Modelling, Uncertainty and Data for Engineers (MUDE)

Week 2.8 : Risk Analysis

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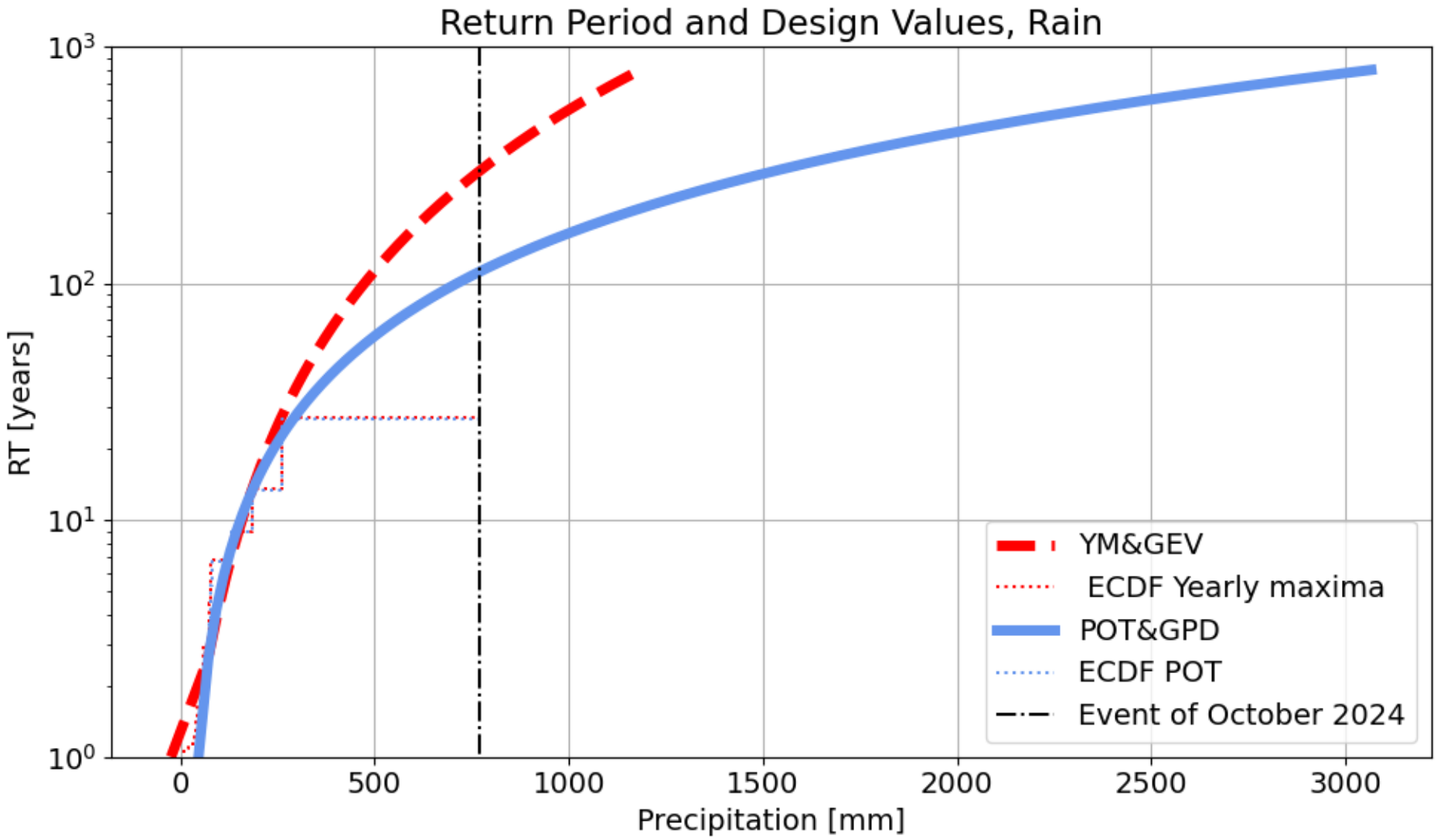
GA 2.7 Rain



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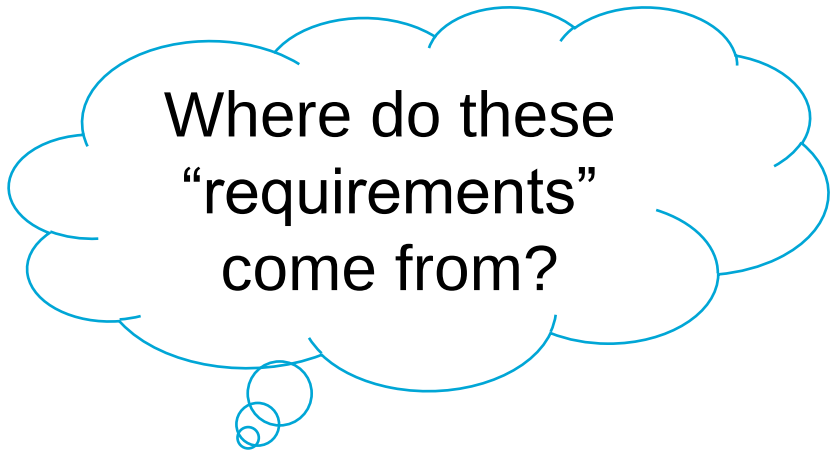
Example Design requirements for a Breakwater

Regulations and recommendations → Exceedance probability or **return period**

Country	Standard	**T_R (years)**	DL (years)	$p_{f,DL}$ (-)
England	BS 6349-1-1:2013	**50-100***	50-100	0.05*
Japan	TS Ports-2009	**50-100**	50	0.40-0.64
Spain	ROM 0.0-01/1.0-09	**113-4,975**	25-50	0.01-0.2

*Not well defined



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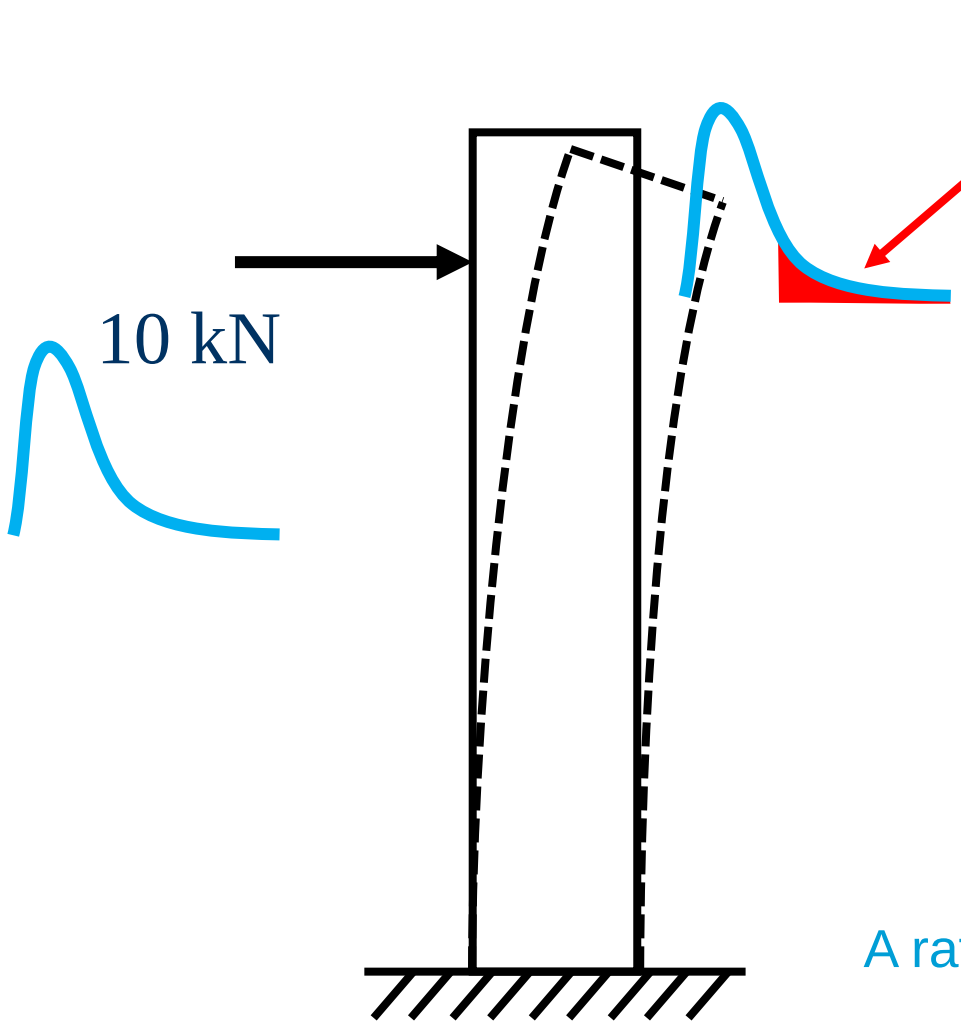
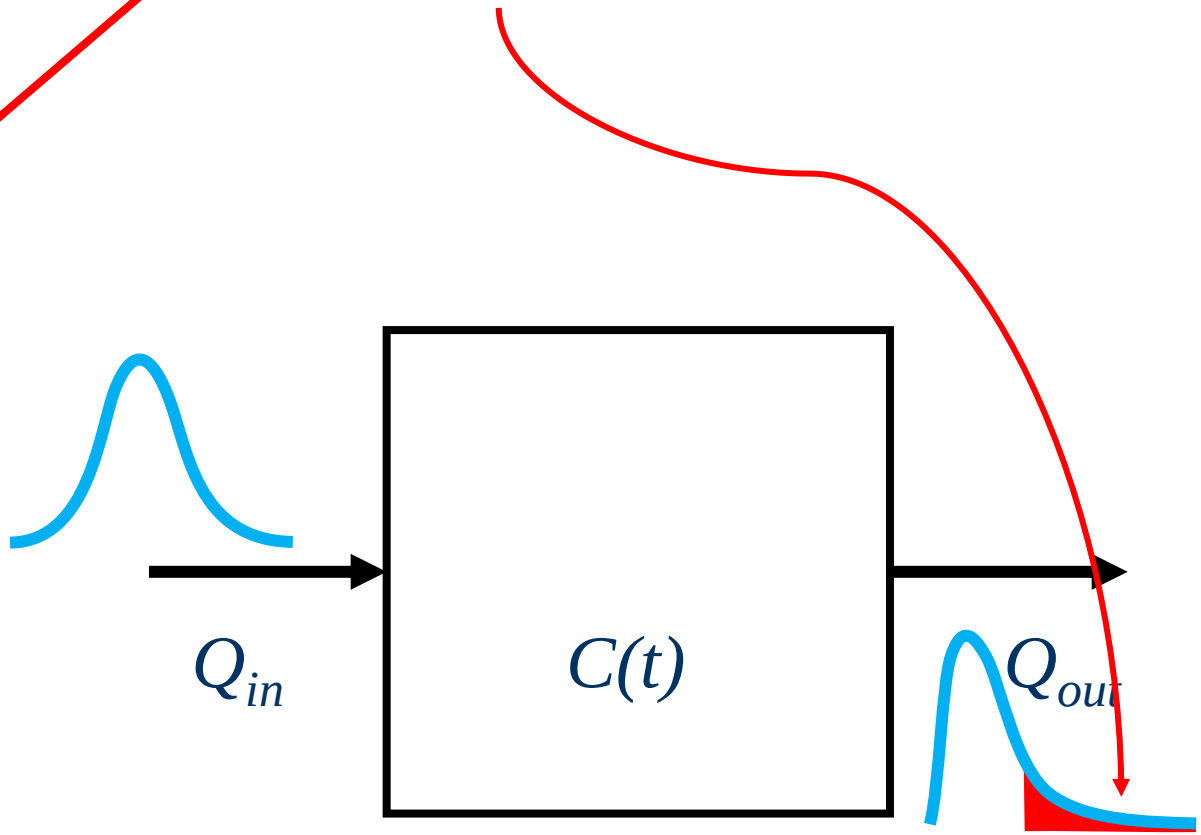
~~Deterministic~~ Probabilistic design – limit P(bad stuff) to a safe level





A rational and quantitative method for evaluating safety

…and determining an acceptable safety level

Week 2.8 Focus

Probabilistic Design

What is it?

- Uncertainty quantification (randomness, lack of information,…)
- Loads and boundary conditions
- Resistance of structure / process
- Alternative models of structure / process






A rational and quantitative method for evaluating safety



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Probabilistic Design

What is it?

- Establish functional requirements
- Use models of structure / process
- Assess whether model results meet criteria

This is important!









A decision-making process prior to construction / implementation

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Probabilistic Design

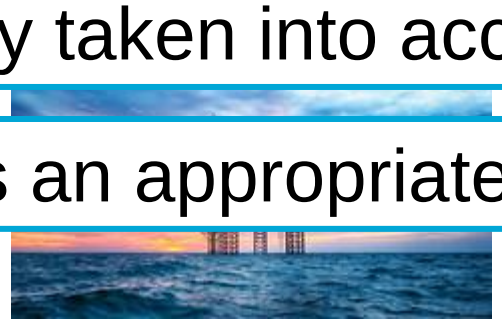
What is the design process like in your field?

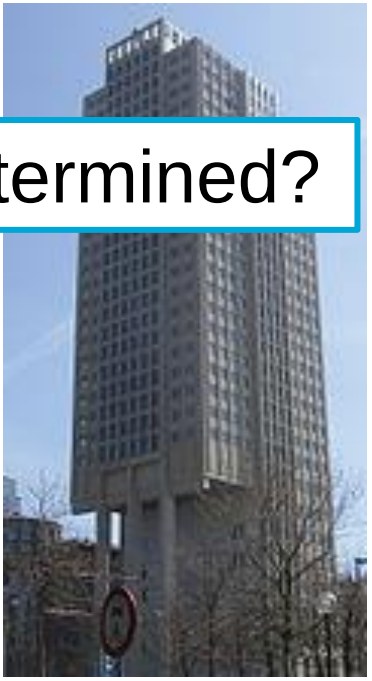



How is safety measured?

How is uncertainty taken into account?

How is an appropriate safety level determined?



