

# Water Forever Whatever the Weather

## The Perth, Australia Groundwater Replenishment Scheme

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# Acknowledgements

- Water Corporation
  - Kevin Guppy, Delivery Manager
  - Stacey Hamilton, Senior Process & Framework Specialist
- CH2M
  - Jon Bates and Amy McCarthy, Design Managers

# Presentation Outline

- Climate change, impact to Perth's water supply and response by the Water Corporation to achieve sustainability
- The Groundwater Replenishment Trial as a key element of Perth's water supply scheme
  - Treatment process
  - Treatment objectives
  - Regulatory aspects
- Full-scale advanced water recycling plant (at Beenyup)
  - Process/equipment selection
  - Regulatory compliance pertaining to pathogen removal
  - Implementation schedule

# Perth, Australia

- Capital and largest city of Western Australia
- Fourth most populous city in Australia
- ~2 million residents in Greater Perth
- Mediterranean climate
- **Historical** average rainfall of 33 in/yr

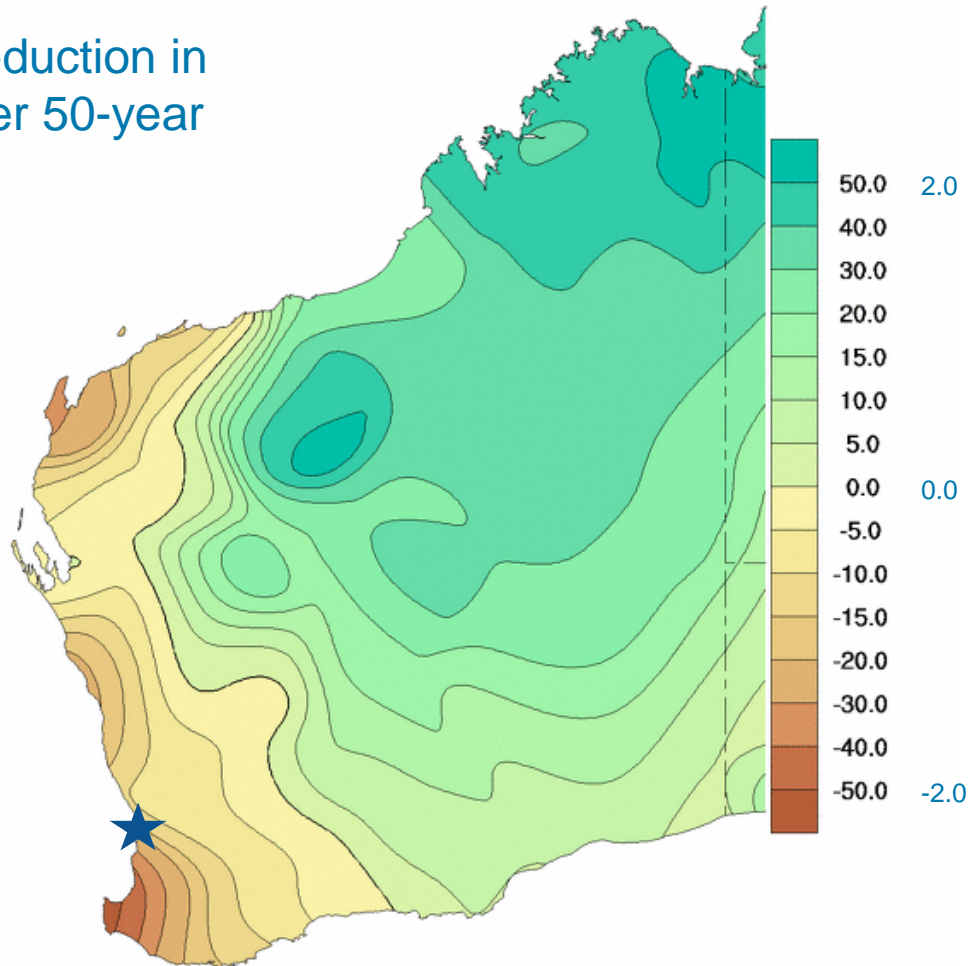


# Why Groundwater Replenishment?

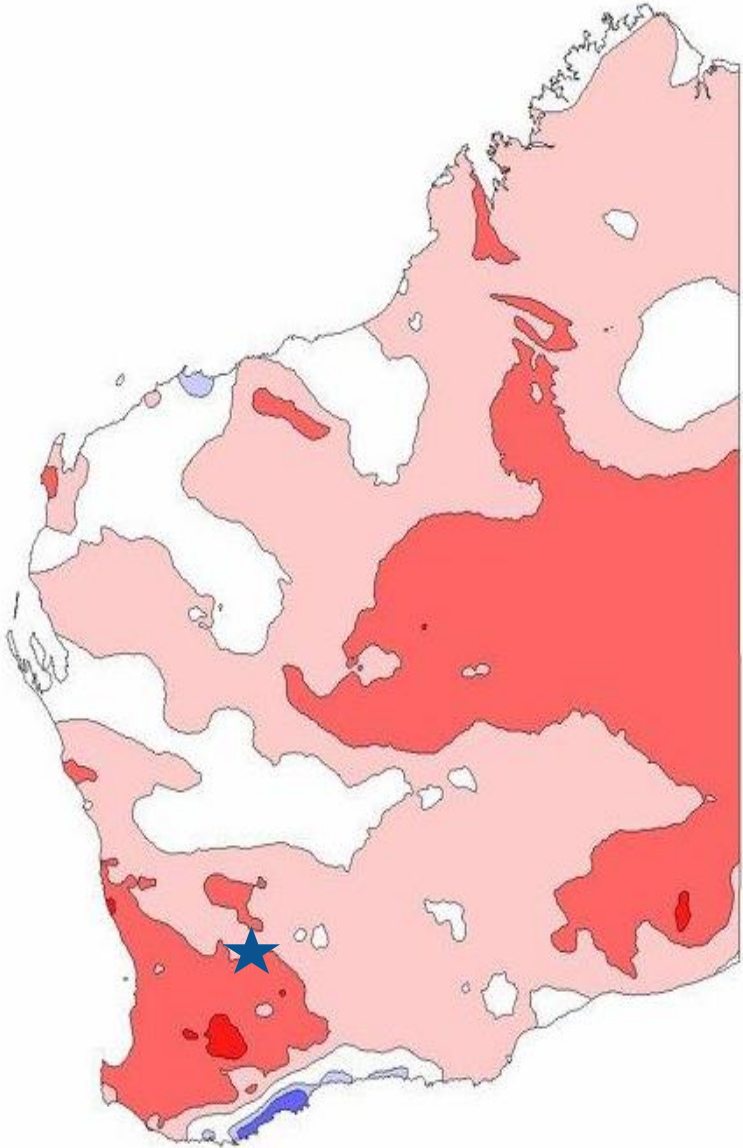
Trend in Annual Total Rainfall

1960-2010 (mm/10yrs) Inches/10 yrs

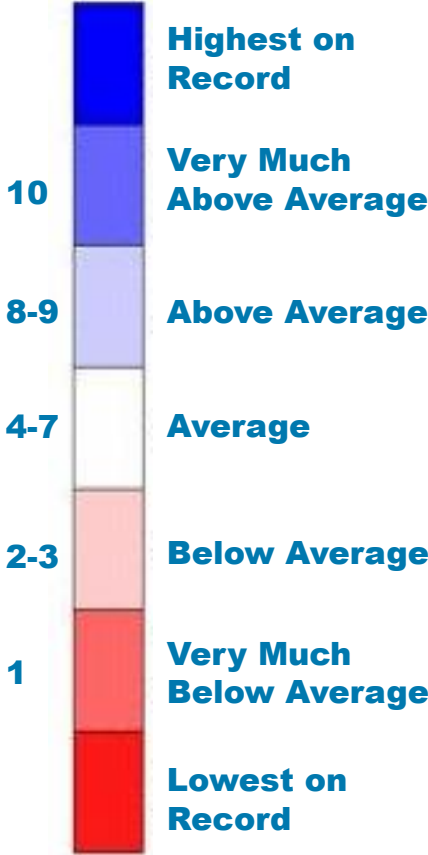
30-40% reduction in rainfall over 50-year period



# Winter 2012

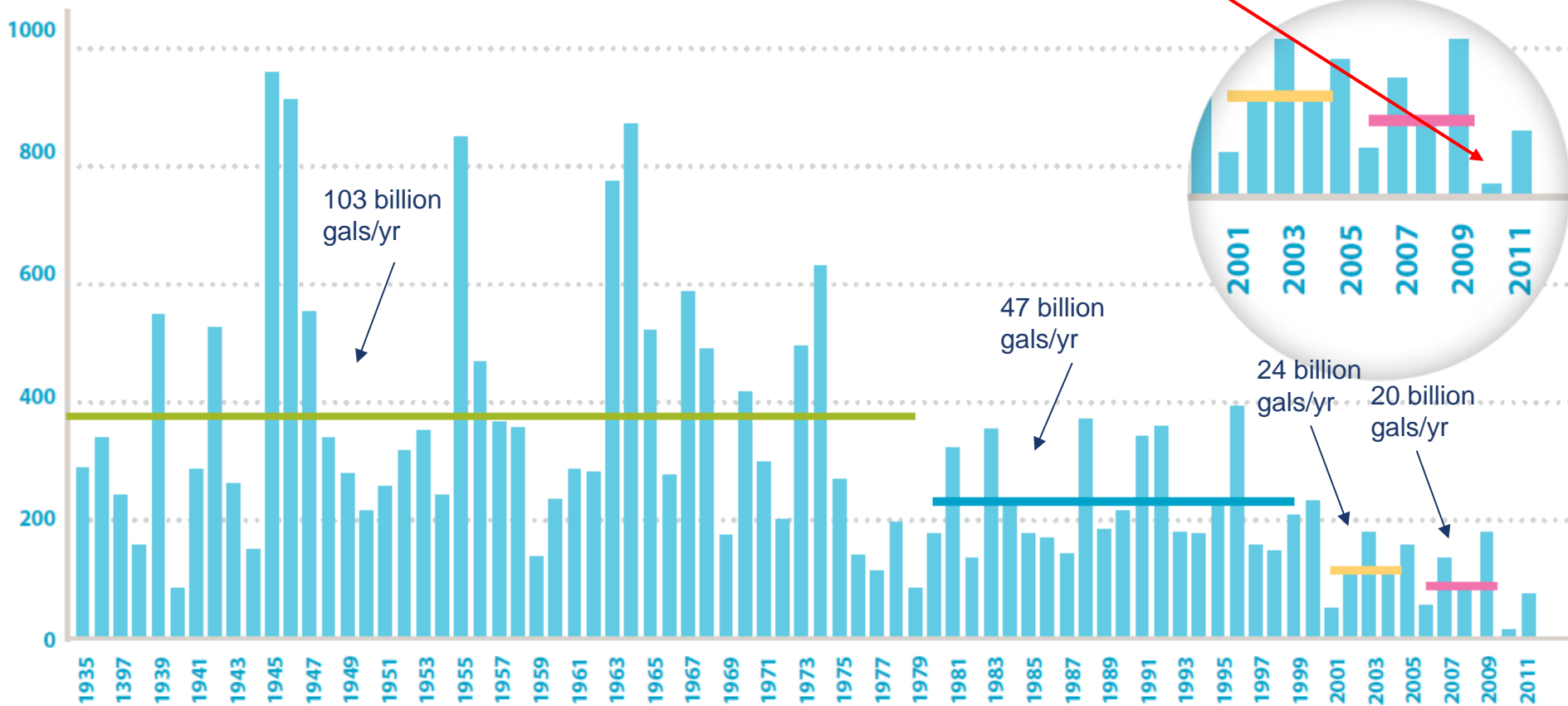


Rainfall Decile Ranges



# Inflow to Metropolitan Dams

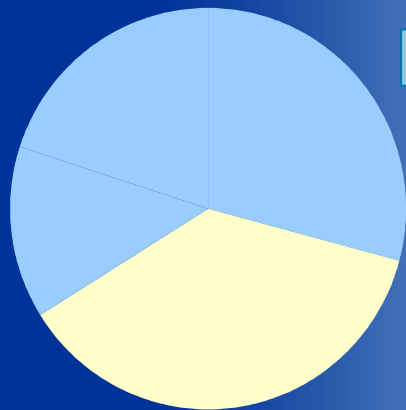
**=13 summer days demand!**



■ Inflow per year (GL)  
■ 1935 to 1974 average (338GL)  
■ 1975 to 2000 average (177GL)

■ 2001 to 2005 average (92.4GL)  
■ 2006 to 2010 average (75.3GL)

