Delft Cluster

Title:	**Consequences of floods - Visits to other countries**

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Abstract

As a part of the Delft Cluster project *"Consequences of floods"* several visits has been made to other countries to learn from their experiences during floods and their consequences. Visits were made to Prague in December 2002, Cambridge in March 2003 and Dresden in April 2003. The reason of these visits was the possibility to collect quantifying data of floods, which could be used for validation of the models made in the project. In general it can be concluded that it is difficult to collect data of recent floods due to the fact that the data is still spread over different authorities. However, valuable information about the consequences of floods has been gathered which is described in this report.

The report of the visit to Prague is written in Dutch the other reports are in English.

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BASEPROJECT NAME:	**Flood Consequences and acceptability**	BASEPROJECT CODE:	**02.03**
THEME NAME:	**Risk of flooding**	THEME CODE:	**02**

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1 Visit to Prague on the 1st, 2nd and 3rd of December 2002

In het kader van het Delft Cluster project *"Gevolgen van overstromingen"* is een bezoek gebracht aan Praag. Het project "*Gevolgen van overstromingen"* is een onderdeel van het Delft Cluster thema *Risico's van Overstromingen.* In dit project wordt een inventarisatie gemaakt van de gevolgen van overstromingen. Daarnaast zullen modellen worden ontwikkeld voor het kwalificeren en zo mogelijke kwantificeren van de gevolgen van een overstroming. Het uiteindelijk streven is te komen tot een standaard model voor de bepaling van de gevolgen van overstromingen. Gegeven een bepaalde inundatieontwikkeling en een inundatiepatroon dient de te verwachten aard en omvang van de gevolgen te kunnen worden geschat. Verschillende typen gevolgen kunnen worden onderscheiden, te weten slachtoffers, economische schade en milieu schade. Omdat Praag in Augustus 2002 is getroffen door een grote overstroming is een bezoek gebracht aan Praag om de gevolgen van deze overstroming te inventariseren op het gebied van:

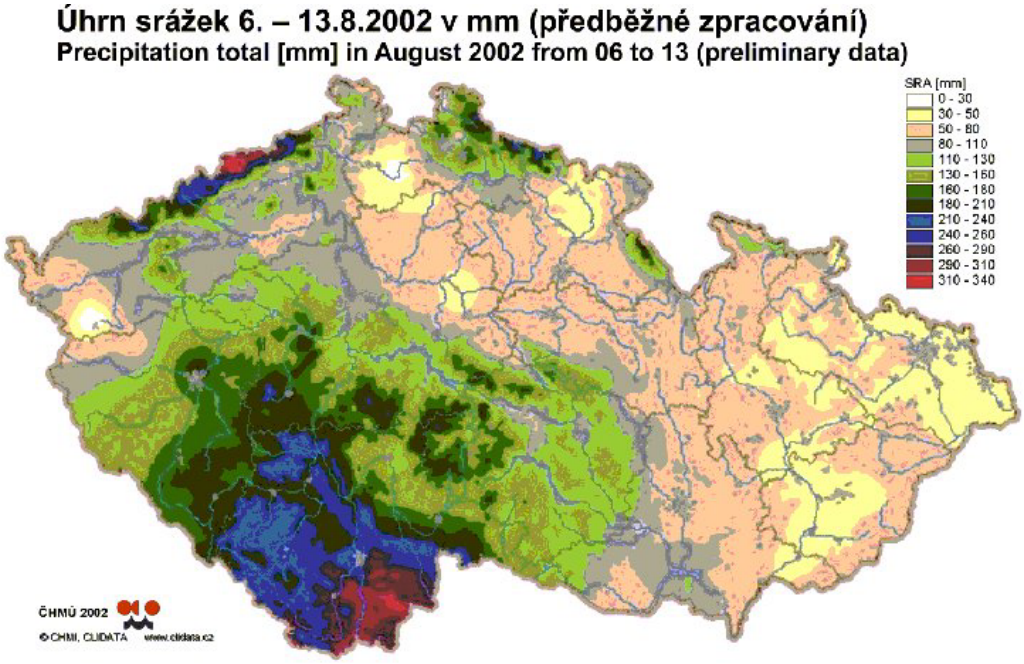
1. evacuatie, slachtoffers en rampenbestrijding
2. de gevolgen voor van gebouwen tijdens en na overstroming;
3. De schade aan het milieu in de rivier en in weer droog vallend gebied na overstroming.

Voor de inventarisatie van de gevolgen op de hierboven aangegeven gebieden is contact gelegd met diverse instanties in Praag, te weten de Technische Universiteit van Praag (ČVÚT), afdeling civiele techniek, het CHMI en het Klockner Instituut.

Tegelijkertijd werd een bezoek aan Praag gebracht door Nils Ligthart (Ministerie van Binnenlandse Zaken) en Menno van Duin (COT / NIBRA). In het kader van een te sluiten "joint agreement" tussen Nederland en Tsjechië oriënteerden zij zich op de rampenbestrijding bij de overstromingen. Om tot een optimale kennisverwerving te komen zijn enkele onderdelen van beide bezoeken samengevoegd.

1.1 Beschrijving van de overstroming in Tsjechië in augustus 2002

In Tsjechië hebben begin augustus 2002 door overvloedige regenval (zie figuur 1) omvangrijke overstromingen plaatsgevonden. Met name hoge waterafvoer in de rivieren in Zuid-Bohemen, het stroomgebied van de Vltava (Moldau), veroorzaakten vernietigende overstromingen. De Vltava loopt door Praag en stroomt vervolgens in de Elbe. Door de grote waterafvoer in de Vltava is Praag overstroomd en zijn vervolgen ook grote steden aan de Elbe overstroomd, zoals Dresden.



