Australia's National
Science Agency

AquaWatch Australia

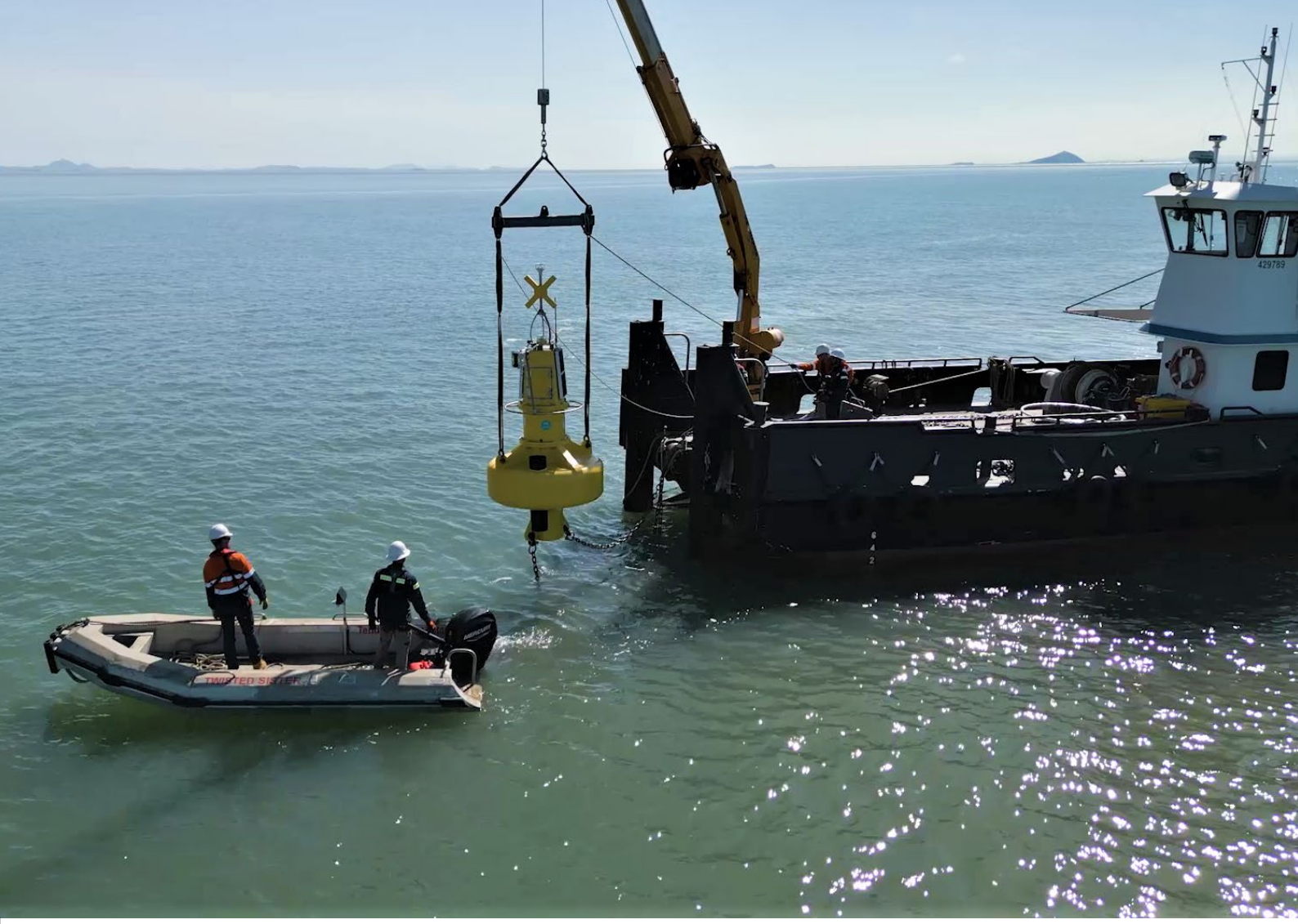
Developing a world class integrated water quality monitoring and forecasting system nationally and internationally, to support better water quality management.

