



Uncertainty – general considerations

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Why consider uncertainty?

Red River Flood, Grand Forks USA, 1997

- Levee height: **51 feet**
- River height *prediction*: **49 feet**

- **Actual flood height: 54 feet**

51

49

Why consider uncertainty?



Red River Flood, Grand Forks USA, 1997



- **Cost: \$3-4 billion + credibility & trust**

51

49

Why consider uncertainty?



Red River Flood, Grand Forks USA, 1997

- Levee height: **51 feet**
- River height *prediction*: **49 feet**
- **Uncertainty: ± 9 feet** (Silver 2012)

Information needed for decision-making:

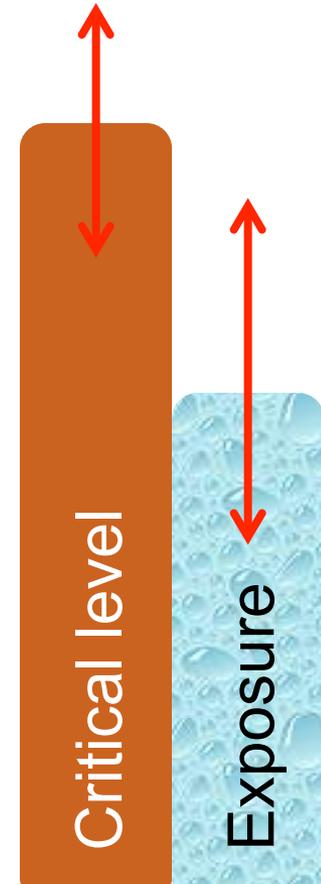
- *How much* higher might the river rise?
- *How likely* is it to exceed the levee height?



The same issues apply to all types of risk assessment



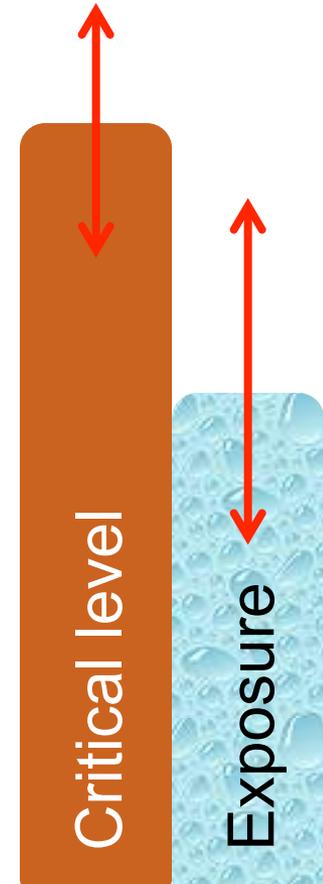
- How much larger might the exposure or effect be?
- How much lower might the critical level for that exposure or effect be?
- What's the *likelihood* that exposure or effect exceeds the critical level?



Assessing uncertainty



- Identify all potential sources of uncertainty
- Characterise their impact on the assessment
- Expressed in terms of the **range and likelihoods of alternative outcomes**



Methods for assessing uncertainty



- *Qualitative* methods:
 - Descriptive (narrative text)
 - Ordinal (e.g. low, medium, high)
- *Quantitative* methods:
 - Assessment/safety/uncertainty factors
 - Intervals, what-if calculations (ranges of values)
 - Probability distributions (range & likelihood)
 - Imprecise or bounded probabilities

Assessing uncertainty



- Overall uncertainty should be **quantified** as far as is scientifically achievable (Codex, EFSA, Aqua...)

WHY?!?

Why quantify

- Clearly expresses range & likelihood of outcomes
- Avoids ambiguity of qualitative expressions
- Avoids implying value judgements
- Can be used in subsequent calculations

