WATER SUPPLY OPTIMISATION

Presented by

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- Acknowledgement

AMSI Optimise for sponsoring the talk

Support

WaterNSW

Prof George Kuczera

WaterNSW Who we are..

- Australia’s largest water supplier.
- Manage 41 large dams across NSW.
- Deliver water for agriculture and drinking water supply customers.
- Protect the health of drinking water catchments to supply high quality water.
- Formed by the merger of Sydney Catchment Authority and State Water Corporation in 2015

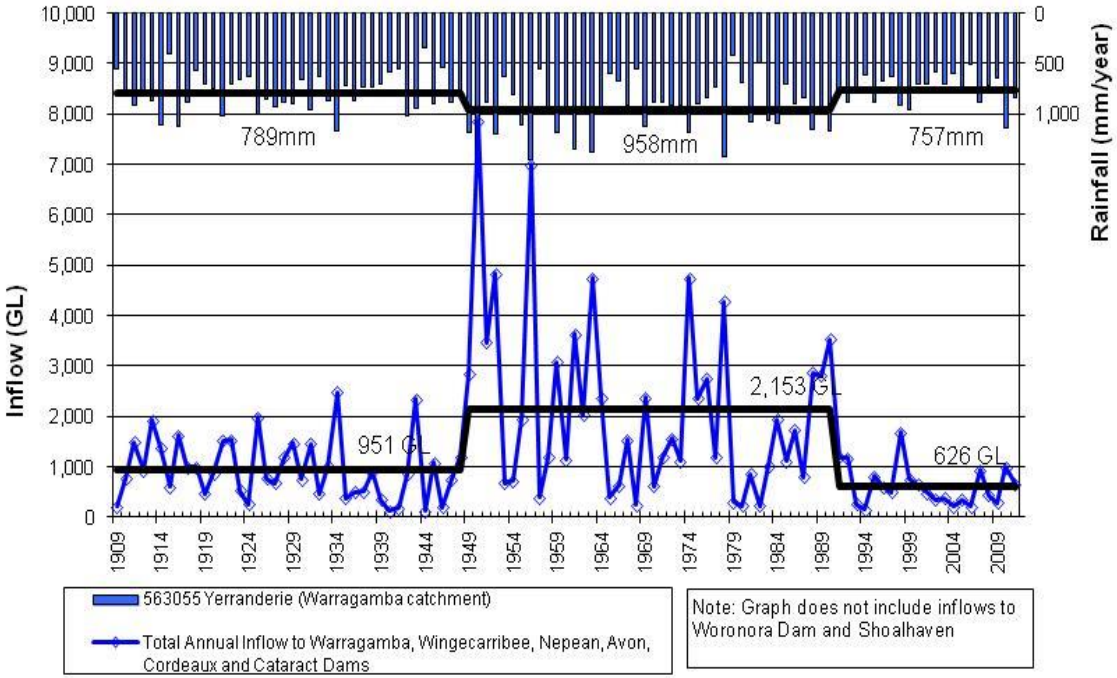
Presentation Outline

- Urban/Rural Water supply challenges
- Climate variability
- Water Supply Planning
- Supply System Optimisation
- Long term planning - Optimisation
- Optimisation challenge
- Optimisation future

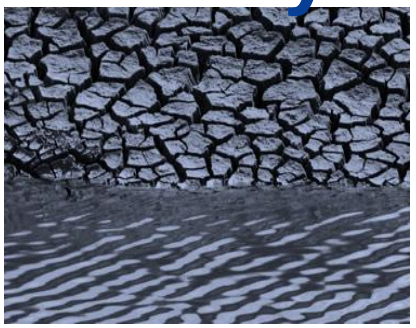
Urban/Rural water supply challenges

- Source availability - Surface water, groundwater, desalination, recycled water
- Delivery infrastructure - Dams, pipes, tunnels, canals
- Shared Resource with Nature - Highly regulated market, policy, environment as customer
- Water quality (Source Protection) - Catchment management, Multi-barrier approach
- Cost - Capital and operational
- Levels of Service – Reliability, Security, other subsidiary services

