Smart Water Fund Trial Nowcasting Project – DRAFT REPORT

Introduction

The Bureau of Meteorology (Bureau) operates three radars in Victoria that are suitable to support quantitative radar rainfall estimation and forecasting. These radars are the Melbourne, Bairnsdale, and Yarrawonga radars. The radar rainfall estimation and forecasting is done by the Rainfields system, which was developed locally by the Bureau. The major steps in using radar observations to estimate rainfall are quality control of the radar reflectivity observations, converting the radar reflectivity into rainfall intensity, and finally blending the radar accumulations with real-time gauge observations so that the rainfall estimates near the gauges are closer to the gauge observations. The main parameter that is needed to convert radar reflectivity into rainfall is calibrated in real-time to minimise any biases in the average rain rate over the radar domain.

The radar rainfall estimates from each radar in Victoria are combined into a 500 km x 500 km map with a 10 min, 2 km resolution. This rainfall map is used to make very short term rainfall forecasts, called nowcasts. The error in the radar nowcasts increases rapidly with increasing lead time so the Bureau has developed a technique to blend the radar nowcasts with the high resolution Numerical Weather Prediction forecasts of rainfall to extend the lead time of the forecasts from 2 to 12 hours. Rainfall forecasts have significant errors and the Bureau has developed statistical models for forecast errors which are used to generate a 35-member ensemble of forecasts that can be used to evaluate the uncertainty in the forecast.

Rainfields generates over 2000 products an hour over Australia and the number and complexity of the products is a significant barrier to the uptake of these products by end users. This project included a significant effort to work with the water industry to better understand their needs and to arrive at an optimal small set of products that yield the most benefit.

Scoping the project

Meeting on 28 March 2013 at the Smart Water Fund offices to select the area for potential investment by SWF in Bureau products.

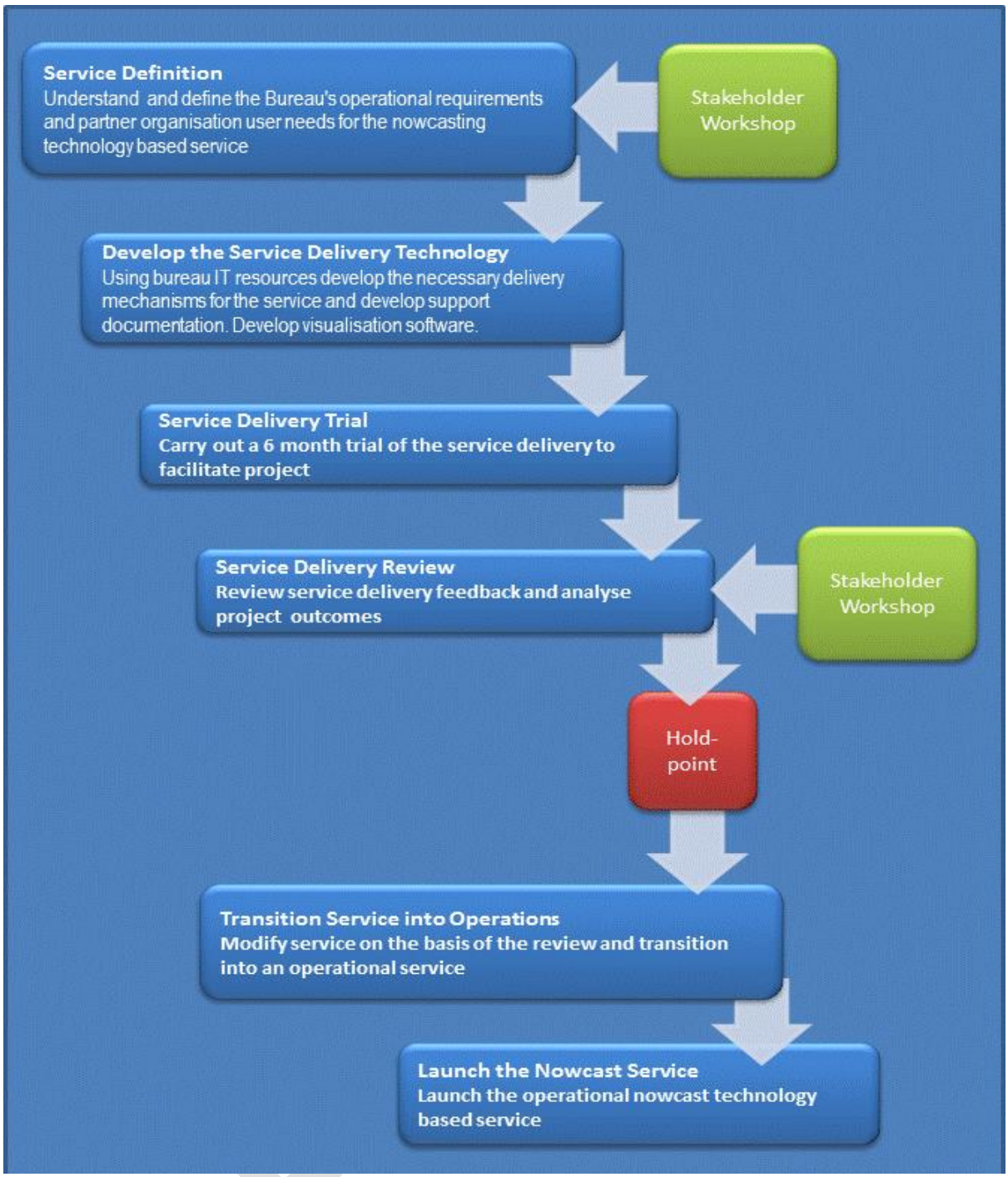
Four options were proposed and the meeting ranked them as follows:

Nowcast	206
Synthetic storms	167
Real time radar rainfall	142
Weather data dashboard	150

A vote was then held to select either Nowcasting or Synthetic Storms and Nowcasting was selected unanimously.

A scoping workshop was held on 7 August 2013 and a project plan was drafted. It was apparent during this meeting that there were two major groups of users; the network operators who were interested in the real time visualisation of the products and the modellers who needed real-time data so that they could run hydrological models in real-time. The trial was launched in June 2014 and will continue until the transition to operations has been completed.

The Project Plan



Selecting the products

The catalogue

Rainfields product list, 29 August 2013

Rainfields collects the raw radar reflectivity data from 18 weather radars, applies some quality control on the reflectivity and then converts the data into rainfall accumulations. This includes using real-time rain gauge observations to adjust the mean bias of the radar estimates. The radar rainfall depths are accumulated up from 6 or 10 minutes to a number of rainfall accumulations over specific period of times . These are called RainAccum products (Table 1).

A further processing step uses these radar rainfall estimates to interpolate between the rain gauge observations, this blended product agrees with the gauge observation at the gauge, and gradually relaxes to the radar estimate as the distance from the nearest rain gauge increases. This is the highest quality quantitative precipitation product in the product set and is called BlendedAccum.

The rainfall forecasts are generated in two ways. For the 0-90 minute period the forecasts are generated by advecting the observed radar rainfall maps into the future. A 30-member ensemble is generated using a statistical model for the changes in the rainfall pattern during the forecast period (these products are named “nowcasts”). For the 0 – 6 hour period the ensembles are generated by blending the radar nowcasts into the high resolution numerical weather prediction rainfall forecasts.

Table 1 List of products that are generated by *Rainfields*

Name	Description	Updates
Forecast (Fig.1)	6 ,10 min time series of an ensemble member (mm/h)	Every scan (6 or 10 min)
ForecastAccum (Fig.2)	30,60,90 min accumulations of ensemble mean	Every scan (6 or 10 min)
ForecastEnsemble (Fig.3)	30 member ensembles of 6,10, or 60 min forecasts	Every scan (6 or 10 min)
BlendedAccum24hr	Blended interpolated gauge and radar field 9 AM to 9 AM local time accum (mm)	every 30 min
BlendedAccum30 (Fig.4)	Blended interpolated gauge and radar field 30 min accum (mm)	every 30 min
BlendedAccum60	Blended interpolated gauge and radar field 60 min accum (mm)	every 30 min
BlendedAccum120	Blended interpolated gauge and radar field 120 min accum (mm)	every 30 min
BlendedAccum180	Blended interpolated gauge and radar field 180 min accum (mm)	every 30 min

BlendedAccum360	Blended interpolated gauge and radar field 360 min accum (mm)	every 30 min
BlendedAccumSince 9am	Blended interpolated gauge and radar field since 9AM accum(mm)	every 30 min
Probability (Fig.5)	Probability of rain accumulation > 0.1, 1,2,5,10,20,30,50 mm (%)	Every scan (6 or 10 min) in next 60 minutes, per hour for next 6 hours
Rainfall	Radar estimate of rainfall in next 6 or 10 minutes (mm)	Every scan (6 or 10 min)
RainfallAccum24hr	Radar estimate of rainfall 9 AM to 9 AM local time accum (mm)	Every 24 h
RainfallAccum30	Radar estimate of rainfall 30 min accum (mm)	Every scan (6 or 10 min)
RainfallAccum60	Radar estimate of rainfall 60 min accum (mm)	Every scan (6 or 10 min)
RainfallAccum120	Radar estimate of rainfall 120 min accum (mm)	Every scan (6 or 10 min)
RainfallAccum180	Radar estimate of rainfall 180 min accum (mm)	Every scan (6 or 10 min)
RainfallAccum360	Radar estimate of rainfall 360 min accum (mm)	Every scan (6 or 10 min)
RainfallAccumSince9am	Radar estimate of rainfall accumulation since 9 AM (mm)	Every scan (6 or 10 min)

The Bureau extended the range of products that are delivered by Rainfields to include probability that a forecast will exceed a certain threshold and expressing the rain accumulation as average recurrence interval (in years).

