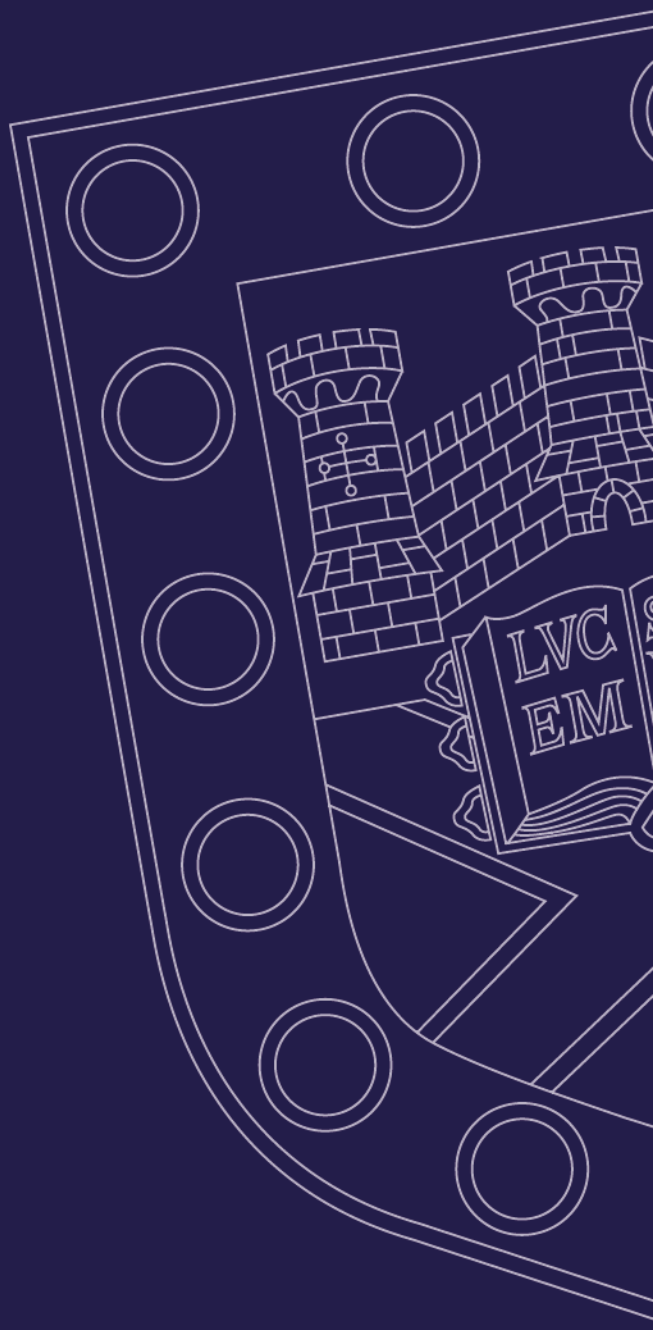
UNIVERSITY OF EXETER



Life after the CDT

Diego Panici
22nd July 2021

CDT-SIS

The good ol' days

How it started:

- September 2014 with a bunch of other 4 PhDs
- First taught year
  - Group design project on dam removal effects on downstream geomorphology (Canada and Brazil)
  - Summer project on woody debris transport and accumulation at piers

CDT-SIS

The good ol' days

How it continued:

- Three experimental campaigns in the large flume in Chilworth
  - Two winter sessions (2016 and 2017) and one summer (2016)
  - First campaign: study variables affecting debris accumulations
  - Second campaign: study effects of pier shape and debris shape
  - Third campaign: study variables forgotten in the first two campaigns!

CDT-SIS

The good ol' days

How it continued:

- Some crucial results:
  - Debris jams follow three phases (unstable, stable, and critical)

CDT-SIS

The good ol' days

How it continued:

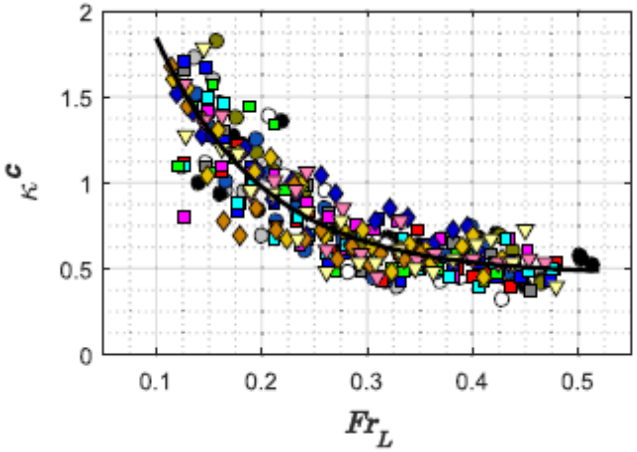
- Some crucial results:
  - Debris jams follow three phases (unstable, stable, and critical)
  - Critical phase=failure of debris jams by rotating about the pier

