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Integrating risk analysis in EA for fracking projects

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Does Risk-based EA guarantee environmental security for fracking projects?

QUESTION FOR THIS PAPER

Present summary information to support …

Starting argument: risk-based approach enriches EA of fracking projects

Conclusion: Under current circumstances, risk-based EA does not guarantee environmental security of fracking projects

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RISK

- Expresses what we know we don't know, the *known unknowns*,
- Risk = probability (i.e., likelihood) of event x cost (i.e., impacts) of event

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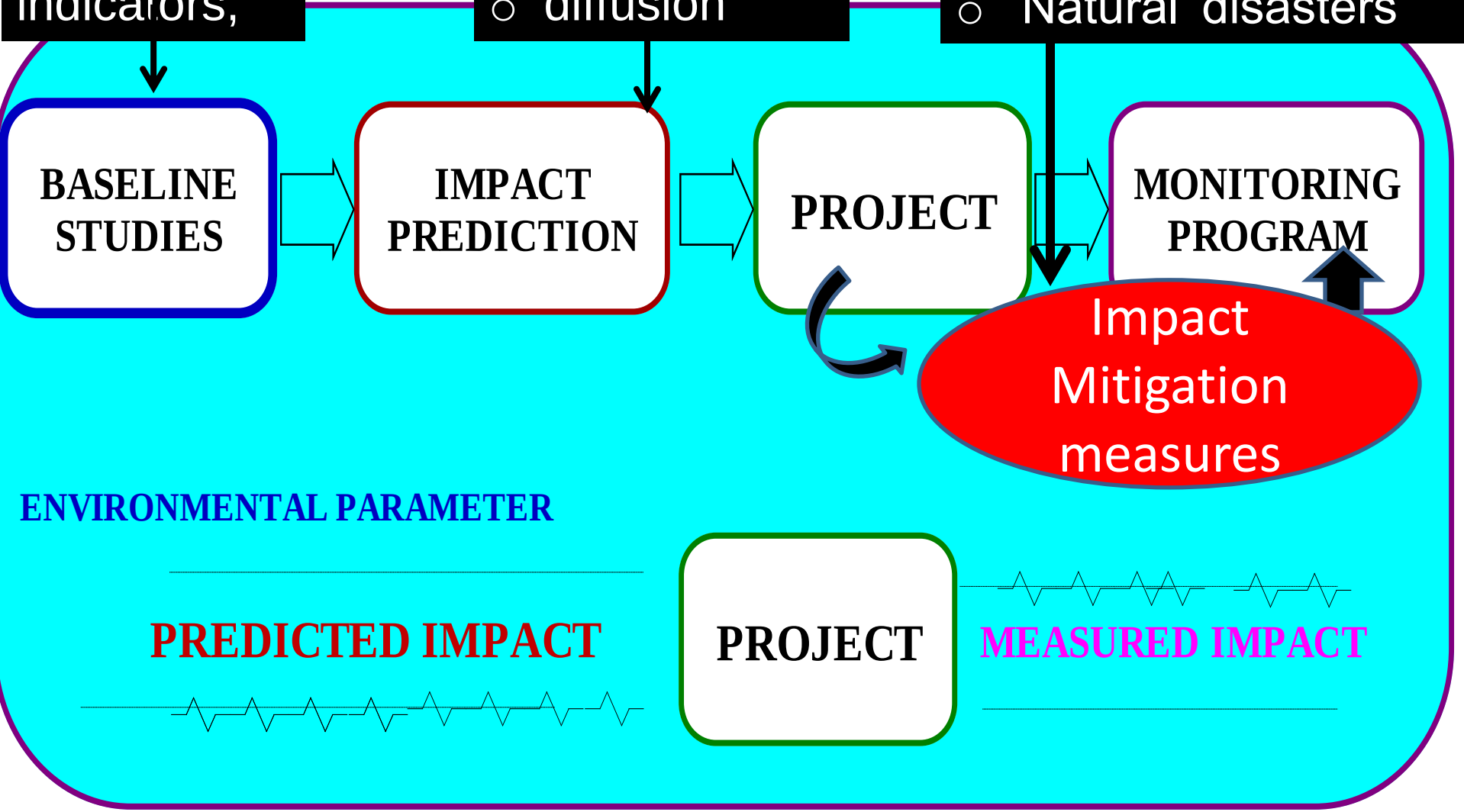
Sources of uncertainties in EA

