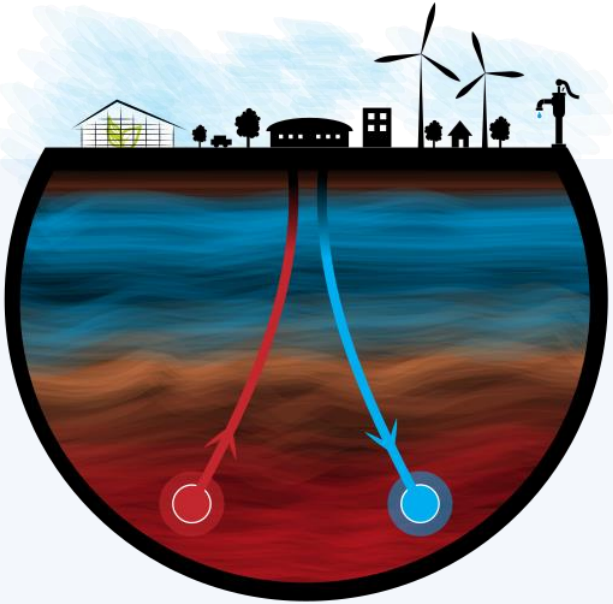


(Environmental) impact of inhibitors in the geothermal sector

Scope: operational phase, the Netherlands

Fenna van de Watering/Raphaël van der Velde

Kennisagenda Aardwarmte van het ministerie van Landbouw, Natuur en Voedselkwaliteit, het ministerie van Economische Zaken en Klimaat, LTO Glaskracht Nederland en het programma Kas als Energiebron

