DESTRESS

Demonstration of soft stimulation treatments of geothermal reservoirs

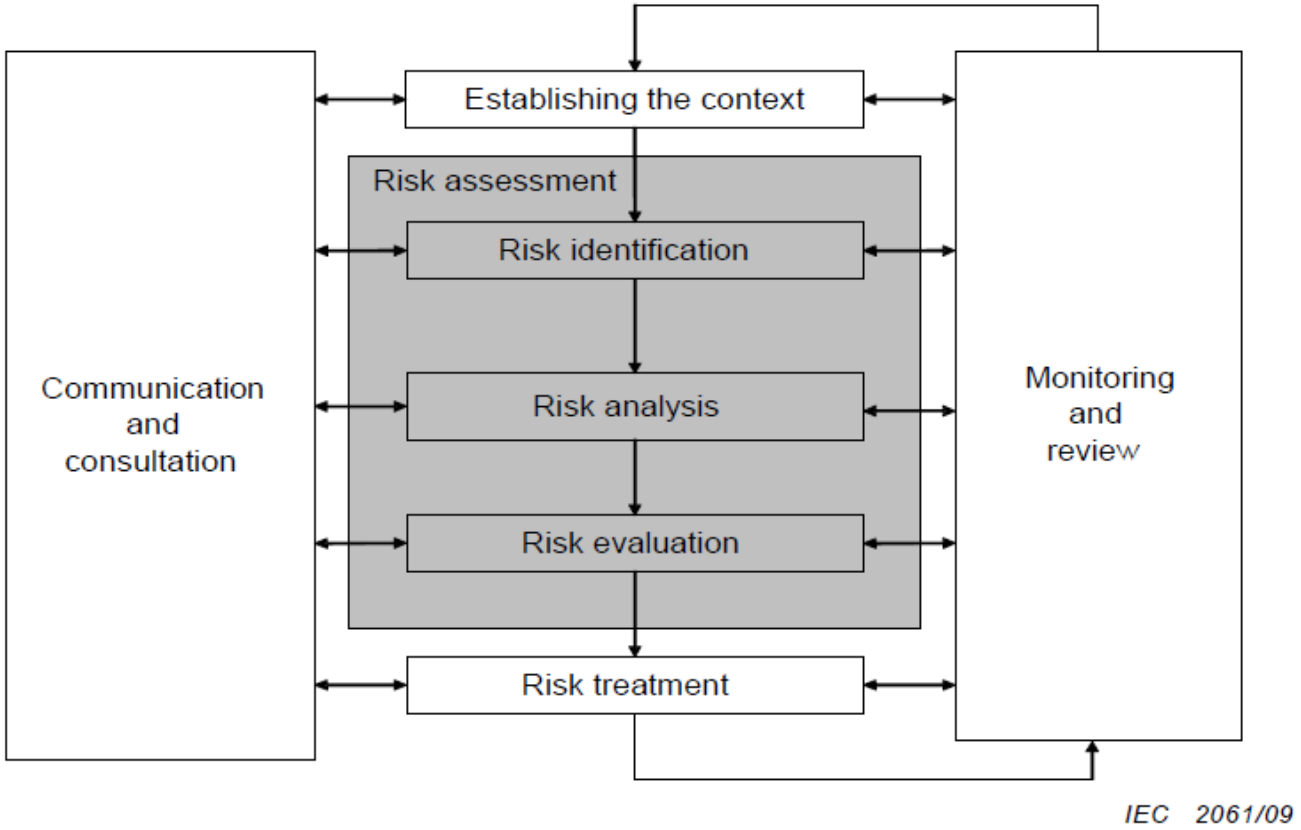
Risk assessment for chemical stimulation

April 2018

Abigaëlle Peterschmitt & Régis Hehn ESG

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 691728

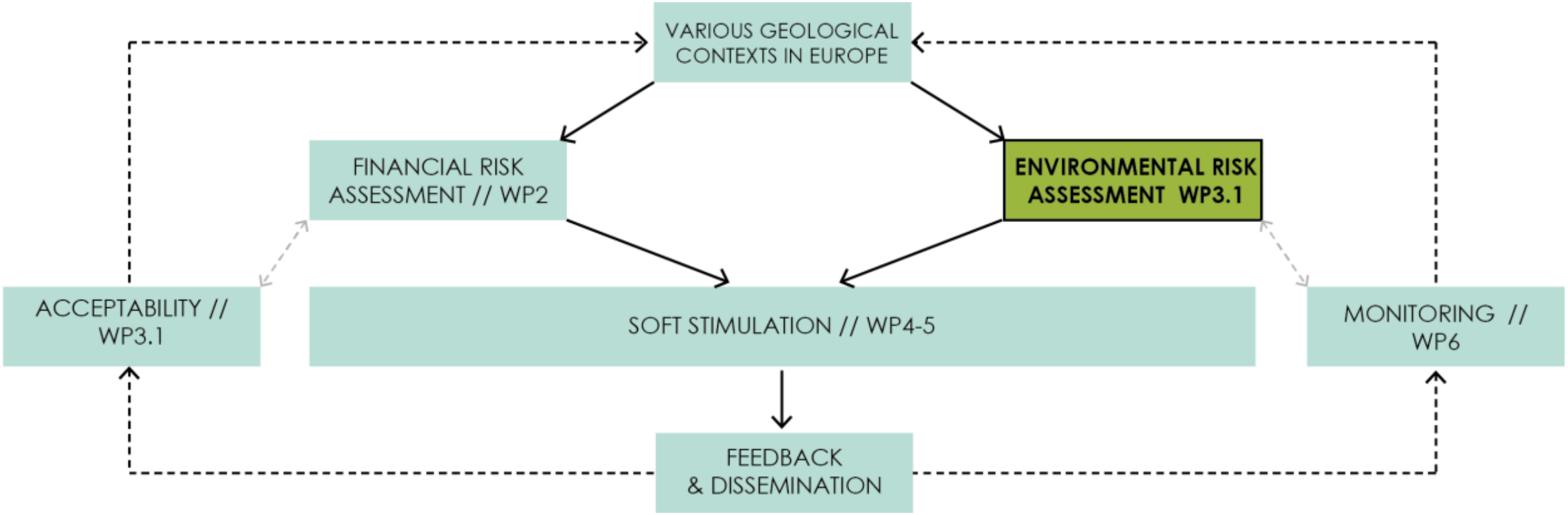
What is risk management?



