MiReCOL Mitigation and Remediation of CO_2 Leakage

The MiReCOL tool for corrective measures

Dealing with Liability, Session 3: Leakage mitigation

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TNO innovation for life

Overview

- MiReCOL Introduction
  - Explanation
    - Demonstration
      - Purpose of Tool
        - End use of Web App
          - Next steps

MiReCOL Introduction

MiReCOL Introduction

- Intended for CO_2 storage

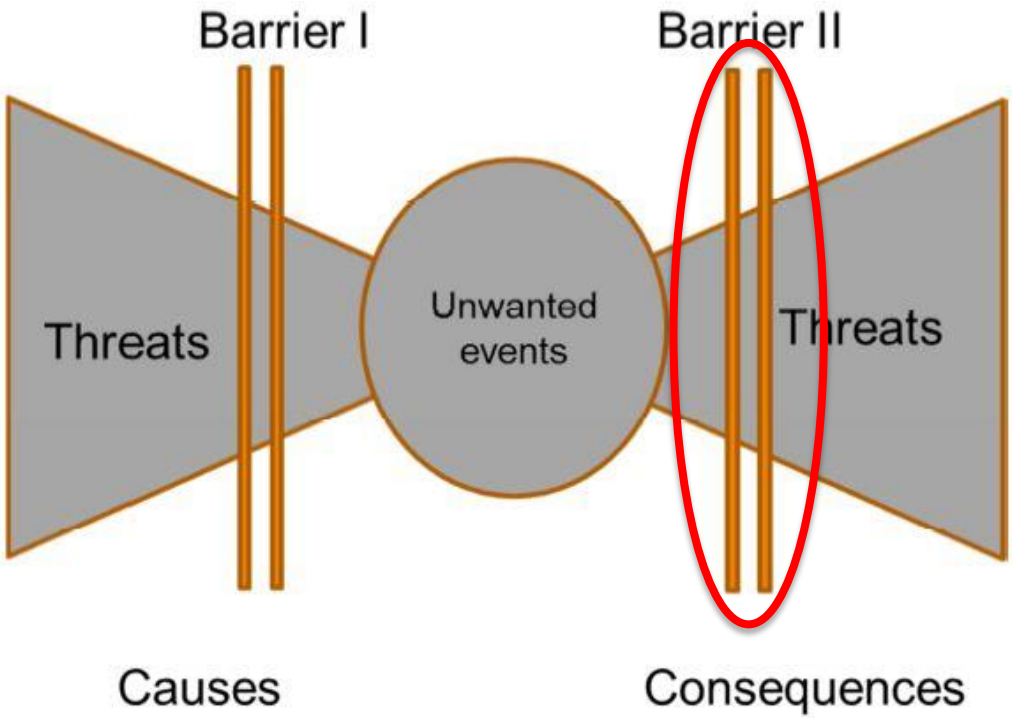
operators **regulators**

- Provides **RISK-BASED analyses** of

mitigation and remediation techniques

MiReCOL Introduction

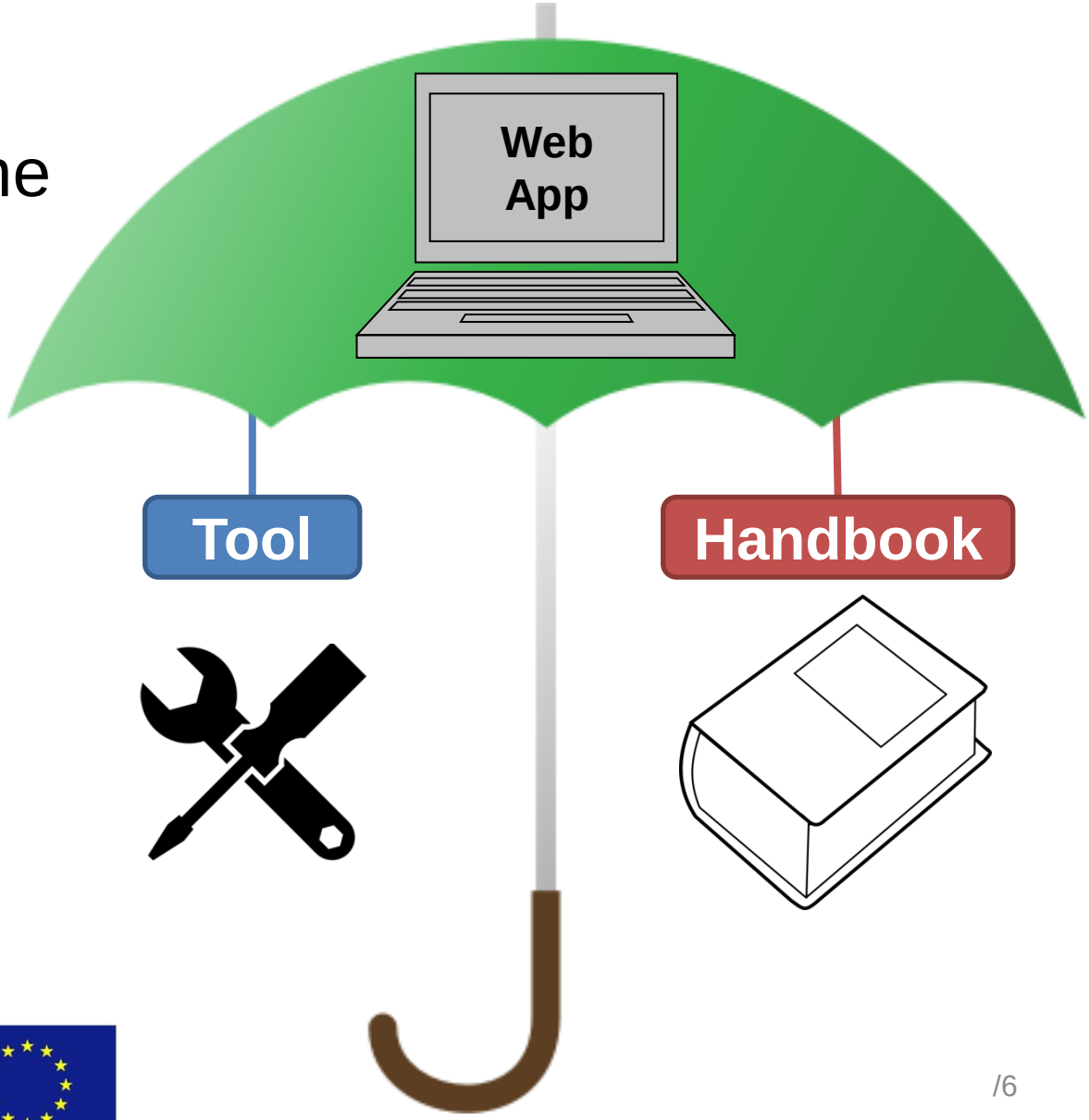
- On the bow-tie diagram



After detection of significant irregularity

Explanation