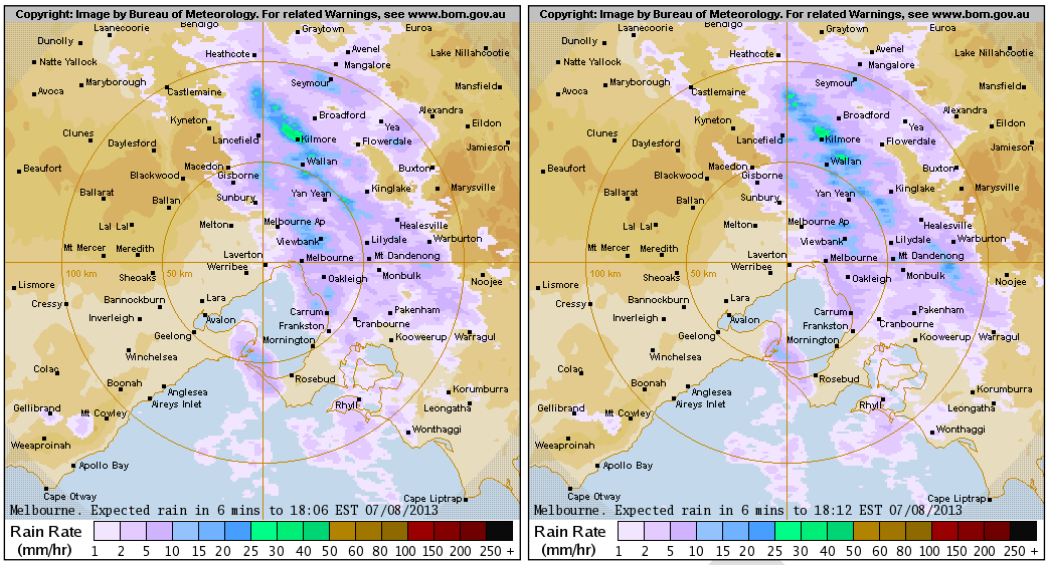


Fig.1: Forecast: Expected rain in 6 minutes steps

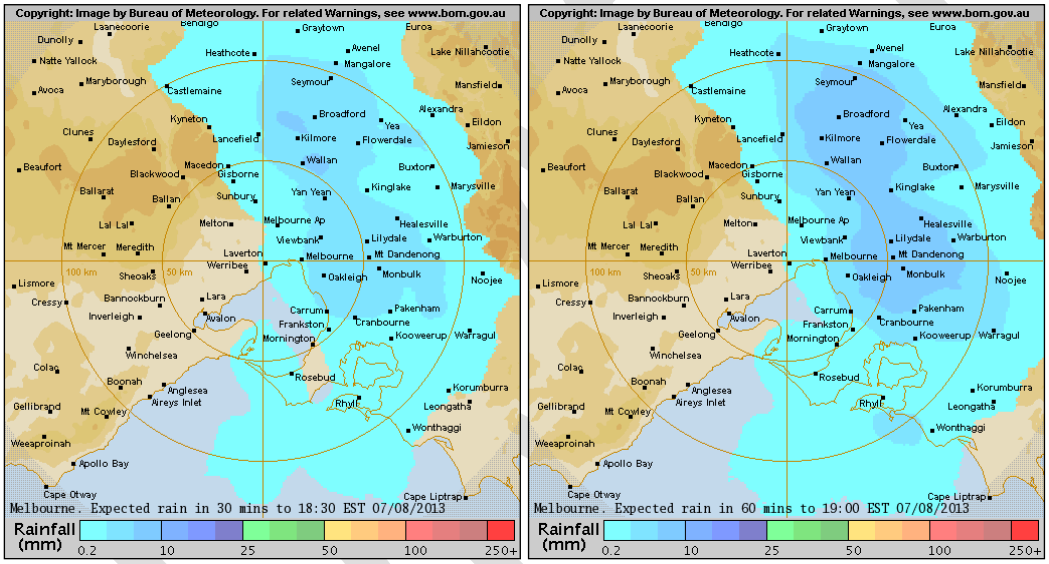


Fig.2: Forecast accumulation in 30 minutes, 60 minutes.

