CSIRO

CSIRO AquaWatch Mission

Thursday 28 September

10.00am - 4.30pm

PROCEEDINGS

End User Consultation Workshop:
HABs Early Warning and Forecasting

End Users views and expectations
Moving from Thresholds to impact based forecasting

Zoom meeting, Program & Abstract Booklet link

Proudly supported by WaterRA

Water Research AUSTRALIA

AquaWatch Mission End User Consultation Workshop: HABs Early warning and forecasting

Date: Thursday, 28 September 2023 (Day 3| 8th ANZ Cyanobacteria Workshop)

Time: 10 AM – 4.30 PM (AEST)

Venue: Department of Civil Engineering, Monash University

Hybrid Event: Join online at CSIRO AquaWatch ZOOM or go to Monash University and enter meeting ID: **882 0238 9318** and passcode: **224390**

Background

Many inland water bodies in Australia and around the globe experience harmful algae blooms that can impede with public health, since many of them supply for domestic water and agriculture. In Australia, water from reservoirs is mainly used for human, industrial and stock needs, irrigation, recreation, flood mitigation and hydroelectricity, demonstrating the significant socioeconomic impact that water quality outbreaks might incur.

The CSIRO AquaWatch Australia Mission supported by Foundation Partner, SmartSat CRC, aims to provide a routine, continental scale inland and coastal water quality information, including cyanobacteria detection and forecasting for major water bodies across the continent. In collaboration with partners, the mission team has begun testing the AquaWatch system concept by establishing several pilot trials across the globe for developing a 24/7 water quality information system using on-ground-and-satellite sensors for measuring real-time water quality data, predictive modelling, and data integration and analytics platform. When fully operational, it will enhance situational intelligence for water regulators, emergency planners, water related industry professionals and local communities.

Workshop overview

The AquaWatch Mission aims to establish a complete value chain linking science with the water sectors actual needs and therefore is keen for an ongoing comprehensive consultation process with end users, traditional custodians, scientists and water professionals, ensuring the co-development of added value, intelligent products and services for HABs early warning and predictive management. This workshop intends to continue discussion on possible ways of re-purposing short to medium term water quality forecasts into an early warning service for HAB outbreaks.

Objectives

- Inform local/regional stakeholders on the current research of AquaWatch projects and demonstrate an early version of the operational forecasting service for inland freshwater systems
- Share experiences from managing HAB related risks in Australian freshwaters
- Discuss how forecast-based early warning services for HABs can improve risk management
- Identify expectations of end-users from AquaWatch Mission information services

Participants

- Representatives from local and regional water utilities, water authorities, water managers, federal and state gov agencies, traditional custodians (cultural water), researchers and water professionals.

Online Joining Link:

Please click this URL to start or join.
https://monash.zoom.us/j/88202389318?pwd=eU5yMVRXZzlVTWhYRHdUVndmSjg4UT09 or go to https://monash.zoom.us/join and enter **meeting ID: 882 0238 9318** and **passcode**: **224390.**
Ensure your device has a dedicated microphone and webcam.

****Please do not share these details with those not on the participant list****

For further information, please contact Dr Tapas Biswas (CSIRO).

AquaWatch Workshop Program **Thursday 28 September**

TIME (AEST)	Session I: Opening & Update on AquaWatch Mission	Alex Held (Chair), AquaWatch Mission Lead, CSIRO (Chair)
10.00	Welcome	Alex Held – CSIRO
10.05	Workshop objectives, structure and feedback tool ONLINE TOOL: https://join.groupmap.com/3D2-E42-88E	Tapas Biswas – CSIRO
10.15	Development of the AquaWatch Australia system	Alex Held
10.30	Application and development of EO sensors	Tim Malthus – CSIRO
10.45	Pilot projects in AquaWatch Australia	Nagur Cherukuru – CSIRO
11.00	AquaWatch Data Integration and Analytics Systems	Rob Woodcock – CSIRO
11.15	Introducing EO-based forecasting services for hydro-ecological hazards reduction in freshwater systems.	Apostolis Tzimas – EMVIS, Greece
11.30	The operational PrimeWater platform for short-term hydro-ecological forecasting in freshwater reservoirs	Evangelos Romas – EMVIS, Greece
11.45	Update on communications and engagement for AquaWatch Australia	Maigan Thompson & Flora Kerblat – CSIRO
12:00	LUNCH BREAK	
	Session II: End users/stakeholders views and expectations	Nick Crosbie (Chair), Melbourne Water
13.00	How satellite technology can help Melbourne Water to manage and improve water quality	Nick Crosbie – Melbourne Water
13.15	Making use of various technologies for detecting blue-green algae in NSW and reporting the risks to the water users	Gerhard Schulz – Water NSW
13.30	Hunter Water and the Aquawatch Mission	Andrew Olrich – Hunter Water
13.45	Status of research into blue-green algae in Canberra’s urban lakes	Ralph Ogden – ACT Govt
14.00	Cyanobacteria and more cyanobacteria – Dealing with ongoing cyanobacterial challenge	David Cook – SA Water
14.15	Wetlands and water quality management: Sydney Olympic Park experience	Swapan Paul – Sydney Olympic Park Authority
14.30	Future research, development and innovation for HABs	Arash Zamyadi – Monash Uni
14.45	Discussion	
15.00	AFTERNOON TEA BREAK	
	Session III: Moving from thresholds to impact based forecasting	
15.15	End Users expectations – Round Table discussion. Online Feedback Tool: END USER preferences for AquaWatch services for HABs	Arnold Dekker – CSIRO (Lead) Tapas Biswas & Samuela Guida – IWA (UK)
16.15	Closing remarks	Alex Held – CSIRO
16.25	Vote of thanks and workshop close	Tapas Biswas – CSIRO

AquaWatch Mission End User Consultation Workshop:

HABs Early warning and forecasting

Thursday, 28th September 2023

10:00 AM – 16:30 PM AEST

Department of Civil Engineering
Monash University, Melbourne

CSIRO

Water Research AUSTRALIA

SMARTSAT Cooperative Research Centre

https://monash.zoom.us/join. Meeting ID: **882 0238 9318** and passcode: **224390**

Program

Time	Item	Responsible
10.00 – 12.00	**Session I:** Welcome, objectives and update on AquaWatch Mission	AquaWatch Team (7 speakers)
	• Welcome • Workshop objectives, structure and feedback tool ONLINE TOOL: https://join.groupmap.com/3D2-E42-88E	Alex Held - CSIRO AquaWatch Mission Tapas Biswas – CSIRO AquaWatch Mission
	• Update on AquaWatch Mission	AquaWatch Team (7 speakers)
12:00-13:00	LUNCH BREAK	
13.00 – 15.00	**Session II:** End users/stakeholders views and expectations	END USER presentations (7 speakers)
15.00 – 15.15	AFTERNOON TEA BREAK	
15.15 – 16.15	**Session III:** Moving from thresholds to impact based forecasting: • End Users expectations – Round Table discussion • Online Feedback Tool: END USER preferences for AquaWatch services	Arnold Dekker – AquaWatch Mission (Lead) Samuela Guida (IWA), Tapas Biswas
16.15 – 16.25	Closing remarks	Alex Held - CSIRO AquaWatch Mission
15.25 – 16.30	Vote of thanks and workshop close	Tapas Biswas – CSIRO AquaWatch Mission

Session I: Opening & Update on AquaWatch Mission

Welcome	*Alex Held*
Workshop objectives, structure and ONLINE FEEDBACK TOOL: https://join.groupmap.com/3D2-E42-88E	*Tapas Biswas*

Objectives of the workshop

This workshop intends to initiate a discussion on short to medium-term water quality forecasts into an early warning service for HAB outbreaks.

The main objectives of the workshops are:

- Inform local/regional stakeholders on the current research of AquaWatch projects and demonstrate an early version of the operational forecasting service for inland freshwater systems
- Share experiences from managing HABs related risks in Australian freshwaters
- Discuss how forecast-based early warning services for HABs can improve risk management
- Identify expectations of end-users from AquaWatch Mission information services

Update on AquaWatch Mission
Chair: Alex Held, AquaWatch Mission

10.15	Development of the AquaWatch Australia system	Alex Held
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AquaWatch END USER Workshop
LUNCH BREAK: 12.00 – 13.00

Session II: End users/stakeholders views and expectations

Chair: David Cook, SA Water

13.00	How satellite technology can help Melbourne Water to manage and improve water quality	Nick Crosbie – Melbourne Water
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Break

Session III: Moving from thresholds to impact based forecasting

Chair: Arnold Dekker, AquaWatch Mission

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Roundtable discussions

Key points to be considered in the discussion:

1. Current and future issues with freshwater HABs
2. User needs (AquaWatch early detection, monitoring and forecasting), what are missing?
3. Decision and management tools- application for endusers
4. User friendliness, reliability and confidence
5. Economic aspects: cost/benefit

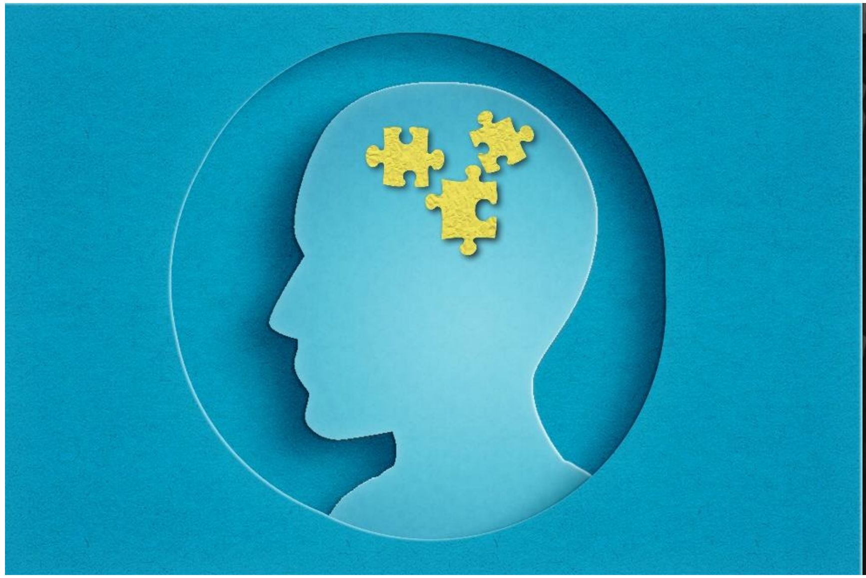
User preferences for AquaWatch services

- This survey contributes to the AquaWatch Mission's Water Quality information services and it is targeted to **anyone interested in water quality monitoring and forecasting services**.

- It will also contribute to our understanding on **social and institutional attributes to the adoption of AquaWatch services in decision-making**.

- *Anonymous questionnaire*

Closing Remarks and vote of thanks



Workshop Abstracts & Presentations

Session – I @ 10:15 AEST

1. Update on Development of the AquaWatch Australia system

Alex Held*

*Lead presenter, alex.held@csiro.au
CSIRO Space and Astronomy, Canberra

Key words: water quality, Earth Observation, in-situ sensing, data analytics

Abstract:
AquaWatch Australia will establish an integrated ground-to-space national water quality monitoring and forecasting system, to help safeguard our freshwater and coastal resources. We will present an early progress update on the implementation of the AquaWatch Australia Mission, its key technical elements and forward plans.

AquaWatch Australia

A ‘weather service’ for water quality

Australia’s National Science Agency

I would like to begin by acknowledging the Traditional Owners of the land that we're meeting on today, and pay my respect to their Elders past and present.

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Ambition: Water Quality is a Global Challenge

SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD

Sediments & Floods

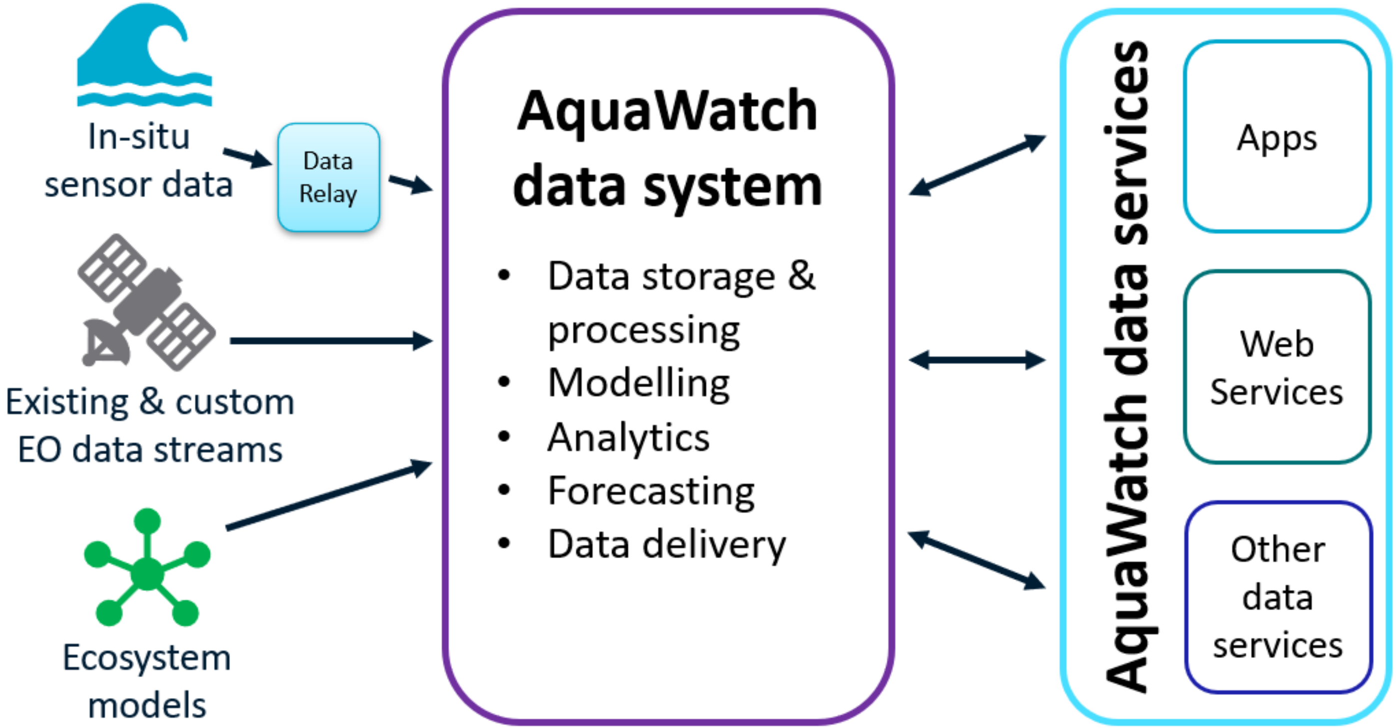
Fish-kill events

Sewage/Pollution

Harmful Algae Blooms

3 Billion people world-wide don’t have access to clean water and sanitation

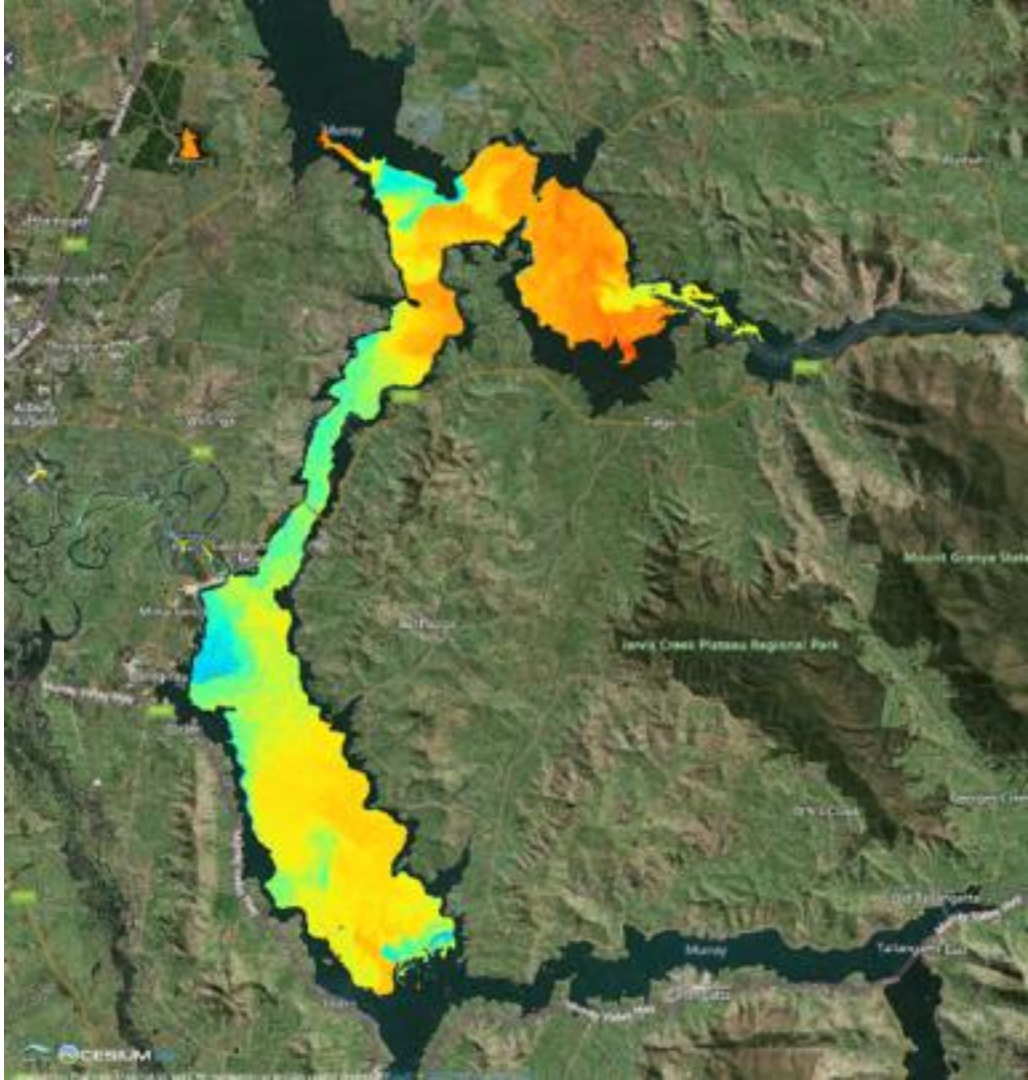
AquaWatch Technical Elements



CSIRO Scope of AquaWatch

- **Technology Element** for space-to-ground water quality monitoring and forecasting, with key milestones in 2026 and 2030.

- **Research program**, for continuous improvement, with aligned R&D and support for growth in the user base.



Australian Pilot Sites

Keppel Bay/Fitzroy River (QLD)
Objective: Estimate sediment and carbon fluxes flowing from Fitzroy river into Keppel Bay region, and their impact on GBR region coastal water quality.

Moreton Bay (QLD)
Objective: To integrate and visualise multiple space and ground-based sensor data streams, combined with hydrodynamic model outputs to understand the link between water quality changes and white spot disease.

Lake Hume (NSW)
Objective: To demonstrate a 'ground-to-space water quality monitoring and forecasting tool' for toxic algal bloom detection and mapping.

Cockburn Sound (WA)
Objective: Integrated in situ and remote sensing approach to study water quality response to coastal infrastructure development.

Spencer Gulf (SA)
Objective: Demonstrate the integrated use of data derived from in-situ sensors and Earth Observation satellites to support environmental monitoring and sustainable growth of the aquaculture industry.

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Global Pilot Sites

In-situ Sensor Network and Dashboard Development : e.g.HydraSpectra & Senaps

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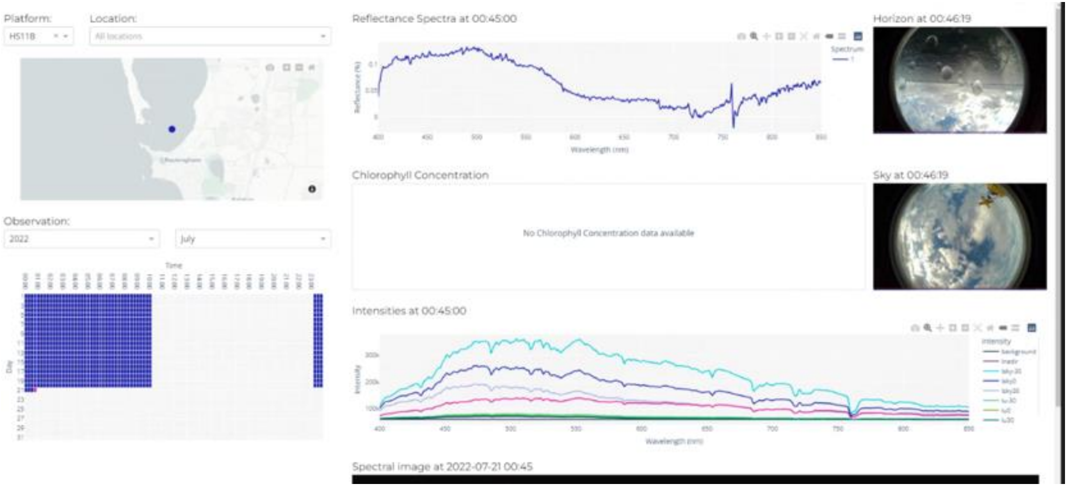
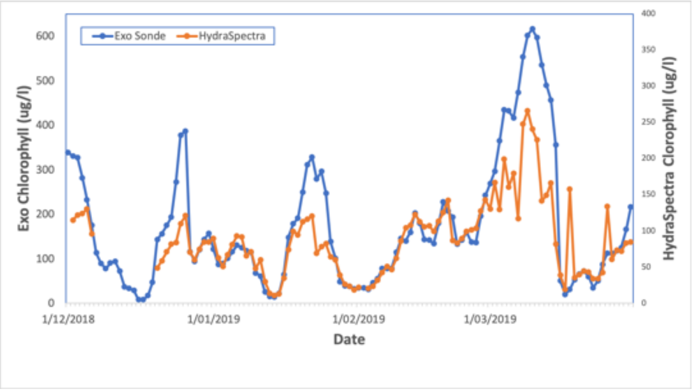


- Hydraspactra Developed by CSIRO) measures above-surface reflectance to support continuous:
  - Algal bloom alerting
  - Water quality monitoring
  - Satellite validation
- Patented technology, low cost, low maintenance
- **Senaps** is a CSIRO-developed Internet of Things (IoT) Application Enablement and Data Management tool commercialised by Eratos



HydraSpectra Mk IV

CSIRO

Pilot Site Instrumentation Stations for In-situ Water Quality Measurement and Satellite Data Validation

Instruments include:

- CSIRO Hydraspectra
- TriOS Ramses E_d, L_{sky} and L_w
- Pan/tilt unit
- Weather station
- Cameras horizontal and forward-looking
- Water temperature (below surface & 2 depths (4/8m)

HydraSpectra Mk IV

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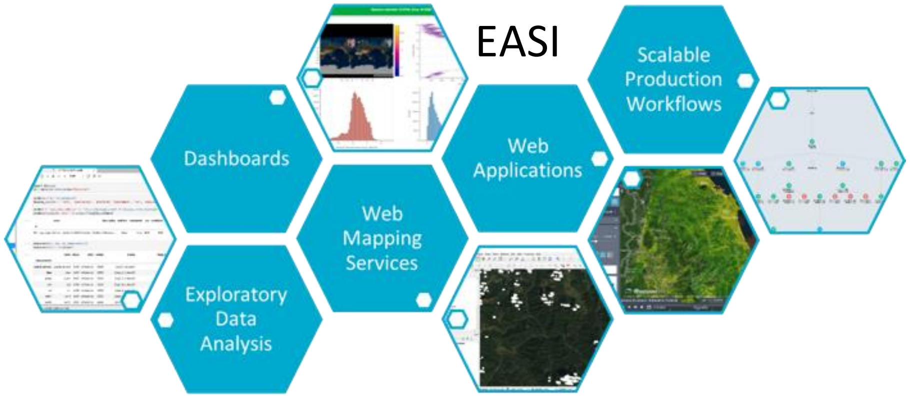
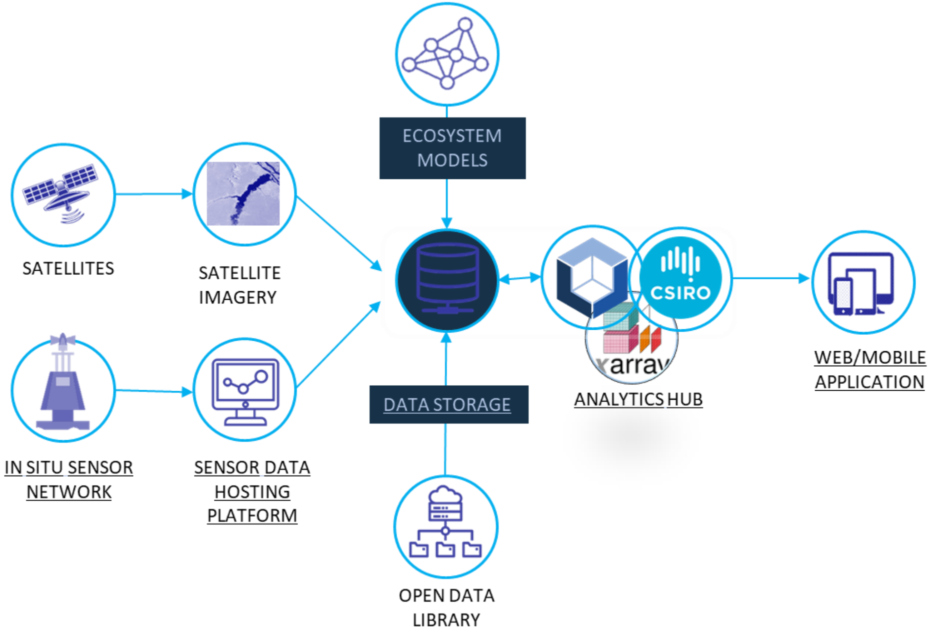
Multi-sensor Data integration and analytics





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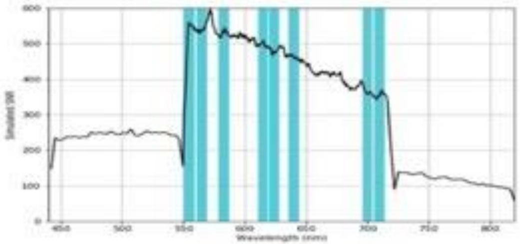
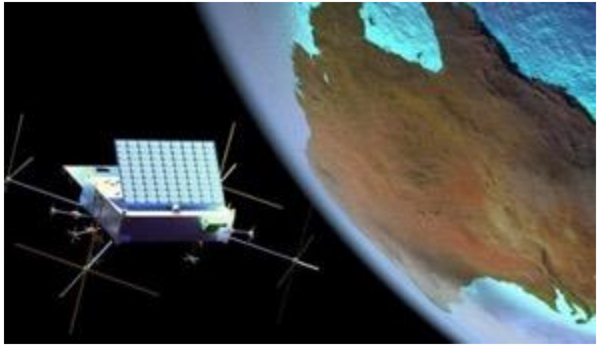
AquaWatch Satellite Sensor Development
CyanoSens Payload – Launched June '23

This project has built and delivered a payload imager suitable for flight on a standard satellite bus specifically designed for detection of cyanobacterial algal blooms.

The payload will have a 3U form factor and will be ready for integration into a variety of industry standard satellite buses for launch.



High signal to noise ratio in critical bands



Specification	Value
Volume	3U (300 x 100 x 100 mm)
Nominal Orbit	560 km SSO
GSD*	50 m
Across Track Swath*	24 km
SNR**	60 – 110 across spectral range
Polarisation Sensitivity	< 6 %
Spectral Range	500 – 780 nm
Spectral Resolution	12 - 15 nm
Power	25 W peak
Interface	Serial & Ethernet
Storage & Processing	1 TB with on-board processing capabilities

* At nominal altitude
** For a typical water leaving radiance

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'AquaSAT-1' a CSIRO – JPL Collaboration

Payload Overview

Overall Housing Dimensions

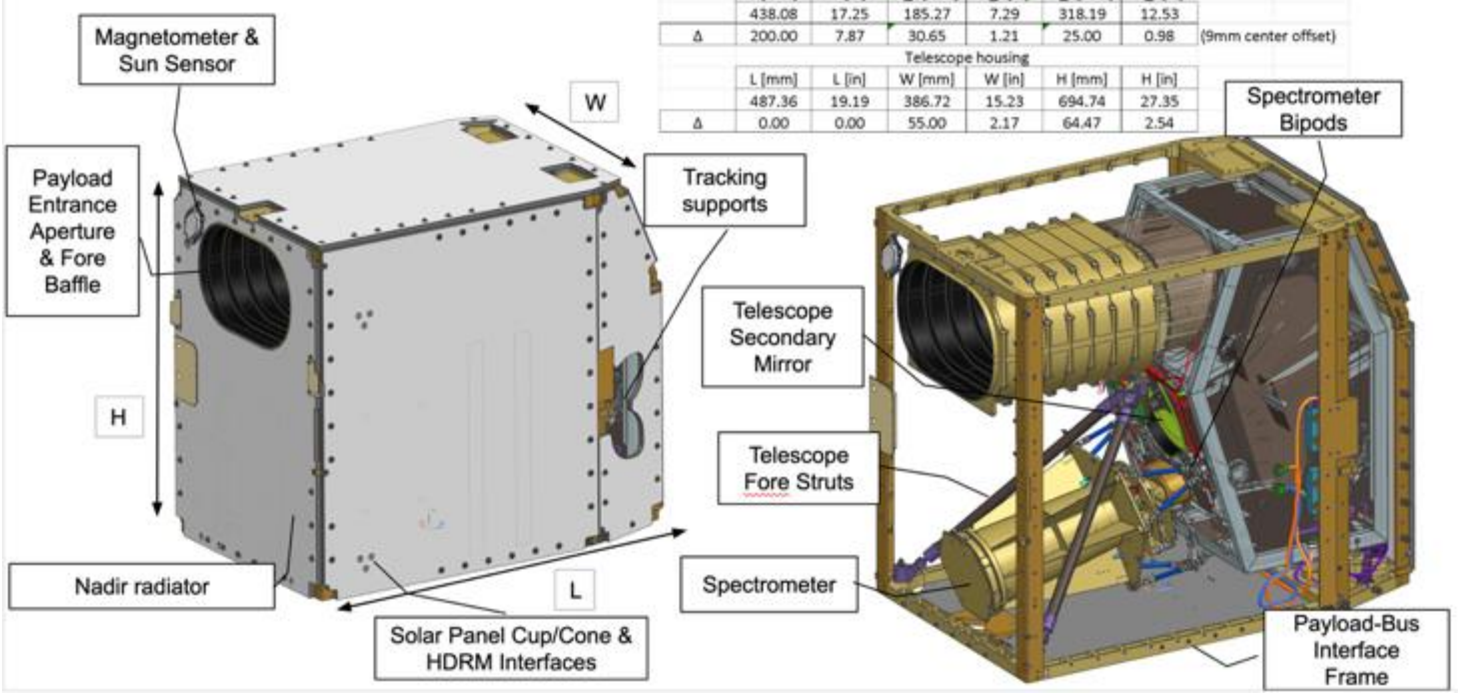
	L [mm]	L [in]	W [mm]	W [in]	H [mm]	H [in]	Mass(kg)	Mass(lb)
	941.85	37.08	602.30	23.71	819.92	32.28	74.33	163.86
Δ	199.60	7.86	55.00	2.17	64.47	2.54	2.44	5.39

Spectrometer overall dimensions

	L [mm]	L [in]	R_r [mm]	R_r [in]	R_f [mm]	R_f [in]	
	438.08	17.25	185.27	7.29	318.19	12.53	
Δ	200.00	7.87	30.65	1.21	25.00	0.98	(9mm center offset)

Telescope housing

	L [mm]	L [in]	W [mm]	W [in]	H [mm]	H [in]
	487.36	19.19	386.72	15.23	694.74	27.35
Δ	0.00	0.00	55.00	2.17	64.47	2.54



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Thank you

Australia's National Science Agency

CSIRO Space & Astronomy
Dr Alex Held

Lead, AquaWatch Australia
Director, Earth Observation Infrastructure

alex.held@csiro.au
csiro.au/en/about/challenges-missions/AquaWatch

Session – I @ 10:30 AEST

2. Application and development of EO sensors

Tim Malthus*

*tim.malthus@csiro.au
CSIRO Environment and AquaWatch Mission

Key words: water quality, AquaWatch Australia, sensors, early warning, decision making

Abstract:
A fundamental element of the AquaWatch Australia Mission is the integrated observations that will be obtained from a diverse range of sensors, in the form of those deployed in situ sensor as well as those deployed in space. For the mission, this integration should realise a step change in monitoring of water quality in Australia's water bodies both at large scale and in a timely manner. Key characteristics required for a nationwide in situ water quality monitoring sensor network include a) cost-effectiveness to both construct and operate; b) maintainability, and c) timely, robust and credible data to integrate with other data sources to address decision making needs.

An Internet of Things (IoT) solution is perhaps seen as the most cost-effective approach to deliver ubiquitous and autonomous sensing across wide spatial and temporal scales, but to date the research only highlights localised examples. Similarly, reliable and cheap water quality sensors suitable for IoT adoption remain largely in the research domain. New sensors will also need to be innovatively and robustly constructed for IoT systems characterised by resource constraints: in communication capabilities, energy, processing capabilities and limited data storage.

The talk will review key challenges in sensor development and progress that CSIRO teams have been making towards these objectives in both the development of in situ and space borne experimental sensors. Results from pilot projects s in a number of inland water systems will be presented.

Application and development of EO sensors

Tim Malthus, CSIRO Environment

Contributors: Klaus Joehnk, Tapas Biswas, Tarun Sanders, Asma Akther, Faisal Islam, Xiubin Qi, Erin Kenna, Nathan Drayson, Nagur Cherukuru, Stephen Gensemer, Josh Pease, Courtney Bright, Arnold Dekker, Neil Sims, Arnold Dekker, Mark Matthews, Janet Anstee, Phillip Ford, Gemma Kerrisk, Tim Bolton

September 2023

Structure

- Key challenges
- Underlying principles
- In situ sensor studies
- Satellite sensor investigations
- Modelling → Forecasts

The challenge of *in situ* monitoring

- Declining surface networks
- Poor data coverage
- Poor temporal continuity
- Inconsistent sampling
- Variation in data accessibility
- Limited understanding of the implications of extreme events on water quality

AquaWatch challenges (some of them…)

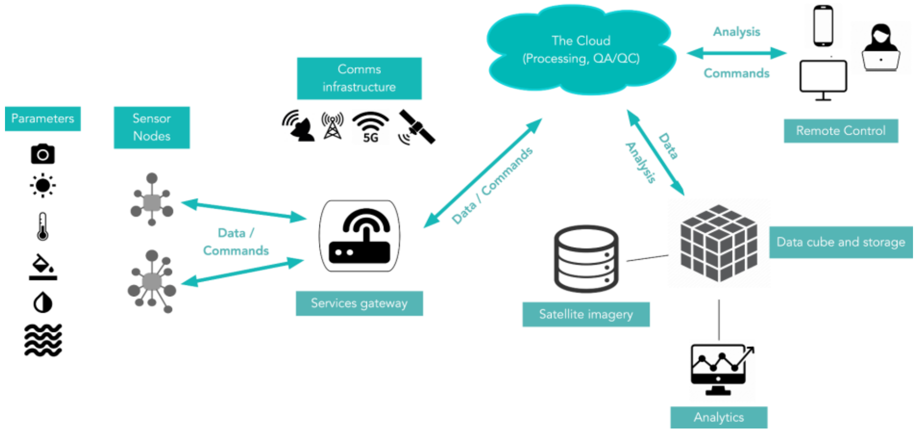
- How do you cost effectively roll out an in situ sensor network at scale? e.g. a continent like Australia, tropics to temperate systems, some very remote
- What parameters – what range and what sensitivity?
- What sensors?
- How do we design and launch satellite sensors from scratch?
- How do we take monitoring and models at local scales to the continental scale for operational forecasting?

Core principle

- **Combining remote sensing, hyperspectral and satellite remote sensing with hydrodynamic modelling will allow for a continuous forecast of water quality parameters, similar to common weather forecast on a local to continental scale**

Core system characteristics

- Cost-effective
- Easy to maintain
- Robust
- Timely
- Credible
- Open
- Representative



Problems to solve

Robustness	Reliability and maintainability	Availability	Interoperability and flexibility	Unit cost (manufacture and deployment)	Integration
Scalability	QA/QC	Standards and protocols	Security	Development of robust AI/ML approaches	Where located?

Hardest

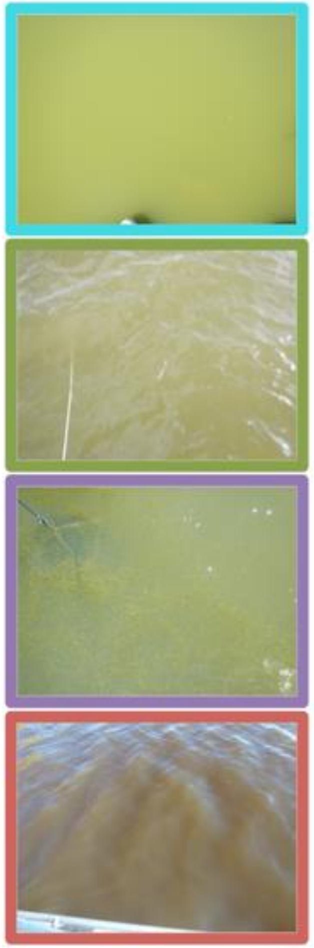
Solvable

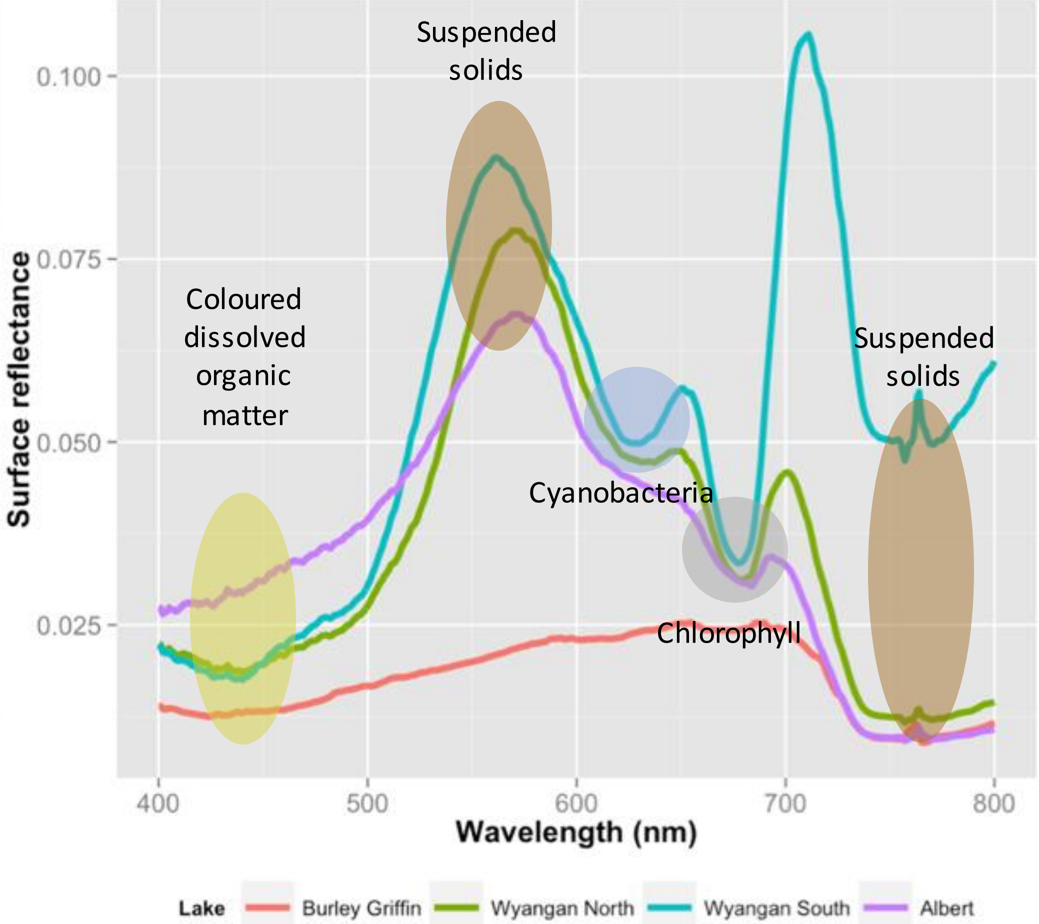
Traceability matrix – approach to develop Req'm

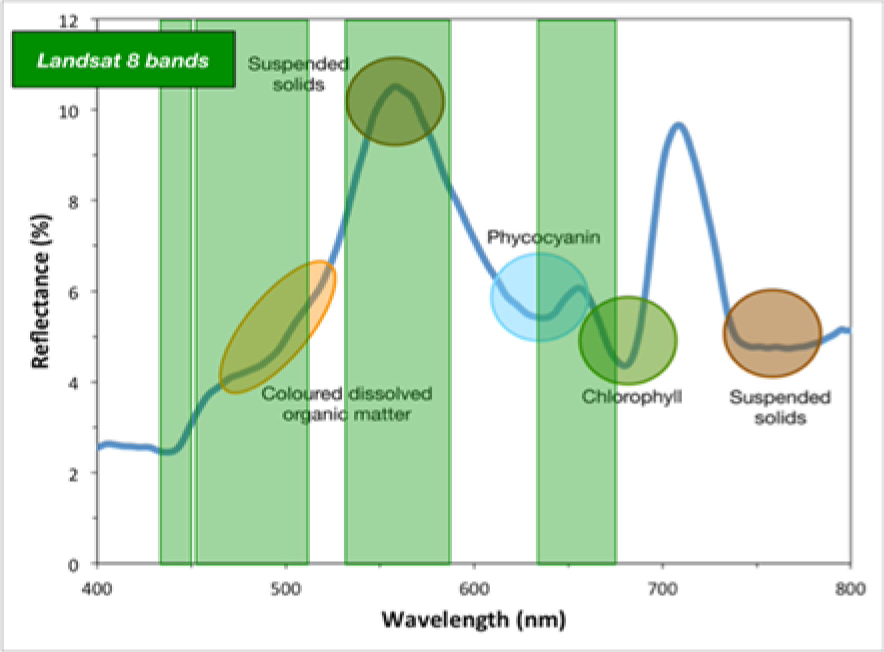
0	1	2	3	3b			4	5
			Measurement Requirements					
Aim	Goals *Science goals are broad and must be identified as "high value," as established by relevant quotes from NASA and National document*	Objectives *Science Objectives are specific and capable of being validated.*	Parameters *(The thing your trying to measure)*				Observables *(e.g., emission line, absorption line, fluorescence, conductivity etc...)*	Instrument Requirements
			Physical Parameters	range/uncertainty or clasification				
				lower limit	upper limit	accuracy		
Deliver a daily water quality forecasting service for Australia	Assess and predict water quality in relation to **Drinking Water**	**Algal blooms:** Detect and predict occurrence of harmful algal blooms in all Australian drinking raw surface water supplies (e.g., lakes, rivers, reservoirs, and coastal waters) a week in advance to inform management and the required water treatment to achieve water quality conforming to the Australian Drinking Water Guidelines.	Chlorophyll-a, CHL (ug/L)	0.7	1500	0.7 ug/L or 10% whichever is greater	Optical reflectance over 415 - 720 nm, with FWHM≤8 nm, sampling interval ≤8 nm, and an accuracy/or precision of x%	
			Cyano-phycocyanin , CPC (ug/L)	?	1500		Optical reflectance over...	
			Cyano-phycoerythrin, CPE (ug/L)	?	1500		Optical reflectance over...	
		Water treatment: Monitor acidity and dissolved and particulate matter in all Australian drinking raw surface water supplies to inform water treatment procedures and decisions including disinfection (e.g., chlorination or UV treatment) and filtration, especially with the occurrence of extreme events (e.g., floods, heavy rain).	Total suspended matter, TSM (mg/l)	0.1	350 [CEOS]		Optical reflectance over...	
			Coloured dissolved organic matter, CDOM (m^-1)	0.1	60 (ref)		Optical reflectance over...	
			Vertical attenuation, Kd (m^-1)	0.2	20 (ref)		Optical reflectance over...	
			Turbidity (NTU)	1	1200	1 NTU or 10% whichever is greater	**Approach 1:** Optical reflectance (white light): **Approach 2:** Scattering at 90 deg at 860 nm at 10% accuracy & absorbance at 860 nm at... / OR **Approach 2:** Acoustic	
			Dissolved organic carbon, DOC (mg-C/L)	0.3	50	0.3 mg-C/L or 10% whichever is greater	Absorbance at 254 nm, over 0.00612 - 0.7218 cm^{-1} (base 10 units) with accuracy of 0.00612 cm^{-1} or 10% whichever is greater	Measure transmission at 254 nm between 0.25 to 1 for 2 cm path length with accuracy less than shown in Fig. 1
			pH	4	9	0.6 or 10% whichever is greater		
			Salinity/Conductivity (mS/cm)	0.02	65	0.02 mS/cm or 10% whichever is greater		
		Trophic status: Monitor the trophic status of all Australian drinking raw surface water supplies (e.g., lakes, rivers, reservoirs, and coastal waters) to assist detection and prediction of harmful algal blooms and microbial pathogens.	Total phosphorous (ug/L)	10	1500			
			Nitrate (mg-N/L)	0.01	15	0.1 mg-N/L or 10% whichever is greater	Absorbance at 235 nm, over 0.000189 cm^(-1) to 0.2889 cm^(-1) (base 10 units) with accuracy of 0.00189 cm^{-1} or 10% whichever is greater	Measure transmission at 235 nm between 0.05 to 1 for 2 cm path length with accuracy less than shown in Fig. 2
	Others: Agriculture, Industrial,							

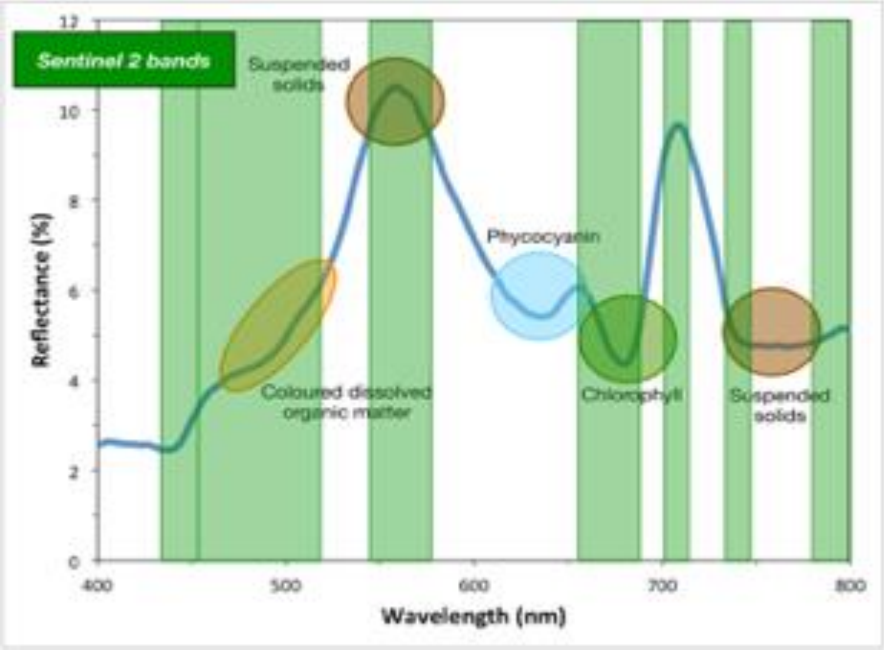
- Referred to Australian drinking water guidelines (phrasing objectives)

Information in spectral reflectance



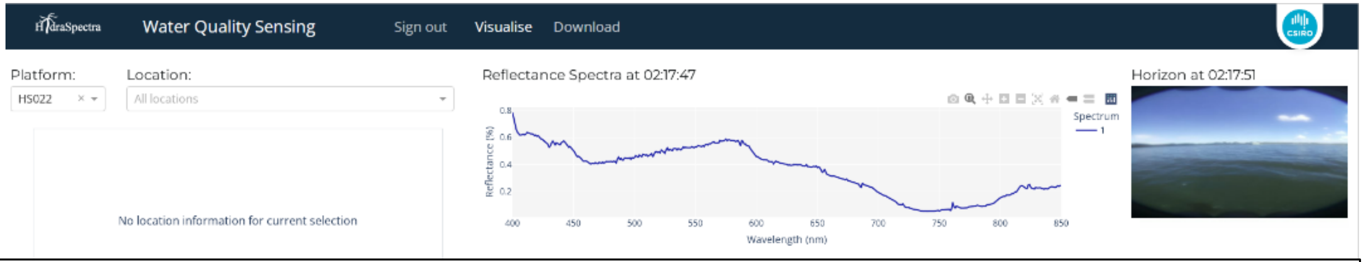


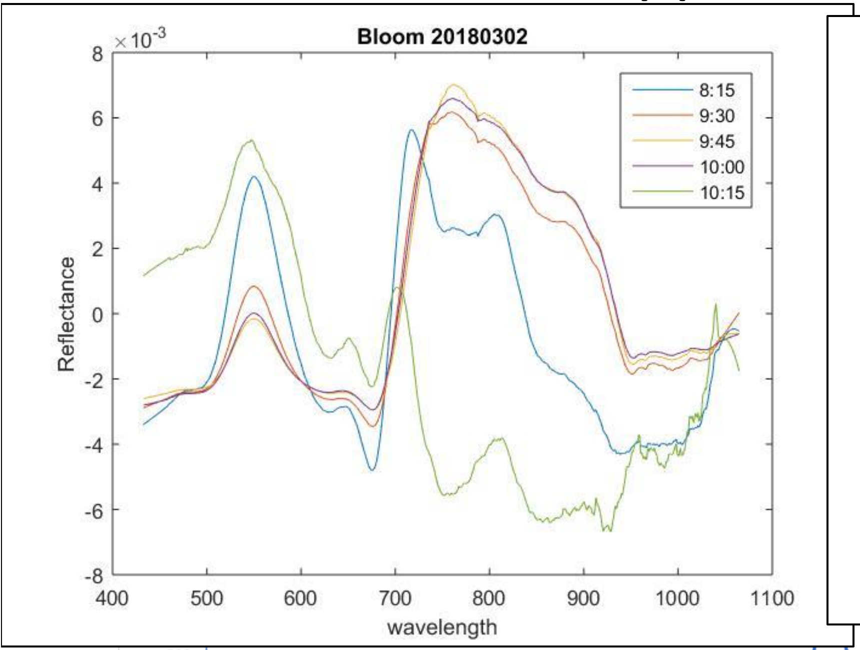


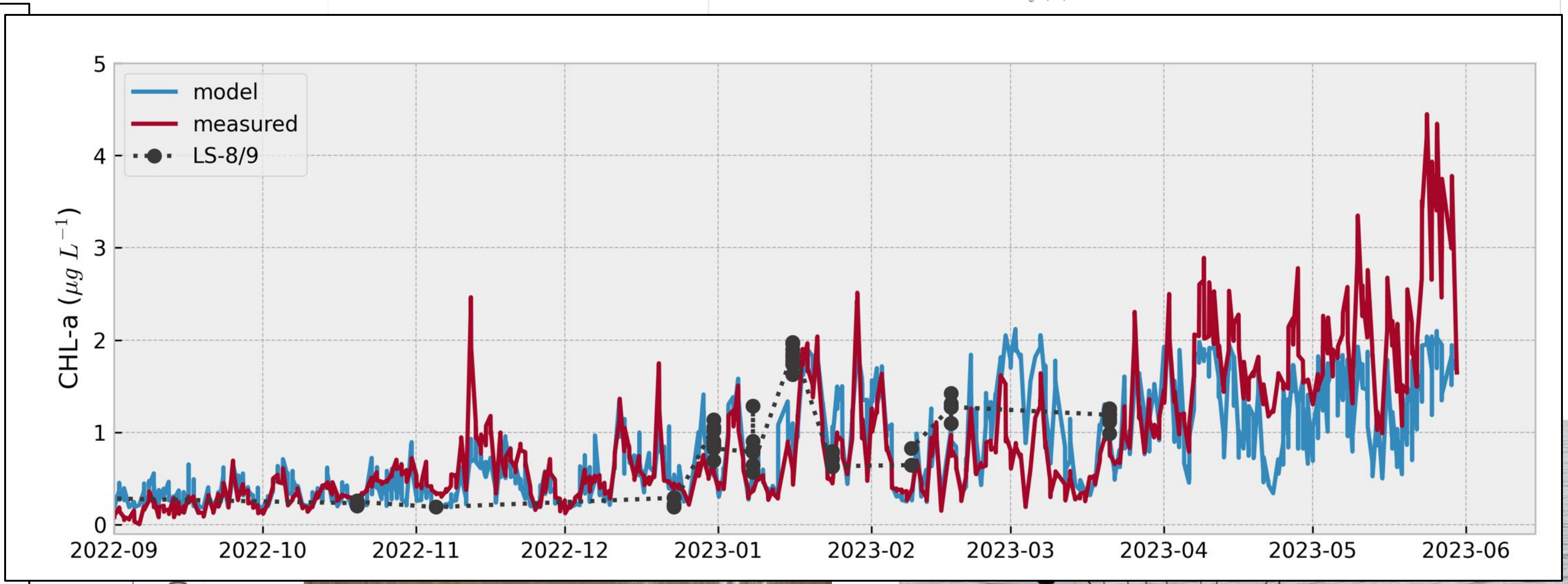


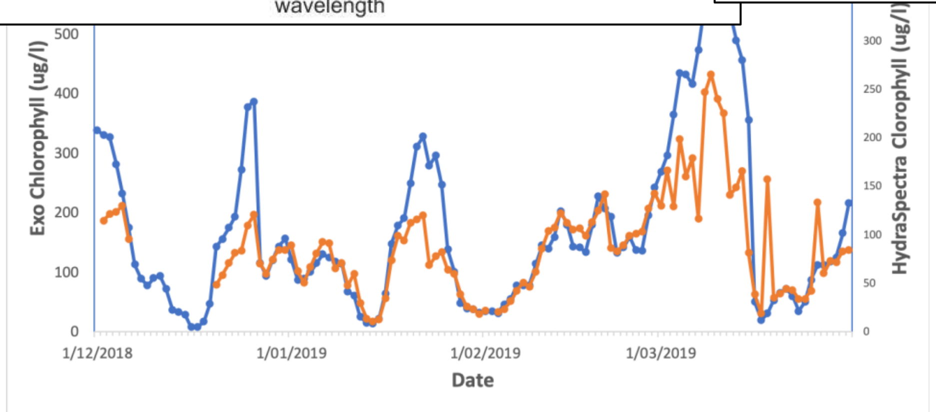
HydraSpectra

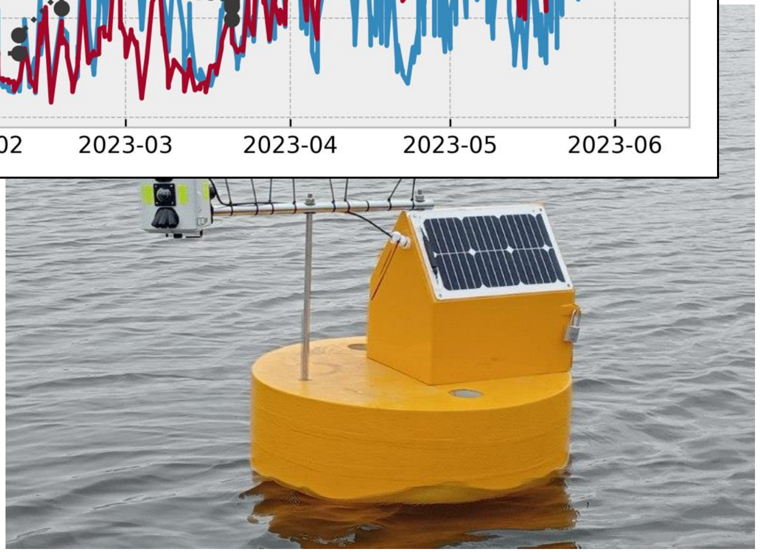
- Measures above surface reflectances to support



