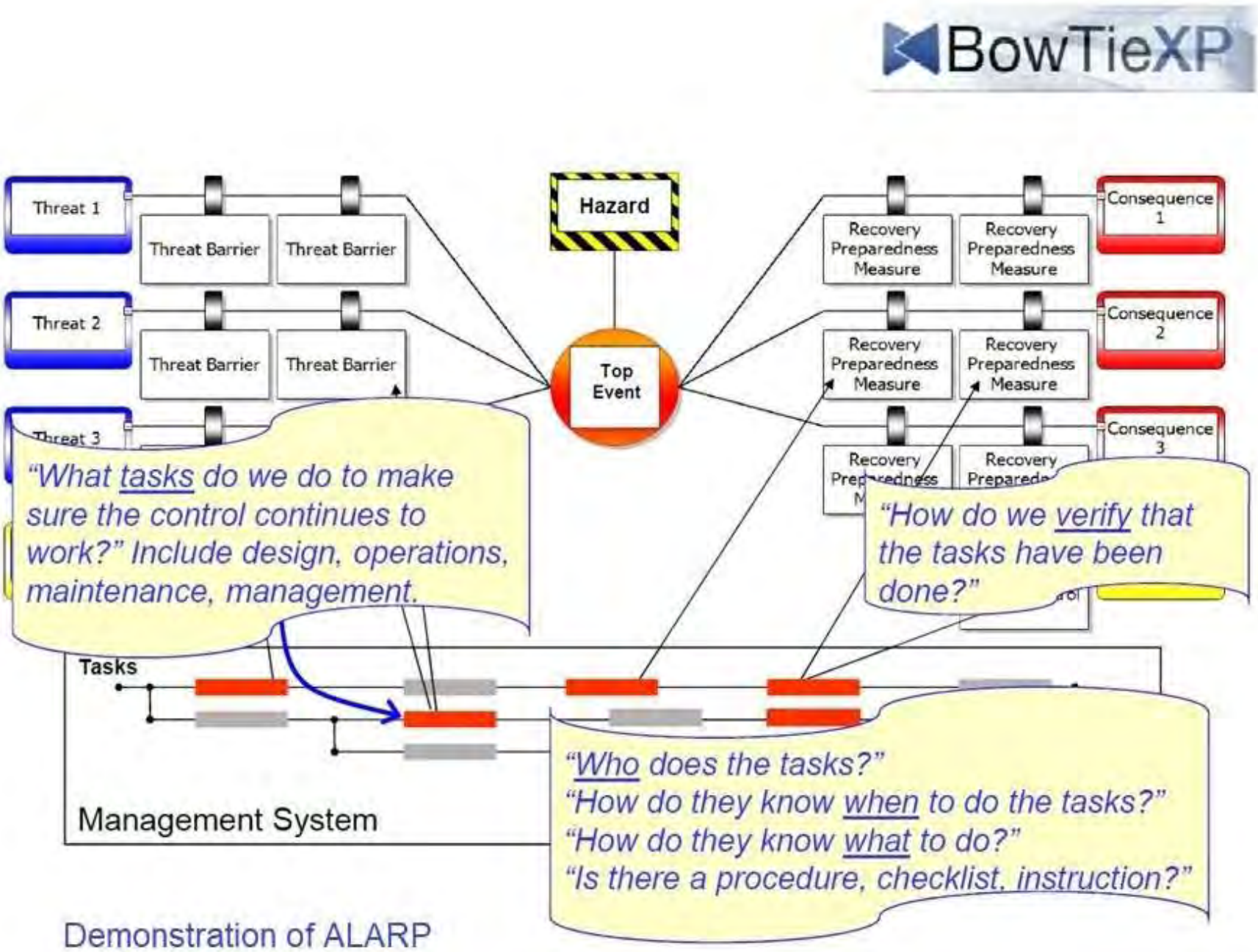
https://www.tweedekamer.nl/kamerstukken/brieven_regering/detail?id=2016Z24088&did=2016D49345