CDT-SIS

The good ol' days

How it continued:

- Some crucial results:
  - Debris jams follow three phases (unstable, stable, and critical)
  - Critical phase=failure of debris jams by rotating about the pier
  - Critical phase=max size of debris jam
  - Debris jam size depends on Froude number and debris length



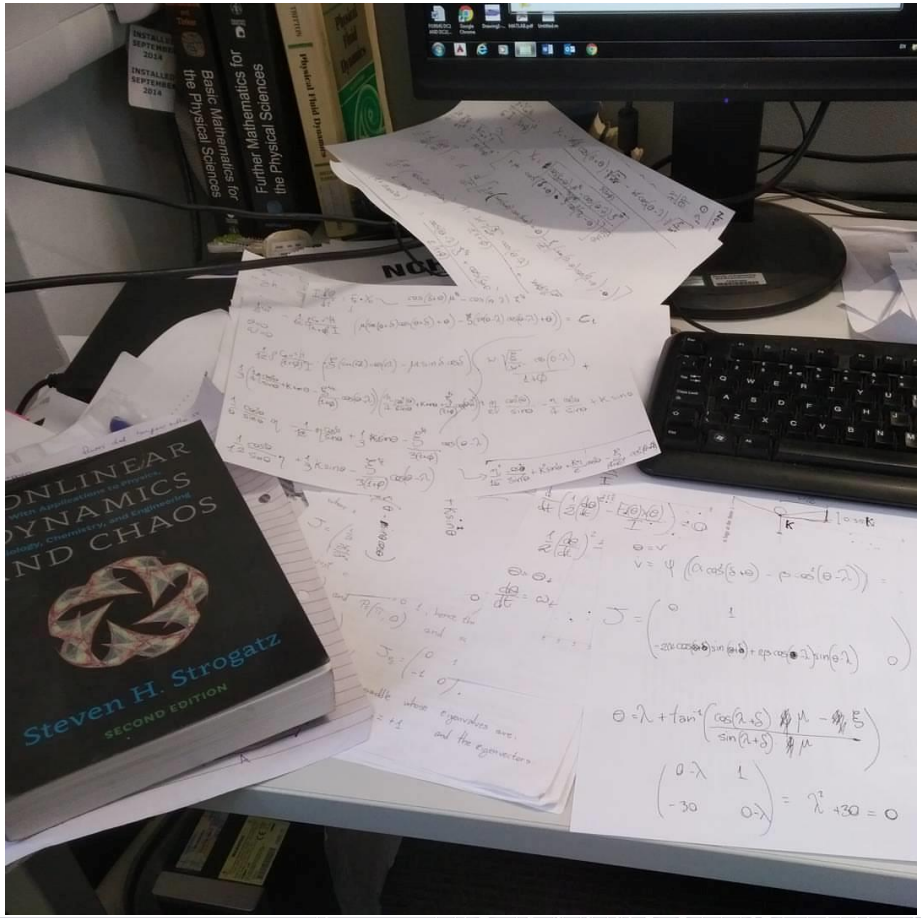
$$\omega^c = 0.988 + 3.238e^{-4.625Fr_L},$$
$$\eta^c = 0.703 - 0.887e^{-3.004Fr_L},$$
$$\kappa^c = 0.466 + 3.720e^{-9.936Fr_L}$$

CDT-SIS

The good ol' days

How it continued:

- Development of a theoretical model for failure of debris jams at bridge piers
  - Based on conservation of angular momentum
  - Use of non-linear differential equations



CDT-SIS

The good ol' days

How it continued:

- Development of a theoretical model for failure of debris jams at bridge piers
  - Based on conservation of angular momentum
  - Use of non-linear differential equations

$$\dot{\theta} = \omega,$$

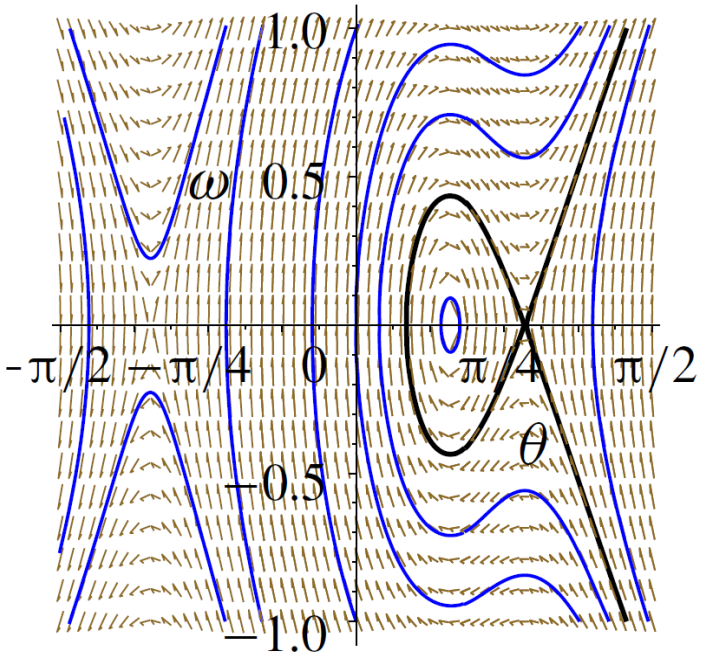
$$\dot{\omega} = \begin{cases} \chi \left[\left(\dfrac{\psi}{\psi+1} \dfrac{\cos(\theta+\delta)}{\cos\delta} \right)^2 - \left(\dfrac{\alpha}{4(1+\beta)(1+\psi)^2} \dfrac{\cos^2\theta}{\sin\theta} + \dfrac{\sin\theta}{\alpha} \right)^2 \right], \\ \qquad \text{for } -\dfrac{\pi}{2} \leqslant \theta < \theta_t^-, \\ \dfrac{\chi}{(\psi+1)^2} \left[\psi^2 \dfrac{\cos^2(\theta+\delta)}{\cos^2(\delta)} - \dfrac{\cos^2(\theta-\tau)}{\cos^2(\tau)} \right], \\ \qquad \text{for } \theta_t^- \leqslant \theta \leqslant \theta_t^+, \\ \chi \left[\left(\dfrac{\alpha\psi^2}{4(1+\beta)(1+\psi)^2} \dfrac{\cos^2\theta}{\sin\theta} + \dfrac{\sin\theta}{\alpha} \right)^2 - \left(\dfrac{1}{1+\psi} \dfrac{\cos(\theta-\tau)}{\cos\tau} \right)^2 \right], \\ \qquad \text{for } \theta_t^+ < \theta \leqslant \dfrac{\pi}{2}. \end{cases}$$

CDT-SIS

The good ol' days

How it continued:

- Development of a theoretical model for failure of debris jams at bridge piers
  - Based on conservation of angular momentum
  - Use of non-linear differential equations
  - Plotting many phase portraits



CDT-SIS

The good ol' days

How it continued:

- September 2018, beginning of nominal year ()
- Writing up of thesis had already started
- Ambition to write a "3-paper thesis"…
- …but rules had changed (and reality hit back)!

In the meantime:

- First paper submitted to Water Resources Research in July 2017, took 13 months to get accepted in August 2018
- August 2018 joined the Environment Agency as Flood modelling coordinator

PostDoc

New beginning in Exeter

But the “dark side” of academia kept calling me back…

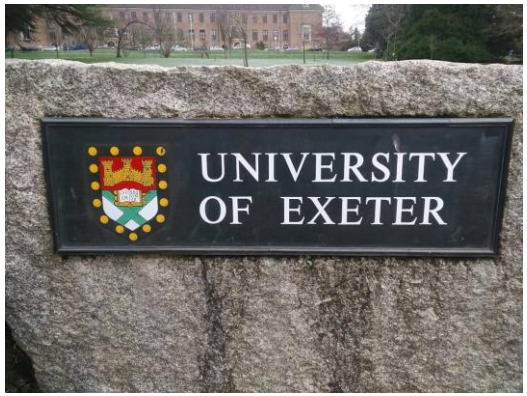
- Applied for three PostDoc positions, was offered a place for all three