Amount, rates, indicators,

Models on
- cause-effect
- diffusion

- Project context
- Human error, malice
- 'Natural' disasters



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Triplet of questions in risk-based EA

1. **What project activities, processes, technologies, byproducts, adversely interact with the environment?**
   - Natural causes
   - Human failure, malice
   - Technology failure
2. **What is the range of magnitude of adverse consequences?**
   - No. of people affected
   - Geographical area
3. **How likely are these consequences?**
   - Historical
   - Laboratory/empirical

Benefits of risk analysis in EA

- **Uncovers weaknesses**
  - Modify design or mitigation measures
- **Quantification of uncertainty**
  - Informs decision on mitigation measures e.g., alternative sites and processes
  - Helps determine areas needing additional research
- **Properly done**
  - allows for greater public understanding of project-related decisions

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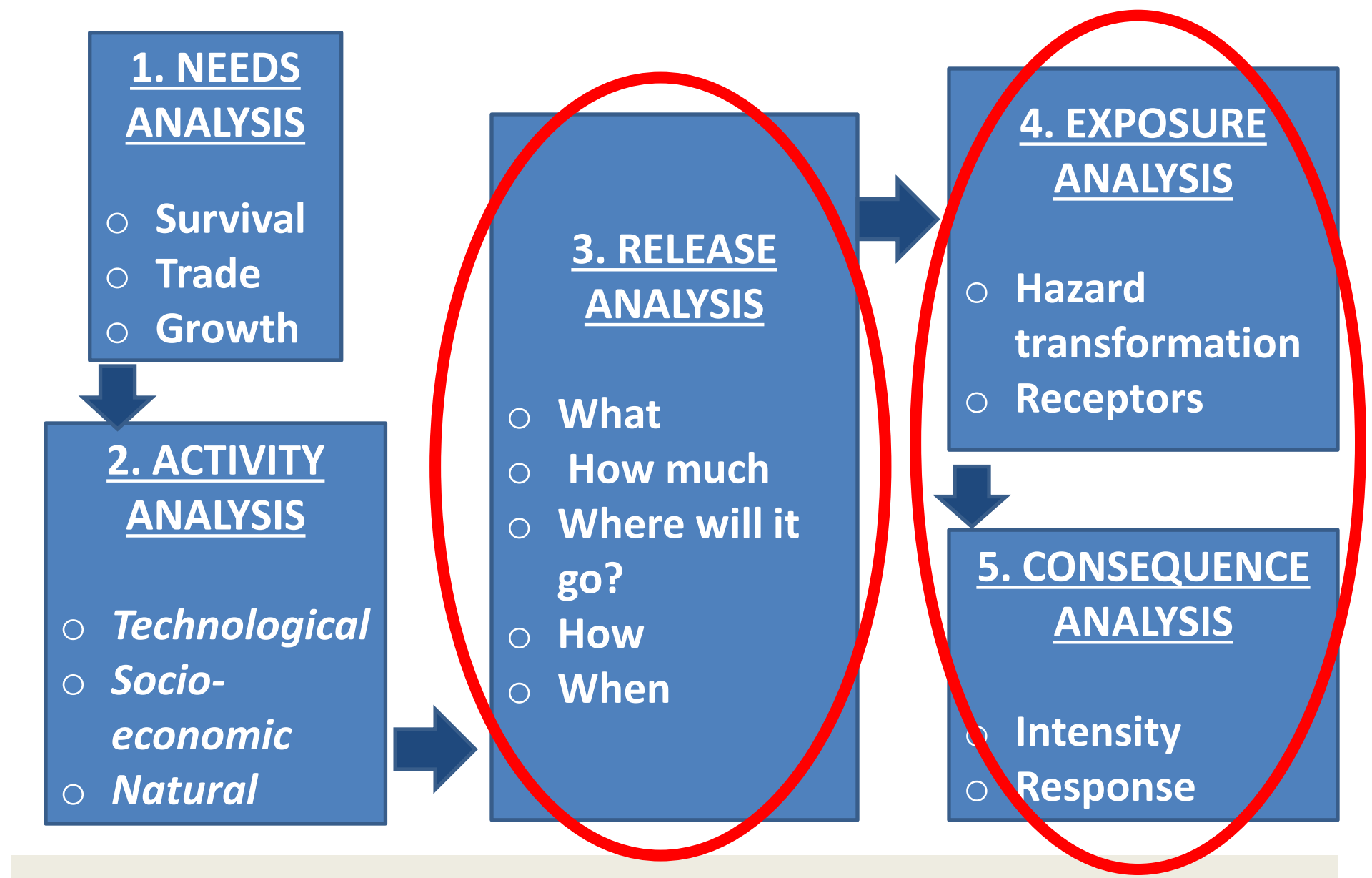
Cautions on ERA

