Viewing Ensembles through the Eyes of the End User

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General Manager, Public Safety
HEPEX Workshop 6-8 February 2018

Australian Government
Bureau of Meteorology

Ensembles and their use by End - Users

- Australia is prone to natural disasters

  - Economic cost $18.2B/annum averaged over 10 years
  - Modelled to increase to a staggering $40B/annum by 2050**

- Water scarcity is an ongoing challenge to securing food security

  - $450M invested initially in the Bureau for Water data, information and insights

**Building Resilience to natural disasters in our states and territories

Australian Business Roundtable. Deloitte Access Economics, Nov 2017

Productivity Commission Inquiry Repot 2014
Natural Disaster Funding Arrangements

- Government thrust in funding response and recovery not efficient, equitable or sustainable
- Encourages cost shifting, ad hoc responses and short-term political opportunism

Paradigm Shift Proposed

- Increased focus on planning and mitigation (insurance and forecasting and warnings included in the initiatives)
- Funding proposed to increase for risk and resilience work

Institutional response to risk and resilience

- Institutional challenges – response agencies

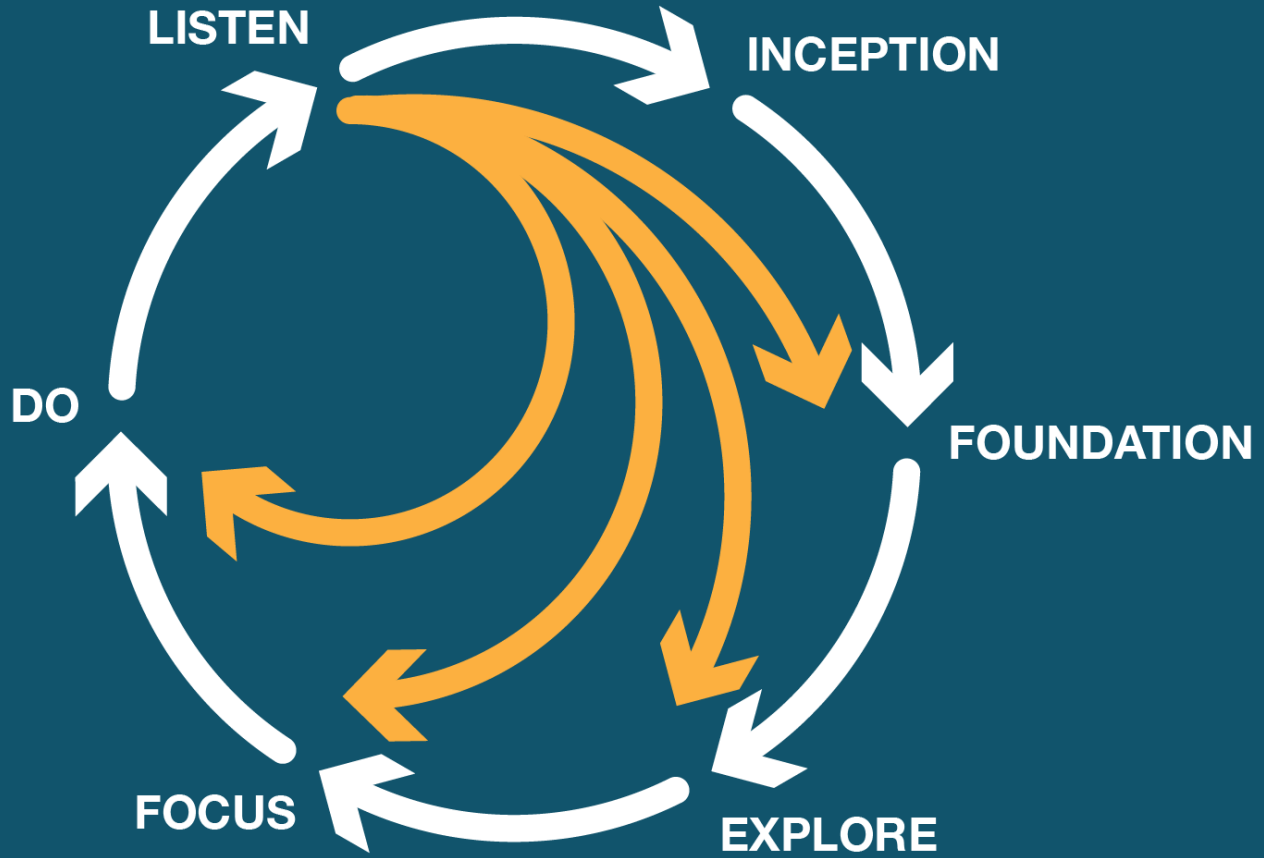
  - Increased financial pressures, high competition for $
  - Need DRR information to seamlessly dovetail with DSS systems
  - Need to understand and respond to risks (zero deaths and save or mitigate damage to critical infrastructure)
  - High public and political scrutiny

Public response to risk and resilience

❑ Understanding risks and valuing autonomy to act

- Informed by digital revolution and unprecedented pace of technology innovation
- Request for more frequent and near-personalised information
- Weary of unreliable 'third party' information providers
- Increased reluctance to evacuate ~ I know better than you, what to do because …….

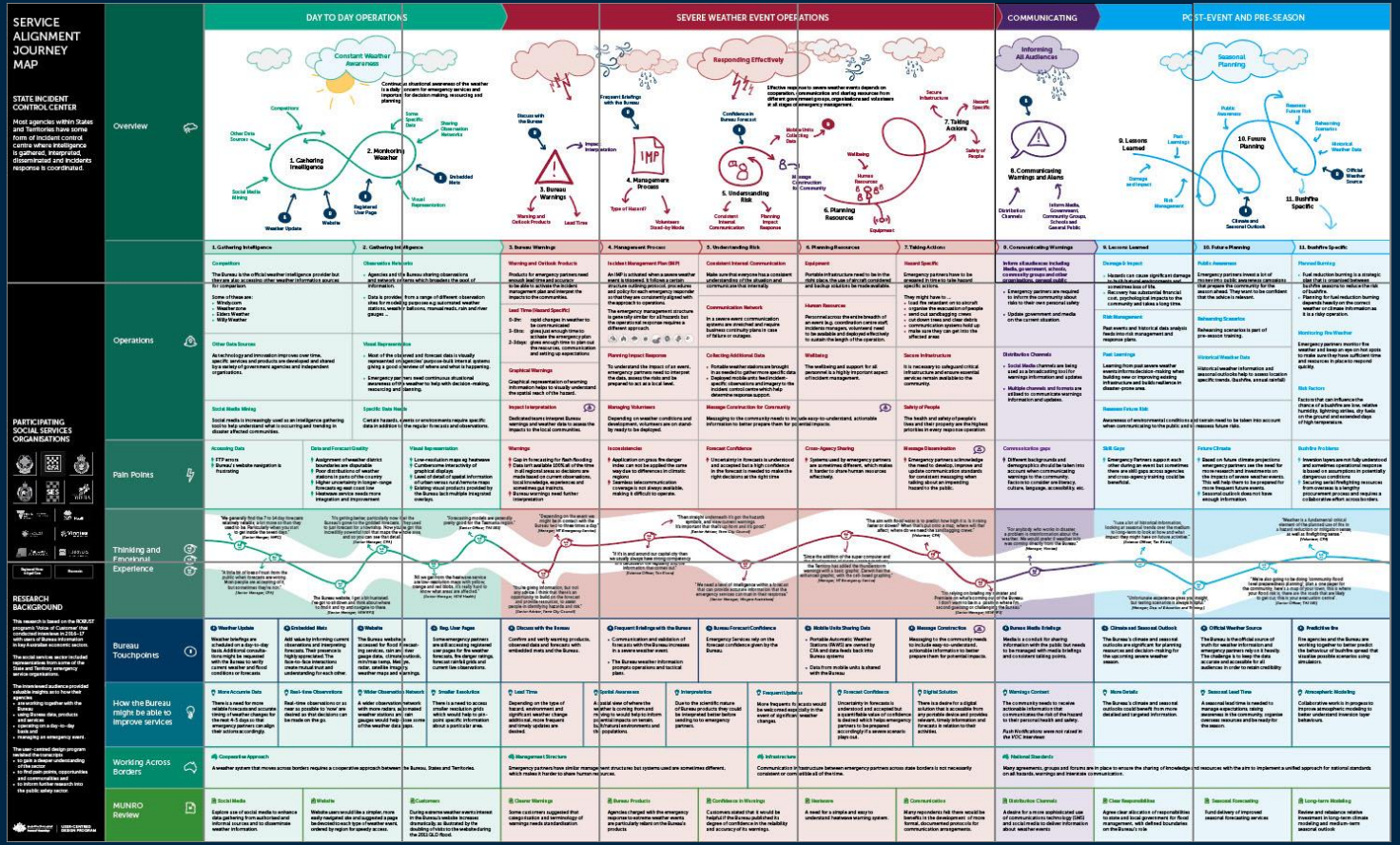
Method



'Voice of customer' data


USER CENTERED
NEW PRODUCTS
REVIEW

VOC - Artefact



The Voice of the Customer (VoC)**

- ❑ Need to be able understand risks associated with decisions
- ❑ Planning phase equally important when developing options to mitigate impacts
- ❑ Qualitative advice is useful, but the need is for quantitative assessments of risk

