Approach to Building Confidence Concerning Geological CO_2 Storage: Risk Assessment Perspective

Mike Stenhouse

Monitor Scientific LLC, Denver, Colorado

METI/IEA GHG Workshop

Mitsubishi Research Institute, Tokyo, Japan

January 24-25, 2007

MONITOR SCIENTIFIC

Outline of Presentation

- Introduction / Background
  - Drivers / issues concerning geological CO_2 storage
- Relevant feedback from regulators on role of RA in geological CO_2 storage projects
  - Summary of key findings from IEA GHG project
- Feedback from other stakeholders
- Public outreach - specific examples
  - Weyburn Public Education and Outreach
  - DOE CO_2 Sequestration Regional Partnership Program
- OSPAR Technical Workshop (2006)
- Summary observations

MONITOR SCIENTIFIC

CCS Projects: Importance of Confidence Building - Role of RA

- **Stakeholder / Public Acceptance**
  - **Stakeholder acceptance, in particular public acceptance, is considered essential to developing CCS projects in a timely manner**
  - **Risk/Safety Assessment (RA/SA), as the quantitative method of demonstrating safety, is likely to be a key component of the regulatory approval process and, hence, public acceptance…..BUT….*not the only component***
  - ***RA/SA is unlikely to be the only means of assuring safety and building confidence* in CCS projects**

MONITOR SCIENTIFIC

Confidence Building Aimed at Two Key Drivers for CCS

- Greenhouse gas (GHG) mitigation
  - CO_2 remains underground - requires *effective reservoir storage*
  - Need to be able to account for any CO_2 released back to the atmosphere
- Health, safety and environmental (HSE) impacts
  - Need to be assured that CO_2 is not released back to the surface / near-surface environment causing harm - also requires *effective reservoir storage*

- *Timescales of two drivers are potentially different*
- *Different stakeholder attitude to GHG / HSE*

