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Design Flood Estimation – A Hydroinformatics Problem

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Context

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Issues to discuss

- What is the Design Flood Problem?
  - Issues
  - Data management
- Design Flood Approaches
- Information Generation

FLOOD PROBLEM

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"*I love a sunburnt country*
A land of sweeping plains,
Of ragged mountain ranges,
Of droughts and flooding rains".

Dorothea Mackellar – My Country

Flood Problem

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Flood prediction and management remain a problem for many catchments.

Effective flood management requires knowledge of the flood risk:

- Probability of flood; and
- Hazard

Identification of hazard without probability does not allow risk to be assessed.

Flood Problem

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Flood Problem

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Flood Problem

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Historical

- Single flood hydrograph characteristic
  - Flow Quantile

Current

- Alternative flood hydrograph characteristics
  - Flow Quantile
  - Level Quantile
  - Flood Volume
  - Rate of Rise of Flood Hydrograph

- System failure

Flood Problem

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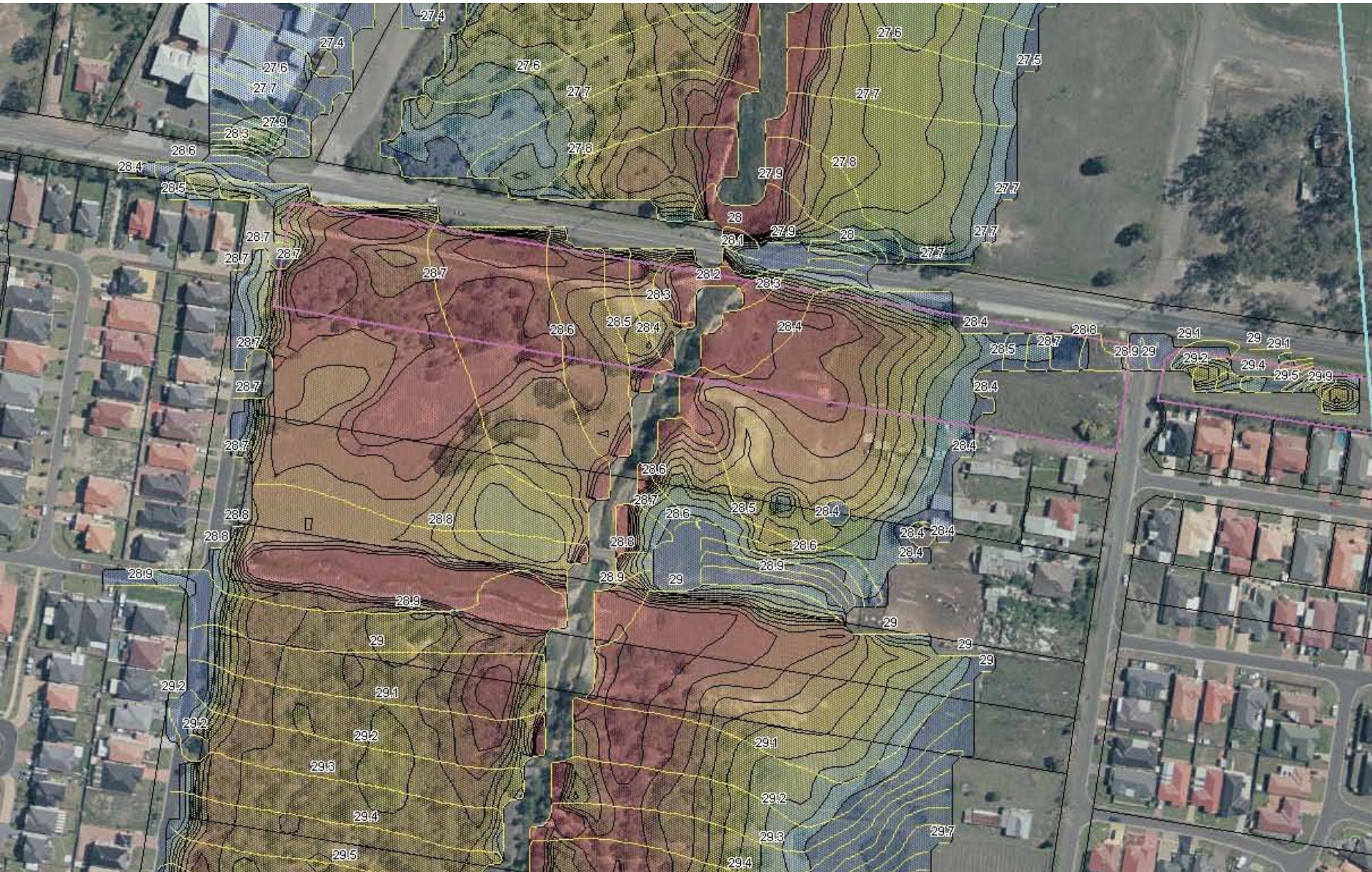

Flood Problem

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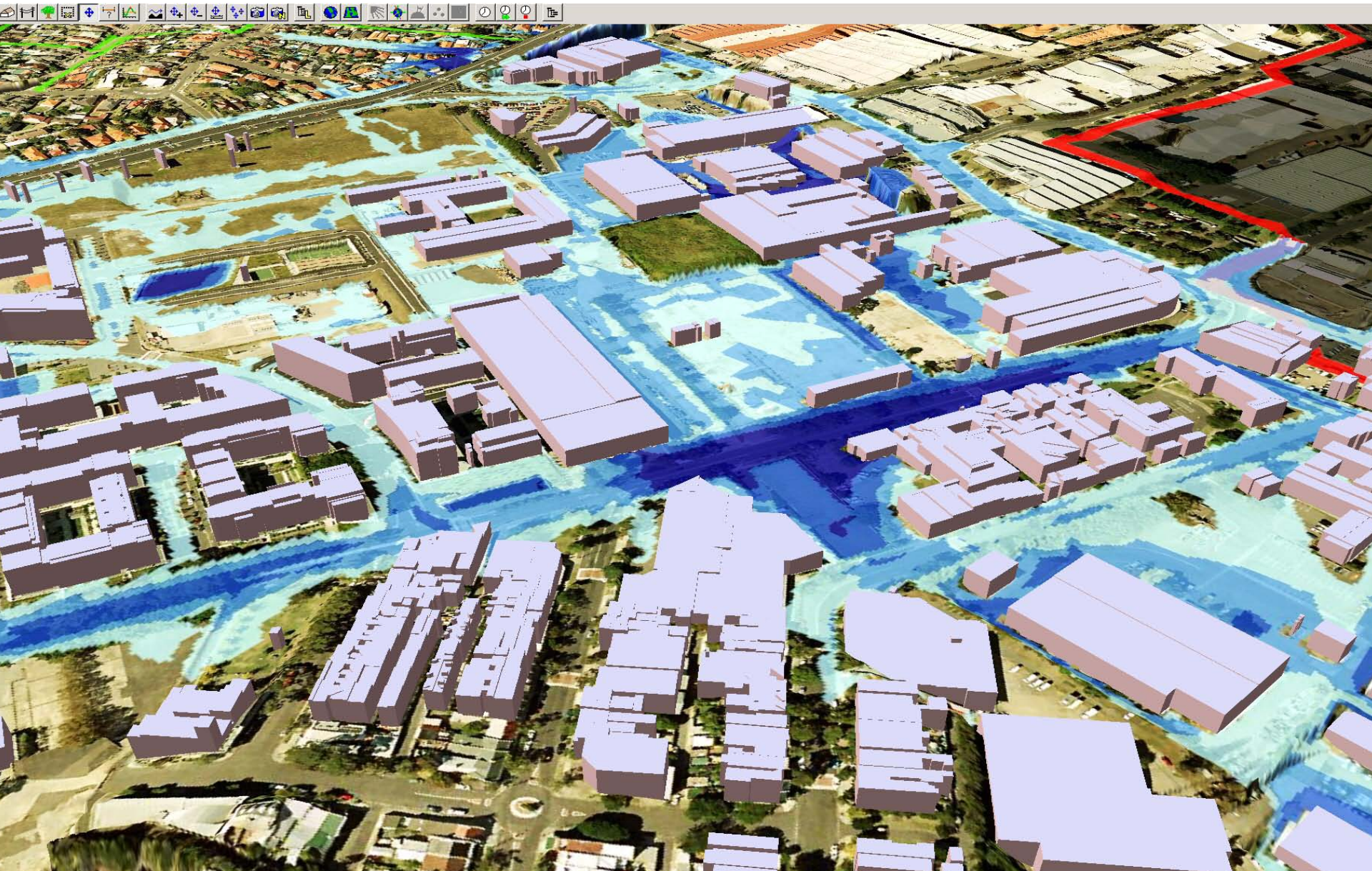
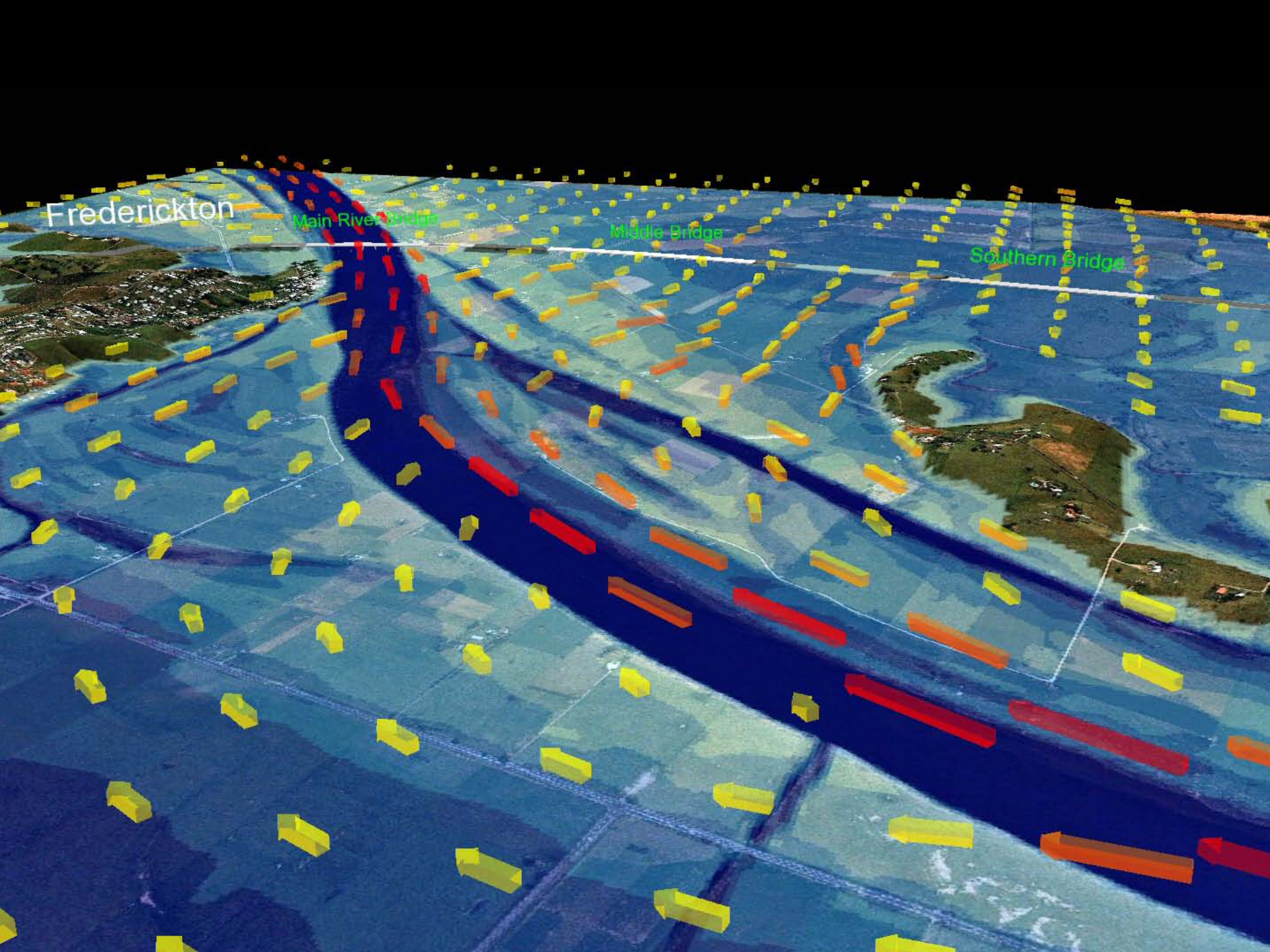



