Australia's National
Science Agency

AquaWatch Australia Mission

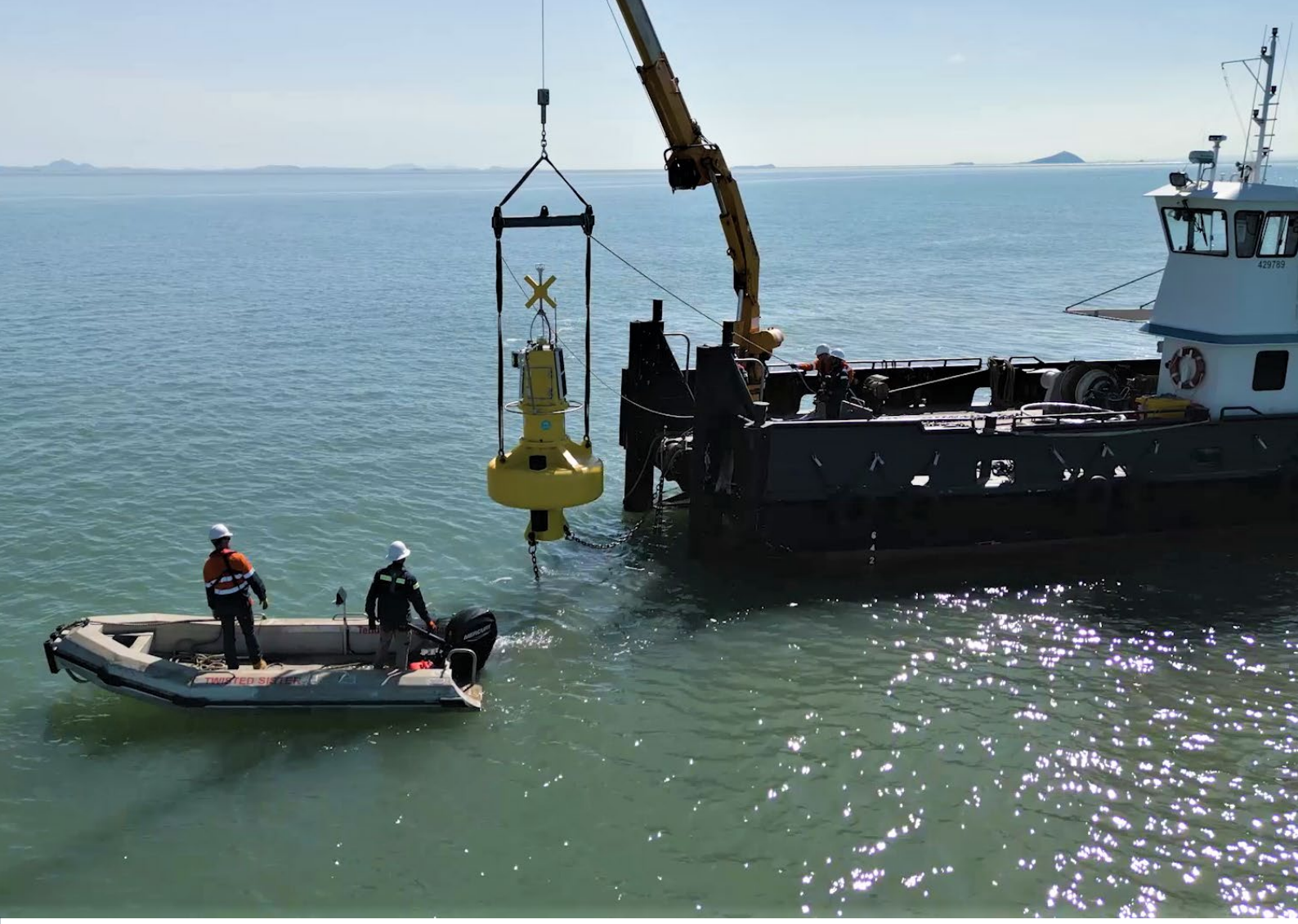
Building a national water quality monitoring and forecasting service to support better water quality management

April 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 from across industry, research and government to co-design and deliver 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: Algal bloom in the Spencer Gulf, South Australia, which is an AquaWatch pilot site for aquaculture farming. Credit: NASA-GSFC.



