National Research FLAGSHIPS
Water for a Healthy Country

CSIRO

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CSIRO RESPONSE TO THE CALL FOR PARTICIPATION (CFP) IN THE 3RD PHASE OF THE GEOSS ARCHITECTURE IMPLEMENTATION PILOT (AIP-3)

3 March 2010

ABOUT CSIRO AND THE WATER FOR A HEALTHY COUNTRY NATIONAL RESEARCH FLAGSHIP

Australia is founding its future on science and innovation. Its national science agency, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), is a powerhouse of ideas, technologies and skills.

CSIRO initiated the National Research Flagships to address Australia's major research challenges and opportunities. They apply large scale, long term, multidisciplinary science and aim for widespread adoption of solutions. The Flagship Collaboration Fund supports the best and brightest researchers to address these complex challenges through partnerships between CSIRO, universities, research agencies and industry.

The Water for a Healthy Country Flagship aims to provide Australia with solutions for water resource management, creating economic gains of $3 billion per annum by 2030, while protecting or restoring our major water ecosystems.

For more information about Water for a Healthy Country Flagship or the National Research Flagship Initiative visit www.csiro.au/org/HealthyCountry.html

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RESPONSE SUMMARY

The Water for a Healthy Country Flagship is a national research program set up by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to address sustainable management of Australian water resources. Integrated Water Information Systems is a research theme in the Water for a Healthy Country Flagship. One of the research topics in the theme is near real-time situation awareness of river flow in regional catchments.

CSIRO has established a prototype Hydrological Sensor Web in the South Esk river catchment, NE Tasmania, to deliver short-term river flow forecasts. This information is required to address two water resource management use cases:

- Apply water restrictions so that water supply surety is maintained
- Announce flood take during peak flow events

These water resource management use cases are closely aligned to the Extreme Precipitation and Drought scenarios detailed in the Call for Proposals for Phase 3 of the Architecture Implementation Pilot (AIP-3). CSIRO proposes to contribute the South Esk Hydrological Sensor Web to AIP-3 and participate in the development of service registries, especially those relating to data provenance. Though the South Esk Hydrological Sensor Web is regional in nature, it has all the elements needed to address a typical GEOSS scenario.

ACKNOWLEDGMENTS

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1. OVERVIEW

1.1. Water for a Healthy Country Flagship

The Commonwealth Scientific and Industrial Research organisation (CSIRO) is Australia's national science agency and one of the largest and most diverse research agencies in the world. The Water for a Healthy Country Flagship is a national research program set up by CSIRO to address one of Australia's most pressing natural resource issues – namely sustainable management of its water resources. The Flagship has four research themes:

- Regional water - aims to develop tools, knowledge and strategies to assess the availability and use of water in Australian river systems and catchments.
- Health water ecosystems - providing the knowledge to protect or restore the health of Australia's water ecosystems.
- Urban water - ensure Australia can meet the demands that climate change and population growth will place on our limited water resources.
- Integrated water information systems - helping to revolutionise Australia's ability to monitor, forecast and manage water demand, supply, quality and use patterns.

One of the research topics in the Integrated Water Information Systems Theme is near real-time situation awareness of river flow in regional catchments (Figure 1). CSIRO is investigating how emerging standards for Sensor Web Enablement (SWE) being developed by the Open Geospatial Consortium (OGC) can be applied in water resource management.

