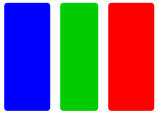
In-situ versus Ex-site Technologies

Sustainable decisions only with an

Integrated Evaluation System

Markus Leuenberger, Switzerland



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water environment waste risk

In-situ versus Ex-site Technologies
SUSTAINABLE DECISIONS - ONLY WITH INTEGRATED EVALUATION!

Full-scale remediation, namely excavation and treatment off-site are not always suitable and reasonable. However, in-situ procedures are often criticized to be less efficient, time consuming and not able to completely solve the problem. Obviously in-situ technologies are underestimated and undervalued. According to our point of view, this wrong basic attitude originates in the fact that most of the time only technical arguments are taken into account in assessments of remediation technologies. If a suitable risk and eco-balance is executed, meaning besides the technical feasibility also the additional ecological consequences and risks as well as the social aspects (politics, acceptance by people) are considered, in many cases the direct comparison will show a different picture. Using an integrated evaluation system, the remediation solution will become an entirety and is assessed on a long-time basis in order to finally achieve a sustainable solution.

A tool for practical use of an integrated evaluation is missing. An easy but comprehensive design would enable a quick analysis and assessment. This instrument should cover the following aspects:

- **Impact of measures** on the environment (nature, mankind, animals)
- **Technical aspects:** Feasibility, restrictions, efficacy (DE, DRE), remediation time, monitoring and maintenance, complexity of the procedure
- **Ecological aspects:** Emissions and risks before and after remediation measures, emissions and risks caused by remediation measures, long-term effect, monitoring requirements, reduction of exposure
- **Economical aspects:** Investment and running costs (situation with or without remediation), insurance costs (e.g. for warranties) and monitoring costs
- **Social and political aspects:** State and company politics, acceptance, image (authorities, residents, media, environmental organizations)

If remediation technologies are assessed with an integrated evaluation tool - meaning beside the technical feasibility also additional risks and emissions as well as potential socio-political aspects are taken into account – it becomes obvious that the in-situ measures have to be considered as equally good as ex-site technologies.

- To see the TRUE value of In-Situ technologies, one has to change it‘s perspective and he has to take into account more criteria. A so called, good solution because of it‘s efficiency to destruct contaminants (ex. Incineration) may be in a first step a better solution than an in-situ remediation... But.... Did we take in consideration ALL the relevant aspects and criteria for the evaluation of a suitable technology...?

- What does it mean, ALL the relevant aspects and criteria ? Normally, the decision process focuses on aspects like „technical feasibility“, „destruction efficiency“, Cost.

- Without taking all the relevant criteria into the evaluation for the selection of a suitable remediation technology, then we risk, that....

THESIS....

...the remediation

may cause

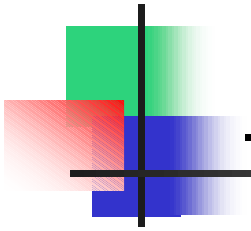
additional

impact and risks

to environment and to men !

...personal background

- I am working now for about 15 years in the environmental engineering and protection area and i touched in this time several bigger problems, especially with industrial waste. In Switzerland, I worked on the 2 industrial landfills, which are both today remediation cases. Very early in this job, I asekd myself, what the best remediation solution could be. A question, for which it was not easy to find an answer.... We found many good solutions, but was it the best one...?
- The starting point of all the discussions about the best remediation solution was the risk assessment. So I designed a special riskmatrix for landfills and contaminated area's.... To show the problem of the site and to show the solution...
- Let me introduce you to this risk-management tool....