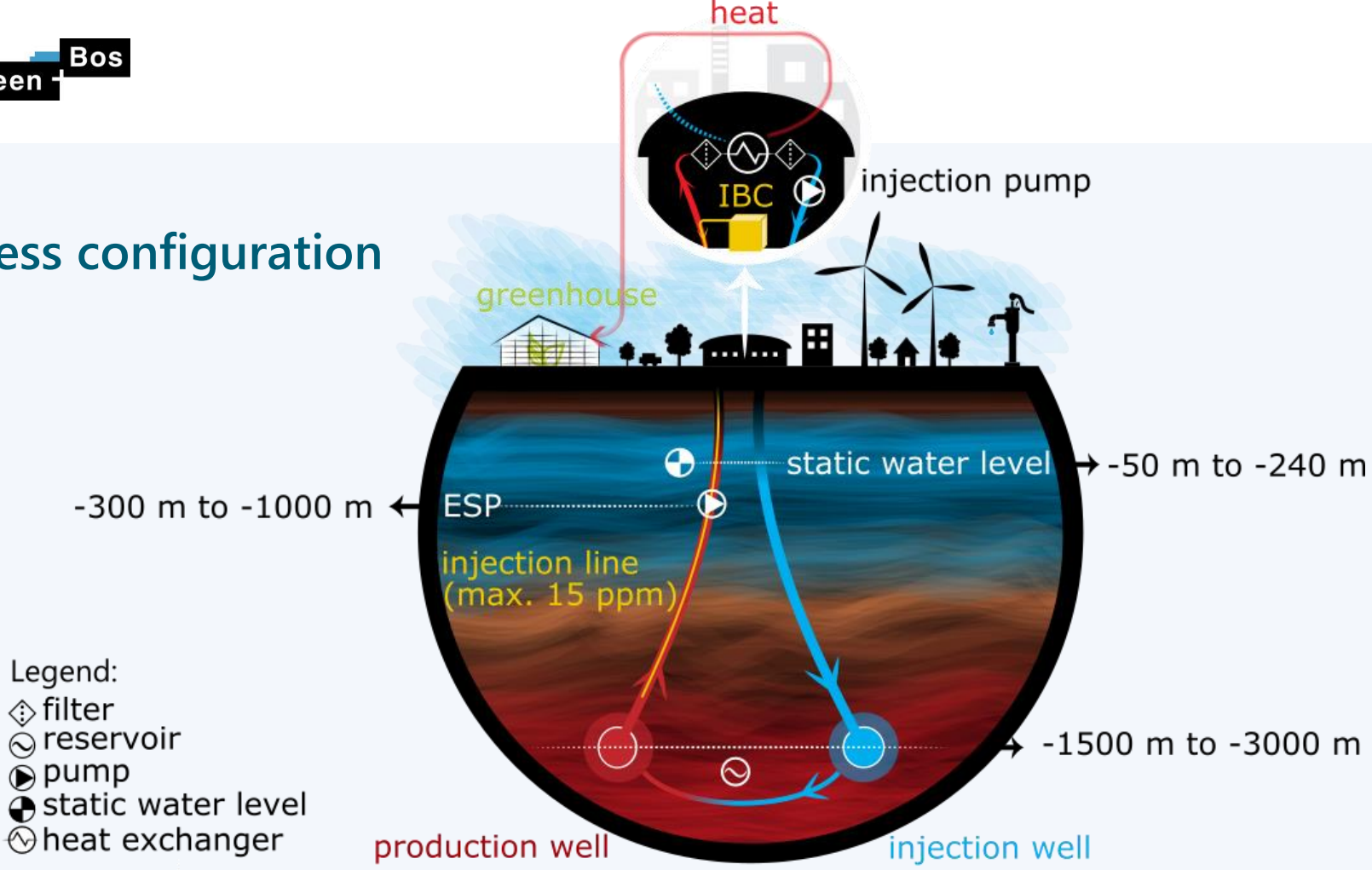
Introduction

- Assignment: kennisagenda aardwarmte
  - Ministry of economical affairs
  - Greenhouse horticulture sector
- Scope: (Environmental) impact of inhibitors, operational phase
  - Technical
  - Environmental

Research phases

1. Assessment process configuration
2. Function and application of inhibitors
3. Risk analysis process
4. Impact on the environment

Process configuration



Characteristics geothermal fluid *

Value	Unit	
temperature, producer	°C	60 – 100
concentration corrosion inhibitor	ppm	0 – 15
pH		5,3 – 6,7
TDS (total dissolved solid)	g/L	81 – 240
carbon dioxide	Mol%gas	0 – 57
methane	Mol%gas	5,6 – 93
oxygen	Mol%gas	0 – 0,065

Compound	Unit	
cadmium	mg/L	<0,001 – 0,05
calcium	g/L	2,7 – 16
chromium	mg/L	<0,005 – 2,6
iron	mg/L	5,6 – 190
lead	mg/L	<0,05 – 13
sodium	g/L	17 – 32
nickel	mg/L	<0,01 – 2,4
zinc	mg/L	0,025 – 420
chloride	g/L	37 – 160
fluoride	mg/L	0,7 – <500

Warm water

Degassing may occur

(slightly) acidic

Toxic components present

-> 2-7 * seawater

Corrosion and scaling potential

* Values from Wood group water gas data - DAGO

Inhibitors – findings

- Two suppliers: Nalco Water and Baker Hughes
  - Corrosion inhibitor ✓
  - Cocktail: 5 wt.% active component
  - 4 – 10 ppm
  - No Scaling, Biocide ✗
- Decrease of iron counts, rate of corroded piping material
- Decrease of lead precipitation
- Scaling of carbonates is operationally handled

Quiz:

Which parameter is the source of corrosion?

(which parameter would still result in corrosion without the other two present?)

A. Temperature

B. Chloride content

C. Acid

Quiz:

Which parameter is the source of corrosion?

(which parameter would still result in corrosion without the other two present?)