Fredericton
Main River Bridge
Middle Bridge
Southern Bridge


Fredericton
Main River Bridge
Middle Bridge
Southern Bridge

Flood Problem

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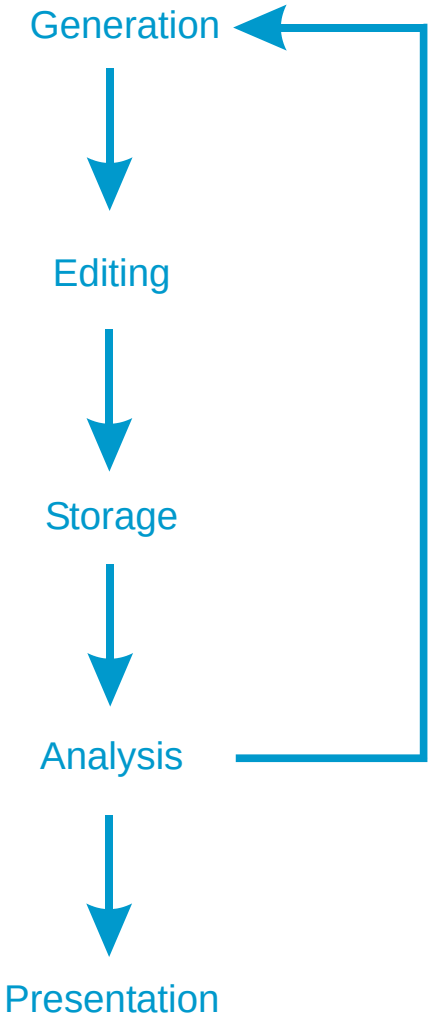
Problem is the estimation of a *statistical parameter* – the probability of a flood hydrograph characteristic.

Conceptually, this is a *data-mining* exercise – essentially the *hydroinformatic problem* of data analysis.

Hydroinformatics

Abbott describes hydroinformatics as the "storage, analysis and use of information about the aquatic environment in a computerised format".

Ball (2000) used the concept of the information cycle (see opposite) to describe hydroinformatic systems.



Data Analysis

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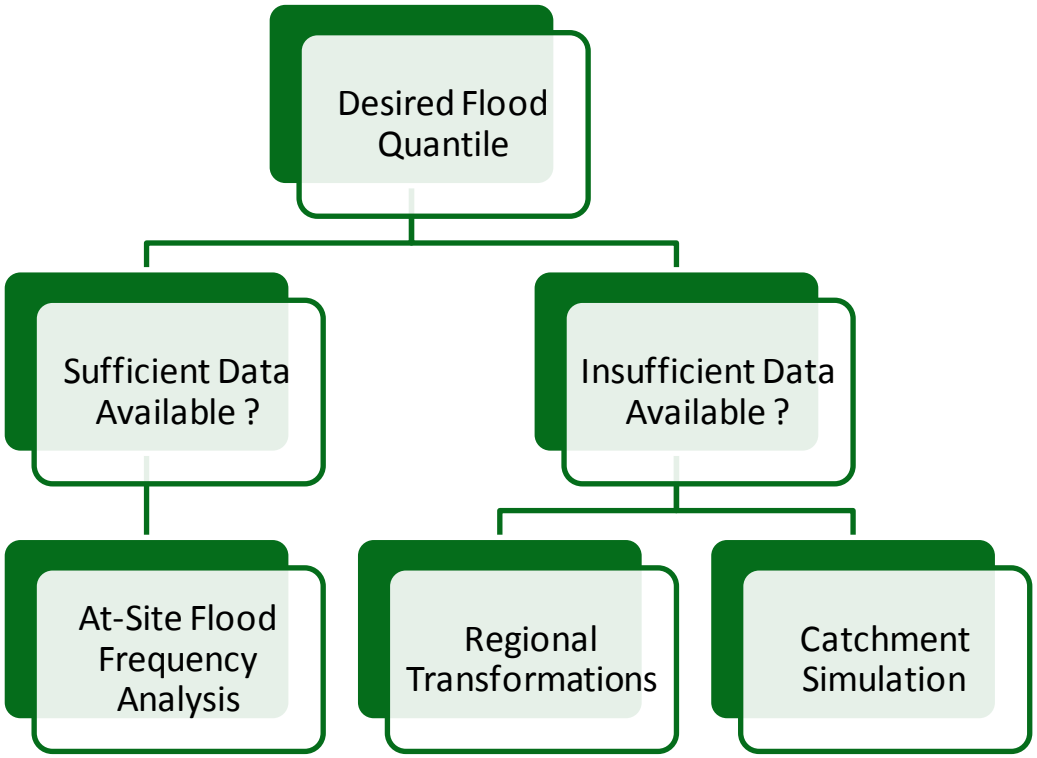
Three alternatives

1. At-Site Flood Frequency Analysis
2. Regional Transformations
3. Catchment Simulation



Data Analysis

Sourcing and managing suitable data is an issue.

Data sources are

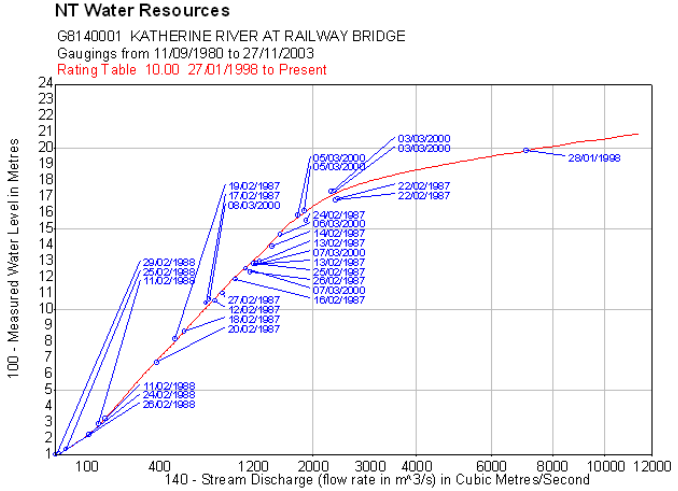
- Catchment monitoring
  - Accuracy
  - Representative
  - Homogeneity / Stationarity
- Catchment modelling
  - Accuracy
  - Predictive robustness
- Regional transformations

Recorded Data

Standard field station measures flood level.