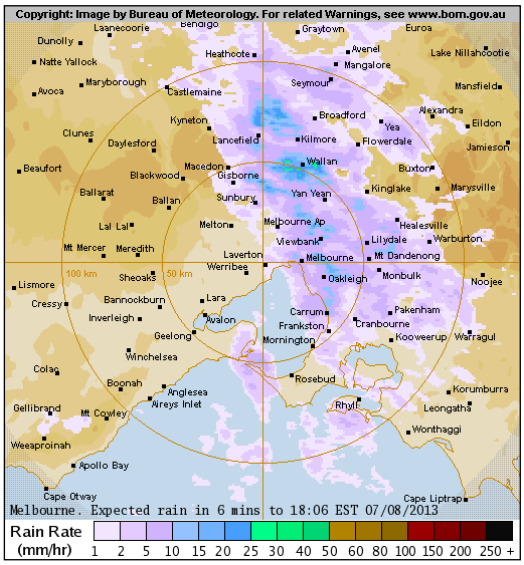


Fig.3: Forecast ensemble of estimated rain in 6 minutes.

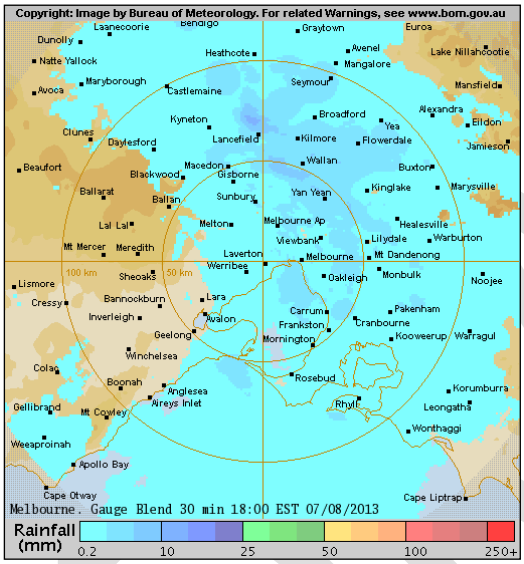


Fig.4: Blended accumulations in 30 minutes.

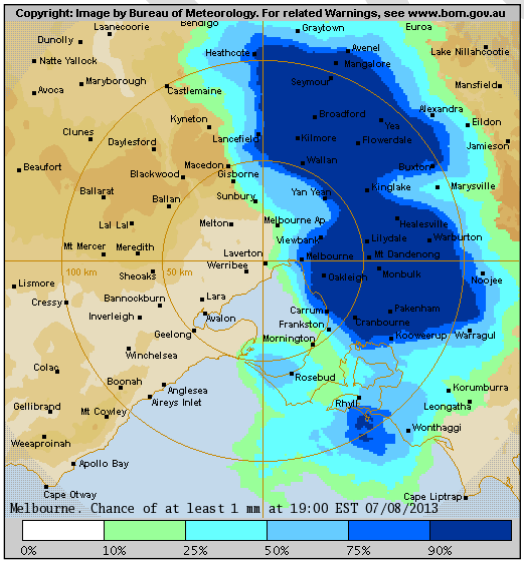


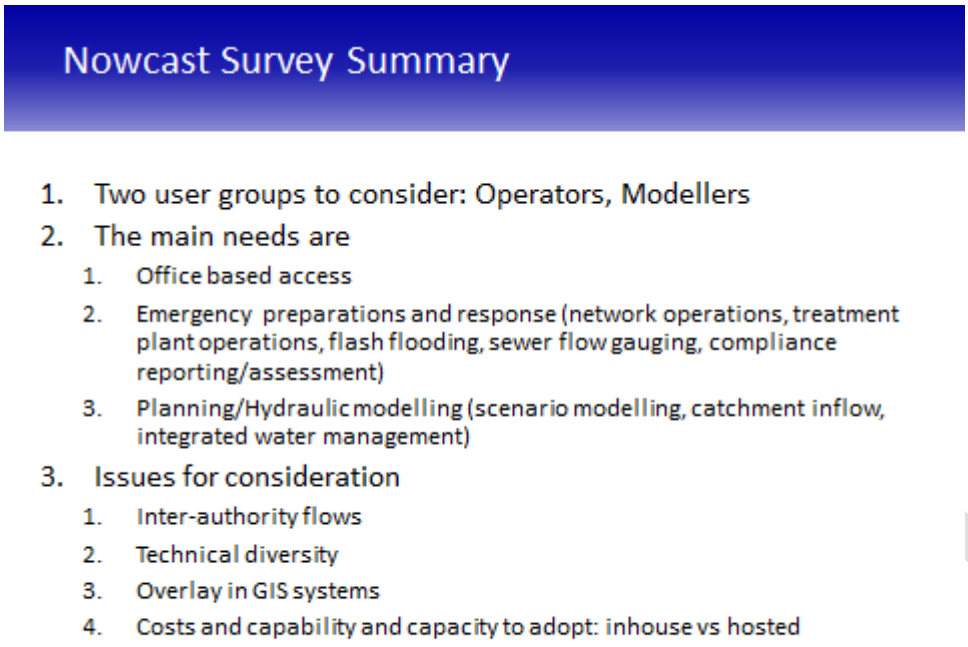
Fig.5: Probability of rain accumulation > 1, in 60 minutes.

