Assessing risks of flash flooding using historical information – three examples from northeast England

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What is a flash flood?

There is no agreed definition of a flash flood. Our definition is:

Flash floods result from intense short duration rainfall, usually convective, that exceeds urban drainage capacity or rural infiltration capacity and hence can cause pluvial flooding of land and property far from rivers. They may also result in very rapid increases in river levels on small catchments which may be transmitted downstream in larger catchments where they may cause danger to life of river users.

Historical flash floods

Are recent flash floods unprecedented or more frequent than they were in the past?'

To answer this, one needs to examine the history of flash flood occurrence.

Since flash floods are uncommon extreme events at a given location, a long record is necessary to attempt to establish whether change has occurred.

Historical chronologies of major river floods have been widely prepared, but none until now of flash floods.

As part of the SINATRA project, flash flood chronologies have been prepared for Northeast England, Northwest England and Southwest England

Flash flood examples

In this study flash floods of contrasting characteristics are examined at three locations :

1. Newcastle upon Tyne Pluvial flash floods, comparing the flood of June 2012 with historical events.

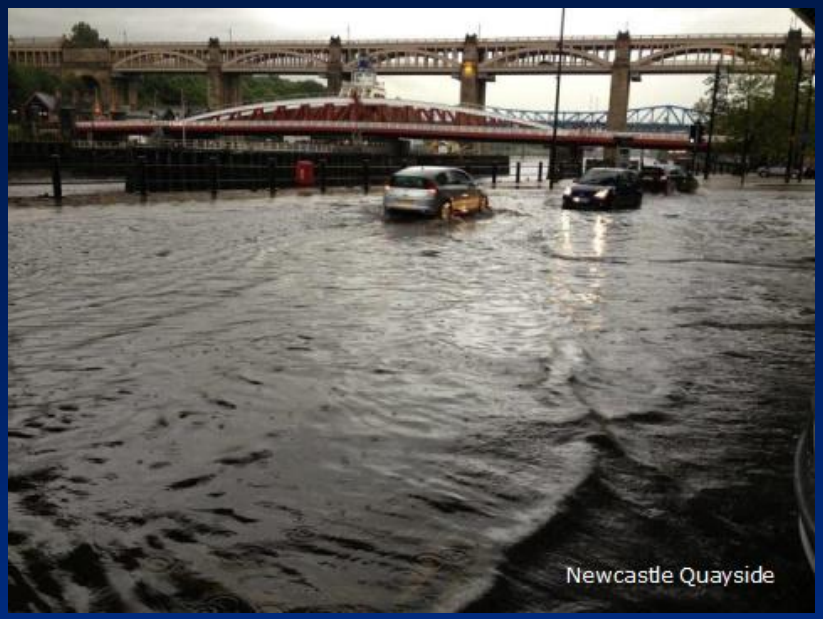
2. Cotting Burn (A small ungauged tributary of the River Wansbeck) which suffered recent repeated flooding and a severe flash flood in 1968 with serious effects in the town of Morpeth.

3. The gauged River Wansbeck itself experienced an extreme rate of rise in river level from an intense upstream storm in August 1994.