Catalogue of monitoring and measures

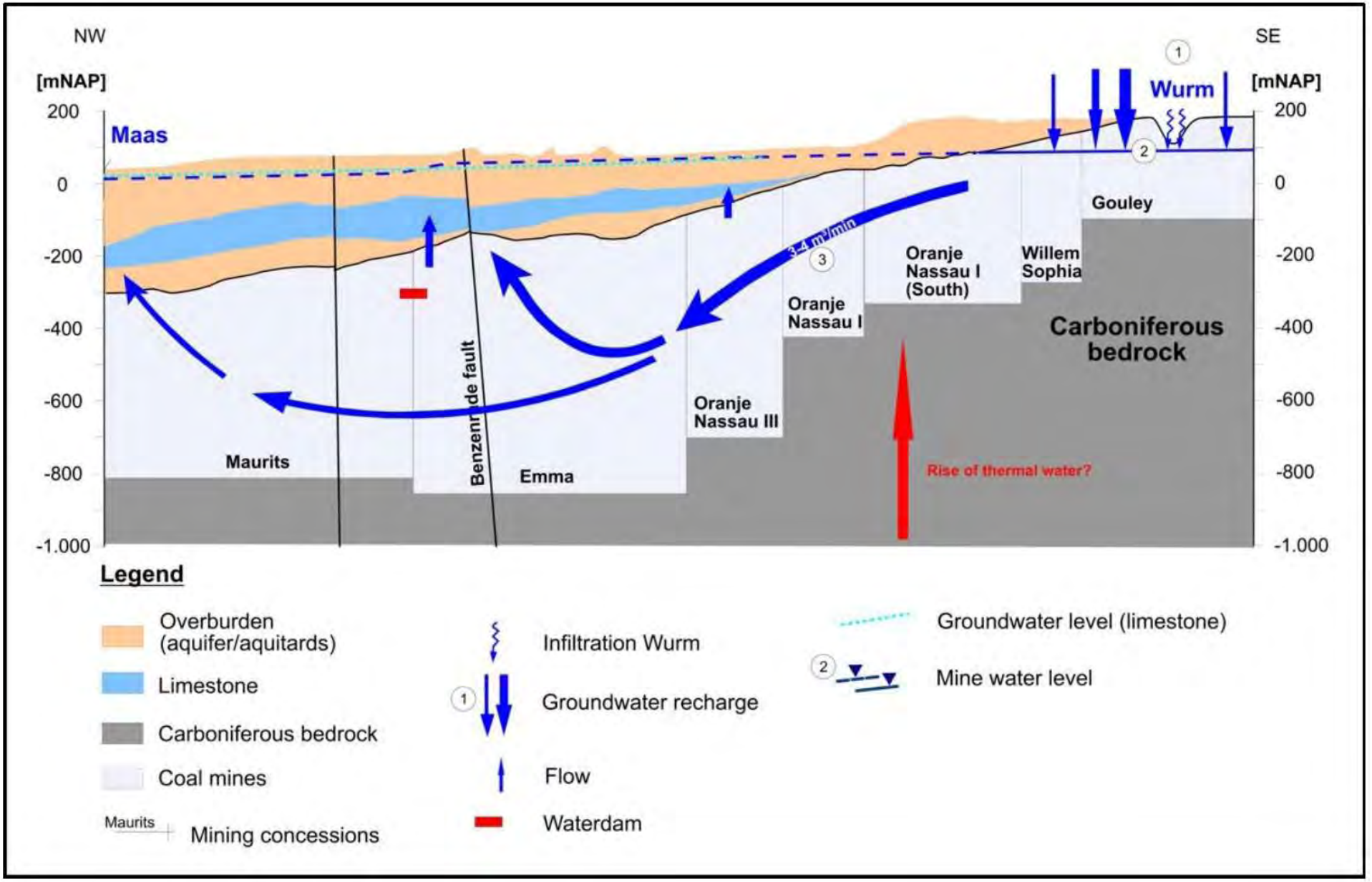
Monitoring	Measures
Cat. 1 - Strongly recommended	
- Monitoring groundwater level	- Installing new piezometers (groundwater)
- Monitoring groundwater quality	- Installing devices in existing piezometers (sounding)
- Monitoring mine water level	
- Monitoring industrial shafts	- Remediation measures at 6 industrial shafts
	- Installation monitoring equipment at industrial shafts
- Site inspections historical shafts	
- Monitoring ground heave: detailed monitoring three potential impact areas	- Installing levelling benchmarks for the detailed profile in three potential impact areas
- Monitoring of mine gas	- Provision instruments for gas measurements
	- Investigation of buildings regarding mine gas
Cat. 2 - Recommended	
- Monitoring ground heave: InSAR: Regional overview	- Remediation measures historical shafts



