Risk Analysis as applied to Dam Safety and Dam Security

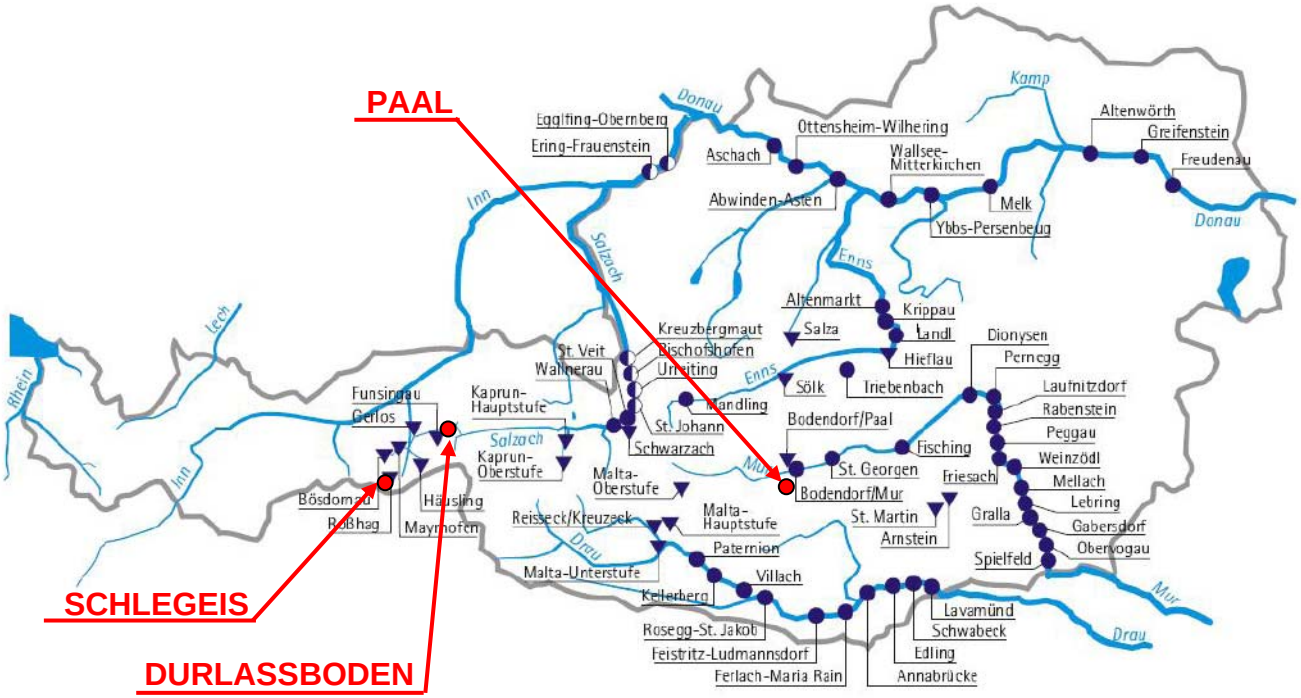
Verification of DAMSE on Austrian Hydro Power dams

DAMSE
EC funded project
JLS/2006/EPCIP/001

Damse - Scope of Work

Austrian Hydro Power - Dams

- Schlegeis Arch Dam, Ziller Valley
- Durlassboden Fill Dam, Ziller Valley
- Paal Arch Dam, Mur Valley



Damse - Scope of Work

Austrian Hydro Power - Dams

- Schlegeis Arch Dam, Ziller Valley
- Durlassboden Fill Dam, Ziller Valley
- Paal Arch Dam, Mur Valley

Assignment of Task

- Preliminary Screening Procedure
- Fault Trees
- Site Surveys ⇨ Worksheets

Preliminary Screening

Possible Effects on Dams

- Loss of Water Retaining Capacity
- Loss of Hydroelectric Generation
- Loss of Water Supply and Irrigation
- Loss of Recreation and Tourism
- Loss of Commercial Navigation

Dam mission losses	Consequences Assessment		
	Public Safety	Economic	Environmental
Loss of Flood Control or retaining capacity			
Loss of Hydroelectric Generation			
Loss of Water Supply and Irrigation			
Loss of recreation, tourism			
Loss of Commercial Navigation			

Table 1 - Consequence values

	Very High Score = 10	High S = 8	Medium S = 6	Low S = 4	Very Low S = 2
Public Safety	**PAR > 5000 people**	**PAR = 1000 to 5000 people**	**PAR = 6 to 1000 people**	**PAR = 1 to 6 people**	**No population at risk**
Economic	National to multi-region disruption. **Massive losses.**	Multi-regional disruption. **Multi-regional losses, major public and private facilities**	Regional disruption. **Regional losses.**	Local to regional disruption. **Local to regional.**	No disruption. **Minimal and confined to facility only.**
Environmental	**Massive** environmental mitigation cost or **impossible** to mitigate.	**Very large** environmental mitigation cost **multi year recovery**	**Large** environmental mitigation cost **1 to 2 years to recover**	**Medium** environmental mitigation cost **less than 1 year to recover**	**Minor** environmental mitigation cost

People involved

Consequence classification			
Single mission loss	2 <= S < 10	10 <= S <= 20	20 < S <= 30
Multiple mission loss	4 <= S < 26	26 <= S <= 53	53 < S <= 80
Category	**Low (L)**	**Medium (M)**	**High (H)**

DAMSE Preliminary Screening Procedure							
Dam missions loss		Consequences Assessment					
		Public Safety	Economic	Environmental	Total Score	Classification	Full Security Assessment ?
x	Loss of Flood Control or retaining capacity	8	8	8	**24**	**H**	**YES**
	Loss of Hydroelectric Generation		n/a		**0**	**n/a**	**NO**
x	Loss of Water Supply and Irrigation		4	2	**6**	**L**	**NO**
x	Loss of recreation, tourism		2		**2**	**L**	**NO**
	Loss of Commercial Navigation		n/a		**0**	**n/a**	**NO**
	Tot. Score	**8**	**14**	**10**	**32**	**M**	**YES**