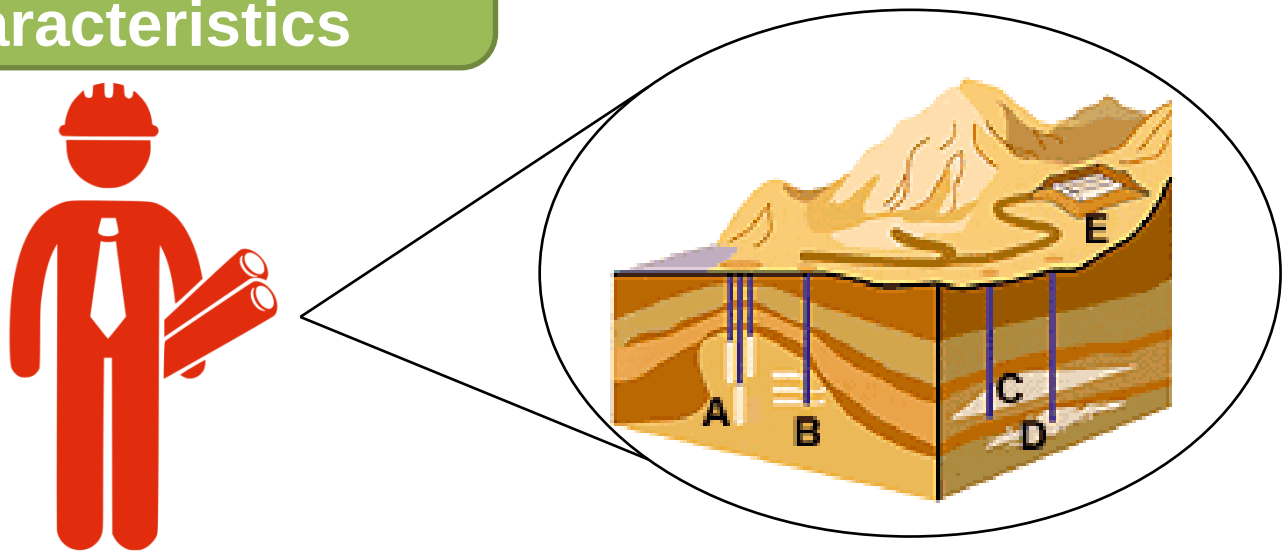
- Two aspects of the web app



Explanation

- **Tool**
- Handbook

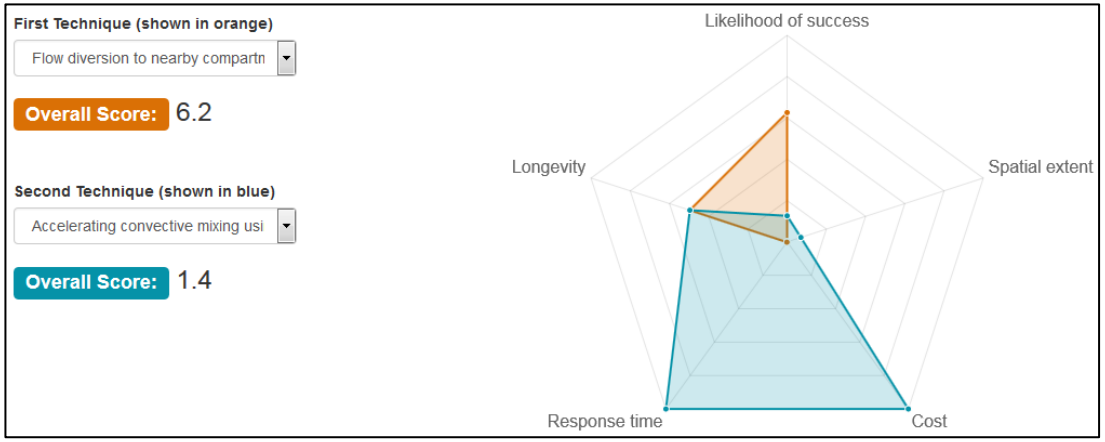
Input: site or well characteristics



Explanation

- **Tool**
- Handbook

Output: information on mitigation and remediation techniques



Appropriate Methods

These results are from the scientific work conducted within the MiReCOL project and not specifically for the site that was input. What this does try to provide is the nearest scientific scenario to the site that was input.

Flow diversion to nearby compartment

Output	Estimated Value
Likelihood of success	50 %
Spatial extent	Unavailable
Cost	Unavailable
Response time	0.28 months
Longevity of remediation	Infinite