.... risk m a trix

RISK MATRIX: **Range of impact and probability**

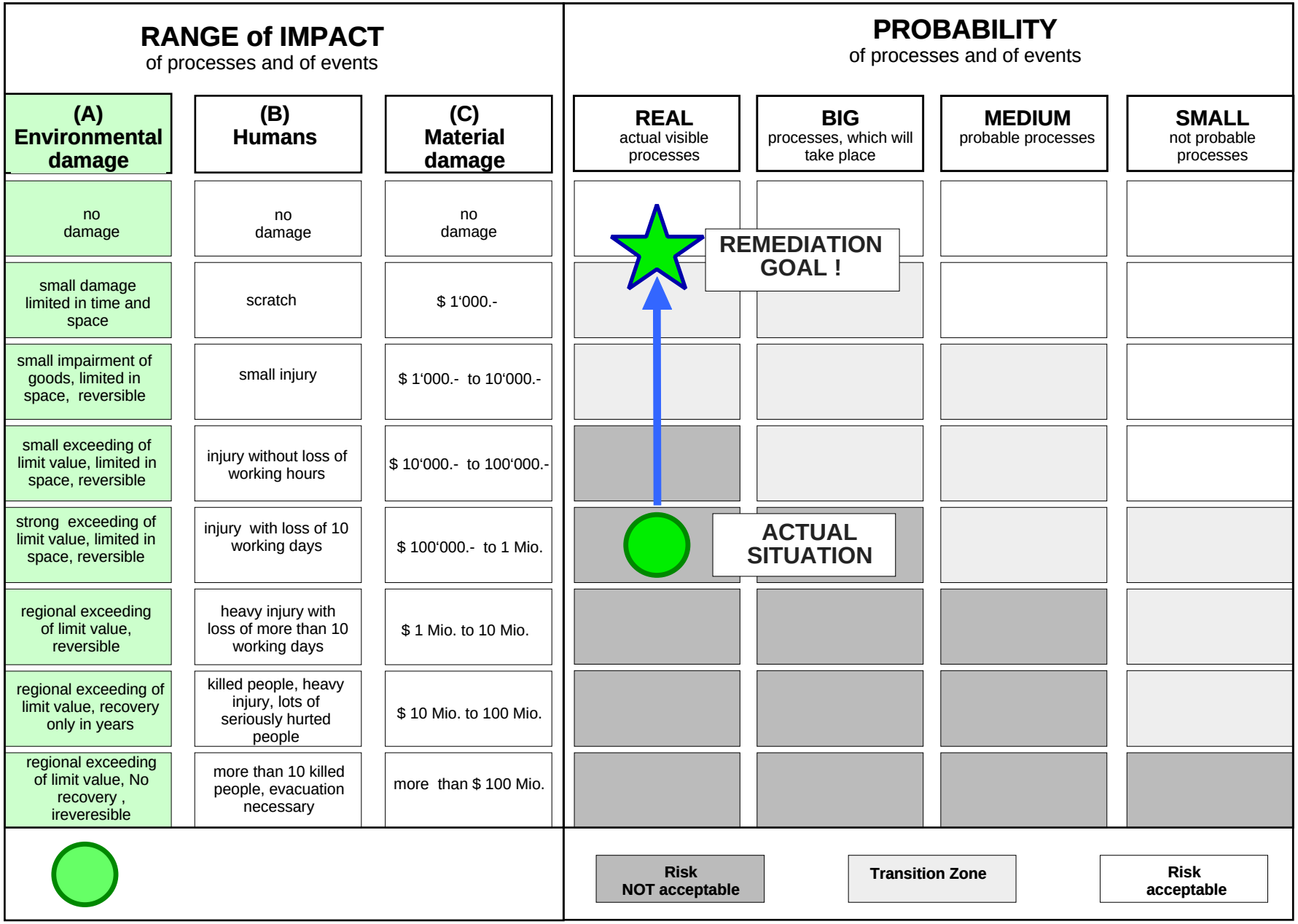
RANGE of IMPACT of processes and of events			**PROBABILITY** of processes and of events			
(A) Environmental damage	**(B) Humans**	**(C) Material damage**	**REAL** actual visible processes	**BIG** processes, which will take place	**MEDIUM** probable processes	**SMALL** not probable processes
no damage	no damage	no damage				
small damage limited in time and space	scratch	$ 1‘000.-				
small impairment of goods, limited in space, reversible	small injury	$ 1‘000.- to 10‘000.-				
small exceeding of limit value, limited in space, reversible	injury without loss of working hours	$ 10‘000.- to 100‘000.-				
strong exceeding of limit value, limited in space, reversible	injury with loss of 10 working days	$ 100‘000.- to 1 Mio.				
regional exceeding of limit value, reversible	heavy injury with loss of more than 10 working days	$ 1 Mio. to 10 Mio.				
regional exceeding of limit value, recovery only in years	killed people, heavy injury, lots of seriously hurted people	$ 10 Mio. to 100 Mio.				
regional exceeding of limit value, No recovery, ireveresible	more than 10 killed people, evacuation necessary	more than $ 100 Mio.				

RISK MATRIX: **Area of acceptability of the risk**

RANGE of IMPACT of processes and of events			**PROBABILITY** of processes and of events			
(A) Environmental damage	**(B) Humans**	**(C) Material damage**	**REAL** actual visible processes	**BIG** processes, which will take place	**MEDIUM** probable processes	**SMALL** not probable processes
no damage	no damage	no damage				
small damage limited in time and space	scratch	$ 1‘000.-				
small impairment of goods, limited in space, reversible	small injury	$ 1‘000.- to 10‘000.-				
small exceeding of limit value, limited in space, reversible	injury without loss of working hours	$ 10‘000.- to 100‘000.-				
strong exceeding of limit value, limited in space, reversible	injury with loss of 10 working days	$ 100‘000.- to 1 Mio.				
regional exceeding of limit value, reversible	heavy injury with loss of more than 10 working days	$ 1 Mio. to 10 Mio.				
regional exceeding of limit value, recovery only in years	killed people, heavy injury, lots of seriously hurted people	$ 10 Mio. to 100 Mio.				
regional exceeding of limit value, No recovery , ireveresible	more than 10 killed people, evacuation necessary	more than $ 100 Mio.				

