West Werribee Aquifer Storage and Recovery Scheme

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1st November 2017

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Presentation content

- Background and current status
- Water quality
- Pressure
- Clogging
- The future

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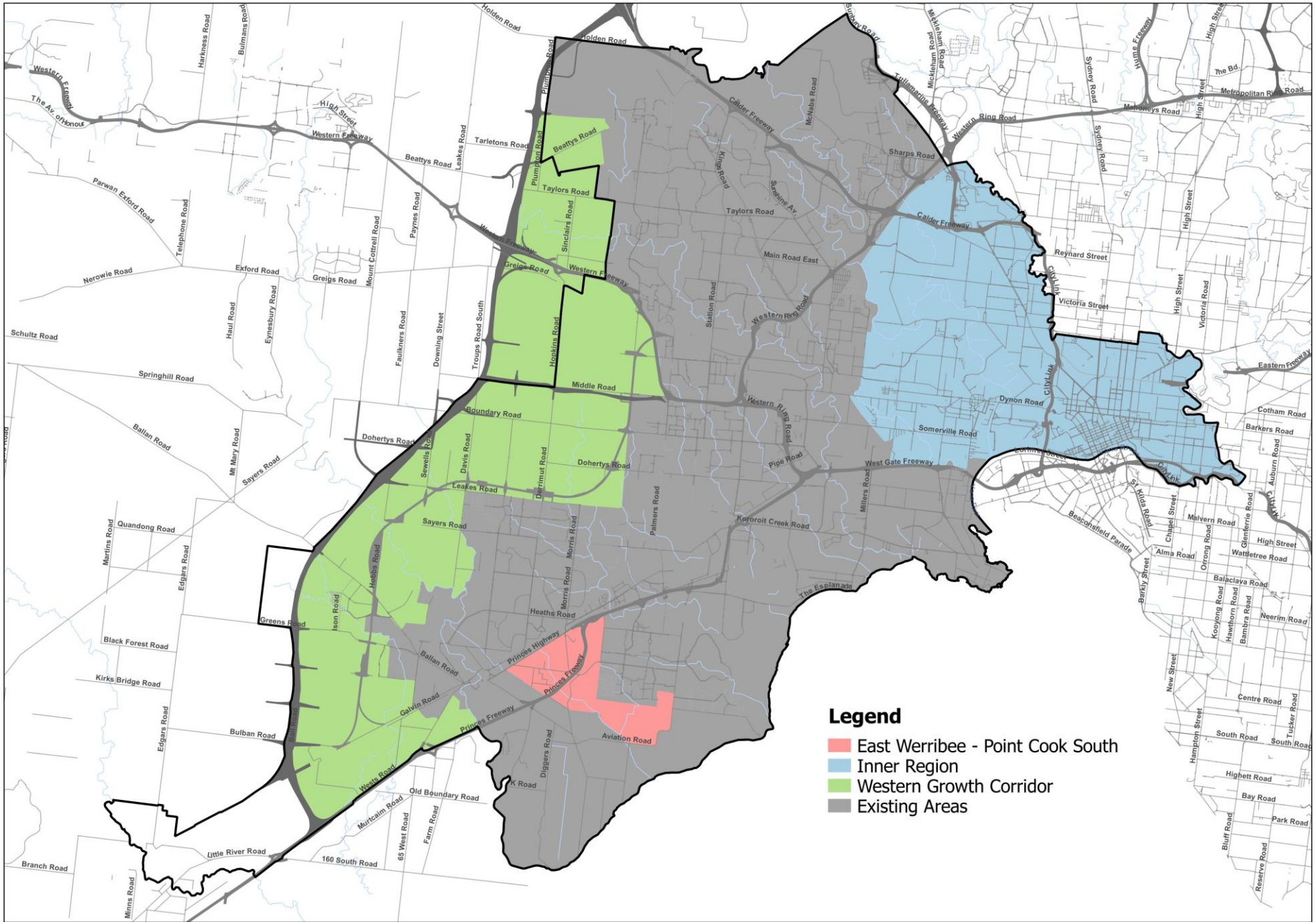
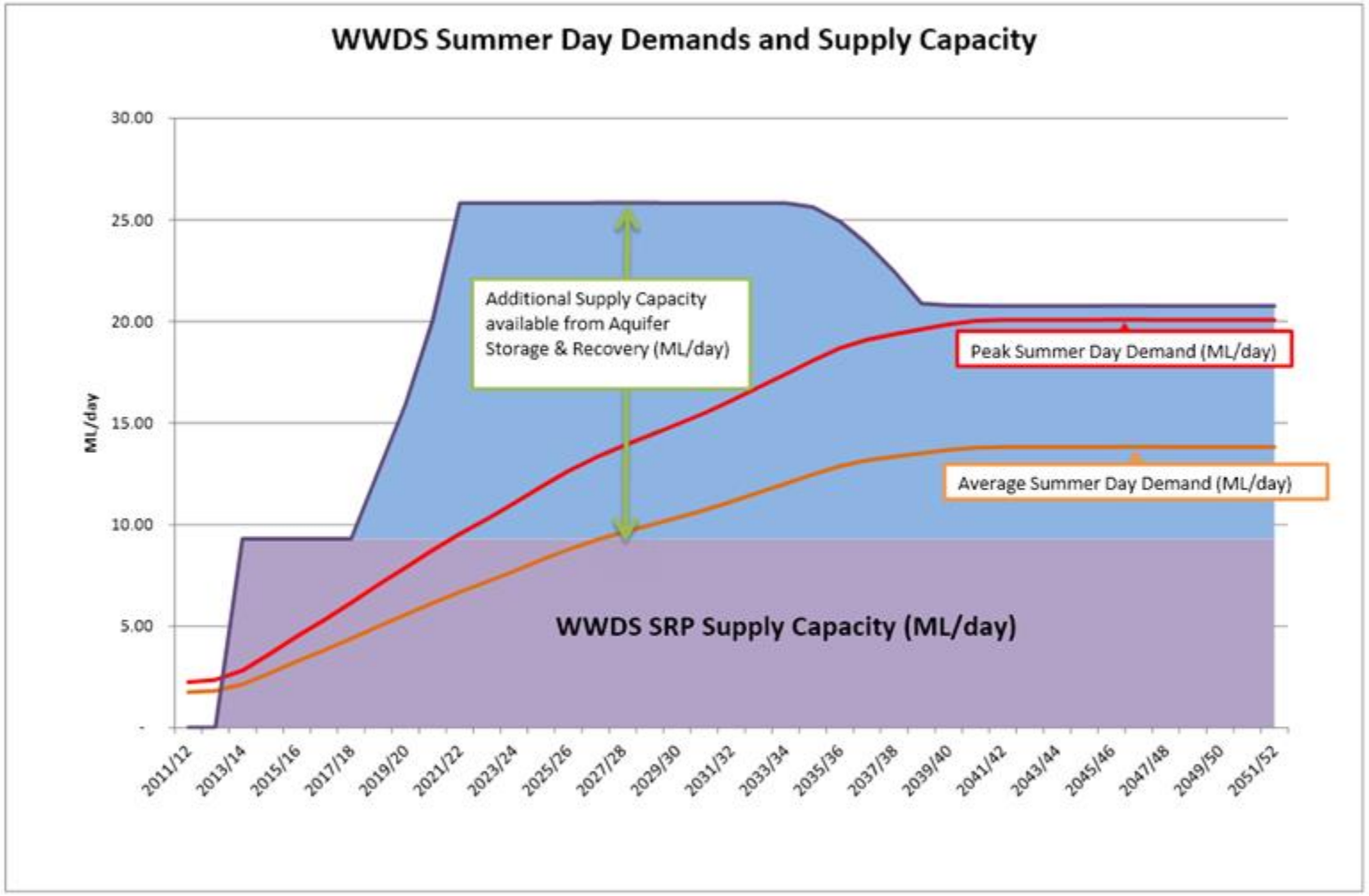
City West Water Servicing Strategy Areas