Hazard: the potential to cause harm



The organisation of appropriate control measures



Inflow of water

Source, IHS/GS-ZL report

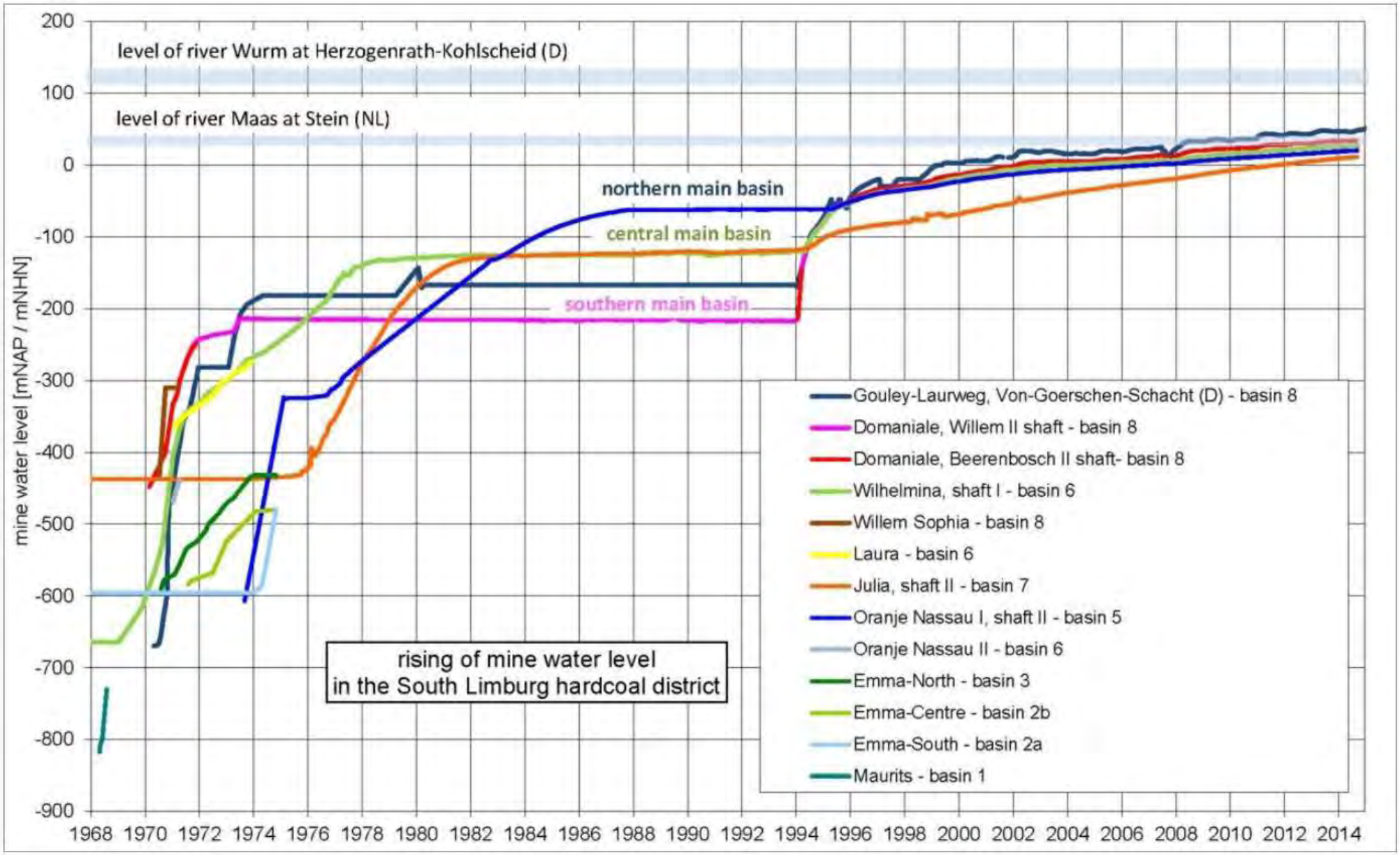
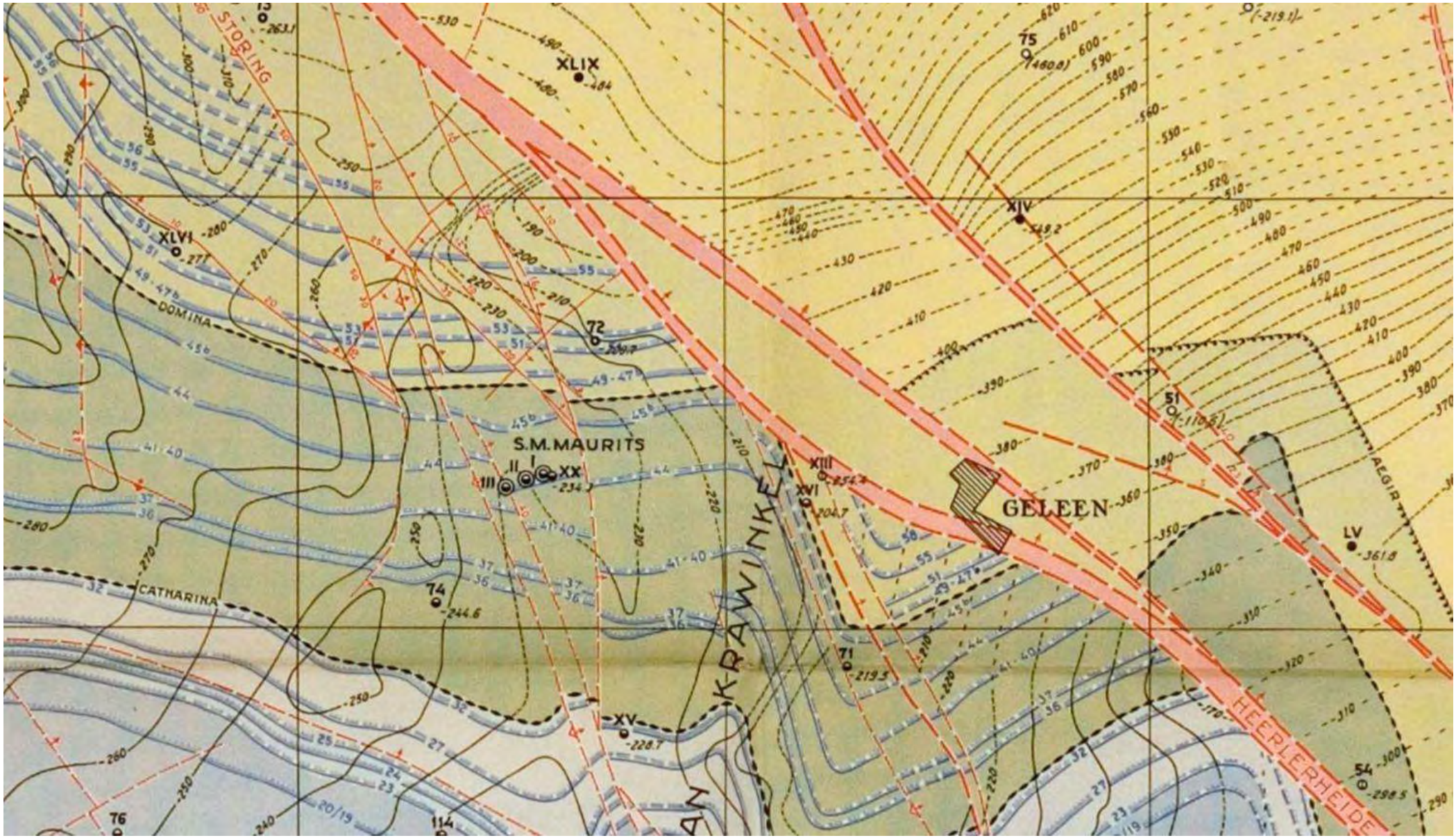