Challenges- Climate variability



Total Annual Catchment Inflow to Hawkesbury-Nepean Dams and Rainfall



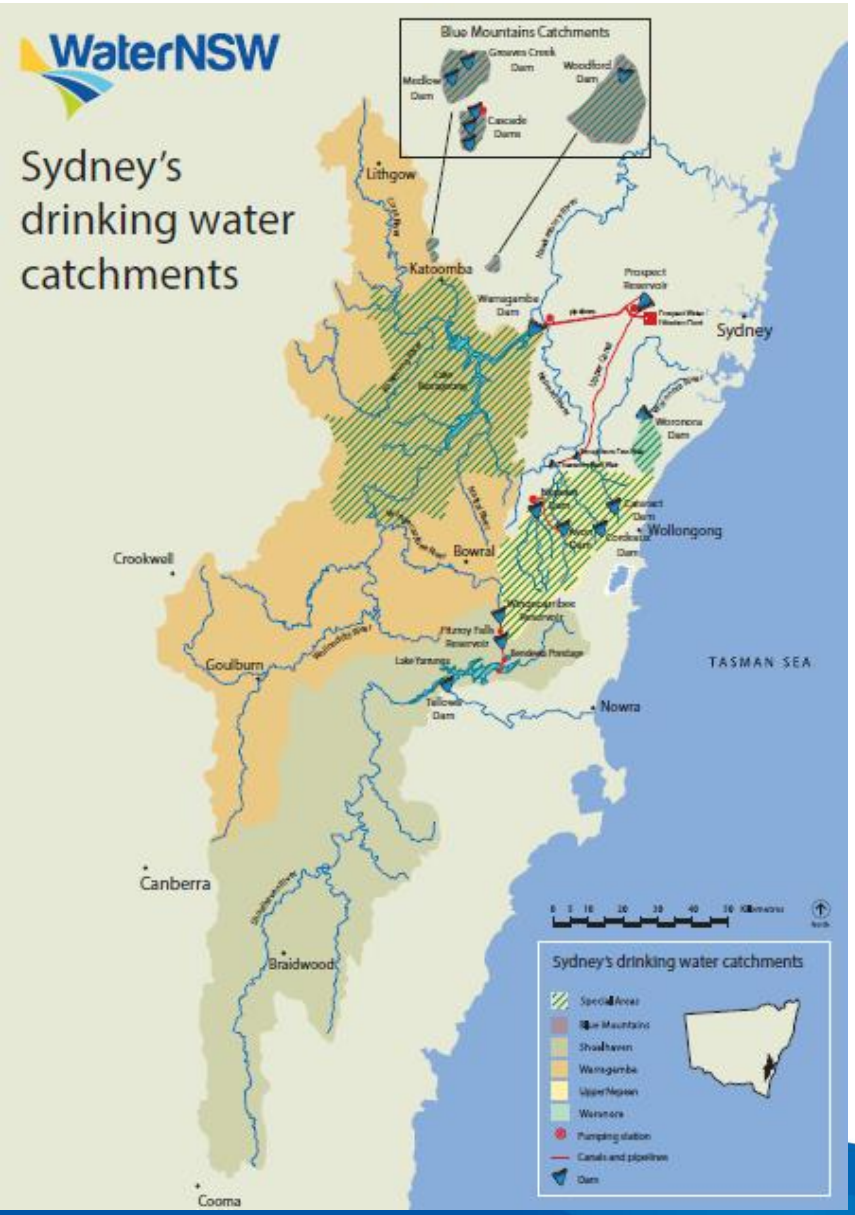
- Dry period' from 1909 to 1947 and from 1990 to now
- Wet period between 1948 and 1990
- Climate mechanisms not very well known!