Risk NOT acceptable | **Transition Zone** | **Risk acceptable**

RISK MATRIX: **Actual Contamination Situation and Remediation Goal**



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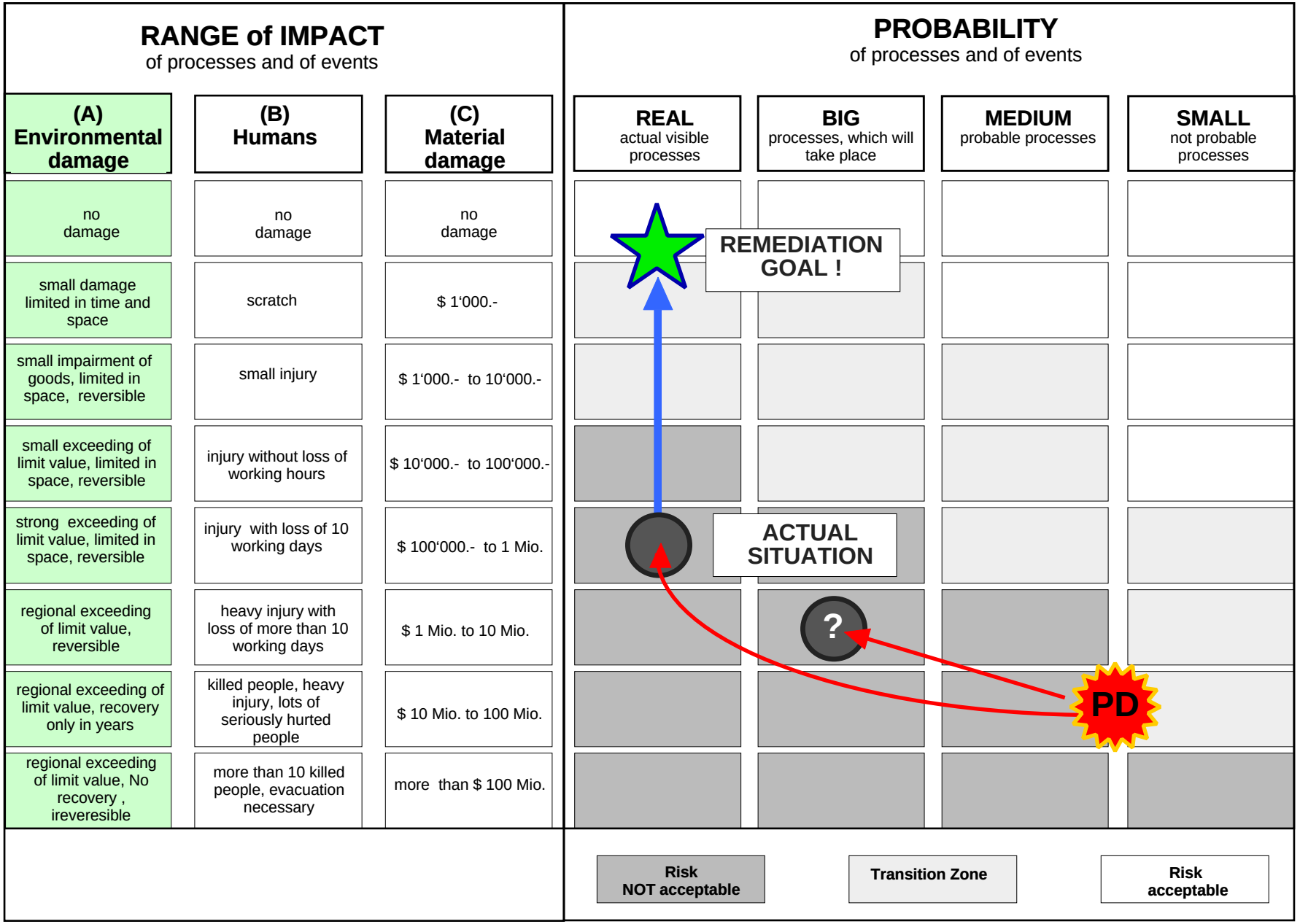
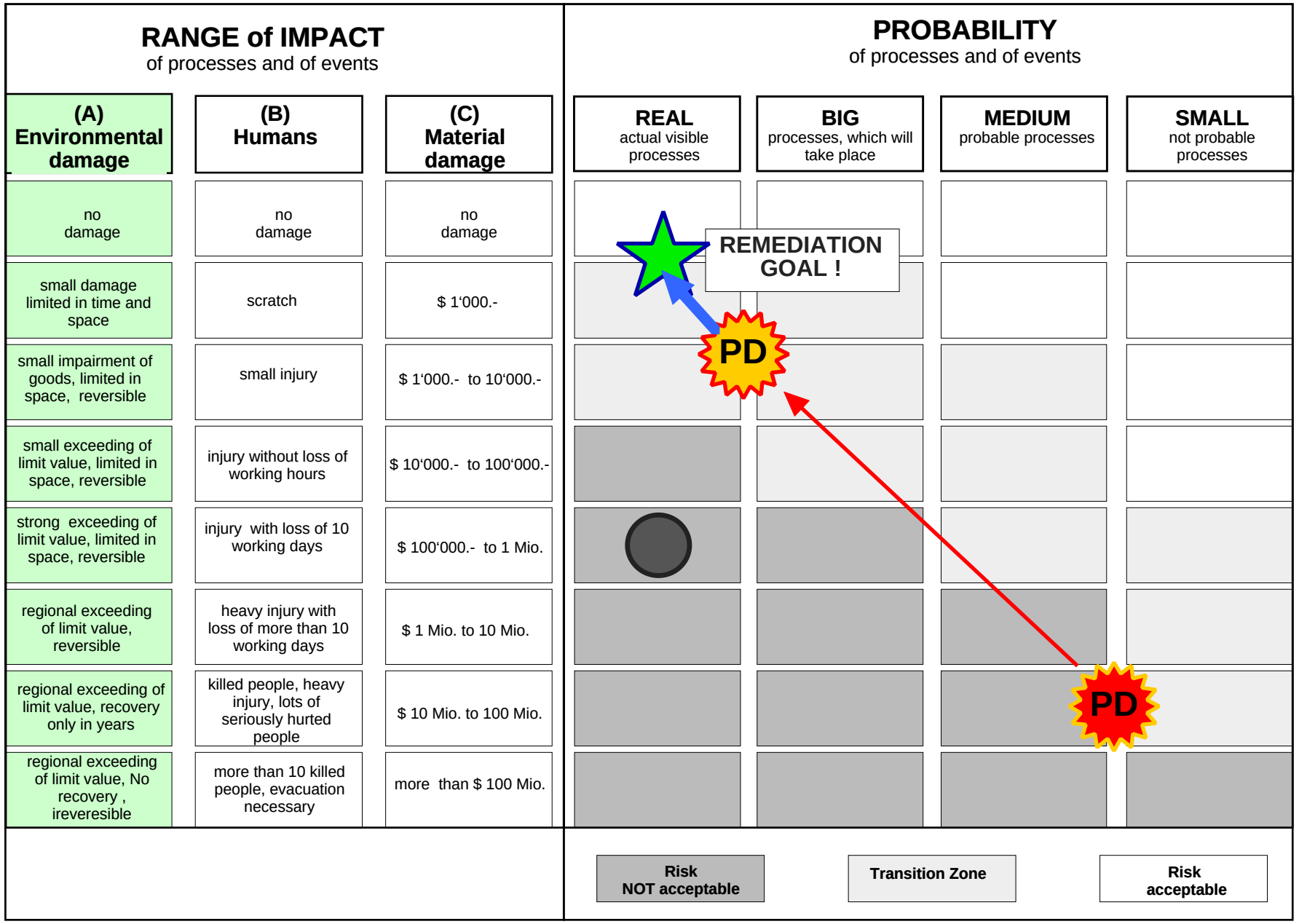
RISK MATRIX: **Potential of Danger**



