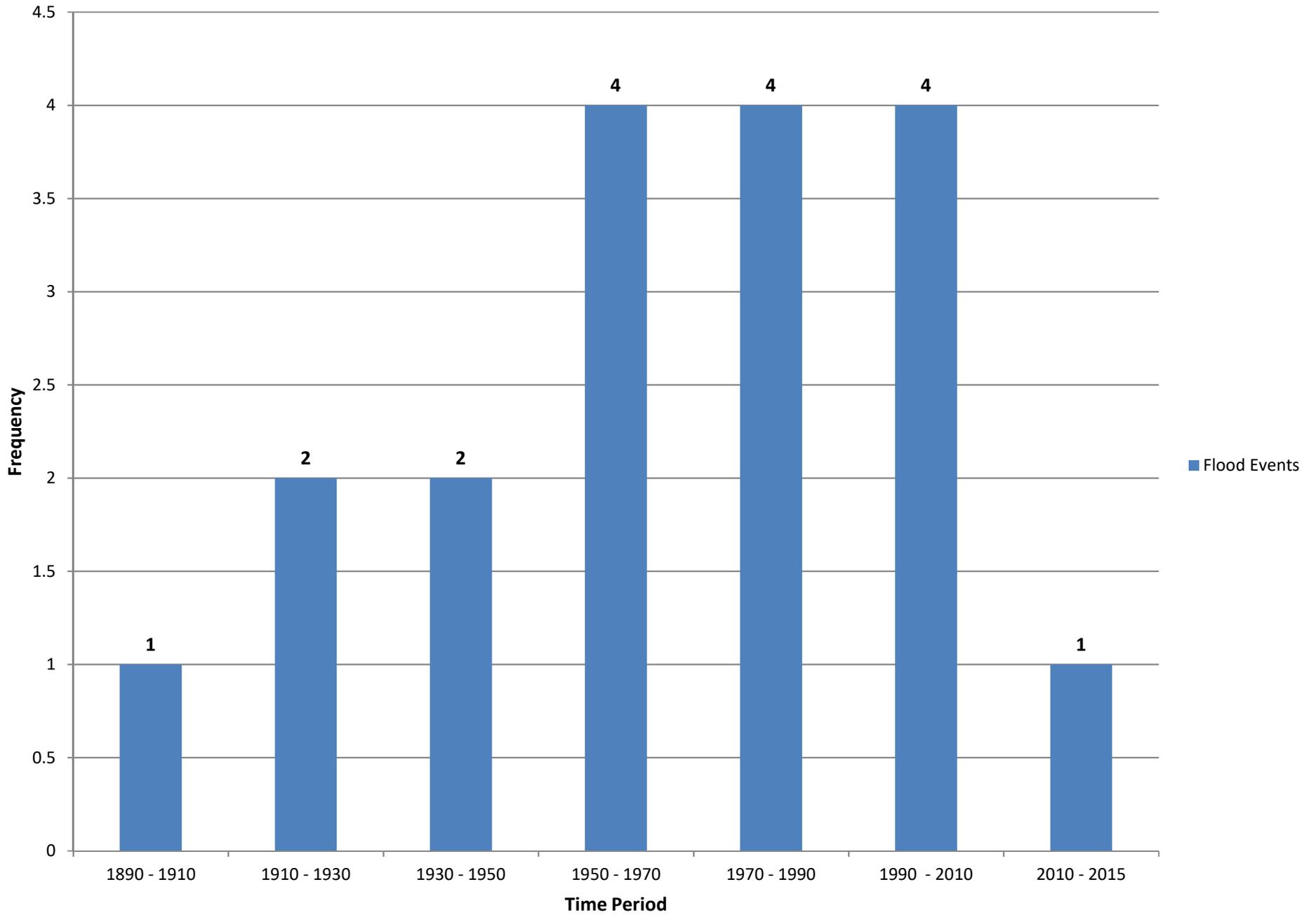


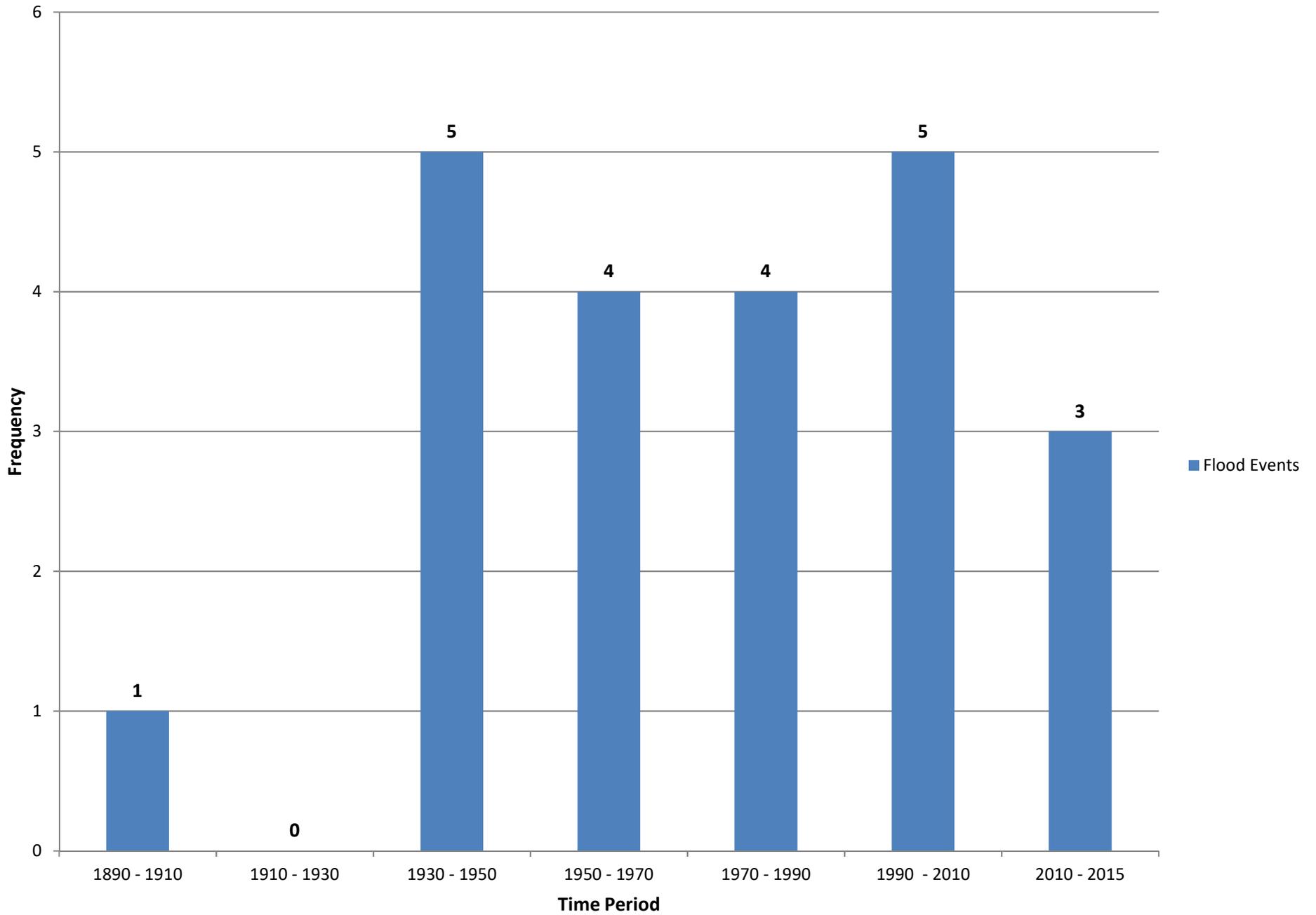


***“A better understanding of flood risk,
resilience & resistance measures”***

Carlisle Flood Events



York Flood Events

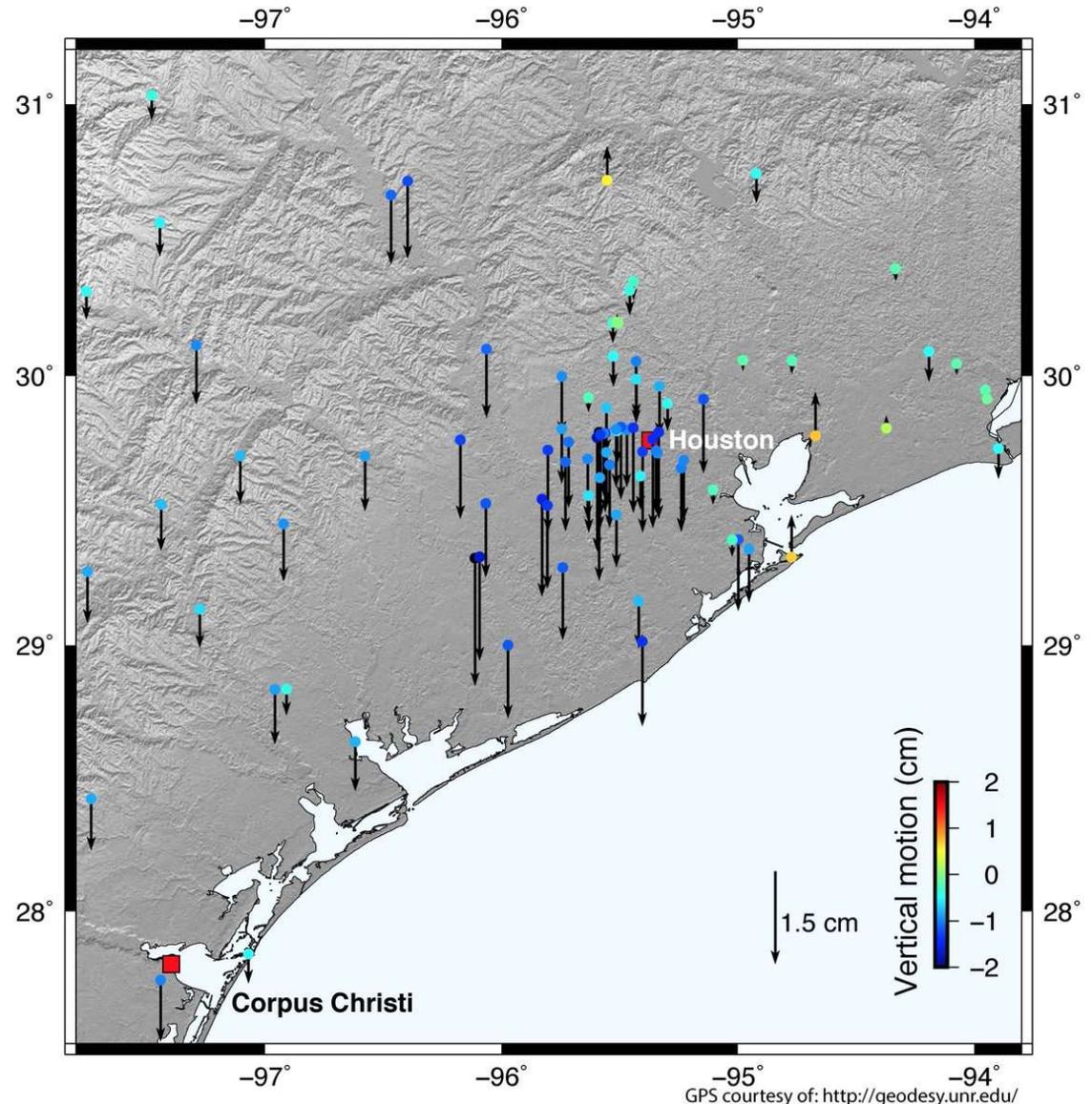


Texas Flood - Hurricane Harvey

Around 33 trillion gallons of water was left behind by the hurricane, four times the amount left by Hurricane Katrina in 2005.

28000 square miles of Houston was flooded adding around 275 trillion pounds of weight to the landmass of the southern US region.

GPS data collected from stations around Houston detected the area had been depressed 2cm under the weight of the water deposited by Harvey.



Calder Valley

The River Calder has a catchment area of $\sim 360\text{km}^2$ with 204,000 living with the Calder corridor. Historical records of flooding dating back to 1600's.