A rating curve is used to translate the level to discharge.

Reliability of flows is dependent on rating curve.

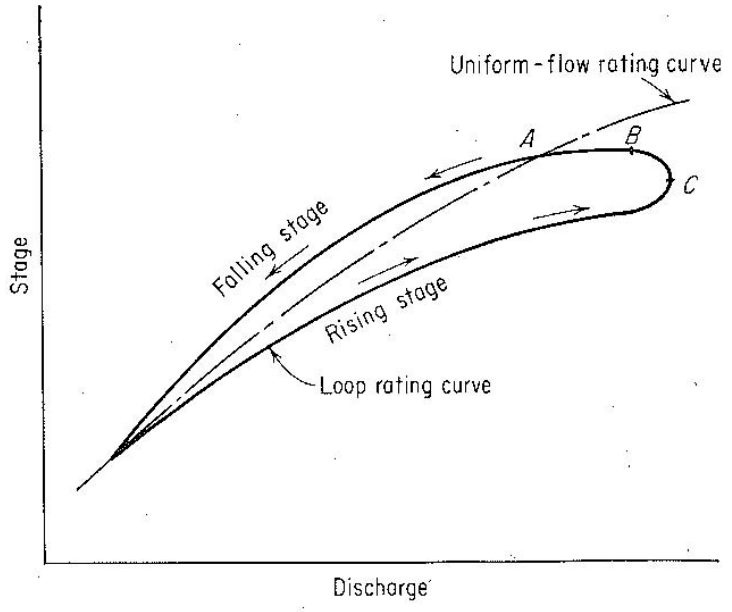


Rating Curves

Typical rating curve shown opposite.

Issues include

- Timing of gauging – used to generate rating curve.
- Levels above highest gauging – extrapolation problem.



Rating Curves

Rating Curves

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Magnitude of extrapolation can be assessed by looking at rating ratio -

$$Rating\ Ratio = \frac{Flow}{Highest\ Gauge\ Flow}$$

Rating Curves

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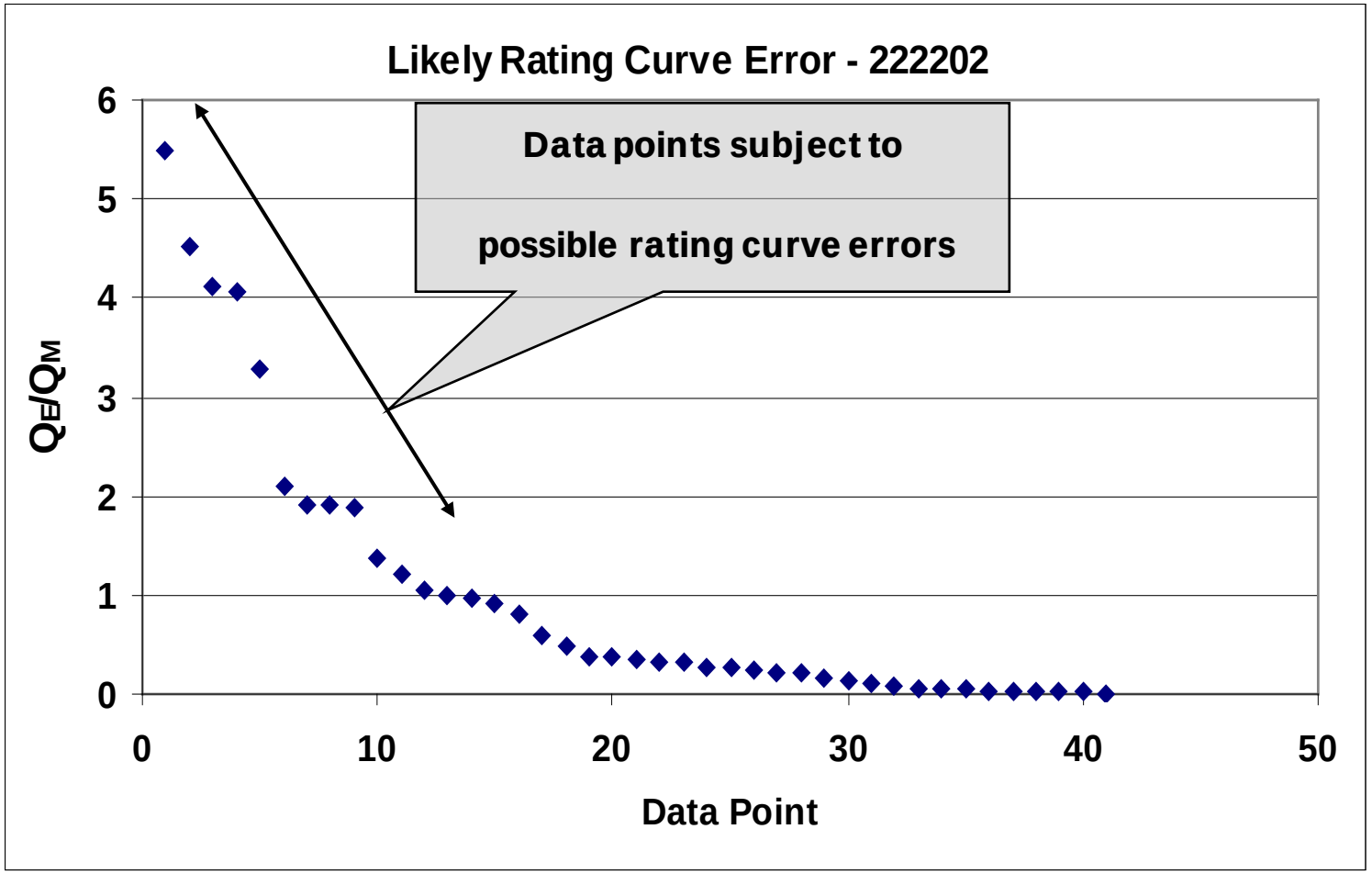

Rating Curves

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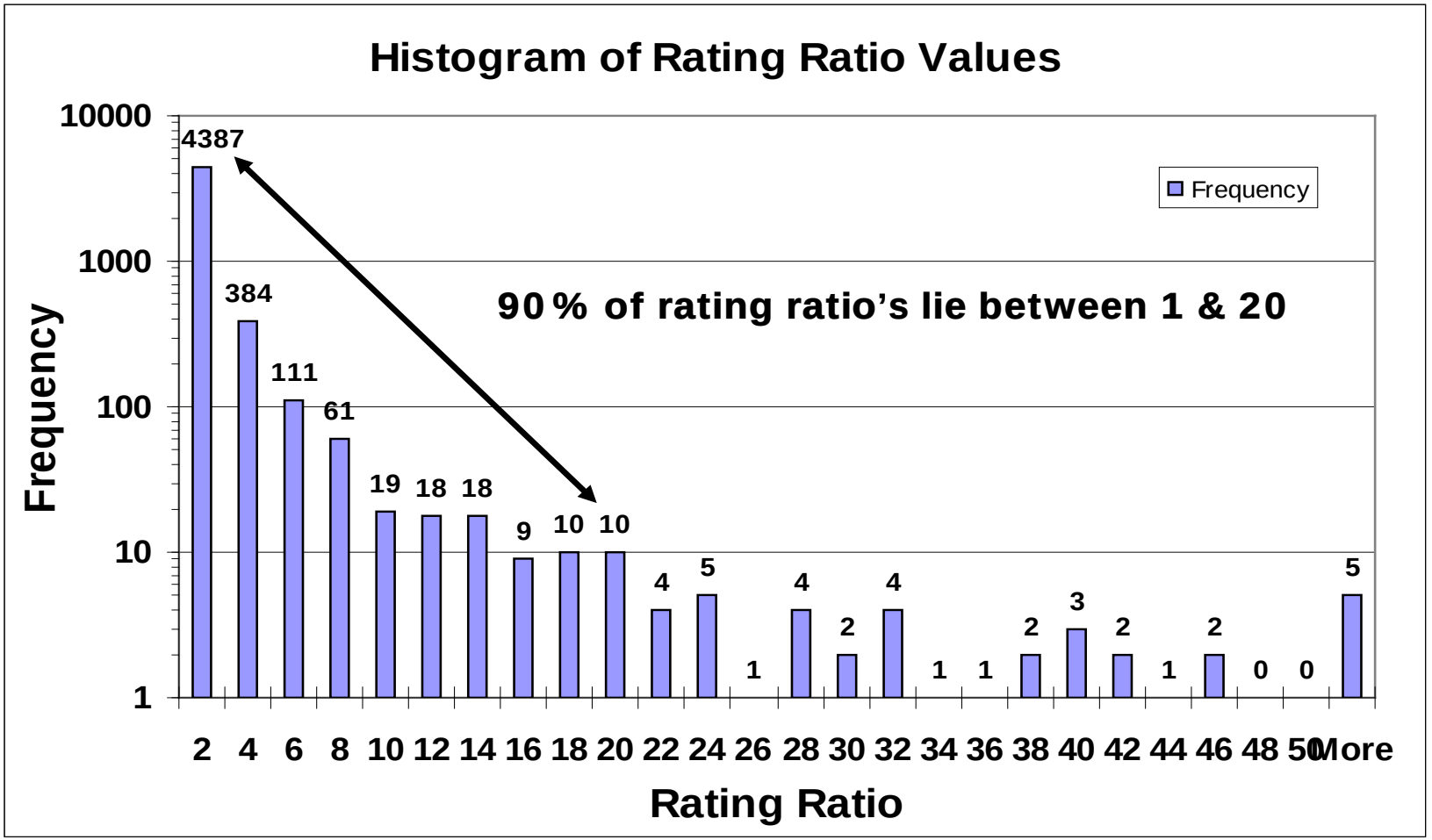
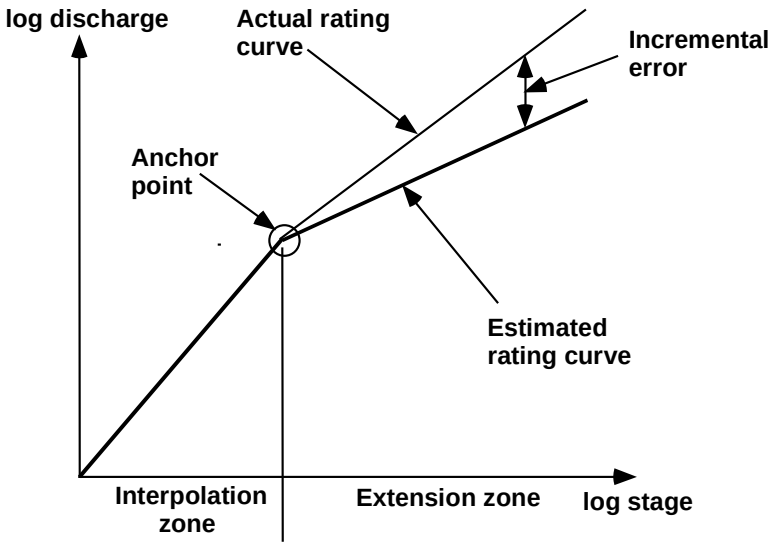