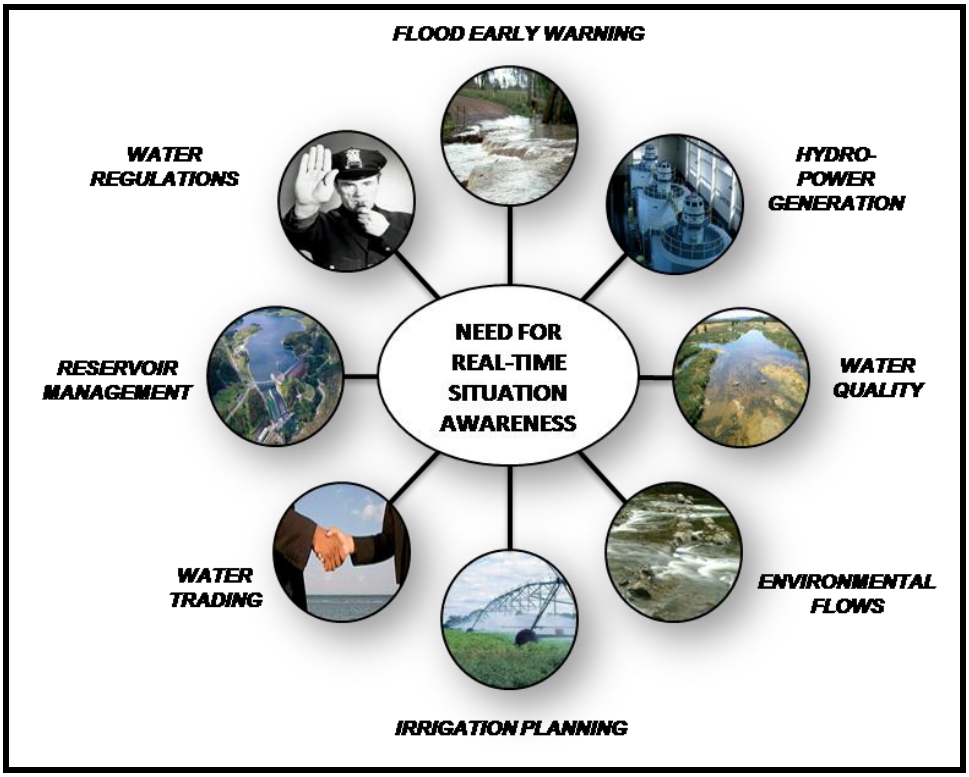

Figure 1 - Effective management of water resources requires an integrated approach to near real-time monitoring of water availability and water use i.e. development of an

open system that provides good situation awareness about all aspects of water resource management.

1.2. South Esk Hydrological Sensor Web

CSIRO is profiling SWE information models and web service interfaces to allow correct encoding and transmission of water information. Part of this process involves the establishment of a prototype Hydrological Sensor Web for the South Esk river catchment in North-Eastern Tasmania (Figure 2).

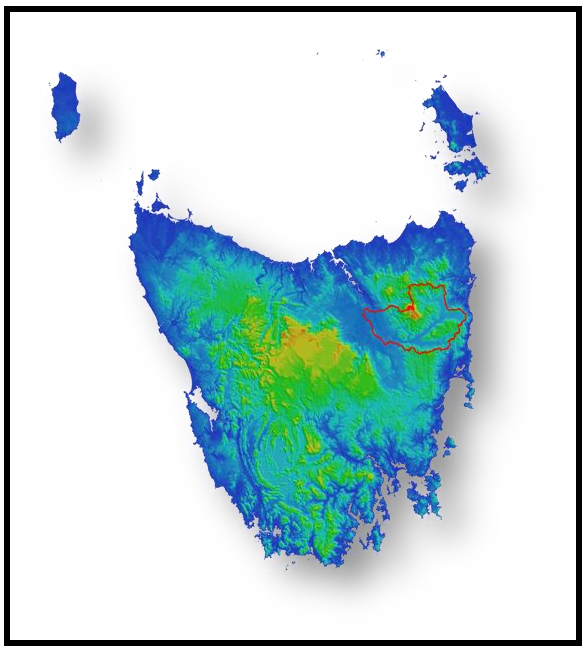

Figure 2 - South Esk River Catchment, North-Eastern Tasmania, Australia

The South Esk is the longest river in Tasmania (approximately 214km from its headwaters to its outflow into the Tamar Estuary). Covering a topographically diverse area of 3350km^2, this mostly unregulated river catchment experiences a highly variable climate and flow regime.