PostDoc

New beginning in Exeter

But the “dark side” of academia kept calling me back…

- Applied for three PostDoc positions, was offered a place for all three
- PostDoc position at Exeter was perfect continuation of PhD
- Also liked the city, the University and the county (Devon)
- Felt a need for change
- In January 2019 switchover from EA to UoE



In the meantime:

- Working on papers and thesis at the same time

PostDoc

New beginning in Exeter

Project: Embedding techniques for assessing debris-induced scour and hydrodynamic forces within practice

- UoS (my PhD): developed equation to establish size of debris accumulations at bridge piers
- UoE (previous Postdoc): developed equations to establish scour depth at bridge piers with debris, depending on debris size

- My position: use equations above to change current UK practice in scour assessment, including debris (and, also, develop some mitigation measures)

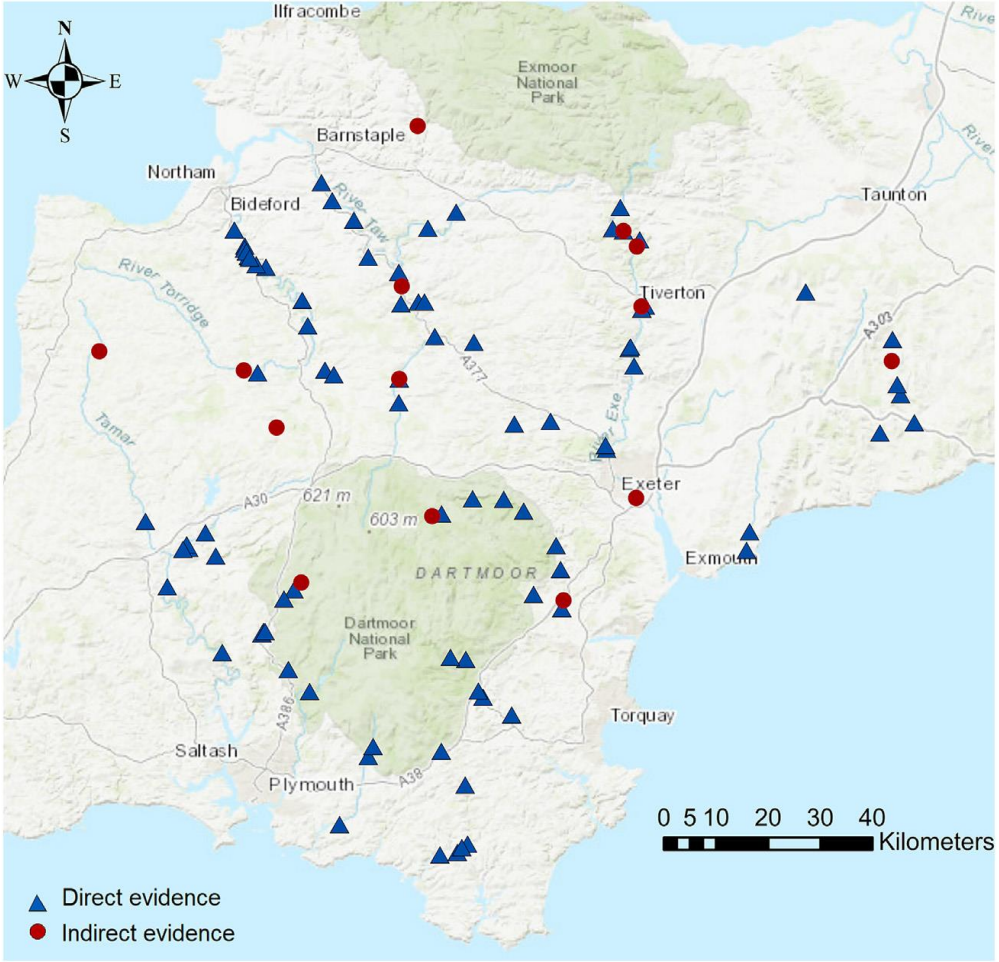
- In the meantime: submitted two papers in December 2018 and March 2019 that cover most of my PhD

PostDoc

New beginning in Exeter

Main outcomes:

- Define bridges at risk of debris accumulations
  - Direct evidence
  - Indirect evidence



PostDoc

New beginning in Exeter

Main outcomes:

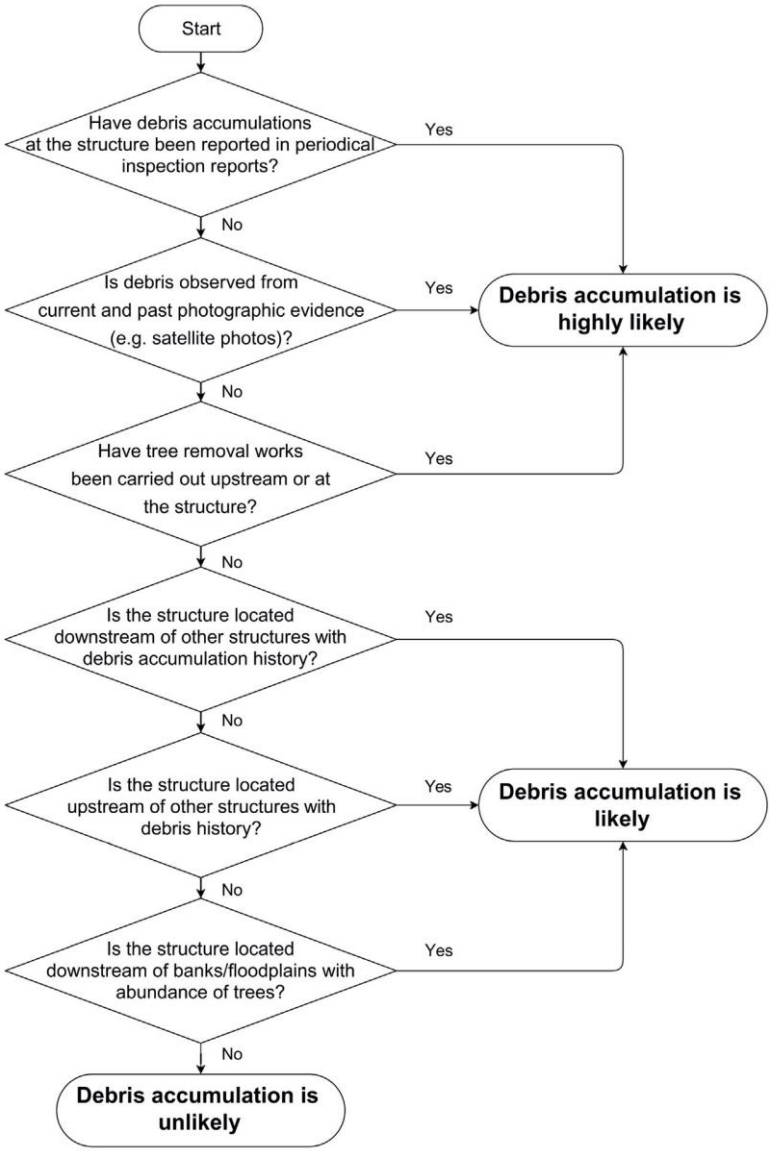
- Define bridges at risk of debris accumulations
- Combine equations for estimation of scour depth due to debris accumulations at bridge piers

PostDoc

New beginning in Exeter

May 2019: get invited to bi-annual meeting with Highways England for research update on bridges

- Highways England keen to introduce effects of debris in scour risk assessment at bridges
- Methodology in PostDoc research fits within HE remit
- HE and UoE begin a long year of work to develop the new CS 469 *Inspection and assessment of scour and other hydraulic actions at structures*