Rating Curves

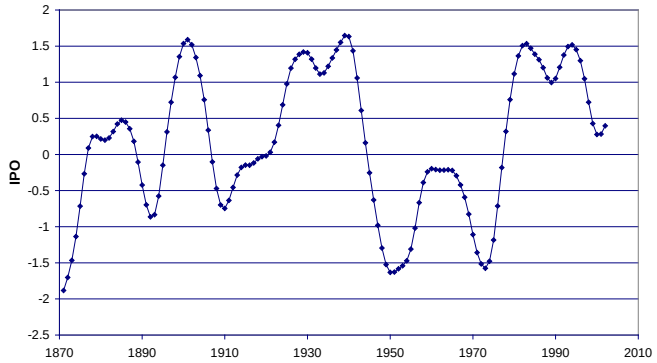
Kuczera (1999) presented a technique for including rating curve error in FFA.

This technique is based on

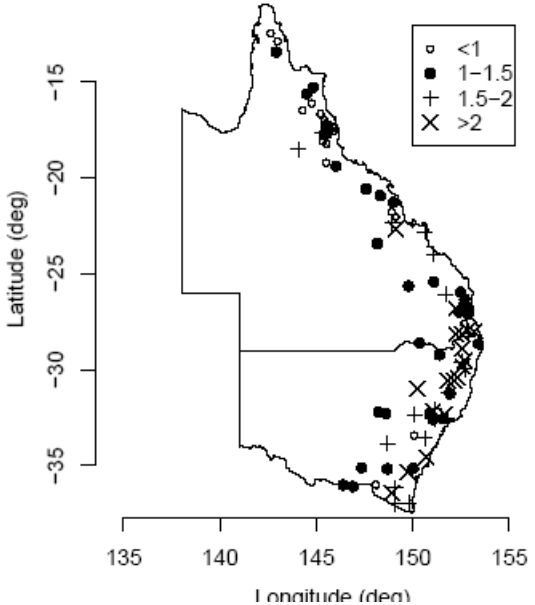
- Bayesian fitting of the statistical model to the available data; and
- Error below rating point insignificant.

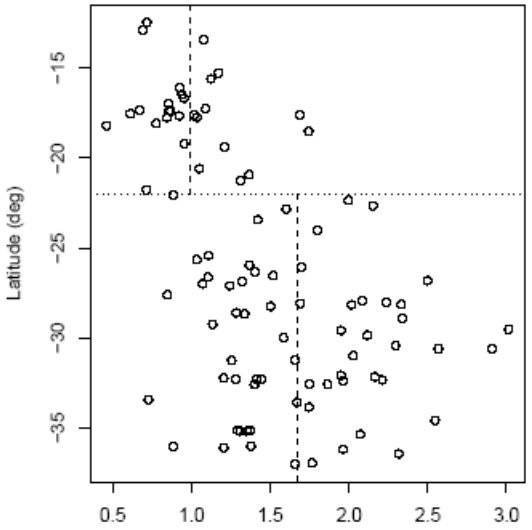


Data Homogeneity



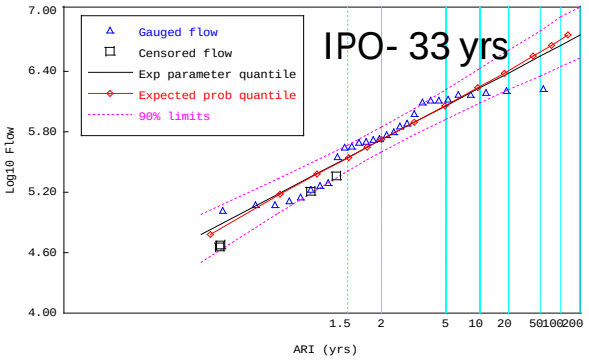
Flood risk appears to vary with Inter Pacific Oscillation (IPO)

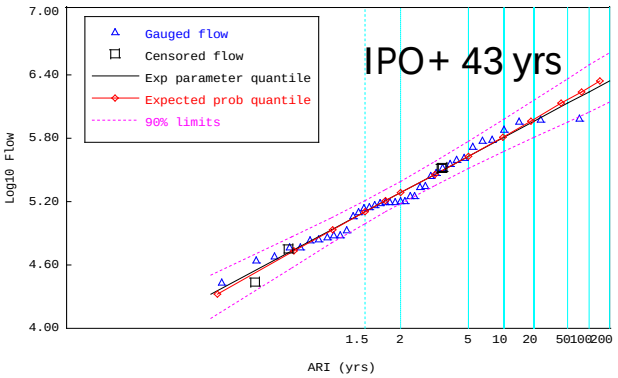


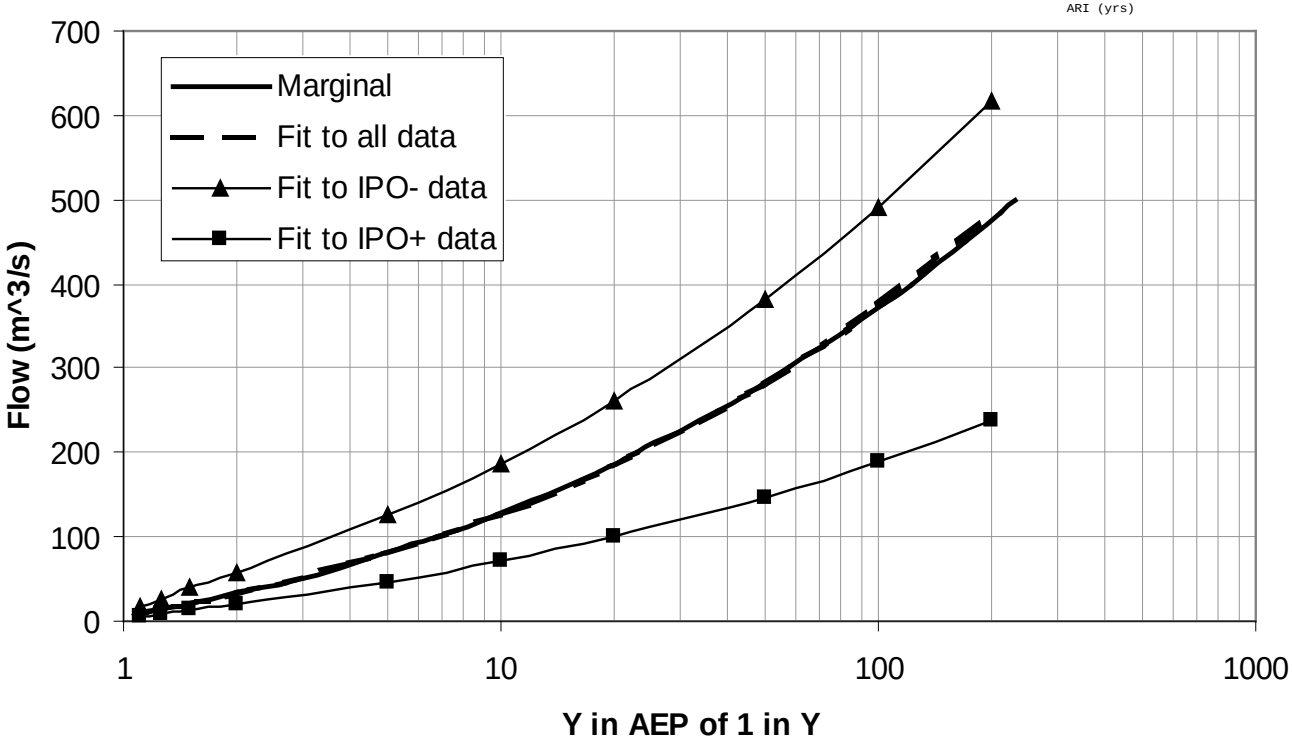


Ratio of 10-year IPO- and IPO+ quantiles (Micevski et al., 2005)