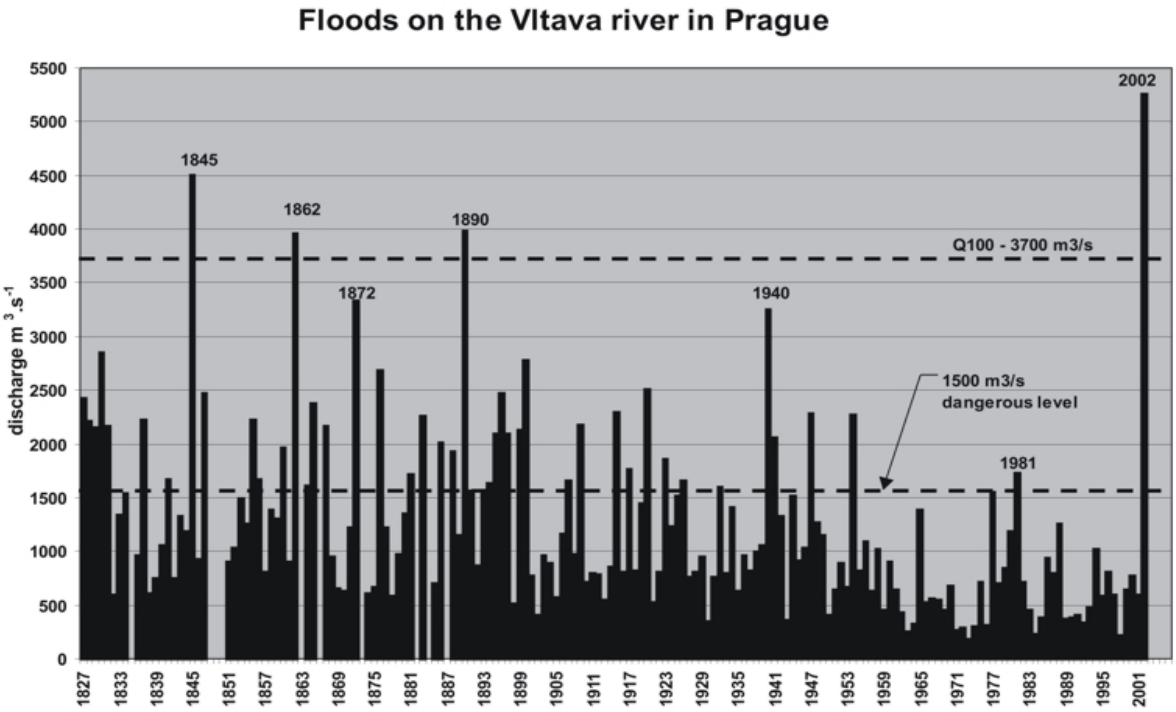
Figuur 1 Hoeveelheden neerslag, in de periode 6 tot 13 augustus 2002

Doordat men in Tsjechië te maken heeft met de bovenloop van rivieren treden normaal al hoge stroomsnelheden op. Bij hogere waterafvoeren dan normaal is de stroomsnelheid dus nog hoger en de vernietigende kracht van het water groot. De hoge waterafvoer van de Vltava ontstaat uit een culminatie van de waterafvoeren van hun zijrivieren, zie bijlage 1 voor een overzicht van maximale rivierafvoeren. Bij hevige regenval is de waarschuwingstijd zeer gering doordat er vele zijrivieren afwateren in de Vltava. Hierdoor is er voor bestuurder, instanties en burgers weinig tijd om beschermende maatregelen te treffen.

Het is daarom van groot belang dat voorspellingen nauwkeurig zijn. Deze voorspellingen zijn in zeer sterke mate afhankelijk van de exacte locatie van de neerslag. Uit de berichtgeving voor de overstroming blijkt dat de voorspellingen voor Praag niet zeer nauwkeurig waren:

- Voorspelling op maandag 12 augustus: maximaal 2500 m³/s.
- Werkelijkheid op dinsdagavond 13 augustus: ruim 4500 m³/s.
- Maximum op woensdag 14 augustus: 5300 m³/s.

Opmerkelijk is hierbij dat sinds 1827 de rivierafvoer 42 maal hoger dan 1500 m³/s is geweest, zie figuur 2. Daarnaast is in deze figuur te zien hoe extreem de overstroming van 2002 was.



Figuur 2 Hoogwaters in Praag sinds begin van de metingen in 1827, bron ČHMÚ

jaar	Berekende rivierwaterafvoer obv waterstand en dwarsprofiel
1845	4500
1862	4000
1872	3400
1890	4000
1940	3250
1947	2250
1957	2250
1981	1600
2002	**5300**

Tabel 1 Historische hoogwaters in Praag

De verantwoordelijkheid voor de waterhuishouding in Tsjechië is in vier lagen opgebouwd en valt in het algemeen onder de verantwoording van het Ministerie van Milieu. Op het laagste niveau valt de verantwoording op gemeentelijk niveau "obec" (niveau van een bebouwde kom), daarboven op regionaal niveau "okres" (een grotere stad en zijn omgeving), daarboven op bovenregionaal niveau van de Tsjechische Milieu-inspectie "Inspekce životního prostředí" en op het hoogste niveau het Ministerie van Milieu als het centrale waterhuishoudingsorgaan van de Tsjechische Republiek. Bescherming tegen overstromingen is geregeld in artikel 6 van de Tsjechische Wet op de Waterhuishouding.

bescherming voor overstroming	**bescherming tijdens overstroming**
Gemeente	gemeentelijke overstromingscommissie
Regio	regionale overstromingscommissie
Stroomgebied	overstromingscommissie per stroomgebied
Ministerie	centrale overstromingscommissie van de Tsjechische Republiek

1.2 Overzicht gevolgen van overstromingen

Door middel van bezoeken aan instanties met verschillende deskundigheden is geprobeerd een beter beeld te krijgen van de verschillende typen gevolgen van de overstroming. De verslagen van deze gesprekken zijn opgenomen in bijlage 2. In dit hoofdstuk zijn de belangrijkste bevindingen met betrekking tot de verschillende typen gevolgen samengevat.