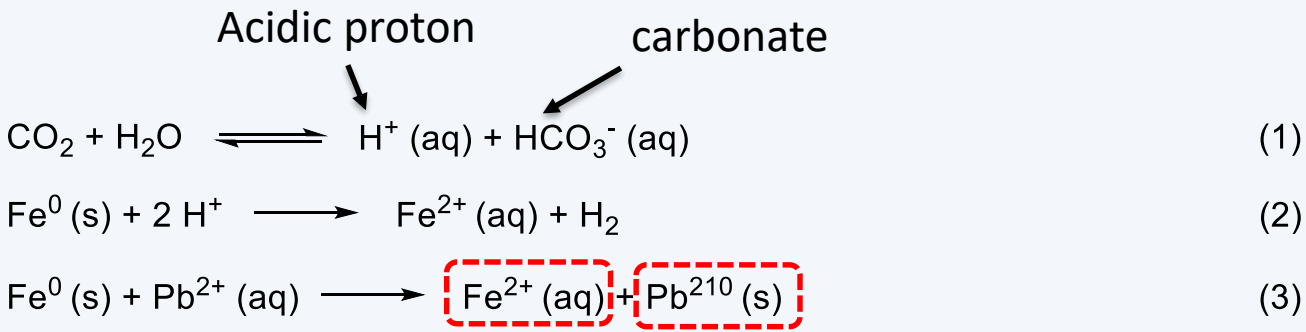
A. Temperature

B. Chloride content

C. Acid

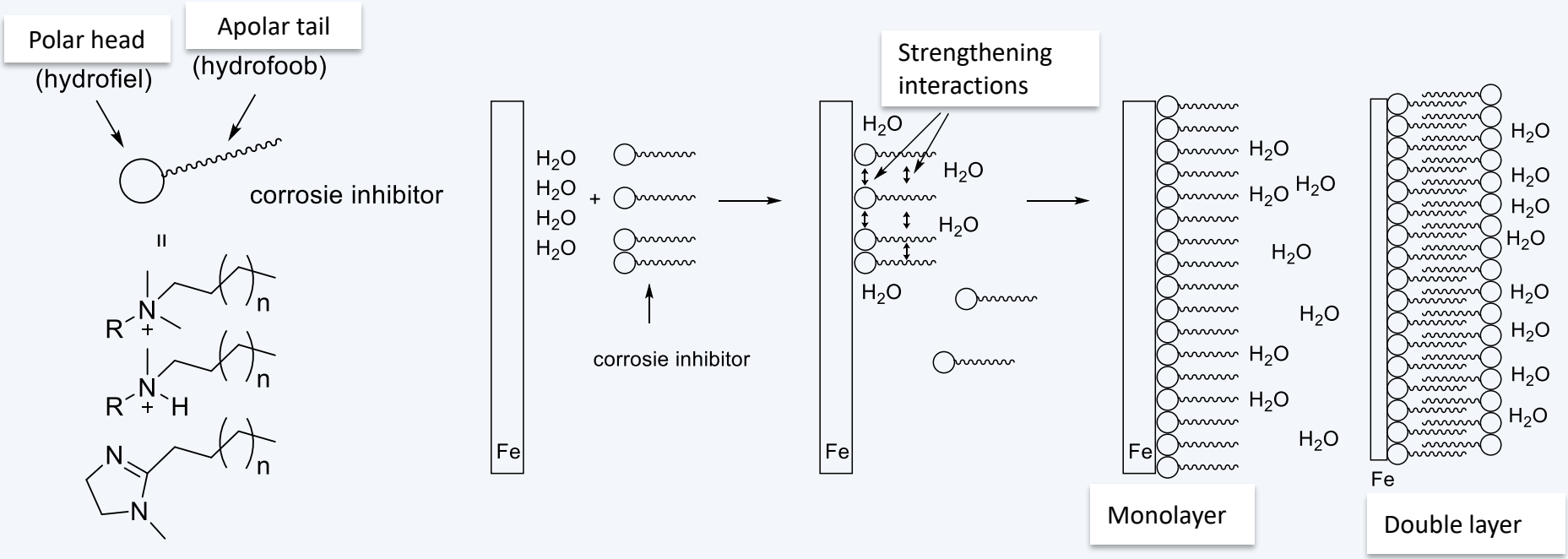
Corrosion

- Pipeline: carbon steel -> Iron (Fe) + carbon



- Catalysed by temperature and chloride concentration

Corrosion inhibitor



Risk analysis process

- HAZOP-method
- Systematically risks
- Group of experts
- Classification matrix

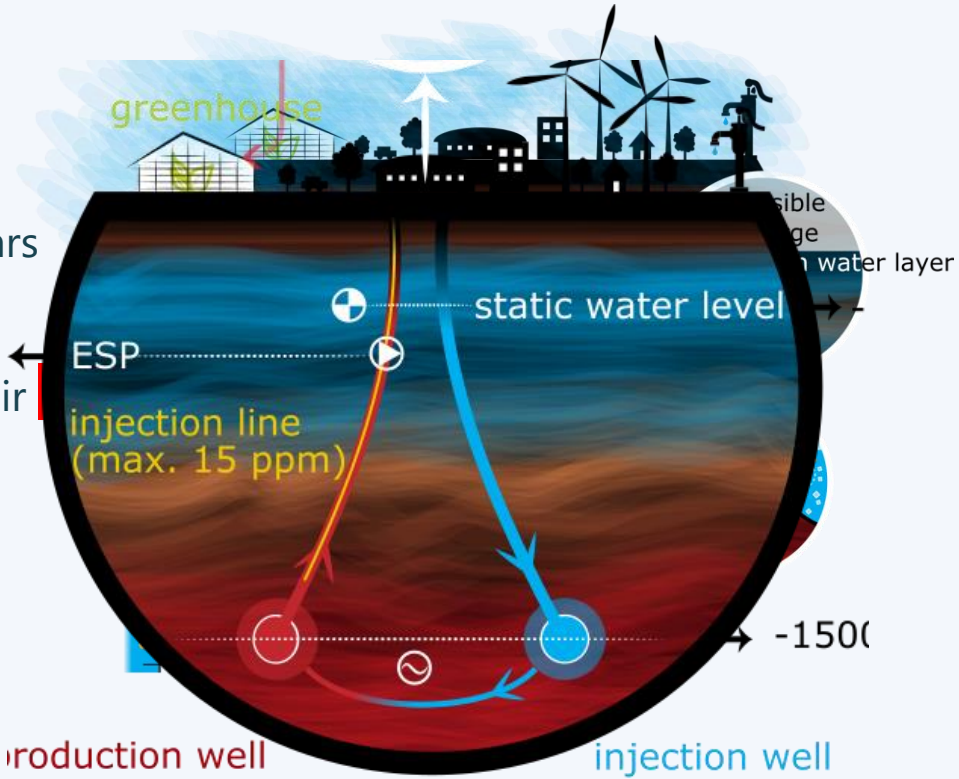
Likelihood → / ↓ Severity	1	2	3	4	5
A	1	1	1	1	1
B	1	1	1	3	3
C	1	2	3	3	4
D	1	3	3	4	5