- All human activities and industrial operation have an impact on the environment
- Contruction of a reflective path to minimize it

ISO/CEI 31010 Risk Management: Risk Assessment Methods

Environmental risk assessment in DESTRESS



D2.1 Risk assessment workflow for soft stimulation

RITTERSHOFFEN
HEAT PLANT

SOULTZ-SOUS-FORÊTS
POWER PLANT

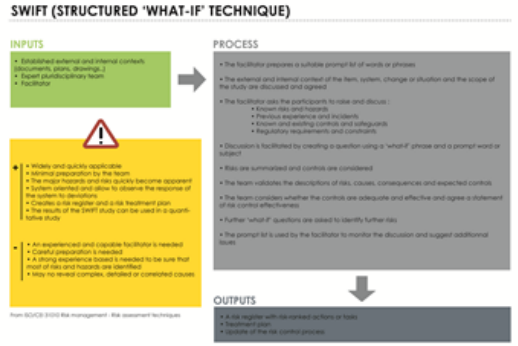
ILLKIRCH
GEOTHERMAL SITE
(Strasbourg Area)

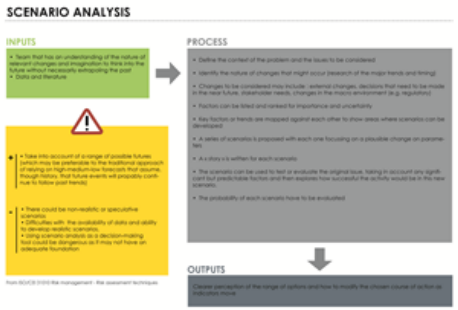
Why chemical stimulation is hazardous?

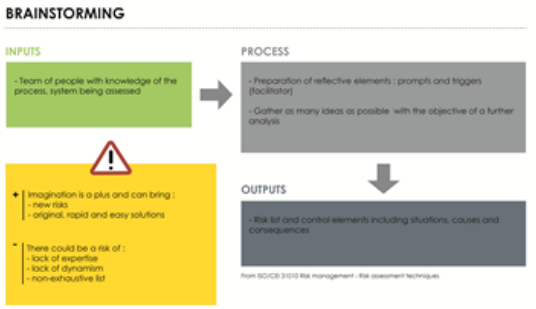
STEPS OF THE CHEMICAL STIMULATION

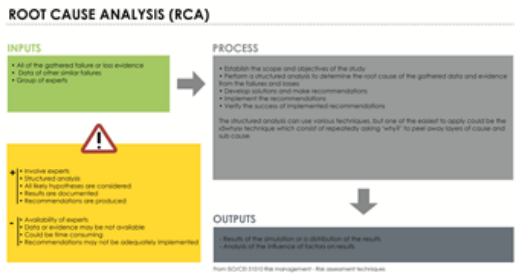
Design	• Pre design • Laboratory experiments	PHASE 1
Transport	• By truck from the warehouse • By crane to the storage place	PHASE 2
Storage	• On the storage place onsite	PHASE 3
Preparation	• Mixing of the acid • Equipment of the well (packer or coiled tubing)	PHASE 4
Acid Job	• Injection from the tanks to the reservoir • Reaction of acid in the tubing and the reservoir	PHASE 5
Post Job	• Production and reaction control • Waste management and decomissioning	PHASE 6