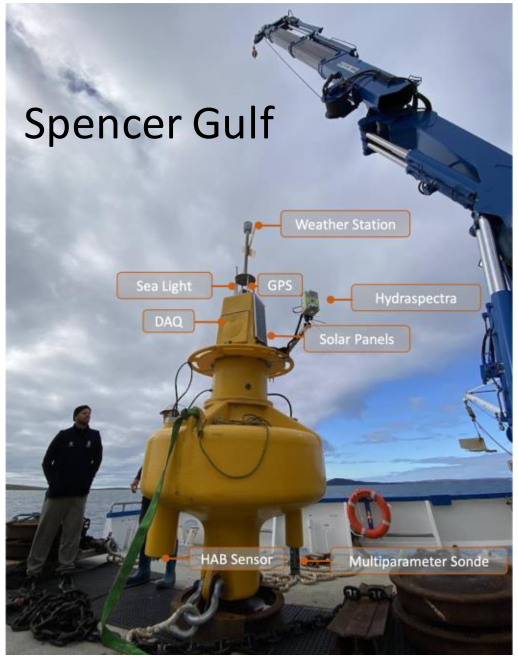


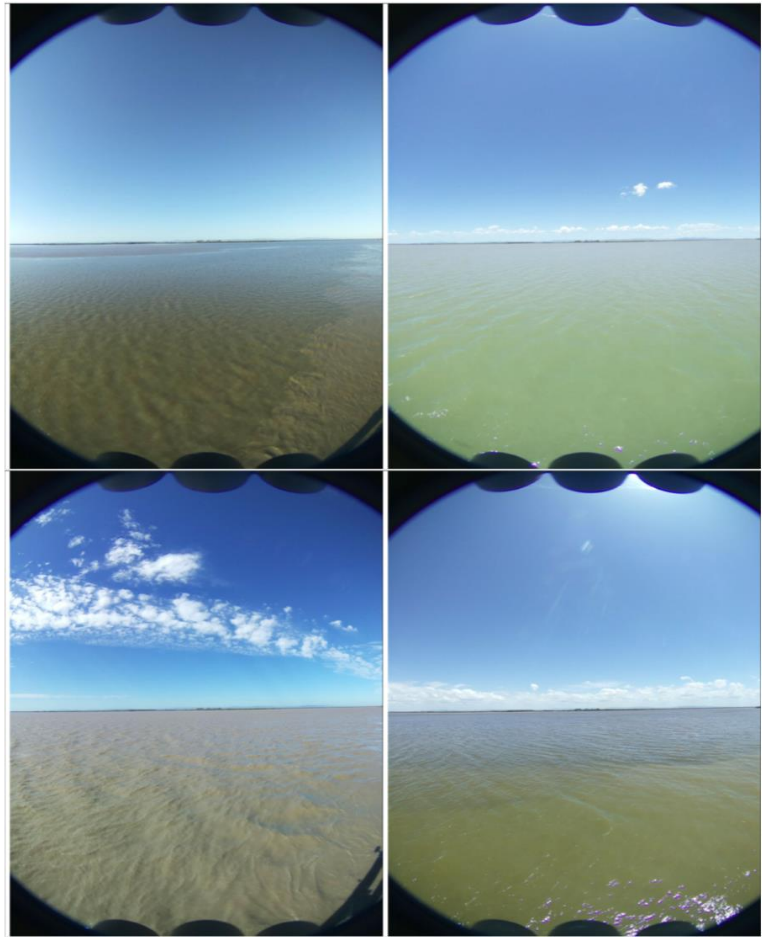




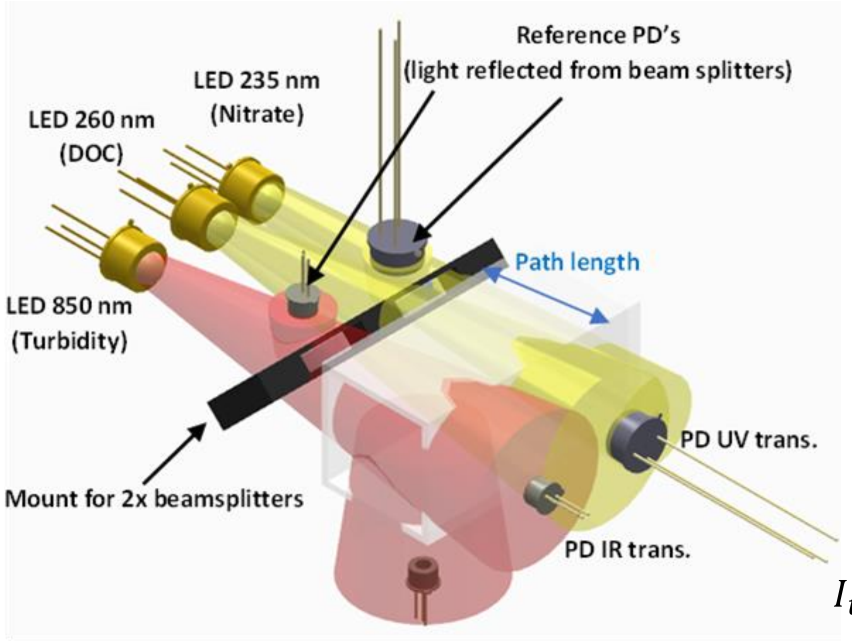


Deployments @ national pilots





Low-cost sensor research

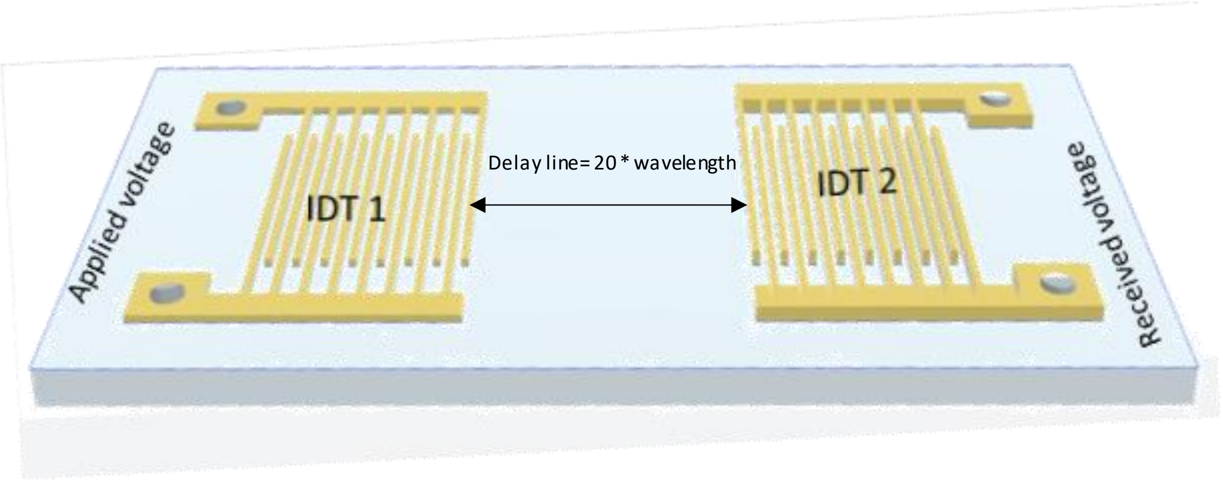


$$I_{trans} = ae^{-bC_X}$$

PD IR scatter

$$I_{scatt\ 90^0} = \alpha T + \beta$$

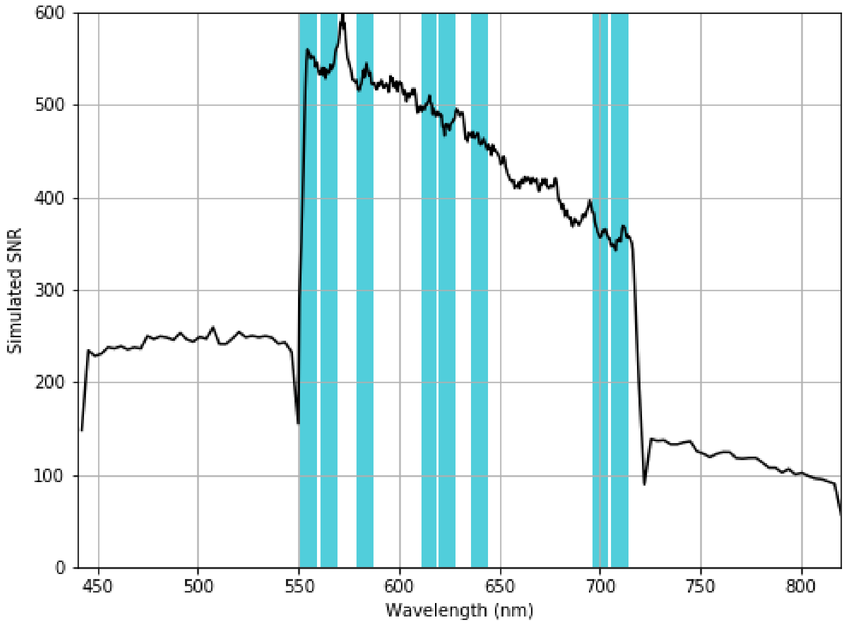
Nitrate – low cost optics

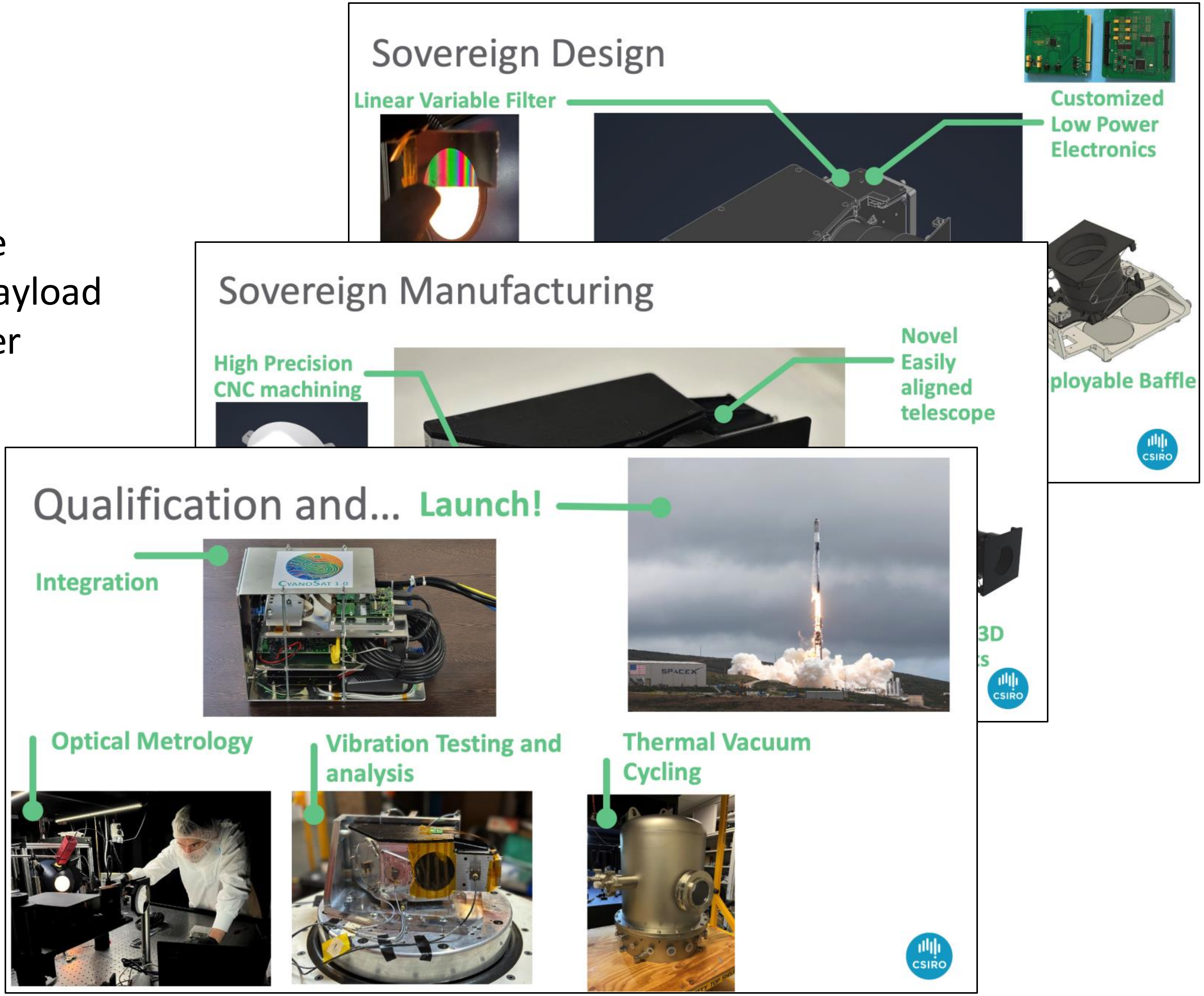


Turbidity – acoustics

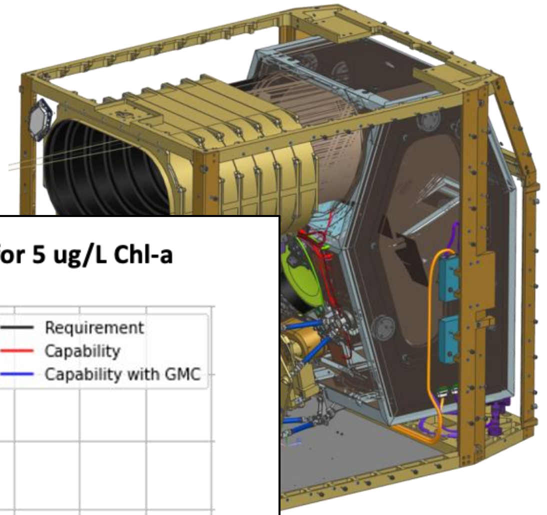
Cyanosat-1

- Aquawatch Pathfinder
- CSIRO Satellite Optics Lab, Adelaide
- Launched – June 12th on Skykraft payload
- Communication with payload, under commissioning
- Cyanosat-2 in development

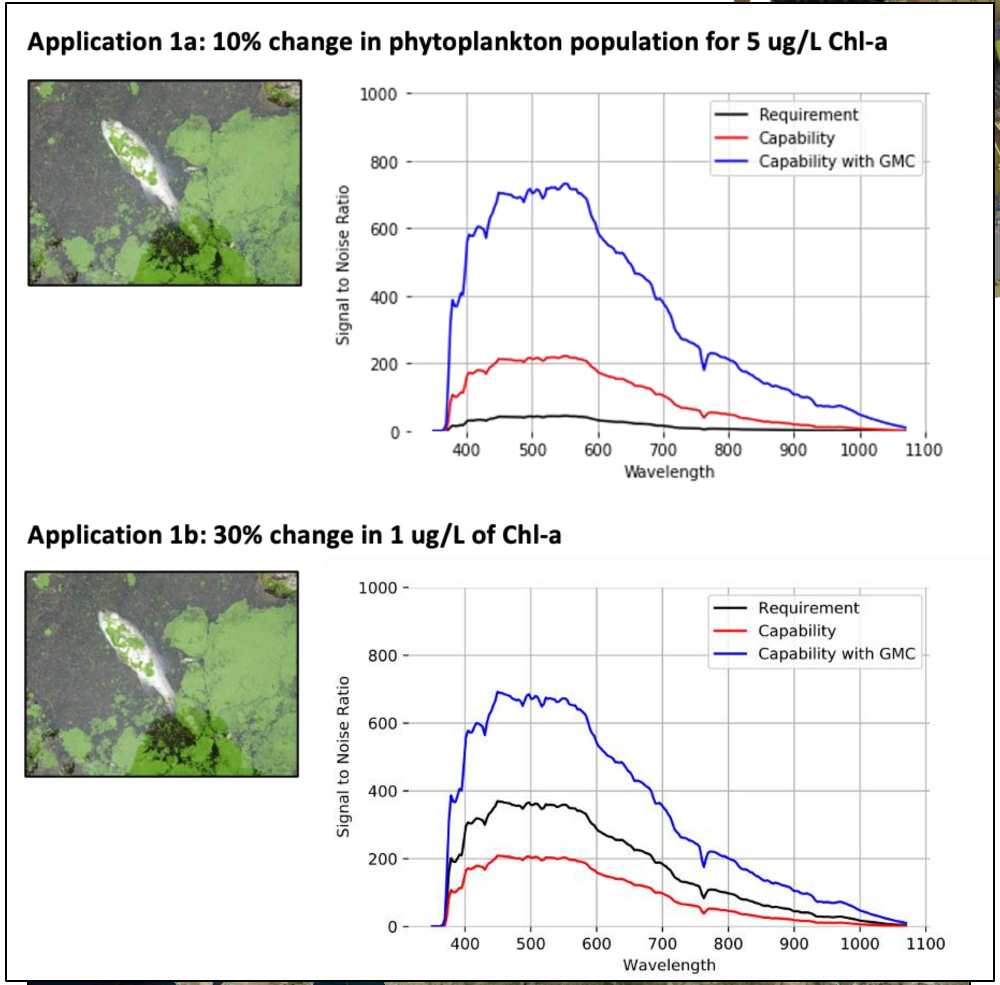


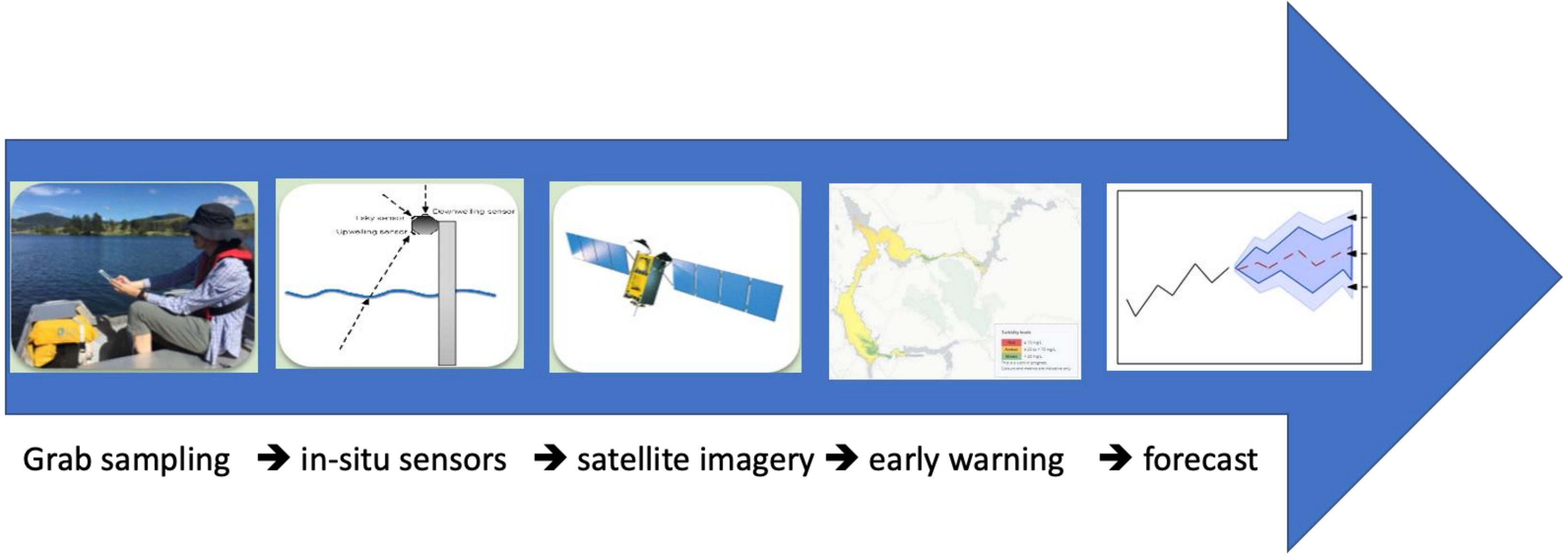


AquaSAT-1 Feasibility study, with NASA JPL

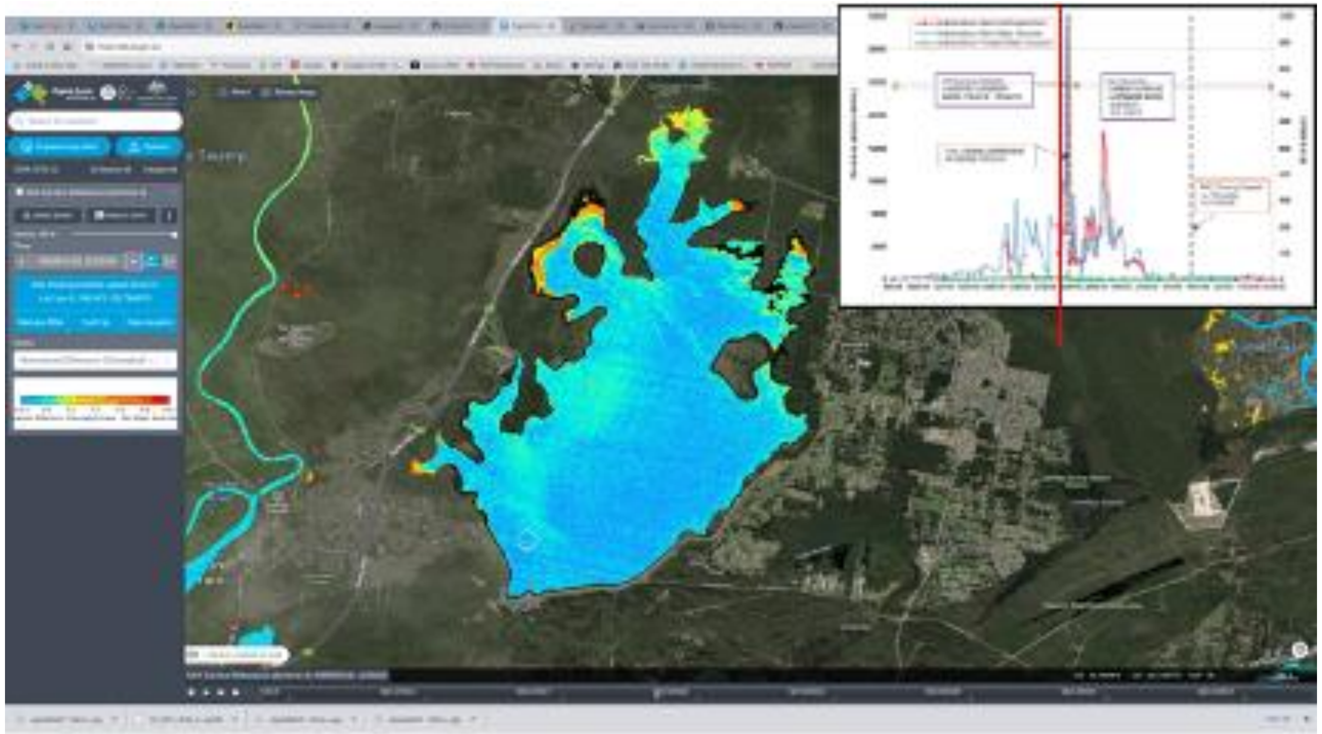


- **Orbit:** sun-synchronous, ~noon crossing time, ~400 km altitude (trade study: 600 km altitude)
- **GSD:** 18 m
- **Imaging coverage:** target sites (key lakes, rivers, estuaries, coral reefs in Australia and the US West)
- **Revisit:** 5 days with +/- 30 deg cross-track slew (not accounting for cloud cover, sunglint, target site conflicts, etc.)
- Dyson imaging spectrometer (350 to 1050 nm, 9.6 nm FWHM)

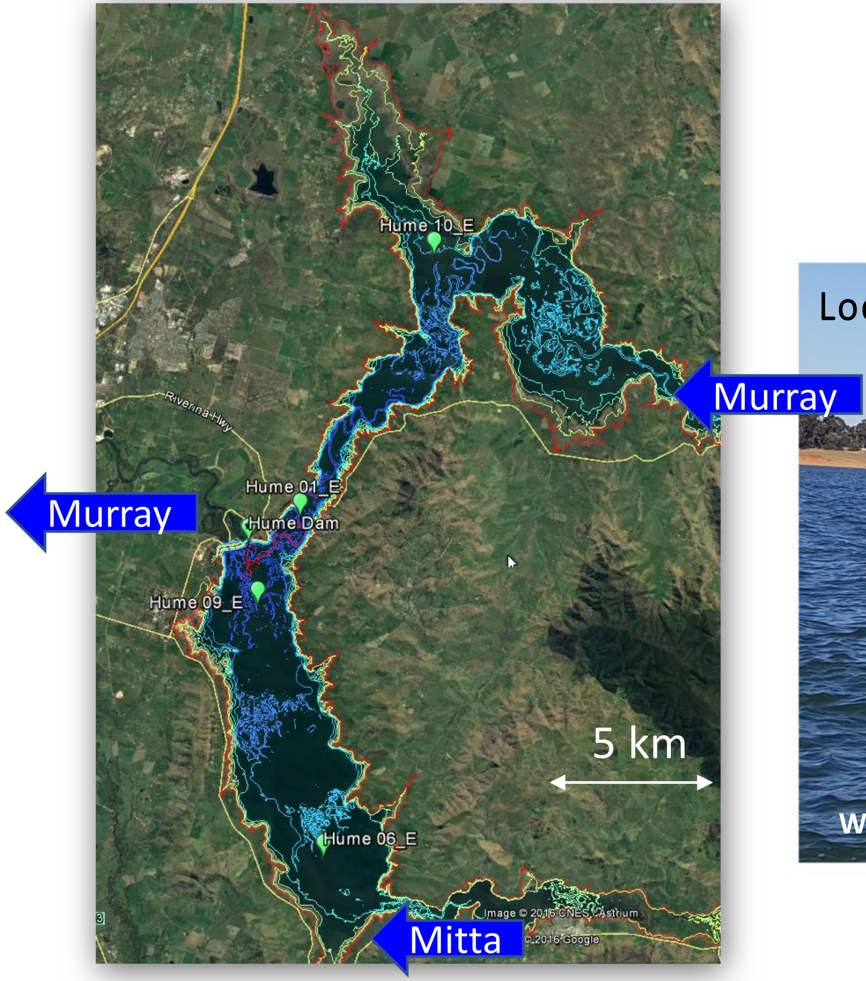


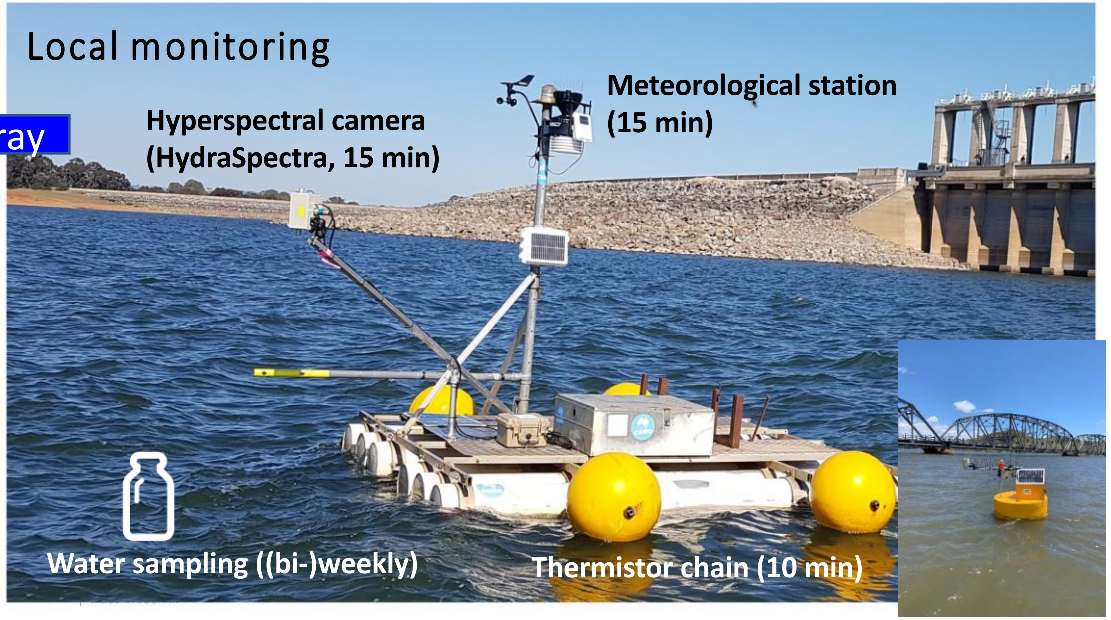

Grab sampling ➔ in-situ sensors ➔ satellite imagery ➔ early warning ➔ forecast

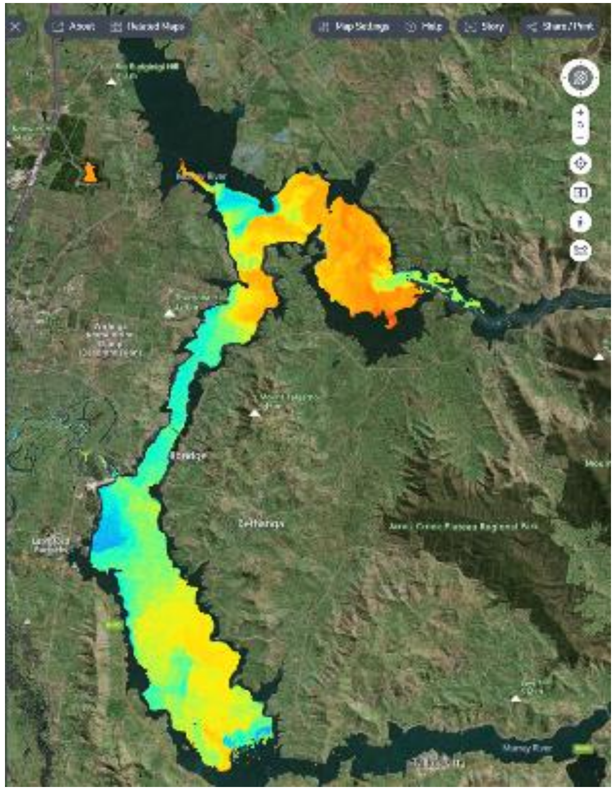

Grahamstown Dam



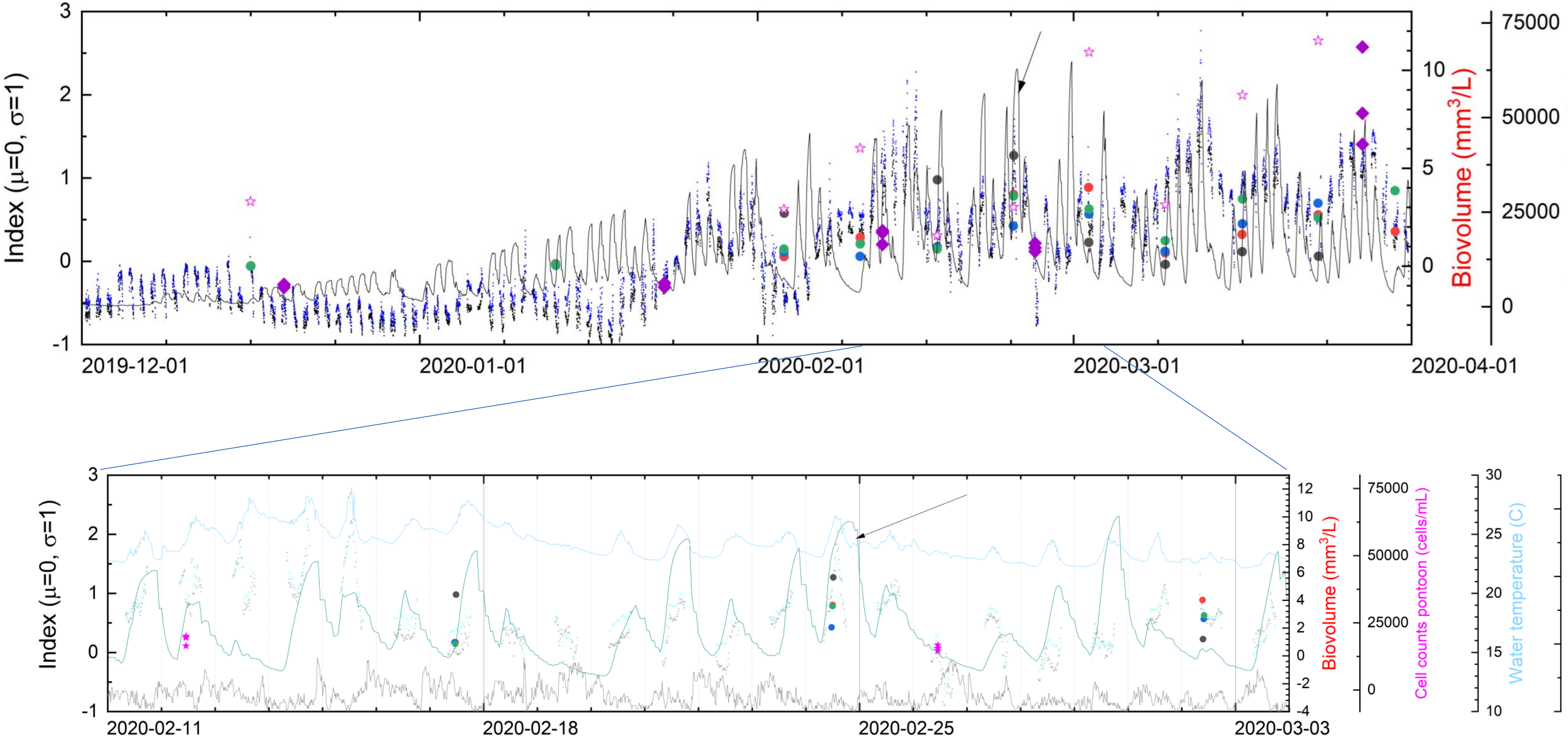
Lake Hume forecasting





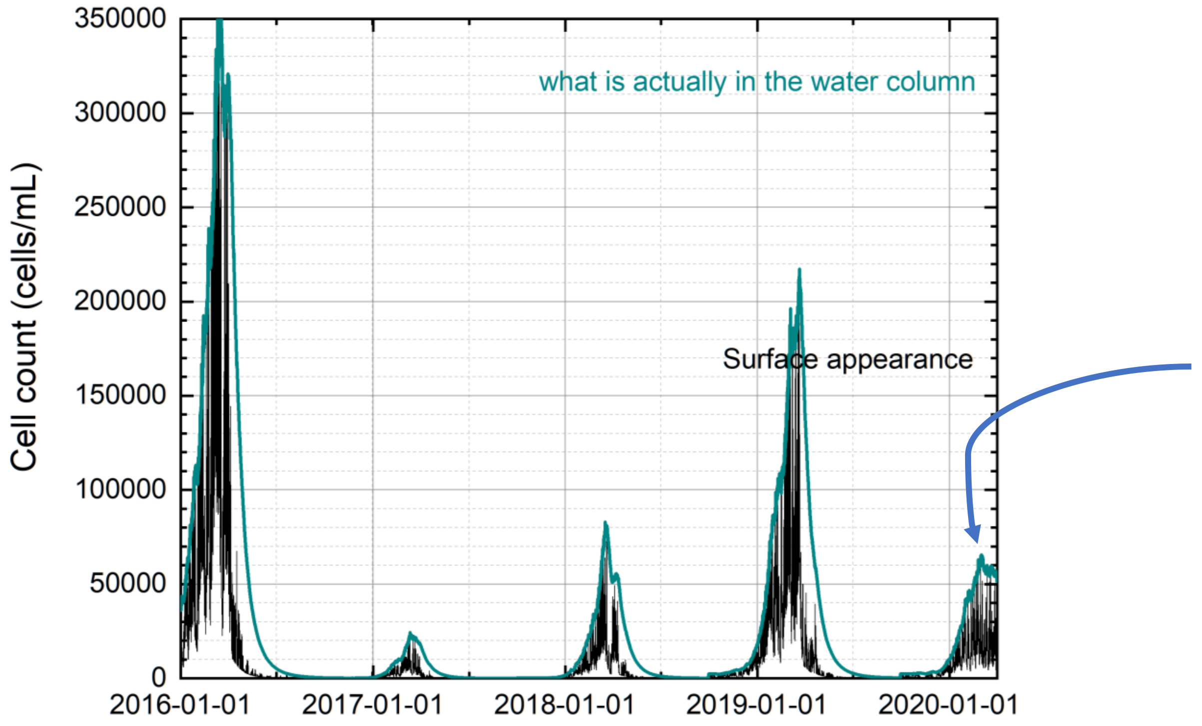


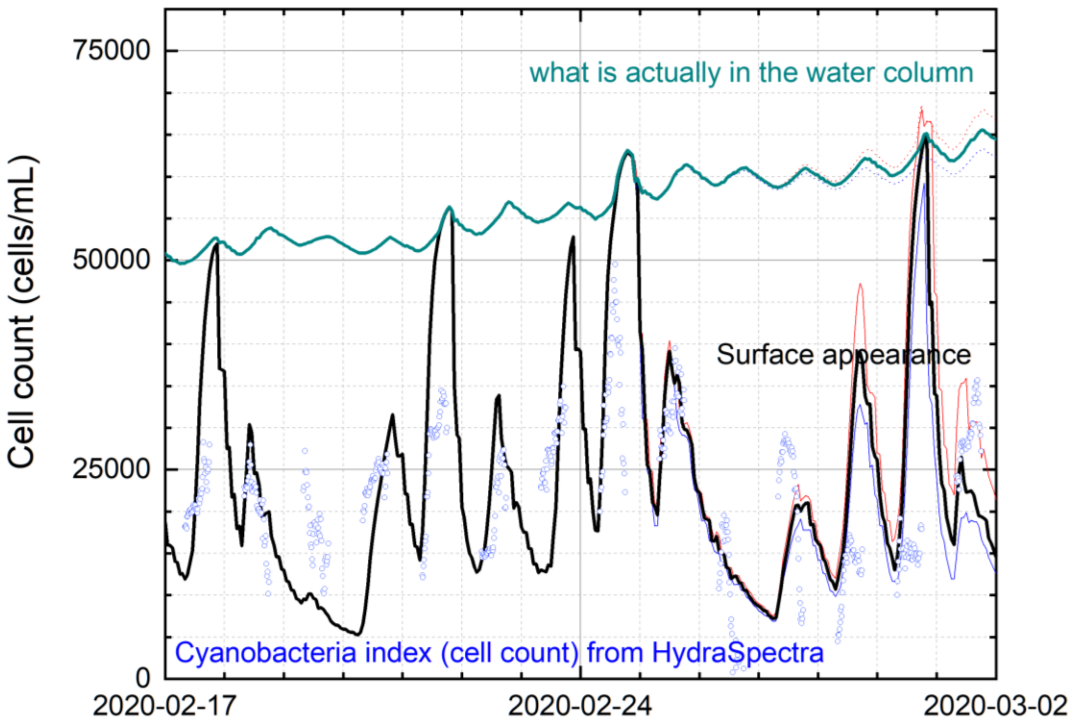
Inland Aquawatch pilot sites: Lake Hume, Lake Tuggeranong, Grahamstown Dam, Melbourne Water WTP



Index (μ=0, σ=1)
Biovolume (mm3/L)
Cell counts (cells/mL)
pontoon, dam wall
2019-12-01
2020-01-01
2020-02-01
2020-03-01
2020-04-01
Index (μ=0, σ=1)
Biovolume (mm3/L)
Cell counts pontoon (cells/mL)
Water temperature (C)
Wind speed (m/s)
2020-02-11
2020-02-18
2020-02-25
2020-03-03

Hyperspectral data vs Model simulations





- The surface appearance of blooms is highly variable and inherently coupled to mixing processes.

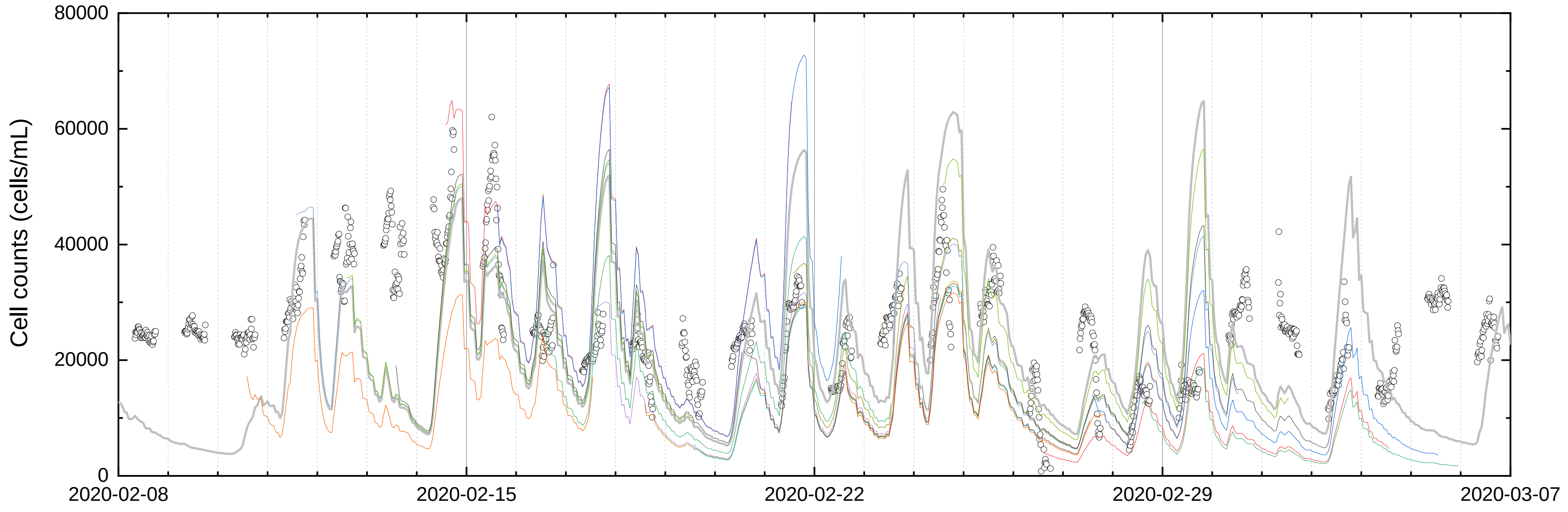
➢ This makes forecasting of bloom dynamics with data only from surface observations difficult: need internal mixing dynamics from models.

➢ Assimilation of high frequency data from hyperspectral reflectance will help to improve 1D model simulations.

Short-term forecast

- Short-term, 7-day ahead forecast based on HydraSpectra cyanobacteria index
- Using actual meteorology
- Index pattern are very well described
- Variations in the range of factor > 2

➢ Uncertainty depending on mixing dynamics → needs high resolution monitoring
➢ Better relation needed between HydraSpectra index and cyanobacteria biovolume



Summary

Interlinked system: grab sampling - sensors - satellite imagery – analytics - modelling → forecasting

Built on underpinning optical science

May address the areas for which other data sources are sparse

Scalable (local – regional - continental) and applies across state boundaries

Collaboration is key: AquaWatch encourages wider collaboration in in situ and and EO sensor development

Thank you

AquaWatch Mission

https://research.csiro.au/aquawatch/

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CSIRO Environment, Brisbane

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Session – I @ 10:45 AEST

3. Pilot projects in AquaWatch Australia

Nagur Cherukuru*[1,3] and Neil Sims[2,3]

*nagur.cherukuru@csiro.au
[1]CSIRO Environment
[2]CSIRO Space & Astronomy
[3]CSIRO AquaWatch Mission

Key words: AquaWatch Australia, water quality, in-situ sensing, remote sensing, forecasting

Abstract:
The health and condition of our inland and coastal water systems face mounting threats due to the escalating impact of human activities including climate change, urbanization, population growth, alterations in land use, deforestation, irrigation, farming needs and contamination. These pressures on our water bodies are adversely affecting water quality, resulting in a multitude of challenges such as harm to aquatic habitats, health risks for both humans and animals, diminishing biodiversity, economic burdens linked to the maintenance of water bodies and the upkeep of water treatment and distribution infrastructure.

To facilitate improvements in the accuracy and availability of water quality information to support more effective monitoring and management of aquatic ecosystems, AquaWatch Australia Mission is establishing an integrated, ground-to-space water quality monitoring and forecasting system. This system is being co-designed in conjunction with partners across the water quality management sector to protect the valuable Australian and international inland and coastal water resources.

To advance this mission, AquaWatch has implemented a range of pilot projects tailored to meet the diverse water quality information requirements of ecosystem and water resource managers, industry stakeholders and the broader community. These pilot projects have been chosen to build partnerships with world leaders in water quality monitoring, assess project feasibility, refine methodologies, gather data, improve data processing workflows and demonstrate the benefits of AquaWatch to a wide range of stakeholders.

This presentation will present an overview of the AquaWatch Australia Pilot Site program, including the research focus, key challenges and successes to date. This presentation will conclude with a high-level overview of 'AquaWatch 2026'; a first critical milestone for the Mission, and a discussion of the key role that pilot sites will play in achieving that milestone.

2023-09-20 00:00 - 2023-09-20 23:59, Sentinel-2 L2A, Highlight Optimized Natural Color

Pilot projects in AquaWatch Australia

Nagur Cherukuru, Neil Sims, **Tapas Biswas**,

Tim Malthus, Xiubin Qi, Rob Woodcock, Nathan Drayson, Gemma Kerrisk, Klaus Joehnk, Tish Dhar, Eric Lehmann, Erin Kenna, Lachlan Phillips, Tim Bolton

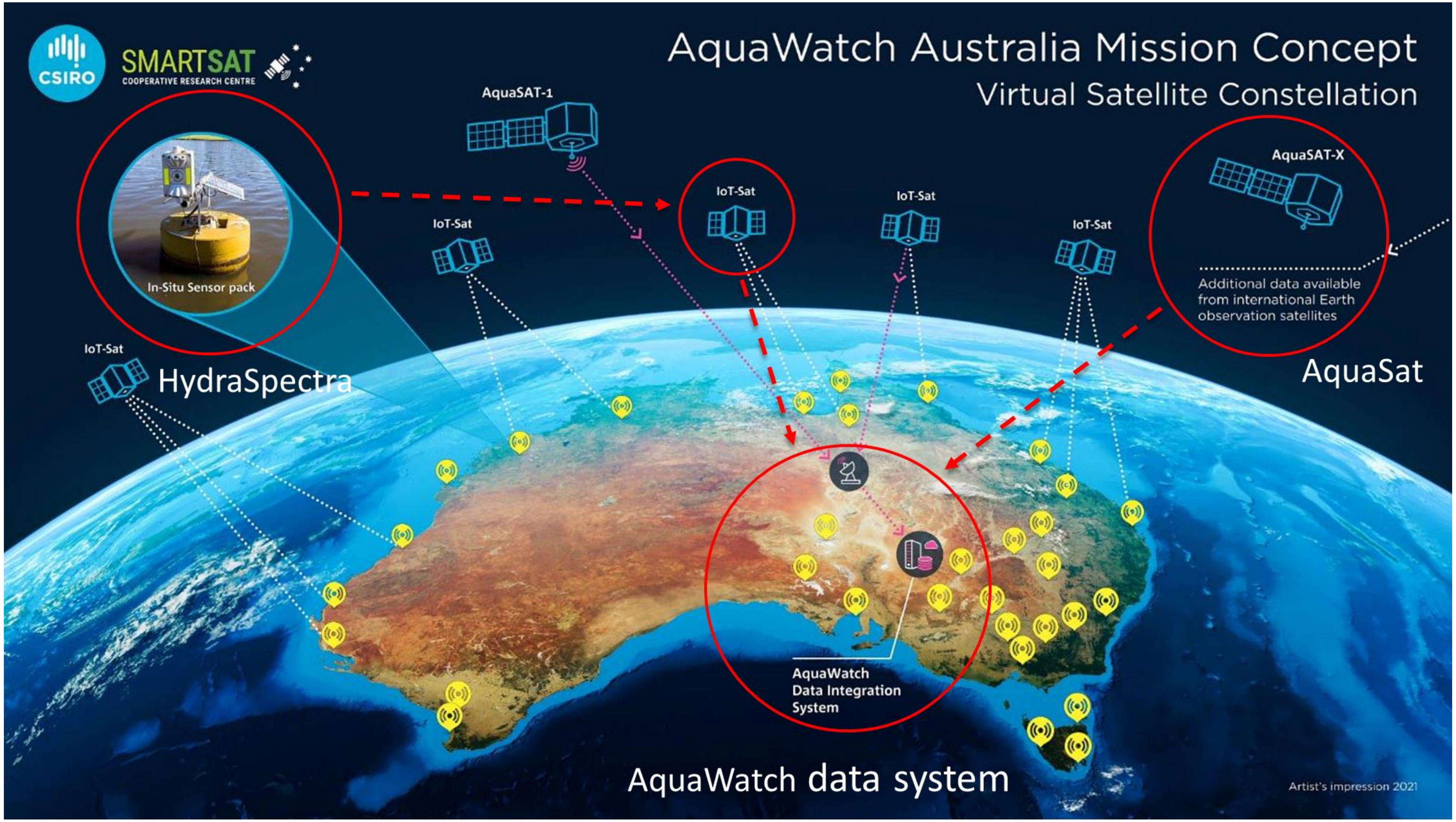
AquaWatch Australia Mission

CSIRO

10 km

Credit: European Union, contains modified Copernicus Sentinel data 2023, processed with EO Browser

AquaWatch Australia Mission

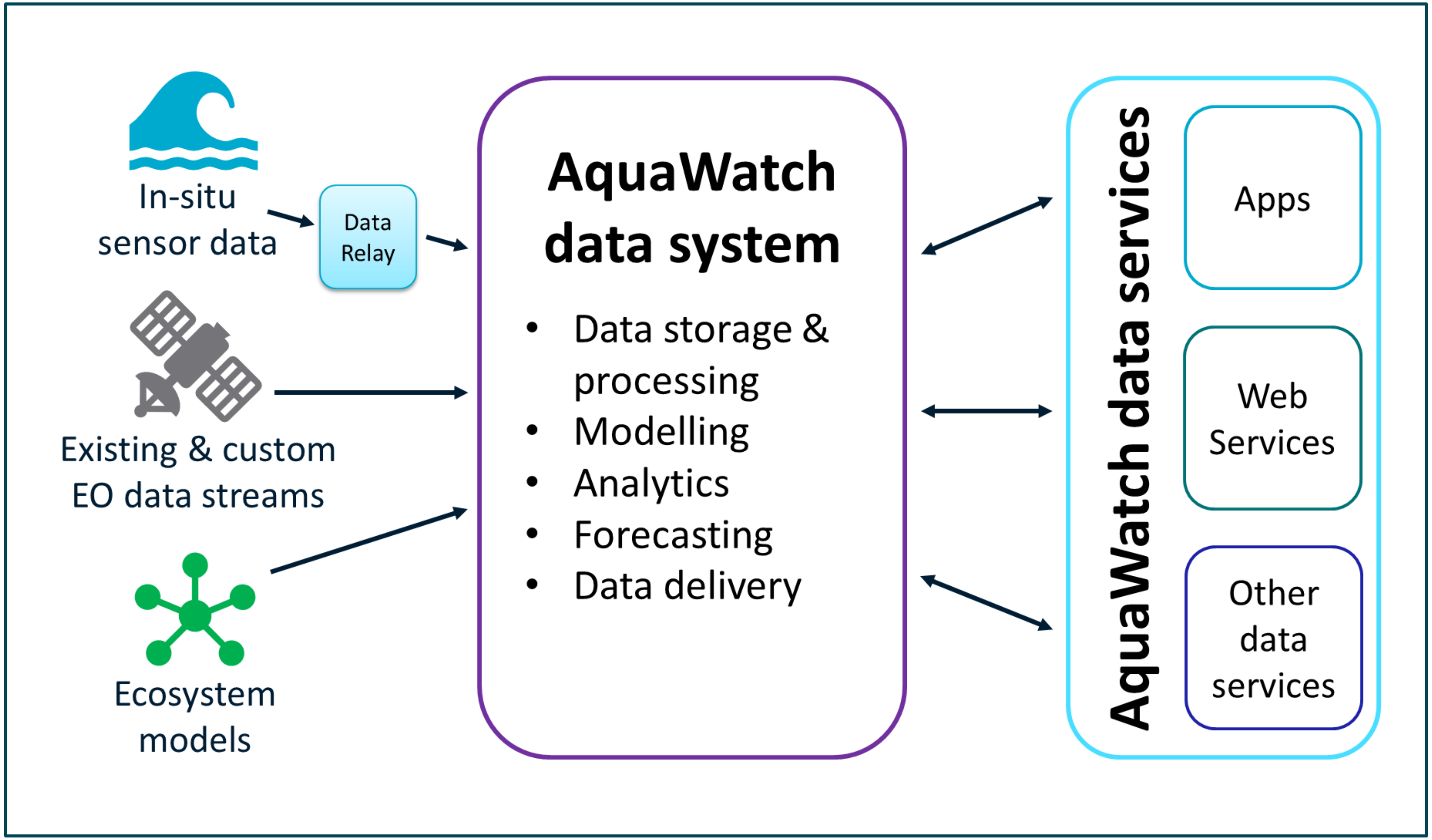


The **AquaWatch Mission aims to connect in-situ and Earth Observation (EO) data sources in an advanced data analytics system to deliver a 'weather service for water quality'** across Australia and the globe.

The **objective is to improve the accuracy and availability of water quality information** to service civilian, commercial, environmental and research community needs by 2030.

AquaWatch Australia Mission Roadmap: https://research.csiro.au/aquawatch/wp-content/uploads/sites/491/2023/09/AquaWatch-Roadmap-v1.0-Aug-202341.pdf

AquaWatch system and data services



'**By 2026**', when a fully functional integrated monitoring system including forecasting will be operational over **10-20 well monitored sites in Australia and overseas**.

'**By 2030**', when the system will be providing **continental coverage across Australia for selected parameters**,

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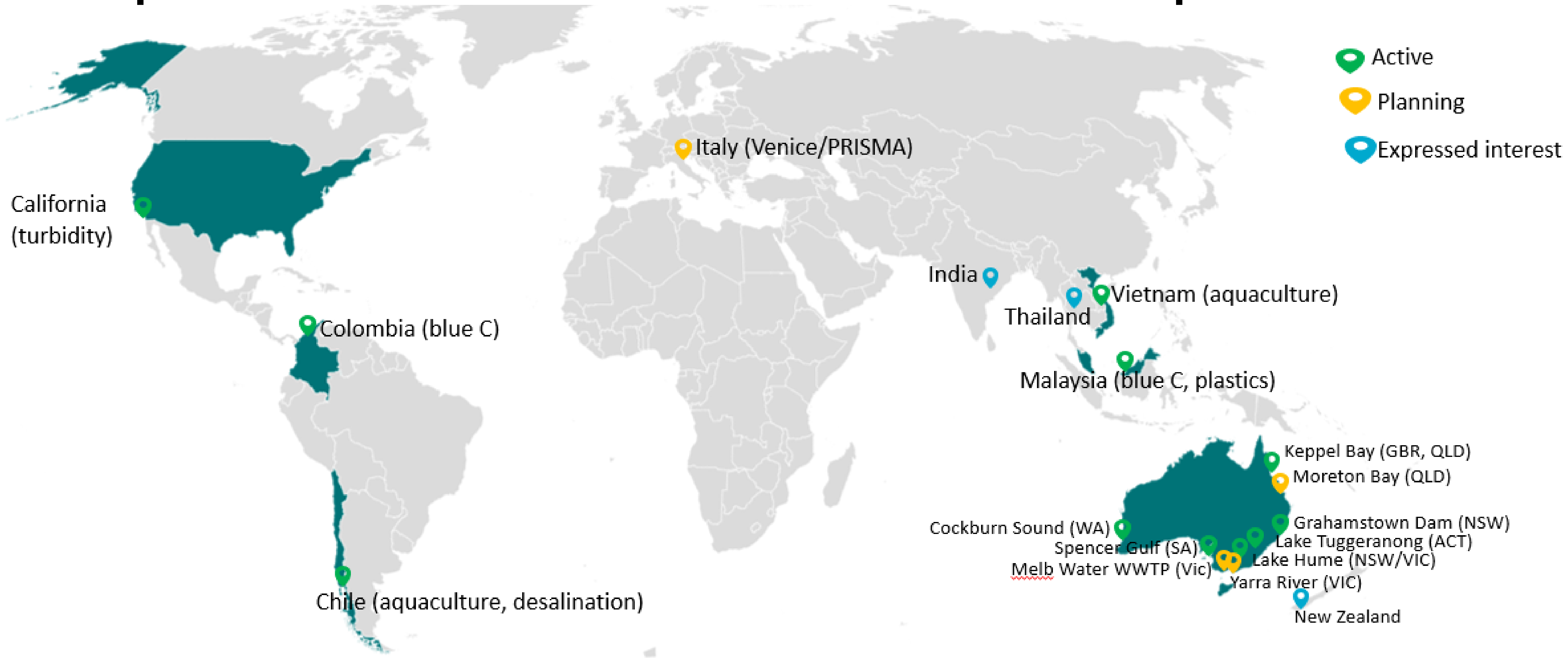
AquaWatch National and International pilots



CSIRO

Importance of Pilot sites within AquaWatch Mission

- Engage with research, government and industry partners to build and improve the robustness and accuracy of the AquaWatch system,
- Build up the user network amongst partners (agriculture, aquaculture, irrigation, drinking water supply, desalination, blue carbon, extreme event management)
- Develop capacity to enable partners to be the key custodians of each site
- Attract co-investment with the project partners to increase the activity at each site and demonstrate locally-applicable outcomes

Role of pilot projects in AquaWatch Mission

- **Proof of Concept**: AquaWatch pilot projects are helping demonstrate the feasibility of a novel *in situ*, remote sensing and modelling based approaches
- **Feasibility Assessment**: Pilots inform AquaWatch Mission on the potential technical challenges or limitations in the research methodology.
- **Data Collection and Preliminary Analysis**: Initial data collected provides AquaWatch data analytics team insights into data collection, sample size, and analytical approaches for the main study.
- **Risk Identification, Mitigation and Refinement**: Pilot projects help identify potential risks, check uncertainties in the research process, develop strategies to mitigate risks and refine approach.
- **Communication and Collaboration**: Pilot projects are facilitating collaboration between AquaWatch partners, allowing them to work together and refine their research objectives and methods.