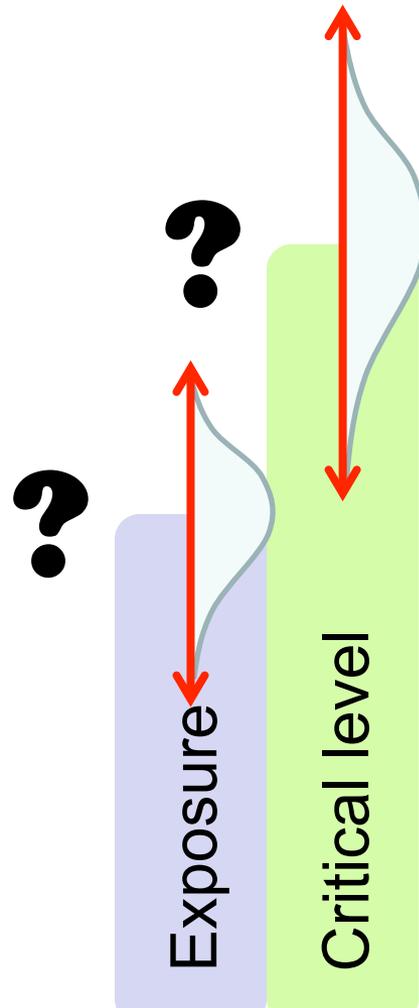
Qualitative

Descriptive:

- Source and nature of uncertainty
- Verbal expressions of magnitude and likelihood, e.g. 'negligible', 'likely'

Ordinal scales:

- Low/medium/high
- -/+ symbols
- Etc.



Quantitative

Range:

- Range of possible outcomes

Probability:

- Range and probability of alternative outcomes
- Probability of *adverse* outcomes

Bounded probabilities:

- E.g. IPCC scale

Term	Likelihood
Virtually certain	99-100%
Very likely	90-100%
Likely	66-100%
As likely as not	33-66%
Unlikely	0-33%
Very unlikely	0-10%
Exceptionally unlikely	0-1%

'quantify as far as scientifically achievable'

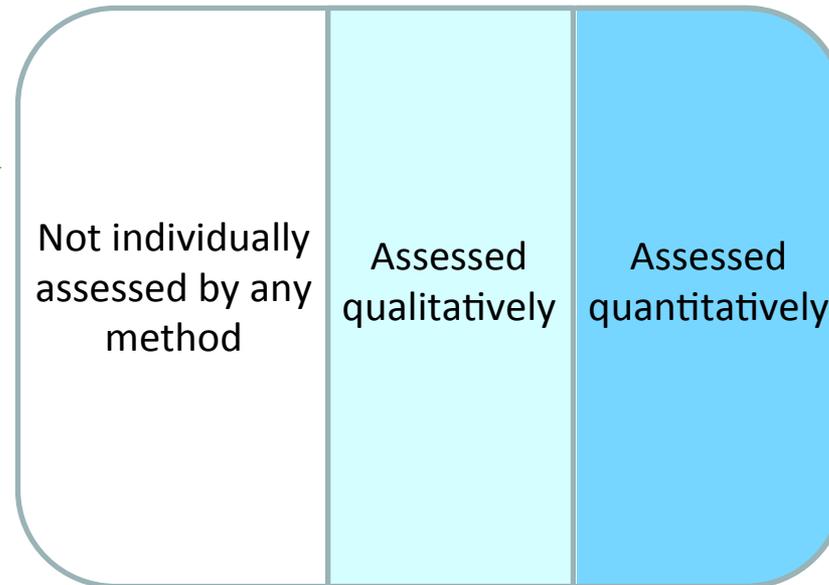
Assessing uncertainty

- It is *necessary* to quantify **overall uncertainty**
 - ...but it is *not practical* to quantify all uncertainties **individually**
- uncertainties that are not quantified *individually* need to be quantified *collectively*

Quantifying overall uncertainty



Identified uncertainties



Quantify combined contribution by *expert judgement*

Individually quantified uncertainties



Combine by *calculation or expert judgement* to assess overall uncertainty

Good practice for expert judgement



- Human judgement is subject to cognitive heuristics and biases, e.g.
 - Anchoring, Availability, Group-think, Over-confidence
- Use techniques from *expert elicitation* to guard against these biases, e.g.
 - Estimate range before central values
 - Consider what might surprise you
- Document your reasoning
- Consider formal elicitation for important uncertainties