** Limited to elements associated with forecasts and warnings.

There are other key messages about value and impact not covered here

Bureau's Response to the VoC

- Commitment to increased Impact Based Forecasting over the next 5 years
- Roadmap to incrementally progress quantitative assessment of risks partnering response agencies
- Initiate a Warnings Framework Review and implement recommendations
- Other complementary initiatives ……..

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Flood Forecasting and Warning
Tropical Cyclone Debbie

Australian Government
Bureau of Meteorology

Flood Warning Decision Making

Flood Forecasters need to decide:

- When to issue a warning?
- What levels will the river reach (minor/moderate/major)?
- Time and height of peak?

Emergency services agencies need advice on:

- When will it reach the bridge level and impact evacuation ?
- When will it exceed the levee or other critical levels (water supply, power, hospital, aged care facilities?
- When will it peak and how high will it get ?
- How long will it stay above a certain level – eg. bridge, major, levee?

Understanding the uncertainty of forecasts at different lead times is critical to these decisions

Users decisions are dependent on timing, amplitude and volume of flood forecasts … and there is uncertainty in all

Minor

Moderate

Major

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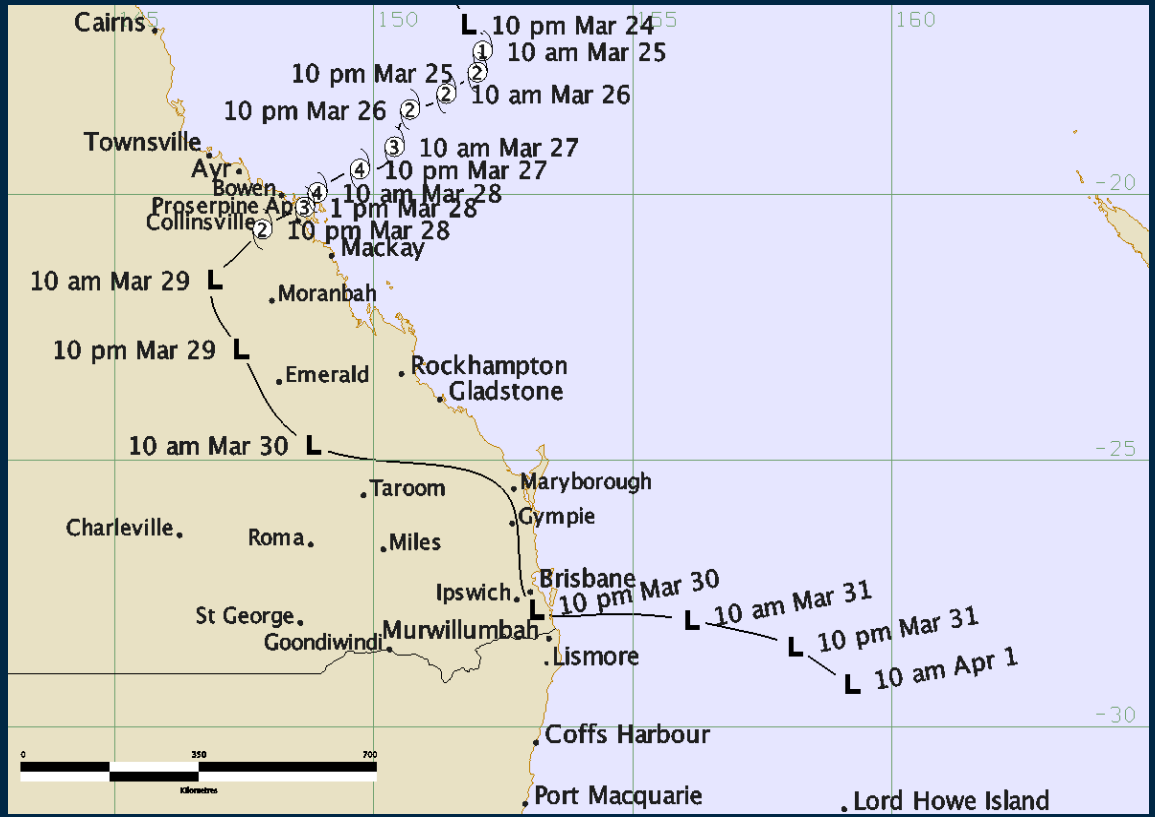
Case study for Severe Tropical Cyclone Debbie

- Severe tropical cyclone Debbie made landfall near Airlie Beach on Tuesday,
  28th March 2017
- After Debbie made landfall and weakened below tropical cyclone strength, it developed into a tropical rain depression and moved southeast