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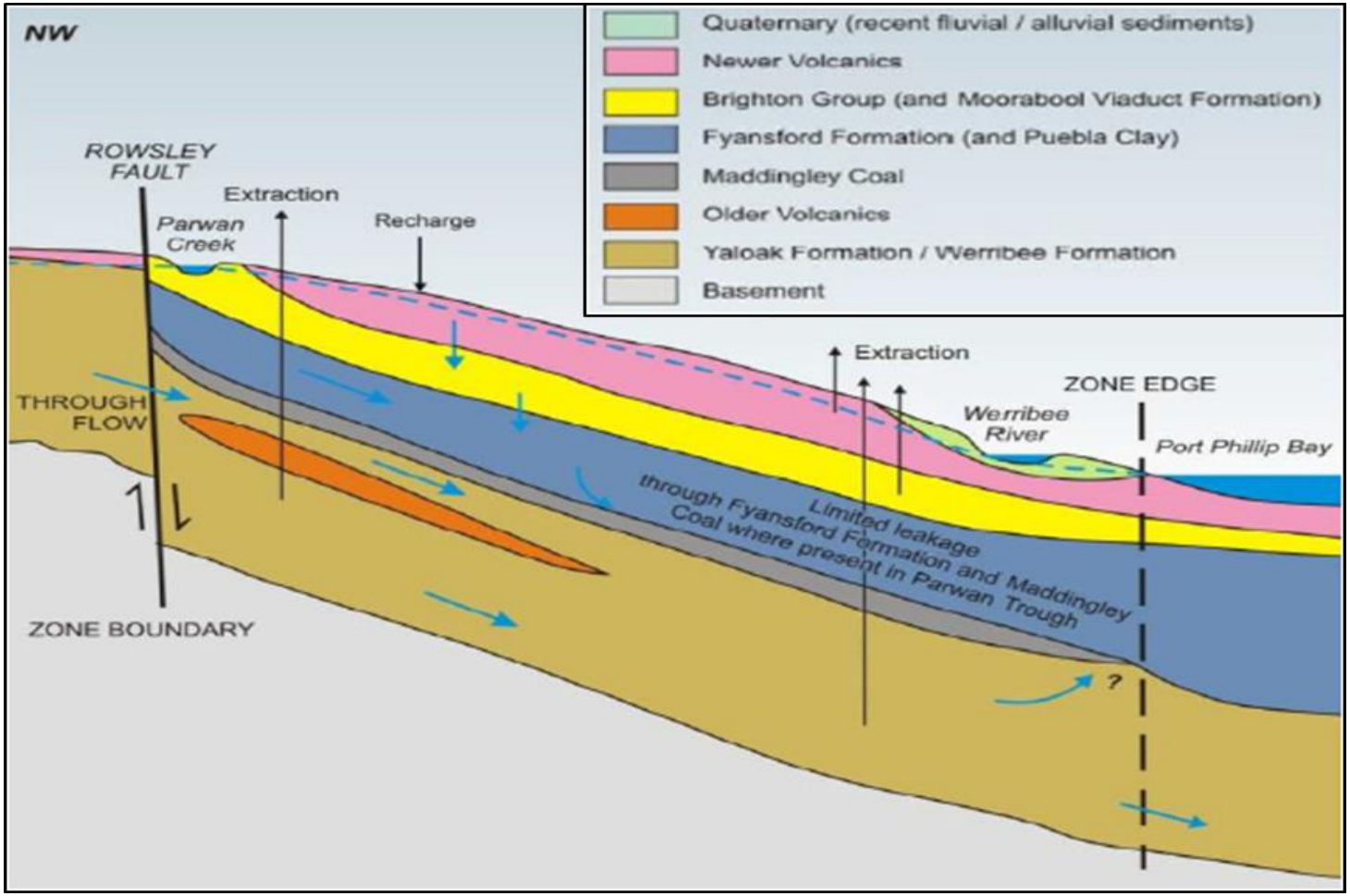
Geology



Generalised geological sequence showing Werribee Formation (GHD, 2012)

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West Werribee Dual Supply Scheme

Ballan Road Storage

Recycled Water Distribution

Werribee ASR Scheme

Melbourne Water Western Treatment Plant

City West Water Salt Reduction Plant

Ballan Rd ASR

Ballan Rd Reservior

COwies Hill Reservior

Greek Hill

West Werribee

Standard Charge

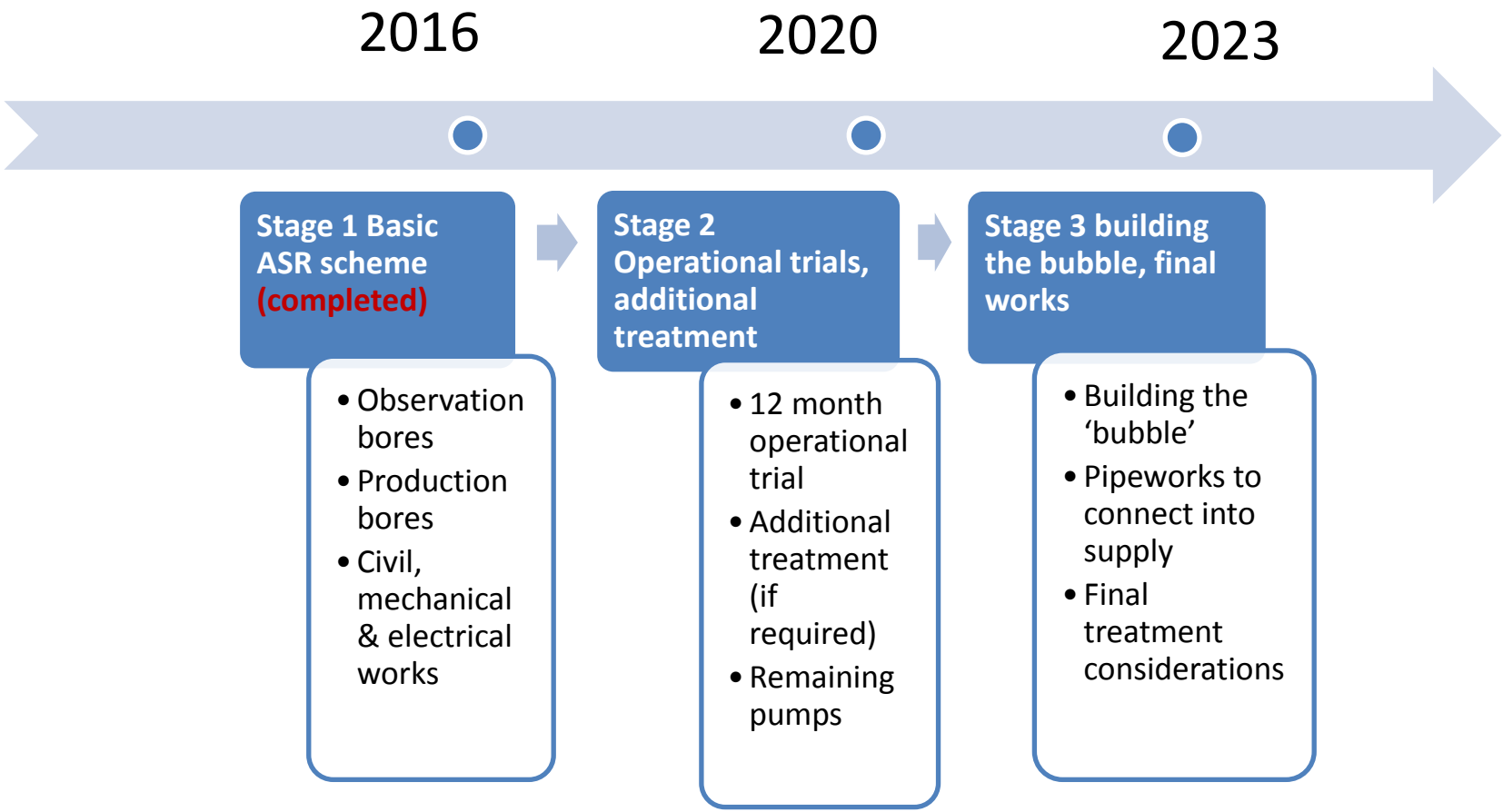
WTP ASR

WWDS SR

Financial

- Approval $15.6M for 3 stages
- $11.4M funded from Federal Department of Agriculture and Water Resources
- Part of National Urban Water and Desalination Plan
- Fund closed April 2016
- Expenditure to date is $12.8M. Scheme costs expected to be up to $15.6M depending on treatment requirements

Werribee ASR Scheme - Staging



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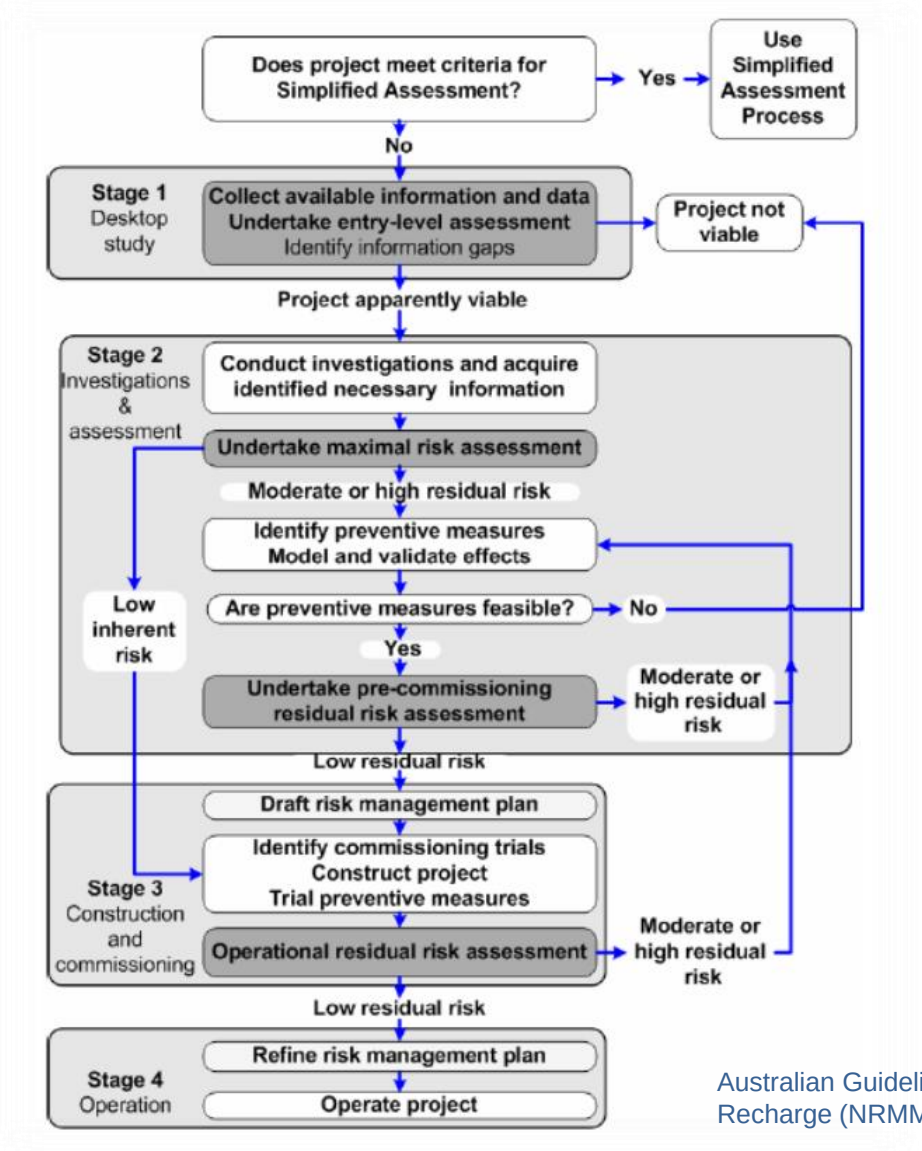
Staged, Risk Based Development Program



