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Netherlands Section of the International
Association of Engineering Geologists
Secretaris: Ir. S. Plasman
Postbus 63, 2260 AB Leidschendam
Postgiro: 3342108, t.n.v.
Penningmeester Ingeo-Kring,
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VAN DE REDAKTIE

Na de organisatie van het symposium "An Overview of Engineering Geology in the Netherlands, was er bij de redaktie weer tijd om zich te richten op het uitbrengen van de Nieuwsbrief. In deze Nieuwsbrief hebben wij een aantal interessante artikelen bij elkaar weten te brengen.

Van de studie activiteiten aan de TU en het ITC zijn inzendingen gewaardeerd met plaatsing in de Nieuwsbrief. Als eerste kunt u een artikel lezen van Robert Berkelaar, dat geschreven is als onderdeel van de Ingenieursgeologische workshop in het vierde cursusjaar. De onderwerpen stonden allemaal in het teken van de milieu-technische ontwikkelingen. In zijn artikel neemt Robert Berkelaar u mee naar het gebied van milieukundig terreinonderzoek. Bernice Baardman haar artikel met de titel "Remedial actions for contaminated soil" geeft een overzicht van bodemsaneringstechnieken.

Michiel Maurenbrecher, de vaste 'columnist' van de Nieuwsbrief neemt u in zijn Engineering Geology Highlights mee naar "tunnels, water levels and earth resources".

Het veldwerk, dat dit voorjaar wederom in Falset (Spanje) gehouden werd leverde een tweetal excursierapporten op, Carlos Carranza Torres schrijft over de problemen van de fundering van de Ribarroja stuwdam en Alberto Concha Fernandez over de aanleg van de Capsacosta tunnel in de Pyreneëen is ook opgenomen.

Van de activiteiten van het Dispuut Ingenieursgeologie zijn een tweetal artikelen in deze nieuwsbrief opgenomen. Het eerste behandelt de excursie naar het boren van de Bergambacht leiding, geschreven door Carl Messemaeckers van de Graaff, het tweede is een verslag van de geothermische excusie naar IJsland, die in samenwerking met het Dispuut Ingenieursgeologie tot stand gekomen is.

De stafleden van de TU sectie hebben een drietal boeken onder de loep genomen en hun conclusies kunt u vinden in de 'book reviews"

De nieuwsbrief wordt gewoontegetrouw afgeloten met een opsomming van de conferenties, symposia en seminars die in de komende jaren gehouden zullen worden op het ingenieursgeologisch vakgebied.

de redaktie:
drs. P.N.W. Verhoef
C.A. Messemaeckers van de Graaff
A.C.W. Bloem

Correspondentie adres:
Redaktie Nieuwsbrief IngeoKring
sectie Ingenieursgeologie
faculteit der Mijnbouwkunde en Petroleumwinning
postbus 5028
2600 GA Delft
tel: 015-784751
fax: 015-784891

DESIGN OF AN ENVIRONMENTAL SITE INVESTIGATION

R. Berkelaar

The author is a student at the Delft University of Technology, section Engineering Geology. This article was written as an assignment for the engineering geological workshop.

INTRODUCTION

There is a relative long tradition and a lot of experience in performing site investigations (SI) for civil purposes, like bridges, tunnels, roads, dams, etc. etc. Throughout the years a certain sequence of steps to perform during a SI has developed and proven its usefullnes. The last 10 years or so a lot of attention is given to environmental problems. A lot of waste dumps and polluted areas have been investigated and treated to prevent any risks for the people living near these areas. As SI for environmental purposes is something relatively new, no clear methodology has developed yet. A good environmental SI gives answers to the following questions:

-is there any pollution at all?
-what is it?
-where and how much is it?
-how is it behaving?
-does it form a risk?

In this paper is tried to make a flow chart that can be used in any situation onshore for all environmental investigations with the aim of remediation. The environmental SI is devided into steps, where after each step an evaluation is performed and if necessary a report is produced.

After this there is a discussion of the applicability of conventional SI techniques for environmental purposes. Finally some examples of new techniques and methodologies are given to indicate in what direction the environmental SI will evolve in the years coming.

DESIGN OF AN ENVIRONMENTAL SITE INVESTIGATION

The best way to perform an environmental site investigation (ESI), which should lead to removing or isolating the pollution, is to split your investigation in steps. This is the most effective way as an evaluation is carried out after each step. A step-like approach is also favourable for the cost factor, as it is possible to adjust the investigation to the results of the foregoing step. All steps and their relation to each other will be discussed, the techniques that are used to obtain field information will be treated seperately.

steps:	I	OBJECTIVE	O
	II	HISTORICAL INVESTIGATION	HI
	III	PRELIMINAIRY INVESTIGATION	PI
	IV	MAIN INVESTIGATION	MI
	V	RISK ANALYSIS	RA
	VI	REMEDIATION INVESTIGATION	RI
	VII	REMEDIATION	R

There is also a zero alternative:

step 0 DO NOTHING

See fig 1 for the flow chart, the way the steps link to eachother.[by author]

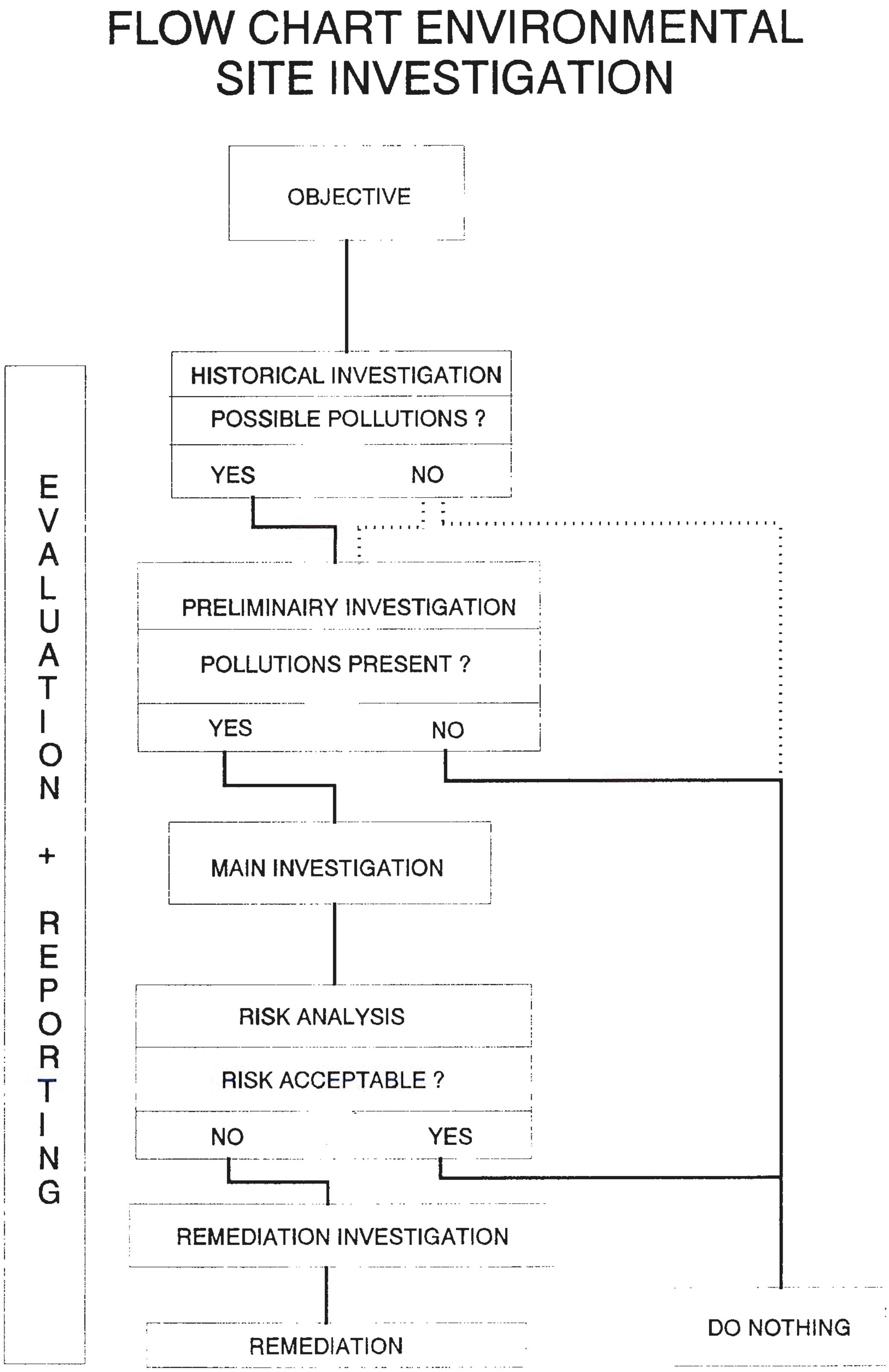

fig 1 Flow chart for an environmental site investigation

I OBJECTIVE

The objective is one of the most important steps in the total process of the ESI, because the SI is focused on the objective. The objective is highly dependent on what the client, for whom the SI is being carried out, wants. An ESI can be carried out for several different reasons ranging from checking the presence of pollutions on your property because of legal liability. This is the case in for example Holland[11] and in Japan[12] there will be a law in three years time which states that when the designation of an area changes an ESI has to carried out.

Other reasons are for example an ESI directed to groundwater extraction, building of houses, preservation of nature reserves etc. In this paper only objectives that are related to possible cleaning up operations are considered, an ESI for example groundwater extraction falls outside the scope of this paper.

II HISTORICAL INVESTIGATION

This step is quite important as it may give clues of the kind of pollutions you might expect on your site[6] The main thing in this stage is gathering background (historical) information. Information about past activities at the site can be extremely helpful by revealing what kind of materials were handled. Consequently this may provide guidance in choosing which parameters to test in the analysis. A historical investigation might also help to indicate what areas were used for specific processes and will thus help in the logical placement of sampling locations.[1]

Methods used during a historical investigation:

-looking through archives, files etc, to find out the history of activity
-looking up old reports of the site
-site visit and talking to locals
-studying of aerial photgraphs

Activities that are not really 'historical' but which have to be carried out in this stage of investigation, is to study all available geological, geotechnical, topographical and hydrogeological data. This will mainly come from maps, reports and published articles concerning the particular site.

The result of the historical investigation is that a possible kind of pollution is indicated. The kind that is indicated, resulting from former activities, is the one you are going to focus on in your further investigation. It is thus very important that this step is carried out carefully.

It is very dangerous to assume there are no pollutions at all when no indications of any pollutions whatsoever appear from the historical investigation. There might have been some activities you don't have any records of! Therefore before you are going to follow the no-path (fig 1) you have to be very sure that there are no pollutions present. When you think the site is suspect anyway then the preliminary investigation will have to be general as you do not know what kind of pollutions to expect. See fig 2 for different groups of pollutions.

Toetsingswaardentabel VROM

Toetsingstabel voor de beoordeling van de concentratieniveaus van diverse verontreinigende stoffen in de bodem.
Indikatieve waarden A - referentiewaarde
B - toetsingswaarde t.b.v. (nader) onderzoek
C - toetsingswaarde t.b.v. sanering(-sonderzoek)

Voorkomen in:	Grond (mg/kg droge stof)			Grondwater (µg/l)		
Stof/niveau	A	B	C	A	B	C
I. Metalen						
Cr (chroom)	*	250	800	*	50	200
Co (cobalt)	20	50	300	20	50	200
Ni (nikkel)	*	100	500	*	50	200
Cu (koper)	*	100	500	*	50	200
Zn (zink)	*	500	3000	*	200	800
As (arseen)	*	30	50	*	30	100
Mo (molybdeen)	10	40	200	5	20	100
Cd (cadmium)	*	5	20	*	2,5	10
Sn (tin)	20	50	300	10	30	150
Ba (barium)	200	400	2000	50	100	500
Hg (kwik)	*	2	10	*	0,5	2
Pb (lood)	*	150	600	*	50	200
II. Anorganische verbindingen						
NH_4 (als N)	-	-	-	*	1000	3000
F (totaal)	*	400	2000	*	1200	4000
CN (totaal-vrij)	1	10	100	5	30	100
CN (totaal-complex)	5	50	500	10	50	200
S (totaal-sulfiden)	2	20	200	10	100	300
Br (totaal)	20	50	300	*	500	2000
PO_4 (als P)	-	-	-	*	200	700
III. Aromatische verbindingen						
benzeen	0,05(d)	0,5	5	0,2(d)	1	5
ethylbenzeen	0,05(d)	5	50	0,2(d)	20	60
tolueen	0,05(d)	3	30	0,2(d)	15	50
xylenen	0,05(d)	5	50	0,2(d)	20	60
fenolen	0,05(d)	1	10	0,2(d)	15	50
aromaten (totaal)	-	7	70	-	30	100
IV. Polycyclische aromatische koolwaterstoffen						
naftaleen	*	5	50	0,2 (d)	7	30
fenantreen	*	10	100	0,005(d)	2	10
antraceen	*	10	100	0,005(d)	2	10
fluoranteen	*	10	100	0,005(d)	1	5
chryseen	*	5	50	0,005(d)	0,5	2
benzo(a)antraceen	*	5	50	0,005(d)	0,5	2
benzo(a)pyreen	*	1	10	0,005(d)	0,2	1
benzo(k)fluoranteen	*	5	50	0,005(d)	0,5	2
indenol(1,2,3cd)pyreen	*	5	50	0,005(d)	0,5	2
benzo(ghi)peryleen	*	10	100	0,005(d)	1	5
PAK (totaal)	1	20	200	-	10	40
V. Gechloreerde koolwaterstoffen						
alifatische chloor-kwst. (indiv.)	*	5	50	0,01 (d)	10	50
alifatische chloor-kwst. (totaal)	-	7	70	-	15	70
chloorbenzenen (indiv.)	*	1	10	0,01 (d)	0,5	2
chloorbenzenen (totaal)	-	2	20	-	1	5
chloorfenolen (indiv.)	*	0,5	5	0,01 (d)	0,3	1,5
chloorfenolen (totaal)	-	1	10	-	0,5	2
chloorpck's (totaal)	*	1	10	-	0,2	1
PCB's (totaal)	*	1	10	0,01 (d)	0,2	1
EOCl (totaal)	0,1	8	80	1	15	70
VI. Bestrijdingsmiddelen						
org.chloor (indiv.)	*	0,5	5	1/0,01 (d)	0,2	1
org.chloor (totaal)	-	1	10	-	0,5	2
niet chloor (indiv.)	*	1	10	1/0,01 (d)	0,5	2
niet chloor (totaal)	-	2	20	-	1	5
VII. Overige verontreinigingen						
tetrahydrofuran	0,1	4	40	0,5	20	60
pyridine	0,1	2	20	0,5	10	30
tetrahydrothiofeen	0,1	5	50	0,5	20	60
cyclohexanon	0,1	6	60	0,5	15	50
styreen	0,1	5	50	0,5	20	60
ftalaten (totaal)	0,1	50	500	0,5	10	50
geoxydeerde PAK (tot.)	1	200	2000	0,2	100	400
minerale olie	*	1000	5000	50 (d)	200	600

* = referentiewaarde
d = detektielimiet

fig 2 Dutch standards for different kinds of pollutions (ABC-values)[6]

III PRELIMINARY INVESTIGATION

The aim of this investigation is to determine the nature and concentration of the pollutions present. The investigation will be focused on the results of the historical investigation (HI). If the HI reveals no possible pollutions, then the preliminary investigation (PI) will have to be undertaken in a general way such that firstly the group or groups of pollutions are known and consequently you can zoom in on a specific kind of contaminant. (fig 2) It is important to realize that pollutions not discovered in this stage will not be revealed anymore in the coming investigation steps.

The fieldwork in this stage consists mainly of drilling and sampling. The details of this will be discussed later. It is important to do your sampling with great care as it will determine the results of the total investigation. Samples are analyzed on chemical composition, again it is important to know what you are looking for as the chemical analyses are specific (= are sensitive for one kind of contaminant), time consuming and expensive.

An important thing to consider in this stage is the inflow of materials over the boundaries of your site. The site might prove to be clean at the moment of testing but it is possible that pollutants flow in through the boundaries of your site. If the site is suspectable to this, it needs intensive investigation in the main investigation. (fig 3)

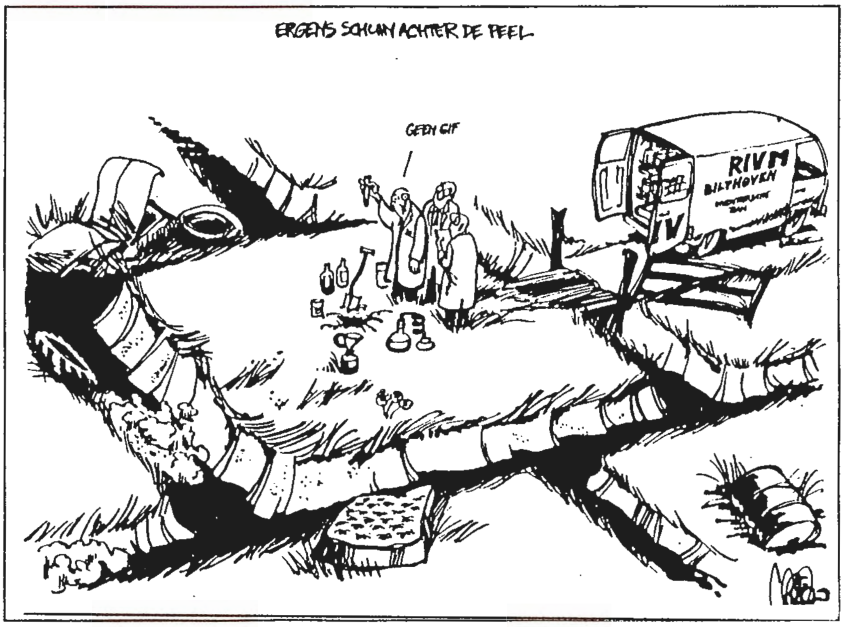

fig 3 Cartoon to illustrate the importance of inflow over borders of the site[3]

The preliminary investigation is concluded with the question: do you expect any problems based on the results of the investigation so far? If the preliminary investigation did not reveal any pollutions then the project can be terminated, if there are any contaminants present then you should go on with step IV: the main investigation to establish the 4-D situation of the pollution.

IV MAIN INVESTIGATION

The main investigation (MI) focuses on the characterization of waste sources, transport path and receptors.[14] Fig 4 lists the criteria for site and waste characterization. A 4-D model will have to be established to fully understand the problem. Thus a picture of the character, amount, concentration, spread and chance on spread of the waste has to be obtained.[8]

The investigations can be categorized as: -studies of waste source, geology, hydrogeology, atmospheric influences, pedology, contaminants, human population and ecology. Techniques to accomplish these are discussed later on. Data collected must be evaluated and assessed. These assessments determine whether the data meets the objective of this step and they present data and interpretations on which it is possible to perform a risk analysis.

V RISK ANALYSIS

The risk analysis is the most complex and disputed step in an ESI. There are two basic approaches in determining the risk and thus answers to the question of going on with the investigation. The first way is to apply standards given by the ministry, the second is to do a real risk analysis.