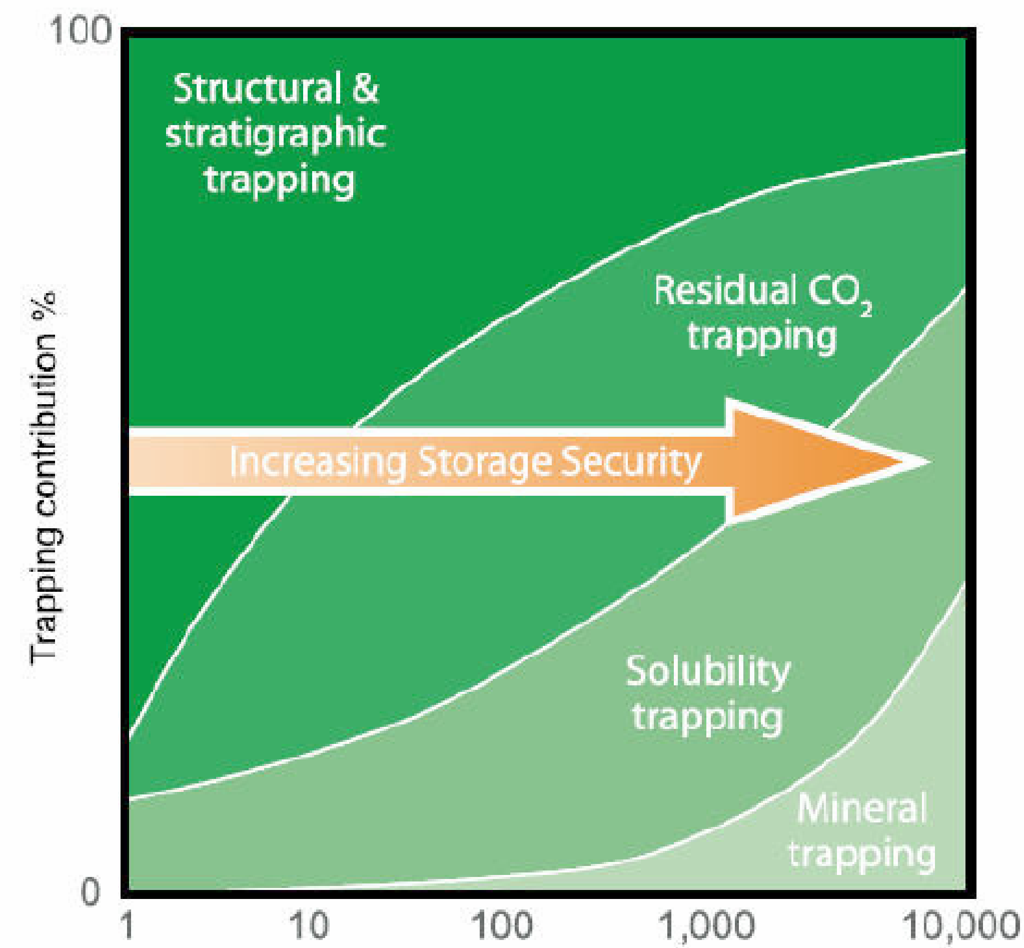
MONITOR SCIENTIFIC

RA for CCS Projects: Timeframes

- **Two timeframes are relevant to CCS depending on the needs of the regulator, whether for *GHG reduction inventory control*, or for HS&E impacts**