AquaWatch Australia: delivering water quality updates and forecasts

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.

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

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:** offering predictive forecasts to help communities, governments and industries preparedness and mitigate water quality issues, such as toxic algal blooms, black water and 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 the right information at the right time, helping key sectors identify the root causes of water quality issues, including the impact of land management practices.

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

About us

AquaWatch has a multidisciplinary team working to build the water quality monitoring system and lead supporting research to enhance its performance.

Working with scientists from across CSIRO, AquaWatch focuses on key research and technology outcomes, which are demonstrated at real-world pilot sites in Australia and internationally. This collaborative approach ensures that AquaWatch will deliver its vision for an integrated water quality monitoring system to support decision makers to benefit human health and wellbeing; the natural environment; economic prosperity; and national security.

AquaWatch focus areas

Technology systems

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

Research programs

focuses on continuous improvement, well aligned research and development which supports the development of applications for key users.

Dr Alex Held, AquaWatch Australia Mission Lead.

Growing capabilities with collaboration

Working with partners, both in Australia and internationally, across industry, academia and government, the AquaWatch team focuses on key capabilities with cutting-edge technology and advanced modelling that will drive impactful results, these include:

Water quality sensors: water-based sensors provide highly accurate water quality measurements used to validate satellite data. We aim to contribute additional sensors, networking expertise and data aggregation capabilities to establish dense national water quality sensor networks.

Earth observation: Data from Earth observation (EO) satellites provides environmental insights to support wider spatial scale monitoring. An end-to-end simulator is being developed to predict satellite performance for water monitoring and specifications for custom-built water quality sensors. We are also working with partners to design novel satellite technologies that are customised for water quality, coral reef and aquatic ecosystem measurement.

Data system: The data is processed using the AquaWatch data system, hosted on our advanced cloud computing analytics platform, Earth Analytics Science and Innovation (EASI). This data system accesses large international databases from multiple satellites, which allow for better analysis of past and current water quality issues world-wide.

Within this system, a range of models can be applied including AI inversion modelling. A diverse range of data services (monitoring and forecast information) can be delivered to suit the application and end user requirements.

Water quality modelling: In the data system, water-based sensor and EO data is integrated with physical models to make predictions about water quality. The use of AI can help to scale up local forecasting models to regional and continental coverage.