In Holland the approach with standards is used often. This is a table (fig 2) produced by the ministry of VROM (public health) which divides pollutions into 7 groups and recognizes three limits. These are the ABC-values, where A is the background value, C is the limit where action is needed on a short term and the B-value is somewhere arbitrary in between. The problem with these standards is that they are absolute. They do not take combinations of different categories into account, these combinations might have a weakening or a strengthening effect compared to the danger of the contaminants apart.

When the concentration of a contaminant is higher than the C-value it does not imply that there is a danger, the pollution might be immobile.[7] There is also a possibility that a local natural concentration exceeds the C-value. This would mean that you would have to sanitate an area where there is no human influence whatsoever.

A better but more complex approach is the total risk analysis. This is based on the chance of possible dangerous effects and consequences from a pollutant. This risk is very sensitive in the public opinion as it is a risk people did not choose for and therefore considered very threatening. This is an important thing to consider in every risk analysis.

It is very difficult to determine what combinations and concentrations of pollutions have dangerous effects on humans. Some research has been done on earthworms[4] but you can not just extrapolate. There might also be dangerous effects that may not influence humans but have harmful effects on the flora and fauna. This is a subject that needs a lot of research to come to a good risk analysis that takes all important factors into account.

The approach nowadays is that exposure to pollutions, as a result of waste, is unacceptable. Exposure can occur by the following ways: air, water, food or direct contact.[6] (fig 5). The standards used in order to judge a soil are based on standards that may vary from country to country.

SITE CHARACTERISTICS

Site Volume
Site Area
Site Configuration
Disposal Methods
Climate
- Precipitation
- Temperature
- Evaporation

Soil Texture and Permeability
Soil Moisture
Slope
Drainage
Vegetation
Depth to Bedrock
Depth to Aquicludes
Degree of Contamination
Direction and Rate of Ground-water Flow
Receptors
Distance to:
- Drinking Water Wells
- Surface Water
- Ecological Areas

Existing Land Use
Depth to Ground Water or to plume

WASTE CHARACTERISTICS

Quantity
Chemical Composition
Carcinogenicity
Toxicity - Chronic and Acute
Persistence
Biodegradability
Radioactivity
Ignitability
Reactivity/Corrosiveness
Treatability
Infectiousness
Solubility
Volatility
Density
Partition Coefficient
Safe Levels in the Environment
Compatibility with Others Chemicals

Source: "Guidance on Remedial Investigations Under CERCLA." EPA/540/G-85/002, U.S. EPA, Washington, D.C. (1985).

fig 4 Criteria for site and waste characterization[14]

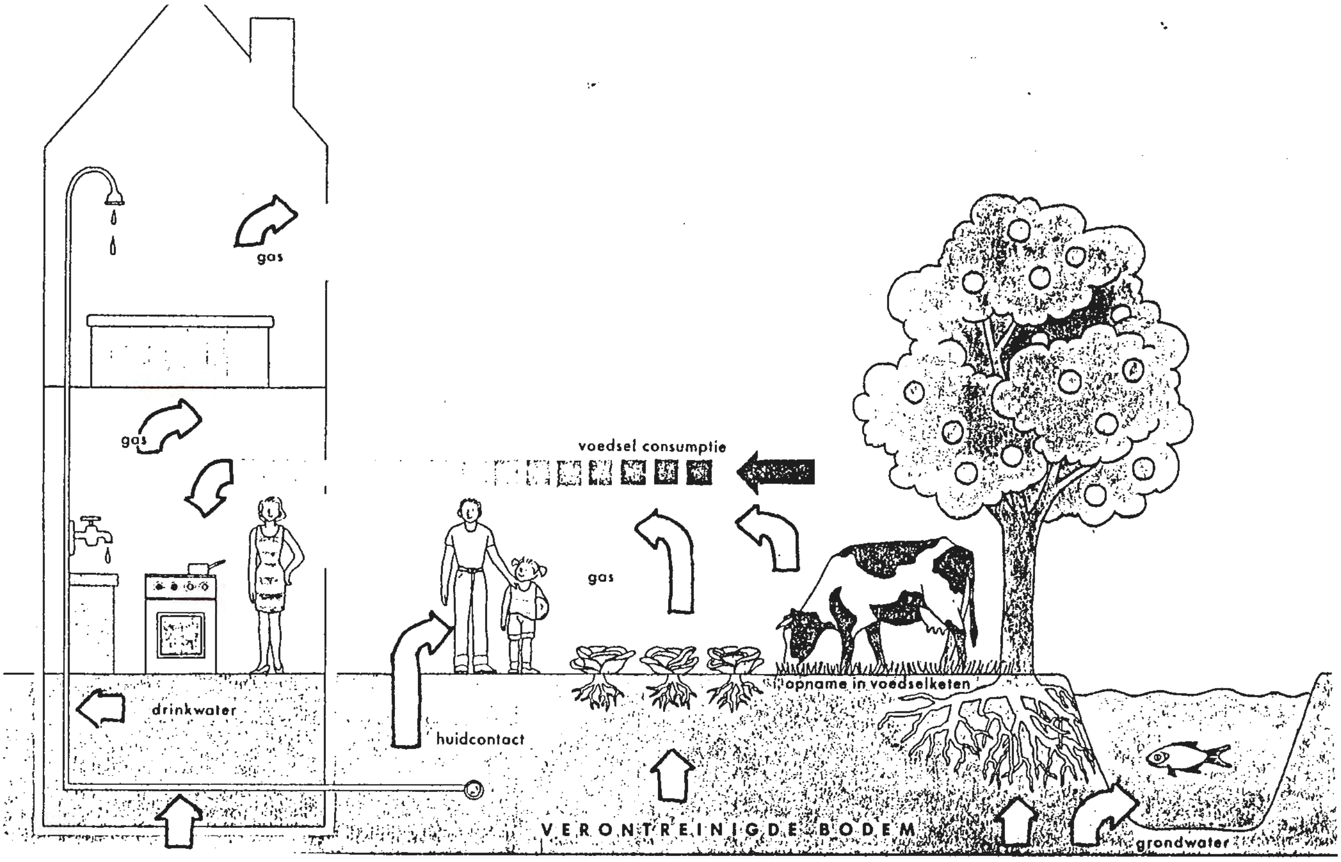

fig 5 Possible ways of contact[6]

VI REMEDIATION INVESTIGATION

In the remediation investigation all possible sanitation techniques are considered and compared on efficiency, technical executability and costs. The investigation and remediation themselves will not be treated in this paper as this goes beyond the scope of it.

SITE INVESTIGATION TECHNIQUES

In this section the applications and restrictions of conventional SI techniques applied on an ESI will be discussed.[13]

*** MAPS**

- -it is important to have recent maps as environmental problems are phenomena from the last few decades
- -examples: topographical-, geological-, hydrogeological-, geomorphological maps etc.

***REMOTE SENSING**

applications:

- -used for geological reconnaissance
- -hydrology: seepage, differences in groundwater temperature
- -comparison of old and new pictures, see what has changed (fig 6)
- -thermal pollutions by infra-red scanning
- -vegetation affected by chemical pollution

restrictions:

- -high costs when no pictures are available and have to be newly taken

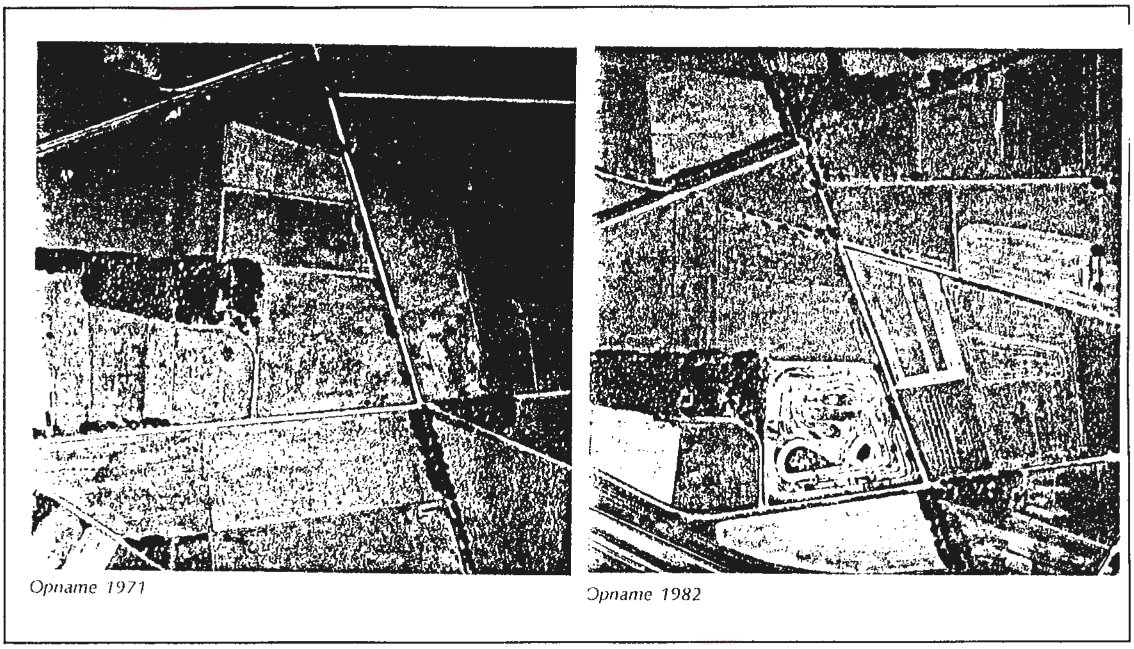

fig 6 Comparison of two pictures of different ages[5]

***DRILLING, SAMPLING**

applications:

- -determine profile for modelling
- -take samples for determining relevant parameters
- -make holes for pumping tests, packer tests etc
- -determine bedrock depth

restrictions:

- -have to take great care when taking samples for chemical analysis as drilling mud, oil, grease, contact with hands or the air might change the chemical composition, you might measure your own induced pollution instead of the one in the soil
- -some chemical tests require anaerobic conditions of the samples, important to seal the samples properly
- -when drilling in permeable layers you might connect a polluted with a nonpolluted aquifer, you are making things worse
- -have to plug-up holes in impermeable layers to prevent short circuiting

-samples taken from greater depths might become contaminated with ground(water) from lesser depths

***GEOELECTRICITY**
applications:

-determine geological picture, groundwater table
-get indication of quality of groundwater
-localize spread of conductive pollutants

restrictions:

-when applying in saline/salt areas contrast becomes less, difficult to interpret
-disturbances from cables, pipes or other metal structures makes it use useless

***ELECTRO MAGNETICS**
see geoelectricity

***SEISMICS**

-information on geological setting, indicate possible boreholes
-determination of groundwater levels

***GEOTHERMAL**

-warming up of ground due to leakage of pipes

***CONE PENETRATION TEST**

-determine geological setting and geotechnical properties
-determine porepressures (geohydrology)
-be aware of short circuiting impermeable layers

The most frequently applied and important techniques are maps, remote sensing, drilling and sampling and the cone penetration test. Other techniques are sparsely used for environmental investigations.

NEW DEVELOPMENTS

Some new techniques and developments will be discussed to illustrate what might be expected in the near future. The trend is towards automation and computer use as will follow from the following examples

Application of Geographic Information Systems (GIS)

Most groundwater models are far too complex to use for impact assessment on a regional scale. More simple computer based approaches can be used for regional assessments of pollution effects on ground water resources. One approach involves the use of a GIS, designed to store, process, retrieve and display spatially referenced data.[4 and b]

Computer aided program Geotox

Geotox is a computer program for waste disposal sites to help environmental engineers is decisions and recommendations. Geotox is designed by Leigh University Bethlehem[1]. Geotox supports the following processes: interpretation, evaluation, classification, screening of sites and in the selection of alternatives. The main help is the organizing and presenting function.

Site Investigation Robot

In the SI robot project[1] robotics and image-processing techniques are used in the investigatory phase of hazardous waste site clean ups. The current focus is the development of an automated subsurface mapping system to locate buried objects and geological structures so that sources and paths of contaminants can be identified.

Groundgas Analysis

When the ground water table is low (this the case in a lot of places outside Holland) groundgas analysis is a technique that can be used. This is a fast nondestructive method which can give indications of volatile contaminants.[2] A 'sonde' is being hammered in the ground and a gas sample is extracted, the sample can be analyzed in a gaschromatoghraph.

A disadvantage is that it is not possible to indicate the amount of pollution present. This is because the concentration of the gas is independent of the thickness of the pollution layer. Bacterial degradation near surface is also possible.

The best way to use this technique is to scan a site quickly on a range of contaminants. subsequently the drilling plan can be adapted to the results of the groundgas survey.

Geo Sensors[2]

Some parameters (pH, temperature, conductivity) can be measured insitu instead of measuring them from samples. There is also a development of 'real' sensors. These sensors are capable of measuring for example: heavy metals or hydrocarbons. Disadvantages are:

-low detection limits must be possible
-interferences are possible due to the complex ground composition
-possible short circuiting of layers
-sensors have to be carefully cleaned after each measurement

Ion Sensitive Field Effect Transitor Chip (ISFET)[2]

These are microchips with a chemical semi-open structure on the surface sensitive for H^+ ions. When applying contaminant selective membranes the chip get selective for certain ions. They can also be used below ground water table. For organic pollutions chips are under development which use spectroscopic techniques.

CONCLUSION

The aim of this paper was to outline a strategy that can be followed when executing an environmental site investigation. This is done in different steps: stating an objective is very important as the ESI will be directed to this. The historical investigation reveals possible pollutions where to look for in a preliminary investigation. If the pollutions are actually present and investigated in detail during the main investigation, a risk analysis has to be done. This is a disputed subject as it is not clear what a 'risk' is. If the risk is not acceptable a remediation investigation is carried out in order to determine the best way of remediation.

Important during the whole site investigation is that sampling has to be done with great care and in accordance with the demands of the analysis. Something that was beyond the scope of this paper but which is very important is dealing with government representatives, contractors and the client. The local law concerning pollutions has to be known as well.

ACKNOWLEDGEMENT

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ENGINEERING GEOLOGY HIGHLIGHTS

Tunnels, water levels and earth resources

P.M.M. Maurenbrecher

This column (as the newspapers would term it) is to report on recent current events that would interest the engineering geologist in the Netherlands. Hence it is open to all those who have, in their opinion, news to relate about recent events which they feel would interest others and keep them up to date as to what is happening in the Netherlands or even abroad but of interest to those working in the Netherlands.

The timetable in my diary at the end of April and beginning of May did not allow me to take a rest of almost continual and intensive lecturing and fieldwork chores since the beginning of this year and make some attempt to chip away at a large backlog of vacation days that now have accumulated to three figures! The reason why is as follows:

Options for tunnelling

The annual International Tunnelling Association conference for 1993 was held at the RAI, Amsterdam. The increasing technological developments made in this field and the general awareness in the Netherlands has increased substantially in the last few years as new tunnels are opened for the highway system, for metros and for the railways. The latter is causing extensive public and government debate with regard to the proposed Betuwe line and the TGV extension from Lille to Brussels and then to Amsterdam. The railway tunnels at Rotterdam and at Schiphol are evidence of increased use of tunnel options in the Netherlands. The most interesting development for the Netherlands is the possibility of the use of bored tunnels instead of the traditional cut-and-cover method used up to now except for the "no-dig" techniques used for pipelines. The latter are increasing to such a size that they can be termed tunnels (two metres diameter) in Tilburg and along the "BAL" line (Bergambacht Leiding).

During ITA conferences working groups convene to discuss and produce documentation on topics requiring research in tunnelling. Working group 4 which looks at planning aspects for tunnelling is particularly interested in obtaining more information on amongst other aspects (fire hazards/safety, uses for old mine spaces) use of geological and geotechnical information systems for planning of tunnel routes. If anybody can contribute towards this subject they are welcome to contact me so that I can compile a state of the art type report for the next meeting of the ITA.

Coming back to the Bergambachtleiding; though no engineering geologists seem to be involved in its planning and construction, the engineers involved seem to be fathering a number of Engineering Geologists as a recent excursion by the DIG (Dispuut Ingenieursgeologie) revealed; two students from Delft and one a doctorate (the first Netherlander so qualified in Engineering Geology, from the Ecole des Mines, Paris; Bianca van Hasselt)! The route planning for this line was a major undertaking and the data collected both preceding and during its construction should form the blue-print for future routes. Not only is the geology of significance but a number of environmental aspects concerning land use, soil science, hidden refuse and waste dumps allowed in days more lax, hidden foundations of dismantled structures and licences for future land use are a number of factors influencing the route line (it certainly contains more bends than the route it is supplementing to the drink-water infiltration dunes in Wassenaar.)

Changes in water levels with respect to changes in ground levels

In 1991 the Engineering Group of the Geological Society, London took the initiative to visit the Netherlands, Germany, France and Belgium in a combined field trip and symposium day. To keep the spirit of joint meetings and excursions alive this year the IngeoKring organised a two-day field trip with symposium choosing a subject relevant to specific problems in the Netherlands: the rise of waterlevels or the drop in ground levels with respect to water levels. Though the geology may not be impressive to look at, some aspects can be impressive: to be able to travel almost a whole day (from Delfzijl to Vlissingen) without seeing a hill except some sand dunes in Zeeland) combined with impressive sea defence works of the Afsluit Dijk and the Delta Works can be regarded as an attraction in its own right. Admittedly we have to probe the earth to discover what the deeper geology is but this did not stop the excursion delegates from photographing the flat fields of Hooghalen (south of Assen) where the underlying salt dome has caused a slight rise in the land requiring precision survey equipment to be able to discern changes in ground level.

The excursion started early Thursday morning at the ferry terminal in Vlissingen. Unfortunately only a few of the delegates could appreciate the full extend of the sea defence works as the bus travelled north to pick up further delegates at the North Sea ferry terminal, Europoort and then meeting up with the rest of the party, who had arrived through Hoek of Holland for the first meeting at the Stormvloedkering site on the nieuwe waterweg. Though a cloudburst occurred just when the party viewed the site, it did not dampen the enthusiasm; the remainder of the excursion remained sunny and dry. The next stop was Lelystad to learn about the effects of taking the land from the sea. The Flevoland polders must be the best documented and monitored polders in the Netherlands. The following two nights were spent in Meppel, Overijssel. The choice was based on the possibility for student delegates (a large party from Newcastle University) to stay at the very delightful Youth Hostel which was located near Meppel's only hotel opposite the railway station.
The second day was hosted by the NAM who is concerned with ground level changes as a result of hydrocarbon extraction and a number of speakers from England, the Netherlands and Belgium presented case histories relevant to the theme of the excursion.

On the final day, a Saturday, a visit was payed to the Waterschap of Eemzijlvest looking at the remedial works they have carried out in anticipation of the changes caused by the Slochteren field gas extraction. Based on the latest prognosis it appears that subsidence will be much less then at first anticipated. The return journey allowed only for a short stop on the Afsluitdijk. Distances are made longer in the Netherlands as the young bus driver dutifully restricted his driving to the legal speed limit of 80 km/hr.

Conservation of the earth - challenges to science and technology:
Geotechnica 93 and Environment

A growing number of engineering geologists in the Netherlands are becoming aware of a unique geological happening at the Koln Messe in Cologne. Though the IngeoKring members visiting the exhibition and conference were still in single figures they were all associated with stands: Jurgen Herbschleb and Ben Degen for Terraware, Hans Grabandt stood at KÖnig Geoconsult (he just joined Geoconsult of Hoensbroek, which firm has just acquired KÖnig engineering consultants of Aken) and René de Wit with a stand of Chemisches Laboratorium, Dr. E.