1.2.1 Evacuatie, slachtoffers en rampenbestrijding

Evacuatie

Ook voor de Tsjechen is de omvang van de overstromingen ongekend. Er werden honderdduizenden mensen, vaak halsoverkop geëvacueerd, 75.000 ervan konden na een week niet terugkeren naar hun huis. 10.000 mensen waren na een maand nog niet teruggekeerd. In heel Tsjechië werden 99 dorpen met 263.000 inwoners geheel en 347 dorpen en steden gedeeltelijk overstroomd. In totaal trof de overstroming naar schatting 1,6 miljoen Tsjechen.

In Praag werden zo'n 50.000 personen geëvacueerd. Doordat de voorspelde afvoeren in een zeer korte periode naar boven werden bijgesteld, was in Praag slechts beperkte tijd (minder dan een dag) beschikbaar om laag gelegen gebieden te evacueren. In de wijk Karlín werden in de nacht van 12 op 13 augustus zo'n 20.000 mensen verplaatst. Ondanks de korte waarschuwingstijd was het grootste deel van de evacuatie voltooid voor de overstromingen. De meeste mensen verlieten het woongebied op eigen kracht, een klein percentage van de bevolking weigerde te evacueren. Met enkele van deze achterblijvers werd een contract getekend waarin de eigen verantwoordelijkheid werd benadrukt. Daarnaast heeft de brandweer tijdens de overstroming per boot enkele personen geëvacueerd, bijvoorbeeld omdat instorting van het huis dreigde.

Slachtoffers

In totaal zijn bij de overstromingen in Tsjechië 14 slachtoffers gevallen. Hoewel over deze gevallen geen getailleerde gegevens bekend waren, bleek uit de gesprekken dat het veelal ging om oorzaken die indirect aan de overstroming waren gerelateerd, bijvoorbeeld personen die probeerden met hun auto de rivier over te steken.

Rampenbestrijding

Uit gesprekken met de brandweer van Praag kwam het volgende met betrekking tot de rampenbestrijding naar voren. Taken van de brandweer tijdens de overstroming omvatten: het aanleggen van noodwaterkeringen, het evacueren van personen, het beschermen van bruggen tegen drijvende objecten. De overstromingen vergden een zeer grote inzet van de brandweer capaciteit die ver uitsteeg boven de normale werkzaamheden.

1.2.2 Economische schade: schade aan gebouwen en infrastructuur

De totale economische schade is geraamd op 60 tot 90 miljard Tsjechische kronen, zo'n 2 à 3 miljard euro.

Schade aan gebouwen

De schade die ontstaan is aan verschillende gebouwen in Praag (en de omgeving daarvan) door de overstroming in augustus 2002 is geïnspecteerd door medewerkers van het Klockner instituut. Dit wetenschappelijk onderzoeksinstituut is verbonden aan de Tsjechische Technische Universiteit in Praag en is voornamelijk actief op de volgende gebieden; betrouwbaarheid van constructies, materiaalkundig onderzoek en dynamisch gedrag van bouwconstructies.

De inspecties gaven een indicatie van de omvang van de schade aan de gebouwen en moesten uitsluitsel geven over de toekomst van de beschadigde gebouwen (afbreken of herstellen). Opvallend is het geringe aantal gebouwen wat geheel is ingestort ten gevolge van de overstroming, in Praag zelf 'slechts' vier. Op het platteland is de meeste schade aan gebouwen geconstateerd. In zijn algemeenheid is door de medewerkers van het Klockner instituut geconcludeerd dat de aanwezigheid

van ongebakken stenen in het metselwerk en een ontoereikende fundering (te geringe wijdte en diepte) veelal de oorzaken waren van het (gedeeltelijk) instorten van gebouwen.

Daarnaast zijn ook andere geotechnische en constructieve factoren de oorzaak geweest van ernstige schade aan gebouwen. Hierbij moet gedacht worden aan de afname van de draagkracht van de grond ten gevolge van het verhoogde grondwater, ondergrondse transporten van sedimenten en grond van grondverbeteringen (opgevulde oude rioolsystemen), veranderde materiaaleigenschappen (volume, sterkte) door vochtopname (hout, metselwerk) en ontoereikende sterkte van een constructie (bijvoorbeeld het ontbreken van randbalken). Uit de analyse van de schade door het Klockner instituut blijkt dat de geconstateerde schade een relatie had met de gevoeligheid van de gebouwen voor overstromingen (bv ongebakken stenen) en niet zozeer met de verhoogde belastingen op de gebouwen door stromingsdruk of golven.

Schade aan infrastructuur
Van de totale schade (enkele miljarden euro's in heel Tsjechië) was meer dan 10% het gevolg van de schade aan de metro. De overstroming van de metro was een niet voorziene gebeurtenis doordat er geen rekening mee werd gehouden dat het scenario van 1 op de 100 jaar zou worden overschreden. Hierdoor waren de getroffen maatregelen soms onvoldoende. Daarnaast bleek onder andere dat (1) ter plaatse van de kabeldoorvoering niet de sealing niet bestand tegen de hoge waterdruk, (2) er op twee plaatsen breuk van de tunnel-lining was ontstaan, (3) de vloeddeuren slecht functioneerden of zelfs afwezig waren. Door deze onvolkomenheden tezamen was het mogelijk dat 17 van de 51 metrostations gesloten moesten worden door de overstroming. Verwacht wordt dat eind maart 2003 de metro weer operationeel is.

Door de vele grote drijvende objecten in het water (caravans, zeilboten, containers, LPG tanks) en de hoge stroomsnelheden in de rivier (3 tot 5 m/s) bestond er een reëel gevaar dat deze bruggen schade op zouden lopen of zelfs deels zouden instorten. Door het plaatsen van grijpers en kranen op de belangrijkste bruggen (om drijvende objecten – o.a. gastanks – tussen de pijlers door te geleiden) zijn dergelijke problemen in Praag voorkomen. In heel Tsjechië zijn echter tientallen bruggen vernield.