July 2024

CSIRO's critical infrastructure, both in space and on the ground will mean better access to robust and reliable water data.

CSIRO is working with collaborators across industry, research and government to co-design AquaWatch Australia as an integrated ground-to-space water quality monitoring system to deliver near-real time updates and predictive forecasts for better water quality management.

Cover: The AquaWatch system is used to enhance water quality management, by providing near-real time updates and early forecasts for issues like algal blooms. Credit: NASA-GSFC.



AquaWatch Australia: Monitoring and forecasting water quality

Water is a vital resource. It has a direct impact on human health and wellbeing; the natural environment; economic prosperity; and national security. Current monitoring methods are fragmented and lack an integrated approach.

AquaWatch Australia (AquaWatch) is developing a world class integrated water quality monitoring and forecasting system for implementation nationally and internationally, providing actionable information on inland and coastal water quality.

AquaWatch is committed to contributing to the United Nations (UN) Sustainable Development Goal (SDG) 6: to ensure the availability and sustainable management of water and sanitation for all, and to SDG 14: to conserve and sustainably use the oceans, seas and marine resources for sustainable development.

AquaWatch will help improve water quality management around the world through:

- **Informed decision-making:** providing essential water quality information for improved decision-making by communities, government agencies and commercial water users, by delivering reliable and robust data.
- **Early warning:** Offers predictive forecasts to help communities, governments and industries awareness to mitigate water quality issues, such as toxic algal blooms, black water events and agriculture run-off contamination.
- **Performance evaluation:** Measuring the outcomes of water resource management and policy changes, to demonstrate evidence-based improvements.
- **Quantifying water quality issues:** Ensuring users have accurate information in addition to assisting key sectors identify the causes of water quality issues, including the impact of land management practices.

CSIRO's HydraSpectra sensor installation in Keppel Bay, QLD as part of the AquaWatch sensor network.

About us

AquaWatch has a multidisciplinary team working to integrate sensor technologies, large scale data analytics and research that will constitute the AquaWatch water quality monitoring a forecasting system.

Working with lead scientists from CSIRO and partner organisations, AquaWatch focuses on key research and technology outcomes, which are tested and demonstrated at pilot sites nationally and internationally. This collaborative approach ensures AquaWatch will deliver a co-designed water quality monitoring system to support different types of decision makers concerned with human health; the natural environment; economic prosperity; and national security.

AquaWatch focus areas

Technology systems

Development of unique water quality monitoring and forecasting systems, software and hardware both for water-based sensor networks and in-space applications.

Research programs

Well-aligned research and innovations that support the development of applications for key users.

Dr Alex Held, Misson Lead, AquaWatch Australia.

Growing capabilities with collaboration

By partnering with partners, nationally and internationally, across industry, academia and government, AquaWatch focuses on using cutting-edge technology and advanced modelling that will drive impactful results.

Water quality sensors: In-situ water quality sensors offer precise measurements essential for validating satellite data and as input to the forecasting models. AquaWatch aims to contribute additional sensors, networking expertise and data aggregation capabilities to establish robust, standardised national and international water quality sensor networks.

Earth observation: Earth observation (EO) data from selected satellites is used to provide water quality information across entire continents and provides environmental insights to support wider spatial scale monitoring. In addition, space engineering experts and aquatic remote sensing experts from AquaWatch have developed the specifications for custom-built water quality satellite sensors.

Data system: Data from various sensors is being integrated with an advanced cloud computing analytics platform – the AquaWatch Data System (ADS). Within this system, AI inversion modelling is also tested to provide a range of additional data services, including monitoring and forecast information, tailored to the application and end users.