On December 26th 2015 over 100mm of rainfall fell within the Calder Catchment, the average for the whole month of December, in 24 hours.

The majority of river gauges along the Calder corridor recorded highest ever river levels. The flood event had an estimated return period of between 1% (1 in 100) and 0.75% (1 in 135).

Over 2,800 homes and 1,600 businesses inundated.

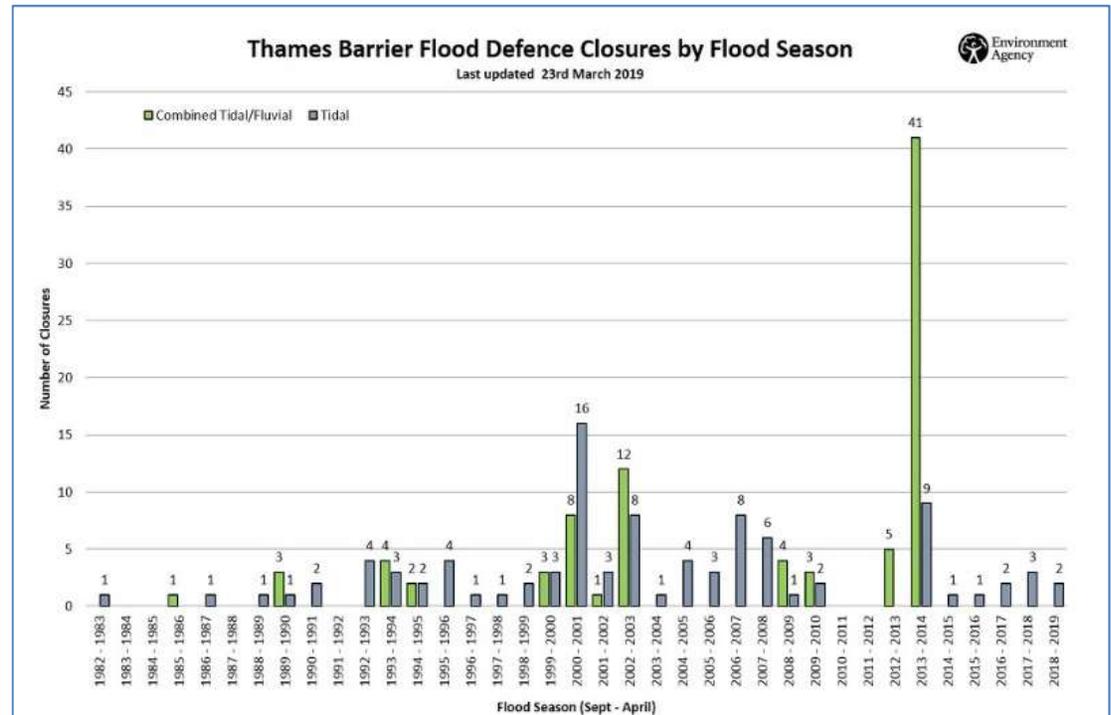


River Thames Tidal Barrier Closures

The Thames Barrier has been closed 184 times since it became operational in 1982 (correct as of March 2019). Of these closures, 97 were to protect against tidal flooding and 87 were to protect against combined tidal/fluvial flooding.

The barrier closed more times in February 2014 (28) than the previous record for a whole winter (24 in 2000-01).

The Thames Barrier closed 50 times in 2014 - already a record for a single year. This period of closures is comparable to 40% of the total closures from when operation began in 1982.