# Integrated Water Supply Scheme 1993



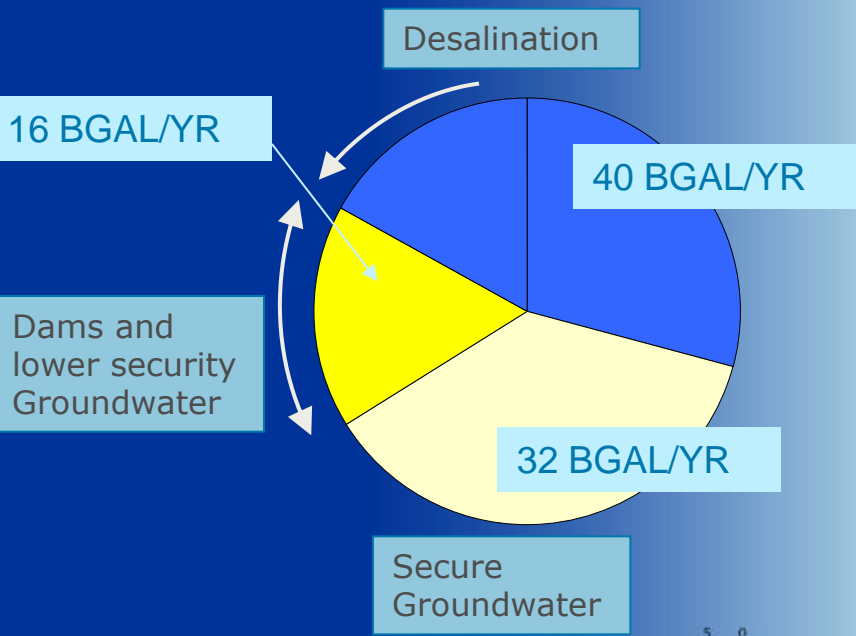
Dams

Groundwater

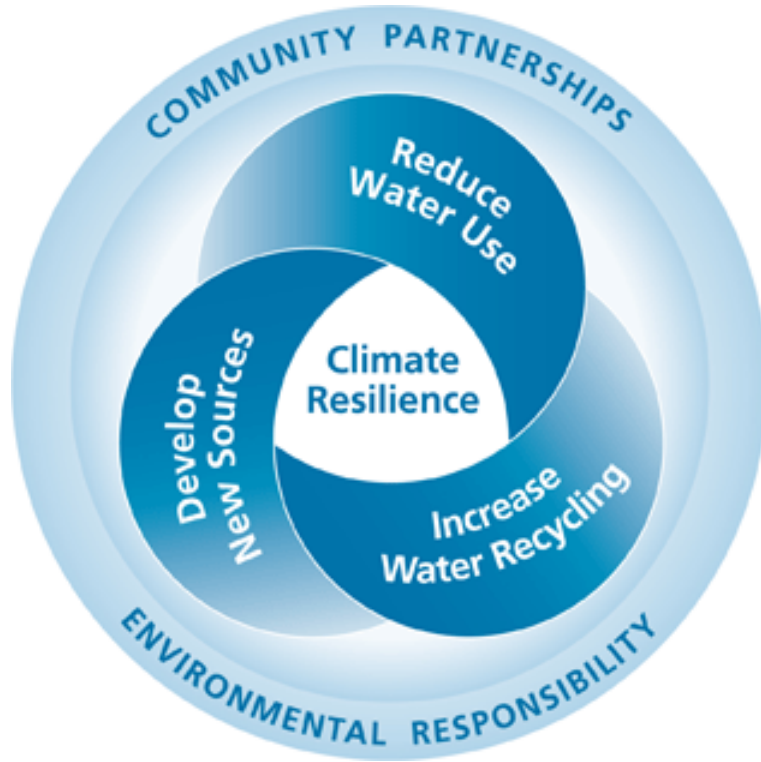




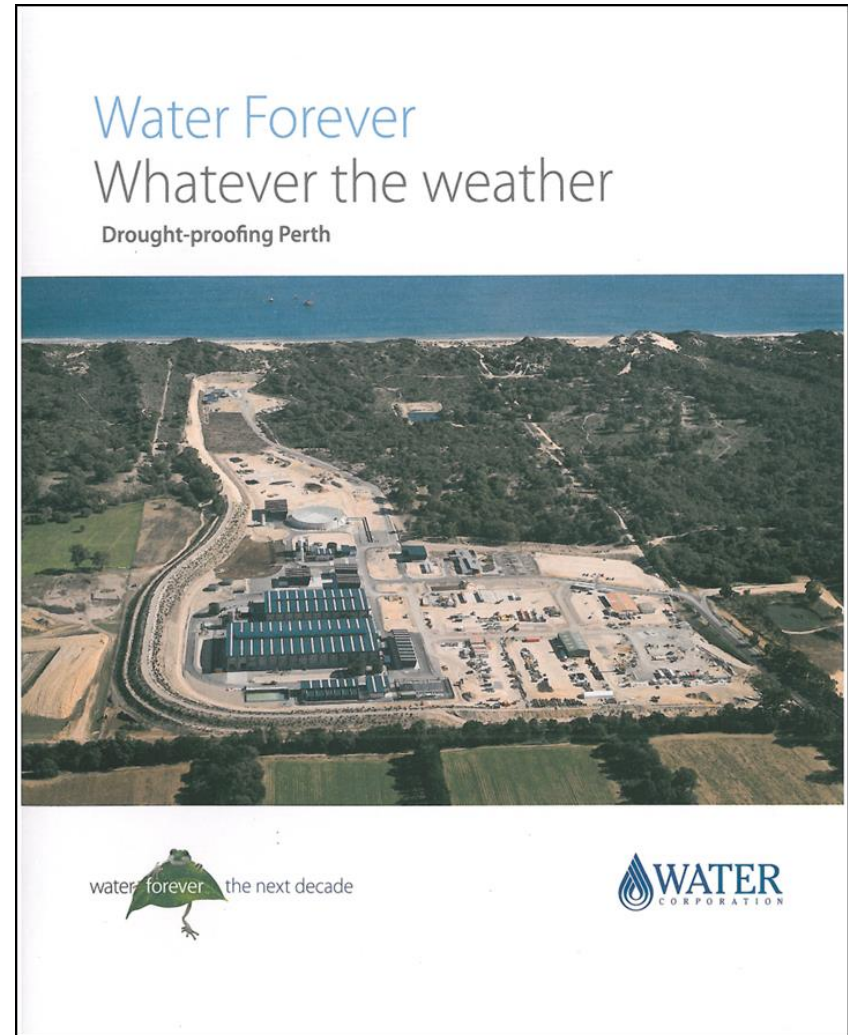
# Integrated Water Supply Scheme 2013



# Water Forever Whatever The Weather



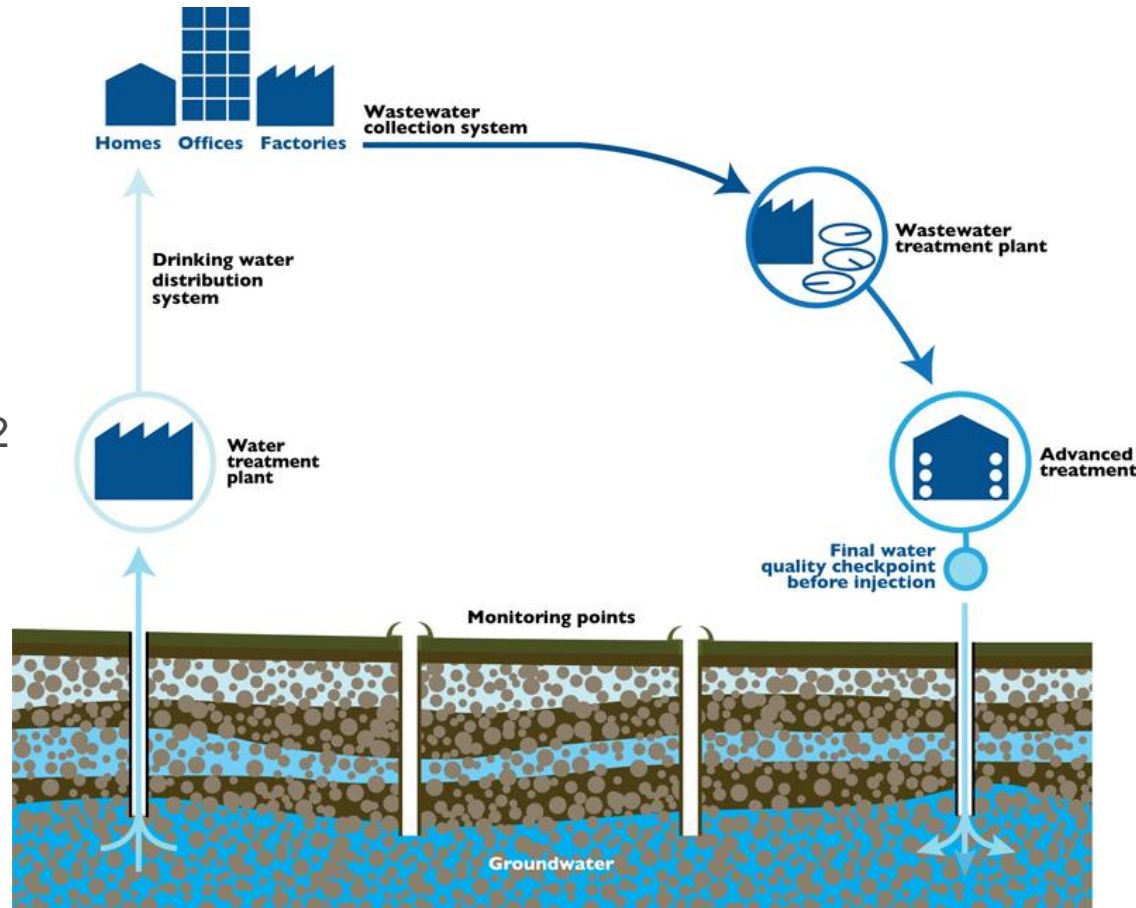
- Reduce demand by additional 15%
- **Recycle 30% of wastewater by 2030**



# Groundwater Replenishment Trial (GWRT)

## Trial Objectives

- Technical feasibility
- Policy and regulation
- Community engagement and discussion
- Conducted from 2009 through 2012
- Evaluated by regulatory agencies
- Endorsed by Government as next major source in 2013