RISK MATRIX: **Remediation by Reduction of the Potential of Danger**



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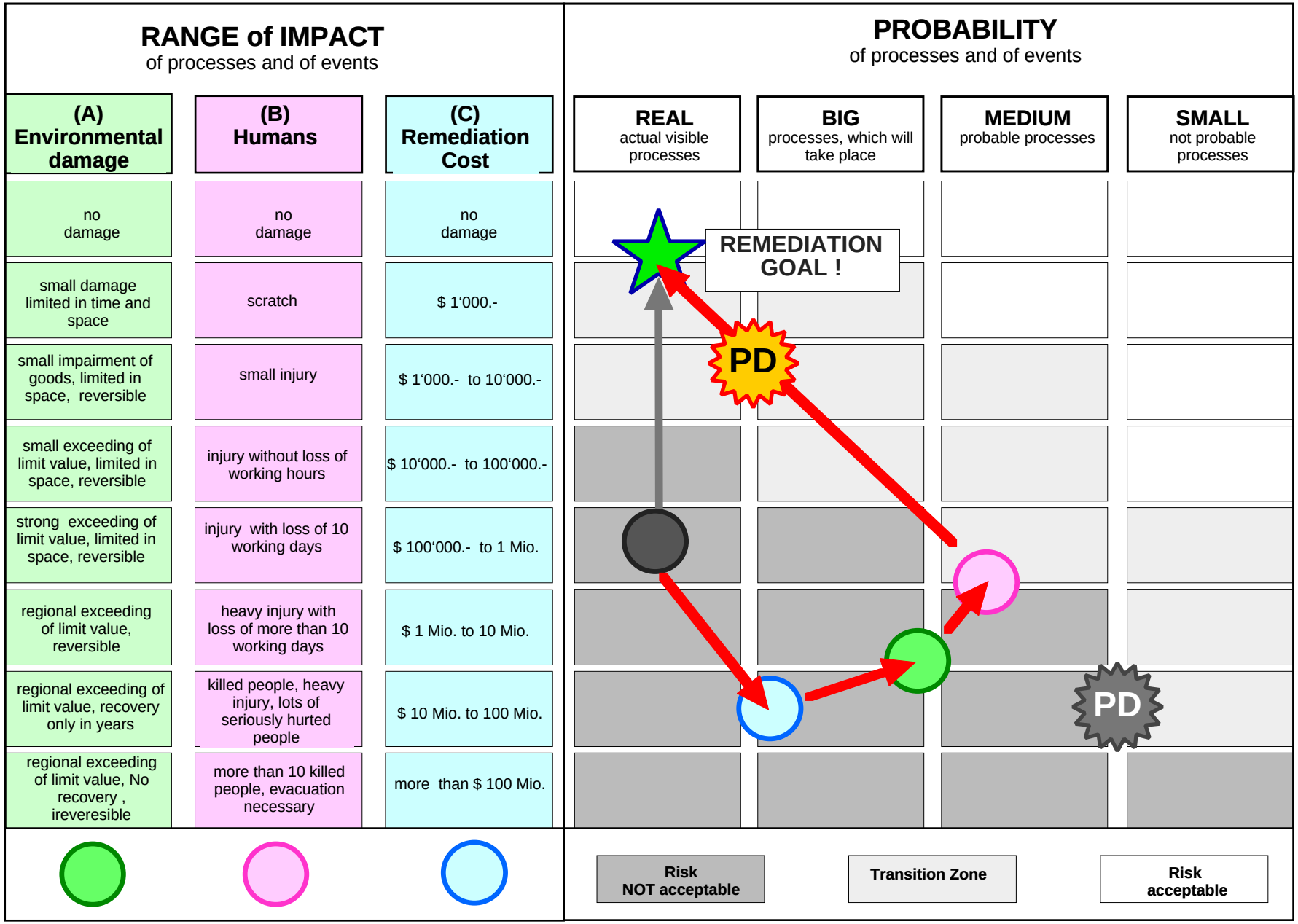
RISK MATRIX: **Additional Risk due to the Remediation**



