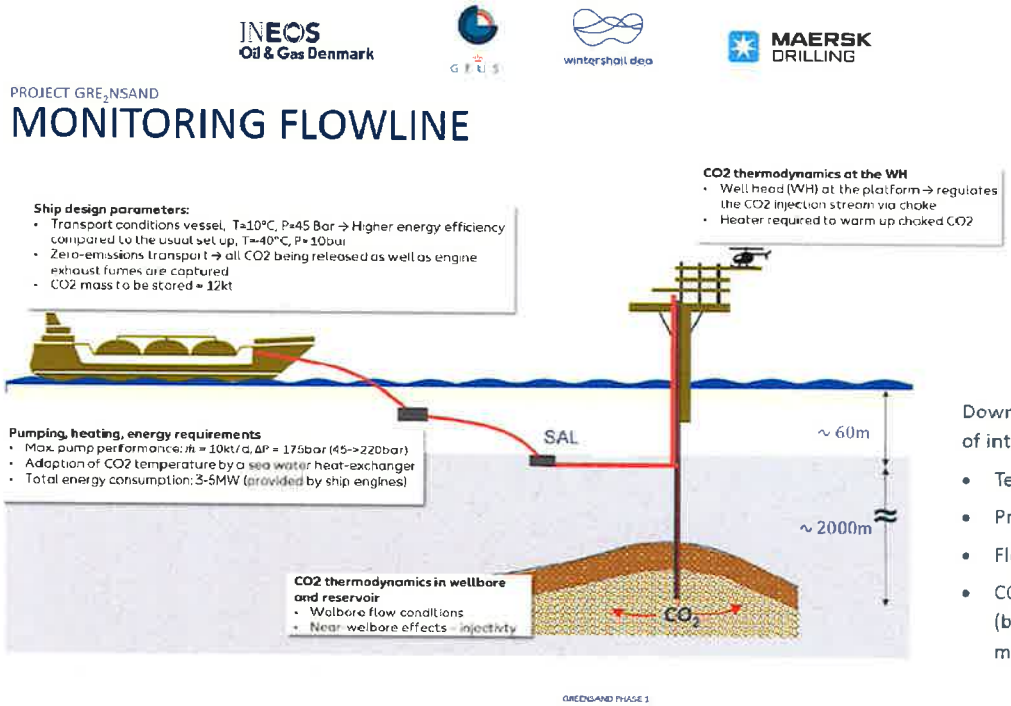
Project Greensand Phase 1

Monitoring Plan

Monitoring plan, Nini West

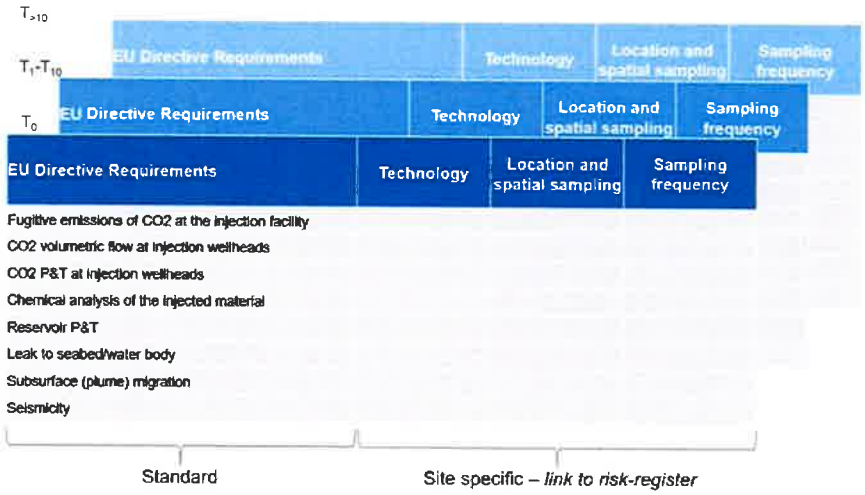
Project Greensand Phase 1

Overview



Downhole measurements of interest:

- Temperature
- Pressure
- Flow rate
- CO2 emplacement (borehole seismic methods)