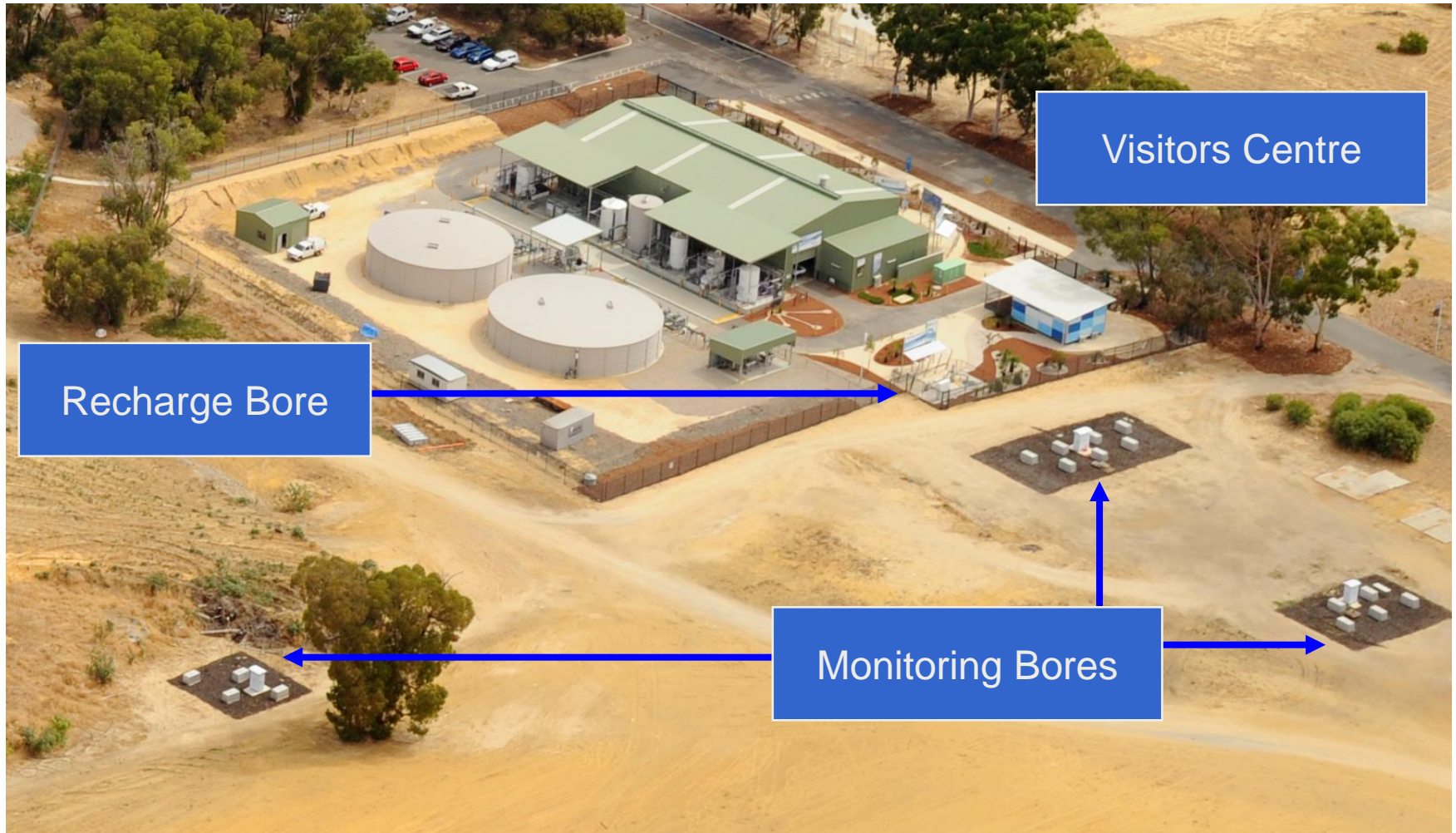
# Management of GWRT

- The Groundwater Replenishment Trial was managed under the Wastewater Quality Framework
- This is a risk based quality management system aligned to the principals of the Australian Guidelines for Water Recycling and the Australian Drinking Water Guidelines
- The same type of approach is used by companies such as Coca Cola to ensure the quality of their products





# Demonstration AWRP



# Treatment Train

## Wastewater Treatment

- Effluent suitable for discharge to ocean

## Ultrafiltration – Removes:

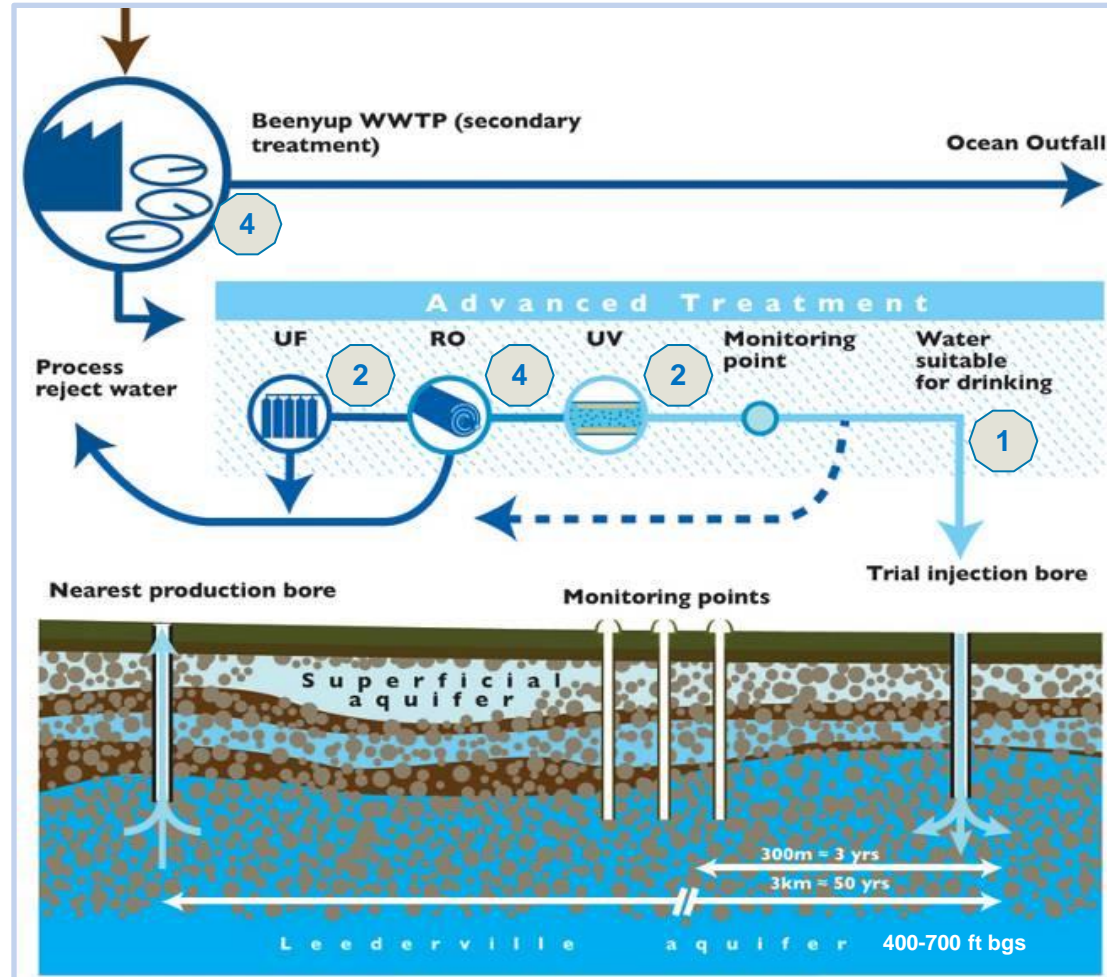
- All suspended solids
- Crypto, giardia, all bacteria
- Viruses (pore size dependent)

## Reverse Osmosis – Removes:

- All viruses
- Inorganics, including nitrogen
- Bulk and trace organics

## Ultraviolet Treatment

- Final disinfection step
- Inactivation of bacteria, crypto, giardia and viruses





# Assurance through Critical Control Points

Breach of any Critical Limit for a Critical Control Point causes automatic diversion of the AWRP



Breach of any Critical Limit for a Critical Control Point causes automatic diversion of the AWRP

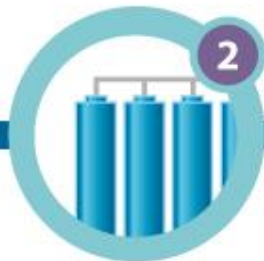
**Turbidity**

1

From ocean outfall  
(ex. Beenyup)



Storage tank



Ultra filtration barrier

- **Pressure Decay**
- **Turbidity**

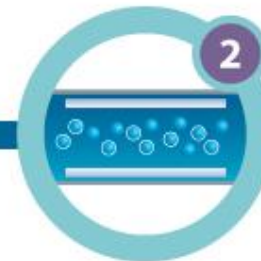


Two - stage reverse osmosis barrier

- **Conductivity (3)**
- **Total Organic Carbon**



De-gassing  
(removing bubbles)