The Tasmania Department of Primary Industry, Parks, Water and Environment (DPIPWE) would like near real-time situation awareness on river flow to better manage this important water resource. This includes observing current flow conditions, forecasting flow conditions over the next few days, and understanding what this means in terms of water resource management decisions.

1.3. Water Resource Management Use Cases

DPIPWE have provided two water resource management use cases for the South Esk Hydrological Sensor Web:

- Apply water restrictions so that water supply surety is maintained
- Announce flood take during peak flow events

DPIPWE want to be able to predict when river water levels will drop below, or exceed, predefined thresholds. This will allow for more proactive and timely management of water restrictions. Currently only one stream gauge is used to manage water restrictions in the South Esk catchment. Given that the main river systems in the South Esk

catchment behave quite differently, DPIPWE would prefer selective management of water restrictions on a sub-catchment basis.

These use cases are applicable not only to other river catchments across Australia, but also to river catchments in other parts of the world.

1.4. Sensor Web Components

Accurate prediction of river flow in each sub-catchment requires a distributed flow forecast model supported by a reasonably dense rain-gauge network. The flow forecast model also needs stream gauges in each sub-catchment to serve as points-of-truth for calibration.

A number of agencies operate sensor assets in the South Esk river catchment including the Bureau of Meteorology (BOM), CSIRO, DPIPWE, Forestry Tasmania (FT) and Hydro Tasmania (HT). These agencies have agreed to allow public access to their sensor observations via Sensor Observation Service (SOS) interfaces. Table 1 list the phenomena observed by each agency. Essentially, the Hydrological Sensor Web provides an interoperability layer over existing sensing infrastructure operated by these agencies CSIRO (Figure 3).

	Rainfall	Climate	Water Level
BOM	6	1	5
CSIRO	7	7	
DPIPWE	4		6
FT		2	
HT	1		1
Total	18	10	12

Table 1 - Observed phenomena in South Esk catchment

CSIRO has implemented a number of workflows in the Kepler Scientific Workflow System to process observations provided by the various SOS instances:

- Harmonising time-series
- Fixing basic errors such as gaps in the time-series and data spikes
- Generation of gridded rainfall surfaces from rain-gauge observations

Kepler can be viewed either as a Sensor Web client or as a proxy for a Web Processing Service.

The gridded rainfall surfaces produced in Kepler feed into a semi-distributed flow forecast model set up by HT Consulting. This model generates hourly river flow predictions at DPIPWE and HT stream-gauge locations. Flow forecasts are published via another SOS instance (model prediction service).

CSIRO has also implemented a numerical weather prediction model that generates 48 hour rainfall forecasts at a one-kilometre grid-cell resolution (CSIRO Cubic Conformal

Atmosphere Model, CCAM). CCAM rainfall forecasts are exposed via an OpenDAP web service.

The intention is to implement another workflow in Kepler that fuses CCAM rainfall forecasts with in-situ rain gauge data to produce an enhanced rainfall surface that can be ingested into the a semi-distributed flow forecast model.