No.	Reference
[1]	Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide; Guidance Document 2; Chartacterication of the Storage Complex, CO_2 Stream Composition, Monitoring and Corrective Measures (p.94) (-> also referred to as the **EU Directive Guideline**)

1. Fugitive emissions of CO2 at the injection facility (and vessel + SAL)

Time period: T_0 (pre-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS
Fugitive emissions of CO_2 at the injection facility (and vessel + SAL)	Pressure and temperature gauges	ship, wellhead, connection pipes	continuous	intended
	Laser technique for CO_2-detection	ship, wellhead, connection pipes	continuous	intended
	Passive acoustics (geophones, -> **UoS**)	water column	baseline	alternative
	GHR Lidar Dial measurements (-> **DFM& NLIR**)	ship (DNMI), facility	baseline	alternative
	Lander (-> NOC) (pH-dectector)	seafloor (SAL)	baseline	alternative

Time period: $T_{1\ to}T_{10}$ (injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS
Fugitive emissions of CO_2 at the injection facility (and vessel + SAL)	Pressure and temperature gauges	wellhead, connection pipes	continuous	intended
	Laser technique for CO_2-detection	wellhead, connection pipes	continuous	intended
	Passive acoustics (geophones, -> **UoS**)	water column	injection phase, continuous	alternative
	GHR Lidar Dial measurements (-> **DFM& NLIR**)	ship (DNMI), facility	injection phase, continuous	alternative
	Lander (-> NOC)	seafloor (SAL)	injection phase, continuous	alternative

Time period: $T_{>10}$ (assumption: well not yet abandoned); (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	Status	Remark WD_INEOS
Fugitive emissions of CO_2 at the injection facility (and vessel + SAL)	Pressure and temperature gauges	wellhead, connection pipes	continuous	intended	

Time period: $T_{>>10\ to}T_{40}$ (assumption: abandonment); (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	Status	Remark WD_INEOS
Fugitive emissions of CO_2 at the injection facility (and vessel + SAL)	---	---	---	---	Euipment would be decommissioned

REMARK:
1) Each section is labeled as a 'STAND-ALONE CHARACTER: (causing repetition of devices)

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2. CO2 volumetric flow at injection wellhead

Time period: T_0 (pre-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
CO_2 volumetric flow at injection wellhead	Pressure gauges -> permanent gauges	wellhead	continuous	intended	
	Temperature detector	wellhead	continuous	intended	

Time period: $T_{1\ to}T_{10}$ (injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
CO_2 volumetric flow at injection wellhead	Pressure gauges -> permanent gauges	wellhead	continuous	intended	
	Temperature detector	wellhead	continuous	intended	
	Flow meter	wellhead	injection phase	intended	Fiscal meter on platform, reference meter on vessel; That will be a parameter in the fiscal model (include heel).

Time period: $T_{>10}$ (assumption: well not yet abandoned) (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
CO_2 volumetric flow at injection wellhead	Pressure gauges -> permanent gauges	wellhead	continuous	intended	
	Temperature detector	wellhead	continuous	intended	

Time period: $T_{>>10}$ to T_{40} (assumption: abandonment); (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS
CO_2 volumetric flow at injection wellhead	---	---	---	---

REMARK:
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3. CO2 pressure and temperature at injection wellhead

Time period: T_0 (pre-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS
CO_2 pressure and temperature at injection wellhead	Pressure gauges -> permanent gauges	Injection facility, wellhead	continuous	intended
	Temperature detector	Injection facility, wellhead	continuous	intended
wellbore (and well integrity) CO_2 pressure and temperature	Permanent Downhole Pressure Gauge (PDG)	Downhole injection well, at reservoir interval	continuous	intended
	Permanent Downhole Temperature Gauge	Downhole injection well, at reservoir interval	continuous	intended
	Distributed Temperature Sensing Systems (DTS)	Injection well, along wellbore	optional/ basline	alternative
	Distributed Acoustic Sensing Systems (DAS)	Injection well, along wellbore	optional/ basline	alternative