Water Supply System Modelling

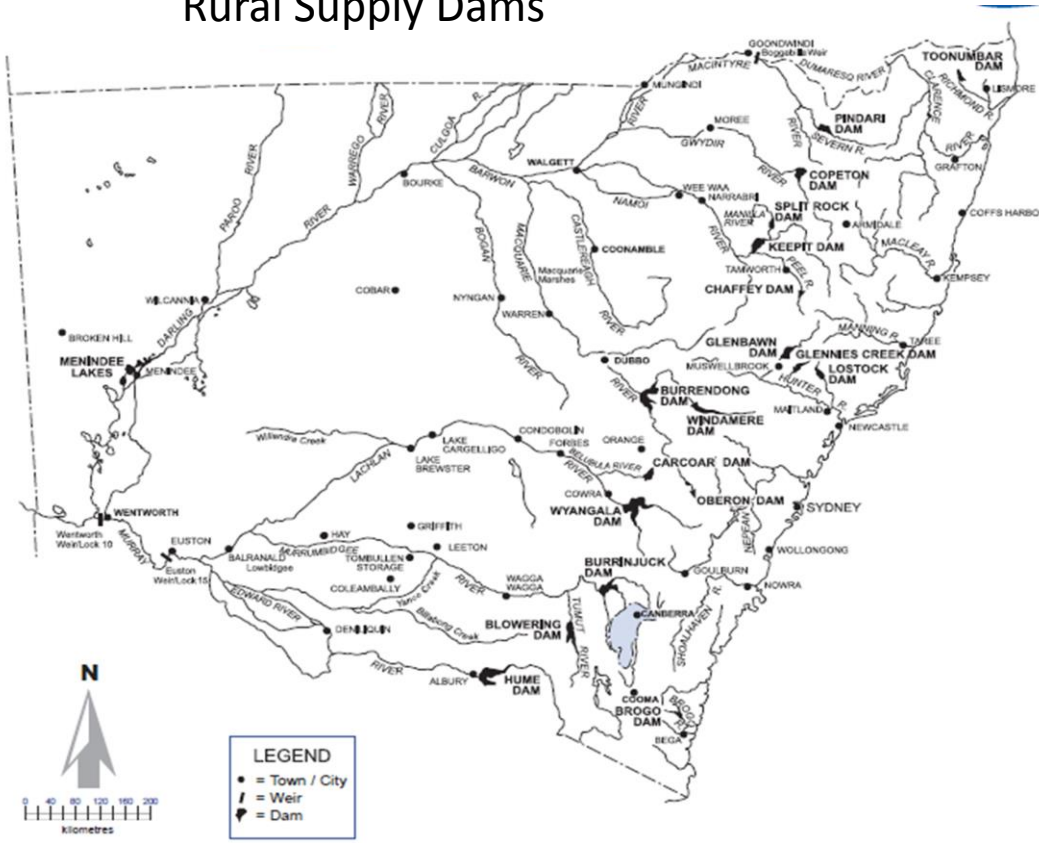
- Operational planning
  - Provide Source Selection rules
  - Depletion projections
  - Provide Operational Triggers (pumping, restrictions, desalination)

- Long term planning
  - Augmentation (Optimisation and scheduling of supply portfolios)
  - Climate change (Validate robustness of supply solutions under climate change scenarios)

