Regulatory framework and environmental monitoring strategy: a risk-based approach

Laurence Pinturier, Northern Lights project

Agenda

- → **Short overview of project**
- → **Regulatory framework**
- → **Environmental risk assessment & Monitoring Strategy**

Langskip - Northern Lights

Northern Lights

NORTHERN LIGHTS SCOPE

CO_2 capture

Capture from industrial plants.
Liquefaction and temporary storage.

Transport

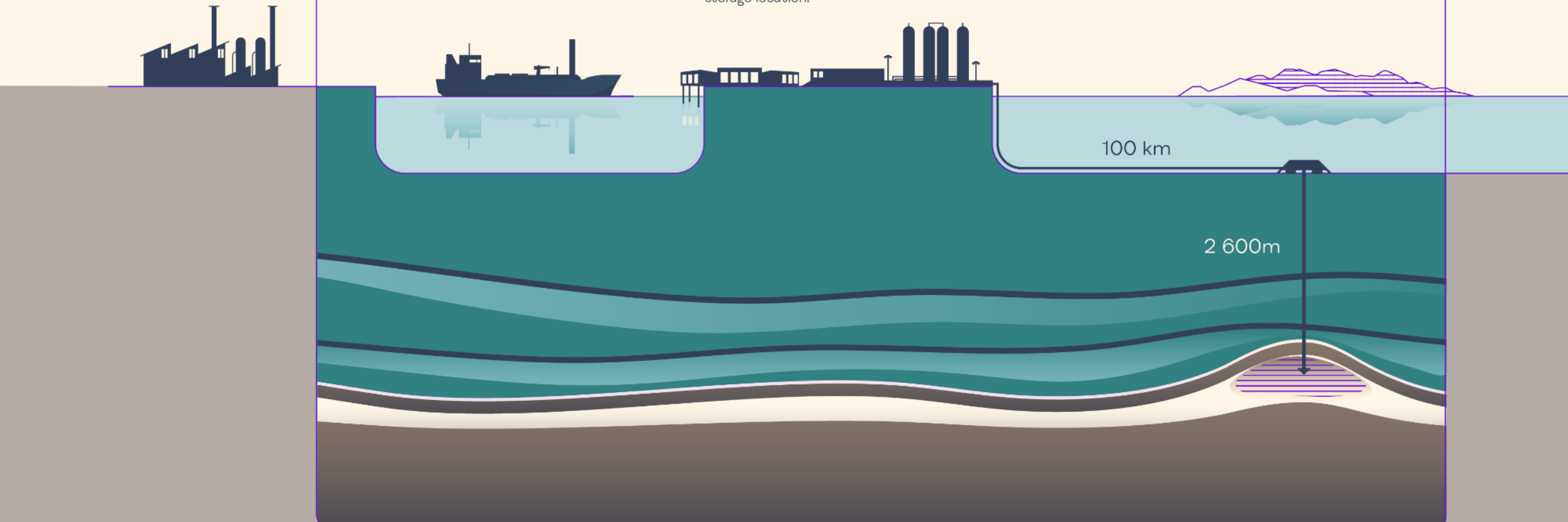
Liquid CO_2
transported by ship.