Improving reliability

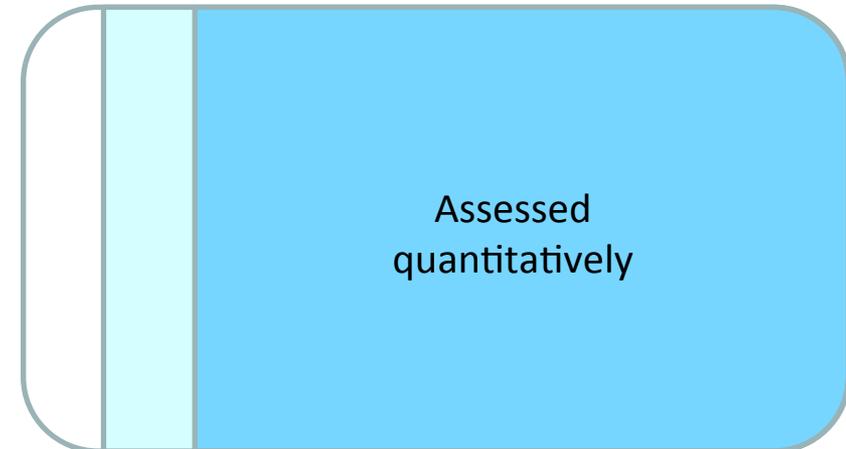


- Combine uncertainties by calculation when possible
- Reduce the proportion of overall uncertainty that is quantified *collectively*
 - *target individual quantification* on the most important uncertainties