- Probability distributions (PD)
  - dependent on existing information and knowledge; usually not available
- Assigning PD to data is complicated
  - Involves subtle pitfalls, requires expertise in statistics
- The smaller the sample the more complicated the process



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Stages of environmental risk analysis

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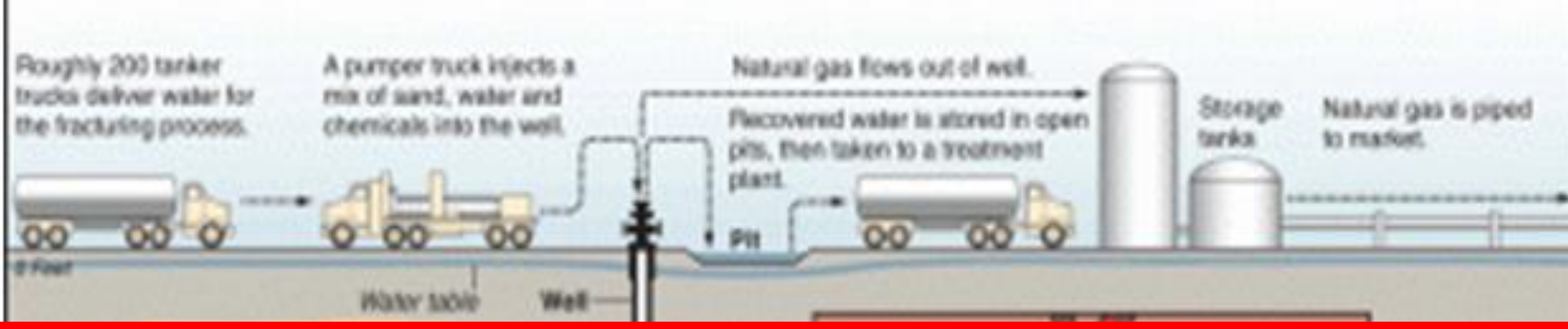
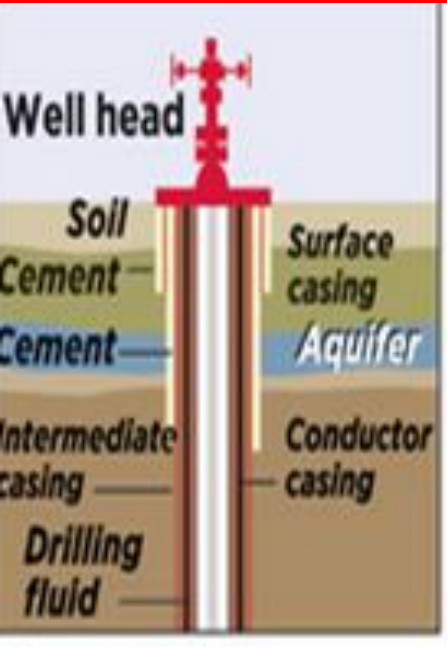
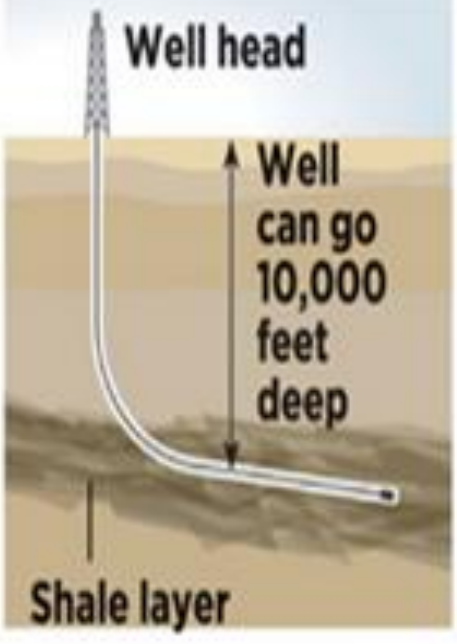
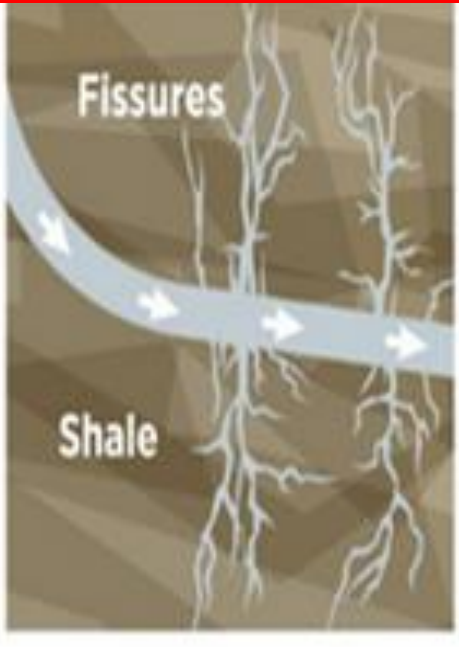
"Fracking"

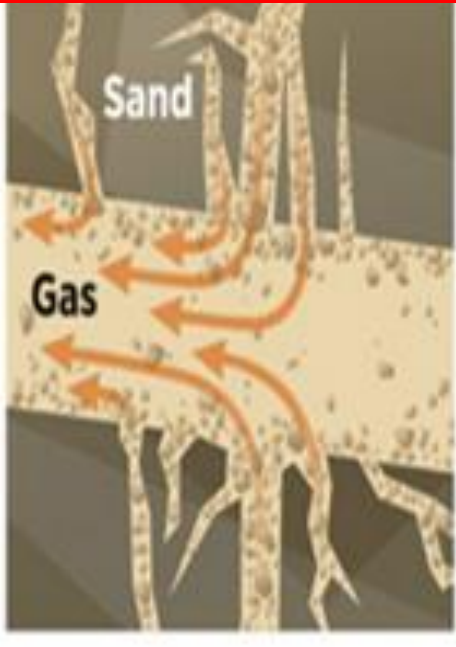
- Combination of horizontal drilling and multi-stage *hydraulic fracturing*
- Hydraulic fracturing - high pressure solutions create & maintain fissures allowing easy flow of gas, oil & water
- Applied to shale gas deposits, tight oil deposits, shale oil, tight gas strata











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SOURCE: Los Angeles Times

McClatchy Tribune

Well is bored using directional drilling, a method that allows drilling in vertical and horizontal directions to depths of more than 10,000 feet.

Large amounts of water, sand and chemicals are injected into the well at high pressure, causing fissures in the shale.