Background

- Critical National Infrastructure (CNI)
- Determine flood risk at a site specific level
- Provide flood resilience/resistance measures

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Onsite Survey

- Site specific GPS ground level survey
- Identify critical/vulnerable assets
- Provide flood resilience/resistance measures
- Recommend competent companies

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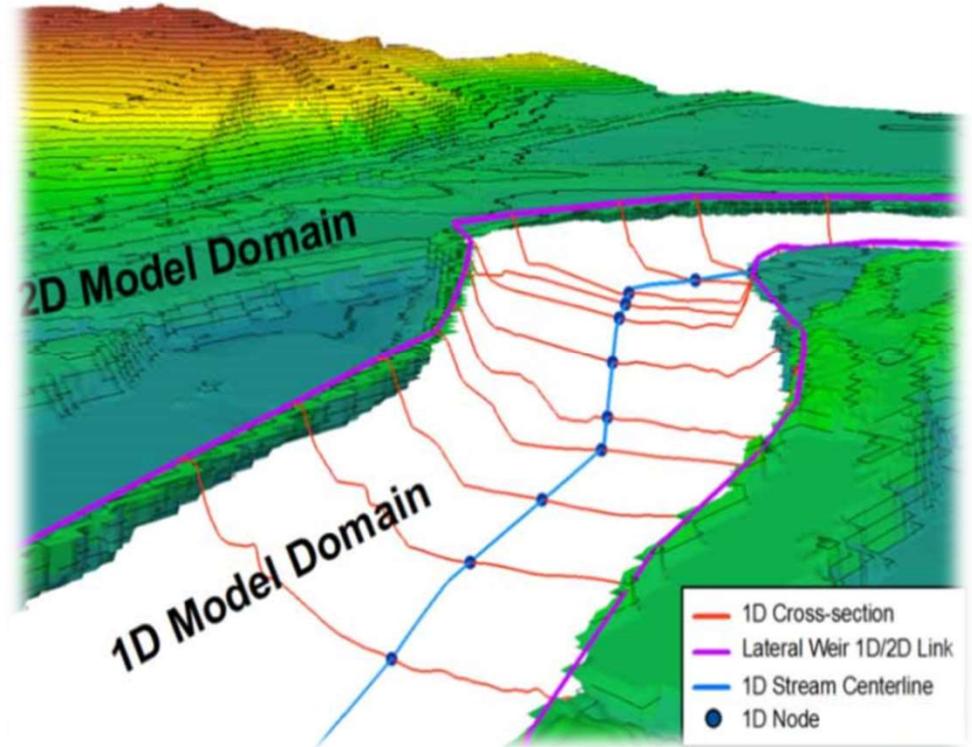
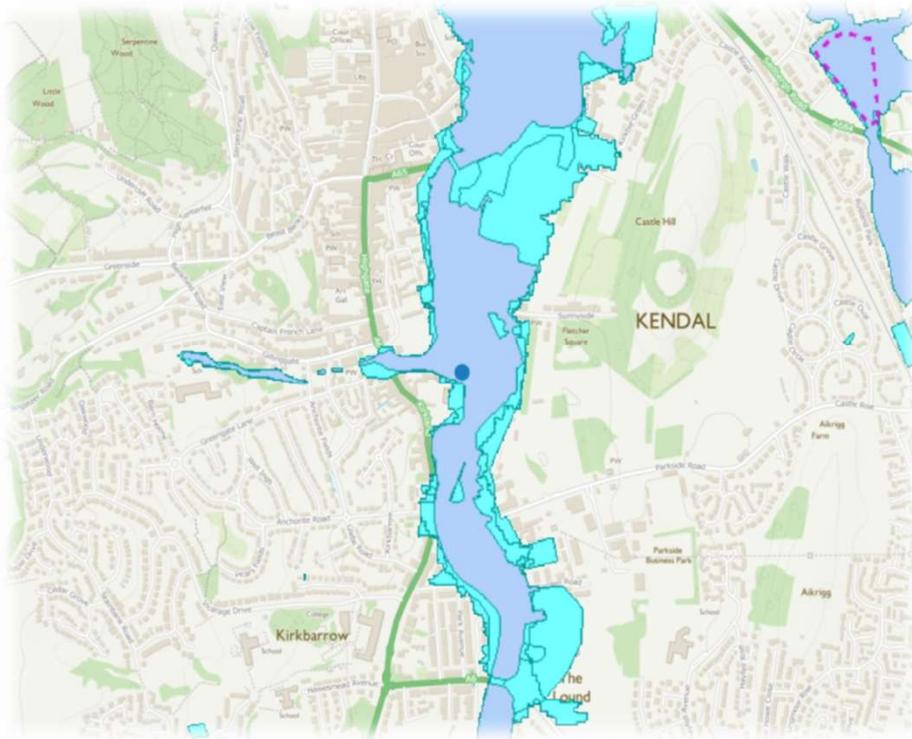