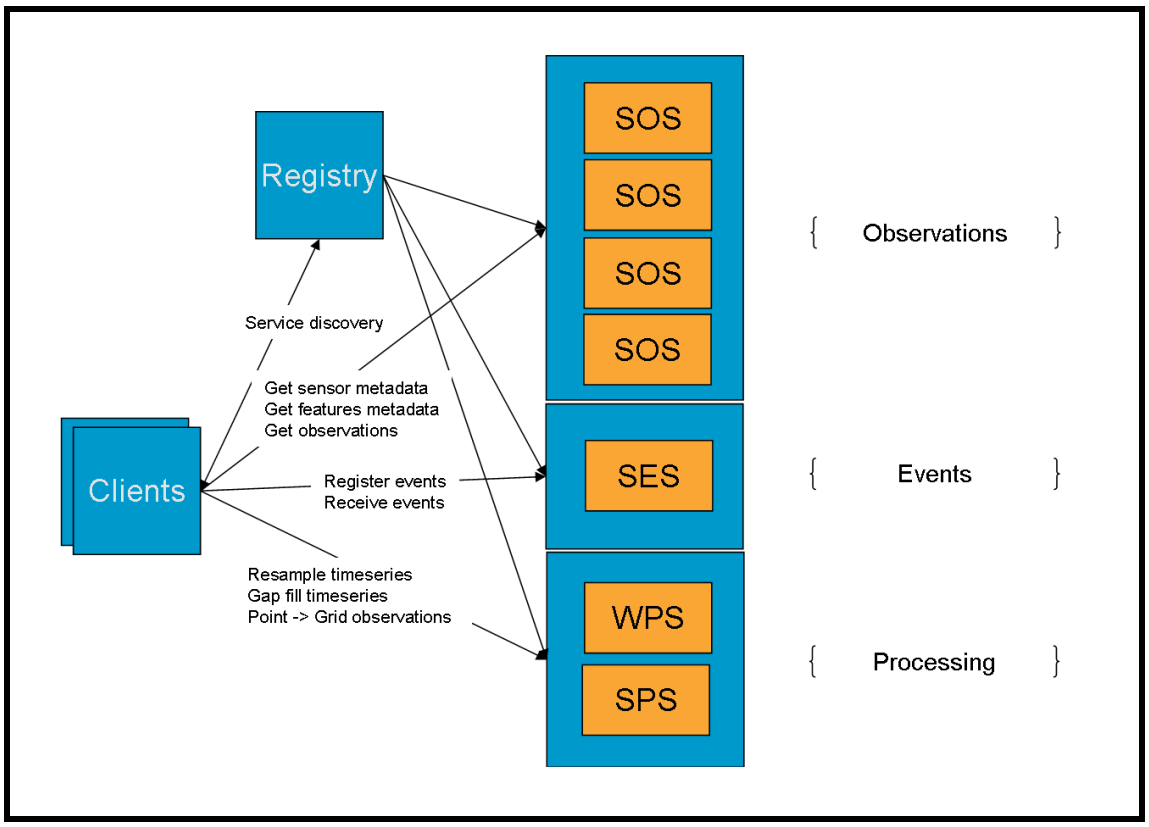

Figure 3 - Draft high-level architecture of the Hydrological Sensor Web.

2. PROPOSED CONTRIBUTIONS

2.1. Overview

CSIRO intends to contribute to the AIP-3 on three fronts:

- Scenarios - water resource management use cases.
- Component and service registration – profiles of SWE information models and service interfaces that allow correct encoding and transmission of water information.
- Architecture – possible contributions to the Data Harmonization and Vocabularies technology themes.

CSIRO believes it can contribute in these areas because of its expertise in the water domain, contributions to the international hydrology efforts and experience designing and building hydrology systems.

CSIRO intends to do this by providing use cases that provide detailed requirements relevant to the scenarios. Furthermore, CSIRO will register services and components that have implemented these use cases in functioning systems and shall participate in testing of the services with other participants in AIP-3.

2.2. Societal Benefit Area Alignment and Support

Three new scenarios have been introduced in the water theme for AIP-3. The CSIRO response to each of these scenarios is detailed below.

Extreme precipitation

The aforementioned Announce Flood Take During Peak Flow Events use case is well-aligned to this scenario. Though this use case is about taking advantage of extreme precipitation events that occur in the South Esk catchment, it also addresses the societal benefit of reducing loss of life and property from natural and human-induced disasters.

Water quality

CSIRO will not be addressing this scenario.

Drought scenario

The aforementioned Apply Water Restrictions So That Water Supply Surety Is Maintained use case is well-aligned to this scenario. The goal of the use case is to sustain environmental flows during extended dry periods.