Australian Guidelines on Managed Aquifer Recharge (NRMMC, 2009)

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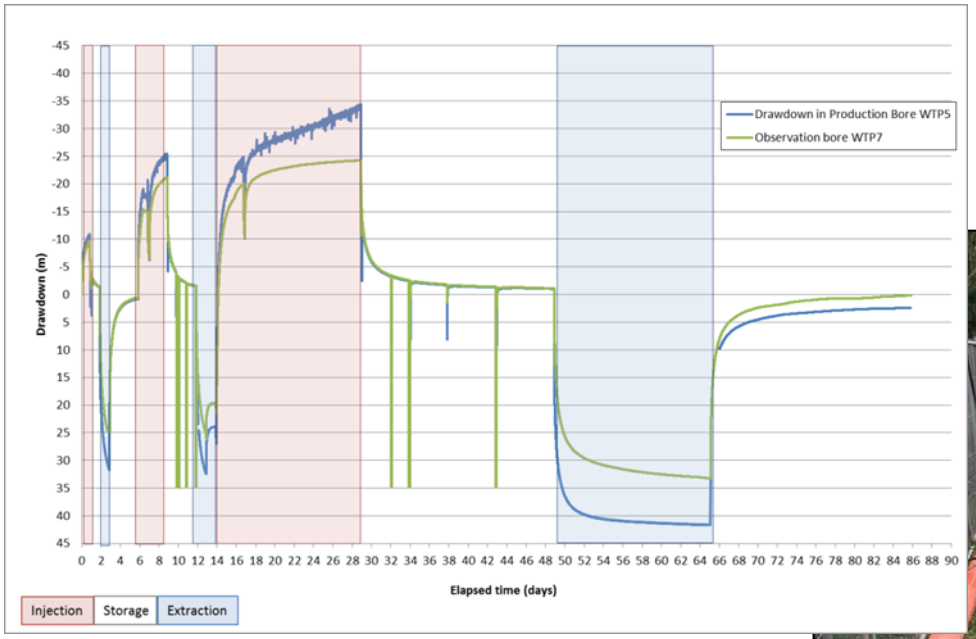
Stage 2 Injection Trial at Salt Reduction Plant (SKM) 2012/13



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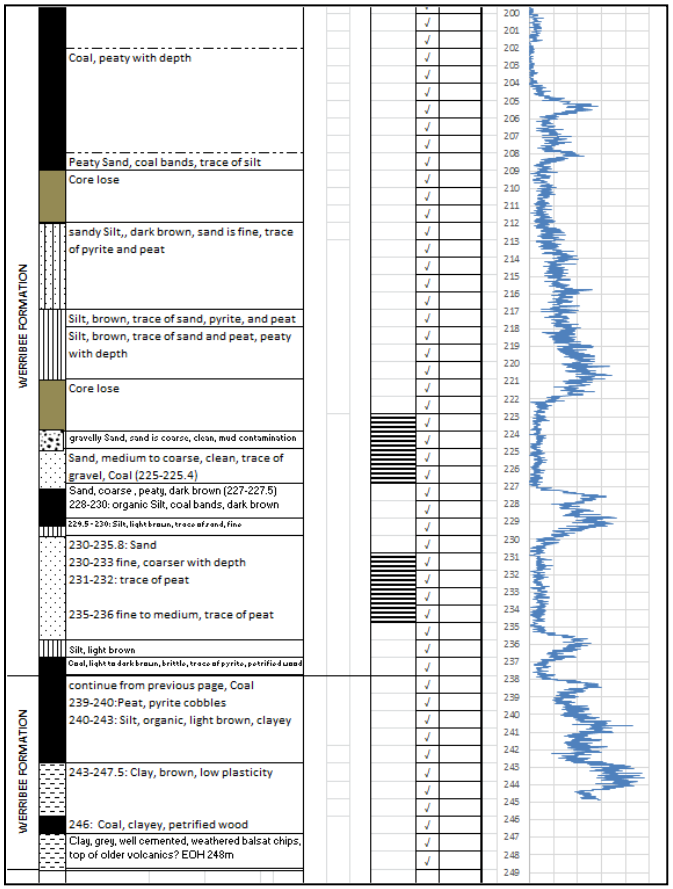
Drilling



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Why do we need an operational trial ?

Clogging

- to understand bore clogging
- can it be managed operationally ?
- is additional treatment required?

Chemistry

- how will chemistry in the aquifer change over time?
- is additional treatment required?

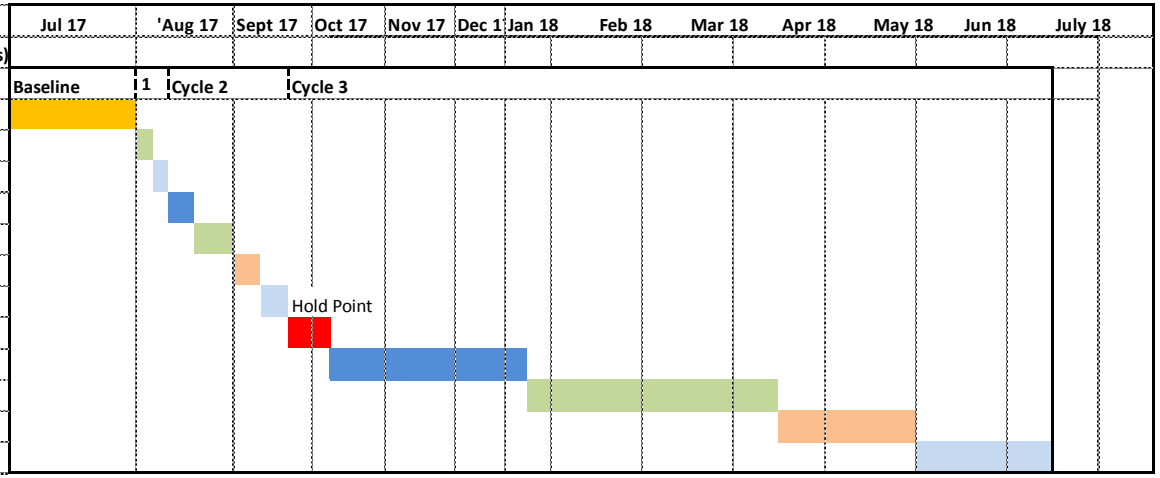
Operation

- what are the optimal rates, volumes and duration of injection/extraction ?
- what initial ‘buffer’ volume is required ?
- how do we optimise the salinity of the recovered water ?

Trial Program

West Werribee ASR Operational Trial 2017/2018 (Program as of 20 June 2017)

Activity	Total days	Flow Rate (l/s)
Baseline testing	7	up tp 30 l/s
1 Day Inject+ 3 day Store + 1 day extract	5	15
Rest period and assess results	2	
7 day Injection	7	15
21 day storage	21	
7 day extraction	7	15
Rest period and assess results	21	
Hold Point/decision	14	
90 day Injection	90	20
90 day storage	90	
60 day extraction (max)	30	20
Assess results	60	



Timing of Phase 3 is subject to results of Phase 1 and 2

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Water quality monitoring program

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Water Quality Monitoring Objectives

Changes in water quality:

- Geochemical reactions between the source water, ambient groundwater and the aquifer matrix
- Changes in salinity, nutrients, inorganic compounds
- Levels of H2S
- Indicators of clogging
- Radioactivity

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West Werribee ASR Monitoring Network

Sampling Locations

Source Water/Injectant

ASR Bore

Monitoring Bores

Private Bore

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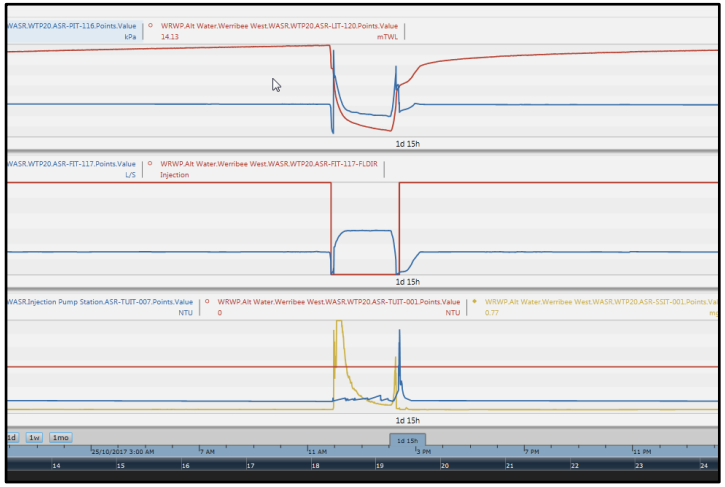
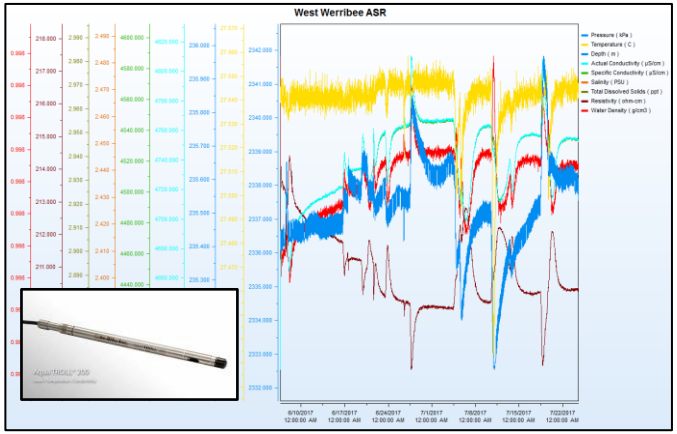
Monitoring Plan