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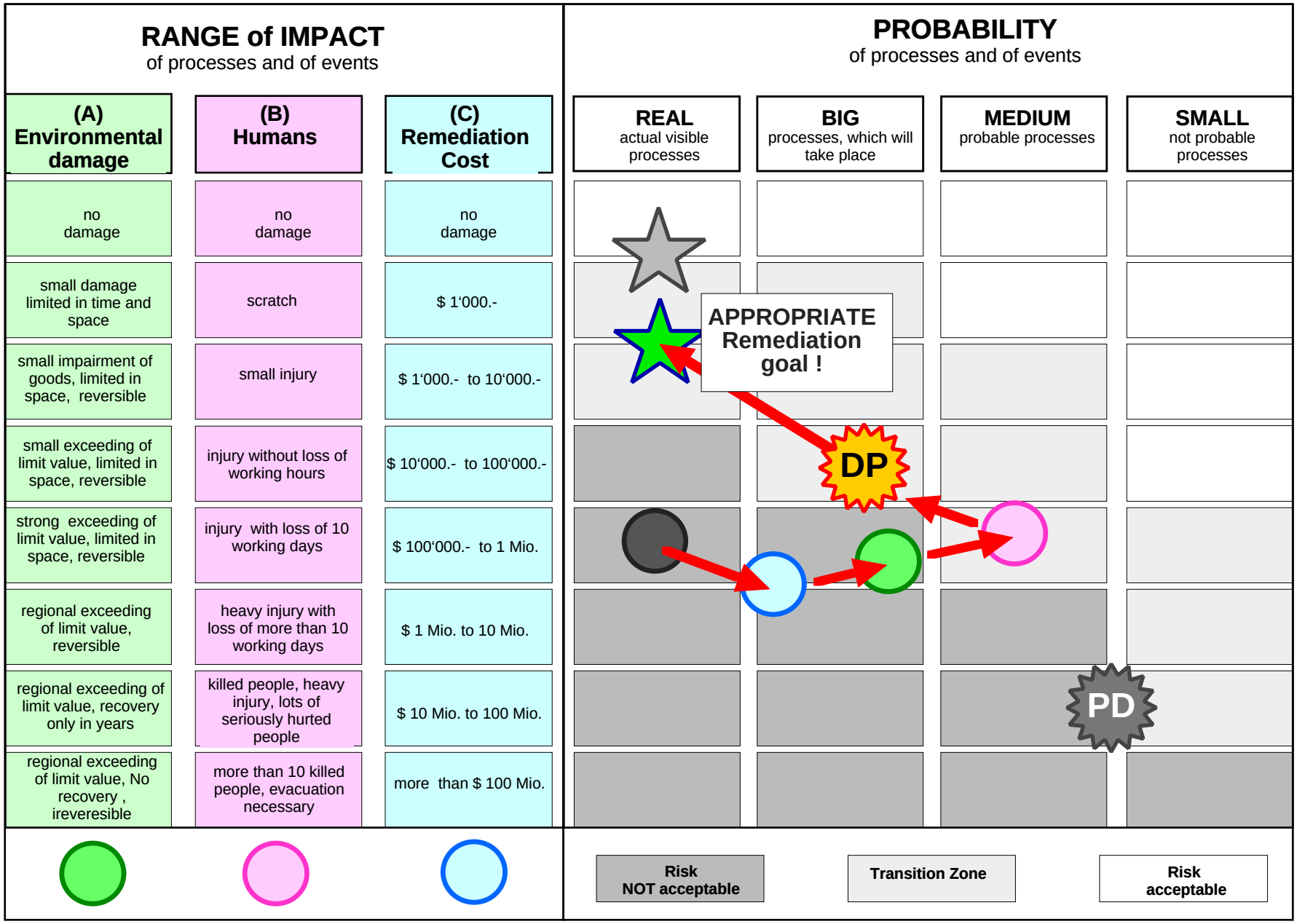
RISK MATRIX: **Appropriate Remediation Goal; Lower Impact due to R.**



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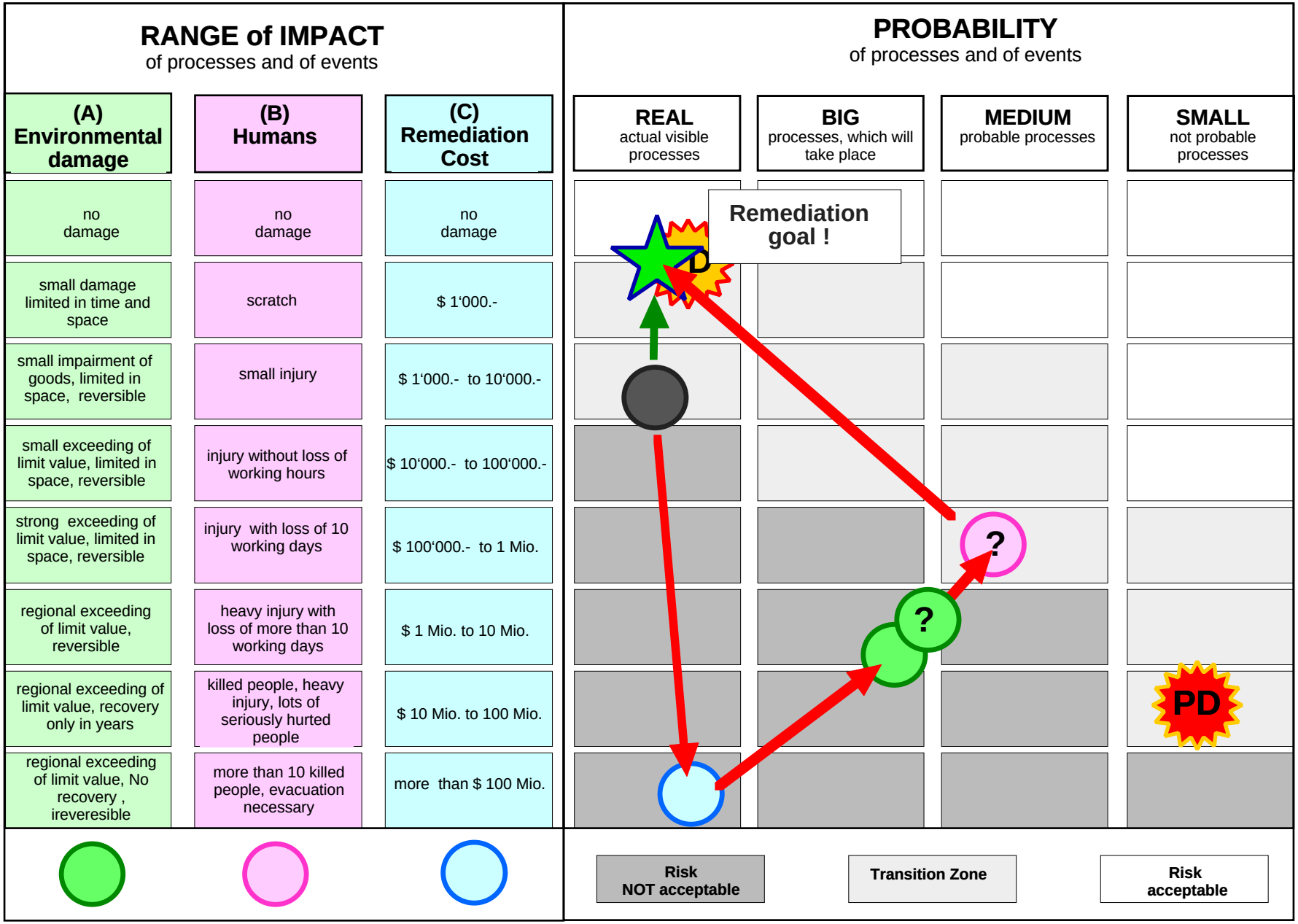
RISK MATRIX: **Case Study; Industrial Landfill of Bonfol, Switzerland**



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LOOKING FOR THE BEST SOLUTION

Best solution in terms of...