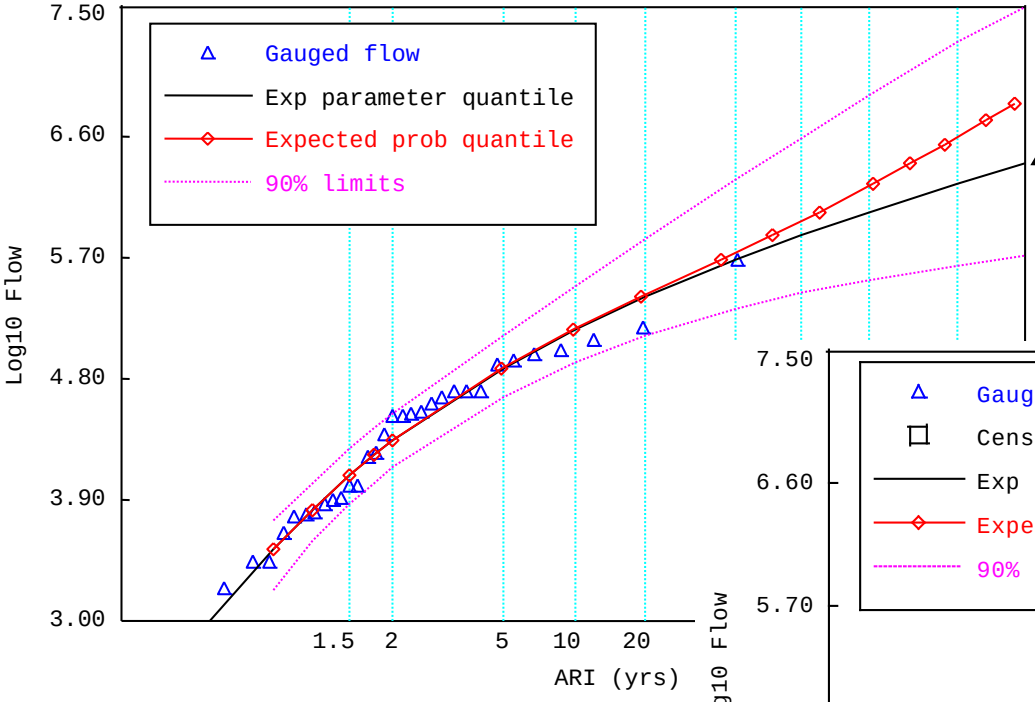
Data Homogeneity



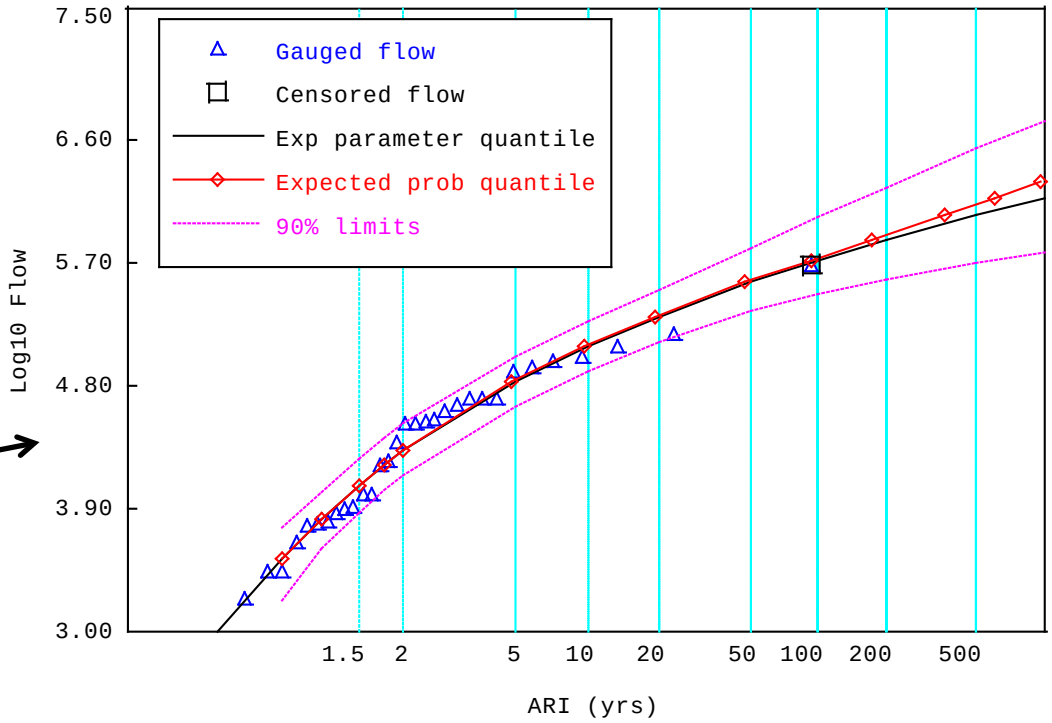




At-Site Flood Frequency Analysis



FFA – gauged data



FFA – Gauged data + historical data

Regional Transformations

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Characteristics

- Regression relationship
- Based on recorded data
  - Assumes catchment stationarity
  - Assumes data reliable
- Typical usage requires extrapolation outside bounds of available used for regression

Catchment Modelling

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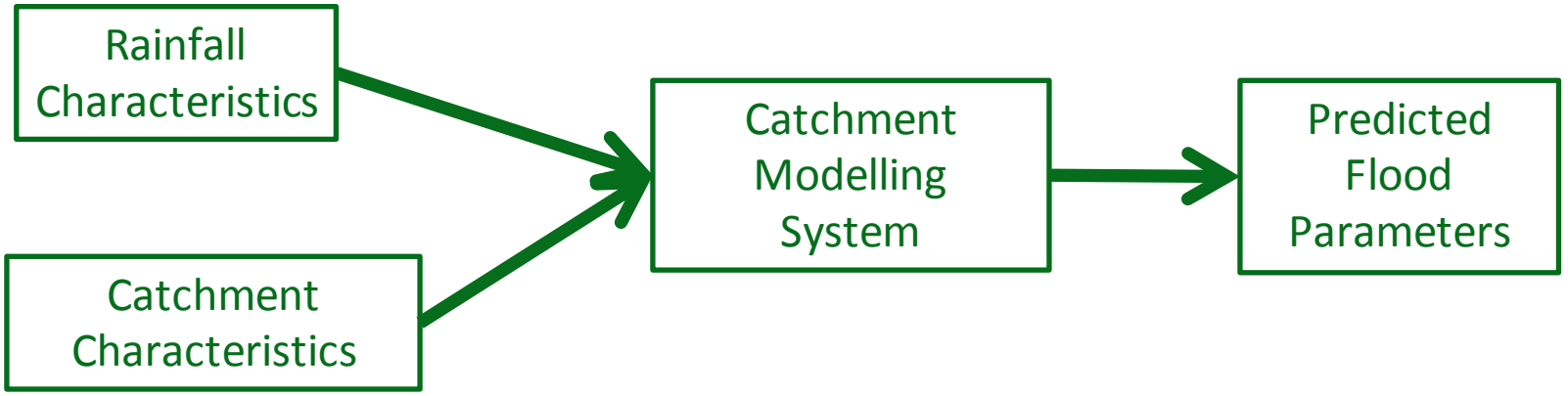
Common approach to data generation is through catchment modelling.



Data is being generated for frequency analysis – not for prediction of flood quantile.

Catchment Modelling

Need flow estimates and associated probabilities

- Issues

Uncertainty in prediction.

Absence of data – PUB problem

Extrapolation.