Site Specific Flood Risk

- Based on the best available data
- Fluvial, pluvial or coastal/tidal and combinations
- EA, SEPA, NRW & Local Authorities

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Flood Mechanisms

- **Primary Natural Mechanisms**
 - Fluvial (Rivers)
 - Coastal/Tidal (Sea)
 - Pluvial (Surface Water)
- **Primary Artificial Mechanisms**
 - Reservoir Breach/Dam Break
 - Canal Failure
- **Secondary Mechanisms**
 - Groundwater (Rising Water Table)
 - Sewer Flooding

Fluvial Flooding

- Prolonged, heavy rainfall in the catchment.
- Flow of the natural river channel is exceeded.
- Water overflows on the surrounding land.
- Duration: up to several weeks
- Flood warning given days in advance.

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Coastal/Tidal Flooding

- Combination of weather elements: low pressure, driving winds, astronomic tides.
- Weather elements cause the sea surface to rise (storm surge).
- Storm surge overwhelms low lying coastlines.
- Duration: peak storm surge can last up to 2 hours.
- Flood warning given days in advance.

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Pluvial (Surface Water) Flooding

- Prolonged heavy rainfall or extreme sudden bursts (cloud burst).
- Natural ground drainage and local drainage network overwhelmed.
- Surplus water pools on the ground surface.
- Duration: usually up to 30 minutes
- Flood warning not given due to spontaneity of events.

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Flood Defence Techniques

Flood Resistance - A flood resistant building is constructed in such a way to prevent entry of water in to the structure and damaging its fabric/contents.

Flood Resilience - A flood resilient building is designed and constructed to reduce the impact of flood water entering the building so that no permanent damage is caused, structural integrity is maintained and drying and cleaning is easier.

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Entrance point protection



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Flood glazing doors and window



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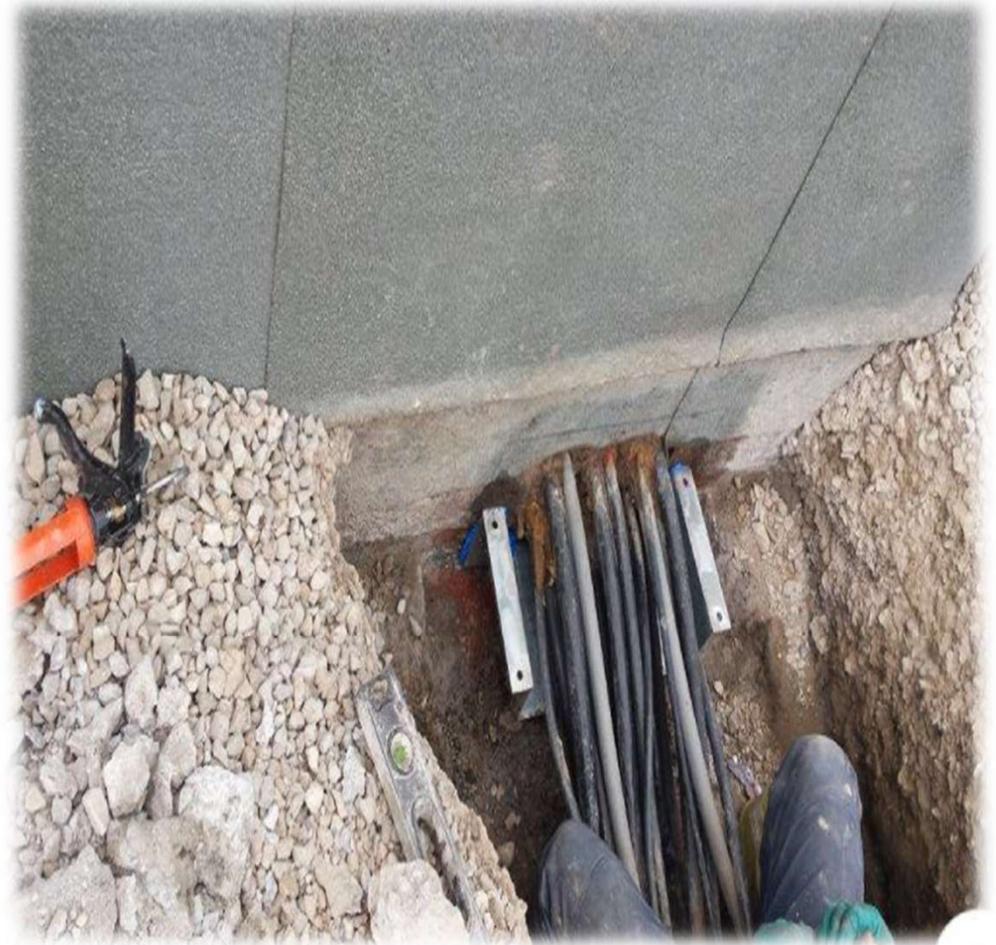
Cable Entry Sealing