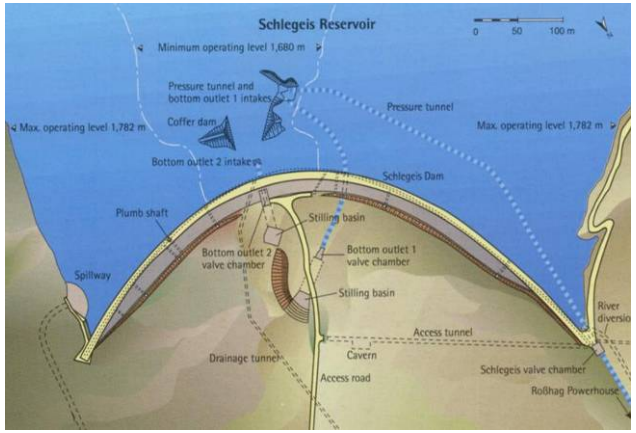
Screening of Verbund dams

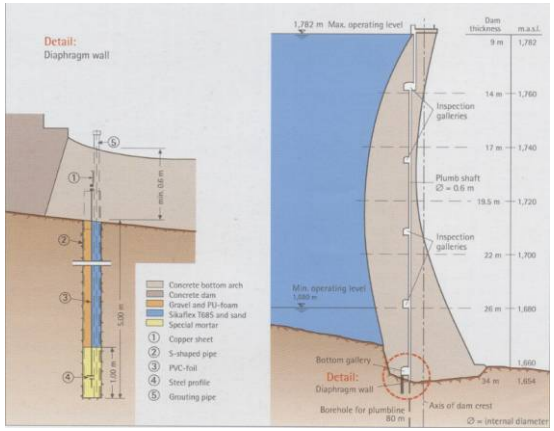
DAMSE Preliminary Screening Procedure												
Dam Description						Consequences Assessment					
Name	Location	Type	Year of construction	Storage Capacity	Dam Missions Loss	Public Safety	Economic	Environmental	Total Score	Classification	Full Security Assessment ?
Durlassboden	Gerlosbach Zell/Ziller Tyrol	TE - Earthfill Dam	1966	50.7 mio m³	x Loss of Flood Control or retaining capacity	10	10	10	30	H	YES
					x Loss of Hydroelectric Generation		8		8	L	NO
					Loss of Water Supply and Irrigation		n/a	n/a	0	n/a	NO
					x Loss of recreation, tourism		10		10	M	YES
					Loss of Commercial Navigation		n/a		0	n/a	NO
					Tot. Score	10	28	10	48	M	YES
Schlegeis	Zemm Bach Mayrhofen Tyrol	VA - Gravity Dam	1970/71	126.5 mio m³	x Loss of Flood Control or retaining capacity	10	10	10	30	H	YES
					x Loss of Hydroelectric Generation		8		8	L	NO
					Loss of Water Supply and Irrigation		n/a	n/a	0	n/a	NO
					x Loss of recreation, tourism		8		8	L	NO
					Loss of Commercial Navigation		n/a		0	n/a	NO
					Tot. Score	10	26	10	46	M	YES
Paal	Mur Murau Styria	VA/PG - Gravity / Arch Dam	1982	0.22 mio m³	x Loss of Flood Control or retaining capacity	8	8	8	24	H	YES
					x Loss of Hydroelectric Generation		6		6	L	NO
					Loss of Water Supply and Irrigation		n/a	n/a	0	n/a	NO
					Loss of recreation, tourism		n/a		0	n/a	NO
					Loss of Commercial Navigation		n/a		0	n/a	NO
					Tot. Score	8	14	8	30	M	YES

Schlegeis Dam

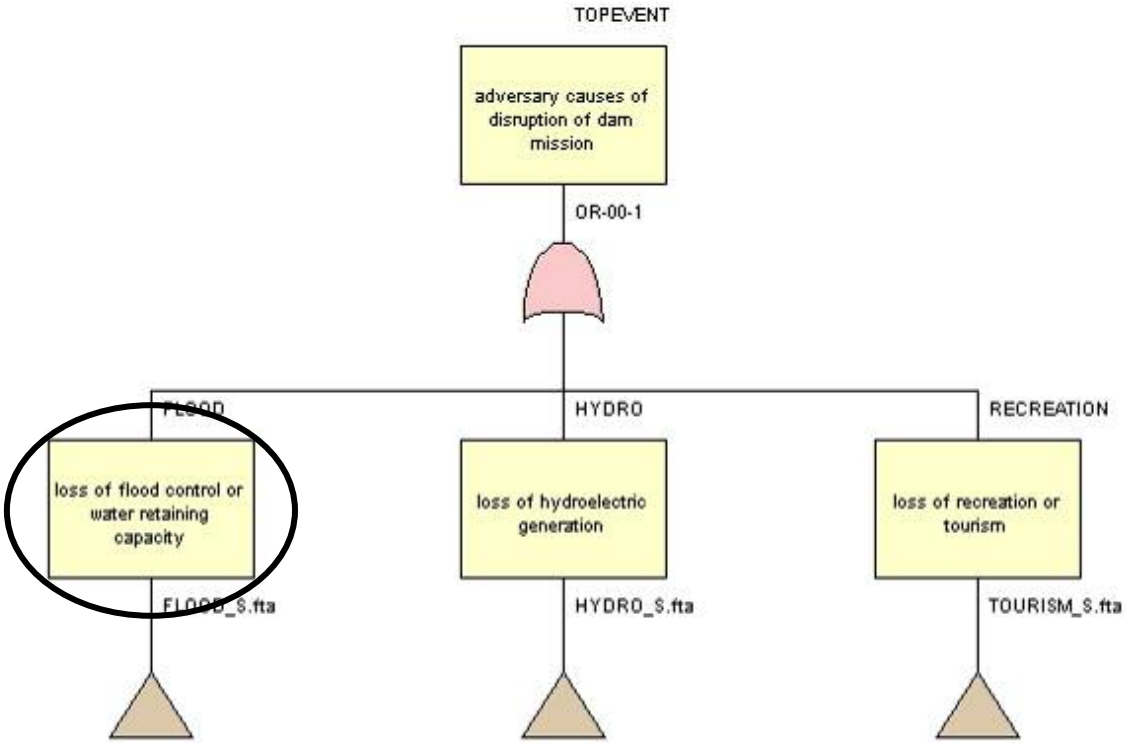
Dam Data

- Gravity Arch Dam
- Ziller Valley, Tyrol
- Built in 1970/1971
- Purpose: Retaining Water, Power Generation
- Height 131 m, Crest Length 725 m, Storage 126,5 Mio m³
- Freeboard 2,3 m