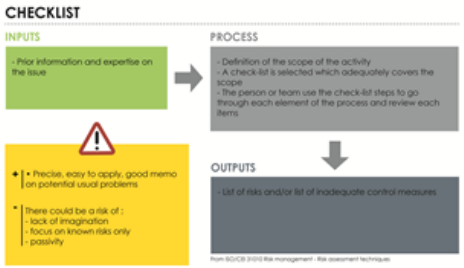
Risk assessment methods

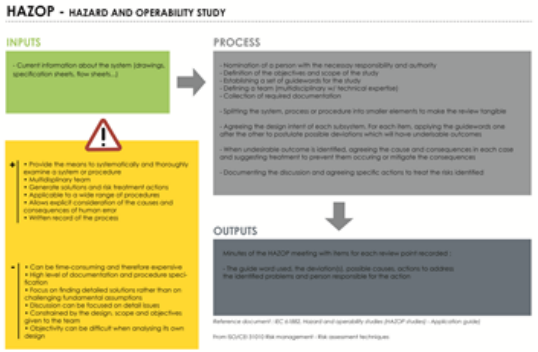








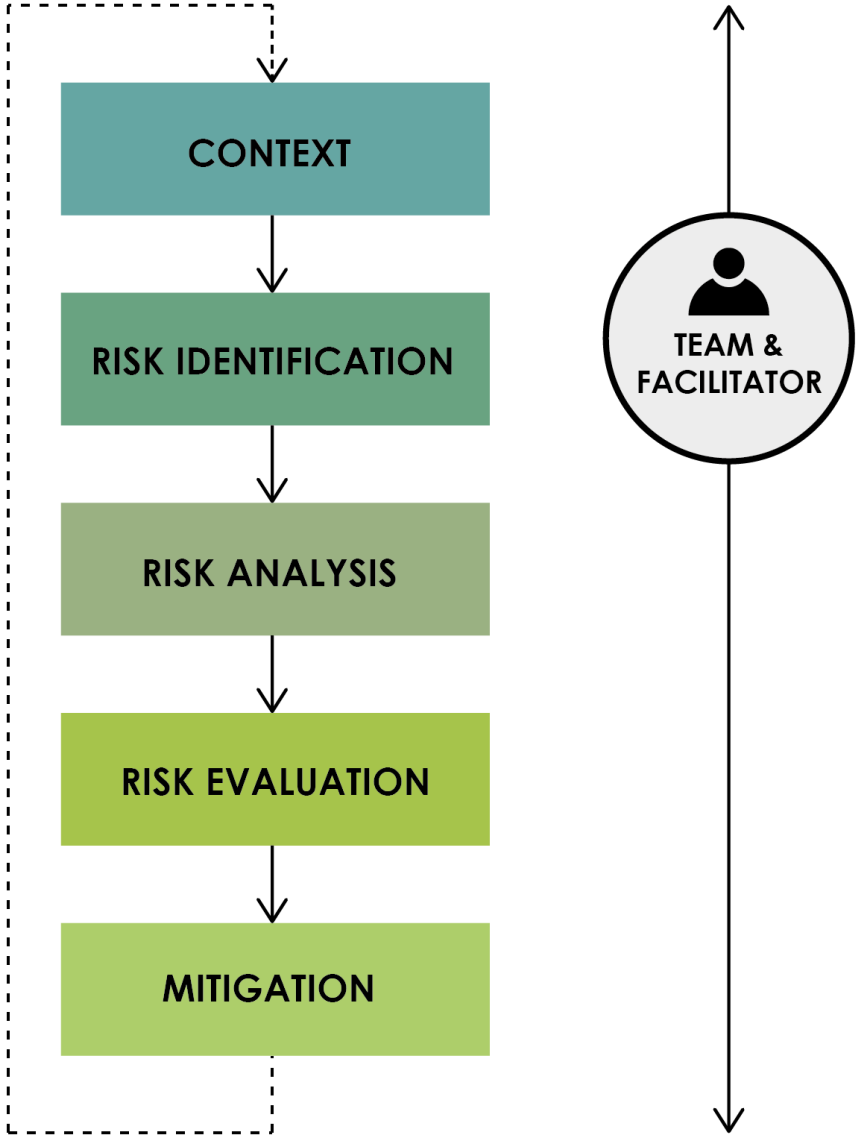




- More than 15
- Qualitative or quantitative
- Availability of data
- Time and resources

ISO/CEI 31010 Risk Management: Risk Assessment Methods

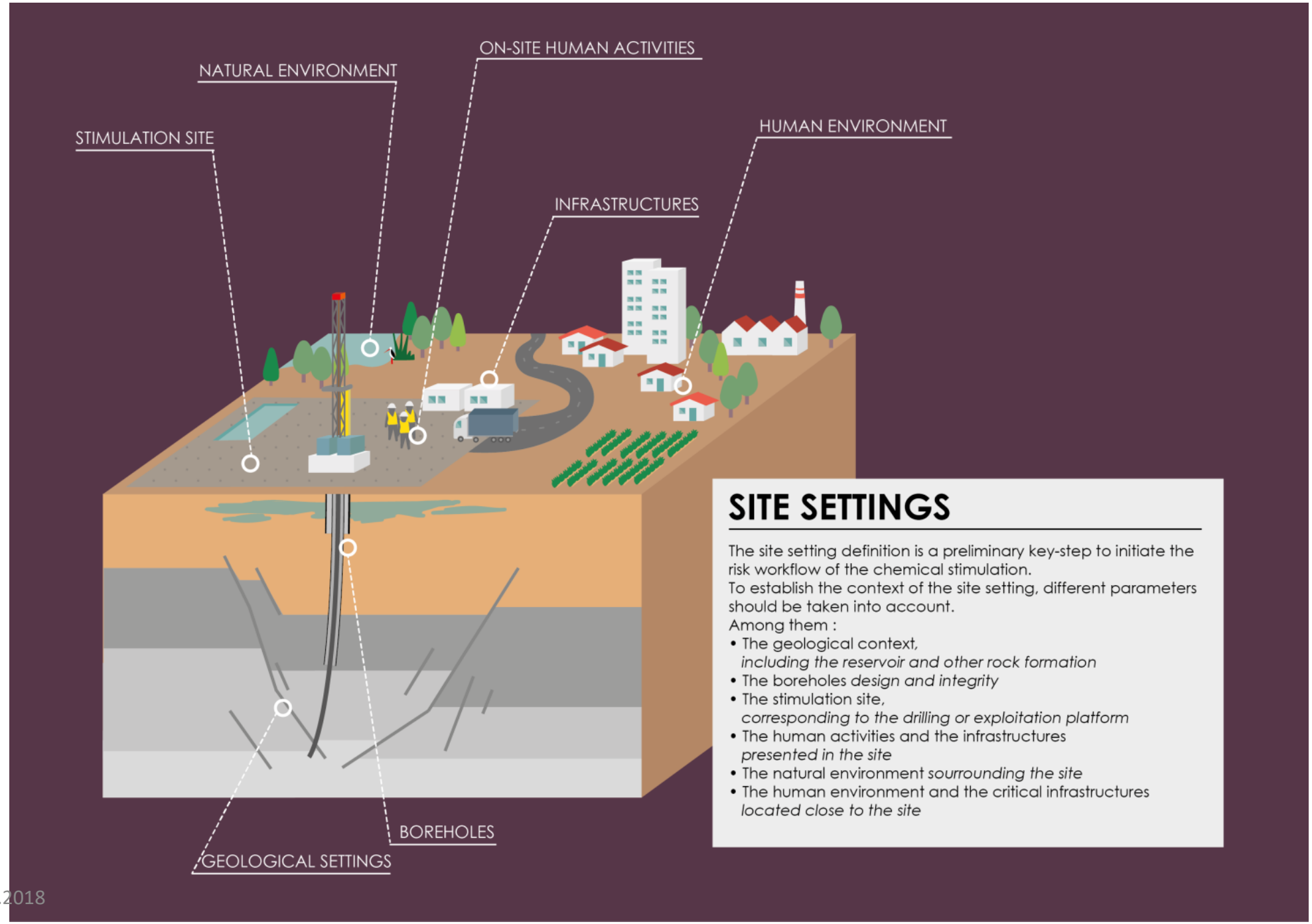
Global roadmap



- Context is important
- Expert team mobilisation
- Transversal skilled facilitator
- Time consuming/Exhaustivity balance
- Threshold subjectivity