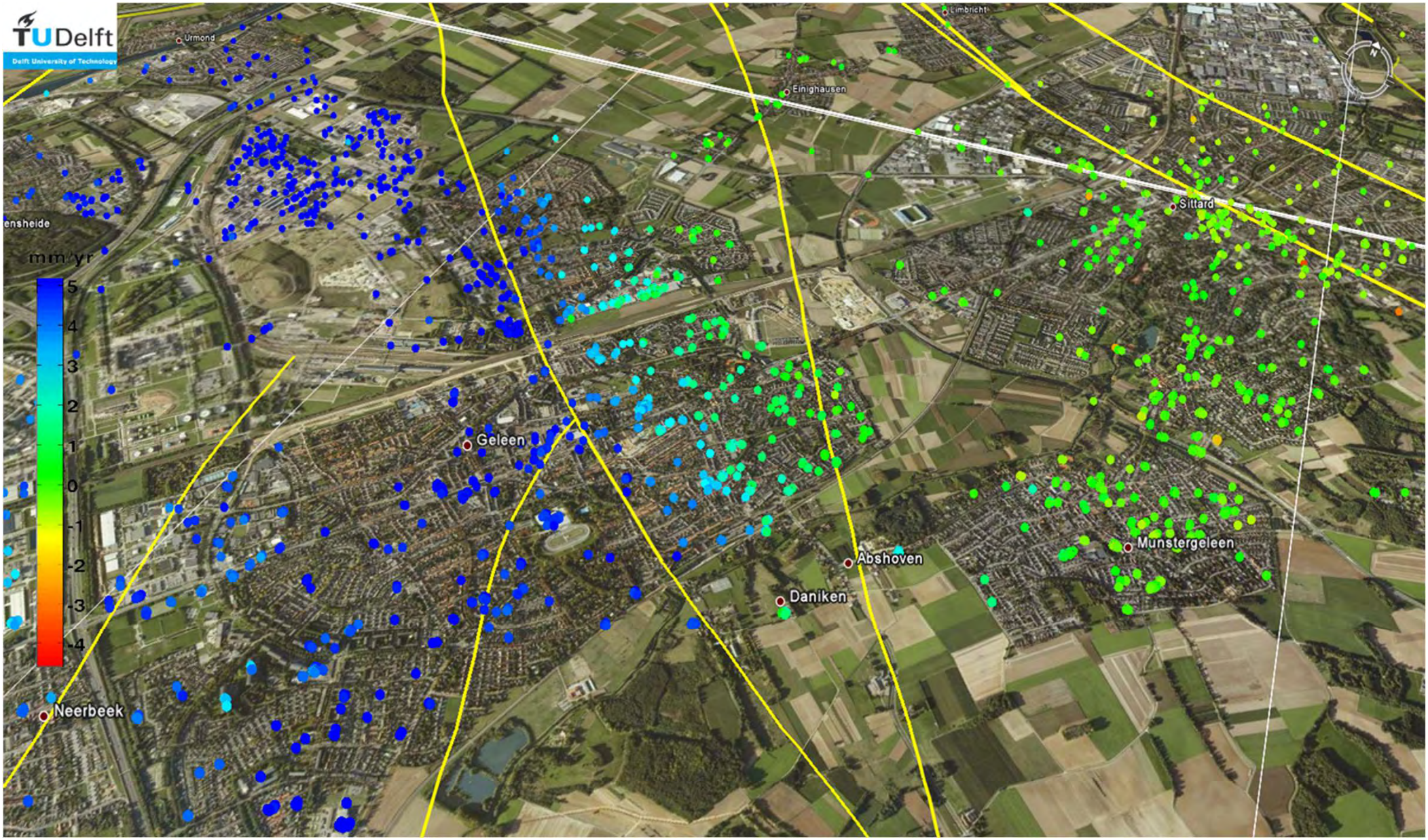
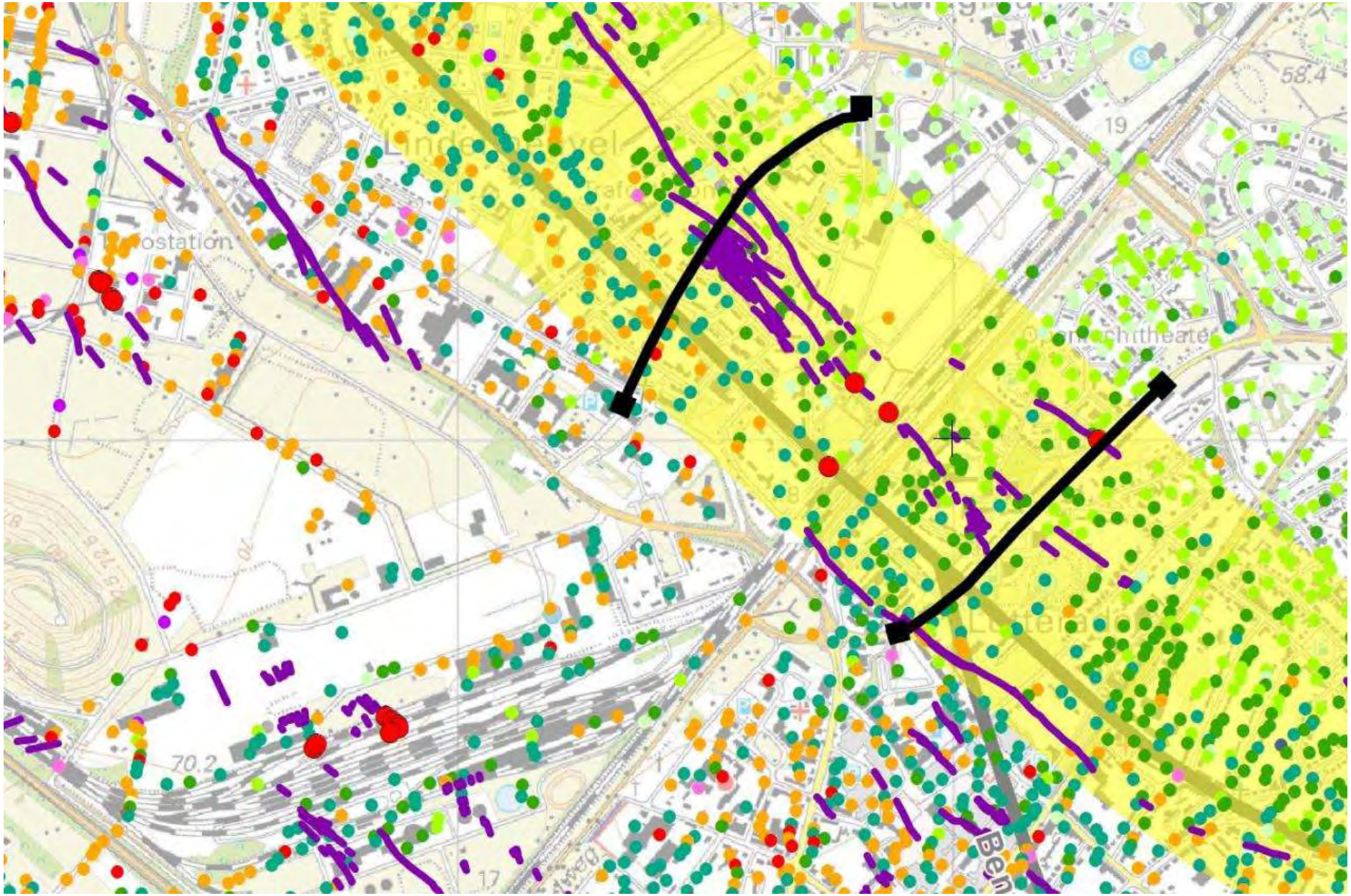