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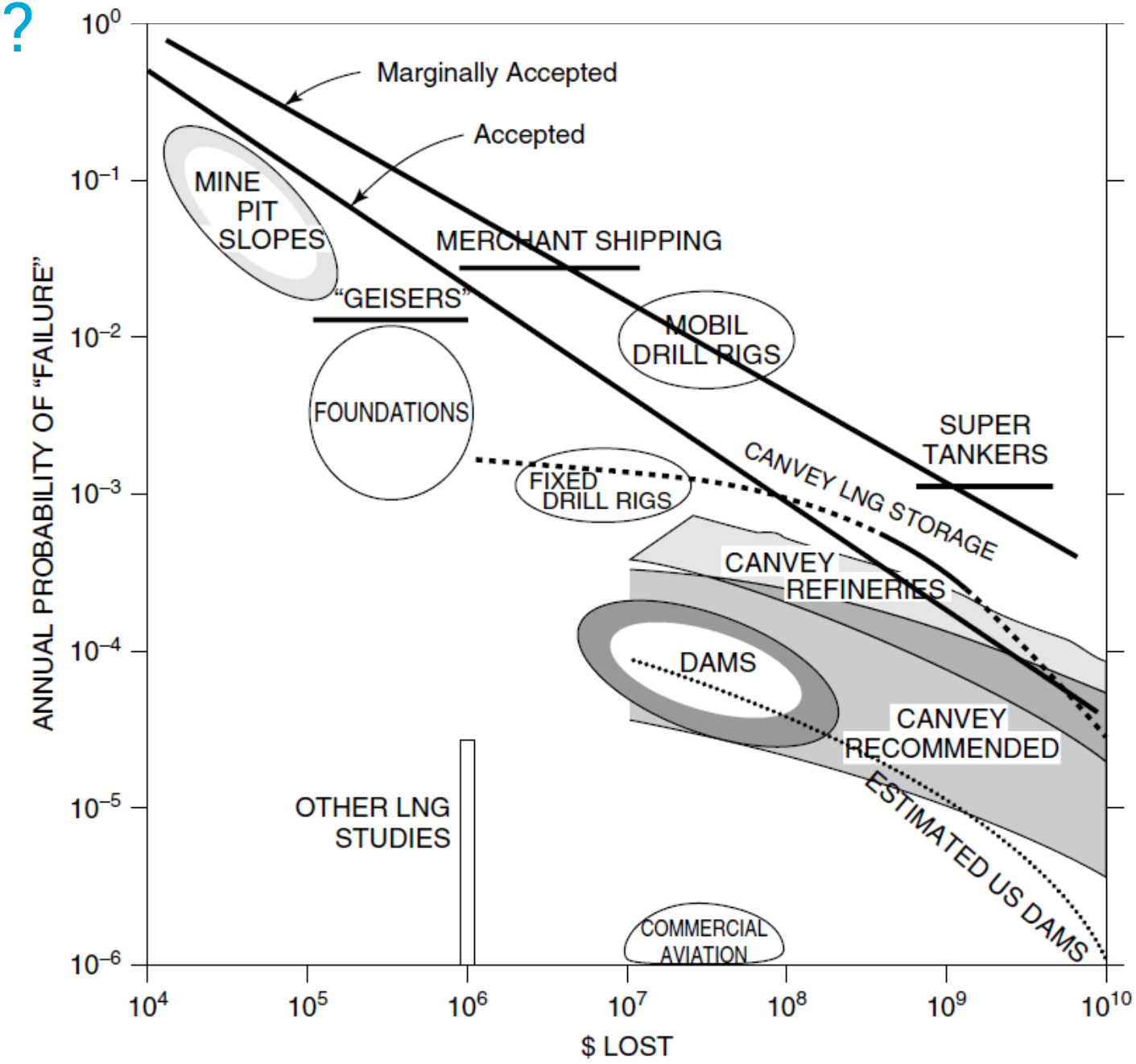
How safe is “safe enough”?

The FN (or FD) Curve

Empirical Exceedance Probability Distribution of Consequences

An infamous figure
see backstory in Chapter 8.1



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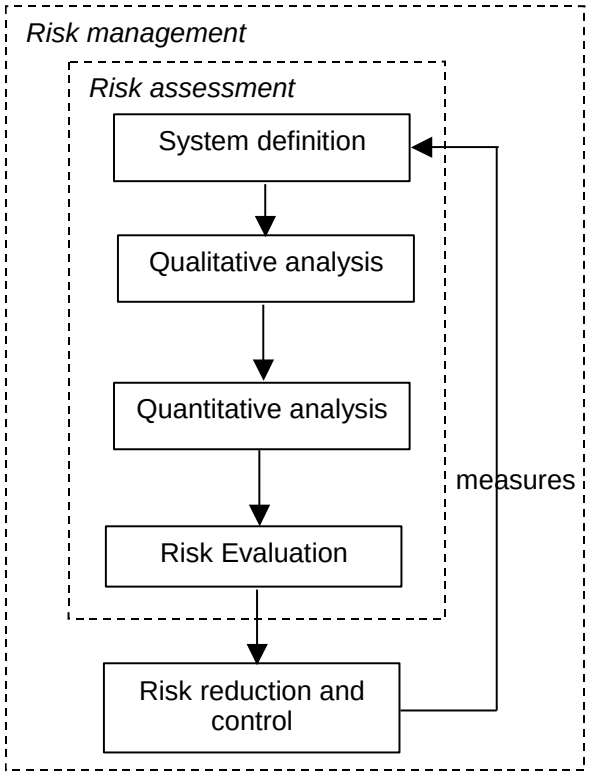
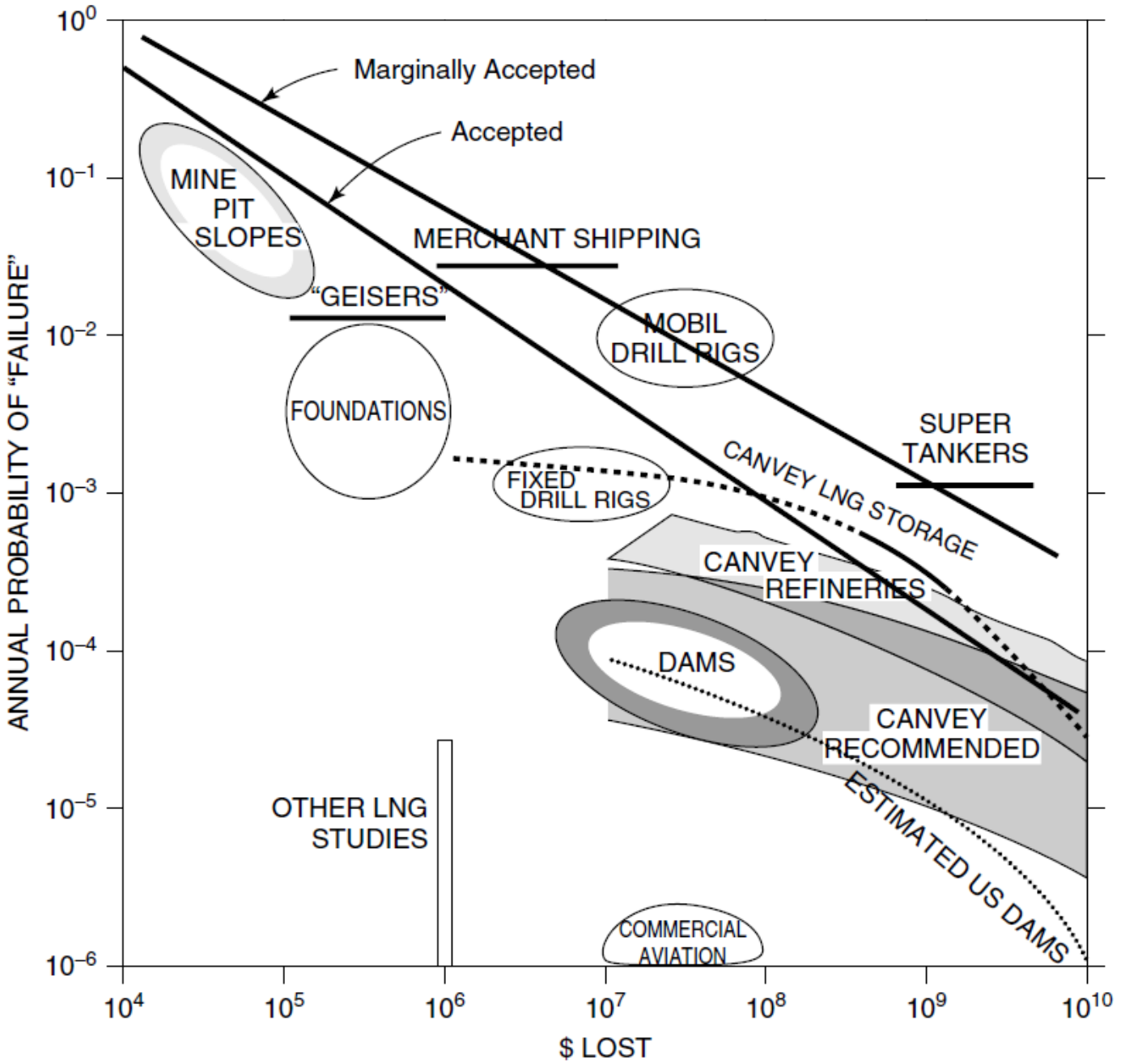
Probabilistic Design

Risk = combination of

probability and consequence

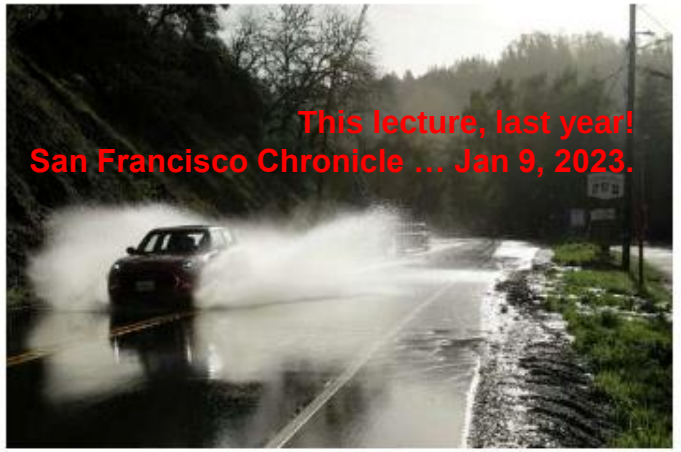
Our “function of random variables” methods





Flood management used as case study

- Covers many fields in CEG
- Wide range of risk and reliability applications
- Local expertise (NL)
- Relevant!

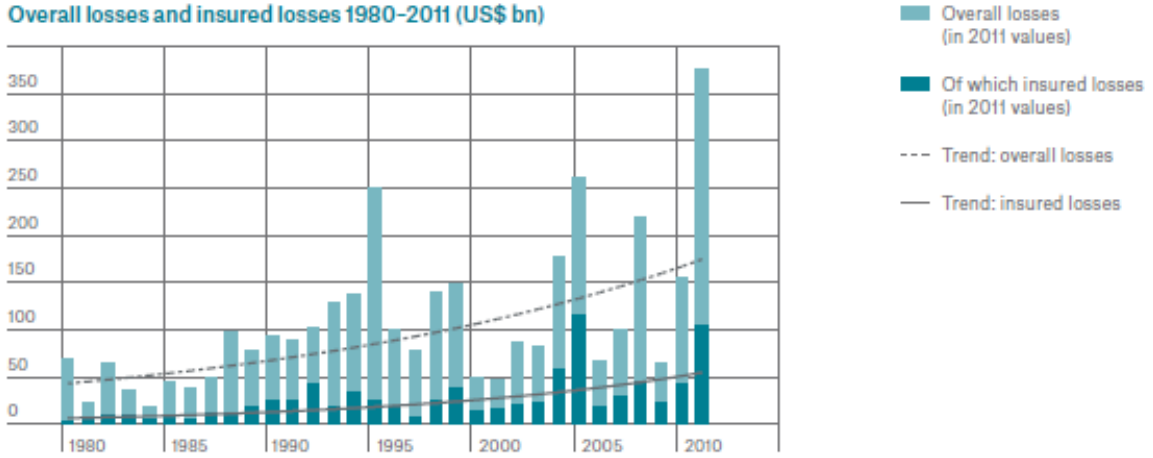


WORLD NEWS

Heavy rains leave parts of England and Europe swamped in floodwaters

AP News, January 5, 2024.

Increasing Coastal Flood Risk Worldwide



ATHER & CLIMATE

ith next storm wave minent, Bay Area mops up and prepares for more

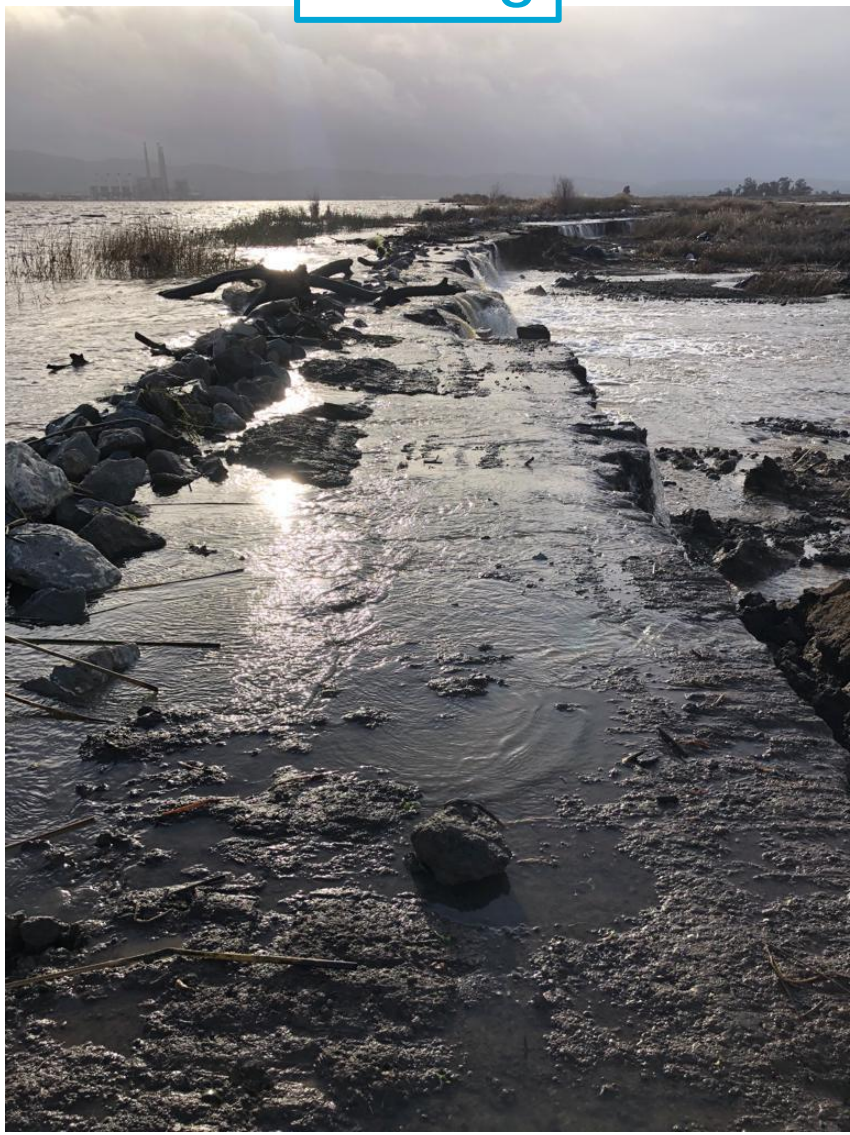
The Bay Area took advantage of a brief break from powerful winter storms Sunday to clean up damage and prepare for another battering overnight and into Monday.

- **Here's where California reservoirs stand after atmospheric river storms**
- **California and Bay Area live storm map: Rain, snow and flood risk**
- **Recent rains have improved California's drought. Where do we stand now?**
- **Flooded S.F. residents, businesses say city taking**

Before

During

During



…After?