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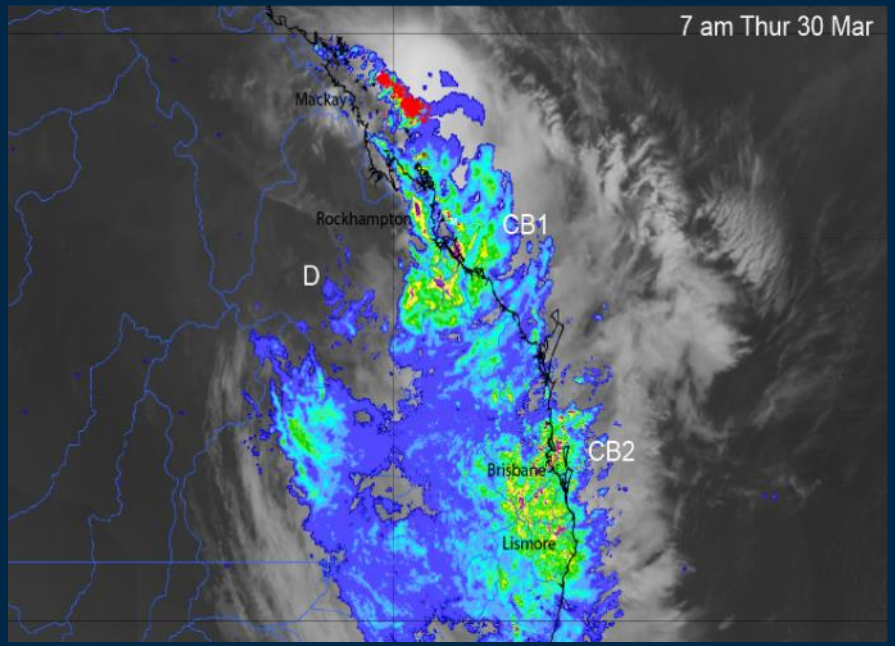
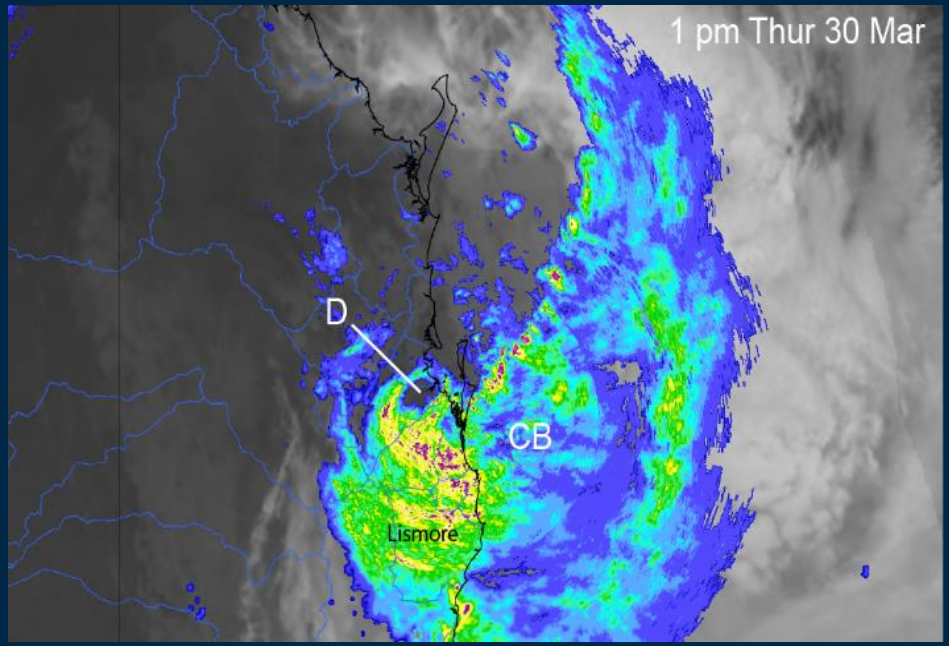
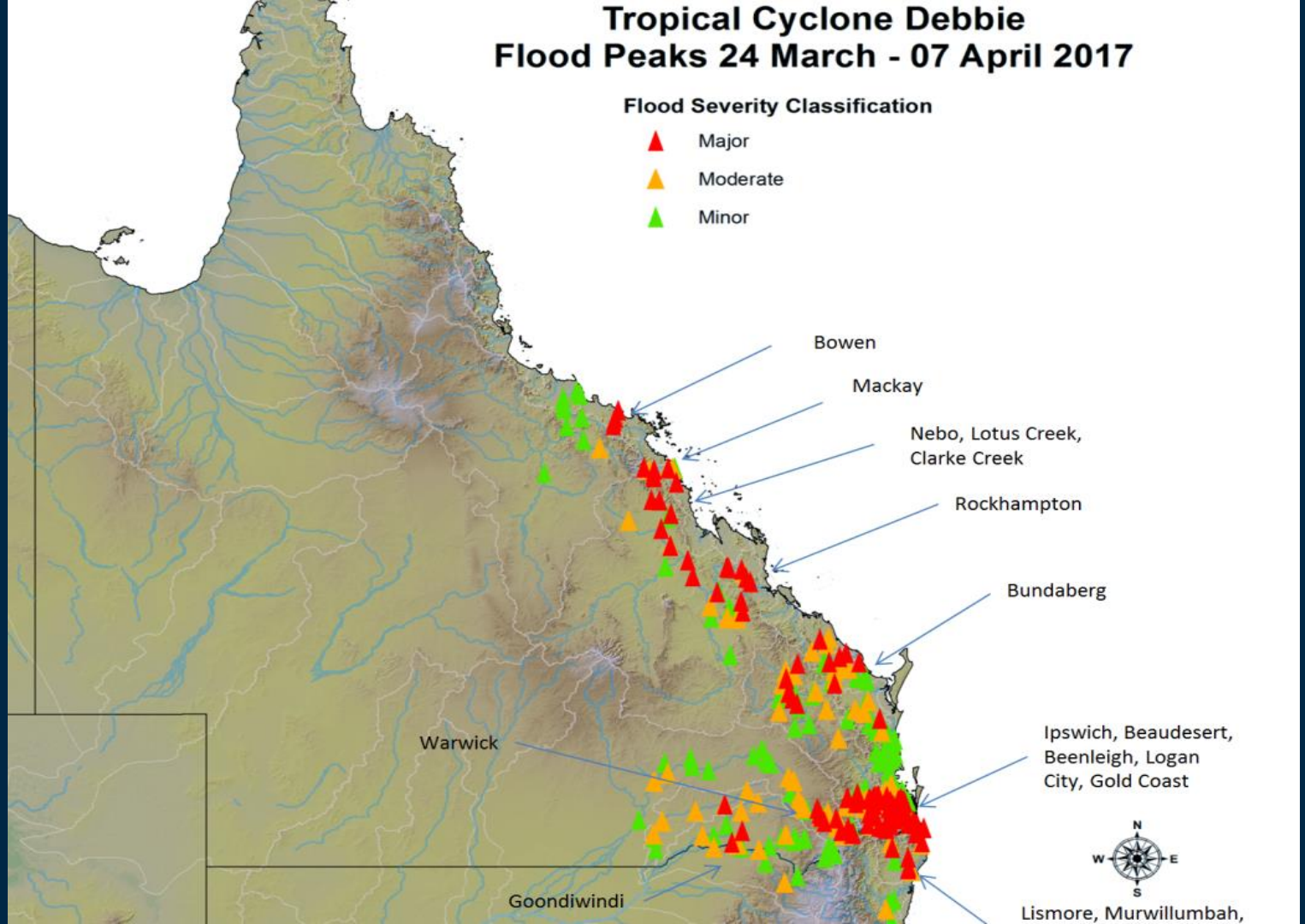
Severe tropical cyclone Debbie

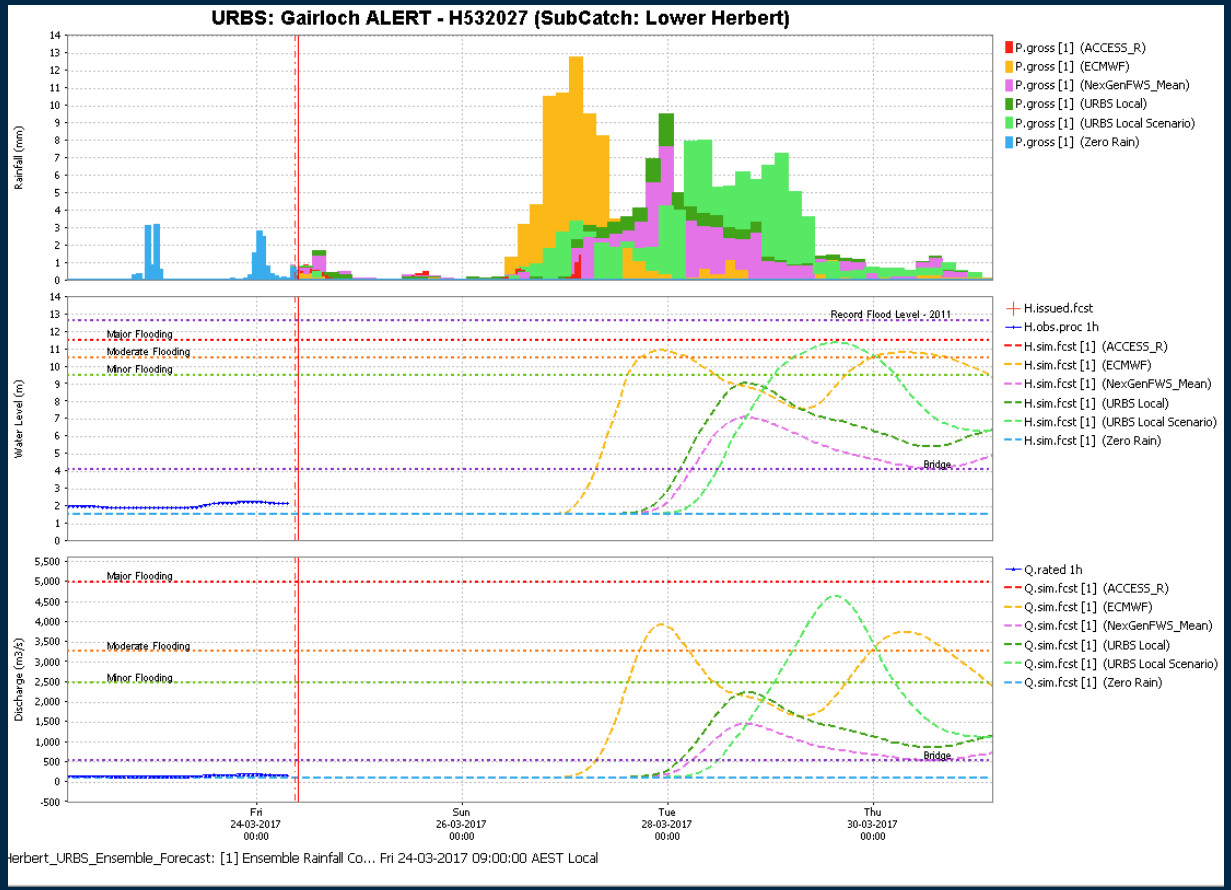




CB1 & CB2:Convective bands 1 and 2. D indicates the centre of the cyclone


Tropical Cyclone Debbie
Flood Peaks 24 March - 07 April 2017
Flood Severity Classification
Major
Moderate
Minor
Bowen
Mackay
Nebo, Lotus Creek,
Clarke Creek
Rockhampton
Bundaberg
Warwick
Ipswich, Beaudesert,
Beenleigh, Logan
City, Gold Coast
Goondiwindi
Lismore, Murwillumbah,
N
W
E
S