Number of uncertainties

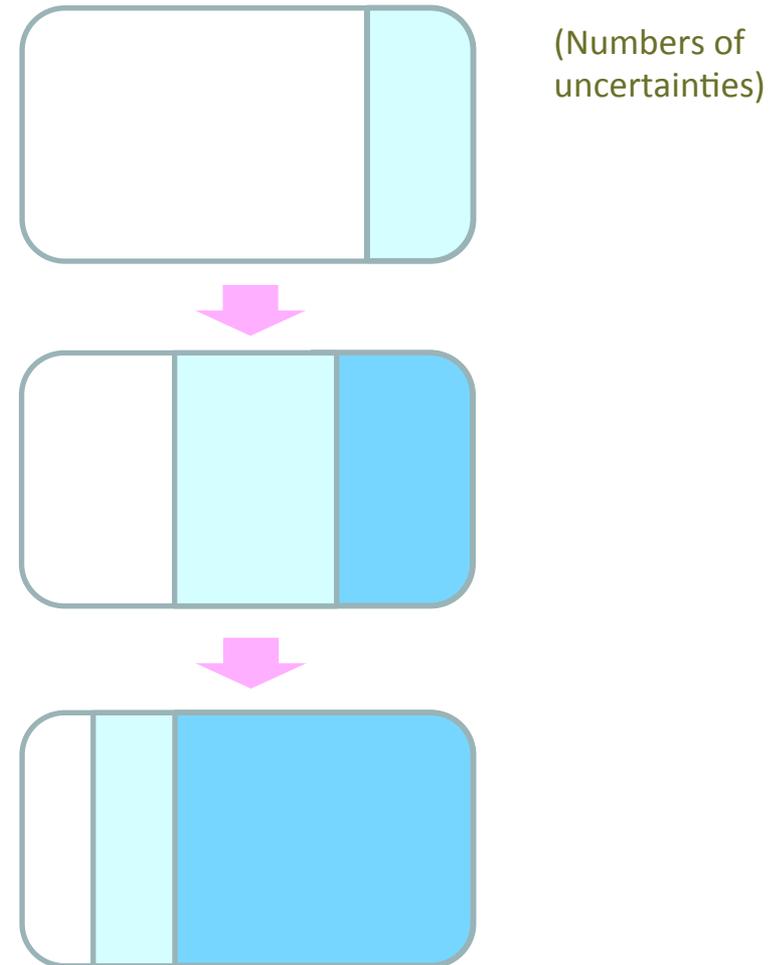


Proportion of overall uncertainty



Fit for purpose

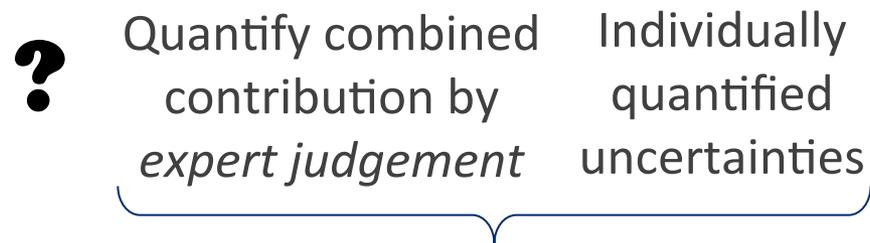
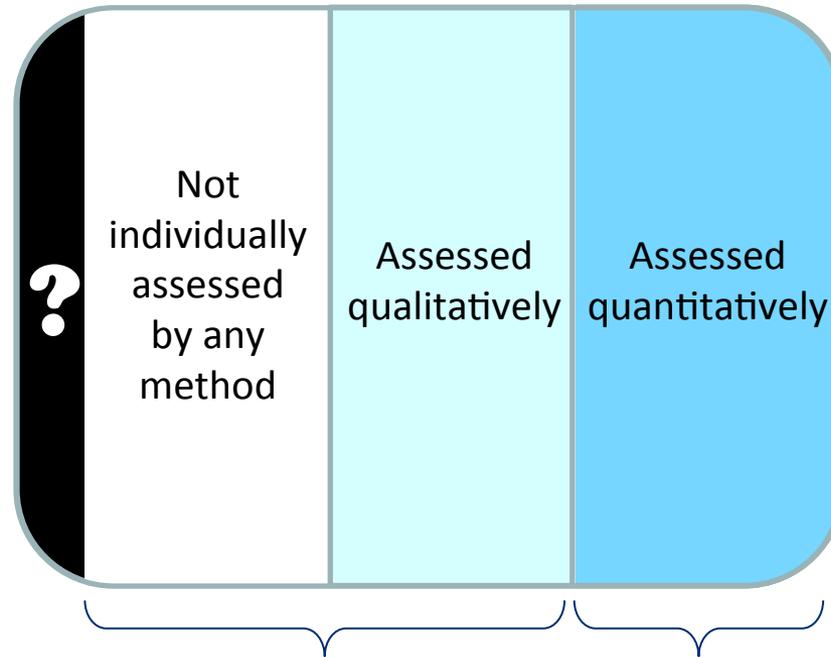
- Start *simple*
- *Target* refined approaches on the most important uncertainties
- Refine *only as far as is needed for decision-making*



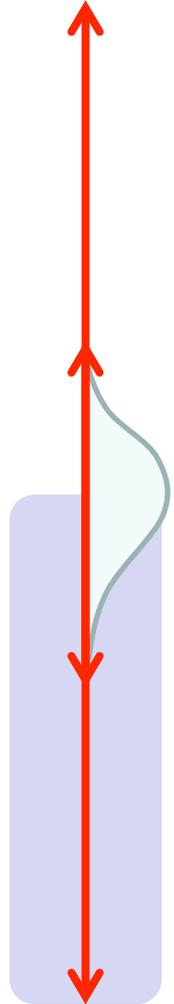
Unquantifiable uncertainty

If even one source of uncertainty is literally unquantifiable...

...then so is overall uncertainty



? Combine by *calculation or expert judgement* to assess overall uncertainty



Judgements & decision-making



- Different experts will make different judgements
- The real outcome is uncertain
- Ultimately it is the decision-maker's judgement that matters
- ...*informed* by experts

“Some of our intelligence officers thought that it was only a 40 or 30% chance that Bin Laden was in the compound. Others thought that it was as high as 80 or 90%. At the conclusion of a fairly lengthy discussion where everybody gave their assessments I said: ‘this is basically 50-50’... we couldn't know for certain... even though I thought it was only 50-50 that Bin Laden was there, I thought it was worth us taking the shot.” – *Obama**

‘resolving the impact of uncertainty on decision-making is the responsibility of risk managers, not risk assessors’ (Codex)

Uncertainty and C4SLs

- Need to address uncertainty when...
 - setting C4SLs
 - using C4SLs
 - conducting DQRA

...see later talks...