Newcastle pluvial flood – 28 June 2012

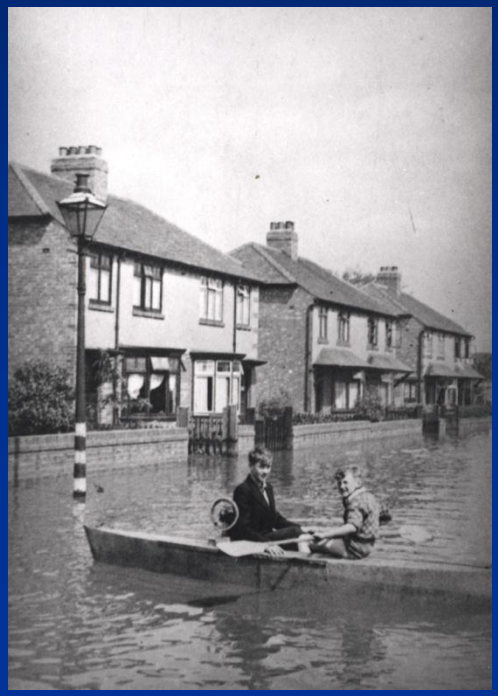
- The event covered much of the Tyneside area and parts of south Northumberland and Durham.
- The highest Newcastle storm total was 51 mm, of which 26 mm fell in 30 minutes, 32 mm in 1 hour and 49 mm in 2 hours (Environment Agency, 2012).
- Rainfall return periods were estimated at up to 130 years for periods between 1 and 2 hours.
- A total of 377 streets were reported flooded, of which 227 suffered highway damage. Over 500 homes had water in their property and 54 businesses were flooded.

Photos from the 2012 flood



Newcastle – historical pluvial floods

- 22 June 1941 50 mm rainfall occurred in 35 minutes and 95 mm in 85 minutes (British Rainfall). There are no newspaper accounts of flood effects due to wartime restrictions on reporting. However the City Library holds a collection of photographs of effects along an urban watercourse the Denton Burn in west Newcastle.



Newcastle - historical pluvial floods

- 16 September 1913 67 mm occurred in 1 hour 30 minutes on Newcastle Town Moor. Detailed newspaper descriptions and photos of this event show similar pathways of flood flow and location of ponding in the city as in 2012.
- 12 August 1890 No short period rainfalls are reported but five daily rainfall stations registered totals between 56 and 67mm in thunderstorms.
- 18 June 1872 No rainfall measurements were available but impacts and locations were similar to or greater than 2012. Storm was accompanied by large hailstones which broke windows and glass roofs on every street in the town. Three peoples were killed by lightning.
- 8 Jun 1839 Flood impacts and locations were similar to 2012. People were rescued from homes where water reached ceilings.
- 11 Jun 1833 Serious flooding occurred in shops and houses.

Newcastle – Assessing flash flood risk

- Risk assessment of pluvial floods is difficult as there is no defined channel in which to compare flow. Risk can be assessed by comparing rainfall and flood impacts (source areas, flood pathways, areas of repeated ponding).

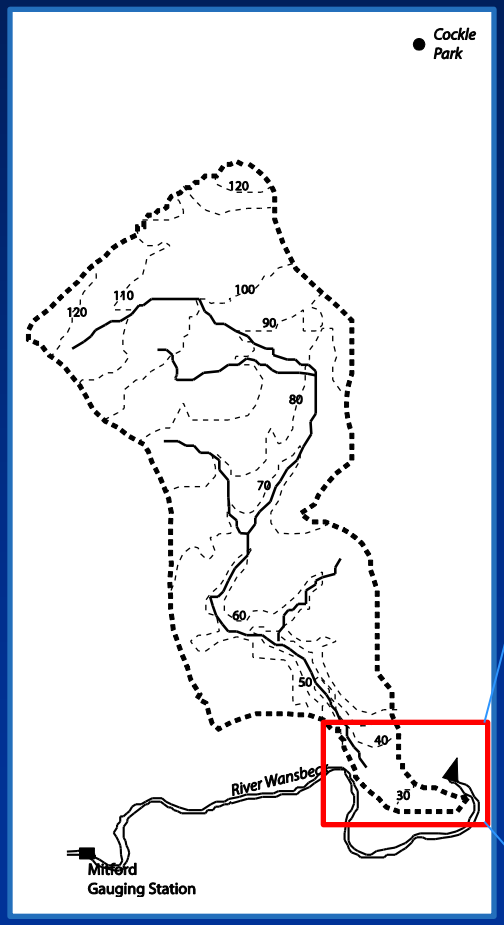
- An example is provided in the paper of one site (Newgate Street) where repeated flooding occurred.

