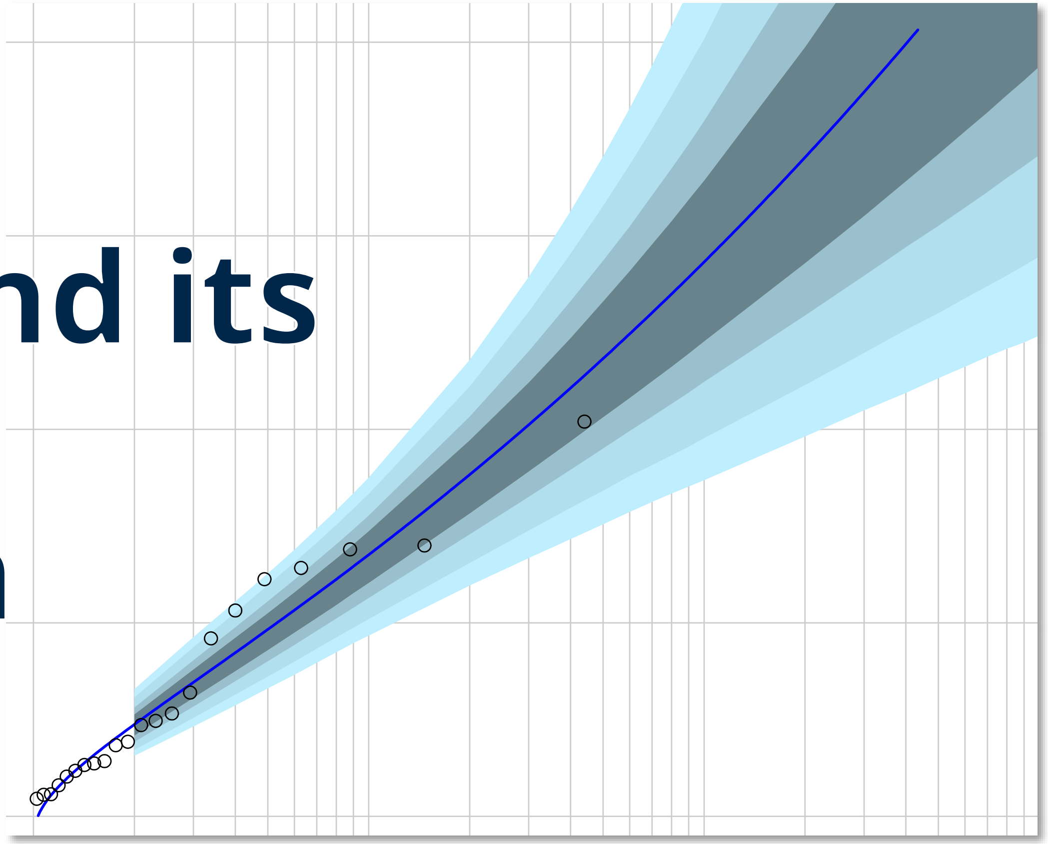
PICO3.5

Uncertainty in flood frequency analysis and its implications for infrastructure design



Daniele Ganora
Politecnico di Torino – daniele.ganora@polito.it

Politecnico di Torino
Dipartimento di Ingegneria dell'Ambiente, del Territorio e delle Infrastrutture
DIATI
Ministero dell'Università e della Ricerca
Finanziato dall'Unione europea NextGenerationEU
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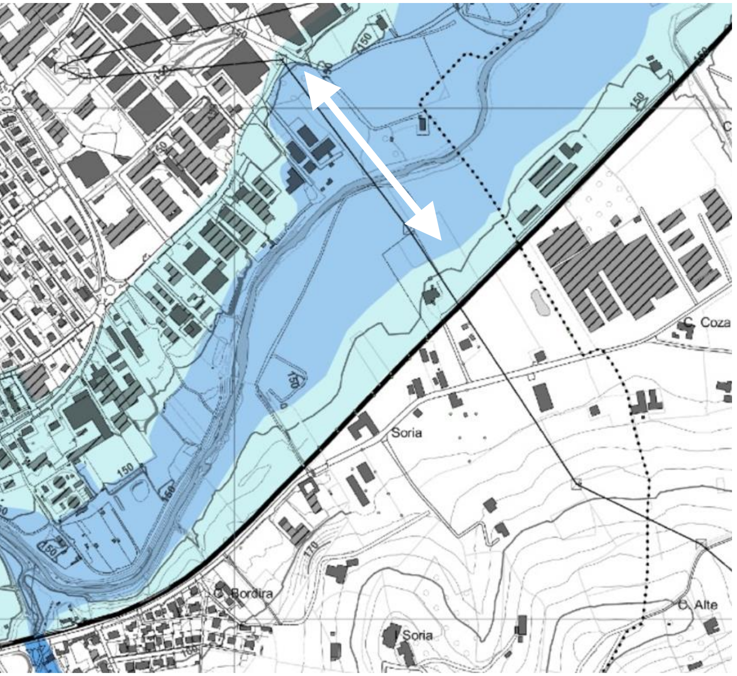
Return