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Sealing Cable Entries Example



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Sealing Cable Entries Example



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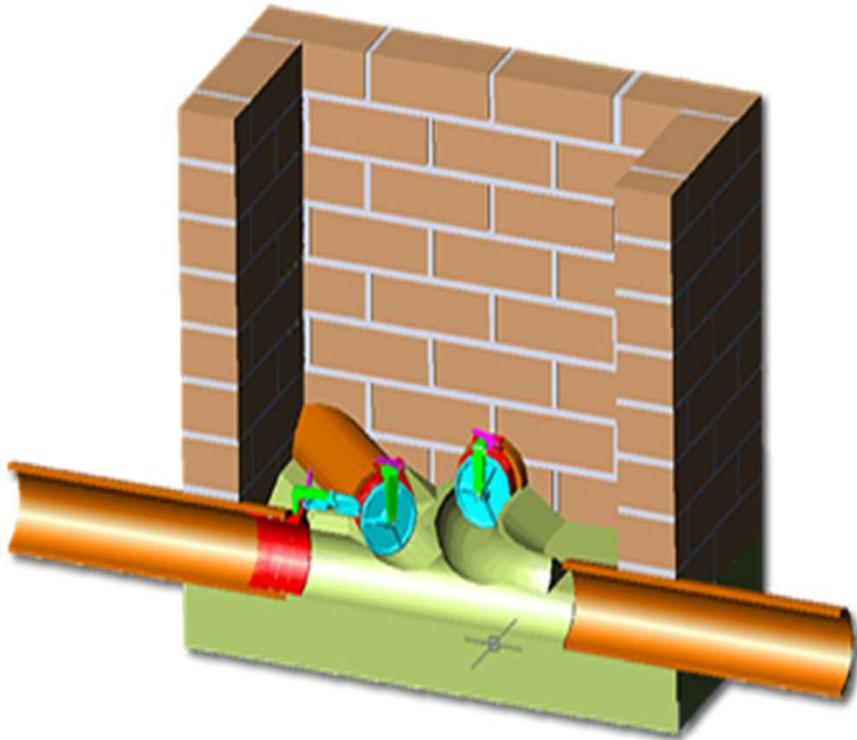
Vents / Pumps