Wessling, a German Environmental Company he commutes to in Altenberge from his house in Enschede. Besides these stands familiar old colleagues from Fugro-McClelland-IGF were also there and further Dutch companies prominent at Geotechnica were A.P. van den Berg, Begeman, Elseviers, Eijkelkamp (opposite Terraware!), Goorbergh Geotechniek BV of Breda (with Mercedes Benz!) and OYO Center of Applied Geosciences of Nieuwegein. Both Goorbergh and KÖnig-Geoconsult had outside their cone penetration test trucks. Louk Snijders, manager of KÖnig-Geoconsult, who was there, said next time he would have to combine with DAF.
Geotechnica is the largest trade fair of its kind specific to geology and a conference with the theme of the earth conservation. The first three days are very full with visitors; the number diminished on the Saturday possibly because of the good weather. This, did, however, give a chance for the stand holders to visit each other and carry out business transactions. The conference was in contrast less spectacular, possibly too overshadowed by the success of the trade fair. Cost for attendance was at bargain prices, with special reductions for teaching staff. Simultaneous translation was provided. The conference parallel sessions were situated in halls requiring sometimes a long walk through the exhibition halls and did not encourage contact between the delegates. The presentations were, though, very relevant to engineering geology, especially with regard to increasing emphasis at the Faculty of Mining and Petroleum engineering, Delft to become more involved with environmentally related problems such as efficient use of raw materials, processing without wastage and contamination and recycling. Titles touch on aspects that could read like new curricula for Mining Engineering:

Environmentally aware exploitation of resources,
- extraction and processing of raw materials,
- production and supply of energy,
- soil and landscape,
- water and surface water,

Acquisition of information
- prospecting and exploration
- surveying technologies and analysis
- remote sensing and photogrammetry
- model building and simulation
- geo-information systems

Waste disposal and restoring nature
- derelict sites
- restoring nature
- avoidance and disposal of waste
- waste storage

Preventive and environmentally protective measures
- conservation of landscape and nature
- clean air
- conservation of water and surface water
- soil conservation

Environmental policies and their acceptance

The most controversial presentation was given by Professor W.S. Fyfe, the President of the International Union of Geological Sciences who stressed the three P's Pollution, Poverty and Population as the main Problems confronting humanity. He then said "I can name a fourth.....", which he then did (in Catholic Germany), "....Pope!" followed by applause from the audience. He emphasised that the main solution to this problem is to educate women.
On that last, controversial, note of Professor Fyfe, one can conclude that problems are caused through ignorance. Governments spend less on education (the Netherlands no exception) encourages ignorance rather then learning and hence touches at the root of where problem solving starts. Despite their learning, politicians seem incapable of recognising this simple truth, possibly because education did not go sufficiently far in their time.

RIBARROJA DAM EXCURSION

Carlos Maria Carranza Torres

Mr. Carranza Torres, from Argentina, participated in the Engineering Geology Course at ITC last year and is now following the MSc. course at ITC.

Introduction.

The visit to the Ribarroja Dam took place on Monday 13th April. Travelling by car from Falset we arrived to the place close to lunchtime. After meeting staff members of the project, we received an introductory explanation of the dam characteristics and aspects related with its problems due to the presence of gypsum in the foundation. We have visited the inspection galleries where we could see the deleterious effects of this mineral, as it is described later in this report.
We have visited the civil engineering and mechanical parts of the scheme as well. In the afternoon and after a meal that was offered by our hosts we returned to Falset.

Location.

The Ribarroja hydroelectric scheme is located on the Ebro river in the northeast part of Spain. With the Mequinenza Dam situated up-stream of the first, constitute the two largest projects on this river. Those dams belong to the hydroelectricity company ENHER (Empresa Nacional Hidroelectrica de Ribarroja S.A.) which started in 1955 with the studies and construction of those projects.
The construction of the Ribarroja dam started in 1961 and it was completely finished in 1969 with the put in service of the last of the 4 turbines.

Basic Description of the Project.

The hydrological basin has an area of 80823 Km^2 with a medium discharge of 460.61 m^3/s. The reservoir has an area of 20289 Km^2 and a total volume of 267Hm^3 for a water level of +73m.
The concrete dam of gravity type, has a trapezoidal section with a height of 60m from the foundation and a crown length of 562.40m. A volume of 800000m^3 was placed and 1600000m^3 of rock were excavated for a foundation area of 11650m^2.
The power central station has 4 Kaplan turbines with a medium discharge of 4x225=900m^3/s, and they generate 36800HP of power, with a water head of 33m.
In Figure 1 the different parts of the dam are indicated.

Geology of the Area.

The area where the hydroelectric project is located corresponds to the Oligocene epoch (Tertiary period) covered in some places by Quaternary deposits. Structurally there is no evidence of faults, and basically the site can be considered as a sequence of horizontal layers of marls and sandstones. Lithologically in the foundation area, those layers of a thickness varying between 0.50 and 0.30m, contain fibrous gypsum interbedded with an average thickness of 4 to 5 cm. During the visit inside the galleries and in the left abutment as well, the presence of the gypsum was easily recognized. From the geological report of the ENHER publication and from conversation with our hosts we conclude that before and during the construction they had complete knowledge of the existence of gypsum in the area.

Site investigation period.

During the site investigation period, tests for estimation of bearing capacity and permeability of the foundation were carried out. The ENHER publication indicates the number and type of tests.

In Situ tests:
- -4 Shear tests. 2 with natural moisture content and the others saturated.
- -4 Deformability tests.
- -2 Permeability tests.
- -2 Passive Strength tests.

Laboratory tests:
- -They were carried out over samples and as complement of in situ tests.

It is easy to realise that the number of tests for a large project and a lithology like this was not adequate, but more important is the fact that the rock mass seems to have been considered as impervious, apparently because of the presence of marl; then the solution of gypsum layers was not taken as an important potential problem. This is easy to see if we consider the type of tests that were done: c and ϕ values along gypsum-marl contact, permeability test without considering the time required for the solution, etc.

Beside the fact that the basin is considered as perfectly impervious before construction (textual translation from the ENHER report) to correct some possible leakage through the marl-gypsum rock mass, the foundation has a system of grout curtains of supersulphured cement that extends between 16 and 32m below the foundation level. The system is formed by 3 curtains upstream (PAR, SAR and PIAR) and 1 downstream (PAB) as it is shown in Figure 2. The dam structure has a net of 4 inspection galleries; below the foundation there are two galleries (G1 and G1') that are used to collect water from leakage and to avoid uplift pressures.

A system for the monitoring of the post-construction behaviour was installed, with the following elements:
- -Pendulum system.
- -Piezometer system.
- -Filtration Parshall measuring fumes.

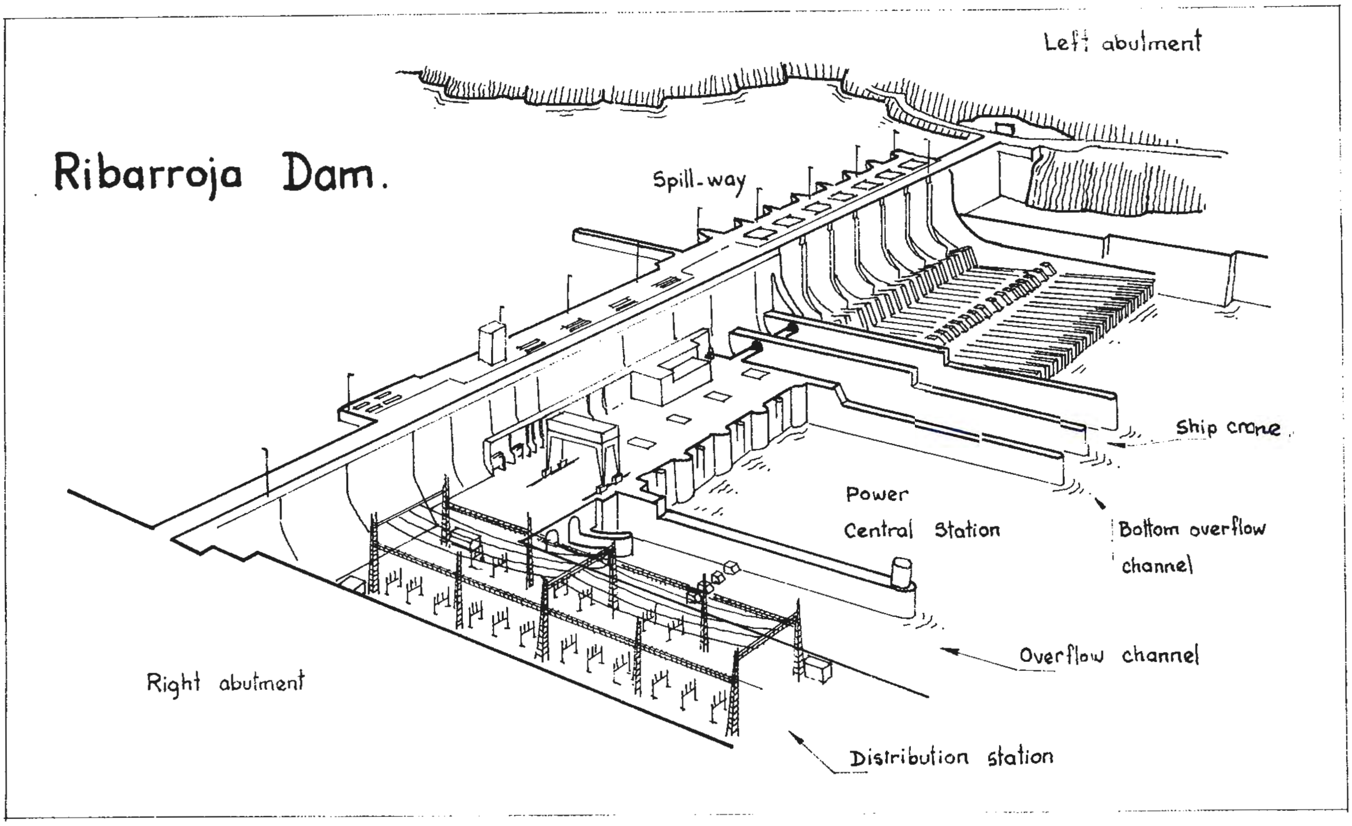

Figure 1 Ribarroja Dam

-Drainage curtain control.
-Concrete joint control.
-Geodesy system for dam movement control.

Post-Construction Period.

The behaviour after construction was not as they had expected. Large problems with gypsum solution appears with a consequent high economic cost to seal with grouting the leakage that has appeared since the time they have filled the lake.
Another effect of gypsum is related with corrosion. The solution of gypsum gives rise to sulphate bearing ground water; that is affecting mainly steel elements and the concrete as well. During the visit to the galleries it was possible to see effects of this corrosion.
It was noted that the attention paid to the monitoring system described above is not very important. As an example, in the first chamber containing a pendulum we entered, we could only see remainders of corroded steel elements.

Conclusion.

From the engineering geology point of view the present state of the Ribarroja Dam is the result of underestimating potential problems when dealing with soluble materials as gypsum in the rock mass.
Besides the economic problem that means such important maintenance work as it is the periodic grouting, is not possible to avoid questions related with safety:
The drainage curtains are indispensable to detect areas with filtration problems due to gypsum solution. What would happen if the erosion problem starts to develop in an area not covered by curtains?
Settlement is a common feature in structures founded in formation containing gypsum (i.e. embankments made with siltstone of Middle Muschelkalk T_{g22} we have visited during the fieldwork). The dam certainly must be suffering important settlement. In those cases the monitoring system plays a fundamental role, but unfortunately we only could see careless instrumentation.
We know that it is not recommendable to locate a dam on a lithology like this, but when no other possibilities exist Engineering Geology and maintenance become (or should become) the base of every project.

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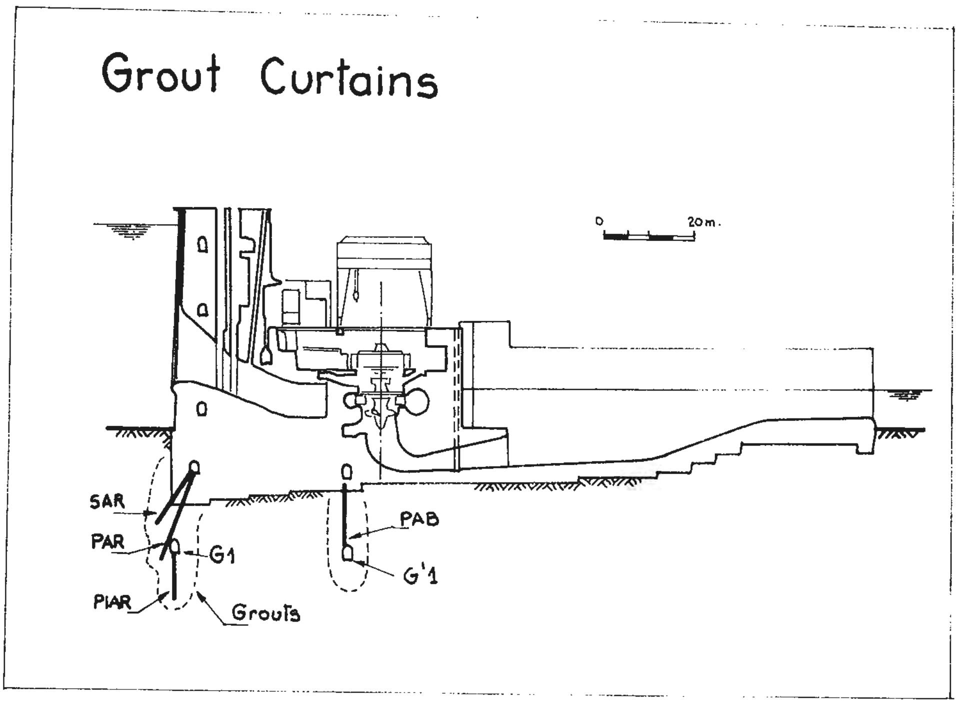


Figure 2 Grout curtains and galleries in power central station foundation.

GEOTHERMIE EXCURSIE 1993 IJSLAND

A.C.W. Bloem

De auteur is president van het Dispuut IngenieursGeologie.

De studenten die het vierdejaars keuzevak mp 4500 "Geothermie" volgden kwamen op een ochtend tot de conclusie dat voor het bekijken van de echte geothermische bronnen maar één land geschikt was, IJsland, het land dat in de reisgidsen beschreven staat als het walhalla voor geologen. De plannen werden gemaakt, en op dinsdag 20 april vertrokken de vijftien studenten tezamen met Prof. Walter, met Icelandair naar de luchthaven Kevlavik, zo'n vijftig kilometer van de hoofdstad Reykjavik. Vanuit het vliegtuig was het landschap goed te zien, de gletsjers en het landschap dat veel weg had van een plaatje van de maan, vielen het meest op. Het vliegveld Kevlavik ligt op Boven Pleistocene lavas, terwijl in de route naar Reykjavik, de holocene basische lavas de aanwezigheid van de Mid-Atlantische rug aantoonden. Een verlaten landschap, waar de eerste bomen die gezien werden pas op de begraafplaats van Reykjavik stonden. In de avond was de eerste confrontatie met een produkt van geothermische energie, het zwembad van Reykjavik: terwijl de buitenlucht rond de vijf graden Celsius was, was het water in het zwembad een aangename dertig graden.

Energievoorziening

Tachtig procent van de ongeveer 250.000 IJslanders woont in gebouwen die met geothermische warmte verwarmd worden. Dat is ongeveer driekwart van alle huizen in IJsland. Verder wordt de warmte gebruikt voor verwarming van de kassen, met een totaal oppervlak van 150.000 m^2, die de helft van het jaar produktief zijn, de rest van het jaar is het te donker. Men hoopt op hulp uit Nederland om ook dat probleem op te lossen. Ook worden landbouwgronden met aardwarmte ontdooid, om het landbouwseizoen eerder te kunnen beginnen. Dit wordt op 120.000 m^2 gedaan. Verder worden door 'vloerverwarming' straten ontdooid. De aardwarmte wordt niet alleen gebruikt voor de directe verwarming, de hoge enthalpie velden worden ook gebruikt voor elektriciteit opwekking. Er wordt gesproken van een hoog enthalpie veld als de temperatuur op 2000 meter diepte hoger is dan 200°C. In 1990 was 4.6% van de elektriciteit produktie door aardwarmte.
De geothermische energieopwekking is in een stroomversnelling gekomen na de oliecrisis. Sinds 1970 heeft de bevolking van IJsland drie miljard dollar bespaart op de invoer van aardolie. Het gebruik van aardolie voor verwarming is in die periode afgenomen van 50% in 1970 tot 3% hedendaags. De totale energievoorziening in IJsland was in 1990 85.115 TJ, wat voor 45.4% opgewekt werd met aardwarmte, 17.6% met waterkracht, 34.2% uit olie en 2.8% met kolen. Het percentage van energievoorziening door aardwarmte is het hoogst in de wereld.

Opsporing

De opsporing van de geothermische reservoirs wordt door de Orkustofnun gedaan. Met geofysisch onderzoek worden de warmtereservoirs gezocht. Hiervoor maakt men elektrische weerstands sonderingen. Hoe hoger de temperatuur in het reservoir, hoe lager de weerstand. In een hoog enthalpie reservoir is de weerstand kleiner dan 10 ohm. Verder gebruikt men elektromagnetische metingen met loops achter snowscooters en magnetometrisch onderzoek voor de detectie van breuken. Tot grote teleurstelling van de aanwezige Petroleumwinners werd er alleen seismisch onderzoek gedaan op de Engineering Geological department. Voor de mogelijke aanleg van een tunnel onder de Hvalfjördur werd een 2D multi-channel survey geschoten om het grensvlak te vinden tussen de basaltische bed rock, met een voortplantingssnelheid van 3000 tot 5000 m/s, en de glaciale sediment opvulling, met een voortplantingssnelheid van 1600 tot 2000 m/s, in dit fjord. Ondanks de grote diepte, ongeveer 250 meter onder de zeespiegel, waarop de bedrock ligt wil men door de basalt tunnellen, aangezien dit goedkoper is dan in het losse sediment. De hardheid van de basalt vereist de tunnelbouw methode volgens het "drilling & blasting" principe. De bevolking staat echter sceptisch tegenover de tunnel, vanwege twijfels over de veiligheid. Vulkaanuitbarstingen en aardbevingen zijn een vast onderdeel van het leven op IJsland, maar een tunnel onder water blijkt toch iets te veel van het goede.

Het grootste probleem bij de aardwarmte winning is 'scaling', het neerslaan van silica en $CaCO_3$ in de leidingen. In de regel wordt aangehouden dat de neerslag begint bij een temperatuur van 100° beneden de veldtemperatuur.

Geologie

Geologie is populair in IJsland. Er zijn op de bevolking van een kwart miljoen bijna tweehonderd gediplomeerde geologen, dat is relatief gezien twee keer zoveel als in de Verenigde Staten. Op de middelbare scholen is geologie ook een verplicht vak en IJsland's populairste dichter is ook een geoloog, de lange koude nachten van het eiland bleken genoeg inspiratie te geven.