Fault Tree - Schlegeis

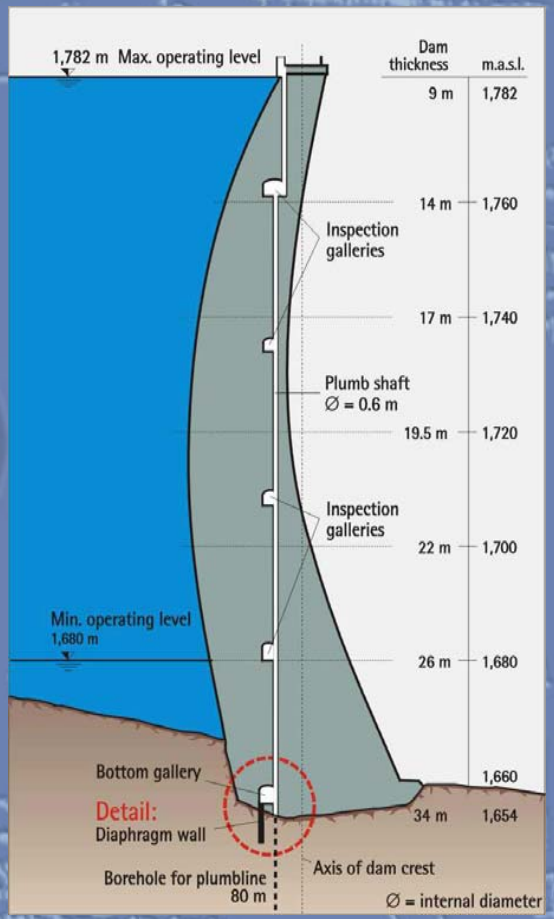


INTEGRITY ASSESSMENT OF LARGE CONCRETE DAMS

ICOLD - Dam Analysis

Committee on Computational Aspects of Analysis and Design of Dams

NETWORK MANAGEMENT



DAM CALCULATION

DAM PERFORMANCE

DAM MAINTENANCE

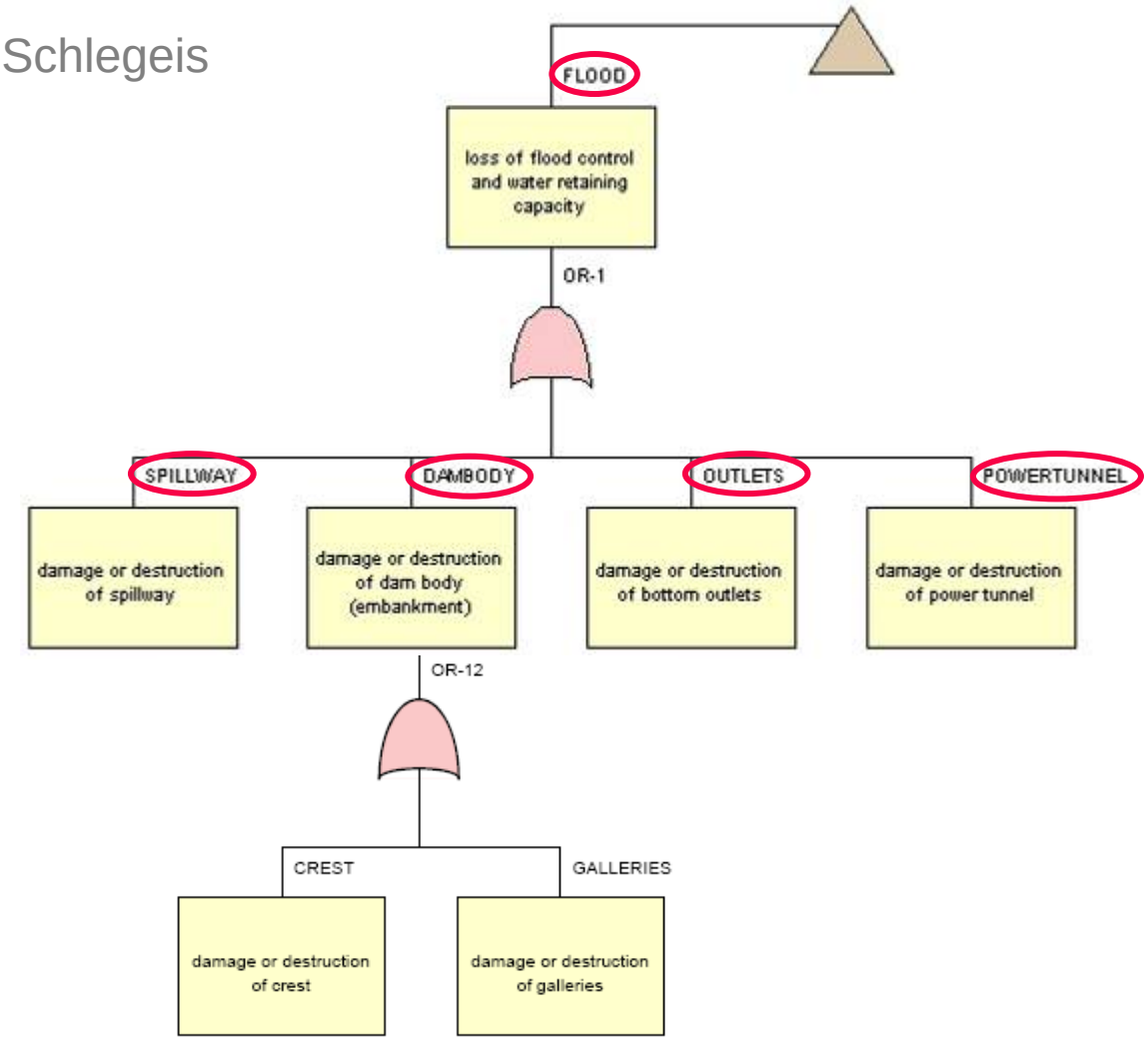
DAM SAFETY

http://nw-ialad.uibk.ac.at

EUROPEAN RESEARCH NETWORK FUNDED BY THE EC

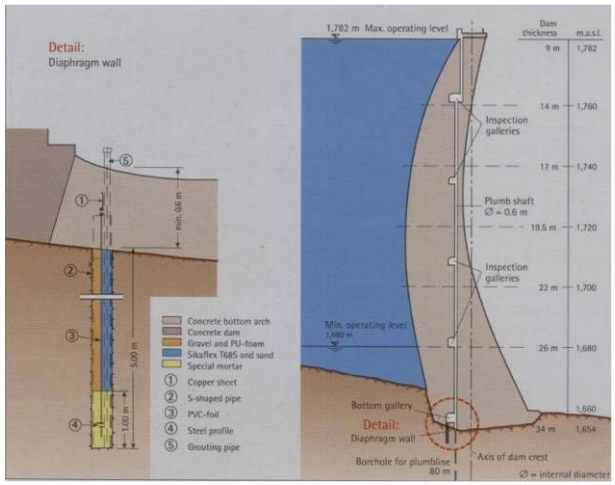
Fault Tree - Schlegeis

Critical Assets



Loss of Retaining Capacity

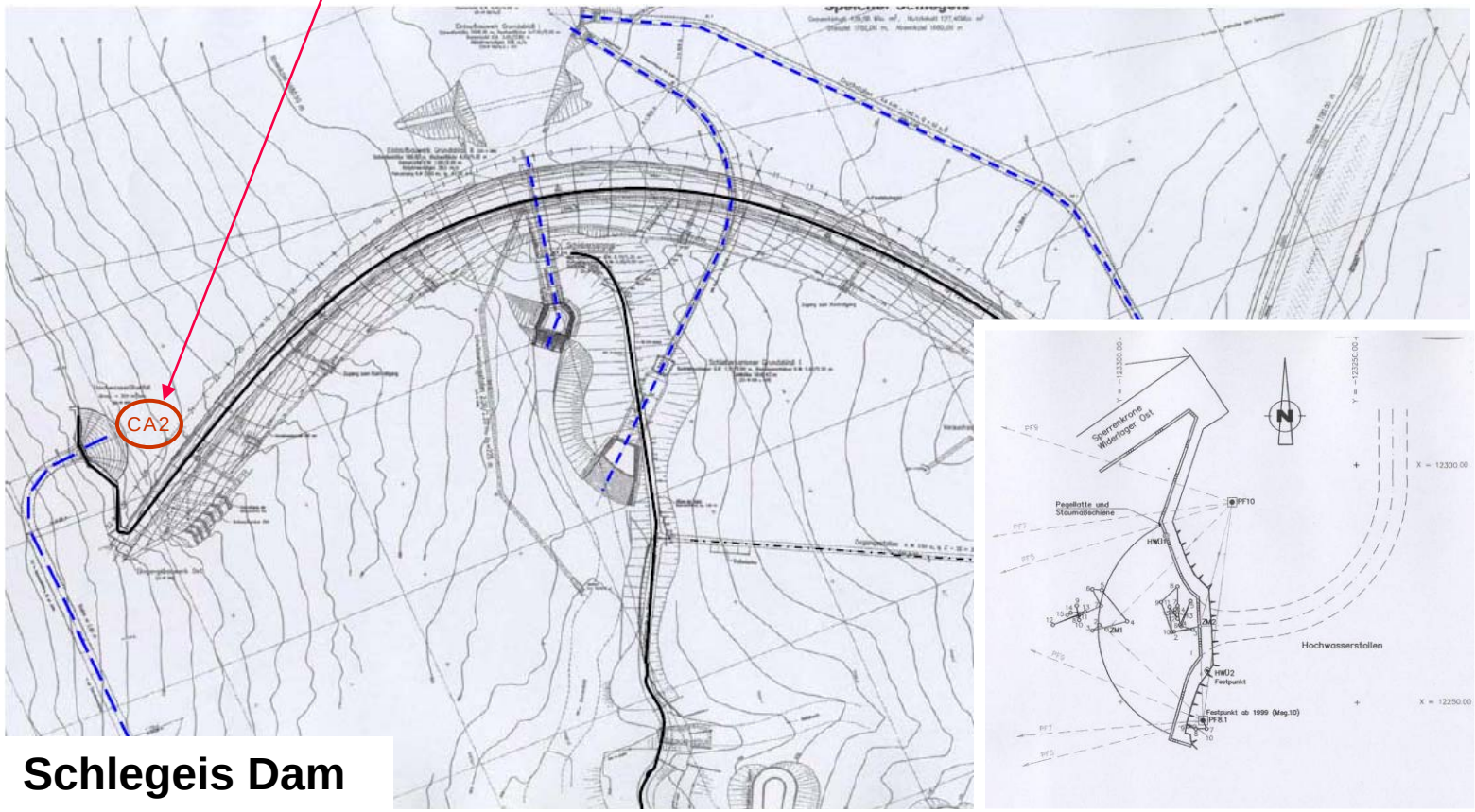
– Dam Body (CA 1)