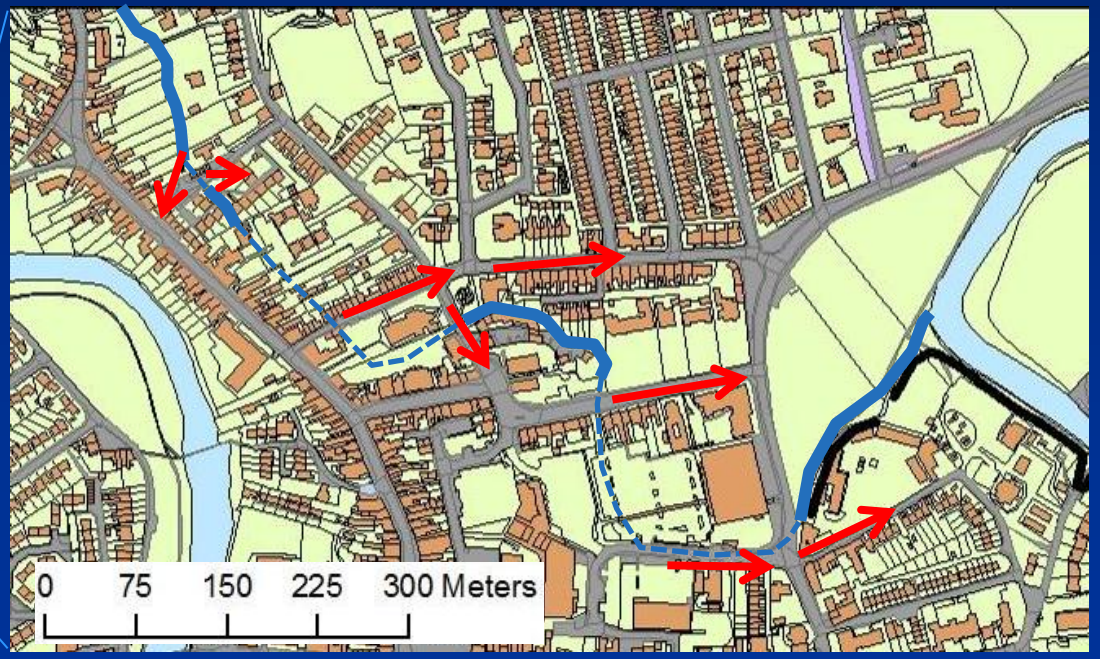
- Six historical events were of similar magnitude and impact to the flash flood of June 2012, whilst the floods of 1941, 1913 and 1872 were probably greater. Knowledge of comparative historical floods changes the perception of the 2012 flood as ‘unprecedented in living memory’ to an event which probably ranges from Rank 4 to Rank 7 in a 200 year period.

- An estimated return period for the 2012 flood (using Gringorten plotting position) is between 31 and 56 years.

Cotting Burn – small catchment urban floods

- Catchment area 5.8 km^2, mostly rural
- Altitude range approx. 25 to 120 mASL
- Channel is culverted through parts of Morpeth town centre
- Overbank flows during floods run through streets into adjacent areas





Cotting Burn – recent flood events

- Cotting Burn has flooded 3 times in the past 6 years, each event causing damage to properties in Morpeth. Flooding on 6 Sept 2008 and 25 Sept 2012 was from rainfall also causing widespread flooding from the Wansbeck, with high river levels affecting the lower parts of the burn. The 2010 event was a localised event in Cotting Burn.

Cotting Burn – historical comparisons

- 13 September 1968 An intense localised storm with 72 mm of rain over 4 hours, again flooding the town streets from out-of-bank flow, in this case exacerbated by partial collapse of a culvert.

- 1 June 1924 Prolonged and widespread rainfall of 105 mm over 36 hours, causing combined flooding from the Wansbeck and Cotting Burn.