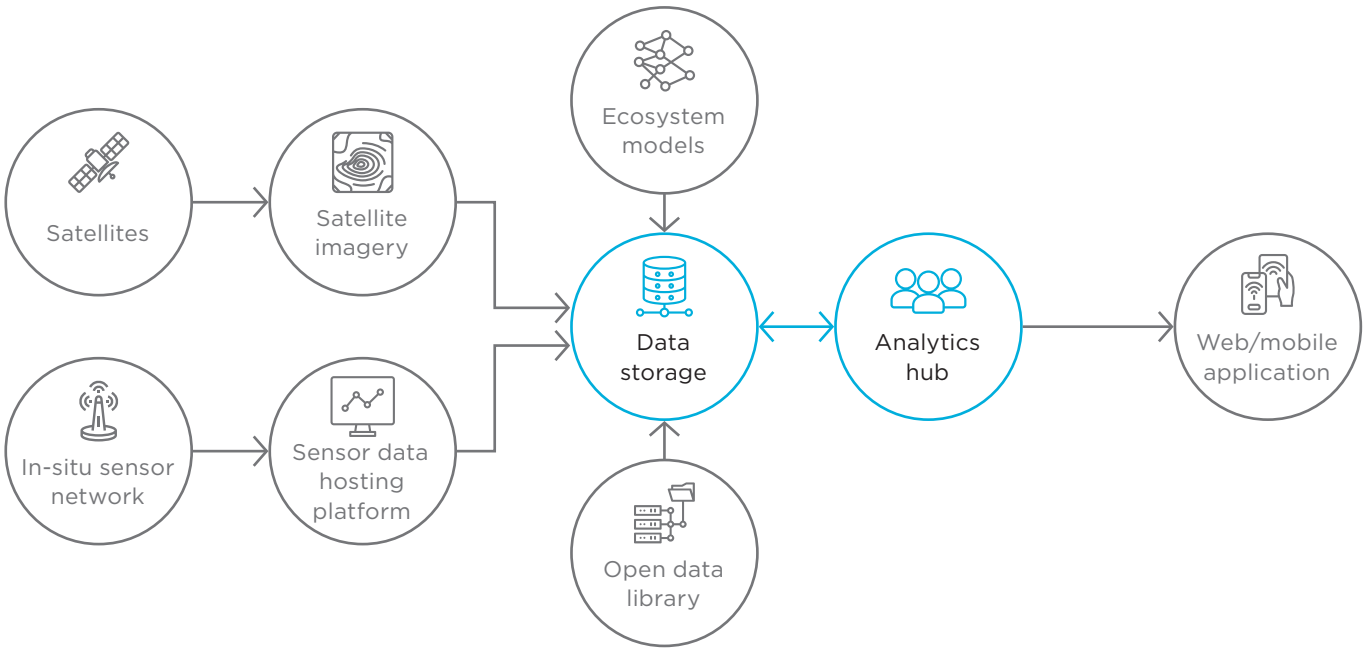
Water quality modelling: Sensor and EO data are integrated with physical models to predict water quality. The use of AI is being tested to enable the scaling of local forecasting models to regional and continental coverage.

Technology demonstrators

AquaWatch leverages strategically aligned pilot sites to showcase and advance technology and capabilities across diverse aquatic systems and water quality parameters, and to build new partnerships.

These pilot sites cover a range of inland and coastal water bodies, nationally and internationally. They ensure that the ADS is co-designed and tested with local partners to deliver high-value, specific and timely information, supporting decision making for industry, research and governments. A key element of the AquaWatch service will be the close engagement and co-design with First Nations people and their specific water information requirements.

Data flow in the AquaWatch system of integrated technologies



Water quality sensors

Water-based ‘in-situ’ sensors are central to the AquaWatch system.

AquaWatch has successfully integrated sensor data into the ADS for near-real time observations of water quality. Additionally, AquaWatch has developed low-cost nitrate and turbidity sensors with provisional patents underway.

The ADS has been demonstrated to also integrate third-party in-water sensors at various pilot sites. The additional water quality data can be used for validation of derived water quality measurements from EO, and as input to improve water quality forecasts.

Comprehensive monitoring

- Water-based (in-situ) sensors are deployed directly into water bodies, providing real-time data on various water quality parameters such as temperature, pH, dissolved oxygen, turbidity, salinity and nutrient levels.
- Integrating water-based sensors into the AquaWatch system anchors and validates the satellite data, providing a comprehensive coverage across in-land rivers, waterways and coastal environments.

