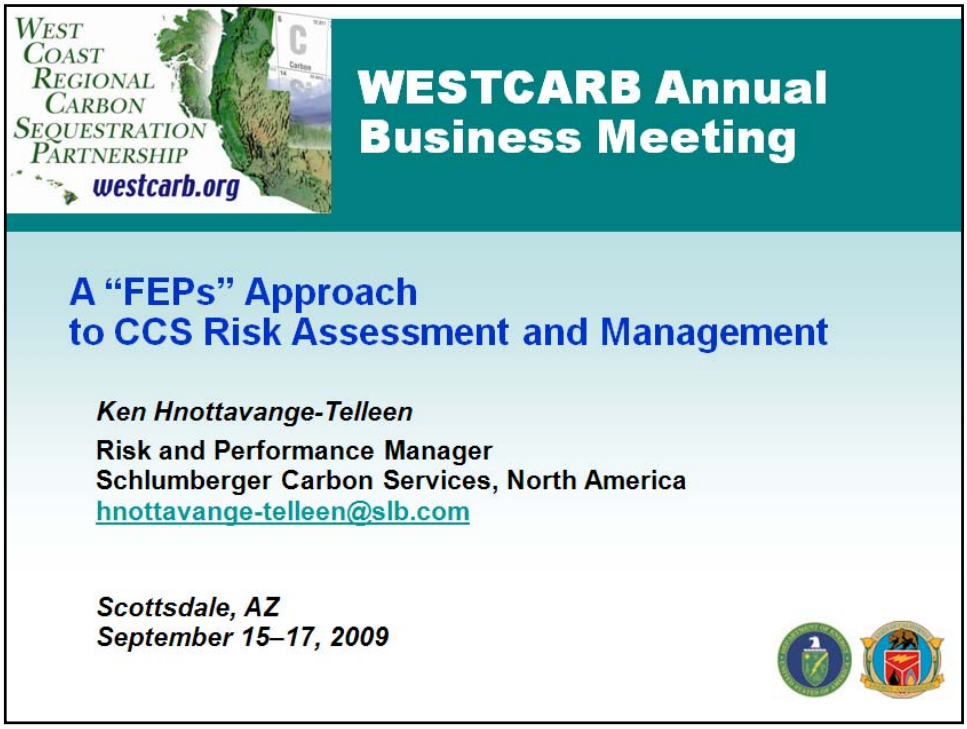

West Coast Regional Carbon Sequestration Partnership
westcarb.org
WESTCARB Annual Business Meeting
A "FEPs" Approach to CCS Risk Assessment and Management
Ken Hnottavange-Telleen
Risk and Performance Manager
Schlumberger Carbon Services, North America
hnottavange-telleen@slb.com
Scottsdale, AZ
September 15–17, 2009


Kimberlina Project Site
2

FEPs ranked by Best-Guess score tally

Tally of L*S scores of FEP risk, sorted by descending high-score count.

23 INDIVIDUAL respondents, all data: 1097 rows.

FEP	BEST-GUESS RISK, individual scores														bg risk, Gp consensus			
	x	1	2	3	4	5	6	8	9	10	12	15	16	20	25	n	mean	C	L	O	S
CO2 Ownership and/or Custody					1			3					1	1		6	10.7		8		
Economics - exogenous - general					1				1		4			1		7	11.6		12		
Economics - exogenous - supply prices							1	1	1				4			7	12.4		16		
Legal/regulatory: property rights and trespass					1		3		4		2		2			12	9.5	9	16		
Economics specific to project	2			1	1		1	1	2		2		1			11	8.8			8	
Economics - exogenous - CCS-specific			1				1	1	1		2		1			7	9.3		12		
Displacement of formation fluid (capillarity)									1	5		1		1		8	10.1				9
Accidents and unplanned events: Project					2		1	1	2					1		7	8.0			9	
Procurement delays: aboveground infrastructure				1	1		2		6			2				12	8.6		15	9	
Legal/regulatory: seismic survey, drilling, and UIC permits					1		2	2	4		3	1				13	9.2	9	14		
Contracting: CEC/State							1		1		3	1				6	11.0		12		
CO2 source: change in injection demand							4	1			1	1				7	8.4		6		
Procurement delays: drill rig, well tubulars, well hardware			1	2			3	1	3			1				11	6.9		15	3	
Schedule and planning					1		3		3		4					11	8.8		12	9	
Support from Government - political basis					1		1	1	1		4					12	7.6	4	12		
Heterogeneity in reservoir							3		1		4					8	9.4				12
Actions and reactions: local community: local and regional SIGs							2		1		4					7	9.9	12			
Legal/regulatory: construction, discharge, and other operations permits					1		2	2	5		2					12	8.4	9	12		
Fractures and faults: open pathway			1	1	1		3	1	4		2					13	7.3				12
Construction and Operations Activities (project) other than drilling and well completion			1		1			1	2		2					7	8.0			9	
Legal/regulatory: lawsuits			1					1	2		2					6	8.7		12		
Seismicity (non-project-related earthquakes)			1		4		3	1	1		2					12	6.4	4		2	
Well Records and Data Management			3		3		3				2					11	5.5		2	6	
Data acquisition conflicts			2		1		1	3	1	2	1					11	7.2				10
Fractures and faults: movement			1	2			3			1	1					8	6.0	4			6
Monitoring or Verification Wells			2		1		2		6		1					12	7.2			6	9
Modeling and simulation issues			1	1	4				5		1					12	6.5	4			9
CO2 Delivery System facility construction					1		2		3		1					7	7.9			12	
Other elements of CO2 Delivery System							2	1	2		1					6	8.3			9	
Well Plugging / Sealing / Closure		2	2	1	3		1		2		1					12	4.8		4	1	
Support from Government - technical basis			2				4	4	1		1					12	6.8	6	8		
Industrial equipment and construction related and unrelated to project					1		1	2	1		1					6	7.8		8		
CO2 source: interruptions of CO2 source plant	1		2				6	1	1		1					12	6.3			8	
CO2 source: interruptions of CO2 processing facility		1	1		1		8		1		1					13	5.8			6	6
Post-project administrative control		3	2	1	6		3		1		1					17	4.3	4	6	1	

tally1092-BG | tally1092-UB | C | L | O | S | Chart-BG | Chart-UB

3

OUTLINE

1. *What are the "Risked Entities"? – FEPs and Scenarios*
2. *"Quantifying" risk through Expert Panels*

3. *Responding to Risk*
4. *Tracking Risk*
5. *Managing ...*

4

FEPs

• A Feature is a static attribute of a system.
Example: Reservoir porosity.