De oudste gesteentes op IJsland zijn van Tertiaire ouderdom. Deze zijn te vinden aan de oost en west rand van het eiland. In het noordwesten, op de Amerikaanse plaat is het Tertiair wijdverspreid aanwezig. Het oudst gedateerd zijn de bruinkool afzettingen van ongeveer 10 miljoen jaar geleden. Naar het midden toe worden de gesteentes jonger, tot op de neo-vulkanische zone, die opgesplitst kan worden in de noordoostelijke, de westelijke en de oostelijke vulkanische zone. De noordoostelijke zone, waar de plaatrand van de Amerikaanse en Europese platen noordzuid georiënteerd is, bestaat uit vijf vulkanische systemen, waarvan de Krafla tot 1984 actief was. Hier bevindt zich een magma kamer op 2600 meter diepte. De westelijke vulkanische zone beweegt jaarlijks gemiddeld acht millimeter uit elkaar. In de afgelopen 9000 jaar is de slenk bodem zestig tot negentig meter dieper komen te liggen. De centrale vulkaan, de Hekla, ligt in de oostelijke vulkanische zone, een kort spleetsysteem dat van noordoost naar zuidwest loopt. De uitbarstingen van deze vulkaan zijn gevaarlijk vanwege de uitstoot van vulkanische as met puimsteen en vulkanische bommen met een doorsnede van een meter. De as kan tot een hoogte van tien tot dertig kilometer uitgeblazen worden. De lavastroom is zeer visceus, en daarom minder gevaarlijk. Tijdens historische uitbarstingen is in totaal 5 km^3 as en 8 km^3 lava uitgestoten.

Warmte centrales

Er werden twee warmte centrales bezocht, de Svartsengi centrale en de Nesjavellir centrale. De Svartsengi centrale is een cogeneration plant, er wordt zowel warm water als elektriciteit geproduceerd. De centrale ligt zuidwestelijk van Reykjavik, in de westelijke vulkanische zone en voorziet in de energiebehoefte van het zuidwestelijk deel van IJsland, met daarop onder andere de luchthaven. In totaal zijn er zo'n vijftienduizend inwoners die van de energie van deze centrale gebruik maken.
Het reservoir ligt op vijfhonderd meter diepte en heeft een temperatuur van 240° C. Sinds het opstarten van de centrale in 1978 is de reservoirdruk met twintig bar gedaald, maar de jaarlijkse drukverlaging is nu ongeveer een bar. De vloeistof in het reservoir is een oplossing met een zoutgehalte van ongeveer tweederde van het zeewater. De pekel wordt via hoge druk afscheiders gescheiden. De hoge druk stoom wordt via turbines

gebruikt voor elektriciteit opwekking. De lage druk pekel wordt gebruikt om via warmtewisselaars zoet water uit een nabijgelegen meer te verwarmen, Het hete water met een temperatuur van honderd graden wordt vervolgens verpompd naar de gebruikers. De totale produktie van deze centrale is 125 MW aan verwarmd water en 16.4 MW aan elektriciteit. Het afvalwater wordt onbehandeld naar de hoog permeabele lavas in de omgeving gepompt, waar door verstopping met neergeslagen silica een blauw meer is ontstaan, dat nu onder de naam 'the blue lagoon' als zwembad met heilzame werking geëxploiteerd wordt.

Een nieuwe co-generation plant die gebouwd is ongeveer 30 kilometer ten oosten van Reykjavik is de Nesjavellir geothermal power plant. Op het moment wordt de centrale alleen gebruikt voor warm water produktie voor Reykjavik, de elektriciteit opwekking staat nog stil, aangezien de elektriciteit behoefte al voorzien is. Het warm water gaat via een 27 kilometer lange pijpleiding met een doorsnede van 800 mm naar Reykjavik. Deze leiding is ontworpen voor water met een temperatuur van 97°C en een snelheid van 1870 liter per seconde. Het reservoir onder de Nesjavellir plant heeft een temperatuur van 300 tot 400°C, en ligt net als de Svartsengi centrale op de as van de Mid-Atlantische rug. De laatste uitbarsting in de buurt van de centrale vond twee duizend jaar geleden plaats. De porositeit van het reservoirgesteente is laag, ongeveer zes procent. Door het samenkomen van twee breukzones is het gesteente door de breuken hoog permeabel.
Het koude water wordt vanuit een nabijgelegen meer gepompt naar de centrale en verwarmd. Dit wordt gedaan omdat de hoge enthalpie velden een zwavelgehalte hebben van meer dan 2000 mg/l, in de lage enthalpievelden, zoals onder Reykjavik is het zwavelgehalte maar 0.2 mg/l, dit water kan gelijk in het publieke warm water stelsel.

EXCURSIEVERSLAG BERGAMBACHTLEIDING

C.A. Messemaeckers van de Graaff

De schrijver van dit verslag is secretaris van het Dispuut Ingenieurs Geologie, en op het moment aan het afstuderen bij Visser & Smit Hanab.

Woensdag 19 mei 1993 heeft het DIG een excursie georganiseerd naar een horizontaal gestuurde boring, uitgevoerd door Visser & Smit Hanab. De bus vertrok om 9.45 voor het faculteitsgebouw van mijnbouw en petroleumwinning. Dit was een kwartier te laat, veroorzaakt door Albert B: president van het DIG. De opkomst van de studenten was goed alleen de stafleden van de sectie ingenieursgeologie lieten het op het laatste moment een beetje afweten, met als positieve uitzondering natuurlijk de heer Maurenbrecher.

Ons eerste doel was 'Het oude Raedthuys' in Moerkapelle. Hier zetelt het team dat de leiding heeft over het project. We kregen hier uitleg over het project van de project manager en van een ingenieur van Grondmechanica Delft, het ingenieursbureau dat de benodigde grondmechanische gegevens verzamelt en interpreteert. Het blijkt dat er verschillende problemen reizen bij de aanleg van de waterleiding die een lengte krijgt van 55 kilometer en een binnendiameter zal hebben van 1.60 meter. De tweede bergambachtleiding die de provincie Zuid-Holland in 1995 van drinkwater moet voorzien wordt uitgevoerd in voorgespannen betonbuizen. De kruisingen van wegen en waterstaatswerken wordt uitgevoerd met gewapend betonnen buizen met plaatstalen kern met buitendiameter van 1.90 meter. In het trace zitten bijna 50 kruisingen waarvan een aantal belangrijke kruisingen wordt uitgevoerd door Visser & Smit Hanab uit Papendrecht.

Na een goede uitleg en koffie werd na een korte rit richting Krimpenerwaard de excursie vervolgd met een bezoek aan een boring in uitvoering. De boring die we bezochten werd uitgevoerd ten behoeve van een kruising met een gasleiding. De waterleiding moest voldoende diep geboord worden zodat de verticale afstand met de gasleiding voldoende groot zou zijn en er geen gevaar was voor zetting van de gasleiding. Het deel door de Krimpenerwaard voert door een veenpakket met een dikte van 15 meter. Hieronder bevindt zich het pleistocene zand. Ontwatering en inklinking van het veen in de Krimpenerwaard worden tegengegaan door aanleg in den natte. Als gevolg van de geologische situatie is bronbemaling in de Krimpenerwaard verboden. Om deze reden werd voor de boring gekozen voor aanleg van een bouwput met een bodem van onderwaterbeton. De lengte van het te boren traject was 204 meter. Er werd geboord volgens de EPBS methode (NL: grondrukbalans schild, Eng: Earth-Pressure-Balanced-Shield). De grond aan het graaffront was plastisch genoeg om hydraulisch afgevoerd te kunnen worden. Het grootste probleem was het niet op de goede hoogte blijven van de boormachine. In het begin werd er niet continu geboord. Na dat de daling werd waargenomen werd besloten het boren 24 uur per dag voort te zetten om zo te voorkomen dat de minimaal te bereiken hoogte in de tweede persput gehaald zou worden. Toen wij aanwezig waren was men positief gestemd en men dacht dat de boorkop niet te laag zou uitkomen, waarschijnlijk door het feit dat deze zich op een gegeven moment heeft kunnen afzetten op een laag met een wat hogere dichtheid. De afwijking met de geplande hoogte was maximaal 2 meter.

Mogelijke oorzaken van de aangetroffen

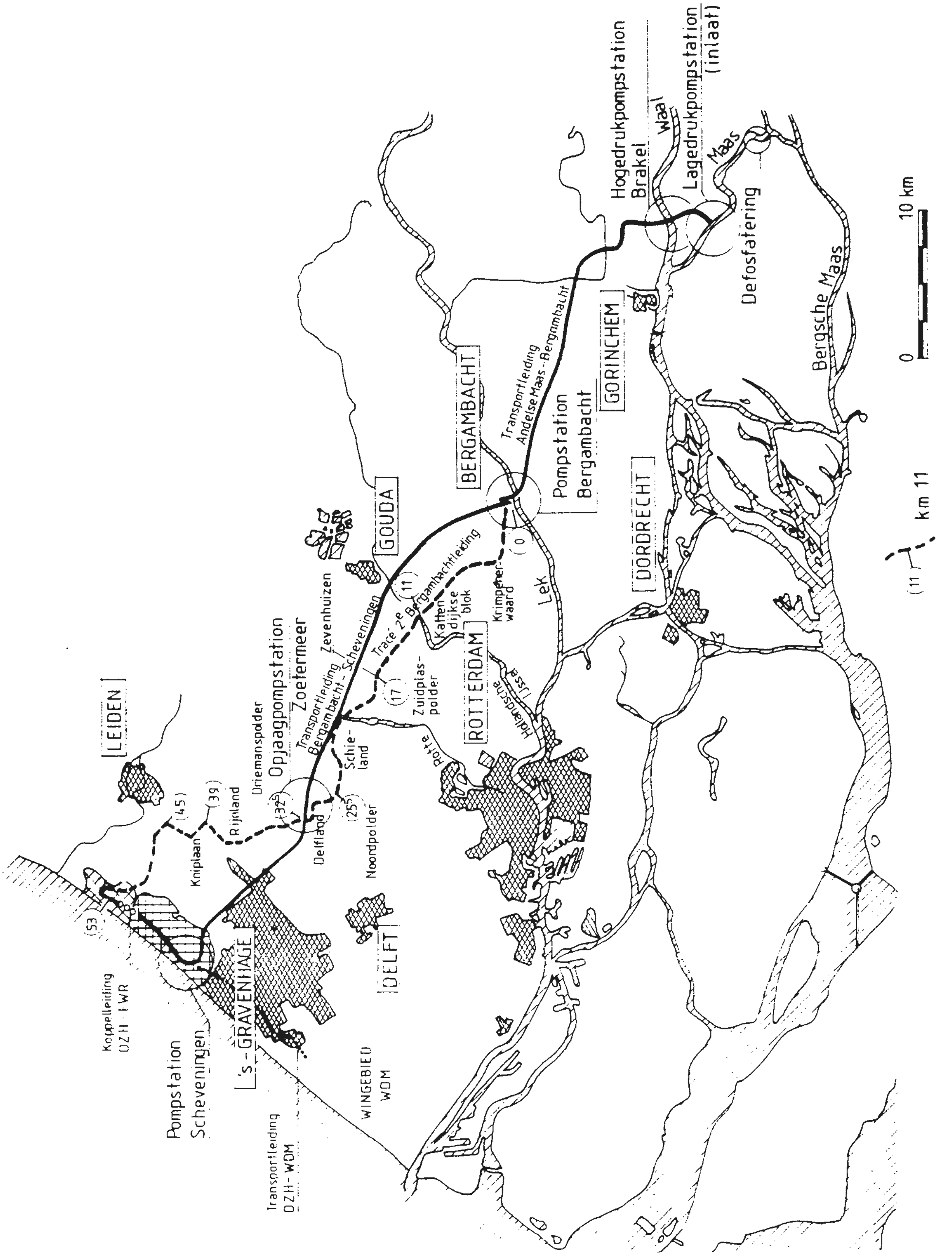
problemen:

- Het starten van de boring terwijl de boormachine niet de goede helling heeft.
- Het hoge eigengewicht van de boormachine en de opdrijvende krachten van de erachter doorgeperste leiding zorgen ervoor dat de helling negatief wordt beinvloedt. De discontinuiteit van het proces in het begin werkte zakken in de hand.
- De slappe bodem waardoor de boorkop zich niet af kan zetten door middel van de hydraulische vijzels in de boormachine.

Tevens werd verteld over een gedeelte van het project wat het boren van de leiding onder de spoorlijn Den Haag/Gouda en Rijksweg 12 tussen Zoetermeer en Den Haag betreft. Hierbij is schade ontstaan aan spoorlijn en snelweg. Uit grondonderzoek bleek voldoende hoge sondeerwaarden om zonder problemen de kruising te realiseren. In werkelijkheid voerde het boorschild alleen 'prut' af waardoor een zetting van 30 centimeter werd veroorzaakt (zie ook: Land & Water, juni 1993).

Ontwikkelingen in de praktijk lopen vooruit op het theoretisch onderzoek. Mede door het zojuist voorval en door de expliciete vraag uit het bedrijfsleven blijkt dat horizontaal gestuurd boren nog veel onderzoek vraagt. Naar mijn mening kan ingenieursgeologie daar een zeer belangrijke rol in gaan spelen.
De excursie werd afgesloten met een lunch aangeboden door Visser & Smit Hanab. De heer van Hasselt van de Grontmij, uitgeleend aan het Duinwaterleiding bedrijf Zuid-Holland, had het hoogste woord en over de dochters van deze man uit de praktijk is inmiddels veel bekend. Bij deze gelegenheid wil ik ook de heer van der Horst van Visser & Smit hartelijk bedanken voor het mogelijk maken van deze naar mijn mening zeer geslaagde excursie.

Ligging van de bestaande en nieuw aan te leggen rivierwatertransportleiding.



REMEDIAL ACTIONS FOR CONTAMINATED SOIL

Bernice Baardman

This report results from a one week literature survey which forms part of the fourth course of the study Engineering Geology at the faculty of Mining and Petroleum Engineering, Delft University of Technology, the Netherlands. The author has graduated in August 1993.

SUMMARY

An overview is given of present remedial actions for contaminated soils. The techniques can be divided into:
- in-situ techniques
- excavation followed by transport and treatment in a remote unit
- excavation combined with on-site treatment.

The various techniques are explained, their advantages and disadvantages are discussed, and some research centers are named. Finally some useful literature is indicated.

1. INTRODUCTION

Though we had never heard of soil contamination before the 1980's, it is a very old problem. Ever since the existence of larger cities a waste problem occurred. With ongoing technology development more and more waste was produced, stored and transported. This growth results in an increased amount of toxic compounds in the soil, air and water.
On any terrain where toxic compounds have been used for some time the soil might be contaminated, and the terrain can be a danger for the environment. For all these terrains a historical investigation should be done, leading to a simple field investigation. If pollution is detected, an evaluation must be made whether the environment can be harmed or not. This depends on the type and concentration of the contaminants, the possibilities of spreading via the groundwater and the future use of the terrain. If any danger exists a comprehensive investigation should be done in order to establish the best remedial action.

Not in all countries soil remediation has been applied yet. Reports have been published in countries like the USA, Canada, Japan and Western Europe. [Noorman, J., 1992] states that remediation techniques in the Netherlands have been developed quite far in comparison to other countries. This may account for the fact that a lot of literature found was from Dutch origin.

In the Netherlands a reference table was established to indicate the concentration for various contaminants at which immediate measures should be taken (the 'C-value'), the concentration at which further investigation must be done (the 'B-value') and the safe concentration (the 'A-value'). A copy of such a table is given in figure 1. If remedial actions are undertaken the Dutch government prescribes that the resulting concentration after treatment must be below the 'A-value'; if not, this remedial technique is not allowed to be used. In other countries the effects of cleaning are expressed as a remediated percentage, paying less attention to the question whether the residual concentration is still harmful. As many remedial techniques can not yet reach the 'A-value' problems are expected in the Netherlands, especially because since 1993 the government inhibits the dump of polluted ground that can be cleaned.

2. CLASSIFICATION OF REMEDIAL ACTIONS

A summary of the subdivision of possible treatments of polluted soil is given in figure 2. The two main groups of methods are:

a. those who aim at inhibiting the contamination to spread to their direct environment
b. those who aim at removing or destroying the contamination.

The first category is subdivided into civil engineering techniques, geohydrological methods and immobilization techniques. This will shortly be discussed in chapter 5.

The remedial techniques are subdivided into:

b.1 cleaning of the soil in-situ, without previous excavation
b.2 excavation of the soil and transport to a treatment unit
b.3 excavation of the soil and remediation on-site

The techniques used on-site are similar to some of the in-situ and after-excavation techniques, and will not be described separately.
Table 1 gives an overview of advantages and disadvantages of each remedial technique, an indication of the costs per ton of treated soil, toxic compounds which the method is suitable for, and soils which the method is suitable for.
In the next chapters the techniques will be explained and discussed.

Examination framework for several soil pollutants: indicative values for concentration levels (4th revised version Leidraad Bodemsanering, november 1988)

Indicative values — *A - reference value*; *B - indicative value for (further) investigation*; *C - indicative value for cleaning-up*

Occurance in:	Soil (mg/kg dry matter)			Groundwater (µg/l)		
substance level	A	B	C	A	B	C
1. Metals						
Cr (chromium)	*	250	800	*	50	200
Co (cobalt)	20	50	300	20	50	200
Ni (nickel)	*	100	500	*	50	200
Cu (copper)	*	100	500	*	50	200
Zn (zinc)	*	500	3.000	*	200	800
As (arsenic)	*	30	50	*	30	100
Mo (molybdenum)	10	40	200	5	20	100
Cd (cadmium)	*	5	20	*	2,5	10
Sn (tin)	20	50	300	10	30	150
Ba (barium)	200	400	2.000	50	100	500
Hg (mercury)	*	2	10	*	0,5	2
Pb (lead)	*	150	600	*	50	200
2. Anorganic compounds						
NH_4 (as N)	-	-	-	*	1000	3.000
F (total)	*	400	2.000	*	1200	4.000
CN (total-free)	1	10	100	5	30	100
CN (total-complex)	5	50	500	10	50	200
S (total-sulfides)	2	20	200	10	100	300
Br (total)	20	50	300	*	500	2.000
PO_4 (as P)	-	-	-	*	200	700
3. Aromatic compounds						
benzene	0,05 (d)	0,5	5	0,2 (d)	1	5
ethylbenzene	0,05 (d)	5	50	0,2 (d)	20	60
toluene	0,05 (d)	3	30	0,2 (d)	15	50
xylenes	0,05 (d)	5	50	0,2 (d)	20	60
phenols	0,05 (d)	1	10	0,2 (d)	15	50
aromats (total)	-	7	70	-	30	100
4. Polynuclear aromatic hydrocarbons (PAH)						
naphthalene	•,°	5	50	0,2 (d)	7	30
phenanthrene	•,°	10	100	0,005 (d)	2	10
anthracene	•,°	10	100	0,005 (d)	2	10
fluoranthene	•,°	10	100	0,005 (d)	1	5
chrysene	•,°	5	50	0,005 (d)	0,5	2
benz(a)anthracene	•,°	5	50	0,005 (d)	0,5	2
benzo(a)pyrene	•,°	1	10	0,005 (d)	0,2	1
benzo(k)fluoranthene	•,°	5	50	0,005 (d)	0,5	2
indeno(1,2,3-cd)pyrene	•,°	5	50	0,005 (d)	0,5	2
benzo(ghi)perylene	•,°	10	100	0,005 (d)	1	5
PAH (total)	1	20	200	-	10	40

Table 1: Indicative values for concentration levels of several pollutants in soil

Figure 1: Descripton of the Dutch A, B and C-values.