Time period: T_1 to T_{10} (injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS
CO_2 pressure and temperature at injection wellhead	Pressure gauges -> permanent gauges	Injection facility, wellhead	continuous	intended
	Temperature detector	Injection facility, wellhead	continuous	intended
	Flow meter	wellhead	injection phase	intended
	Permanent Downhole Pressure Gauge (PDG)	Downhole injection well, at reservoir interval	continuous injection stage; later stage: Essential for reservoir simulation.	intended
wellbore (and well integrity) CO_2 pressure and temperature	Permanent Downhole Temperature Gauge	Downhole injection well, at reservoir interval	cotinuous	intended
	Distributed Temperature Sensing Systems (DTS)	Injection well; along wellbore	optional/periodical (re-start injection/ 1/2 year)	alternative
	Distributed Acoustic Sensing Systems (DAS)	Injection well; along wellbore	optional/periodical	alternative

REMARK:
1) Each section is labeled as a ´STAND-ALONE CHARACTER: (causing repetition of devices)

3. CO2 pressure and temperature at injection wellhead

Time period: $T_{>10}$ (assumption: well not yet abandoned); (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS
CO_2 pressure and temperature at injection wellhead	Pressure gauges -> permanent gauges	Injection facility, wellhead	continuous	intended
	Temperature detector	Injection facility, wellhead	continuous	intended
wellbore (and well integrity) CO_2 pressure and temperature	Permanent Downhole Pressure Gauge (PDG)	Injector well, downhole at reservoir interval	continuous	intended
	Permanent Downhole Temperature Gauge	Injector well, downhole at reservoir interval	continuous	intended
	Distributed Temperature Sensing Systems (DTS)	Injection well; along wellbore	optional/periodical (tbd)	alternative
	Distributed Acoustic Sensing Systems (DAS)	Injection well; along wellbore	optional/periodical (tbd)	alternative

Time period: $T_{>>10}$ to T_{40} (assumption: abandonment); (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS
CO_2 pressure and temperature at injection wellhead	---	---	---	---
wellbore (and well integrity) CO_2 pressure and temperature	---	---	---	---

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4. Chemical analysis of the injected material

Time period: T_0 (pre-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
4. Chemical analysis of the injected material	Analytical Sensor Systems	onshore	per each ship transfer	intended	Recommend onshore certificate, offshore analysis not feasible
	Analytical Sensor Systems	onshore	tbd	alternative	QC recommended (onshore) e.g. optical sensor, GC-measurements

Time period: T_1 to T_{10} (injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
Chemical analysis of the injected material	Analytical Sensor Systems	onshore	per each ship transfer, injection phase	intended	Recommend onshore certificate, offshore analysis not feasible
	Analytical Sensor Systems	offshore	tbd	alternative	QC recommended (onshore) e.g. optical sensor, GC-measurements

Time period: $T_{>10}$ (assumption: well not yet abandoned); (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
Chemical analysis of the injected material	---	---	---	----	

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5. Reservoir pressure and temperature (CO2 phase behaviour)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS
Reservoir pressure and temperature (CO_2 phase behaviour)	Permanent Downhole Temperature Gauge (PDG)	Downhole injection well, at reservoir interval	continuous	intended
	Permanent Downhole Pressure Gauge (PDG)	Downhole injection well, at reservoir interval	continuous	intended
	Distributed Temperature Sensing Systems (DTS)	Injection well; along wellbore	optional/ basline	alternative
	Simulation (PVT/EOS...Equation of St	—	continuous	intended

Time period: T_1 to T_{10} (Injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS
Reservoir pressure and temperature (CO_2 phase behaviour)	Permanent Downhole Pressure Gauge (PDG)	Downhole injection well, monitoring wells, at reservoir interval	continuous	intended
	Permanent Downhole Temperature Gauge (PDG)	Downhole injection well, at reservoir interval	continuous	intended
	Distributed Temperature Sensing Systems (DTS)	Injection well; along wellbore	optional/ periodical (re-start injection/ 1/2 year)	alternative
	downhole fluid sampling	Injection well, all spots of interest	optional/ periodical (re-start injection)	alternative
	Simulation (PVT/EOS...Equation of St	—	continuous	intended