Tech demonstrators

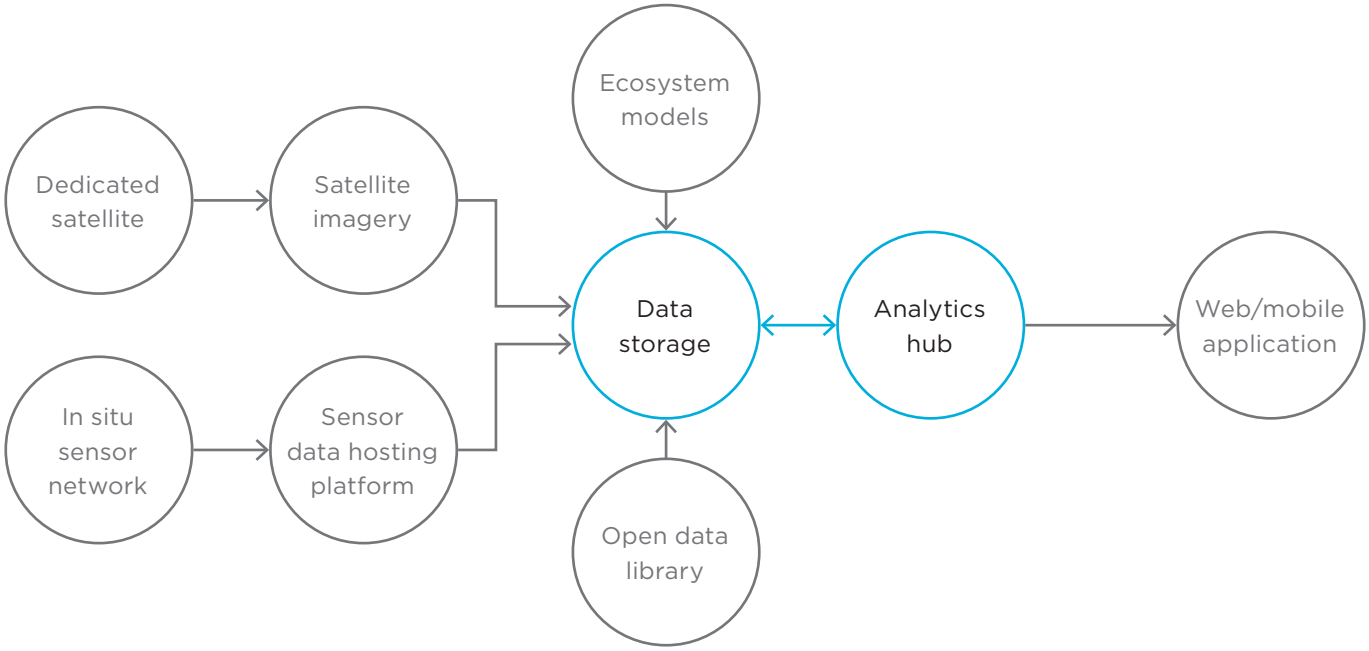
To move towards a fully operational system, AquaWatch relies on pilot sites to demonstrate and develop our technology and capabilities across a wide range of aquatic systems and water quality parameters.

National pilot sites: Locations around Australia have been selected to test the AquaWatch technologies in real-world applications for end users. These sites include both inland and coastal waters, chosen strategically and delivered with local partners.

International pilot sites: International pilot site locations have been selected in collaboration with partners around the world to test the AquaWatch concept in different ecosystems and duplicate the system for use by other countries.

We highly value all our collaborators and partners who provide support, different locations and expertise to demonstrate our system for global operations.

Functional architecture



Water quality sensors

Water-based ‘in-situ’ sensors are central to the AquaWatch system. To date, AquaWatch has successfully integrated sensor data into the AquaWatch data system for near real time observations of water quality. The AquaWatch team have also developed low-cost nitrate and turbidity sensors with provisional patents.

The AquaWatch sensor system can also function in conjunction with and complement third party sensors, seemlessly integrating existing water quality sensors at a site. The additional water quality data can be ingested into the AquaWatch data system to increase the understanding of the water quality, which supports and improve existing water quality management practices.

Comprehensive monitoring:

- Water-based sensors (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.
- By integrating water-based sensors into the AquaWatch network, we achieve comprehensive coverage across inland rivers, waterways and coastal environments.

Accuracy and precision:

- These sensors offer high accuracy because they measure conditions directly at the source and provide precise local measurements. The highly accurate data can be used to validate the broader coverage from satellite data.