Occurance in: substance level		Soil (mg/kg dry matter) A	B	C	Groundwater (µg/l) A	B	C
5. Chlorinated Hydrocarbons							
alifatic CHC	(individual)	•,∘	5	50	0,01 (d)	10	50
alifatic CHC	(total)	-	7	70	-	15	70
chlorobenzenes	(individual)	•,∘	1	10	0,01 (d)	0,5	2
chlorobenzenes	(total)	-	2	20	-	1	5
chlorophenols	(individual)	•,∘	0,5	5	0,01 (d)	0,3	1,5
chlorophenols	(total)	-	1	10	-	0,5	2
chloor PAH	(total)	•,∘	1	10	-	0,2	1
PCB	(total)	•	1	10	0,01 (d)	0,2	1
EOCl	(total)	0,1	8	80	1	15	70
6. Pesticides							
organic chlorinated	(individual)	•,∘	0,5	5	1/0,01 (d)	0,2	1
organic chlorinated	(total)	-	1	10	-	0,5	2
non chlorinated	(individual)	•,∘	1	10	1/0,01 (d)	0,5	2
non chlorinated	(total)	-	2	20	-	1	5
7. Other pollutants							
tetrahydrofuran		0,1	4	40	0,5	20	60
pyridine		0,1	2	20	0,5	10	30
tetrahydrothiophene		0,1	5	50	0,5	20	60
cyclohexanone		0,1	6	60	0,5	15	50
styrene		0,1	5	50	0,5	20	60
Phtalates	(total)	0,1	50	500	0,5	10	50
oxidized PAH	(total)	1	200	2.000	0,2	100	400
mineral oil		•	1000	5.000	50 (d)	200	600

Table 1 (cont.): Indicative values for concentration levels of several pollutants in soil

* = Reference values for heavy metals, arsenic en fluor (table 2)
• = Reference values for organic compounds in soil (table 4)
d = Detection limit

For metals marked with *, the A-value relates to the clay content (C) and/or the organic matter (O) content of the soil according to:

Substance	Soil (mg/kg dry matter) Calculation method	Standard soil (C=25 / O=10)	Grondwater (µg/l)
Cr (chromium)	50 + 2C	100	1
Ni (nickel)	10 + C	35	15
Cu (copper)	15 + 0,6 (C + O)	36	15
Zn (zinc)	50 + 1,5 (2C + O)	140	150
As (arsenic)	15 + 0,4 (C + O)	29	10
Cd (cadmium)	0,4 + 0,007 (C + 3O)	0,8	1,5
Hg (mercury)	0,2 + 0,0017 (2C + O)	0,3	0,05
Pb (lead)	50 + O + C	85	15
F (fluor)	175 + 13C	500	-

Tabel 2: Reference values for heavy metals, arsenic en flur

For organic compounds marked with ∘, the A-value relates to the organic compound content of the soil according to:

$$Referencevalue\ (O = 0\text{-}2\ \%) = \frac{referencevalue\ (O = 10)}{10} \times 2$$

Substance		Groundwater	Remarks
nitrate phosphate phosphate	 (total)	5,6 mg N/l 0,4 mg P/l sandy areas 3,0 mg P/l clayey and boggy areas	For protection of poor areas, lower values may be required
sulphate bromides chlorides fluorides ammonium compounds		150 mg/l 0,3 mg/l 100 mg/l 0,5 mg/l 2 mg N/l sandy areas 10 mg N/l clayey and boggy areas	In areas with naval influence, higher values occur naturally (salt and brackish groundwater)

Tabel 3: Reference values for other anorganic compounds

Substance	Reference values at 10 percent organic matter (O=10)
a) Halogenated hydrocarbons en choline esterase inhibitors	
hexachlorocyclohexane; endrin tetrachloroethane; tetrachloromethane; trichloroethane; trichloroethylene; trichloromethane PCB IUPAC numbers 28 and 52	less than 10 µg/kg dry matter, per substance
chloropropene; tetrachloroethylene; hexachloroethane; hexachlorobutadiene; heptachlorepoxide; dichlorobenzene; trichlorobenzene; tetrachlorobenzene; hexachlorobenzene; monochloronitrobenzene; dichloronitrobenzene aldrin; dieldrin chlordane; endosulfan; trifluralin; azinphos-methyl; azinphos-ethyl; disulfoton; fenitrothion; parathion (and -methyl); triazophos PCB IUPAC numbers 101, 118, 138, 153 and 180	less than 10 µg/kg dry matter, per substance
DDD, DDE, pentachlorophenol	less than 100 µg/kg dry matter, per substance
b) Polynuclear aromatic hydrocarbons (PAH)	
naphtalene; chrysene	less than 10 µg/kg dry matter, per substance
phenanthrene; anthracene; fluoranthene; benzo(a)pyrene	less than 100 µg/kg dry matter, per substance
benzo(a)anthracene	less than 1 mg/kg dry matter, per substance
benzo(k)fluoranthene; indeno(1,2,3-cd)pyrene; benzo(ghi)perylene	less than 10 mg/kg dry matter, per substance
c) Mineral oil	
total	less than 50 mg/kg dry matter, per substance
octane, heptane	less than 1 mg/kg dry matter, per substance

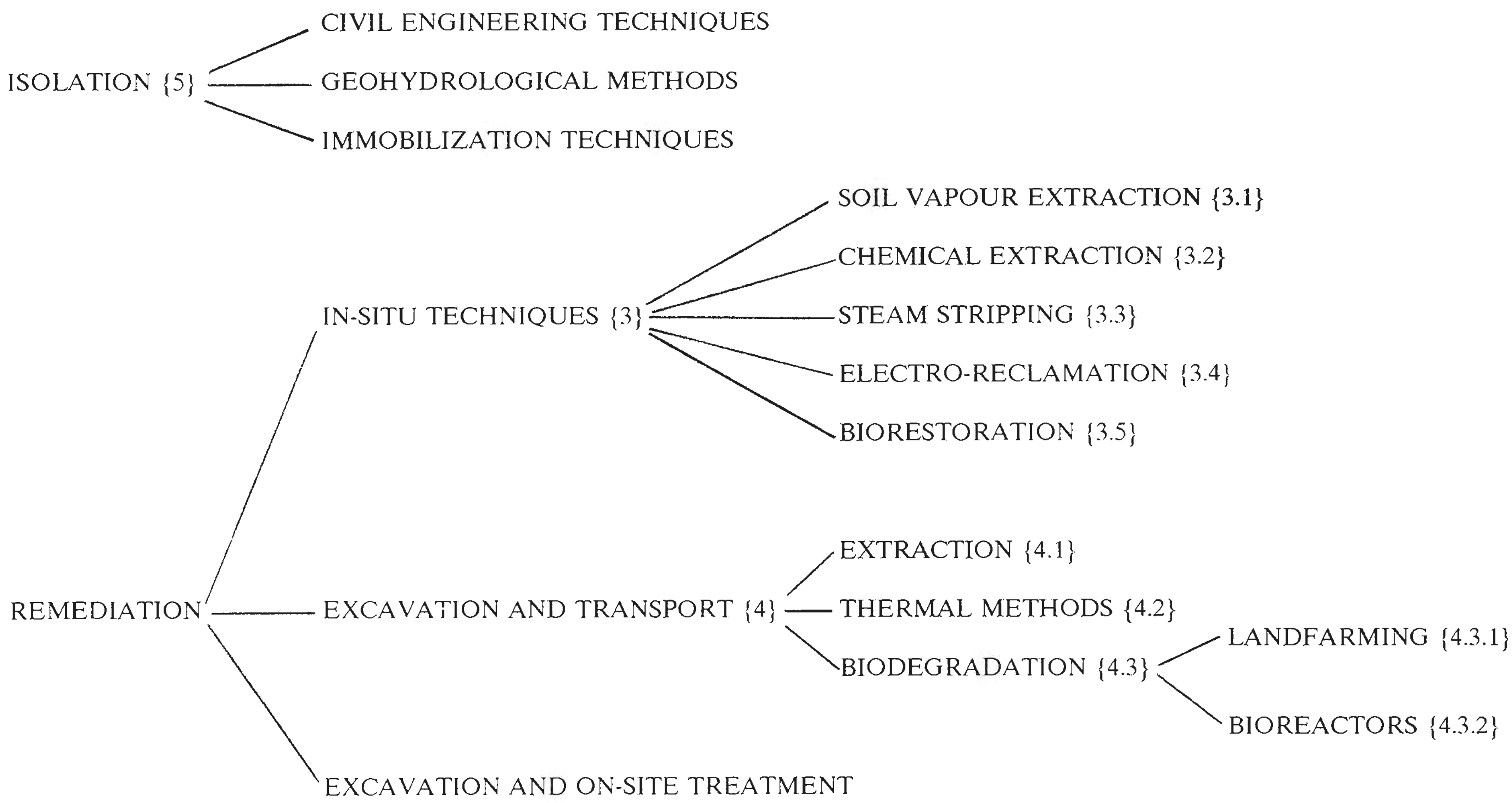


Figure 2: An overview of treatment methods for polluted soil. The numbers refer to the paragraphs where the method is explained and discussed.

REMEDIATION TECHNIQUE	ADVANTAGES	DISADVANTAGES	COSTS PER TON	COMPOUNDS	SOILS
SOIL VAPOUR EXTRACTION	-CHEAP -'A-VALUE' CAN BE REACHED	-AIR MUST BE CLEANED -ONLY FOR VOLATILE COMPOUNDS -ONLY IN PERMEABLE SOILS	?	-AROMATES -MINERAL OIL	ONLY PERMEABLE AND RATHER HOMOGENEOUS SOILS
CHEMICAL EXTRACTION	-MANY DIFFERENT COMPOUNDS CAN BE TREATED	-WATER MUST BE CLEANED -ONLY IN PERMEABLE SOILS -LITTLE EXPERIENCE IN PRACTICE	?	-HEAVY METALS -CYANIDE -AROMATES -LIGHT OILS -CHLORINE SOLVENTS	ONLY PERMEABLE AND RATHER HOMOGENEOUS SOILS
STEAM STRIPPING	-MORE POWERFUL THAN SOIL VAPOUR EXTRACTION	-HIGHER COSTS -DIFFICULT TO EXECUTE -STEAM MUST BE CLEANED -ONLY IN PERMEABLE SOILS -POSSIBILITY OF UNCONTROLLED RELEASE OF POLLUTED STEAM	?	-AROMATES -HEAVIER OILS	ONLY PERMEABLE AND RATHER HOMOGENEOUS SOILS
ELECTRO-RECLAMATION	-SUITABLE FOR HEAVY METALS -SUITABLE FOR CLAY AND PEAT -'A-VALUE' CAN BE REACHED	-HIGH ENERGY COSTS -LITTLE PRACTICAL EXPERIENCE -ONLY BIODEGRADABLE COMPOUNDS CAN BE TREATED	FL. 125 - 250	HEAVY METALS	-DEPENDS ON CHEMICAL COMPOSITION OF SOIL -SUFFICIENTLY HOMOGENEOUS
BIORESTORATION	-CHEAP -SOIL STAYS 'ALIVE'	-VERY SLOW PROCESS -'A-VALUE' USUALLY NOT REACHED	?	- LIGHT OILS, GASOLINE	ONLY SUFFICIENTLY PERMEABLE SOILS
EXTRACTION	-SUITABLE FOR ALL CONTAMINATIONS -SUITABLE FOR 'COCKTAILS' OF CONTAMINANTS	-MORE EXPENSIVE THAN THERMAL AND BIOLOGICAL METHODS -NOT SUITABLE FOR CLAYEY SOILS -'A-VALUE' NOT ALWAYS REACHED	FL. 125 - 150	ALL TYPES	NOT TOO MANY FINE PARTICLES
THERMAL METHODS	-'A-VALUE' CAN BE REACHED -SHORT PROCESS TIME	-SOIL IS 'DEAD' -HIGH ENERGY USE -NO HEAVY METALS CAN BE REMOVED	FL 100 - 150	-CYANIDE -AROMATES -POLYCYCLIC AROMATIC HYDROCARBONS -OILS	ALL
BIODEGRADATION	-NO RESIDUAL PRODUCT -NO USE OF ENERGY -SOIL STAYS 'ALIVE'	-LONG PROCESS TIME -'A-VALUE' USUALLY NOT REACHED -ONLY LIGHTER OILS CAN BE REMOVED	FL 70 - 90	-LIGHT OILS	ALL SOILS

Table 1: aspects of remedial techniques, based on [Didde, R., 1993], [Misset's Milieu Magazine, March 1992, pp 52 and 53] and others.

3. IN-SITU TECHNIQUES

The interest for in-situ techniques has grown significantly during the last years. Reasons for this are the huge amount of discovered contaminated grounds, also present below infrastructure, e.g. in city centers and industrial estates. Furthermore in-situ techniques are usually simple to execute and therefore mostly cheaper than other techniques. Problems are:

- the nature and extent of the pollution can never be known exactly
- heterogeneity of the soil
- the long duration of remediation
- the difficult inspection whether really all of the soil has been treated.

To solve these difficulties a lot of site investigation has to be carried out before actual cleaning, thus raising the costs of relatively cheap methods.

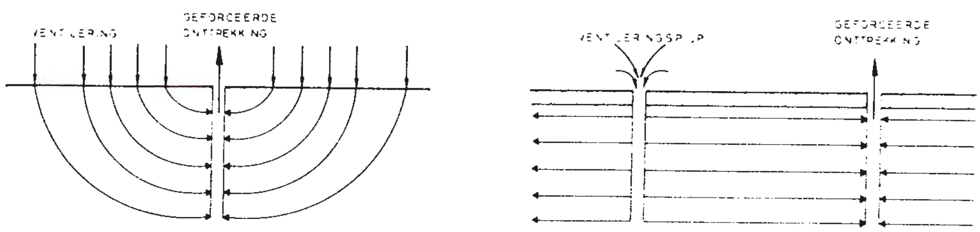
Generally the criteria favourable for applying in-situ techniques are the following [Vree, H.B.R.J. van, 1992]:

- the permeability of the soil is reasonable
- no disturbing layers of clay or peat in the subsoil
- the contamination is infiltrated (i.e. not buried)
- the quantity of contaminated soil is substantial
- the contaminant can be biodegraded or
- the contaminant can be leached or volatilized

In the next paragraphs common in-situ techniques will be explained.

3.1 SOIL VAPOUR EXTRACTION

Soil vapour extraction, or in situ vapour stripping, is a rather simple method. By creating negative pressure gradients in a series of zones within the unsaturated soil a subsurface air flow is induced. Air can be injected via the total surface of the contaminated site, or via injected boreholes, causing horizontal flow. See figure 3. The flow volatilizes the contaminants present in the unsaturated soil and the air with the contaminants is drawn up through the extraction well. The extraction wells are individually connected to the transfer pipes, then manifolded to a vacuum unit. The soil vapour is transported to a soil vapour treatment system which can consist of a demister to remove excess water and an activated carbon filter or catalytic incineration to remove organic contaminants. See figure 4.



OPEN OPPERVLAKTESTRUCTUUR **GESLOTEN OPPERVLAKTESTRUCTUUR**

Figure 3: [Handboek bodemsaneringstechnieken, 10.2]

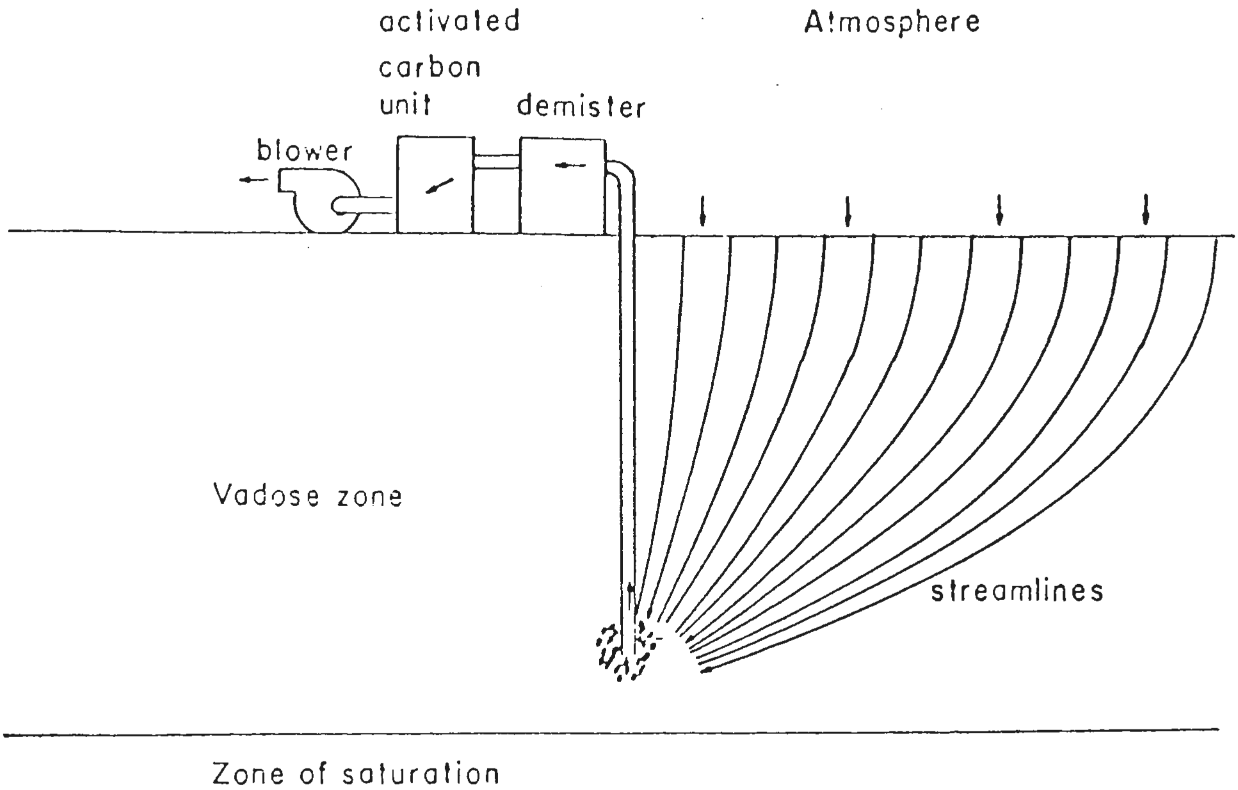


Fig. 4. Diagram of soil vapor stripping operation.
[Wilson, D.J., *In situ treatment of contaminated soil and rock*, Vanderbilt University, Nashville.]