Time period: $T_{>10}$ (assumption: well not yet abandoned); (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS
Reservoir pressure and temperature (CO_2 phase behaviour)	Permanent Downhole Pressure Gauge (PDG)	Downhole injection well, monitoring wells, at reservoir interval	periodical (tbd)	intended
	Permanent Downhole Temperature Gauge (PDG)	Downhole injection well, at reservoir interval	periodical (tbd)	intended
	Simulation (PVT/EOS...Equation of St	—	continuous	intended

Time period: $T_{>>10}$ to T_{40} (assumption: abandonment); (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS
Reservoir pressure and temperature (CO_2 phase behaviour)	Simulation (PVT/EOS...Equation of St	—	continuous	intended

REMARK:
1) Each section is labeled as a 'STAND-ALONE CHARACTER: (causing repetition of devices)

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6. Location and migration paths of CO2 (subsurface, surface)

Time period: T_0 (pre-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
6. Location and migration paths of CO_2 (subsurface, surface)	Bottom Hole Pressure (BHP) -gauge	Injection well	continuous	intended	essential for simulation
	by intervention using an adequate logging tool to obtain the required information (-> standard/specialized logging tools)	Injection well (problem specific)	tbd	alternative	Cement Bond Logging; Multifinger Caliper ; Veriable Density Sonic Logging (VDSL); Ultra Sonic Imaging tool (USIT) ; Electromagnetic imaging...
	by intervention using an adequate acoustic logging tool (cement issues)	Injection well (problem specific)	tbd	alternative	e.g. Cement Bond Logging; Veriable Density Sonic Logging (VDSL); Ultra Sonic Imaging tool (USIT) ;
	Pressure testing of annulus	Injector / monitoring wells; preferably at any well in CO_2 contact	baseline	intended	
	Leakoff test/FIT	injection well	baseline	intended	
	Seismic spot imaging	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	baseline	intended	to be tested in phase 2
	Micro-seismicity	Faults & Fractures	----	intended	would be included in spot imaging
	Streamer 3D seismic	water surface; all spots of interest (Siri fairway)	----	alternative	
	using an adequate logging tool to obtain the required information wrt saturation near wellbore)		optional/ baseline	alternative	
	Simulation	---	history match	intended	
	Eddy Covariance (flux concentration measurement)	water column, flux measurement	baseline,	alternative	Risk register: no potential high leakage detected; tools are denoted as alternative
	ROV (Remotely Operating Vehicle) – visual inspection	water column	baseline		
	Lander/in-situ benthic chambers -> equipped with chemical sensors (lab-on-chip chemical sensors for pH, Optode optical sensors)	benthic, **at risk areas** (wells, seismic anomalies)	baseline		
	Monitoring bubbles in the water column (sonar technoology); mounted on lander	water column (**in risk areas**)	baseline		
	Conductivity-Temperature-Depth (CTD) Casts	water column (in risk areas)	baseline		
	Lander– Acoustic (passiv)	water column	baseline		
	Sediment microprofiler	seafloor and sub-seafloor, insitu-profile	baseine		
	Autonomous Underwater Vehicle Chirp Profiler (AUV)	seafloor and sub-seafloor	baseline		

REMARK:
1) Each section is labeled as a ´STAND-ALONE CHARACTER: (causing repetition of devices)

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6. Location and migration paths of CO2 (subsurface, surface)

Time period: $T_{1\,to}T_{10}$ (injection phase)