HydaSpectra

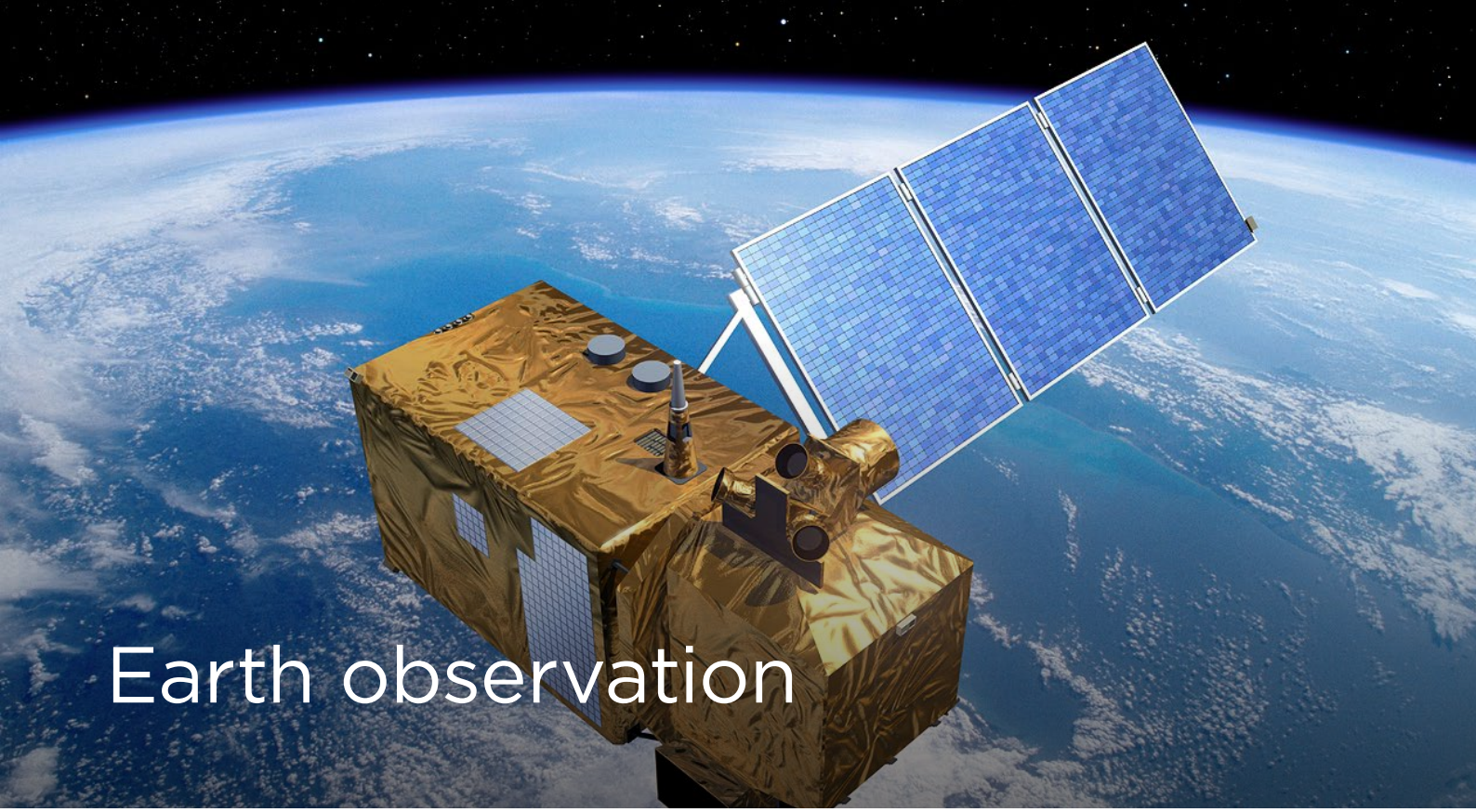
The HydraSpectra is an optical sensor developed by CSIRO and a key technological component of the AquaWatch system. It offers our users a solution to enhance the efficiency and accuracy of water quality monitoring, water compliance and risk assessment across geographically dispersed sites.

Hydraspectra features:

- Low cost and robust for accessibility and uptake
- Sits above the water surface, reducing the need for frequent maintenance.
- 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.

AquaWatch is always interested in new partners and incorporating HydraSpectra sensor installations into new co-designed pilot sites.

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 issues from 600 kilometres away in space. By doing so, it delivers critical data for managing health, environmental impact and industrial activities.