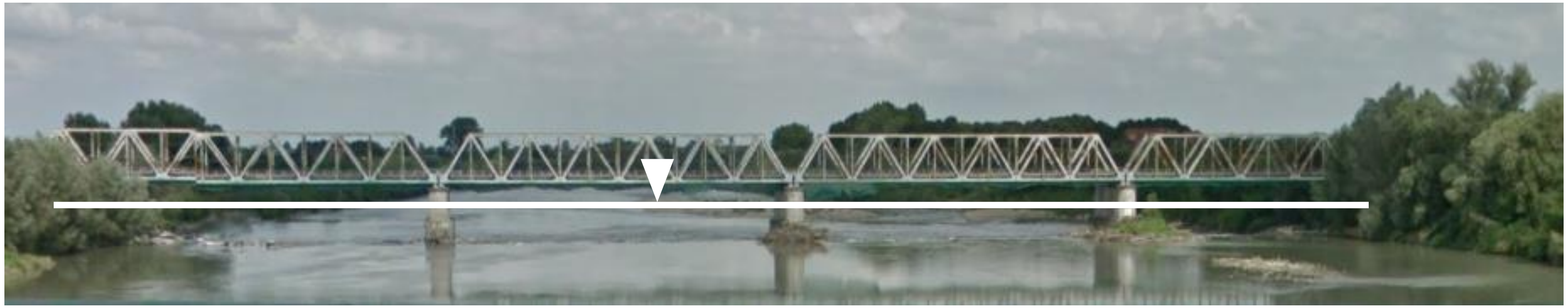
Design flood discharge

Flood hazard/risk mapping



Levees

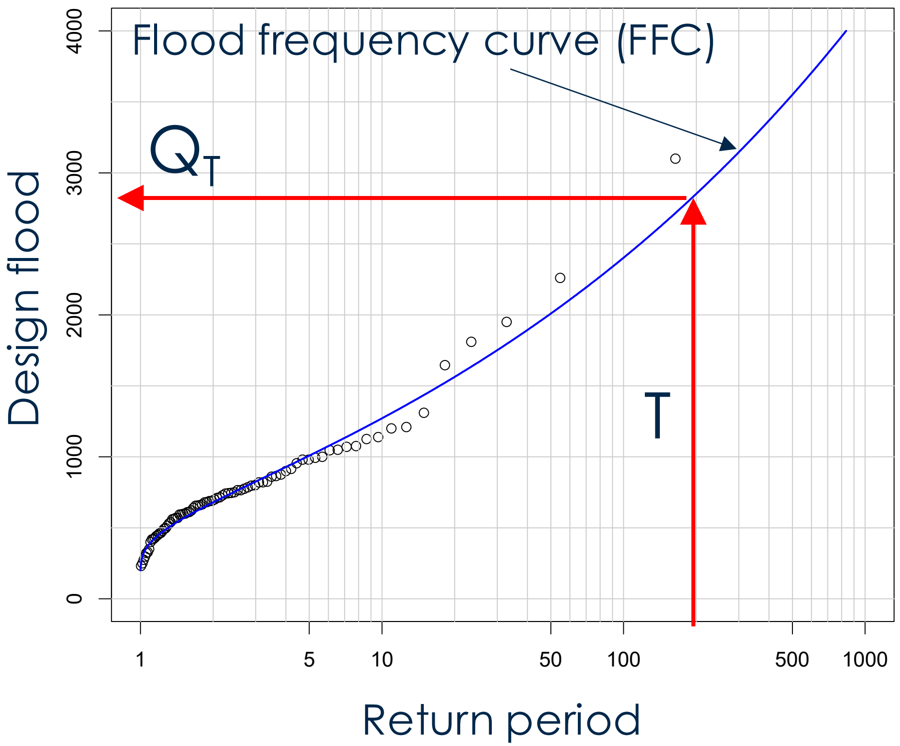
Dams



Bridges