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Non Return Valves



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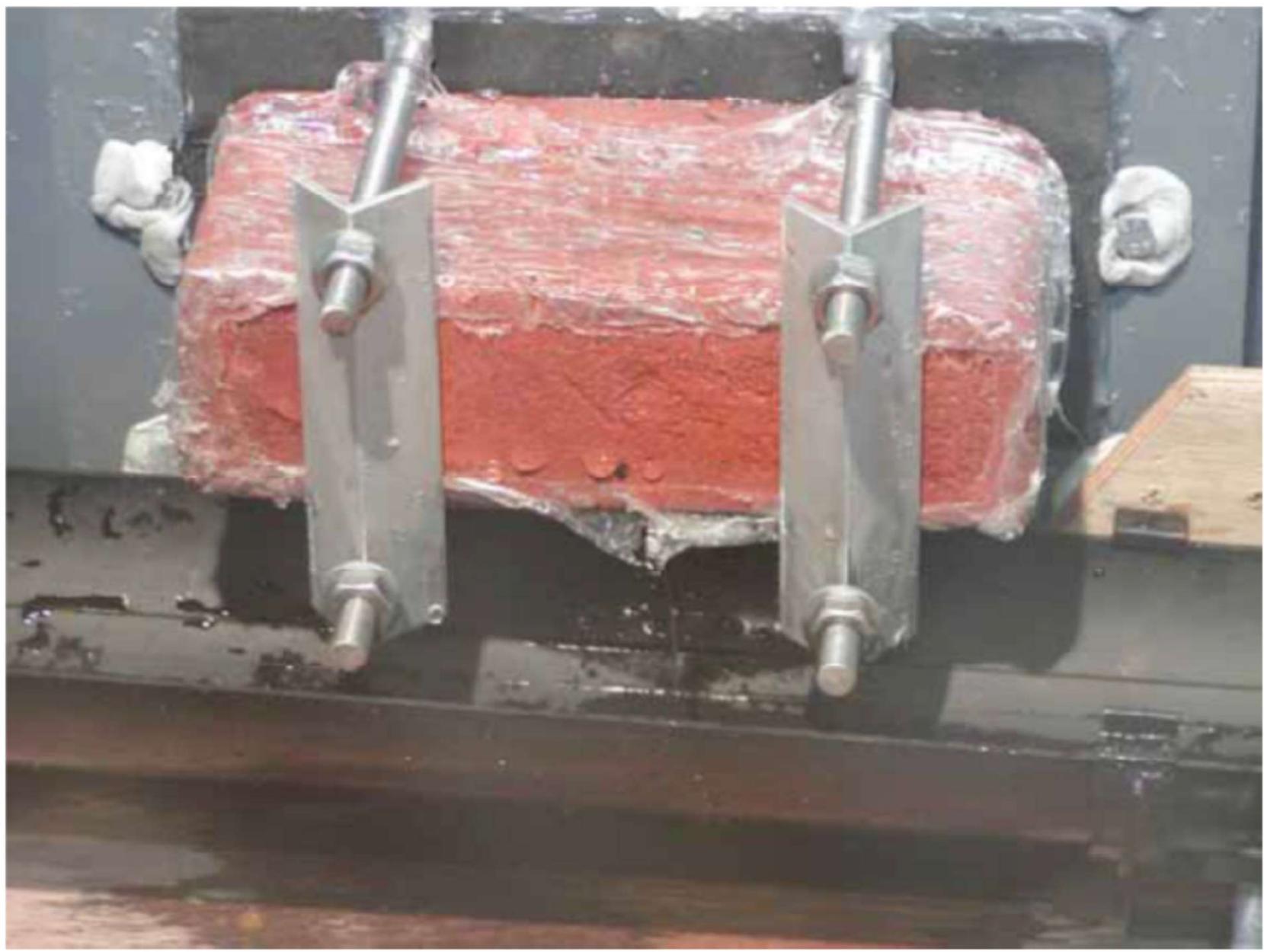
Flood Membrane Example



7kN block (high density) under test . 20 l/hr seepage at 1m head of water.



Michelmersh facing brick under test. 3.5 l/hr seepage at 1m head of water.



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Flood Proof Cabinets Example



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Flood Proof Cabinets Example



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Flood Gate Examples



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Demountable Barrier Systems – Permanent Foundation



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Demountable Barrier Systems – No Foundation



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Demountable Barrier System – Case Study



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Onsite Flood Testing Examples



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Flood Resilience

- **Flooring**
 - Avoid the use of carpets, wooden or water absorbent materials
 - Use ceramic tiles, vinyl or painted flooring where possible
 - Retractable rugs instead of carpet
- **Walls**
 - Avoid standard gypsum based plaster or water absorbent materials
 - Use lime based plaster, cement render or plastic superficial sheeting
- **Planning**
 - Create a flood plan which can include:
 - Moving vulnerable contents
 - Turning off utilities
 - Installing flood protection measures
 - Create a safe route of egress
 - Plan property reoccupation