1.2.3 Mileuschade

In Tsjechië zijn tijdens de overstromingen verschillende chemiecomplexen onder water komen te staan. Daarnaast zijn vele vaten, schepen en tanks op drift geraakt. De chemische fabriek Spolana, gelegen aan de rivier, kwam als gevolg van het hoge water grotendeels onder water te staan. Bekend is dat tanks omhoog gedrukt werden en losgerukt van hun leidingen. Tot twee maal toe ontsnapte een flinke chloorwolk en daarnaast kwamen grote hoeveelheden van zware metalen en chloor (80 ton) vrij in de rivier de Moldau.

Mark Rider van de ČHMÚ gaf aan dat monitoring was uitgevoerd. Daarbij zijn zowel watermonsters als drijvende- stof monsters genomen. Hierin zijn geen verhoogde gehaltes gevonden, wel verhoogde gehaltes aan radioactiviteit. In Duitsland zijn in de maand na de overstromingen metingen uitgevoerd naar de waterkwaliteit. Hierbij zijn geen verhoogde concentraties van nutriënten en zware metalen aangetroffen, maar wel hogere waarden voor alpha-HCH en beta-HCH en bepaalde herbiciden. In slib en sediment worden door het CHMU geen metingen gedaan. Uit een persbericht uit februari 2003 blijkt dat in metingen door de milieuorganisatie Arnika, in het slib van de rivier de Elbe onder Spolana ‘hoge’ gehaltes aan PCB zijn aangetroffen.

Een belangrijke schadepost was het onderlopen van de waterzuiveringsinstallatie direct benedenstrooms van Praag. Behalve directe schade heeft dit ook een langdurige lozing van ongezuiverd afvalwater vanuit Praag in de Moldau tot gevolg gehad. In de gesprekken kwam naar voren dat er bij de Tsjechen weinig aandacht was voor de milieuproblemen.

1.3 Afsluiting: evaluatie en herstel

In Tsjechië is de evaluatie van de gebeurtenissen nog volop gaande. Tijdens de verschillende gesprekken zijn door verschillende partijen verschillende meningen over de oorzaken van de overstromingen gegeven. In deze paragraaf is daarom volstaan met het noemen van enkele belangrijke punten die in de gesprekken naar voren kwamen.

In de eerste plaats bleek de late voorspelling van het hoogwater, slechts een dag voor het optreden van de overstroming, een belangrijk probleem. Door verschillende gesprekspartners is aangegeven dat een betere inzet van bovenstrooms gelegen reservoirs de omvang van de overstromingen had kunnen beperken. Ook is er veel onduidelijkheid over de verantwoordelijk voor de hoogwatervoorspellingen en de te nemen acties tijdens de overstroming.

In Tsjechië bestaat de mogelijkheid van verzekering tegen overstromingsschade. dat gebeurt zelfs ook. Er zijn zelfs gevallen bekend van Tsjechen in Zuid-Bohemen, die zich na de eerste top, maar nog voor de tweede top verzekerden én uitgekeerd kregen. Uit gesprekken met de verschillende betrokkenen kwam naar voren dat de extreme afvoer geen reden was om de juistheid van de beschikbare statistieken in twijfel te trekken. Daarnaast leeft bij velen de gedachte dat het bij deze overstromingen ging om een zeer extreme gebeurtenis, maar dat aanvullende beschermingsmaatregelen niet direct noodzakelijk zijn.

Bijlage 1: Maximaal opgetreden waterstanden en rivierafvoeren in de Tsjechische rivieren tijdens de overstromingen van 2002, bron ČHMÚ

rivier	locatie, naam meetstation	water-stand [cm]	rivierwater-afvoer [m³/s]	datum	tijd	terugkeertijd (geschat) [jaren]
Jizera	Bakov n. J.	557	450	14-aug-02	17	10
Vltava (Moldau)	Březí	410	620	13-aug-02	12	> 1000
Malše	Roudné	465	440	13-aug-02	10	100
Vltava	České Budějovice	652	1000	13-aug-02	14	500
Lužnice	Klenovice	530	580	15-aug-02	18	> 1000
Lužnice	Bechyně	630	620	16-aug-02	9	1000
Otava	Katovice	380	375	13-aug-02	9	50
Otava	Písek	850	1200	13-aug-02	11	1000
Sázava	Nespeky	467	350	15-aug-02	9	5
Kosový p.	Svahy – Třebel	214	136	13-aug-02	9	>100
Mže	Stříbro	290	230	13-aug-02	18	50 – 100
Úterský potok	Trpísty	134	25,1	13-aug-02	4 – 5	2
Radbuza	Staňkov	350	79,1	13-aug-02	8 – 9	5
Radbuza	Lhota	425	91,3	13-aug-02	13 – 17	5
Úhlava	Klatovy	362	129	13-aug-02	6 – 7	>100
Úhlava	Štěnovice	507	201	13-aug-02	11	50
Berounka	Bílá Hora	725	693	13-aug-02	16	50 – 100
Úslava	Koterov	368	260	13-aug-02	8	>100
Klabava	Nová Huť	294	120	13-aug-02	6 – 7	10 – 20
Berounka	Liblín	621	1200	13-aug-02	8:30	100
Litavka	Čenkov	224	62,8	13-aug-02	5 – 6	20
Berounka	Beroun	796	1800	13-aug-02	23 – 24	250
Vltava (Moldau)	**Praha – Chuchle**	**785**	**5300**	**14-aug-02**	**12**	**500**
Labe (Elbe)	Mělník	1035	5300	15-aug-02	13 – 16	500
Rolava	Stará Role	259	72,1	13-aug-02	2:30	20
Teplá	Březová	110	64,4	13-aug-02	7	5
Ohře	Karlovy Vary	254	274	13-aug-02	5 – 6	5
Bystřice	Ostrov	163	46,2	13-aug-02	3	10
Labe (Elbe)	Ústí n. L.	1185	5100	16-aug-02	14 – 17	250
Labe (Elbe)	Děčín	1230	5100	16-aug-02	19 – 24	250
Lužická Nisa	Hrádek	320	115	14-aug-02	10	5
Smědá	Frýdlant	275	246	14-aug-02	10	50
Dyje	Raabs (Rak.)	602	350	13-aug-02	16 – 17	> 500
Dyje	Vranov	378	374	14-aug-02	9	150
Dyje	Znojmo	464	379	14-aug-02	15	150
Jihlava	Dvorce	236	58	14-aug-02	2	50 – 100