WaterNSW Water Supply System



Rural Supply Dams



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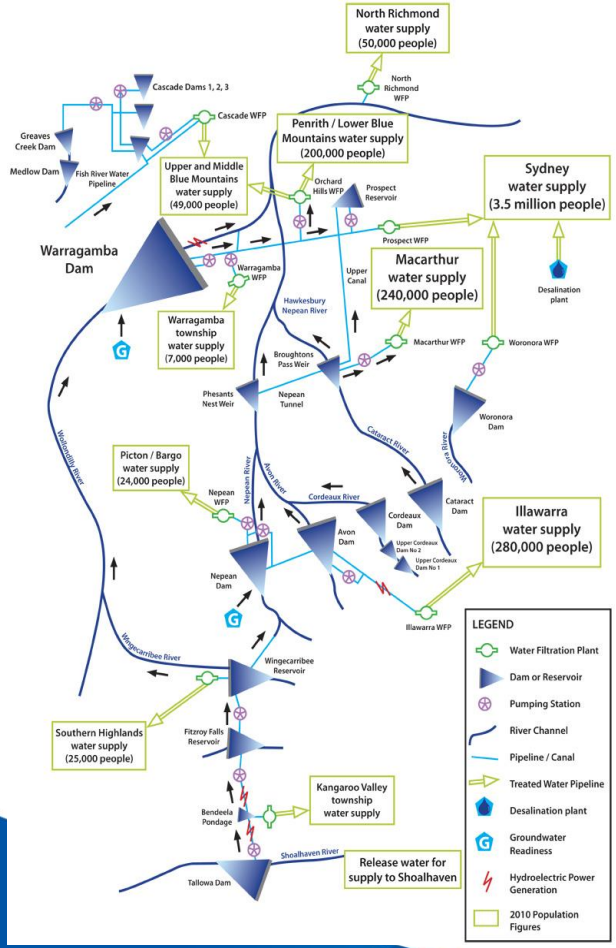
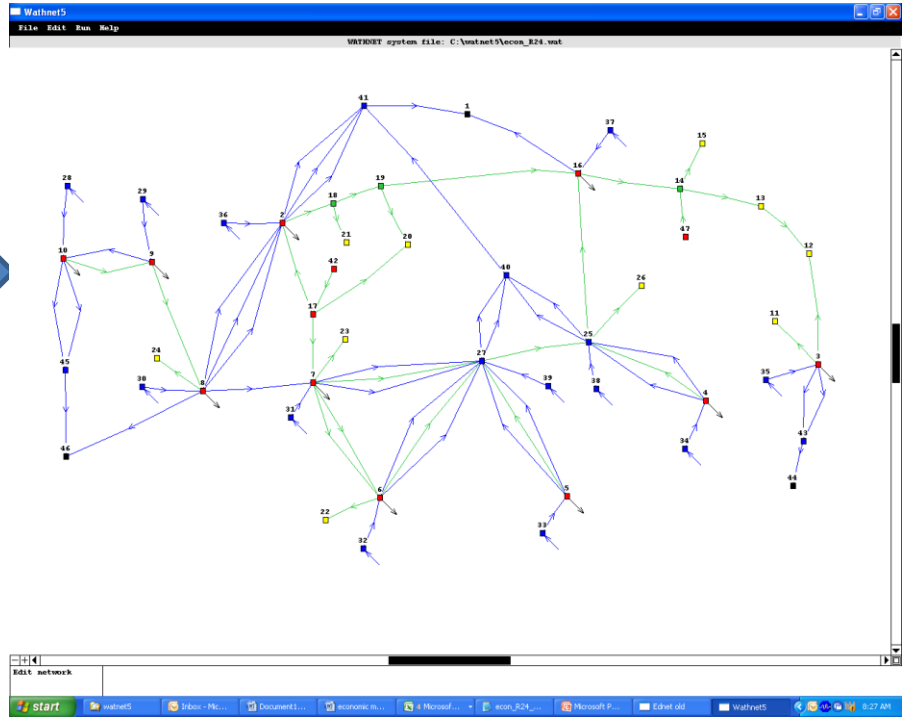
Water Supply Modelling Software

- WATHNET modelling software is used for water supply planning for Greater Sydney
- WATHNET is developed by Prof George Kuczera of University of Newcastle
- eWater Source modelling software is used for rural supply planning
- Mike (developed by Danish Hydraulic Institute) Software suite is used for River and Storage operations systems

Wathnet Model





Wathnet Model Features

- Model uses NFP (Network Flow Program) to simulate water resource systems
- A NFP is a linear program which finds the minimum cost solution for conveying water through a network of unidirectional arcs interconnecting supply, demand and transhipment nodes
- Storage selection rules are optimised to minimize spills (Cost Penalty Curves).
- Storage characteristics, transfer system constraints, demand characteristics and all triggers are represented in the model. (Scripts based software)
- Hydrological data is extended by stochastic models
- Interconnected system is optimised to maximise supply