- Scope

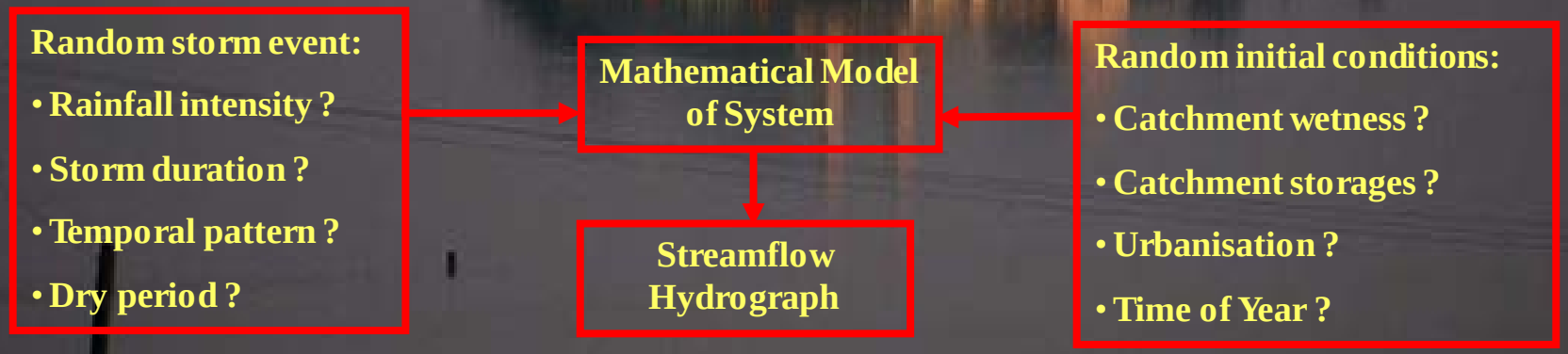
Range of frequencies.

Range of catchment scale.

Points and network systems.

Changing catchments.

- Estimation Methodology



ARR Flood Estimation

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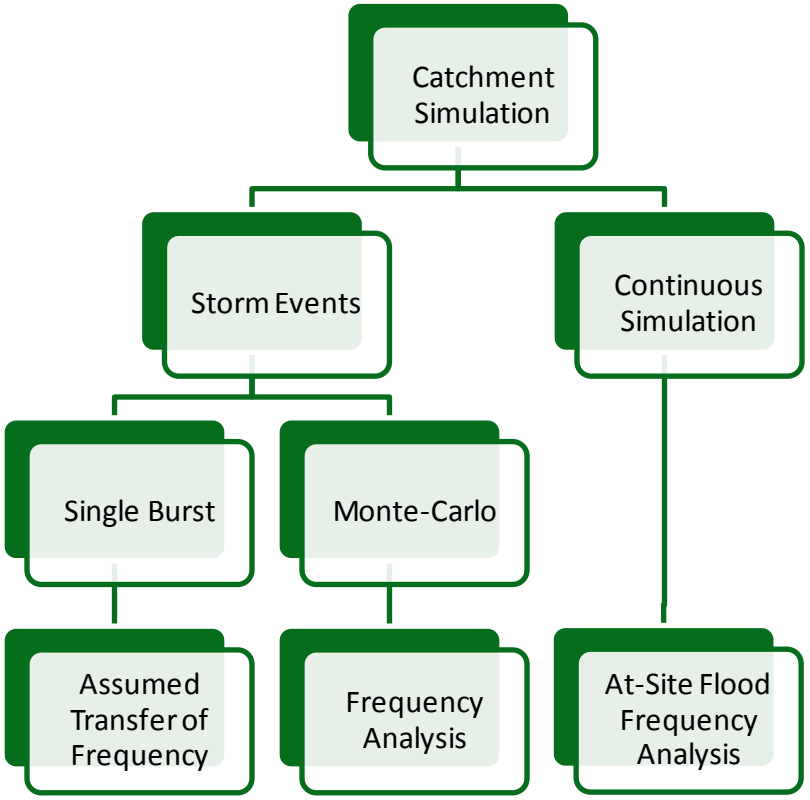
Modelling approaches may be:

1. Single burst;
2. Monte-Carlo; and
3. Continuous simulation.



Flood Simulation Approaches

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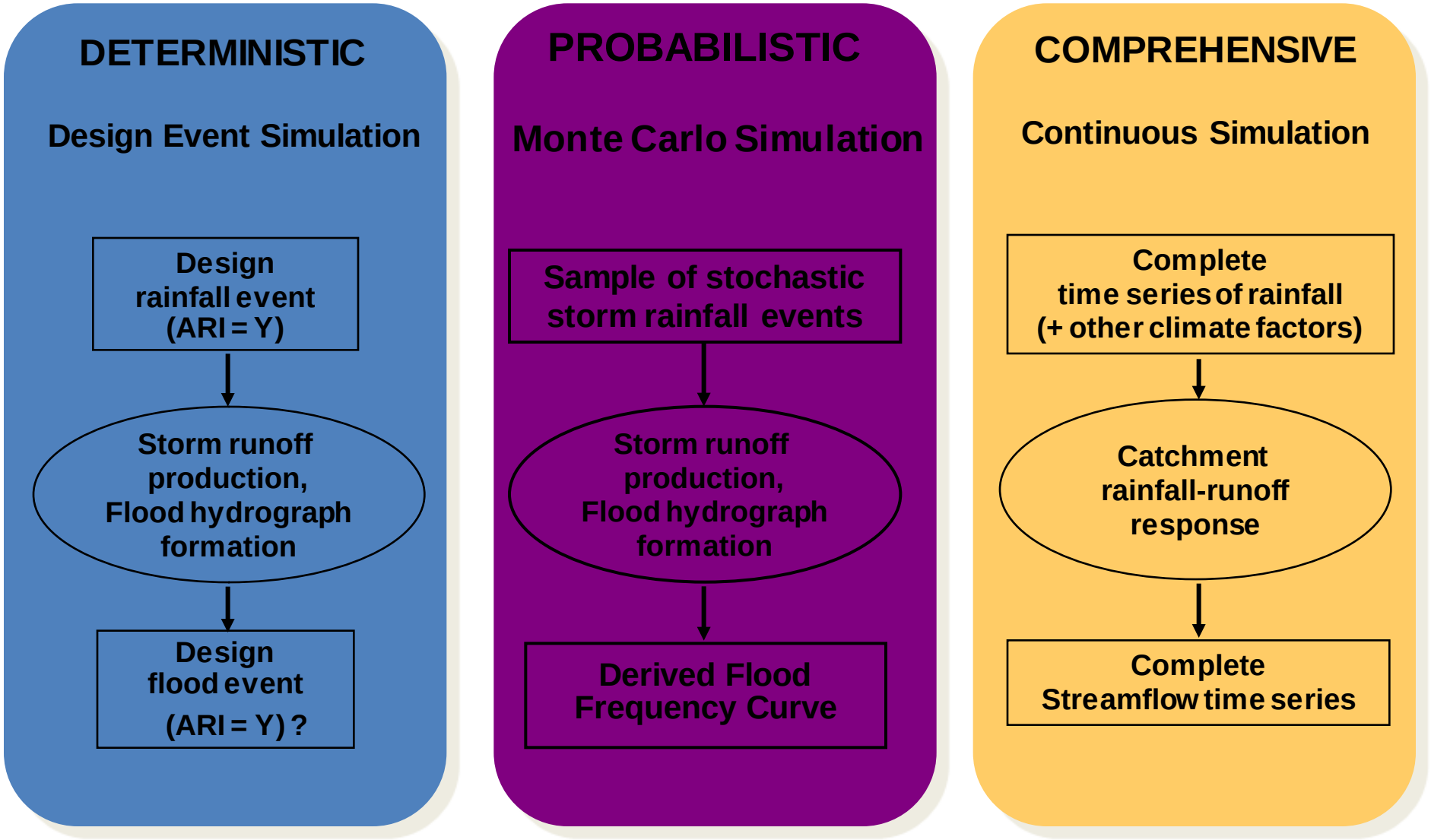