• An Event is a sudden change in the system or its environment.
Example: Lightning strikes the dehydration equipment.

• A Process is a way in which system attributes or conditions change in a relatively slow and progressive way.
Examples:
Injected CO_2 ...
... displaces formation brine near the injection well,
... migrates updip away from the injection well,
... partially dissolves into formation brine.
Manufactured components ...
... decay and degrade over time, in various ways.

5

FEP concepts

• Any scenario involves multiple F's – E's – P's; one FEP may have multiple risks. There IS "redundancy" that minimizes the chance of overlooking an important risk.

• The Basic Questions

1) "If something went wrong related to this FEP ...
- How Severe would the impact be?
- How Likely is it that project values would be negatively impacted?"

2) "What are the specific risk targets, and how do we reduce risk to those targets?"

• Risk is "associated with" each FEP; not necessarily "caused by", nor via a prescribed pathway. You, the panelists, must imagine the scenarios that bear risk.

6

4 Expert Panels / 4 Working Groups ...

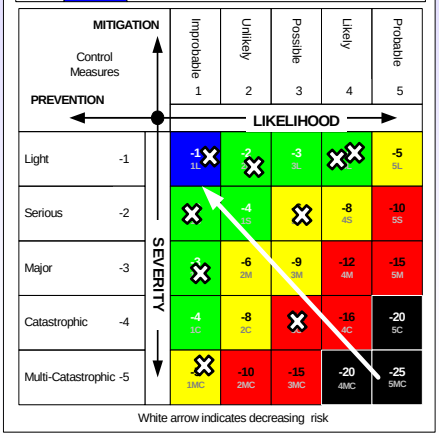
- **Science – MVA**: reservoir, caprock, other strata, wellbore, aquifers, fluid movement, characterization uncertainties, *faults, seismicity, seismic data,* geomechanics, hydrochemistry, surface data acquisition, models and simulation, ...
- **Operations – HSE**: Coordination, drilling, accidents, dust, noise, CO_2 in atmosphere/breathing space, emissions, traffic, security, buildings, pits/cuttings/waste, office space, wildlife, wellhead, utility corridors, personal exposure (weather, fumes), soil contaminants, quality control, data archiving, personnel, CO_2 capture, compression, dehydration, pipelines, plant integration, ...
- **Communications-Outreach-Nonmember stakes**: all offsite spaces: air, surface, subsurface, people, ecosystems, cultivation, demographics, local industry and land use, ...
- **Legal-Permits-Management-Economics-Contracts**: legal, financial, regulatory, political, image, equity, resource ownership, organizational, management, administrative, ...

... 5 – 8 experts per group.

7

Risk Assessment Matrix

-25 to -20	BLACK	NON-OPERABLE: Evacuate the zone and or area/country
-16 to -10	RED	INTOLERABLE: Do not take this risk
-9 to -5	YELLOW	UNDESIRABLE: Demonstrate ALARP before proceeding
-4 to -2	GREEN	ACCEPTABLE: Proceed carefully, with continuous improvement
-1	BLUE	NEGLIGIBLE: Safe to proceed



White arrow indicates decreasing risk

Why analyze risk?

(a) To respond:
•Reduce Likelihood (PREVENT)
•Reduce Severity (MITIGATE).

(b) To intelligently construct Scenarios that can be modeled.

(c) To efficiently apply simulation resources.

Hazard Analysis and Risk Control Standard SLB-QHSE-S020

8

Fundamentals

- *DEFINED PROJECT VALUES.*
- *L AND S SCALES.*
- *HEURISTICS,* "Rules of thumb".
- *ANCHORING, GOOD ANCHORING, BAD ANCHORING.*
- *BEST GUESS, LOWER BOUND, UPPER BOUND.*

9

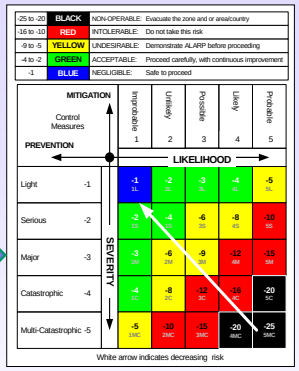
What values are at risk?

PROJECT VALUE	Statements that establish this value *for RCSP Phase III in general or K3 in particular*
Health & Safety	*The Phase III efforts will be carried out to ensure the health and safety of workers and the general public.*
Financial	*Execute project within budget.* *Use operational and expense data to enable cost reductions in commercial-scale CCS.* *K3: Prevent negative financial impact to CES' commercial power generating undertaking.*
Environment	*Comply with UIC permitting, NEPA, and CEQA requirements.* *Demonstrate that no adverse environmental impact has occurred.*
Research Goals	*(1) Validate the entire process of pre-injection characterization, injection process monitoring, and post-injection monitoring to understand CO_2 fate.* *(2) Assess the acceptance by the saline reservoir of CO_2 (injectivity), the ability of the reservoir to store CO_2 (capacity), and the integrity of seals and the entire system.* *(3) Develop improved technologies for modeling/simulation, risk assessment, and monitoring.*
Industry Viability	*One of the K3 goals is to understand all issues necessary to develop and operate a commercial-scale sequestration project in the Southern San Joaquin Valley of California.* *Project outreach and communications will be designed to build informed and supportive constituencies.*