PostDoc

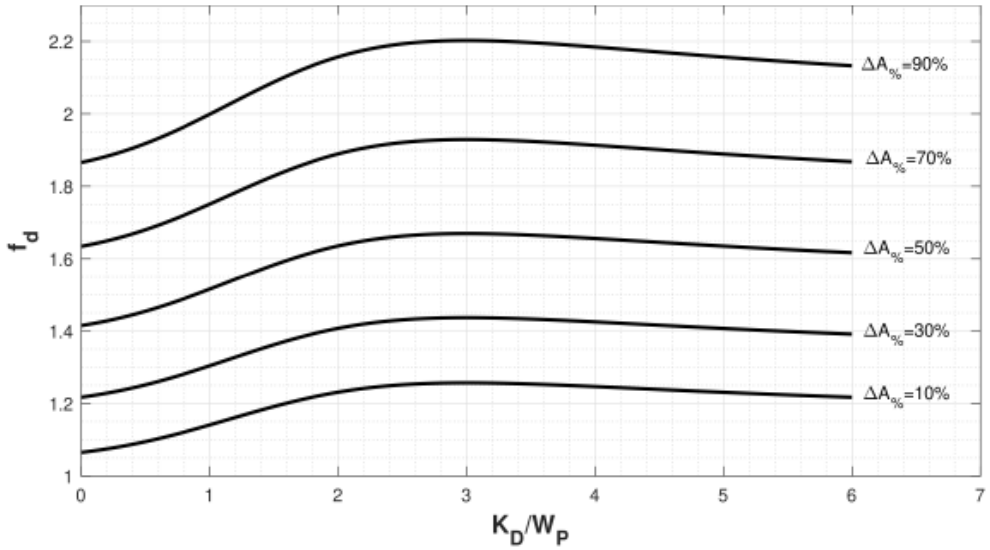
New beginning in Exeter

Inclusions to CS 469

- Additional vulnerability factor due to debris accumulations
- Develop simplified and rigorous methods for estimation of additional scour depth due to debris
- Both define scour risk

$$P_f = H \cdot F \cdot M \cdot Tr \cdot V \cdot D$$

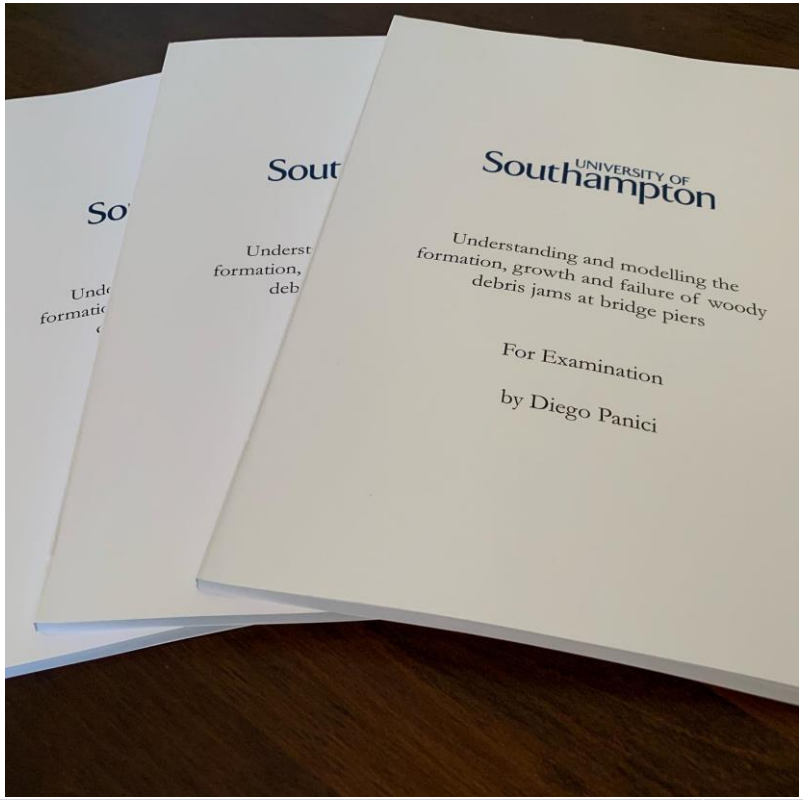
$$D_{\text{l,pier}} = 1.5 \cdot W_P \cdot f_{PS} \cdot f_{PA} \cdot f_g \cdot f_d$$



PostDoc

Let’s not forget about the PhD!

July 2019: thesis submission (2 years today!)



PostDoc

Let’s not forget about the PhD!

July 2019: thesis submission (2 years today!)

September 2019: Viva

PostDoc

Let’s not forget about the PhD!

July 2019: thesis submission (2 years today!)