  - **Overall timeframe for RA of several thousand years……BUT**
  - **Natural processes exist that can act to *reduce the potential hazard over time***

MONITOR SCIENTIFIC

Geological CO_2 Storage - Trapping Mechanisms



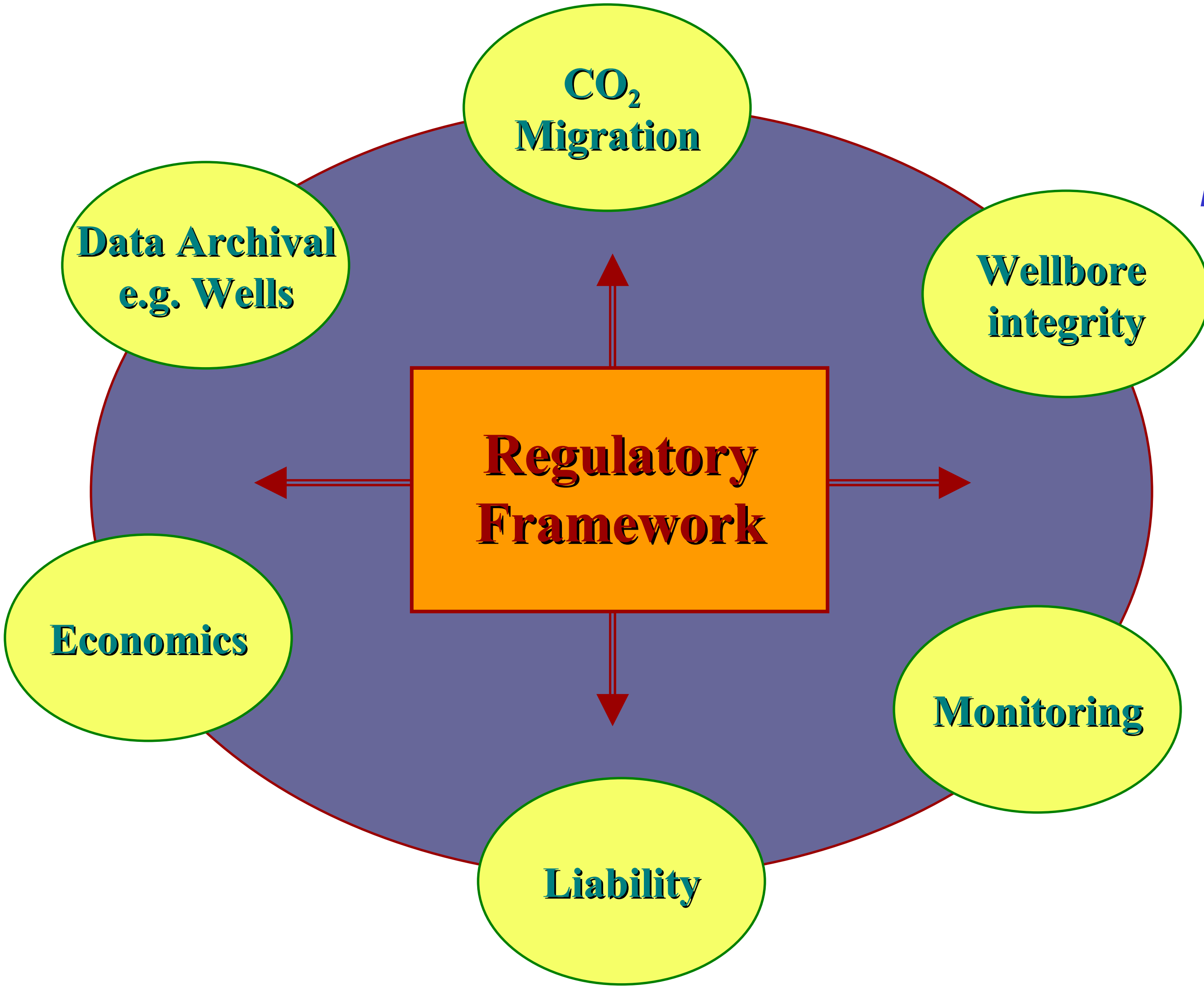
Timeframe (years)]