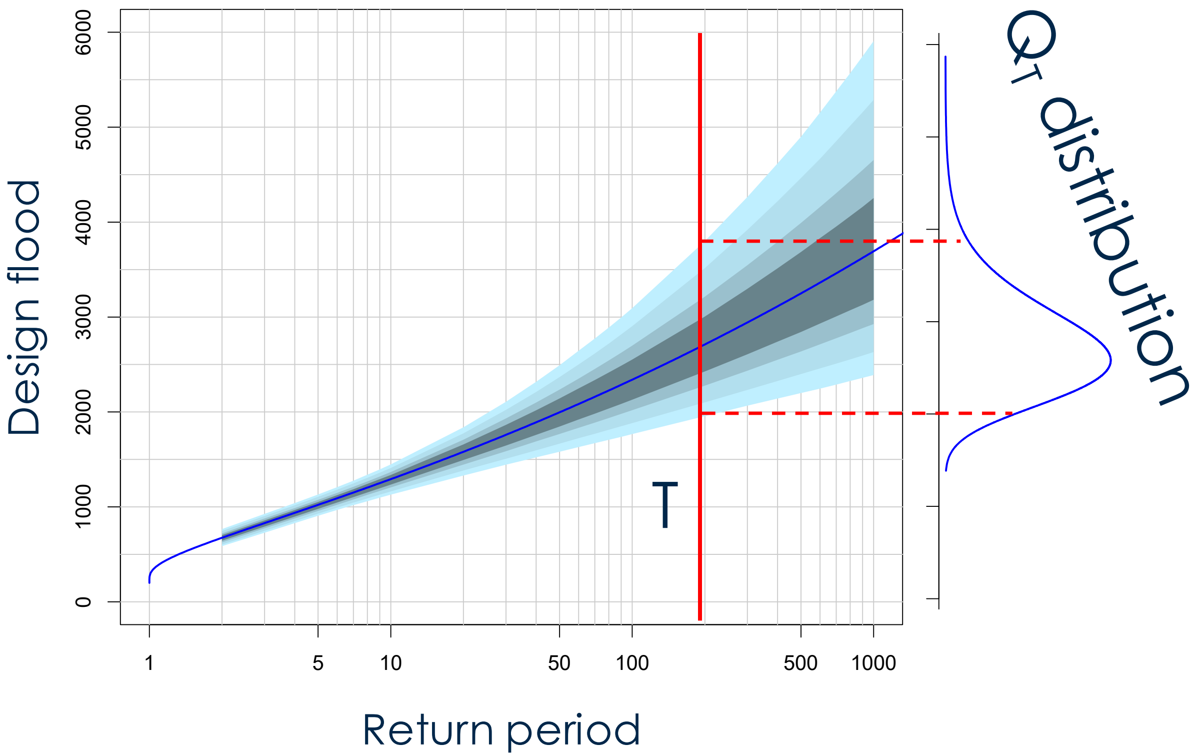
Uncertainty of the design value

Traditional approach
(hazard-based)



$Q_{DESIGN} = Q_T$

FFC uncertainties



Q_{DESIGN} = ??