10

Severity scale

Severity of Impact		PROJECT VALUES that may be at risk (**bold**: SLB Severity Matrix standard. *Italics*: proposed standard.) Health & Safety	Financial (USD); *escaped tons CO₂ @ $30/t*	Environment	Research	Industry Viability
Light	-1	Minor Injury or Illness, First Aid	<10K$ *<333t*	Discharge < reporting thresholds; Hazmat Spill <100 Liters; Produced Water Spill <50 Barrels	*Little or no progress toward 1 of 4 goals.*	*Project Lost Time >1day. Moving-vehicle citations.*
Serious	-2	Temp. Disability, Hospital to 1 day, Lost Days 1-100	10-100K$ *333-3333t*	Discharge > reporting thresholds; Hazmat Spill <1000 Liters; Produced Water Spill <250 Barrels	*Little or no progress toward 2 of 4 goals.*	*Project Lost Time >1 wk. Regulatory Notice without fine. Local allegations of unethical practice or mis-management.*
Major	-3	Perm. Disability, Lost Days >100, Intensive Care >1 day	100-1000K$ *3333-33,333t*	Discharge causes area evacuation or wildlife loss; Hazmat Spill <10K Liters; Produced Water Spill <500 Barrels	*Little or no progress toward 3 of 4 goals.*	*Project Lost Time >1 mo. Permit suspension. Majority local opposition or substantial negative local media coverage.*
Catastrophic	-4	Fatality	>$1,000,000 *>33,333t*	Uncontrolled release of radioactive matl.; Hazmat Spill >10K Liters; Produced Water Spill >500 Barrels	*Little or no progress toward 4 of 4 goals.*	*Project Lost Time >1 yr. Int'l media coverage of law violations, questionable ethical practices, or mismanagement.*
Multi-Catastrophic	-5	Multi-fatality	*>333,333t*	Multi-Catastrophic	*No gain in understanding applicable to future projects*	*Negative public experience results in legal ban on similar projects.*



11

Severity of Impact		PROJECT VALUES that may be at risk: Health & Safety	Financial (USD); *escaped tons CO_2 @ $30/t*	Environment	Research	Industry Viability
Light	-1	Minor Injury or Illness, First Aid	<10K$ *<333t*	Discharge < reporting thresholds; Hazmat Spill <100 Liters; Produced Water Spill <50 Barrels	*Little or no progress toward 1 of 4 goals.*	*Project Lost Time >1day. Moving-vehicle citations.*
Serious	-2	Temp. Disability, Hospital to 1 day, Lost Days 1-100	10-100K$ *333-3333t*	Discharge > reporting thresholds; Hazmat Spill <1000 Liters; Produced Water Spill <250 Barrels	*Little or no progress toward 2 of 4 goals.*	*Project Lost Time >1 wk. Regulatory Notice without fine. Local allegations of unethical practice or mis-management.*
Major	-3	Perm. Disability, Lost Days >100, Intensive Care >1 day	100-1000K$ *3333-33,333t*	Discharge causes area evacuation or wildlife loss; Hazmat Spill <10K Liters; Produced Water Spill <500 Barrels	*Little or no progress toward 3 of 4 goals.*	*Project Lost Time >1 mo. Permit suspension. Majority local opposition or substantial negative local media coverage.*
Catastrophic	-4	Fatality	>$1,000,000 *>33,333t*	Uncontrolled release of radioactive matl.; Hazmat Spill >10K Liters; Produced Water Spill >500 Barrels	*Little or no progress toward 4 of 4 goals.*	*Project Lost Time >1 yr. Int'l media coverage of law violations, questionable ethical practices, or mismanagement.*
Multi-Catastrophic	-5	Multi-fatality	*>333,333t*	Multi-Catastrophic	*No gain in understanding applicable to future projects*	*Negative public experience results in legal ban on similar projects.*

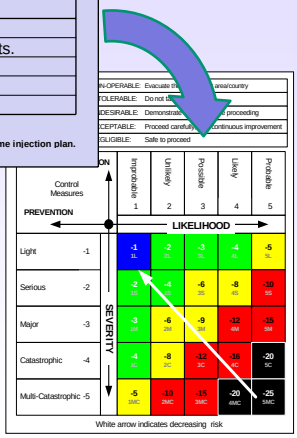
12

Likelihood scale

Likelihood of Impact
... during Project Storage Time Horizon (assume 100 years)

		If there were 100 projects *like this one*, impact related to this risk element (FEP) would occur ...
Improbable	1	... probably not at all; never.
Unlikely	2	... fewer than three times among the 100 projects.
Possible	3	... 5 or 10 times among the 100 projects.
Likely	4	... in around half of the 100 projects.
Probable	5	... in most or nearly all of the projects.

* Similar setting, similar levels of knowledge and uncertainty at this stage of the project, same injection plan.