MiReCOL Reports

D03.1 - Current flow diversion techniques relevant to CO2 leakage remediation
D03.2 - Adaption of injection strategy as flow diversion option

Water injection and production

Polymer-gel remediation

Foam generation and transport

Explanation

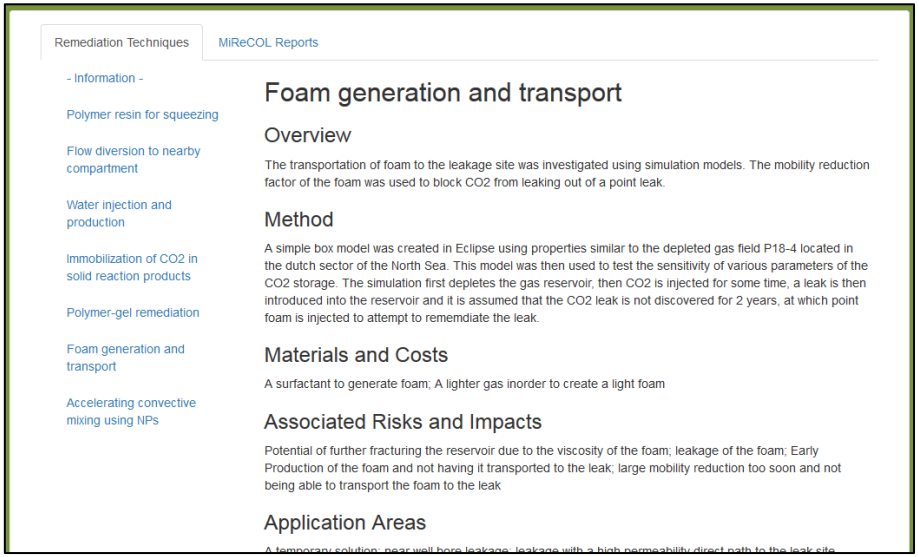
- Tool
- **Handbook**

Operator or regulator can view

MiReCOL reports

and

remediation techniques



Demonstration

Purpose of the Tool

"The results will be published both as handbook and as an interactive web-based tool, to

inform

both

storage project operators and

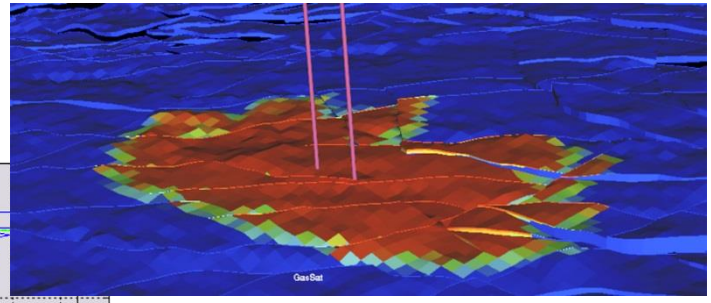
competent authorities

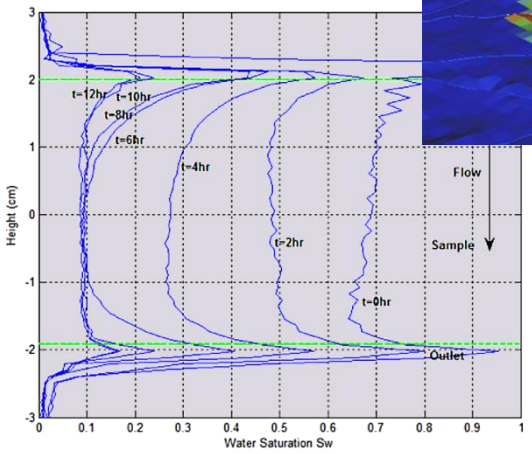
on the

options available for remediation and mitigation."