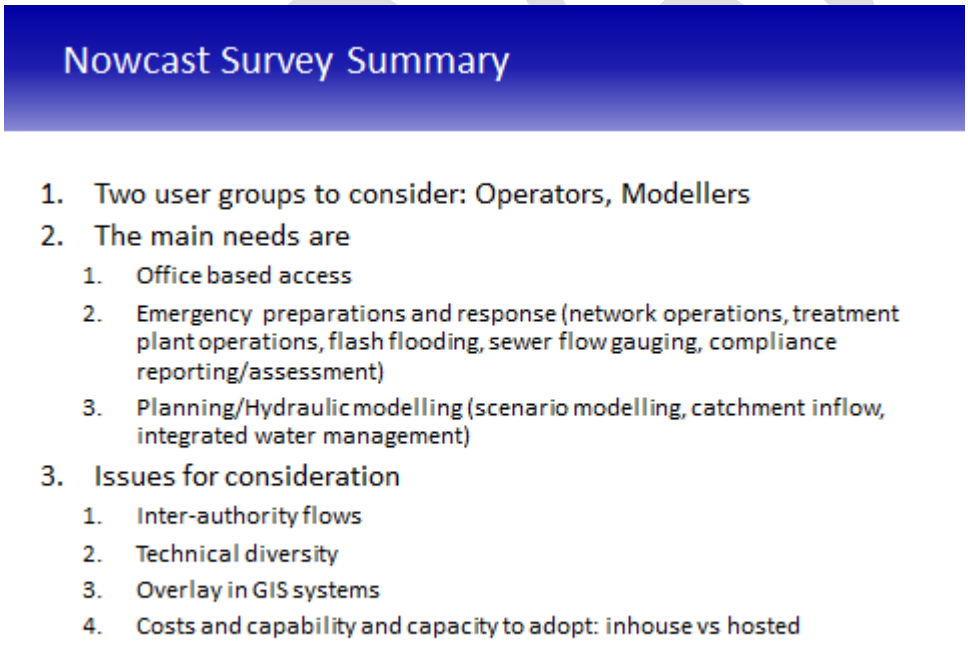
The survey

A survey was placed on SurveyMonkey on 15 November 2013. The link to the survey is:

https://www.surveymonkey.com/s/JT8QL9Y

A total of 35 surveys were completed and the summary is found in the following figures:





Nowcast Survey Summary

4. Operators want
    1. as much warning as possible of rain events
        1. Daily rainfall mm 1 to 7 days out
        2. Forecast Rainfall: mm & prob. exceeding 1:5yr ARI up to 6hrs ahead at hourly intervals
        3. Nowcast : mm & prob. exceeding 1:5yr ARI up to 6hrs ahead at 10min intervals
        4. and other ARI's >1:10, >1:20,etc
    2. location
    3. probability of ARI 1 in 5 year (and other ARI's >1:10, >1:20,etc)
    4. time lapse visual presentation with asset overlay
    5. inflows from other authorities
    6. post-rain event data: Eg. estimated rainfall mm by location last 24 hrs, accumulation since 9am, exceedence of 1:5yr ARI

Nowcast Survey Summary

5. Modellers want
    1. Access to Operations views to enable identification of upcoming events of interest
    2. Download targetted events for input
    3. Data in different formats: WMS, CSV, WFS, netCDF, (format for eWater)
    4. Rainfall event data mm, probability of exceeding 1:5yr ARI (and other ARI's)

The trial service

Based on the results of the survey three delivery mechanisms were identified as needed:

- Live interactive map (mobile device compatible) to provide network operators with situational awareness
- Web Map Service to deliver images to GIS and other visualisation systems
- FTP data feed to deliver grids of data in real-time to end-user applications

The Bureau of Meteorology operates behind a Firewall and the initial plan was to host the service on a stake holder server, but it became apparent that this was not practical. The development of the prototype behind the Bureau Firewall went ahead, but there was a significant delay as the Bureau worked through the policy and practical issues of hosting the service and it became available to the Stake Holders in June 2015.

A short video introducing the trial service is available on the project landing page.