IPCC [2005]

- **Physical trapping *cf.* hydrocarbons**
- **Residual trapping (pore trapping)**
- **Solubility trapping (CO_2 dissolution)**
- **Mineral trapping (CO_2 reactions with rock-water system)**

Monitor Scientific

Geological CO_2 Storage: Issues?



Discuss in the context of GHG and HSE drivers and timeframes ……[previous IEA GHG project]

Monitor Scientific

Key Issues: Main Conclusions

- **Regarding assurance of safety and confidence, no hurdles specific to geologic CO_2 storage that have not been addressed in other types of projects, with the exception of CO_2 migration and how this affects GHG mitigation / accreditation accountability**
  - ***Only the relevant timeframes are different***
- **With regard to regulatory oversight, *flexible system* is preferable in order to be able to adapt to, and take advantage of, the benefits of increased knowledge from collective understanding and experience of CCS projects**

MONITOR SCIENTIFIC

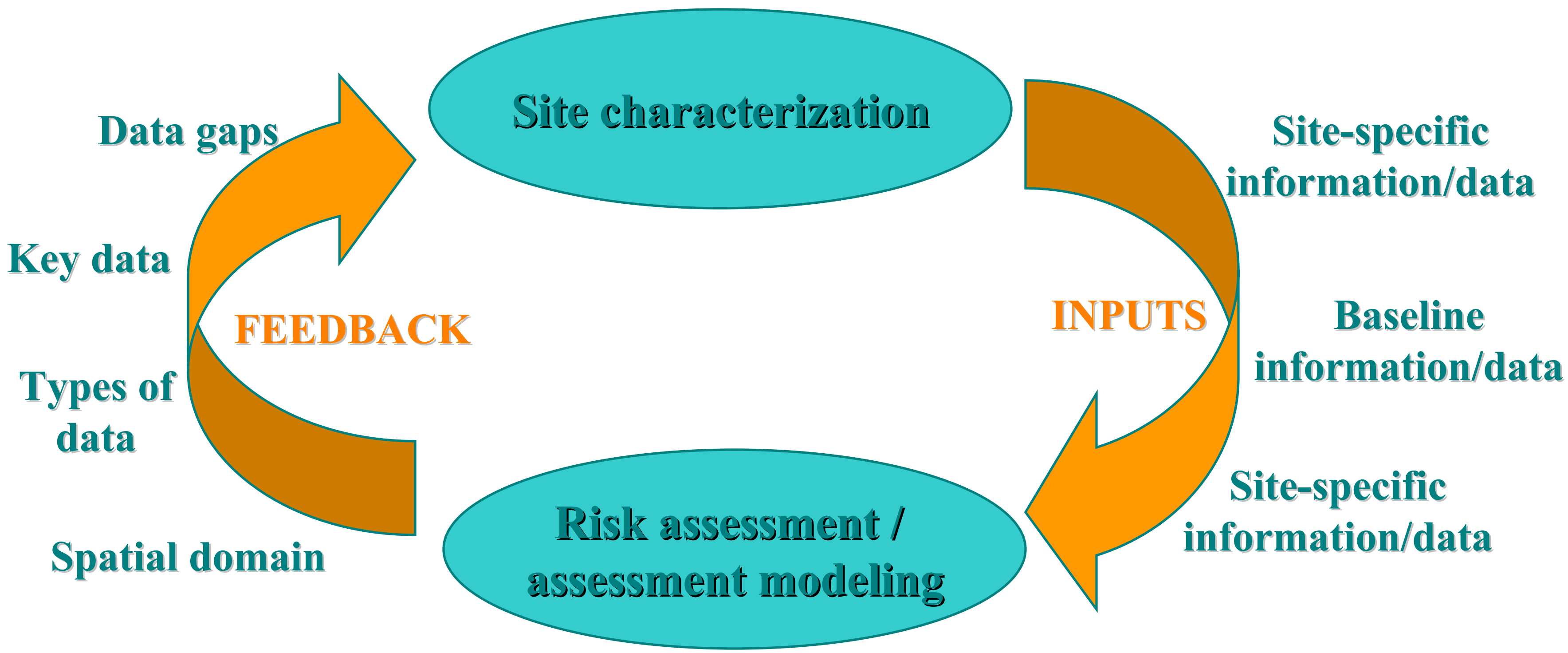
Role of RA at Different Stages of Project

Stage of Project Development	RA Role	Input Data
Preliminary site characterization - site selection	Screening	Generic data
Detailed characterization	Guidance	SC data primarily; generic data to fill gaps
Licensing / Permitting phase	Major	SC data primarily
Injection phase	Testing predictions	SC and monitoring data
Post-injection phase	Major	SC and monitoring data

RA = risk assessment; SC = site characterization

MONITOR SCIENTIFIC

RA - Iterative Process



Iterative nature of RA leads to increased confidence

Monitor Scientific

2006 IEA GHG Study: Role of RA in Regulatory Framework: Objectives

- To establish whether there are existing (regulatory) provisions for authorizing CO_2 storage projects and whether these are sufficient / adequate for future implementation of large-scale geologic CO_2 storage projects
  – Are there any ‘disconnects’ between regulator and implementer in terms of timeline?
- To identify key gaps associated with RA and its role in regulatory oversight and confidence building
  – ===> RA needs

MONITOR SCIENTIFIC

Project Feedback Questionnaire

- Regulators from 9 countries participated in project by responding to questionnaire on variety of topics associated with RA and CCS
  - Australia, Canada, France, Germany, Japan, The Netherlands, Norway, U.K., U.S.A.
- Responses of regulators supplemented with those of implementers involved in major CO_2 storage projects
- *Substantial comments* provided supporting "Yes/No" answers

Monitor Scientific

Regulator Feedback - General

- Regulators (and implementers) view the *assurance of long-term safety to be essential to the successful progress of CCS projects*. One way of building confidence is to have a rigorous methodology
  - Flexibility in methodology and modeling approach
- Link between RA results and monitoring
  - *Confirmation* of predictions
  - As means of *ensuring safety* (HSE impacts)
- Integrated ('end-to-end') assessment framework preferred, where
  - Predictions of releases linked directly to potential HSE impacts