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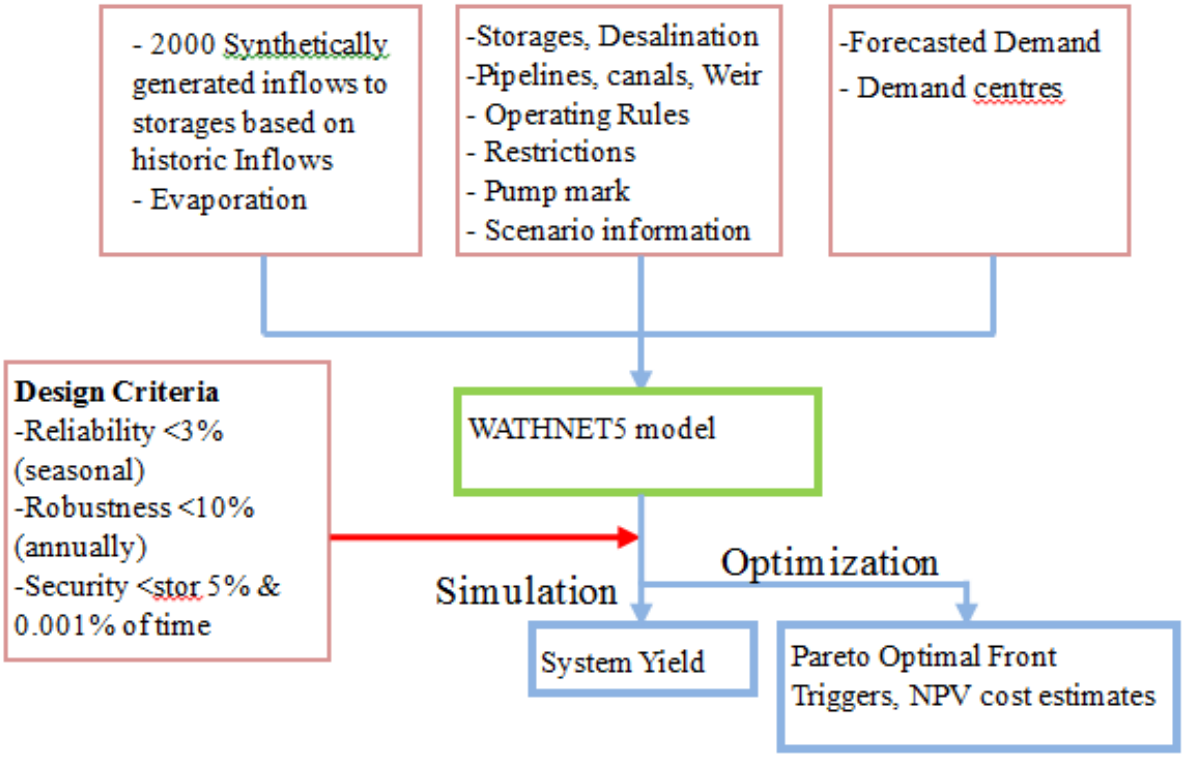
Wathnet Modelling Process
(includes economic capabilities)



Optimisation for Longterm Planning

- Water Demand increases with population growth.
- Supply capacity expansion involves re-optimisation of operating parameters for existing infrastructure and the provision of new infrastructure tapping new sources of water.
- The decisions to expand capacity can be implemented at different points of time over the planning period to take advantage of delaying a portion of investment outlays.
- Although the construction of large infrastructure at the start of the planning period exploits the economies of scale, the time discounting of costs and the dynamics of growth may nonetheless favour smaller projects staged over the planning period.
- In this case, the objective is to schedule a set of capacity expansion projects that minimized the total present worth cost.
- Multiple decisions describing a mix of operational and infrastructure options can be optimized at each planning stage

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Optimisation Parameters

Component	**Variables ranges optimised**
Measure-A Supply Source (fixed availability)	Commissioning triggers, timelines, Capacity
Environmental Releases	On and off (Flow regime on transparent and translucent release components)
Measure-B Supply Source (varied availability)	Transfer capacity Transfer triggers Commissioning timeline
……	……

Optimisation objectives and constraints

Objectives

Two of the objectives were used:

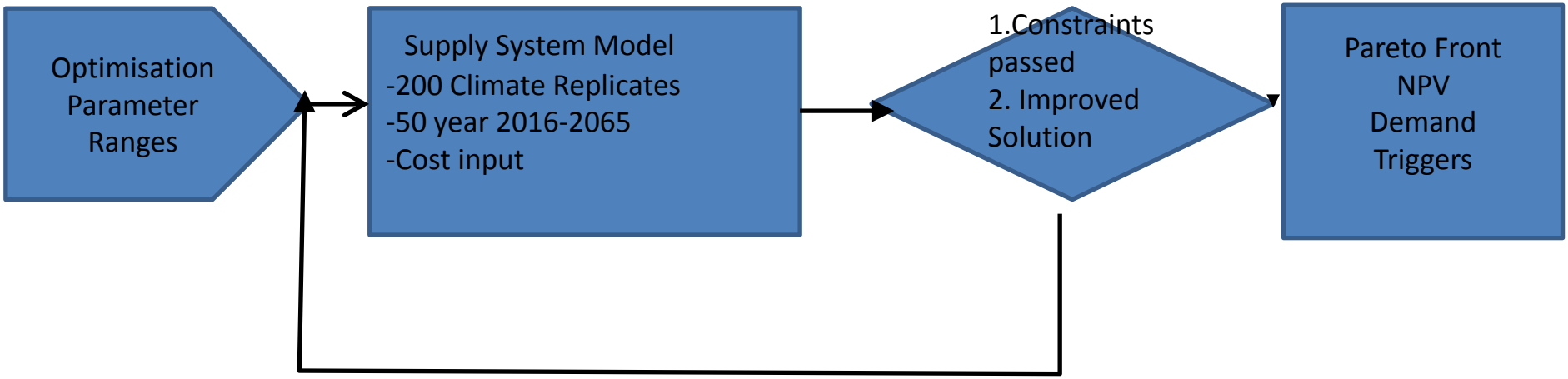
- Annual Demand - Maximise
- NPV of all costs – Minimise