EU Directive MANDATORY [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
location and migration paths of CO2 (subsurface, surface)	Bottom Hole Pressure (BHP) -gauge	Injection well	continuous	intended	essential for simulation
	by intervention using an adequate logging tool to obtain the required information (-> standard/specialized logging tools)	Injection well (problem specific)	tbd	intended	Cement Bond Logging; Multifinger Caliper; Veriable Density Sonic Logging (VDSL); Ultra Sonic Imaging tool (USIT) : Electromagnetic imaging, Distributed Acoustic Sensing Systems (DAS), Distributed Temperature Sensing Systems (DTS)
	Seismic spot imaging	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	continuous (monthly)	intended	to be tested in phase 2
	Micro-seismicity	Faults & Fractures	continuous	intended	would be included in spot imaging
	Streamer 3D seismic	water surface; all spots of interest (Siri fairway)	every 5 years	alternative	
	Simulation		adapted to outcome	intended	
	using adequate logging tool to obtain the required information wrt saturation near wellbore)		optional	alternative	
	Eddy Covariance (flux concentration measurement)	water column, flux measurement	continuous, tbd	alternative	Risk register: no potential high leakage detected; tools are denoted as alternative
	ROV (Remotely Operating Vehicle) – visual inspection	water column	continuous		
	Lander/in-situ benthic chambers -> equipped with chemical sensors (lab-on-chip chemical sensors for pH, Optode optical sensors)	benthic, **at risk areas** (wells, seismic anomalies)	continuous		
	Monitoring bubbles in the water column (sonar technoology); mounted on lander	water column **(in risk areas)**	tbd		
	Conductivity-Temperature-Depth (CTD) Casts	water column (in risk areas)	tbd		
	Lander– Acoustic (passiv)	water column	tbd		
	Sediment microprofiler	seafloor and sub-seafloor, insitu-profile	continuous		
	Autonomous Underwater Vehicle Chirp Profiler (AUV)	seafloor and sub-seafloor	continuous		

REMARK:
1) Each section is labeled as a ´STAND-ALONE CHARACTER: (causing repetition of devices)

6. Location and migration paths of CO2 (subsurface, surface)

Time period: $T_{>10}$ (assumption: well not yet abandoned); (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
location and migration paths of CO2 (subsurface, surface)	Bottom Hole Pressure (BHP) -gauge	Injection well	continuous	intended	essential for simulation
	by intervention using an adequate logging tool to obtain the required information (-> standard/specialized logging tools)	Injection well (problem specific)	tbd	intended	Cement Bond Logging; Multifinger Caliper; Veriable Density Sonic Logging (VDSL); Ultra Sonic Imaging tool (USIT) ; Electromagnetic imaging, Distributed Acoustic Sensing Systems (DAS), Distributed Temperature Sensing Systems (DTS)
	Pressure testing	Injection well	tbd	intended	
	Seismic spot imaging	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	tbd	intended	to be tested in phase 2
	Streamer 3D seismic	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	every 5 year	alternative	
	simulation		adapted to outcome	intended	
	Eddy Covariance (flux concentration measurement)	water column, flux measurement	continuous, tbd	alternative	Risk register: no potential high leakage detected; tools are denoted as alternative
	ROV (Remotely Operating Vehicle) – visual inspection	water column	continuous		
	Lander/in-situ benthic chambers -> equipped with chemical sensors (lab-on-chip chemical sensors for pH, Optode optical sensors)	benthic, **at risk areas** (wells, seismic anomalies)	continuous		
	Monitoring bubbles in the water column (sonar technoology); mounted on lander	water column (**in risk areas**)	tbd		
	Conductivity-Temperature-Depth (CTD) Casts	water column (in risk areas)	tbd		
	Lander– Acoustic (passiv)	water column	tbd		
	Sediment microprofiler	seafloor and sub-seafloor, insitu-profile	continuous		
	Autonomous Underwater Vehicle Chirp Profiler (AUV)	seafloor and sub-seafloor	continuous		

REMARK:
1) Each section is labeled as a ´STAND-ALONE CHARACTER: (causing repetition of devices)

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6. Location and migration paths of CO2 (subsurface, surface)

Time period: T>>$_{10}$ to T_{40} (assumption: abandonment); (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
location and migration paths of CO_2 (subsurface, surface)	Seismic spot imaging	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	not yet regulated	intended	to be tested in phase 2
	Streamer 3D seismic	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	not yet regulated	alternative	
	simulation		adapted to outcome	intended	
	Eddy Covariance (flux concentration measurement)	water column, flux measurement	continuous, tbd	alternative	Risk register: no potential high leakage detected; tools are denoted as alternative
	ROV (Remotely Operating Vehicle) – visual inspection	water column	continuous		
	Lander/in-situ benthic chambers -> equipped with chemical sensors (lab-on-chip chemical sensors for pH, Optode optical sensors)	benthic, **at risk areas** (wells, seismic anomalies)	continuous		
	Monitoring bubbles in the water column (sonar technoology); mounted on lander	water column (**in risk areas**)	tbd		
	Conductivity-Temperature-Depth (CTD) Casts	water column (in risk areas)	tbd		
	Lander– Acoustic (passiv)	water column	tbd		
	Sediment microprofiler	seafloor and sub-seafloor, insitu-profile	continuous		
	Autonomous Underwater Vehicle Chirp Profiler (AUV)	seafloor and sub-seafloor	continuous		