Purpose of the Tool

- Translate





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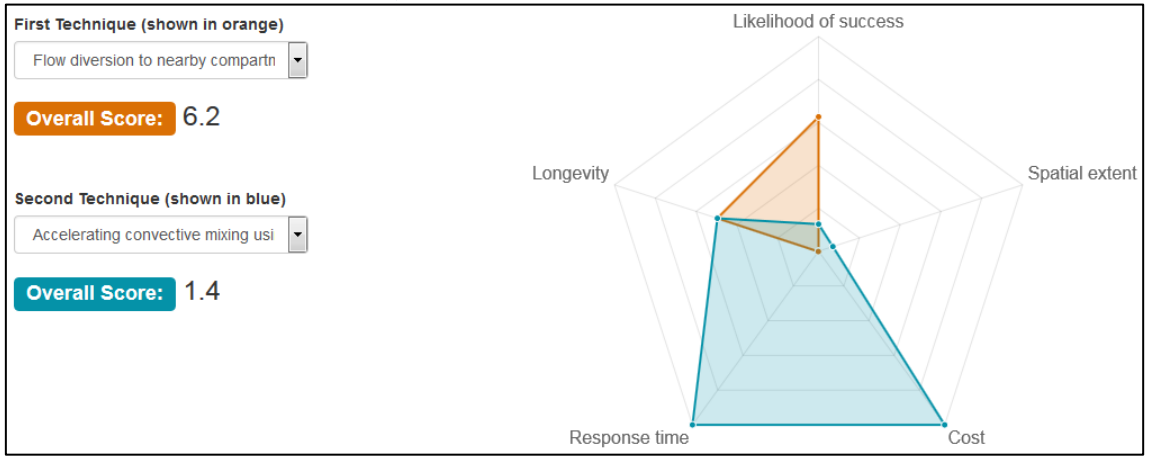


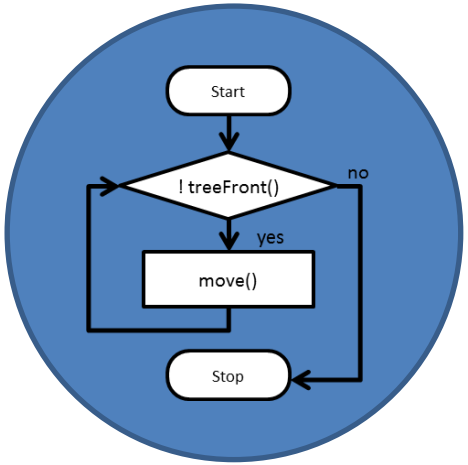
Purpose of the Tool

- How is this done?
  - Scientists generate various scenarios of sites for their technique
  - For those scenarios, the scientist provides 5 outputs →
  - The tool displays the closest match, along with an uncertainty value

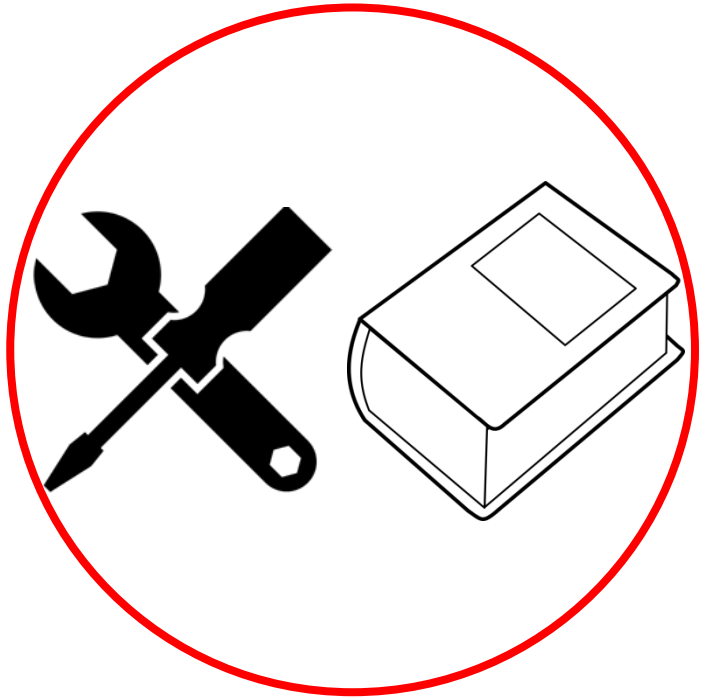
1. **Likelihood of success**
2. **Spatial extent of remediation**
3. **Economic cost**
4. **Response time of remediation**
5. **Longevity of remediation**

