

# **Saving Water with Statistics**

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# Outline

- Background
- Model Structure
- Data and model fitting
- Applications
  - Quantification
  - Prediction
  - Risk analysis



# Background

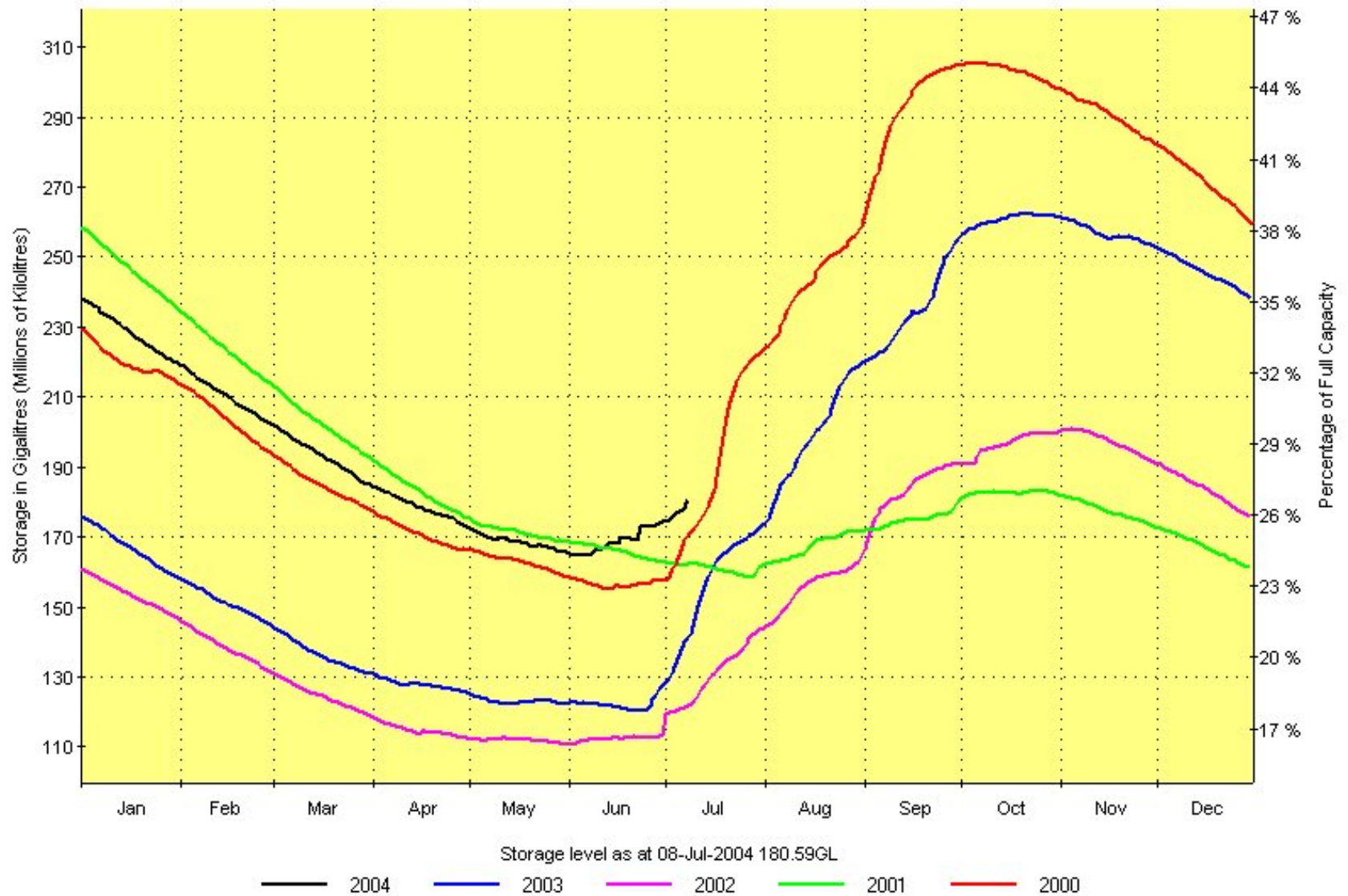
→ **By the end of 2001 Perth dam levels were extremely low**

- Low rainfall and runoff into the dams over winter
- High water consumption

→ **Water restrictions were introduced in September 2001**

- Perth sprinkler use was restricted to two days a week
- Households were only allowed to water their gardens on specified days

# Dam Storage



Source: Water Corporation, WA

[www.daa.com.au](http://www.daa.com.au)