Van Sickle Island, Jan 2023

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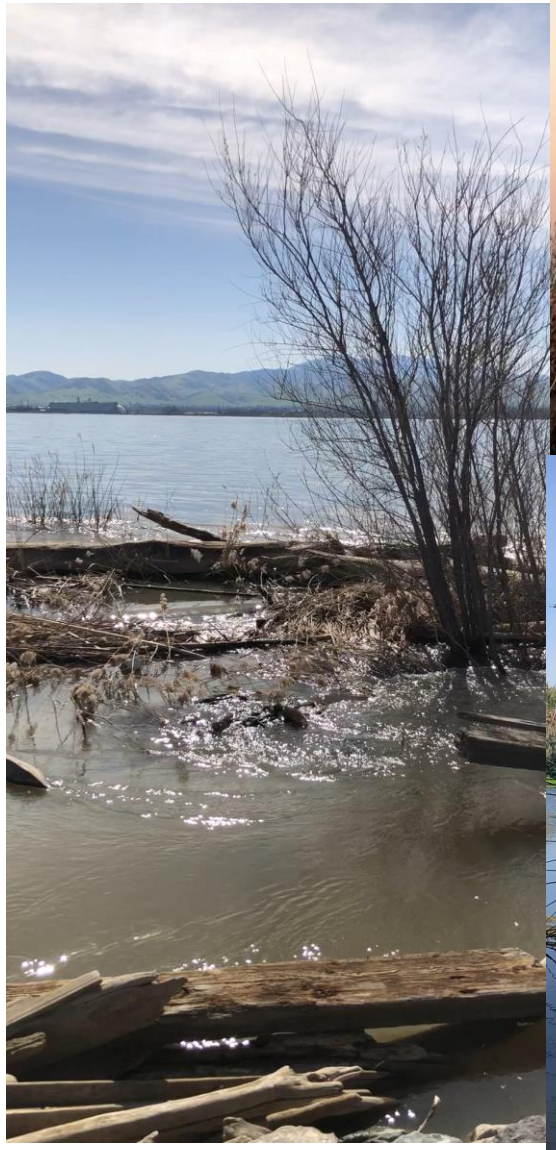
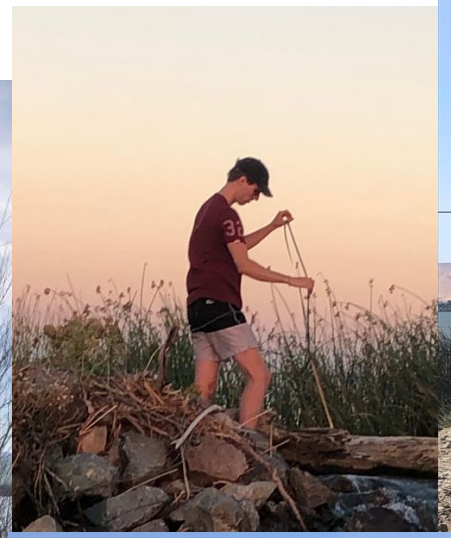
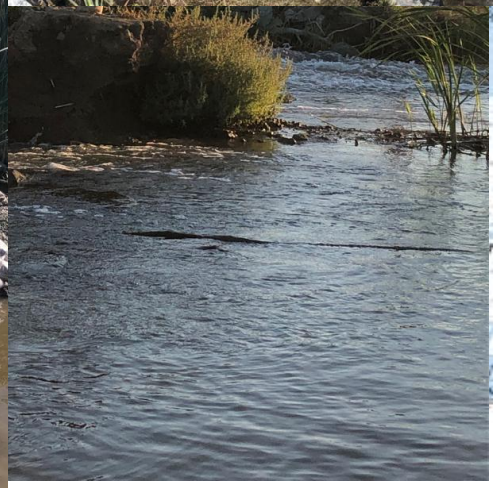
...a few days later





...one year later

TUD Students (MDP)



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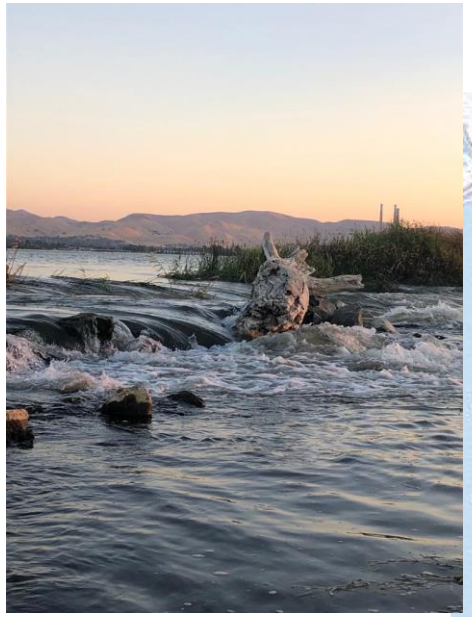
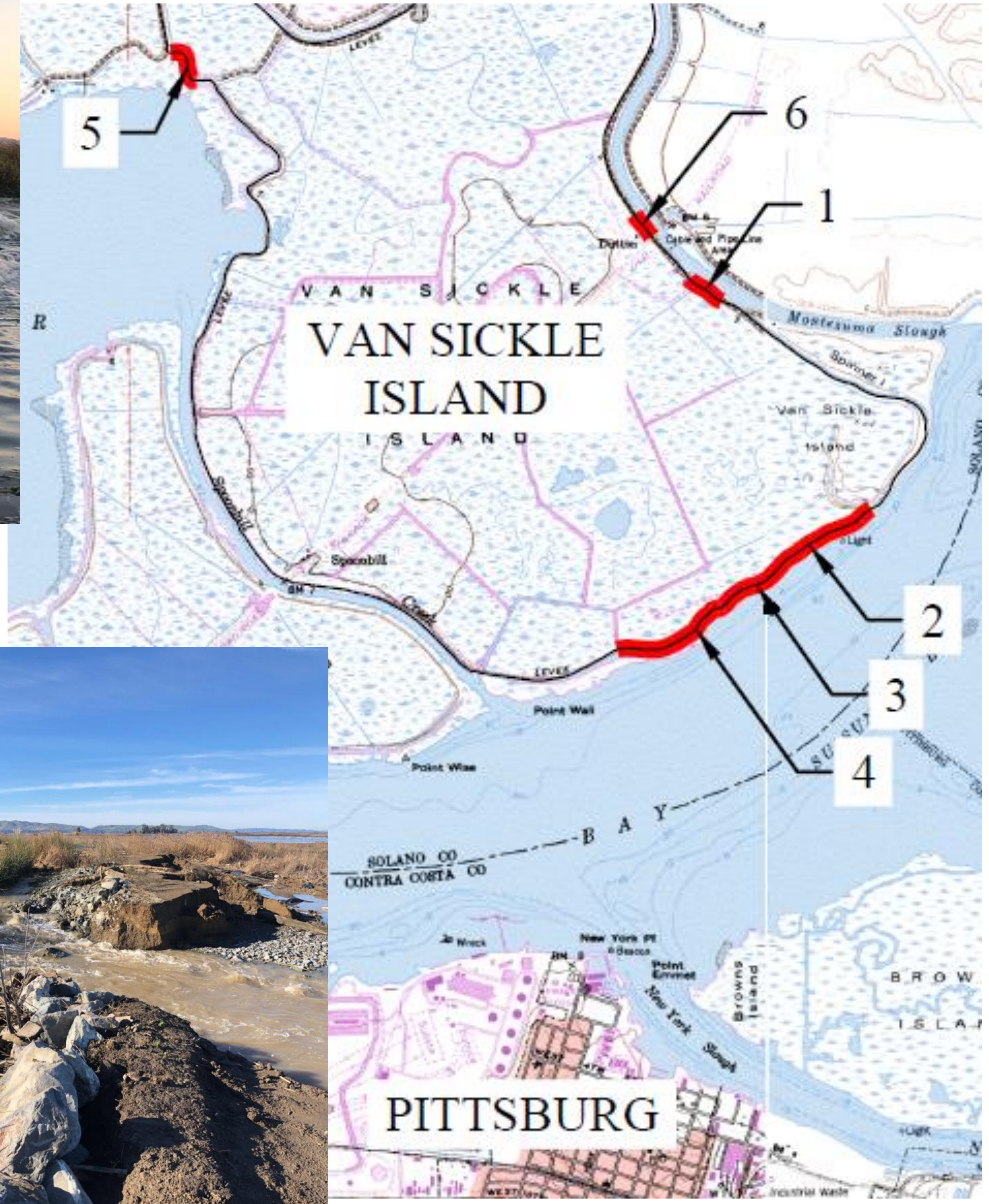
Safety Standards

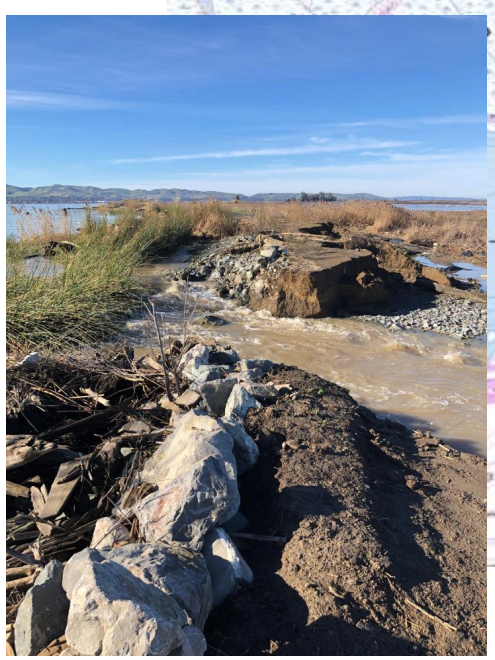
- Low!
  - No year-round residents
  - Little infrastructure

  → consequences are “small”





- Costs becoming unmanageable by the district
  - Flooding occurs every 10 years
  - …perhaps more like 3-5 years is the new trend
  - Is it cost effective to continue maintaining?



- What about a “large” consequence case?

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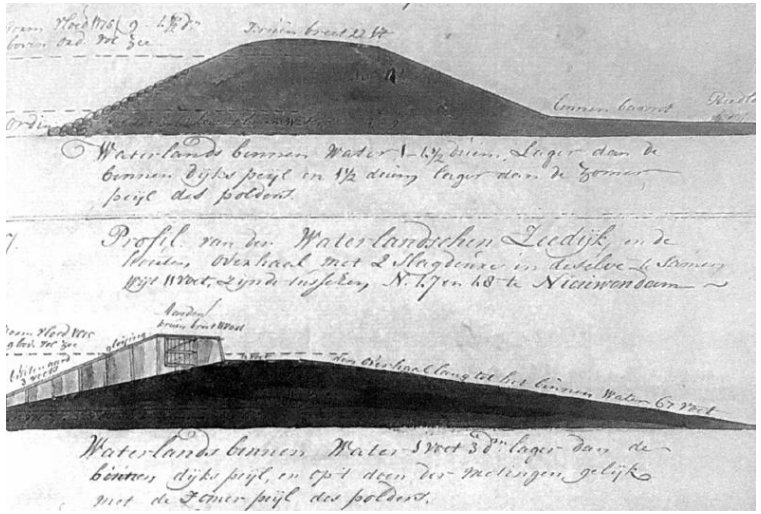
Initial Approach in NL: Higher than last time!



Centuries-old cost-cutting dike design?

St. Elizabeth's Flood in 1421

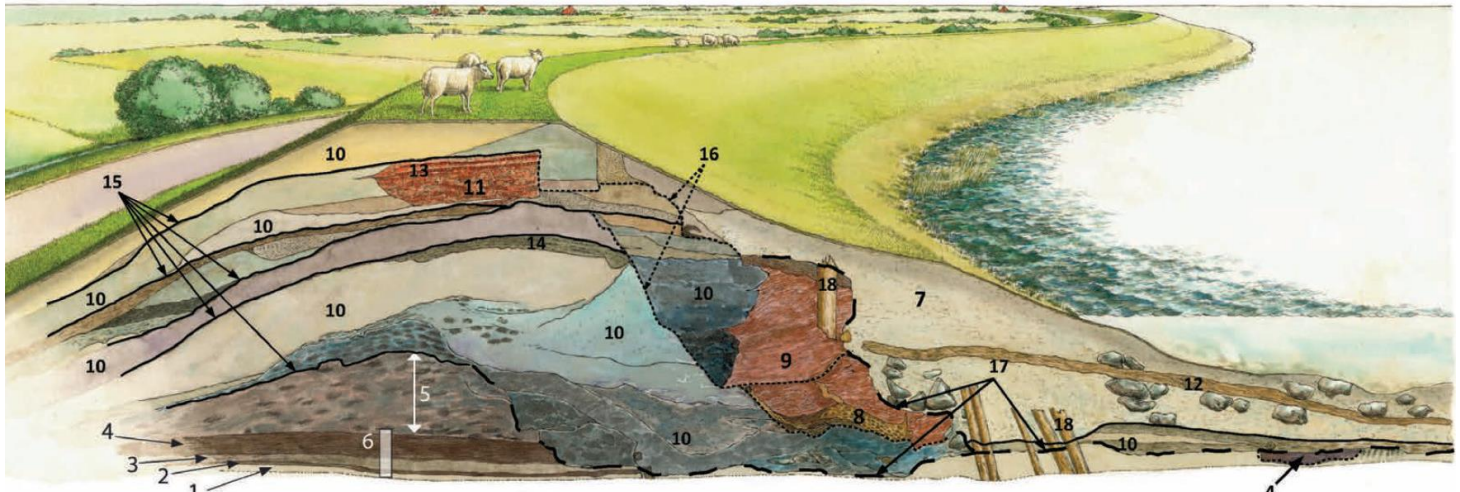
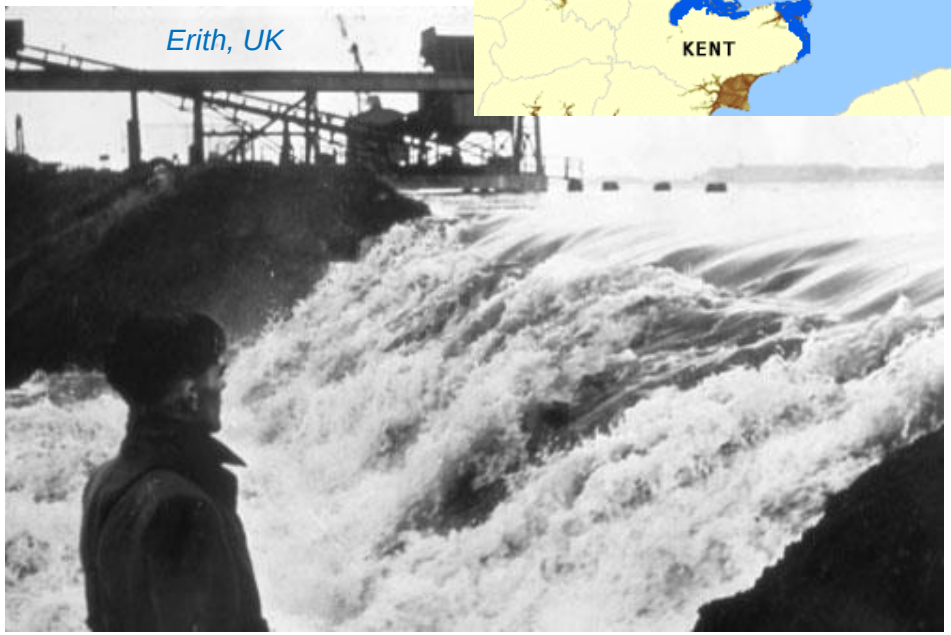