Schlegeis Dam

Loss of Flood Control and Retaining Capacity

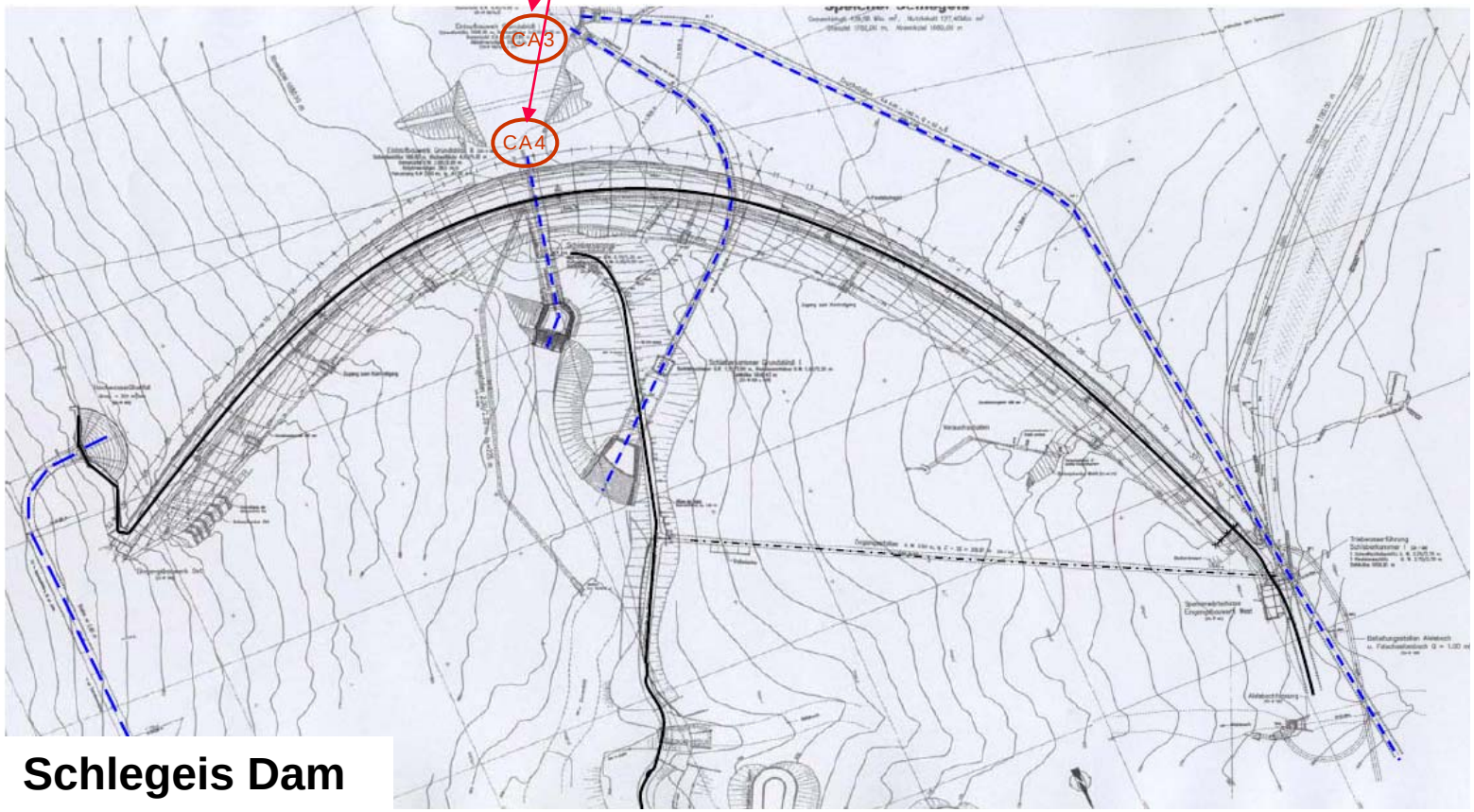
- Dam Body (CA 1)
- Spillway (CA 2)



Schlegeis Dam

Loss of Retaining Capacity

- Dam Body (CA 1)
- Spillway (CA 2)
- Bottom Outlet I (CA 3)
- Bottom Outlet II (CA 4)
- Power Tunnel (CA 5)



Schlegeis Dam

Loss of Retaining Capacity

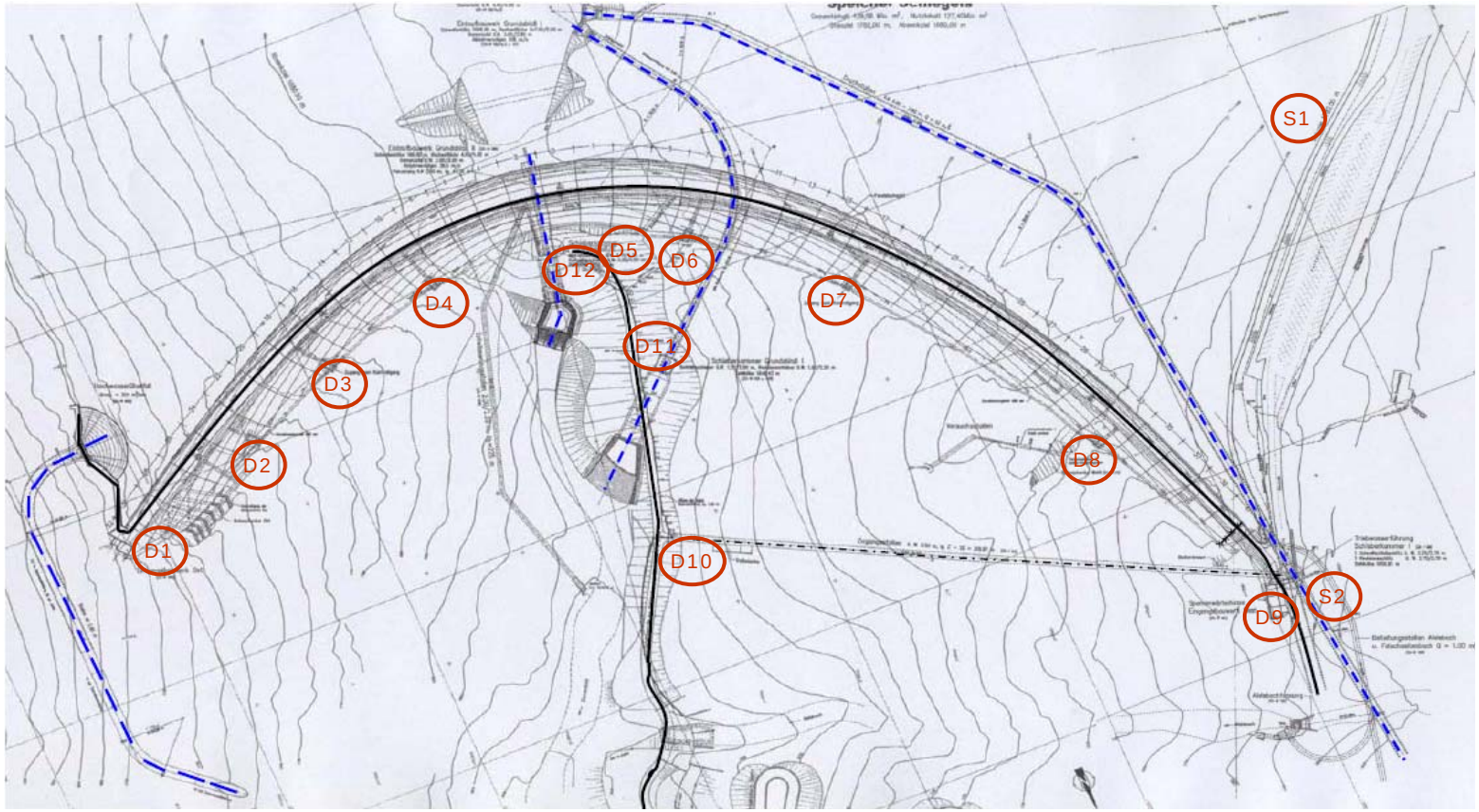
- Dam Body (CA 1)
- Spillway (CA 2)
- Bottom Outlet I (CA 3)
- Bottom Outlet II (CA 4)
- Power Tunnel (CA 5)