- 26 October 1900 A total of 79 mm of rain, initially as snow and sleet, fell over about 12 hours, with overbank flow from Cotting Burn running into streets through the town centre.

Cotting Burn 13 Sep 1968

Clockwise from top left

1. Flood in Dacre Street
2. Pointing to flood mark
3. Demolished wall
4. Mobile classroom mobilised.

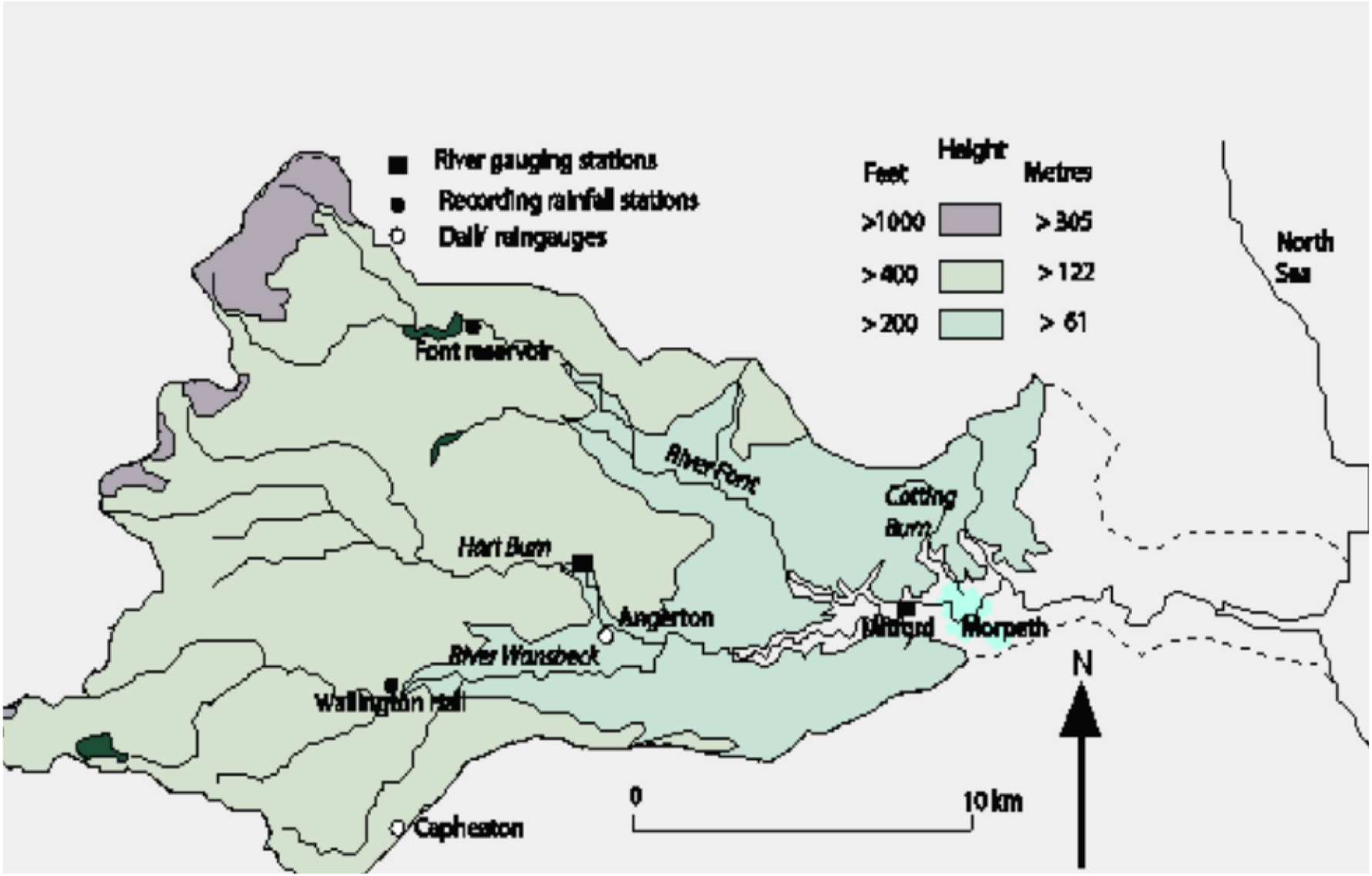
Cotting Burn – assessing flash flood risk