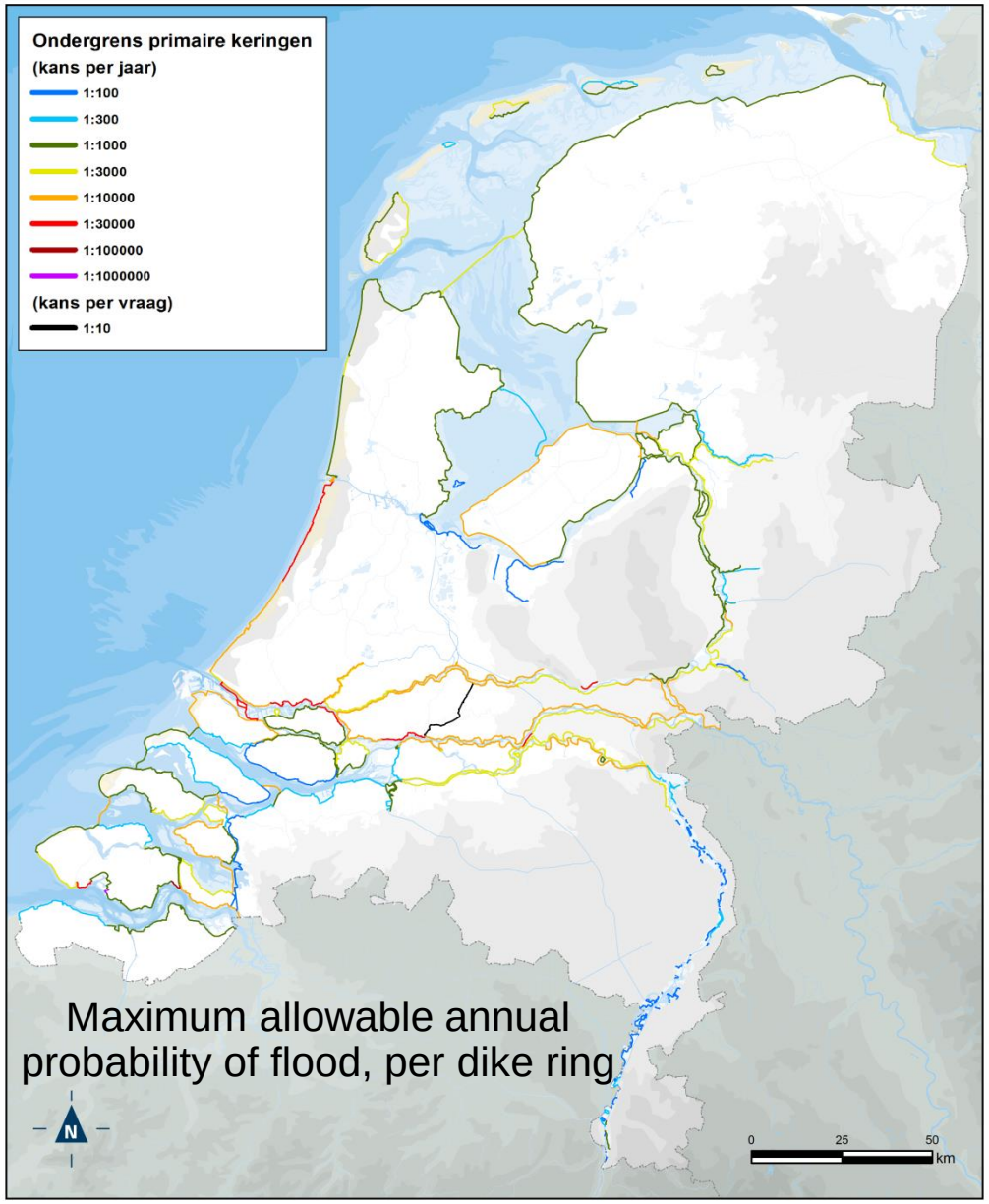
Image from ILH Chapter 3

1953 Flood: Netherlands (and UK)

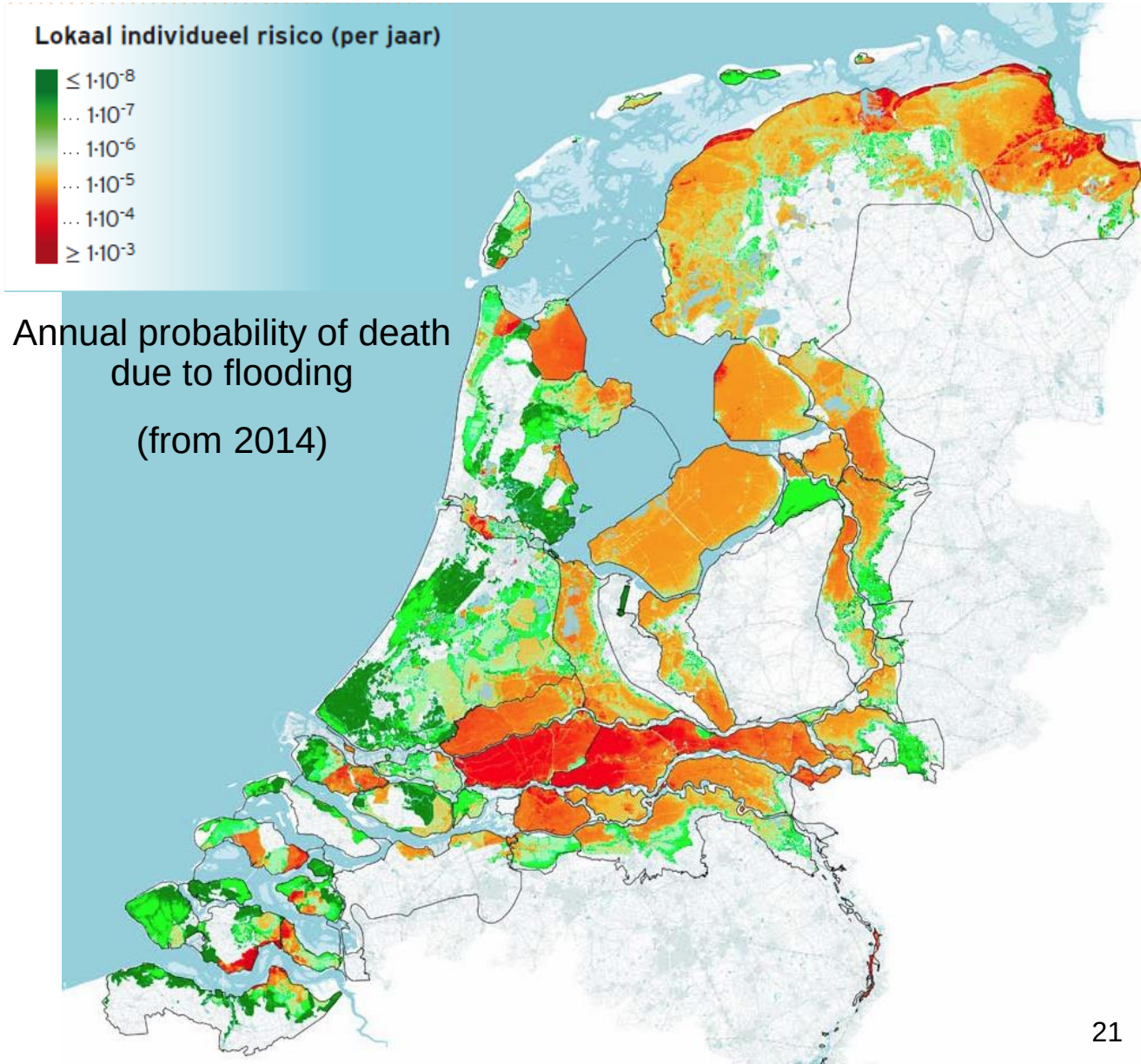
- National wake-up call in NL
- Decision:
  - How safe?
  - Design: how to meet safety criteria?
- Post-1953–2017: probability of exceedance approach (design water level)



NL safety standards for flood protection (since 2017)



Maximum allowable annual probability of flood, per dike ring



Annual probability of death due to flooding

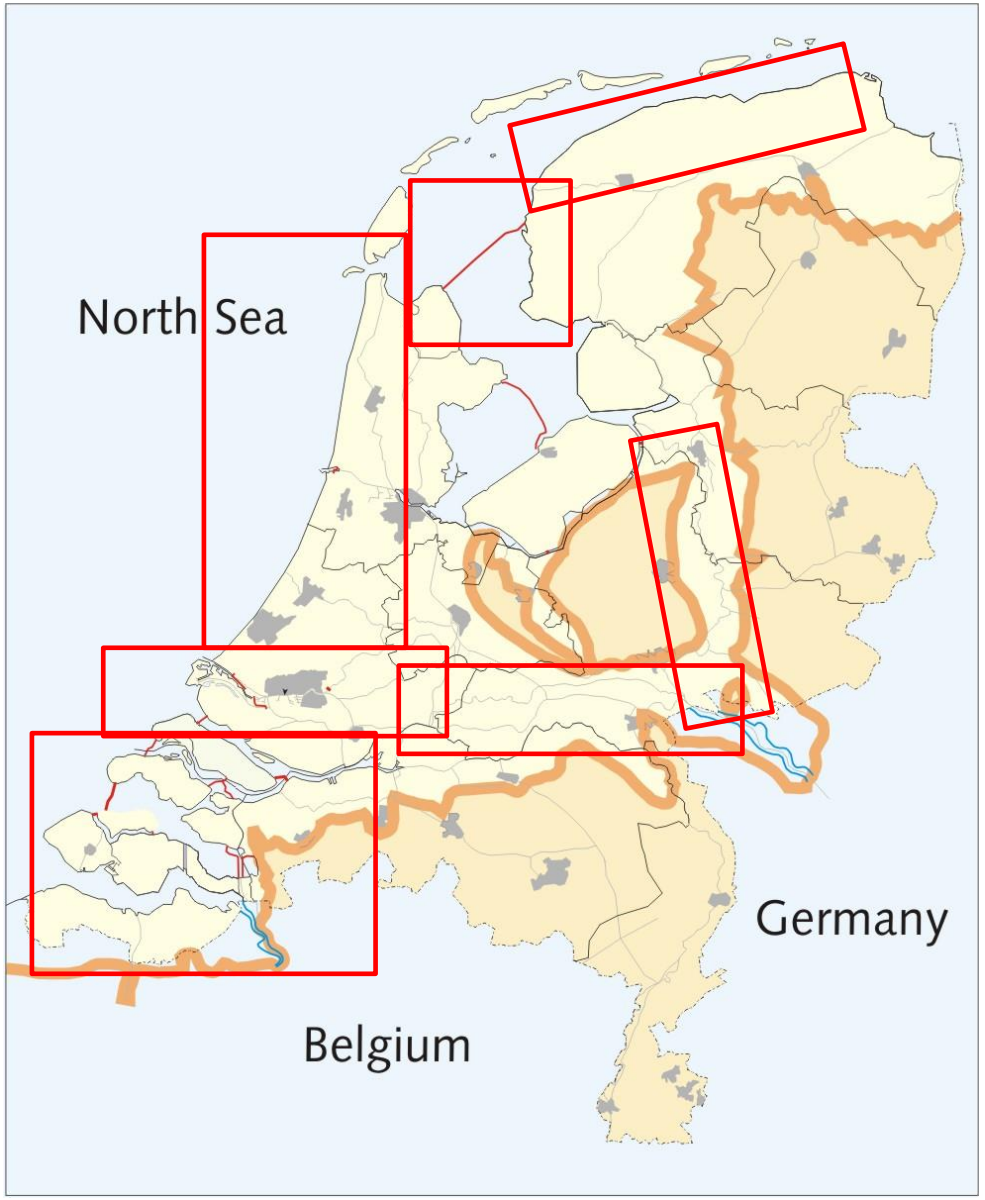
(from 2014)