A modified design value

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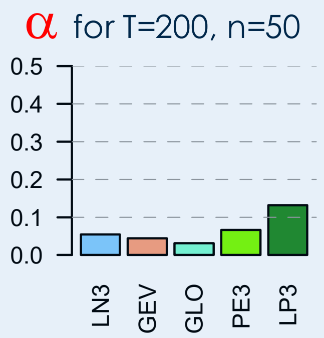
Non-experts & experts

$Q_{UNCODE} = (1+\alpha)\, Q_T$



Practical operational tool

Easy way to visualize uncertainty

Experts "scared" of uncertainty

Robust new techniques (CB) introduced, handling well uncertainty

Traditional approach is a special case of CB

Don't worry about using new techniques! (risk-based approach)

2 targets

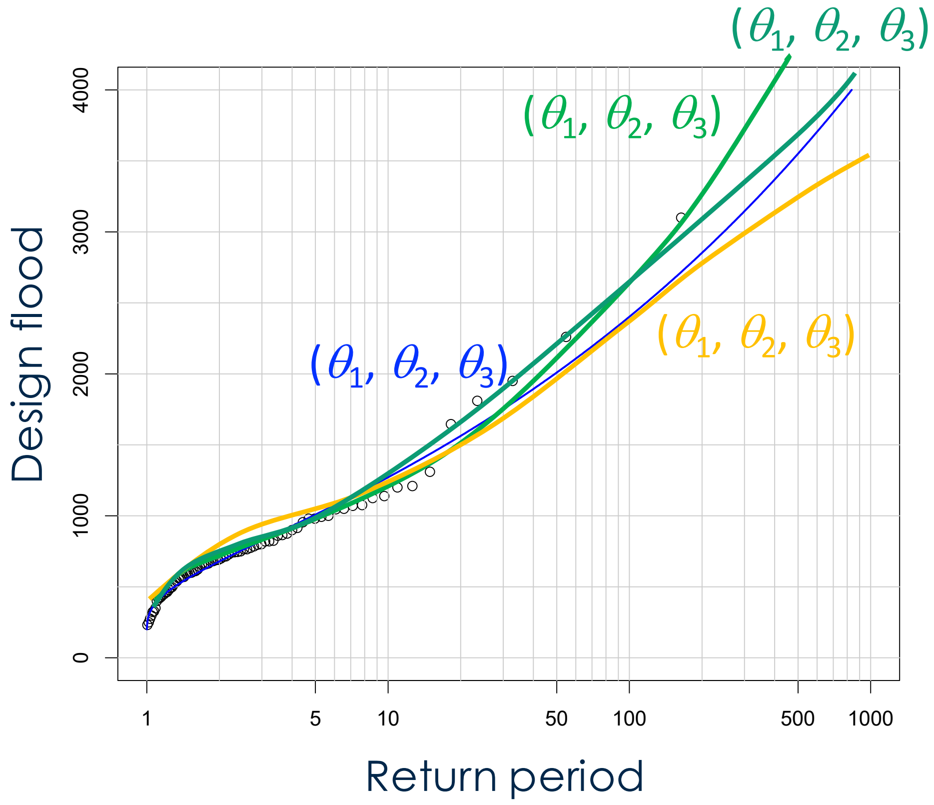
Simplified cost-benefit (CB) analysis accounting for uncertainty

$Q_{DESIGN} = Q_{UNCODE}$

Basics of UNCODE

UNCODE = uncertainty compliant design flood estimator

Current implementation considers only "sample" uncertainty



Data sample

↓

Flood frequency curve (FFC) parameters $(\theta_1, \theta_2, \theta_3)$

↓

Sample uncertainty

(different sets of parameters, Monte Carlo simulations)