Regulator Feedback: Specific Comments

- Risk communication - Regulator:
  - "should be involved in public communication and safety, by providing as much fact-based information as possible for the public to be aware, and make a determination, of all potential risks"
  - should "ensure that project operator……provides adequate information"
  - should "NOT be a proponent of individual projects"
  - can participate in "project-specific interaction with the public….conveying information on a qualitative basis, involving identification of risks and strategies for mitigation"
- Comprehensive risk modeling approach may not be appropriate when interacting with the public

RA Needs - Regulator Feedback

- **Perceived gaps / issues and building confidence:**
  - **Nature of long-term risks and associated institutional management**
    - **Better understanding of timeframe in the context of potential hazards - if/how this changes with time**
  - ***Wellbore and caprock integrity*, especially with regard to long-term storage performance**
  - **Monitoring, in the context of *quantifying CO_2 leakage/migration***
  - **Improved knowledge of *specific environmental impacts*, in particular groundwater different ecosystems, and offshore environmental impacts**
- **Many of the above concerns are linked to *uncertainties in the long-term predictions* and how these uncertainties are communicated to the various stakeholders**

MONITOR SCIENTIFIC

RA, Confidence Building and Role of Natural Analogues

- Natural Analogues (NA) serve a number of purposes linked to RA and , the most quantitative purpose being the *validation of predictive modeling results*. In the absence of quantitative information, NA examples can be used to *support risk communication with stakeholders*, by identifying geological environments that are suitable for long-term CO_2 storage, and, on the other hand, by explaining why bad sites leak.
- Stakeholder / Public Acceptance
  - All indications suggest that science-based information is not sufficient to satisfy public concerns, and other avenues of communication, *e.g.*, natural and industrial analogues, are needed to support the science-based approach, particularly when *RA techniques are not easy to communicate*.

Monitor Scientific

Risk Assessment / Knowledge Gaps - Implementer Perspective

- Experience with different types of storage site, in particular deep aquifers
- Wellbore seal longevity
- Quantitative information from natural analogues
- Fundamental data
  - Thermodynamic behavior of CO_2 - effect of impurities
  - Thermodynamic, kinetic data (mineral reactions)
- Coupling between geochemical and geomechanical processes - include in modeling
- Benchmarking of RA modeling approaches

Monitor Scientific

Geological CO_2 Storage: Public Awareness Study [1]

- 2004 UK study [Shackley et al.] found public awareness and understanding to be low; in absence of information, people tend not to have an opinion or, if they do, slightly negative
- Provision of some, even limited information on the topic moves public opinion to a more positive stance
- Public support tends to depend on concern over climate change and global warming, with CCS being viewed as one positive strategy
- Uncertainties about the potential risks of CCS, in particular the risks of accident and leakage, need to be addressed and reduced

Monitor Scientific

Geological CO_2 Storage: Public Awareness Study [2]

- Battelle study on public attitudes linked to Mountaineer Project (Ohio, USA) had similar findings:
  - Discussion of CCS issues tended to be at national and conceptual level, with little comment at local public level
  - Local concern expressed over leakage and potential for environmental and health effects
    - "What could be done to minimize their potential /or detect and mitigate their effects if leakage occurs?"

Monitor Scientific

Public Outreach

IEA Weyburn CO_2 Monitoring and Storage Project: Public Outreach

- Key activity for Phase 2 (commenced 2005) is development and implementation of public communication strategy
- 2006 Workshop on Public Education and Outreach (PEO) - Natural Resources Canada - key findings:
  - Framework for PEO should be broader than just Weyburn; focus on longer term large-scale CCS deployment
  - General education materials on CCS technology should be open, transparent and unbiased - NOT marketing!
  - Commitment to ongoing communication and feedback mechanism for answering questions and addressing concerns
  - Share information with community before project starts