Receiving terminal

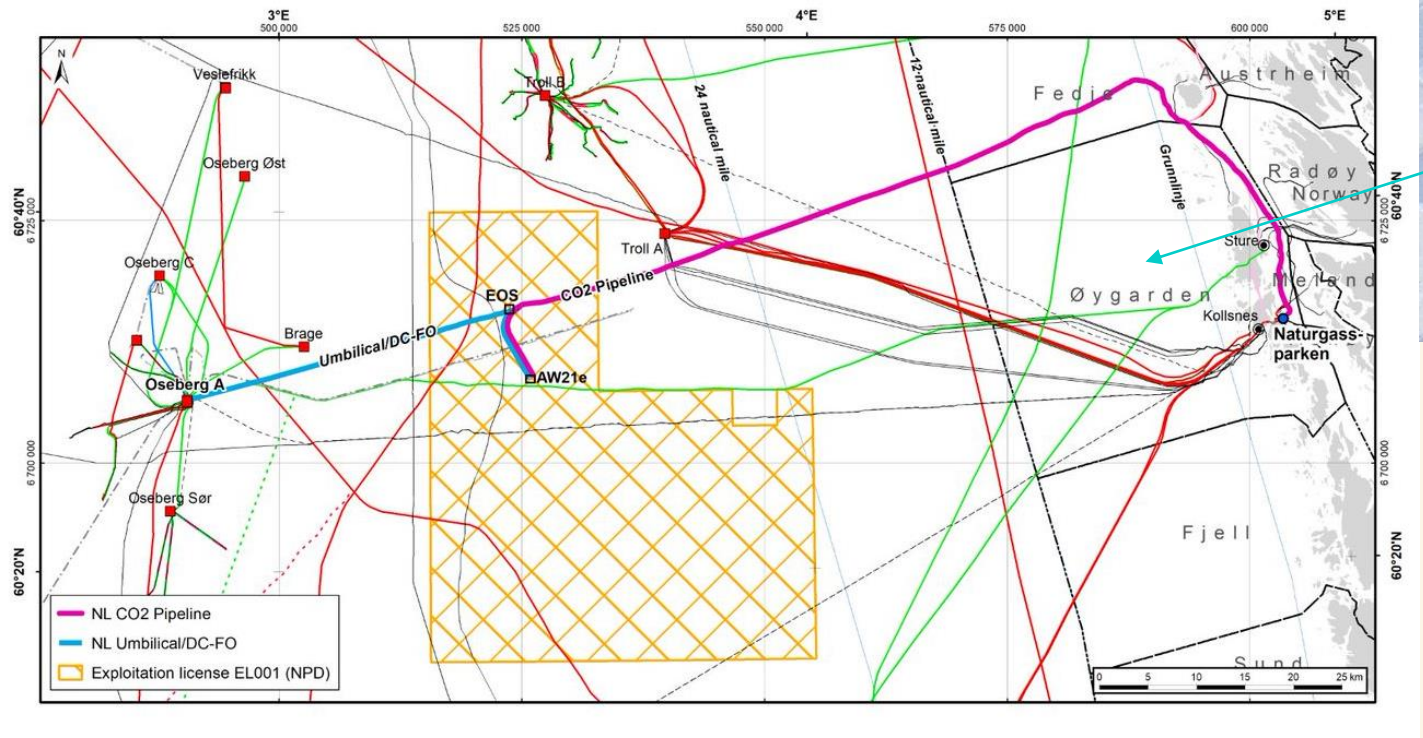
Intermediate onshore storage.
Pipeline transport to offshore
storage location.

Permanent storage

CO_2 is injected into a saline aquifer.



Where?


3°E
500 000
525 000
4°E
550 000
575 000
600 000
5°E
60°40'N
60°20'N
6 725 000
6 700 000
Vestefrikk
Oseberg Øst
Oseberg C
Brage
Oseberg A
Oseberg Sør
Troll B
Troll A
24 nautical mile
12-nautical mile
Grunnlinje
EOS
CO2-Pipeline
Umbilical/DC-FO
AW21e
Fedje
Austrheim
Radøy
Norway
Sture
Øygarden
Kollsnes
Naturgass-
parken
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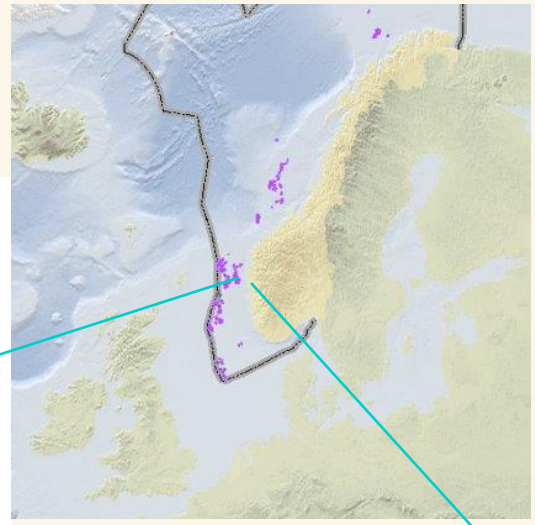
Sund
0 5 10 15 20 25 km
NL CO2 Pipeline
NL Umbilical/DC-FO
Exploitation license EL001 (NPD)