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List of parameters monitored during the ASR trial

Analytes	Parameters	Primary Purpose
General Chemistry	pH, Conductivity, Turbidity, Total Suspended Solids, TDS, SDI	Evaluation recovery efficiency, calibration solute transport, clogging potential
Nutrients	Ammonia, Ammonium, Nitrate, Nitrite, Total Nitrogen, TKN, Total Phosphate, TOC, DOC, Silica, UV-transmission, COD, BCOD	Assessment of clogging potential, Geochemical imput
Algae	Total Count with Biovolume	Assessment of clogging potential, Geochemical imput
Ions	Major Anions, Cations,	
Metals and Major Cations	Dissolved and Total Metals (Aluminium, Antimony, Arsenic, Barium, Beryillium, Boron, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Manganese, Mercury, Molybdenum, Nickel, Selenium, Silver, Strontium, Thorium, Tin, Uranium, Vanadium, Zinc)	Metal reactions, Geochemical modelling Imput
Microbiological and bacteria	E. Coli, HPC Total Coliform, SRB, IRB, NGS	Quality check of components of Class A water, to detrmine residual levels and attenuation rates
Radioactivity	Gross alpha & beta (with Potassium 40 correction),Radium 226 and Radium 228, Natural Radionuclides by HR gammaspectrometry (Th-234, Th-230, Ra-226, Pb-210, U-235, Pa-231, Ac-227, Th-227, Ra-223, Ra-228, Th-228, K-40), Radon 222, Thorium 232, Uranium 238	Check on radionuclides in ambient, stored and recovered water
Gases	Un-ionised Hydrogen Sulphide (UHS),Dissolved Oxygen, Carbon Dioxide, Methane	H2S impact assessment, Geochemical Modelling
THM	Chloroform, Dibromochloromethane, Bromodichloromethane, Total chlorine residual, Bromoform, Dichloromethane, Carbon tetrachloride	Disinfection by-products
HCAA	Chloroacetic acid, Dichloroacetic acid, Trichloroacetic acid,	
Emerging Pollutants	PPCPs, PFAS, DBPs	

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Water Quality Results

- Preliminary results obtained from cycle 1& 2
- Lag of several weeks for lab analysis to become available
- Potable Class A source water: stable, SS above theoretical limit 0.1mg/L
- Extension of the plume did not reach the outer bores
- No water quality trigger levels have been crossed so far

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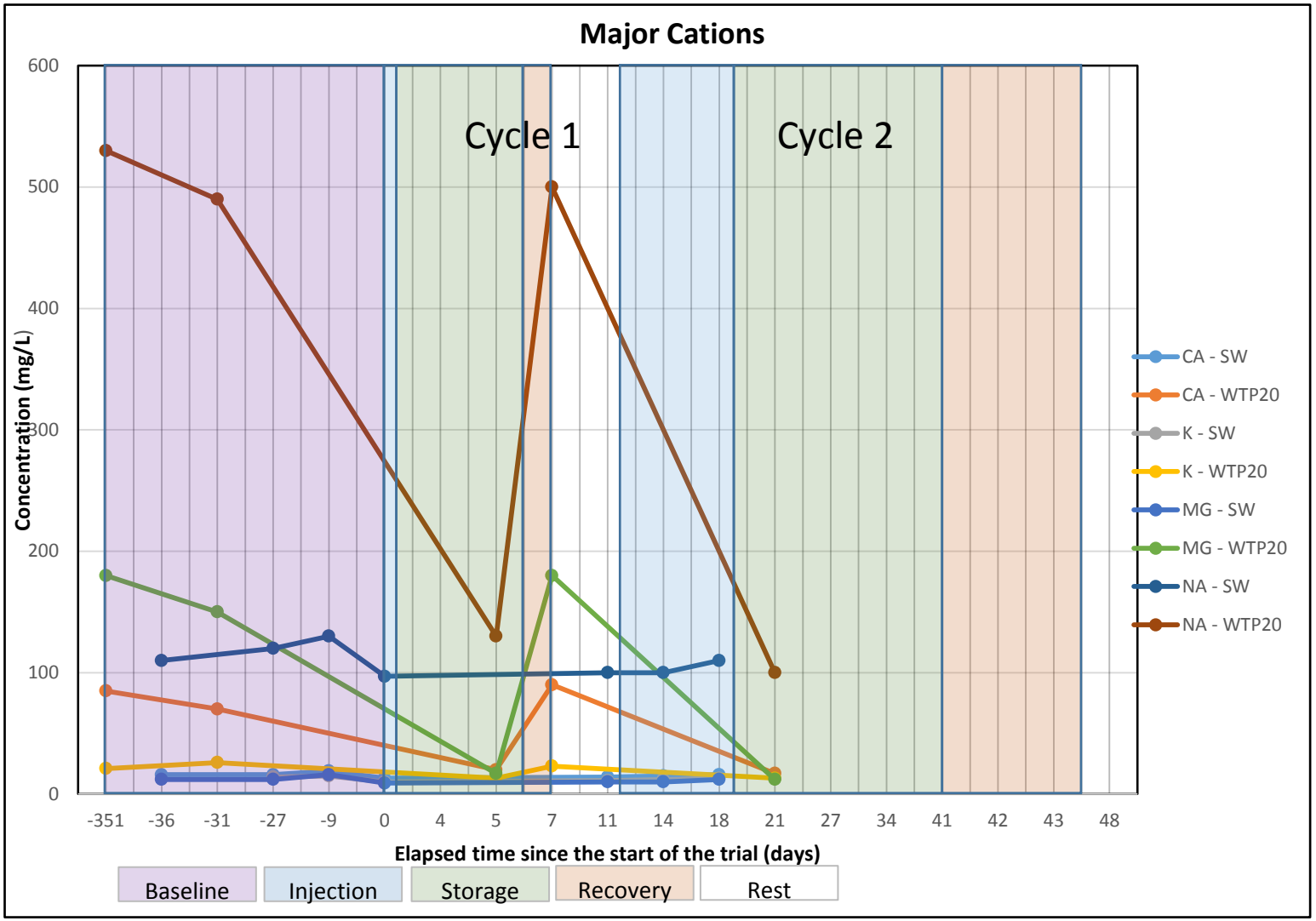

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Average values

Parameter	Units	Trial Source Water	Ambient Groundwater
Total dissolved solids (TDS)	mg/l	440	3,000
Turbidity	NTU	0-15	0-5
Nitrate	mg/l	26	0
Phosphorus	mg/l	10	0.1
DOC	mg/l	10	1
BDOC	mg/l	2.2	1.2
Ammonium	mg/l	0.01	0.8
pH		6.9	6.5
Temperature	^{O}C	17	25
Oxidation Reduction potential	E_H Volt	+0.1	-0.3
Dissolved oxygen	mg/l	8.7	0
Total Iron	mg/l	0.1	2.0
Total Managanese	mg/l	0	0.1
Arsenic	mg/l	0.001	0.002

Trigger Levels

West Werribee ASR Water Quality Trigger Parameters and Values (Cont)

Parameter (mg/L unless stated)	Injection water (salt reduced Class A) 90th %ile	Guideline values - Primary Contact Recreation	Guideline values - Stock Watering	Guideline values - Aquaculture	Proposed Trigger value	Ambiant Groundwater - West Werribee (MAX recorded)	Comment
Sodium Adsorption Ratio SAR (units)	6.8	-	-	-	-	-	no trigger value proposed
Nutrients							
Ammonia	0.42	10	-	100	10	0.95	Recreation values used
Nitrite	-	1	30	100	1	<0.01	
Nitrate	9.8	10	400	100000	10	0.03	
Organic nitrogen	-	-	-	-	-	<0.1	no trigger value proposed
Total Kjeldahl Nitrogen	-	-	-	-	-	2	no trigger value proposed
Total phosphorus	5.52	-	-	-	-	0.15	no trigger value proposed
Total Organic Carbon	-	-	-	-	-	2	no trigger value proposed
Assimilable Organic Carbon	-	-	-	-	-	1.2	no trigger value proposed
Biodegradable dissolved organic carbon					-	0.02	no trigger value proposed
Organic chemicals							
Benzene	-	10	-	-	10	not detected	Recreation values used
Benzo(a)pyrene	-	0.01	-	-	0.01	not detected	
Carbon tetrachloride	-	3	-	-	3	not detected	
1,1-Dichloroethene	-	0.3	-	-	0.3	not detected	Recreation values used
1,2-Dichloroethane	-	10	-	-	10	not detected	
Pentachlorophenol	-	10	-	-	10	not detected	
Polychlorinated biphenyls	-	0.1	-	2	0.1	not detected	Recreation values used
Tetrachloroethene	-	10	-	-	10	not detected	
2,3,4,6-Tetrachlorophenol	-	1	-	-	1	not detected	
Trichloroethene	-	30	-	-	30	not detected	Recreation values used
2,4,5-Trichlorophenol	-	1	-	-	1	not detected	
2,4,6-Trichlorophenol	-	10	-	-	10	not detected	
Turbidity and particulates							
Total suspended solids	3.2	-	-	75	-	16	no trigger value proposed, this will be heavilly influenced by sampling method and bore condition
Algae - Microcystis (cells/mL)	-	-	11500	-	11500	-	stock value used
Radionuclides							
Gross alpha (Bq/L)	-	0.1	0.5	-	0.6	0.47	**Ambient groundwater exceeds guideline values. Radionuclides not detected in Injection water.** NOTE: Drinking water guideline value is a dose of 1mSv/year. A 'worst case' ingestion volume for recycled water is 2L/yr (Based on the recycled water QMRA). The dose from this volume would be 0.001mSv/year. To obtain a dose of 1mSv/year, a volume of 1800L would need to be consumed or the radionuclide concentrations would need to be 500Bq/L. **The trigger for gross alpha and gross beta is based on ambient values + 0.1 Bq/l.**
Gross beta (Bq/L)	-	0.1	0.5	-	0.7	0.58	
Aquifer dissolution							
pH (units)		6.5-8.5	-	6 to 9	6 to 9	6.5	