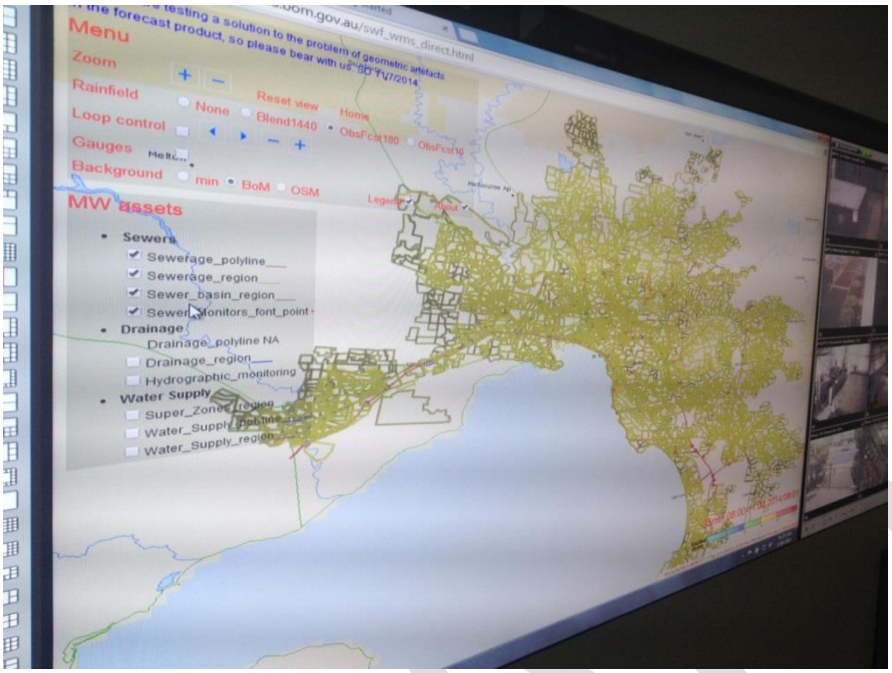
Interactive map

The products that are able to be viewed on the map are:

Product	Description	Update frequency
24 h rainfall accumulation	Gauge-radar blend for last 24 h	Hourly
1:5 year ARI maximum probability forecast	Maximum probability of exceeding any 1:5 year ARI in the next 6 h for accumulations ranging from 30 min to 6 h	10 min
Maximum ARI for past 6 h	Maximum ARI for radar rainfall accumulations ranging from 10 min to 6 h	10 min
Observed and forecast 3 h rainfall accumulations	3 h rainfall accumulations and forecasts from last 9 h to 12 h ahead	60 min
Observed and forecast rainfall intensity	Rainfall intensity observations and forecasts from last 60 min to 90 min ahead	10 min

User Case Study: Melbourne Water Sewerage Transfer Control Room

The interactive map is being displayed internally within Melbourne Water, who has a password protected layer of their sewerage, drainage and water supply assets that can be turned on. This is an option to any utility that have the same need. Some feedback from operators includes needing plain English description of the different products. They found having information on their specific assets helpful.



User Case Study: City West Water Live feed

City West Water tested the live interactive map for a period of time with a permanent display within their offices. The uptake was challenging due to issues with firewall access at the time, as well as no rain to understand how the nowcast data would appear. The Bureau established a demonstration case study of a rain event on the project landing page to overcome this obstacle. Uptake was also difficult, given operators were not familiar with the products hence required significant investment in their time without a clear understanding of how it could help their day to day work. Another challenge during research project such as this, the site was in a state of flux which could be confusing to users who prefer to wait to the end to see the final outcome.