Sand flows into the fissures, keeping them open so the oil or natural gas from the shale can flow up and out of the well.

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Focus: water pollution (health impacts) risk from WW disposal, recognising …

OTHER CONCERNS

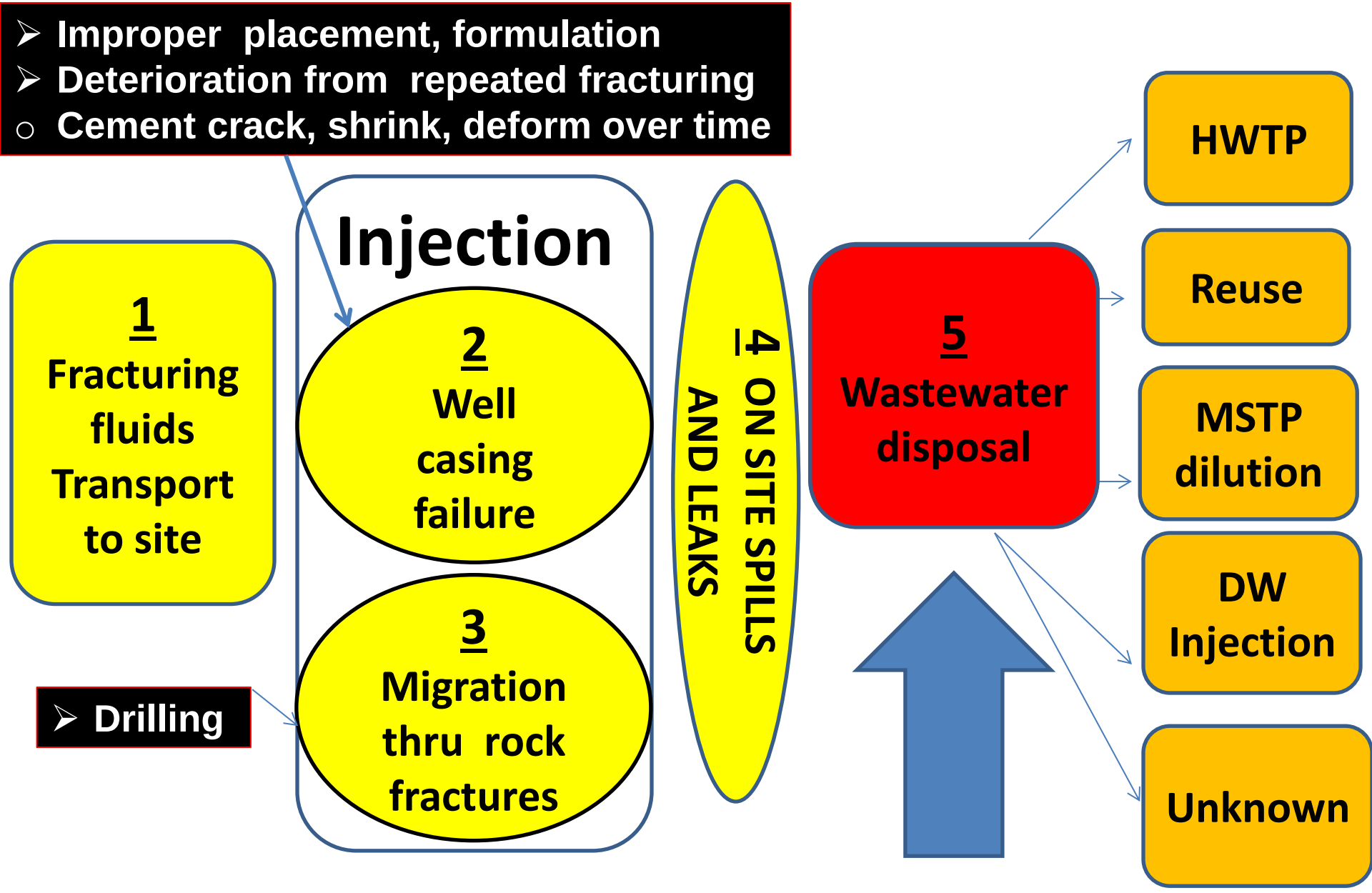
- Air quality
- Water use: high volumes in short periods of time
- DWI & seismicity (OK, TX, PA)