Ultra violet disinfection barrier

- **Flow**
- **UV Intensity**



Storage and monitoring

1

**pH**



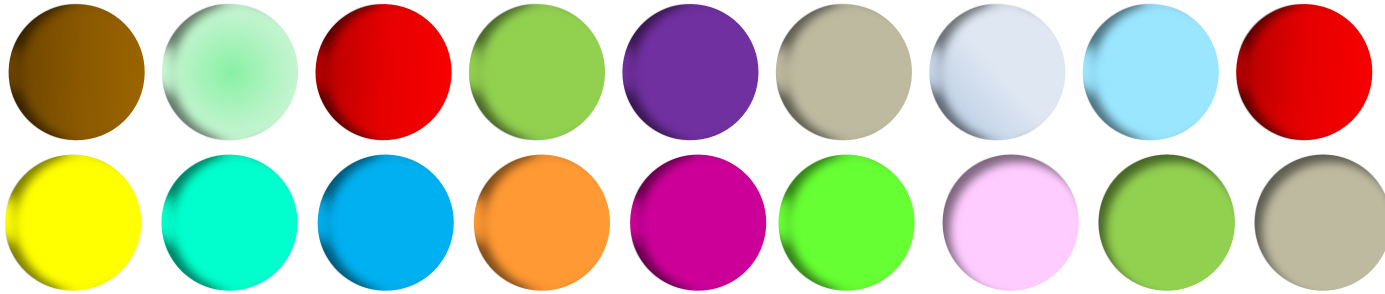
Water suitable for recharge

 Critical Control Points

Total Critical Control Points: 13

# Recycled Water Quality Indicators

**18 Recycled Water Quality Indicators**



**292 Recycled Water Quality Parameters**



# Recycled Water Quality Indicators

	Indicator	Group Represented
1	Boron	Metals and metalloids
2	Nitrate as N	Inorganic anions
3	NDMA	N-nitrosamine DBPs
4	Chlorate	DBP anions
5	1,4-Dioxane	Miscellaneous organics
6	Chloroform	DBPs
7	1,4-dichlorobenzene	Volatile organics
8	Fluorene	Polycyclic aromatic compounds
9	2,4,6-trichlorophenol	Phenols

# Recycled Water Quality Indicators

	Indicator	Group Represented
10	Carbamazepine	Persistent pharmaceuticals
11	Estrone	Hormones
12	EDTA	Complexing Agents
13	Diclofenac	Acidic Pharmaceuticals
14	Trifluralin	Pesticides
15	Octadioxin	Dioxins, furans & dioxin like PCBs
16	MS2 Coliphage	Microbial pathogens including virus
17	Alpha Particle Activity	Radioisotopes
18	Beta Particle Activity	Radioisotopes

# Microbial Log Reduction Credits

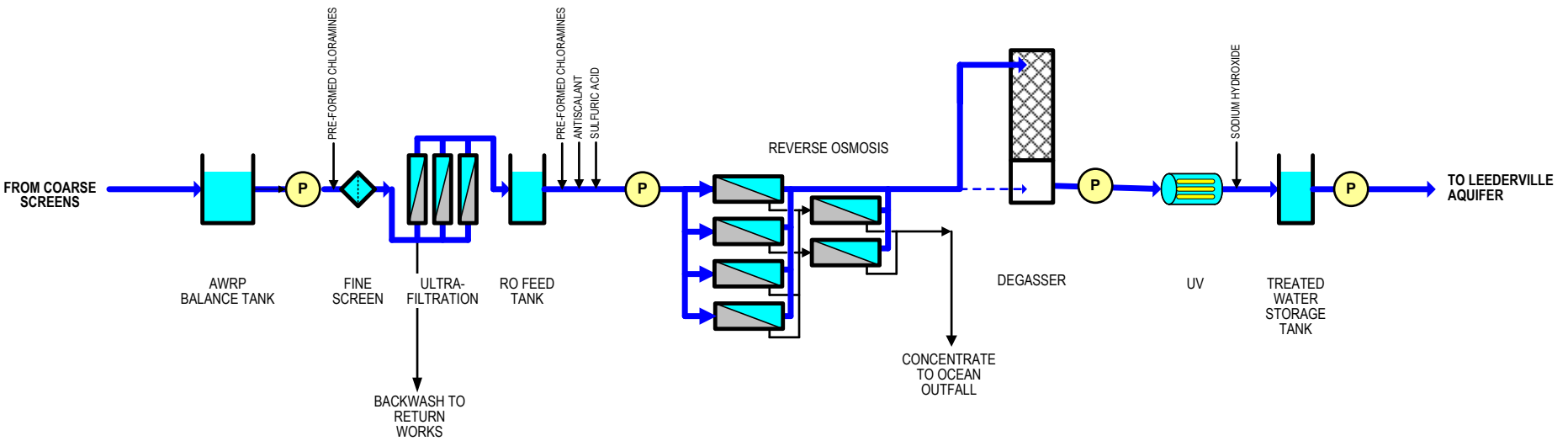
	Equivalent Log Reduction Credits		
	Bacteria	Virus	Protozoa
Wastewater Treatment	1	1	0.5
<b><i>BAWRP Process Unit</i></b>			
UF with chloramination >1.5 mg/L	3	3	3
Reverse Osmosis	3	3	3
UV Disinfection at >186 mJ/cm <sup>2</sup>	4	4	4
<b>Total AWRP ELRC</b>	10	10	10
<b>Total (WWTP &amp; BAAWRP)</b>	11	11	10.5
<b>DoH Requirement</b>	8.5	9.5	8
Excess credits (safety factor)	2.5	1.5	2.5



# Full-Scale (Beenyup) Advanced Water Recycling Project (BAWRP)

- In August 2013 the WA Government approves groundwater replenishment as a next major water source for Perth
- In November 2013 Water Corporation selects two teams to develop preliminary design and total outturn cost (TOC) for three separate replenishment stages (capacities)
- In July 2014 Water Corporation selects the Joint Venture of CH2M HILL and Thiess (aka CHTJV) to design, construct and commission the 14 GL/yr Beenyup AWRP, incorporating both Stages 1 and 2