IEA Weyburn CO_2 Monitoring and Storage Project: PEO

- Communication strategies:
  - Website with opportunities for questions and feedback from 'experts'
  - Mailouts to local community and local bulletin boards
  - Provide media articles - preferably using well-known and trusted reporters
- How to monitor effectiveness of communication?
  - Number of hits on websites
  - Periodic surveys
  - Media monitoring
- Sensitive to balance between providing balanced information on potential risks and benefits, and raising concerns unnecessarily

MONITOR SCIENTIFIC

DOE Regional Carbon Sequestration Partnership Program

- One of the key goals is public outreach and education, each Partnership developing a range of materials for this purpose:
  - Fact sheets
  - Interactive websites
  - Videos
  - Town hall meetings
  - Focus groups
  - National Environmental Policy Act (NEPA) allows for public involvement
- Programs themselves are phased, one stage allowing for validation through field tests

MONITOR SCIENTIFIC

OSPAR Convention; Technical Workshop on RA Framework

- **London Convention/Protocol (LC/LP) and OSPAR Convention are focused on protecting marine environment**
  - **Influential treaties that will shape national guidelines/regulations**
- **Risk assessment framework was developed and adopted by LC/LP**
- **Technical framework discussed at OSPAR Workshop October 2006**
  - ***RA considered within broader risk management framework***
  - **Acknowledgement that *RA is not sufficient for assuring safety / building confidence***

MONITOR SCIENTIFIC

Framework For Risk Assessment and Management (FRAM)

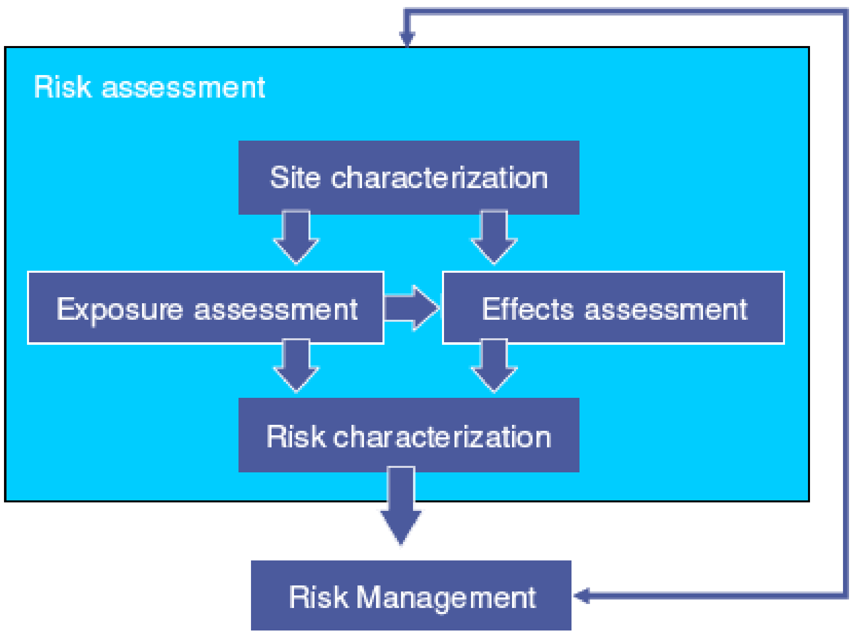


Diagram courtesy of TNO, The Netherlands

- Framework directly applicable to storage of CO_2 under seabed, but generally applicable to other environments
- Integration of RA and risk management
  - *Some emphasis given to monitoring, mitigation remediation plans*