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# Measuring the Effect

- **Water Corporation needed to measure the effect of water restrictions on usage**
- **Daily water consumption was modelled**
  - To quantify the “two day a week” effect
- **Basis of model**
  - Data Analysis Australia had successfully modelled water consumption in 2000 to measure the impact of advertising on water usage
  - The model was used to separate effects such as weather and time of year from the advertising effect
  - Now interested in the impact of restrictions

# Model Structure

→ Models daily consumption for Perth and Mandurah since 1980

→ Because weather has an effect felt on the day

→ A Gamma Distribution

→ Data is positive, skewed to the right

→ Multiplicative model

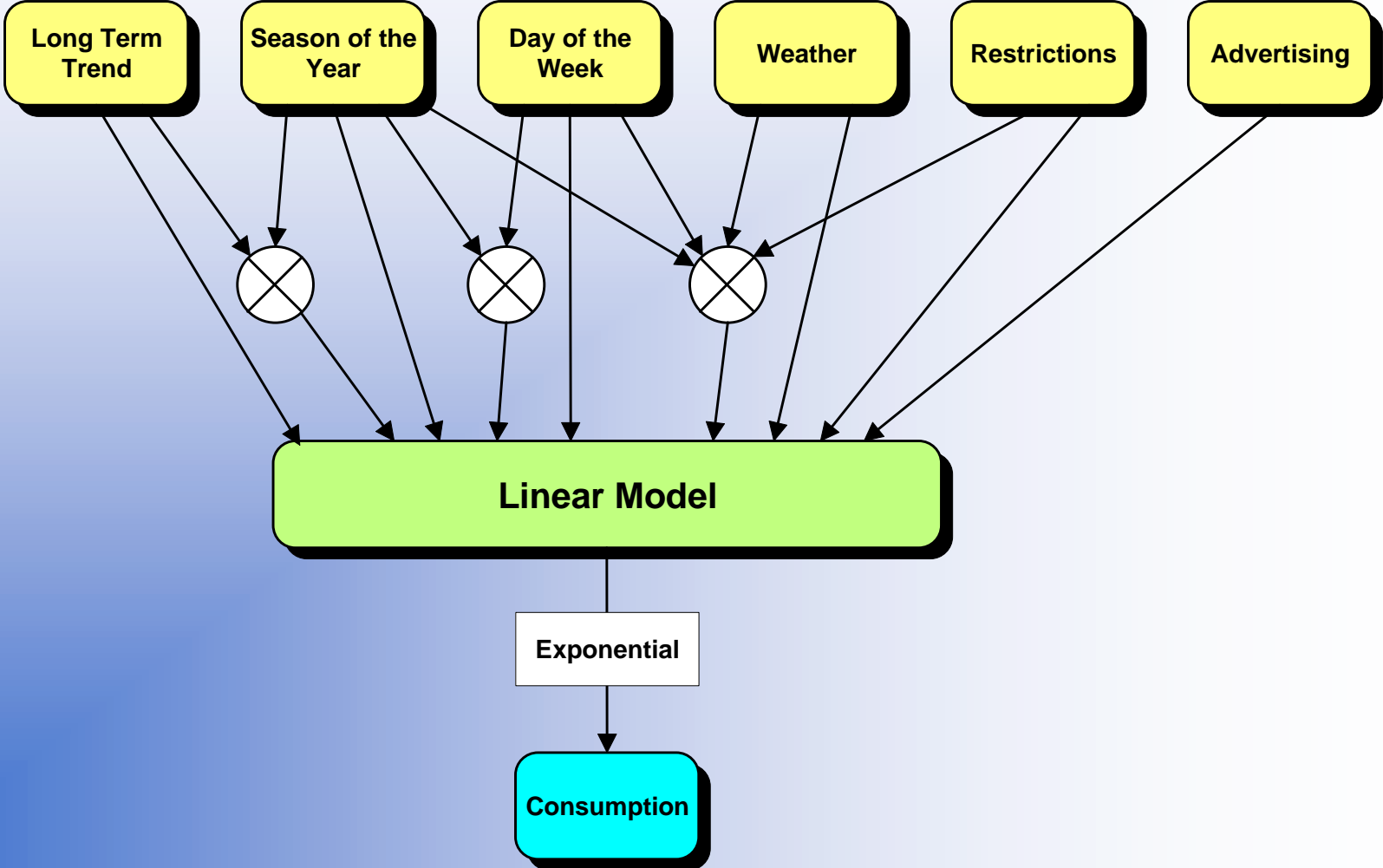
→ Effects are relative

→ Linear on a log scale

→ Fitted using a Generalised Linear Model

→ R statistical system

# Model Structure



# Model Parameters (1)

## → Trend over time

- Essentially linear
- Contains a lot of issues – growth of Perth, changing housing and gardens, economy etc

## → Annual cycle

- Fourier series representation – gives continuity with not too many parameters

## → Day of the week

- Also by Fourier series

## → Advertising, restrictions, free water allowances etc

- Need to know the precise timing

# Model Parameters (2)

## → Weather is complex

→ Maximum and minimum temperatures

- Includes carry over from previous days
- Borderline non-linear effect

→ Rainfall

- Also non-linear (square root)

## → And lots of interactions

→ For example, rain in winter has different effect from rain in summer

## → Giving over 100 parameters

→ But also lots of data available since it is daily data since 1980.