Fig. 21: Rising mine water levels in the South Limburg hard coal district


STORING
XLIX
XLVI
XIV
DOMINA
S.M.MAURITS
CATHARINA
GELEEN
XV
XVI
XIII
LV
HEERLERHEIDE
ALGIR



InSAR picture with differential movements Heerlerheide breuk (TU Delft)



Zone with differential movements. Historical sinkholes (red) close to ‘steps (Source GS-ZL)

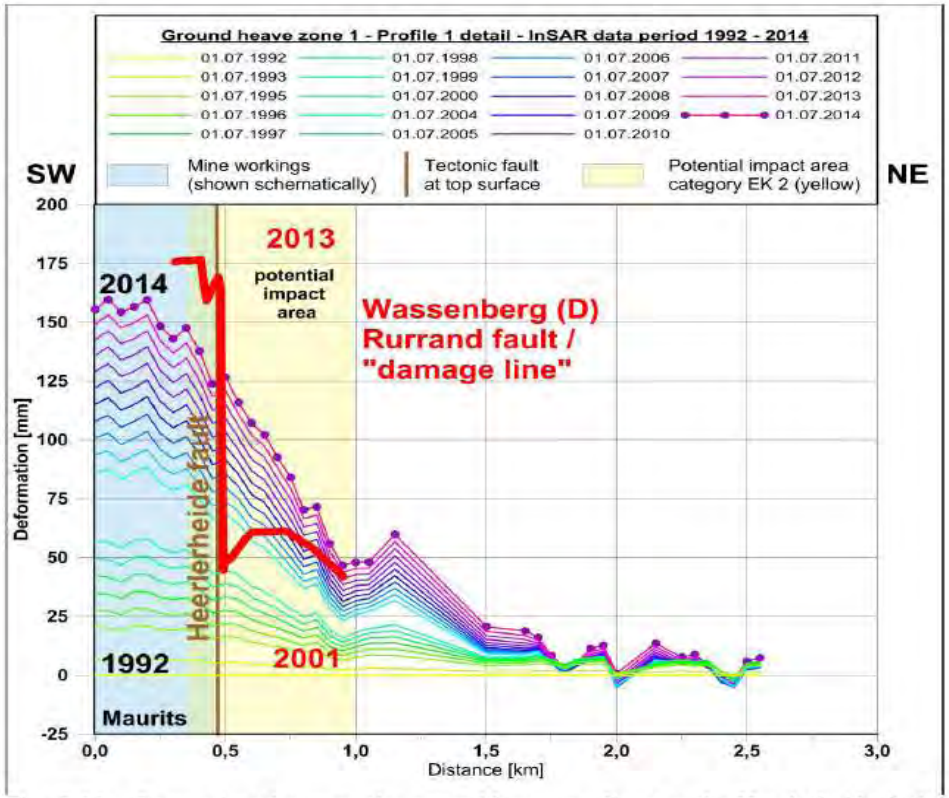


Fig. C 19: Comparison between the ground heave gradients at the Heerlerheide fault in the Geleen area (ground heave zone 1) and the Rurrand fault in the Wassenberg area, Germany

Summary rapport IHS/GS-ZL

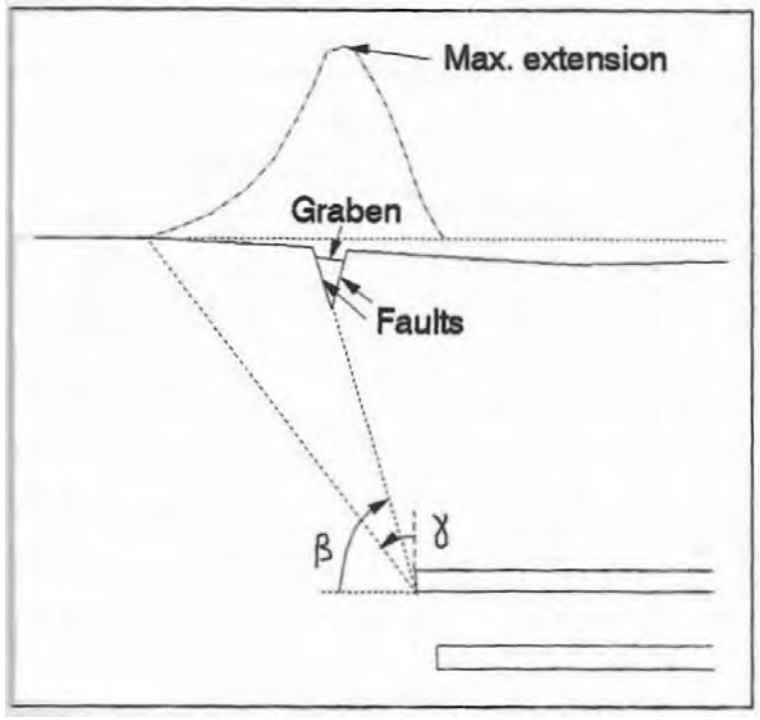
Ground movements induced by the rise of mine water constitute only a fraction of the primary effects of mining induced ground movements (up to 10 m of subsidence due to coal extraction by active mining).

……

The risk that serious damage occurs to existing buildings is low…..

However, sometimes damage did occur e.g. in a house a few meters from an old ‘step’ …
Finally the house is demolished (right picture)

Small sinkhole of a few m3 did develop close to another old ‘step’, about 50 m away



Examples of (old ?) damage near steps/small grabens

Hypotheses:
1. (Reactivation of) old steps ?
2. Differential settlements ?
3. Water inflow and material transport in small graben/steps?

Observations near a ‘step’ in Brunssum during drilling operation (a.o. fluid losses)

Source: Kragten

Mijnbouwkundig
adviseur ir. J.P.A.Roest

Risicosignalering na-ijlende effecten steenkoolwinning

Delft, 5 dec. 2018

Abstract:

Signalering van risiconiveaus op basis van monitoring, inspecties en tussentijdse beoordelingen en beheersmaatregelen door samenwerkende, autonome partijen

1. Niveaus signaleringsysteem voor drie zones met differentiële bodembeweging:
Geleen (EK2), Brunssum (EK3) en Eygelshoven (EK3)

Signalen van 'gedetailleerde monitoring bodembeweging' in zones (o.a. InSAR/meettrajecten)	Resultaat visuele inspecties schades in potentiële effect zone	Detail monitoring van gebouwen in de potentiële effect zones (o.a. scheurmeters, tiltmeters, etc.)
Waakzaamheidsniveau		
Geen signalen van lokale differentiële bodembeweging (d.w.z. < 4 mm/jr) en/of lokale verzakkingen gemeten	Geen toenemende trends bij schades aan bebouwing	Metingen geven geen significante waarden
Signaleringsniveau		
Lokale depressie/stijging. Duidelijke trends van lokale differentiële bodembeweging > 4 mm/jr	Signalering van toenemende trends bij de ontwikkeling van schades	Geen detail monitoring mogelijk Lichte trends bij scheurmeters
Interventieniveau		
Verzakking of sinkhole. Doorgaande lokale differentiële bodembeweging > 8 mm/jaar	Grote schade en causaal verband schades en geologische storing en/of mijnbouw	Meetresultaten tonen doorgaande beweging en scheurvorming in gebouwen