Multiconsult

Regulatory framework

→ **Norwegian regulations – Based on the EU CCS Directive***

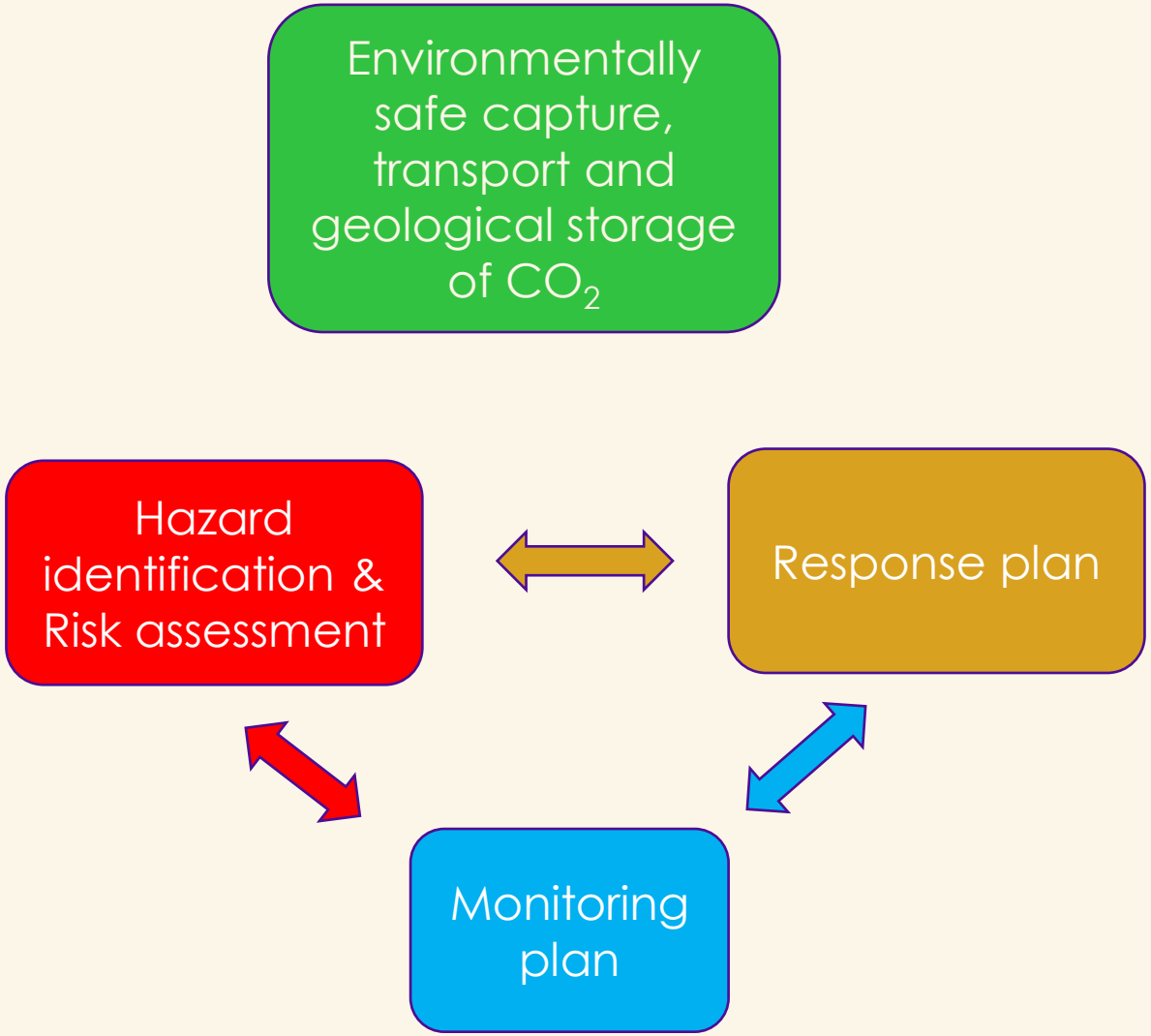
- CO_2 storage regulation
- CO_2 safety regulation
- Pollution regulation

→ **Risk-based framework**

- Plan for development, installation & operation
- Permits for injection &storage
- Permits for taking into use facilities