Multi-model spaghetti ensemble - what the flood forecaster currently uses to make decisions



Decision making under great uncertainty:

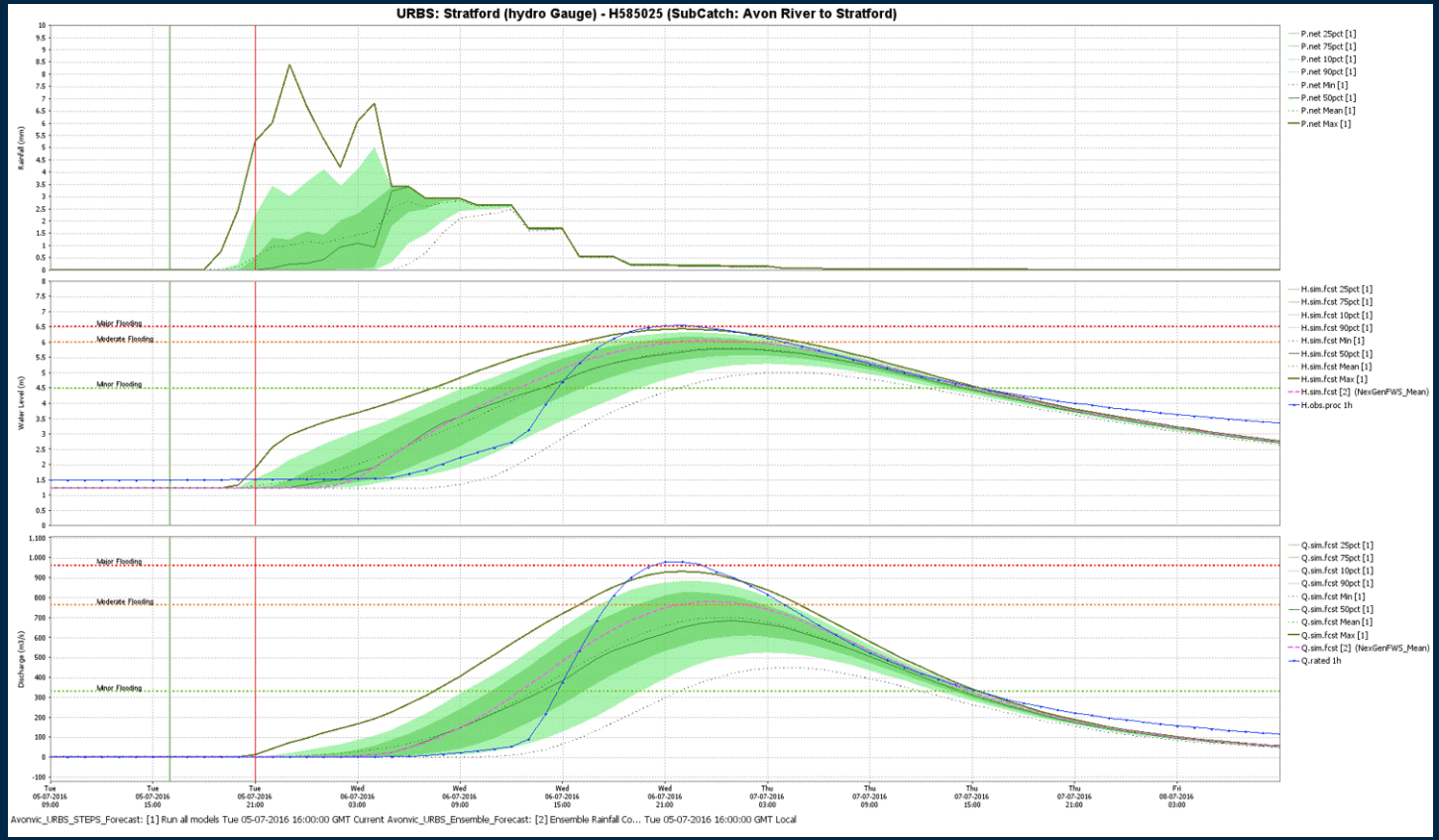
- ECMWF gives two moderate peaks two days apart
- ACCESS gives one major peak 24 hours after the first ECMWF peak
- Forecaster enhanced gridded rainfall gives below minor

What we provided our customers … great result but we can do better !

Catchment	Now (Thurs pm)	Thursday night and Friday	Possible Saturday and Future
Lower Burdekin	Minor	Minor easing	Easing to below minor
Don	Minor easing	Easing to below minor	
Pioneer	Fallen below minor.		
Fitzroy	**Major** in Connors/Isaac, Moderate in the Mackenzie,	Possible minor to moderate in the Dawson, Don and Callide, **Major** in the Mackenzie	Potential moderate to **major in Rockhampton** developing next week
Baffle, Kolan, Calliope	Moderate	Major possible	Major possible
Burnett	Minor in Upper Burnett	**Moderate** in upper Burnett	Potential **minor** flooding in Bundaberg
Noosa, Sunshine Coast	Some further rainfall and flash flooding possible	Stream rises and possible minor flooding	
Mary	Some further rainfall and flash flooding possible	Minor possible	Minor possible
Brisbane, Pine, Brisbane Creeks (Bremer, Lockyer, Laidley, Warrill creeks)	Minor to Moderate in the upper catchment, widespread flash flooding	**Moderate to Major** in Brisbane tributaries	Minor flooding at high tide in Brisbane city
Logan, Albert	Heavy rainfall and flash flooding	**Major** flooding in upper catchment, **moderate** in lower catchment.	Rises to **major flooding** likely
Condamine	Heavy rainfall and flash flooding possible	Rises to **moderate** possible	Rises **moderate to major** flooding possible
Balonne and Maranoa	Heavy rainfall and flash flooding	Some minor flooding possible	Rises **minor to major** flooding possible
South Coast / Nerang	Heavy rainfall and flash flooding	Stream rises and possible minor flooding	

"*TC Debbie was probably the best planned disaster we have ever had*". Inspector General of emergency Management

Example – Major flood Avon River at Stratford (VIC) – July 2016



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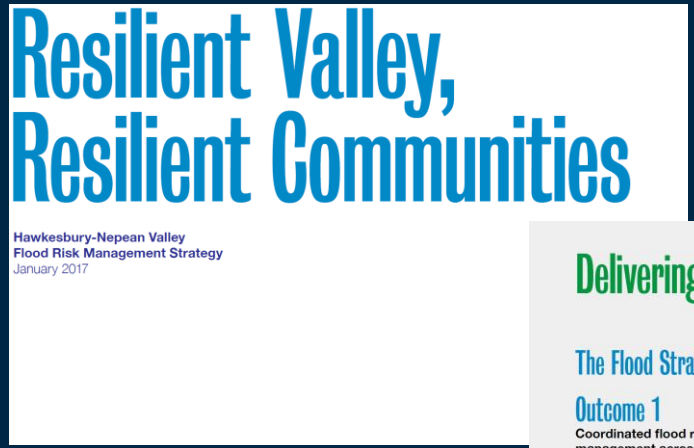
Optimising reservoir operations and extending flood warnings

Hawkesbury-Nepean Valley Flood Risk Management Strategy



Source: Infrastructure NSW, 2017. Resilient Valley, Resilient Communities. Hawkesbury-Nepean Valley Flood Risk Management Strategy.