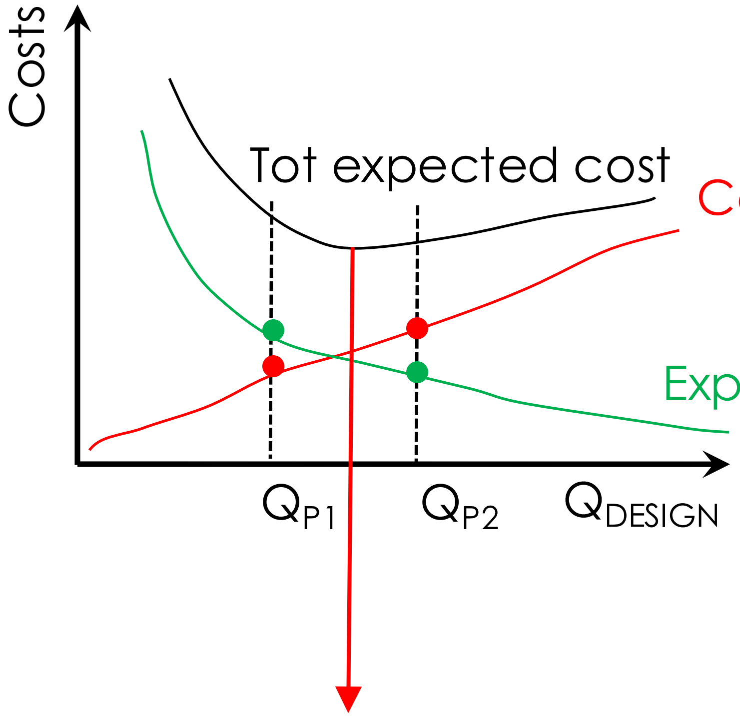
↓

Uncertainty of the FFC

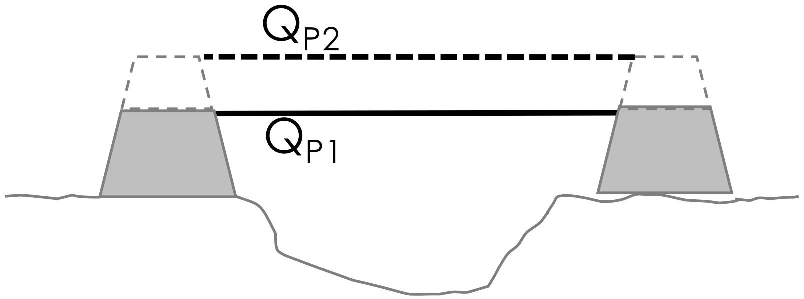
Botto et al., 2014; https://doi.org/10.1002/2013WR014981

Cost-Benefit (without uncertainty)

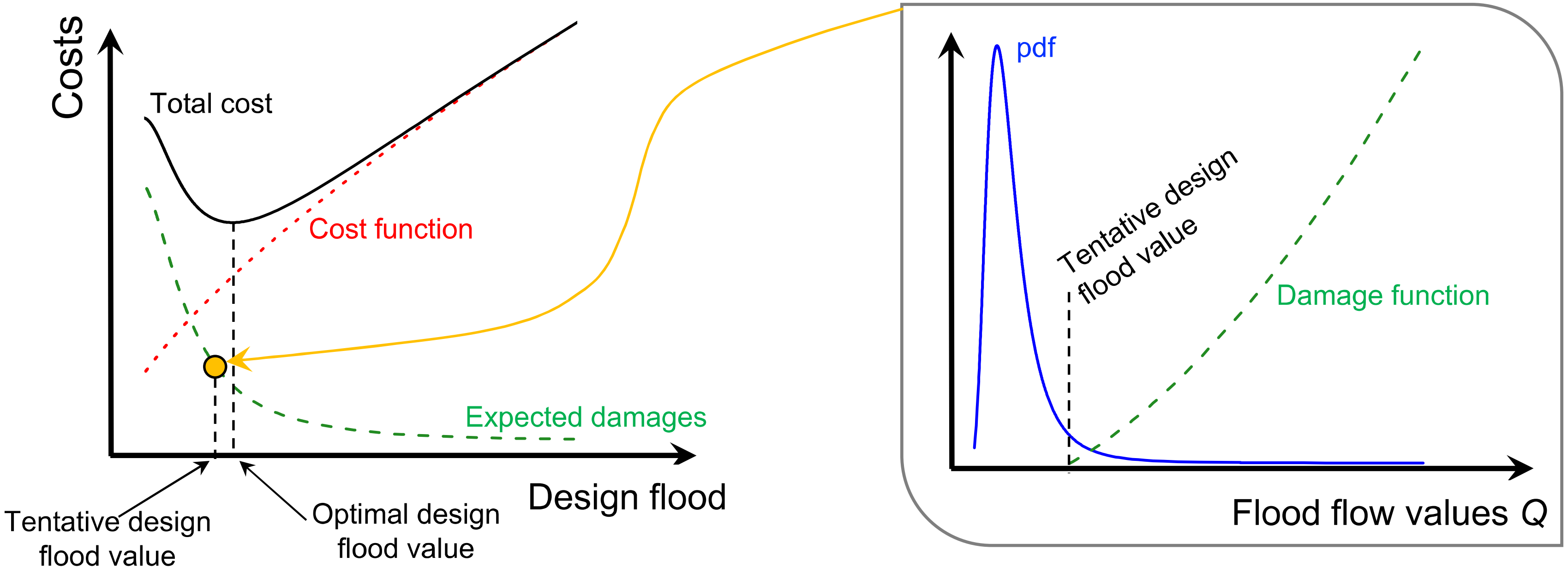
Simple conceptual "levee-based" design approach