E	2	3	4	5	5

Risk analysis process

- No risks production site
- No continual monitoring injection - 3 years
- Three risks identified:
  - Injection into the geothermal reservoir
  - Discharge into drinking water layer
  - Discharge into brackish water layer

high risk level

average risk level



Toxicity of inhibitors

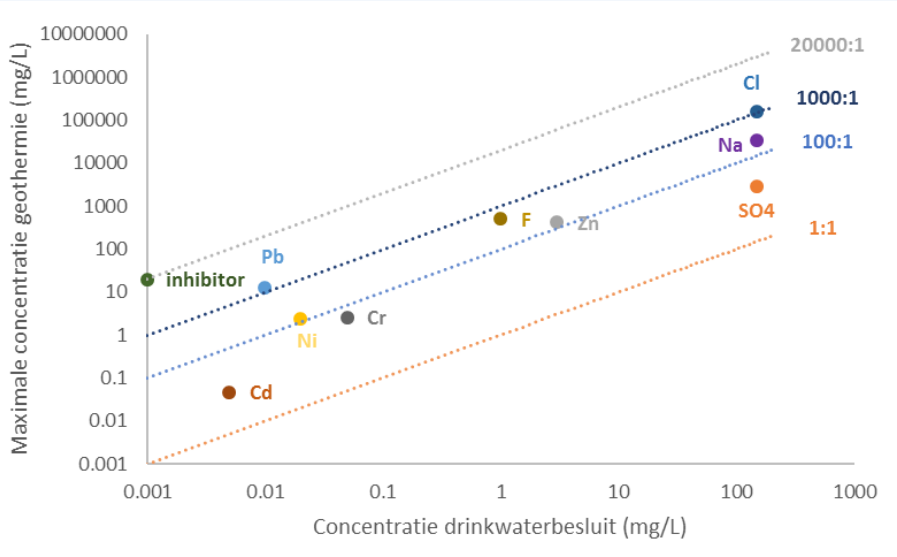
- Different contradicting incomplete classifications
  - Cefas – offshore -> Netherlands
  - WGK – Germany
  - aerobic conditions