NL Flood Defence System Today

Holland Coast

Rotterdam

Southwest Delta



Wadden Coast

Afsluitdijk

Rivers

The 2021 floods in the South of the Netherlands

Limburg

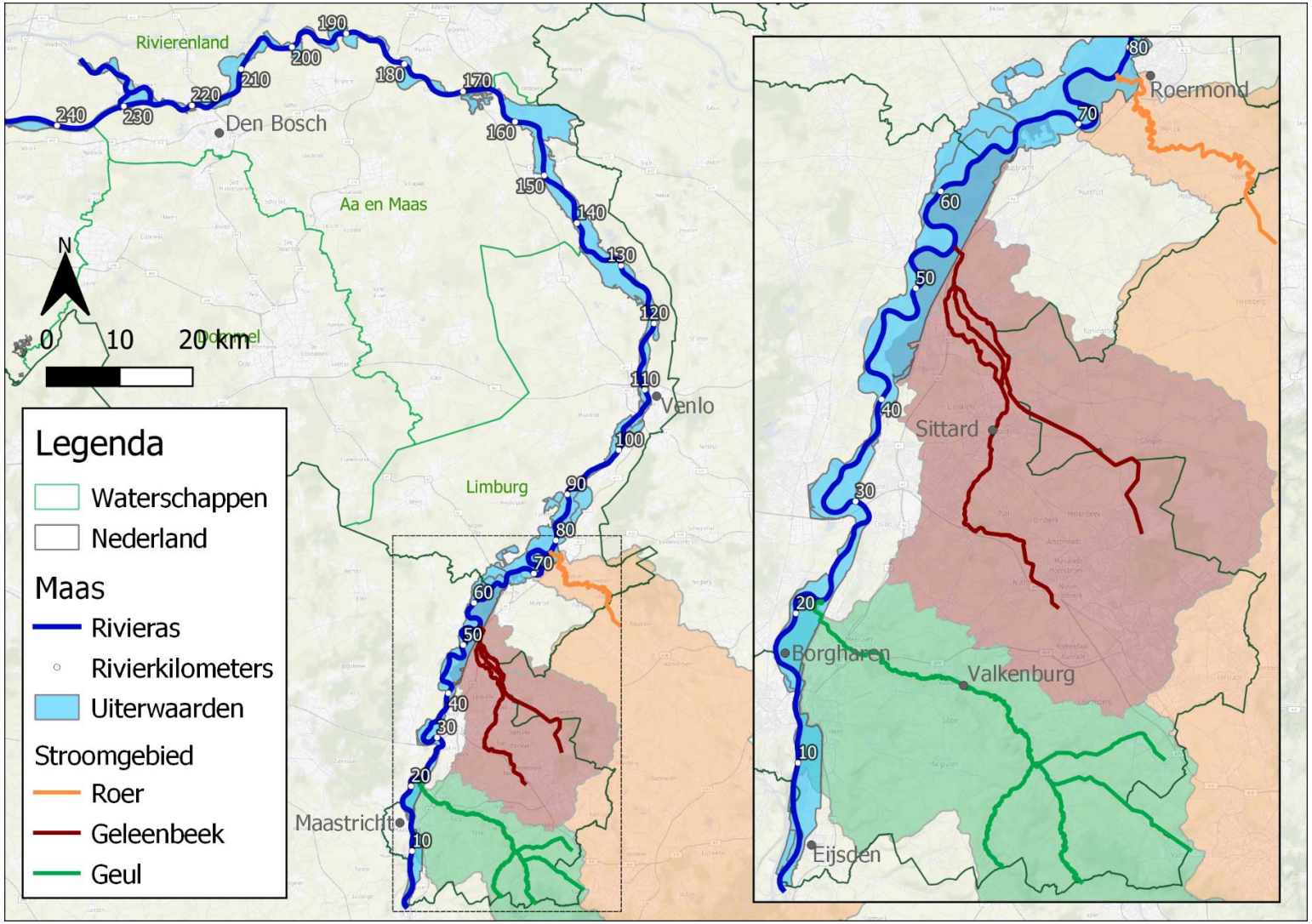


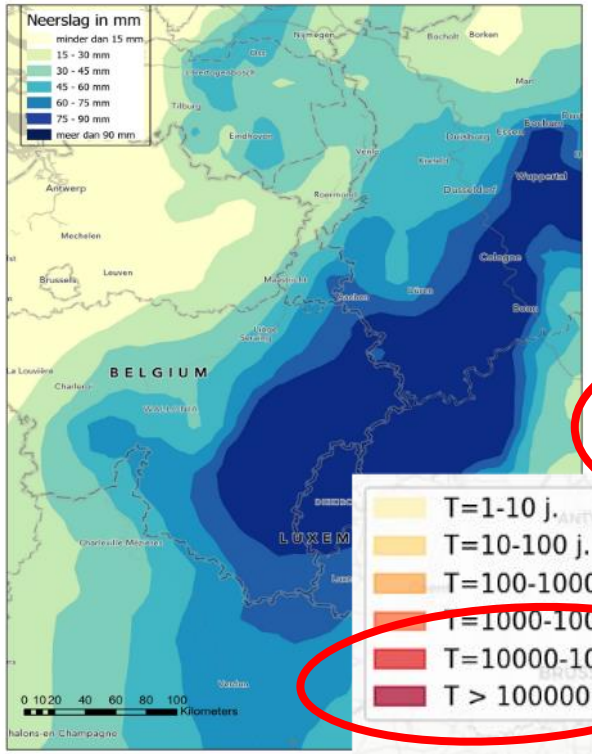
Foto: Marcel van den Bergh

Foto: Jos Simissen

See note at beginning of 2021 section

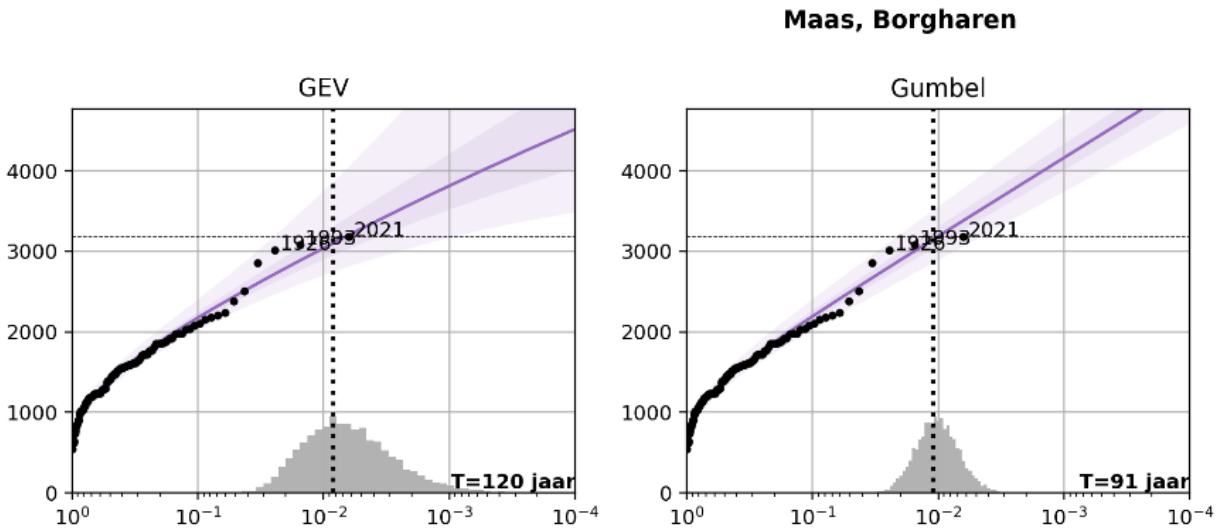
Fact finding

Rain 14 July

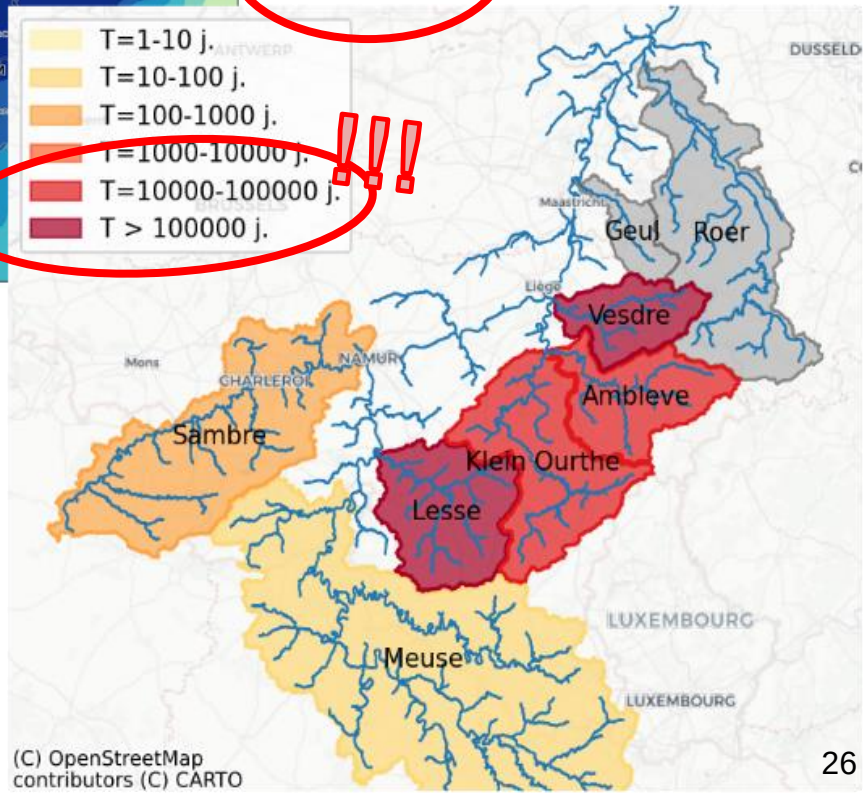


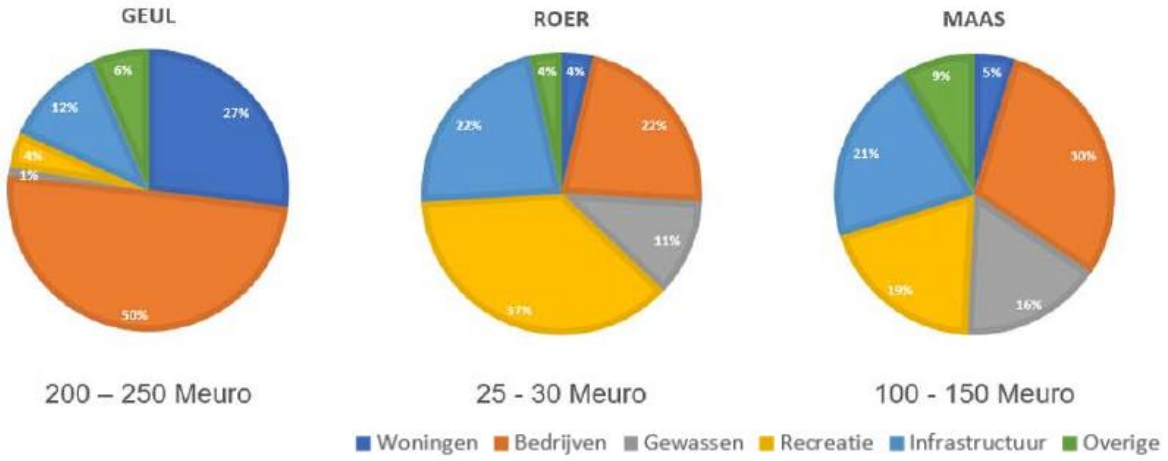
See Fact Finding report for more details: enwinfo.nl/publicaties/

Annual max m3/s

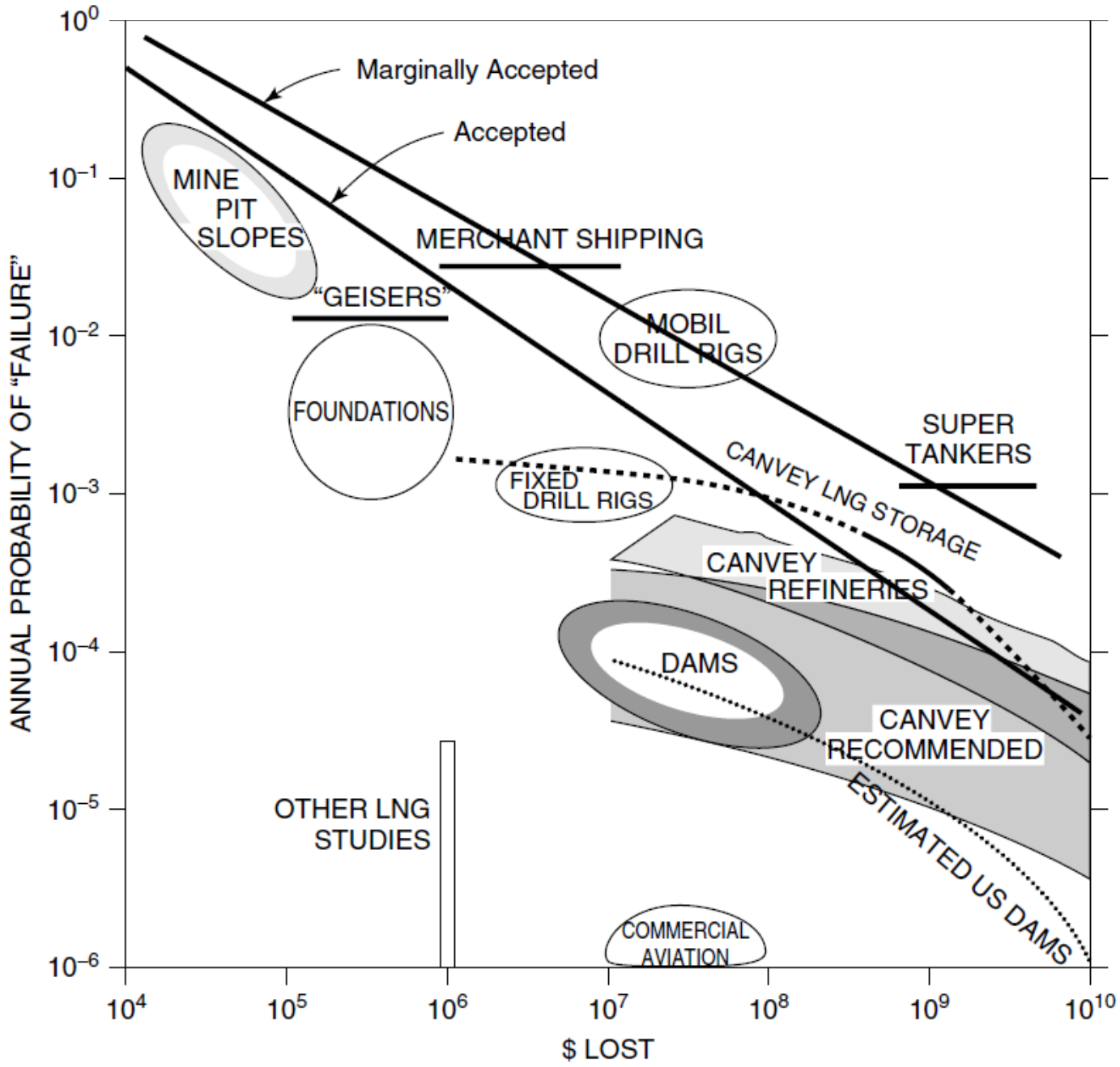


Summer return periods





What is this?



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FD Example – Part I

- A risk analysis has been completed.
  Your job is to check whether the system is “safe enough”

- P[N>10] = 1 e -3
- P[N>100] = 5 e -5

- C = 0.1, α = 2

FD Example – Part I

- A risk analysis has been completed.
  Your job is to check whether the system is “safe enough”

- P[N>10] = 1 e -3
- P[N>100] = 5 e -5

- C = 0.1, α = 2

Solution:
- The figure looks like a step function, where the point at 10 and 100 has value 1e-3 and 5e-5, respectively.
- Can also find P[N<=10]=1 – 1e-3 – 5e-5
- Can easily check that for N = 10, C/N^a is just safe, but this is not the case for N = 100
- Note that because of the way the step function works, it would also be implied that all the values greater than N = 10 would also not satisfy the criteria; it is hard to tell if this is appropriate for this simplistic model. In reality we should include more points
- Note also that this case has 2 “scenarios”…the flood exercises to follow are computed in the same way, but there are many more scenarios!

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FD Example – Part II

- How can we fix the system?

- Imagine that this is small polder (flood protection area) where 100 people are protected by a wall.

FD Example – Part II

- How can we fix the system?

- Imagine that this is small polder (flood protection area) where 100 people are protected by a wall.

Solution:
There are 3 main ways we can improve things:
1. Reducing the probability of exceedance
2. Reducing the consequences
3. Changing the limit line (policy decision)

Depending on the application, some of these may not be possible. For example, in the flooding exercise to follow, it is hard to reduce consequences by asking people to move out of NL. However, it *is* possible to reduce consequences by improving evacuation effectiveness.