2 Visit to CURBE - on the 24th and 25th of March 2003

On March 24 and 25 two participants (Bas Jonkman, Paul Waarts) in the Delft Cluster "Impacts of floods" visited the CURBE institute at Cambridge University. Reasons for the visit were the mutual research interests in flooding impacts, and specifically in the subjects damage buildings and flood fatalities.

CUBRE
We spoke to dr. Ilan Kelman, deputy director of CURBE. CURBE was established to create a structure for interdisciplinary collaboration for disaster and risk research and application. Topics studies at CURBE include **CURBE projects include:** Disaster Diplomacy, Earthquakes, Floods, Islands, Shelter, Volcanoes. As far as flooding is considered special projects focus at Damage to buildings and flood fatalities.
More information can be found http://www.arct.cam.ac.uk/curbe/index.html

2.1 Damage to buildings

A project has been carried out by CURBE to assess the vulnerability of residential buildings to the hazards associated with a major North Sea storm surge. By combining detailed analysis of the buildings in specific case study sites with sophisticated hydrodynamic modelling of potential storm surge events, the research identified features which determine the vulnerability of residential dwellings to flood damage. During the meeting similarities and differences with the model for the assessment building collapse developed in the Delft Cluster project were discussed.

2.2 Loss of life caused by floods

The importance of flood loss estimation has been discussed, and the lack of the existing applicable models. Ideas and concepts have been discussed on the prediction of flood fatalities. CURBE has archived information from the UK 1953 floods which resulted in 310 fatalities on UK territory. As a special case study in the DC project, detailed information on the deaths due to this event has been collected.
As a mutual effort data on fatalities for the Netherlands 1953 floods has been archived in "CURBE Fact Sheet 6: Netherlands Deaths from the 1953 Storm Surge" (http://www.arct.cam.ac.uk/curbe/infosheets.html). Information on flood deaths has been exchanged and plans are made to set up a mutual CURBE / Delft Cluster publication on the subject of loss of life caused by floods. Since the visit many information has been exchanged on this subject. Further cooperation will also focus on other health effects of flooding

2.3 Other topics

During an investigation in the CURBE archive, some interesting documents on building damage, loss of life and chemical plant hazards, have been found, which have been distributed among the DC partners.
CURBE will (co-) organize the International Scientific Meeting at the Royal Society (London The Big Flood: North Sea Storm Surges, at May 23 (unfortunately the same date as the DC seminar). Proceedings of this seminar will be sent to DC participants.

References:
Kelman I., Physical flood vulnerability of residential properties in coastal eastern England, PhD thesis, Cambridge University, 2002

3 Visit to Dresden on the 15th and 16th of April 20003

On the 15th and 16th of April 2003 a group of four persons of the Delft Cluster project *"Consequences of floods"* visited Dresden. Dresden was affected, as other parts in Central-Europe, by extreme floods in August 2002. The possibility to collect quantifying data of this flood, which could be used for validation of the models made in the project, was the reason for visiting Dresden. Meetings were arranged with people of the ministry of Saxony, the municipality of Dresden, the TU Cottbus and the research institute IOER, who were involved in the survey of the damage caused by the flood.

The talks consisted mainly of discussing the consequences in terms of casualties, economical loss and environmental impact.

3.1 The flood

Because of heavy precipitation in whole Central-Europe, in Dresden the Weißeritz river and Elbe river overflowed its banks. The Weißeritz river is a tributary of the Elbe that flows into the Elbe river in Dresden (Figure 1). The flood in the Elbe river was estimated to have a return period of about 100 years, whereas the flood in the river Weißeritz had a return period of about 1000 years. Not only the return periods of the floods in both rivers were different, also the flooding characteristics differed. Water levels of the Elbe river rose gradually (about 5 cm per hour) and overbank flow velocities were low. Water levels in the Weißeritz river rose rapidly. The flood in this river reached its maximum within a few hours. Moreover, flow velocities, inbank as well as overbank, were high. This caused a lot of damage. This damage increased even further as the Weißeritz broke trough its bank and shifted back into its old riverbed (Figure 1), in which many buildings as well as the main railway station of Dresden are now located. This was the third time that the Weißeritz shifted back into its old bed during flood.

One of the most striking consequences of the flood was the raise of the ground water level outside the inundated area. Because of this, the damage wasn't restricted to the inundated area alone. It is expected that it will last two more years before the ground water level is back to its normal level.