Accuracy and precision

- Sensors offer high accuracy and higher frequency by measuring conditions directly at the source and providing precise local measurements. This data is essential for validating and enhancing the broader coverage from satellite data.

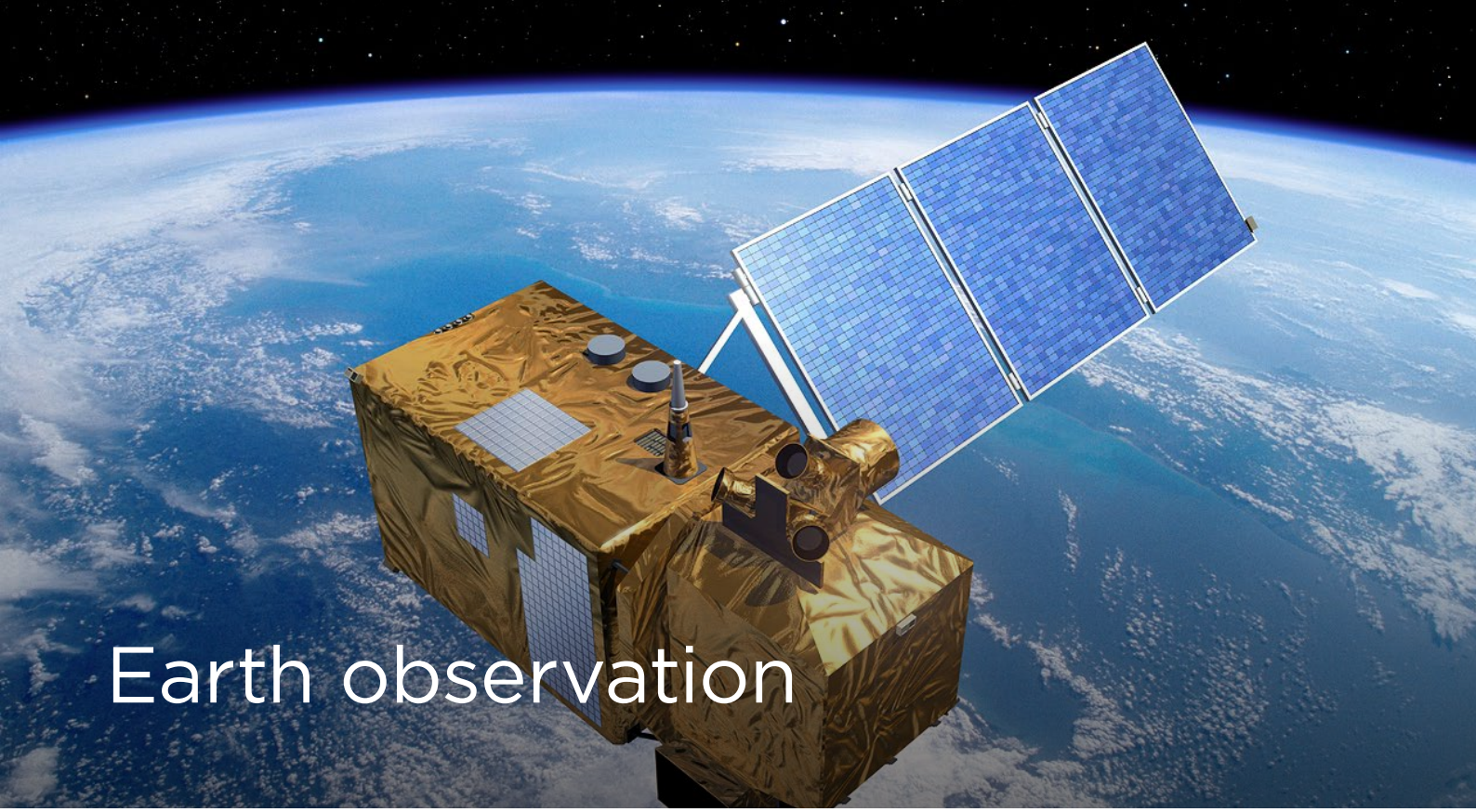
HydaSpectra

The HydraSpectra is an optical sensor developed by CSIRO, and a key component of the AquaWatch system. It offers our users a solution to enhance the efficiency and accuracy of water quality monitoring, water compliance and risk assessment across geographically dispersed sites.