Hawkesbury-Nepean Valley PMF

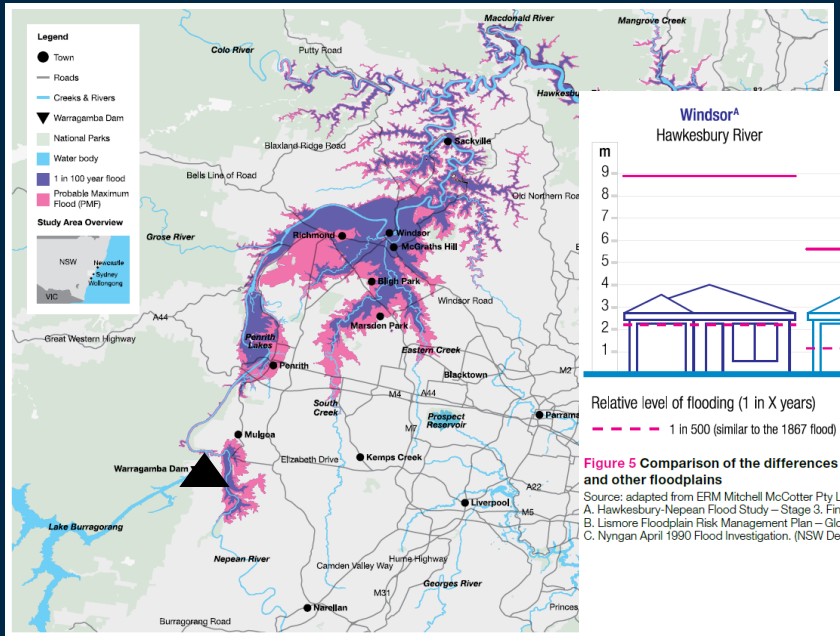


Figure 1 The Hawkesbury-Nepean Valley Floodplain

Base data courtesy of NSW State Emergency Service

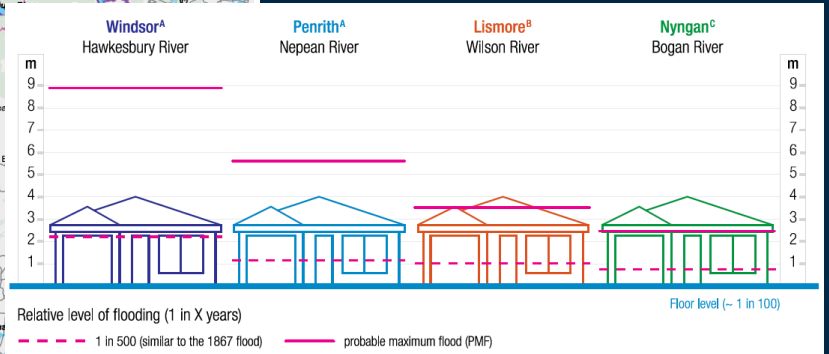


Figure 5 Comparison of the differences in flood levels and flood risk between the Hawkesbury-Nepean River at Windsor and other floodplains

Source: adapted from ERM Mitchell McCotter Pty Ltd (1995). Proposed Warragamba Flood Mitigation Dam – Environmental Impact Statement (Volumes 1, 2 & 3).
A. Hawkesbury-Nepean Flood Study – Stage 3. Final Report (WMAwater Pty Ltd, March 2016)
B. Lismore Floodplain Risk Management Plan – Glossary and Appendices (Lismore City Council, 2014)
C. Nyngan April 1990 Flood Investigation. (NSW Department of Water Resources, 1990)

Source: Infrastructure NSW, 2017. Resilient Valley, Resilient Communities. Hawkesbury-Nepean Valley Flood Risk Management Strategy.

Hawkesbury-Nepean Valley Flood Impacts

If these floods happened today (2016)

In a flood similar to the Brisbane 2011 floods (1 in 100 chance per year):

5,000
residential properties impacted

$2 bn
in damages

64,000
people need to evacuate

In a flood similar to the largest flood in European history (1867 flood):

12,000
residential properties impacted

$5 bn
in damages

90,000
people need to evacuate

Or by 2041

By 2041, impacts of an 1867-like flood are estimated to increase dramatically, even under conservative assumptions

$7 billion
in damages

158,000 – 171,000
people need to evacuate

Infrastructure NSW | Hawkesbury-Nepean Valley Flood Ris

Image 1 Impact of a 1 in 500 chance per year flood at Penrith (similar in size to the largest flood on record – the 1867 flood).

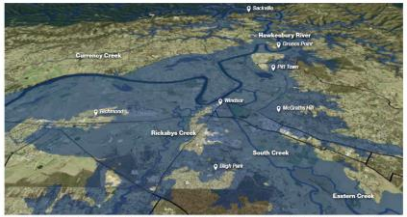


Image 2 Impact of a 1 in 500 chance per year flood at Windsor (similar in size to the largest flood on record – the 1867 flood).

Image 3 The corner of Macquarie Street and Windsor Road, Windsor today (2014) and the extent of flooding in 1961 (between a 1 in 20 to 1 in 50 chance per year flood).
Source (L): Barry Gibbons Collection, Courtesy of Hawkesbury Regional Museum
Source (R): Hawkesbury Camera Club, Courtesy of Hawkesbury Regional Museum

Image 4 George Street, Windsor today (2014) and during the 1961 flood (between a 1 in 20 to 1 in 50 chance per year flood).
Source (L): Barry Gibbons Collection, Courtesy of Hawkesbury Regional Museum
Source (R): Hawkesbury Camera Club, Courtesy of Hawkesbury Regional Museum

Infrastructure NSW | Hawkesbury-Nepean Valley Flood Risk Management Strategy Summary report 15

Source: Infrastructure NSW, 2017. Resilient Valley, Resilient Communities. Hawkesbury-Nepean Valley Flood Risk Management Strategy.

Hawkesbury-Nepean Valley Evacuation Modelling

Data61 Evacuation Planner

https://research.csiro.au/data61/nicta-evacuation-planner/

DATA 61 CSIRO

NICTA Optimisation Research Group
Published on May 27, 2015

Motivation for the HNV Project

- The Bureau's Service Level Specification (SLS):
  - Penrith 8 hours for > 11.3 m
  - North Richmond 15 hours for > 18 m
  - Windsor 15 hours for > 16 m
- Flood evacuation modelling shows the above lead times are insufficient for effective safe evacuation of HNV
- Each additional hour of lead time may provide opportunity for evacuation of up to 6000 additional cars

IDN36609
Australian Government Bureau of Meteorology
New South Wales

MINOR TO MODERATE FLOOD WARNING FOR THE NEPEAN RIVER

Issued at 9:46 am EST on Sunday 5 June 2016

Flood Warning Number: 1

Up to 285 millimetres of rain has fallen over the Nepean River catchment in the last 24 hours to 9am this morning [5/6/16]. However, rain has intensified in the last 6 hours, with up to 190 millimetres falling during this period.

This rainfall is expected to cause moderate flooding in the Nepean River at Menangle, and minor flooding at Camden and Wallacia.

Further heavy rainfall, in the order of 100 to 150 millimetres, is forecast for the Nepean, Wollondilly and Hawkesbury River valleys in the next 12 hours.

Flooding of the Hawkesbury-Nepean River at Penrith and downstream is possible with this forecast rain. The situation is being closely monitored and predictions will be issued if necessary.

At this stage it is not possible to predict the flood peak because of uncertainty over how much more rain will fall.

Predicted River Heights/Flows:

Menangle

- exceed moderate flood level (9.2 metres) around 5pm Sunday [5/6/16]
- with forecast rain reach 11 metres around 10pm Sunday [5/6/16], with moderate flooding
- further rises possible

Camden Weir

- with forecast rain reach minor flood level (6.8 metres) around 8pm Sunday [5/6/16].
- further rises possible

Wallacia Weir

- reach minor flood level (5.0 metres) around 5pm Sunday [5/6/16].
- further rises possible

FloodSafe advice is available at www.ses.nsw.gov.au

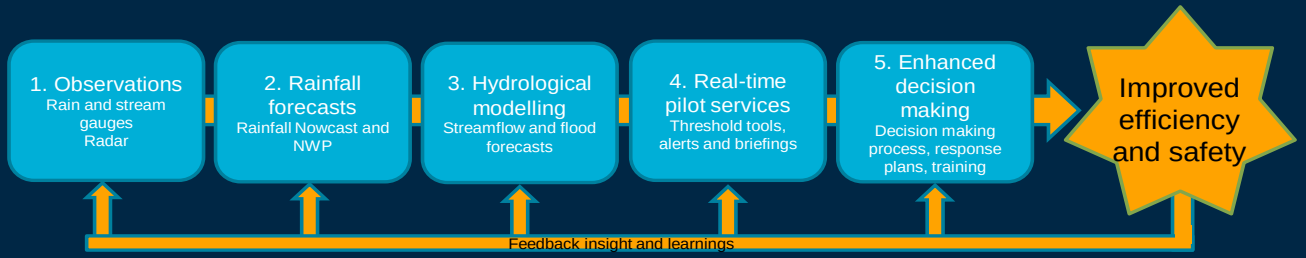
For emergency assistance call the SES on telephone number 132 500.
For life threatening emergencies, call 000 immediately.