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Emerging Contaminants

OMPs are to known to have low concentrations in recycled water

CWW is testing a broad range of Emerging Contaminants/Organic Micropollutants:

- Pharmaceutical, Hormones, and Personal Care Products (PPCPs)
- Per-and Poly-Fluoroalkyl PFAS
- 1,4-Dioxane[New]
- DBPDs

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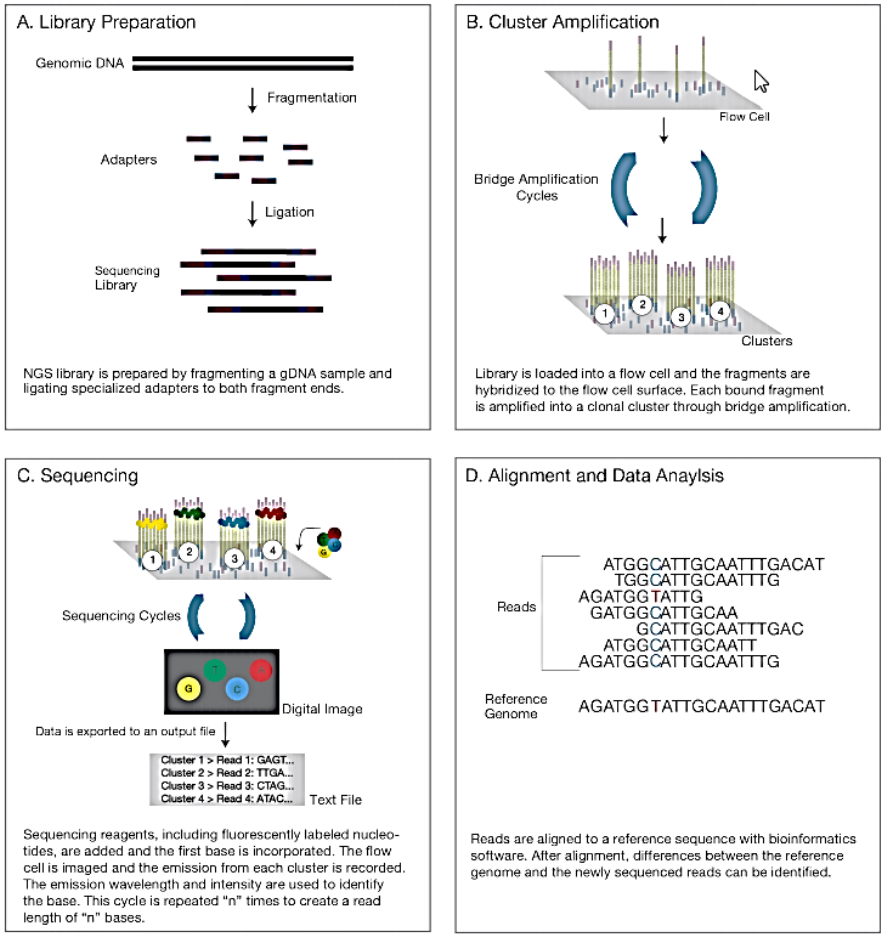
Next Generation Sequencing- NGS



NGS techniques can be used to understand microbial composition of a water sample

DNA sequencing technology has been instrumental in the sequencing of complete DNA sequences or genomes of numerous types and species of life, including microbial species in ambient groundwater and other sources

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illumina®

		Total		5283651.16S	5288151.16S
Legend	Taxonomy	count	%	%	%
	Unassigned;Other;Other	0	1.4%	1.4%	1.4%
	k__Archaea;p__Crenarchaeota;c__MCG	0	0.0%	0.0%	0.1%
	k__Archaea;p__Euryarchaeota;c__Methanobacteria	0	0.0%	0.0%	0.0%
	k__Archaea;p__Euryarchaeota;c__Methanomicrobia	0	0.0%	0.0%	0.1%
	k__Archaea;p__[Parvarchaeota];c__[Parvarchaea]	0	0.0%	0.0%	0.1%
	k__Bacteria;Other;Other	0	0.1%	0.0%	0.2%
	k__Bacteria;p__;c__	0	0.4%	0.0%	0.7%
	k__Bacteria;p__Acidobacteria;c__Acidobacteria-6	0	0.0%	0.0%	0.0%
	k__Bacteria;p__Acidobacteria;c__Holophagae	0	0.2%	0.0%	0.5%
	k__Bacteria;p__Acidobacteria;c__Solibacteres	0	0.9%	1.8%	0.0%
	k__Bacteria;p__Acidobacteria;c__[Chloracidobacteria]	0	0.0%	0.0%	0.0%
	k__Bacteria;p__Actinobacteria;c__Acidimicrobiia	0	0.0%	0.0%	0.0%
	k__Bacteria;p__Actinobacteria;c__Actinobacteria	0	1.3%	2.6%	0.0%
	k__Bacteria;p__Actinobacteria;c__Thermoleophilia	0	0.0%	0.0%	0.0%
	k__Bacteria;p__BRC1;c__PRR-11	0	0.1%	0.2%	0.0%
	k__Bacteria;p__Bacteroidetes;c__Bacteroidia	0	3.3%	0.0%	6.6%
	k__Bacteria;p__Bacteroidetes;c__Cytophagia	0	0.2%	0.3%	0.0%
	k__Bacteria;p__Bacteroidetes;c__Flavobacteriia	0	1.8%	3.5%	0.0%
	k__Bacteria;p__Bacteroidetes;c__[Saprospirae]	0	0.2%	0.4%	0.0%
	k__Bacteria;p__Chlorobi;c__	0	0.1%	0.0%	0.1%

- Taxonomic composition of bacteria and description of microbial communities
- Differences between various groundwater types
- Microbial population description during different stages of the trial
- Identification of microorganisms for clogging evaluation
- Efficacy of disinfection, shock chlorination
- Comparison of different methodologies i.e. Lumin test

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Aquifer/bore pressure monitoring program

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Pressure Monitoring Objectives

- Aquifer parameters, gradients
- Performance of the bores
- Monitor impacts on groundwater users and environmental impacts