End Use of the Web App

- **Operators**



Corrective measures plan

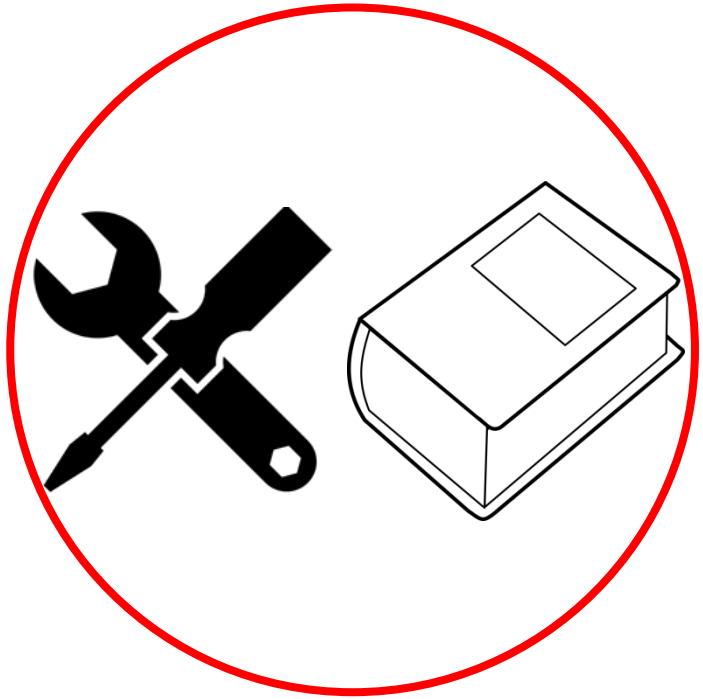


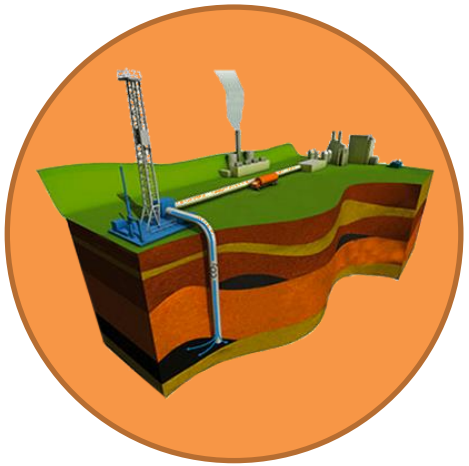
Options available

End Use of the Web App

- **Regulators and authorities**

Options available

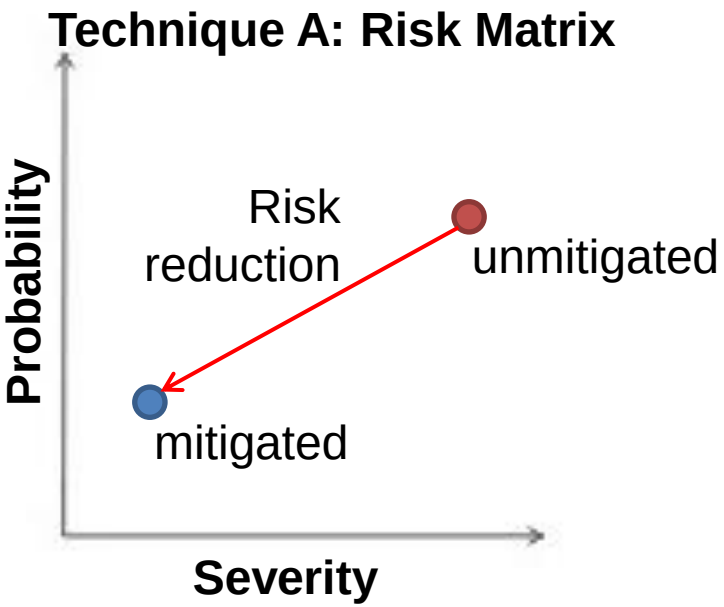




Implications of remediation

Next Steps

- Upload other remediation techniques to the tool and handbook
- Continue gathering ideas on functionality and use of the tool
- Include capability of the operator to investigate the different scientific scenarios
- Plot of overall risk reduction expected per technique



Conclusions

- Compilation of old and new remedial measures
  - Note: does not replace contingency plan
- Tool allows interactive comparison of remediation techniques
  - Based on scientific studies/simulations
- Handbook serves as a reference for
  - **Operators**
  - **Regulators**
  - **Public**
- Step to ensure safe storage and understand risks

Thank you for your attention!