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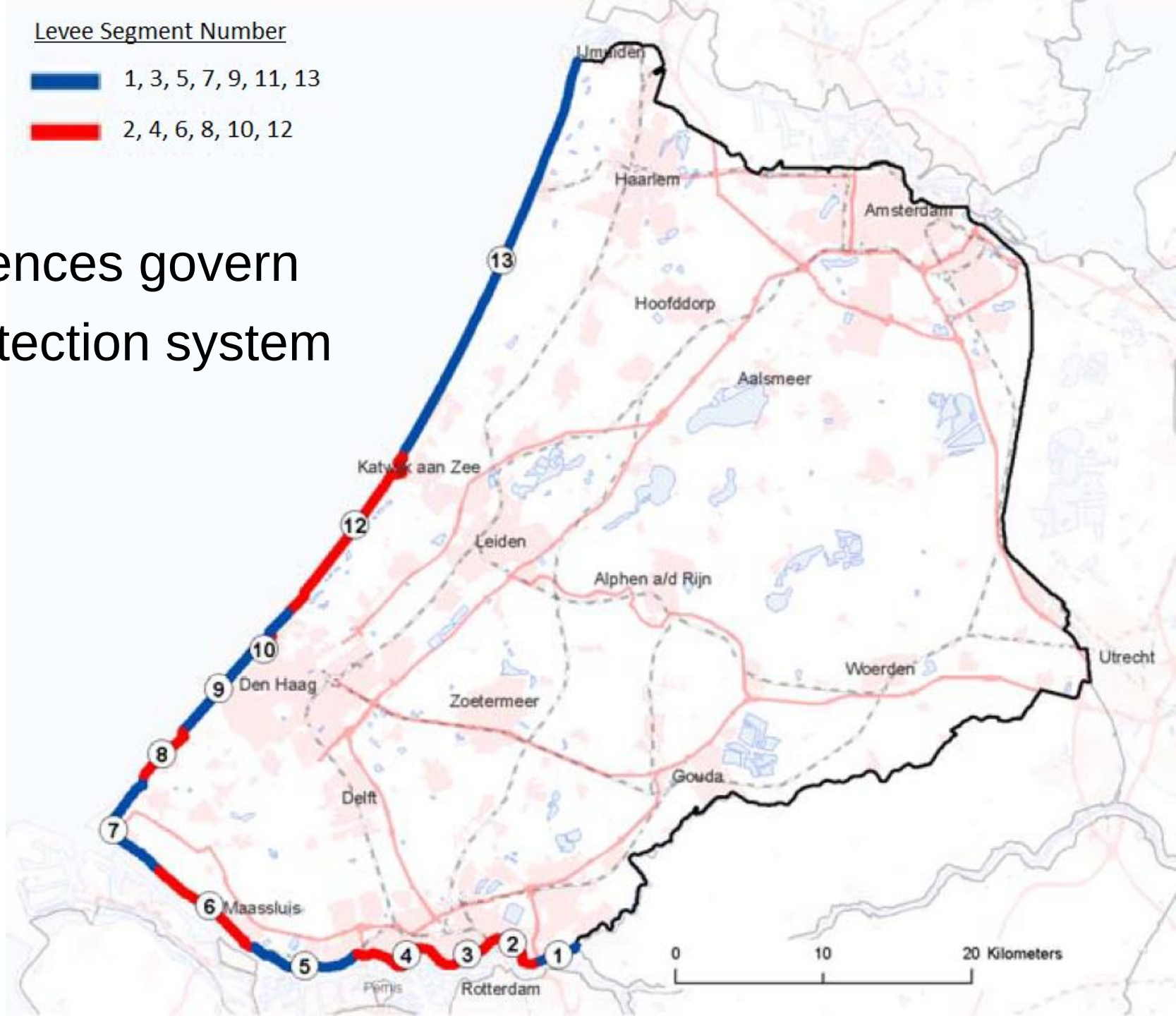
South-Holland

What type of consequences govern design of the flood protection system in South Holland?



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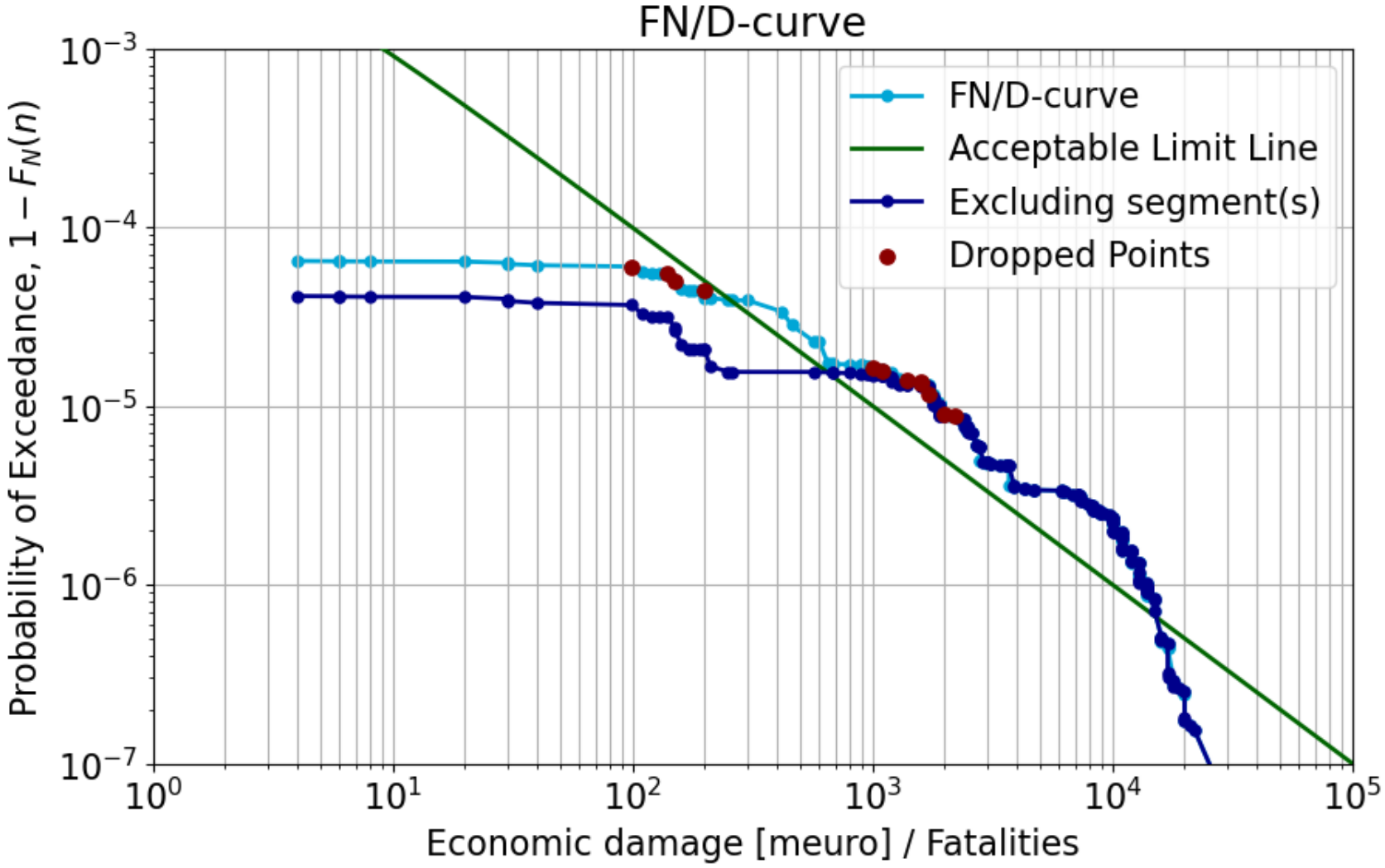
South-Holland Flood Protection System



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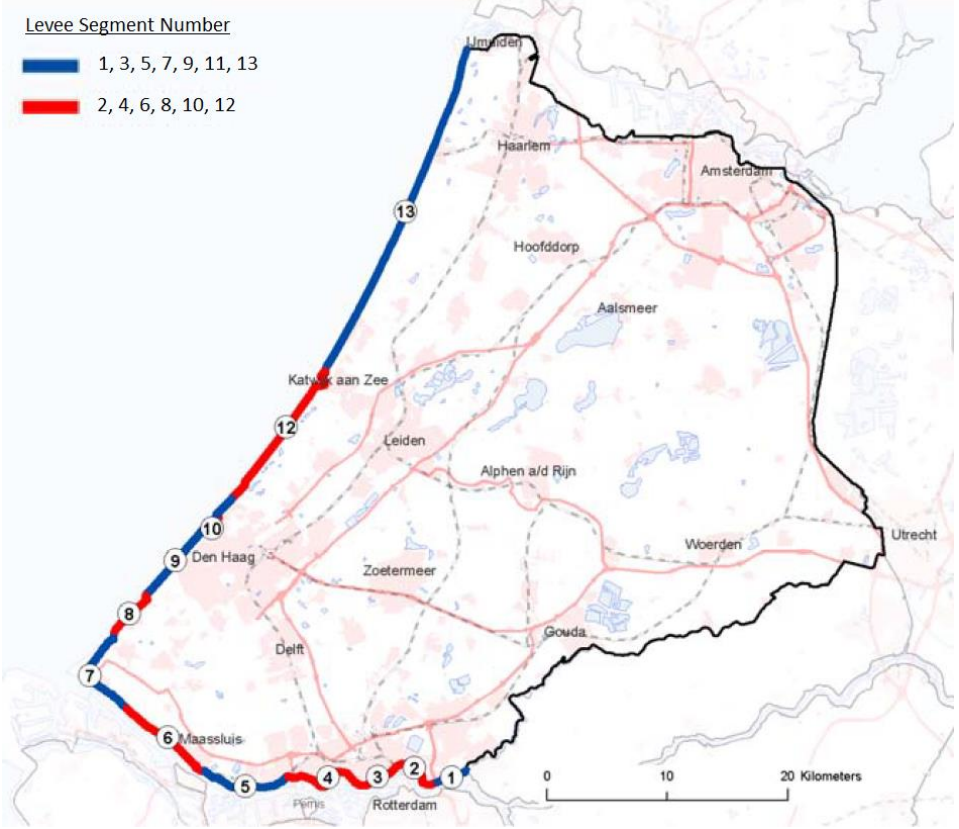
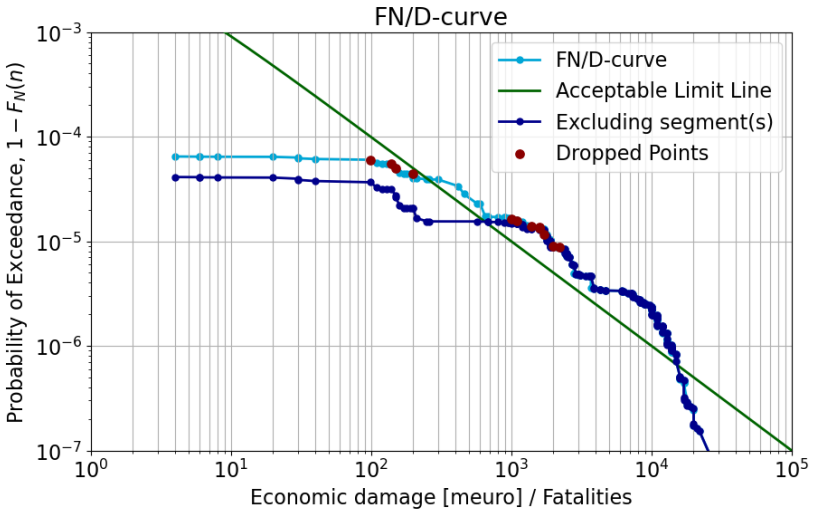
Component and System Reliability

- Framework for computing probabilities associated with many components and combining them together

- Combined with consequences to build FN/FD-curve

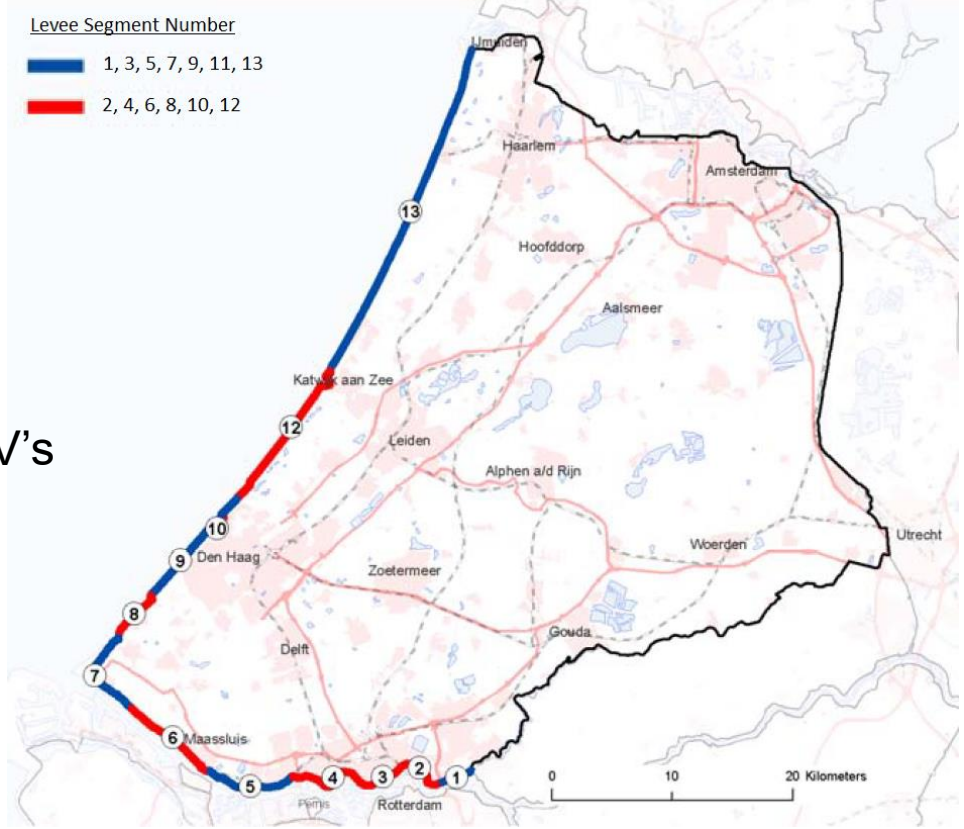
(not part of MUDE)

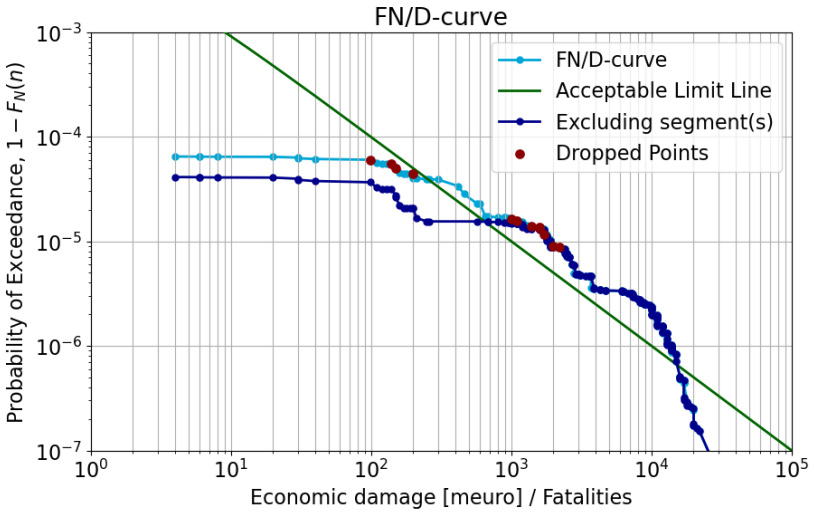




Key Topics: Risk & Reliability

- Risk definition, probabilistic design context ← This week
- Component reliability ← Q1, Function of RV's
- System reliability ← "Hints" in 1.8
- Risk analysis ← This week
- Risk evaluation ← This week





Week 2.8 Content

- Large breadth of material, but the topics are simple.
- Focus is on FN/FD curves and assessing risk

Related courses open to all students:

- Elective (Q5):

  CIEM4303 Flood Risk

- Cross-over (Q6):

  CEGM2005: Probabilistic Modelling of real-world phenomena through ObseRvations and Elicitation (MORE)

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End theory part…
Questions?

Next:

- Announcements
- End-of-module logistics
- Activities this week

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Week 2.8

Announcements

End-of-MUDE Logistics

GA 2.8 Introduction

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Announcements

Interested in being a MUDE TA?

- Can start as early as Q3, but we hire on a rolling basis until Q1 next year
- Get in touch with Robert or send an email to CEG-MUDE@tudelft.nl

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Announcements - Exams

- Q2 Exam: Thu., Jan. 23, 13:30 (Week 2.10)
  - Question hour next Tue., Week 2.9, same time, room 1.98
- Q1 Resit Exam: Wed., Jan. 30, 13:30 (Week 2.10)
  - Question hour Tue. (day before), same time, room 1.98
- If registration is closed, come anyway and show up 10 minutes early!