-> Monitoring plan

- Conformance & containment
- Response plan



* DIRECTIVE 2009/31/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006

Overall monitoring plan

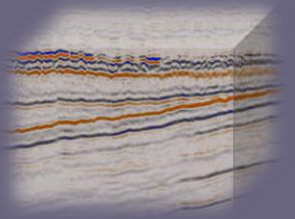
Ship and land facility monitoring

Regular inspection and test of pipeline and subsea installation

Well operations monitoring

Environmental monitoring: Triggered monitoring plan

Active and passive seismic monitoring of the underground



Environmental Risk Assessment

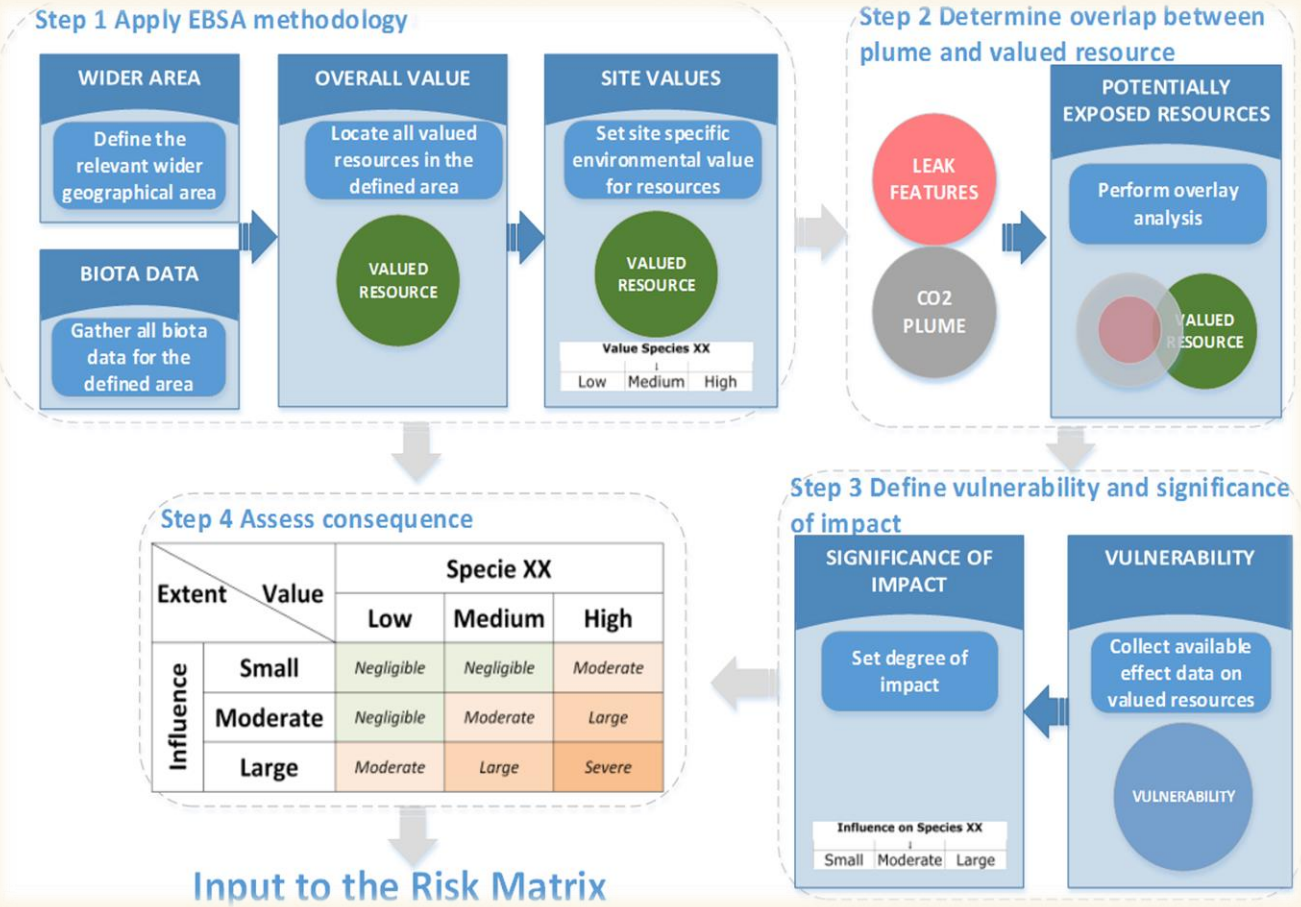
→ Best practice guideline from DNV ECO_2 project

→ Hazard scenarios extracted from

- Containment risk analysis
- Pipeline rupture analysis
- Onshore risk analysis

→ Ph changes as a proxy for effect assessment

→ Resource mapping based on available data (large dataset)



Environmental Risk Assessment main conclusion

Pipeline

- Small size hole to full rupture
- Several vulnerable resources identified inshore
- Low environmental risk for small leakage on seabed
- Low to moderate risk at the sea surface for large rupture