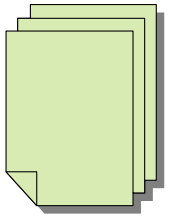
Additional slides

Backend of the tool

How the tool works

Scientists **decide** all site scenarios

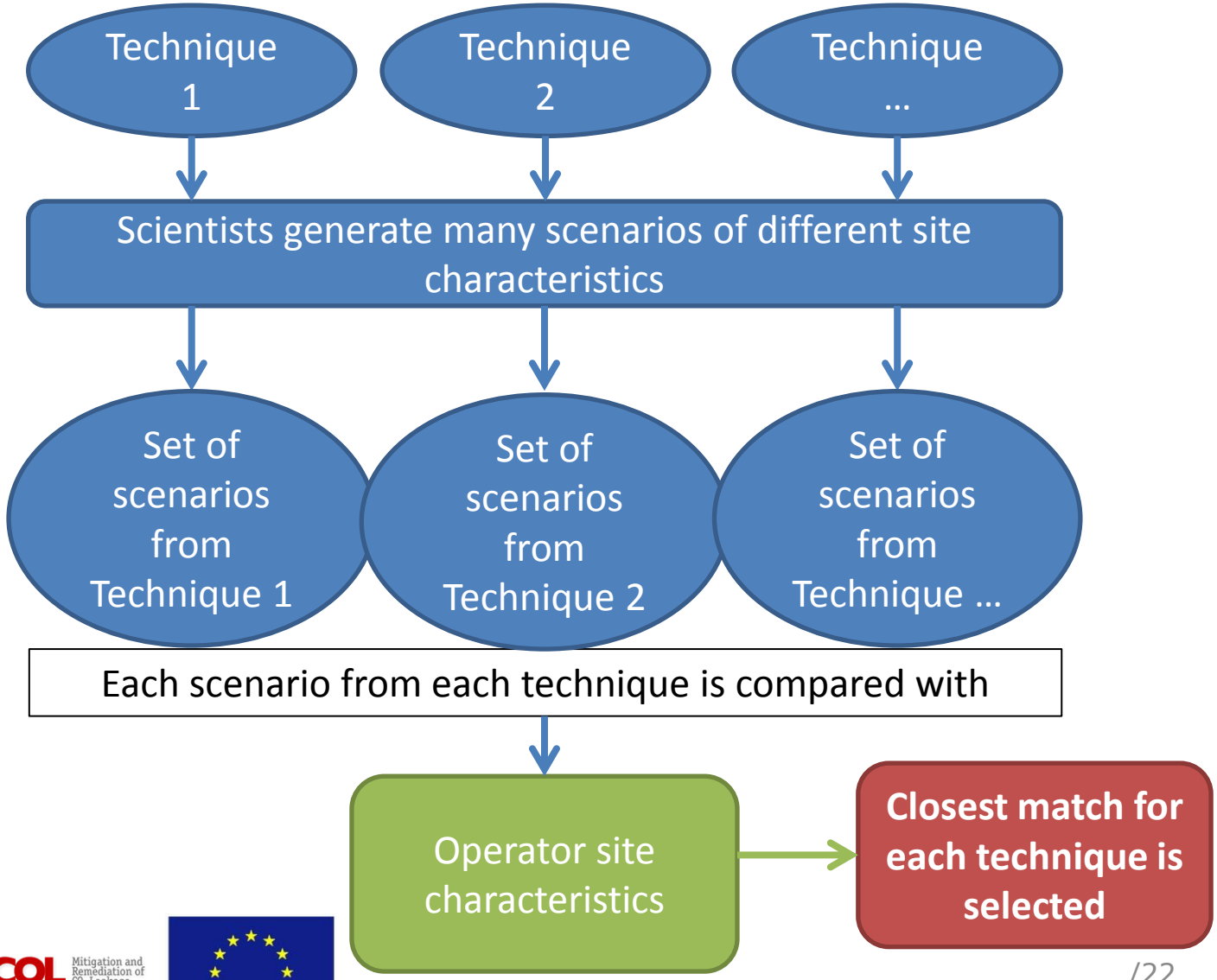
and determine output for each site scenario



Outputs

Web tool finds closest site scenario to the operator input

How the tool works



How the tool works

Technique 1:

Inputs from the scientist

Key Parameters	Scenario 1	Scenario 2	Scenario 3	Scenario …
Temperature	30º	40º	40º	…
Porosity	0.1 %	0.1 %	0.25 %	…
CO_2 present	5 MT	6 MT	10 MT	…