Setting C4SLs

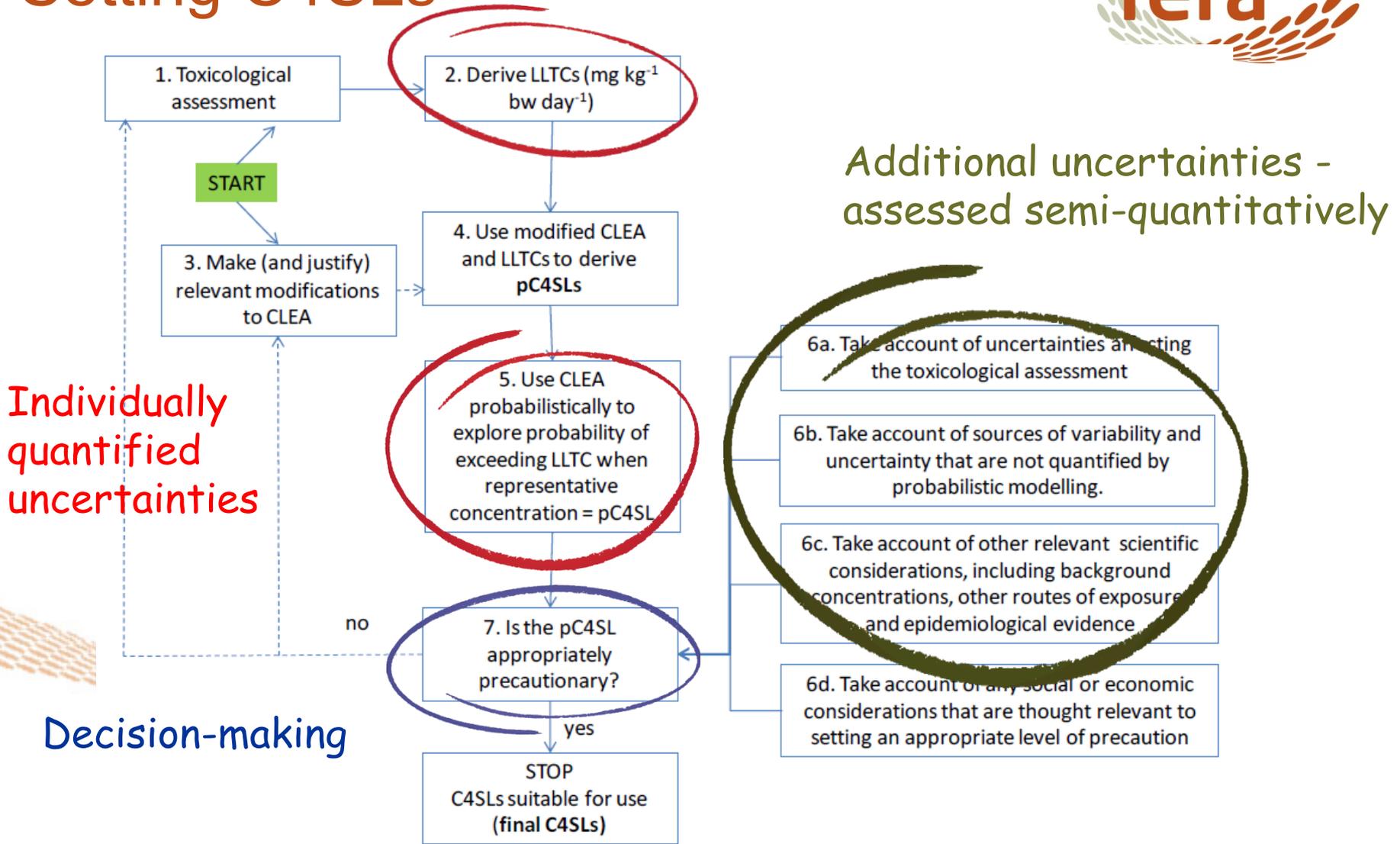
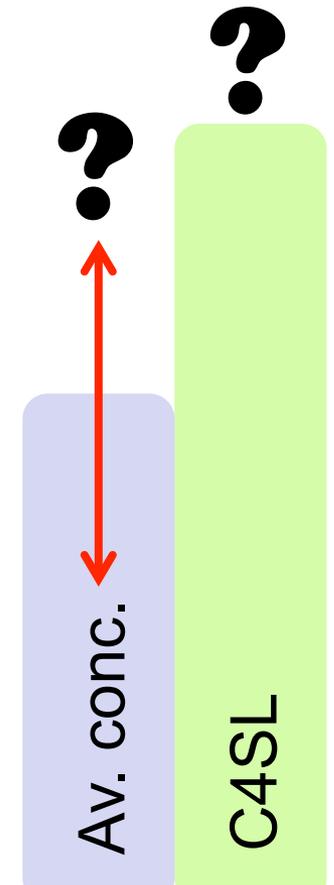


Figure 5.1: Suggested overall methodology for developing C4SLs. *CL:AIRE Final Report, 2014.*

Using C4SLs



- Compare C4SL to 95% upper confidence limit for mean concentration in relevant 'averaging area' of site
- Consider other uncertainties affecting:
 - definition of averaging area
 - average concentration
 - applicability of C4SL
 - other relevant factors?



Summary

- Need to address uncertainty
- Quantify overall uncertainty as far as possible
- Need for expert judgment
- Combine uncertainties by calculation where possible
- Start simple, refine as far as is needed
- Prioritise the most important uncertainties
- Identify unquantifiable uncertainties
- Inform decision-making