Table 10 Environmental risk matrix for small leakage rate (larger influence area). The numbers are representing the environmental resources at risk (ref DNV-GL, 2019). 17,18,19,20,25,31 are seabirds and 42 an otter. The yellow colour indicates moderate environmental risk. *

Probability	Consequences			
	Negligible/Low	Moderate	Large	Very large
Unlikely (<1 %)	3,4,5,8,9,10,11,12,13	1,2,6,7	42	
Possible (1 – 10 %)	15,16, ,21, 22,23, 24,26,27 28,29,30,32,33,34,35, 36,37,38,39,40	17,18,19,20, 25,31		
Likely (>10 %)				

17 Common guillemot (*Uria aalge*), 18 Puffin (*Fratercula arctica*), 19 Common tern (*Sterna hirundo*), 20 Velvet scotter (*Melanita fusca*), 25 Northern fulmar (Fulmarus glacialis), 31 Black guillemot (*Cepphus grylle*), 42 Otter

Storage complex

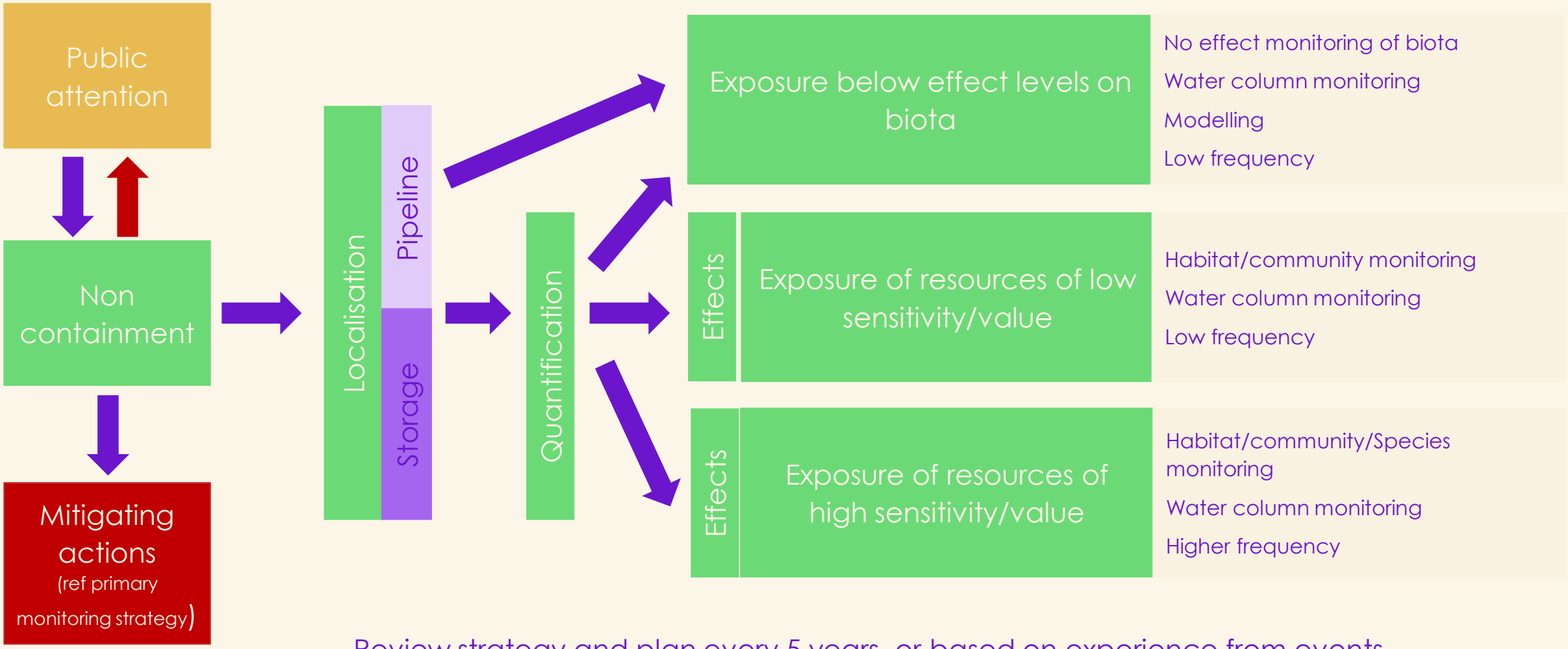
- Injection wells, legacy wells and geological pathways
- No vulnerable resources identified
- Influense area limited
- No CO_2 reaching sea surface
- Low risk