# Results

→ Advertising and restrictions after Sept 2001 could not be separated

→ Were introduced at the same time

→ Effect of “two day a week” sprinkler restrictions

→ Biggest effect is in summer and on extreme days

→ Examination of residuals

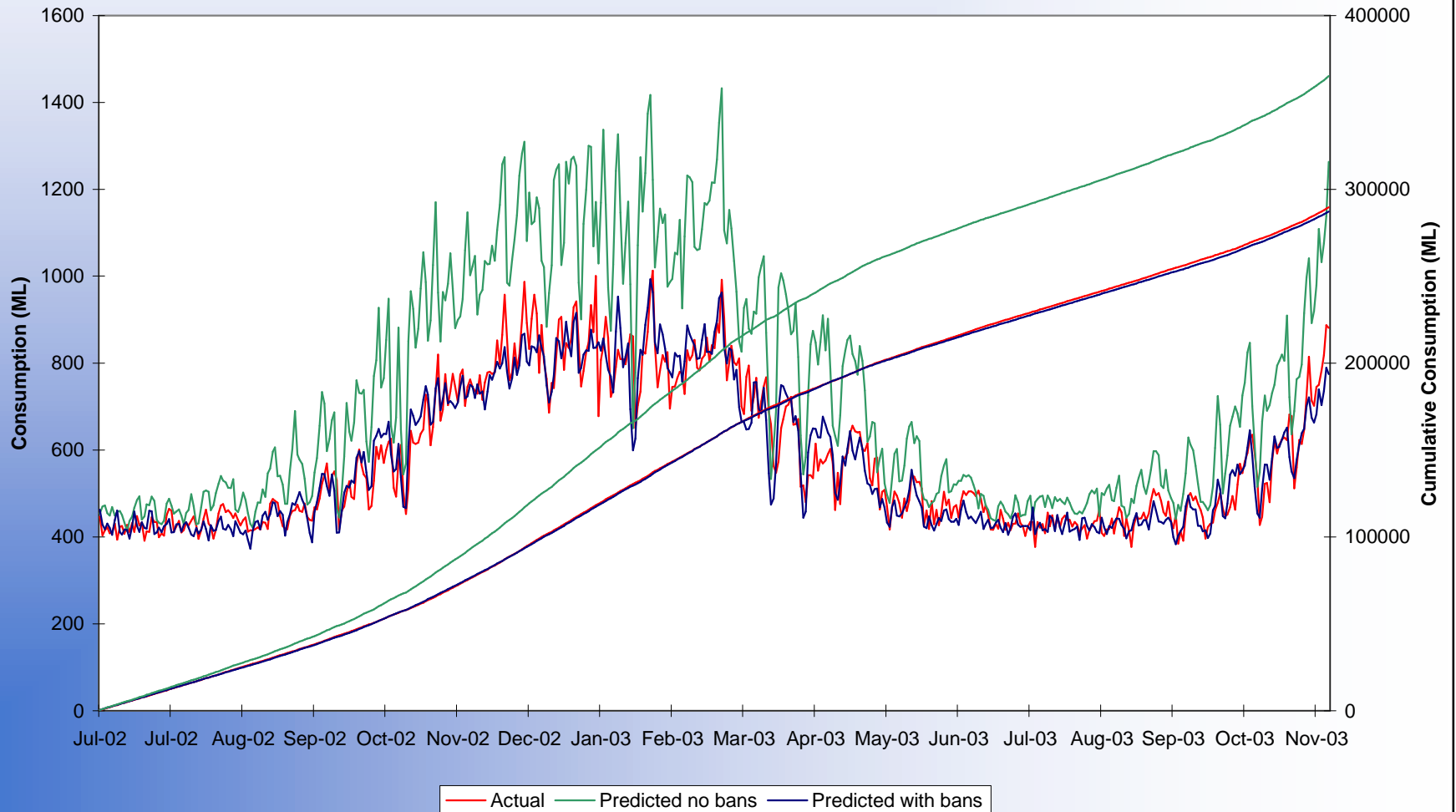
→ Differences between predicted and actual values

→ Residuals were high on extreme days

→ Added non-linear terms to the model (square root of rainfall)