REMARK:
1) Each section is labeled as a 'STAND-ALONE CHARACTER: (causing repetition of devices)

7. CO2 plume

Time period: T_0 (pre-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
CO_2 plume (pressure volume and areal/vertical behaviour) purpose: refinement of 3D simulation	Permanent Downhole Pressure Gauge (PDG)	Downhole injection well; at reservoir interval	continuous	intended	
	by intervention using adequat logging tool to obtain the required inforamtion (-> standard/specialized logging tools)	Injection well (problem specific)	periodically	intended	
	Seismic spot imaging	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	baseline	intended	to be tested in phase 2
	Streamer 3D seismic	water surface; all spots of interest (Siri fairway)	---	alternative	
	Simulation	---	history match	intended	

Time period: T_1 to T_{10} (injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
	Permanent Downhole Pressure Gauge (PDG)	Downhole injection well, monitoring wells; at reservoir interval	continuous	intended	
CO_2 plume (pressure volume and areal/vertical behaviour) purpose: refinement of 3D simulation	by intervention using adequat logging tool to obtain the required inforamtion (-> standard/specialized logging tools)	Injection well (problem specific)	periodically	intended	
	Seismic spot imaging	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	continuous (monthly)	intended	to be tested in phase 2
	Streamer 3D seismic	water surface; all spots of interest (Siri fairway)	every 5 years	alternative	Define in terms of injection volume for the monitor survey (e.g. @ 10%, 50%, 100%)
	Simulation	---	adapted to outcome	intended	

REMARK:
1) Each section is labeled as a 'STAND-ALONE CHARACTER: (causing repetition of devices)

7. CO2 plume

Time period: $T_{>10}$ (assumption: well not yet abandoned); (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
CO_2 plume (pressure volume and areal/vertical behaviour) purpose: refinement of 3D simulation	Permanent Downhole Pressure Gauge (PDG)	Downhole injection well, monitoring wells: at reservoir interval	continuous	intended	
	Seismic spot imaging	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	continuous (monthly)	intended	to be tested in phase 2
	Streamer 3D seismic	water surface; all spots of interest (Siri fairway)	every 5 years	alternative	
	Simulation	---	adapted to outcome	intended	

Time period: $T>>_{10}$ to T_{40} (assumption: abandonment); (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
CO2 plume (pressure volume and areal/vertical behaviour) purpose: refinement of 3D simulation	Seismic spot imaging	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	not yet regulated	intended	to be tested in phase 2
	Streamer 3D seismic	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	not yet regulated	alternative	
	Simulation	---	adapted to outcome	intended	

REMARK:
1) Each section is labeled as a 'STAND-ALONE CHARACTER: (causing repetition of devices)

8. Potential leakage pathway (areal dimension)

Time period: T_0 (pre-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
8. Potential leakage pathway (areal dimension)	Eddy Covariance (flux concentration measurement)	water column, flux measurement	baseline, continuous	alternative	Risk register: no potential high leakage detected; tools are denoted as alternative
	ROV (Remotely Operating Vehicle) – visual inspection	water column	baseline		
	Lander/in-situ benthic chambers -> equipped with chemical sensors (lab-on-chip chemical sensors for pH, Optode optical sensors)	benthic, **at risk areas** (wells, seismic anomalies)	baseline, continuous		
	Monitoring bubbles in the water column (sonar technoology); mounted on lander	water column **(in risk areas)**	baseline		
	Conductivity-Temperature-Depth (CTD) Casts	water column (in risk areas)	baseline		
	Lander– Acoustic (passiv)	water column	baseline, continuous		
	Sediment microprofiler	seafloor and sub-seafloor, insitu-profile	baseine		
	Autonomous Underwater Vehicle Chirp Profiler (AUV)	seafloor and sub-seafloor	baseline		
Seismicity	Seismic spot imaging	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	baseline	intended	to be tested in phase 2
	Micro-seismicity	Faults & Fractures	----	intended	would be included in spot imaging
	Streamer 3D seismic	water surface; all spots of interest (Siri fairway)	----	alternative	
	Simulation	---	continuous	intended	