The drought scenario describes several requirements for a system that will inform drought response measures. Some of those requirements and how CSIRO intends to address these requirements in AIP-3 are listed below:

- Access to hydro-meteorological observations via registered components – CSIRO will register HydroSOS, a profile of the Sensor Observation Service (SOS) that supports WaterML2.0
- Modelling – A semi-distributed flow forecast model has been implemented. Model output is exposed via a SOS
- Reliable estimation and monitoring - CSIRO is implementing real-time quality assurance as part of a provenance management framework for Hydrological Sensor Webs

3. COMPONENT AND SERVICE CONTRIBUTIONS

3.1. Definitions

GEOSS Service - describes a service interface to a component resource and is typically implemented as an Internet-accessible resource e.g. a Sensor Observation Service serving a network of sensors.

GEOSS Component - describes earth observation resources such as observing systems, data sets and products, catalogues, websites, models, training materials, or initiatives. Registered services can be defined and linked to a Component to explain access.

3.2. Services

CSIRO will contribute its existing web service instances. These include:

- Five SOS instances that provide near real-time climate, rainfall and stream-gauge observations
- One SOS instance that provides hourly river flow predictions at DPIPWE stream gauge locations
- One OpenDAP instance that provides gridded hourly weather forecasts

CSIRO will also make available new service instances as these become available. These should include:

- HydroSOS instances that provide rainfall and stream-gauge observations. HydroSOS is a profile of a SOS that supports time-series encoded in WaterML2.0
- A Web Processing Service that provides access to the Kepler Scientific Workflow System
- A Sensor Event Service (SES) for issuing river flow alerts

3.3. Components

CSIRO will provide the following components:

- Current and historical hydro-meteorological observations collected by DPIPWE, BOM, FT, HT and CSIRO in the South Esk over the past 30 years.
- Numerical weather predictions in NetCDF file format.
- The draft WaterML2.0 encoding standard for water information. This is a profile of O&M being developed by the OGC Hydrology Working Group of which CSIRO is a co-lead.
- Software applications for visualising observations provided by SOS/HydroSOS instances. These include:
    - A thin client based on Google Maps (http://wron.net.au/au.csiro.OgcThinClient/OgcThinClient.html)
    - A thick client based on the Java version of NASA World Wind.

3.4. Architecture and Interoperability Arrangement Development

CSIRO will contribute to the development of service registries. CSIRO is particularly interested in those aspects relating to data provenance. This includes encoding standards for provenance (e.g. Open Provenance Model, Proof Mark-Up Language) and technology for harvesting provenance information at service interfaces.

4. DESCRIPTION OF RESPONDING ORGANIZATION

CSIRO is Australia's national science agency and one of the largest and most diverse research agencies in the world (http://www.csiro.au).

5. MILESTONES

The Call for Participation outlines a schedule for the execution of AIP-3. The following table is a summary of those milestones (Table 2). The proposed outputs from CSIRO are included in the summary.

Milestone	Date
AIP-3 Call for Proposal issued	29 Jan 2010
Responses due date	3 Mar 2010
Kick-off workshop	11-12 Mar 2010
Complete registration of components and services	5-Apr-10
Complete use cases	3-May-10
Component integration phase I – Event Service	7-Jun-10
Record AIP-3 demonstrations workshop	Sept 2010
Final report	4 Oct 2010
Interim results presented at GEO Plenary, Beijing, China	3-5 Nov 2010
Final results of AIP-3 tabled	Dec 2010

Table 2 – AIP-3 Milestones

5.1. Resourcing

CSIRO's contribution to AIP-3 will be done as part of a funded research project in the Integrated Water information Systems Theme. This activity covers nine FTE (full-time equivalent) split equally between research scientists and research engineers. Resources will be assigned to specific AIP-3 tasks on an as needed basis, subject to theme and project priorities, and budget constraints.

5.2. Contacts

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