13

FEP* scoring: Expert Panel consensus

"Best-Guess" Likelihood

"Best-Guess" Severity

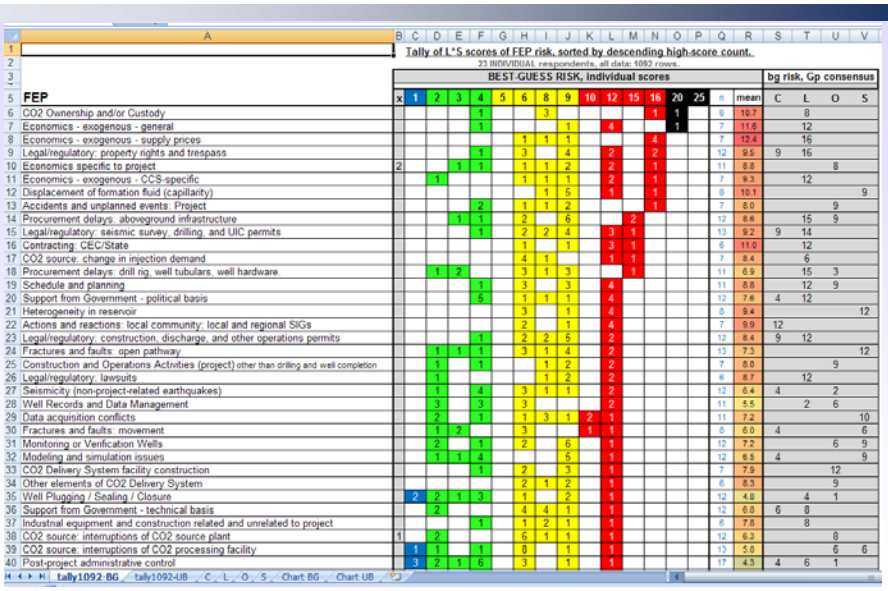
* Feature, Event, or Process	Project-Specific Information	L LB	L Best Guess	L UB	S LB	S Best Guess	S UB	Best-Guess L*S
Accidents and unplanned events: External	Activities unrelated to the project, such as traffic on site-margin roads, including those related to ADM or other nearby industrial operations, could expose personnel, wellhead, wellbore, and image to risks.	2	3	4	1	2	4	6
Accidents and unplanned events: Project	Activities of driving, drilling, CO2 compression, field data acquisition, and other surface operations could expose personnel, wellhead, wellbore, and image to risks.	3	3	4	2	2	3	6
Add a New FEP	(Add information for new FEP)	L	L	L	s	S	s	= L * S
Asphyxiation effects	Asphyxiation requires high CO2 concentration in occupied (usually confined) space, plus either poor ventilation or high release rate. The pipeline and wellhead area could experience high CO2 release rates. Within 100 years after injection ceases, the subsurface area where CO2 saturation exceeds 30% is expected to be limited to a 1250-ft radius (above which there are few or no basements, excavations, or low areas now). The plume could move beyond this area.	1	1	2	5	5	5	5

Lower Bound / Lowest Credible L

Upper Bound / Highest Credible L

14

FEPs ranked by Best-Guess score tally

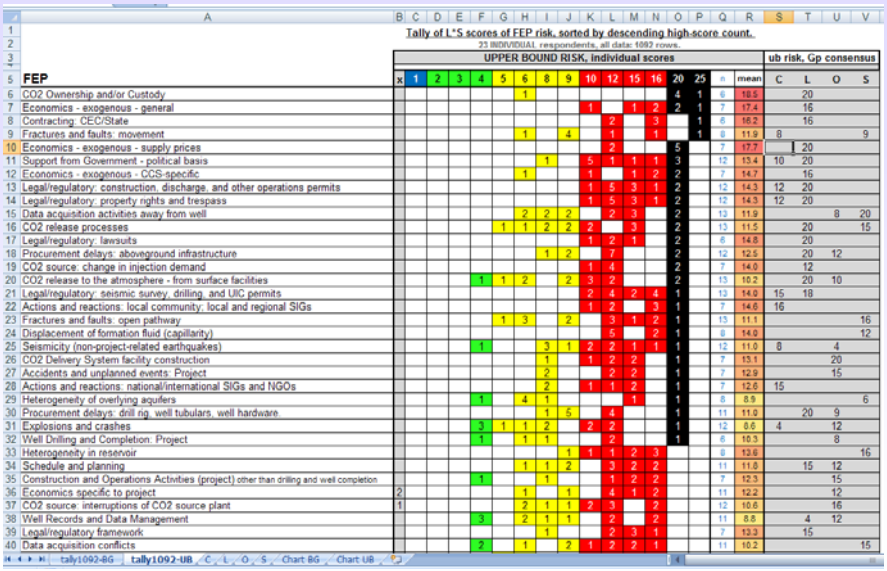


Tally of L*S scores of FEP risk, sorted by descending high-score count.
23 INDIVIDUAL respondents, all data: 1092 rows.

FEP	BEST-GUESS RISK, individual scores														bg risk, Gp consensus			
	x	1	2	3	4	5	6	8	9	10	12	15	16	20	25	n	mean	C	L	O	S
CO2 Ownership and/or Custody					1			3					1	1		6	10.7		8		
Economics - exogenous - general					1				1		4			1		7	11.6		12		
Economics - exogenous - supply prices							1	1	1				4			7	12.4		16		
Legal/regulatory: property rights and trespass					1		3		4		2		2			12	9.5	9	16		
Economics specific to project	2			1	1		1	1	2		2		1			11	8.8			8	
Economics - exogenous - CCS-specific			1				1	1	1		2		1			7	9.3		12		
Displacement of formation fluid (capillarity)								1	5		1		1			8	10.1				9
Accidents and unplanned events: Project					2		1	1	2				1			7	8.0			9	
Procurement delays: aboveground infrastructure				1	1		2		6			2				12	8.6		15	9	
Legal/regulatory: seismic survey, drilling, and UIC permits					1		2	2	4		3	1				13	9.2	9	14		
Contracting: CEC/State							1		1		3	1				6	11.0		12		
CO2 source: change in injection demand							4	1			1	1				7	8.4		6		
Procurement delays: drill rig, well tubulars, well hardware			1	2			3	1	3			1				11	6.9		15	3	
Schedule and planning					1		3		3		4					11	8.8		12	9	
Support from Government - political basis					5		1	1	1		4					12	7.6	4	12		
Heterogeneity in reservoir							3		1		4					8	9.4				12
Actions and reactions: local community: local and regional SIGs							2		1		4					7	9.9	12			
Legal/regulatory: construction, discharge, and other operations permits					1		2	2	5		2					12	8.4	9	12		
Fractures and faults: open pathway			1	1	1		3	1	4		2					13	7.3				12
Construction and Operations Activities (project) other than drilling and well completion			1		1			1	2		2					7	8.0			9	
Legal/regulatory: lawsuits			1					1	2		2					6	8.7		12		
Seismicity (non-project-related earthquakes)			1		4		3	1	1		2					12	6.4	4		2	
Well Records and Data Management			3		3		3				2					11	5.5		2	6	
Data acquisition conflicts			2		1		1	3	1	2	1					11	7.2				10
Fractures and faults: movement			1	2			3			1	1					8	6.0	4			6
Monitoring or Verification Wells			2		1		2		6		1					12	7.2			6	9
Modeling and simulation issues			1	1	4				5		1					12	6.5	4			9
CO2 Delivery System facility construction					1		2		3		1					7	7.9			12	
Other elements of CO2 Delivery System							2	1	2		1					6	8.3			9	
Well Plugging / Sealing / Closure		2	2	1	3		1		2		1					12	4.8		4	1	
Support from Government - technical basis			2				4	4	1		1					12	6.8	6	8		
Industrial equipment and construction related and unrelated to project					1		1	2	1		1					6	7.8		8		
CO2 source: interruptions of CO2 source plant	1		2				6	1	1		1					12	6.3			8	
CO2 source: interruptions of CO2 processing facility		1	1		1		8		1		1					13	5.8			6	6
Post-project administrative control		3	2	1	6		3		1		1					17	4.3	4	6	1	