METHODS

- Brainstorming
- Scenario analysis
- Checklist
- Environmental risk assessement



SITE SETTINGS

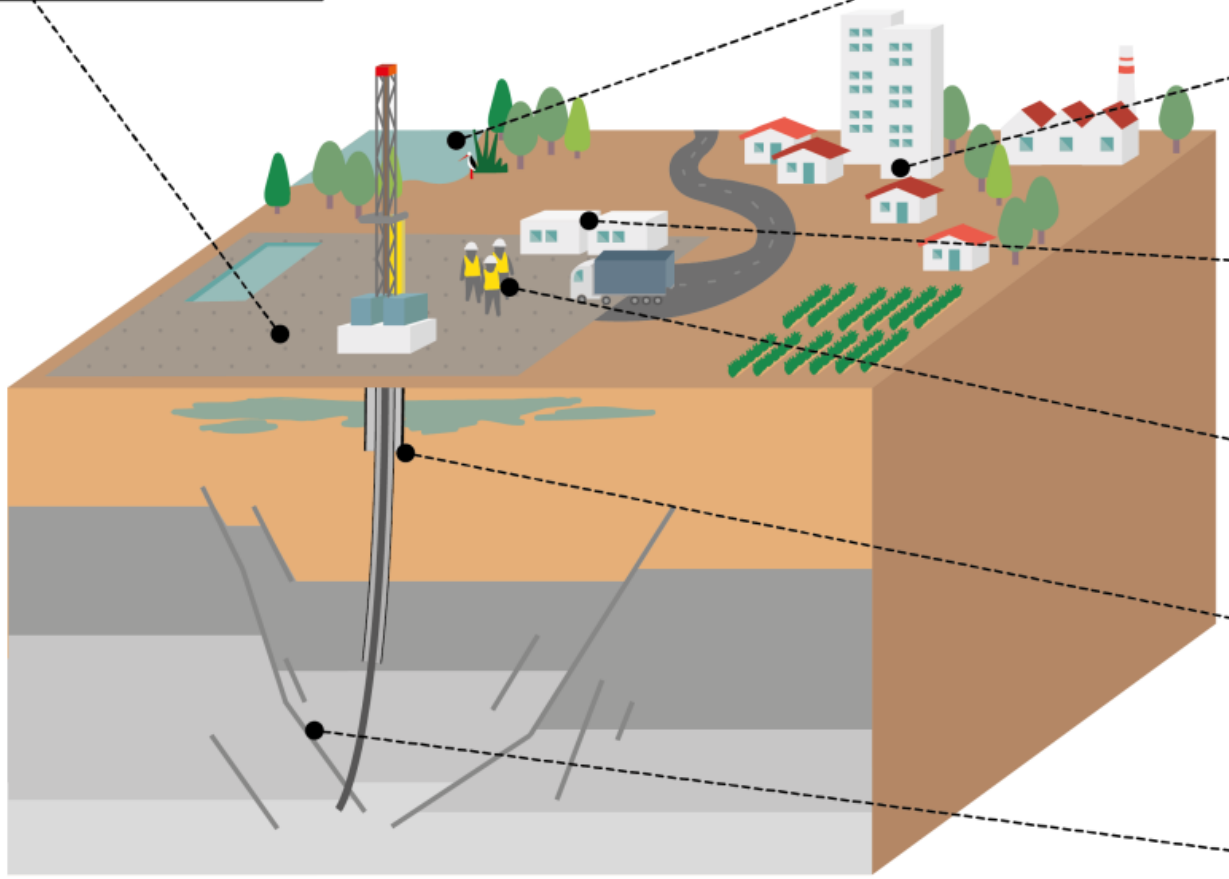
The site setting definition is a preliminary key-step to initiate the risk workflow of the chemical stimulation.
To establish the context of the site setting, different parameters should be taken into account.
Among them :

- The geological context, *including the reservoir and other rock formation*
- The boreholes *design and integrity*
- The stimulation site, *corresponding to the drilling or exploitation platform*
- The human activities and the infrastructures *presented in the site*
- The natural environment *sourrounding the site*
- The human environment and the critical infrastructures *located close to the site*

RISK ASSESSMENT // CHEMICAL STIMULATION

CASE STUDY: ILLKIRCH GEOTHERMAL SITE CONTEXT

Stimulation design
- Preliminary laboratory tests
- Biodegradable product and HCl
- Corrosion inhibitor, clay stabilizer and intensifiers
- Triple phase injection
- Solid powder chemicals transportation and storage
- Adequate equipment
- Qualified human resources
- Duration : 1 week, at the end of summer



Natural environment
- Summer season with potential occurence of thunderstorm
- Protected zones closed to the site
- Rhine aquifer, Rivers arround the site
- Arable land

Human environment and neighbouring infrastructures
- Urban area with low population density
- Political support of the project and positive feedback of the population
- Good acceptability
- Good transport networks
- No cultural or historical heritage nearby
- Tertiary sector and industries

Platform, infrastructure and site access
- Provisory gravel road
- Rig SMP 106 / Base Camp / Mud pit onsite / Forklift and cranes
- 1.5 Ha platform / 25 t/m^2 / Draining system

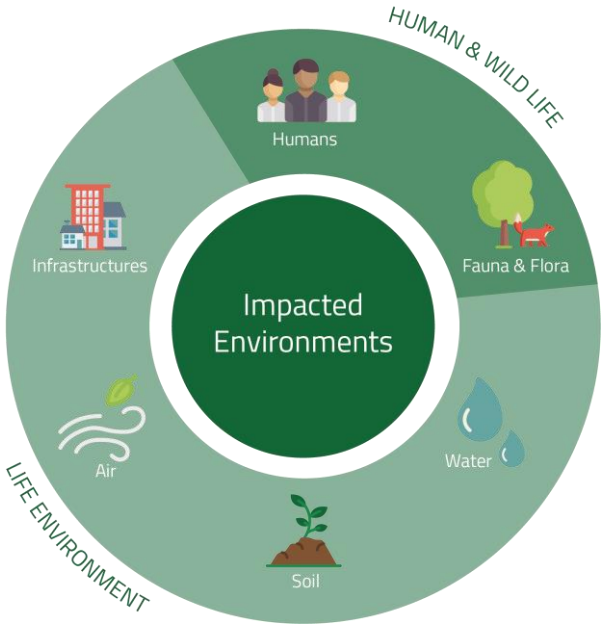
Human activities
- 20 to 30 people on site
- No simultaneous activities
- Highly trained multilingual workers
- Coordinator for the security and safety protection
- QHSE service provided by the service company

Borehole
- Directional wells with a classical borehole completion scheme
- New casings and fully cemented wells
- Fractured reservoir dominated by a fault structure

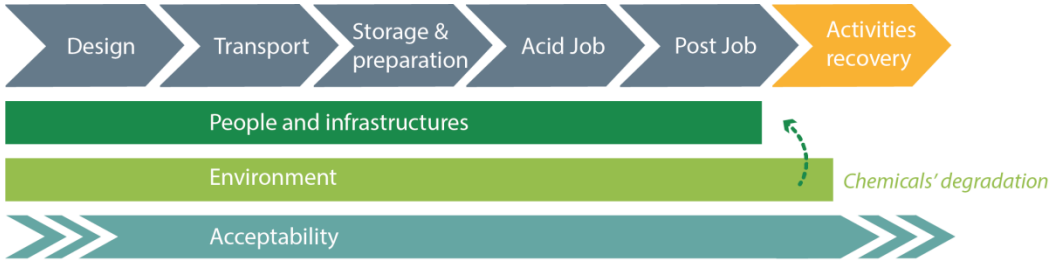
Reservoir
- Granite & Sandstone
- Fractures permeability and low matrix porosity
- 2.5-3km/150-160°C/ 250-300bar
- NaCl dominated brine, TSD 100g/L with CO_2 (GLR 1:1)