Q_{DESIGN} = Q(min tot cost)



Cost-Benefit (without uncertainty)



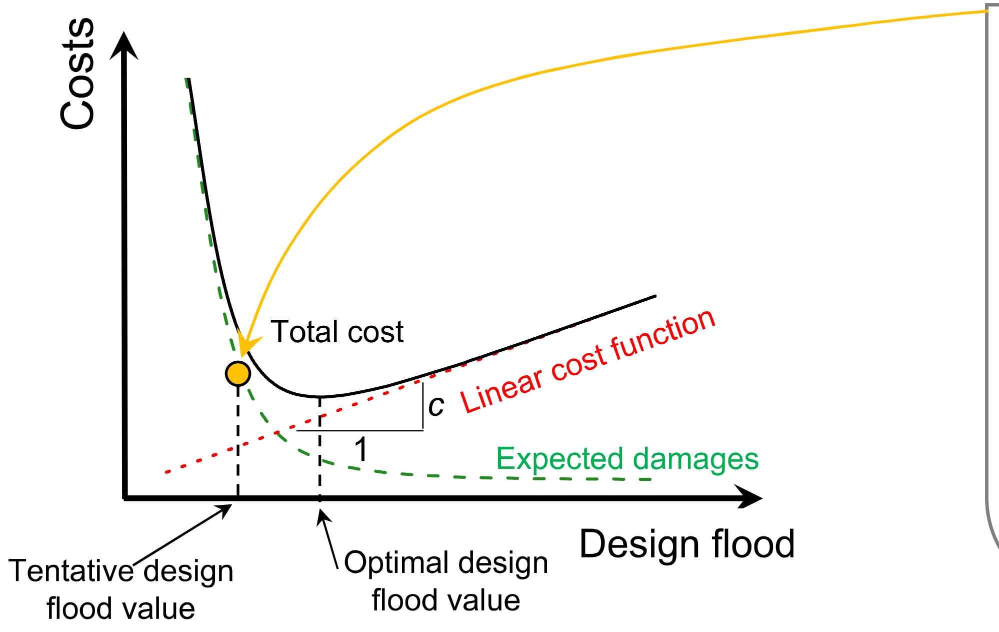
$$\text{Expected Damage} = \int_{Q^*}^{\infty} \Delta\left(Q^*, Q|\mathcal{D}\right) \cdot p\left(Q|\boldsymbol{\Theta}\right) \mathrm{d}Q$$

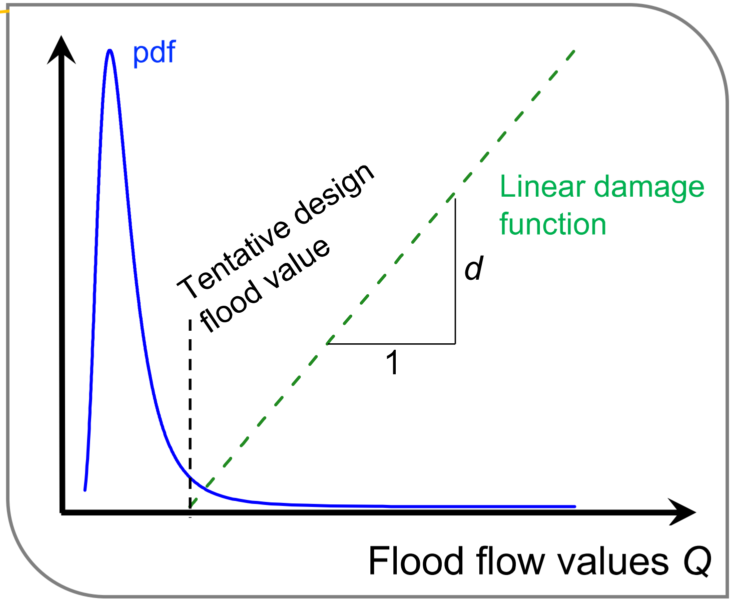
- $\Delta(\cdot)$ = Damage Function
- $\mathcal{D}$ = parametri della funzione Δ
- $p\left(Q|\boldsymbol{\Theta}\right)$ = pdf della variabile Q
- $\boldsymbol{\Theta}$ = parametri della pdf di Q