15

FEPs ranked by Upper Bound score tally



Tally of L*S scores of FEP risk, sorted by descending high-score count.
23 INDIVIDUAL respondents, all data: 1092 rows.

FEP	UPPER BOUND RISK, individual scores														ub risk, Gp consensus			
	x	1	2	3	4	5	6	8	9	10	12	15	16	20	25	n	mean	C	L	O	S
CO2 Ownership and/or Custody								1						4	1	6	19.5		20		
Economics - exogenous - general										1		1	2	2	1	7	17.4		16		
Contracting: CEC/State											2		3		1	6	16.2		16		
Fractures and faults: movement							1		4		1		1		1	8	11.9	8			9
Economics - exogenous - supply prices											2			5		7	17.7		20		
Support from Government - political basis								1		5	1	1	1	3		12	13.4	10	20		
Economics - exogenous - CCS-specific							1			1		1	2	2		7	14.7		16		
Legal/regulatory: construction, discharge, and other operations permits										1	5	3	1	2		12	14.3	12	20		
Legal/regulatory: property rights and trespass										1	5	3	1	2		12	14.3	12	20		
Data acquisition activities away from well						2	2	2			2	3		2		13	11.9			8	20
CO2 release processes					1	1	2	2	2			3		2		13	11.5		20		15
Legal/regulatory: lawsuits										1	2	1		2		6	14.8		20		
Procurement delays: aboveground infrastructure								1	2		7			2		12	12.5		20	12	
CO2 source: change in injection demand										1	4			2		7	14.0		12		
CO2 release to the atmosphere - from surface facilities					1	1	2		2	3	2			2		13	10.2		20	10	
Legal/regulatory: seismic survey, drilling, and UIC permits										2	4	2	4	1		13	14.0	15	18		
Actions and reactions: local community: local and regional SIGs										1	2		3	1		7	14.6	16			
Fractures and faults: open pathway						1	3		2		3	1	2	1		13	11.1				16
Displacement of formation fluid (capillarity)											5		2	1		8	14.0				12
Seismicity (non-project-related earthquakes)					1			3	1	2	2	1	1	1		12	11.0	8		4	
CO2 Delivery System facility construction								1		1	2	2		1		7	15.1			20	
Accidents and unplanned events: Project								2			2	2		1		7	12.9			15	
Actions and reactions: national/international SIGs and NGOs								2		1	1	2		1		7	12.6	15			
Heterogeneity of overlying aquifers					1		4	1				1		1		8	8.9				6
Procurement delays: drill rig, well tubulars, well hardware								1	5		4			1		11	11.0		20	9	
Explosions and crashes					3	1	1	2		2	2			1		12	6.6	4		12	
Well Drilling and Completion: Project					1		1	1			2			1		6	10.3			8	
Heterogeneity in reservoir										1	1	1	2	3		8	12.6				16
Schedule and planning							1	1	2		3	2	2			11	11.0		15	12	
Construction and Operations Activities (project) other than drilling and well completion					1			1			1	2	2			7	12.3			15	
Economics specific to project	2						1		1		4	1	2			11	12.2			12	
CO2 source: interruptions of CO2 source plant	1						2	1	1	2	3		2			12	10.6			16	
Well Records and Data Management					3		2	1	1		2		2			11	8.8		4	12	
Legal/regulatory framework								1			2	3	1			7	13.3		15		
Data acquisition conflicts					2		1		2	1	2	2	1			11	10.2				15

16

Scenarios and Risk Reductions from scored FEPs

FEP	Project-Specific Information	S LB	S UB	S Best Guess	L LB	L UB	L Best Guess	L*S ub	L*S bg	H,F, E,R, V	Scenarios causing higher risk	Risk Reduction Measures
CO2 release to the atmosphere - from surface facilities	Before injection, CO2 could be released directly to the atmosphere from the delivery system by accident or through intentional venting.	1	3	2	3	5	4	12	8	H, E, R, v	1) Catastrophic release due to impact with surface piping or failure due to weld flaws, fatigue, or corrosion. 2) Manual/automatic venting for maintenance shutdowns/emergency shutdowns. 3) Fugitive emissions from valves, flanges, compressor seals.	1a) Piping design and protective structures should minimize opportunities for catastrophic release. 1b) The EPC contractor should provide a comprehensive piping materials specification that ensures adequate structural strength, including reference to standard welding procedures, required corrosion allowances; reinforcement details for attachment points (valves, sample taps, etc.)... 2a) Vent points should be at adequate height and location to ensure dispersion. 2b) O&M procedures should specify acceptable and unacceptable venting procedures for routine and emergency maintenance and other anticipated operating scenarios. 3) Scan literature for articles evaluating the possibility of future fugitive emissions standards applicable to CO2.
Well Plugging / Sealing / Closure	Plan is for K3 Project injector and verification wells to be abandoned, per regulatory acceptance criteria to be determined in future. While well seals will eventually degrade, this is not expected for the duration of the project. Seal monitoring or repair may be needed; could be unsuccessful.	1	4	3	2	4	3	12	9	H, F, E, R, v	1) Inadequate cementing design; 2) poor contractor performance; 3) unanticipated downhole conditions.	Selection of service contractors (and contractor personnel) is the key to obtaining good cementing - do not use low bid procurement.
Pre-closure monitoring of storage	K3 Project has research objectives for which extensive pre-closure monitoring is planned. Pre-closure monitoring could be inadequate to achieve various project goals. Some monitoring activities may themselves involve risks. Assume that "pre-closure" ends 2-3 years after injection stops.	1	3	2	2	4	3	9	6	F, R, v	1) Inadequate design allowance could preclude some future monitoring. 2) Greatest risk is in DOE and CEC budgeting?	1) Perform "What-If" exercises prior to well construction. 2) Maintain communications channels and currency of reporting to support future project success.