Event Simulation

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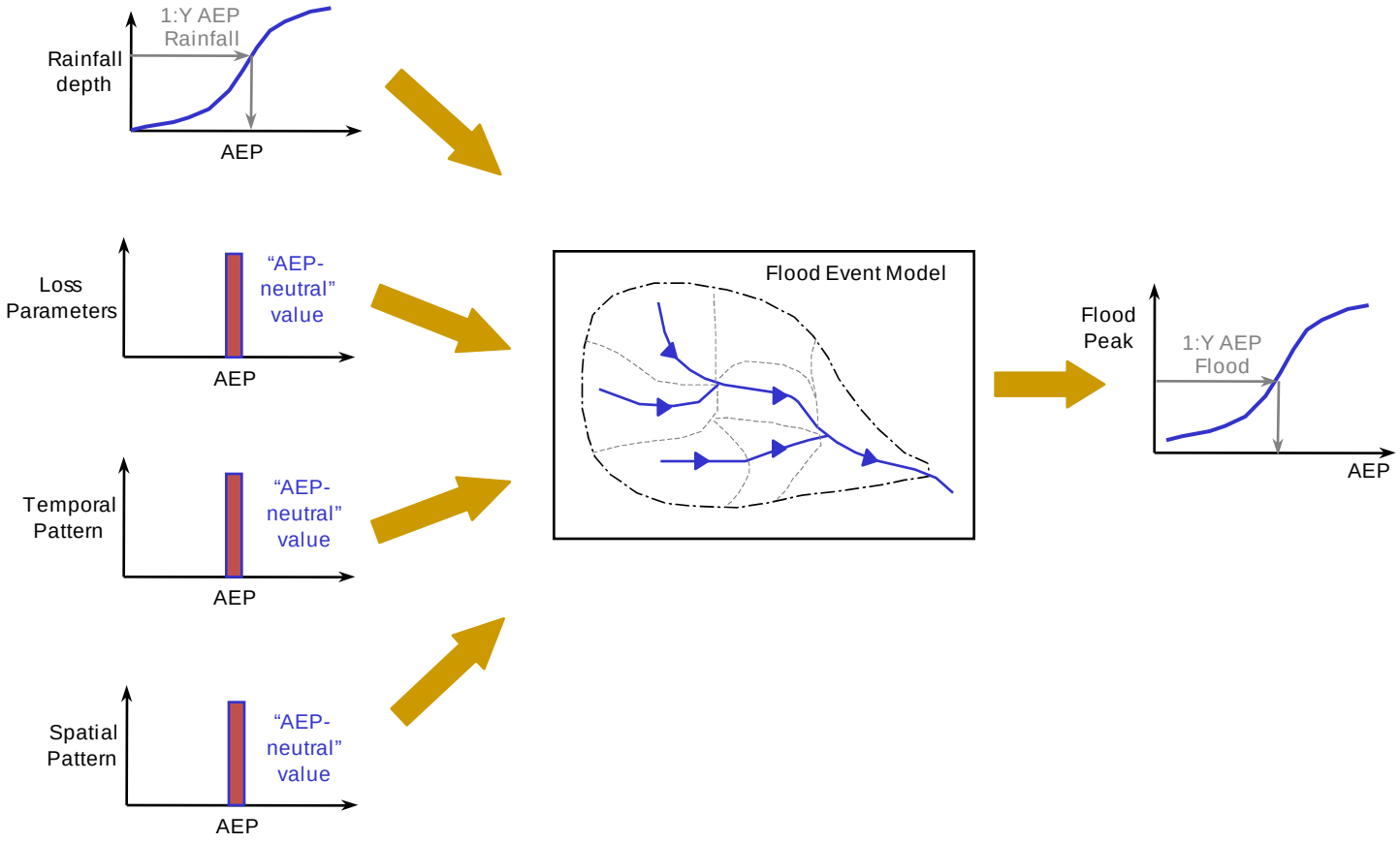
Traditional approach.

Issues include

- Volume of runoff, particularly when most intense burst used, i.e. existing ARR temporal patterns.
- Storm variability and movement.
- Need for AEP Neutral parameters

Design Event Approach



Monte-Carlo Approach

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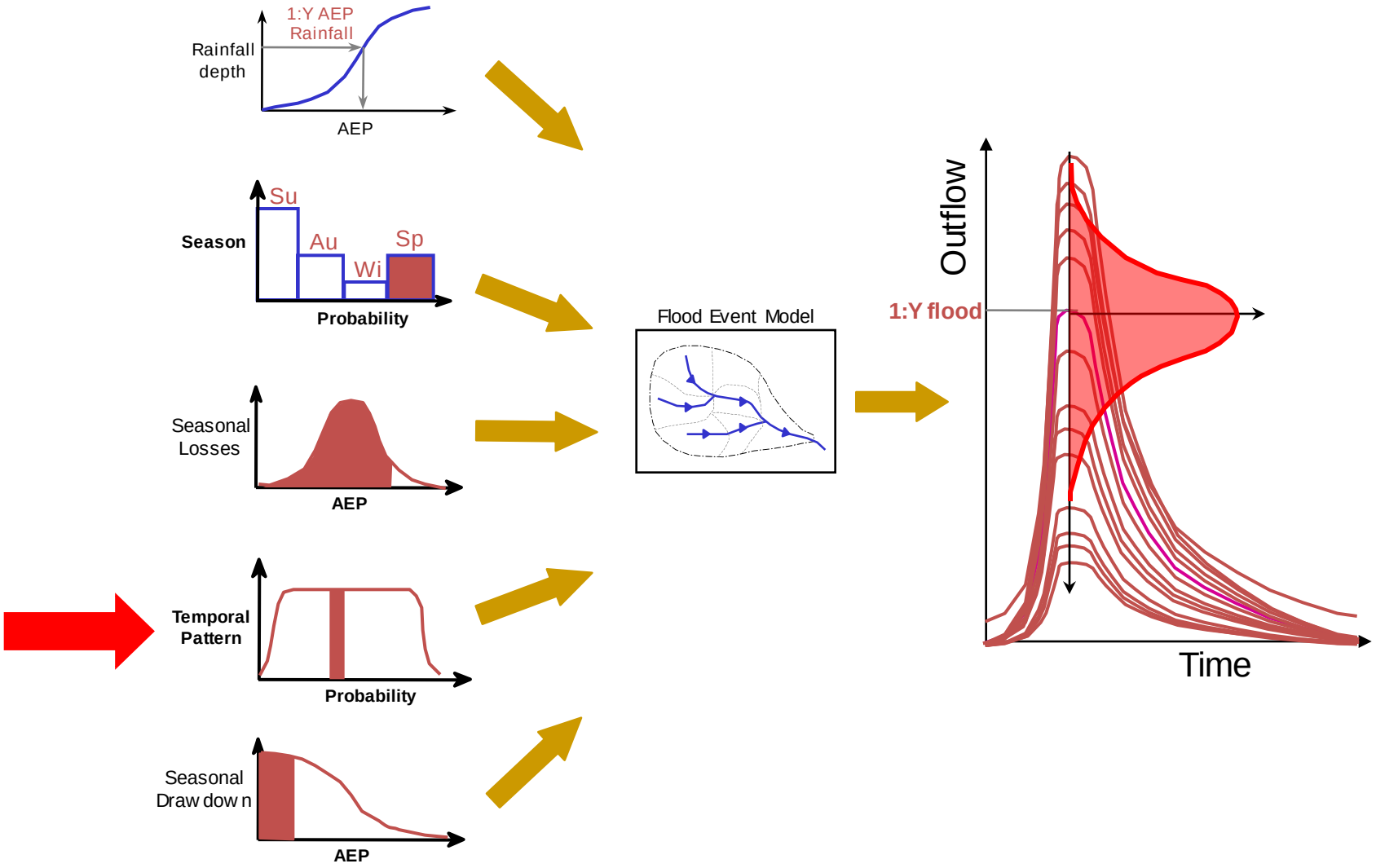
Based on development of event modelling.

Needs information about variability of input parameters.

Produces distribution of likely flood events and hence uncertainty in prediction.

Monte-Carlo Approach



Continuous Models

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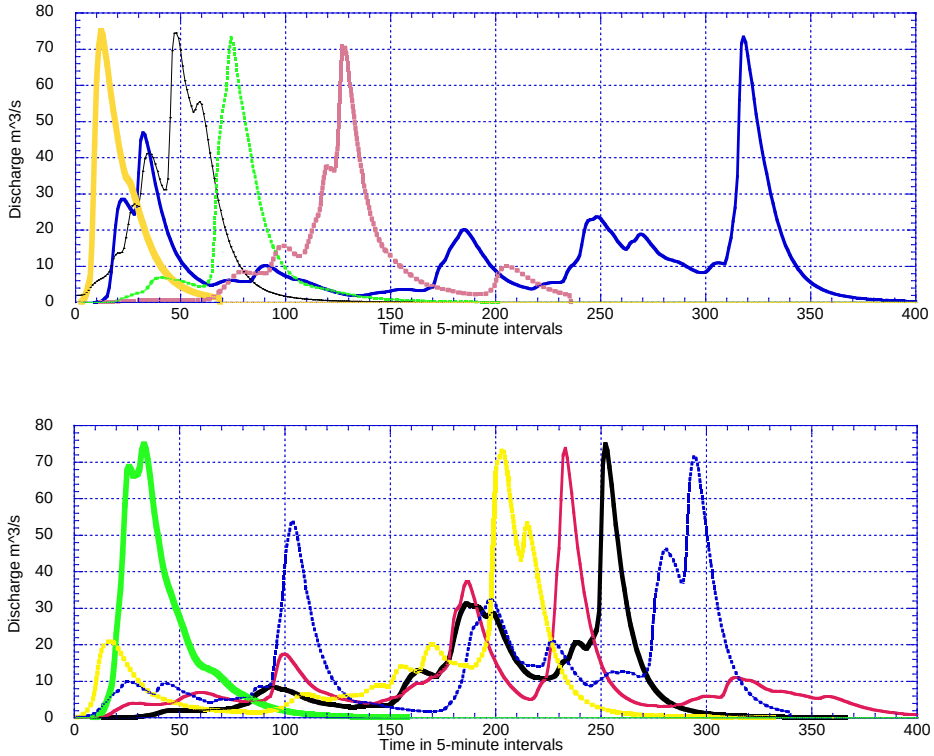
Basic idea is the reproduction of flow variability in the system.

To achieve this requires consideration of parameter or information variability.

Also removes the need to assume concurrence between rainfall and flow frequencies.