Q ≠ design flood
(Q is the annual max flow)

Cost-Benefit (without uncertainty)

Cost and damage function are usually difficult to evaluate.
However, without uncertainty, standard frequency analysis <u>is equivalent</u> to CB analysis with specific cost and damage functions.

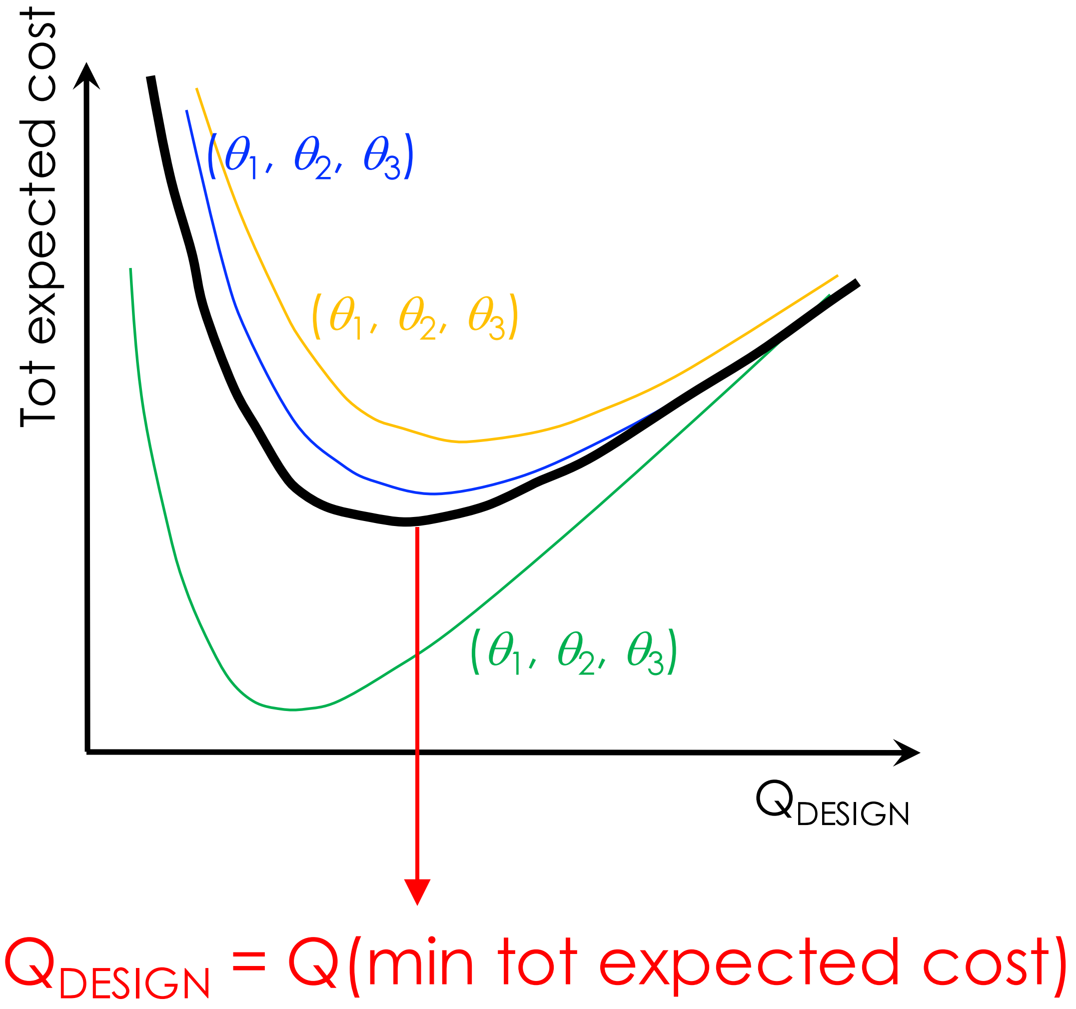




$$\frac{d}{c} = \frac{1}{1-P} = T$$

Cost-Benefit (with uncertainty)