17

Impacts and Responses

All text info. both cohorts. all FEPs

			RISK TARGETS					RISK RESPONSES																
			Impact Receptors: Project Values					Characterize					Monitor			Manage			Comms		Hard ware			
FEP Name	PROJECT-SPECIFIC INFO	FEP RANK	HSE: from CO2 injection	HSE: other	Financial cost	Research goals	Industry, image	Core	Logs	Surface Geophysics	Other Data	Mech Testing	Geophysics	Geochemistry	Other Monitoring	Plan, Coordinate	Training, EH&E	DATA Mng, Analyze, Model	Comms: esp. Internal	Comms: esp. External	Hardware, Materials, Tools			
Accidents and unplanned events: External	Activities unrelated to the project, such as traffic on site-margin roads, including those related to plant or other nearby industrial operations, could expose personnel, wellhead, wellbore, and image to risks.	44		o	f	r	i									P	T				H			
Accidents and unplanned events: Project	Activities of project-related driving, drilling, CO2 compression, field data acquisition, and other surface operations could expose personnel, wellhead, wellbore, and image to risks.	7	c	o	f	r	i									P	T							
Actions and reactions - local community	Actions and reactions from the local community could affect project permitting, injection or monitoring operations, surface access, or schedule.	14			f		i													X			

18

One FEP > Multiple Scenarios

FEP Name	RISK-BEARING SCENARIO
Accidents and unplanned events: External	**Accident damages custom-manufactured equipment, sensor, tool; replacement or repair delay causes irretrievable information loss during an injection phase.**
Accidents and unplanned events: External	**Action causes public opposition which results in permit or project delay.**
Accidents and unplanned events: External	**Cost implications of any accident, including emergency response, medical, equipment damage, delay.**
Accidents and unplanned events: External	**Heavy rail traffic results in derailment blocking access to site.**

19

Multiple FEPs > Same Scenario

FEP Name	RISK-BEARING SCENARIO
Data acquisition activities at well	**Weather conditions prevent using a monitoring method or retrieving data at a critical point in time.**
Data acquisition activities away from well	**Weather conditions prevent using a monitoring method or retrieving data at a critical point in time.**
Geographic location	**Weather conditions prevent using a monitoring method or retrieving data at a critical point in time.**
Human activities in the surface environment: off site	**Weather conditions prevent using a monitoring method or retrieving data at a critical point in time.**
Meteorology, weather	**Weather conditions prevent using a monitoring method or retrieving data at a critical point in time.**

20

IBDP: 89 Scenarios from 1350 FEP text responses

RISK-BEARING SCENARIO	Count of RISK-BEARING SCENARIO
A permit is modified by government agency to require increased data access and approval by NGOs and/or public; this causes delays leading to price escalation.	1
Accident damages custom-manufactured equipment, sensor, tool; replacement or repair delay causes irretrievable information loss during an injection phase.	7
Action causes failure to comply with permit.	25
Action causes permit delay	38
Action causes public opposition which results in permit or project delay.	42
After injection ceases and the pre closure monitoring continues there will be a shift of focus on HSE that existed during the active injection period, resulting in an accident or unplanned event.	3
An accident by any member of the team reflects badly upon the project, and/or upon the image of another consortium member.	8
An unexpected situation arises that is not technically impacting, but the appearance of unpreparedness spurs public concern ...	14
Any unexpected situation arises for which prep is inadequate, thus impact occurs.	6
Breakdown of sensor or tool; replacement or repair delay causes irretrievable information loss.	7

21

IBDP: Risk Response Action Groups (RRAGs)

"micro" Risk Reduction Action	RRA Group
Conduct thorough risk-management practices to minimize the chance of a ***justified*** suit.	**g100 - Risk Mgmt**
Execute a thorough risk ID process to reduce likelihood of unexpected situations.	**g100 - Risk Mgmt**
Sample natural-gas storage facilities to observe similar effects.	**g101 - Site & AOR**
Use all obtainable data sources (governmental, private, and anecdotal) to minimize the chance that an unidentified active or orphan well exists within the Area Of Review.	**g101 - Site & AOR**
Conduct regional study of the geologic occurrence of toxic components, and site the project to minimize risk from this source.	**g101 - Site & AOR**