In the saturated zone air can be injected to volatilize the contaminants present in the groundwater. The contaminated air is withdrawn by the vapour extraction system.
The air injection also serves as a means of delivering oxygen to the aquifer in order to enhance bioremediation. In the future more combinations of existing techniques are expected to develop.
The treatment of the air is a cost determining factor in the in-situ remediation operation. A significant reduction of the costs can be achieved by biological treatment. A bioreactor can mineralize the vapours in the withdrawn air as well as the dissolved contaminants in the pumped up groundwater. Such a bioreactor was developed in the USA and has been used in the Netherlands by TAUW Infra Consult B.V. [Vree, H.B.R.J. van, 1992]. Mathematical modelling and laboratory testing of vapour stripping is done by the Departments of Chemistry and of Civil and Environmental Engineering of the Vanderbilt University, Nashville [Wilson, D.J.].
Soil vapour extraction is suitable for volatile contaminants like gasoline, benzene, toluene, kerosine, but not for heavier oils or polycyclic aromatic hydrocarbons. Last years a lot of experience has been gathered.
Advantages of the method are that it is cheap, and that the Dutch 'A-value' sometimes can be reached. Disadvantages of soil vapour extraction are that only contaminants can be removed which are volatile and not strongly connected to the soil particles, that the soil has to be sufficiently permeable and that the air has to be cleaned. The process can last several years.

3.2 IN-SITU CHEMICAL EXTRACTION

Instead of injecting air into the contaminated soil water or a chemical solution can be injected. Injected water will flush aromates, light oils and chlorine solvents. A chemical solution will cause a strong acid or alkaline hydrolysis that degrades and dissolves large molecule weight species, metals and cyanides present in the soil. The chemical extractant is typically introduced to the contaminated soil by means of numerous small well points. The extractant solution must be fully recovered after contact with the soil so careful placement of recovery wells or other types of collection systems are essential. The collected extractant is then subjected to conventional treatment, like ion exchange, to remove the contaminants and the solution is recycled.
There is little experience with chemical extraction and only in few cases the 'A-value' has been reached. Often a heterogeneous soil obstructs a homogeneous flushing of the total site.

3.3 STEAM STRIPPING

With this method steam is injected into the soil and extracted. It will take some time before all of the soil is heated by the steam and no more condensation occurs. Steam stripping results in a more powerful extraction than in the case of soil vapour stripping, so more types of contaminants and heavier oils can be removed. Disadvantages are the higher costs due to production of steam, more complex installation and the possibility of uncontrolled release of contaminated steam. At present steam stripping is not often applied, but will become more important in the future [Weststrate, 1992]. Research is carried out to predict the time needed to complete the process and the results.

3.4 ELECTRO-RECLAMATION

With this method heavy metals and other contaminants as well as groundwater can be removed from the soil.
Rows of electrodes are put into the ground and a direct current flows through the contaminated site. The voltage difference causes three electro-kinetic processes in the soil:
- electro-osmosis: the flow of groundwater from the anode to the cathode, caused by moving ions.
- electro-phoresis: movement of all charged particles, like colloid particles, organic particles and clay particles floating in the water, under influence of the electric field. This movement is usually slower than electro-osmosis.
- electrolysis: movement of ions or ion-complexes because of the electric field. The velocity is about ten times slower than electro-osmosis.

The electrodes have a mantle in which a special fluid is recirculated. In this way precipitation to the electrodes is avoided, and the ions can be removed from the fluid in a mobile container. See figure 5.
The removal of metal ions from ground water changes the chemical equilibria, and causes some heavy metals from the solid phase to dissolve in the liquid phase. Complex chemical considerations are required to predict the results.
Geotechnical parameters to be known to predict the effects of electro-reclamation are chemical composition of the soil and groundwater, the porosity, water content and the conductivity of the pore fluid.

Electro-reclamation can also be used on-site, in this way conditions can be optimized. Research is carried out by the company Geokinetics, the Netherlands, on the electrical parameters and the combination of electrics and biodegradation [Lageman, R., 1992]. This last combination can be particularly useful for treating dredged mud which typically contains both heavy metals and organic compounds.
Advantages of electro-reclamation are that the method is also suitable for non-permeable soils like clay or peat, heavy metals can be removed and the 'A-value' can be reached. Disadvantages are the high energy costs and only little field experience is present. Further metal objects, present in the subsoil, can cause problems, just as heterogeneous soils can.

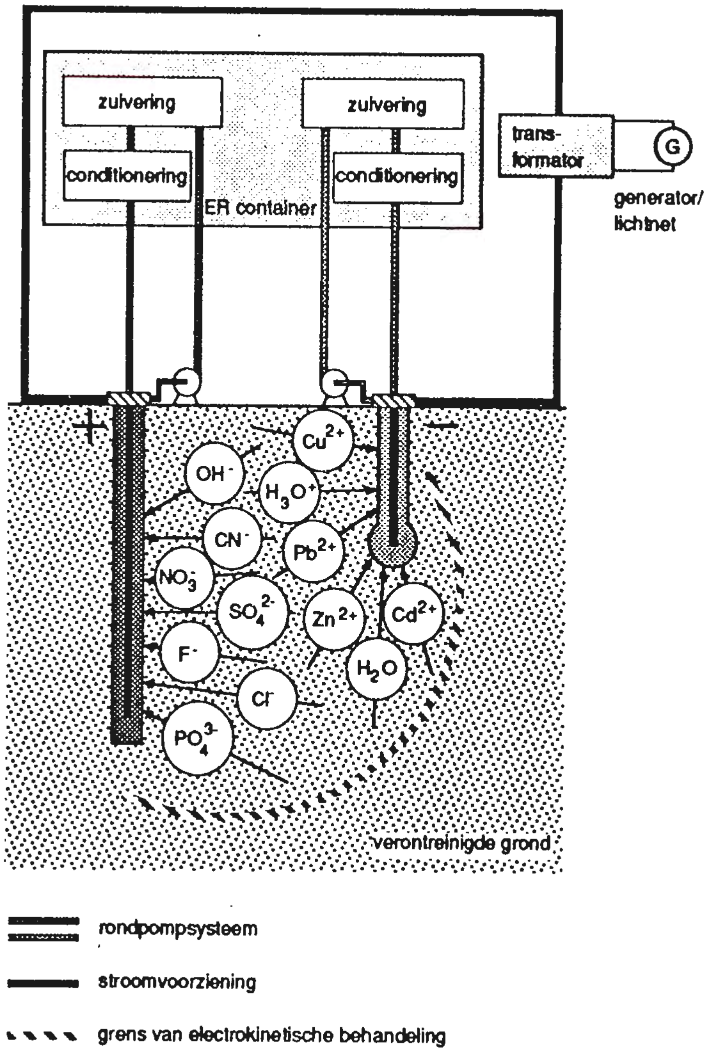


Fig. 5: Schematische voorstelling van de veldopstelling en electrokinetisch transport in de ondergrond
[Lageman, 1992]

3.5 BIORESTORATION

In-situ biological degradation by microorganisms is called biorestoration.
Usually water with additions is injected above the contaminated layer, and pumped up from below this layer. The water is treated above ground and reinjected. See figures 6 and 7. The infiltration of water has three purposes [Staps, J.J.M., 1990]:
- increase of biological activities by increasing the moisture content of the soil
- increase of desorption and leaching of contaminants in the subsoil, making them available for biological degradation
- water is a transport medium for oxygen and nutrients, possibly also for microorganisms or heat, to accelerate biodegradation of the contaminants.

Requirements for the microorganisms are oxygen, nutrients like nitrogen and phosphorus, and a favourable pH. Oxygen sources can be pure oxygen dissolved in the water or hydrogen peroxide which reacts in the subsoil into water and oxygen.
To obtain good results the soil has to be permeable and rather homogeneous.
Special attention should be paid to prevent spreading of the contamination, this can be achieved by geohydrological isolation.

Advantages of biorestoration are [Staps, J.J.M., 1989]:
- applicable below buildings
- treatment of both soil and groundwater, also adsorbed materials can be treated
- no costs for removal and transport of the soil
- contaminations which have penetrated to great depths can be treated
- no generation of waste products, these are carbon dioxide and water in case of total degradation
- soil fertility is not destroyed

Disadvantages of the method are:
- can only be applied to biodegradable components
- does not work for subsoils with low permeabilities
- can be inhibited by toxic components like metals
- up till now rather high residual concentrations remain in the soil, usually above the 'A-value'
- long term effects are insufficiently known
- soil can be clogged by excessive bacterial growth, precipitation etc.
- treatment is generally for a relatively long period

In-situ biorestoration is a relatively young, developing technology and has already been applied at several locations, mainly in the USA. Experience has especially been gained at hydrocarbon-contaminated petrol stations and industrial sites.
A lot of research is being done, in the Netherlands a.o. by Biochemical laboratory of University of Groningen and RIVM/TNO.

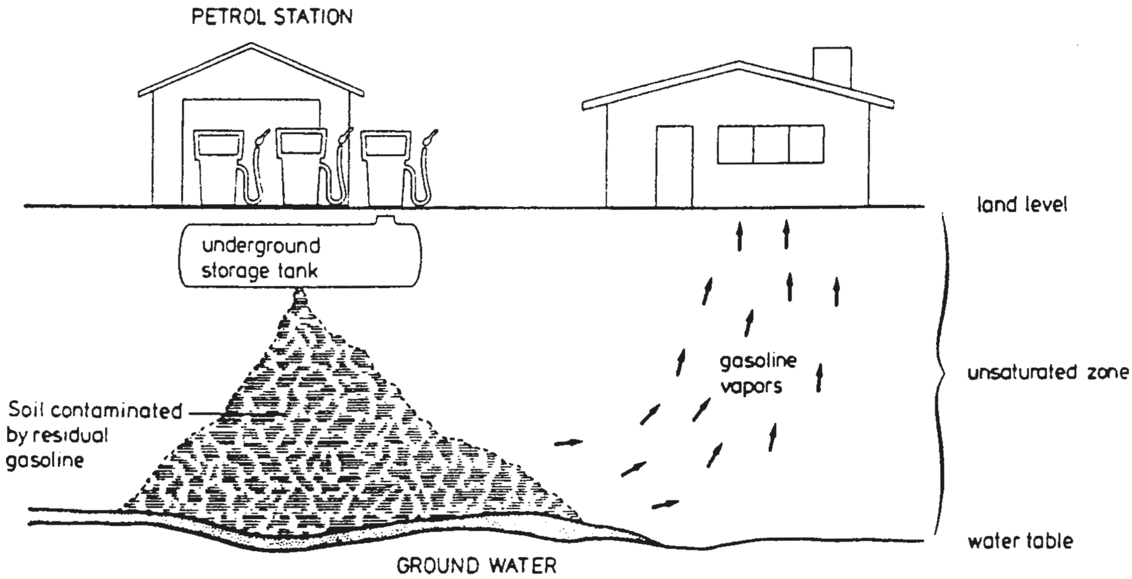


Figure 6:Overall view showing leakage and dispersion of contamination.

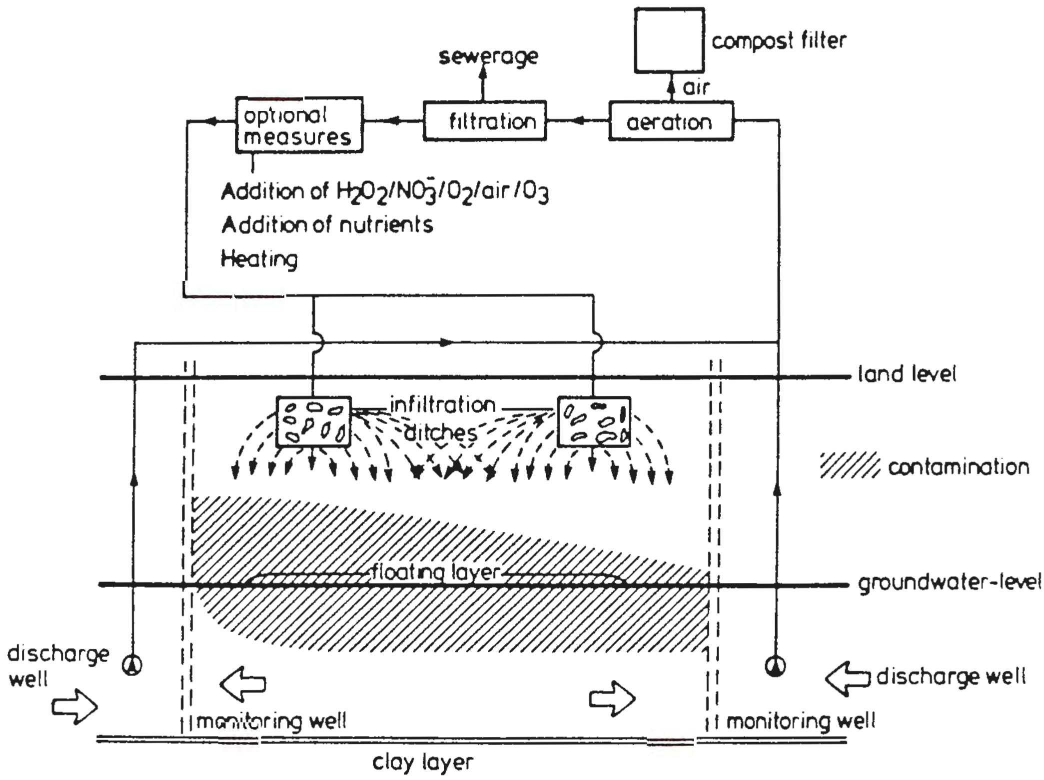


Figure 7: General in-situ biorestoration system for contaminated soil and groundwater.

4. REMEDIATION OF EXCAVATED SOIL

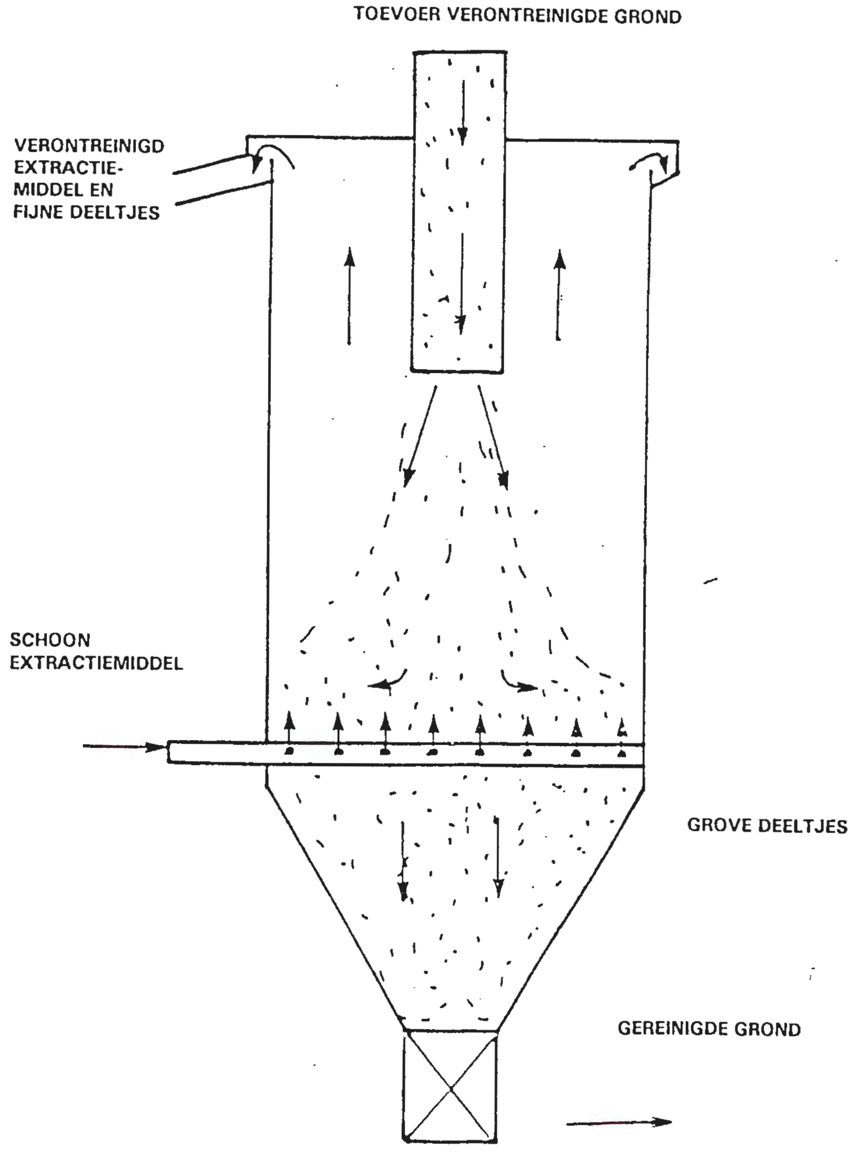
4.1 EXTRACTION FROM EXCAVATED SOIL

This procedure combines both physical and chemical methods to extract the contamination from the soil. The process consists of three steps [Rulkens, W.H., 1992]:

1. intensive contact between solvent, usually water with chemicals, and contaminated soil to dissolve or disperse the contaminants adsorbed to the soil particles
2. separation of the contaminated solvent and the clean soil particles
3. cleaning of the solvent. The residual product usually is chemical waste.

Separation of the contaminated and clean soil particles can be done in various ways:

- systems based on gravity, e.g. fluidized beds, see figure 8. The heavily contaminated fine particles will flow upward, the clean or slightly contaminated particles will flow downward.
- systems based on centrifugal forces like hydrocyclones, see figure 9.
- flotation systems in which the contaminated particles are connected to air bubbles by chemical compounds, see figure 10.
- systems which are used in mining. Separation is based on vibration, flow and gravity.