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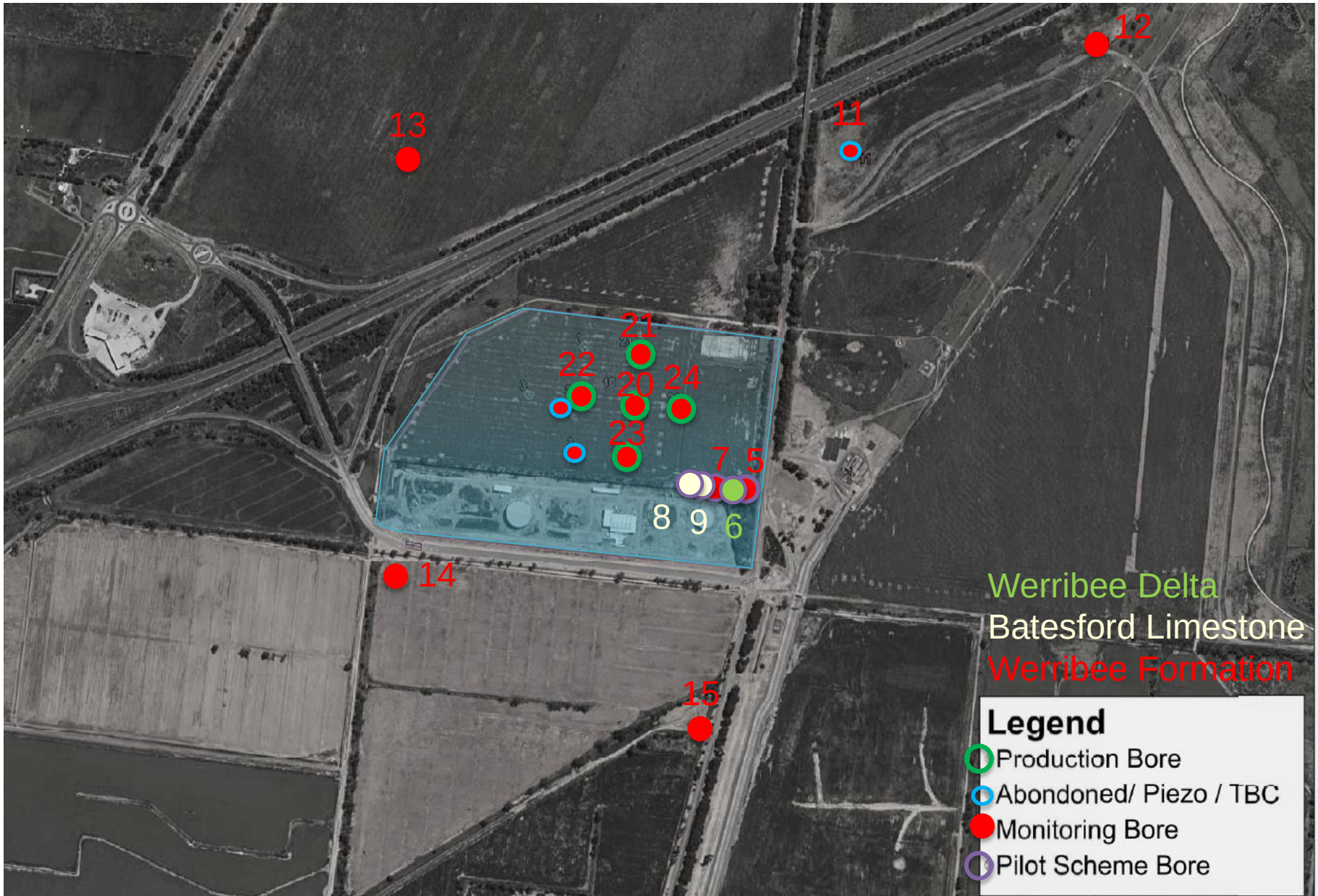
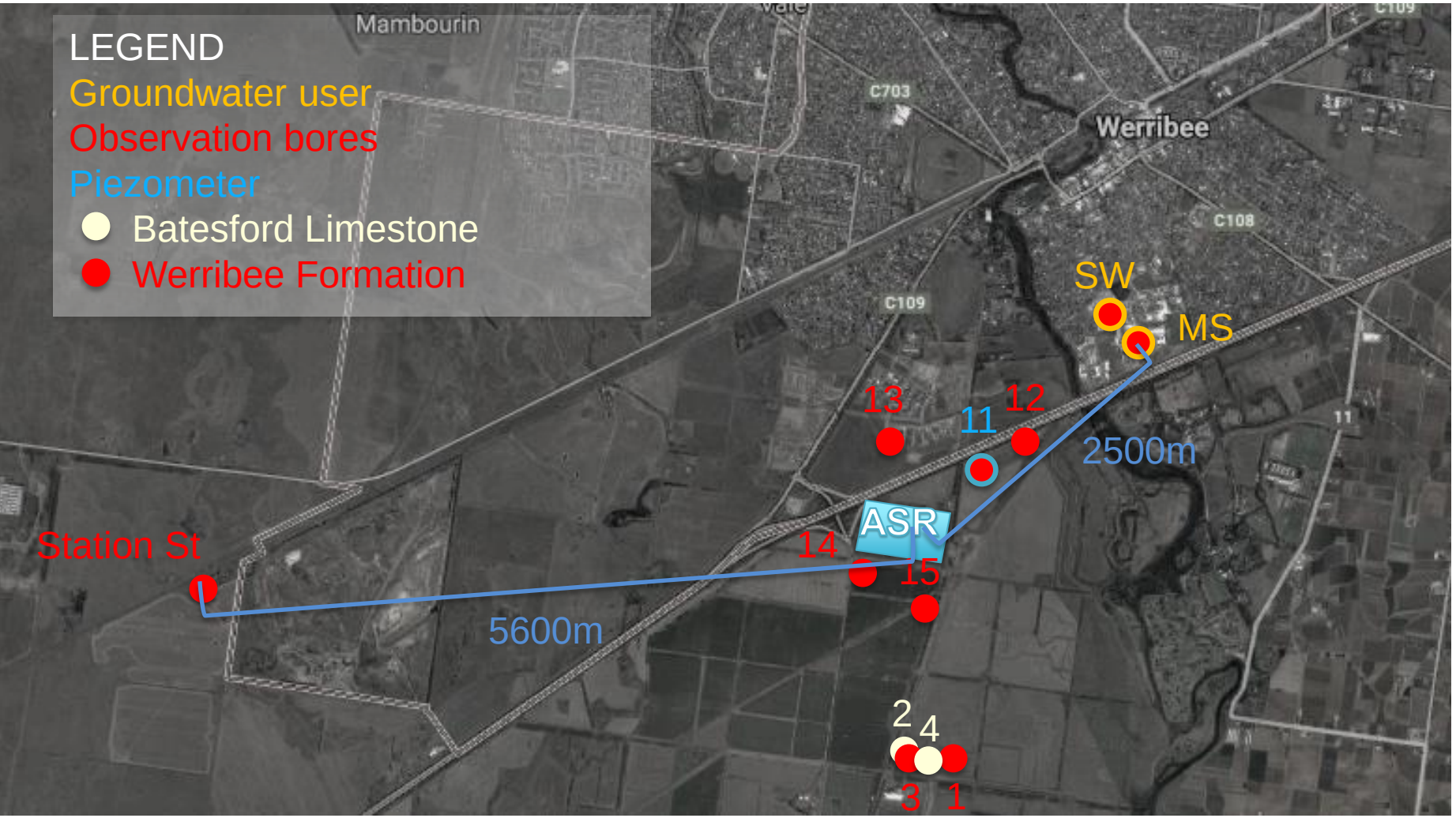
Water pressure monitoring network

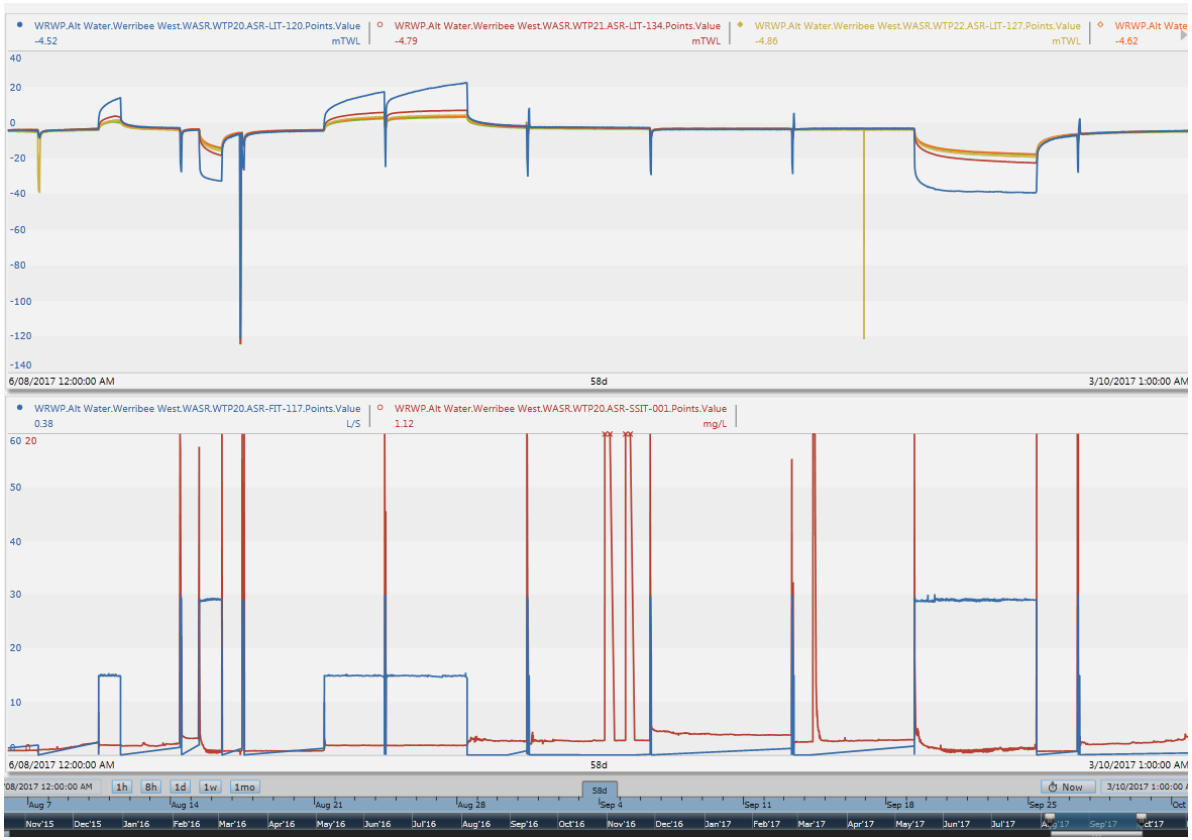


Water pressure monitoring network



Data collection methods

- Manual dipping
- Level loggers
- Multi-parameter probes
- Pressure gauges
- Telemetry



Trigger levels

Agreed with stakeholders
Early warning signs of changes
Limit drawdown impact on GWU
Communication with stakeholders

Bore ID	Aquifer	Potential Hazard	*Trigger level
MS-1	Werribee Formation	Extra drawdown or artesian conditions at licensed bores.	2m below lowest background level on record
WTP11	Werribee Formation	Extra drawdown or artesian conditions at Statewide and Mainstream licensed bores.	2m above the highest background level on record
WTP12			
WTP20	Werribee Formation	Excessive impressed head which could fracture the formation	Impressed head limit of 100m above ground level
WTP6	Werribee Delta	Pressure and/or water quality impacts on overlying aquifers and the environment	2m below the minimum background level on record (drawdown)
WTP9	Batesford Limestone	Impacts on overlying aquifers and the environment	2m above highest background level on record (impressed head)
PZ01	Fyansford Formation	Impacts on overlying aquifers and the environment	
PZ02	Brighton Group	Impacts on overlying aquifers and the environment	
77033	Werribee Formation	Artesian conditions leading to groundwater dicharge	2m above highest background level on record (impressed head)