Product name	HQ Band (Cefas)	WGK
Cortron CK990-G	Gold	2
CRW83133	Silver	1
CGW80007	-	3
FX2099	-	1

-> Need for European anaerobic guidelines

Impact on the environment

- Signalling value: 0,001 ppm
  - unknown substances drinking water guideline (drinkwaterbesluit)
- Inhibitor has highest relative concentration
  - But <5 wt.% toxic component

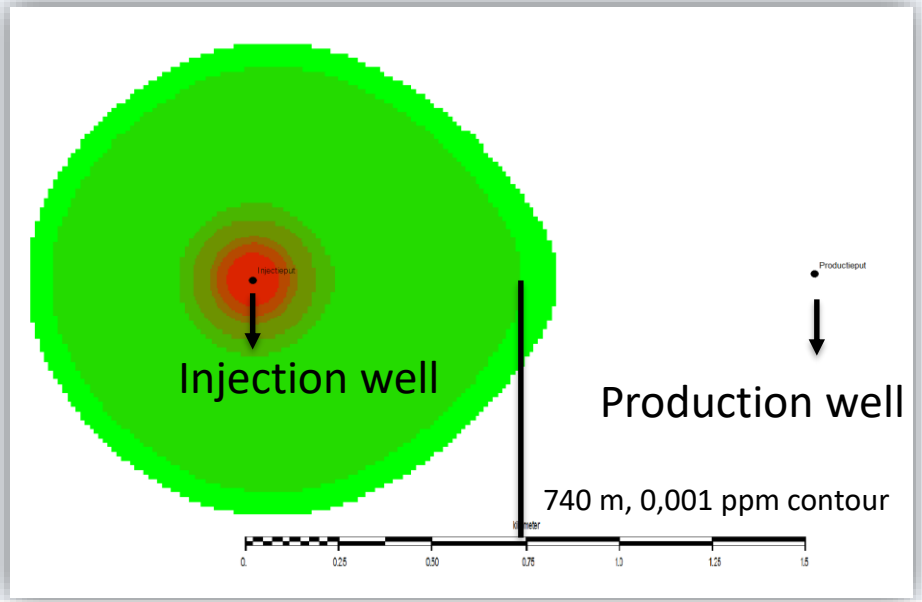


Impact on the environment

- Geohydrological modelling (Modflow and MT3DMS)
  - Worst case
    - No retardation
    - No biodegradation
    - 25 m^3/d leakage flow
    - 3 years before detection
    - Active use of groundwater layers
- Group of experts - review