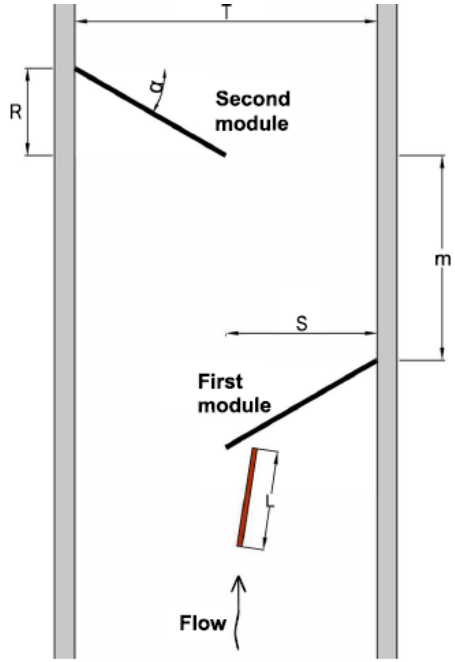
September 2019: Viva

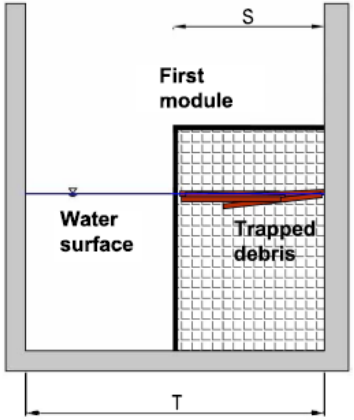
December 2019: award

PostDoc

Project development

- Laboratory experiments for debris trapping
- Laboratory experiments for scour and debris porosity





PostDoc

Papers

Long awaited, papers start to get accepted:

- 3rd December 2019: two acceptances in one day!
  - **Journal of Fluid Mechanics** → Theoretical model on debris failure
  - **Journal of Hydraulic Engineering** → Pier and debris shape on accumulations (experiments)

- April 2020: **Science of the Total Environment** → Methodology for assessing bridges liable to debris and application of scour assessment
- October 2020: **Journal of Hydraulic Engineering** → New debris catchers, efficiency and effect on flood risk (experiments)
- July 2021: **Water Resources Research** → Debris transport, experiments and model (experiments and theory – used data from summer project in 2015!)

PostDoc

Further developments

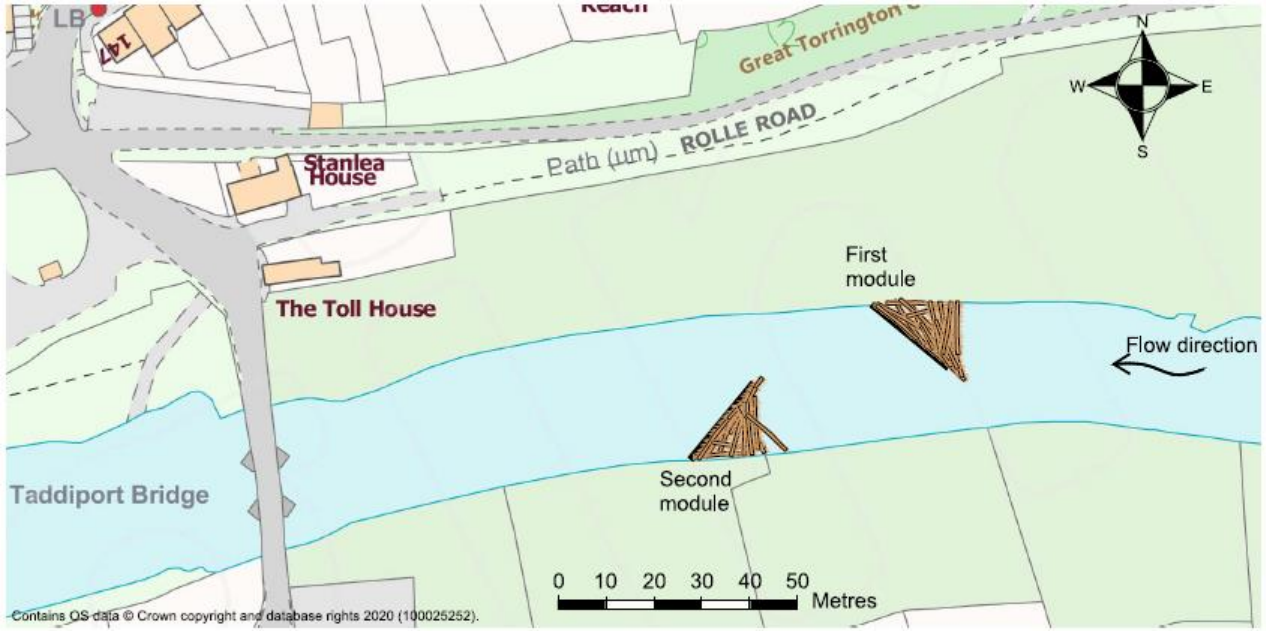
- CIRIA
  - Selected as steering group member for the new scour manual (now published)
  - Inclusion of several papers in the new manual, e.g. debris size equations, debris scour, debris trapping systems