Other rock formations
- Hydrocarbon reservoir in the shallow layers
- Presence of clays and saline rocks
- Deep aquifers (not exploited)
- Potential vertical natural inter-connections between aquifers

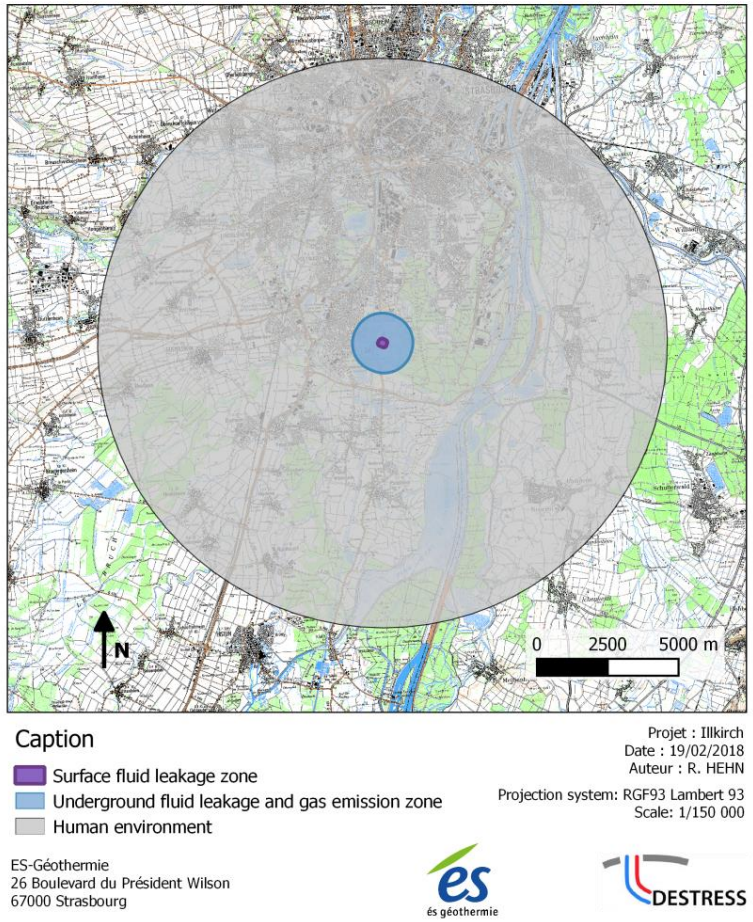
Limits



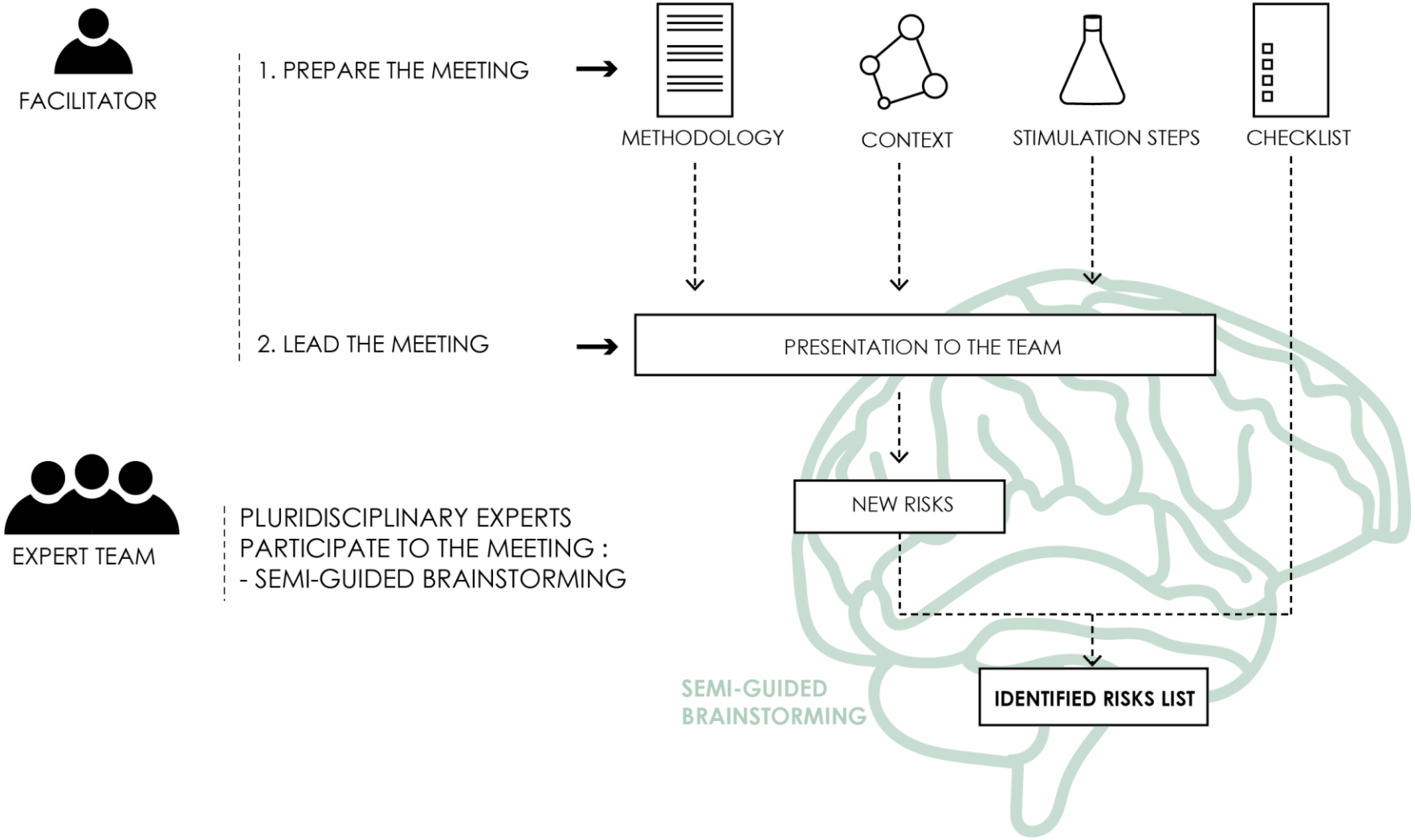
Temporal



Spatial



RISK IDENTIFICATION



Case study

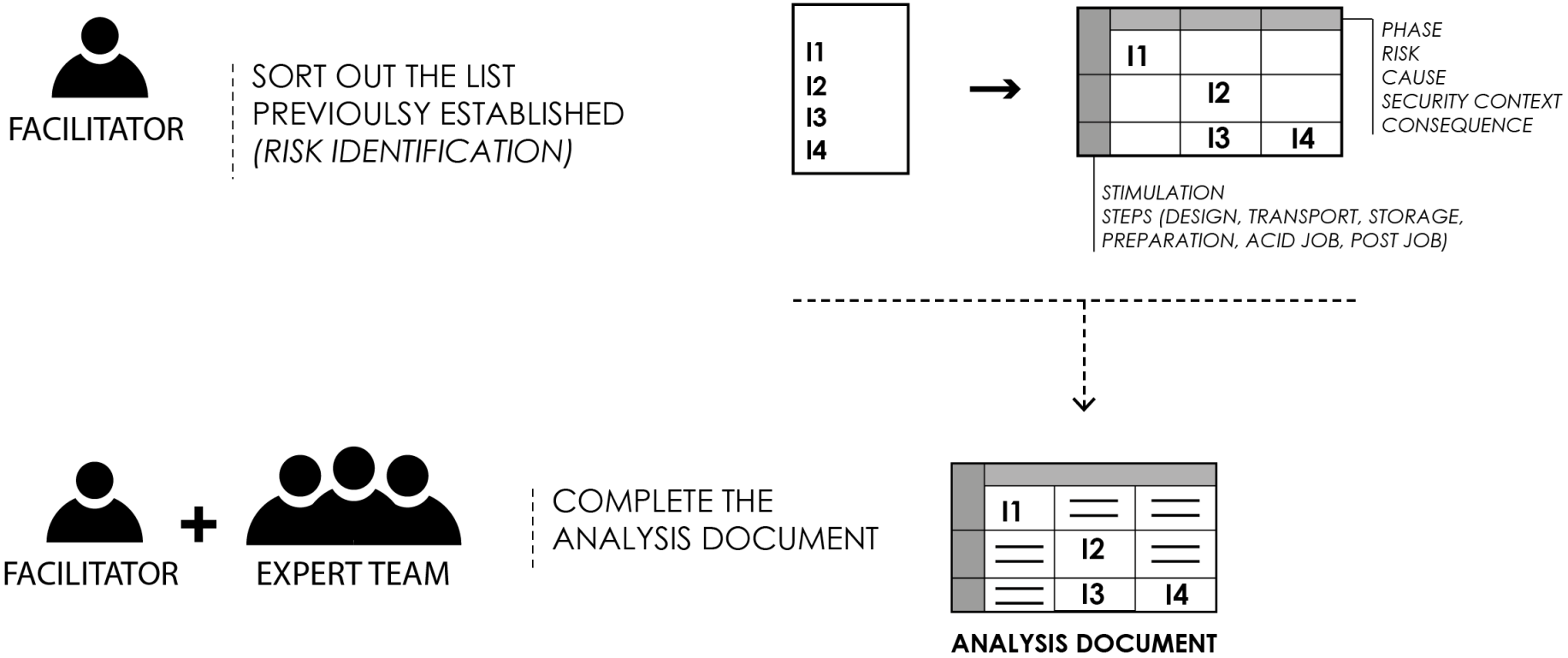
Phase	Risk
Design	Office work related musculoskeletal disorder
Design	dent
Design	
Transpo	structures
Transport	Truck accident with injury on people
Transport	Truck accident with damages on surface water
Transport	Truck accident with damages on soil
Transport	Crane accident on site with release of chemicals on the platform and damage on nearby environment
Transport	Crane accident on site with release of chemicals and acid burns
Transport	Crane accident on site with injury
Storage	Leakage on the storage place because of accidental damage on acid reserve and damage on nearby environment
Storage	Leakage on the storage place because of accidental damage on acid reserve and damage on people

Phase **Risk**

Transport	Crane accident on site with injury
Storage	Leakage on the storage place because of accidental damage on acid reserve and damage on nearby environment
Storage	Leakage on the storage place because of accidental damage on acid reserve and damage on people
Preparation	Chemical burns due to acid manipulation
Preparation	Injury due to accident during coiled tubing and packer jobs
Preparation	Noise and vibration nuisance due to mixing machines
Acid job	Injury due to high pressure accident
Acid job	Acid burns due to high pressure accident
Acid job	Pollution of nearby environment due to high pressure accident
Acid job	Corrosion of the casing due to bad injection procedure, or

RISK ANALYSIS

IDENTIFICATION LIST OF RISKS, SITUATIONS AND CONSEQUENCES



Case study

Phase	Risk	Cause	Security context	Consequence
Design	physical harm	bad ergonomy of working place	Labour doctor consulted	musculoskeletal disorder
Design	chemical burn	laboratory accident	Security measures and formation of the stimulation service company	severe injury