Name:	BOTTOM OUTLET I	Label:	CA3	Location:	CENTRAL
Physical description:	• Intake works: tie level 1668 m a.s.l. stoplog ⇨ 3.65/2.80 m • removal capacity 108 m³/s • Valve chamber: controlled by two gates (regulation and guard gate), 1648.43 m a.s.l., access gallery on road R2 • Channel: hard-facing 123.35 m • Stilling chamber				
Function :	Collect water from the upstream of the dam to the downstream side				
Condition :	⊗ Good		Average		Bad
How often is this asset visited?	All the time	Couple of times per day	Once per day	Couple of times per week	⊗ Once per week	Randomly	Rarely
Who visits the asset?	dam guard				
Comments, notes, sketches…:	• Inspections: Bottom Outlet control inspection ⇨ once a year at high water level and after special events: dam operator, dam officer, dam guard, Operating department, company; documentation; operating instructions ⇨ once at the end of winter: dam officer, dam guard, operating department, company; documentation **Bottom Outlet control walkabout ⇨ once a week**: dam guard; dam control book Bottom Outlet I and II function control ⇨ with full opening (dry): twice a year; company; dam control book; operating instructions ⇨ with partial opening at high water level (wet): once a year; dam operator, dam officer, dam guard, operating department, company; dam control book; operating instructions ⇨ with full opening (wet): decennial; dam operator, dam officer, dam guard, operating department, Company; dam control book • Power Supply: main power supply, back-up power supply				

Table 13: Worksheet 4. Detailed Description of Critical Assets – Schlegeis

Location and description of security systems

- Camera (S 1)
- Camera (S 2)
- Door Sensors

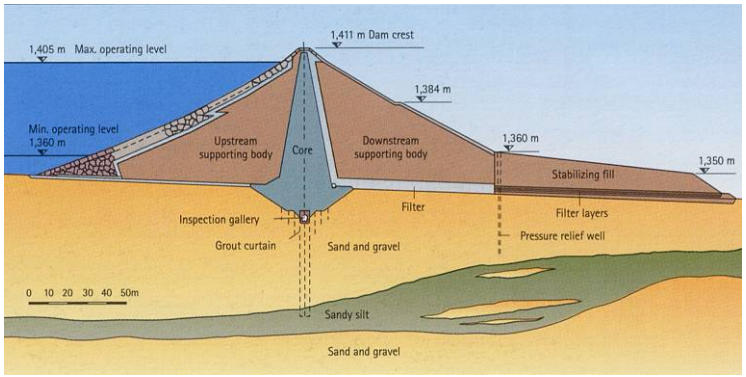


Durlassboden Dam

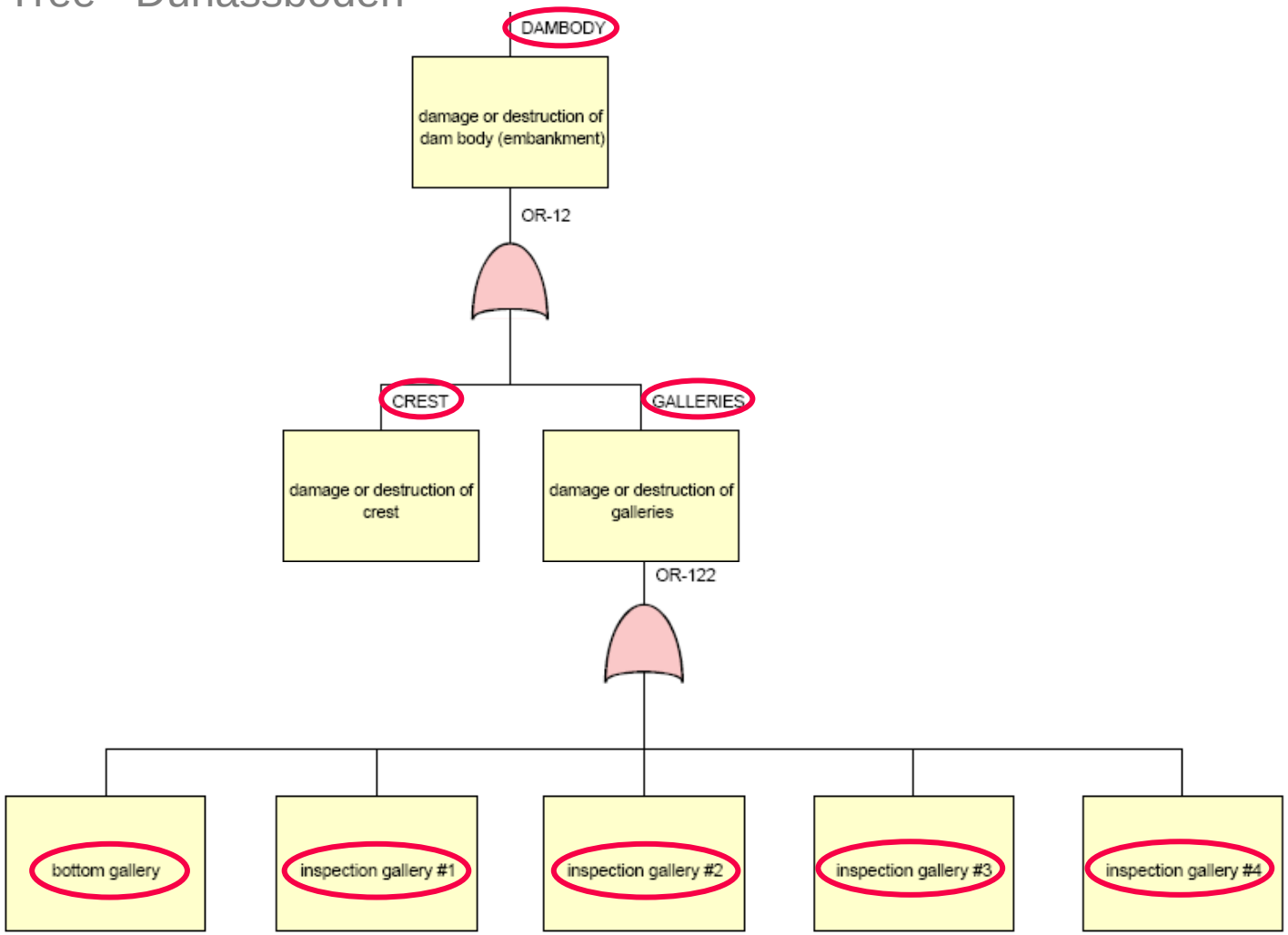
Dam Data

- Earthfill Dam
- Ziller Valley, Tyrol
- Built in 1966
- Purpose: Retaining Water, Power Generation
- Height 83 m, Crest Length 470 m, Storage 50,7 mio m³
- Freeboard regular case ⇨ 8 m (1403 m a.s.l.)

  August till end of November ⇨ 6 m (1405 m a.s.l.)