- Devon County Council
  - Designing full-scale debris catchers
  - Working on scour risk assessments and improvement of importance factors for next Highways England release

PostDoc

Further developments

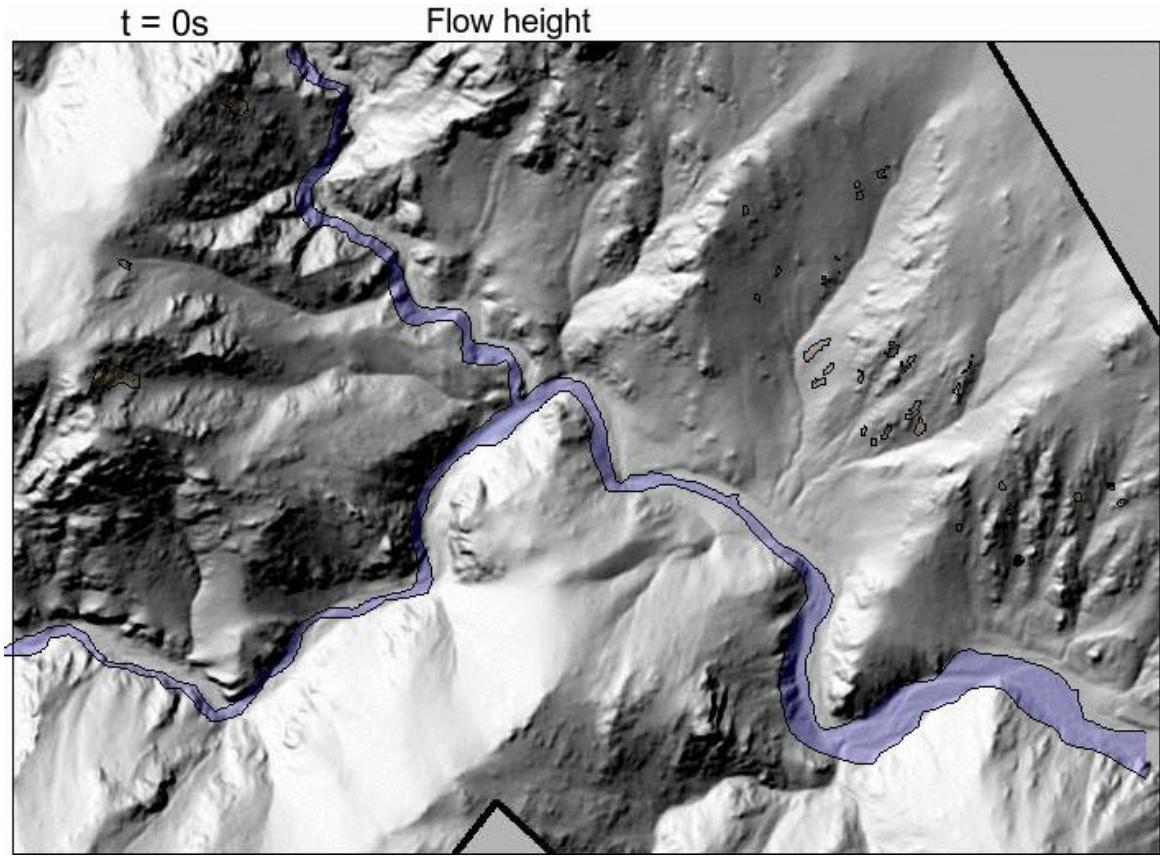
- Devon County Council
  - Designing full-scale debris catchers



PostDoc

New projects

- Cascading landslide hazard in the Philippines
  - Multi-phase modelling (solid, fine and liquid) of landslides and channels
  - Interactions between landslides and floods
  - Sediment delivery to channels



PostDoc

New projects

- Managing water abstraction in rivers under climate pressure
  - Won a grant for the project
  - Collaboration UK-Australia
  - Many interested project partners

PostDoc

New projects

- Several papers in production
  - Mostly from PostDoc, but still a few from PhD!
- Building new networks:
  - Bridge resilience (Bristol, Milan, Japan, MIT, ETH)
  - Landslide-channel interactions (Glasgow, Philippines)
  - Water abstractions (Queensland)
  - Industrial partners

PostDoc

Conclusions

- PhD in Southampton invaluable experience
- PhD substantially contributed to my formation
- I could develop a significant track record
- PostDoc in Exeter also invaluable experience
- Fruits of research took time…
- …but then came abundant!

Thank you!