Figuur 8 : Vloeistof gefluïdiseerd bed (opstroomkolom)

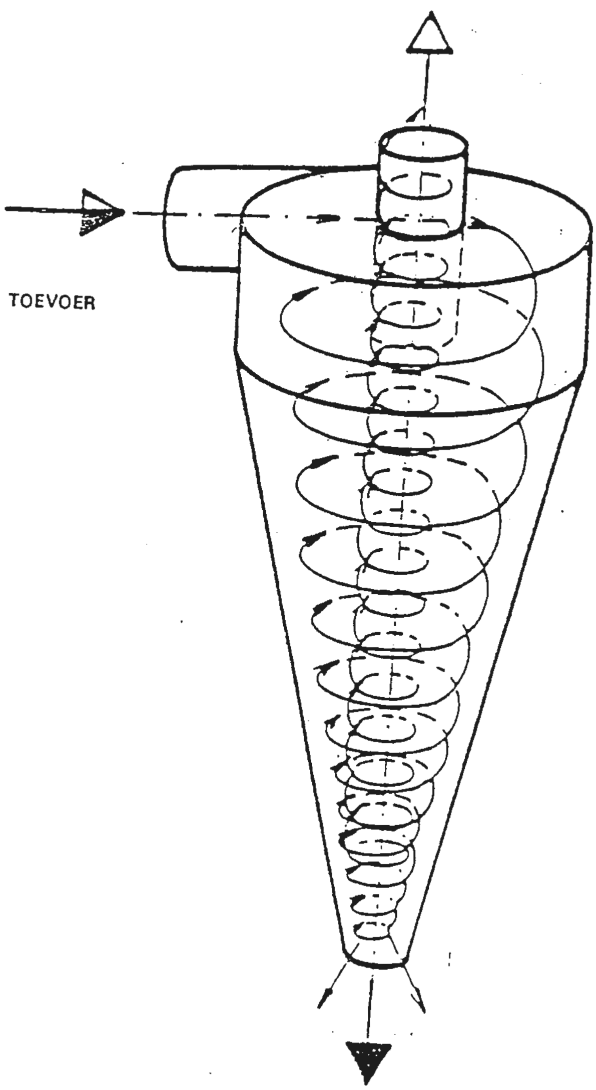
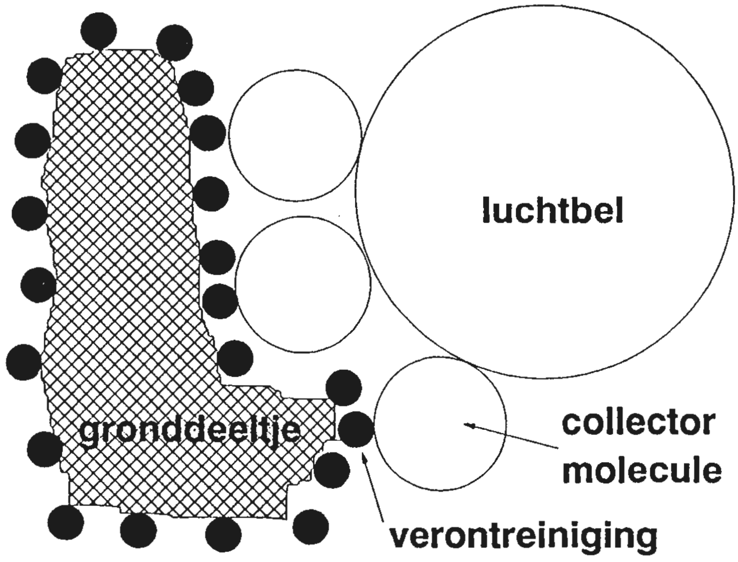


Figure 9: hydrocyclone [Mosmans, 1992]

Extraction is more suitable for sandy soils than for clay or peat. The reasons are that clay particles strongly adsorb many types of contaminants, which makes separation very difficult. Additionally the clay particles have about the same size as the contaminants when present detached, again complicating separation. Most of the clay particles will end in the residual product and handled as chemical waste.
The method can remove all types of contaminations.
The principle of flotation and some case histories are described in a paper by [Mosmans, C., 1992]. Research on flotation in contaminated soil is executed a.o. by the Delft University of Technology. A promotion report on extraction of heavy metals from contaminated clay soils was published by [Tuin, B.J.W., 1989].



Figuur 10: Principe van flotatie [Mosmans, 1992]

4.2 THERMAL REMEDIATION OF EXCAVATED SOIL

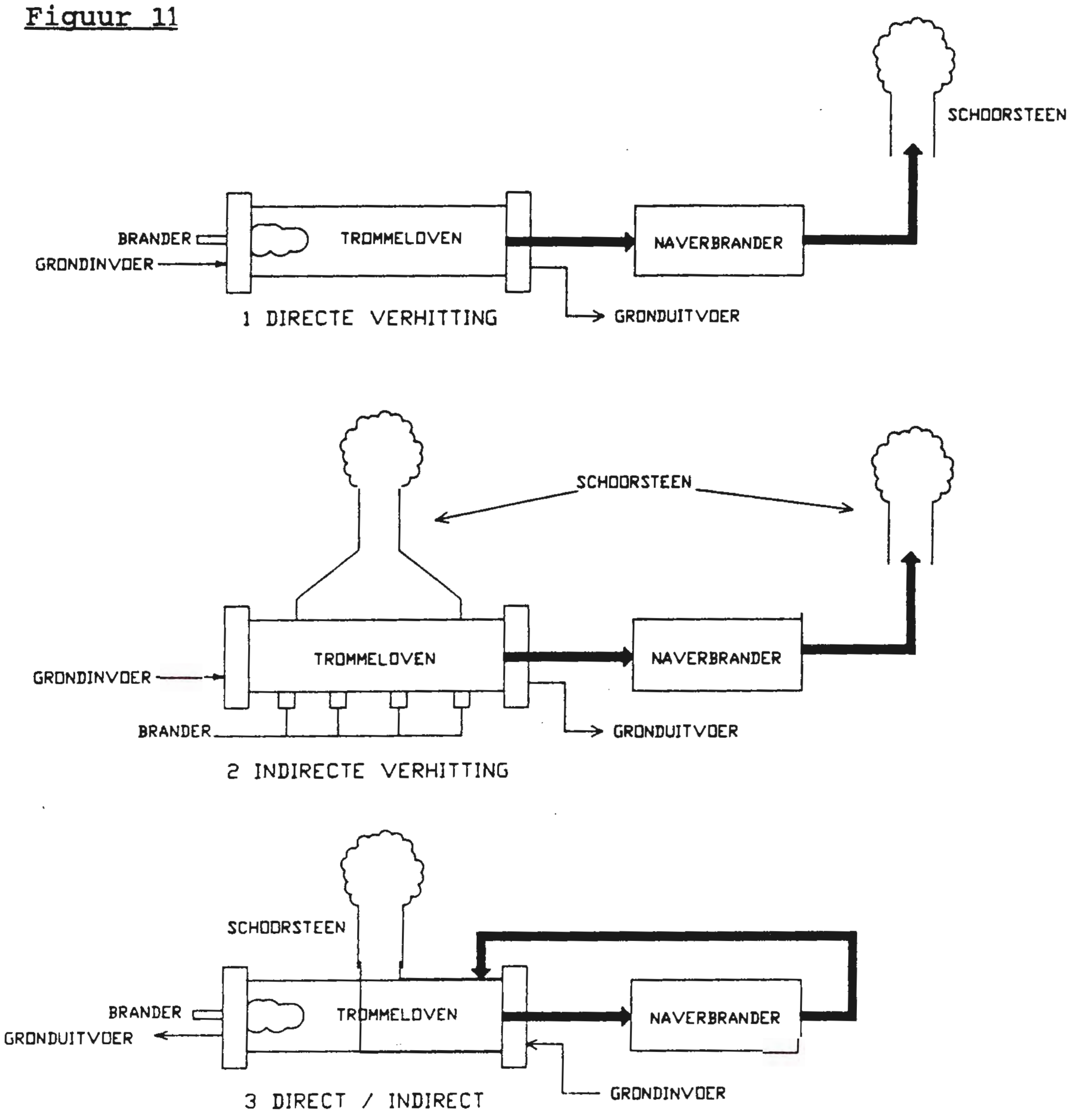
At present this method is most applied in the Netherlands. Techniques have fully been developed [Noorman, F., 1992].
Three systems are in use, see figure 11:

- direct heating, in which the flames are in contact with the soil. Large quantities of gas are produced, which stimulates volatization, but raises the costs of cleaning the gas.
- indirect heating, in which the flames are not in contact with the soil. Less gas is produced, but the soil has to stay in the incinerator for longer time.
- a combination of both techniques, in which a great part of the energy is re-used.

With increased temperature several thermal reactions will occur. First the water will evaporate, from 200° C to 300° C volatile compounds like organic solvents and some oils disappear. The structure of the ground stays intact. Till 500° C also polycyclic aromates will evaporate directly. Various anorganic compounds like complex cyanides and sulfides will react to volatile compounds or oxidize. At temperatures of 800° to 1000° C all organic compounds could be removed.
The soil itself will change above 300° C, because the humus oxidizes or pyrolyses. In absence of oxygen the soil turns black unless there was no humus present. Oxygen concentration is kept low to avoid explosions in the incinerator.
In an afterburner the produced gas is broken further at temperatures of 800° to 1100° C. The residual gas finally contains low concentrations of carbon monoxide and PCA's, besides a lot of dust.
To be used again the soil must usually be enriched with organic material and should not contain heavy metals.
Research is being executed by the Dutch companies Ecotechniek and NBM to develop a techniques with which also chlorine contaminations can be treated. At present this is still forbidden because the very toxic compounds dioxin and furane could be produced.
The thermal method can treat all kinds of soils, fine particles cause no problems.

[Noorman, J., *Thermische grondreiniging*, Stichting Postacademisch Onderwijs, Gezondheidstechniek en Milieutechnologie, Delft, course 'Reiniging van vervuilde grond en waterbodems', March 1992.]

<u>Figuur 11</u>



1. Direct (ATM, Broerius)
2. Indirect (NBM)
3. Direct/indirect (Ecotechniek)

4.3 BIODEGRADATION

4.3.1 LANDFARMING

In landfarming, excavated polluted soil is spread out in a special depot as a layer, 0.5 - 1 meter thick. To this layer bacteria are added in combination with nutrients and oxygen, transport is enhanced by means of ploughing or forced aeration. The bacteria specie Pseudomonas has proven to be very effective in degrading oils. Organic pollutants are mineralized to harmless products like carbon dioxide and water with hardly any toxic compounds being formed.
On-site treatment is possible if the location is large enough to allow the polluted soil to be spread out.
Disadvantages are the requirements for large areas of land, the low conversion rates: treatment may exceed two years. Also in winter the bacteria are hardly active and the remediation slows down. Advantages are that no residual product results, no energy is used and the soil remains biologically active.
Results of experiments in the Netherlands have been summarized by [Soczo and Staps, 1988] and by [Soczo et al., 1990].

4.3.2 BIOREACTORS

In bioreactors the process conditions are better controllable than in landfarming and higher conversion rates can be reached.
Dry bioreactors can treat only sandy soils. Wet bioreactors are divided into slurry and suspension reactors and can handle all types of soils. The contaminations degrade fast during the first days and decreases with decreasing concentration of the contaminant. Disadvantages are the high residual concentrations left in the soil and the process time, 2 to 3 weeks at present.
The report of the workshop 'Bioreactors for soil cleaning' describes some recent research results. [Kleijntjens, R., 1991] published his promotion on slurry processes.

5. ISOLATION TECHNIQUES

Three main groups are distinguished:
- civil engineering techniques. A sealing construction in the subsurface like sheet pile walls or cement bentonite walls, inhibits spreading of the contaminants
- geohydrological methods. Certain groundwater flows around the polluted area are restrained by pumping out water.
- physical/chemical techniques, immobilization. Contaminants are fixed to the soil or ground is treated in such a way that groundwater can no longer reach the contamination. In the United Kingdom, the USA, Germany, Canada and Japan this method has often been applied.

Usually a combination of the techniques is applied. When a layer of clean soil is placed on the contaminated soil, separated by an impermeable foil, the terrain can be used for various purposes.
In most cases isolation of a contamination is cheaper than remedial actions, and can also be applied in situations where excavation is not possible or desirable, for example when the contaminated zone extends to great depths or very large terrains. A third advantages is that it can be used as a temporary measure before in-situ techniques can be applied successfully. Environmental protection organizations reject the method because the pollution is not removed. The Dutch government prefers the removal of the pollution, and provides extra money for remediation techniques.

6. CONCLUSIONS/RECOMMENDATIONS

6.1 CONCLUSIONS

Last decade the number of terrains known to contain polluted soil has increased enormously. Slowly the insight grows that the financing of cleaning all contaminated soils for multi-purpose functions cannot be yielded by one generation and that costs might have to be spread over at least two generations.
Therefore it is of extreme importance that ongoing research provides more effective methods in order to reduce remediation costs. At present most of the mentioned methods are indeed still under development.

Simultaneously prudent considerations raise in society whether it is absolute necessary to clean all soils for multi-purpose use as the Dutch government prescribes at present. If a polluted terrain cannot harm any living creature nor will harm anyone in future, in other words, it is no risk for the environment, then many costs could be saved by not cleaning the soil.

6.2 RECOMMENDATIONS

Only a brief review of present remedial techniques could be given in this paper. For more specific information the reader is referred to the literature. Some useful literature and literature lists are given below.

Walle, F. de, 1992, gives a comprehensive overview of developers of current American technology of thermal, chemical, physical, biological methods and material handling and solidification/stabilization.

The *Handboek bodemsaneringtechnieken* describes extensively which techniques have already been used in the Netherlands, the companies involved, the research being done and new developments.

Speerpunten Programma Bodemonderzoek describes the research projects which the Dutch government supports.

In association with the international NATO/CCMS pilot project Staps, J.J.M., (1990) summarized the results of experiments in-situ biorestoration in the Netherlands, Germany and the USA.

The fundamental aspects of biological soil remediation when xenobiotic compounds are present, are described in a paper by Schraa, G., 1992, while the literature list includes many reports of research projects on specific compounds to be treated.

The proceedings from *In-situ and On-Site Bioreclamation: An International Symposium 1991*, Hinchee, R.E., and Olfenbuttel, R.F., editors, contain a lot of information about.biological methods.

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REPORT STUDY-TRIP VISIT TO CAPSACOSTA TUNNEL

A. Concha Fernandez
The author is a civil engineer from Lima, Peru who participated in the Engineering Geology course at ITC Delft in the period 1992-1993. This report was written as a part of the Falset Fieldwork assignment.

INTRODUCTION

During the fieldwork in Falset-Spain students of ITC and TU Delft following the Engineering Geology Course had the opportunity to do some excursions to visit engineering works. One of these excursions was done on march 31, and had as purpose to observe a tunnel under construction. All the group was composed by 18 students and 3 staff members.

The departure from Falset was about 9:00 a.m., arriving to the place of the tunnel at 1:00 p.m. approximately, going by Reus and taking the highway E15 and then to the North East in direction to Girona, and finally taking the road in direction to Olot and then to Camprodon.

In the site of the tunnel the group was received by two persons. Mr. Juan Guibernao who is the Chief Engineer of the road for the Contractor Company "Dragados", and Mr. Pedro Perez who is a Geologist working as Director of the Tunnel for the Consultant Company "Euro Geotecnica".

OBJECTIVE OF THE TUNNEL

The counties of La Garrocha and El Ripolles, which belongs to the Girona province, Generalitat de Catalunya, are separated by a mountain range belonging to the Pyrenees, and at the present they are communicated by the highway C153 which has many curves of very reduced radius. This added to the high gradients, the use of the road by heavy trucks, the formation of ice on the road surface due to the lack of drainage, which often interrupts the traffic, leads to a low maximum velocity of 40 Km/hour.

Due to all these reasons the Local Government of Catalunya decided to construct a new highway. As a result of the new two lanes highway, the distance between the two counties will be reduced and the maximum velocity will increase until 70 to 80 Km/-hour, to get finally a more safe highway. This will benefit specially La Garrocha County for the installation of industries, improving considerably the trade between the two counties and also finishing the isolation of La Garrocha due to the frost on the road surface which used to occur during the winter season.

The total length of the road is 7 Km.+ 800 m. and the tunnel has a length about 1845 m. and a uniform gradient of 2%.

GEOLOGY AND GEOMORPHOLOGY OF THE SITE

The site of the tunnel is characterized by sedimentary formations, which could also be appreciated along the present road.

Along the tunnel there are two zones clearly differentiated, separated by a transitional zone of about 50 m., identified as a fault zone, which is oblique to the direction of the tunnel.

From the North Portal the first part of the tunnel is composed by siltstone, marlstone and argillaceous claystone. This material is identified by its homogeneous grey colour.

The second part of the tunnel is composed by fine sandstone, siltstone and some cobbles and conglomerates. This material can be recognized by its red colour.

The fault zone is very jointed and contains much clay and swelling materials.

Geomorphologically, the tunnel is located in a mountainous area with an abrupt topography. From the observation of the fault into the tunnel it can be deduced that this zone is tectonically affected.

The tunnel crosses through a synclinal structure.

GEOTECHNICAL PROPERTIES OF THE ROCKS ALONG THE TUNNEL

The grey material is considered as a low to medium hard rock. Its uniaxial compressive strength is in average about 200 to 500 Kg/cm^2. At the beginning of the tunnel the rock is medium jointed with a RMR value of 46 to 57 corresponding to a fair rock.

The red material is a low medium to hard rock ranging from 25 to 1000 kg/cm^2. This material is described as a low jointed rock. Its RMR is higher varying from 55 to 73 which correspond to a fair to good rock.

ENGINEERING PROBLEMS DUE TO GEOLOGY

Tunnelling method

The conventional tunnelling method is being used for the Capsacosta Tunnel. The sequence of advance is according to the Top Heading and Bench Construction Method, which implies to excavate first the upper part of the cross section. In this case it represents approximately 65 % of the total section.

This upper part will continue being excavated until the meeting of the two fronts, which is expected to occur in the next October. Then the bench will be started.

Support of the tunnel

The original project considered three kinds of linings for the support:

Type I : The lighter one is composed by 6 bolts per meter covered by 10 cm. of wet shotcrete.

Type II : The medium support is composed by 16 bolts per meter with a total thickness of 14 cm. of wet shotcrete.

Type III: The heaviest support consists on steel sets and 25 cm. of wet shotcrete.

Also, at the entrance of the tunnel, near the Portal, steel ribs were used, one per meter.

No other definitive support was considered.

The shotcreting includes the use of wet shotcrete and steel fibre as a reinforcement inside the shotcrete. The compressive strength of the concrete is about 300 Kg/cm^2. Often controls of the thickness of the shotcrete layer and the tensile strength of the steel bolts are done.

The three types of lining have been installed until now. The heaviest one was installed in the portal and in the fault zone.

The three types of lining have been installed until now.

Type I lining has been used in the red formation, which is considered to be the best formation due to its low jointing. Because of the material is not hard enough this support has been reinforced increasing a little the number of bolts.

Type II lining was used in the grey formation.

Type III lining, which is the heaviest one, was installed in the portal and in the fault zone.

Type of blasting

The type of blasting is classified as smooth wall blasting which could be appreciated in the walls of the tunnel in the zone that is being working now, where cylindrical surfaces have been obtained. The diameter of the boreholes were 49 mm. and the consume of explosive was 0.8 Kg. per cubic meter.

Infiltration control

Due to the fault zone there is an important inflow of water of 1 m^3/min approximately. At the present this water is being pumped out but when the tunnel is finished the water will be collected by lateral drains. To avoid the formation of ice in the roof, plastic sheets will be used to take the water to both sides of the tunnel and to be collected by the lateral drains.

Monitoring

Deformations are being controlled in different sections of the tunnel by using convergencymeters. With the use of these instruments the control of the stabilization of the deformations is done. If they continue or accelerate, the support is reinforced by using steel ribs.

OTHER ASPECTS

Program of Construction

The tunnel was started from the North Portal, on October 16 of last year and up to now 500 m. have been already excavated. The other front has not started yet. In October or November both fronts will meet each other and 6 months later the benching will be finished.

The progress in the excavation is in a medium average of 4.6 m/day. In the best week the advance was 37 m. and in the best month was 153 m.

The progress in the excavation was considerably reduced when the fault zone was reached advancing only 1 meter per day. There are two shifts of 12 hours each one, which start at 6 a.m. and 6 p.m.. On Saturdays the works are only for maintenance, ventilation and illumination of the tunnel, and the shift is from 7 a.m. to 2 p.m..

Topographical control of the tunnel

A polygonal base is established for the tunnel with tolerances of about 2 cm. in plant and 2 cm. in elevation. This base net is checked by two polygonals, one made by the construction manager's office and the other one by the contractor company. Another control is made by a topographic company.

END OF THE EXCURSION

After one hour of visit the tunnel and receiving explanations from our hosts all the group was invited to have lunch at a restaurant located close to the works.

The way back started at about 4:00 p.m. arriving at Falset four hours later to continue with the fieldwork.