Weather Forecast:
For the latest weather forecast see www.bom.gov.au/nsw/forecasts/

Next Issue:
The next warning will be issued by 2pm Sunday [5/6/16].

Flood warning issued for the June 2016 East Coast Low

HNV Project Components



Project objectives:

- Confirmation of the suitability of the flood warning network underpinning the proposed HNV flood warning system and radar-rainfall estimation systems.
- Identify extensions to the network that may be required to extend the flood warning service to new locations.

- Extension of STEPS to enable longer lead time hydrological forecasts.
- Evaluate the accuracy of the STEPS rainfall forecasts over the HNV catchment.

- Improve the quality and accuracy of the hydrological models.
- Integrate the latest ensemble forecast rainfall into HyFS.
- Set up real time ensemble hydrological forecasts.
- Peer review of hydrological models.

- Forecast services are provided that meet SES and other stakeholder needs.
- Provide a pilot service.
- Provide a proposal and outline plan for transitioning from pilot to operations.

- Stakeholders understand how project deliverables can be used in risk based decision making.
- Forecasts integrated into WaterNSW and SES processes.
- Risk based decisions are based on the best available evidence.
- Lessons learned can be addressed in future operationalisation.

Outcomes:

- Vulnerable communities evacuated when required.
- Optimised dam operations (pre, during and post event releases).
- Longer lead times for decision making.
- Services and processes that stand up to community and government scrutiny.

Work packages:

1.1 Audit of network to ensure it meets coverage, quality and availability requirements.

2.1 Extension of STEPS to provide longer lead-time predictions.
2.2 Evaluation of the likely accuracy of rainfall forecasts.

3.1 Full review and recalibration of the hydrological models
3.2 Integrate ensemble rainfall forecasts in HyFS
3.3 Set up real time ensemble hydrological forecasts.
3.4 Peer review of flood forecasting models.

4.1 Co-designed tailored forecast products for WaterNSW and SES.
4.2 Pilot forecasting service.

5.1 Work with SES and WaterNSW to develop processes to use forecasts
5.2 Training of WaterNSW and SES Staff.
5.3 An end-to-end flood simulation exercise.
5.4 External review of processes and protocols to meet expectations.

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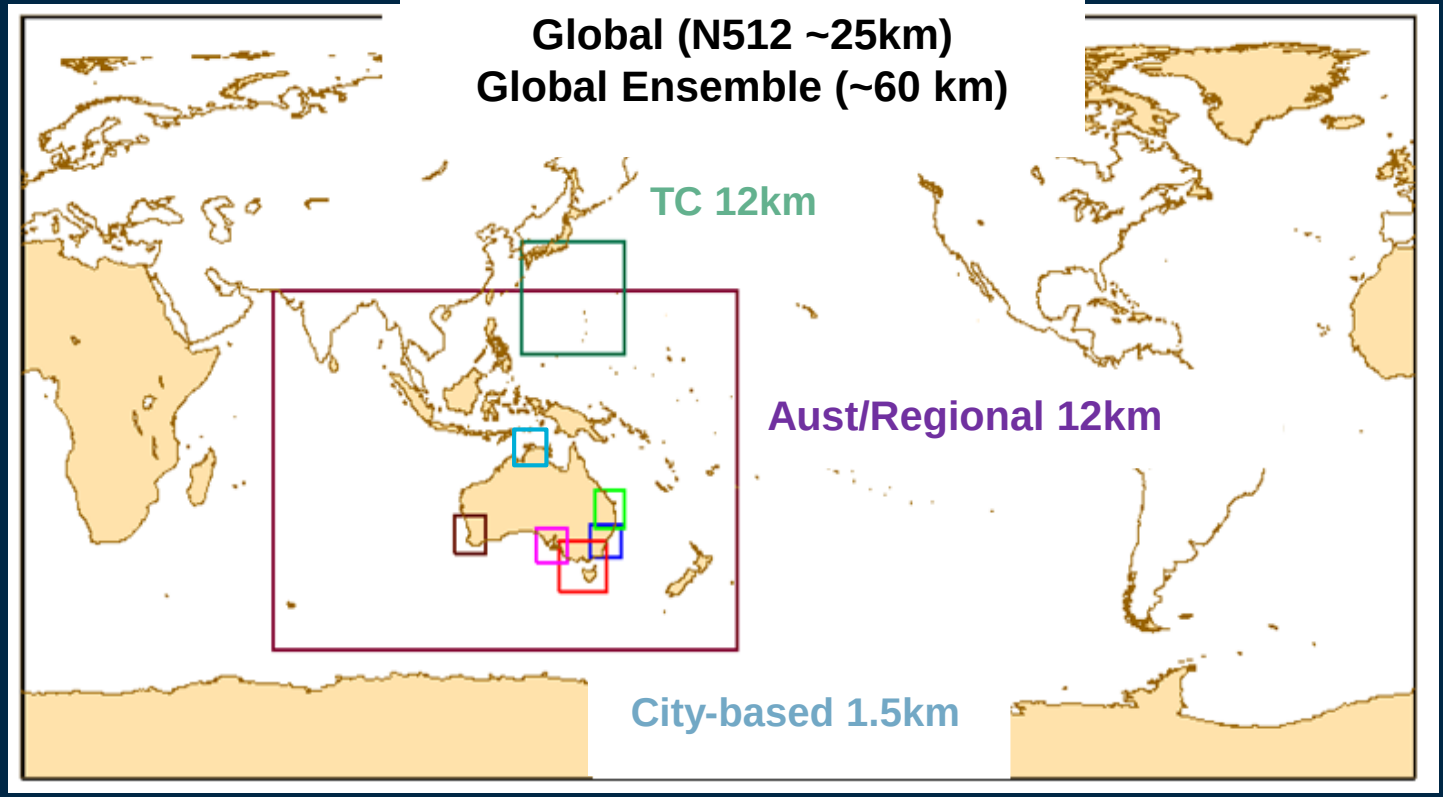
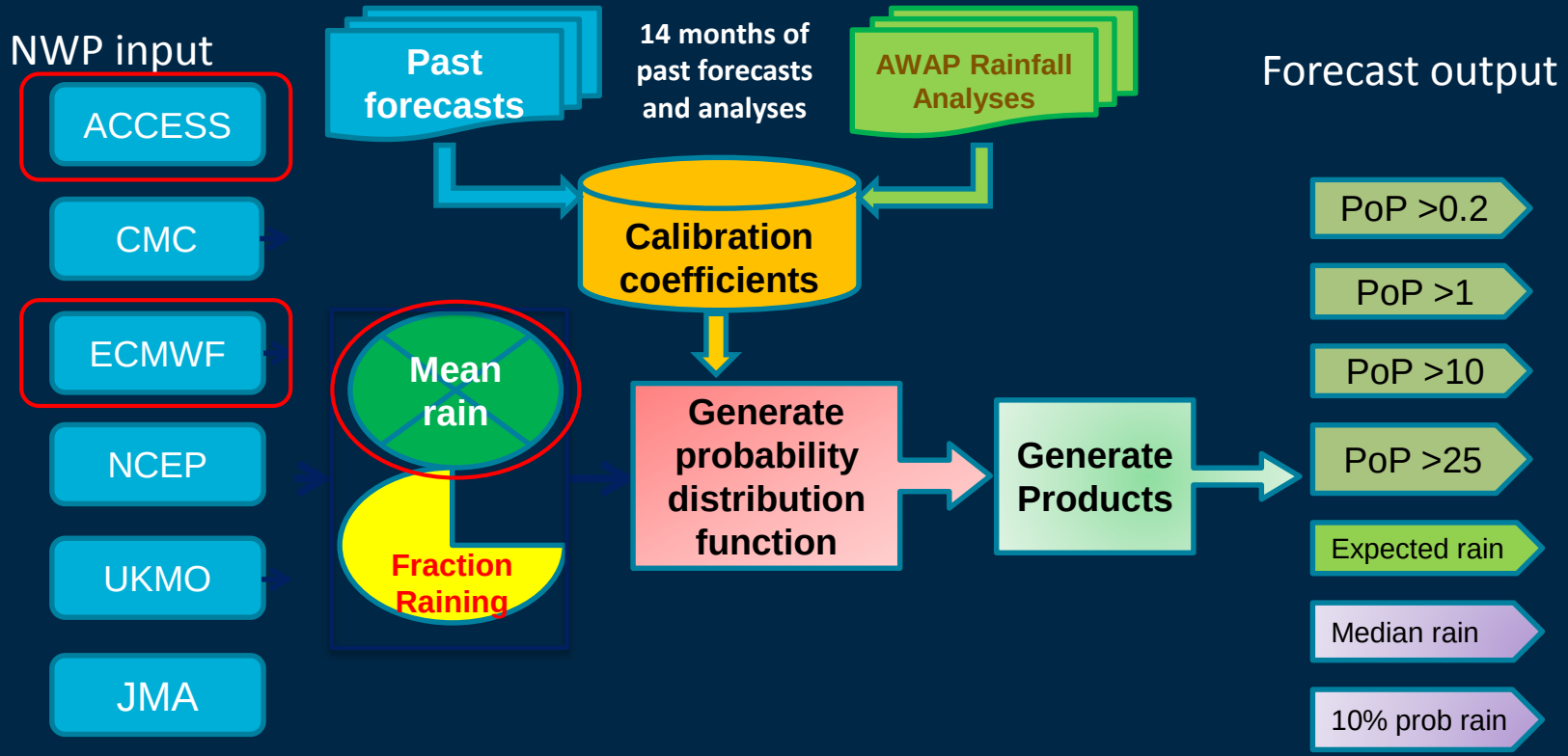
Short-term water forecasting services – Managing Environmental Flows