Current pilot projects in AquaWatch Australia Mission

AquaWatch
Inland Water Pilots


Grahamstown Dam


Lake Hume


Lake Tuggeranong

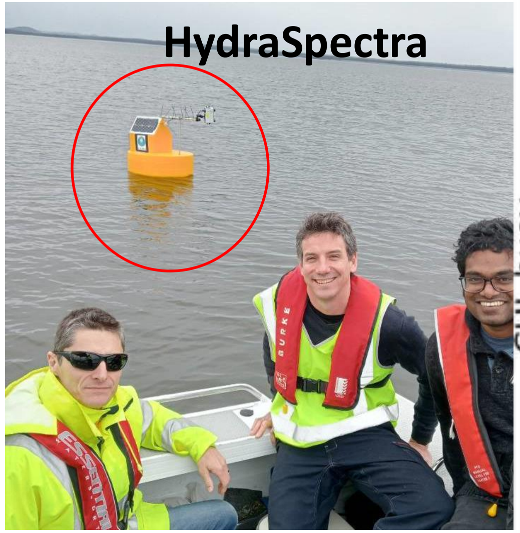
Tapas.Biswas@csiro.au

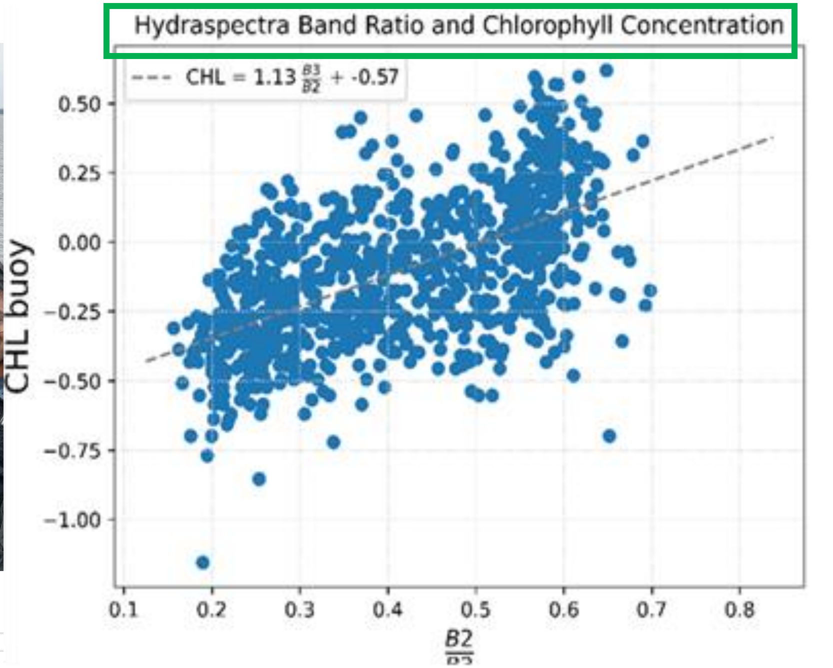
Which data are we collecting in inland water pilot projects?

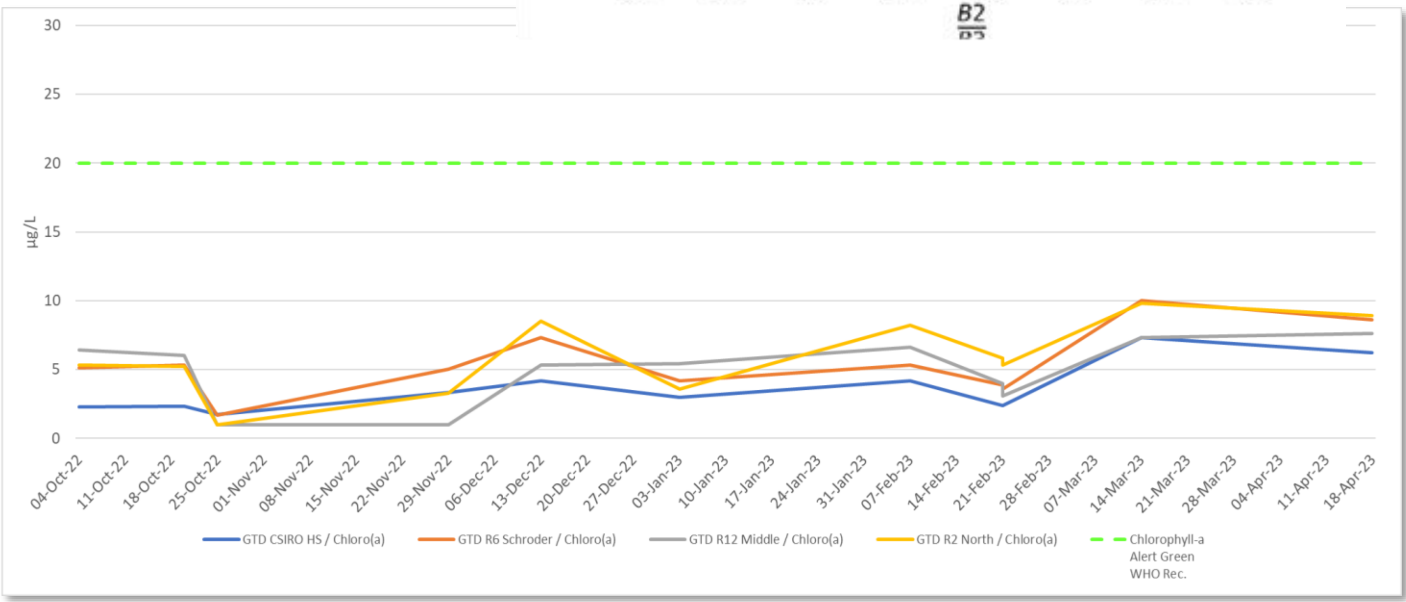
- Ground sensor (**CSIRO HydraSpectra**)
- Profile temperature (**thermistor chain**)
- Grab samples for ***Chl-a* and cell counts**
- **Weekly samples** for WQ and algae
- Sentinel 2 **satellite data** (NDCI)
- Lake bathymetry
- Weather data

Data collected is helping:

- **calibration and validation** of **in situ and remote sensing** products
- to Support **Water Quality Modelling**
- to **measure variables that EO cannot measure**







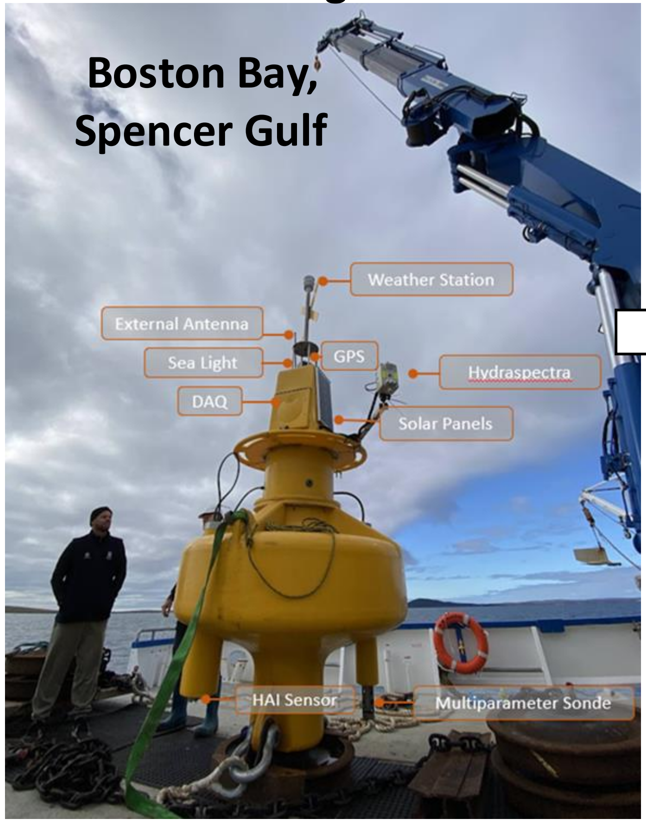
Output: Visualisation Dashboard (prototype)

Spencer Gulf pilot in support of Aquaculture industry

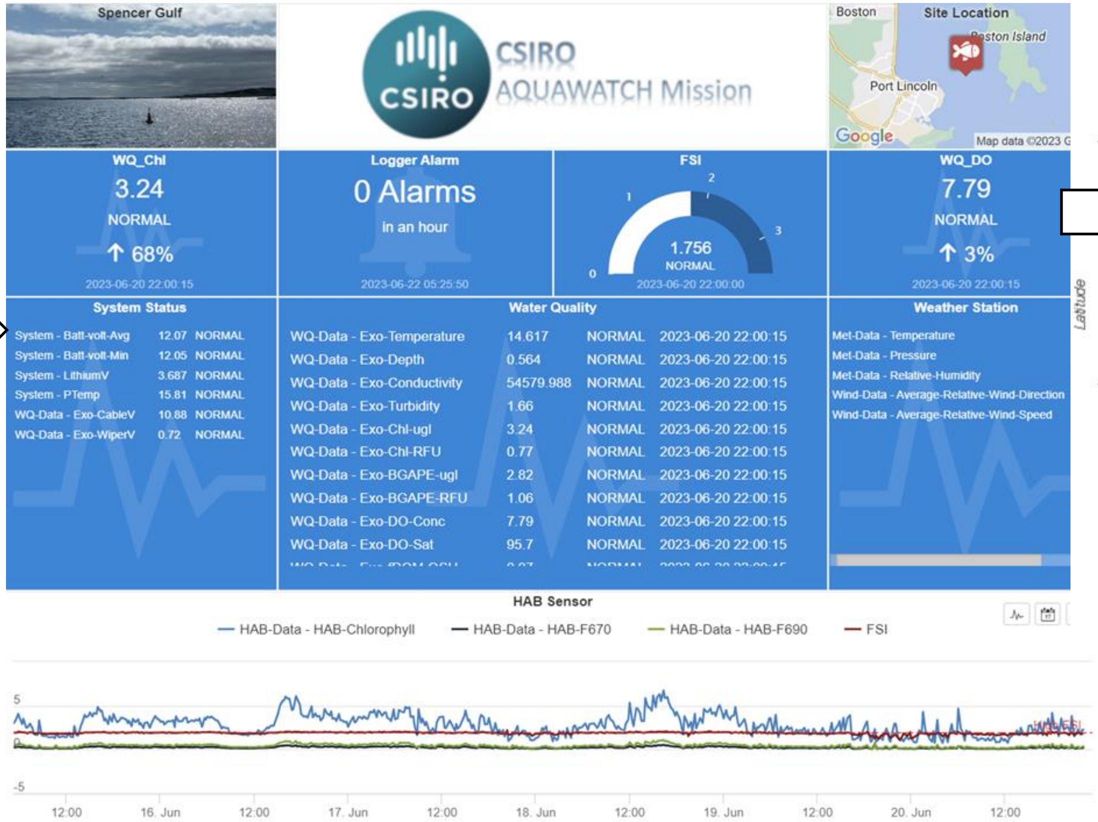
Objective:

- Develop and deploy a **fixed water quality monitoring station** in Boston Bay, Spencer Gulf
- Implement **remote sensing** water quality algorithms to analyse and monitor changes
- Demonstrate the **integration of in-situ and satellite water quality** observations

AquaWatch water quality monitoring station



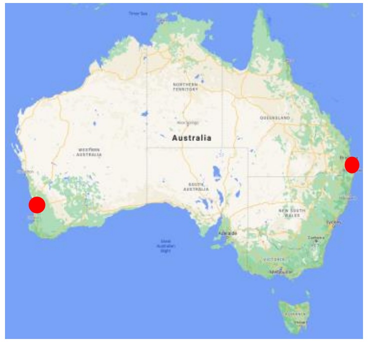
AquaWatch water quality dashboard



Satellite Chlorophyll-a map

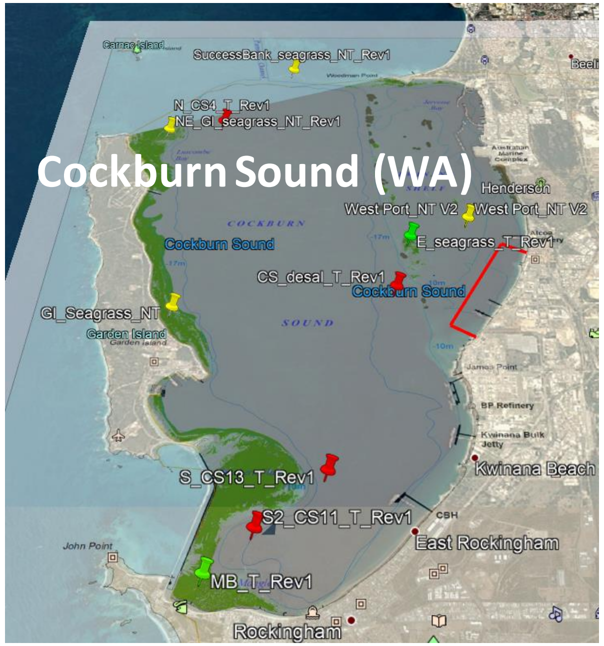
Nagur.Cherukuru@csiro.au

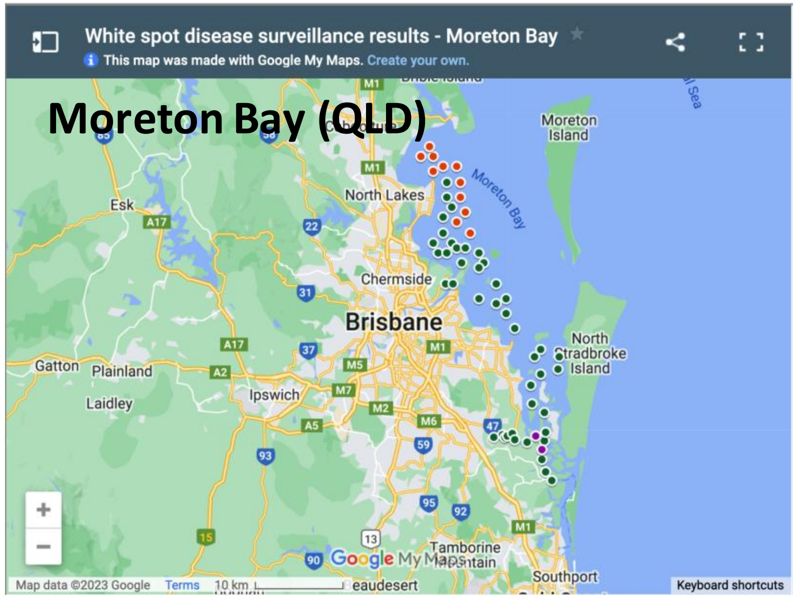
Coastal water quality Pilot: Moreton Bay (QLD) and Cockburn Sound (WA)



Objective: Data integration and visualisation tools to target water quality management issues in two coastal embayments of high ecological and recreational value

- **Cockburn Sound, Western Australia**
  - Baseline monitoring is required prior to construction of Westport terminal
  - Partnership with WA Department of Water and Environmental Regulation
- **Moreton Bay, Queensland**
  - Outbreaks of white spot disease and related harmful pathogens
  - Partnership with QLD Department of Agriculture and Fisheries

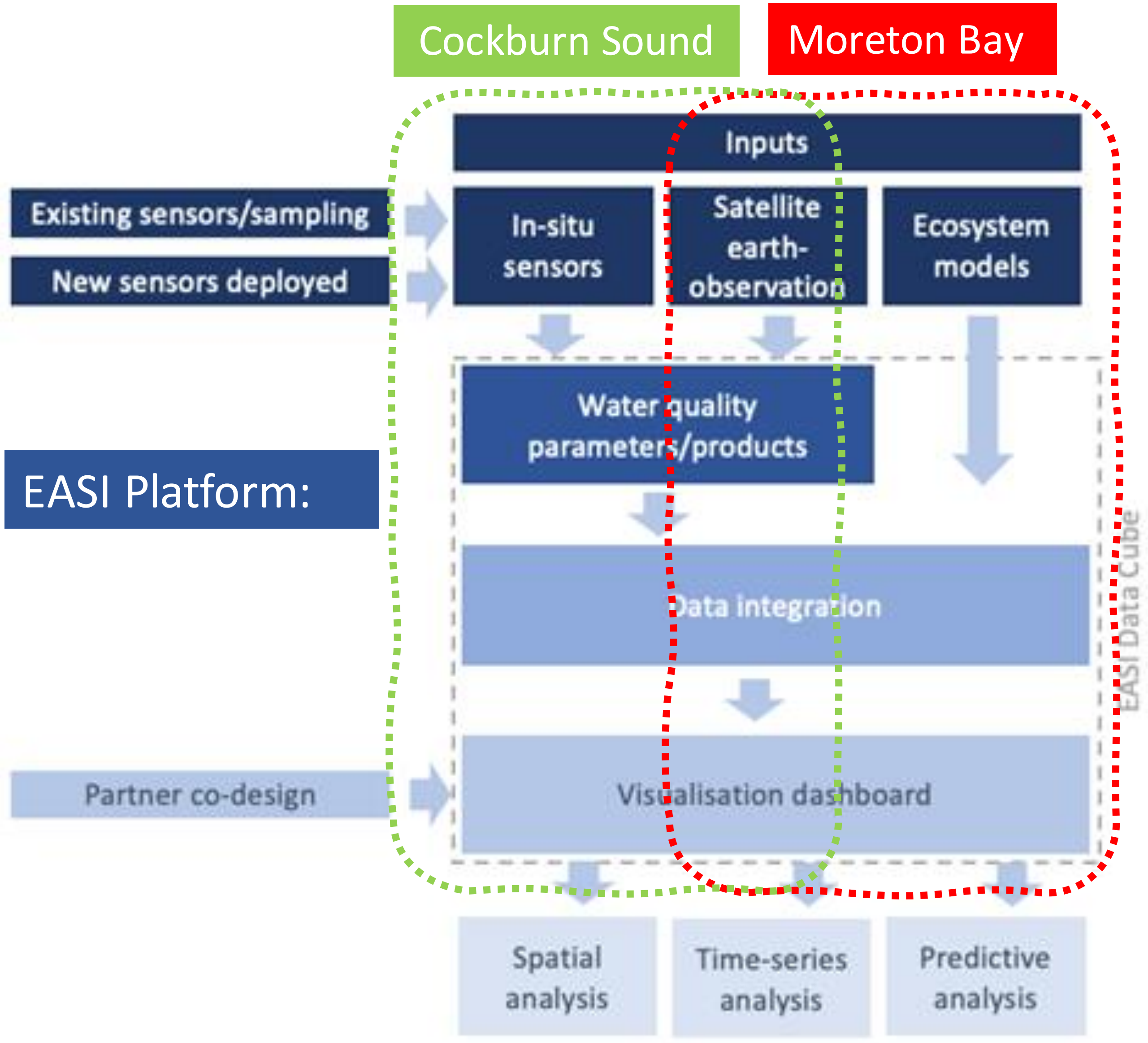




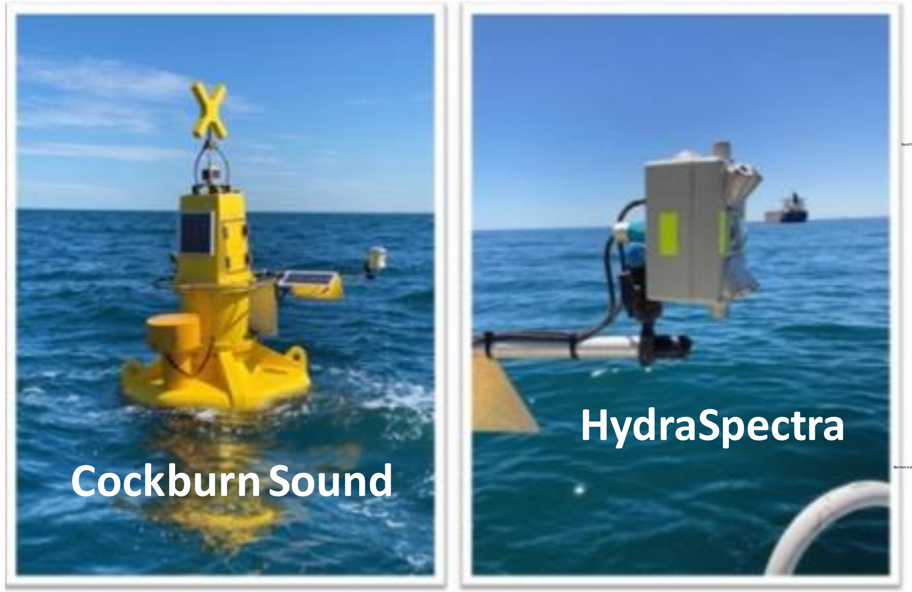
Tim.malthus@csiro.au

CSIRO

Conceptual approach:



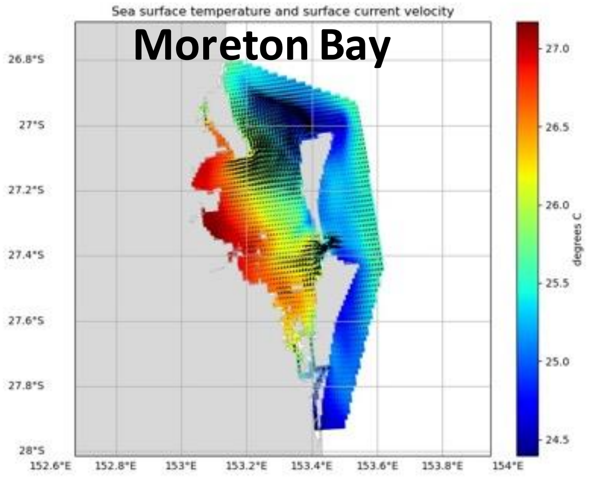
In situ sensors



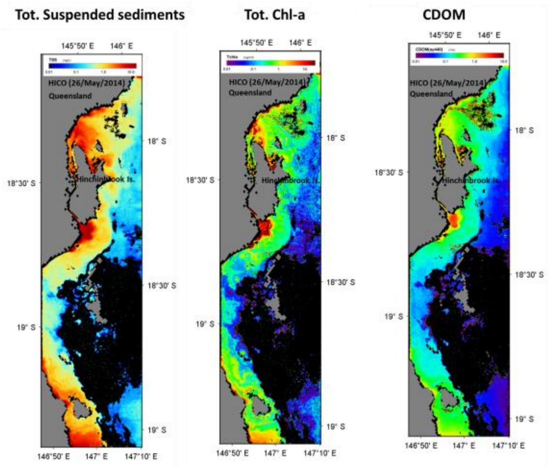
- Temperature
- Turbidity
- Salinity
- DO
- pH
- PAR...

- Chlorophyl
- CDOM
- BGA (PC,PE)
- Nutrient
- Heavy metals
- Cell ID

Hydrodynamic modelling



Remote Sensing maps



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Fitzroy River and Keppel Bay pilot (S. Great Barrier Reef)

- **Objective**: To **estimate river to ocean sediment and carbon fluxes for coastal management**

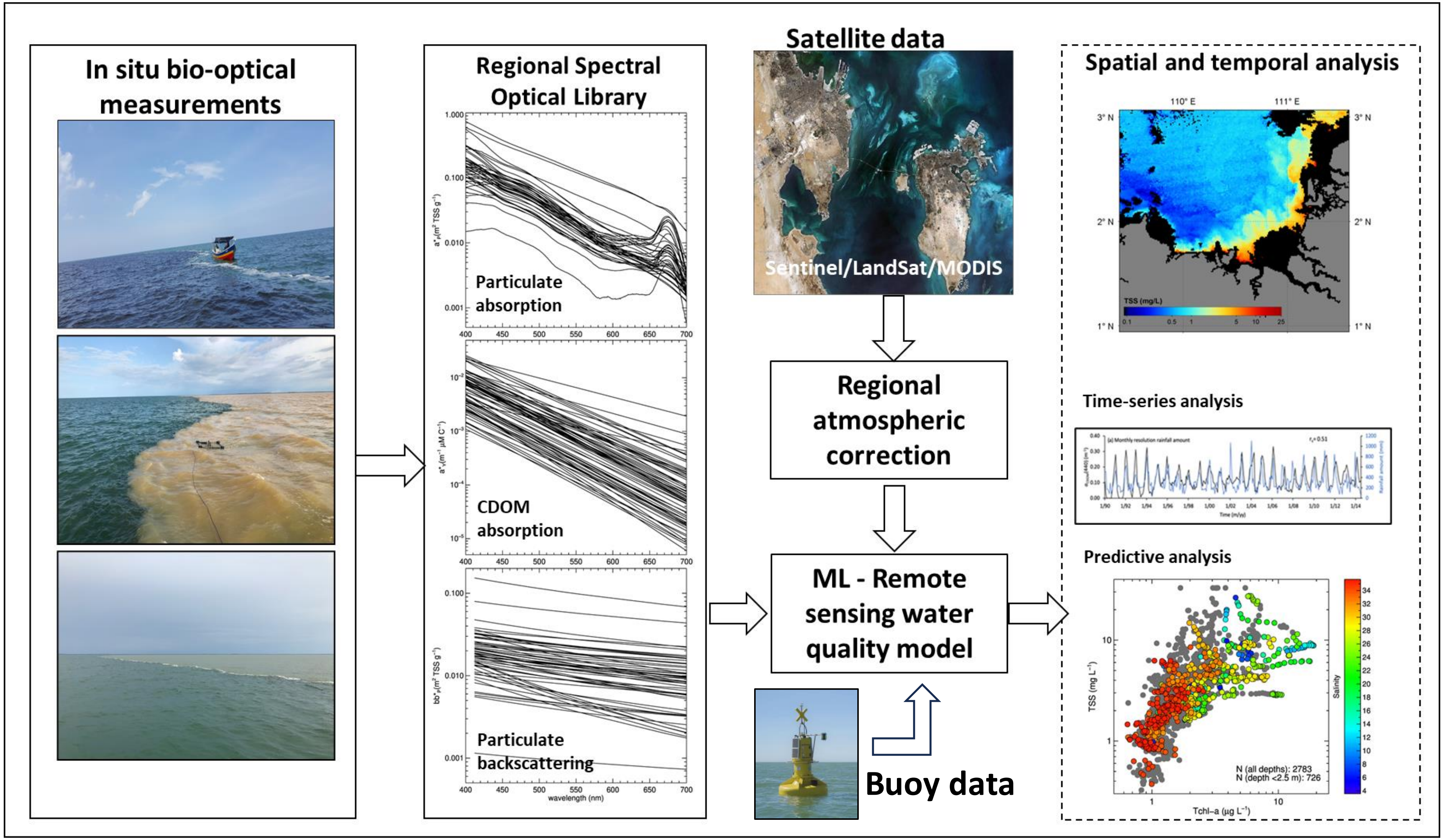
- **Study region** : Fitzroy Estuary and Keppel Bay, Queensland (**Southern Great Barrier Reef**)

- **Approach**: Integration of *in situ* buoy data, satellite sediment estimates and modelling.

- **Uptake**: GBR Marine park authority and Queensland DES

Nagur.Cherukuru@csiro.au

Machine learning models to map water quality parameters using remote sensing



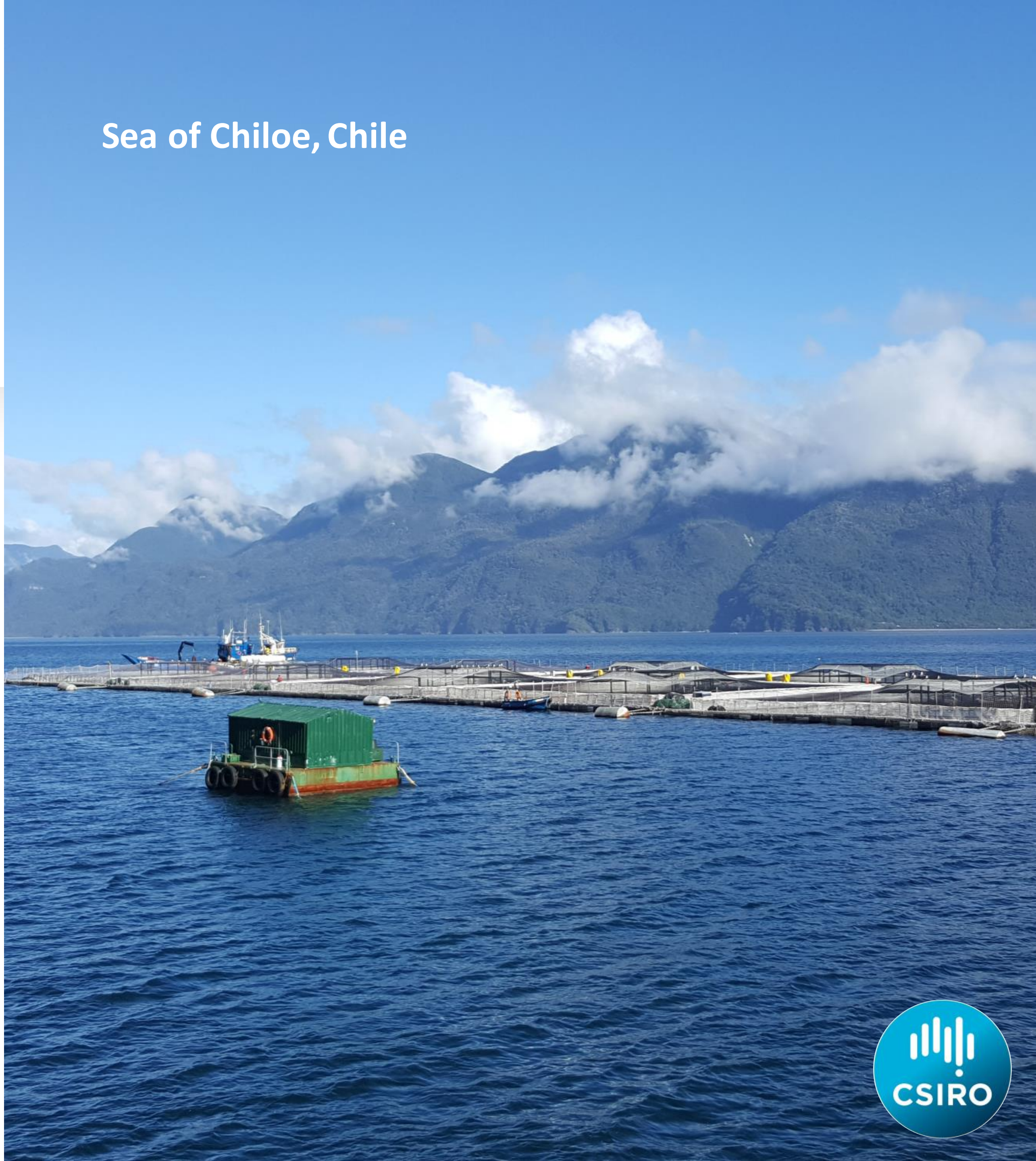
Objective:

- This project will investigate the potential of new ML approaches in predicting water quality parameters through ***fusing data from in-situ water quality sensors and satellite data***.
- **Collaborators**: La Trobe Univ. (lead) and CSIRO
- **Partners**: Queensland and WA state gov. depts.
- **Project time**: Jan/2023-Jan/2025

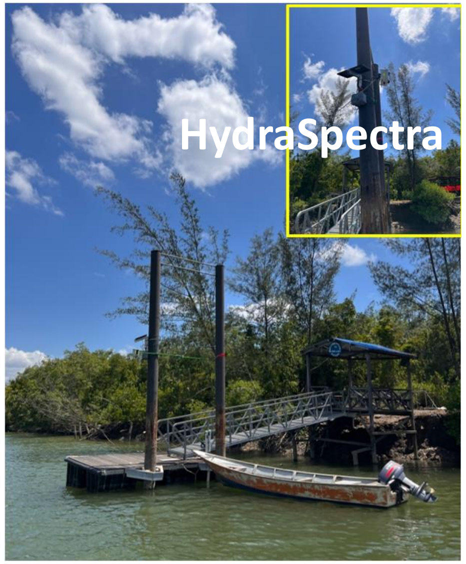
Xiubin.qi@csiro.au

AquaWatch International Pilot projects

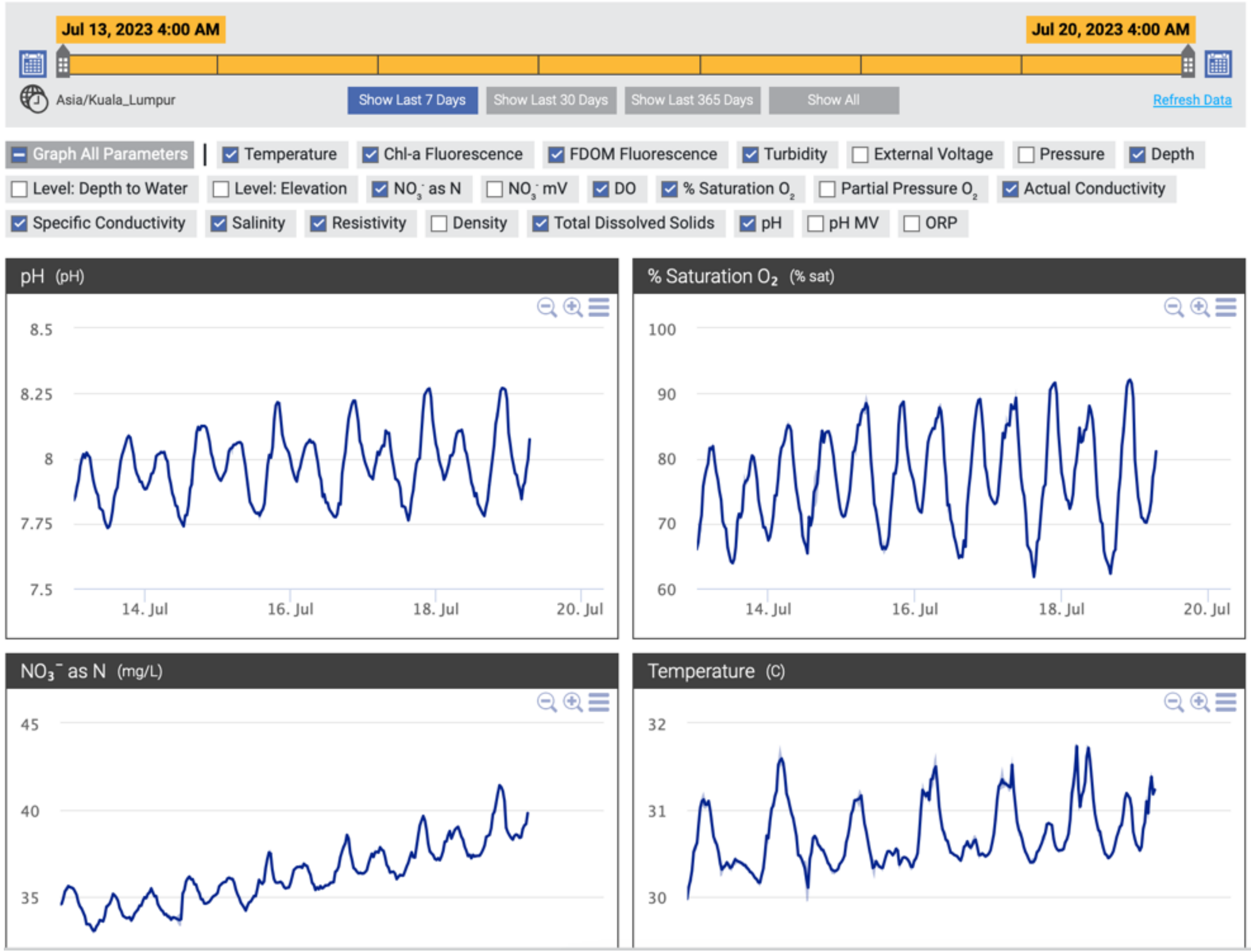
- **<u>Objective</u>**: To reliably monitor water quality changes in support of (a) desalination plant intakes and (b) Salmon aquaculture



Monitoring DOC dynamics in Mangroves (Malaysia)



Objective: To test the accuracy, reliability and suitability of the AquaWatch system to monitor changes in dissolved organic carbon (DOC) in the coastal waters and adjacent mangroves.



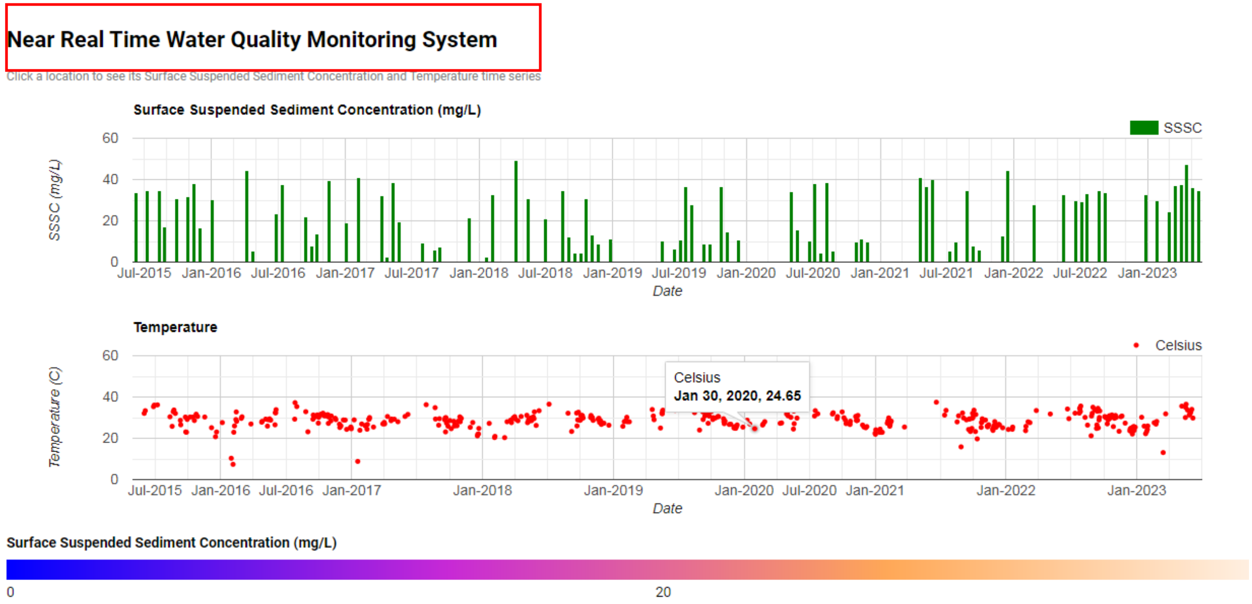
In situ data collected in Kuching, **Malaysia.**

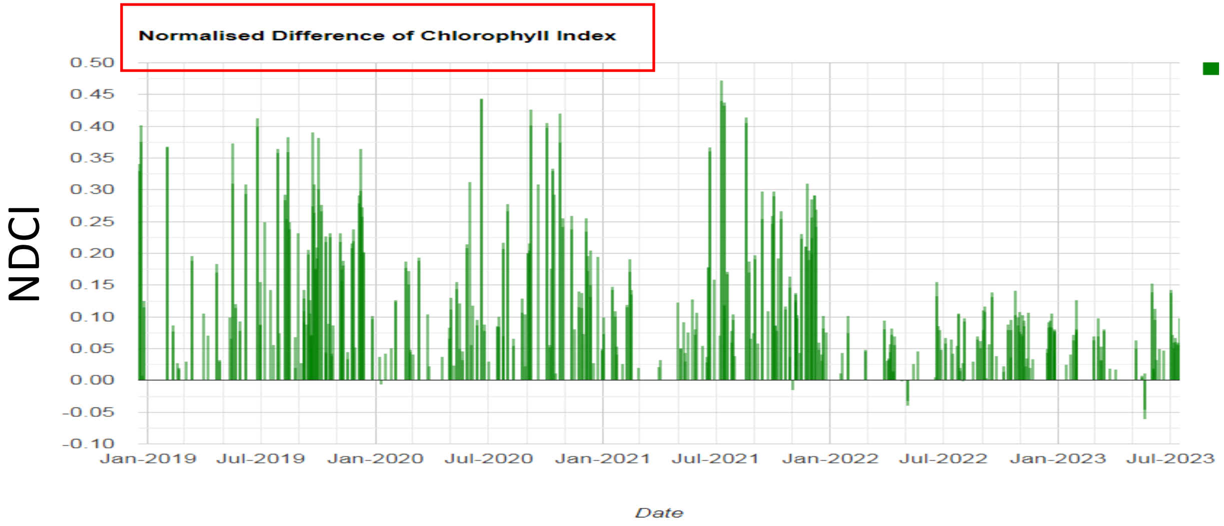
SWINBURNE UNIVERSITY OF TECHNOLOGY SARAWAK CAMPUS

CSIRO

Water quality mapping in Vietnam

Objective:
Monitor changes in Total Suspended Sediments (TSS) and Chlorophyll concentrations in relation to water supplies for consumptive uses, and for hydro-electricity water supplies.





CSIRO

Summary

AquaWatch Mission successfully initiated pilot studies in multiple national and international locations.

Current pilot studies are focussing both on inland and coastal water quality challenges

In situ and Remote sensing data processing chains are available in AquaWatch analytics platform.

By 2026 AquaWatch will demonstrate the integration of insitu sensing, remote sensing and forecasting capabilities at pilot sites.

AquaWatch encourages wider collaboration and co-operation to initiate further pilot projects in inland waters.

Thank you

AquaWatch Mission

https://research.csiro.au/aquawatch/

Contacts:

Nagur Cherukuru and Tapas Biswas
CSIRO Environment and CSIRO Data61
Black Mountain, Canberra

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E: Tapas.biswas@csiro.au

Session – I @ 11:00 AEST

4. AquaWatch Data Integration and Analytics Systems

Dr Robert Woodcock*

*Robert.Woodcock@csiro.au
CSIRO Data61 and CSIRO AquaWatch Mission

Key words: analysis, Earth Observation, cloud, visualisation, in-situ sensors, data

Abstract:
Integrating data from In-situ sensors and Earth observation satellites, implementing generic bespoke algorithms to convert these data sets into water quality information and providing a customizable interface to summarise, present and interact with the data is critical to the success of AquaWatch. The AquaWatch Data Integration Analytics System supports research and ultimately operational users of AquaWatch by providing:

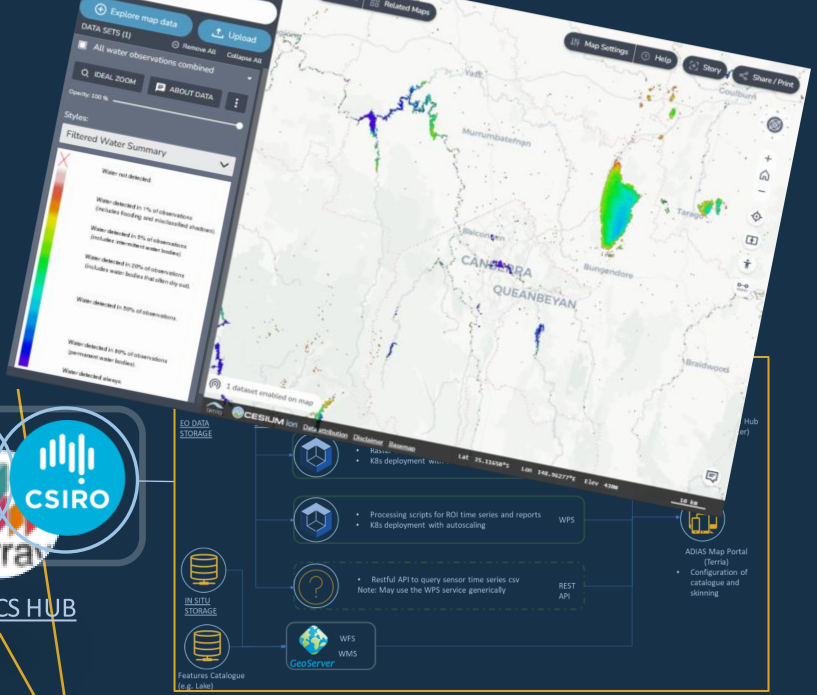
- In-situ and Earth Observation data acquisition and access services.
- Scalable computational resources in the Cloud for continental scale data analytics including Machine Learning.
- An Exploratory Data Analytics and visualisation environment
- Web services and map portals for downstream use of water quality products and services.

AquaWatch Data and Analytics System

Dr Rob Woodcock | September 2023

Australia's National Science Agency

What is ADIAS?



- In Situ Sensor integration pipeline and Query API

aws

Data Catalog - https://explorer.adias.aquawatcaus.space
Analytics Hub - https://hub.adias.aquawatchaus.space

ADS in use

MODIS

Sentinels

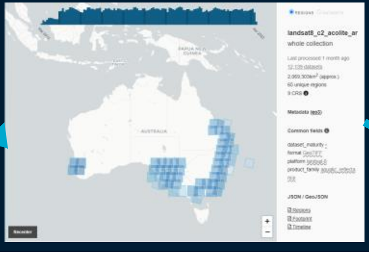
Landsats

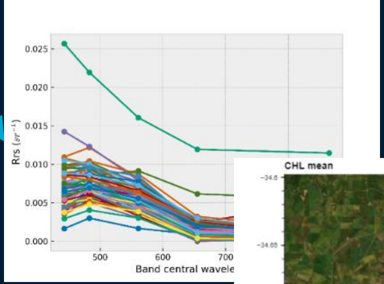
Aquatic Reflectance

Query EO data

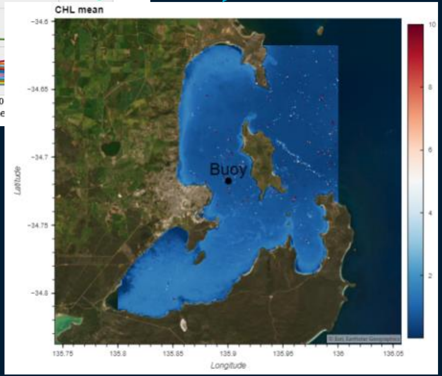
```
buff = 0.1

latitude = lat-buff, lat+buff

#longitude = (135.85, 136.5)
longitude = long-buff, long+buff

out_crs = "EPSG:3557"

time = ('2013-02', '2023-07')
```

```
ls9 = dc.load(
        product='landsat9_c2_acolite_ar',
        x = longitude,
        y = latitude,
        output_crs=out_crs,
        resolution=(30, -30),
        time = time,
        dask_chunks ={"time":1},
        measurements = ['rrs_443', 'rrs_482', 'rrs_561', 'rrs_654', 'rrs_865']
    )

ls8 = dc.load(
        product='landsat8_c2_acolite_ar',
        x = longitude,
        y = latitude,
        output_crs=out_crs,
        resolution=(30, -30),
        time = time,
        dask_chunks ={"time":1},
        measurements = ['rrs_443', 'rrs_483', 'rrs_561','rrs_655', 'rrs_865' ]
    )
```





Integrated Analysis

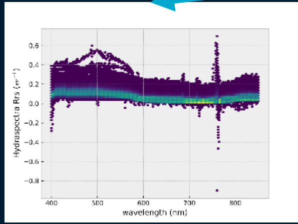


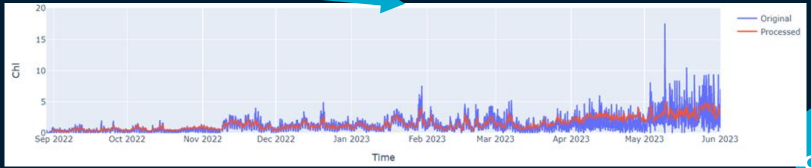
Sensor time series aggregation

Query time series

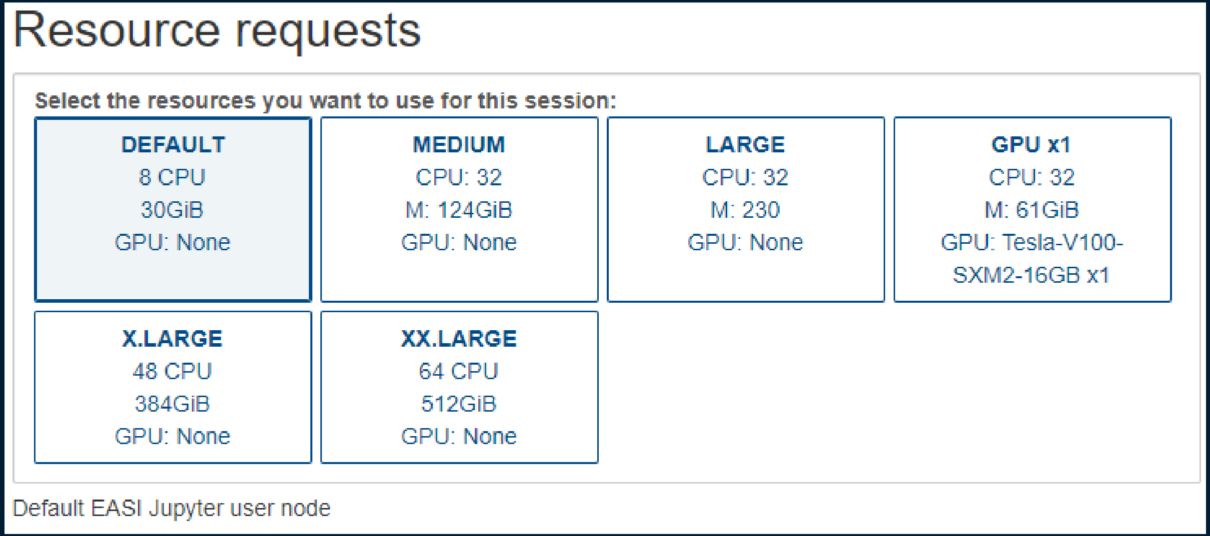
```
[4]: cursor = connect(s3_staging_dir="s3://095077079535-mainprod-aw-prod-athena-results",
                      work_group="mainprod-aw-prod-workgroup",
                      region_name="us-west-2",
                      result_reuse_enable=True,
                      result_reuse_minutes=60,
                     cursor_class=PandasCursor).cursor()

[5]: hsres = cursor.execute('SELECT * FROM "mainprod-aw-prod-db"."mainprod-aw-prod-senaps-allvectors-staging"')
```

Multiparameter Sonde





Resources available



Anything here: https://aws.amazon.com/ec2/instance-types/

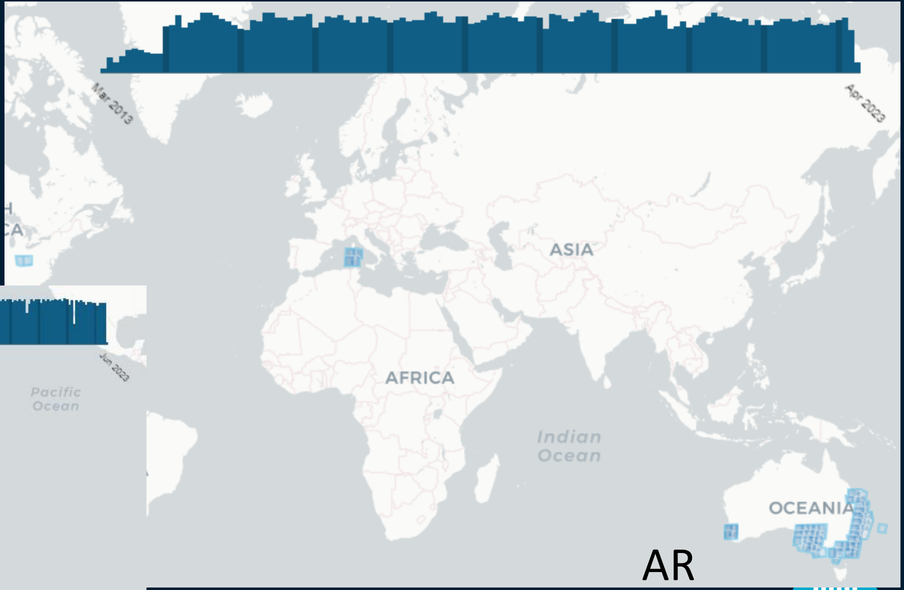
- Workloads tested to 6400 core load average (single user)
- Dash clusters average 100s of cores per user

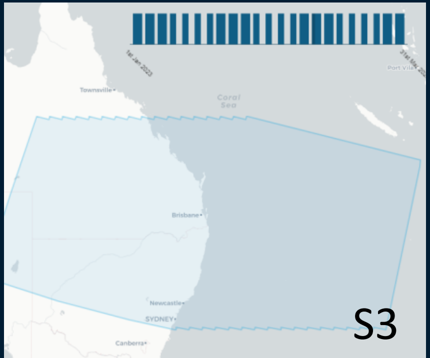
"[ADS] is an excellent development platform"

Nathan Drayson, AW Spencer Gulf Pilot

Aquatic Reflectance

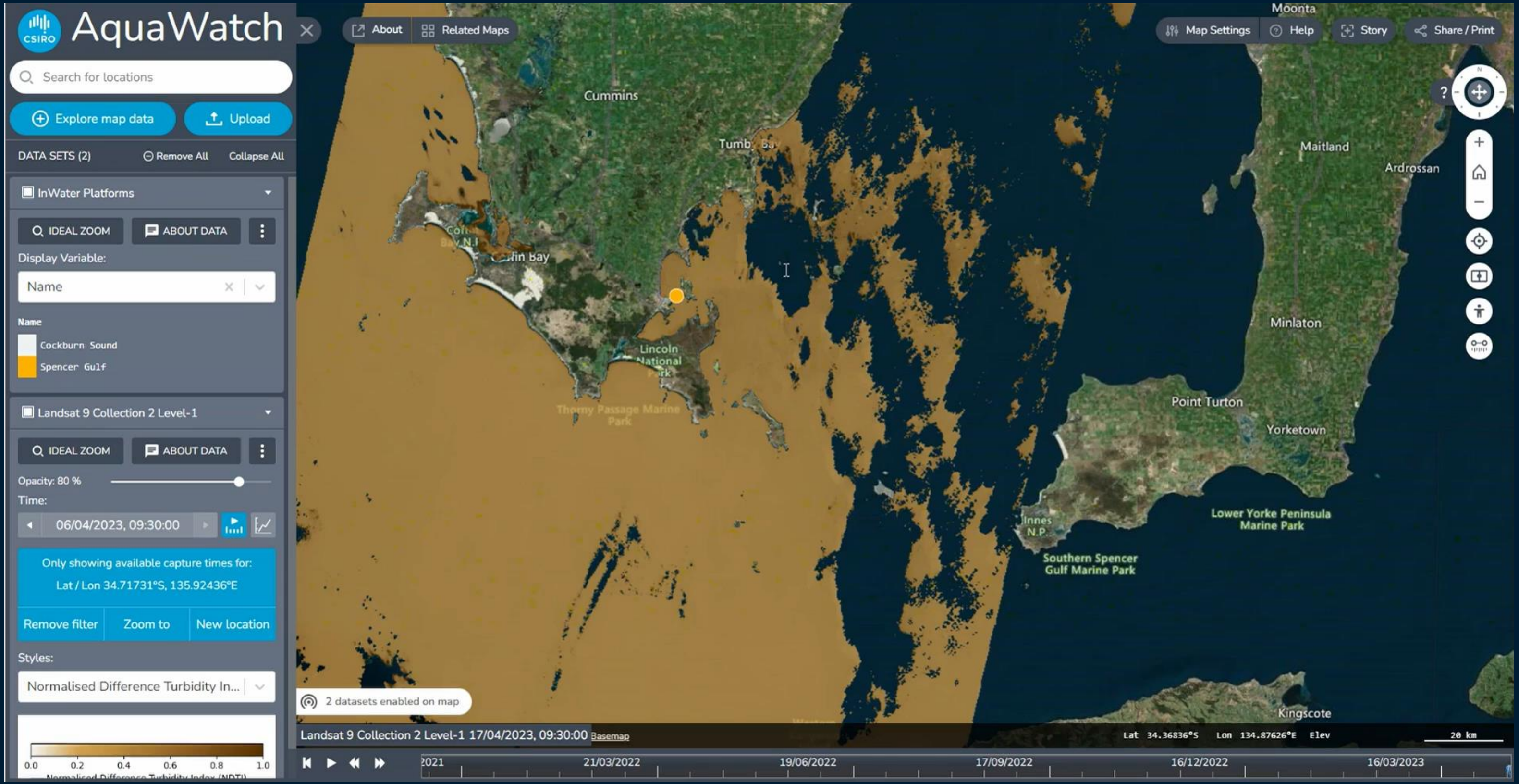
Satellite	Data
Landsat 5,7,8,9	USGS SR, ST – L1C and L2A Acolite Aquatic Reflectance
Sentinel-2	L1C (EU), L2A, Acolite Aquatic Reflectance
MODIS Aqua	IOP, OC, SST
Sentinel-3	L1B Acolite Aquatic Reflectance



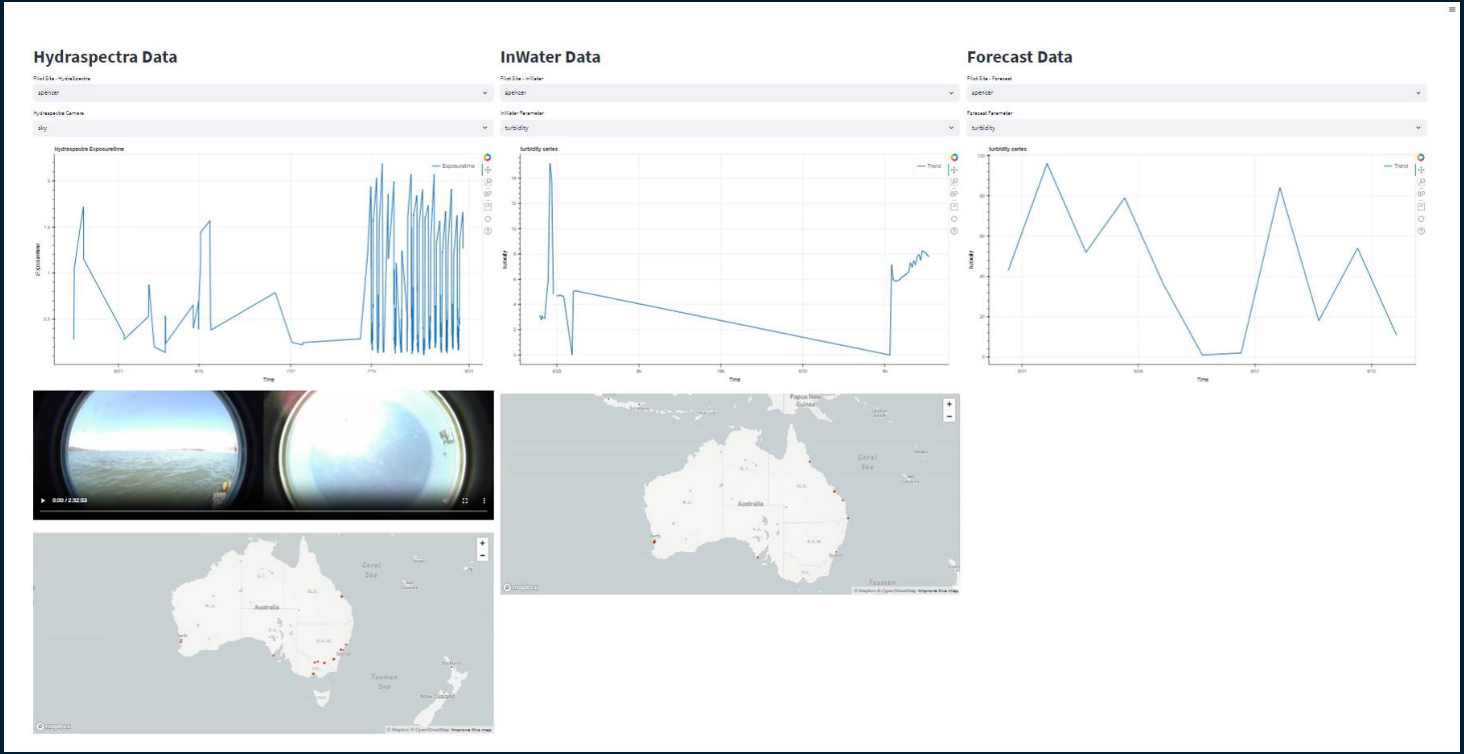


CSIRO

Data Delivery Web Portal (Prototype - Video)



Dashboards - Insitu



Powered by CSIRO EASI technology
Reliable, Scalable, Flexible, Cost Effective

CSIRO

What's next?