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Announcements

- PA's
  - Final deadline is Monday, Jan 20 at noon (week 2.9)
  - Brightspace is updated manually and does not always reflect GH Status
  - As long as the check mark is green in GitHub, you passed! (only last check mark matters)
  - Any doubts? → COME TO QUESTION HOURS THIS WEEK!!!

- Assignment Portfolio Closure
  - Points for PA, BC, GA will be finalized in Brightspace after Monday Jan 20
  - Questions about points, static checks, etc → question hours + MUDE email
  - Grade in Osiris by Mon., Feb 12 (W3.1 ("2.12"): issues can be discussed after exams)

Weekly Schedule for Finishing Q2

2.8	Lecture	QH	WS		GA 2.8
2.9	ALL PA's DUE NOON	QH		Q2 Exam	
2.10		QH!	Q1 Resit		

3.1 (“2.12”)	Assignment Portfolio Grade in Osiris				

Preliminary Grade, Portfolio

Work out remaining Grade Issues (portfolio)

Questions?!

Week 2.8 – Risk Analysis

- Tuesday, Thursday: as usual

- Wednesday (in class)
  - Simple case study applying book concepts (minimal programming)
  - Gezelligheid principle in effect: if rooms are empty, we may consolidate

- Friday is final GA: focus on reflecting on MUDE (good to review prior to exams)

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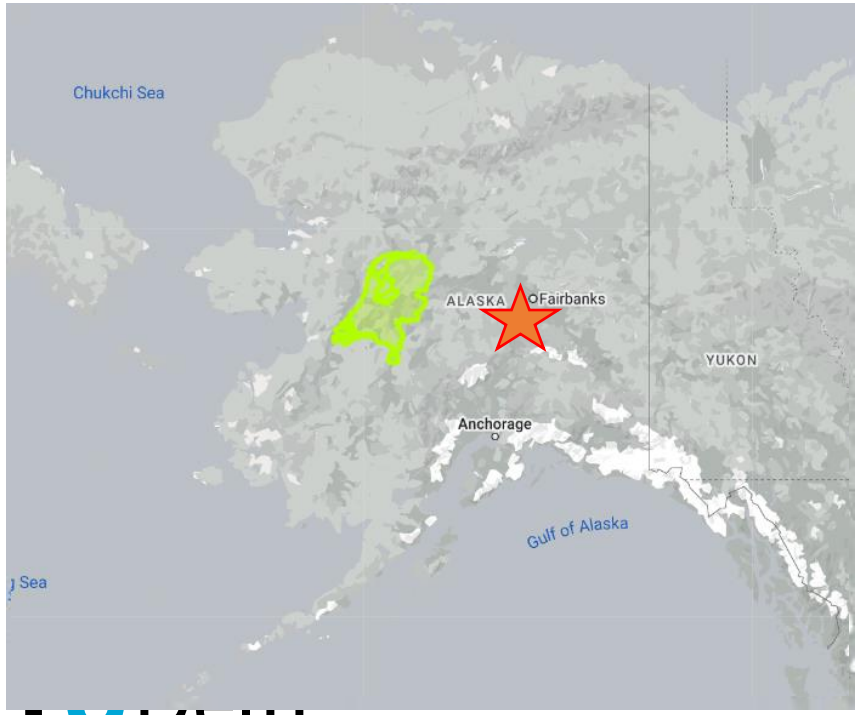
What can we study that links all MUDE topics together?!

Nenana Alaska Ice Classic



Last year's winnings: $222,101

What does the Nenana Ice Classic have to do with MUDE?

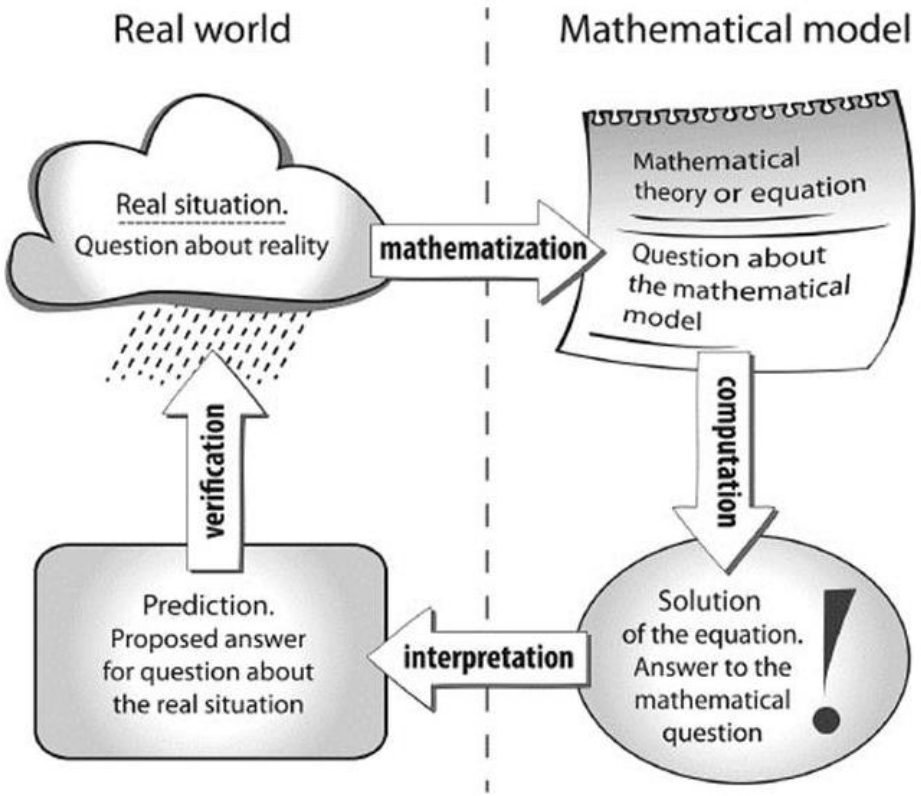
- Analyze the data (time series, signal processing)
- Formulate physics-based and data-driven models to predict break-up date and time
- Maximize probability of success
- Optimize the betting strategy

These are all MUDE topics!

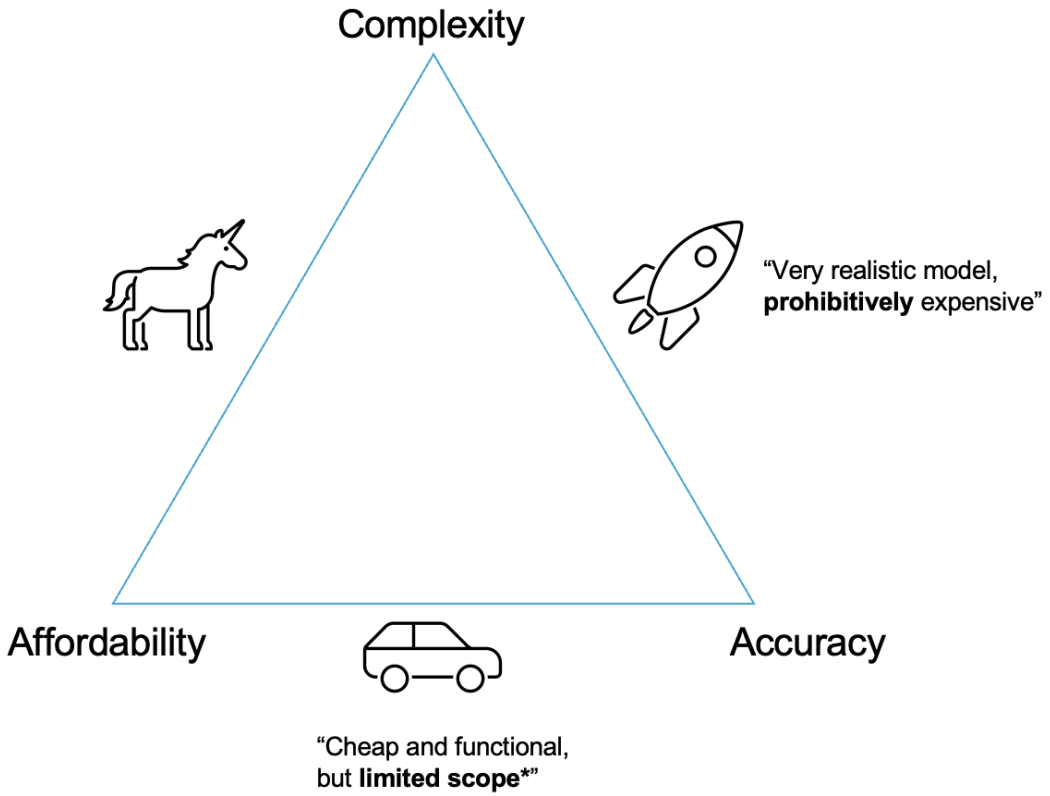
What is a Model? Classification, Decisions…

A model is a purpose-built abstraction of physical reality

- How detailed/complex do I need it to be?



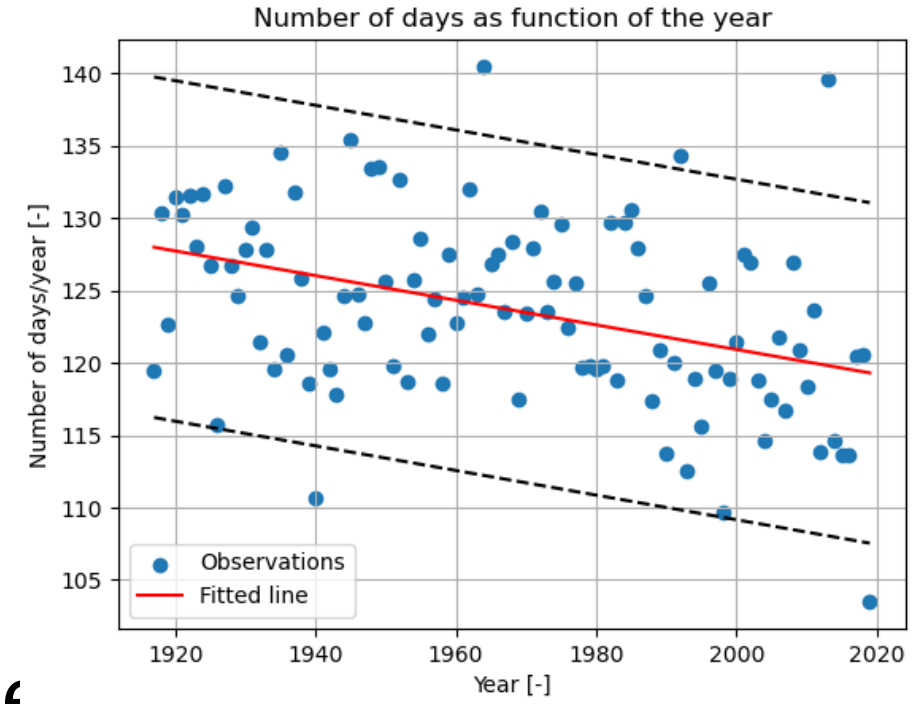
Retrieved from: https://schoolbag.info/mathematics/numbers/103.html

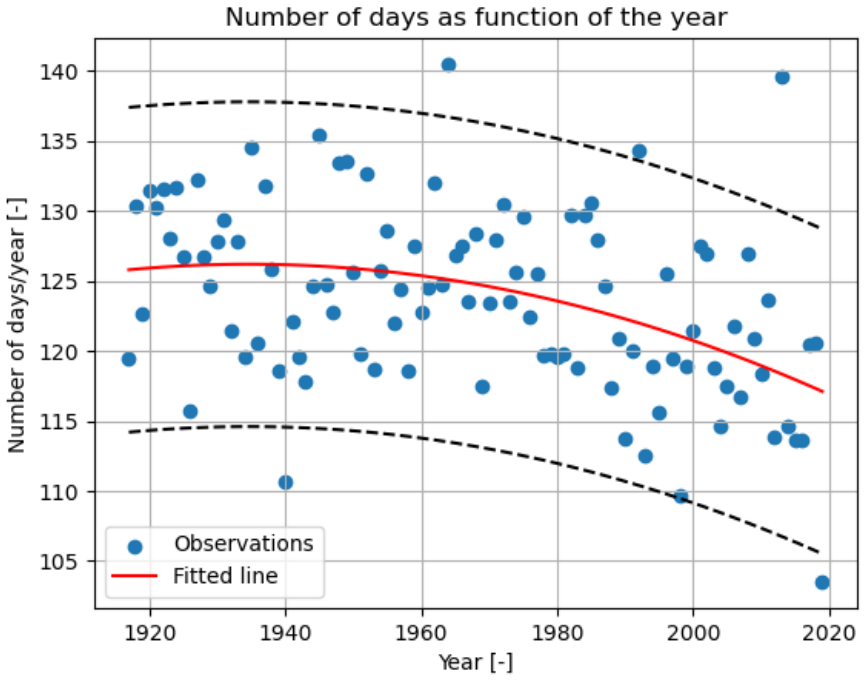


Acknowledgement: the conceptual diagram is from Marco Rinaldi

Were our models “good enough?”

	No. Parameters	RMSE	R^2	rbias
Line	2	6.00	0.15	0.002
Parabola	3	5.92	0.18	0.002

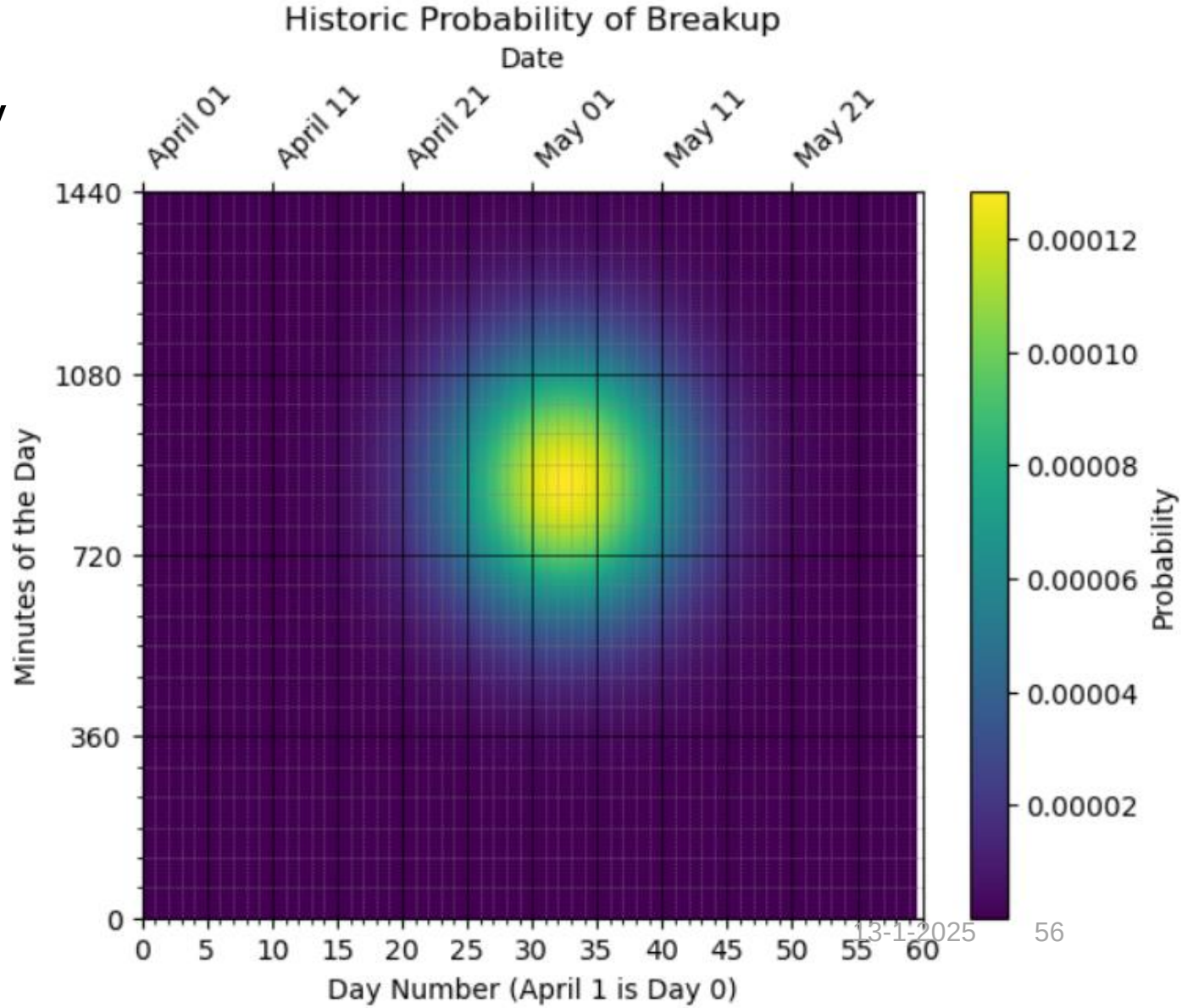




GA 2.8: Revisiting the Nenana Ice Classic

- Breakup typically in April and May
- Tickets cost $3
- Payout ~$300,000

How many tickets should you buy?