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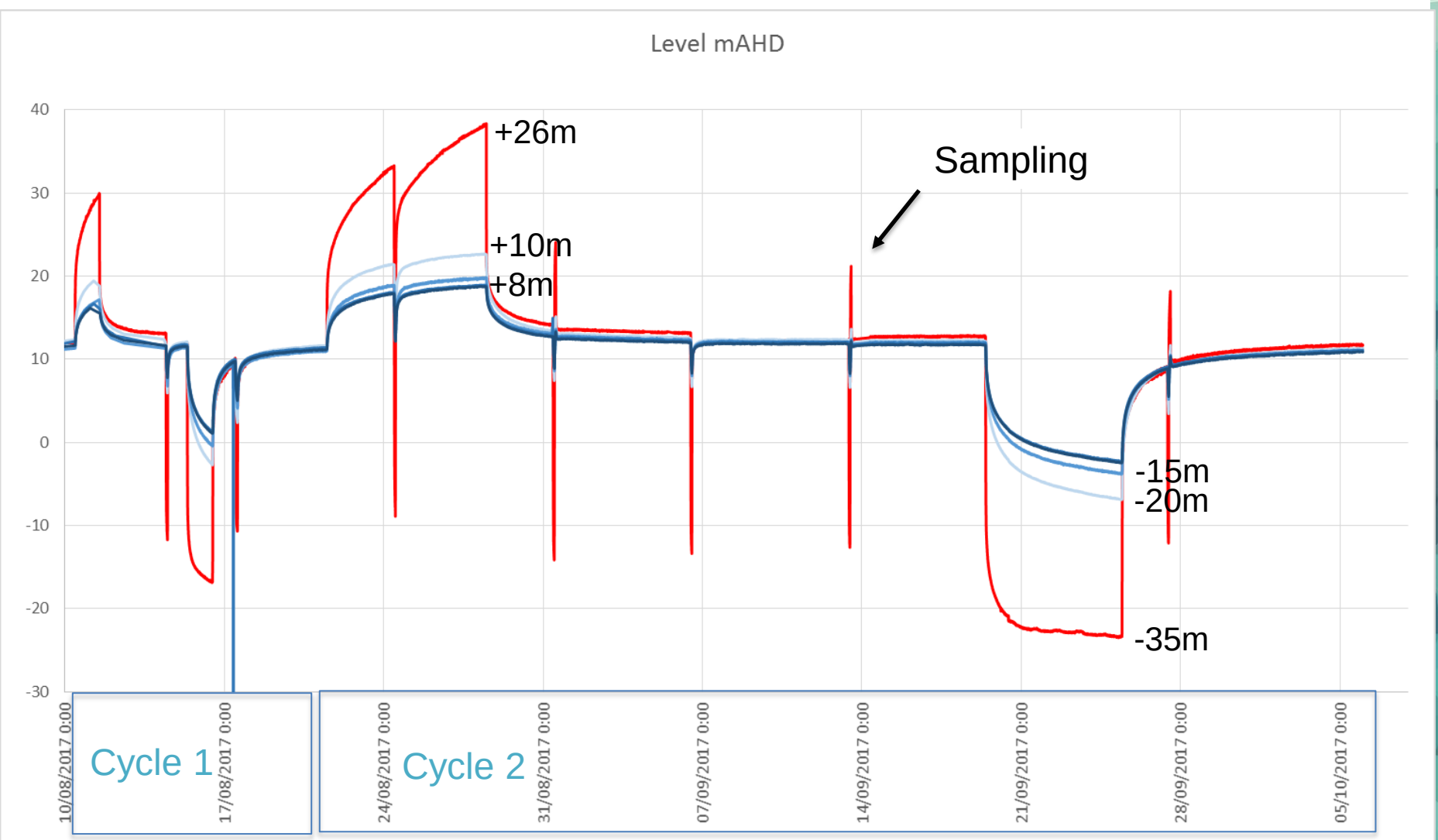
Pressure Monitoring – production bores



Central bore

WTP20

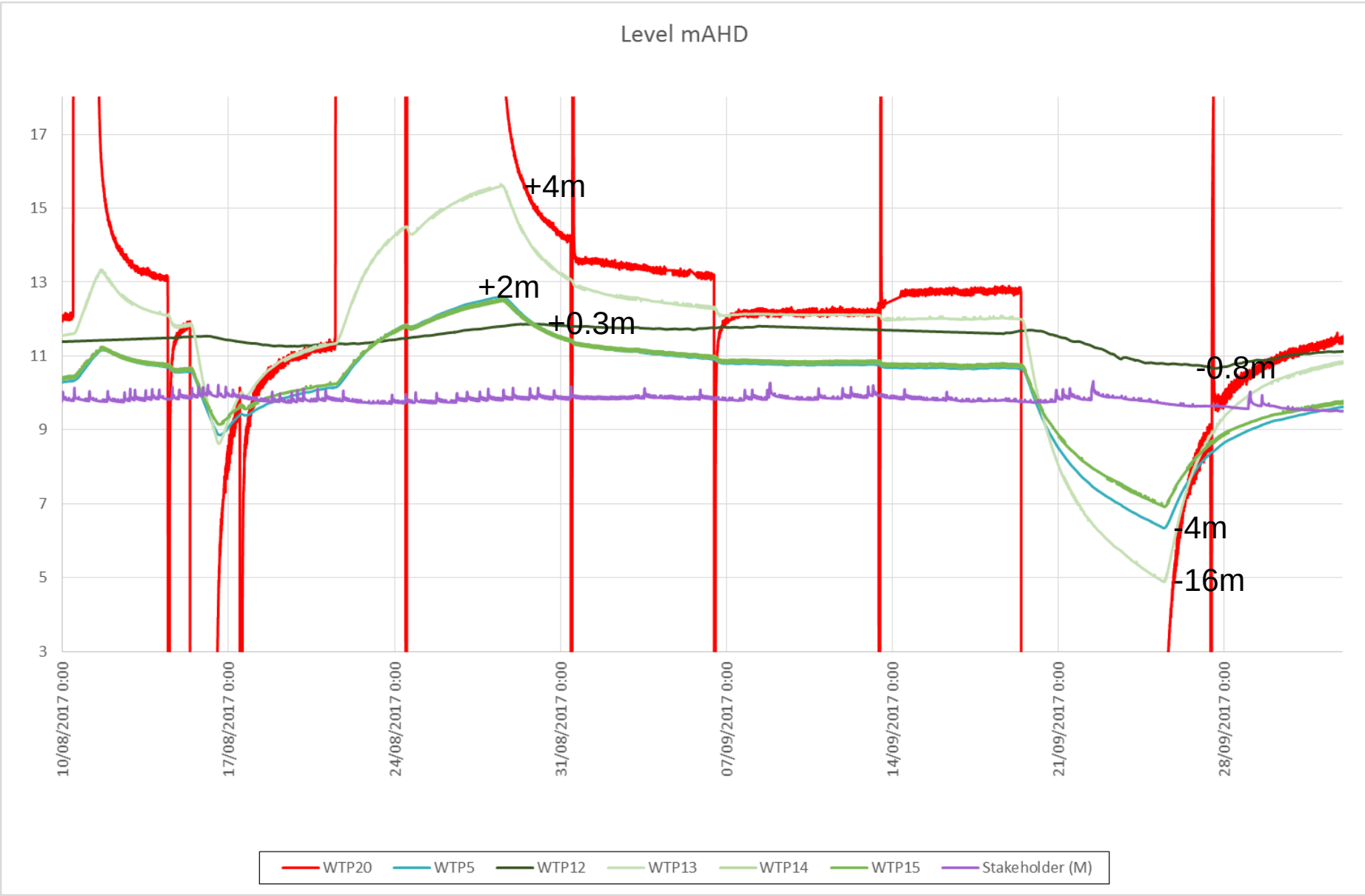
Outer bores

WTP21 WTP22 WTP23 WTP24

Injection 15L/s

Extraction 30L/s

Pressure Monitoring



Clogging

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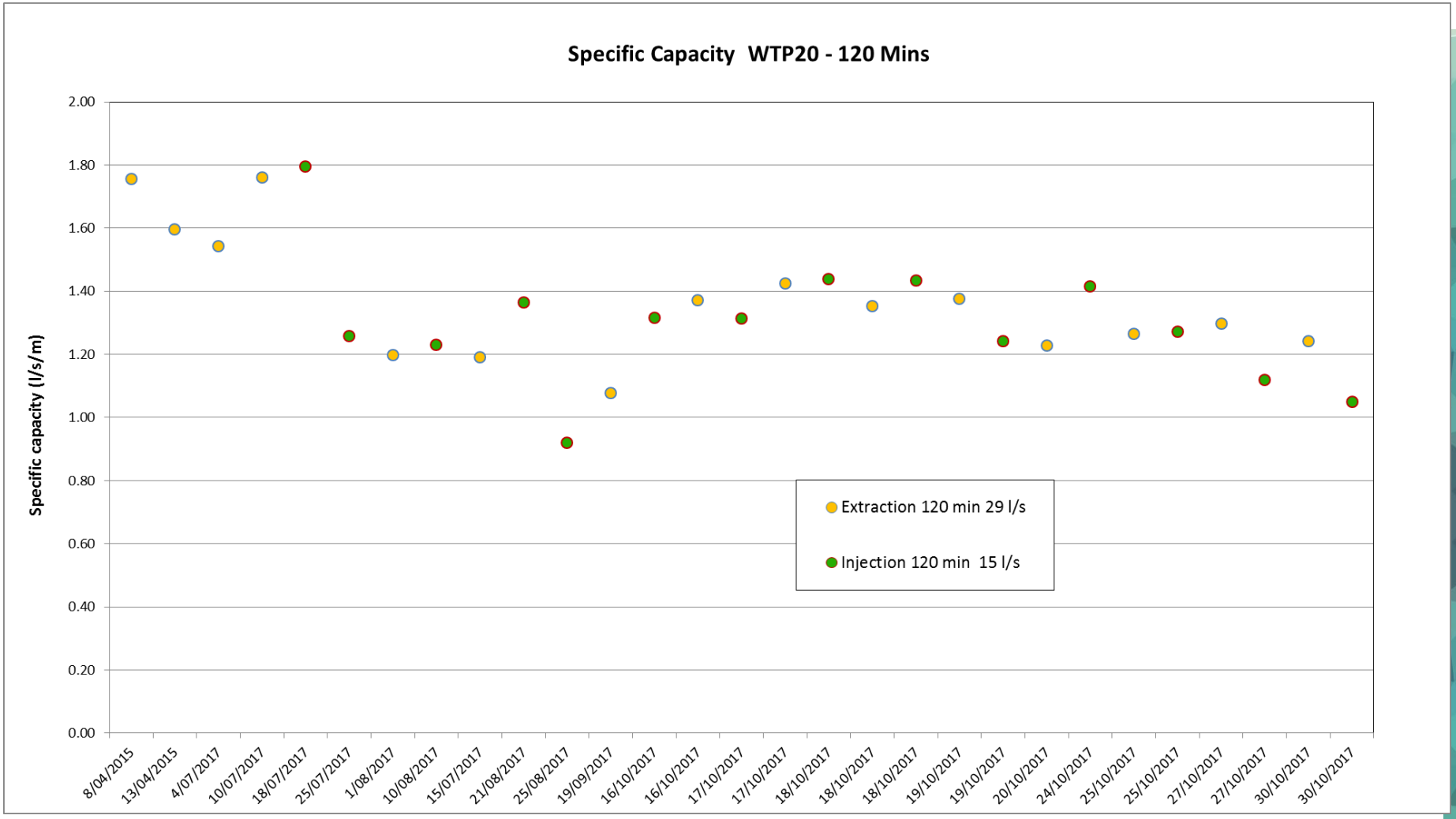