Design	explosion or heat production	laboratory accident	Security measures and formation of the stimulation service company	severe injury
Transport	Infrastructure damage		Control of driving skills by the employer and	destruction of 1st priority infrastructure
Transport				
Transport				
Transport				
Transport	environmental harm	crane accident	and respect of working procedure onsite	pollution of nearby environment
Transport	chemical burn	crane accident	Control of crane driving skills by the employer and respect of working procedure onsite	severe injury
Transport	physical harm	crane accident	Control of crane driving skills by the employer and respect of working procedure onsite	casualties, injury
Storage	environmental harm	storage integrity issue	Respect of working procedure onsite and of the storage regulation	pollution of nearby environment
Storage	chemical burn	storage integrity issue	Respect of working procedure onsite and of the storage regulation	severe injury
Preparation	chemical burn	manipulation accident	Formation of operators	severe injury
Preparation	physical harm	operation accident	Formation of operators, respect of working procedure onsite	casualties, injury
Preparation	noise and vibration nuisance	working operation	Far from houses	nervous breakdown
Acid Job	physical harm	operation accident	Respect of working procedure onsite, formation of operators and certified equipment	casualties, injury
Acid Job	chemical burn	operation accident	Respect of working procedure onsite, formation of operators and certified equipment	severe injury
Acid Job	environmental harm	operation accident	Respect of working procedure onsite, formation of operators and certified equipment	pollution of nearby environment
Acid Job	environmental harm	well integrity accident	Respect of injection procedure	pollution of aquifer
Acid Job	physical harm	unexpected geological response	Presence of BOP	casualties, injury
Acid Job	environmental harm	well integrity accident	Adequate well completion	pollution of aquifer
Acid Job	Infrastructure damage	Induced seismicity	Respect of regulation	destruction of 1st priority infrastructure