ALTERNATIVES

- FRACTURING LIQUIDS - N_2 gas, N_2 - based foam, CO_2 & LPG
- WW DISPOSAL - WW reuse
- CSSD est standards

5 pathways - water contamination [4]

- Improper placement, formulation
- Deterioration from repeated fracturing
  - Cement crack, shrink, deform over time



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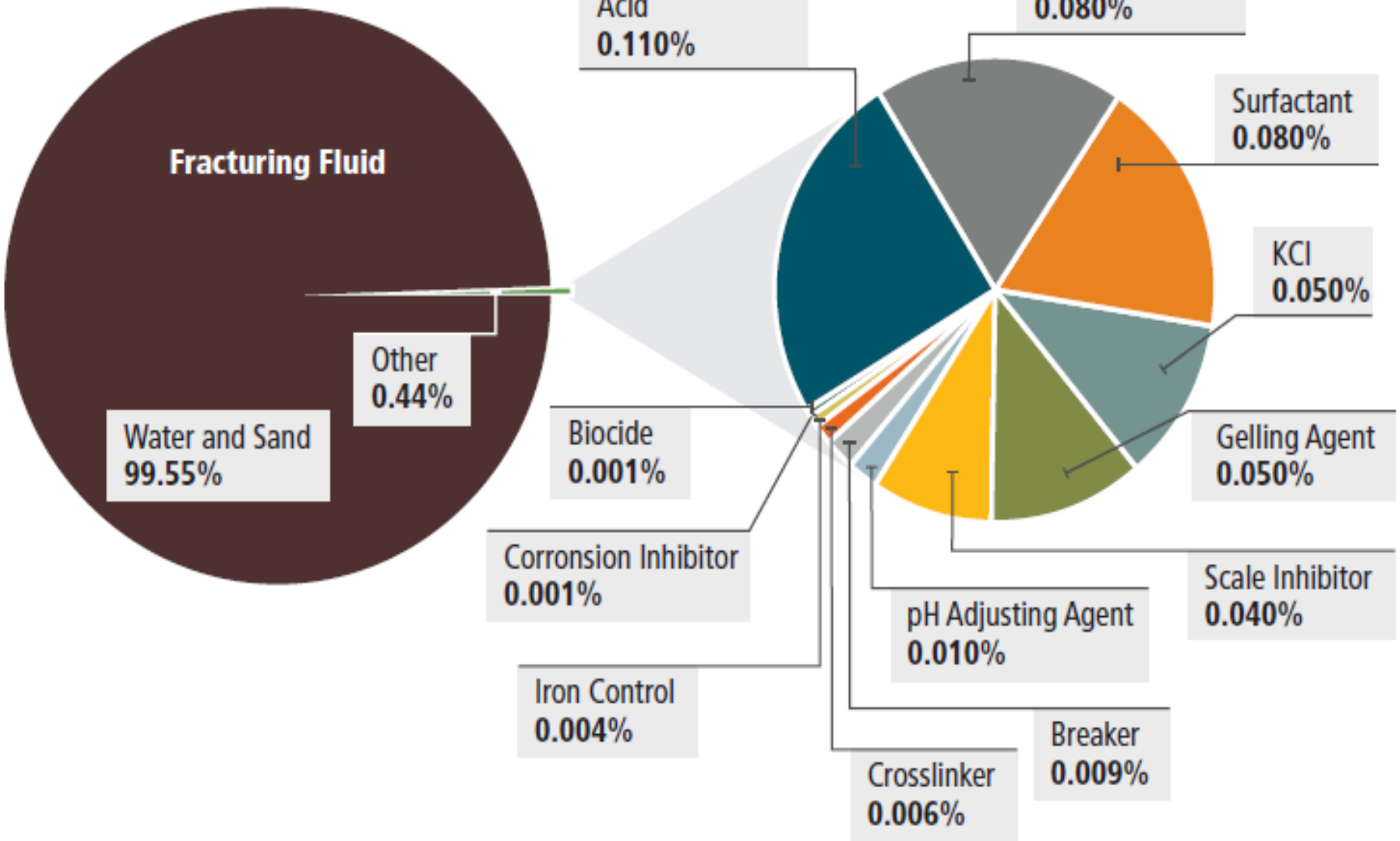