# BAWRP Process Schematic



# Ultrafiltration

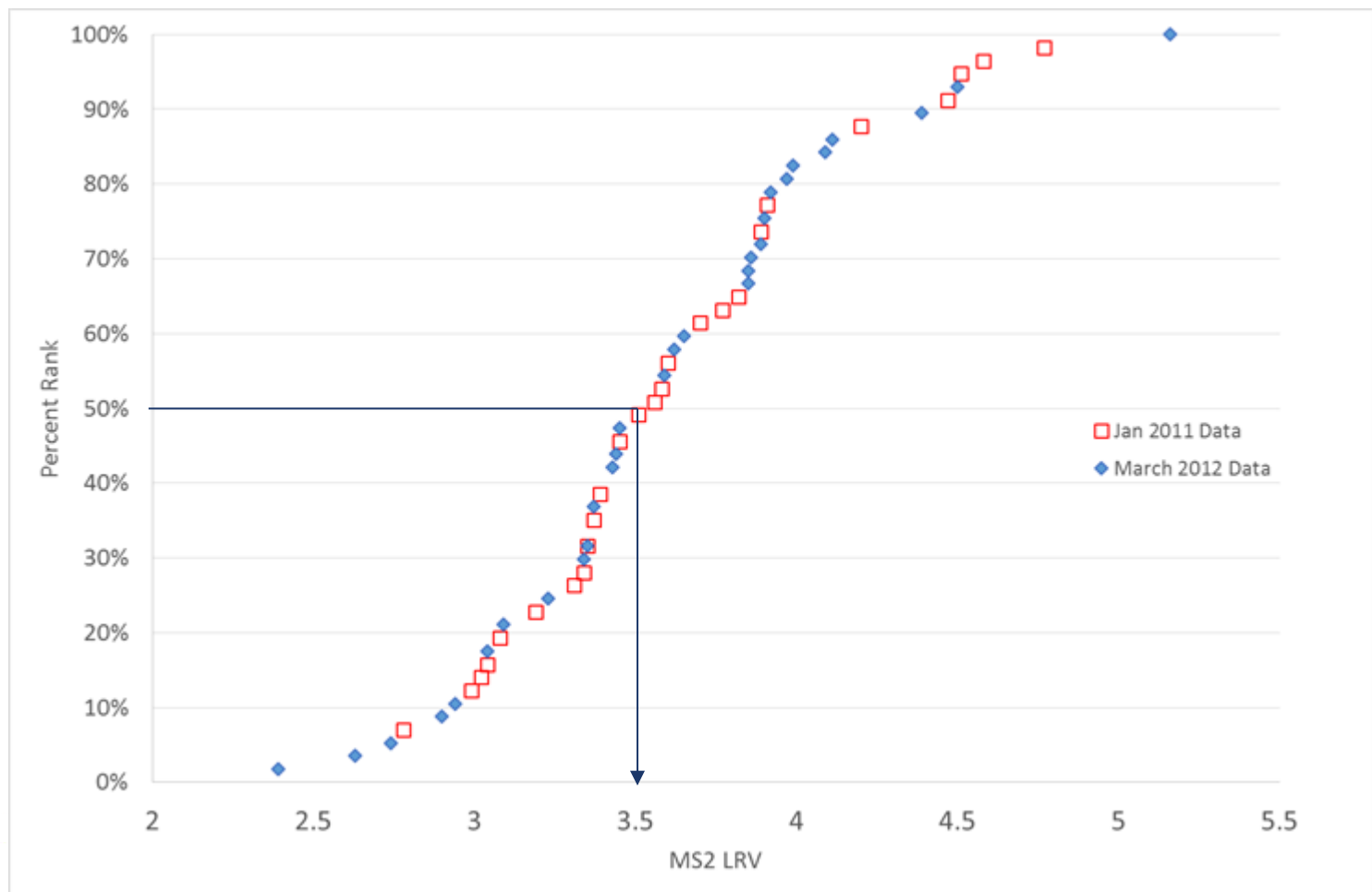
- 2,989 m<sup>3</sup>/hr (17.3 mgd) gross filtrate flow
- 8+1 Skids (manufactured by Hager + Elsasser)
- Dow SFD-2880 UF modules (Toray)
- 104 modules per skid
- 49 LMH (29.5 gfd) max inst. flux
- 92% recovery
- Key performance requirement:
  - 3-log removal of MS-2 phage to comply with ELRC
  - Demonstration via:
    - Full-scale system if sufficient MS-2 in UF feed
    - Test rig if insufficient level through seeded challenge test
- SFD-2880 module selected based on NSF ETV MS-2 phage results