- UI/UX development
- Hyperspectral support in ODC
- Operational EO workflows for Aquatic Reflectance
- In situ workflows
  - Controlled vocabularies
- Machine Learning
- Digital Academy AW Training
- Forecasting and ancillary data

	TECHNOLOGY SYSTEM	RESEARCH PROGRAM
By 2026	• Implement ingestion pipelines for required in-situ and EO data sets • Ingest relevant EO data from suitable, public satellites • Implement data dashboard and analytics interface • Implement analytical and/or machine learning water quality retrieval models from in-situ and EO data • Present validated water quality information spatially • Generate baseline historic water quality maps at continental scale	• Continuous improvement of cloud optimisation • Develop training materials • Develop mechanisms to ingest high resolution and/or hyperspectral data • Feasibility study for production of gap-free data products • Review opportunities for integration of Quantum computing into AquaWatch • Review opportunities for integration of generative AI into AquaWatch
By 2030	• Supervise scaling of network • Ingest aquatically optimised EO data • Support customisation for end user applications	• Develop citizen science/mobile platform apps

AW Roadmap

CSIRO

Contact Us

Mineral Resources
Dr Robert Woodcock

robert.woodcock@csiro.au

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Mr Tisham Dhar

Tisham.Dhar@csiro.au

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Session – I @ 11:15 AEST

5. Introducing EO-based forecasting services for hydro-ecological hazards reduction in freshwater systems.

Apostolos Tzimas*

*atzimas@emvis.gr
EMVIS, Athens, Greece

Abstract:
PrimeWater, an EU-funded collaborative R&I project, has developed an integrated business solution, the Water Quality Intelligence Suite (WQiS), that can be a reliable tool for improving preparedness and increasing resilience against extreme flood/drought events, algae blooms and turbidity outbreaks in reservoirs.

The operational WQiS services provide water managers with access to operational, short-term forecasts of water quantity and quality characteristics from the catchment level down to the water reservoirs and lakes for effectively managing hydro-ecological risks in complex, inter-connected freshwater systems.

The service integrates meteorological forecasting with hydrological modelling in the upstream catchments and 3D hydrodynamic and water quality modelling in the reservoir. This enables the production of short-to-medium term forecasts (up to 10 days) of hydrological quantities (river discharges, water temperatures, nutrient & suspended sediment loads) as well as critical water quality related parameters (algae, nutrients, dissolved oxygen, etc.). On the same time satellite imagery from Landsat-8 and Sentinel-2A/B is used to observe a set of key variables for water quality like chlorophyll-a, turbidity and surface temperature, which are used along with in-situ monitoring data to improve the predictive skill of ecological forecasting through Data Assimilation techniques. The performance of the process-based models is further improved using Machine Learning (ML) models to identify and correct systematic errors. In addition to the process-based models, ML models are used to forecast phytoplankton dynamics using hydro-meteorological predictors.

Forecasted data are fed into an Early Warning System aiming to create interpretable warnings for water reservoir managers and indicate high impact changes on critical reservoir parameters, allowing for proactive informed decision making.

Furthermore, a forecast-based downstream service for dynamic multi-reservoir water blending has been developed, to optimize water transfer between interconnected reservoirs, introducing water quality considerations.

CSIRO AquaWatch Mission

End User Consultation Workshop:
HABs Early Warning and Forecasting

Thursday 28 September 2023 | 10.00am - 4.30pm AEST
Dep. of Civil Eng., Monash University, Melbourne

Introducing EO-based forecasting services for hyrdo-ecological hazards reduction in freshwater systems

Apostolos Tzimas, PrimeWater Project Co-ordinator, atzimas@emvis.gr
Evangelos Romas, Head of EMVIS R&I Unit, romasvag@emvis.gr

EMVIS
WATER RESOURCES & ENVIRONMENT MANAGEMENT

Organized by:

CSIRO

In collaboration with:
Water Research Australia & Monash University

Water Research AUSTRALIA

A Quick reflection from yesterday …

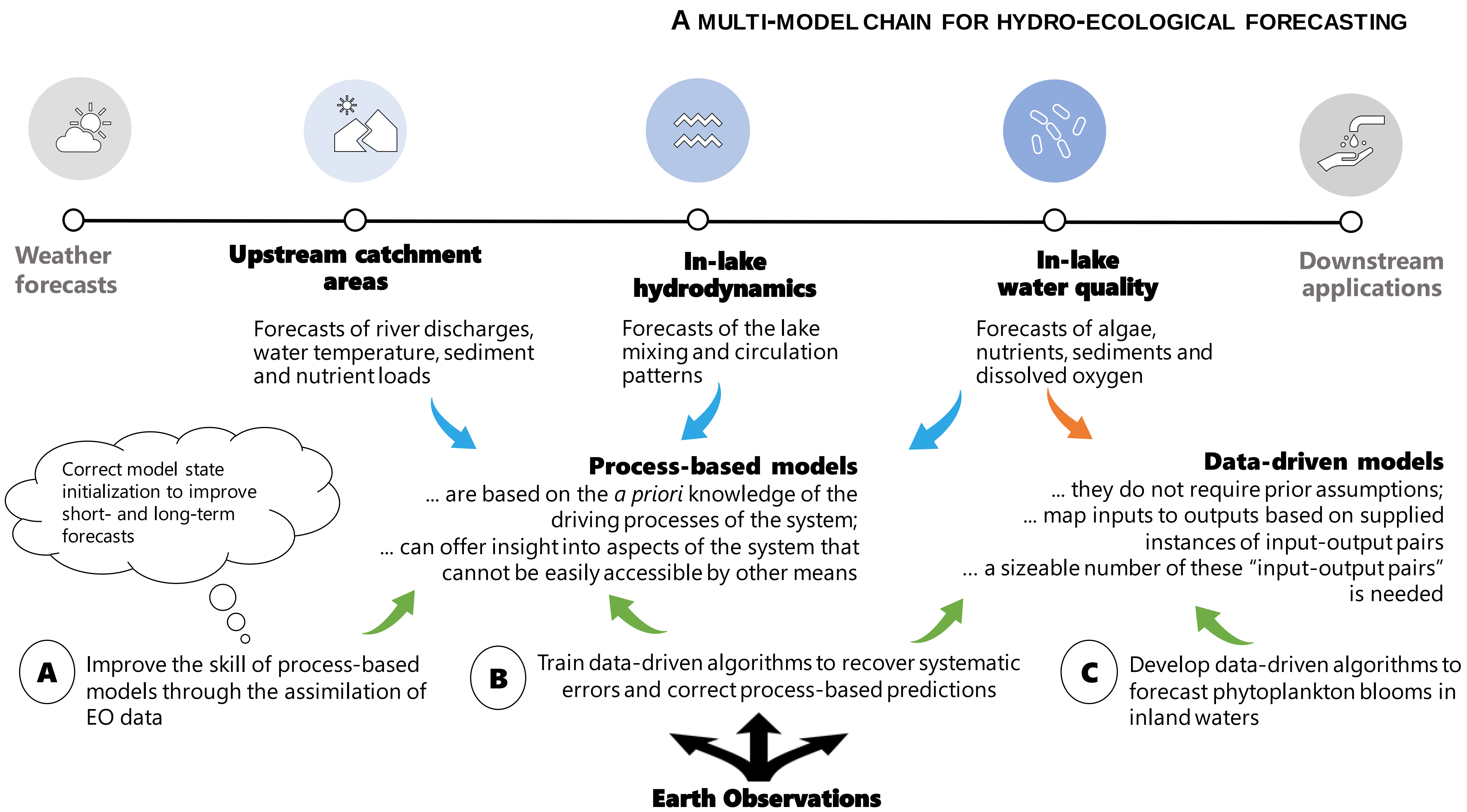
WHO – One Health

Response

Prediction

Prevention

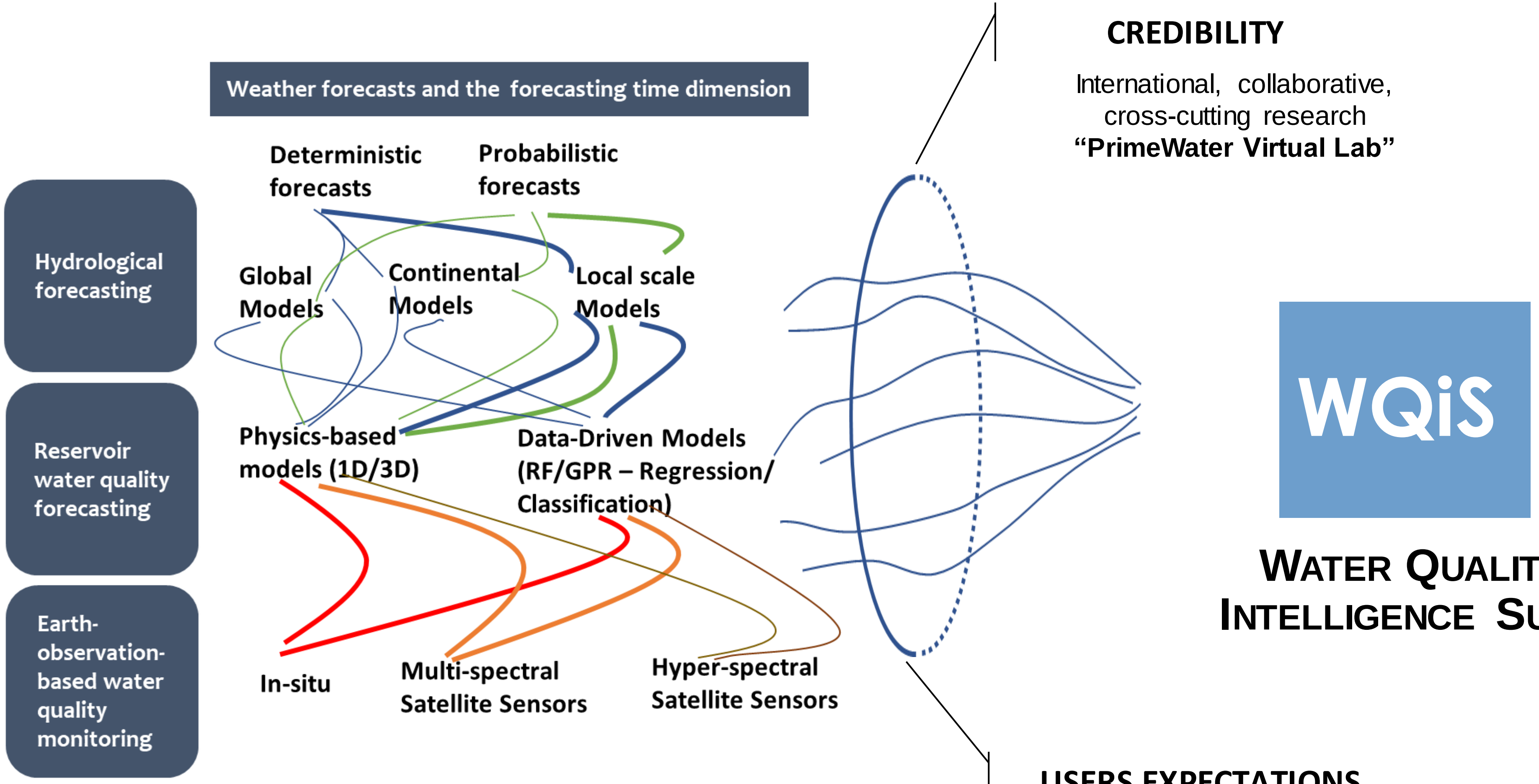
Mitigation


A MULTI-MODEL CHAIN FOR HYDRO-ECOLOGICAL FORECASTING
Weather forecasts
Upstream catchment areas
In-lake hydrodynamics
In-lake water quality
Downstream applications
Forecasts of river discharges, water temperature, sediment and nutrient loads
Forecasts of the lake mixing and circulation patterns
Forecasts of algae, nutrients, sediments and dissolved oxygen
Correct model state initialization to improve short- and long-term forecasts
Process-based models
... are based on the a priori knowledge of the driving processes of the system;
... can offer insight into aspects of the system that cannot be easily accessible by other means
Data-driven models
... they do not require prior assumptions;
... map inputs to outputs based on supplied instances of input-output pairs
... a sizeable number of these "input-output pairs" is needed
A
Improve the skill of process-based models through the assimilation of EO data
B
Train data-driven algorithms to recover systematic errors and correct process-based predictions
C
Develop data-driven algorithms to forecast phytoplankton blooms in inland waters
Earth Observations

Delivering high reliability water quality forecasts for the water industry

Intelligent Services Value Model

From Science to Operational Services for the Industry



Water Quality Intelligence Suite

CREDIBILITY

International, collaborative, cross-cutting research

“PrimeWater Virtual Lab”

USERS EXPECTATIONS

-User-Driven Service Co-Development

Co-design Co-creation Co-evaluation

-Understanding behavioral patterns of the water sector towards innovation

WATER QUALITY INTELLIGENCE SUITE

…in a glance

WQiS facilitates Water Industry to identify Hydro-ecological Risks at an early stage and…

Key features

- **Connect** — Bring into your decision-making data from any sensor, anytime, anywhere
- **Monitor** — Filling in Water Quality information gaps in time and space with satellite-based measurements
- **Predict** — Get Hydro-ecological forecasts just like weather forecasts
- **Pro-act** — Get advantage of the time lead with downstream services for preventive management of WQ threats

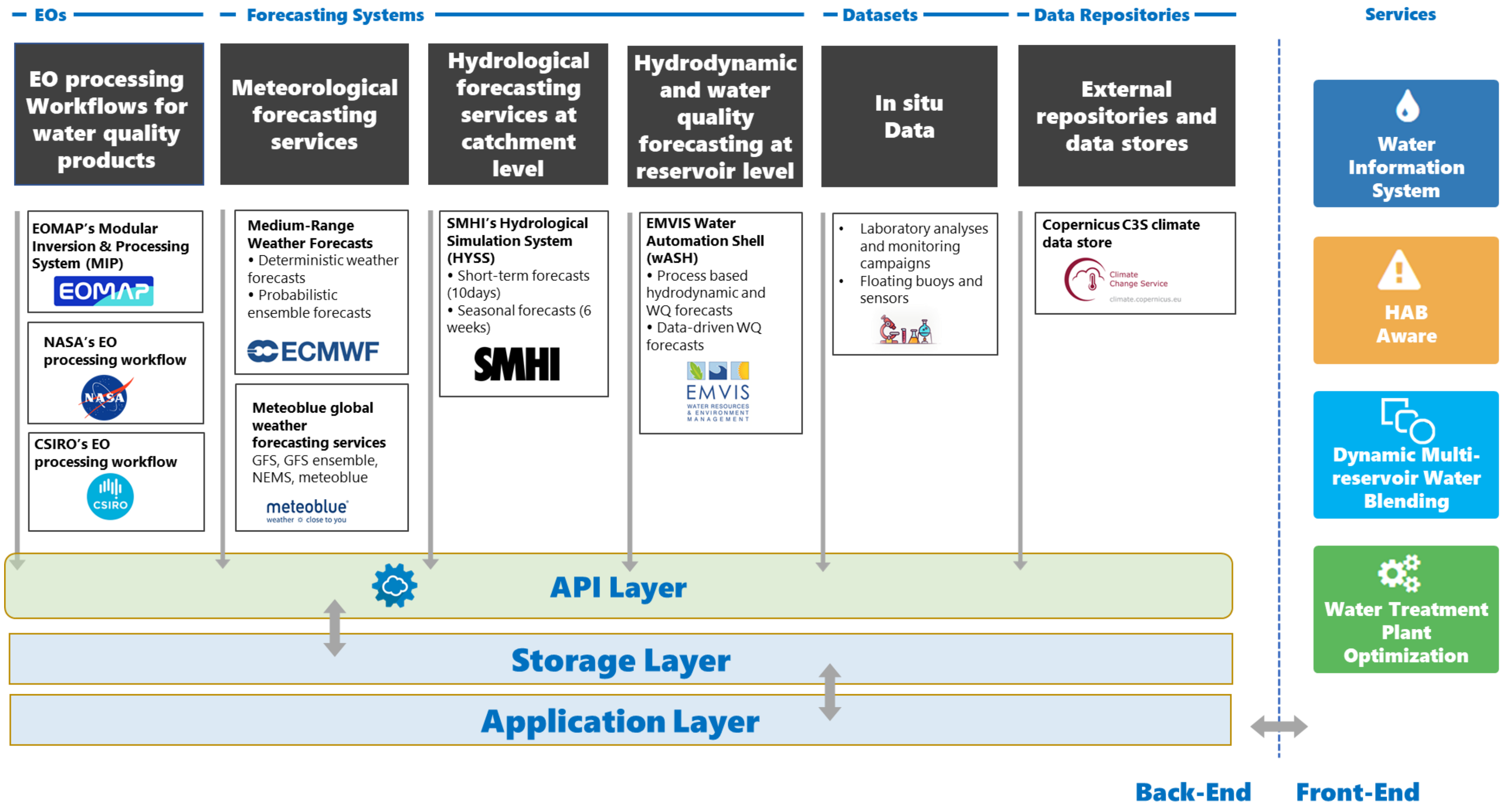
…Pro-act instead of Re-act

Connect

Capitalize on intersections of data

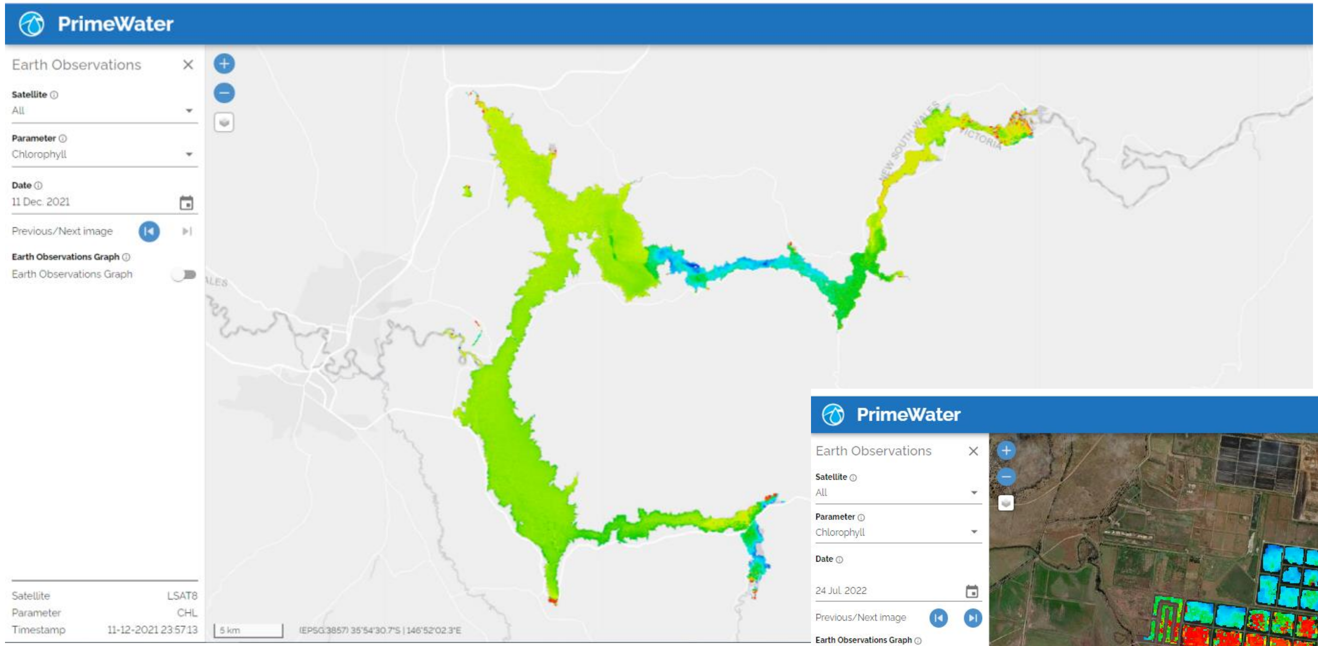
Bridging the data silos

Connect your proprietary data with near real-time, satellite-based water quality data and other remote sensing data and simplify environmental reporting and hydro-ecological hazards risk assessment.



Monitor

Water Quality Data from Space



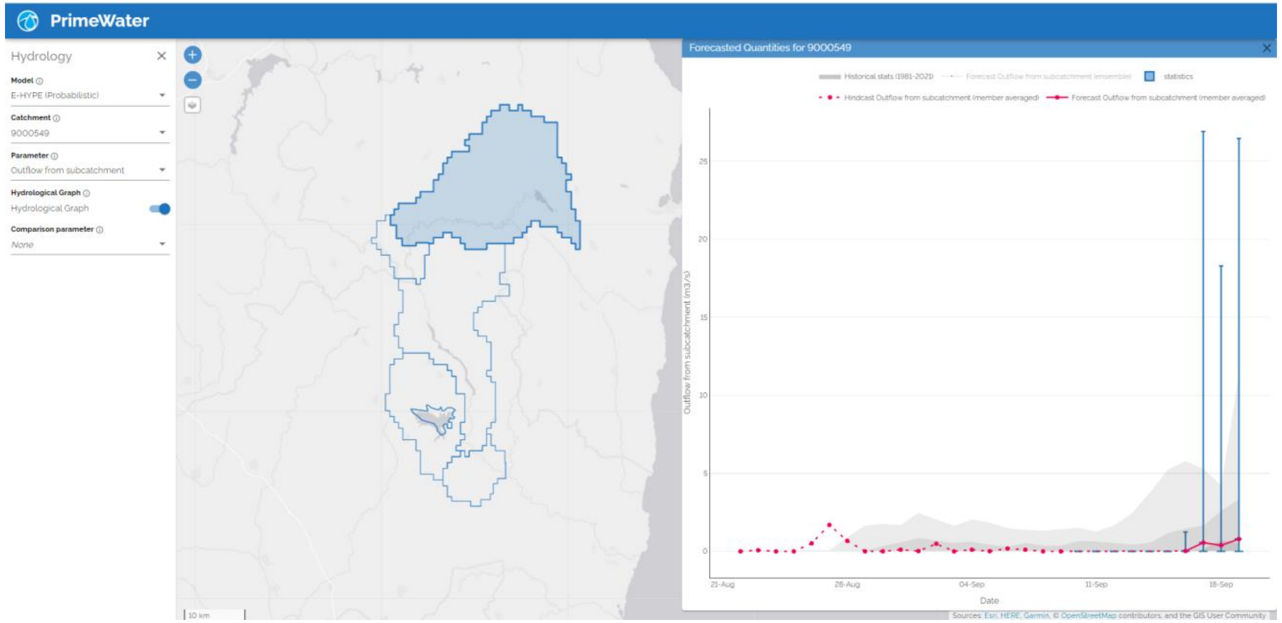
Making intelligent decisions

Filling in Water Quality information gaps in time and space and increase your efficiency, save costs and lower operations risks

Sentinel-2A/B and Landsat 8 imagery processed by EOMAP Modular Inversion and Processing System (MIP)

Predict

Hydrological Forecasts as a Service



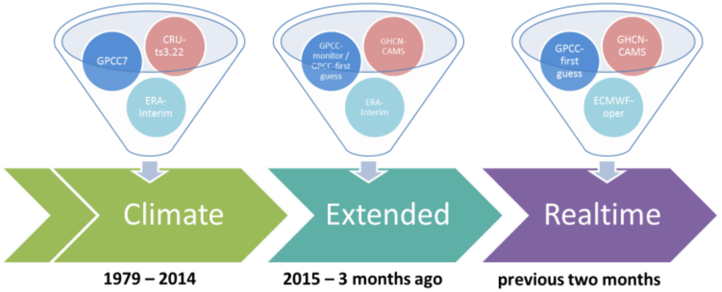
Transform weather forecasts into river flows in your watershed

Forecast river discharges, water temperature, sediment and nutrient loads for up to 10d ahead.

Hydrological forecasts provided by SMHI HYPE Model

SMHI's operational global forcing dataset (HydroGFD)

Bias-adjusted reanalysis data for daily precipitation and minimum, mean, and maximum temperature.

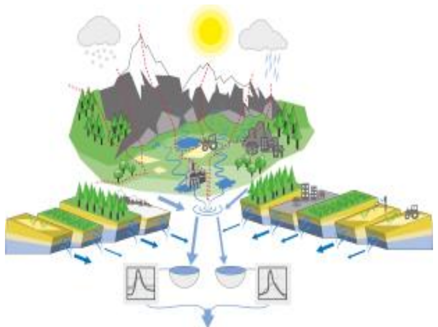


Today - Today +10d

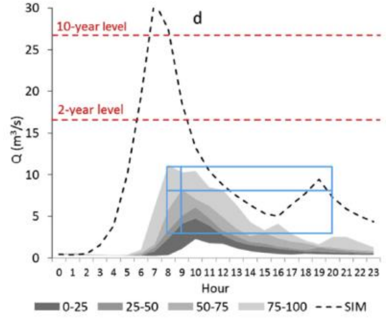
ECMWF DET/ EPS (51 members)

Any high-resolution forecast

Global, Continental or Local HYPE model set up for hydrological forecasting



Short to medium range forecasts



Discharge

Water temperature

Solids (TS & VC)

Phosphorus (PP & SP)

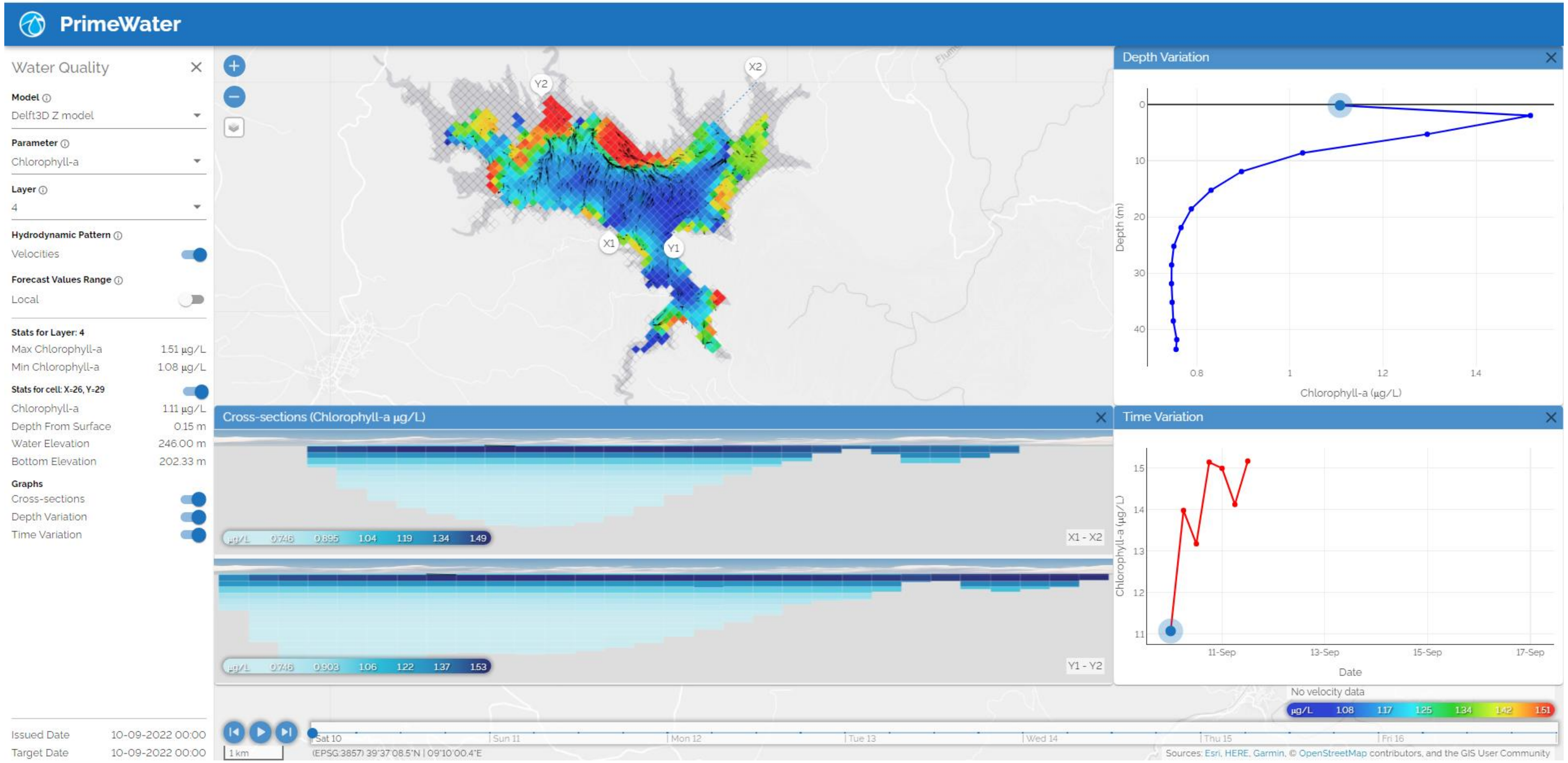
Nitrogen (ON & IN)

Predict

Water Quality Forecasts as a Service

Get Hydro-ecological forecasts just like weather forecasts

Forecast key attributes for water quality in lakes and reservoirs to promote safety and drive efficiency. Identify risks so you can mitigate exposure to water related hazards at an early stage.



Process-Based Water Quality Forecasting

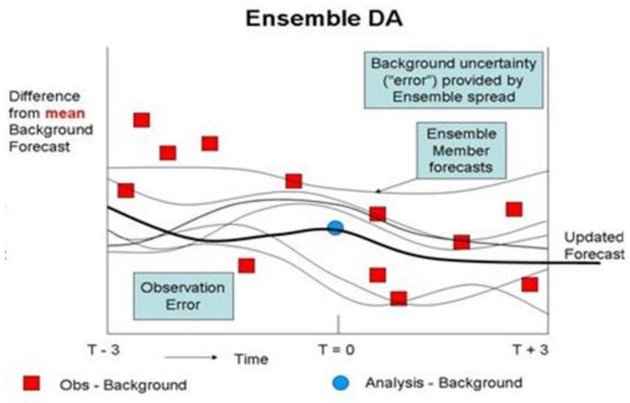
Process-Based hydrodynamic and WQ forecasts are provided by EMVIS Water Automation Shell (WASH) using Delft 3D model

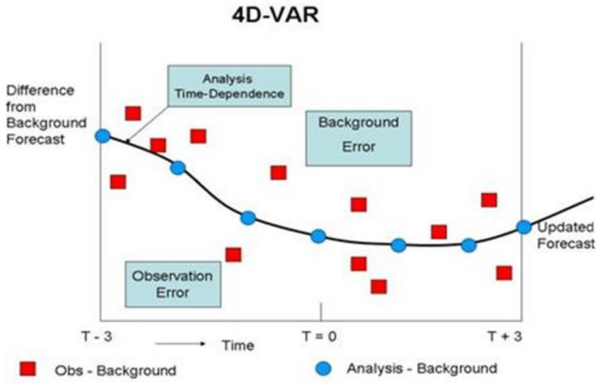
Advancing the Skill of Process-Based Water Quality Forecasting

…real-time EO data assimilation in the WQ Model to improve model performance

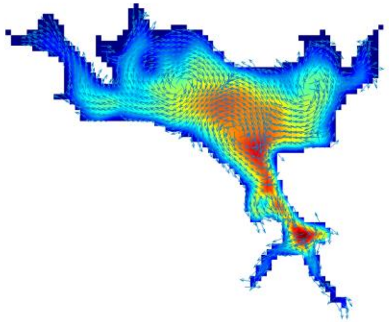
- EO-derived water **temperature improves** model-based **predictions of water temperature** when assimilated in hydrodynamic models, but it **does not impact chlorophyll-a** predictions.
- in-situ data (even from a single station) can efficiently correct most of the modeling domain for **chlorophyll-a safeguarded** against **extreme errors**.
- The **impact** of data assimilation **dissipated** within **few days**.

Improve forecasting skill through Sequential (Ensemble Kalman Filter) or Variational (modified 4D-VAR) Data Assimilation

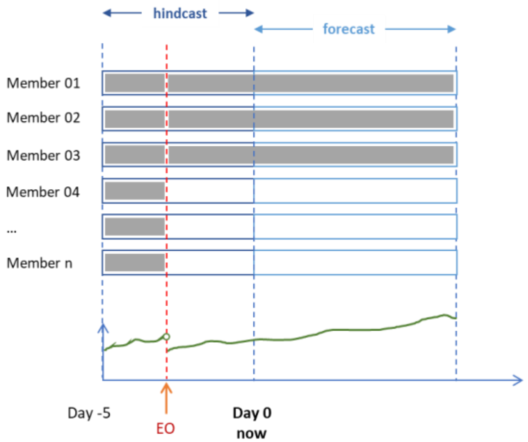




Operational coupled Hydrodynamic and Water Quality forecasting for Freshwater

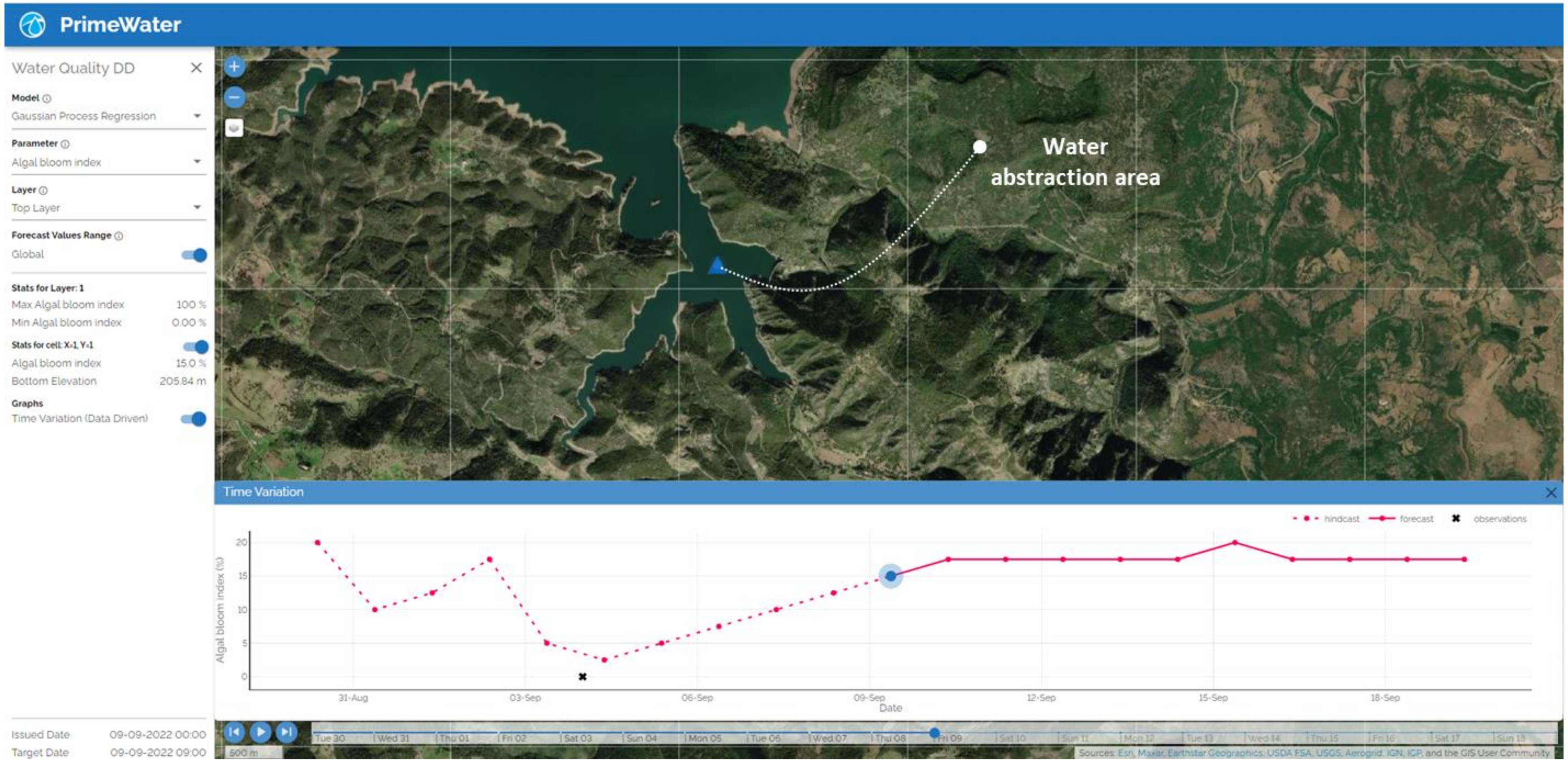


Automated, near real-time data assimilation of in-situ monitoring datasets and EOs to correct initialization state of ecological modelling and improve forecasting skill.



Benefit from the power of ML

Machine Learning algorithms (random Forests, Gaussian Process Regression, Quantile regression forests) are used for Water Quality predictions, assessment of prediction uncertainty and systematic errors correction in forecasting systems.



ML Water Quality Predictive Models

Data – Driven WQ forecasts are provided by EMVIS Water Automation Shell (WASH)

What if we knew how a phytoplankton outbreak will evolve 10 d in advance

WATER SECTOR

Can this information trigger early actions ?

- Are any actions that can be taken considering the information?
- Can the lead time available for the HAB event provide sufficient time to implement early actions and mitigate impacts in advance?

What is at stake as an outcome of a decisions?

What is the cost/benefit from using the next-best substitute for the information ?

How certain decisions are based on forecasts?

Factors influencing the Value of Forecasting Information

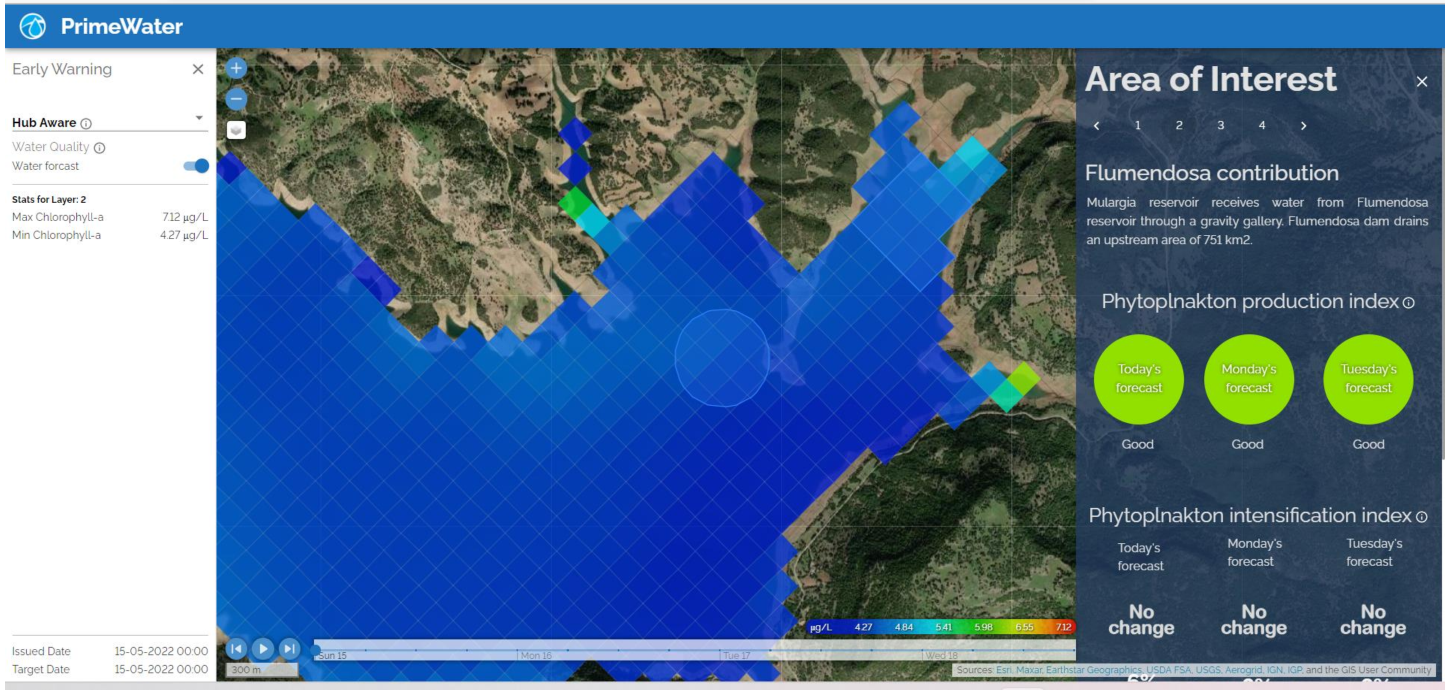
Pro-act

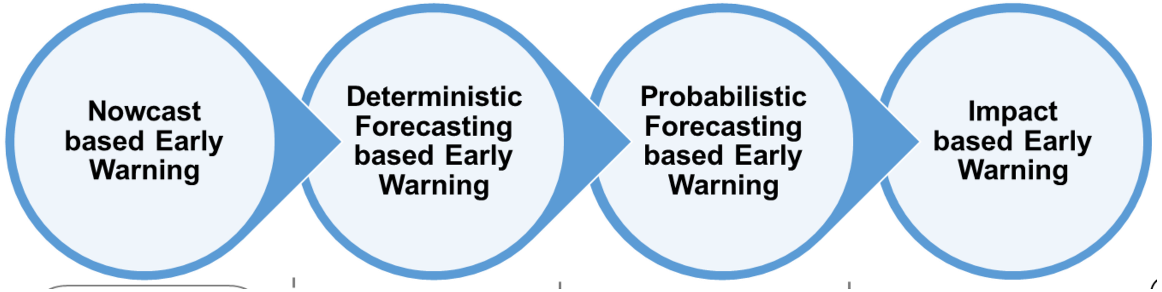
HAB Aware

Moving from Thresholds to impact based forecastingc

Improve Preparedness Against Water Hazards

Turn forecasts into assessments of how water quality will impact your operations, and initiate anticipatory actions at an early stage





Pro-act

Downstream Services for in-lake preventive management of hydro-ecological threats

Pro-act instead of Re-act and optimize existing practices for Water Quality Hazards exposure and vulnerability reduction

Proactive Management of HAB impacts

Get advantage of the time lead in predicting the response of highly complex and dynamic systems and respond in advance with in-lake management measures to reduce the impacts from water quality outbakes.

Switching or blending water from different sources

Chemical assisted algae control

Aeration

Biologically Derived Control

Mixing/ De-stratification

UV Lighting Algae Control

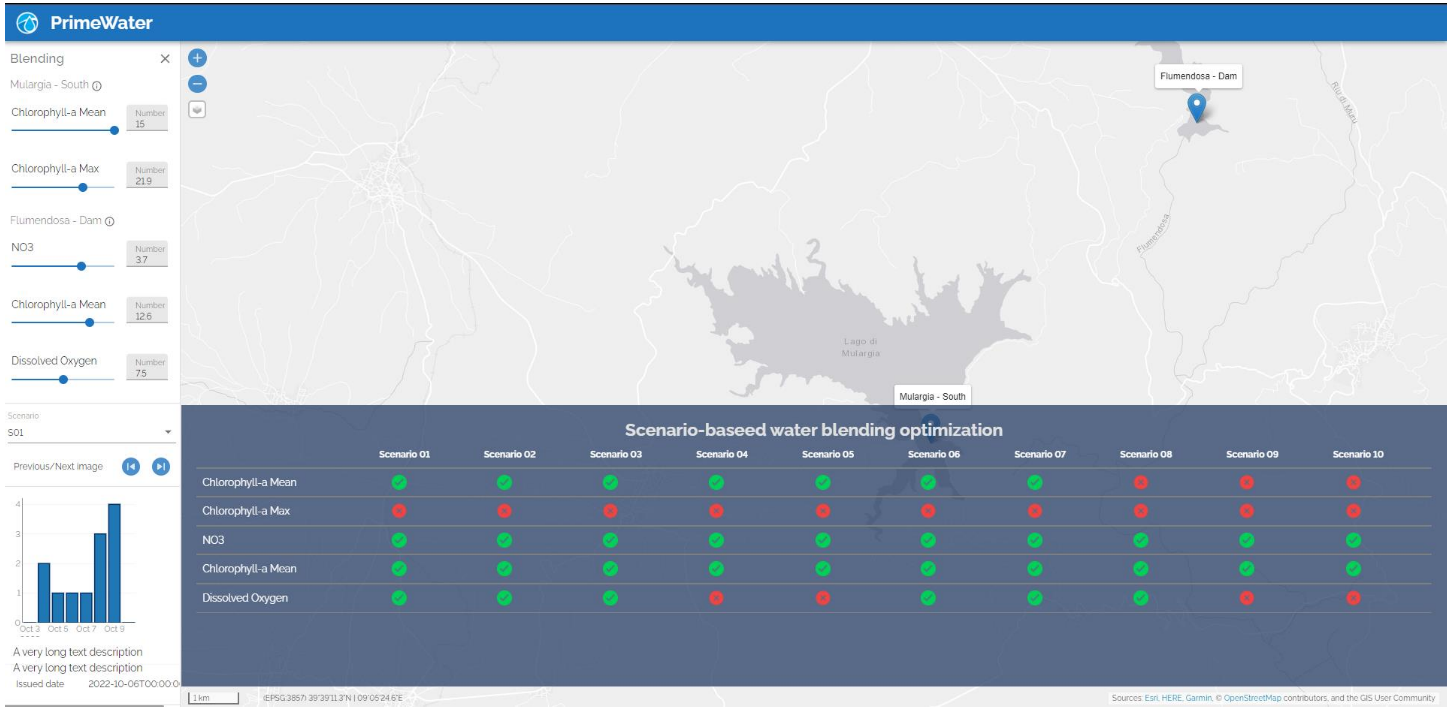
Pro-act

Dynamic Multi-reservoir Water Blending as a Service

Preventing the evolution of an algae bloom by combining different sources of water

Reducing the impact of an algae bloom before it evolves

Improve water transfers among your interconnected reservoirs to mitigate in advance, upcoming water quality hazards and reduce impact to downstream uses



- ❑ Combining different sources of water is a complex and multi-parametric problem when it comes to Water Quality, which requires advanced modelling tools.
- ❑ EMVIS 10 days forecasting capacity enables early detection of quality deterioration and allows bulk water managers to be proactive and start transferring water from upstream reservoirs before the bloom spreads across the reservoir.
- ❑ Dynamic Multi-reservoir Water Blending Service may further facilitate reservoir managers to improve their operations by quickly assessing the effectiveness of various water transfer scenarios in terms of volume, timing and duration.

Our Show Cases

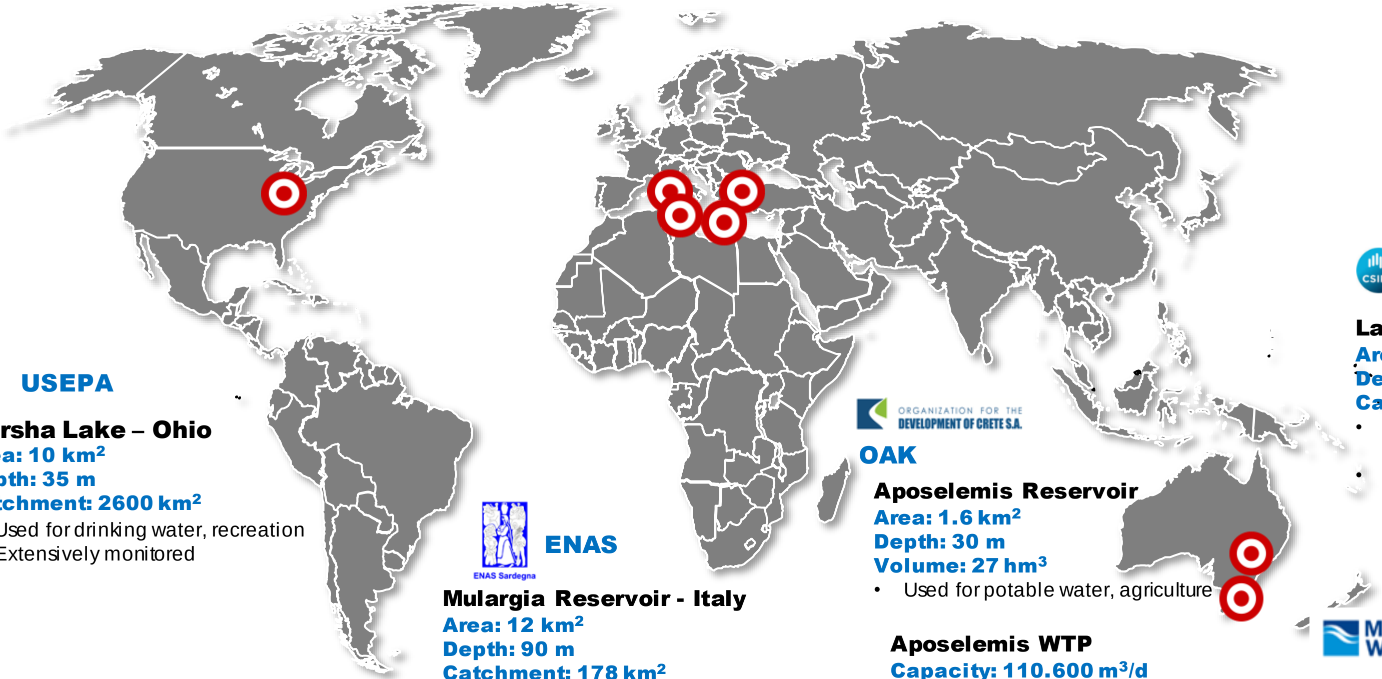
WQiS is deployed in freshwater and coastal waters across Europe, United States and Australia

Advanced services for the Water Sector

Demonstrating the capabilities of cross-cutting, data-driven applications

Discover our Operational Show Cases at:

https://www.primewater.eu/operational-platform/



USEPA

Harsha Lake – Ohio
Area: 10 km^2
Depth: 35 m
Catchment: 2600 km^2

- Used for drinking water, recreation
- Extensively monitored

ENAS

Mulargia Reservoir - Italy
Area: 12 km^2
Depth: 90 m
Catchment: 178 km^2

- Used for potable water, industry, agriculture
- Series of interconnected reservoirs
- In-situ monitoring stations and sampling campaings

Abbanoa

Simbirizzi WTP, Cagliari - Italy
Max flow: 1.5 m^3/s
Served pop.: 320.000 PE
Capacity: 155.000 m^3/d

- Provides drinking water for the town of Cagliari and metropolitan area, and 20 villages in the greater area

OAK

Aposelemis Reservoir
Area: 1.6 km^2
Depth: 30 m
Volume: 27 hm^3

- Used for potable water, agriculture

Aposelemis WTP
Capacity: 110.600 m^3/d

- Provides drinking water to Heraklion, Hersonissos and Agios Nikolaos

RO Desalination Plant
Capacity: 7.000 m3/day
Provides potable and demineralized water for MOTOR OIL HELLAS – Corinth Refineries.

CSIRO

Lake Hume - Australia
Area: 200 km^2
Depth: 40 m
Catchment: 15300 km^2

- Used for flood mitigation, hydro-power, irrigation, water supply
- Hydrodynamic modelling and early warning system based on remote sensing from previous project

MW

Melbourne Water Western Treatment Plant
Lagoon-based WWTP

- Provides Class A and Class C water
- Lagoon depth ranges from 3 to 5m

Delivering high reliability water quality forecasts for the water industry

Key conclusion…

COMBINE

satellite data with proprietary data and hydro-ecological models

GENERATE

operational forecasts of water quantity and quality changes such as temperature oxygen, turbidity and phytoplankton

INTEGRATE

forecasts into industry specific downstream services

Acknowledgments

PrimeWater Team:

The project has received funding from the European Union's Horizon H2020 Research and Innovation Programme under Grant Agreement No 870497

Thank you!

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MANAGEMENT

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Session – I @ 11:30 AEST

6. The operational PrimeWater platform for short-term hydro-ecological forecasting in freshwater reservoirs

Evangelos Romas*[1], Apostolos Tzimas[1]

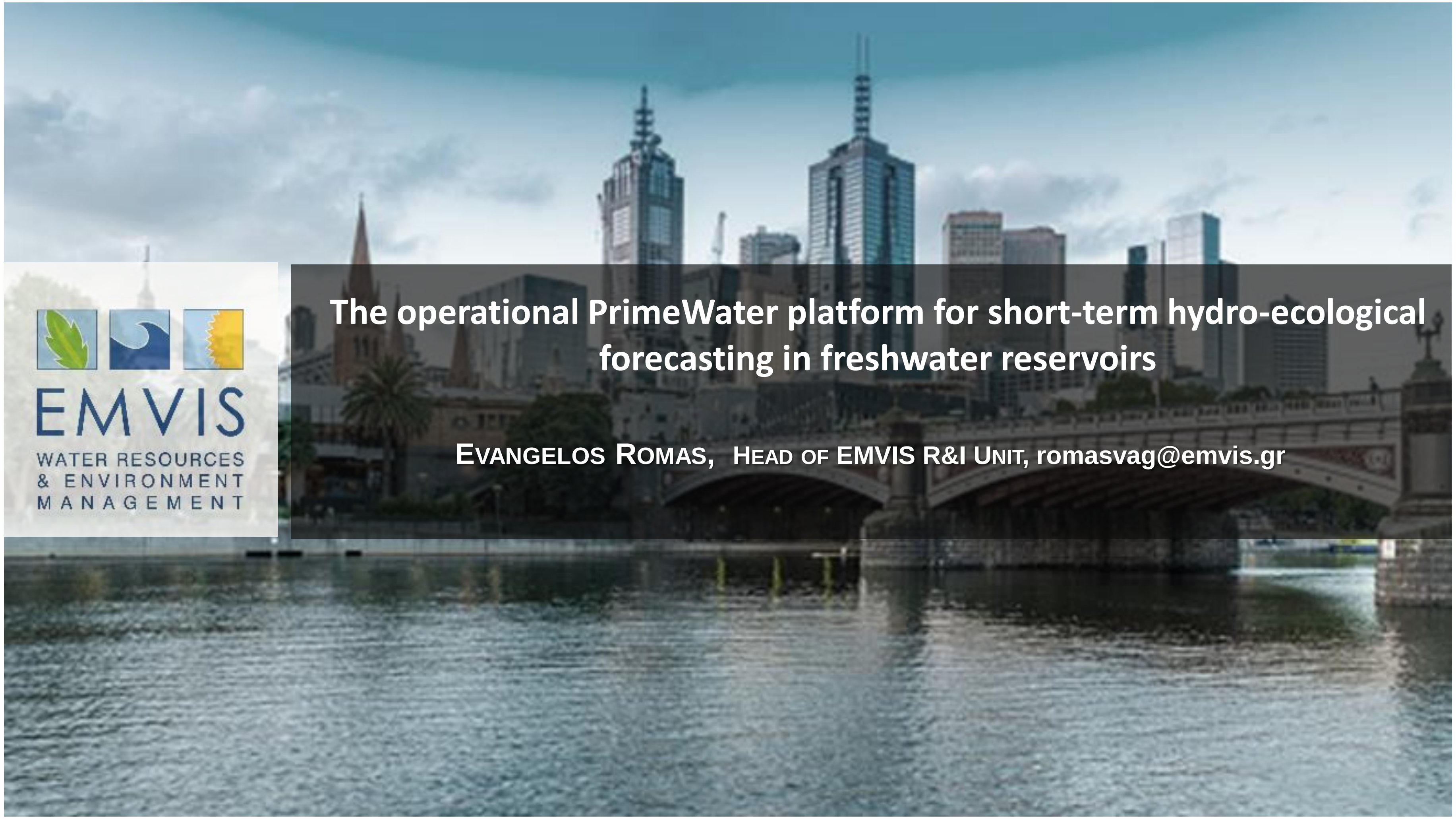
*romasvag@emvis.gr
[1]EMVIS, Athens, Greece.