Suite of ACCESS numerical weather prediction models



Rainfall uncertainty and post processing



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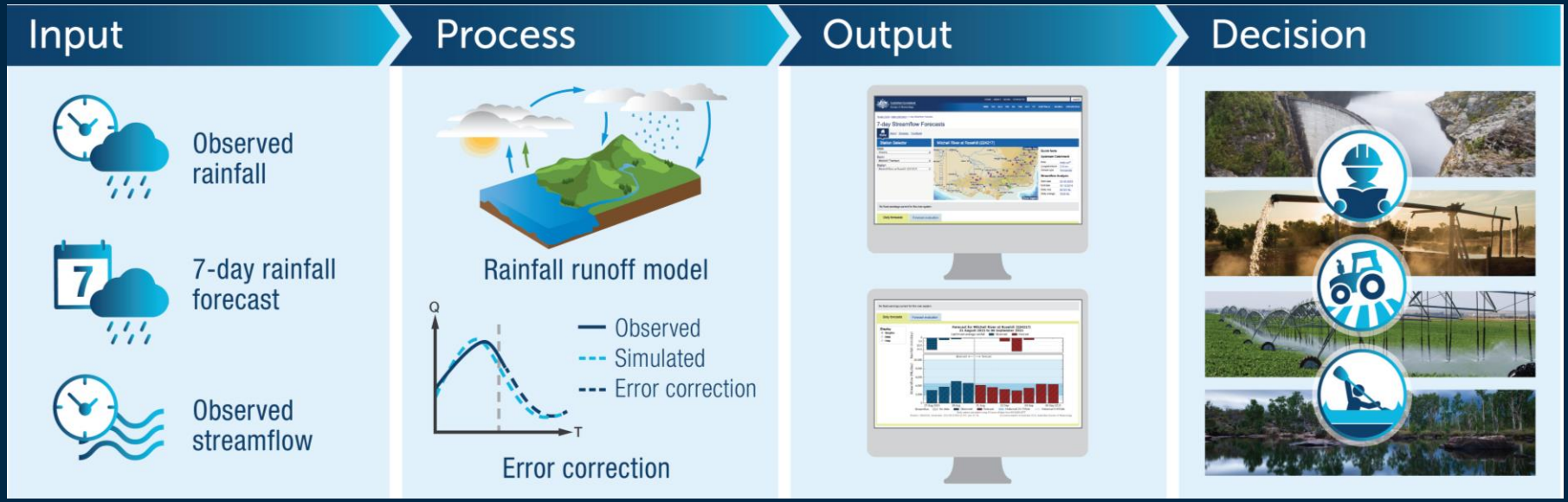
Sourced from Phil Riley, Bureau of Meteorology

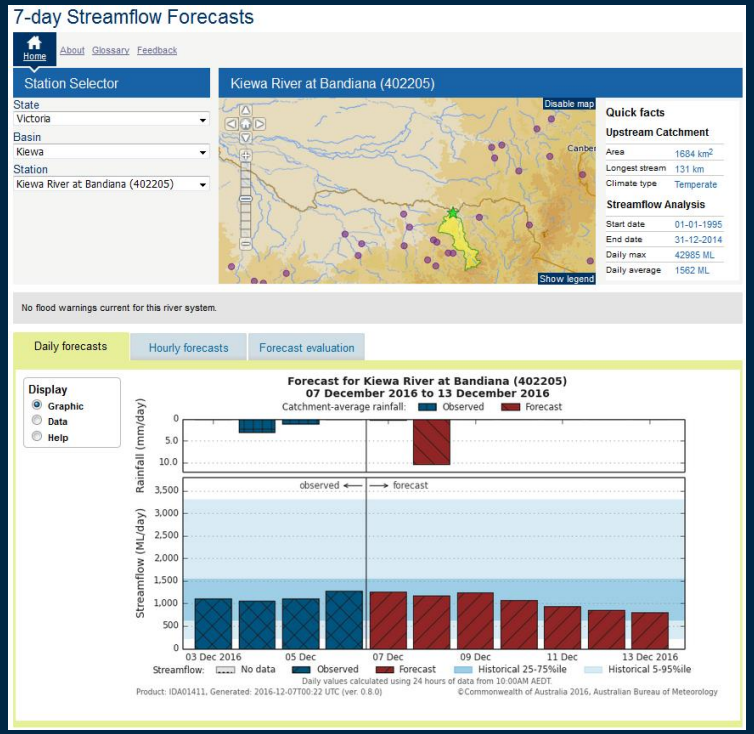
7 day streamflow forecast service



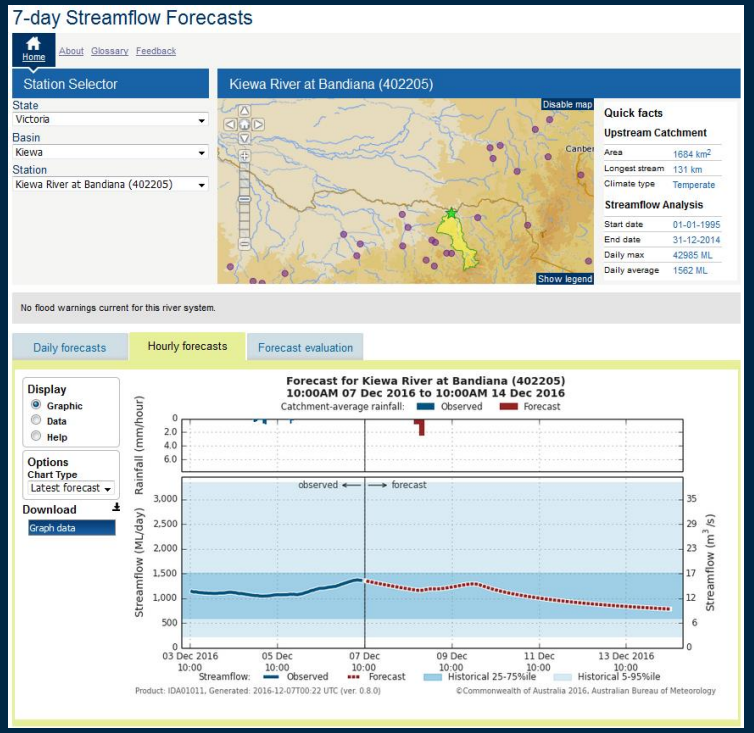
http://www.bom.gov.au/water/7daystreamflow