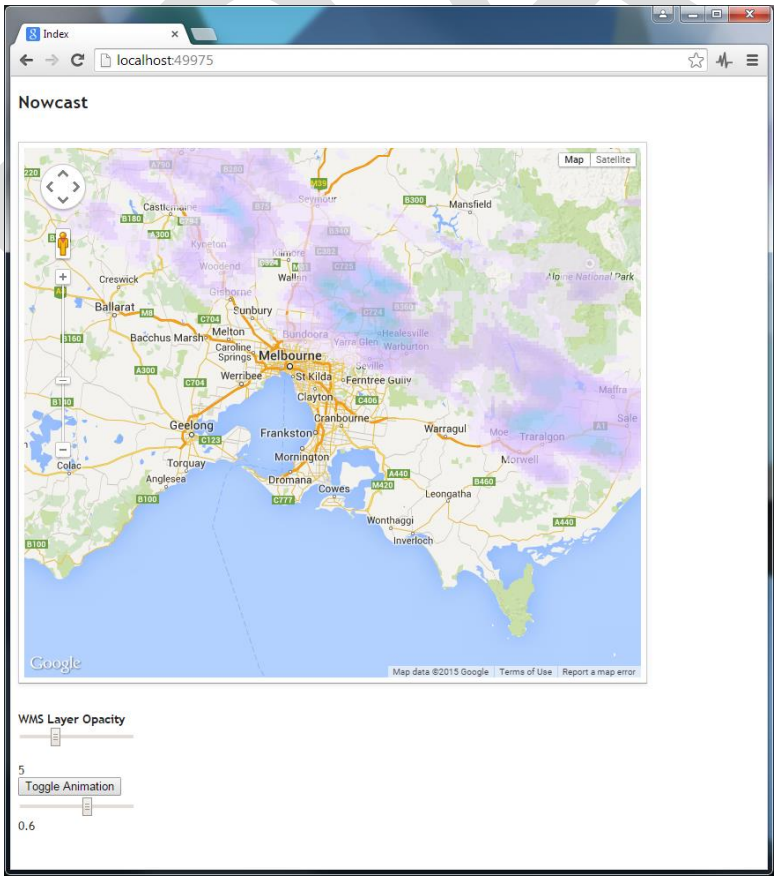
Web Map Service

A Web Map Service is a standard protocol that can provide clients with images of maps together with the associated geo-referencing so that the images can be placed correctly in the mapping tool like a GIS or a web page like the Interactive Map for example. The WMS also provides a way for a user to download the data file (in netCDF format) that was used to generate a specific image, but the preferred method to download the data files is the FTP site.

Product	Description	Update frequency
10 min rain rate (mm/h)	Radar rainfall intensity	10 min
10 min rain depth (mm)	Radar rainfall accumulation	10 min
30,180, 1440 min rainfall accumulation (mm)	Radar and rain gauge blended accumulation for 30,180,1440 min	30 min
Maximum ARI for past 6 h	Maximum ARI for radar rainfall accumulations ranging from 10 min to 6 h	10 min
Rainfall forecasts – 90 min	Forecasts of 10 min rainfall to 90 min	10 min
Rainfall forecasts – 12 h	Forecasts of 3 h rainfall to 12 h	30 min
Maximum probability – 6 h	Maximum probability for rainfall accumulations ranging from 10 min to 6 h to exceed ARI thresholds	10 min

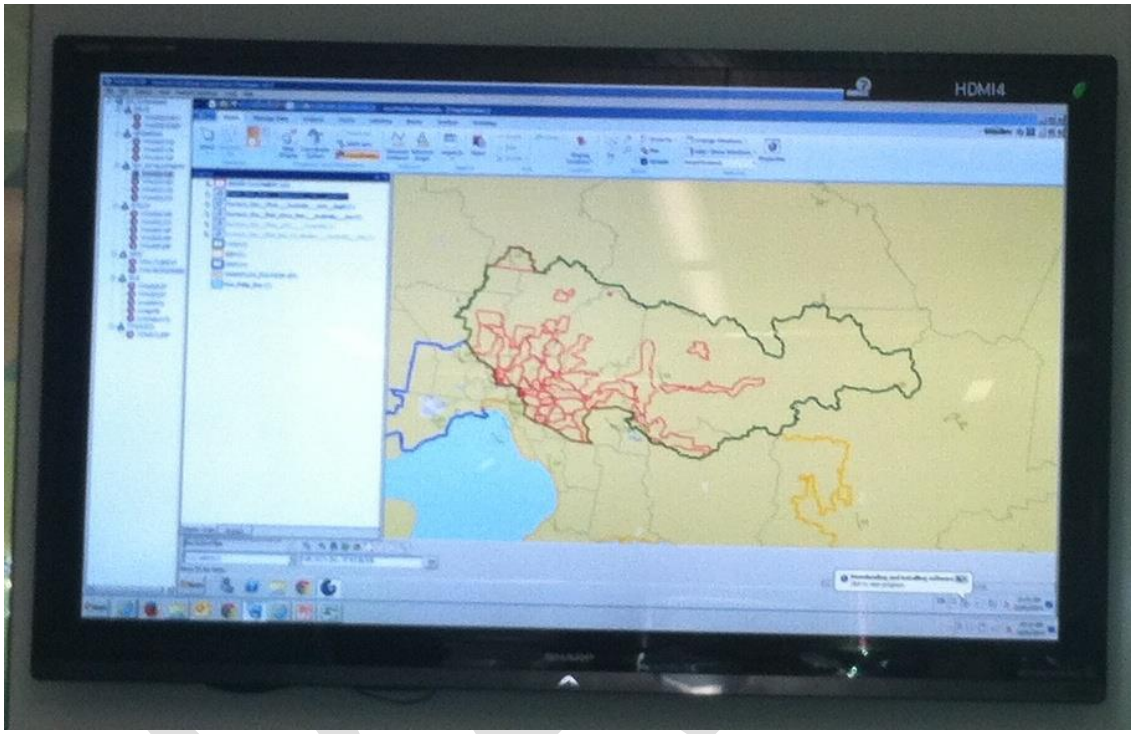
User Case Study: South East Water OneAsset Platform

An example of a Google Maps page showing the 90-min accumulation forecast that has been developed as a prototype by South East Water is shown below.