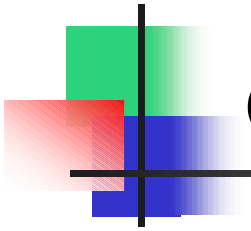
... technical feasibilty

... ecological benefit

... optimized cost

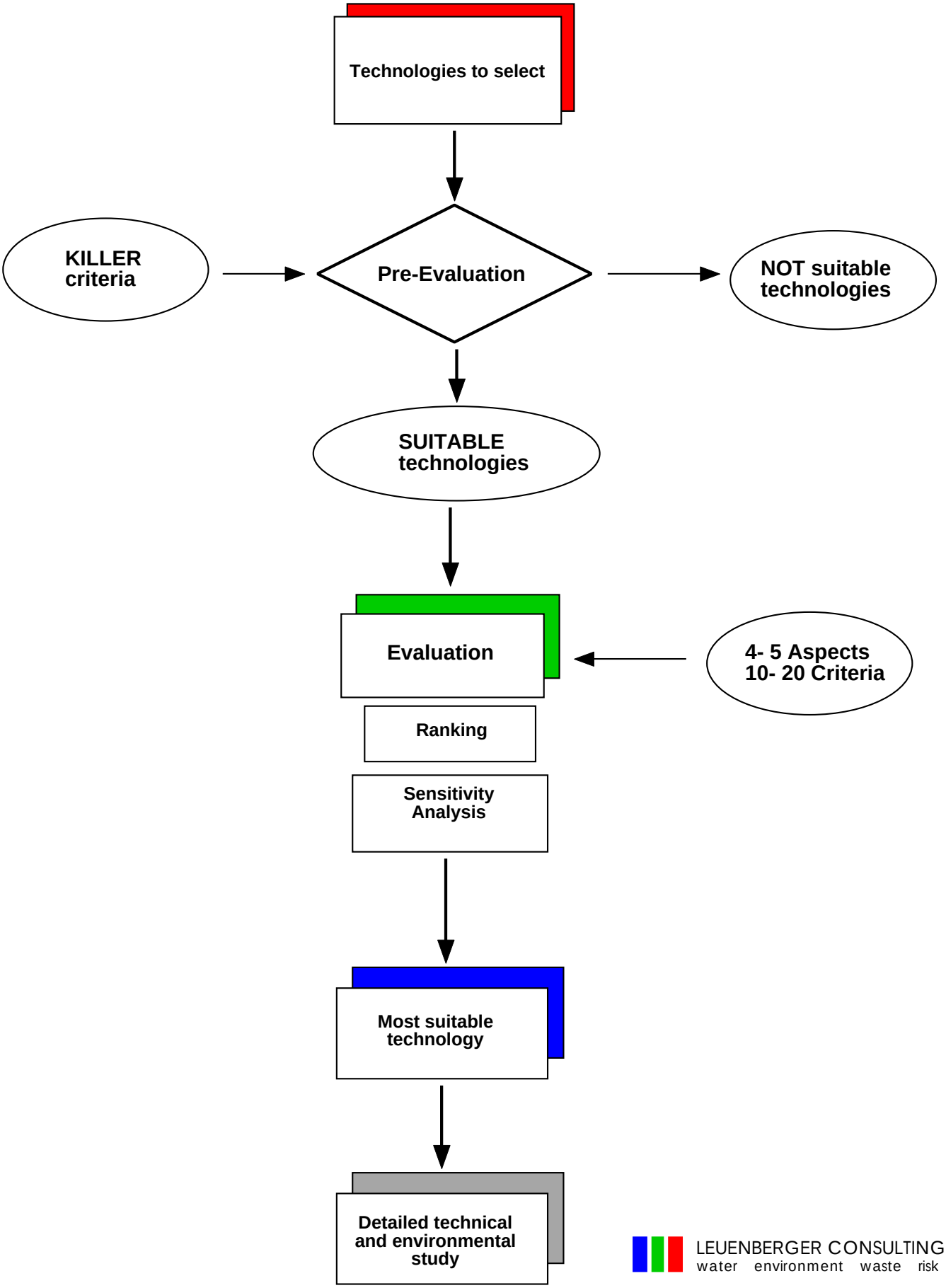
... socio-political aspects

å **I**ntegrated **E**valuation **S**ystem (I-E-S)



GRAFIK I-E-S

EVALUATION PROCESS



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CRITERIA FOR **I-E-S**

TECHNICAL ASPECTS

- feasibility
- restrictions
- efficiency (DE, DRE)
- remediation time
- maintenance
- complexity of the process

ECOLOGICAL ASPECTS

- emissions and risks before and after remediation
- emissions and risks caused by the remediation
- long-term effect
- need of ressources (energy, water, agents)
- reduction of exposure

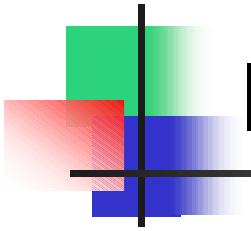
CRITERIA FOR **I-E-S**

ECONOMICAL ASPECTS

- investment
- running cost
- insurance (warranty)
- monitoring
- special safety at work

SOCIO-POLITICAL ASPECTS

- state and company politics
- acceptance (authorities, residents, media, organizations)
- image



I-E-S as a tool

ECOLOGICAL ASPECTS — 700 points

(6) EMISSIONS *DURING* THE TREATMENT

high emissions	10
medium emissions	50
low emissions	100

(7) EMISSIONS *AFTER* THE TREATMENT

high emissions	10
medium emissions	50
low emissions	100

(8) RISKS FOR THE ENVIRONMENT

high risk	10
medium risk	50
low risk	100

(9) RISKS FOR HUMANS

high risk	10
medium risk	50
low risk	100

(10) REQUIREMENT OF RESOURCES

high consumption	10
medium consumption	50
low consumption	100

(11) PRODUCED WASTES AND SUPERVISION

needs complexe furhter treatment or long term supervision	10
needs only simple further treatment or simple supervision	40
needs no further treatment and no supervison	70
commercial exploitation of the produced waste is possible	100