AquaWatch is working with space technology partners to design the optimal satellite imaging system for high quality and high-resolution measurement of water quality from space.

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

Space technology: CyanoSense

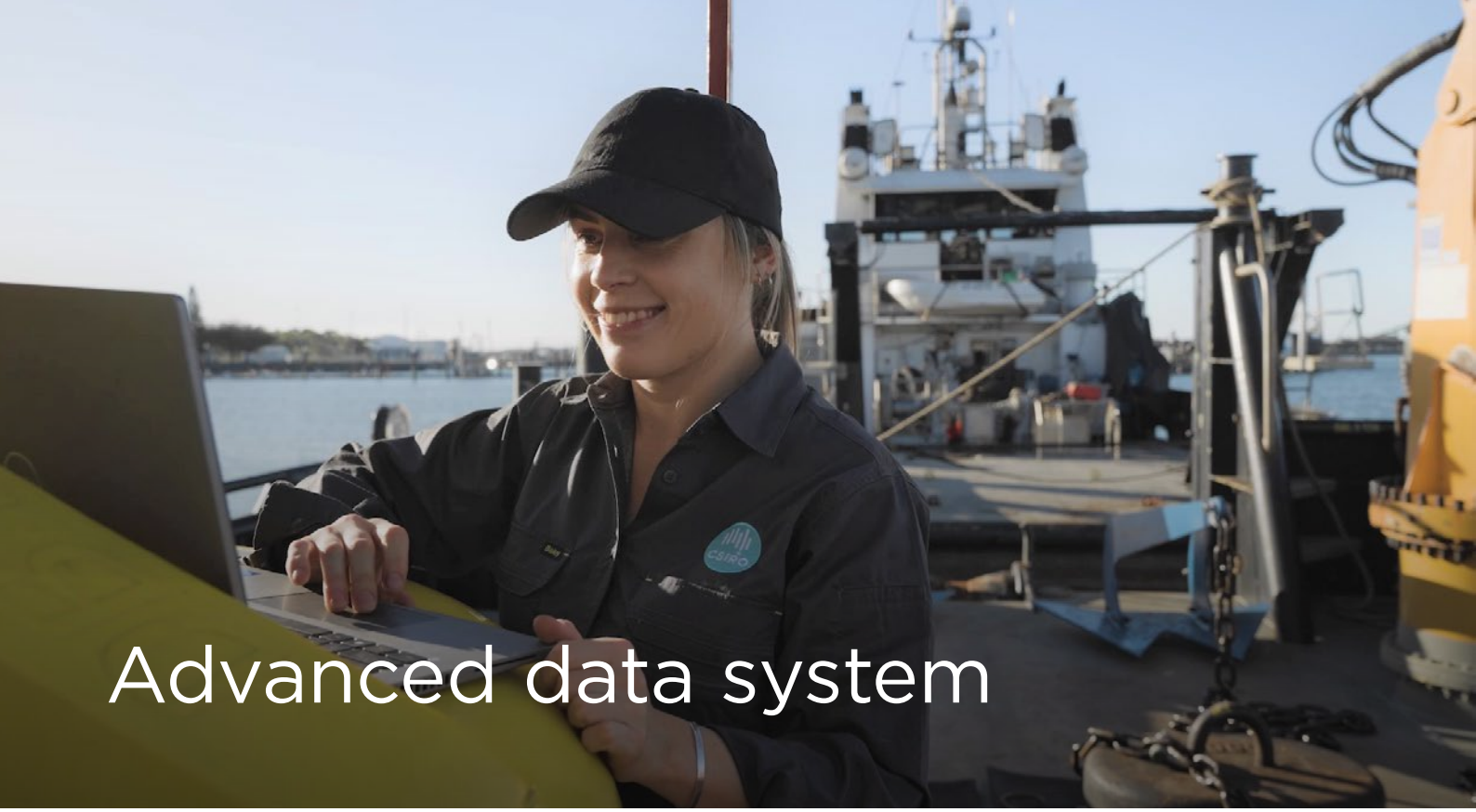
CSIRO's CyanoSense satellite payload technology, captures hyperspectral images, aquiring spectra for each individual pixel from space to discriminate the composition of objects on Earth's surface.