Continuous Models



- 2 year ARI events extracted from 100 years of simulated flows
- Differences in shape (one, two and three-peaked hydrographs, duration and volume (ranging from 41 to 223 mm)

Parameter Estimation

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Prediction errors arise from

- Process errors;
- Structural errors in the system;
- Data errors in the information used for modelling;
- Parameter errors - input information to the modelling system; and
- Data errors in the recorded data.

Parameter Estimation

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Calibration is concerned with parameter errors while acknowledging other errors.

Identification of parameter values is a hydroinformatic exercise – data mining.

Parameter Estimation

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Desire is generic values for these parameters – values applicable to more than a single event and suitable for extrapolation.

Recognised now that there are numerous sets of parameter values capable of similar performance.

Hence, a pdf of possible parameter values can be developed.

Parameter Estimation

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Over-fitting parameter values is a common problem.

Can be avoided by monitoring of the calibration.

Will not result in best simulation for a single event but best simulation for numerous events.

Parameter Estimation

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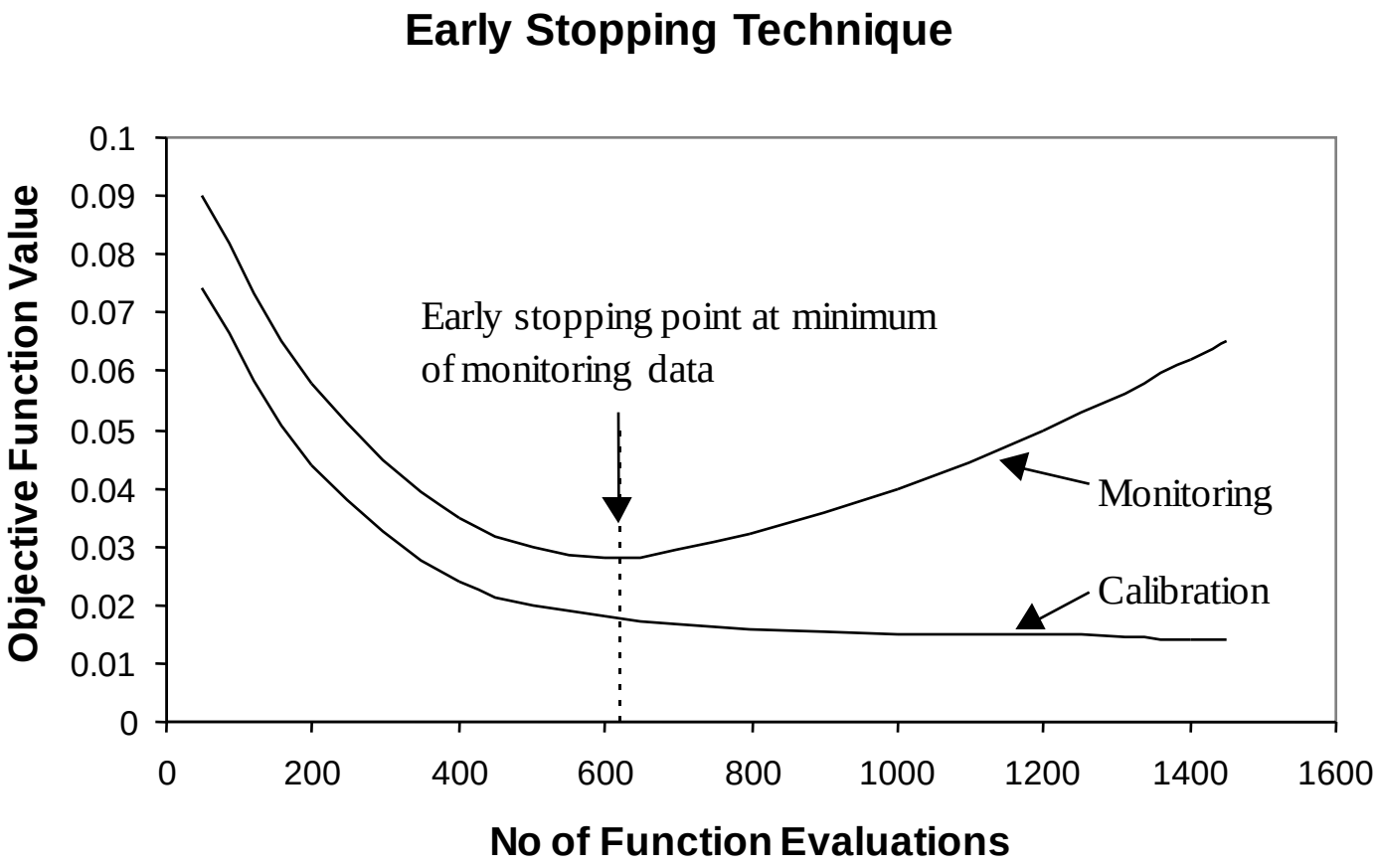

Parameter Estimation

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Approach applied to a catchment in Sydney, Australia.

Alternative models were considered – differing complexity.

Results were

- 81% Early Stop Point
- 6% Start Point
- 13% End Point

Parameter Estimation

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A further complication is the arbitrary subdivision of parameters into measured and inferred parameters.

Usually, only values of inferred are sought – values of measured parameters are assumed correct.

Parameter Estimation

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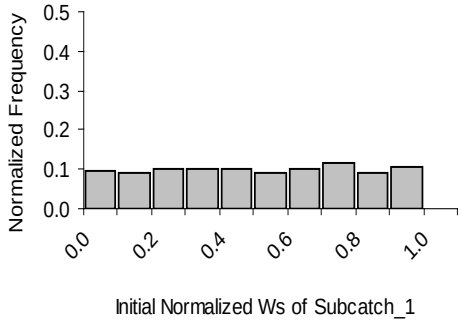
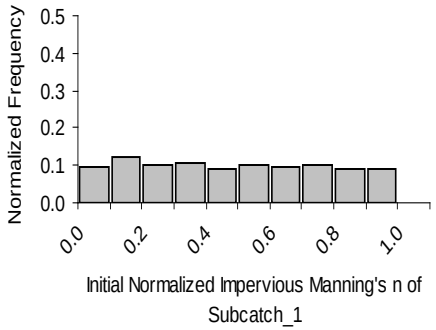
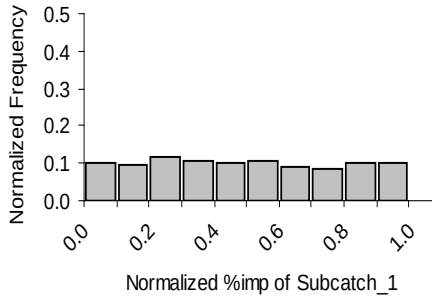
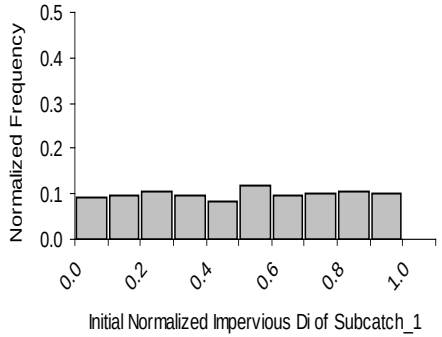
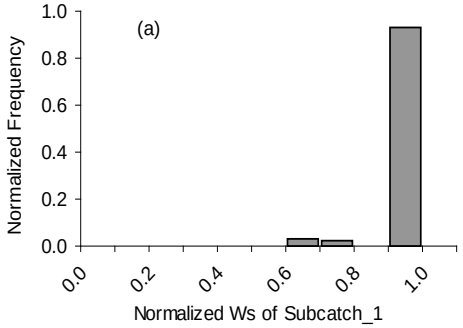
Parameter Estimation

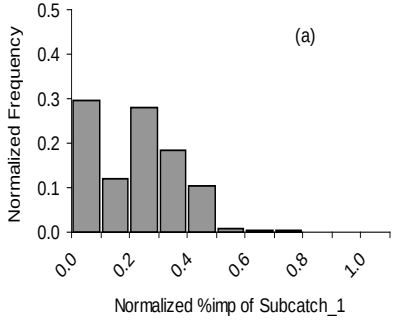


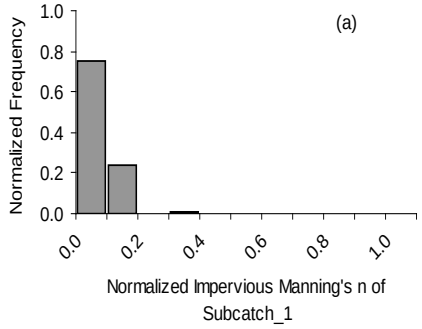


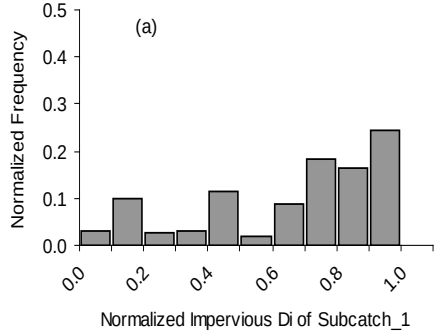












Conclusions

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- Design Flood Estimation is a problem in predicting a statistical parameter.
- This is a hydroinformatic problem – essentially a data-mining exercise.
- This hydroinformatic problem exists at multi-levels.


Thank you