Abstract:
PrimeWater is an EU-funded Research and Innovation collaborative project, which generates information on the effects of upstream changes on future water quality and quantity. PrimeWater has demonstrated different perspectives of adaptive water management based on short term hydro-ecological forecasts, in four full-scale international case studies, located in Europe, USA and Australia. In lake Hume, AU, a complete hydrological forecasting system has been setup and calibrated, allowing for the generation of 10-days ahead forecasts of river discharges, sediment and nutrient loads, entering the reservoir from the upstream catchments. Hydrological forecasts were consequently combined with meteorological forcings and were used to develop Machine Learning models for predicting chlorophyll-a concentrations in selected Areas of Interest inside lake Hume for 10-days ahead. The ML models were trained with EO-based chlorophyll-a concentrations generated from Landsat-8 and Sentinel-2A/B imagery. In Lake Harsha, US, and lake Mulargia, Italy, PrimeWater has also deployed 3Dimensional hydrodynamic and water quality models using the Delft3D suite. The process-based models offer 7-days ahead forecasts of various critical water quality related parameters (algae, nutrients, dissolved oxygen, etc.) for the entire reservoir area including vertical profiles. Finally, for interconnected lakes Mulargia and Flumendosa in Italy, a customized solution for optimizing the volume and timing of water transfer between the reservoirs has been deployed based on 3D water quality forecasting models for both reservoirs. The operational PrimeWater case studies are available through https://app.primewater.eu/primewater.

CSIRO AquaWatch Mission

End User Consultation Workshop:
HABs Early Warning and Forecasting

Thursday 28 September 2023| 10.00am - 4.30pm AEST
Dep. of Civil Eng., Monash University, Melbourne



The operational PrimeWater platform for short-term hydro-ecological forecasting in freshwater reservoirs

Evangelos Romas, Head of EMVIS R&I Unit, romasvag@emvis.gr

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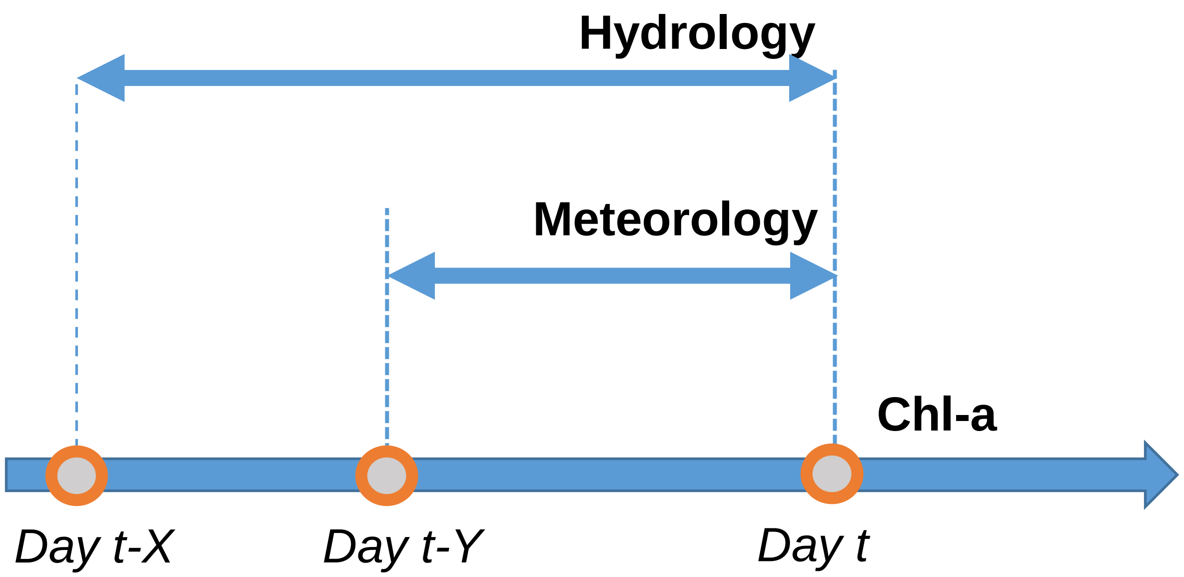
PrimeWater - Major scientific questions

Leverage the wealth of multispectral satellite data in short-term hydro-ecological forecasting and operational decision making

1. Data assimilation of EO-based products into process-based model to increase predictive skill
2. Developing credible and explainable Machine Learning models for prediction of phytoplankton dynamics
3. Hybrid solution – Coupling process-based models with an error correction mechanism based on data-driven solutions

A theory-guided model architecture

$$\text{Chl-a}(t) = f\,(\text{Meteo}(t-t_2), \text{Hydro}(t-t_1))$$



The sliding window prediction strategy

Upstream catchments

- Total nitrogen and phosphorus loads of the last X days

Meteorology

- Total radiation of the last Y days
- Hours for wind speed > 3 m/s over the last Y days
- Total precipitation of the last Y days
- Mean air temperature of the of the last Y days

Chlorophyll-a

- Concentration retrieved from multi-spectral satellite data at day *t*

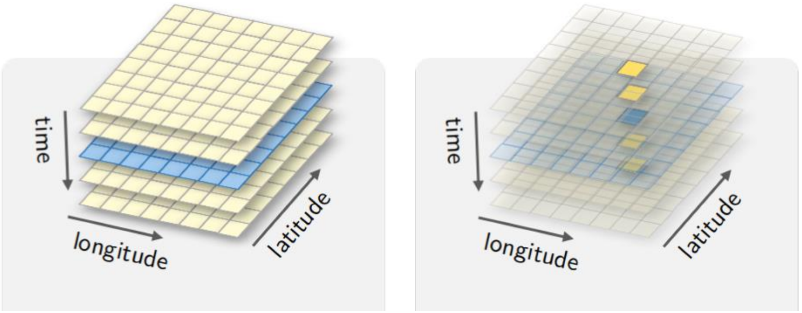
Model development for Lake Hume (AU)

- **Data sources for hydro-meteorological forcings**

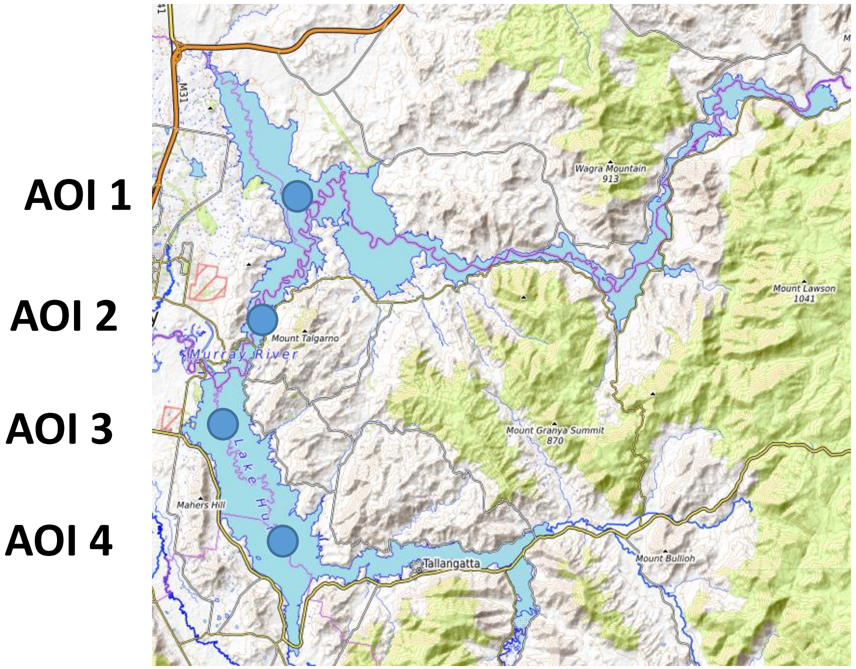
➢ Meteorological data: Bias corrected ERA-5 Land (2015-2019)
➢ Hydrological data: AU-HYPE model (2015-2019)

Individual ML models trained for 4 Areas of Interest

Data sources for chl-a

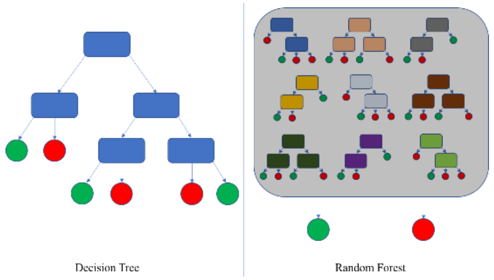


Time series derived from multi-spectral data (Landsat-8 , Sentinel-2)
Sensor-independent, physics-based MIP for chl-a retrievals (EOMAP) - 143 data points

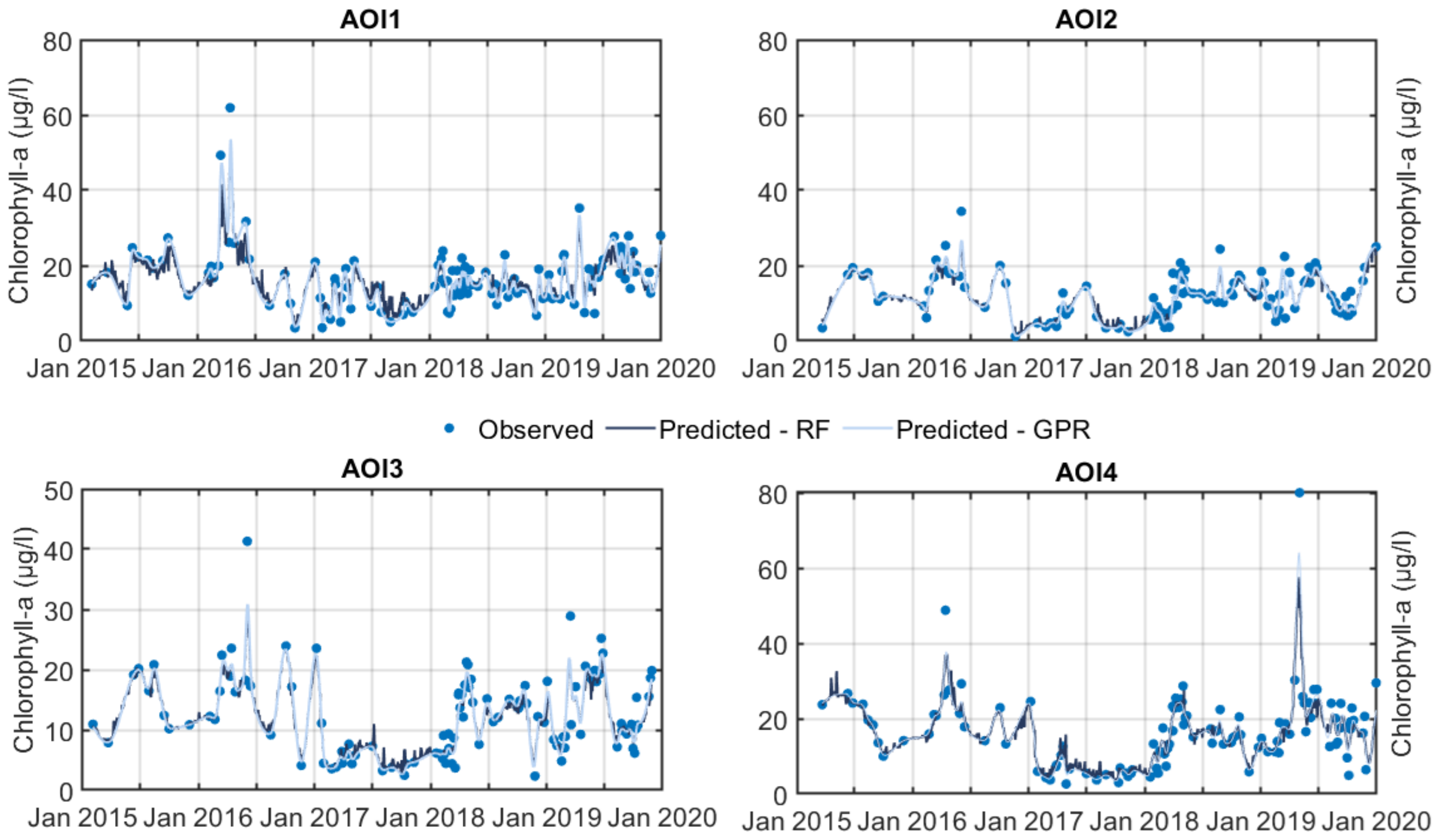


Two families of ML algorithms

➢ Random forests
➢ Gaussian Process Regression

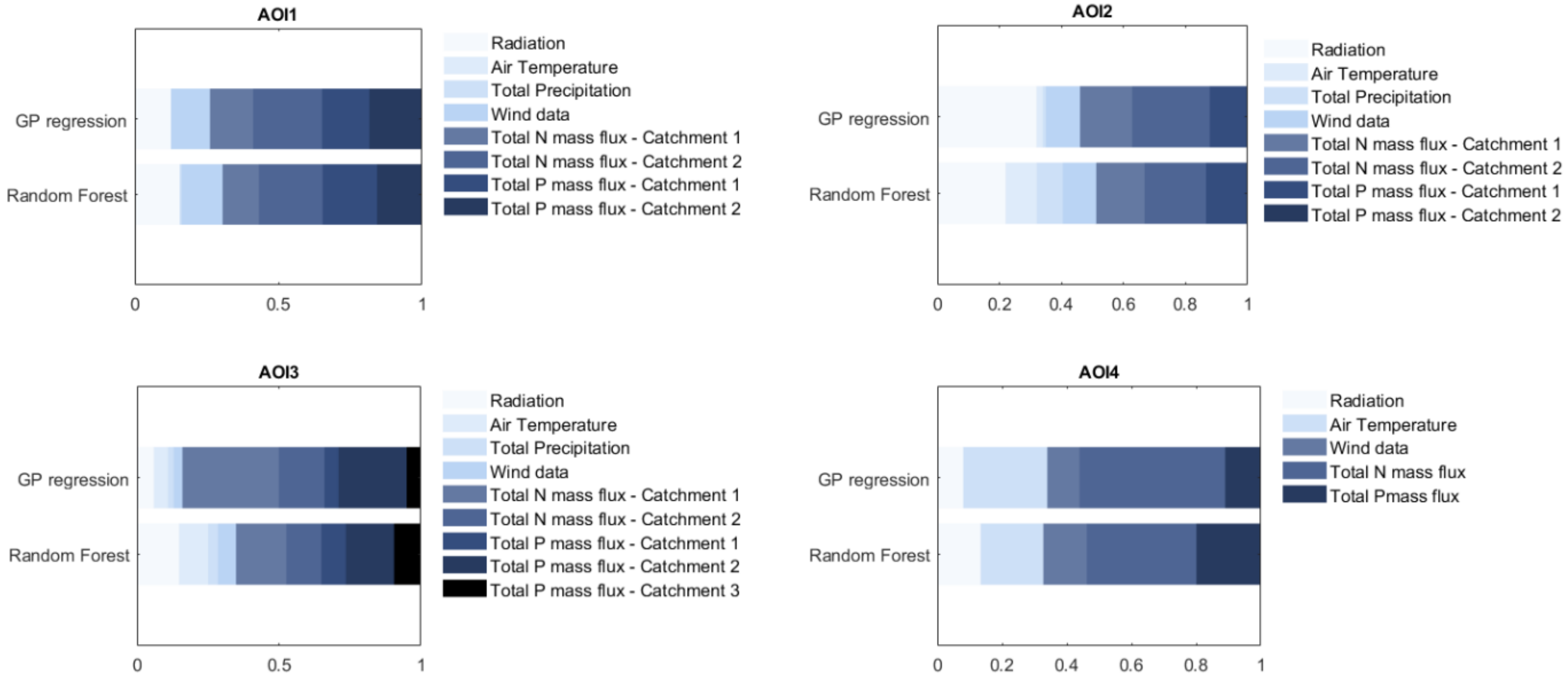


Model Results



- Both ML models perform well, capturing the temporal variability of chl-a.
- Mean Absolute Error for RF (**6.0 µg/l** for AOI2 to **9.4 µg/l** for AOI4)
- MAE for GPR (**5.9 µg/l** to **9.7 µg/l**)
- GPR model offered smoother predictions compared to Random Forests.
- The timing of peak values was accurately captured
- Models consistently underpredict high chl-a values above 30 µg/l.

Model Interpretability



- Random forests and GP regression models had minor differences in terms of absolute importance of each feature
- Between AOI there were more noticeable differences in predictors importance
- In Hume the contribution of nutrient mass influxes drives phytoplankton dynamics

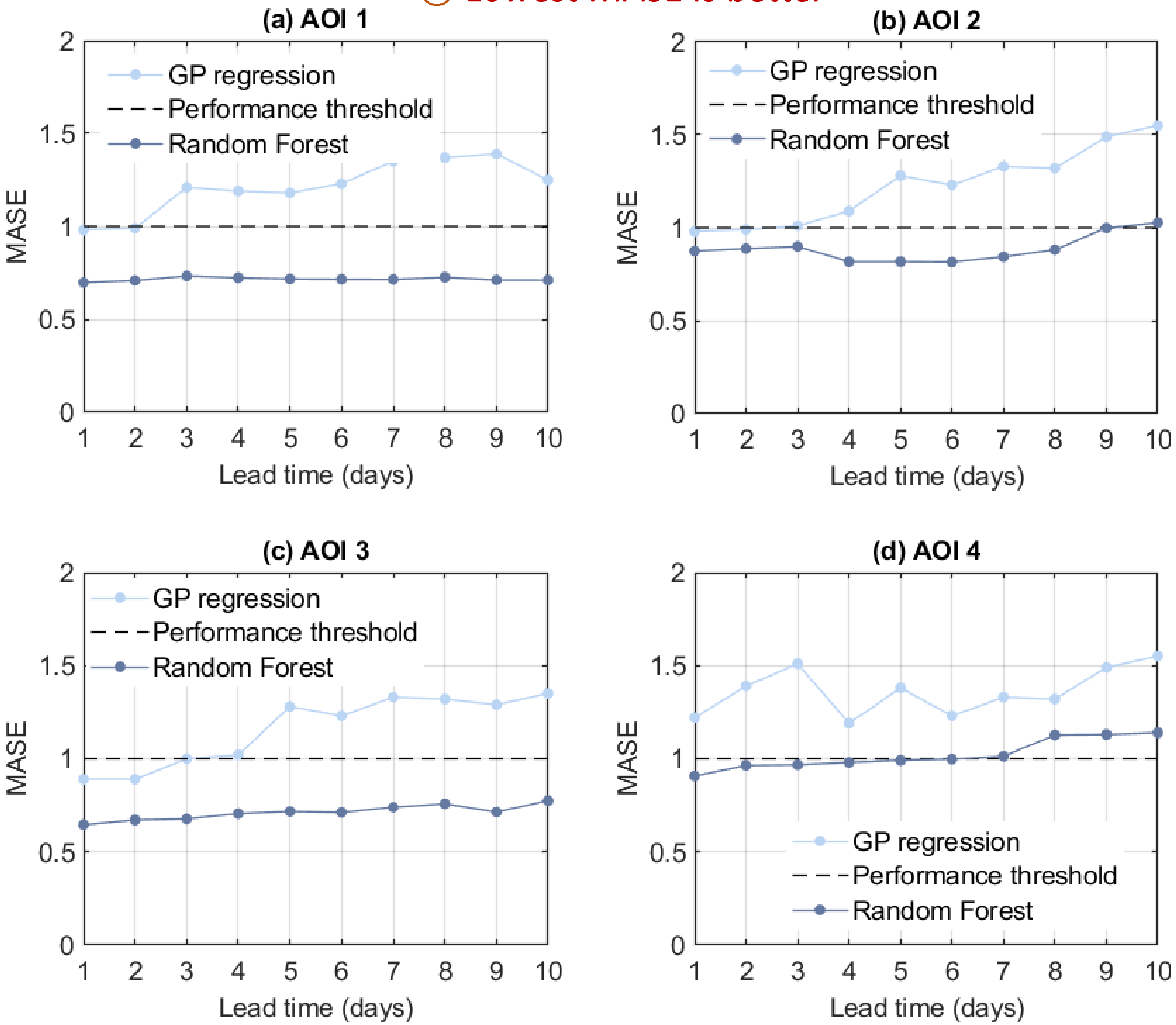
Model benchmarking - Forecasting limits assessment

How do we perform if we “push” the model in near-real time forecasting?

- Four-year-long reforecast experiment
- Benchmarking against a naïve alternative, i.e., the persistence of the last available observation.
- Mean Absolute Scaled Error (MASE)

➢ RFs were more accurate than GPR for all AOIs.
➢ RFs were better than naïve alternatives for up to 10 days ahead, in almost all AOIs
➢ Performance slightly deteriorates but still within acceptable limits
➢ Meteorological forecasts are the major source of uncertainties

ⓘ *Lowest MASE is better*



Lessons learned from all the case studies

Multi-spectral satellite data are a valuable source of observations for data-driven applications.

Even if no algorithm should be presented as the best-performing solution, RFs provided accurate and generalizable models, while they offered transparent and, thereby, trustworthy predictions.

Forecasting

- RFs was robust in most cases and better than the naïve alternative for up to 10 days
- Meteorological forecasts are the major source of uncertainties

Machine learning is not a silver bullet!

When representative data are missing, machine learning won’t make a difference.

EMVIS
WATER RESOURCES
& ENVIRONMENT
MANAGEMENT

https://app.primewater.eu/primewater

PrimeWater

EMVIS S.A.	National Research Council of Italy	Swedish Meteorological and Hydrological Institute	EOMAP GmbH & Co.KG	International Water Association	Burgundy School of Business	Ente Acque della Sardegna	US Environmental Protection Agency	Commonwealth Scientific and Industrial Research Organization	Melbourne Water	SatDek Pty Ltd

European Commission
Horizon 2020
European Union funding
for Research & Innovation

Session – I @ 11:45 AEST

7. Update on communications and engagement for AquaWatch Australia

Maigan Thompson*[1], Flora Kerblat[2]

*maigan.thompson@csiro.au
[1]CSIRO Corporate Affairs
[2]CSIRO Space & Astronomy

Key words: AquaWatch, water quality, communication, engagement, stakeholders

Abstract:
As one of CSIRO's Missions, which by their very nature are collaborative, it is essential that AquaWatch Australia attracts and engages with a variety of key stakeholders across government, research and industry, both nationally and internationally. We will provide an update on planning and recent activity to bring our stakeholders on the journey of delivering a world-first 'weather service' for water quality together with CSIRO.

AquaWatch Australia Communications & Engagement

Maigan Thompson | Flora Kerblat

We would like to begin by acknowledging the Traditional Owners of the land that we’re meeting on today, and pay my respect to their Elders past and present.

Communication vision

In the future, AquaWatch is:

An understood and supported mission, well-connected with stakeholders that trust CSIRO to deliver impact.

AquaWatch communications & engagement strategy 2023-24

INPUTS

What we invest

- Staff hours/salary
- Comms budget
- Engagement budget
- CSIRO-owned channels
- Media relationships
- CSIRO team technical expertise
- CSIRO team comms expertise
- Formal partner relationships (financial support)
- Informal collaborator relationships (in-kind support)

ACTIVITIES/PROCESSES

What we do & for whom

- Deliver Mission launch event
- Create pipeline of stories on pilot sites & partnerships
- Promote AquaWatch to end users
- Support communication & engagement with suite of assets, including website
- Identify & support priority events
- Develop and support culturally appropriate comms resources to assist the pilot site teams with respectful & meaningful Indigenous engagement
- Support internal comms at Exec level, wider CSIRO level & AW level

OUTPUTS

What the program produces

- Mission launch coverage
- Pilot stories published
- Partnerships confirmed & announced
- Comms & engagement assets delivered, including website
- AW representation at prioritised events
- Indigenous relationships established
- Internal comms assets delivered & channels developed

OUTCOMES

Direct changes from the program

- Mission launch reduces barriers & increases enablers for AW team
- We attract high-quality partners & investors for the sustainability of the mission
- End users participate in AW & incorporate it into their processes
- Key government departments & political figures support AW
- AW creates opportunities for Indigenous Peoples & strengthens CSIRO ties with Indigenous communities
- AW has strong internal support from BUs, ET & board

IMPACT

Long term change in condition

- AquaWatch is a well-known, well-respected and well-used service equivalent to the weather service
- Water quality management is improved across all applications (environment, health, industry etc.)

Trusted **Connected** **Understood** **Collaborative**

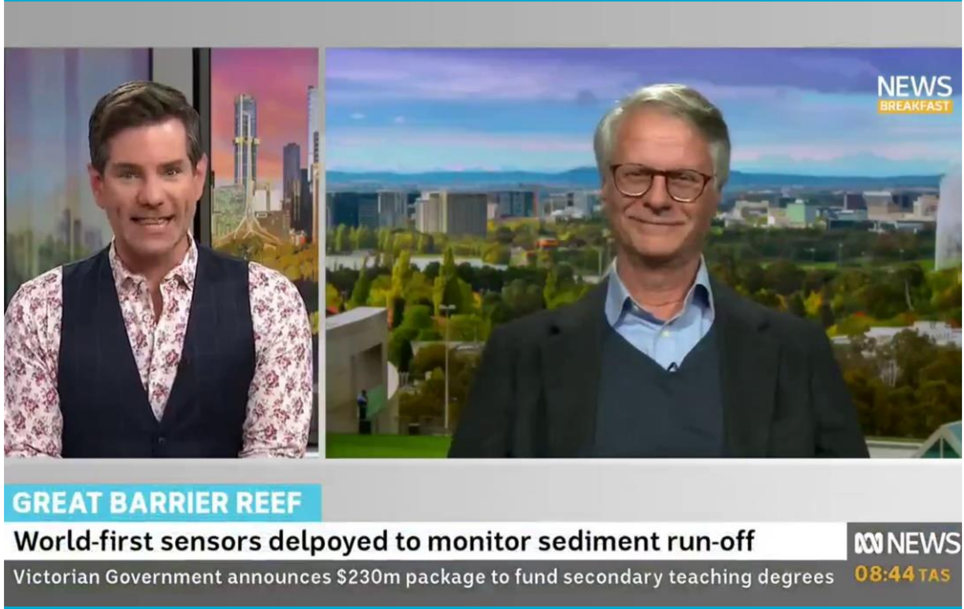
CSIRO

Official launch:
22 March 2023

- UN Water Conference
- Ministers' involvement
  - Industry and Science
  - Environment and Water
- CSIRO channels & media
- Government briefings

Media

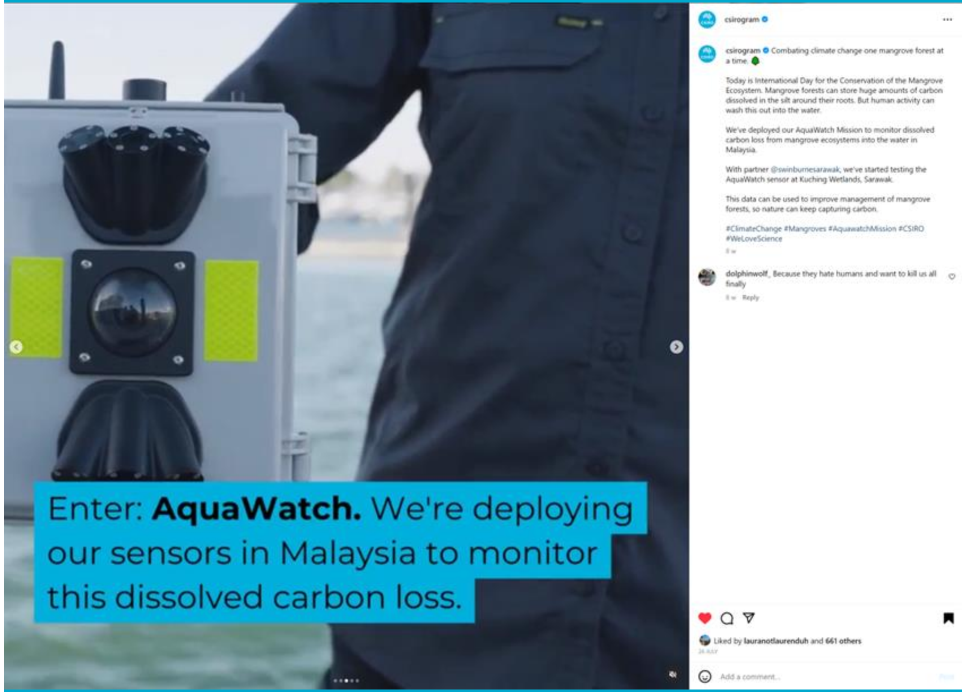
- Television
- Online and print articles
- Radio segments
- Podcast episodes



Social media

- Regular touchpoints between AquaWatch and the public

- LinkedIn – professionals, government & industry
- Instagram – public (under 35)
- Facebook – public (over 35)
- X (Twitter) – journalists & professionals



Website

- Summary of AquaWatch
- Project case studies
- Collaboration information
- News and updates

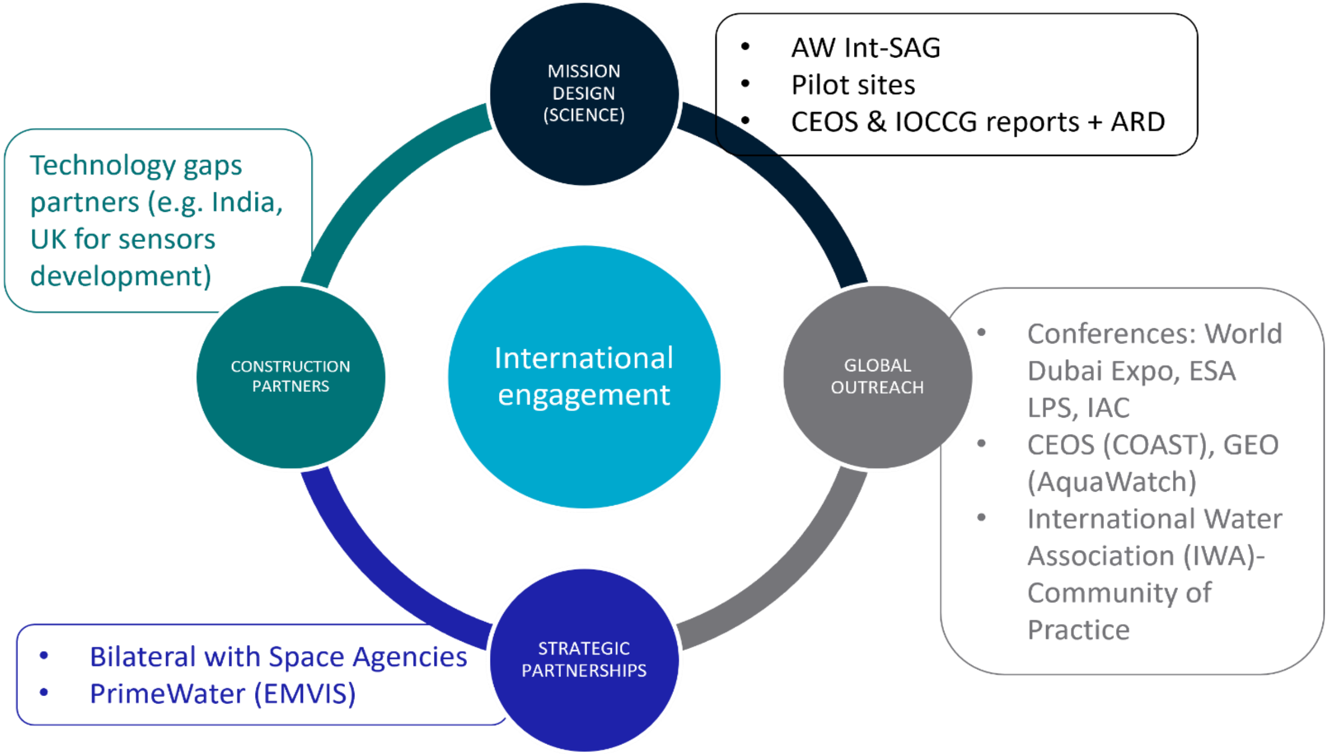
Events

- National and international
- Present on AquaWatch
- Meet potential collaborators
- Engage with end users
- Seek insights and feedback

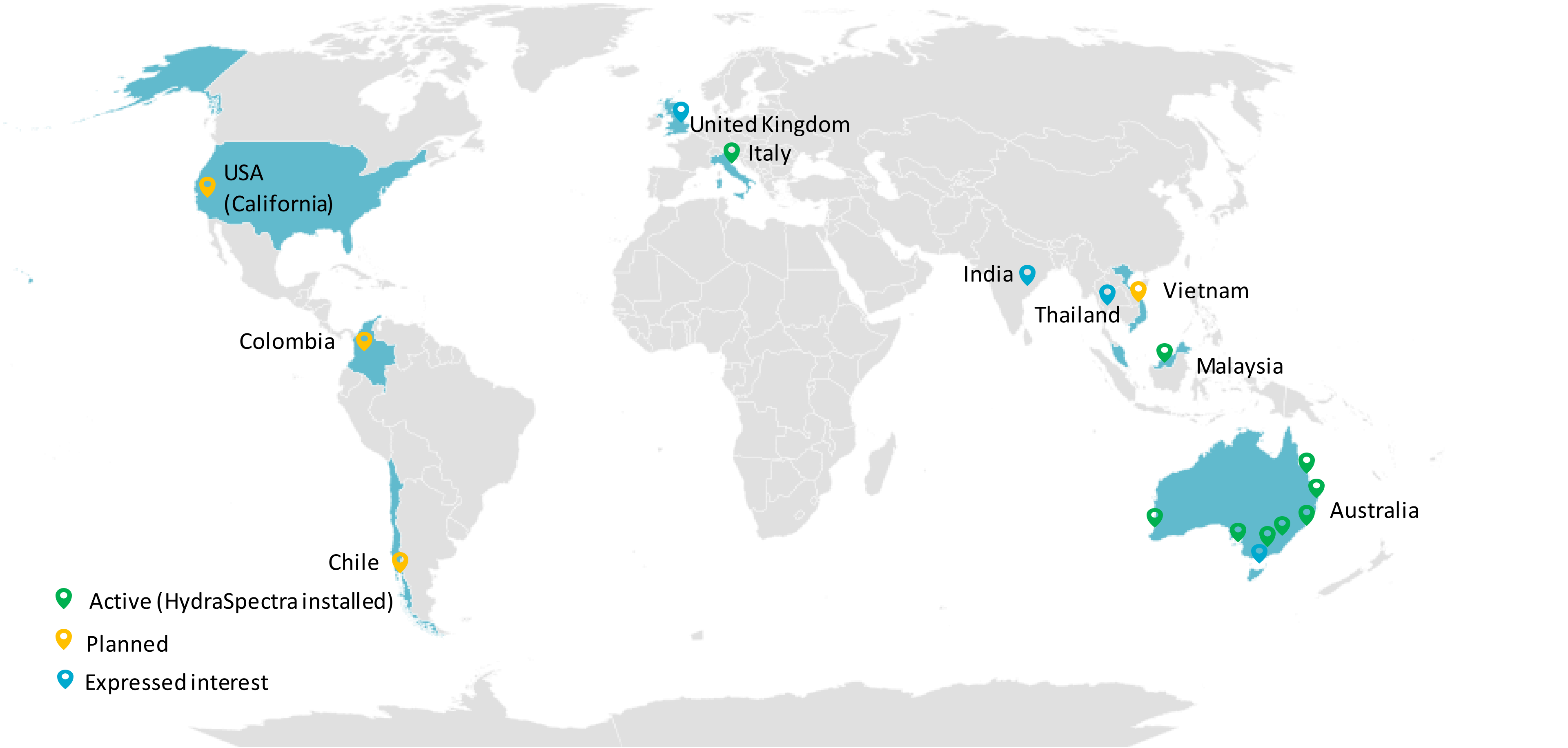
What’s next?

- Partner and AquaWatch user newsletter
  - Quarterly updates
  - Contact Maigan Thompson to join mailing list
- Indigenous engagement
  - Outreach to pilot site Traditional Custodians
  - Exploring Indigenous-led pilot

International coordination



Global pilot sites



	Outputs	Impacts	Timeline
Global outreach & engagement	Initial outreach to targeted institutions (CEOS, GEO AquaWatch, IW, PrimeWater) Webinars delivery Research papers, Conferences attendance Participation in high level or potential high-impact events (water quality monitoring) Indigenous engagement (UN Challenge with GEO AquaWatch)	Direct implementation of national EO Roadmap from Space Increased visibility for AquaWatch and SmartsatCRC (foundation partner) Increased partnerships opportunities for CSIRO (beyond AquaWatch) Implementation of current cooperation agreements Growth of Australian EO & Space industry	Ongoing
Pilot sites	Agreements fully executed Implementation monitored (project management)	Diversified access to expertise in water monitoring, and increased variety of users and conditions to test tools (sensors) Improved AquaWatch products and mission delivery	Established by Dec 2023 (initial 5)
Science Advisory Group	Quarterly meetings (20-30 participants) reviewing AW updates, discussing technical challenges, and seeking advice on issues	Valuable access to International scientific expertise in water monitoring, and mission planning Safeguarded AW mission delivery success Improved AquaWatch products and mission delivery	Established by June 2022
Strategic partnerships	Initial discussions (ongoing bilateral at CEOS meetings) Bilateral with PrimeWater project owners (existing project with CSIRO)	Implemented collaborations on water monitoring Constellation of water quality monitoring satellites Previous project lessons learned used to improve AquaWatch program	Ongoing
Construction partners	Technical discussions (workshops and meetings) with UK, India, and others	Streamlined science innovation EO & Space industry capability developed	Initial design phases

CSIRO

What's next?

- Streamline our international engagement (strategic priorities), assess opportunities and formalise partnerships (UK, India, etc.),
- Monitor and evaluate implementation of active projects
- Explore contractual mechanisms to simplify and formalise partnerships and collaborations
  - Italy: new pilot site model "research collaboration agreement"
- Discuss continuity of pilot projects (case by case): extension of agreements timeframe, scope ?
- Support stronger engagement in GEO (through GEO AquaWatch) and IWA (global communities) to help attract external investors
- Establish a global "Community of Practice" for AquaWatch Australia: WP leads, Pilot sites managers, SAG and other interested stakeholders

Maigan Thompson

Communication & Engagement Lead, AquaWatch

maigan.thompson@csiro.au +61 409 743 148

Flora Kerblat

International Research project Coordinator (Centre for Earth Observation) & Engagement Lead (AquaWatch)

Flora.kerblat@csiro.au +61 436 675 265

Session – II @ 13:00 AEST

1. How satellite technology can help Melbourne Water to manage and improve water quality

Nick Crosbie*

nick.crosbie@melbournewater.com.au
Melbourne Water Corporation, Melbourne, VIC

Key words: Earth Observation, water quality, climate change, urbanisation

Abstract:
Melbourne Water, Australia's second-largest water authority, manages water supply catchments, treats and supplies drinking and recycled water, removes and treats most of Melbourne's sewage, and manages waterways and drainage systems in the Port Phillip and Westernport region. Melbourne Water is also the Catchment Management Authority for the Port Phillip and Westernport region.

Climate change and urbanisation are driving changes in water quality on global, regional, and local scales. Advances in satellite technology should help to document these changes (supporting business cases and policy improvement) and contribute to the development of planning and operational water quality models, particularly given the scale and interconnectedness of Melbourne Water's remit and area of management.

For the full promise of satellite technology to be realised, however, measurement uncertainties will need to be more systematically described and presented to end users, and vendors will need to understand how satellite information and derived products will be consumed by Melbourne Water for them to deliver trusted and sustainable services.

How satellite technology can help Melbourne Water to improve water quality

Dr Nick Crosbie

Aquawatch meeting, Sept 2023

We manage all parts of the water cycle

Water

Providing clean drinking water to retailers

Sewerage

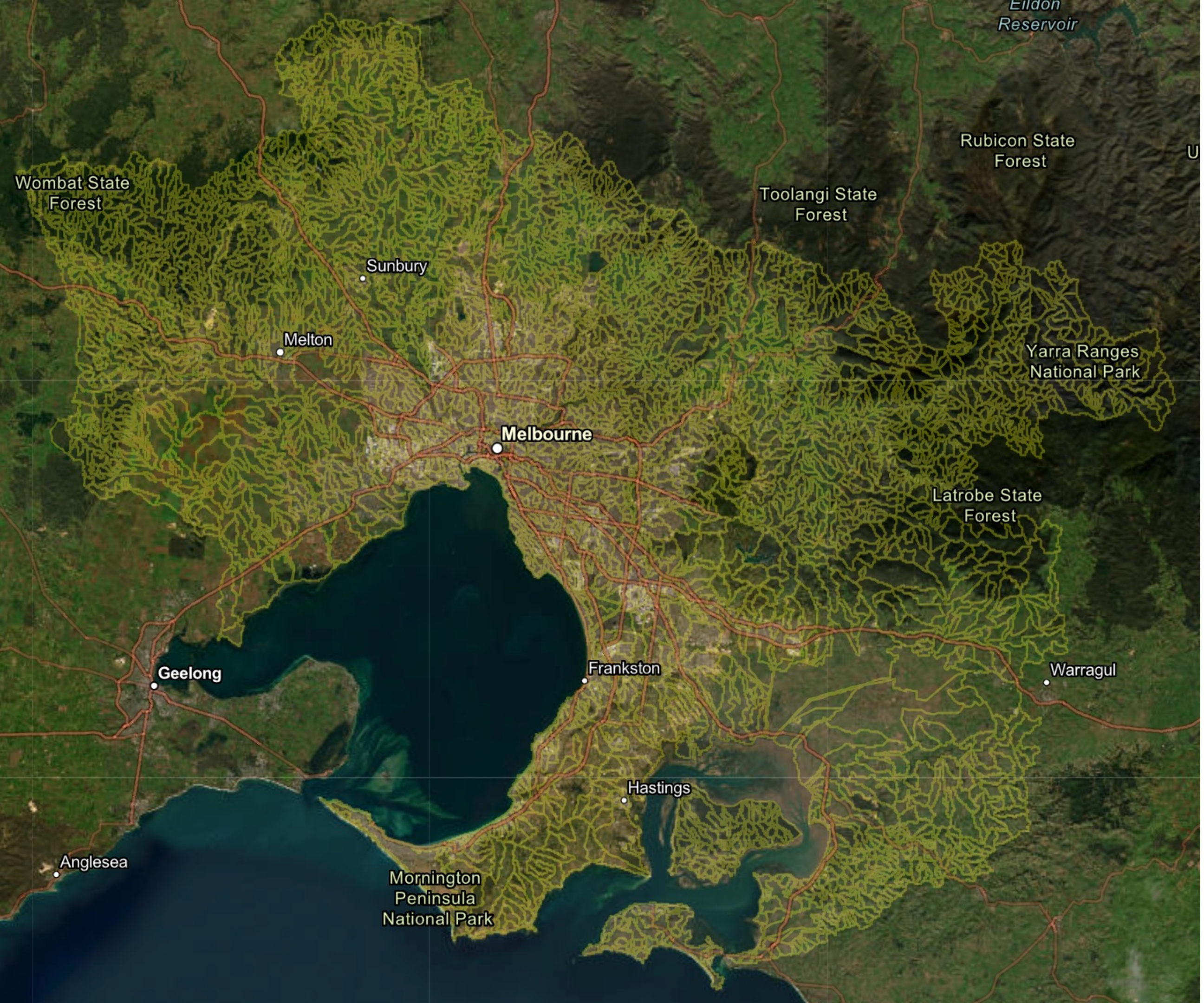
Treating sewage so we can recover and re-use our valued resources

Flood & drainage

Planning to manage flooding

Waterways and catchments

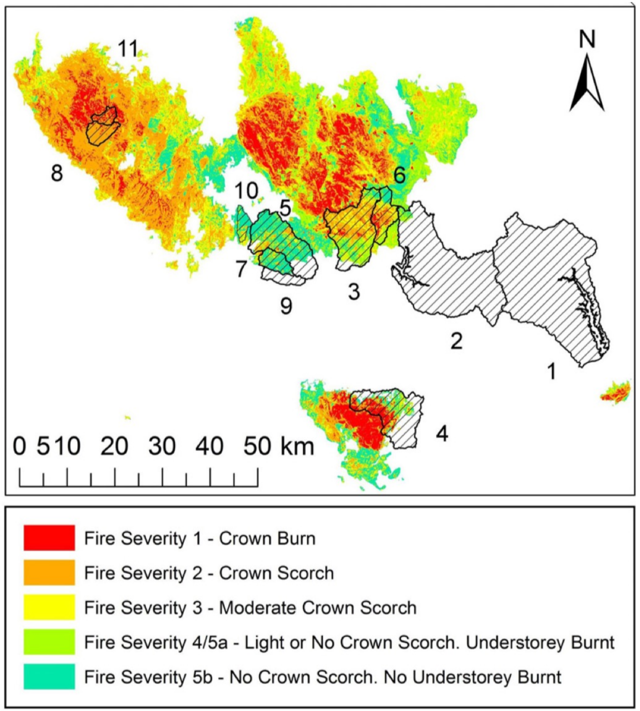
Keeping all 25,000km of Melbourne’s rivers, creeks and catchments healthy



Surface water catchments in Melbourne Water's area of operation

Influence of climate, fire severity and forest mortality on predictions of long term streamflow: Potential effect of the 2009 wildfire on Melbourne's water supply catchments

Paul M. Feikema *, Christopher B. Sherwin, Patrick N.J. Lane



Calculated a fire severity rating using data from SPOT and Landsat TM.

This was used to model the potential impact of the 2009 wildfires on Melbourne's water supply catchments

dx.doi.org/10.1016/j.jhydrol.2013.02.001

Predicting post-wildfire overland flow using remotely sensed indicators of forest productivity

Philip J. Noske [1] | Patrick N. J. Lane [1] | Petter Nyman [1,2] |
René E. Van der Sant [3] | Gary J. Sheridan [1] DOI: 10.1002/hyp.14769

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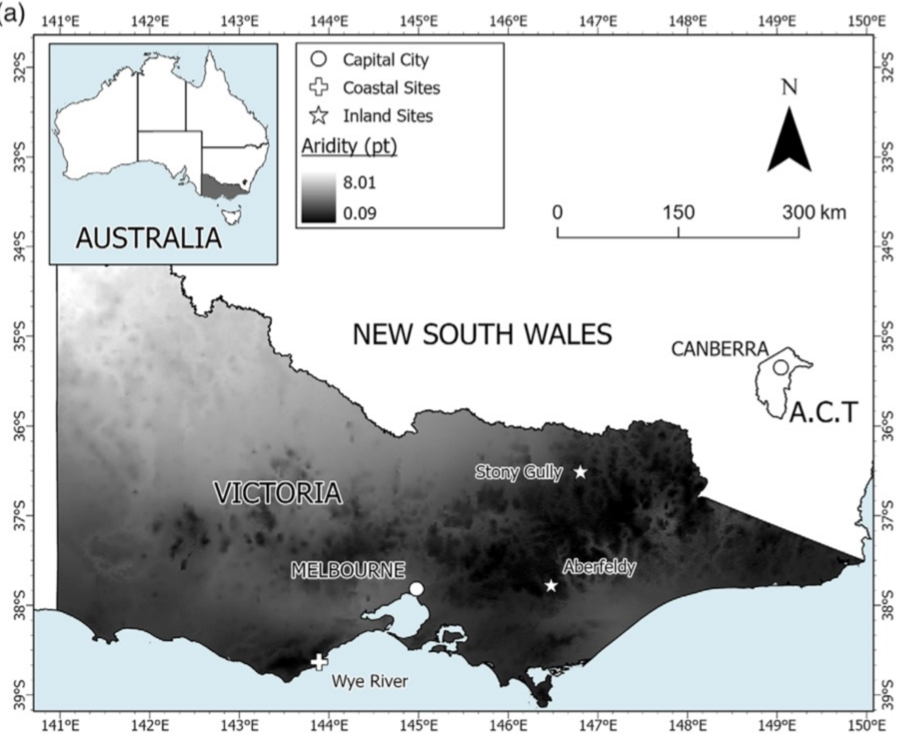
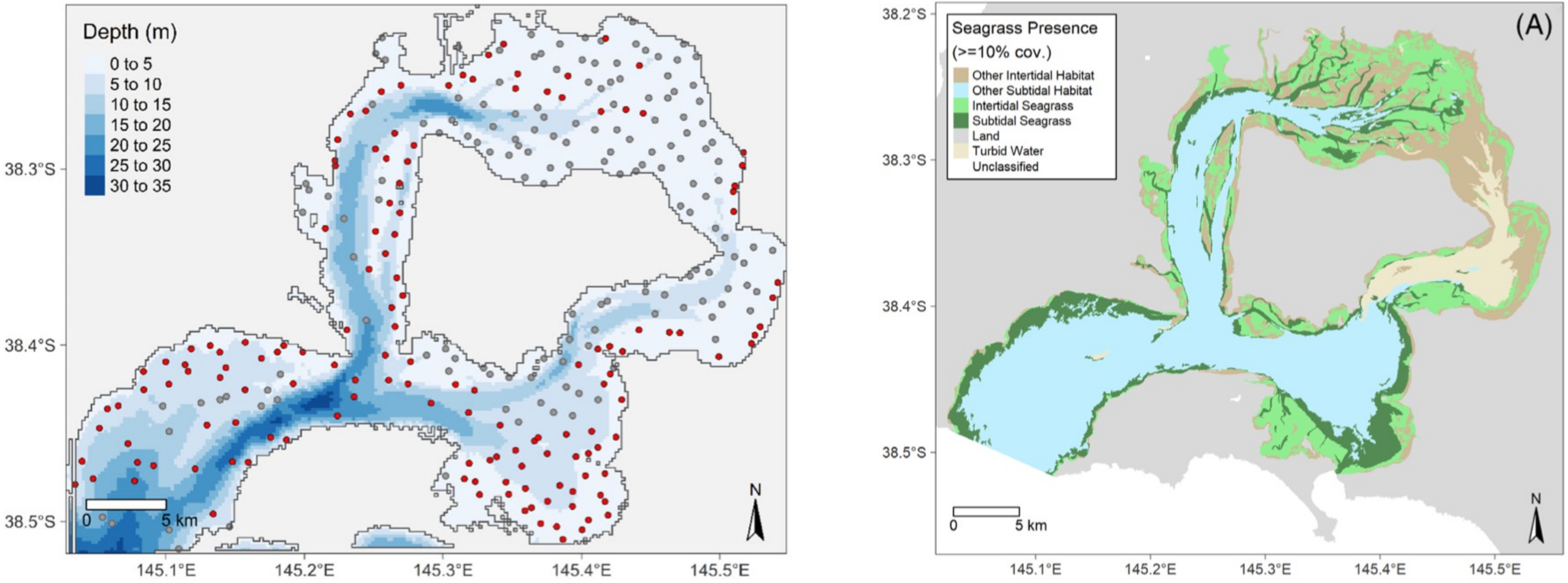


Identifying spatio-temporal trends in seagrass meadows to inform future restoration

Oliver Dalby[1], Nicolas Pucino[2], Yi Mei Tan[1], Emma L. Jackson[3], Peter I. Macreadie[4], Rhys A. Coleman[5], Mary A. Young[2], Daniel Ierodiaconou[2], Craig D. H. Sherman[1,2]



doi.org/10.1111/rec.1378
7

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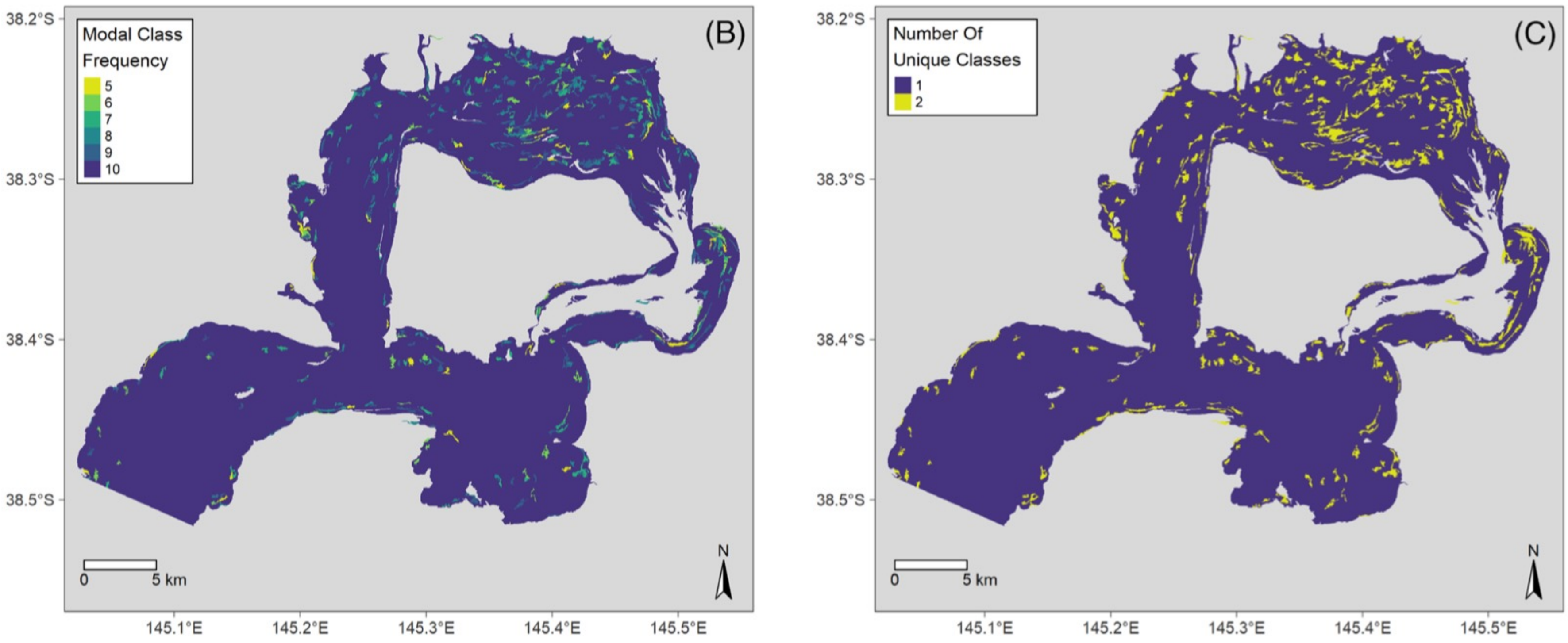
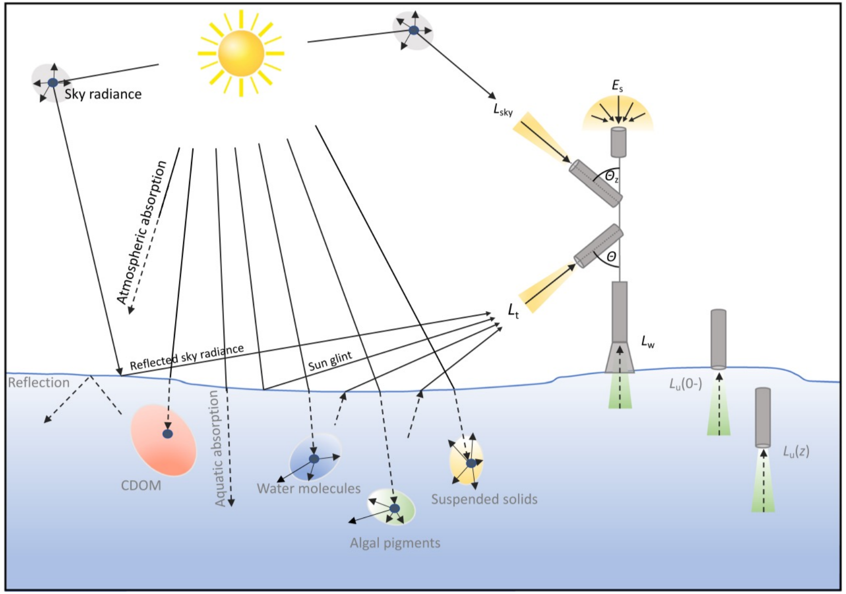
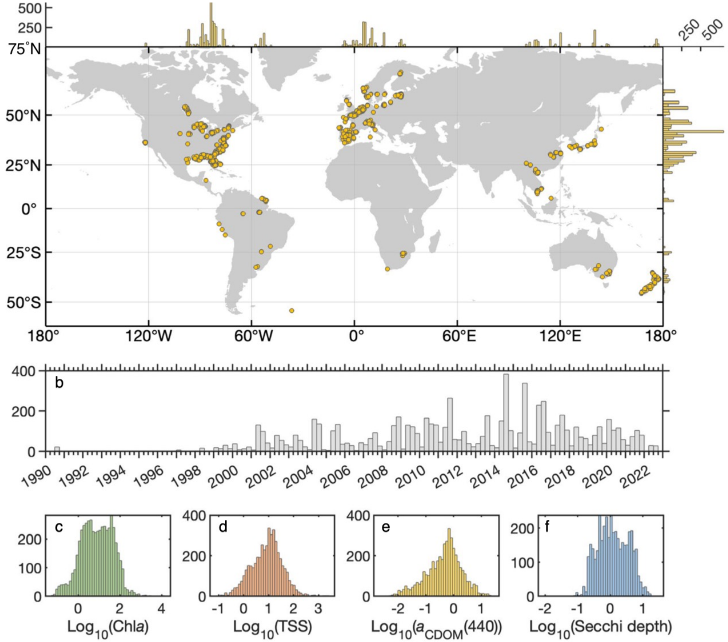