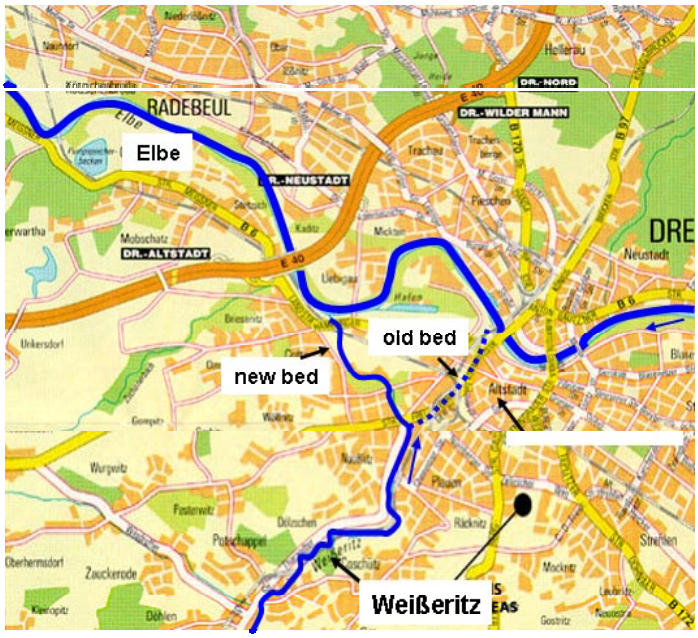


Figure 1 Location of the river Weißeritz

Figure 2 The Weißeritz during the flood

3.2 Casualties

In total 21 persons died due to the flood in Germany. However, most of the persons didn't die because of drowning in their houses. Heart attacks, ignorance and unawareness of the seriousness of the situation and failure of rescue operations were the main causes of death. No people were killed by the collapse of buildings. An overview of the fatalities in Germany due to the flood is given in appendix 1.

In Germany 337.000 people were affected by the flood. In Dresden only, 35.000 people were evacuated. The biggest evacuation operations in Dresden were the complete evacuations of two hospitals that were located within the flooded area. It took about two days to evacuate the hospitals and elderly homes. In the same time, the people who were able to cope for oneself had left their houses. About 10% of the inhabitants did not want to leave.
After the flood it appeared that those who had left their houses immediately after receiving the warning had lost all their furniture and personal belongings, while people who left at the last moment were able to store their valuable properties in safer places. It is therefore expected that in case of a future flood, inhabitants will no longer leave immediately after having received the warning message.

The administration of evacuated people from hospitals and elderly homes was chaotic, because computer data bases were not used, partly because of the lack of electricity.

Because epidemics were feared 100.000 to 200.000 people were vaccinated.

Figure 3 Evacuation of hospital

3.3 Economic loss

Concerning the direct damage to infrastructure, a big amount of research has been done by the municipalities and the Saxony ministry. According to their definition, *public* infrastructure[1] consists of railways, roads and bridges, flood defense systems, social institutes (schools, hospitals), sport and leisure facilities, water and waste treatment, and supply of drinking water and electricity. The report "Schadenausgleich und Wiederaufbau im Freistaat Sachsen"[2] consists of a full survey of the economical consequences in the state of Saxony.

3.3.1 Direct loss

Electricity and telephone
In some parts of the city of Dresden the electricity fell out. Although this lasted for some time (days to weeks) it caused no big problems. More serious problems occurred when the mobile network was overloaded and no mobile telephone communication was possible for two hours. This caused problems by communication during rescue operations. Stationary telephone network was overloaded as well, but it did not fail.

Water supply
Water reservoirs that were constructed along the tributaries of the Elbe are multi-functional. They are used for flood water retention purposes, supply of drinking water and electricity, and recreation. According to Prof. Grünewald, the turbid flood waters remained in the upper part of the water column so that water in the lower parts of the reservoirs was still available for drinking water. Limitations in the supply of drinking water to households in Dresden were related to failure of water pumps due to a lack of electricity. However, according to Dr. Schanze, water from the reservoirs could not be used for drinking water. Mr. Rißmann mentioned that several waterworks were damaged during the flood and that water was delivered to the inhabitants in trucks and bottles.

Transportation
The main railway station is situated in the old riverbed of the Weißeritz. Because the Weißeritz river had broken through its old bed the main station was inundated completely. Consequently, public transport by train was disrupted for several months. The transportation of the people was taken over by buses during these months.

Figure 4 The railway station during the flood

[1] *Private* infrastructure is reported separately. This type of division and definition can be explained by the purpose these are used for. The primary goal of the team evaluating the flood damage was fast and effective damage assessment with the further money division between the victims. Thus theoretical infrastructure definition was ignored.
[2] Freistaat Sachsen; **"Schadensausgleich und Wiederaufbau im Freistaat Sachsen"**; Leitstelle Wiederaufbau, January 2003

Several bridges over the Elbe river could not be used during the flood. The largest bridge that remained open had to remain available for medical staff and other authorities. This implied that local residents could not cross the Elbe river during the flood.

Infrastructure
180 bridges and 20% of the railroad tracks were destroyed by the flood. The damage to the bridges was caused mostly by debris. The roads around Dresden were heavily affected as well by scour and until now some roads are still damaged. It is expected that not all undermined roads have been detected yet and that additional damage underground is to be expected.

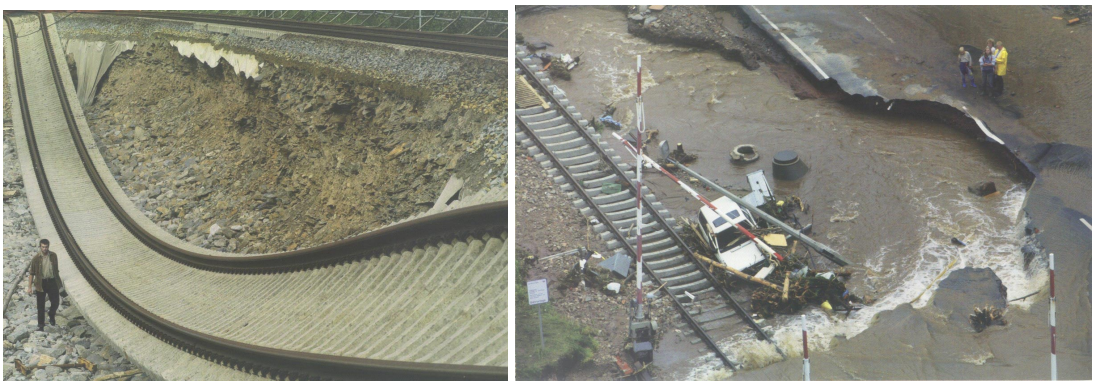


Figure 5 Scour of railways and roads

Underground infrastructure (cables and pipes)
Due to the increased water pressure, pipes were damaged in the underground. Also some pipes and cables were washed away by the water. Fibre optics cables were damaged because of the sensitivity to water. All fiberglass cables that got wet during the flood have to be replaced. Damage to the underground infrastructure mainly depends on water depth (pressure) and flood duration.