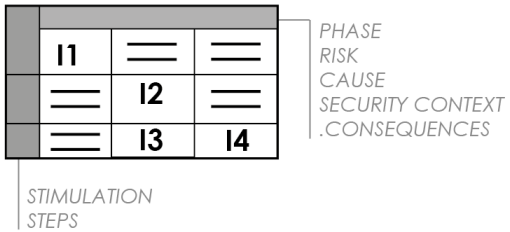
Phase | Risk | Cause | Security context | Consequence

RISK EVALUATION

EXPERT TEAM

1. EVALUATION OF THE RISKS BASED ON EXPERIENCE

ANALYSIS DOCUMENT

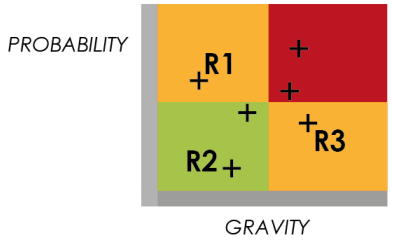


GRAVITY
- VULNERABILITY
- EXPOSITION
- DURABILITY

PROBABILITY

2. SET UP THE THRESHOLDS

3. FILL OUT OF THE RISK EVALUATION GRAPH



+ EVALUATED RISKS

FACILITATOR

NOTA BENE :
THE FACILITATOR IS INVOLVED DURING ALL THE STEPS OF RISK EVALUATION

Case study

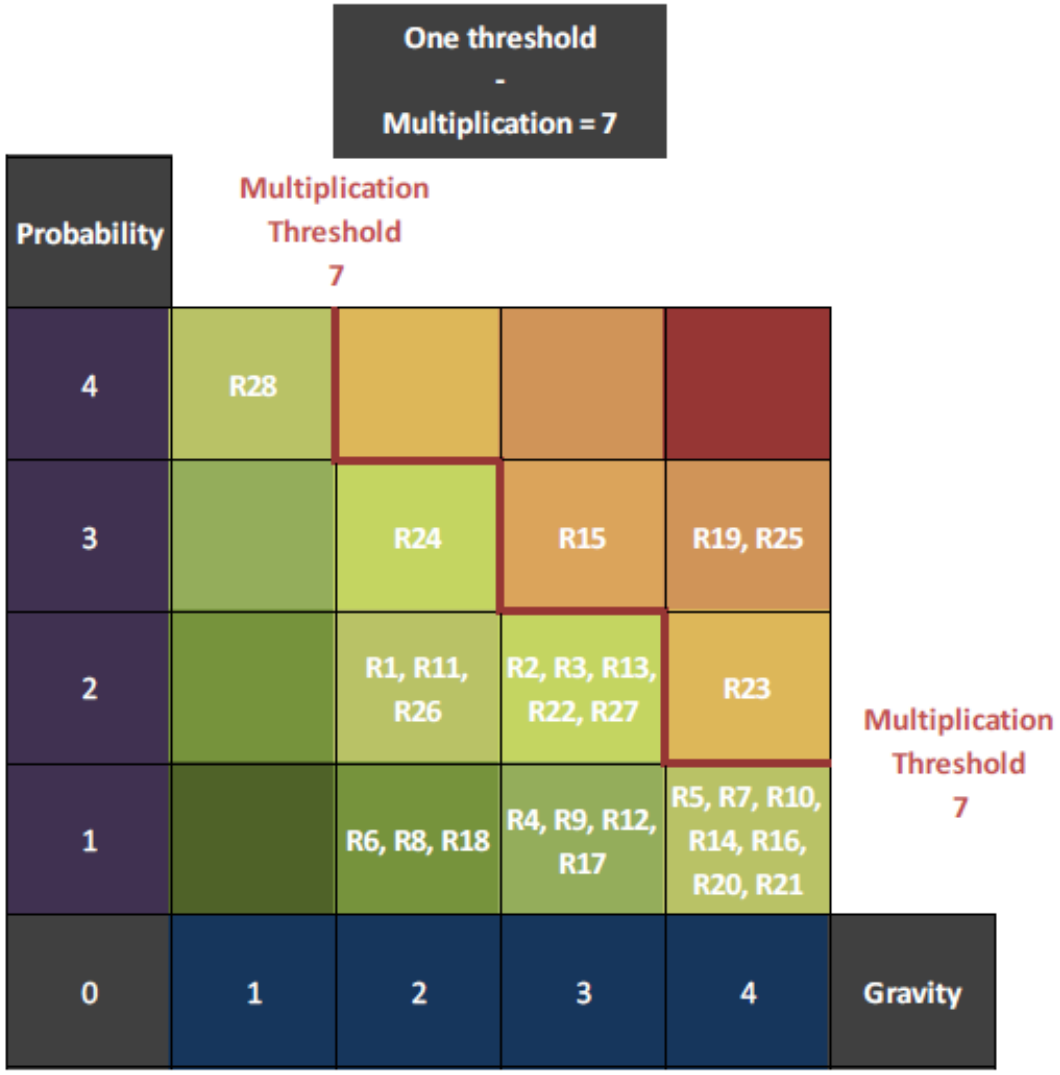
Référence	Phase	Risk	Cause	Security context	Consequence	Frequency	Gravity	Final level
R1	Design	physical harm	bad ergonomy of working place	Labour doctor consulted	musculoskeletal disorder	2	2	4
R2	Design	chemical burn	laboratory accident	Security measures and formation of the stimulation service company	severe injury	2	3	6
R3	Design	explosion or heat production	laboratory accident	Security measures and formation of the		2	3	6
R4	Transport	Infrastructure damage	road accident			1	3	3
R5	Transport	Physical and psychological harm	road accident			1	4	4
R6	Transport	environmental harm	road accident			1	2	2
R7	Transport	environmental harm	road accident			1	4	4
R8	Transport	environmental harm	crane accident			1	2	2
R9	Transport	chemical burn	crane accident			1	3	3
R10	Transport	physical harm	crane accident			1	4	4
R11	Storage	environmental harm	storage integrity issue			2	2	4
R12	Storage	chemical burn	storage integrity issue			1	3	3
R13	Preparation	chemical burn	manipulation accident			2	3	6
R14	Preparation	physical harm	operation accident	procedure onsite		1	4	4
R15	Preparation	noise and vibration nuisance	working operation	Far from houses	nervous breakdown	3	3	9
R16	Acid Job	physical harm	operation accident	Respect of working procedure onsite, formation of operators and certified equipment	casualties, injury	1	4	4
R17	Acid Job	chemical burn	operation accident	Respect of working procedure onsite, formation of operators and certified equipment	severe injury	1	3	3
R18	Acid Job	environmental harm	operation accident	Respect of working procedure onsite, formation of operators and certified equipment	pollution of nearby environment	1	2	2
R19	Acid Job	environmental harm	well integrity accident	Respect of injection procedure	pollution of aquifer	3	4	12
R20	Acid Job	physical harm	unexpected geological response	Presence of BOP	casualties, injury	1	4	4
R21	Acid Job	environmental harm	well integrity accident	Adequate well completion	pollution of aquifer	1	4	4
R22	Acid Job	Infrastructure damage	Induced seismicity	Respect of regulation	destruction of 1st priority infrastructure	2	3	6
R23	Acid Job	physical harm	Induced seismicity	Respect of regulation	casualties, injury	2	4	8
R24	Post job	environmental harm	unexpected reaction/corrosion products	Adequate design of the chemicals	Pollution of environment	3	2	6
R25	Post job	physical harm	unexpected reaction/corrosion products	Adequate design of the chemicals. Gas detectors in surface	casualties, injury, desease	3	4	12