GLORIA - A globally representative hyperspectral *in situ* dataset for optical sensing of water quality

Moritz K. Lehmann *et al.*#





doi.org/10.1038/s41597-023-01973-y

GLORIA - A globally representative hyperspectral *in situ* dataset for optical sensing of water quality

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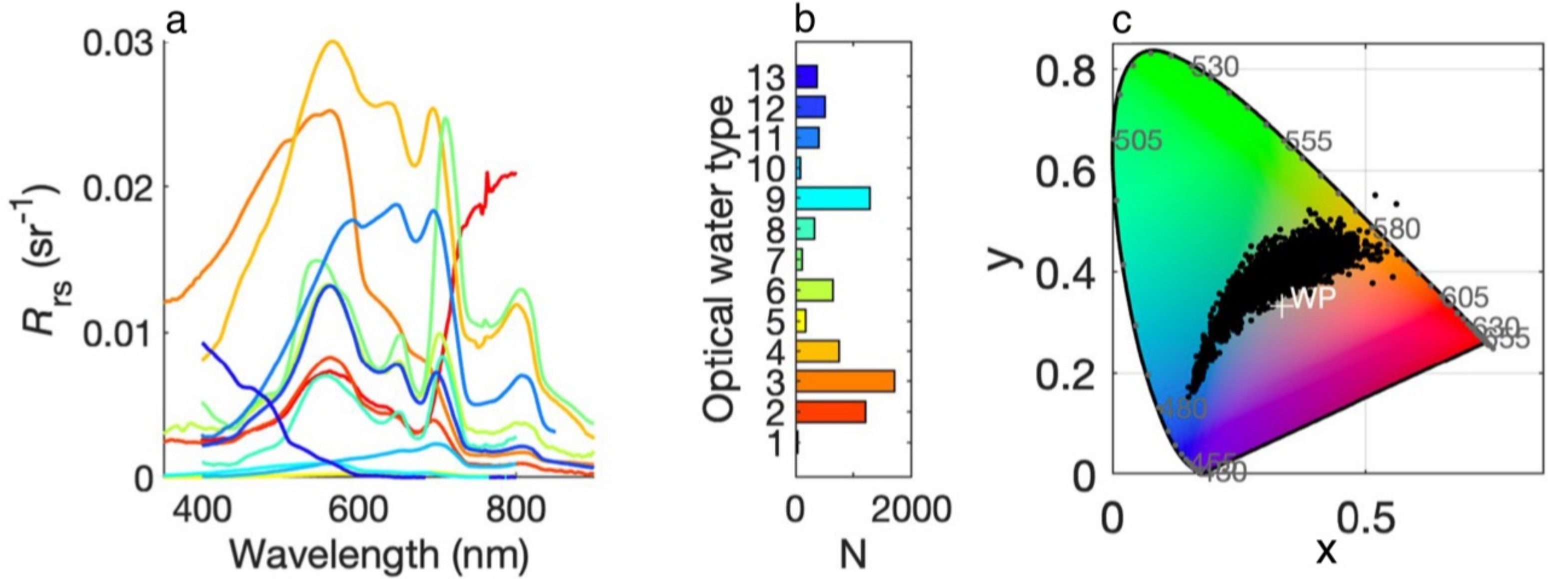
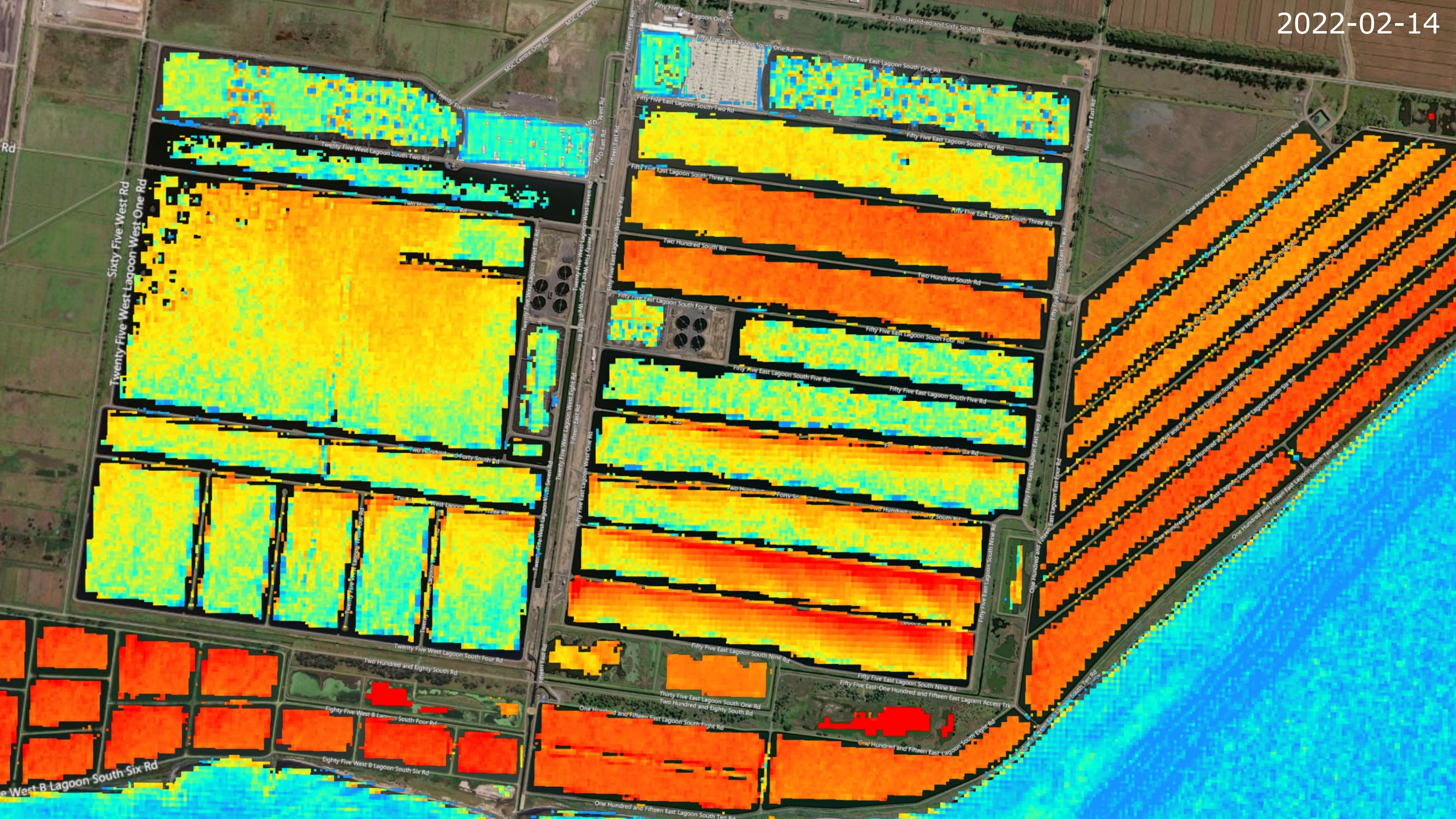


doi.org/10.1038/s41597-023-01973-y


2022-02-14
Sixty Five West Rd
Twenty Five West Lagoon West One Rd
e West B Lagoon South Six Rd
Twenty Five West Lagoon South Two Rd
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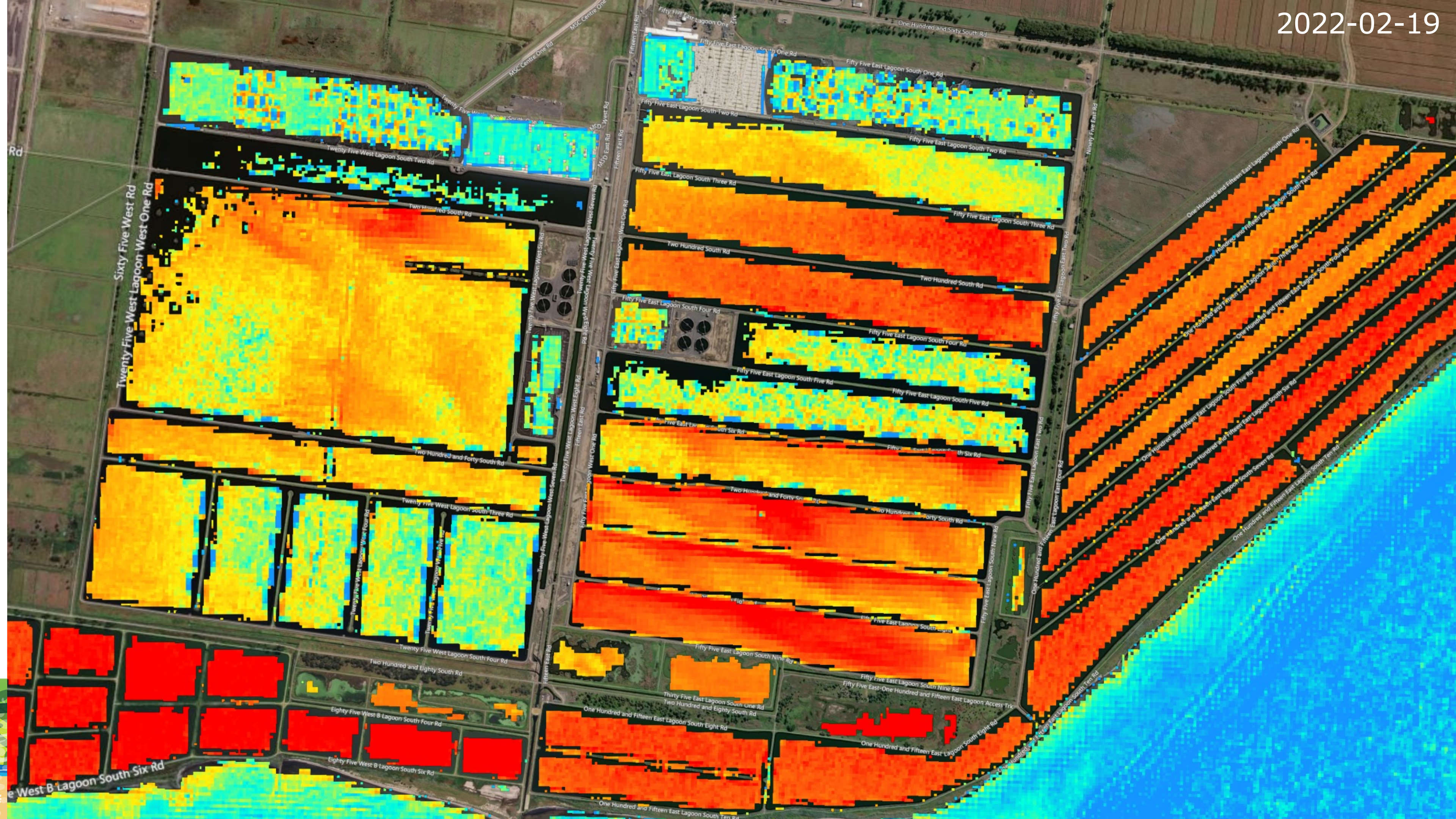
Two Hundred and Eighty South Rd
Eighty Five West B Lagoon South Four Rd
Eighty Five West B Lagoon South Six Rd
Fifty Five East Lagoon South One Rd
Fifty Five East Lagoon South Two Rd
Fifty Five East Lagoon South Three Rd
Fifty Five East Lagoon South Four Rd
Fifty Five East Lagoon South Five Rd
Fifty Five East Lagoon South Nine Rd
Two Hundred South Rd
Thirty Five East Lagoon South One Rd
One Hundred and Fifteen East Lagoon South Eight Rd
One Hundred and Fifteen East Lagoon South Ten Rd
One Hundred and Sixty South Rd


2022-02-19
Sixty Five West Rd
Twenty Five West Lagoon West One Rd
e West B Lagoon South Six Rd

Australian Bureau of Meteorology hacked by foreign spies, cybersecurity report reveals

Foreign powers stole documents and installed malicious software in brazen attack, as report warns of terrorist cyber attacks within three years

The Guardian (Australia), 12th Oct 2016

AUSTRALIA

Security of Critical Infrastructure Act 2018

No. 29, 2018

Australian Government
Department of Home Affairs

CYBER AND INFRASTRUCTURE SECURITY CENTRE

Security Legislation Amendment (Critical Infrastructure Protection) Act 2022

The *Security Legislation Amendment (Critical Infrastructure Protection) Act 2022* (SLACIP Act) amends the *Security of Critical Infrastructure Act 2018* (the SOCI Act) to build upon the existing framework and uplift the security and resilience of Australia's critical infrastructure.

Thank you

Insert contact details here if required

Session – II @ 13:15 AEST

2. Making use of various technologies for detecting blue-green algae in NSW and reporting the risks to the water users

Gerhard Schulz*

*Gerhard.Schulz@waternsw.com.au
WaterNSW, Deniliquin, New South Wales

Key words: remote sensing, cyanobacteria, phytoplankton.

Abstract:
Blue-green algal reporting and management have evolved over the past decade to include custom script satellite imagery for detecting phytoplankton blooms in NSW water storages and rivers.

This paper refers to some of the challenges for overcoming limited resources by integrating layers of information, such as dissolved oxygen readings and field observations into the existing sampling and analysis processes for detecting phytoplankton blooms.

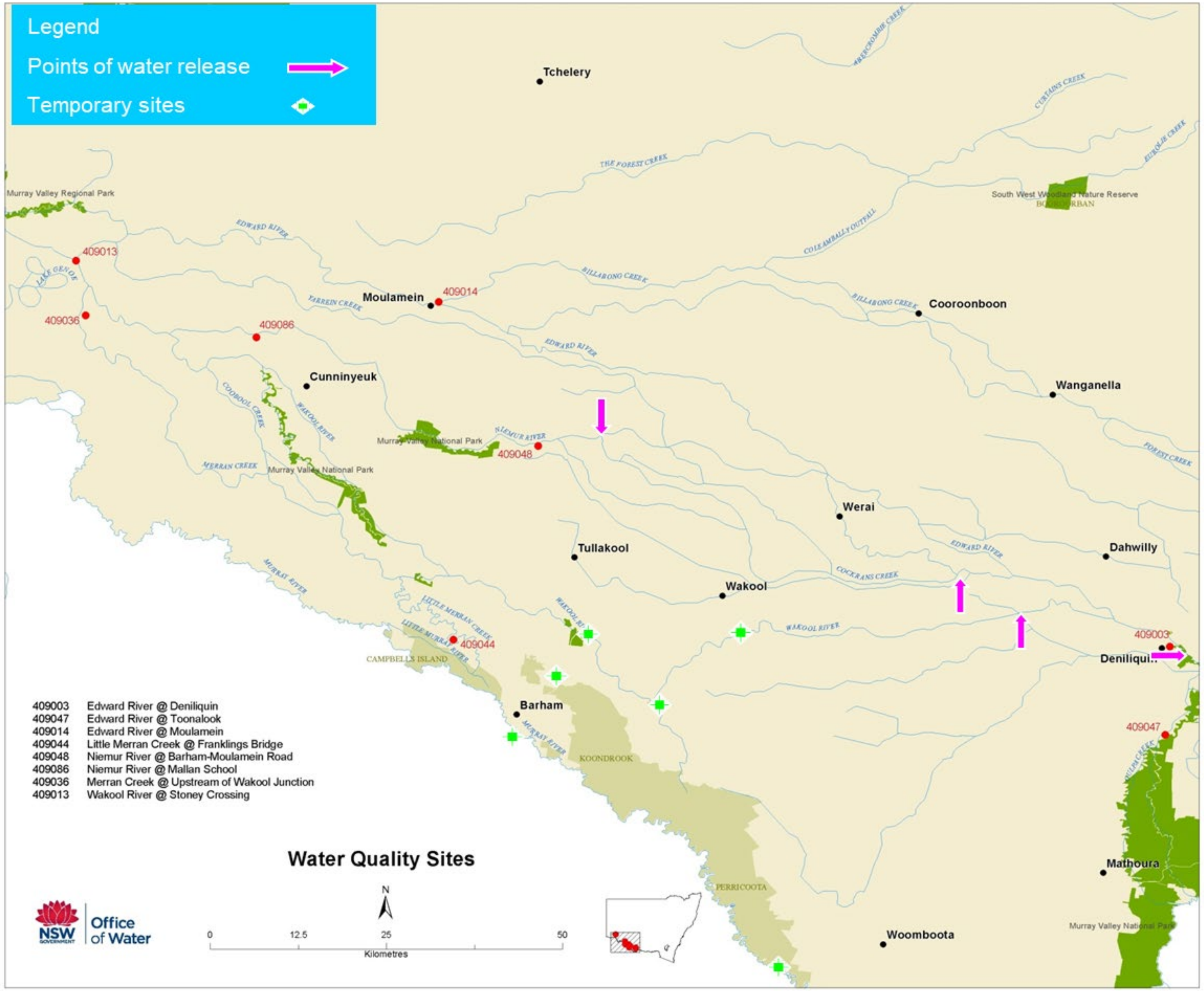
Making use of various technologies for detecting blue-green algae in NSW and reporting the risks to the water users.

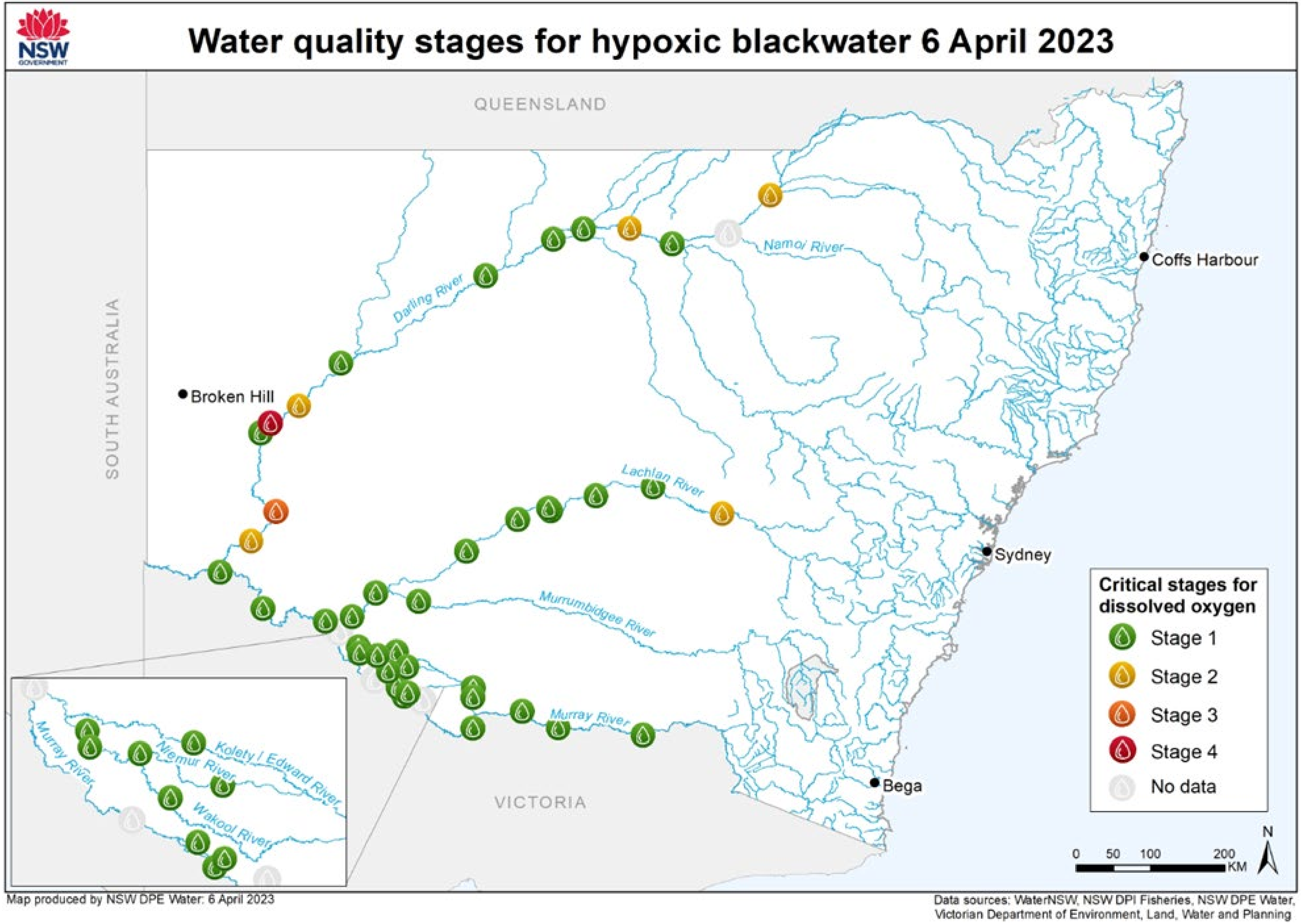
By Gerhard Schulz

WaterNSW

Low dissolved oxygen blackwater events

Low dissolved oxygen blackwater events





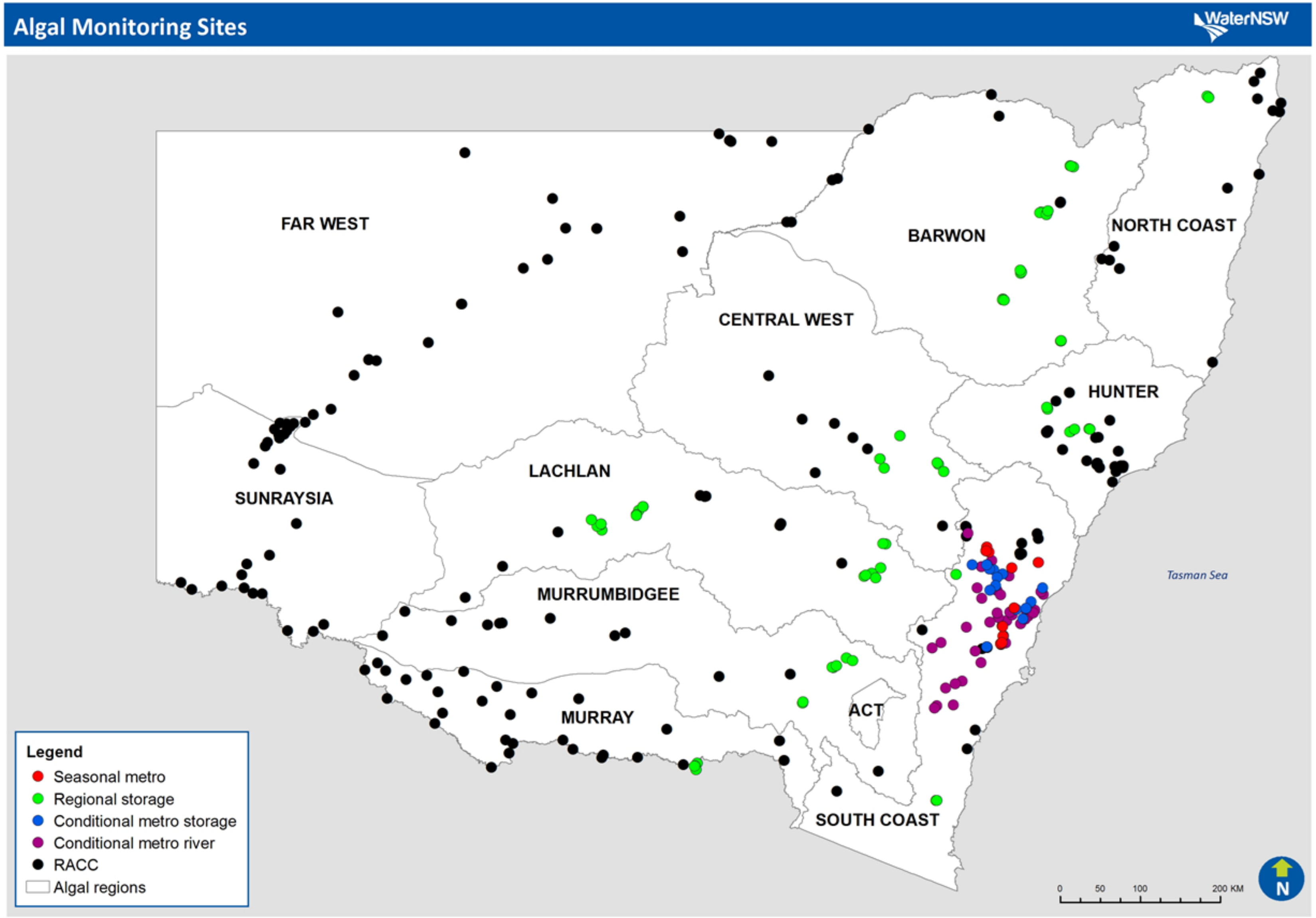
https://www.industry.nsw.gov.au/

WaterNSW

Blue-green algal monitoring sites

Unique features

1. WaterNSW has the largest surface and groundwater monitoring network in the southern hemisphere with more than 40 dams across the state and over 70 surface water sites in the rivers
2. WaterNSW- main authority responsible for managing **BGA** monitoring and reporting. Also involved in the process are Hunter Water, Mid Coast Water, Murrumbidgee Irrigation and councils such a Griffith City Council. 4 RACC coordinators
3. **BGA** analysis by external laboratory
4. **BGA** alerts– on website. RACC coordinators initiate e-mailed reports to customers, algal hotline, media releases and liaison with parties concerned with **BGA** related risks
5. Annual **BGA** management meetings

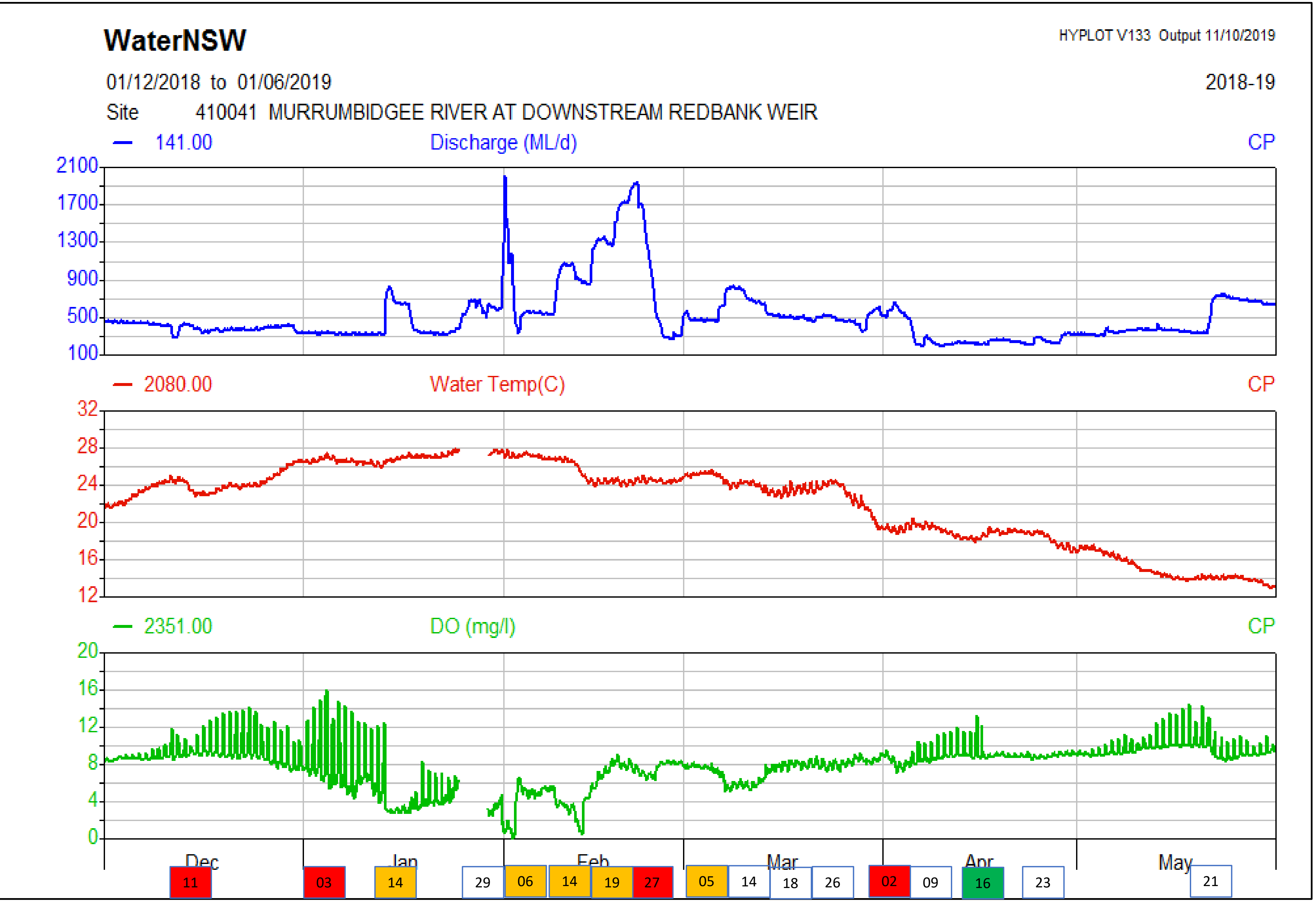


Period of main blue-green algal activity during 2019/2020

	Date of blue-green algal report	14/01/2020	23/01/2020	29/01/2020	4/02/2020	11/02/2020	18/02/2020	21/02/2020	26/02/2020	4/03/2020	11/03/2020	24/03/2020	1/04/2020	7/04/2020	16/04/2020	23/04/2020	28/04/2020
Site Number	Site name																
DWYA01	Wyangala Junction Lachlan & Abercrombie	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	RED	AMBER	AMBER	AMBER	AMBER	AMBER
DWYA02	Wyangala Junction Lachlan & Sandy Ck	RED	AMBER	RED	RED	RED	RED	RED	RED	GREEN	GREEN	RED	RED	RED	RED	RED	RED
DWYA04	Wyangala Dam Downstream	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	RED	RED	RED	No Alert	GREEN	GREEN
DWYA05	Wyangala Abercrombie R	RED	AMBER	RED	RED	RED	RED	GREEN	GREEN	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	RED	RED
DWYA06	Wyangala Inland Waters Park	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	RED	RED	RED	RED	AMBER
DWYA08	Wyangala Dam Wall Station 1	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	RED	RED	RED	RED	RED	RED
N1168	Lachlan River at Cowra	No Alert	GREEN	GREEN	GREEN	GREEN	No Alert	No Alert	No Alert	No Alert	No Alert	AMBER	AMBER	GREEN	GREEN	GREEN	No Alert
DCAR01	Carcoar Dam Station 1 (Dam Wall)	No Alert	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
DCAR02	Carcoar Downstream (Belubula River)	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	GREEN	GREEN	GREEN	GREEN	No Alert	No Alert	No Alert	No Alert	No Alert
N1022	Lachlan River at Cottons Weir (Forbes)	No Alert	AMBER	AMBER	AMBER	AMBER	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	AMBER	AMBER	AMBER	AMBER
N1024	Lachlan River @ Condobolin Bridge	No Alert	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	No Alert	No Alert	No Alert	No Alert
N1100	Goobang Creek at Condobolin	No Alert	AMBER	AMBER	AMBER	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
N1101	Memorial Park Condobolin																
N1097	Gum Bend Lake																
DCRG01	Lake Cargelligo Outlet @ Lake Creek	RED	RED	RED	AMBER	RED	RED	RED	RED	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	No Alert
DCRG02	Lake Cargelligo Town Water Supply 41210042	AMBER	AMBER	GREEN	GREEN	No Alert	RED	RED	RED	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER
DCRG03	Lake Cargelligo Boatshed	AMBER	AMBER	AMBER	AMBER	RED	RED	RED	RED	RED	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER
DCRG04	Lake Cargelligo Weir	No Alert	No Alert	No Alert	No Alert	No Alert	GREEN	GREEN	No Alert	No Alert	No Alert	No Alert	GREEN	GREEN	No Alert	No Alert	No Alert
DCRG05	Lake Cargelligo intake downstream of Curlew Waters	AMBER	AMBER	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	No Alert	AMBER	GREEN	GREEN	GREEN	GREEN	AMBER	GREEN
DCRG06	Lake Cargelligo Lachlan River ds Lake Carlweir																
DBRW01	Lake Brewster Inflow 412102	GREEN	GREEN	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER
DBRW02	Lake Brewster Inf wetland u/s eastern spillway																
DBRW03	Lake Brewster Regulator C																
DBRW04	Lake Brewster Outlet Channel 412108	GREEN	AMBER	AMBER	No Alert	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER
DLOS06	Lachlan River @ Willandra Weir	AMBER	AMBER	GREEN	GREEN	AMBER	AMBER	AMBER	AMBER	AMBER	GREEN	AMBER	AMBER	AMBER	GREEN	No Alert	No Alert
N1025	Lachlan River at Hillston	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert
N1023	Lachlan River at Booligal	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
N1026	Lachlan River at Corrong	No Alert	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	No Alert	No Alert	No Alert	No Alert	No Alert

Period of main blue-green algal activity during 2020/2021

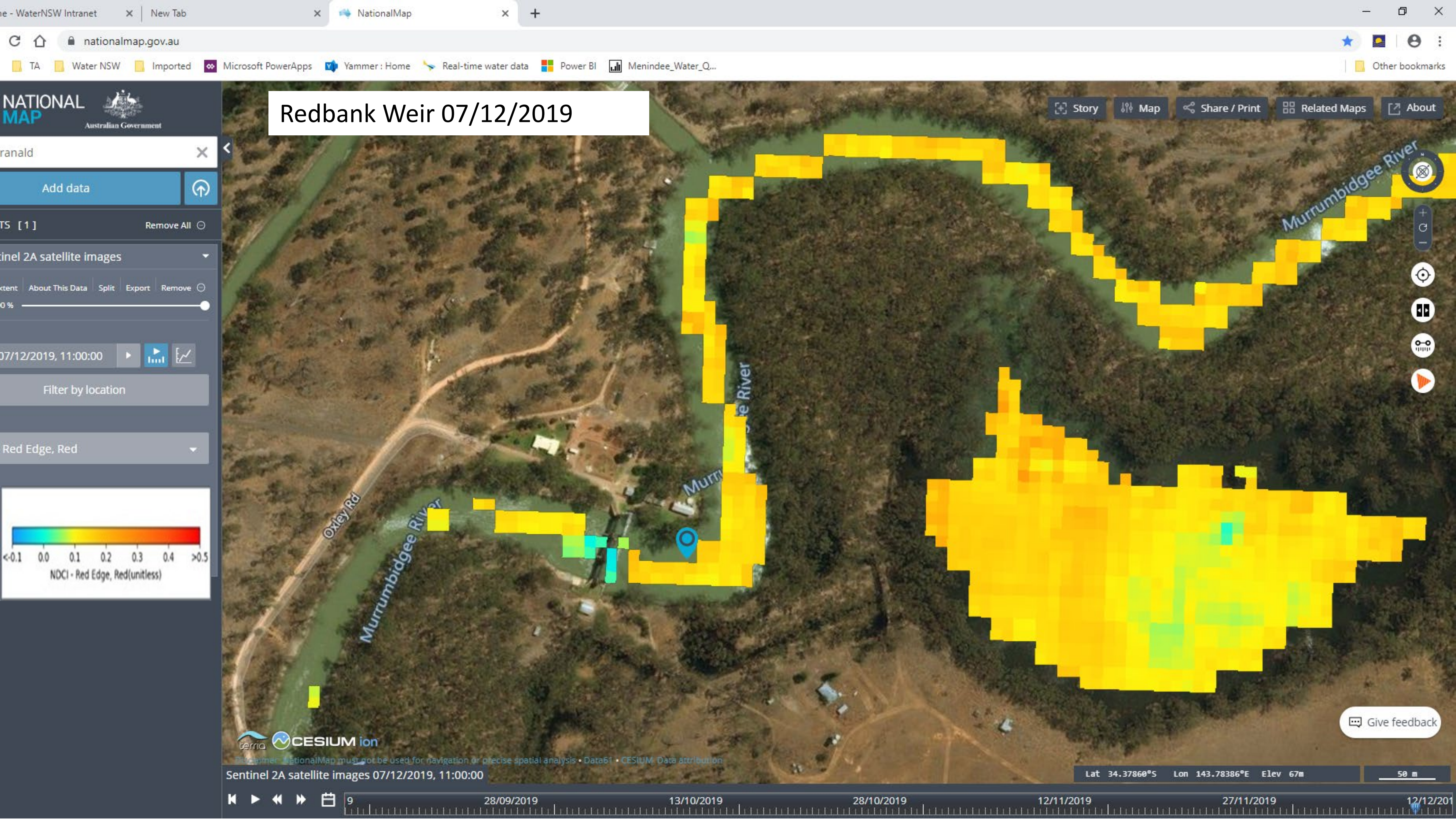
Site Number	Date of blue-green algal report	8/01/2021	18/01/2021	20/01/2021	28/01/2021	5/02/2021	11/02/2021	18/02/2021	24/02/2021	5/03/2021	11/03/2021	19/03/2021	25/03/2021	1/04/2021	8/04/2021	16/04/2021	22/04/2021	28/04/2021	4/05/2021	6/05/2021
DWYA01	Wyangala Junction Lachlan & Abercrombie	AMBER	AMBER	GREEN	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	AMBER
DWYA02	Wyangala Junction Lachlan & Sandy Ck	No Alert	No Alert	No Alert	AMBER	AMBER	GREEN	AMBER	AMBER	AMBER	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	AMBER	AMBER	AMBER	AMBER
DWYA04	Wyangala Dam Downstream	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	GREEN	GREEN	No Alert
DWYA05	Wyangala Abercrombie R	No Alert	No Alert	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	GREEN	GREEN	GREEN
DWYA06	Wyangala Inland Waters Park	No Alert	No Alert	GREEN	No Alert	No Alert	GREEN	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	GREEN	AMBER	AMBER	AMBER
DWYA08	Wyangala Dam Wall Station 1	No Alert	No Alert	GREEN	GREEN	GREEN	GREEN	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	GREEN	GREEN	GREEN	AMBER
N1168	Lachlan River at Cowra	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	GREEN	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert
DCAR01	Carcoar Dam Station 1 (Dam Wall)	No Alert	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	RED	RED	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	RED	RED	RED	GREEN
DCAR02	Carcoar Downstream (Belubula River)	No Alert	No Alert	No Alert	No Alert	GREEN	GREEN	No Alert	No Alert	GREEN	No Alert	GREEN	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert
N1022	Lachlan River at Cottons Weir (Forbes)	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert
N1024	Lachlan River @ Condobolin Bridge	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	AMBER	AMBER	AMBER	AMBER	AMBER
N1100	Goobang Creek at Condobolin		No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	GREEN	GREEN	GREEN	GREEN	GREEN	No Alert	No Alert	No Alert	No Alert	No Alert
N1101	Memorial Park Condobolin																			
N1097	Gum Bend Lake																			
DCRG01	Lake Cargelligo Outlet @ Lake Creek	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	GREEN	AMBER	AMBER
DCRG02	Lake Cargelligo Town Water Supply 41210042	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	No Alert	AMBER	AMBER	AMBER	AMBER	AMBER
DCRG03	Lake Cargelligo Boatshed	AMBER	No Alert	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER
DCRG04	Lake Cargelligo Weir	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert
DCRG05	Lake Cargelligo intake downstream of Curlew Waters	GREEN	No Alert	GREEN	No Alert	No Alert	No Alert	GREEN	GREEN	GREEN	GREEN	No Alert	GREEN	AMBER	AMBER	No Alert	No Alert	No Alert	GREEN	GREEN
DCRG06	Lake Cargelligo Lachlan River ds Lake Carlweir	No Alert	GREEN	No Alert		No Alert	No Alert		No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert	No Alert
DBRW01	Lake Brewster Inflow 412102	AMBER	AMBER	GREEN	AMBER	AMBER	AMBER	GREEN	GREEN	No Alert	No Alert	GREEN	GREEN	GREEN	GREEN	No Alert	No Alert	No Alert	GREEN	GREEN
DBRW02	Lake Brewster Inf wetland u/s eastern spillway															GREEN	GREEN	No Alert	No Alert	GREEN
DBRW03	Lake Brewster Regulator C	GREEN	RED	AMBER	AMBER	AMBER	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	No Alert	No Alert	RED	GREEN	AMBER	AMBER	AMBER	GREEN
DBRW04	Lake Brewster Outlet Channel 412108	AMBER	RED	RED	RED	RED	RED	AMBER	RED	AMBER	AMBER	AMBER	RED	RED	RED	RED	RED	RED	GREEN	No Alert
DLOS06	Lachlan River @ Willandra Weir	GREEN	RED	AMBER	GREEN	GREEN	GREEN	No Alert	No Alert	No Alert	No Alert	No Alert	AMBER	AMBER	AMBER	No Alert	No Alert	GREEN	No Alert	No Alert
N1025	Lachlan River at Hillston	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	No Alert	No Alert	No Alert	No Alert	No Alert	GREEN	GREEN	GREEN	GREEN	GREEN
N1023	Lachlan River at Booligal	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	AMBER	AMBER	AMBER
N1026	Lachlan River at Corrong	GREEN	AMBER	AMBER	RED	RED	RED	RED	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER	AMBER



Downstream of Redbank Weir and algal sample site

Laboratory results from samples taken inside weir pool

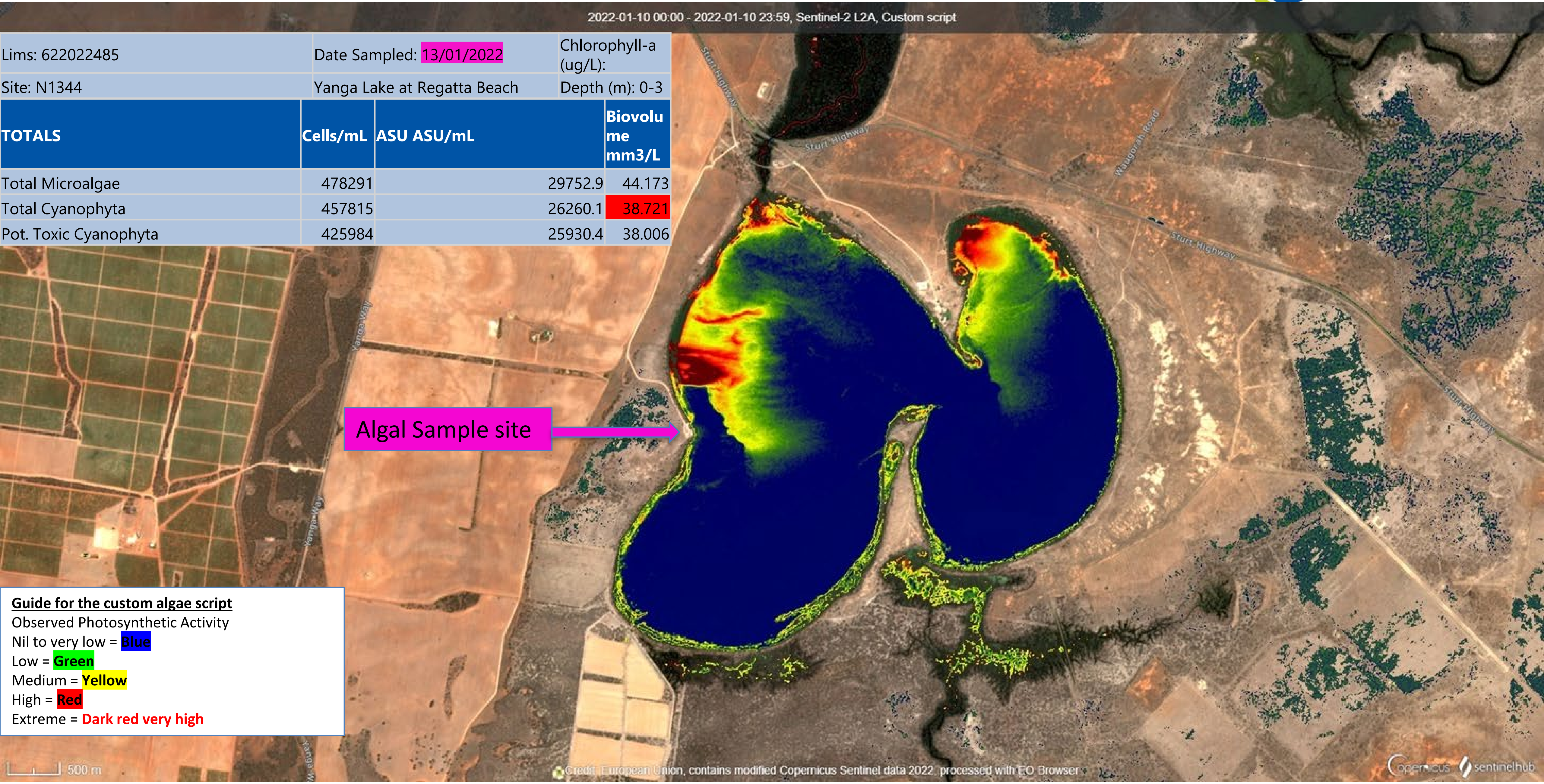
Redbank Weir 07/12/2019



Redbank Weir 11 December 2019 13:23 WaterNSW

Lims: 622022485	Date Sampled: 13/01/2022	Chlorophyll-a (ug/L):
Site: N1344	Yanga Lake at Regatta Beach	Depth (m): 0-3

TOTALS	Cells/mL	ASU ASU/mL	Biovolume mm3/L
Total Microalgae	478291	29752.9	44.173
Total Cyanophyta	457815	26260.1	38.721
Pot. Toxic Cyanophyta	425984	25930.4	38.006



Guide for the custom algae script

Observed Photosynthetic Activity

Nil to very low = **Blue**

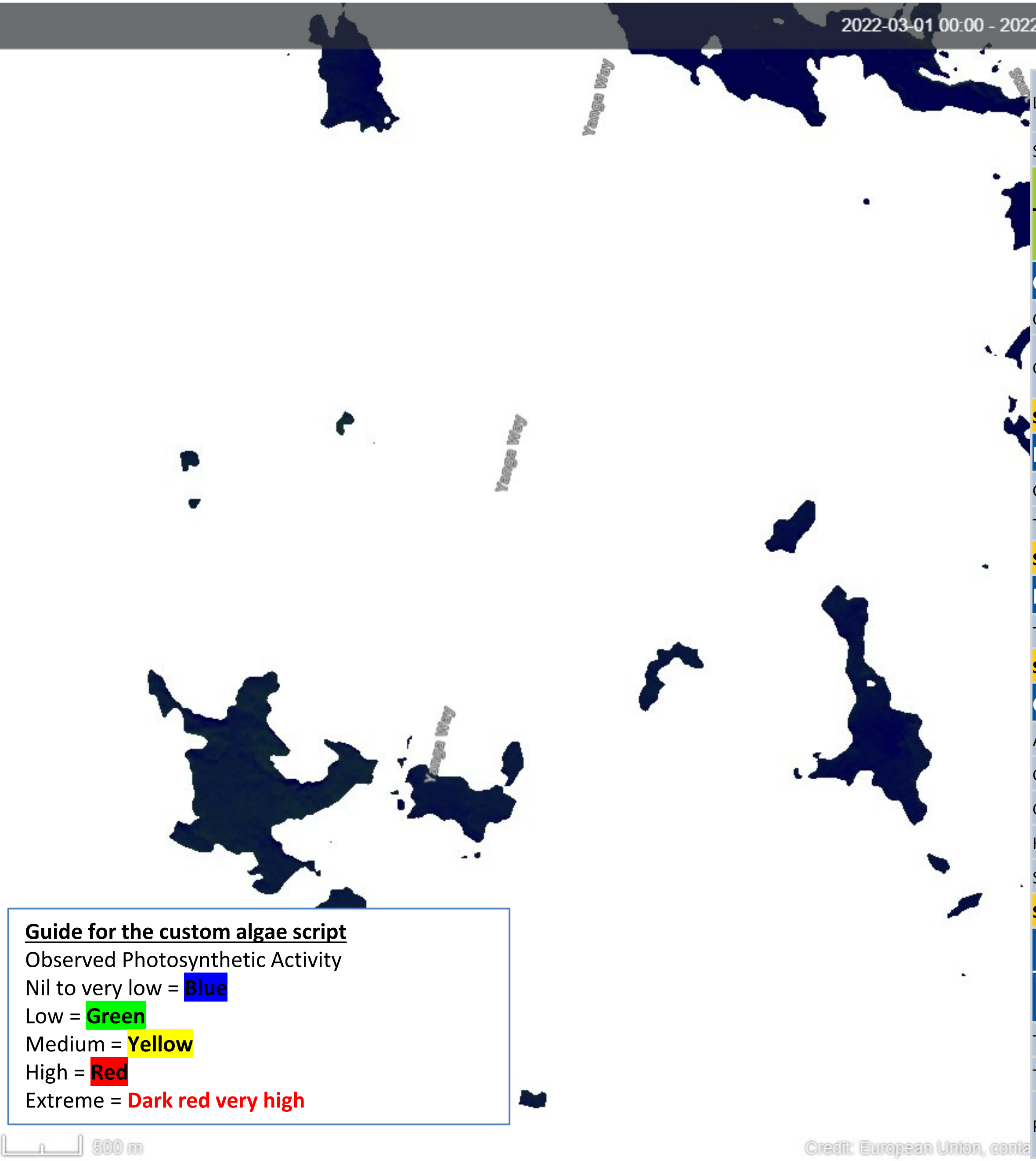
Low = **Green**

Medium = **Yellow**

High = **Red**

Extreme = **Dark red very high**

WaterNSW



Lims: 622023590		Date Sampled: 01/03/2022		Chlorophyll-a (ug/L):	
Site: N1344		Yanga Lake at Regatta Beach		Depth (m): 0-3	
TAXA	**Cells/mL**	**Significance**	**Pot. Txic ?**	**ASU ASU/mL**	**Biovolume mm3/L**
Cryptophyta (brown to olive green)					
Chroomonas sp.	346	Common after flood	No	30.6	0.04
Cryptomonas sp.	553	Common after flood, Taste & Odour	No	185.9	0.472
Subtotal	899			216.5	0.512
Bacillariophyta (Diatom)					
Cyclotella species 4	121	Filter clogging	No	188.9	1.704
Thalassiosira sp.	760		No	387.6	0.152
Subtotal	881			576.5	1.856
Euglenophyta (green)					
Trachelomonas sp.	138	Common after flood	No	122.4	0.653
Subtotal	138			122.4	0.653
Chlorophyta (Green)					
Ankistrodesmus falcatus	35		No	15.4	0.008
Chodatella_(Lagerheimia) sp.	69		No	13.3	0.017
Closterium sp.	17		No	170.6	0.246
Kirchneriella sp.	207		No	21.1	0.015
Sphaerocystis sp.	1526		No	122.1	0.187
Subtotal	1854			342.5	0.473

TOTALS	**Cells/mL**	**ASU ASU/mL**	**Biovolume mm3/L**
Total Microalgae	3772	1257.9	3.494
Total Cyanophyta	0	-	-
Pot. Toxic Cyanophyta	0	-	

Guide for the custom algae script

Observed Photosynthetic Activity

Nil to very low = Blue

Low = Green

Medium = Yellow

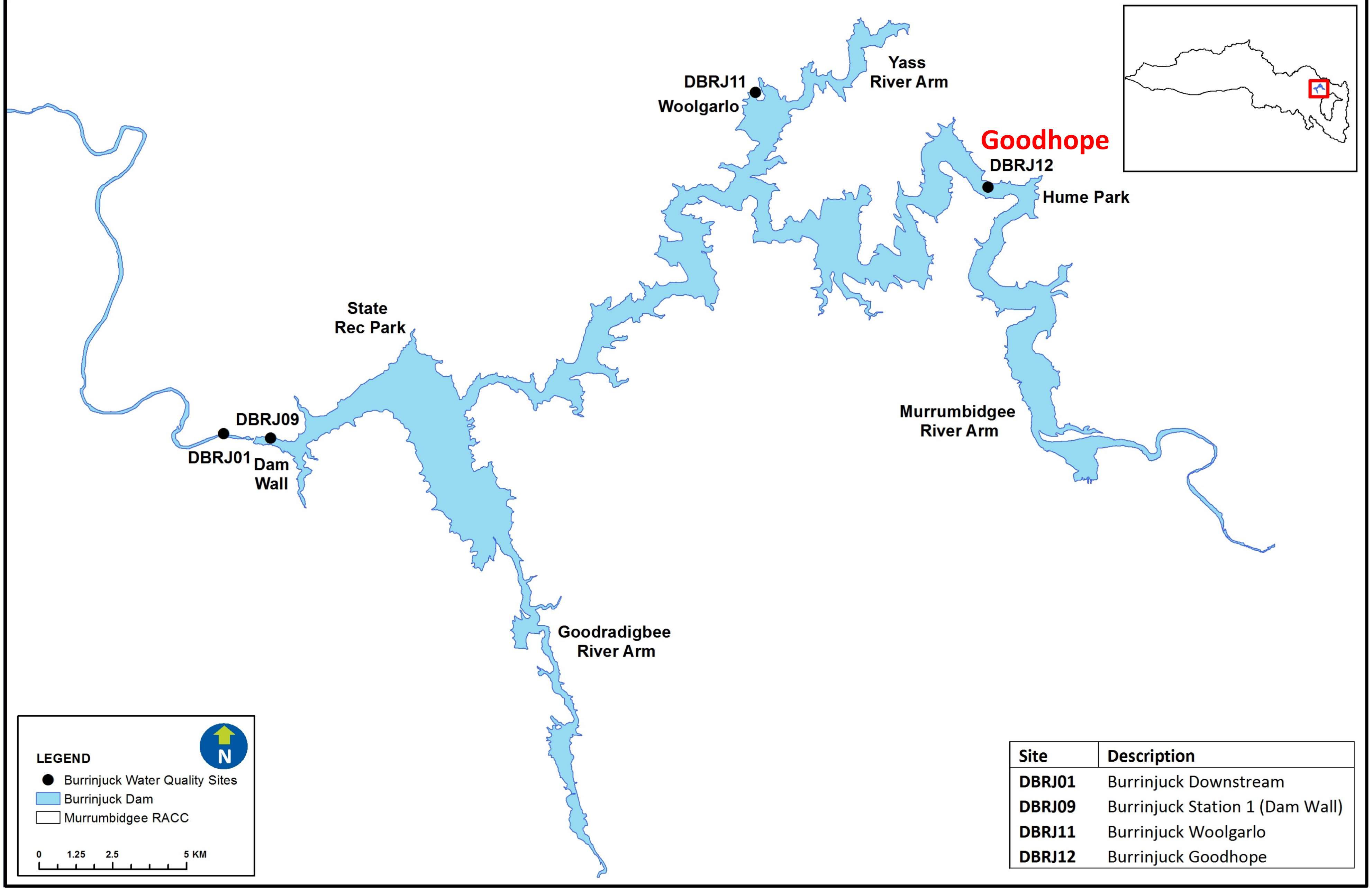
High = Red

Extreme = Dark red very high

copernicus sentinelhub

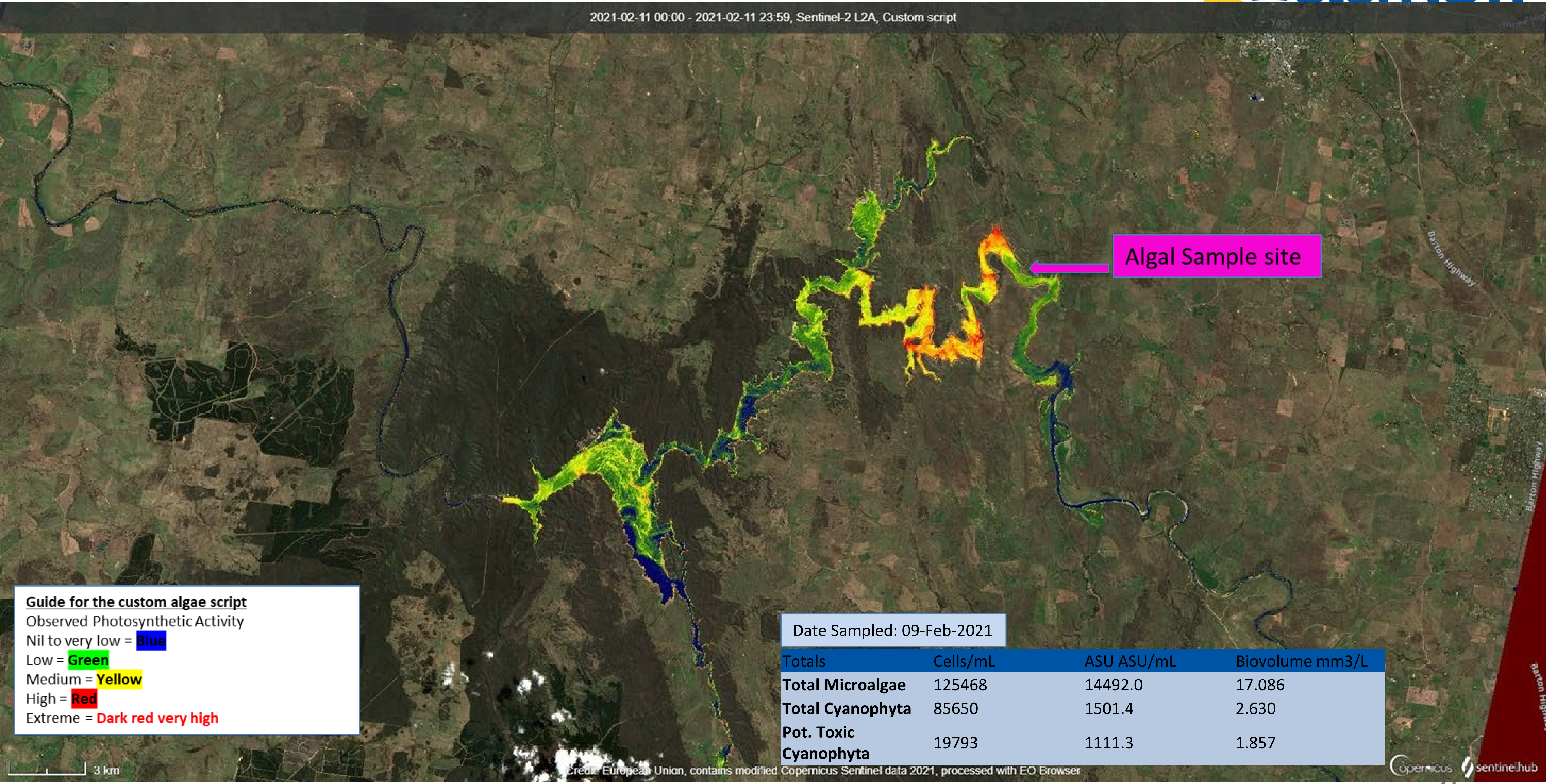
Water Quality Sites - Burrinjuck Dam

WaterNSW



Site	Description
DBRJ01	Burrinjuck Downstream
DBRJ09	Burrinjuck Station 1 (Dam Wall)
DBRJ11	Burrinjuck Woolgarlo
DBRJ12	Burrinjuck Goodhope