GA 2.8: Revisiting the Nenana Ice C

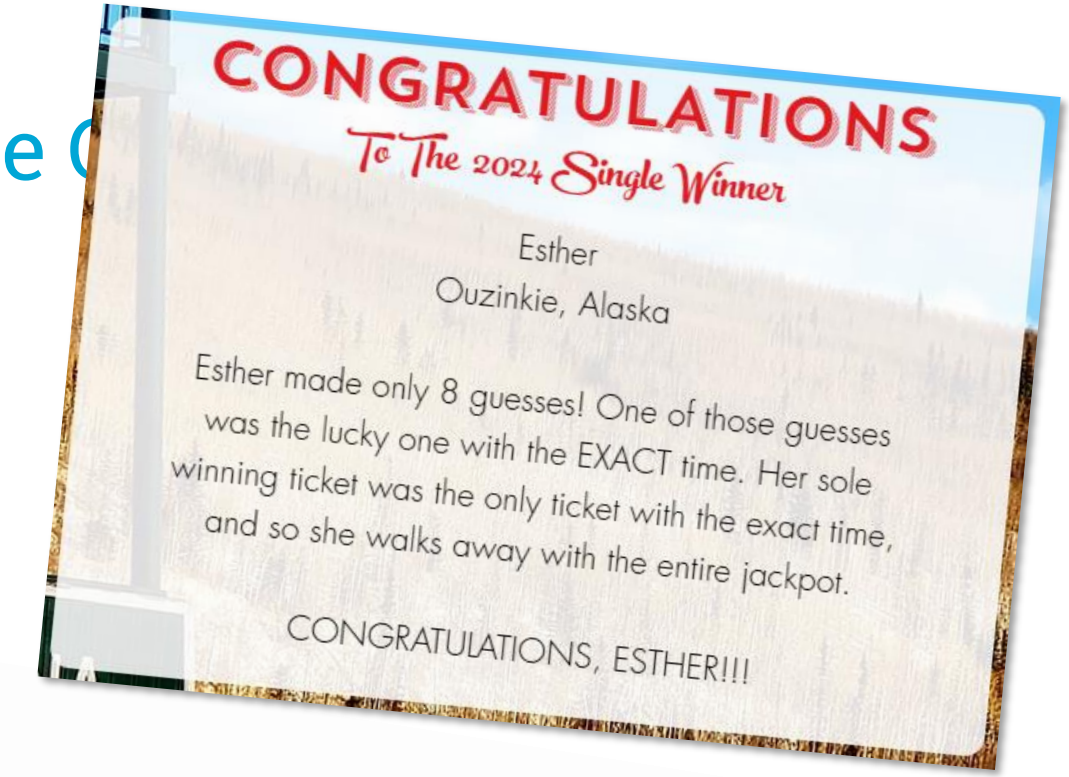
- Payout ~$300,000

Sometimes many winners!

Minimizing “risk” of losing big?

Maximizing possible payout?

This will be our focus on Friday



Alaska News

44 winners to split Nenana Ice Classic's $300K pot

By Associated Press
Updated: July 8, 2016
Published: May 10, 2016

each ticket holder will pocket $6,818.

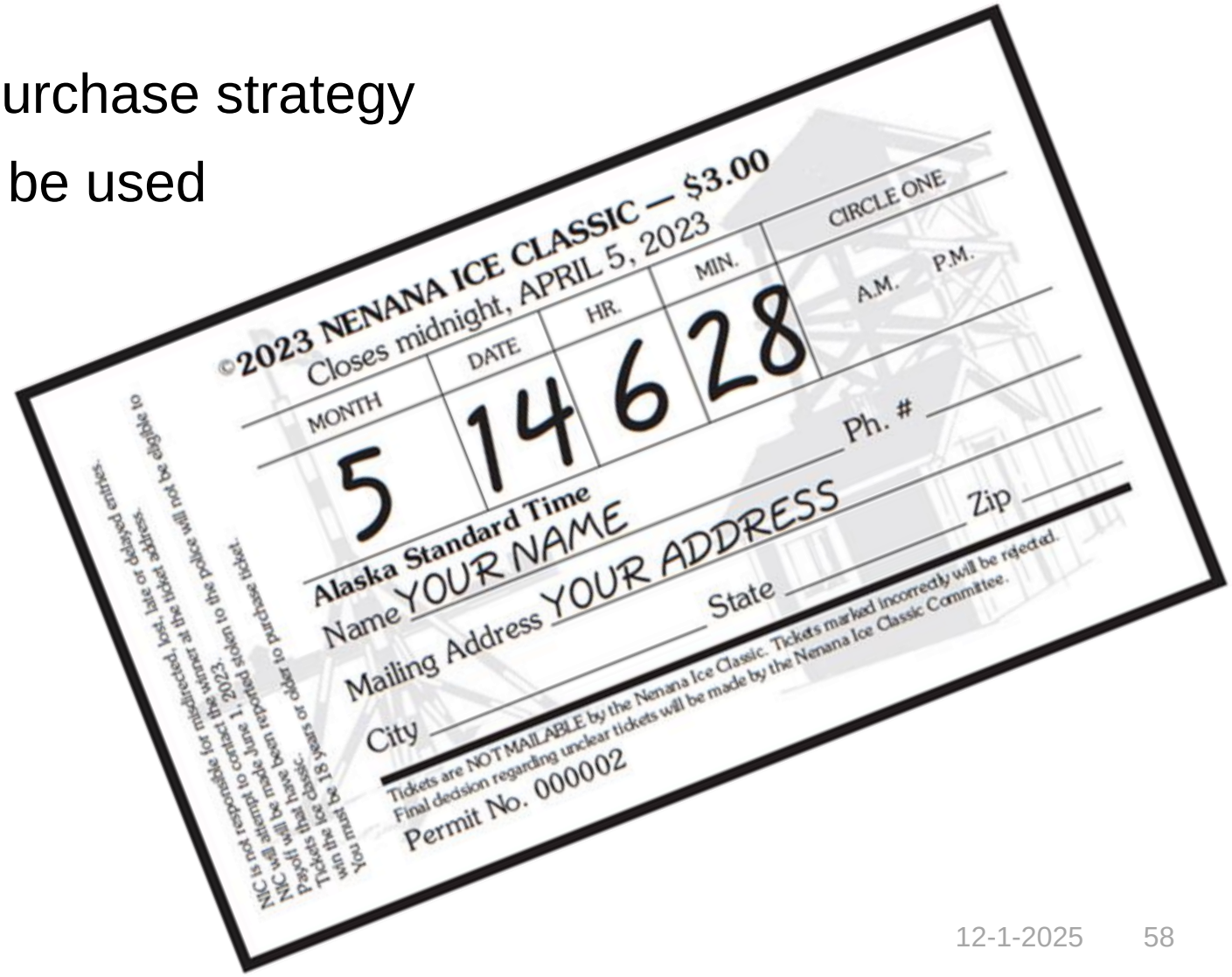
NENANA -- Alaska's favorite gu there were 58 winning tickets in 1973.

There were a whopping 44 winners of the Nenana Ice Classic, evenly splitting the $300,000 jackpot. The annual game is a prediction of when the ice will go out on the Tanana River in Nenana. The trip on the ice was tripped at 3:39 p.m. Alaska Standard Time on April

GA 2.8: Revisiting the Nenana Ice Classic

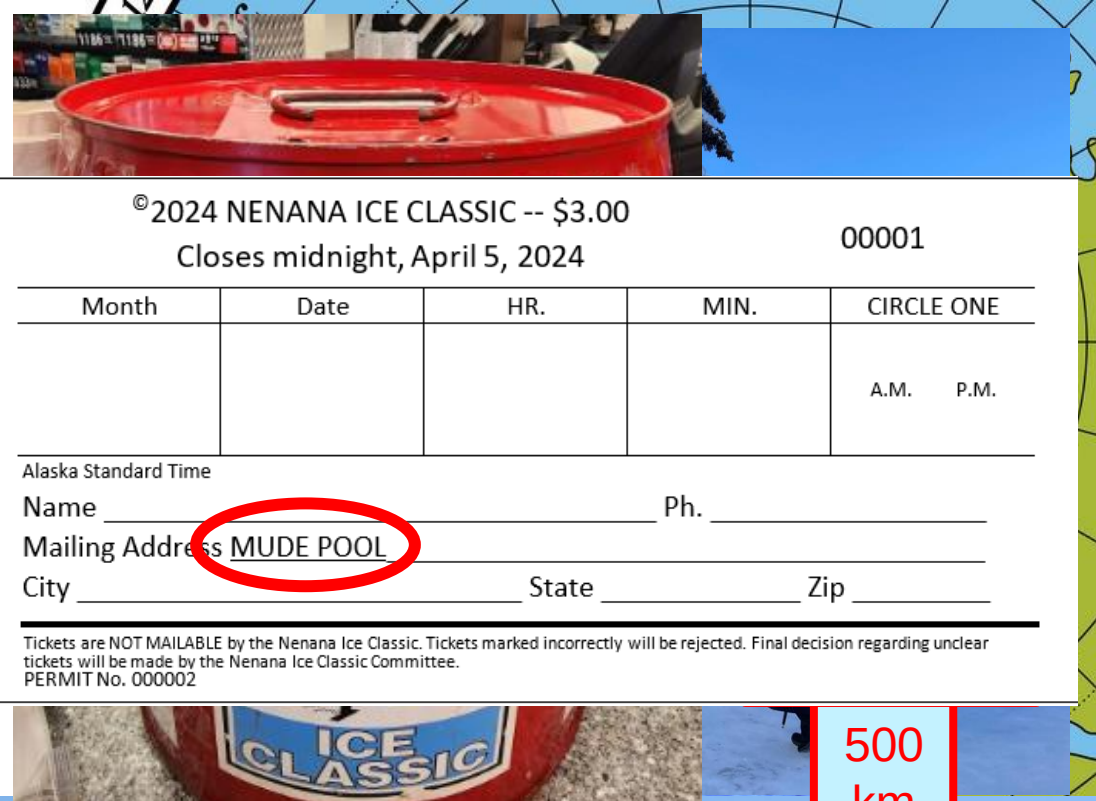
- Apply risk topics to our ticket purchase strategy
- Identify how MUDE topics can be used
- Process some of the ice data
- Make a bet!

A REAL bet!!!



GA 2.8: You Bet!

- 1 ticket + bet per group; submit Friday 12:30
- MUDE pool: if 1 wins, we all win (and share)
- Internal MUDE competition: closest group



WIN THE AMAZING MUDE PRIZE!

Details released with project README.md

Sad that your MUDE journey is ending? Interested in analyzing data and making a guess on April 5?

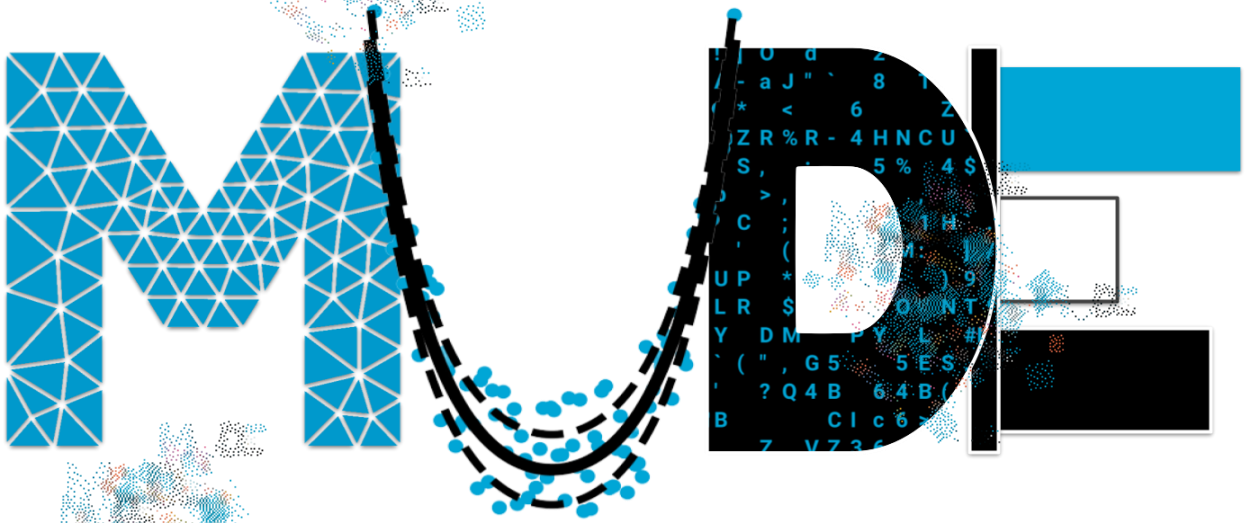
Keep an eye on Brightspace for MUDE Q3!

500 km this way!

Highest point in North America, Denali = 6,190 m

Closing

Thanks for joining the...



Modelling, Uncertainty, and Data for Engineers

Last Lecture!

The Nenana Ice Classic ... MUDE Edition!

2023 Jackpot $222,101

©2024 NENANA ICE CLASSIC -- $3.00

Closes midnight, April 5

00001

Month	Date	HR.	MIN.	CIRCLE ONE
				A.M. P.M.

Alaska Standard Time

Name _____ Ph. _____

Mailing Address MUDE POOL _____

City _____ State _____ Zip _____

Tickets are NOT MAILABLE by the Nenana Ice Classic. Tickets marked incorrectly will be rejected. Final decision regarding unclear tickets will be made by the Nenana Ice Classic Committee.
PERMIT No. 000002

2023 Winning Time: May 8th, 4:01 PM AST

What will your bet be?