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

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

The development of specialised satellite sensors for water quality measurements, like CyanoSense, 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.



Advanced data system

The AquaWatch system collects extensive data from both water-based sensors and Earth observation 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. By integrating environmental modelling and artificial intelligence (AI), we can develop forecasts to better anticipate future conditions. This new high-performance platform enables us to "turbo-charge" the capacity to process and integrate large amounts of data.

The flexibility of the EASI platform allows customisation to meet the needs of specific end users of the AquaWatch data system. The adaptability enables AquaWatch to deliver a diverse range of data services tailored to specific requirements and applications.

Currently, CSIRO is operationalising AquaWatch deployments of EASI for the national test sites and is in the process of testing for international sites.

Early warning system

AquaWatch's water-based sensors serve as an early warning system for potential hazards such as toxic algal blooms, blackwater incidents, and contamination from runoff.

For example, water quality alerts generated by the AquaWatch system enable environmental managers to rapidly intervene, minimising the impact on both aquatic ecosystems and human health.

In situations such as bushfire aftermath or floods, water-based sensors help assess water quality recovery.

Aquawatch utilises cutting-edge technology such as petabyte-scale multi-sensor data assimilation, cloud-computing and advanced visualisation techniques to enhance the effectiveness of its monitoring and alert system.

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, Earth observation and physical models to accurately depict the biogeochemical characteristics of water bodies and coastal areas.

One important feature of AquaWatch's water quality system will be its early warning tool. This forecasting model combines hydrodynamic and biogeochemical modelling tools for more 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 them with Earth observation data, the AquaWatch system can assimilate these diverse data streams and evaluate predictive accuracy and uncertainty.

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

The establishment of new test sites broadens AquaWatch's capabilities, allowing it to include a wider array 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.

The AquaWatch team 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.
- Developed a scalable model for hypoxia in low flow rivers and lakes.

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

Algal bloom at Lake Tuggeranong, Canberra. Credit: Alica Tschierschke.

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.