Buildings
The buildings in the vicinity of the Weißeritz river were affected by the high flow velocities, in contrast to the buildings in the vicinity of the Elbe river, which were not exposed to high velocities. This caused different kind of damages in the city. The main or most serious damage to structures is caused by high flow velocities of the Weißeritz. However, the wiring in the houses was affected in both areas (Weißeritz and Elbe) due the fact they are mostly located in the cellar of the buildings. Therefore the electrical wiring and fibre optics cables must be rewired completely.

Figure 6 Damaged buildings

Another consequence of the flood was the raise of the ground water level in bigger parts of the city. This caused flooding and uplifting of the cellars and material damage. Additional studies into the state of the foundation of houses still have to be carried out.

After the flood people put damaged furniture from the basement and ground floor, together with other debris, outside on the streets. This caused 100.000 tons of waste on the streets.

Figure 7 Debris on the streets

Businesses
The losses attributed to the private businesses were not explicitly reported in the official statement. Mostly, all the losses suffered by this category were included into the 'built structures' losses group, such as damage to buildings and other personal belongings, infrastructure, etc. Nevertheless from the discussions with the Ministry and Municipality representatives it cleared out that no major industrial site was damaged. This is due to the fact that the flooded area mostly covered the center of the city,

while all the large industrial objects are found on the outskirts of the city, which lie sufficiently higher. Thus, it can be concluded that the group that was affected most by the flood are small (private) businesses, which seem to close down after the food. Still, no precise information could be gained either on the number of those enterprises, nor on the number of employees or on the output they produced.

3.3.2 Indirect loss

Beyond the indirect business disruption, economic loss due to indirect causes is even more difficult to estimate or pass any reasonable judgment upon. For example, on the loss of production because employees in Dresden were prevented from going to work, not to mention the production spillover effects on the enterprises located outside the affected area. It was possible nevertheless for some companies to let employees continue their work at home by computer, if they still had electricity at home, but mostly this wasn't the case. As mentioned before, a number of small businesses were forced to close down. Companies in flooded areas often have been out of business for about three months. According to Mr. Rißmann about 400 companies in Germany will close their doors permanently. The question of the increased unemployment remained unclear. Whereas the Staatskanzlei stated that the flood has had no or negligible impact on the unemployment rate in Dresden (which in relative terms is doing good in comparison with cities of similar size in former Eastern Germany), Dresden city Municipality pointed at the risen unemployment rate. No figures were provided for this case, but presumably this additional unemployment was created by the small companies that appeared to stay out of business. For reference, the average unemployment rate in Leipzig is 22%, whereas in Dresden it is 14%.

Buildings

Some damages to buildings occurred after some time. Frost damage of wetted buildings caused an extra damage of 40 million euros.

3.4 Environmental impact

Water pollution

- Point sources

One of the biggest problems in dwellings with environmental impact were the oil tanks for heating. These tanks mostly are accommodated in the basements of the dwellings. They were exposed to the water and started to float. Many oil tanks burst open and started to leak. The oil was spread by the river water.

- Area sources

There were no problems with the big industries in the vicinity of Dresden, but there were in Bitterfeld. This is an area with many petrochemical industries that may have had big problems during the flood. What happened exactly is not known. There might still be an increased environmental risk, but the fact that this area was already the most polluted region in Europe before the flood must be taken into account as well. According to Prof. Grünewald the industrial area was protected in time with mobile dikes. Mr. Jekkel from the Sächsische Staatskanzlei spoke about 'potential' damage in this area. No data is available to determine what the exact damage is in this industrial area.

Because of the overflow of the sewage water treatment in Dresden, the sewage water flowed into the Elbe river without being cleaned. This lasted for approximately two weeks. After that, the treatment plant was gradually taken into production again. As admitted by the officials, the short escape from the hygienic catastrophe due to the unavailability of clean drinking water is attributed solely to the small scale of the flood. Should the disaster last longer or induce more electricity (and other) disruptions, catastrophe would be unavoidable.

Sediments contaminated with heavy metals were picked up near mining sites in the upper part of the catchments in Germany and the Czech Republic because of the high flow velocities. This, together

with local pollution sources resulted in a high load. However, due to the large volume of water flowing through the river, concentrations remained relatively low.

Figure 8 Sediment on the streets

Fish
The Havel catchment, situated along the river Elbe downstream of Dresden, was used as an emergency detention area. The catchment was mainly used for the cultivation of maize. The large amounts of organic matter present in the area withdrew oxygen from the water. The oxygen shortage resulted in a high fish mortality.

Agriculture
No damage to agricultural areas has been reported. Small scale problems did occur in kitchen gardens and allotments as these plots had to be cleaned. The same applies to play grounds and recreation areas. This was however, no serious item of damage.

3.5 Recovery

Recovery from flood was initially planned to be as fast and as effective as possible. As far as the immediate after-flood recovery is concerned, the estimation of direct damage has been carried out and thus accordingly the reimbursement was (and still is) assigned. Nevertheless the meetings with state and city officials as well as with the academic staff revealed the necessity of discriminating between the short-term and long-term recovery and planning. Here it should be interesting to outline at least two separate points.

First is the water management problem. As for the immediate recovery rebuilding or reconstruction of the existing structures is done. It refers both to the reconstruction of the buildings and the reinforcement of the existing dams. This is also prescribed by the Administrative law provisions. Nevertheless in the long-term prospective this is not always an optimal solution. In some cases floodplain should be widened, thus living (or otherwise occupied) areas should be moved outside it or dams should be raised in another place. The problem of such physical reallocation has several sources. First of all, the social aspect – it is not easy for people of the whole community to move to another habitation area. Secondly, there are a number of legal thwarts for such a decision. Administrative law poses certain limits in this respect. Especially if it's the case where two or more Länder are concerned: each Land has its own legal regulations[3], thus there is a necessity to harmonize the law within the country. Finally, and also mostly important for our research, is the matter of water management and spatial planning. In fact this is the drawing power for the proposals of new spatial decisions. And here, the Saxon government official recognizes that the flood problem has not only inter-regional dimension (between the federal Länder), but it should be considered in the European context.