REMARK:
1) Each section is labeled as a 'STAND-ALONE CHARACTER: (causing repetition of devices)

8. Potential leakage pathway (areal dimension)

Time period: T_1 to T_{10} (injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
8. Potential leakage pathway (areal dimension)	Eddy Covariance (flux concentration measurement)	water column, flux measurement	continuous, tbd	alternative	Risk register: no potential high leakage detected; tools are denoted as alternative
	ROV (Remotely Operating Vehicle) – visual inspection	water column	continuous		
	Lander/in-situ benthic chambers -> equipped with chemical sensors (lab-on-chip chemical sensors for pH, Optode optical sensors)	benthic, **at risk areas** (wells, seismic anomalies)	continuous		
	Monitoring bubbles in the water column (sonar technoology); mounted on lander	water column (**in risk areas**)	tbd		
	Conductivity-Temperature-Depth (CTD) Casts	water column (in risk areas)	tbd		
	Lander– Acoustic (passiv)	water column	tbd		
	Sediment microprofiler	seafloor and sub-seafloor, insitu-profile	continuous		
	Autonomous Underwater Vehicle Chirp Profiler (AUV)	seafloor and sub-seafloor	continuous		
Seismicity	Seismic spot imaging	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	continuous (monthly)	intended	to be tested in phase 2
	Micro-seismicity	Faults & Fractures	continuous	intended	would be included in spot imaging
	Streamer 3D seismic	water surface; all spots of interest (Siri fairway)	every 5 years	alternative	
	Simulation	---	adapted to outcome	intended	

REMARK:
1) Each section is labeled as a 'STAND-ALONE CHARACTER: (causing repetition of devices)

8. Potential leakage pathway (areal dimension)

Time period: $T_{>10}$ (assumption: well not yet abandoned); (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
8. Potential leakage pathway (areal dimension)	Eddy Covariance (flux concentration measurement)	water column, flux measurement	continuous, tbd	alternative	Risk register: no high potential leakage detected; tools are denoted as alternative
	ROV (Remotely Operating Vehicle) – visual inspection	water column	continuous		
	Lander/in-situ benthic chambers -> equipped with chemical sensors (lab-on-chip chemical sensors for pH, Optode optical sensors)	benthic, **at risk areas** (wells, seismic anomalies)	continuous		
	Monitoring bubbles in the water column (sonar technoology); mounted on lander	water column (**in risk areas**)	tbd		
	Conductivity-Temperature-Depth (CTD) Casts	water column (**in risk areas**)	tbd		
	Lander– Acoustic (passiv)	water column	tbd		
	Sediment microprofiler	seafloor and sub-seafloor, insitu-profile	continuous		
	Autonomous Underwater Vehicle Chirp Profiler (AUV)	seafloor and sub-seafloor	continuous		
Seismicity	Seismic spot imaging	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	continuous (monthly)	intended	to be tested in phase 2
	Micro-seismicity	Faults & Fractures	continuous	intended	would be included in spot imaging
	Streamer 3D seismic	water surface; all spots of interest (Siri fairway)	every 5 years	alternative	
	Simulation	---	adapted to outcome	intended	

Time period: $T_{>>10}$ to T_{40} (assumption: abandonment); (post-injection phase)

Directive 2009/31/EC [1]	Tools	Location and spatial sampling	Sampling frequence	STATUS	Remark WD_INEOS
Seismicity	Seismic spot imaging	water surface; all spots of interest (Siri fairway) seafloor -> aquifers	not yet regulated	intended	to be tested in phase 2
	Streamer 3D seismic	water surface; all spots of interest (Siri fairway)	not yet regulated	alternative	
	Simulation	---	adapted to outcome	intended	

REMARK:
1) Each section is labeled as a ´STAND-ALONE CHARACTER: (causing repetition of devices)