Constraints

- Reliability: Reliability is defined as the percentage of the months, on average, that the restrictions will not need to be applied (not more than 30 months in 1000 months i.e. 3% or 5%)
- Security: Security defined by the chance the operating storage will not fall below 5% (no more often than one month in 100,000 months i.e. 0.001%).

Cost Input for Operations and Capital expenditure

Optimisation Process

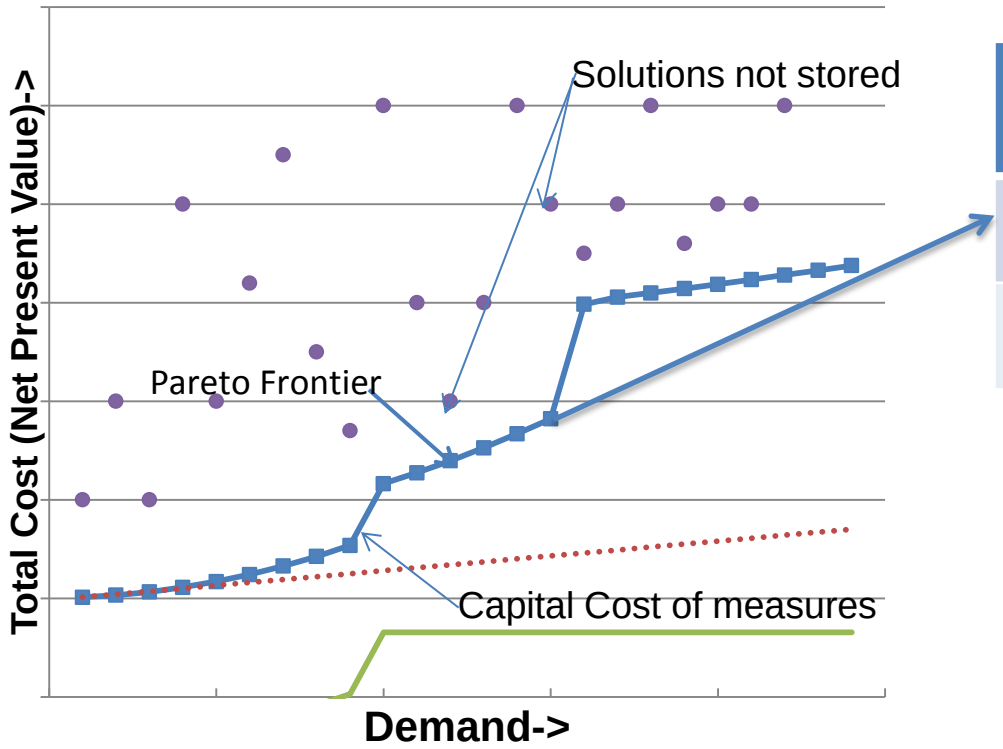


600,000 generations
Run in 3 days in AWS
(32 unix servers)

- Pareto efficiency, or Pareto optimality, is a state of allocation of resources in which it is impossible to make any one individual better off without making at least one individual worse off.
- Software automatically searches for the Pareto optimal set using the ε-dominance multi-objective evolutionary algorithm (εMOEA).

284 Set of optimised solutions found

Optimisation Output



Measure	Operational Triggers
Source 1	…
Source 2	…

- Least cost solution for each demand level
- Operational triggers for each solutions
- Scheduling of infrastructure for future demands
- Model used for Greater Sydney Metro Water Plan 2017

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Optimisation Challenges

- Simplified model need validation
- Robust optimisation for uncertainties
- Techniques for efficient solutions
- Parametrising objectives for trade-offs
- Research continuing….

Thank You
Questions?