22

IBDP: Scenarios x RRAGs crosstab

Scen ID#	min (highest) Scen rank by any of 3 ranking methods (source: ScenCompile.xls)	Scenario text	g100 - Risk Mgmt	g101 - Site & AOR	g102 - USDW Baseline	g103 - Permits	g104 - QHSE	g105 - QHSE Bridging	g106 - Site Security	g107 - CO2 Resistant	g108 - Drilling	g109 - Logging	g110 - Completion	g111 - Verification Wells	g112 - MVA	g113 - Surface Seismic	g114 - Simulation	g115 - Inj Ops Planning	g116 - Inj Ops Monitoring	g117 - Inj Ops Envelope	g118 - Weather	g119 - Equipt Sparing	g120 - Budget	g121 - Tech Teams	g122 - Staff & Coord	g123 - Data Mgmt	g124 - Activity	g125
#Ci21	1	Action causes public opposition which results in permit or project delay.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1
#Op04	1	Cement dissolution results in very small amounts of CO2 gas present in intermediate/injection string annulus after two years of injection causing remedial work to be performed to finish project.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#Ci19	2	Action causes permit delay	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	0	0
#Mg05	2	CO2 exits storage reservoir and crosses caprock via fault or fracture.	0	0	0	0	0	0	0	0	0	0	0	0	3	1	1	0	0	0	0	0	0	0	0	0	0	0
#Ci09	3	Public knowledge of significant planning error causes loss of public confidence in ability to conduct CCS.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#Rs04	3	Subsurface condition impairs seismic imaging, groundwater sampling, logging, or other data acquisition, impairing ability to track plume.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#Ci20	4	Action causes failure to comply with permit.	0	3	1	3	0	1	0	2	0	2	0	0	2	0	1	1	0	0	0	0	2	0	0	1	0	0
#Hs02	4	CO2 moves via wellbore or fault directly into USDW	0	1	0	0	0	0	0	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
#Hs03	4	CO2-acidified brine moves via wellbore or fault, dissolving metals along the way, into USDW.	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#Ci10	5	Public fears of CO2 injection or monitoring, though technically not well founded, create opposition that impedes operations.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Prominent accident (especially involving CO2 release) raises questions about																										

23

K3 Project Risk Database

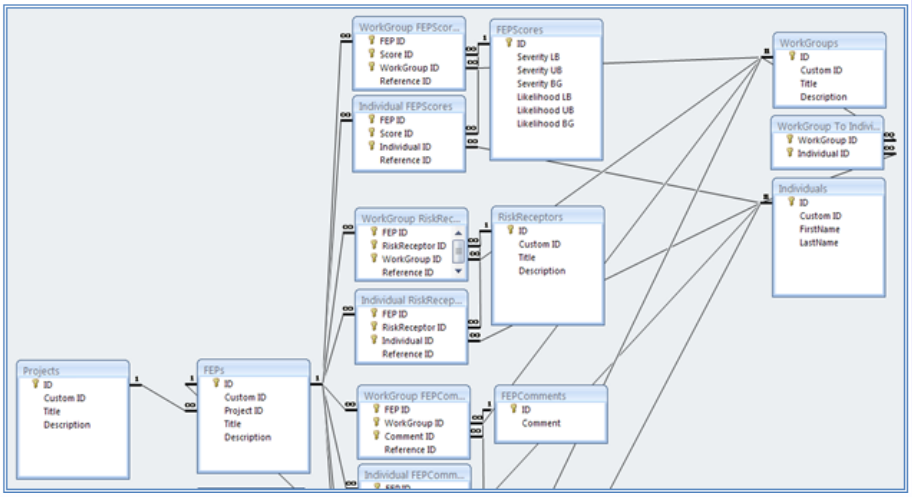
Schlumberger

The K3 Project Risk Database

Contents

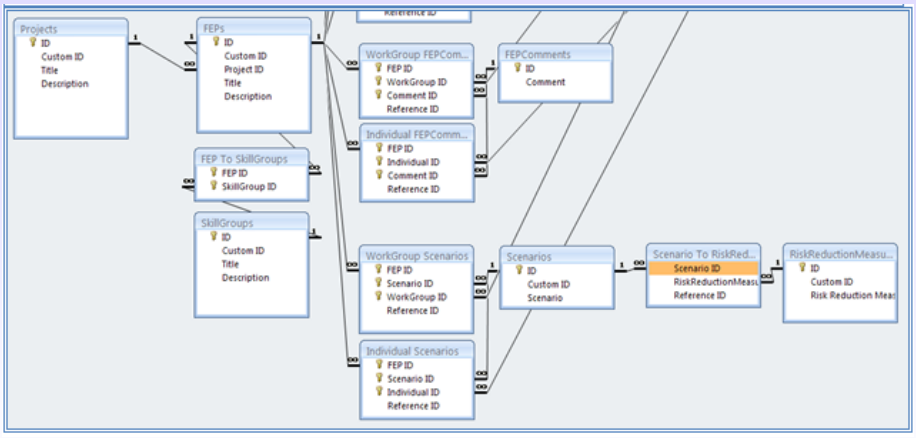
24

K3 Project Risk Database: Table Relationships 1/2



25

K3 Project Risk Database: Table Relationships 2/2



26

K3 Project Risk Database: Intended Usage

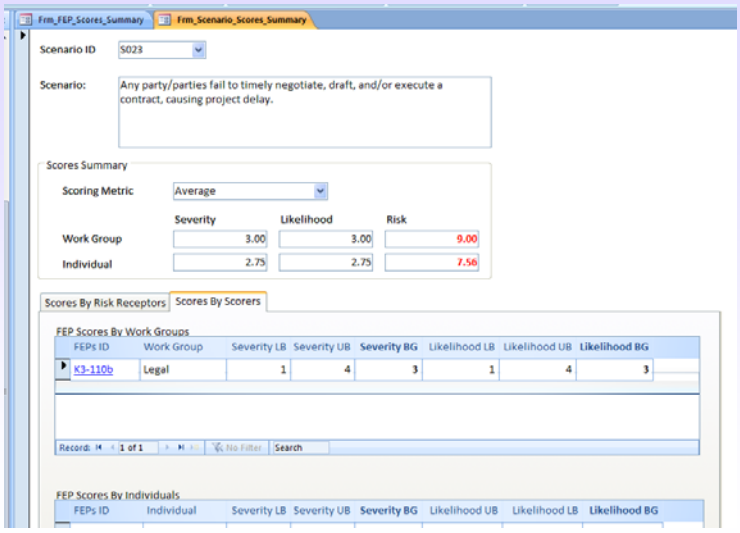
2.3 Intended usage

As of 1 April 2009, the next intended direct usage of the K3 risk database is as a resource for further definition of scenarios and risk reduction measures (RRMs). RRMs – often imprecisely and/or complexly described at first – are to be converted into precise, assignable, and trackable Risk Reduction Actions (RRAs). The Forms should simplify bringing together the information from FEPs of interest (e.g. high-risk FEPs), and from scenarios that are related by their linkage to FEPs.