- Previous assessments of flood risk from Cotting Burn for design of flood alleviation schemes in Morpeth are determined mainly on the basis of events where flows exceed the threshold of the carrying capacity of the culverts.

- Calculations using the FEH rainfall-runoff method suggested that flooding would occur for events of less than 1:100 year return period only if there is significant blockage of culverts.

- The evidence from the flood history records (6 events in 112 years, 3 events in the last 6 years) suggest that either culverts are normally in a blocked state during major events, or more likely that the FEH flood event magnitudes for a given return period are underestimated

River Wansbeck –rapid rate of rise

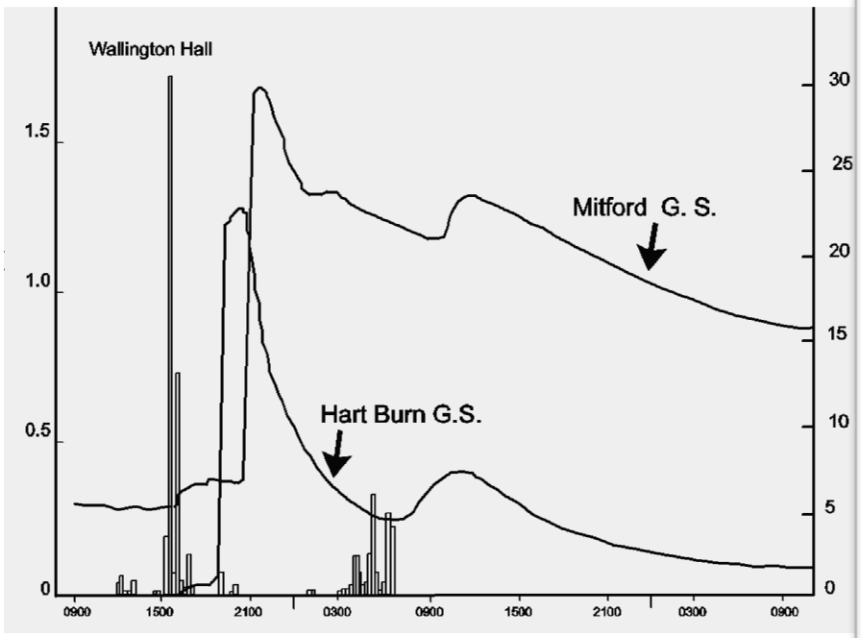


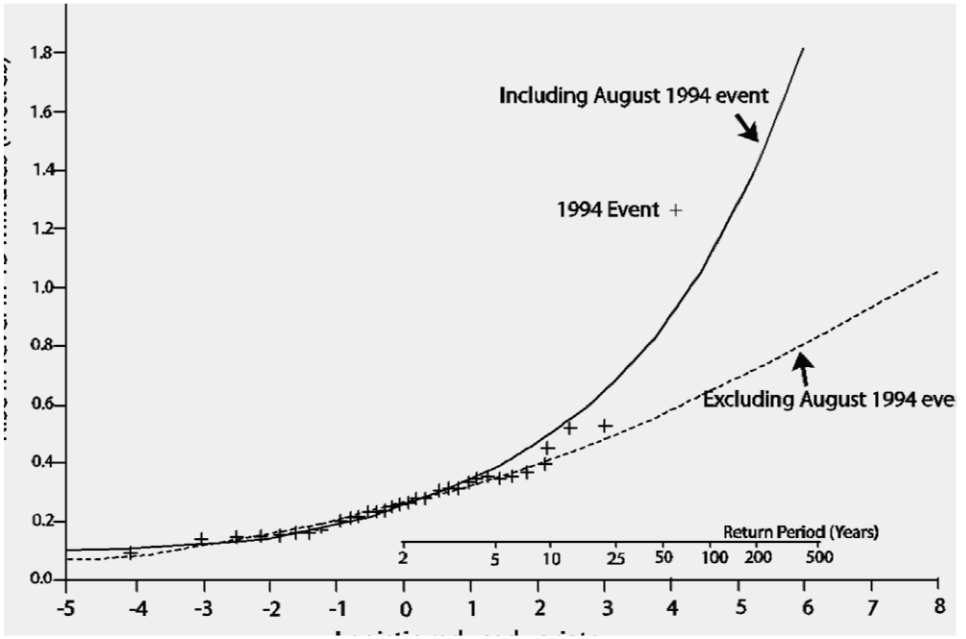
River Wansbeck exceptional rate of rise

3 August 1994

- Wansbeck catchment is predominantly rural with 300 km^2 catchment area
- Heavy thunderstorm rainfall occurred in mid catchment with 15 minute total of 30 mm at Wallington, hourly total of 47 mm and daily total of 100 mm.
- Rapid rates of rise pose serious risk of life to users (eg on stepping stones) in Morpeth (although the peak level and discharge was not exceptional).
- The event was unprecedented in the gauged record.

River Wansbeck – August 1994





A. **Level hydrographs on the Hartburn tributary and at Mitford G.S.** Rapid rate of rise in tributary and main catchment of 1.26 m in 15 minutes (from 0.6 to 44.5 m^3/s).
B. **Frequency distribution of 15 minute annual maximum rise in level at Mitford** suggests a return period of at least 140 years.

River Wansbeck – historical comparisons

- On 7 September 1898 the greatest ever short period rainfall in the northeast was recorded at Angerton where 170 mm fell in 3 hours.
- In Morpeth it was reported. ‘It came with a strong head and increased volume so rapidly that it was in a few minutes rolling over the weirheads’.