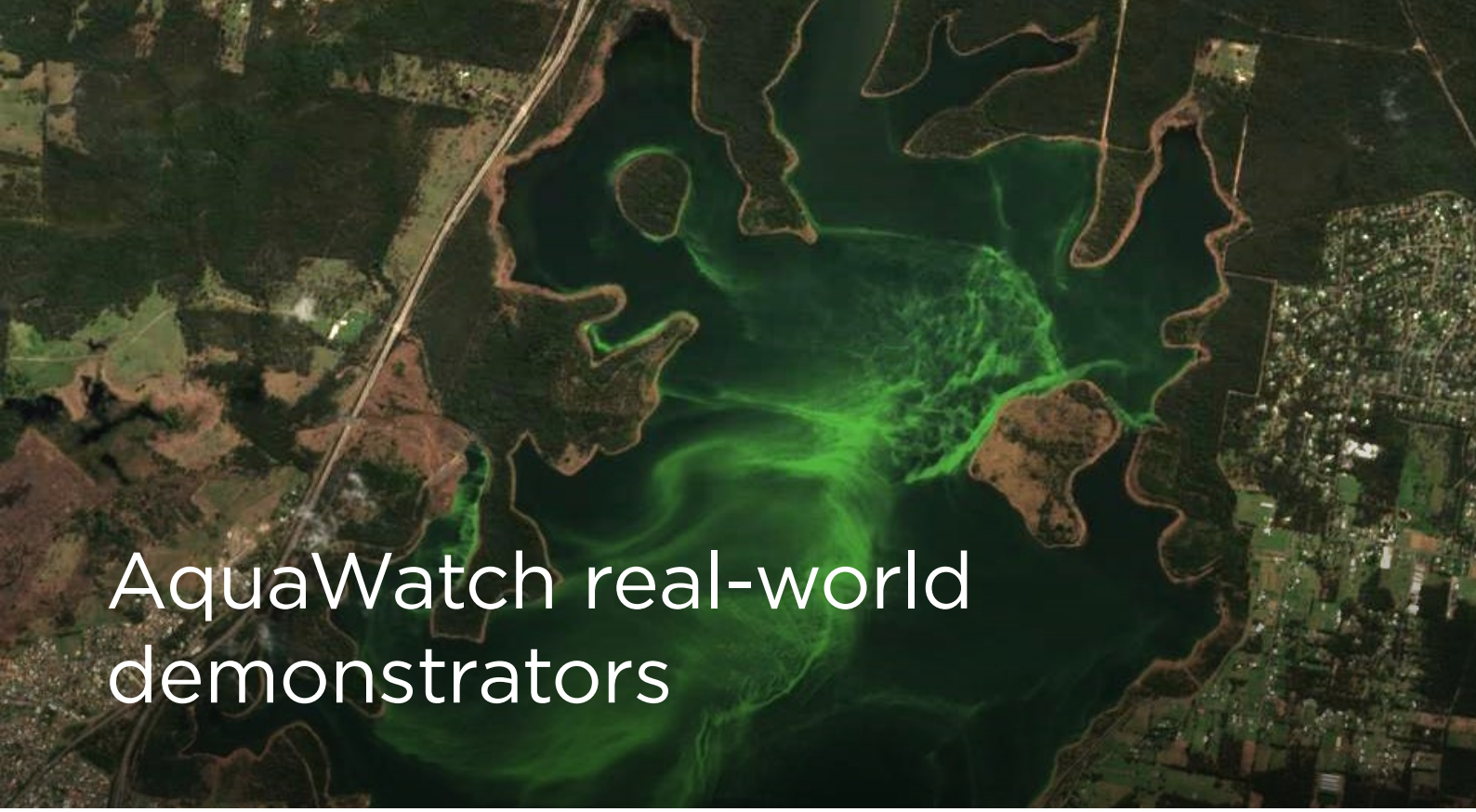
Co-designed pilot sites are developed in collaboration with partners from across industry, academia, government and more, each of whom have an important water story.

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.

Contact us to enquire about partners and pilot sites: AquaWatch@csiro.au

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



AquaWatch real-world demonstrators

AquaWatch integrates data from cutting-edge ground-based equipment and satellite remote sensing to monitor and predict cyanobacteria (blue-green algae) presence in both drinking and recreational water sources.

Pilot 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 real-time water quality information.

Water story: safe drinking water

In the Grahamstown reservoir and Williams River pilot site, the AquaWatch system has offered the following advantages:

Reduced risk to resources: the technology reduces the necessity for manual algal inspections, thereby cutting the costs and potential risks associated with resources (people, vehicles and boats) associated with manual sampling.

Improved resolution and visibility: near-real time and comprehensive visualisation of water quality at sites like Grahamstown Reservoir, with a surface area of 28 square kilometres, is made possible.

Reduced exposure windows: access to a rapid algal risk management tool ensures delivery of information faster than current manual techniques and with greater spatial overview.

Expanded data capture: by comparing baseline samples results 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. Experts highlight the potential transformative impact of the AquaWatch information provided, foreseeing it as 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 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 is being tested to detect algal blooms in the Grahamstown Dam, which stores drinking water 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.

CSIRO. Creating a better future for everyone.

Contact us
1300 363 400
+61 3 9545 2176
csiro.au/contact
csiro.au

For further information
Space and Astronomy | AquaWatch Australia Mission
Dr Alex Held
AquaWatch Australia Mission Lead
aquawatch@csiro.au
csiro.au/aquawatch

B&M | 24-00187