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From >750 chemicals: benign to not so benign

ADDITIVE	FUNCTION / EXAMPLES
Proppant	"props" open fractures, e.g., sand, Al_2O_3 , ZrO_2, ceramic beads
Acid	Cleans up perforations, dissolves some rocks, generally HCl
Breaker	Reduces viscosity, e.g., peroxydisulfates
Bactericide/biocid	e.g, gluteraldehyde, formaldehyde,
Buffering agent	Adjusts/controls pH, e.g., Na(K) carbonate , acetic acid
Clay stabiliser	Prevents clay swelling/migration , e.g., KCl
Corrosion inhibitor	e.g., Ammonium bisulfate, methanol
Cross linker	e. g.. potassium hydroxide, borate esters
Friction reducer	e.g., sodium acrylate, -acrylamide copolymer, petroleum distillates (benzene, ethylbenzene, toluene, xylene, naphthalene , etc)
Gelling agent	Increases fluid viscosity e.g., guar gum, cellulose polymers, petroleum distillates
Iron control	e.g., ammonium chloride, ethylene glycol
Solvent	e.g., various PAHs, benzene, toluene

Each fracturing treatment uses ca **20,000 m^3** of fracturing fluid, with …

- 1.5M kg of proppant, 100,000 l acid, 1,000kg of friction reducer, 900kg of disinfectant, 300 l corrosion inhibitor.
- Wastewater -> *Flowback* – 20 to 40% of original volume plus *formation* water with minerals from the shale formation – TDS, chlorides, bromides, arsenic, barium, NORM [Th-90, *Ra-226, Rn-222* > Po-210, Pb-21