[3] An example provided to us by the Ministry representative about the move of the whole village proved to be hard to implement, but still possible.

The second set of important issues concerns long-term economic development. From the very outset economic issues stood on the agenda of Saxony authorities. These trace back to the reunification of Germany, which resulted in the general industrial activity decay in the former Eastern Germany. Thus the outstandingly high unemployment figures mentioned before are observed till today. In this context flood itself has contributed to the 'wound' existing for a decade and though it was not considered big countrywide, it was a very substantial hit for the region. The immediate after-flood measures introduced are the tax-cuts and partial credit allowances for the enterprises, which are hoped to revive the economic activity in the region. Nevertheless it is also admitted that the coverage of costs for the small and individual businesses[4] affected by the flood is not sufficient to restart their operation. This means that new companies need to enter the business to regain the lost production. Much more should be done to achieve the further growth. It is clear therefore that the issue of economic development of the Land of Saxony (and the whole of the Eastern Germany) needs a sufficient consideration taken from the long-term strategy viewpoint. In this extent government officials try to make the whole Land attractive for investors providing certain economic environment conditions as well as improving infrastructure. The hopes of the authorities lie in the measures taken, well-trained and friendly people, but most interestingly – in the possibility of the hosting the Summer Olympics of 2016 in Leipzig and the World Football Championship of 2006.

3.6 Conclusions

As stated in the preface, the aim of the visit to Dresden was to collect quantifying data for validation of the models which were made in the project. However, during our visit it appeared that this data was spread over different authorities and not digital available. Therefore, no quantifying data was brought back. Anyhow, valuable information about the consequences of floods has been gathered. In relation to the project can be concluded that

- the consequences of floods which have been described in the project cover to a considerable extent the consequences which were found in Dresden (e.g. damage to houses, economy, infrastructure, etc.)
- the difference in scale between the Elbe flood near Dresden and the Rhine flood simulated in the project implies that not all aspects of flood damage encountered in Dresden can be projected on the case study area of our project and vice versa. Differences in topography, infrastructure and housing strengthen this difference. This implies that the set of possible consequences assessed in the project for the central part of Holland needs to be checked and possibly adapted when applied to different areas.
- the impact of some consequences of floods lasts for more than a year, i.e. the raise of the groundwater level
- immediate recovery goals do not always meet the goals of long-term strategy.
- The problem of floods is recognized as at least national (as opposed to regional or local), with the wish to encourage international cooperation in the fields of disaster mitigation and recovery (especially in water management:), loss evaluation.

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[4] Mounting up to 80 to 90% of the lost asset value.

Appendix 1 Germany floods August 2002, Fatalities

CRED / OFDA disaster database

killed	27
injured	108
Affected	330000

Date	Age	Gender	Location	Cause	Comments
12-Aug	81	m	Pirna	drowning	
12-Aug	35	m	Pirna-Zuschendorf		fireman drowned during rescue
13-Aug	71	m	Reichstadt	drowning	
13-Aug	44	m	Mulde river	boat	
13-Aug	51	m	Mulde river	boat	
14-Aug	35	m	Dresden - Cotta	drowning	
14-Aug	52	m	Grimma	?	
16-Aug	58	m	Dresden - Zscahchwitz	drowned in cellar	
13-Aug	51	m	Raum Chemnitzer Land	missing since 13-8, found 3-10 in a branch of Muglitz river	
12-Aug	68	f	Dresden	heart attack	
14-Aug	70	m	?	heart attack after evacuation	
12-Aug	65	m	?	heart attack	
13-Aug	77	f	?	heart attack	
?	77	f	Pirna	Schwache-anfall (stroke)	
				Schwache-anfall (stroke)	
14-Aug	76	f	?	died due to rescue by helicopter, died in hospital	
21-Aug	35	m	?	accident with shovel in flood, died in Leipzig hospital	
?	50	m	Muglitz river	found in glass factory	
14-Aug	?	m	Kottewitz	broken neck	
20-Aug	39	f	near Muhlbach	?	found 20 aug
22-Aug	52	m	Dresden-Leuben	?	found 22 aug
25-Aug	?	f	Dohna	?	found 25 aug
missing	4				
Total (incl. missing)		25			

Flood fatalities
http://www.sachsen.de/de/bf/hochwasser/katastrophe/tote_verletzte/index.html

General Appendix: Delft Cluster Research Programme Information

This publication is a result of the Delft Cluster research-program 1999-2002 (ICES-KIS-II), that consists of 7 research themes:
►Soil and structures, ►Risks due to flooding, ►Coast and river , ►Urban infrastructure, ►Subsurface management, ►Integrated water resources management, ►Knowledge management.

This publication is part of:

Research Theme	:	Risk of Flooding			
Baseproject name	:	Consequences of floods			
Project name	:	Consequences of floods			
Projectleader/Institute		Prof. A.C.W.M. Vrouwenvelder	TNO		
Project number	:	02.03.03			
Projectduration	:	01-02-2002	-	1-07-2003	
Financial sponsor(s)	:	Delft Cluster			
		Ministry of Public Works, Road and Water Management			
		GeoDelft			
		WL|Delft Hydraulics			
		TNO			
		Delft University of Techonology			
Projectparticipants	:	Twente University			
		Alterra			
		CSO			
		Delphiro			
Total Project-budget	:	€ 450.000			
Number of involved PhD-students	:	2			
Number of involved PostDocs	:	0			

Delft Cluster is an open knowledge network of five Delft-based institutes for long-term fundamental strategic research focussed on the sustainable development of densely populated delta areas.

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