Key Parameters	Operator Input
Temperature	37º
Porosity	0.1 %
CO_2 present	7 MT

Closest scenario →

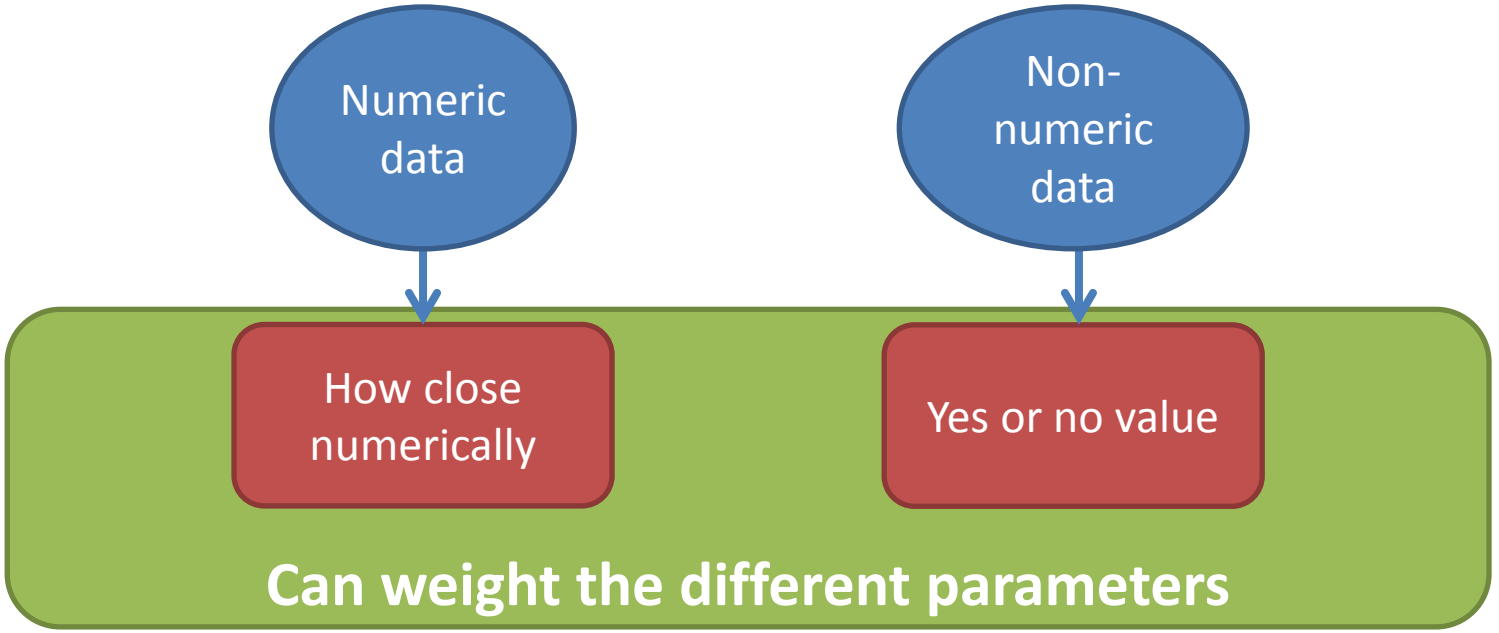
Scenario 2
40º
0.1 %
6 MT

→ **Outputs for Scenario 2**

REPEAT THIS PROCESS FOR THE OTHER TECHNIQUES

How the tool works

- How is the closest scientific scenario selected?
  - Gower similarity



Filling the tool with scientist input

- We will now ask the scientists for 4 things:
  - 1. List of key parameters
  - 2. List of possible ranges for key parameters
  - 3. List of scenarios
  - 4. Outputs for each scenario

Filling the tool with scientist input

- 1. List of key parameters:
  - These are site characteristics that are important/affect the output of your remediation results
  - For example:

	INPUT
	Key parameters
1	Permeability [mD]
2	Leakage Rate [SM3/DAY]
3	Dip Angle [*]
4	Depth [m]
5	CO2 in Place [Mt]
6	Permeability variation coefficient (Dykstra-Parsons)
7	Porosity [-]
8	Gas Injection Rate [SM3/DAY]
9	Leak Distance From Injection Site [m]
0	Foam Injected [kg]

	INPUT
	Key parameters
1	Temperature (°C)
2	Porosity (%)
3	Permeabillity (mD)
4	Distance to leak (m)
5	Leakage rate (kg/s)
6	Spatial extent leak (m)*
7	Type of reactive substance**

Might not be the same key parameters from technique to technique. Operator will only see the entire list.

Filling the tool with scientist input

- 2. List of possible ranges for key parameters
  - The operator will choose from these options
  - Also want to know the center value of these ranges
  - For example:

	Key parameters	bin 1	bin 2	bin 3	bin 4
1	Permeability [mD]	0-10	11-29	30-70	71-329
2	Leakage Rate [SM3/DAY]	1-50	51-149	150-250	
3	Dip Angle [*]	-1 - 1	2-7	8-12	
4	Depth [m]	1500-2500	2501-3500	3501-4500	
5	CO2 in Place [Mt]	10-30	30-50	50-70	
6	Permeability variation coefficient (Dyks	0-0.025	0.026-0.06	.06-.1	
7	Porosity [-]	0.01-0.09	0.1-0.2	0.21-0.29	
8	Gas Injection Rate [SM3/DAY]	50000-150000	150000-250000	250000-350000	
9	Leak Distance From Injection Site [m]	0-50	50-100	100-250	250-500
0	Foam Injected [kg]	100000-200000	200000-300000	300000-400000	400000-500000

Filling the tool with scientist input

- 3. List of <u>scenarios</u>
  - One scenario is a set of values for each key parameter
  - Scientist varies the key parameters to span the realistic possibilities
  - For example:

	INPUT	Scenarios					
	Key parameters	1	2	3	4	5	
1	Permeability [mD]	20	20	20	20	20	
2	Leakage Rate [SM3/DAY]	100	100	100	100	100	
3	Dip Angle [*]	5	5	5	5	5	
4	Depth [m]	3000	3000	3000	3000	3000	
5	CO2 in Place [Mt]	10	10	10	10	10	
6	Permeability variation coefficient (Dykstra-Parsons)	1	1	1	1	1	
7	Porosity [-]	0.15	0.15	0.15	0.15	0.15	
8	Gas Injection Rate [SM3/DAY]	100000	100000	100000	100000	200000	3
9	Leak Distance From Injection Site [m]	375	375	375	375	375	
0	Foam Injected [kg]	310000	150000	250000	450000	310000	3

Vary permeability between 5 and 200 mD

The more scenarios the better, since there is higher chance that the operator's site will match the scientist scenario!