Table 6-2: Env. Risk Storage complex*

	Environmental consequences			
probability	Negligible/low	Moderate	Large	Very Large
Unlikely (1%)	b,c,d,e,g,h,l,l			
Possible (1-10%)				
Likely (>10%)				

*** ENVIRONMENTAL RISK ANALYSIS AND STRATEGY FOR ENVIRONMENTAL MONITORING –EQUINOR, 2019-0745, rev1, DNV**

Environmental monitoring strategy



Review strategy and plan every 5 years, or based on experience from events

Identified vehicles and sensors

	ROV-design	AUV-design	Supplementary Monitoring Solutions
Location	ROV study with hydroacoustic equipment Applicability: 3 Maturity: 3	AUV study with hydroacoustic equipment Applicability: 3 Maturity: 3	Surface vessels with hull mounted hydroacoustic equipment Applicability: 3 Maturity: 3
Verification	Direct targets in the gas bubbles -Flux chamber -pCO2 sensor Applicability: 3 Maturity: 3	Transect examination as close to the source as possible -pO2 / pCO2 sensor -pH sensor Applicability: 2 Maturity: 2	
Quantification	Direct targets in the gas bubbles -Flux chamber Applicability: 3 Maturity: 3	Establishment of model -pO2 / pCO2 sensor -pH sensor -Current Measurements Applicability: 2 Maturity: 2	
Effects	Transect examination as close to the source as possible -pO2 / pCO2 sensor -pH sensor Applicability: 3 Maturity: 2	Transect examination as close to the source as possible -pO2 / pCO2 sensor -pH sensor Applicability: 2 Maturity: 2	Ocean acidification program Establishment of model Obtaining current data from measurements or modeled current (North Coast 800) Applicability: 3 Maturity: 3 Biodiversity measurements - through sediment monitoring (M-300) Applicability: 2 Maturity: 3

Kongsberg AUV &Glider

HUGIN:
Flexible System with Unmatched Performance

SEAGLIDER:
Extreme Long Endurance, Low Cost AUV

Reshaping Underwater Operations — Eelume

Baseline surveys and data

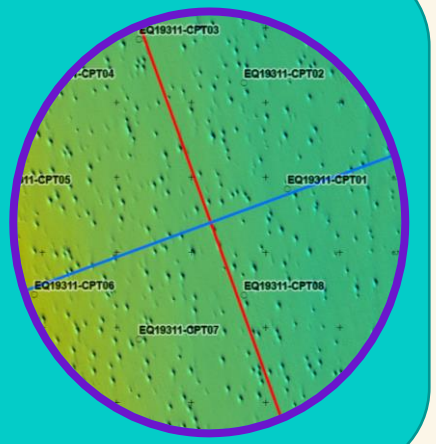
→ **No planned environmental survey before injection**

- Seabed surveys
- 4 D Seismic baseline
- Regular environmental sediment monitoring in the area
- Extensive databases for O&G risk assessment

→ **Consider field test of instrument/underwater vehicles**

- Improve simulation model for underwater CO_2 release
- Qualify/test instrument for CO_2 detection & quantification (vehicle and sensor)

- Flat
- Covered with shallow pockmarks
- Sonar investigations show no gas seepage
- No connection to the deep CO_2 storage



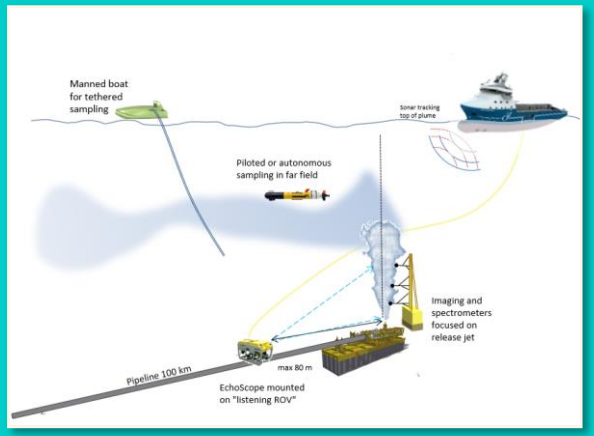


Illustration from SINTEF

Summary Environmental monitoring strategy NL

Strategy defined based on risk as per regulation

Triggered plan in case of irregularities /potential leakages

Plan to be submitted to the authority as per permit approval