HydraSpectra features

- Simultaneously captures water reflectance and surface photos at 15-minute intervals, offering continuous monitoring capabilities.
- Data enables determination of algal pigment/biomass concentrations and sediment levels in surface waters.
- Facilitates tracking of algal bloom or sediment plume formation and dissipation.
- Integration with hydrodynamic modelling and prediction enhances the utility of this information.
- Deployed as a network of sensors and coupled with satellite imaging technologies, the instrument is part of a system-wide overview of potential blooms, as well as assessing of individual water body dynamics.
- Low cost and robust for accessibility and uptake.

HydraSpectra water sensor used by AquaWatch mounted on a buoy at Lake Tuggeranong in Canberra to monitor for toxic blue green algal blooms.



Earth observation

Earth observation (EO) data is the collection of satellite and in-situ information about Earth's surface and it's physical, chemical and biological systems. It provides unprecedented capabilities and efficiencies in monitoring the dynamics of our planet.

EO data from satellites can detect water quality issues like algal blooms and sediment plumes using colour signatures visible from space. AquaWatch uses high-quality satellite imagery in combination with its water-based sensors and data analytics to support continental-scale water quality monitoring.

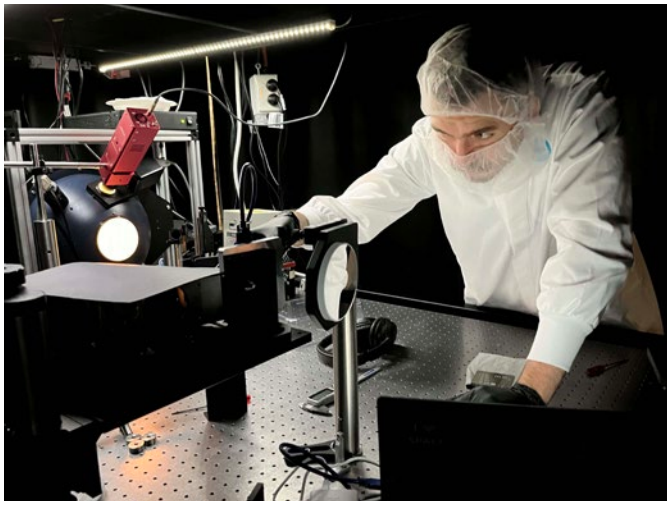
AquaWatch leverages this technology to measure water quality parameters from 600 kilometres away in space. By doing so, it delivers critical data for managing health, environmental impact and industrial activities.

AquaWatch values our international partners who provide us access to EO data from their satellites.

Space technology: CyanoSense

CSIRO's CyanoSense satellite payload technology, captures hyperspectral images, acquiring spectra for each individual pixel from space, to discriminate the composition of objects on Earth's surface.

The CyanoSense imager is designed to differentiate harmful cyanobacteria from other algae in coastal and inland waterways for the AquaWatch system.



CSIRO's Cyanosense satellite water quality sensor.

In June 2023, CyanoSense was the first Australian-manufactured hyperspectral sensor successfully launched into space on a Skykraft satellite for early-stage testing.

CSIRO's second space sensor – CyanoSense-2 is currently under development. The development of specialised satellite sensors for water quality measurements will enhance the AquaWatch system with higher quality data from space.

The European Space Agency's Sentinel-2 satellite is one source of satellite data for the AquaWatch Mission Credit: European Union.