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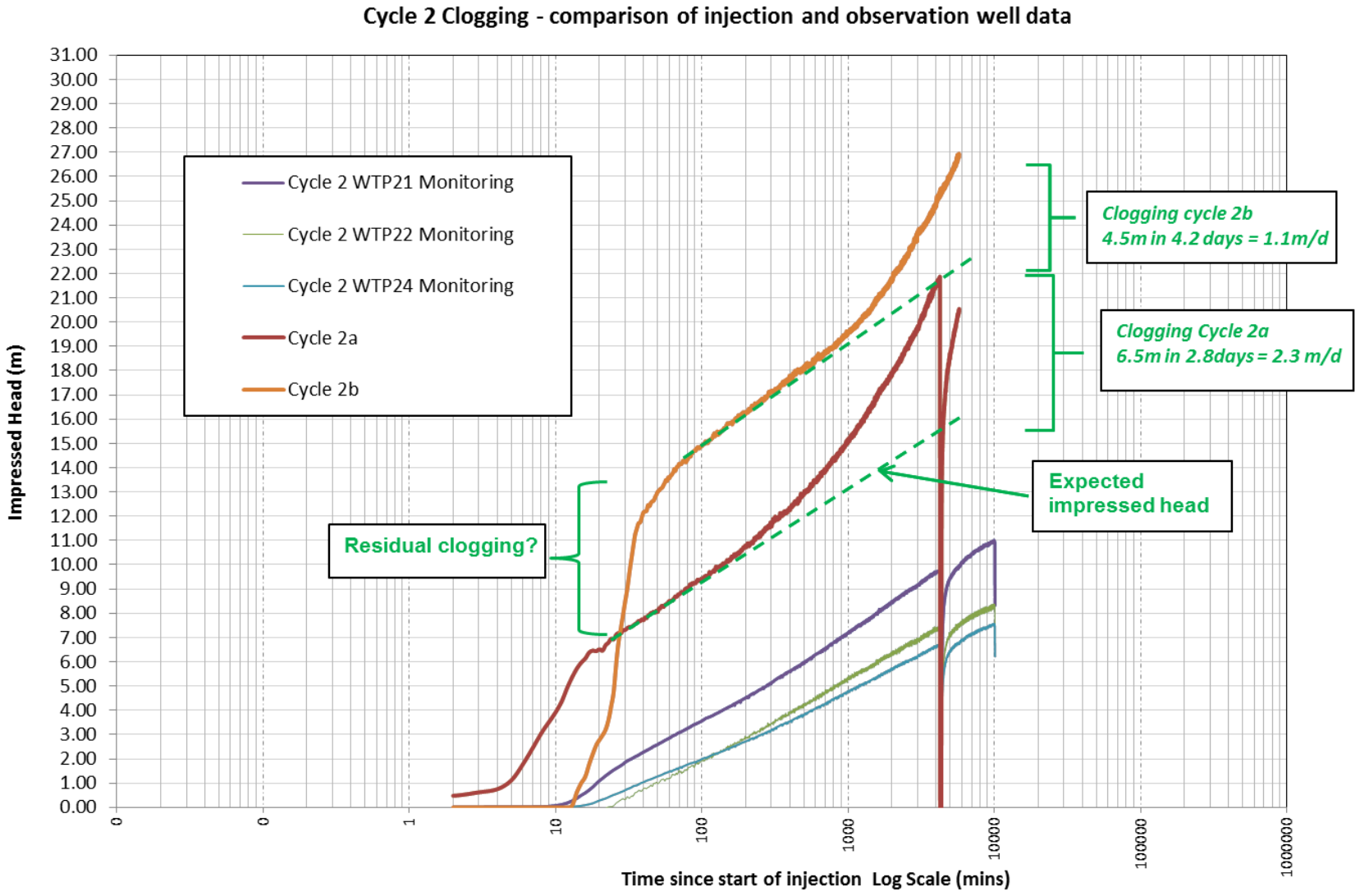

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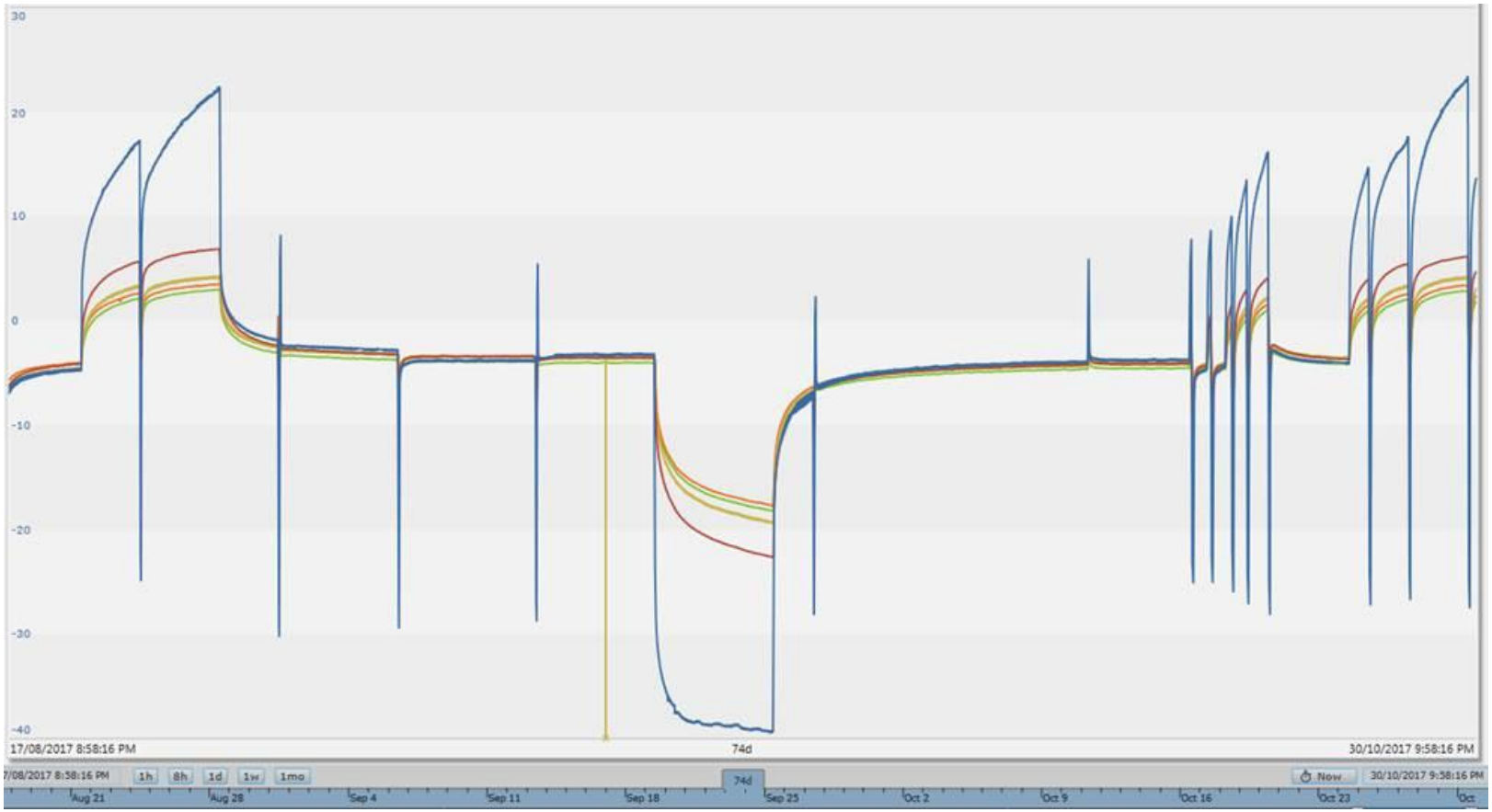
Cycle 2 and 3 – current status



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Conclusions

- ASR is an innovative water management technology which can provide a relatively low cost water storage to help meet future growth in the West. The technology is adaptable and can improve water resource and supply resilience.

- Results to date are positive, but some aspects need to be better quantified and managed

- Operational trialling will be key to quantifying key risk factors and determining any additional infrastructure requirements, and the optimal operating regime.

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