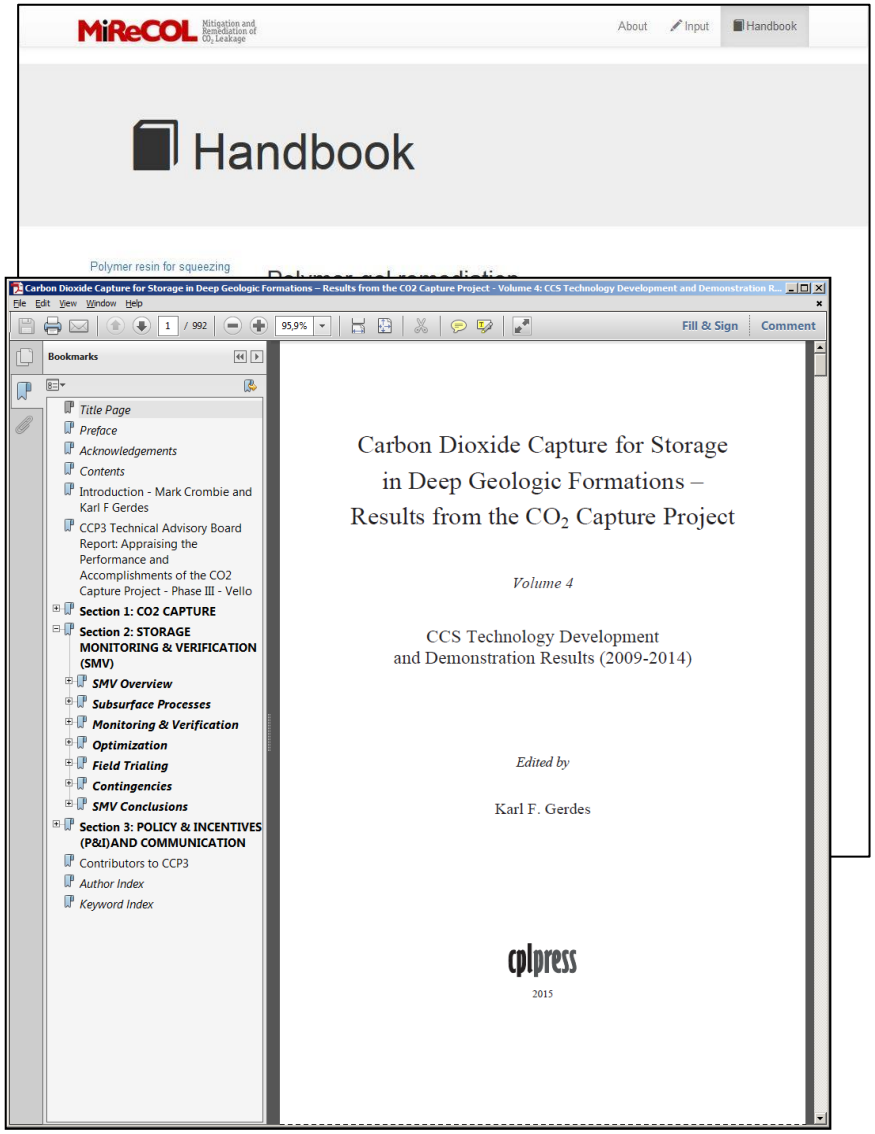
Filling the tool with scientist input

- 4. Outputs for each scenario
  - 1) Likelihood of success
  - 2) Spatial extent of remediation
  - 3) Economic cost
  - 4) Response time of remediation
  - 5) Longevity of remediation
  - For example:

	INPUT	Scenarios			
	Key parameters	1	2	3	4
1	Permeability [mD]	20	20	20	20
2	Leakage Rate [SM3/DAY]	100	100	100	100
3	Dip Angle [*]	5	5	5	5
4	Depth [m]	3000	3000	3000	3000
5	CO2 in Place [Mt]	10	10	10	10
6	Permeability variation coefficient (Dykstra-Parsons)	1	1	1	1
7	Porosity [-]	0.15	0.15	0.15	0.15
8	Gas Injection Rate [SM3/DAY]	100000	100000	100000	100000
9	Leak Distance From Injection Site [m]	375	375	375	375
10	Foam Injected [kg]	310000	150000	250000	450000
	OUTPUT (as best as you can estimate) for the operator				
	likelihood of success [%]	3	4	3	3
	spatial extent of remediation (km)	0.375	0.375	0.375	0.375
	economic cost of remediation (€) OR list of materials required	37372000	35772000	36058000	37344000
	response time of remediation (months)	48	48	47	46
	longevity of remediation (months)	2.76	1.33	2.22	4.00

Handbook part of the tool

- Part of MiReCOL web app
- Descriptions of remediation techniques (after MiReCOL reports; TNO action)
- PDFs of MiReCOL reports (e.g., see CCP3 report)



Handbook part of the tool

- Format for web app
  - Overview
  - Method
  - Materials and costs
  - Associated risks and impacts
  - Application areas
  - Case studies
  - References