AquaWatch Data System

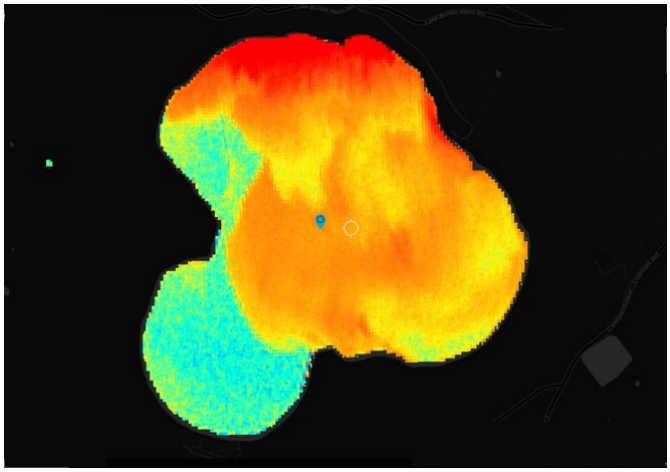
The AquaWatch Data System (ADS) integrates extensive data from in-situ sensors and EO satellites. Advanced data analytics is essential to transform the raw data into actionable insights, facilitating informed decisions from water management to preparedness for climate change impacts.

AquaWatch uses CSIRO's Earth Analytics Science and Innovation (EASI) platform to aggregate and analyse water quality data. EASI is a cutting-edge data analytics platform developed by CSIRO, designed to process satellite imagery at scale. It transforms complex data into actionable intelligence, fostering innovation across scientific domains. The flexibility of the EASI platform allows customisation to meet the needs of specific end users of the AquaWatch data system, which enables AquaWatch to deliver a diverse range of data services tailored to specific requirements and applications.

CSIRO will operationalise AquaWatch deployments of EASI nationally and internationally.

Early warning system

AquaWatch supports climate action and community resilience through comprehensive monitoring of the impacts of key policy and community interventions, as well as information on disasters and their effects on ecosystems, water quality and coastal resources.



Water quality issues such as development of algal blooms can be visualised for early warning in the AquaWatch Data System.

It provides early warning on harmful events such as toxic algal blooms, blackwater, offshore harmful algae blooms and accidential sewage, farm-and mine site discharges. This will reduce economic impacts to coastal aquaculture, fishing and tourism linked to harmful algal blooms and contaminant.

The AquaWatch data system is crucial to delivering end-users insights.

Water quality modelling

AquaWatch employs an advanced water quality modelling approach that integrates data from water-based sensors, EO and physical models to accurately depict the biogeochemical characteristics of water bodies.

The early warning forecasting combines hydrodynamic and biogeochemical modelling tools to provide accurate forecasts of water quality in diverse aquatic systems including rivers, lakes and coastal waters.

With the capacity to ingest data from various sources, including third-party water-based sensors and CSIRO's HydraSpectra, and integrate it with Earth observation data, the AquaWatch system can assimilate these diverse data streams to evaluate predictive accuracy and uncertainty.

AquaWatch's water quality modelling uses remote sensing-derived and in-situ sensor data streams to sequentially update model outputs. Additionally, AquaWatch has developed hybrid models to improve forecasting skills and reduce uncertainties. By linking the AquaWatch system to various real-world sites, it showcases tailored capabilities and delivers specialised data streams for specific use cases.

The establishment of new test sites expands AquaWatch's capabilities, addressing a broader range of water quality challenges. These small-scale test sites are invaluable for testing predictive skills and refining the system's effectiveness in addressing specific problems.

AquaWatch has achieved the following:

- Successfully integrated Hydraspectra data into forecasting streams in both coastal and freshwater environments on the AquaWatch data system.
- Developed a prototype for forecasting harmful algal blooms with options to include other water quality parameters.
- Created a scalable model for hypoxia in low flow rivers and lakes.

AquaWatch's water quality modelling combines process models with machine learning algorithms to improve forecasts, reduce uncertainty and establish causality relations.

Sediment and dissolved carbon flows from Fitzroy River to Keppel Bay during floods.

Partnerships for AquaWatch

Partnerships are essential to AquaWatch's success, spanning research, academia, industry and government sectors.