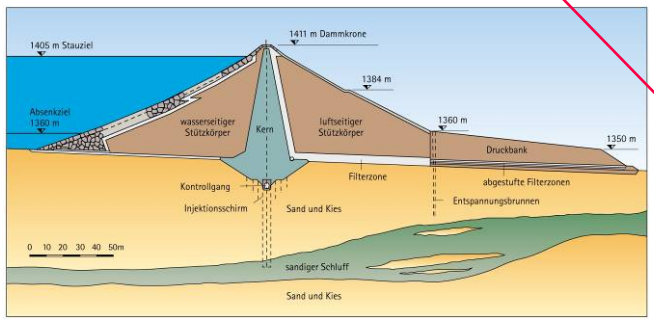


Fault Tree - Durlassboden



Loss of Retaining Capacity

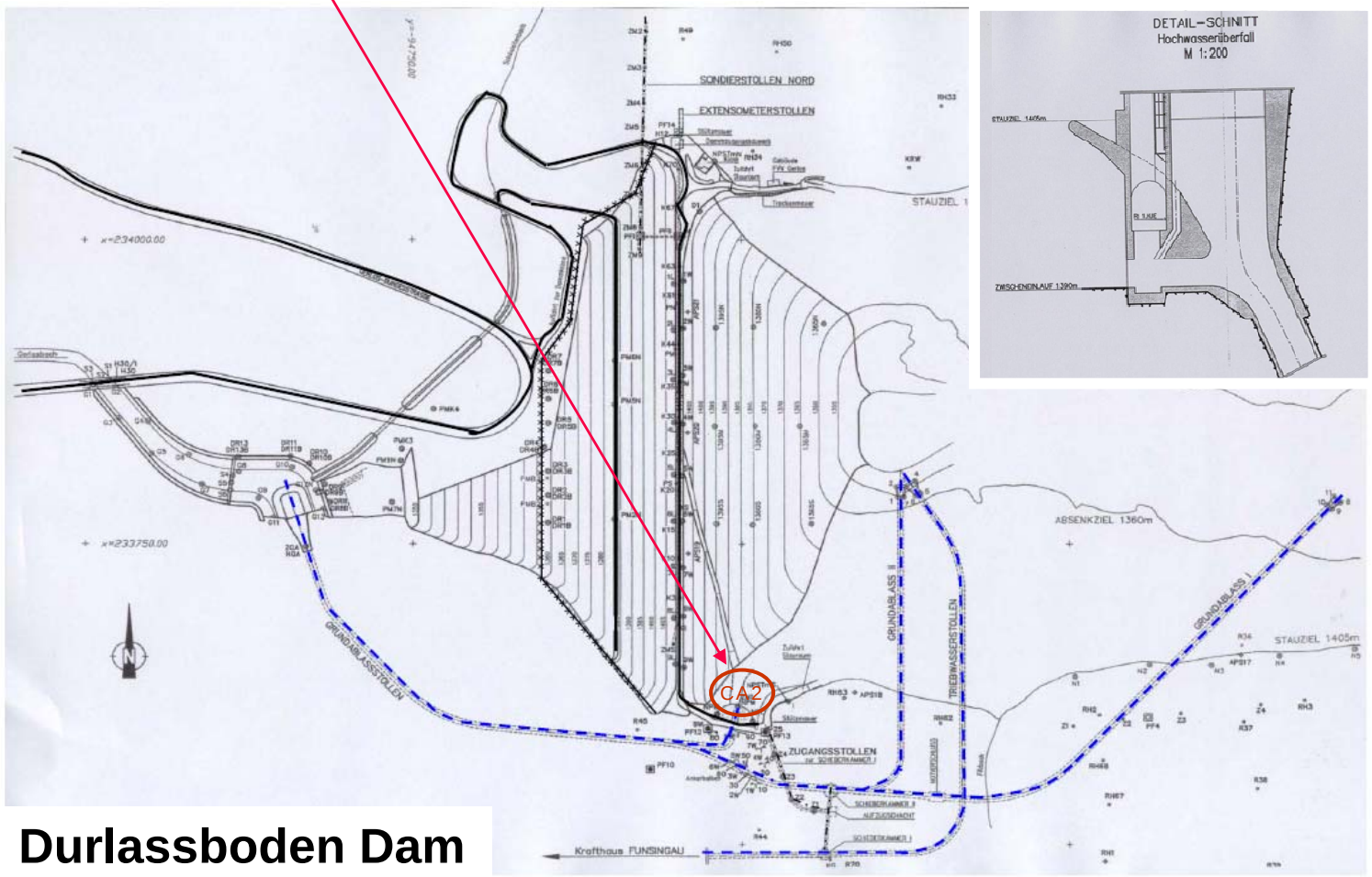
– Dam Body (CA 1)



Durlassboden Dam

Loss of Flood Control and Retaining Capacity

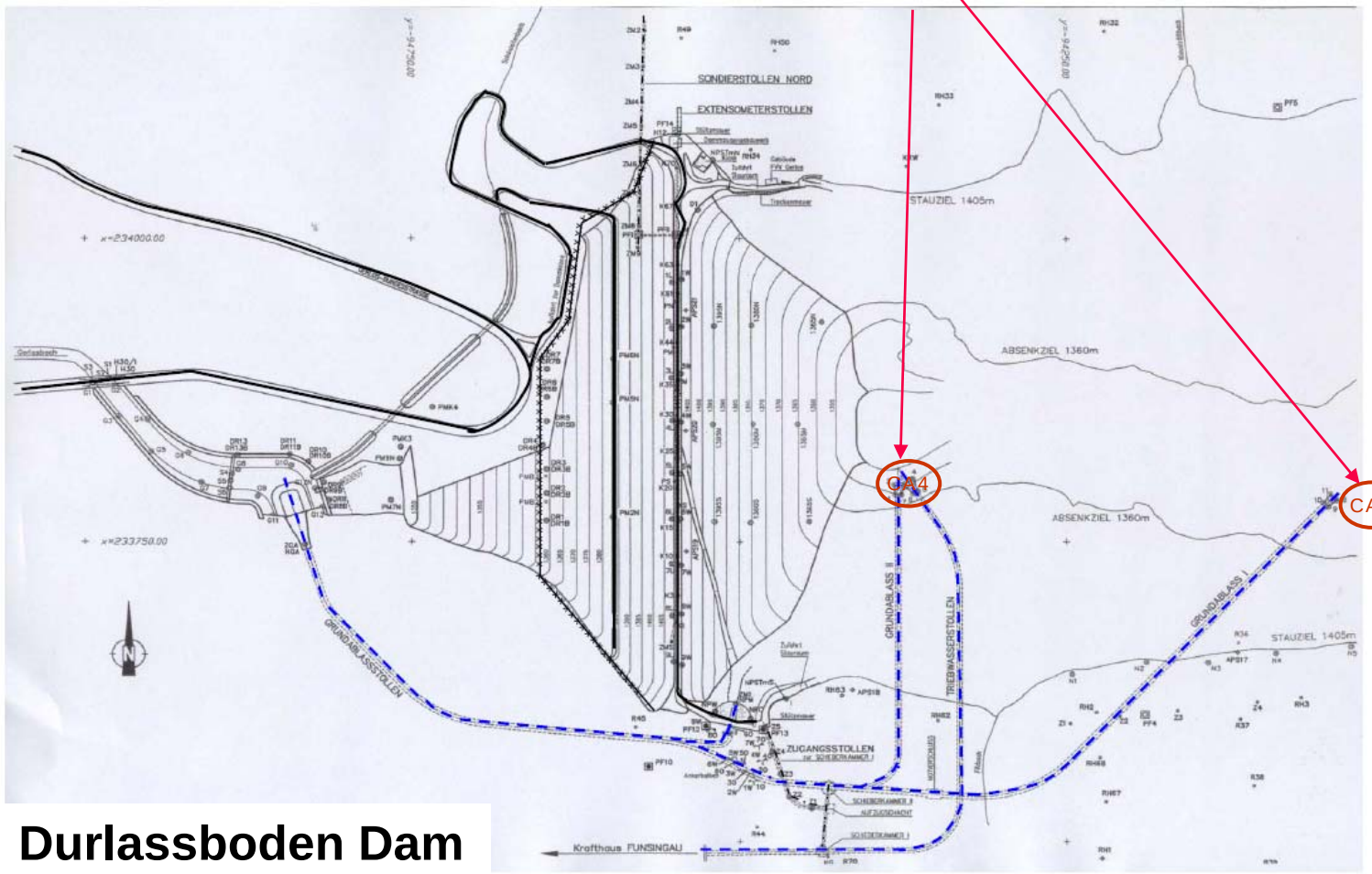
- Dam Body (CA 1)
- Spillway (CA 2)