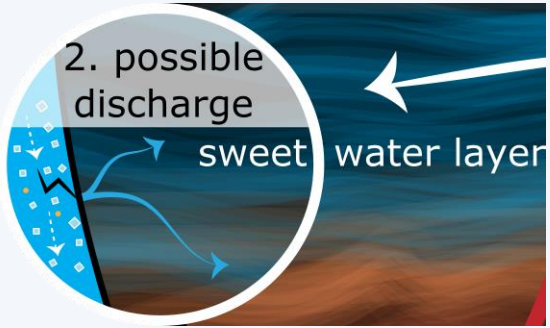
Impact on the environment – scenario 1

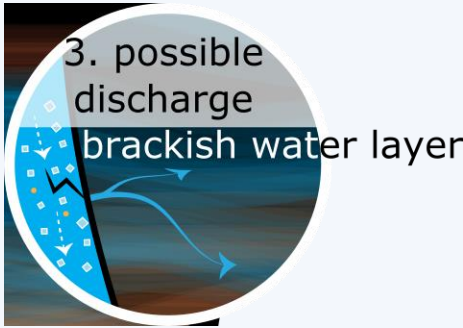
- 10 ppm inhibitor concentration
- 30 years: doesn't reach production well
- Impact on environment: unknown
  - lack of knowledge



Impact on the environment – scenario 2 and 3

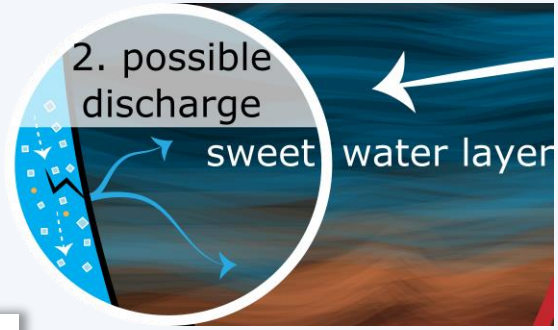
- Water extraction well guidelines:
  - 25 years zone
  - Travel path ground water to well

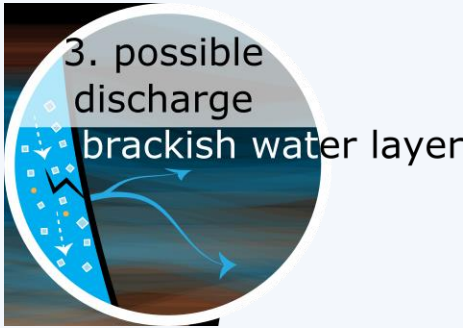


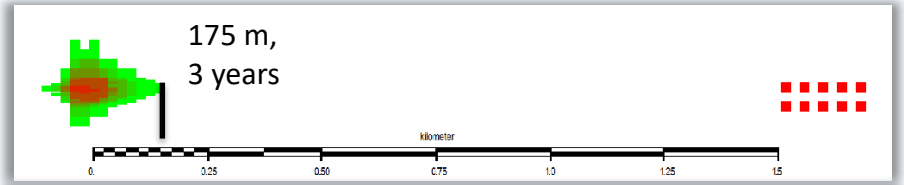


Impact on the environment – scenario 2 and 3

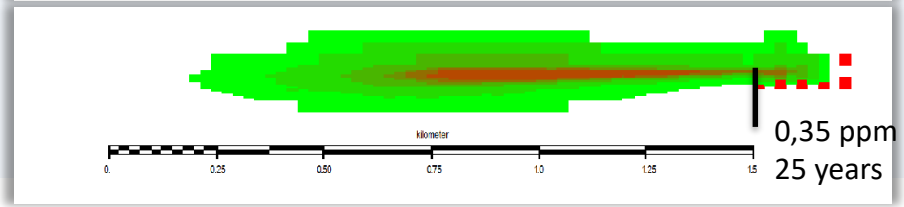
- 10 ppm inhibitor concentration
- Water extraction well:
  - 1500 m, 25 years zone







Without a water extraction well



With a water extraction well

Conclusions

- Inhibitors have a positive effect
  - protective effect against corrosion
  - precipitation of radioactive lead reduced.
- Risk of leakage of inhibitors on the injection side (3 scenario's).
- Geothermal fluid incl. inhibitors has effect on biology
- Geothermal extraction wells not effected
- Fresh or brackish extraction wells can be effected

Recommendations

- Continuous monitoring integrity injection well
- Obtain more knowledge on inhibitor characteristics:
  - Degradation (products)
  - Environmental impact
  - (Optimal)concentration throughout installation
  - Diffusion rate inhibitors
- Explore other construction materials for well

Questions ?

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