User Case Study: Yarra Valley Water GIS Platform

YVW was an early tester of the webmap service which was ingested into their Intergraph GIS system. They are currently seeking an understanding of future subscription costs before rolling out the service within their internal systems for user testing. It was considered premature to roll out before having this understanding. The display was demonstrated during initial stakeholder consultation workshop in January 2014 with operational staff from the Victorian water authorities.



FTP Data Download

The FTP data feed is designed to serve products that are of interest to the hydrological modellers when running their models in real-time and therefore includes the ensemble forecasts. The files that are under the /03day/ directory are resident for three days and files in the /10day/ directory are resident for 10 days after being placed on the FTP site.

Product	Description	Update frequency
10 min rain depth (mm)	Radar rainfall accumulation	10 min
30,60 min rainfall accumulation (mm)	Radar and rain gauge blended accumulation for 30,60 min	30 min
Maximum ARI for past 6 h	Maximum ARI for radar rainfall accumulations ranging from 10 min to 6 h	10 min
10 min rainfall forecasts	5 member rainfall forecast ensemble of 10 min rainfall to 12 h	10 min
60 min rainfall forecasts	35 member rainfall forecast ensemble of 60 min rainfall to 12 h	30 min
Maximum probability – 6 h	Maximum probability for rainfall accumulations ranging from 10 min to 6 h to exceed ARI thresholds	10 min

User Case Study: Melbourne Water Flood Integrated Decision Support System

Melbourne Water engaged an external contractor to develop a flood management system, similar to the modelling systems the bureau has adopted in the flood forecasting group. As part of this, Melbourne Water is ingesting live FTP feed of multiple products for modelling and visualisation as of December 2014. These include nowcast products and other standard registered user rainfall products. The system is not operating and undergoing internal user testing. Melbourne Water will be evaluating the additional benefits of nowcast products. As part of this they are keen to understand the ongoing costs, in order to perform cost benefit assessment.

Fully supported operational service

The Commercial Weather Services Section of the Bureau has agreed to transition the trial service into a service that will meet the operational requirements of availability and support. A service level agreement will be established as part of the service contract. This will include defining the number of contact hours for support and a costing framework should further support and training be required. The cost to the Bureau to establish and run the service for the first year will be $49500. As this cost must be covered for the Bureau to provide this service, it is envisioned that this cost will be shared among interested parties receiving the information, with the cost apportioned how the parties decide. In subsequent years, the on-going annual support cost is estimated to reduce marginally. Note that the ongoing costs are largely for maintenance and support and are therefore insensitive to number of products that a particular party subscribes to. Enhancements to the existing service so as to include other products would require a separate proposal with funding. Ongoing relationship between the external agencies and the Bureau is managed by the Commercial Weather Services Section.

The Interactive Map cost has been removed from this pricing in an effort to reduce the total cost to the stakeholders and will be developed separately by the Bureau and offered via an annual subscription at $1500 per agency. It is also in recognition that the interactive map is a basic entry point to enable users to become familiar with Bureau products and could be used as an external facing portal for testing other products, such as lightning, wind etc.

Other features of a fully supported operational service:

- The Bureau will have a dedicated team to respond to inquiries and address issues. This can be increased to 24/7 support at an enhanced cost.
- The service is hosted on an operational server with relevant archive capability and dedicated support and appropriate redundancy and backup.
- The changeover from the trial service will be seamless for our users - we don't envisage changes being required from the user end.
- Timely automatic warnings when any changes do occur, is part of standard bureau operational services and changes will be discussed and communicated to our users as required.
- As part of continuous improvement, the Bureau will consistently work to enhance the service through engagement with stakeholders.

Future product additions:

- The Bureau would like to discuss this opportunity with relevant stakeholders, and consider the investment required. A proposal can be provided separately.

Next Steps

We propose to workshop these options at the Smart Water Fund project closure meeting on the 4th March 2015. Commercial Weather Services Section will take this service forward and they will be the key contact point within the Bureau going forward with the closure of the Smart Water Fund research project on 31st March 2015.

It has been agreed the trial site be available for another 6 month for Smart Water Fund stakeholders to facilitate uptake and the transition from development servers to fully supported operational infrastructure. There will be continuity of service during this period.

Beyond this the Bureau will work with each client to help them with getting to the point where they can decide to subscribe and use the data.