1. Niveaus signaleringsysteem differentiële bodembeweging (in de drie zones) met maatregelen

		Betrokken partijen
Waakzaamheids-niveau	Meting bodemstijging in regio en vergelijking met prognoses; detail monitoring trajecten Inventarisatie gevoelige gebouwen-richtlijnen landgebruik/funderingen effectzone Reguliere inspecties; ook vastleggen observaties van bewoners Analyse inspectieresultaten, opgetreden effecten en metingen Signalering bodembeweging door screening met InSAR (ook meettrajecten)	Gemeenten Projectontwikkelaars Grondeigenaren Gegevenshuis Specialisten
Signaleringsniveau	Preventieve inspecties en 'site investigation' (ook van breukzones) Gerichte monitoring, meettrajecten lokale waterpassing, tilt- , scheur- of rekmeters. Statistische analyse bodembeweging rondom discontinuïteiten (ook InSAR) Tussentijdse analyses en risicobeoordeling. Uitwerking plan van aanpak. Communicatie	Gemeenten Grond- en huiseigenaren Gegevenshuis Veiligheidsregio
Interventieniveau	Voorkomen van escalatie door acute maatregelen en veilig stellen, communicatie Tijdelijke constructies en versterkingen; opvullen van lokale verzakkingen. Analyse oorzaken schade en vaststellen eventueel causaal verband mijnbouw (beheer data) Ander gebruik grond, aanpassen nieuwbouw; grootschalig afbraak of herstelmatregelen	Gemeenten /Eigenaren Veiligheidsregio Tcbb /EZK

De Gulikstraat, zo te zien een doodgewone straat in een woonwijk. Links in het midden het blok van acht woningen dat opgekocht en gesloopt moet worden. Rechts nieuwbouw met goede fundering.
© WMW

Newspaper article about Gulikstraat
in Eygelshoven-Kerkrade (Feldbiss-fault)

REPORTAGE MIJNSCHADE

Slopen enige optie acht huizen in Gulikstraat

Vanwege ernstige mijnschade en vrijwel zeker te verwachten toekomstige schade worden acht woningen in de Gulikstraat in de wijk Op de Bossen in Eygelshoven (Kerkrade) opgekocht en gesloopt. Een primeur in Limburg.

DOOR WIEL BEIJER
KERKRADE

De stichting Calamiteitenfonds Mijn(water)schade Limburg koopt vier zwaar beschadigde woningen in de Gulikstraat op. Om deze aankoop uit dit noodfonds te financieren, is toestemming verkregen van het ministerie van Economische Zaken.
De vier overige woningen - twee aan elke kant van de vier ernstig beschadigde - wil de provincie voor eigen rekening opkopen. Deze woningen hebben nog geen ernstige last van schade.

Foto Gemeente
Kerkrade

February 2019

From Mining to Post-Mining: The Sustainable Development Strategy of the German Hard Coal Mining Industry