(12) LONG TERM EFFECTIVENESS

effectiveness < 5 years	10
effectiveness 10 to 20 years	50
effectiveness > 20 years	100

ECONOMICAL ASPECTS — 100 points

(13) OVERALL COST

very high (> 200 US$/t)	10
high (100-200 US$/t)	40
medium (20-100 US$/t)	70
low (< 20 US$/t)	100

ACCEPTABILITY — 200 points

(14) REGULATORY ACCEPTABILITY

controvesial acceptance	10
medium opposition	50
no fundamental opposition	100

(15) COMMUNITY ACCEPTABILITY

controvesial acceptance	10
medium opposition	50
no fundamental opposition	100

Technology (A)

			Assessment	Justification
TECHNICAL ASPECTS		**500** points	**410**	
(1)	**FEASIBILITY / COMMERCIAL AVAILABILITY**			
	Conceptual-scale	20		
	Laboratory-scale	40		
	Demonstration-scale	60		
	On-going industrial scale	80		
	Completed Remediation Project	100	**100**	
(2)	**TECHNICAL LIMITATIONS**			
	important	10		
	medium	50		
	not important	100	**100**	
(3)	**DESTRUCTION EFFICIENCY (DE)**			
	poor DE	10	**10**	
	good DE	50		
	very good DE	100		
(4)	**ESTIMATED TIME TO COMPLETE THE TREATMENT**			
	long (>20 years)	10		
	medium (<10 years)	50		
	short (<5 years)	100	**100**	
(5)	**MAINTAINABILITY / COMPLEXITY OF THE PROCESS**			
	complexe system, high maintenance	10		
	average complexe system	50		
	Simple system, low maintenance	100	**100**	
ECOLOGICAL ASPECTS		**700** points	**590**	
(6)	**EMISSIONS *DURING* THE TREATMENT**			
	high emissions	10		
	medium emissions	50		
	low emissions	100	**100**	
(7)	**EMISSIONS *AFTER* THE TREATMENT**			
	high emissions	10		
	medium emissions	50		
	low emissions	100	**100**	
(8)	**RISKS FOR THE ENVIRONMENT**			
	high risk	10		
	medium risk	50		
	low risk	100	**100**	
(9)	**RISKS FOR HUMANS**			
	high risk	10		
	medium risk	50		
	low risk	100	**100**	
(10)	**REQUIREMENT OF RESOURCES**			
	high consumption	10		
	medium consumption	50	**50**	
	low consumption	100		
(11)	**PRODUCED WASTES AND SUPERVISION**			
	needs complexe furhter treatment or long term supervision	10		
	needs only simple further treatment or simple supervision	40	**40**	
	needs no further treatment and no supervison	70		
	commercial exploitation of the produced waste is possible	100		
(12)	**LONG TERM EFFECTIVENESS**			
	effectiveness < 5 years	10		
	effectiveness 10 to 20 years	50		
	effectiveness > 20 years	100	**100**	
ECONOMICAL ASPECTS		**100** points	**100**	
(13)	**OVERALL COST**			
	very high (> 200 US$/t)	10		
	high (100-200 US$/t)	40		
	medium (20-100 US$/t)	70		
	low (< 20 US$/t)	100	**100**	
ACCEPTABILITY		**200** points	**150**	
(14)	**REGULATORY ACCEPTABILITY**			
	controvesial acceptance	10		
	medium opposition	50		
	no fundamental opposition	100	**100**	
(15)	**COMMUNITY ACCEPTABILITY**			
	controvesial acceptance	10		
	medium opposition	50	**50**	
	no fundamental opposition	100		
Maximum points possible		**1500**	**1250**	
Percentage of the maximum		**100%**	**83%**	

Technology (A)

			Technology (A)	Technology (B)	Technology (C)	Technology (D)
TECHNICAL ASPECTS		**500** points	**400**	**430**	**240**	**120**
(1)	**FEASIBILITY / COMMERCIAL AVAILABILITY**					
	Conceptual-scale	20				20
	Laboratory-scale	40				
	Demonstration-scale	60				
	On-going industrial scale	80		80	80	
	Completed Remediation Project	100	100			
(2)	**TECHNICAL LIMITATIONS**					
	important	10				10
	medium	50			50	
	not important	100	100	100		
(3)	**DESTRUCTION EFFICIENCY (DE)**					
	poor DE	10				
	good DE	50	50		50	50
	very good DE	100		100		
(4)	**ESTIMATED TIME TO COMPLETE THE TREATMENT**					
	long (>20 years)	10				
	medium (<10 years)	50		50	50	50
	short (<5 years)	100	100			
(5)	**MAINTAINABILITY / COMPLEXITY OF THE PROCESS**					
	complexe system, high maintenance	10			10	10
	average complexe system	50	50			
	Simple system, low maintenance	100		100		
ECOLOGICAL ASPECTS		**700** points	**620**	**450**	**300**	**270**
(6)	**EMISSIONS *DURING* THE TREATMENT**					
	high emissions	10				
	medium emissions	50		50	50	50
	low emissions	100	100			
(7)	**EMISSIONS *AFTER* THE TREATMENT**					
	high emissions	10				
	medium emissions	50			50	50
	low emissions	100	100	100		
(8)	**RISKS FOR THE ENVIRONMENT**					
	high risk	10				
	medium risk	50			50	50
	low risk	100	100	100		
(9)	**RISKS FOR HUMANS**					
	high risk	10		10		
	medium risk	50			50	50
	low risk	100	100			
(10)	**REQUIREMENT OF RESOURCES**					
	high consumption	10			10	10
	medium consumption	50	50	50		
	low consumption	100				
(11)	**PRODUCED WASTES AND SUPERVISION**					
	needs complexe furhter treatment or long term supervision	10				10
	needs only simple further treatment or simple supervision	40		40	40	
	needs no further treatment and no supervison	70	70			
	commercial exploitation of the produced waste is possible	100				
(12)	**LONG TERM EFFECTIVENESS**					
	effectiveness < 5 years	10				
	effectiveness 10 to 20 years	50			50	50
	effectiveness > 20 years	100	100	100		
ECONOMICAL ASPECTS		**100** points	**100**	**10**	**10**	**10**
(13)	**OVERALL COST**					
	very high (> 200 US$/t)	10		10	10	10
	high (100-200 US$/t)	40				
	medium (20-100 US$/t)	70				
	low (< 20 US$/t)	100	100			
ACCEPTABILITY		**200** points	**200**	**100**	**100**	**100**
(14)	**REGULATORY ACCEPTABILITY**					
	controvesial acceptance	10				
	medium opposition	50		50	50	50
	no fundamental opposition	100	100			
(15)	**COMMUNITY ACCEPTABILITY**					
	controvesial acceptance	10				
	medium opposition	50		50	50	50
	no fundamental opposition	100	100			
	Maximum points possible	**1500**	**1320**	**990**	**650**	**500**
	Percentage of the maximum	**100%**	**88%**	**66%**	**43%**	**33%**
			1	**2**	**3**	**4**