When scenarios and risk reduction measures have been fully captured and their tables linked, the final database will enable instantly finding, for example, all FEPs (and their risk ratings) that are related to a given RRA; or all RRAs that address scenarios that are of high risk to project finances; or other desired outputs. If desired, additional tables may be created to track progress and status of RRAs, or this information may be retained using other software.

27

K3 Risk Database: Scenario Score Summary form



28

Draft Risk Response Action Groups (IBDP)

QHSE PLAN: Subsurface and Seismic Operations	COMPLETION PLAN: Geophone wells	COMMUNICATIONS POLICY
QHSE PLAN: Surface and Injection Operations	COMPLETION PLAN: Shallow groundwater monitoring wells	COMMUNICATIONS PREPARATION
SITE SELECTION AND AOR	CO2-RESISTANT WELL CONSTRUCTION	COMMUNICATIONS PROACTIVE
WEATHER EFFECTS PREPARATION	MVA PLAN	COMMUNICATIONS GROUNDWATER
USDW BASELINE CHEMISTRY	SURFACE SEISMIC	INJECTIVITY BACKUP PLAN
PERMITS	STATIC EARTH MOD	INJECTION OPS AND SHUTIN PLAN
SITE SECURITY PLAN	MULATION PLAN	EQUIPMENT SPARING PLAN
DRILLING PLAN	MANAGEMENT PLAN	OPERATIONAL MONITORING PLAN
LOGGING PLAN: In-Zone Wells	BUDG	INJECTION OPERATIONS ENVELOPE
LOGGING PLAN: Geophone wells	STAFF AND COORDINATION	NONCONTAINMENT RESPONSE PLAN
LOGGING PLAN: Shallow groundwater monitoring wells	TECH AND LEADERSHIP TEAMS	GOAL TRIAGE
COMPLETION PLAN: In-Zone Wells	ACTIVITY LOG	OVERALL RISK MANAGEMENT

29

RRAGs & RACI (IBDP)

				RESPONSIBLE "Doer"	ACCOUNTABLE "Reviewer"	CONSULT with	INFORM
flow order	RRA Group Title	DONE	Due	R	A	C	I
1	QHSE PLAN: Subsurface and Seismic Operations	x	pre-drilling	SLB-pth	MGSC-rf SLB-sm	LWD WG	All
2	QHSE PLAN: Surface and Injection Operations	x	pre-edt	ADM-ts	MGSC-rf	TRIM SLB	All
3	SITE SELECTION AND AOR			ISGS-hl	ISGS-rf	ADM SLB	MGSC IEPA SLB NETL
4	WEATHER EFFECTS PREPARATION - MVA			ISGS-rl	ISGS-igk		All
5	USDW BASELINE CHEMISTRY			ISGS-hl	ISGS-igk		IEPA
6	PERMITS			ISGS-seg	ADM-df	SLB TRIM	IEPA NETL
7	SITE SECURITY PLAN			ADM-mc	ADM-ts		All
8	DRILLING PLAN	x	15-Mar-09	SLB-pth	SLB-sm	SLB-jk SLB-R&E ADM	NETL IEPA MGSC
9	LOGGING PLAN: IN-ZONE WELLS	x	6/1/2009	SLB-ec	SLB-sm	SLB-R&E ISGS-SLB-os	IEPA NETL
10	LOGGING PLAN: GEOPHONE WELLS	x	6/1/2009	SLB-ec	SLB-sm	SLB-R&E ISGS-SLB-os	IEPA
11	LOGGING PLAN: SHALLOW GROUNDWATER MONITORING WELLS	x	6/1/2009	ISGS-rl	ISGS-igk		

30

Risk re-assessment

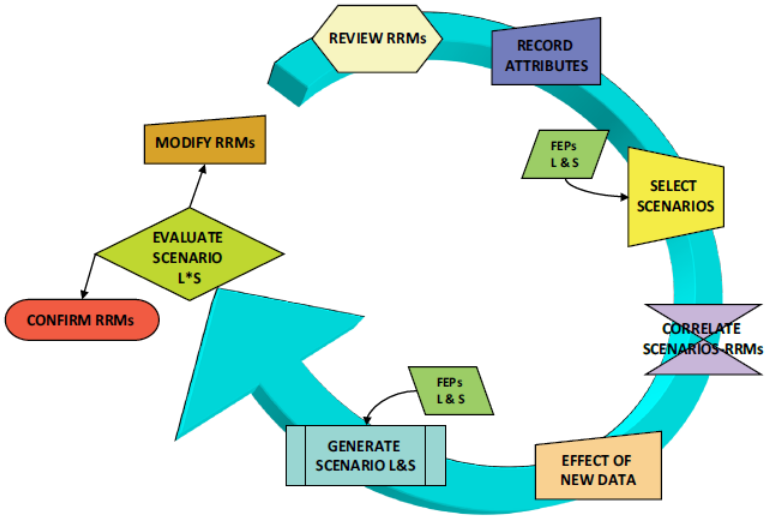


***Figure 4**, Flow chart of risk re-assessment process*

31

Ken Hnottavange-Telleen
Risk and Performance Manager
Schlumberger Carbon Services
(508) 395-2730 (office / mobile)
hnottavange-telleen@boston.oilfield.slb.com
One Hampshire Street, Cambridge, MA 02139

32