Durlassboden Dam

Loss of Flood Control and Retaining Capacity

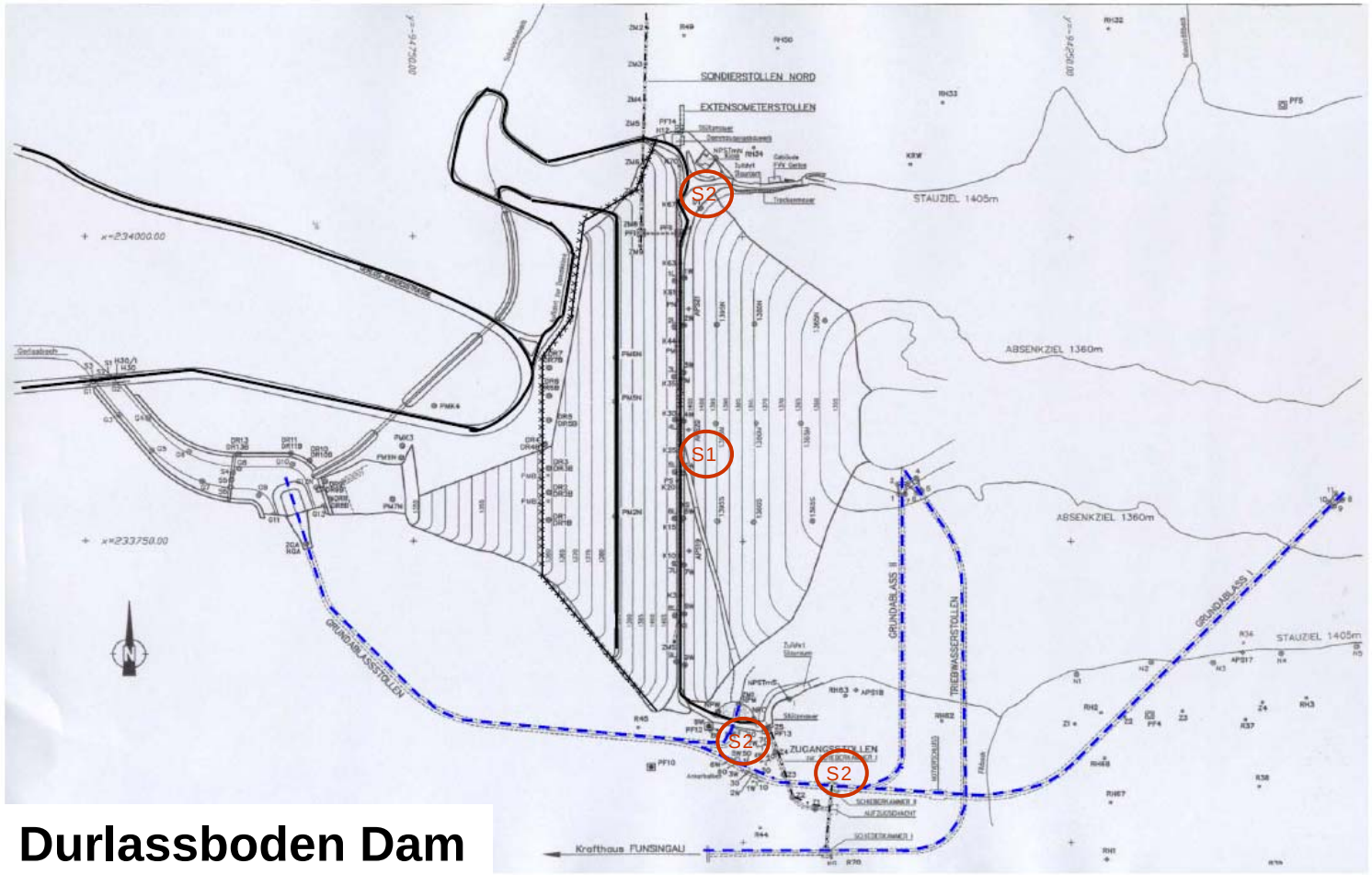
- Dam Body (CA 1)
- Spillway (CA 2)
- Bottom Outlet I (CA 3)
- Bottom Outlet II (CA4)



Durlassboden Dam

Location and description of security systems

- Camera (S 1)
- Door Sensors (S 2)



Durlassboden Dam

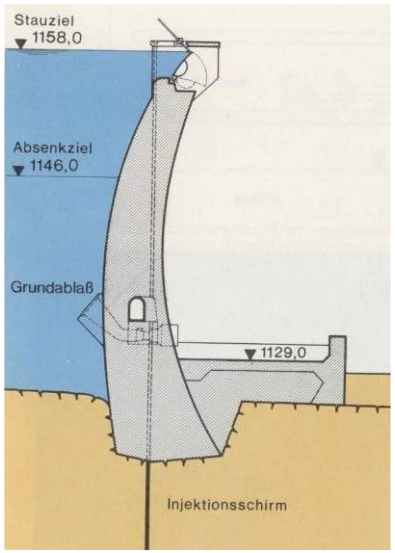
Paal Dam

Dam Data

- Arch Dam
- Mur Valley, Styria
- Built in 1962
- Purpose: Retaining Water, Power Generation
- Height 37,5 m, Crest Length 118 m, Storage 220.000 m³
- Freeboard 1 m

Loss of Retaining Capacity

– Dam Body (CA 1)



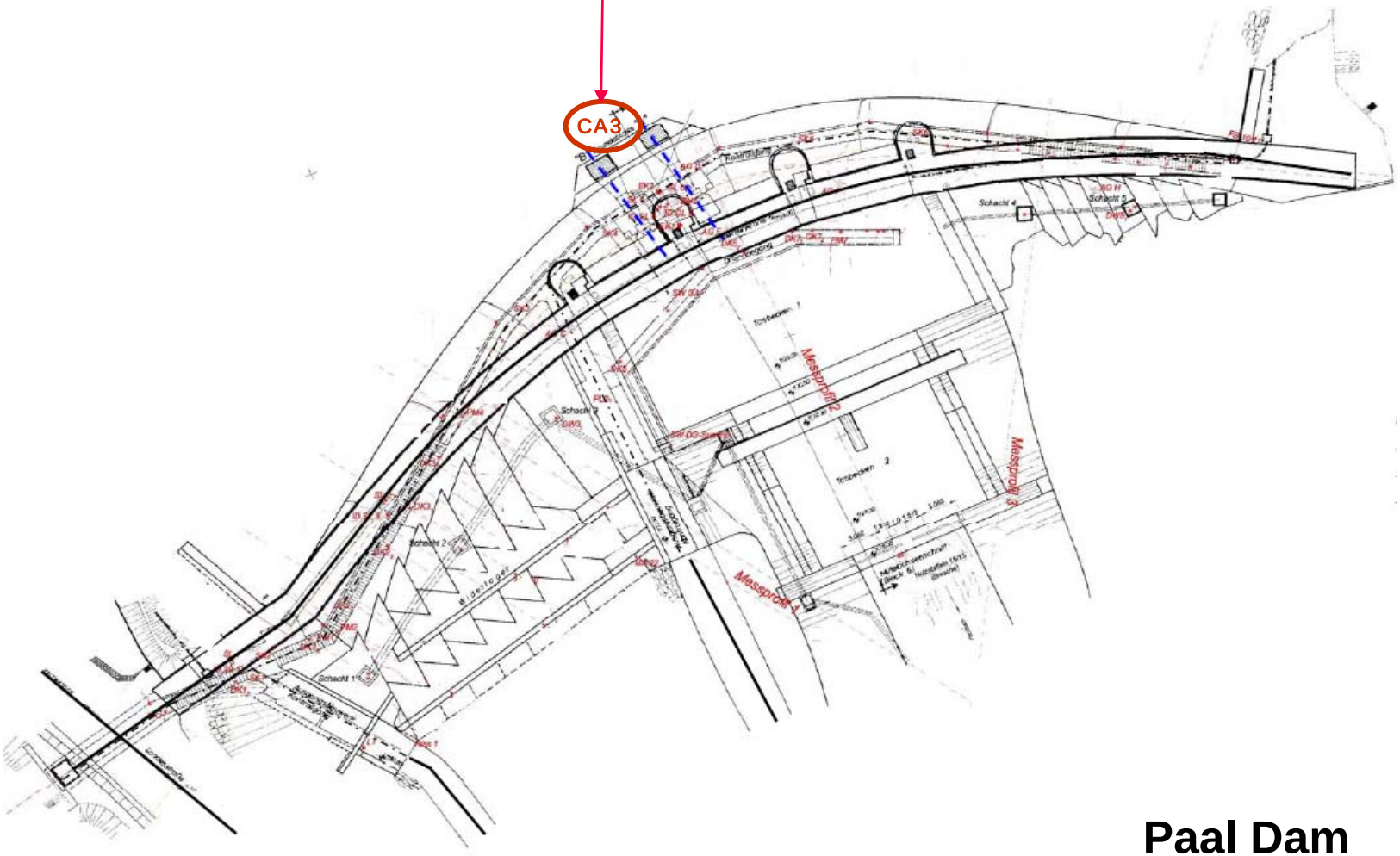
Paal Dam

Loss of Flood Control and Retaining Capacity

- Dam Body (CA 1)
- Spillway (CA 2)