By collaborating with key partners and co-designed pilot sites, AquaWatch drives innovation and capacity building across space and technological development. These partnerships also enhance the utilisation of water-based data sources, ensuring a more robust and effective monitoring system.

Aligned with AquaWatch's vision, like-minded partners actively contribute to and derive benefits from our integrated ground-to-space system. Partner involvement is instrumental in realising AquaWatch's mission of establishing a water quality monitoring system, with global benefits.

We welcome both national and international partners who want to co-invest and collaborate with us to build the system. Our partners gain early access to data and have the opportunity to co-design solutions tailored to their specific needs and objectives.

Co-designed pilot sites: telling your water stories

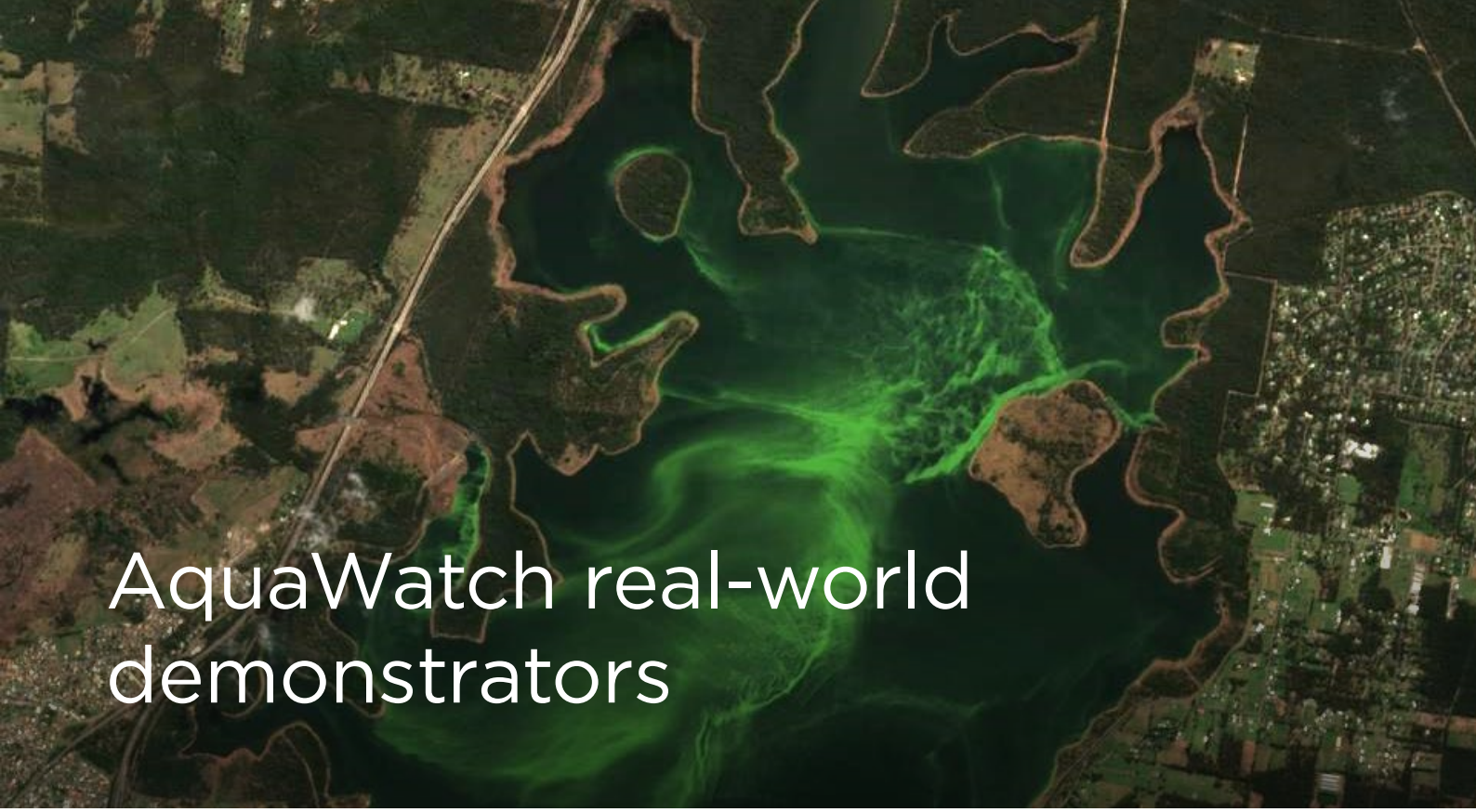
Co-designed pilot sites are central to the success of AquaWatch. Pilot sites help us demonstrate and improve the AquaWatch system, whilst providing improved data to inform water quality management decisions.