			Technical Aspects	Ecological aspects	Economical Aspects	Acceptability
Ranking		***Weighting***	***30%***	***50%***	***5%***	***15%***
1	**A**	**Technology**	400	430	240	120
2	**B**	**Technology**	620	450	300	270
3	**C**	**Technology**	100	10	10	10
4	**D**	**Technology**	200	100	100	100

Case-study - SMDB

- landfill for industrial waste
- volume 115‘000 t
- disposal from 1961 to 1976
- closed in 1976
- very good hydrogeo-logical situation
- low contamination in groundwater
- convention between industry and government
- decision for a total remediation due to the convention
- estimated cost 130 Mio US$
- Project with many different parties (Industry, government, EPA, engineers, environ-organizations)

Case-study - EVALUATION

4 ASPECTS

- **Technical feasibility**
- **Socio-political acceptance**
- **Total cost**
- **Environmental compatibility**

- **Pre-evaluation**
  of 20 technologies
- **Evaluation**
  of 8 technologies (for waste and under-ground material)

Case-study - TECHNOLOGIES

- Off-site incineration
- On-site incineration (new incinerator)
- In-situ vitrification
- On-site vitrification

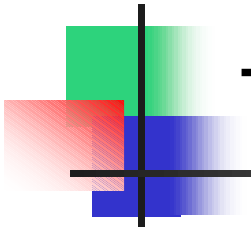


Tabelle SMDB Evaluation

Industrial Landfill of Bonfol

Evaluation

	Off-site Incinceration		On-site Incineration		In-Situ Vitrification	On-Site Vitrification	
	A,C,D	B	A,C	B,D		A,C	B,D
Technical feasibility							
Efficiency	+++	+++	+++	+++	+++	+++	+++
Well-known techn.	+++	+++	+++	+++	++		++
Needed infrastructure	++	+	-	-	+++	++	+
Needed time for clean-up	++	++	-	-	+++	++	++
Risk of accidents	-	-	+	+	+++	++	++
Control of succes	+++	+++	+++	+++	+	+++	+++
Need of planing time	+	+	-	-	+++	++	++
Dependences	+	+	-	-	+	+	+
Socio-political Acceptance							
Law conformity	+++	+++	+++	+++	+++	+++	+++
Ability of authorization	++	+	-	-	+++	+	+
Impact on local conditions	+	+	-	-	+++	++	++
Public acceptance	+	+	-	-	++	+	+
Total Cost	+	+	-	-	++	+	+
Environmental Compatibility							
Local and regional impact	+	+	-	-	+++	++	++
External cost (CO2)	++	++	-	-	++	+	+
Emission	-	-	+	+	+++	+	+
After care	+++	+++	+++	+++	+	+++	+++

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CONCLUSION

I-E-S is ...

... a simple and fast to use tool

... able to compare soft and hard criteria

... transparent and open for any discussion

... NOT an expert-tool

... NOT complicated

Benefit of I-E-S...

... early selection of suitable technologies is possible

... power and weakness of all the compared technologies is easy to see

... sensibility of ranking gives additional input

... Needs, after selection of 1-3 technologies, more detailed studies

CONCLUSION

- Using an **I-E-S** the remediation solution will become an entirety and is assessed on a long-time basis in order to finally achieve a **sustainable** and **appropriate solution**.
- Taking into consideration **all** the **relevant criteria**, it becomes obvious, that the in-situ technologies have to be considered in many cases **as equally good or better** as ex-site technologies.

Markus Leuenberger
LEUENBERGER CONSULTING, Switzerland

Markus Leuenberger is a Geologist, Hydrogeologist and Geophysician. Graduated in Hydrology and Hydrogeology at the Centre d´Hydrogéologie de Neuchâtel and EPFL, Switzerland, and assistant at the Institute of Mineralogy of the University of Fribourg. From 1989 to 1995 was project manager at CSD Colombi Schmutz Dorthe AG, leading different landfill-projects concerning the supervision of the contamination situation. From 1995 to 2000 was project manager at Rytec Ltd., with expertises in risk-assessment for landfills, landfill technology in entirety, sanitation of contaminated areas, total waste management concepts, environmental compatibility reports, material balances, security at work, protection of health, evaluation and assessment of remediation technologies and member of different federal working groups. Vice-president, Partner and Project Manager of Rytec Partner Ltd. from 2001 to 2002, is now an independent consultant at Leuenberger Consulting.

E-mail: leuenberger@rytec.com