WaterNSW



Guide for the custom algae script

Observed Photosynthetic Activity
Nil to very low = Blue
Low = Green
Medium = Yellow
High = Red
Extreme = Dark red very high

Date Sampled: 09-Feb-2021

Totals	Cells/mL	ASU ASU/mL	Biovolume mm3/L
Total Microalgae	125468	14492.0	17.086
Total Cyanophyta	85650	1501.4	2.630
Pot. Toxic Cyanophyta	19793	1111.3	1.857

Water quality readings from the Menindee Lakes as received from our Staff at Menindee

Site	Site Name	Sample Date	Sample Time	Sample Depth (m)	Turbidity (NTU)	Temperature (°C)	DO% (Saturation)	DO (mg/L)	Field EC (µS/cm) Compensated@25 °C	pH
N1088	42510002 Lake Wetherell Site 2	25/11/2019	9:16	0.25	72	25.2	99.7	8.2	771	8.6
N1088	42510002 Lake Wetherell Site 2	25/11/2019	9:17	0.50		24.4	81.1	6.8	773	8.5
N1088	42510002 Lake Wetherell Site 2	25/11/2019	9:17	1.00		24.3	69.7	5.8	773	8.3
N1088	42510002 Lake Wetherell Site 2	25/11/2019	9:17	2.00		23.7	48.3	4.1	773	8.2
N1088	42510002 Lake Wetherell Site 2	25/11/2019	9:17	3.00		23.4	35.8	3.0	773	8.1
N1088	42510002 Lake Wetherell Site 2	25/11/2019	9:17	4.00		23.1	19.8	1.7	773	7.9
N1088	42510002 Lake Wetherell Site 2	25/11/2019	9:18	4.50		22.4	6.0	0.5	909	6.6
N1128	42510034 - Menindee Lakes - Cawndilla Outlet	26/09/2022	16:11	0.25	139	17.79	113.4	10.8	408	8.6

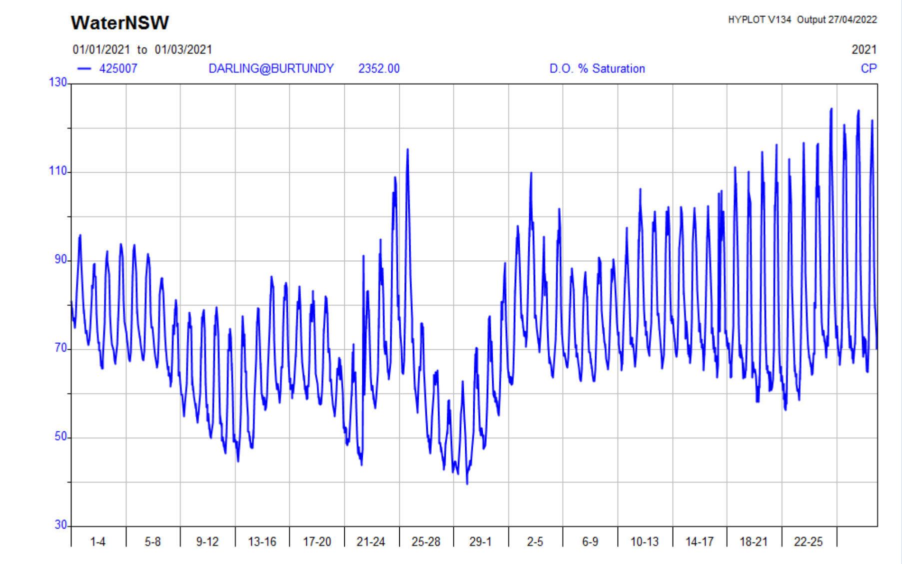
Legend for colour codes				
DO%	Above 100% saturation			
DO	Acceptable >5	Acceptable for adults 5 to 3	Not acceptable <3	DO based on acceptable level for healthy yabbies on a yabby farm
EC	<1000	1000 to 2500	>2500	

Current complementary methods for detecting and reporting potentially harmful blue-green algae

Routine algal sampling and distribution of analysis results

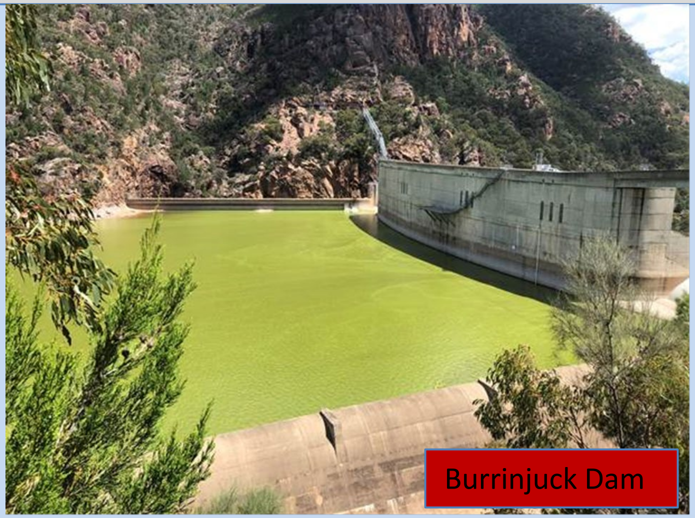
Site	Description	Latest Sample Date	Cyanobacteria Total Count (cells/mL)	Cyanobacteria Biovolume (mm3/L)	Potentially Toxic Cyanobacterial Count (cells/mL)	Potentially Toxic Cyanobacterial Biovolume (mm3/L)	Current Status (based on Latest Sample)	Previous Status	Cyanobacteria dominant potentially toxic taxa	Comments
Burrinjuck Dam										
DBRJ12	Burrinjuck Goodhope	25/01/2022	8,061	0.028	885	0.023	No Alert	No Alert	*Microcystis Unknown*	Potentially toxic, taste & odour
DBRJ11	Burrinjuck Woolgarlo	25/01/2022	692,606	15.584	604,576	15.536	RED	RED	*Microcystis Unknown*	Potentially toxic, taste & odour
DBRJ10	Burrinjuck Waters State Park	25/01/2022	306,604	7.103	276,812	7.076	RED	RED	*Microcystis Unknown*	Potentially toxic, taste & odour
DBRJ09	Burrinjuck Station 1 (Dam Wall)	25/01/2022	1,690,481	43.214	1,690,481	43.214	RED	RED	*Microcystis Unknown*	Potentially toxic, taste & odour
DBRJ01	Burrinjuck Downstream	25/01/2022	6,395	0.133	5,842	0.132	AMBER	AMBER	*Microcystis Unknown*	Potentially toxic, taste & odour
Blowering Dam										
DBLO01	Blowering Station 1 (Dam Wall)	11/01/2022	19,927	0.518	16,747	0.516	AMBER	GREEN	*Radiocystis sp.*	Potentially toxic
DBLO02	Blowering Downstream	11/01/2022	1,383	0.043	1,383	0.043	GREEN	No Alert	*Radiocystis sp.*	Potentially toxic

Water quality readings such as Dissolved Oxygen and pH



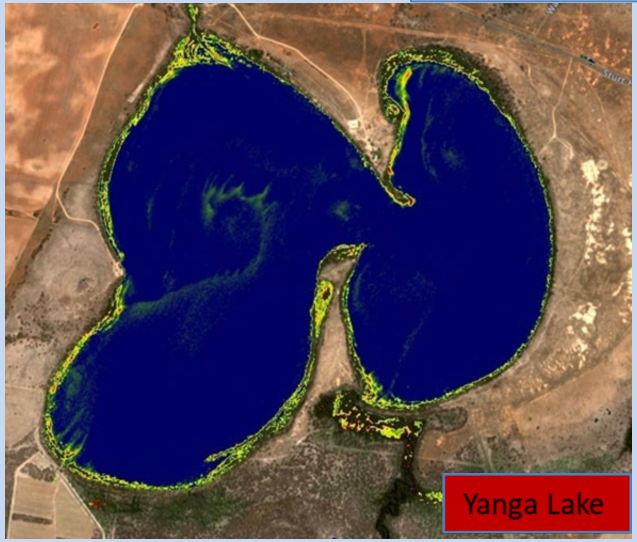
Additional sampling when elevated algal numbers are expected

Observations by field staff during sampling runs & Observations by RACC members and the public

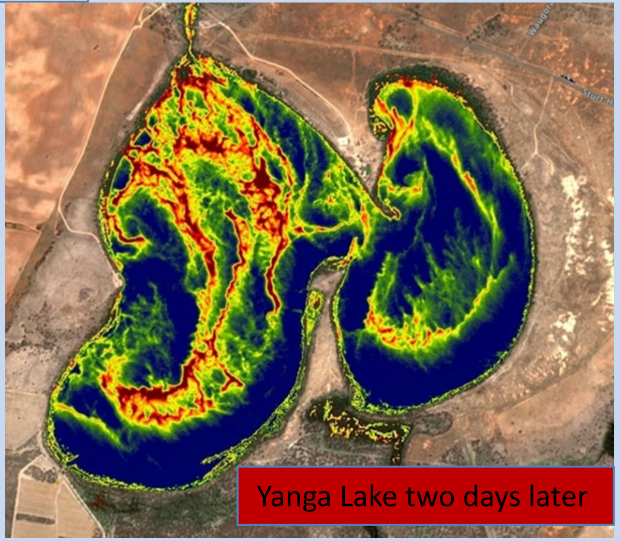


Burrinjuck Dam

Satellite images

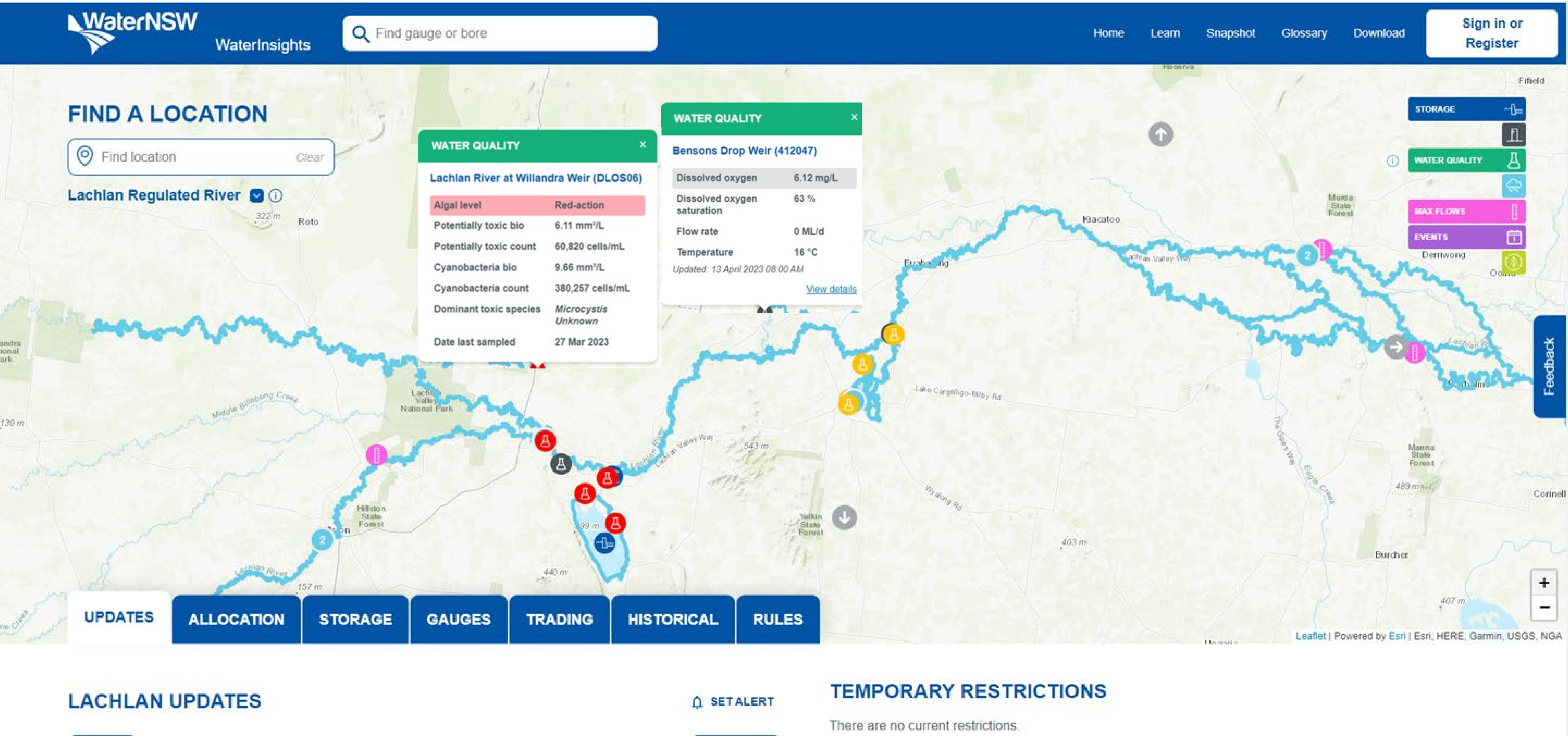


Yanga Lake



Yanga Lake two days later

WaterInsights – one-stop technology for information that is currently being implemented at WaterNSW



End

Session – II @ 13:30 AEST

3. Hunter Water and the Aquawatch Mission

Andy Olrich*[1], Tapas Biswas[2], James Van Der Helm[1], Klaus Joehnk[2]

*andrew.olrich@hunterwater.com.au
[1]Hunter Water Corporation NSW Australia
[2]CSIRO Environment, ACT Australia

Key words: remote sensing, satellite, cyanobacteria, forecasting, water quality

Abstract:
Everyone needs and deserves access to clean, safe drinking water. As the world moves towards an uncertain climate future, Hunter Water is at the forefront of trialling innovative tools to manage our most precious resource.

Hunter Water is partnering with the CSIRO and the SmartSat Cooperative Research Centre to form the AquaWatch mission to develop a comprehensive national inland and coastal water quality information service.

Hunter Water's Grahamstown Reservoir near Newcastle is one of multiple sites participating in the national pilot program. Using additional pilot sites in the ACT and Victoria, CSIRO aims to grow the program into an integrated system to provide holistic aquatic ecosystem information or a 'weather service for water quality'.

Hunter Water deployed the first hydraspectra device in June 2022. Since then, Hunter Water has been undertaking some correlation and analysis with the CSIRO team of the data captured to assist with validating the process plus helping to develop the Hydrologic model. Hunter Water has also undertaken some process mapping, evaluation and comparison to understand the potential future state value add benefits realised for the desired outcomes.

As Hunter Water pumps water from the Williams River into Grahamstown Reservoir, CSIRO and Hunter Water will add another floating sensor in the Williams River this September. There will also be some additional monitoring of the 8km infeed canal (Balickera canal). After the two-year trial, Hunter Water will keep the equipment and data, and staff will integrate the system into existing monitoring and visualisation programs.

“Ground Control to Grahamstown…and beyond!”

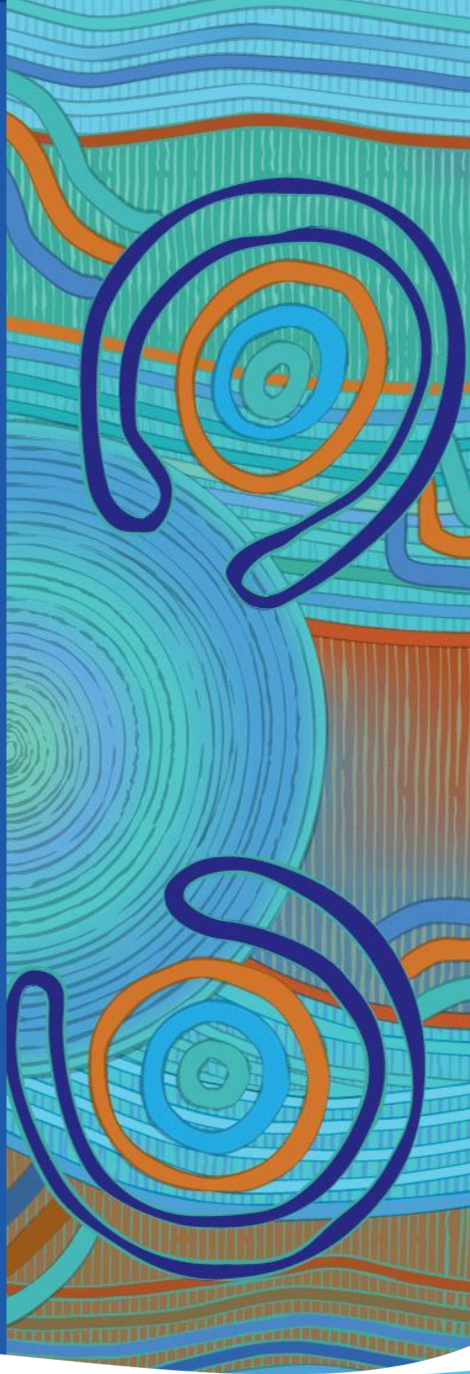
Hunter Water and the AquaWatch Mission

ACKNOWLEDGEMENT OF COUNTRY

Hunter Water acknowledges the First Nations Peoples and Countries of the Lands on which we operate.

This project specifically, is located on the Lands of the Traditional Custodians of the Worimi.

I acknowledge we gather here today on the lands of the Bunurong People and pay respects to elders past, present and emerging.



Introductions

Daniel Levingston

Team Leader Science and Research

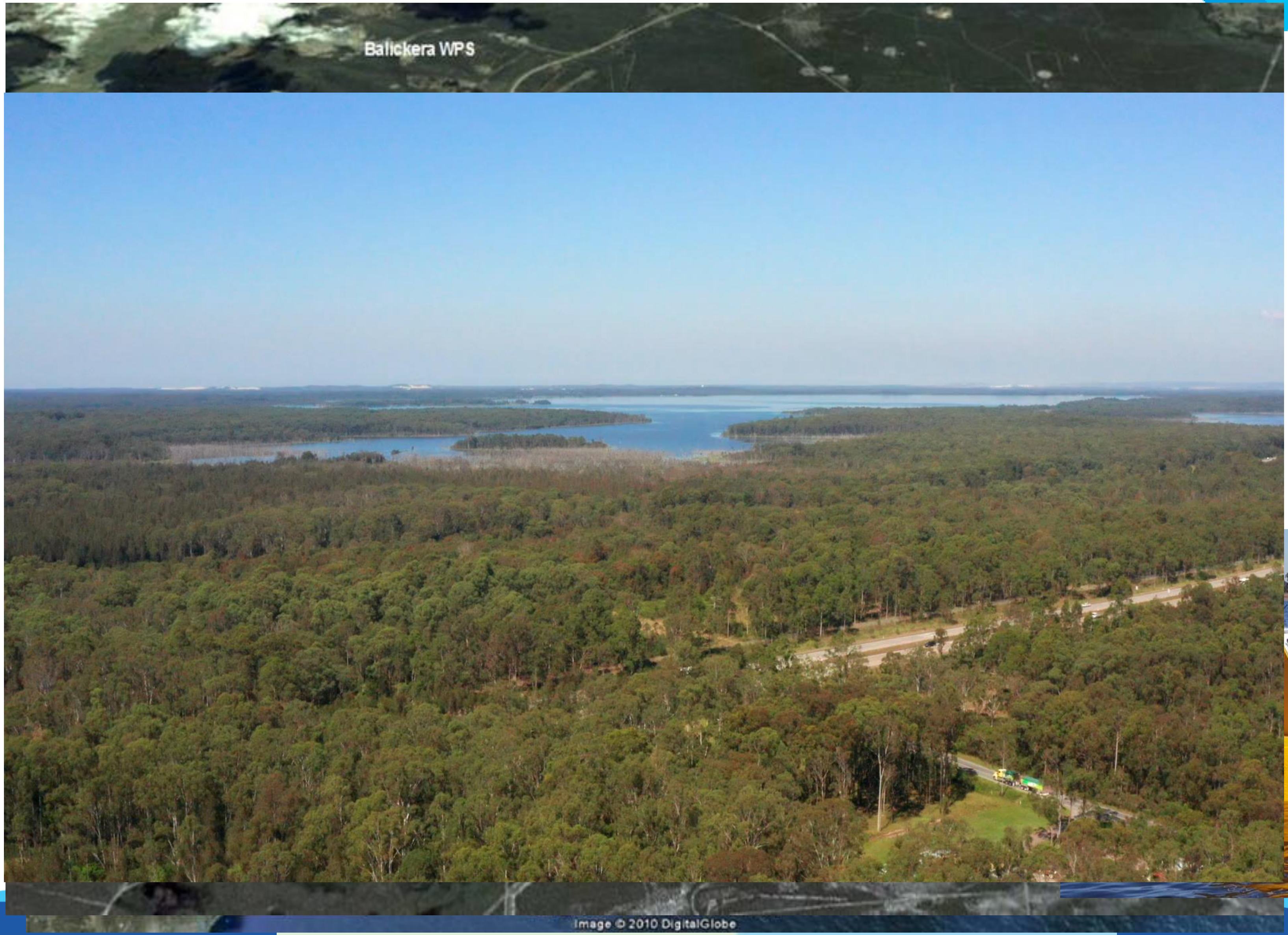
Andy Olrich

Continuous Improvement and Innovation Lead

James Van Der Helm

Senior Water Scientist

Hunter Water – Area of Operations



Recap and timeline

July 2022
Procure Instruments

Sept 2022
Pilot Launch
HW Trial Launch
Grahamstown Dam Instrument Deployment

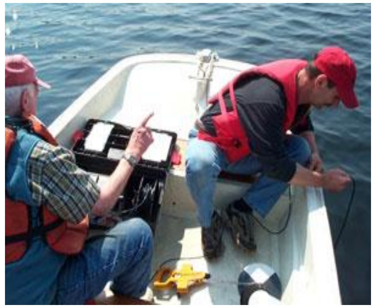
Sept 2023
Williams River & Balickera canal
Instrument Deployment
Continued validation and visualisation

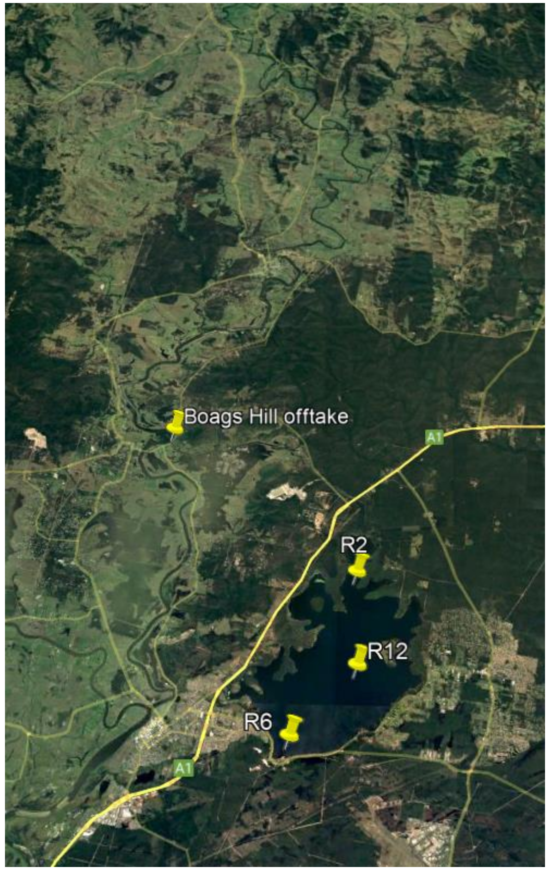
Sept 2024
Lessons learned
Trial Closeout

Design and implement
Determine Protocol
Merge and Manage data
Data integration and Machine Learning

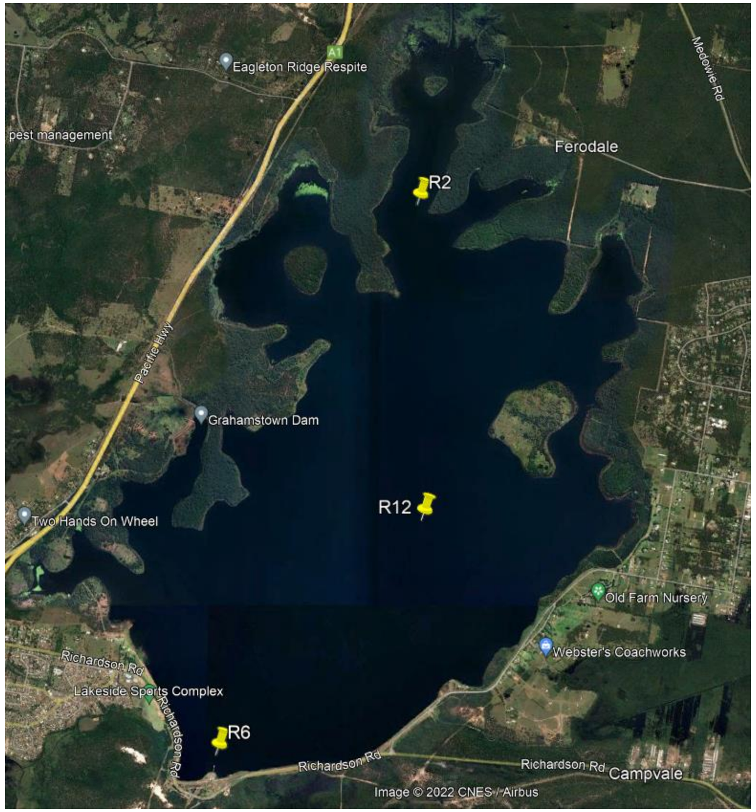
Hunter Water

Current Sampling and Challenges





Williams River



Grahamstown Dam

~180 GL

28 km^2

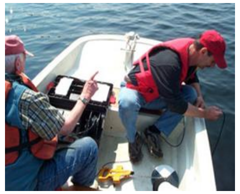
Potential Opportunities

“Exposure Windows”

Current State

Request Sample

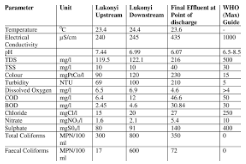
Collect sample



Prepare and send sample

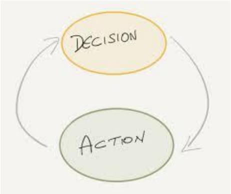
Sample analysis

Results provided



Parameter	Unit	Lukonyi Upstream	Lukonyi Downstream	Final Effluent at Point of discharge	WHO (Max) Guide
Temperature	°C	23.4	24.4	23.6	-
Electrical Conductivity	µS/cm	240	245	435	1000
pH		7.44	6.99	6.07	6.5-8.5
TDS	mg/l	119.5	122.1	216	500
TSS	mg/l	10	10	40	30
Colour	mgPtCo/l	90	120	230	15
Turbidity	NTU	69	100	210	5
Dissolved Oxygen	mg/l	6.5	6.9	4.6	>4
COD	mg/l	6.4	12	46.6	50
BOD	mg/l	2.45	4.6	30.84	30
Chloride	mgCl/l	15	20	27	250
Nitrate	$mgNO_3/l$	1.6	2.1	5.4	10
Sulphate	$mgSO_4/l$	80	91	140	400
Total Coliforms	MPN/100 ml	300	800	350	0
Faecal Coliforms	MPN/100 ml	17	600	72	0

Decision of further actions required or not



Quick Statistics:

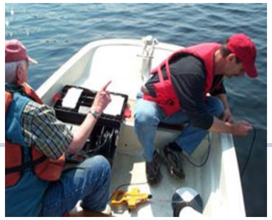
- Standard Lead time per sample – **7 Days (Average)**
- Optimised approach lead time **– 3-7 Days**
- Resources required

➢ 3 persons
➢ 2 vehicles
➢ 1 boat

Opportunities Cont'd

Weekly sample process steps, durations and costs

Current State example



Current costs estimate
~$38k per annum
(weekly sample cycle)

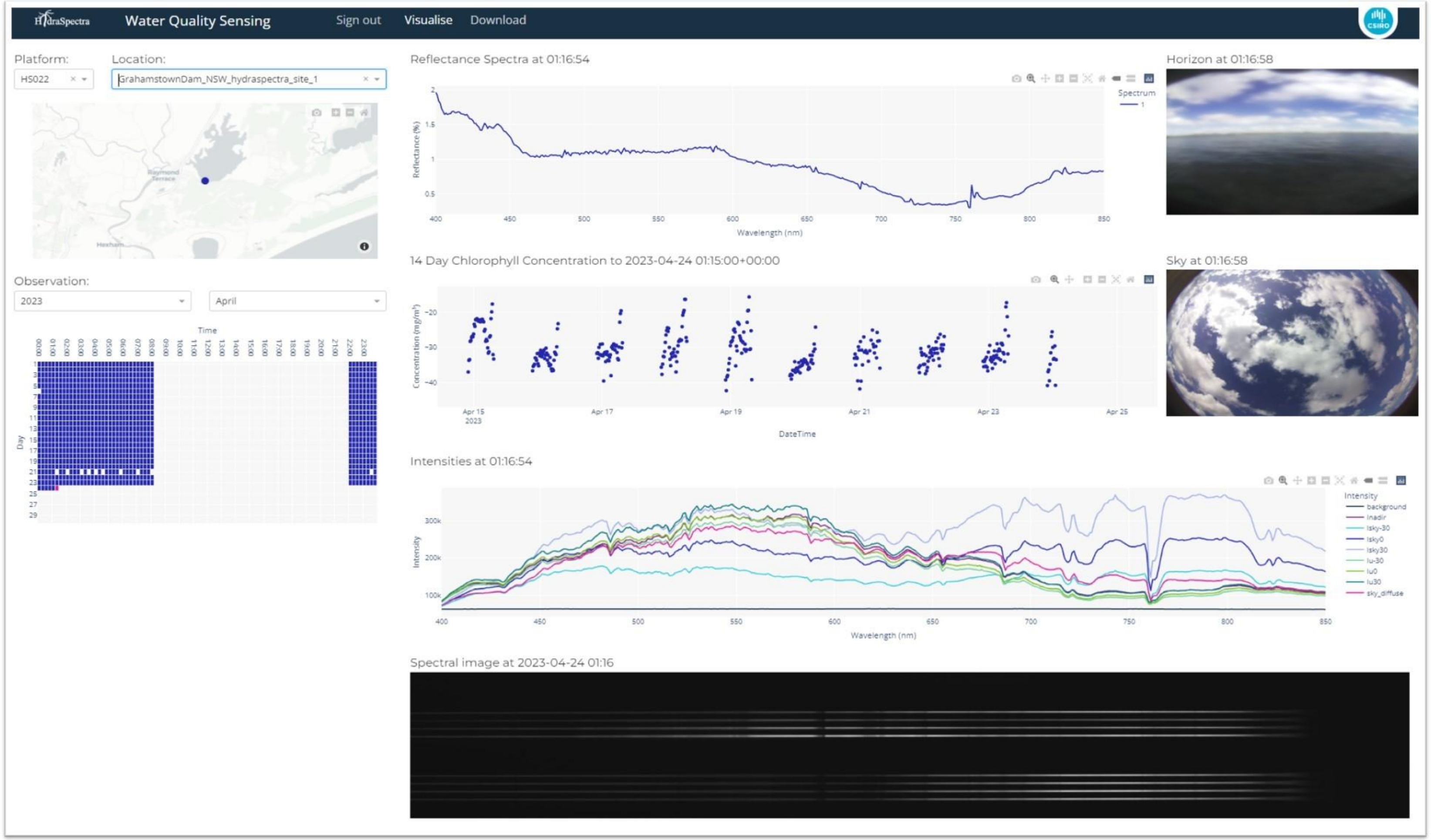
Step	Detail
1	Office to Lab in Mayfield to collect Sample Bottles
2	Lab Mayfield to Dam via Servo to collect ice for sample preservation
3	Tomago depot to Dam.
4	Launch boat, mobilise to Sample location
5	Sampling
6	Return to boat ramp and pack up boat
7	Return Boat to Tomago Depot
8	Pack samples in ice and prepare COC
9	Return back to Head Office via Lab in Mayfield to drop off samples.

Detail	mins	km	Resources
NWC - DAM	45	36	1 vehicle, 1 person
TOM - DAM	20	20	1 vehicle, 1 person, 1 boat
DAM - HS - DAM	60	1	1 Boat, 2 people
TOM - DAM	20	20	1 vehicle, 1 person, 1 boat
NWC - Dam	45	36	1 vehicle, 1 person

NWC – Newcastle office
TOM – Tomago Depot
DAM- Grahamstown
HS – Hydraspectra site

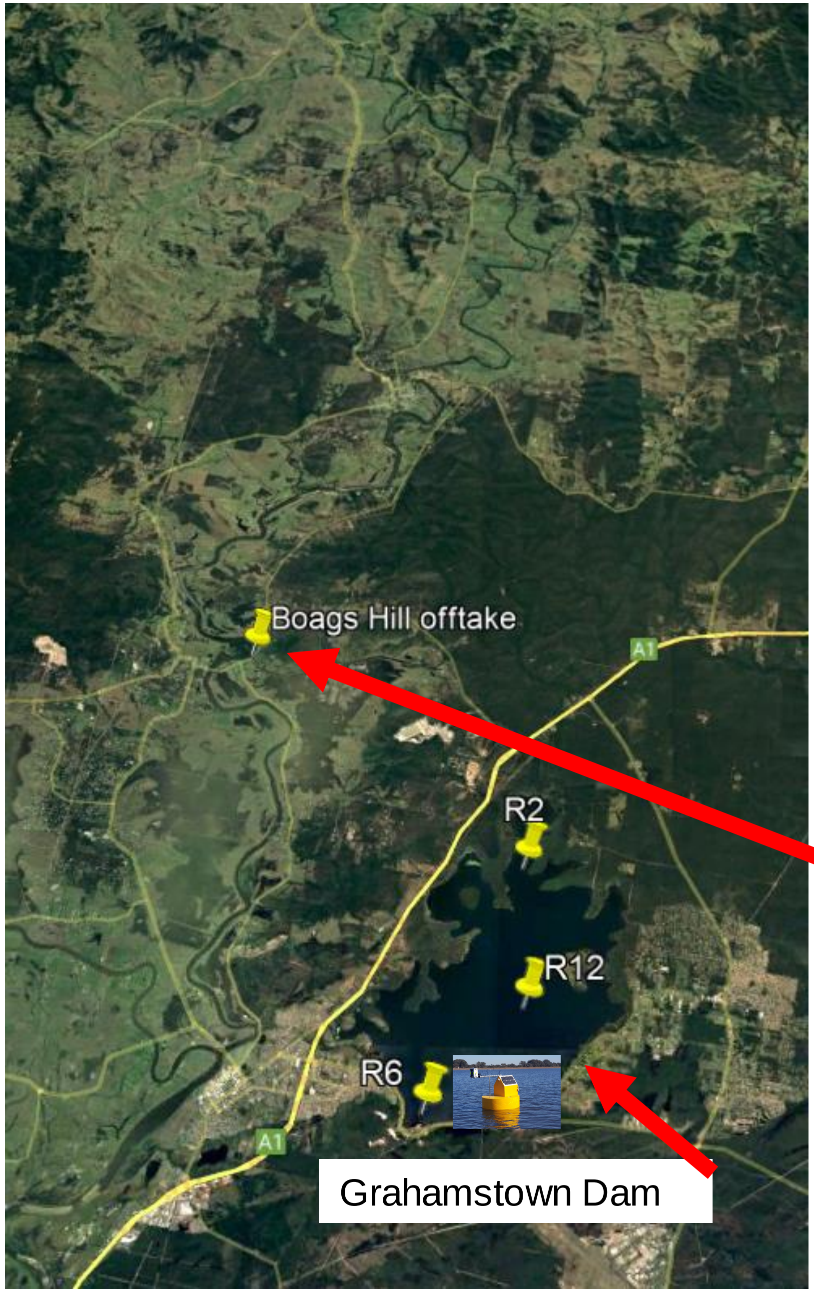
AquaWatch Trial

Grahamstown Dam



Phase two – Williams River

Installation of HydraSpectra #2



Balickera Canal
Water Quality Assessment

Objective:

Quantify change in water quality that may be occurring in the major source waters of Grahamstown Dam.

Balickera Canal Instrumentation

<u>Objective:</u>

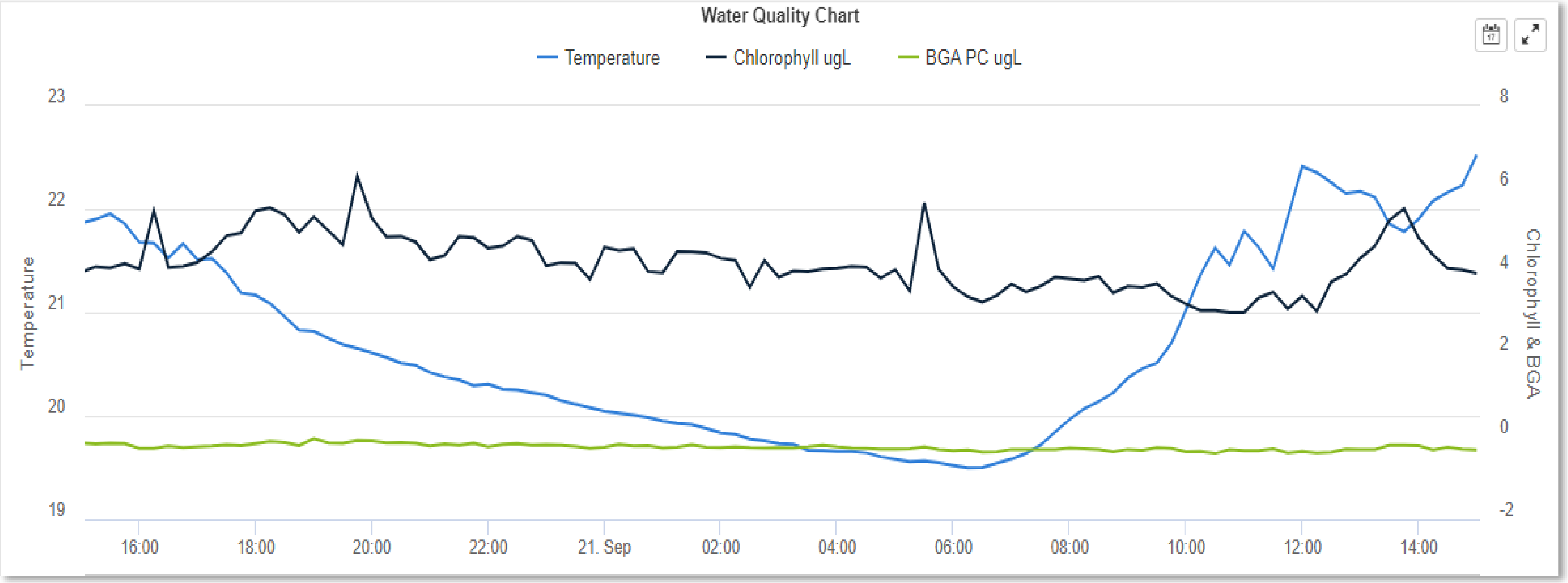
Understanding the effect of still conditions, no flow, sunlight and nutrients on Harmful Algal Blooms.

Balickera Canal Instrumentation

Hunter Water and CSIRO experts install data logging stations in Balickera Canal.

Balickera Bluetooth and Telemetry

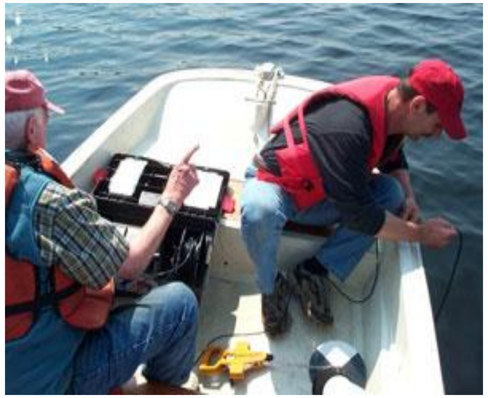
Realtime, Chlorophyll a, blue green algae, lux & temperature data accessed via telemetry and available for operations through EagleIO GUI.



Science based decision making informed through

- Research & Development
- Innovation
- Trials and Partnerships

Further validation and decisions



Next Steps – to Sept 2024

Continued engagement, learning and collaboration

Case study video

HUNTER WATER

love water

WANT TO KNOW MORE?

Please scan QR codes below

DAN

ANDY

JAMES

QUESTIONS

THANK YOU

Session – II @ 13:45 AEST

4. Status of research into blue-green algae in Canberra's urban lakes

Ralph Ogden*

*ralph.ogden@act.gov.au
ACT Healthy Waterways, Office of Water, Environment Planning and Sustainable Development Directorate, ACT Government, Canberra

Key words: blue-green algae, urban lakes, prediction

Abstract:
The ACT Government is investing in research to understand the drivers of blue-green algal (BGA) blooms in Canberra's lakes and ponds. Lake Tuggeranong is the best studied lake and catchment in the region. BGA growth in that lake has been shown to be primarily limited by phosphorus. Either internal or external loads are sufficient to drive an algal bloom, but external loads are 4-5 times greater than internal loads, comprises 50% dissolved forms, and is 99% delivered diffusely in storm events. We are currently tracking down the catchment pollution sources, but data on two candidates for diffuse pollution—leaf/grass litter and fertilisers—indicate that both are likely to be major sources of diffuse pollution. The magnitude of mitigation required to prevent blooms means we will need to combine catchment and in-lake measures to solve the problem of BGA in this lake. The problem of BGA in Lake Burley Griffin is less acute, but development pressures on within its catchment are greater, which means there is a risk that BGA become a chronic problem in the lake in the future.

Some knowledge gaps for the issue of BGA in Canberra's lakes and ponds are: 1) What are the triggers for bloom development, what are their spatial dimensions, and does this information offer some avenues for prevention? 2) Can we accurately predict the growth of algae in response to internal and external loadings? and 3) are there general criteria that can be used to predict whether BGA growth in a pond or lake is driven by either internal or external loads?. Answers to the third question would be useful so that we do not need to sink three years of research into every waterbody before we can understand how to prevent the development of BGA blooms.

ACT Government

Harmful algal blooms in Canberra's lakes & ponds

Dr Ralph Ogden
ACT Healthy Waterways Program Manager
Office of Water, EPSDD

ralph.ogden@act.gov.au

ACT Government

I acknowledge the Ngunnawal people as traditional custodians of the land where I join you from and recognise any other people or families with connection to the lands of the ACT and region.

I acknowledge and respect their continuing culture and the contribution they make to the life of this city and this region.

I also acknowledge and welcome other Aboriginal and Torres Strait Islander people who may be attending today's event.

Lake Tuggeranong

Closed to primary contact an average of 3 months/year due to health risks

ACT Government

Gordon Pond

Photo by resident

Lakes and Ponds Plan of Management
(Planning and Development Act 2007)

The hierarchy of objectives for lakes and ponds:

1. Prevent and control **floods** by providing a reservoir to receive flows from rivers, creeks and urban run-off.
2. Prevent and control **pollution** of waterways.
3. Provide for **public use** of the lake or pond for recreation.
4. Provide **habitat** for fauna and flora.

Some major water quality assets are feature lakes & ponds!

Community views – Schirmer & Mylek 2016

Waterways are well used and highly valued by the community for:

- **aesthetic** qualities
- **appreciation** of the existing natural systems and aquatic life
- **recreational** opportunities, esp fishing, swimming and boating
- **facilities** for family and group gatherings, including barbeques
- **opportunities** to interact with the natural environment.

BGA links to neurodegenerative diseases?

Environmental Science & Technology
pubs.acs.org/est
Critical Review

Toxic Cyanobacteria: A Growing Threat to Water and Air Quality

Haley E. Plaas and Hans W. Paerl*

Cite This: *Environ. Sci. Technol.* 2021, 55, 44−64
Read Online

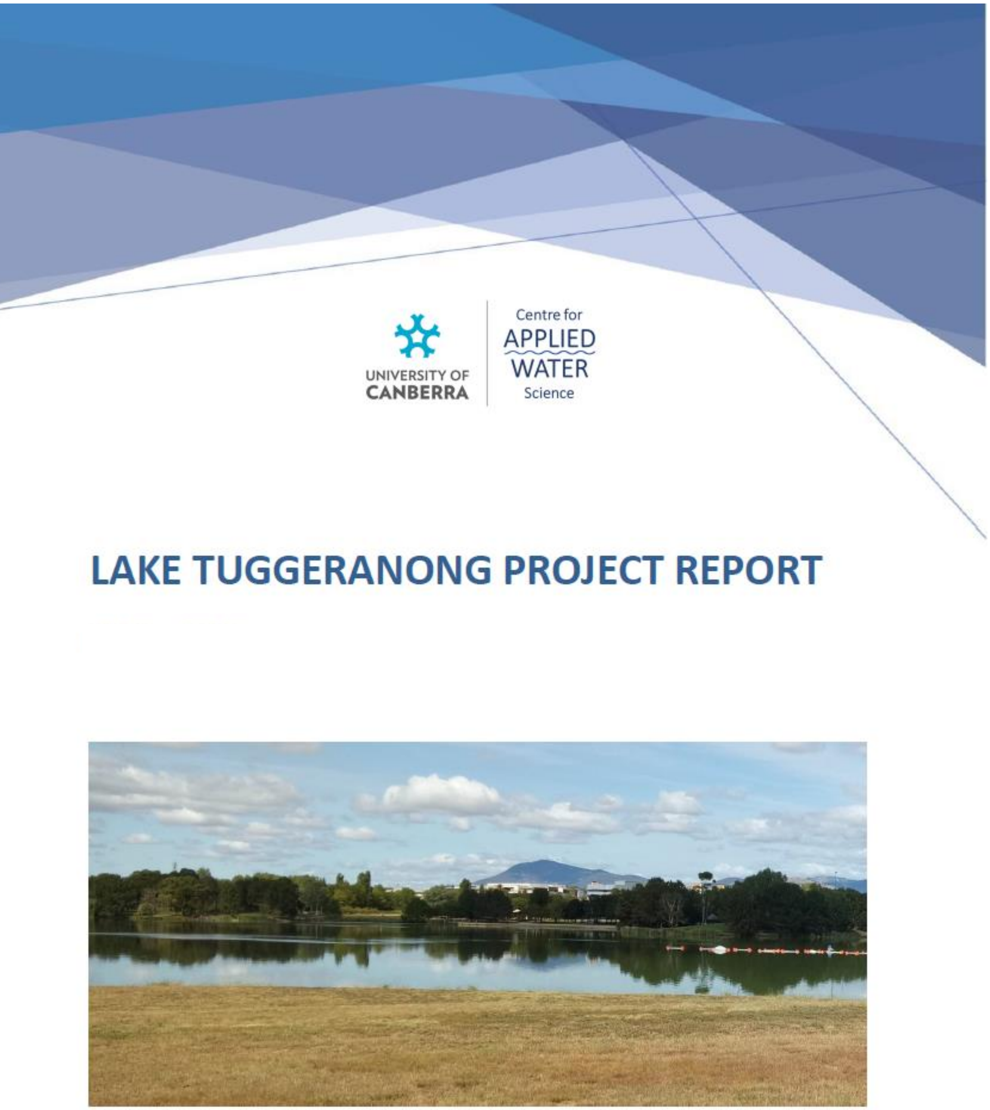
Is there a link between motor neurone disease and blue-green algae? NSW expert calls for closer look

A neurology professor wants MND to be listed as a notifiable disease to help investigate suspected environmental links

Prof Dominic Rowe from Macquarie University has called for the NSW government to list MND as a notifiable disease. Photograph: Macquarie University

A top neurologist has called on the New South Wales government to list motor neurone disease (MND) as a notifiable disease amid suspicions a cluster of diagnoses in the state could be linked to something in the environment.

Research



- P is the key in Lake T
- Lake sediments and tributaries supply enough P to cause blooms
- Catchment supply is 5x sediments
- Most pollution is from storm flows
- 50% of N & P in stormwater is dissolved
- *Therefore: big wetlands low in catchments are necessary but not sufficient to solve problems*
- Nutrient pollution is ‘diffuse’ – coming from everywhere
- Sports fields are a detectable point source but are probably not the predominant source

Research

- Leaves/grass in gutters contributing between 4 to 60% of the estimated annual stormwater supply of P to the lake (U Canberra)
- 90% of nutrients leach out of leaves & grass within 48 hours of continuous wetting
(U Canberra)
- Households using a staggering 0.7kg of P per capita per year
(Concepts of Change)
  - cf. 500 kg annual input of P to the lake in 2019
  - data highly skewed by ‘power users’
- Some other specific pollution sources (e.g. sewage) and the location and relative magnitude of inputs still being studied (U Canberra)

Knowledge gaps relating to AquaWatch

- How can we predict the onset of blooms in real time?
- What are the spatiotemporal dynamics of blooms –
  - where do they start
  - how do they develop
  - what does this tell us about how they might be prevented?

↓

- Can in-lake treatments be targeted to prevent bloom formations?
  - Algicides & algal competitors
  - Placement of macrophyte beds within lakes

ACT Government

QUESTIONS?

ralph.ogden@act.gov.au

ACT Government

Session – II @ 14:00 AEST

5. Cyanobacteria, cyanobacteria and more cyanobacteria – Dealing with ongoing cyanobacterial challenge

David Cook*[1], F. Choo[1] and E. Sawade[1]

*david.cook@sawater.com.au
[1]SA Water, Adelaide, SA

Abstract:
SA Water supplies drinking water to over 1.7 million customers, with approximately 80% receiving treated surface water. All surface waters are susceptible to transient cyanobacteria blooms generally between September and March although recent cyanobacterial challenges suggest the notion of an algal season no longer applies. Surface waters consist of the River Murray, and reservoirs located in the Mt Lofty Ranges, metropolitan Adelaide, Fleurieu Peninsula and Kangaroo Island. In South Australia, 30 water treatment plants (WTPs) have a surface water source with older WTPs (commissioned prior to 2000) relying on coagulation/flocculation and media filtration to remove cells and powdered activated carbon to remove dissolved metabolites. Ten WTPs located along the River Murray, commissioned 2007-09, consist of coagulation/flocculation/ultrafiltration for cell removal and biologically active granular activated carbon for metabolite removal.

Each source water provides a similar challenge being predominantly the earthy/musty taste and odour compounds MIB and geosmin but often produced by different dominant cyanobacteria species. Known toxin producers Dolichospermum circinale (saxitoxins), Cylindrospermopsis raciborskii (cylindrospermopsin) and Microcystis aeruginosa (microcystins) are also often detected.

Analysis of taste and odour challenges in the River Murray (2000-2022) showed increasing frequently from 2015 generally dominated by geosmin challenges, up to 999 ng/L of geosmin and 155 ng/L of 2-methylisoborneol (MIB). Following major flooding in the Murray-Darling system in summer 2022-23 WTPs had to deal with the highest concentrations of MIB ever measured with 2320 ng/L of MIB detected at Renmark WTP inlet. The cyanobacteria species responsible, (Planktothrix perornata_f_attenuata) was rarely detected over the previous 20 years. Increasing frequency and variability (e.g., species, metabolite concentration, length and time of year) means opportunity to maximise learnings from events need to be undertaken.

This presentation will provide an overview of ongoing and future research/investigations related to water treatment performance for cell and metabolite removal.

Cyanobacteria, cyanobacteria and more cyanobacteria - Dealing with ongoing cyanobacterial challenge

SA Water

AquaWatch Workshop

David Cook

28/09/23

Government of South Australia

South Australia – Water sources

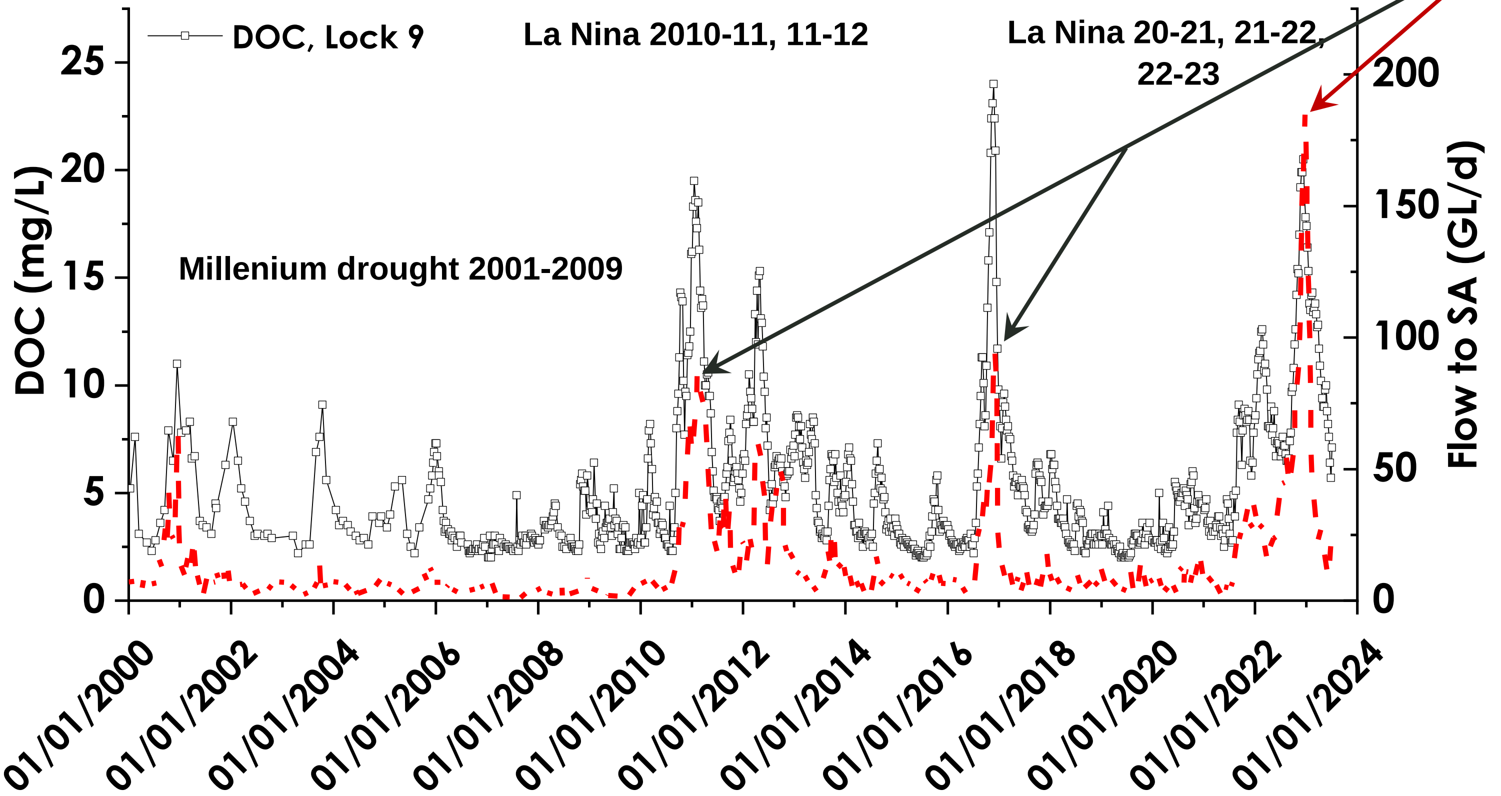
- Dry climate
- High dependency on surface water
  - Susceptible to cyanobacteria blooms
- Few alternatives
  - Although some relief from SWRO desalination plant (Adelaide only)

Population served

1 200 000 in metropolitan Adelaide through **9 220 km** of water mains.