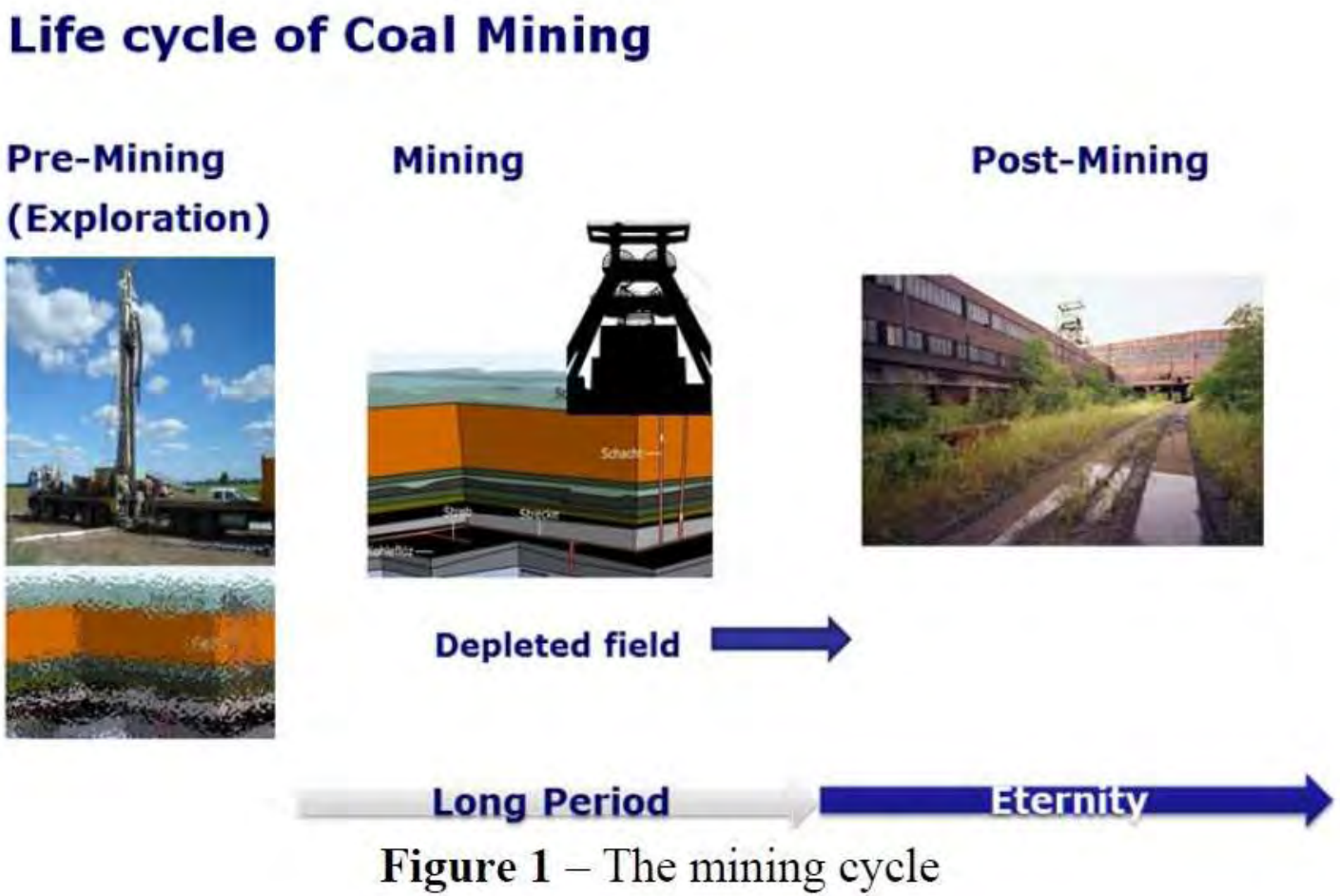


Figure 1 – The mining cycle

1. The exploration phase, in which the deposit is investigated to determine its technical and economic profitability.
2. The actual mining period which usually lasts for a long time and ends latest when all deposits are fully depleted.
3. The longest stage, however, is the post-mining stage as the human interference into geology and nature is usually intensive and irreversible. **Mining can lead to consequences which have a permanently adverse impact on people and the environment; therefore, they have to be managed as best as we can.**

Source: From Mining to Post-Mining: The Sustainable Development Strategy of the German Hard Coal Mining Industry, 2017

Conclusions:

The conclusions of IHS/GS-ZL study are in general supported.
Shallow mining close to overburden with ‘upwards drillings’ is a point of concern.
Pay more attention to signals of settlement/damage close to old ‘steps’ in extension zones.
Apply and evaluate ‘monitoring and control’ approach (e.g. monitoring deformation, groundwater quality, etc. etc. followed by appropriate control measures)
Post-mining legislation: evaluate role for State Supervision of Mines.

Strategy sustainable post-mining phase

Lecacy of historical mining	Current activities	New activities:
Reduce risk with ‘monitoring and control’ Repair damages and Remediate unsafe abandonment	Future-proof abandonment of caverns, wells, etc. Prevent long term risk and damage	Safety by design: geothermal energy and salt caverns for energy transition

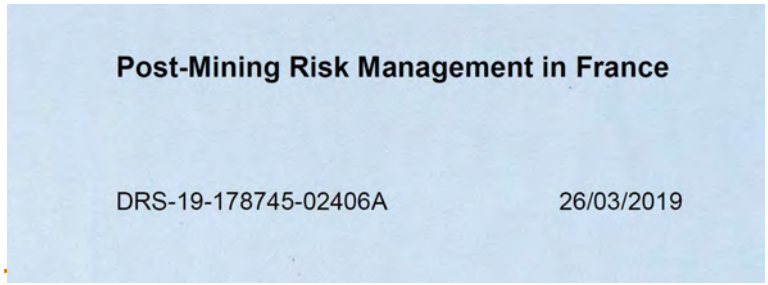
Acknowledgements/References:

- Wiel Miseré, Ilse de Vent, Mira Vasic, State Supervision of Mines
- Risicosignalering na-ijlende effecten steenkoolwinning: Kragten-Witteveen en Bos, dec. 2018
- Figures: a.o. IHS GS-ZL, Provincie Limburg, Kerkrade and other municipalities (and www.gluckauf.nl)
- Technische Hochschule Agricola: The Sustainable Development Strategy of the German Hard Coal Mining Industry
- 'Addendum' Mining Code: Report Ineris: Post Mining Risk Management in France 26/03/2019 :

- Website with results of Research IHS GS-ZL study.
- https://www.tweedekamer.nl/kamerstukken/brieven_regering/detail?id=2016Z24088&did=2016D49345

Questions:

Addendum



Legislation post mining risk management in France

- Law no. 99-245 of March 30, 1999, known as the "post-mining law," reworking the Mining Code, specifically makes the State responsible for risks that persist after mining operations have ended, in the name of national solidarity

…if there is no valid mining title, or if the operator or title holder disappears or fails to act, the French Mining Code renders the State liable for repairing the damages caused by former mining sites that it authorized in the past.

- three objectives of the government: anticipating risk, preventing risk and finally repairing the damages resulting from mining.

- a state-delegated operational management authority on post-mining (site monitoring and safety) was established

- Prevention plans are made – the public is informed on residual mining risks, etc.