Gravity

X

Probability

Case study



Probability
1 = Almost never
2 = Sometimes
3 = Often
4 = Almost always

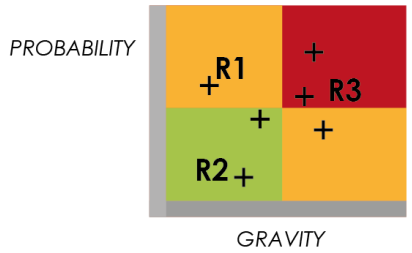
Gravity
1 = almost no damage
2 = minor damage
3 = major damage
4 = exceptional damage

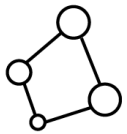
RISK MITIGATION

EXPERT TEAM

THIS STEP OF RISK ASSESSMENT IS AN INTERATIVE PROCESS THAT LEADS TO SUCCESSFUL RISK MITIGATION

EVALUATED RISKS GRAPH





CONTEXT

IDENTIFICATION OF MITIGATION MEASURES

FEASIBILITY EVALUATION

UPDATE RISK ANALYSIS

FEEDBACK

SUCCESSFUL RISK MITIGATION

Case study

Référence	Phase	Risk	Cause	Security context	Mitigation measures	Consequence	Before mitigation			After mitigation		
							Frequency	Gravity	Final level	Frequency	Gravity	Final level
R1	Design	physical harm	bad ergonomy of	Labour doctor consulted		musculoskeletal	2	2	4	2	2	4
R2	Design	chemical burn	laboratory accident	Security measures and formation of the		severe injury	2	3	6	2	3	6
R3	Design	explosion or heat production	laboratory accident	Security measures and formation of the		ry	2	3	6	2	3	6
R4	Transport	Infrastructure damage	road accident			of 1st rastructure	1	3	3	1	3	3
R5	Transport	Physical and psychological harm	road accident			njury, pos	1	4	4	1	4	4
R6	Transport	environmental harm	road accident				1	2	2	1	2	2
R7	Transport	environmental harm	road accident			e wat una and	1	4	4	1	4	4
R8	Transport	environmental harm	crane accident			f nearby nt	1	2	2	1	2	2
R9	Transport	chemical burn	crane accident			ry	1	3	3	1	3	3
R10	Transport	physical harm	crane accident			injury	1	4	4	1	4	4
R11	Storage	environmental harm	storage integrity issue			f nearby nt	2	2	4	2	2	4
R12	Storage	chemical burn	storage integrity issue			ry	1	3	3	1	3	3
R13	Preparation	chemical burn	manipulation accident			ry	2	3	6	2	3	6
R14	Preparation	physical harm	operation accident			injury	1	4	4	1	4	4
R15	Preparation	noise and vibration nuisance	working operation	Far from houses	Noise insulation of equipment	nervous breakdown	3	3	9	3	2	6
R16	Acid Job	physical harm	operation accident	Respect of working procedure onsite, formation of operators and certified equipment		casualties, injury	1	4	4	1	4	4
R17	Acid Job	chemical burn	operation accident	Respect of working procedure onsite, formation of operators and certified equipment		severe injury	1	3	3	1	3	3
R18	Acid Job	environmental harm	operation accident	Respect of working procedure onsite, formation of operators and certified equipment		pollution of nearby environment	1	2	2	1	2	2
R19	Acid Job	environmental harm	well integrity accident	Respect of injection procedure	Consideration of initial well integrity	pollution of aquifer	3	4	12	3	2	6
R20	Acid Job	physical harm	unexpected geological response	Existance of BOP	Adequate BOP and wellhead dimensionment	casualties, injury	1	4	4	1	3	3
R21	Acid Job	environmental harm	well integrity accident	Adequate well completion		pollution of aquifer	1	4	4	1	4	4
R22	Acid Job	Infrastructure damage	Induced seismicity	Respect of regulation	Fine monitoring of the induced seismicity, real time expert analysis	destruction of 1st priority infrastructure	2	3	6	1	3	3
R23	Acid Job	physical harm	Induced seismicity	Respect of regulation	Fine monitoring of the induced seismicity, real time expert analysis	injury	2	4	8	1	4	4

Before vs after mitigation

Conclusion

- Reflective path to minimize the impact of chemical stimulation operation on the environment
- Easily applicable
- It will be applied for the forthcoming chemical stimulation in Soultz-sous-Forêts

Chemical stimulation at Rittershoffen c. ÉS