- On 5 July 1881 it was reported : ’It must have been very heavy in the west for near midday the Wansbeck came down in a rolling flood, the wave being 3 or 4 feet deep. It rushed over the weir head at East Mill and caught a little boy named Dymond who had been plodging in the water and would have been carried away had not three men heard his cries and came to his rescue.

Assessing probability of rate of rise

- Although there are no precise measurements of rates of change in depth, the descriptions of the approaching flood wave are sufficient to conclude that these two events had wave fronts at least equal in magnitude and probably greater than the event in 1994.

- No further events with steeply rising wave front were found in newspaper and other descriptions and the record is probably complete from the middle of the nineteenth century, say 160 years.

- As the Rank 3 event in that period, a return period of 62 years is suggested by the Gringorten plotting position formula compared with a very uncertain 140 years based on the gauged record.

Problems with use of historical information

- For pluvial floods there is no defined channel (or fixed location). Comparison of magnitude must be based on comparative rainfall or on impacts.
- Flash flood risk may be altered by changes in the urban surface permeability (likely to increase flood risk) and improvements to sub surface drainage (likely to decrease flood risk).
- Flash flood history may provide limited guide to future risk in the presence of climate change where climate projections suggest that extreme events will become more frequent.

Conclusions

- Flash floods include pluvial events and extreme rates of rise on both small and large catchments
- Although flood chronologies exist on many rivers, there are no previous historical chronologies of flash floods.
- Historical flash flood chronologies have been prepared for three regions of England as part of the SINATRA project.
- Flash floods at one location are so infrequent that lifetime experience or gauged records provide a poor basis for risk estimation
- Historical flood chronologies show that in the 3 examples flash floods of equal or greater or magnitude have occurred
- Historical data provide a more reliable basis for risk estimation than householder memory or gauged data.