- Total cost for one set of parameters
- Extension to all possible sets of parameters (Monte Carlo simulations)
- Average CB curve



UNCODE estimate

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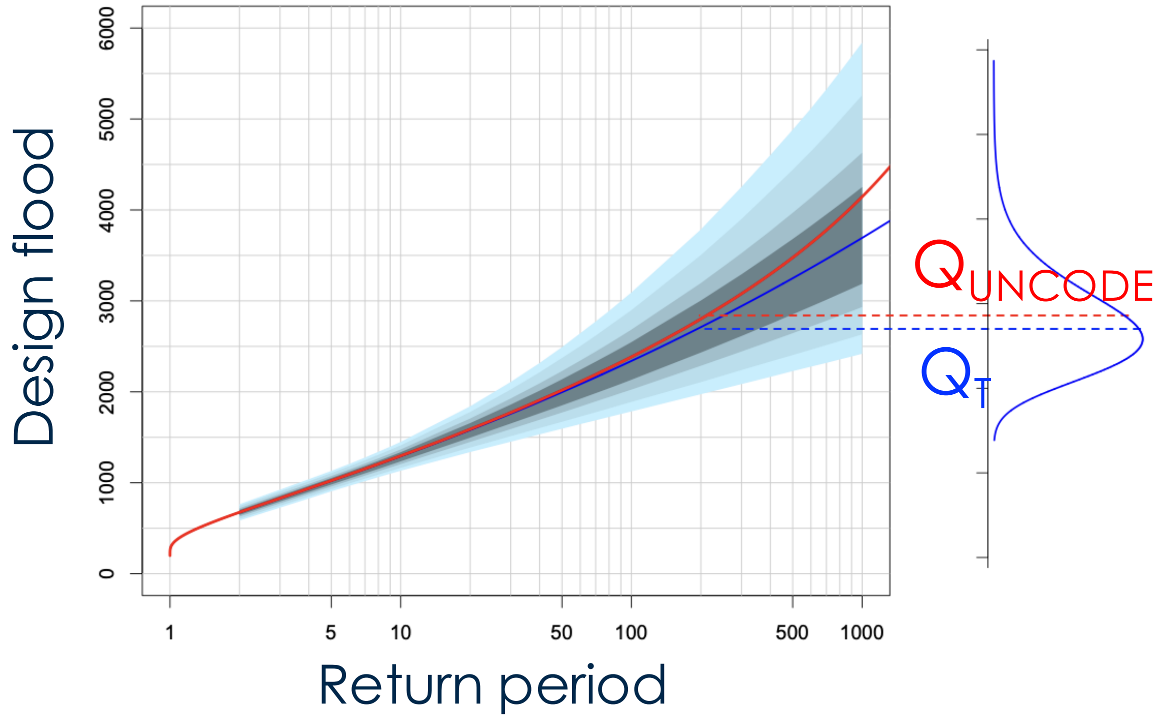
UNCODE is equivalent to the “expected probabilty” (and not the “expected quantile”) estimate and can be interporeted in a cost-benefit framework (risk-based analysis)

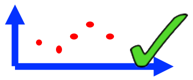


$$Q_{UNCODE} = (1+\alpha)\ Q_T$$

α depends on sample length and return period

Operational tool to quantitatively account for sampling uncertainty

Value of data: for the same confidence level, more data = lower uncertainty = lower α = lower building costs



Even short records with few data can be used

Allows clearer allocation of uncertainties, often encapsulated in a single safety factor (e.g., hydraulic freeboard)

Botto et al., 2017; https://doi.org/10.5194/hess-21-3353-2017, 2017