Monitor Scientific

Components of FRAM

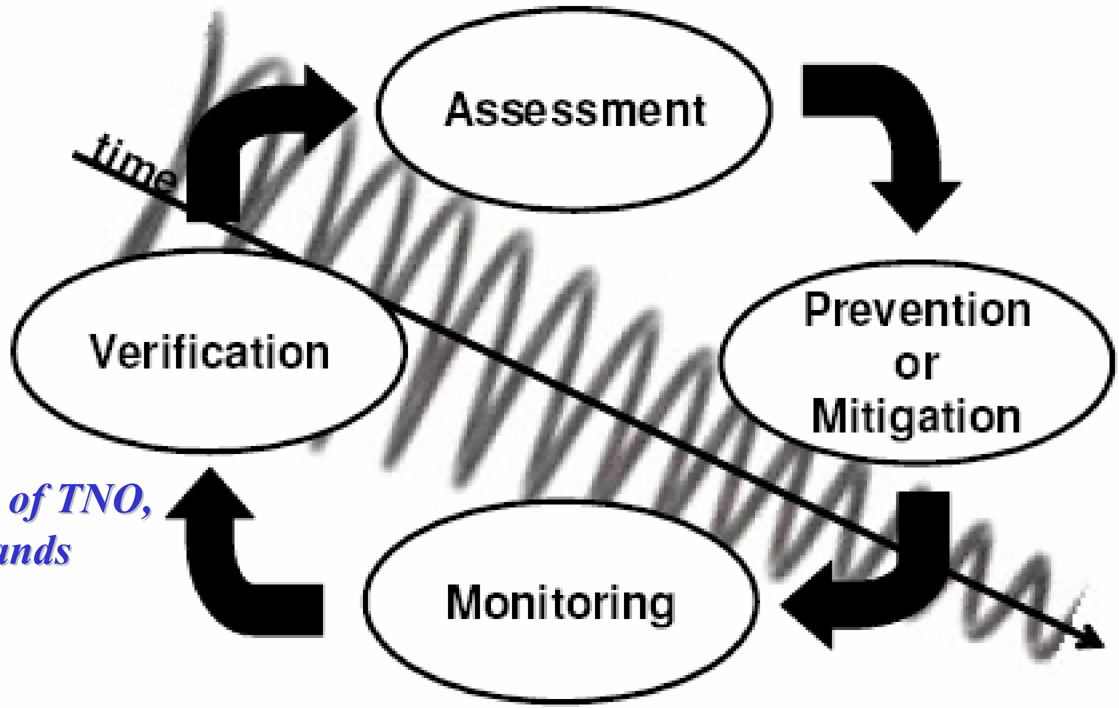


Diagram courtesy of TNO,
The Netherlands

- *Framework aimed at assuring safety and increasing confidence*
- *Acknowledgement that assessment is not sufficient*

Monitor Scientific

Summary Observations

- **Phased approach** to storage projects is beneficial to stakeholder acceptance
- Improved understanding of the processes associated with geological CO_2 storage continues to benefit from the **experience gained** in pilot-scale and full-scale CCS projects, building on the experience gained from projects such as Sleipner and Weyburn
- ***Sharing of project results*** extremely useful
- RA and its results are not sufficient
  - Inclusion of ***monitoring*** and ***remediation plan*** in CCS projects is beneficial to overall acceptance

MONITOR SCIENTIFIC

Ways of Building Confidence

- **Technical standard / protocol** - basic *framework* (flexible)
  - Build on existing documents, e.g. Best Practice Manual, SACS Project, national standards for risk analysis
- **Benchmarking studies** to enhance confidence in different modeling approaches
  - Need to be carefully planned
- **Monitoring**: provide quantitative resolution capability to match needs:
  - Confirmation of RA predictions
  - Quantification of migration of CO_2 for GHG inventory purposes

Monitor Scientific

Acknowledgements

- Much of the input, in particular a discussion of regulator feedback is based on the results of an IEA GHG R&D project
  - Project Manager John Gale
  - Project team of Malcolm Wilson, Wei Zhou, and Matt Kozak
  - Funding from IEA GHG is gratefully acknowledged
- Project could not have been completed without good feedback from participants, which is greatly appreciated

MONITOR SCIENTIFIC