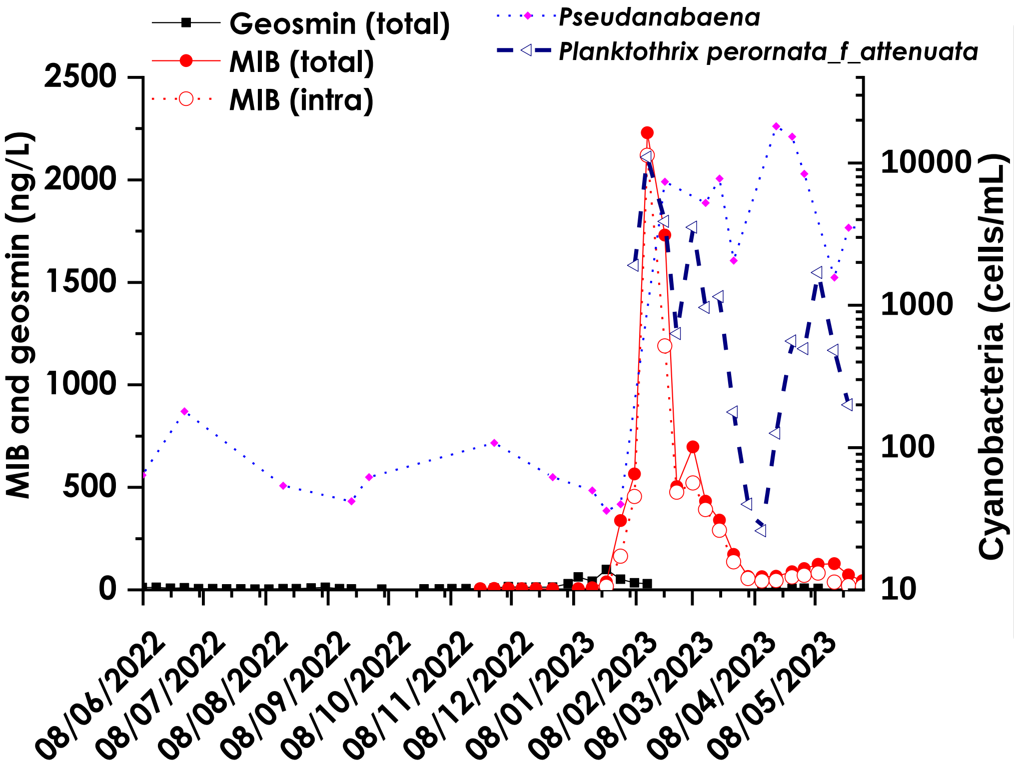
432 000 in country areas through **17 600 km** of water mains.

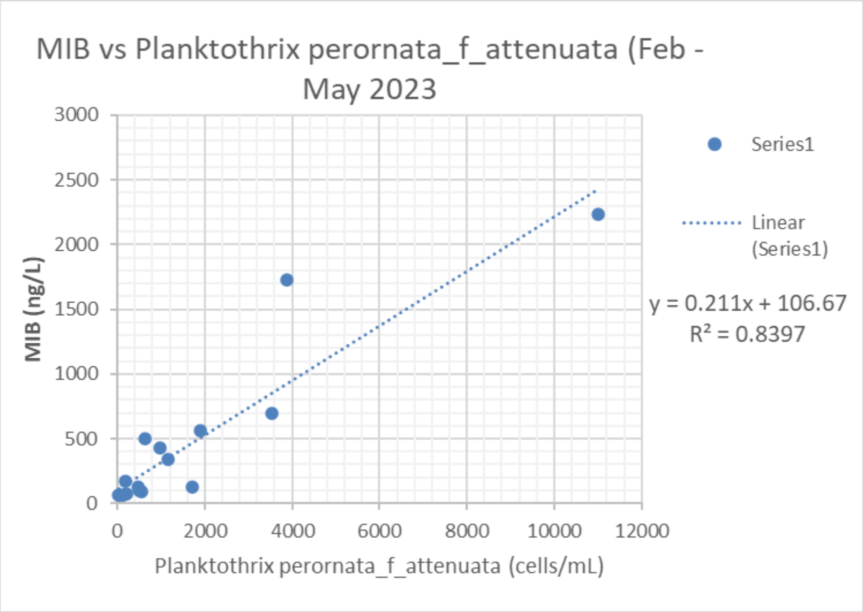
DOC and Flow to SA, Lock 9, 2000-



Flow ≈ double that observed previous two events

Cyanobacteria Challenge – MIB (Renmark WTP)





Fluorescence sensors - Early warning monitoring for WTP process control

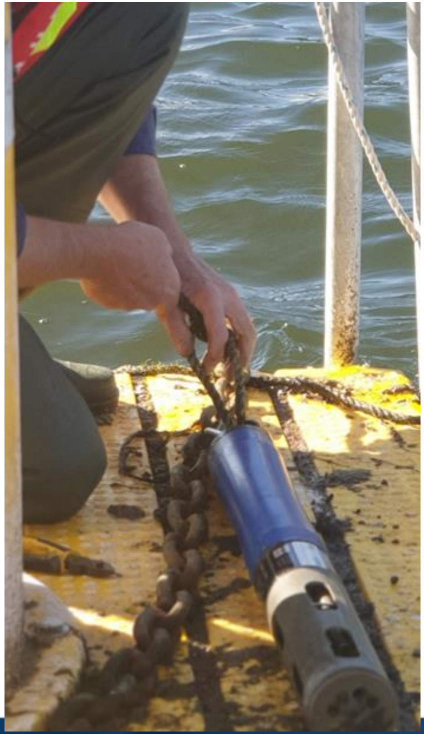
Deployment

- Sensors were installed at a weather station within the reservoir's reserve, and at the inlet of Hope Valley Water Treatment Plant (pictured), Happy Valley WTP and Myponga WTP inlet
- Measurements recorded every 15 minutes for chlorophyll, phycocyanin, fDOM, dissolved oxygen, TDS, and conductivity

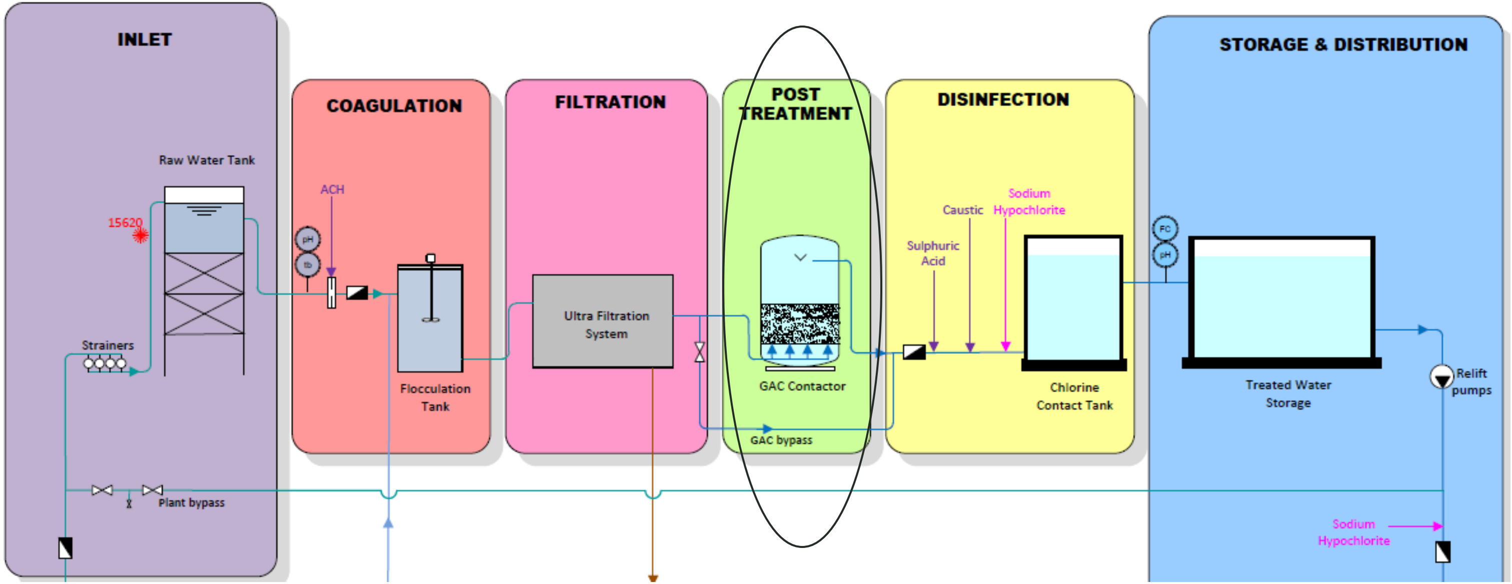
Factors impacting on performance and use (different for each site)

- Water Quality – High DOC (>10 mg/L) at Myponga
- Cyanobacteria challenge – Benthic at Hope Valley Reservoir, also change in DOC
- Catchment Activity – Copper addition at Happy Valley Reservoir

Next step – Simulate Integration into WTP operation decision making process



Ultrafiltration and GAC, 10 WTPs (River Murray)



- Ongoing assessment of GAC performance, adsorption and biodegradation of MIB and geosmin
- Not researching biofilm diversity

Source water and WTP related

Hope Valley Reservoir – Benthic Cyanobacteria Assessment

- Ongoing monitoring into year 3
- Key water quality factors impacting on cyanobacteria proliferation
- Data to inform reservoir management and WTP upgrades

Happy Valley WTP

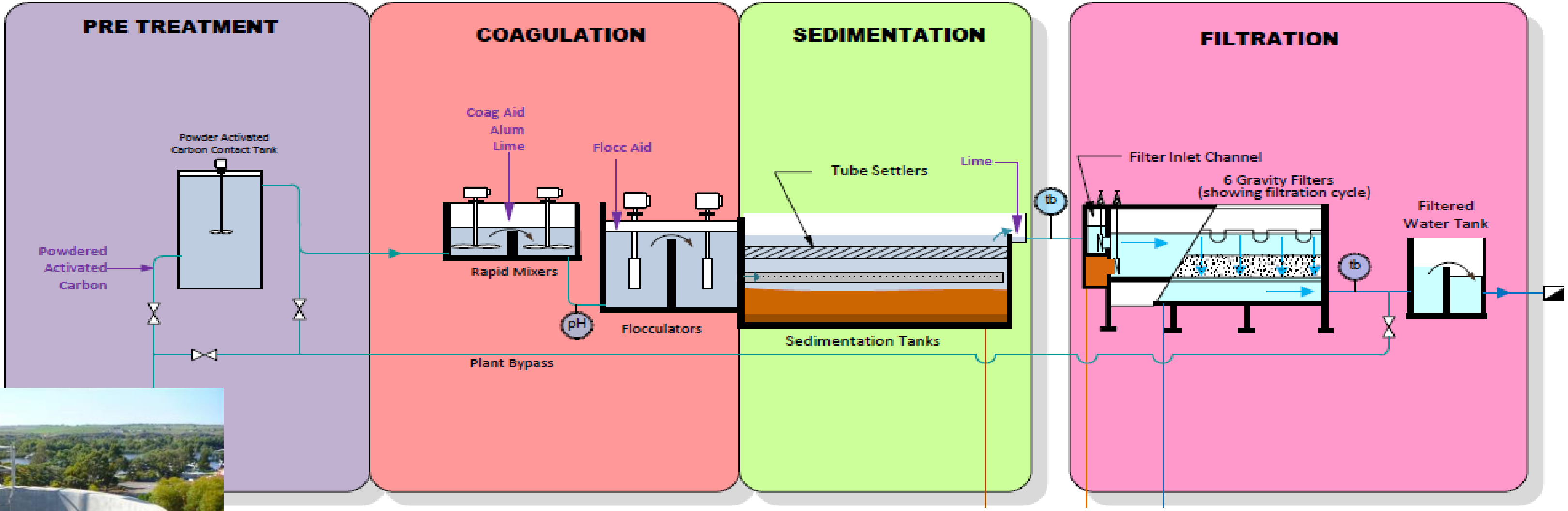
- Pilot plant scale ozone/GAC assessment – multi barrier approach

Opportunistic Works – WTP sampling during bloom events, supported by laboratory experiments

- WTP performance for the treatment of cyanobacterial species not often encountered
- Impact of superintendent return on WTP cyanobacterial and metabolite challenge
- Assessment of PAC for the removal of high MIB concentration

Moving bed biofilm reactor (MBBR) technology

WTP x 10 – Conventional with PAC contact tank



- Moving bed biofilm reactor (MBBR) technology in the front end of the drinking water treatment train
- ARC Linkage Grant to investigate (pilot plant) in collaboration with Seqwater, SA Water, AnoxKaldnes and Queensland Health – commence next year

making life flow

Government of South Australia

SA Water

Session – II @ 14:15 AEST

6. Wetlands and water quality management: Sydney Olympic Park experience

Swapan Paul*

*Swapan.Paul@sopa.nsw.gov.au
Sydney Olympic Park Authority, 5 Olympic Boulevard, SOP NSW 2127, Australia

Key words: wetlands, water quality, Sydney Olympic Park

Abstract:
The mosaic of freshwater and estuarine wetlands in Sydney Olympic Park are the remnant jewel in the crown of the Parramatta River estuary system. Located at a highly urbanised catchment, the challenges that these wetlands face are a microcosm of many that the diverse landscapes of Australia have been confronting. This short presentation will share some of the experiences and shed lights on sensible management approaches that have been yielding desired outcomes.

Wetland and algae management at Sydney Olympic Park

Dr Swapan Paul PWS, Swapan.Paul@sopa.nsw.gov.au

SydneyOlympicPark

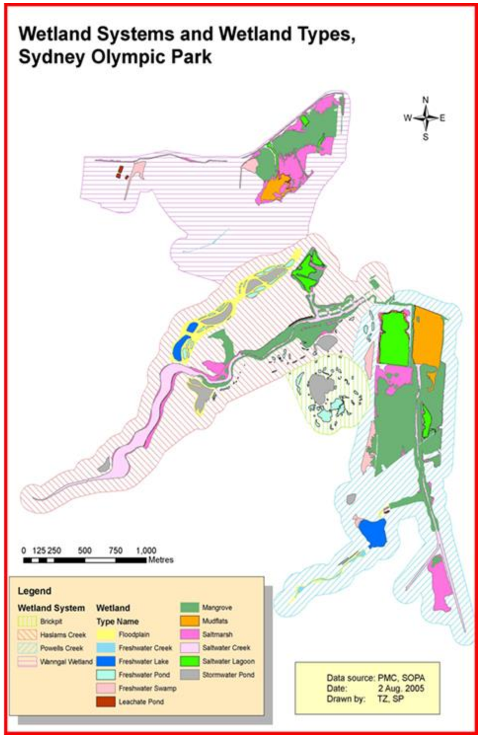
Acknowledgement of the Country

I'd like to begin this presentation by acknowledging the traditional custodians of the **Wangal Country** where Sydney Olympic Park – my workplace – belongs in Sydney, Australia. I'd like to also acknowledge the traditional custodians of those lands from which all of us are attending this event, including the **Larrakia people**. I'd like to pay my respect to the elders of the past, present and emerging and also those indigenous people who are attending this event.

Sydney 2000 Summer Olympics have triggered wetland restoration

Sydney 2000

Sydney Olympic Park: an urban oasis



- 2/3rd of 630ha is parklands
- Olympic Park hosted 11.7 million visitors in 2018
- 5,875 events
- 3.8 million people visit parklands
- Over 1 million attend live shows and concerts
- RAS draws 1.0million people
- Aquatic Centre has 1.0million patrons

High Diversity of Wetlands @SOP

Remnant Constructed Modified Restored Rehabilitated Regenerated	Saltwater	Freshwater
	Mangrove	Lake
	Intertidal Creek	Creek
	Coastal Saltmarsh	Frog Pond
	Lagoon	Stormwater Basin
	Billabong	Reservoir
	Intertidal Mudflat	Bioretention Devices
		Swamp
		Floating Rafts
		Rain Garden
		Leachate Pond

Wetlands are under urban pressures

SydneyOlympicPark

Blue Green Algae Bloom

What to look for:

- Ponds/lakes covered with non-shiny blue-green mass, with milky bands – Blue-green Algae

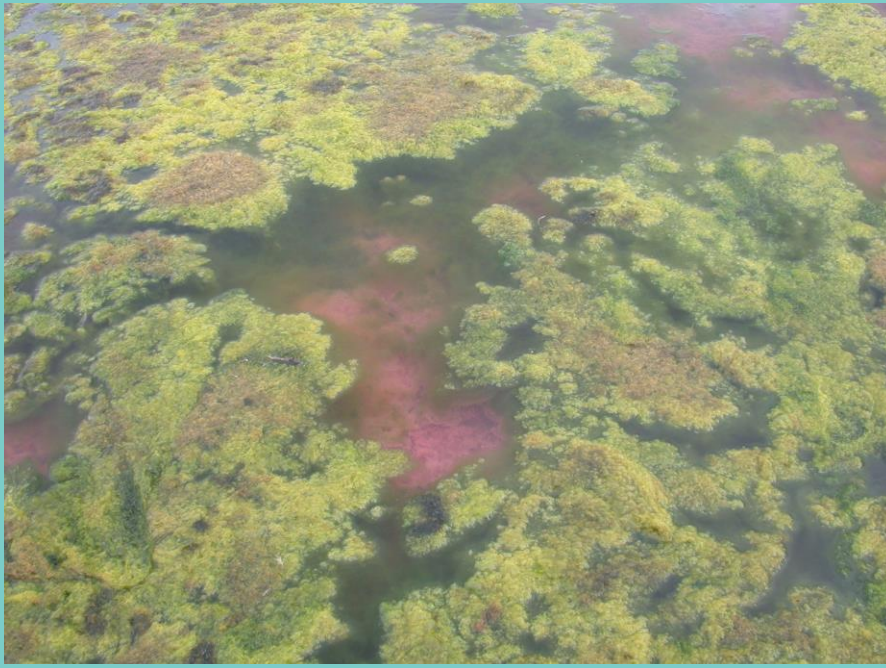
Where to look:

- Teal Pond
- Brickpit Reservoir
- Lake Belvedere

Filamentous Algae Bloom

What to look for:

- Ponds/lakes covered with non-shiny blue-green mass, with milky bands – Blue-green Algae
- Ponds/lakes covered with non-shiny yellow-green mass, with grey bands – Filamentous Algae



Where to look:

- Northern Water Feature
- Eastern Water Quality Control Pond
- Teal Pond
- Waterbird Refuge
- Lake Belvedere
- Saltwater Billabong

Duck Weed Bloom

What to look for:

- Ponds/lakes covered with shiny light-green mass - Duckweed

Where to look:

- Northern Water Feature
- Eastern Water Quality Control Pond
- Teal Pond
- Brickpit Reservoir
- Lake Belvedere
- Wentworth Common Playground Pond

Floating Aquatic Plant Bloom

What to look for:

- Ponds/lakes covered with non-shiny pinkish-green mass – Azolla

Where to look:

- Northern Water Feature
- Eastern Water Quality Control Pond
- Teal Pond
- Brickpit Reservoir
- Lake Belvedere
- Wentworth Common Playground Pond

Algae Management Approaches

Primarily two Management Drivers:

- Place based – ecology
- People centric – public health

Algal bloom vs. tidal restoration for migratory shorebirds

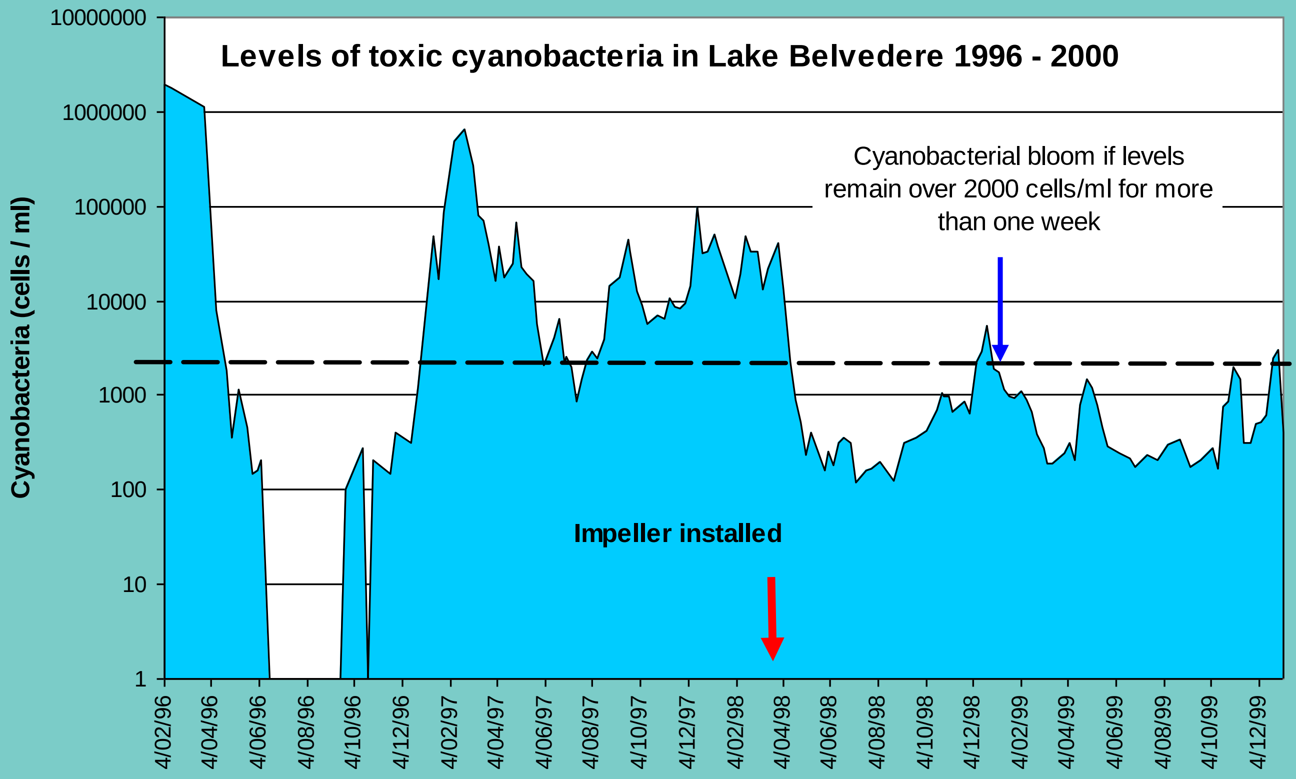
Objectives of tidal restoration

Wish List

- Better Water Quality
- More Shorebirds
- Diverse waterbirds
- Less than 20% algae
- No bad smell
- Better aesthetics
- Diverse marine life
- Sustainable solution

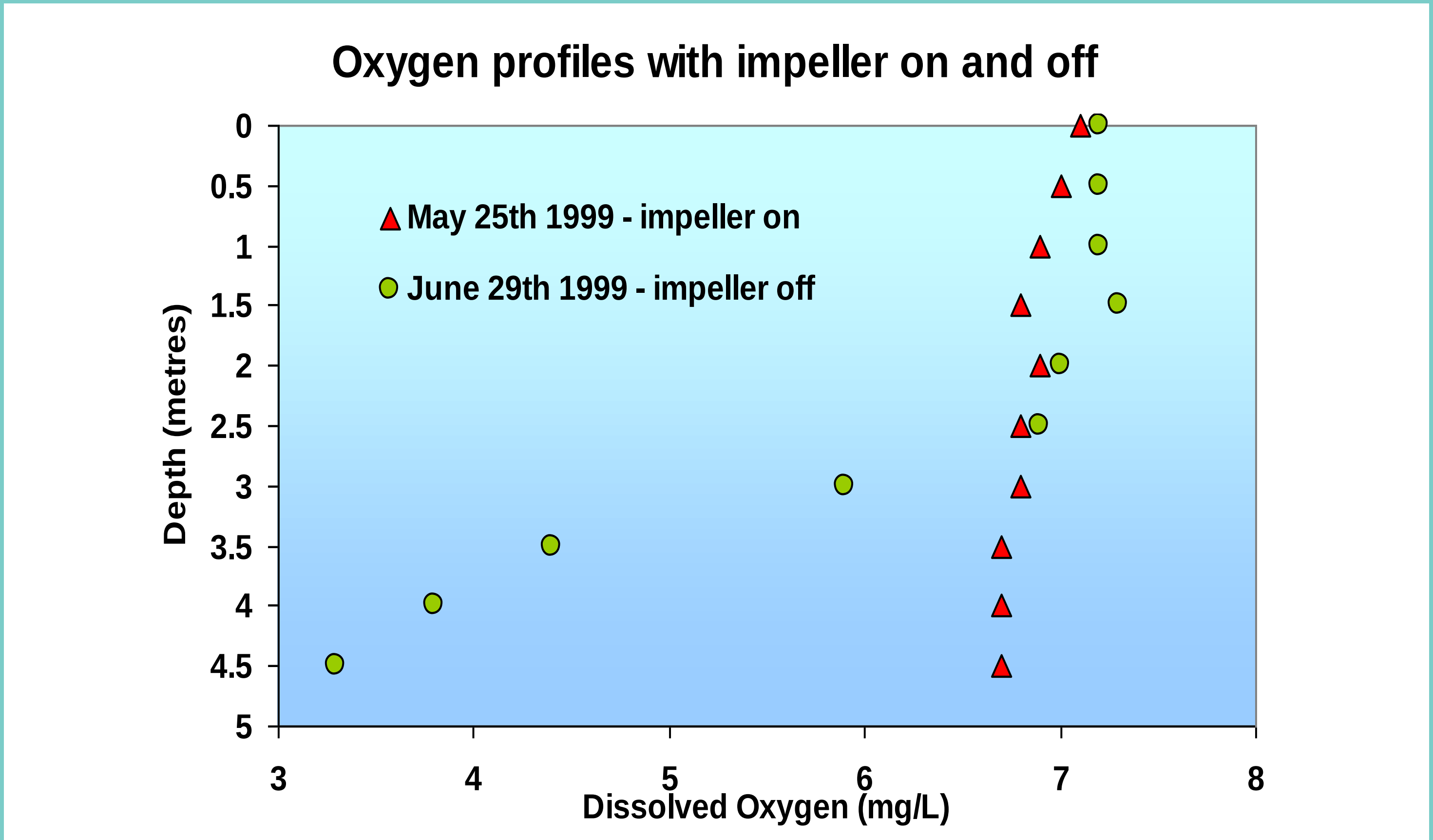
After tidal restoration

Toxic B-G Algae Management: Lake Belvedere



SydneyOlympicPark

Underwater Impeller:
Algae Management in Lake Belvedere



SydneyOlympicPark

Water Quality Challenges

- Chemical properties
- Physical properties
- Sediment and silt
- Litter/Gross Pollutants
- Chemical Pollutants
- Volume and flow rates
- Compliance
- Development Consent
- WSUD elements
- WRAMS compulsions
- Leachate quality

It is a *Living Laboratory*

- Many higher degree research
- Numerous professional studies
- Collaborative research
- Research Partnership programs, including many universities
- Industry partnerships

Upcoming Training in *Algae identification and management*

- 22 & 24 November 2023
- For registration: [Wetland Education and Training (WET) Program Tickets, Wed 22/11/2023 at 8:00 am | Eventbrite]

SydneyOlympicPark

Session – II @ 14:30 AEST

7. Future research, development and innovation for HABs

Arash Zamyadi*[1], Vincent Bianchini[2], Karen Rouse[2]

*arash.zamyadi@monash.edu,
[1]Monash University, Melbourne
[2]Water Research Australia, Adelaide, SA

Key words: management strategy, research and development, innovation, training

Abstract:
Qualitative and quantitative determination of cyanobacteria species in water bodies is vital to understanding the risk associated with the blooms at source and determining a tailored strategy to address that risk. Additionally, long-term monitoring provides data to develop source-specific alert threshold values and response action plans.

Progress in cyanobacteria understanding and analytical methods resulted in the development of tools that can monitor at higher frequencies and with better selectivity. It is possible to classify these monitoring tools based on detection needs: (i) detecting biological activity, (ii) confirming the presence of species cyanobacteria, and (iii) monitoring toxic and odorous metabolites. However, accurately predicting cyanobacterial blooms remains challenging, due to sources of interferences and limitation. Further research and innovation are needed to develop a monitoring tool-kit that can reliably and accurately detects cyanobacteria species and associated metabolites, and provides real-time information at a low cost. A combination of monitoring tools is key in collecting all the necessary information for effective monitoring. The development of an early warning tool-kit and management strategy needs to be tailored to the characteristics of the water source, health targets, training of personnel, monitoring program funds and target treatment efficiency.

Future research, development and innovation for HABs

Arash Zamyadi[1], Vincent Bianchini[2], Karen Rouse[2]

[1] Department of Civil Engineering at Monash University

[2] Water Research Australia

Cyanobacteria blooms: Challenging the entire supply & recycling process

1878	First reported stock death *(South Australia)*
1931	First recorded human illness, 5000-8000 people affect *(West Virginia, USA)*
1959	Swimmers ill after exposure in a recreational lake *(Canada)*
1975	Endotoxic shock during dialysis *(Washington, USA)*
1975	Gastrointestinal outbreak *(Sewickley Pennsylvania, USA)*
1979	Severe illness, liver and kidney damage *(Palm Island, Australia)*
1981	Liver damage reported *(New South Wales, Australia)*
1989	Pneumonia associated with canoeing exercise *(Staffordshire, England)*
1991	Swimmers ill after exposure in a recreational lake *(Canada)*
1993	Epidemiological study suggests liver tumour promotion (microcystin) *(Haimen and Fusui, China)*
1996	76 deaths of dialysis patients *(Caruaru, Brazil)*
2001	Toxic (?) *Phormidium* in Paskeville Reservoir *(South Australia)*
2008	Severe non-toxic bloom in Lake Burragarong *(Sydney, Australia)*
2008	Drinking waters impacted by toxic cyanobacteria, increased research efforts *(Canada)*
2009	Murray Darling system blooms again *(Australia)*
2014	Toledo water source blooms toxic, the US (re-) discovers toxic cyanobacteria *(USA)*
2019	Anatoxin-a detected in Australian waters for the first time *(Australia)*
2019	Benthic cyanobacteria shown to produce all cyanotoxins *(Australia)*
2020	Discovering potential role of cyanobacterial blooms as amplifiers of AMR genes *(China)*
2022	Combined treatment challenges due to flood blackwater and algal T&O breakthrough *(Australia)*

Monitoring and early warning systems

Tier 1: Detection of biological (bloom) activity

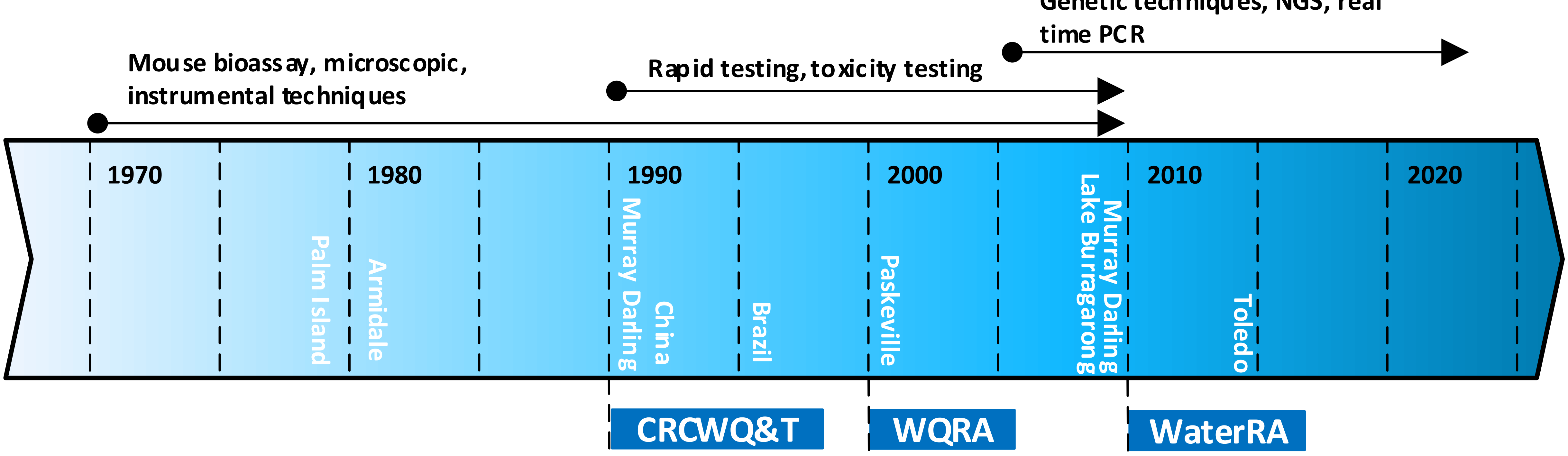
1. Adenosine Triphosphate (ATP)
2. Chlorophyll-a
3. Optical density
4. Visual inspection
5. Secchi depth
6. Turbidity

Tier 2: Confirmation of cyanobacteria presence

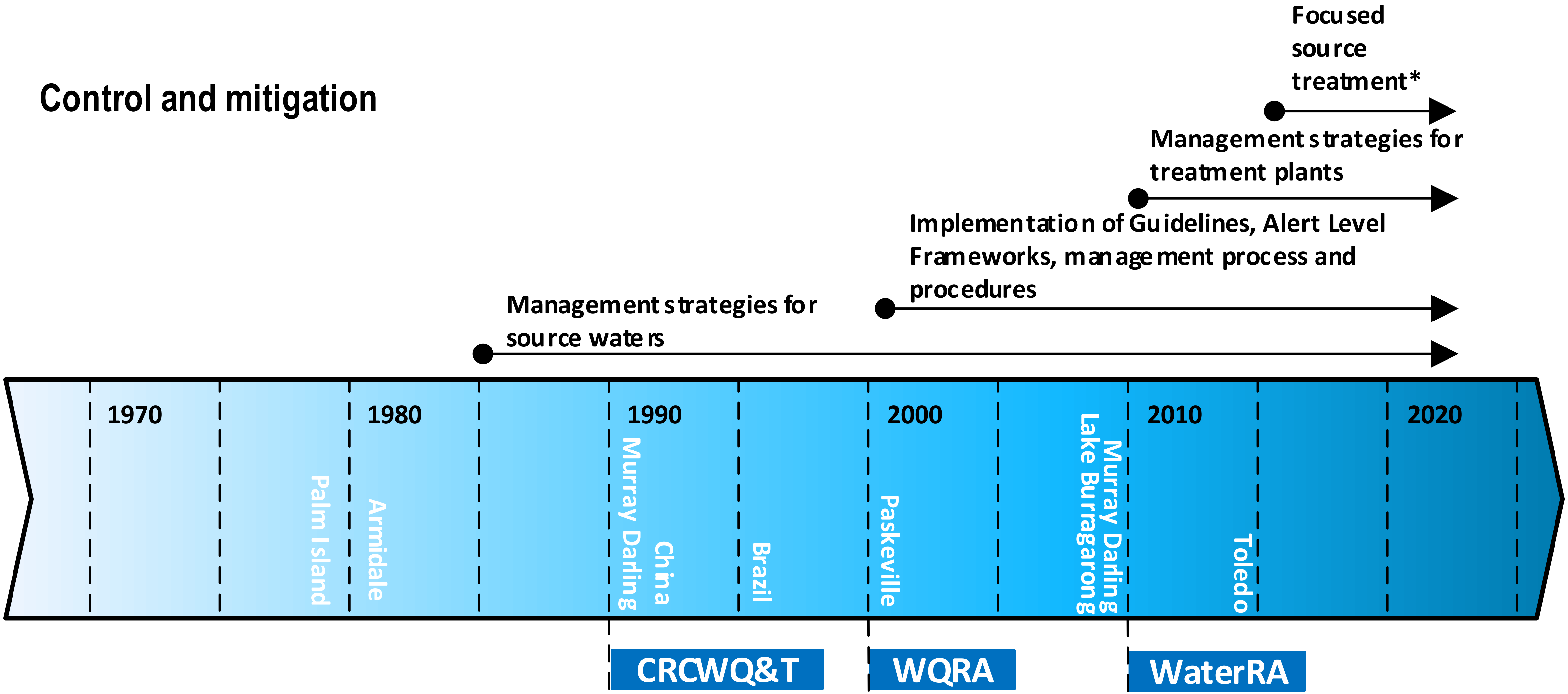
1. Phycocyanin
2. Microscopy imaging & counting
3. Cyanobacteria gene detection using qPCR

Tier 3: Confirmation of metabolite production

1. Cyanotoxins
2. T&O compounds
3. Available analytical tools/methods: qPCR, ELISA, LC-MS/MS

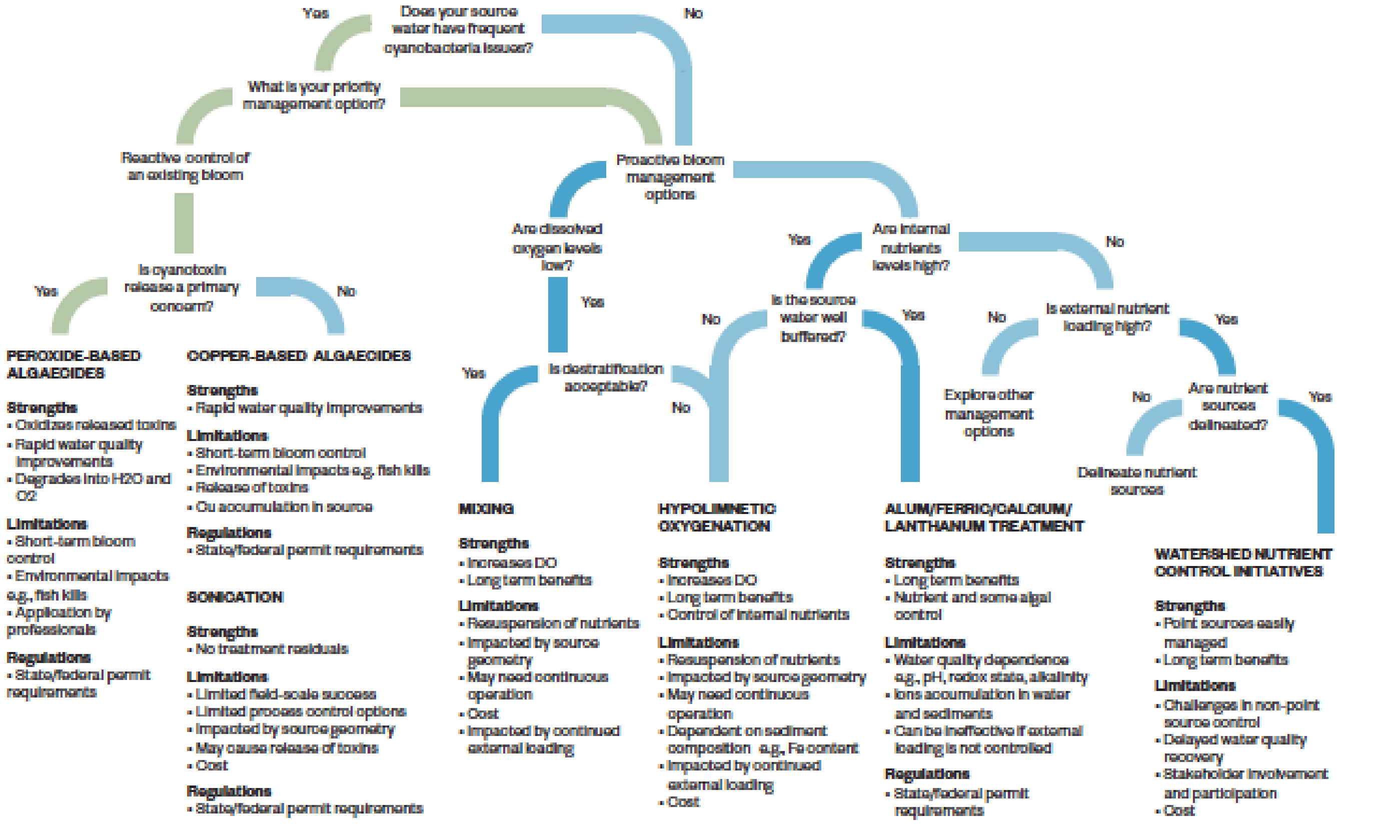


Control and mitigation



Integration strategy (examples from Water Research Foundation (#4912))

Decision tree for managing surface bloom



Decision tree for managing benthic

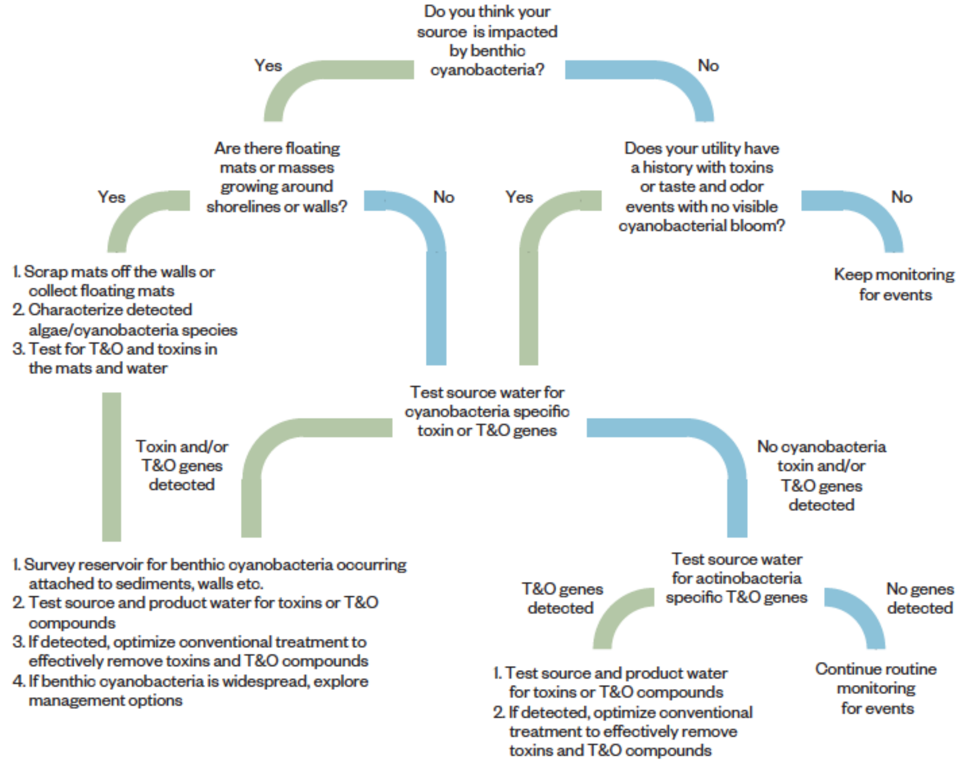


Figure 9. Decision tree on determining issues with benthic cyanobacteria at the drinking water source

What can remote sensing bring to water utility/authority operations?

Industry need

- Understanding existing capabilities and tools currently available, investigating advantages and disadvantages (e.g. limitations and sensitivity) of these technologies and their applications.
- Guidance on technique or tool selection e.g. efficacy or applicability of drone data capture versus use of satellites and beyond
  - New satellite capability is increasing the availability and quality of information available in Australia. Providing higher resolution data and greater coverage and frequency. How is this capability currently being used and by whom and how can this assist the water sector?
  - Uncertainty in predictions and measurements is going to be challenging for inland (optically complex) waters.

Application areas

- Catchment monitoring
- Water demand estimation
- Flood monitoring and mapping
- Farm dam monitoring
- Trends in urbanisation
- Drought forecasting
- Water quality monitoring
- Focused source/lagoon treatment
- Fire spotting

THANK YOU

Contact:
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MONASH University

Water Research AUSTRALIA

CSIRO

SMARTSAT Cooperative Research Centre

Session – III End-Users Workshop @ 14:30 AEST

A Synthesis Report from the AquaWatch End-Users Workshop: Advancing Adoption, Overcoming Barriers, and Meeting Expectations.

Samuela Guida[1] and Tapas K Biswas[2]

[1]International Water Association. London UK (Samuela.Guida@iwahq.org)
[2]CSIRO Environment, Canberra ACT Australia (tapas.biswas@csiro.au)

Introduction:

The AquaWatch Workshop was held at the Monash University, Melbourne, Victoria (https://www.waterra.com.au/anz-cyanobacteria-workshop/), which brought together diverse stakeholders to discuss the adoption, barriers, and expectations related to EO based AquaWatch services and tools for water quality monitoring and forecasting. This report synthesises the key insights from the workshop, focusing on the themes of adoption, barriers, and expectations of AquaWatch services.

Adoption of AquaWatch Services and Tools:

The participants expressed a strong interest in adopting AquaWatch services and tools. They emphasised the need for reliable and value-adding services offered at an appropriate price point. Key considerations for adoption included:

- Deployment Strategies: Deployment of the nutrient sensors alongside hydraspectra reflectance for algae/chlorophyll measurements was recommended for comprehensive water quality assessment.
- Integration and Compatibility: AquaWatch services should integrate seamlessly with Microsoft software and be deployable on field devices and apps for ease of use.
- Bulk Procurement: To address the cost barrier, the idea of bulk procurement for generic outputs e.g., ARD (Analysis Ready Data) output through consortiums or government departments was suggested.
- Service Tiers: Offering multiple service tiers, from basic ARD to bespoke models, was considered beneficial to cater to various utility needs.

Barriers and Solutions:

Several barriers to AquaWatch adoption were identified during the workshop, along with potential solutions:

- Value Demonstration: A compelling case study showcasing added value was suggested to build confidence and trust among potential users.
- Regulatory Compliance: Ensuring compliance with SOCI legislation was deemed essential to gaining the trust of utility clients.
- Cost Considerations: The funding model and federal subsidies were highlighted as critical factors influencing adoption.
- Data Coverage: Addressing the limitation of HydraSpectra's daytime measurements and exploring the possibility of capturing nighttime fluorescence data was discussed.
- Legal and Procurement Challenges: Standardizing legal and procurement processes for utilities and securing endorsements from relevant authorities were proposed solutions.
- Education and Communication: Bridging the gap between science and operations staff, and clearly articulating the value proposition to specific utilities, were identified as important steps.
- Integration Complexity: Ensuring ease of integration with existing in-house systems was considered crucial to facilitate adoption.

Expectations for AquaWatch Tools and Services:

The workshop participants had specific expectations for AquaWatch tools and services:

- Data Accessibility: AquaWatch services should allow easy extraction of data in common formats.
- Frequency of Updates: Access to ARD data at least twice per week, preferably more, was desired.

- Communication: Utility clients should be regularly advised of updates, information, and future plans.
- Compliance and Standards: Services should be certified to quality management systems (QMS), ISO standards, and comply with SOCI legislation.
- Dual Purpose Data: Data should serve both research and operational needs, providing a source of collective information and knowledge.
- Reliability: A well-defined level of service with minimum reliability measures, low cost, and prompt response times to data loss or functionality issues were expected.
- Value Addition: The value provided by AquaWatch services should be commensurate with the cost, endorsed by government, and distinct from other Earth observation approaches.

Need for AquaWatch Tools and Services:

Participants highlighted the need for AquaWatch tools and services in several areas:

- Comprehensive Water Quality Data: Capacity to provide water quality data across multiple storage locations was seen as essential to guide intensive monitoring efforts.
- Long-Term Predictions: Long-term time series predictions with uncertainty levels up to three years into the future were desired for policy development and decision-making.
- Real-Time Visibility: Near real-time visibility and forecasting capabilities were considered crucial for operational response.
- Community Engagement: Engaging smaller operators and businesses with high skill sets and expertise in discussions to ensure they remain informed and included in the community was recommended.
- Operational Value: Satellite services were perceived to add value in policy development, model development, and operational response, with operational response posing the most significant challenge due to reliability and return time requirements.

During the discussion there was a strong emphasis on transitioning from relying solely on thresholds to adopting impact-based forecasting methods. The discussion highlighted the pressing need to extend support to developing countries, considering the diverse range of end users involved. The shift from traditional measurement techniques to more precise cell counts and biovolume calculations was recognised, albeit with the acknowledgement that this translation introduces some errors. Regional-specific calibration of data for individual water bodies emerged as a viable solution to enhance data reliability and build trust. AquaWatch's primary goal was reaffirmed – to make a significant impact on Australia's water quality management. While fostering this ambition, it was emphasised that expectations must be balanced. The meeting also touched upon the importance of distinguishing between different remote sensing techniques available.

Furthermore, the discussion gravitated towards the increasing sophistication of algal bloom services, with the understanding that each utility's needs are distinct. It was deemed unlikely that satellite systems alone could serve as the sole source for making water quality decisions; rather, they should be considered as supplementary information. The integration of in situ measurements and Earth observation data was highlighted, contingent on the specific application and geographical context, with Melbourne expected to have greater capacity compared to Tanzania.

Additionally, the value of time series data in assessing changes in water bodies over time was acknowledged, even if the data isn't exceptionally accurate. Recognising the importance of understanding the uncertainties in the produced data, participants noted that such long time series data would prove valuable guidance for policy development, particularly in assessing catchment management. Finally, the meeting briefly touched on the challenges of measuring greenhouse gas emissions from space, given the inherent weakness of the signal. Strategies for adapting measurement methods and creating standard methodologies for consistency were discussed, alongside the potential resource-intensive nature of managing live data feeds from multiple utilities in a future commercial offering. Key factors like turbidity and surface temperature were underscored as crucial considerations in these efforts.

Conclusion:

The AquaWatch Workshop underscored the growing interest in AquaWatch services and tools while identifying key barriers, expectations, and needs. Addressing regulatory compliance, cost considerations, and communication, along with demonstrating value, will be critical to fostering adoption. Ensuring reliability, accessibility, and compatibility with existing systems are essential to meet the expectations of utility clients. AquaWatch's potential to provide valuable water quality data for policy development, research, and operational response was reaffirmed, highlighting its significance in the broader environmental monitoring landscape.

AquaWatch Participatory Group Map Activity Outcome on the adoption, barriers, and expectations related to EO based AquaWatch services and tools.

Expectation for AquaWatch Tools and Services

- Real point of difference from other EO approaches
- Advised of new updates, information and future plans
- Certified to QMS /ISO etc standards
- Reduction of human error
- The value add needs to be commensurate with the cost
- Trusted and endorsed by government as an acceptable source
- Able to extract data in basic common formats
- Low cost
- Easy to integrate
- Prompt response time to loss of data, functionality
- All service offerings will need to be compatible with 3rd party requirements under the SOCI legislation
- For any service we need a well defined Level of Service, inclusive minimum reliability measures.
- Site-specific model outputs that can be safely injested by in-house systems. i.e., for Melbourne Water, we would prefer to do some of the integration on our side of the fence - so to speak.
- Access to ARD that is at a frequency of at least twice per week, preferably three or more time per week (this could be a compositive of different satellite feeds).
- Dual purpose of the data available for research but also useful information that can be a source of collective information and knowledge to inform end users.

Need for AquaWatch Tools and Services

- Review and correlate historical data
- Long term time series prediction (like what the BOM do on climate change trends) with uncertainity levels up to 3 years in future to promote its importance to governments.
- Capacity to provide water quality data across a large range of multiple storages to guide where more intensive monitoring is required.
- There is a view among operators that AquaWatch doesn't fundamentally improve on current field monitoring for water sources that are currently subject to regular monitoring, even allowing for slightly reduced lead times.
- Near real time visibility and forecast
- Monitoring remote and large storages, inlets, outlets
- We (Melbourne Water) see satellite services as providing value in (i) policy development, (ii) model development, and (iii) operational response. Operational response is the most challenging due to a requirement for high return times and high reliability (including continuity of services) of output.
- Smaller operators and businesses are a resource to build capacity as the demands increase in this area and often have high skill sets, have flexibility in operation, and have expertise and experience. Access to information and tools, inclusion in discussions so that our clients are not disadvantaged by losing touch with the community.

Adoption

- Keep it simple then continually improve through using
- For the more generic outputs - e.g. ARD output, we could 'buy in bulk'. e.g. a consortium of Victorian utilities investing via a WaterRA - CSIRO/BoM contract. Similarly, the respective state and national environment departments could buy on behalf of utility clients.
- Secure and trusted integration with IT
- Easy integration into Microsoft software. Able to deploy to field devices, apps
- You could have several service offerings, e.g. ARD as lowest up to deliver of a bespoke model as the highet tier.
- Deployment of the Nitrate sensor at the same time as hydraspectra reflectance for algae / chlorophylla.
- A reliable, value-adding service at the right price point.

Barrier and solutions

- There needs to be an education process between the science and operations staff. Operations make decisions based upon cost and are generally resistant to change. Need to avoid having dual systems.
- Remote detection of chlorophyll is useful, but if the satellite can detect the pigment then the cyanobacteria are already in the water column.
- Legal and procurement differences between utilities - provide standardised legal and procurement for utilities to look to adapt. Starting endorsed by CSIRO/Fed Government/ state authority. Lobby and advocate them for their support
- Some unknowns of the broader aquawatch entry and other pilots in play - provide csiro presentations to operations etc teams at each utility. Can be hard for the RD and improvement teams to know the full story
- Why should they change current state that meets refractions and risk profile- Clear articulation of the value proposition to a specific utility. Some initial discovery on unique operations then provide specific guidance
- HydraSpectra currently only offers measurements during the day. Possibility of capturing fluorescence data a night, to augment the current acquisitions?
- A compelling case study of added value would help build confidence and trust
- Confidence and trust in the system and its devepers
- Integration with in-house systems.
- Compliance with SOCI legislation.
- Cost may be a barrier depending on the funding model. If aquawatch continues to obtain federal subsidy, that could help.

AquaWatch Mission End User Consultation Workshop: HABs Early warning and forecasting

Participant List

#	First Name	Last Name	Organization
1	Angelina	-	UNSW Sydney
2	James	Anderson	Tamworth Regional Council
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4	Fiona	Beer	University of Tasmania
5	Devesh	Bhogal	CSIRO
6	Tapas	Biswas	CSIRO
7	Richard	Carty	Central Highlands Water
8	Nagur	Cherukuru	CSIRO
9	Joe	Chiocci	Chemiplas Australia
10	Florence	Choo	SA Water
11	David	Cook	SA Water
12	Nick	Crosbie	Melbourne Water
13	Robert	Daly	SA Water
14	Arnold	Dekker	CSIRO
15	Rebecca	Duke	Central Coast Council
16	Isabelle	Fratter	CSIRO
17	Damon	Gray-Stafford	CSIRO
18	Samuela	Guida	IWA
19	Harshanie	Habarakadage	Melbourne Water
20	Alex	Held	CSIRO
21	Rebekah	Henry	Monash University
22	Peter	Hobson	SA Water
23	Fred	Hooper	CSIRO
24	Lindsay	Hunt	Jarvis Hunt Consultancy
25	Erin	Jordan	International Water Association
26	Flora	Kerblat	CSIRO
27	Daniel	Livingston	Hunter Water
28	Fiona	Lynch	Monash University
29	Tim	Malthus	CSIRO
30	Glenn	McGregor	Dept of Environment and Science
31	Jon	Messina	Sunwater
32	Brendan	Murray	Ixom
33	Kumaran	Nagalingam	Coliban Water
34	Ralph	Ogden	ACT Govt
35	Andy	Olrich	Hunter Water
36	Thanusshan	Packiyarajah	University of South Australia
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43	Karen	Rouse	Water Research Australia
44	Gerhard	Schulz	WaterNSW
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46	Shajahan	Siraj	Central Highlands Water
47	Don	Sirimanne	ALS
48	Fiona	Smith	Riverina Water
49	Simon	Tannock	AlgaEnviro
50	Andy	Taylor	Hydro Tasmania
51	Carolyn	Taylor	Macquarie University
52	Maigan	Thompson	CSIRO
53	Elloise	Trotta	SA Water
54	Apostolis	Tzimas	EMVIS, Greece
55	Lee	Wan	Melbourne Water
56	Anusuya	Willis	CSIRO
57	Rob	Woodcock	CSIRO
58	Arash	Zamyadi	Monash University
59	Luca	Zappia	Water Corporation