Co-designed pilot sites are developed in collaboration with partners from across industry, academia, government and more, each of whom have an important water story.

What defines a good pilot site?

- Supports and aligns with the AquaWatch objectives, which focus on human health impacts and wellbeing, ecosystem health and industrial applications.
- Provides complementary and valuable information to help develop AquaWatch products and services to our users (e.g. water use case, type of water quality measurements, modelling capabilities, water colour).
- Relatively easy access/maintenance for local partner (existing infrastructure, local partners).
- Strong, active reliable partnerships with local partners to maximise value and impact for end users.

CSIRO is collaborating with industry partners, such as aquaculture fisheries, to help deliver AquaWatch.



AquaWatch real-world demonstrators

Test sites situated at Lake Hume, on the New South Wales and Victorian border, Lake Tuggeranong in the Australian Capital Territory, and the Grahamstown Reservoir in Australia serve as showcases for cost-effective water quality monitoring systems deployable worldwide.

Each site's participation includes the use of water-based sensors, satellite Earth observation and modelling techniques to deliver near-real time water quality information.

Water story: safe drinking water

At the Grahamstown reservoir and Williams River pilot site, the AquaWatch system has delivered significant advantages:

Reduced risk to resources: The technology minimises the need for manual algal inspections, thereby cutting the costs and potential risks associated with using resources such as people, vehicles and boats for manual sampling.

Improved resolution and visibility: The system enables near-real time and comprehensive visualisation of water quality at sites like Grahamstown Reservoir, with a surface area of 28 square kilometres, providing detailed and continuous monitoring.

Reduced exposure windows: Access to a rapid algal risk management tool ensures delivery of information faster and with greater spatial overview.

Expanded data capture: By comparing baseline samples with historical water quality data, modelling can be applied to develop robust monitoring and forecasting tools. This approach, tested at existing sites is poised to generate a reliable and statistically significant data set, in the near future.

Water story: bolstering the seafood industry

The Spencer Gulf in South Australia is known as Australia's 'seafood basket', with the local industry's production worth more than $238 million annually. AquaWatch is poised to be a game-changer for the seafood industry. This data offers early warnings of temperature and salinity fluctuations that could pose lethal risks to fish stocks.

AquaWatch complements existing water quality systems, which are often time consuming and labour intensive. Its near-real time monitoring enables scalable surveillance and facilitates data-driven decision-making.

One such threat is harmful algal blooms, which can pose threats to aquaculture through release of toxins or depletion of oxygen supply in the water.

Long term, AquaWatch data will contribute to informed decision-making regarding the ecologically sustainable use and development of marine systems, both in Australia and on a global scale.

AquaWatch detecting algal blooms in the Grahamstown Dam, a vital drinking water reservoir for nearby Newcastle, NSW. Credit: European Space Agency.

With foundation partner, the SmartSat CRC, we're seeking collaborators to co-invest and co-design the AquaWatch system with us.

Key partners and co-designed pilot sites both in Australia and internationally will help us develop capability and allow us to test our technology and to ensure that AquaWatch is a globally operational system.

We highly value our partners, and we welcome interest from a range of sectors to be involved in AquaWatch:

Indigenous communities | environmental protection | aquaculture agriculture | water utilities | government agencies | councils research institutions | universities | philanthropic organisations space technologies hydroelectricity | desalination plants emergency response organisations

As Australia's national science agency, CSIRO is solving the greatest challenges through innovative science and technology.

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