# MS-2 Phage Challenge Testing – Dow SFD2880 Module

- Testing conducted by NSF Int'l (EPA ETV program)
- 50% LRV of 3.5



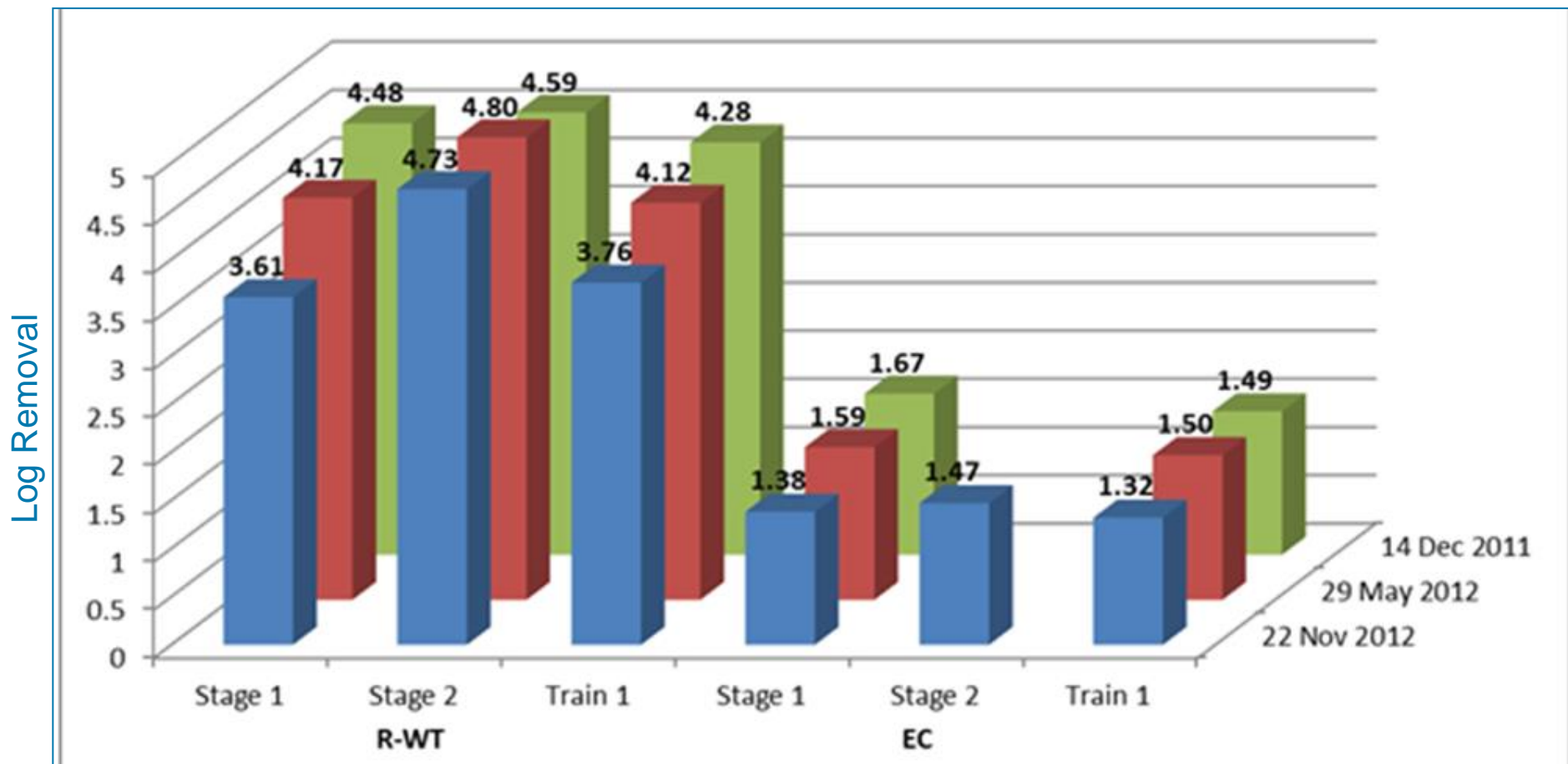


# Reverse Osmosis

- 2042 m<sup>3</sup>/d (13 mgd) permeate flow
- 4+0 skids (manufactured by Hager + Elsasser)
- Hydranautics ESPA2-LD elements (Toray TMD-20)
- 70:35 vessel array using 7M vessels
- Average flux: 19.2 LMH (11.3 gfd)
- Recovery: 75% initial (80% ultimate)
- FEDCO ERD for Stage 2 pressure boost
- Key performance requirement:
  - 3-log virus/bacteria/protozoa removal
    - Demonstrated through challenge testing with Rhodamine-WT (ASTM D6908-06) and sulfate
  - Compliance with ASTM D3923-08 (vacuum testing)
    - <10 kPa/min (1.4 psi/min) decay rate



# Log Removal – ESPA2-LD Rhodamine WT & Conductivity





# Ultraviolet (Light) Disinfection

- 1999 m<sup>3</sup>/hr (12.7 mgd) flow
- 2+0 trains
- Calgon Sentinel 9L24 (UV AOP specific)
- Medium pressure, polychromatic
- MS2 phage RED = 186 mJ/cm<sup>2</sup>
- 94% UVT
- Key Performance Requirement
  - 4-log virus inactivation

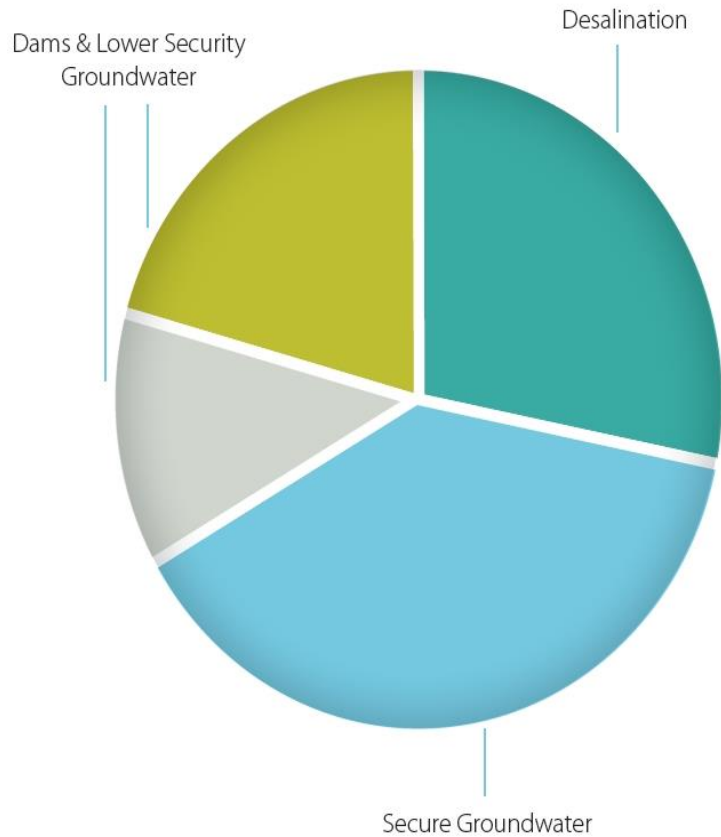


# BAWRP Stages 1&2 Project Schedule

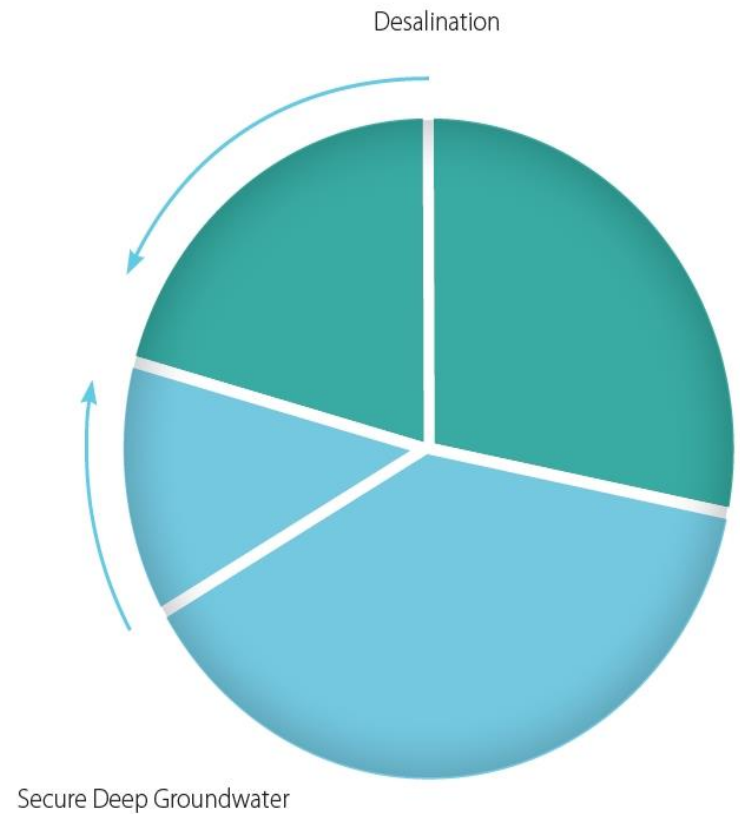
Milestone	Date
Project Award	July 2014
Start of Design	Aug 2014
Design Completion	Feb 2015
UF/RO/UV Systems Delivery	Jun 2015
Construction Completion	Mar 2016
Validation & Verification Completion	Nov 2016

# Looking Ahead – Water Forever

**% IWSS Sources - 2012**



**% IWSS Sources - 2022**



# Questions?

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