# Quantifying Effect

Modelled Consumption with and without Restrictions and Advertising



# Forecasting and Risk Analysis

→ **Future demand depends on future weather**

- Future weather is naturally uncertain
- Forecast must represent this uncertainty



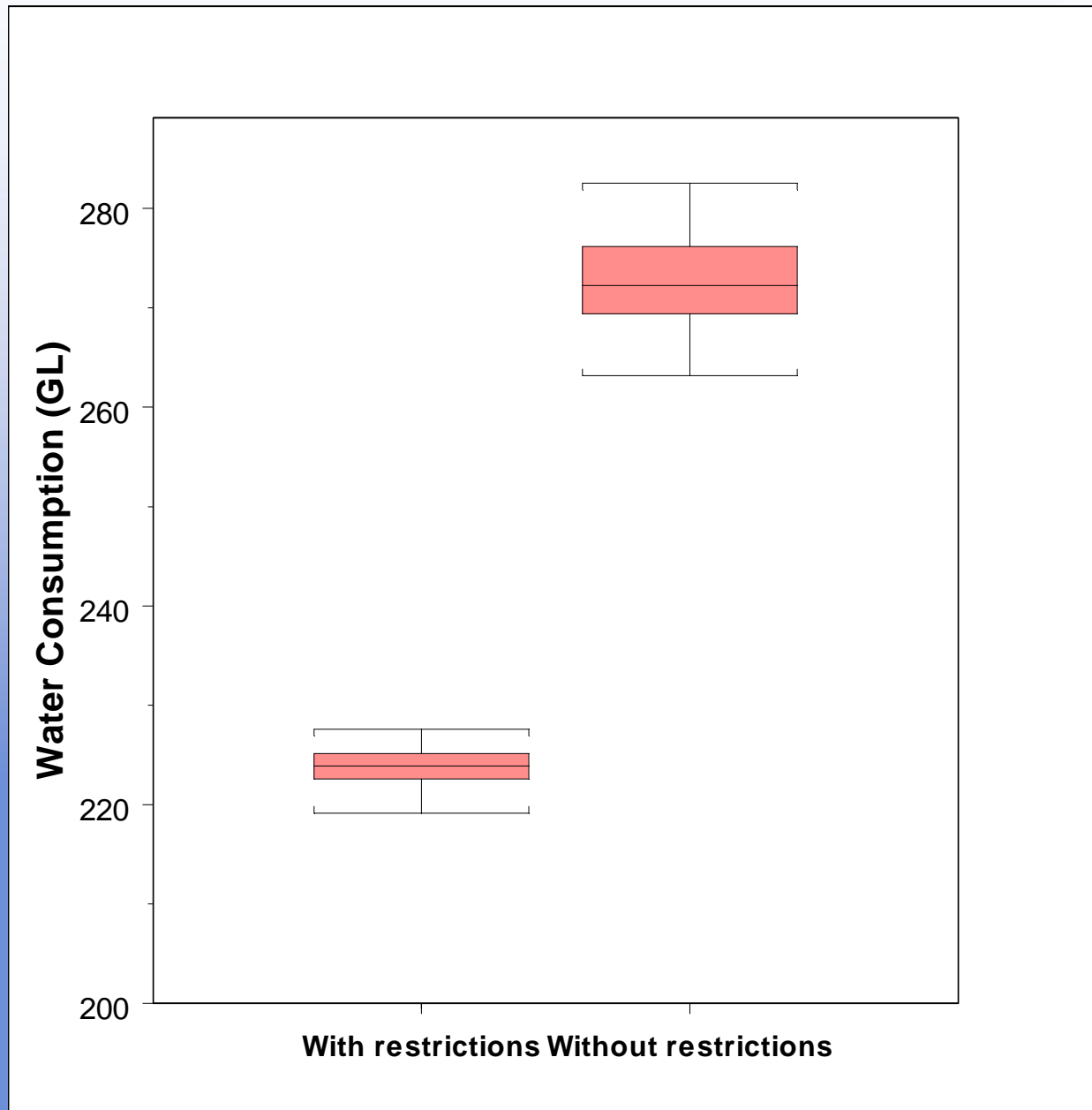
→ **Two choices**

- Model future weather patterns
- Use historical weather

→ **Use historical data (since 1944) to drive predictions**

- Risk analysis approach
- Distribution of outcomes at end of summer

# Water Saved due to Restrictions



# Conclusions

- Can estimate future consumption
- Can measure the effect of “two day a week” restrictions
  - Greater in summer and on extreme days
  - The restrictions lowered usage and reduced the error of the estimates
- Clearer decision making
  - Removing weather and other effects leaves the behavioural pattern
  - Decide whether consumer behaviour needs modification
  - How long should the restrictions be maintained? Is there a need for further restrictions?