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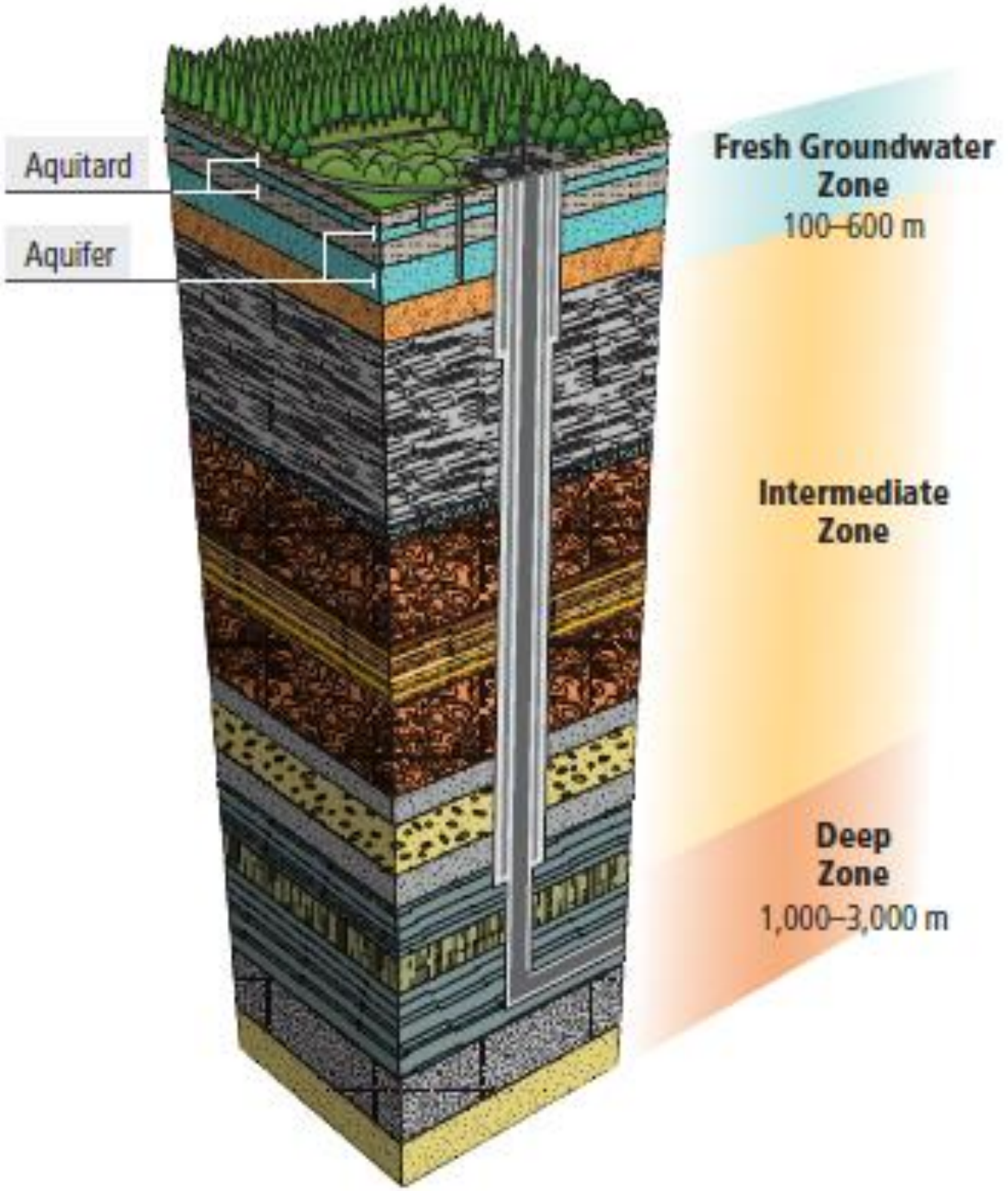

Crucial unknowns persist …

1) Reaction of diverse chemicals in IZ : ca 60-70 C & 18MPa (1.8 tonnes/ thnail [6]
2) Pathways of fracturing chemicals in the environment
3) Human exposure routes & duration
4) Lack of baseline information

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To date, even with risk analysis …

- EA not a reliable tool for establishing environmental security.
- Chemical disclosure important but not sufficient
- Research on AT LEAST HWTP capacity to remove FL chemicals - to est. consequences & mitigation!

THANK YOU!

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References used

1) Council of Canadian Academies, (2014) *Environmental Impacts of Shale Gas Extraction in Canada*. Ottawa (ON): The Expert Panel on Harnessing Science and Technology to Understand the Environmental Impacts of Shale Gas Extraction, Council of Canadian Academies.
2) Hurley, G.V., Barnes, J. L. and Thillet, M (2013). Environmental Risk Assessment. Methodological Framework for Focused Environmental Assessment. A paper presented at 2013 IAIA Conference, Calgary Alberta.
3) Kunreuther, H. (n.d.) Risk Analysis. Available at http://grace.wharton.upenn.edu/risk/downloads/03-13.pdf
4) Rozell, D.J. and Reaven, S.J. (2011) Water Pollution Risk Associated with Natural Gas Extraction in the Marcellus Shale, *Risk Analysis* DOI: 10.1111/j.1539-6924.2011.01757
5) Suter II, Barnthouse, L.W., and R.V.O`Neill (1983). ``Treatment of Risk in Environmental Impact Assessment`. En*vironmental Management,* 11(3) :295-303.
6) http://www.earthlearningidea.com/PDF/189_Pressure_rock.pdf