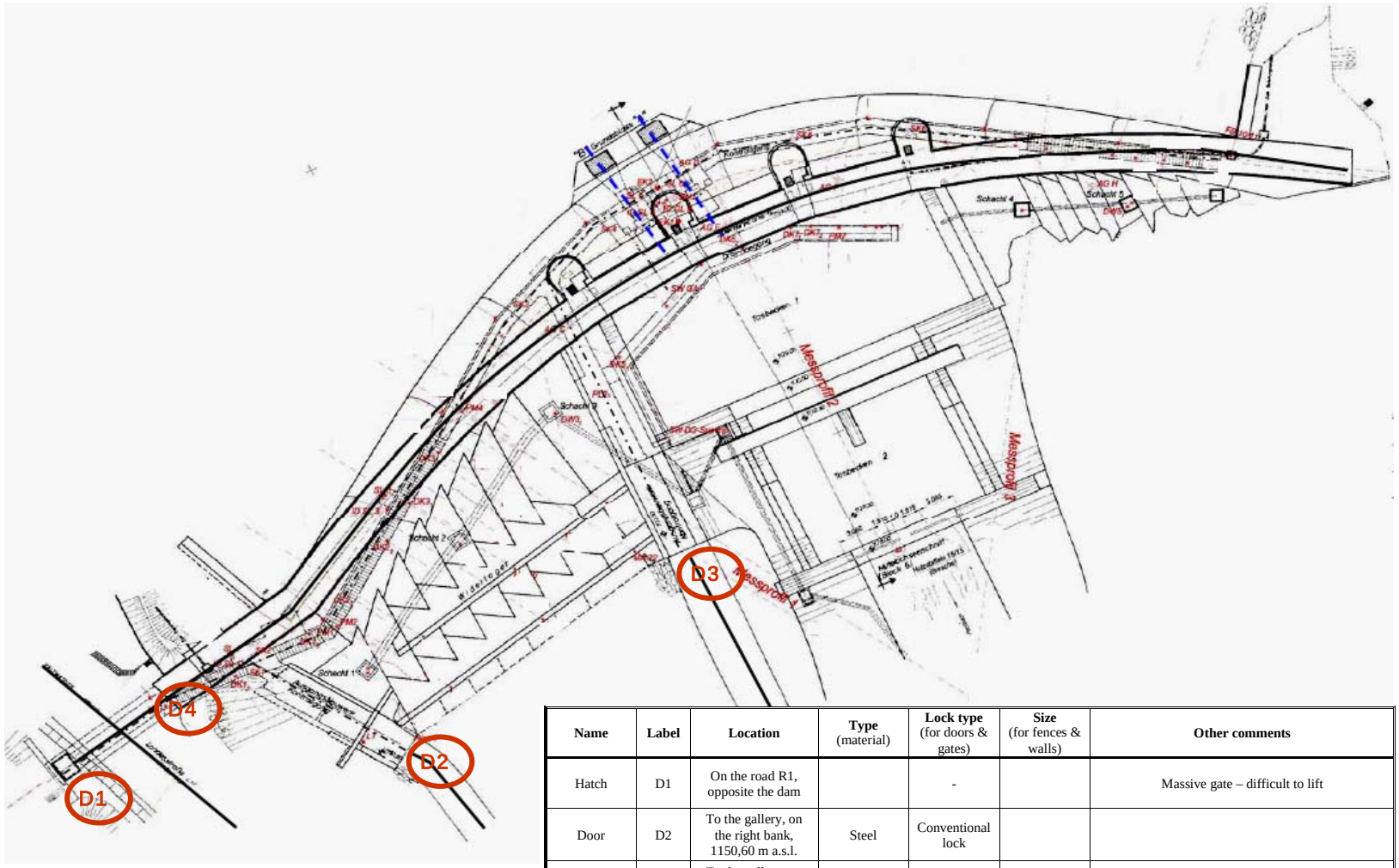
Loss of Flood Control and Retaining Capacity

- Dam Body (CA 1)
- Spillway (CA 2)
- Bottom Outlet (CA 3)
- Power Tunnel (CA 4)



Paal Dam

Location and description of physical barriers



Paal Dam

Name	Label	Location	Type (material)	Lock type (for doors & gates)	Size (for fences & walls)	Other comments
Hatch	D1	On the road R1, opposite the dam		-		Massive gate – difficult to lift
Door	D2	To the gallery, on the right bank, 1150,60 m a.s.l.	Steel	Conventional lock		
Door	D3	To the gallery, on the right bank, 1132,50 m a.s.l.	Steel	Conventional lock		
Gates	D4	On the right bank, access to the crest			Length 2 m	Not across full width, possible to go alongside the gates

Conclusion and Outlook

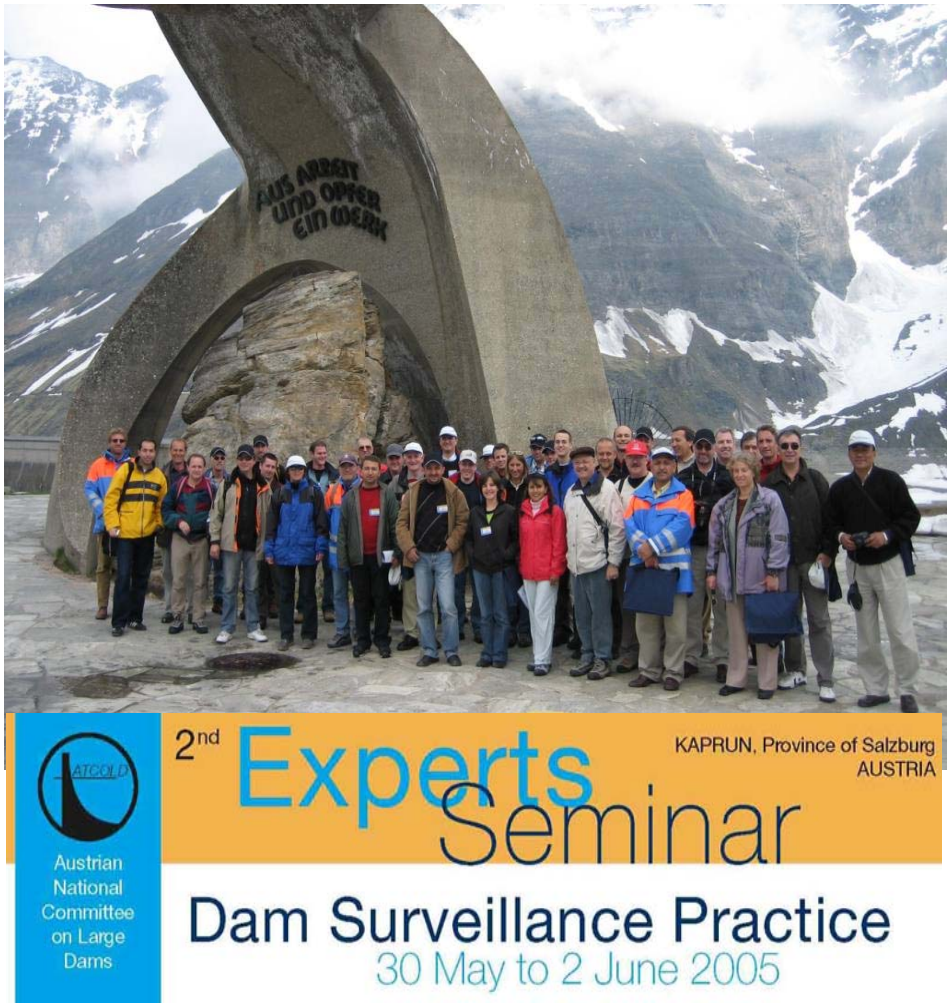
Dams are very well maintained

- Dam book shows continuous records
- Staff is competent and informed

- The equipment is in a proper condition
- Remote sensors are tested and redundant

- Fault Tree describes the entire structure
- Interdependence of different parts

Dam Surveillance Seminar



Link Between Theory and Practice

Dam Safety Monitoring

Education and Practice for emerging countries

Conclusion and Outlook

Take the chance to better understand

-Dam structure

in sense of knowledge transfer

-Systematically and comparable treat maintenance

-Design new HPP schemes

Seminar on ‘Dam Safety’

2009 Graz

2010 Innsbruck