BOOK REVIEWS

K.S. Li & S-C.R. Lo (eds.): **Probabilistic Methods in Geotechnical Engineering**, Proceedings of the Conference on Probabilistic Methods in Geotechnical Engineering, Canberra, Australia, 10-12 February 1993, Balkema, Rotterdam. 333 pp. Price Hfl. 185,-

This book contains a remarkably accessible collection of reviews and cases on the application of statistical methods to geotechnical problems. For someone not too familiar with the ins and outs of statistics, but compelled to regularly use results of regression or probabilistic analyses, the book provides well written discussions on the subject. I suppose many geotechnical engineers and engineering geologists belong to this category of users.

Very illuminating contributions for the above category of readers were written by the authors of invited and keynote lectures. Subjects treated by them are:
Recent developments in geotechnical reliability (Tang)
Limit state design in geotechnics (Li, Lee & Lo)
Simulation of random fields (Hasofer)
Probabilistic design of foundations and earth structures (Kay)
Application of probability and statistics in joint network modelling in three dimensions (Kulatilake)
Probabilistic slope analysis -state-of-the-play (Mostyn & Li) and
Soil variability: Characterisation and modelling (White)

I found the papers of Tang and White particularly instructive. For those involved in slope stability analysis, Mostyn and Li give an interesting discussion of how to take into account spatial correlation of soil and rock properties by modelling these as random fields. A useful part of this paper is the summing up of the variability and type of distribution (Gaussian, log-normal, exponential) of the most important soil and rock mass variables.

The book is further divided into sections on analytical techniques, on modelling of soil and rock properties, on stability of slopes and embankments and on foundations. In the section on analytical techniques I liked the paper of Li and White: Use and misuse of regression analysis and curve fitting in geotechnical engineering. This paper gives nice examples of commonly made misuses, like spurious self correlation (being happy with a high correlation coefficient between Plasticity Index and Liquid Limit, when PI and LL are linearly dependent; PI=PL-LL!), or wrongly applying algebraic manipulations on best-fit regression equations.

The book gives a good impression of the present state of statistical analysis, both in rock and soil mechanical problems. It is recommended.

Peter Verhoef,
Engineering Geology Section TU Delft.

Gunnar Almgren, Uday Kumar & Nick Vagenas (eds.), **Mine mechanization and automation,** Proceedings of the second international symposium on mine mechanization and automation, Luleå, Sweden, 7 - 10 June 1993, Balkema, Rotterdam, Brookfield, 1993, 810 pp, price Hfl. 265,-

Contents

The proceedings contain 98 papers and 3 abstracts. The authors represent about 30 countries worldwide. The organizers of this conference hope to achieve that the exchange of new technologies in mine mechanization and automation leads to improved productivity, reduced cost and enhanced safety in mining. The papers are placed into

9 different groups with the following subjects:
Innovative mining systems: Non energy minerals (metals), industrial minerals
Innovative mining systems: Solid fuel minerals; coals, etc.
Mechanization and automation of drilling operations
Mechanized rock fragmentation
Material handling and data communication
Machine automation and control
Computer applications
Human factors and safety, miscellaneous
Reliability and Maintenance of mining systems

General

The papers are generally clearly written and well illustrated. The print quality is good. The subjects of the papers fall almost all within the field of applied science.

Engineering Geological relevance of the papers

While the papers in this conference are not directly in the field of engineering geology, some papers may be worthwhile to consider, especially for engineering geologists working in the field of rock mechanics and rock excavation. Rock properties are related to machine performance in tunnelling and mining. (New) site investigation techniques like georadar, electric resistivity methods, remote sensing etc. are discussed in several papers.
Especially papers which fall within the group Mechanized rock fragmentation are interesting for engineering geologists concerned with rock excavation processes.

H.J.R. Deketh,
Section Engineering Geology TU Delft

Bawden, W.F. and Archibald, J.F. (eds.), **Innovative mine design for the 21st century**, Balkema Rotterdam, 1993, 1046 pp., price Hfl. 243,80

In this book the proceedings of the international congress on mine design held in Kingston, Ontario (Canada) in August 1993 are brought together. A wide variety of topics related to both surface and underground mining are presented. The more than 90 publications cover the following themes:
Slope stability of open mine pits and mine waste piles
Underground support and backfill
Grade estimation and mine feasibility
Planning and design of open pit and underground mines
Computer applications and numerical modelling
Mine environment
Explosives technology and blast monitoring
Mine management

The aim of the book with its much promising title is to present the state-of-the-art technology, innovative mining practices and evolution in mining trends. Of course the given overview of mining developments cannot be complete. For example the proceedings contain no articles dealing with subsidence. In this aspect it has to be noted that the majority of the cases relate to Canada and, to less extent, to cases in the USA. However, the remaining articles are produced by authors from all over the world. It can be concluded that it is a versatile book which will offer every mining engineer something of his interest.

Ronald F. Bekendam,
Section Engineering Geology TU Delft

ENGINEERING GEOLOGY OF UNCONSOLIDATED SEDIMENTS

Jubilee Symposium Day of the Netherlands Engineering Geology Group

Friday, June 3 1994 in Delft, the Netherlands

The "Ingenieursgeologische Kring" of the Royal Geological and Mining Society of the Netherlands (KNGMG) commemorates its founding 20 years ago with a symposium. During this symposium the Engineering Geology of deltaic environments will be highlighted and an outlook will be given on key issues for the future.
Eight keynote presentations will be given by invited speakers in the English language.
An important part of the day's time schedule will be devoted to **poster presentations** on all aspects of Engineering Geology, with sufficient time for discussion with the poster authors.
Participation in the symposium and the poster presentation is open for non-members and for engineering geologists from the neighbouring countries.
Costs for participants (including printed proceedings) Fl. 50,- for members and Fl. 75,- for non-members.

Themes

1. Developments in Engineering Geology in the Netherlands (1974-1994)

2. Field Data Collection Techniques
   - shallow geophysics
   - unconventional sampling and sounding methods

3. Classification and Characterisation of Soft Soils

4. Subsurface Mapping and Modelling Techniques
   - mapping and geological modelling, (3D)-GIS
   - numerical and analytical geotechnical models

5. Engineering Geology and the Environment

6. The Use of Underground Space in Deltaic Areas

Further Information

Ir. Sven Plasman, Secretary Ingeokring
Fugro-McClelland Engineers BV
P.O.Box 250 tel (31) 70 311 1281
2260 AG Leidschendam fax (31) 70 320 3640

FISOLS HERFST 1995, NEDERLAND

F. Schokking,
Rijks Geologische Dienst (RGD), Postbus 157, 2000 AD Haarlem
tel. 023-300349 fax 023-367064

Het Fifth International Symposium on Land Subsidence zal omstreeks oktober/november 1995 in Nederland gehouden worden. Eerdere symposia vonden plaats in Tokio (1969), Annaheim, Californië (1976), Venetië (1984) en Houston (1991). Op al deze locaties treden verschijnselen van aanzienlijke bodemdaling op.

Nederland was mede om deze reden samen met de Volksrepubliek China kandidaat voor de FISOLS 1995. Nederland kan als gastland op het gebied van zowel door-de-mens-veroorzaakte als natuurlijke bodemdaling en tevens op het gebied van uitgevoerd onderzoek wel het enige laten zien, zoals ondermeer: bodemdaling boven het Groningen gasveld en gasvelden in het Waddengebied, modellering van compactie in aardgasvelden, de effecten van de voormalige kolenmijnbouw in Zuid-Limburg, bodemdaling ten gevolge van grondwaterstandverlaging, regionale natuurlijke bodemverlaging en bodemstijging, bewegingen langs breuken in de Roerdal Slenk en bewegingen bij zoutstructuren in Noord-Nederland.

Het symposium zal bestaan uit de volgende drie hoofdthema's, waarin de subthema's de belangrijkste aspecten c.q. -beweging behandeld zullen worden.

1. Oorzaken van bodemdaling

   door-de-mens-veroorzaakte bodemdaling: grondwateronttrekking; mijnbouw: olie- en gasonttrekking en ontginning van vaste delfstoffen; civiele techniek: tunnels en ondergrondse constructies.

   Natuurlijke bodemdaling c.q. -stijging: tectoniek, natuurlijke compactie, bodembeweging bij ontwikkeling van sedimentaire bekkens; regionale bodembeweging; bodembeweging gerelateerd aan zoutstructuren; karstverschijnselen.

   Alle relevante aspecten, zoals theoretische modelleringen, laboratorium bepalingen van deformatie eigenschappen en ervaringen uit "case studies" zullen behandeld worden.

2. Meten van bodemdaling

   Monitoring van de grootte van bodembeweging om ongewenste effecten te voorkomen en ontwikkeling van modellen die bodembeweging beschrijven (3D/4D GIS); meettechnieken: waterpassingen, Global Positioning System (GPS), Satelite Laser Ranging (SLR), Very Long Baseline Interferometry (VLBI).

   Er zal meer nadruk gelegd worden op de kwaliteit van bewegingsbeschrijvingen en de resultaten van "case studies" (ook in relatie met punt 1.) en op de quantificatie van effecten (punt 3.), dan op de problemen die verband houden met meettechnieken.

3. Effecten van bodemdaling

   Mijnschade aan huizen en infrastructuur; economische schade door grootschalige bodemdaling ten gevolge van vloeistofonttrekking in gebieden waar de oppervlakte waterhuishouding verstoord wordt of waar kustverdediging in gevaar komt; schade door oppervlaktewater- of ondiepe grondwateronttrekking in Holocene gebieden met veen en klei door differentiële zetting van constructies; effecten van bodemdaling in ecologisch waardevolle gebieden; effect van bodemdaling in kustgebieden samenvallend met mogelijke zeespiegelrijzing door het broeikaseffect.

Dus zowel geologische, economische als ecologische aspecten zijn van belang en er worden bijdragen verwacht die schade door bodemdaling beschrijven in die uiteenlopende context en tevens de te nemen tegenmaatregelen.

Naast presentaties van bijdragen en postersessies (4 dagen) zullen er excursies naar bodemdalingsfenomenen in Nederland (1 dag) georganiseerd worden.

In het verleden zijn de International Association of Hydrological Sciences (IAHS) en de United Nations Educational, Scientific and Cultural Organization (UNESCO) als hoofdorganisatoren opgetreden en zullen dit wederom in 1995 doen. Als lokale organisatoren hebben al hun hulp toegezegd: Meetkundige Dienst van de Rijkswaterstaat, Rijks Geologische Dienst, Staatstoezicht op de Mijnen, Shell, NAM, Grondmechanica Delft, KNMI. Ook een aantal beroepsverenigingen is om support gevraagd, waaronder de Ingeokring, die haar ondersteuning al heeft toegezegd.

Indien men verdere informatie wil hebben, suggesties heeft of ondersteuning wil geven, dan gaarne contact opnemen met de auteur.

CONFERENCES, SEMINARS AND SYMPOSIA

1993

Announcement:
Proceedings of the Third International Conference on Case Histories in Geotechnical Engineering, St.Louis, Missouri, June 1-6, 1993, are available for distribution to the profession. They are offered at a pre-publication price of US$450.00 for three volumes, $100,00 for air mail shipment.
Information:
Shamser Prakash, University of Missouri-Rolla, Rolla MO 65401 USA

Recente Ontwikkelingen in de Ingenieursgeologie
9 december 1993
Brussel, België

Naar aanleiding van de uitreiking van de tweede "L.Calembert-erepenning" aan de Duitser Michael Koester organiseert het Belgisch Comité voor Ingenieursgeologie een halve studiedag over de recente ontwikkelingen op het vlak van ingenieursgeologie.

Information:
secretariaat BCIG c/o CFE, t.a.v. de heer C. Trève
Terhulpsesteenweg 164, 1170 Brussel.

1994

International Symposium on Geological Engineering and Geoenvironment Protection
May 23-28 1994
Constantza, Romania

The main topics are:
Agressive processes, and geoenvironment vulnerability (landslides, deep erosion, coastal processes, land subsidence, sinkholes, flood protection, man-made earthquakes, natural earthquake risk)
Impact of the industrial, mining, quarring and land using design on geoenvironment; protection and rehabilitation policy.
Forecasting models for geoenvironment evolution and conservation.
New approaches for waste management using local geologic features.
Geochemical environment and public health.
Tourism promotion and geoenvironment protection.
Promoting conservative and environment ethic for geologists and engineers
Geologic habitat protection in administrative and local regulations

Information:
Prof. Petre Bomboe, Faculty of Geology and Geophysics
Str. Traian Vuia 6, 70139 Bucharest, Romania.

Engineering Geology of Unconsolidated Sediments
June 3, 1994
Delft, the Netherlands

The Jubilee Symposium Day of the Netherlands Engineering Geology Group will highlight the engineering geology of deltaic environments by eight keynote lectures. The themes are:
Development in Engineering Geology in the Netherlands
Field Data Collection Techniques
Classification and Characterisation of Soft Soils
Subsurface Mapping and Modelling Techniques
Engineering Geology and the Environment
The Use of Underground Space in Deltaic Areas

Information:
Ir. Sven Plasman, Fugro McClelland Engineers BV, P.O.Box 250, 2260 AG Leidschendam, the Netherlands, tel. (31) 70 311 1281, fax (31) 70 320 3640.

Third Symposium on Strait Crossings
June 12-15 1994
Ålesund, Norway

The main themes of the Symposium are: bridges, tunnels and ferries. During the first plenum session invited speakers will present large and complex strait crossing projects. In parallel sessions / work shops more specific aspects concerning strait crossings, such as technical solutions and environmental effects are open for discussions and presentations. The official language will be English.

Information:
Strait Crossings Secretariat, Norwegian Road Research Laboratory,
P.O. Box 6390 Etterstad, N-0604 Oslo, Norway.
Tel. +47-2-63 99 00, Fax. +47-2-46 74 21.

EUROCK symposium
August 29 - September 1, 1994
Delft, The Netherlands.

The main objective of this symposium is to bring together rock mechanics researchers and engineers from the petroleum industry with those from the fields of mining and engineering geology. The main themes are:
Rock Mass Characterisation
Excavation and Production
Fracture Mechanics
Rock Mass Response to Hydrocarbon Production
Storage, Waste Disposal and Environmental Applications

Information:
J.P.A. Roest, TU Delft, Fac. M&P, P.O.Box 5028, 2600 GA Delft
tel. 015-781326, fax. 015-784951

7th IAEG Conference "Turning the Century with Engineering Geology"
September 5-9, 1994
Lisboa, Portugal

At the end of the century, increasing environmental problems and development of large cities with the construction of large engineering works, at surface and underground, and with mining activities, will require very accurate engineering geological assessmant of the ground. During the seventh conference of the International Association of Engineering Geologists the following themes will be treated in this scope.
- Developments in Site Investigation and in Engineering Geological Mapping.
- Engineering Geology and Natrural Hazards.
- Engineering Geology and Environmental Protection.
- Construction Materials.
- Case Histories in Surface Workings.
- Case Histories in Underground Workings.
- Information Technologies Applied to Engineering Geology (workshop)
- Teaching and Training in Engineering Geology (workshop)

Information:
Organising Committee 7th IAEG Congress
c/o LNEC- Av. do Brasil, 101
1799 Lisboa Codex - Portugal.
Phone : 351-1-847 38 22
Fax : 351-1847 38 32

Modern Geophysics in Engineering Geology
September 12-15, 1994
Liège, Belgium.

The conference will review current methods and their application to solving a wide range of engineering and geological problems. The following key applications of geophysics will be included:
Determination of the depth of bedrock
Cavity location
Environmental issues
Rock mass condition assessment
Investigation for major civil engineering works
Borehole geophysics

Information:
Mr. S. Baker, Conference Secretary c/o Ready Mix Concrete (UK) Ltd.
RMC House, High Street, Feltham, Middlesex, TWI3 4HA, Great Britain

International Colloquy: Quaternary Events: Consequences on Environment & Human Beings
September 26-October 1, 1994
Sfax, Tunisia

In this century, technical evolution makes it possible to better understand the environmental evolution and to predict the future with lesser uncertainties.
The following subjects will be treated:

Palaeo-environment and Modern Environment
Climatic Changes
Littoral Evolution and Management
Datation Technics and Radiochronlogy of Quaternary
Prehistory
Quarternary Cartography and Tectonics
Hydrogeology and Palaeohydrology

Organization: Tunisian Association of Applied Geology

Information:
Symposium TAAG Secretariat: Department of Geology, Ecole Nationale D'Ingenieurs de Sfax, P/O Box W-3038 Sfax, Tunisia,
Tel: (216)(4) 274 418, Fax: (216)(4) 275 595

1995

Third International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics.
April 2-7, 1995
St. Louis, Missouri, USA.

Themes:
Static and dynamic engineering soil parameters
Liquefaction and ground failure
Stability of slopes and earth dams
Geotechnical analysis of recent earthquakes

Information:
Shamser Prakash, University of Missouri-Rolla, Rolla MO 65401 USA

XI ECSMFE Copenhagen "The Interplay between Geotechnical Engineering and Engineering Geology"
May 28-June 01, 1995
Copenhagen, Danmark.

The Eleventh European Conference on Soil Mechanics and Foundation Engineering is hosted by the Danish Geotechnical Society in 1995. The emphasis of the conference will be on:
- Investigating the effects of the interplay in different engineering situations
- Showing how these effectscan be qualified and incorporated in prediction and analysis

Within the conference theme the main subject areas to be addressed by the conference are:
- Determination of soil properties in situ
- Monitoring of geohazards
- Laboratory test methods
- Glacial soils
- Special problem soils (carbonate environment, loess etc.)
- The geologic record and the behaviour of soils
- Numerical and probabilistic modelling

- Artificial soil material and waste products
- Codes and standards
- Geological aspects of handling polluted soil and groundwater
- Educational aspects of the interplay

Papers for this conference must be submitted before January 15, 1994 by the Secretary of the Ingeokring.

Information:
ICS International Conference Services
P.O. Box 41, Strandvejen 171,
DK-2900 Hellerup, DANMARK
Phone : +45 31 61 21 95
Fax : +45 31 61 20 68

ADVIESBUREAU VOOR GEOFYSICA EN GEOLOGIE
DR. D.T.BIEWINGA

Het Adviesbureau voor Geofysica en Geologie is een onafhankelijk adviesbureau en biedt een compleet pakket geofysische methoden voor diverse onderzoeken; ook adviseren wij bij koop en huur van instrumenten en software.

MILIEU	- opsporing metalen vaten en assenwegen - monitoring van de conductiviteit rond een afvalstortplaats en locatie van de vuiltong
CIVIELE PROJECTEN	- bodemonderzoek bouwlocaties en landslides
GEOL. ONDERZOEK	- voor zand-, grind- en waterwinning
ARCHEOLOGIE	- veldwerk met diverse methoden
BOORGATMETINGEN	- conductiviteit- en gammalogging in gaten met PVC casing
GRONDRADAR	- locatie grondwaterspiegel, enz.
INSTRUMENTEN EN SOFTWARE	- verhuur Geonics EM31, EM34 en EM38 - vertegenwoordiger ABEM en GEONICS.

ADVIESBUREAU VOOR GEOFYSICA EN GEOLOGIE
Johannes Vermeerplantsoen 45
2251 GS Voorschoten - Holland
Telefoon 071 - 616796, FAX 071 - 615933