7 day streamflow forecast service

Public product (daily) – 168 sites



Registered user product (hourly) – 209 sites



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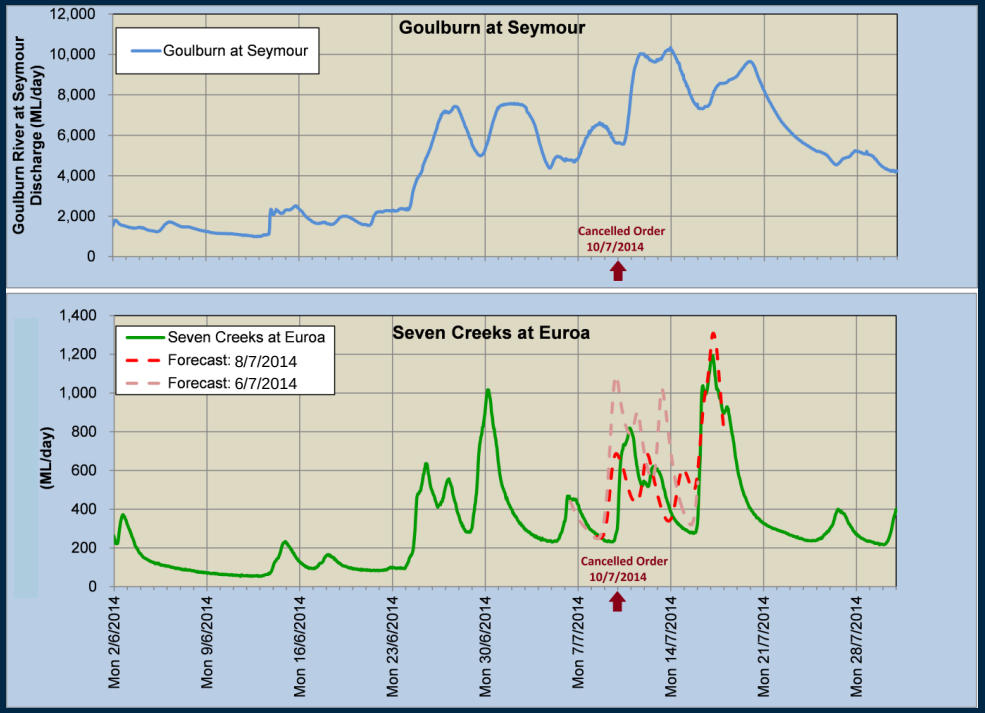
http://www.bom.gov.au/water/7daystreamflow

Case Study – Goulburn Broken Catchment, Victoria



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"reinforced the decision to cancel the planned environmental release" (Andrew Shields, GMW, 25th July 2016).

Case study: Upper Murray (MDBA)

SERVICES IN THE SPOTLIGHT

Forecasting 7-day streamflow for river operations

Water levels in our rivers and reservoirs rise and fall, depending on the amount of rainfall and how much of that reaches our waterways. River operators keep a close eye on these fluctuations to ensure that irrigation and environmental water needs are met throughout the year. A key part of their job is assessing the amount of water likely to flow down rivers and into reservoirs in the coming days, weeks and months. The Bureau of Meteorology's 7-day streamflow forecasts help them make those assessments.

Each day, the Bureau issues 7-day streamflow forecasts for more than 100 locations across the nation. These forecasts are generated by combining real-time observations of rainfall and streamflow with rainfall forecasts and hydrologic models. They provide valuable guidance to river operators who make choices about flow diversions and reservoir releases. The forecasts also benefit irrigators, water traders and people using the rivers for recreation.

The 7-d
forecas
manage
Hume.

Having these forecasts is fantastic! It allows us to more accurately estimate what these natural inflows will be. This means we can meet our Lake Mulwala objectives with greater precision by making the right releases upstream. We can also plan for releases in conjunction with natural flows to improve environmental outcomes downstream.

Andrew Bishop
River Operator
Murray–Darling Basin Authority

Bureau of Meteorology

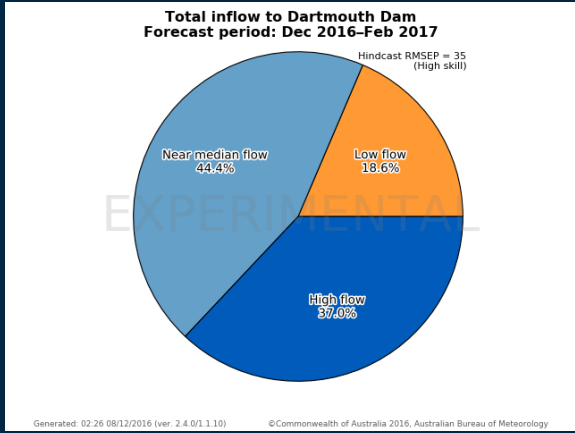
Seasonal streamflow forecast service
Issuing Water Allocations

1-month and 3-month streamflow volumes

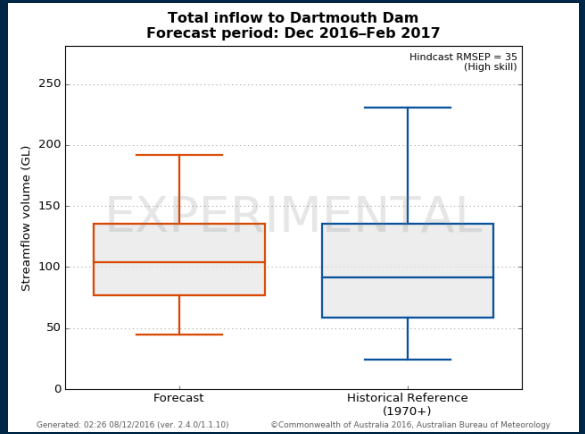
Australian Government
Bureau of Meteorology

Seasonal streamflow forecast products

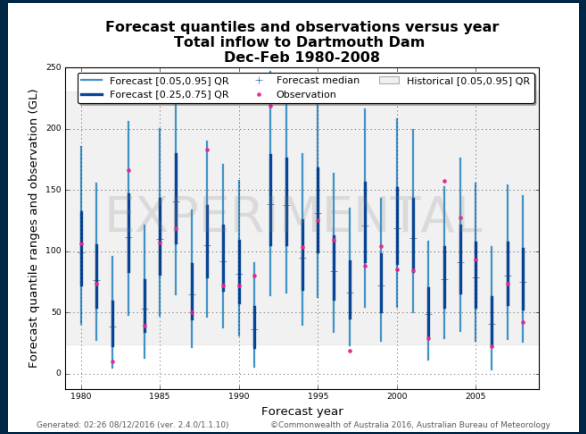
Tercile forecasts



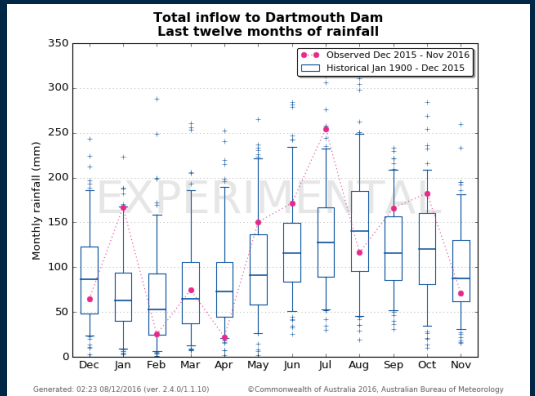
Ensemble forecasts



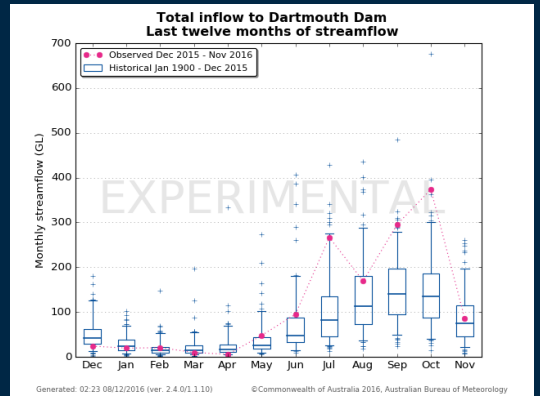
Forecast skill



Catchment rainfall



Catchment streamflow



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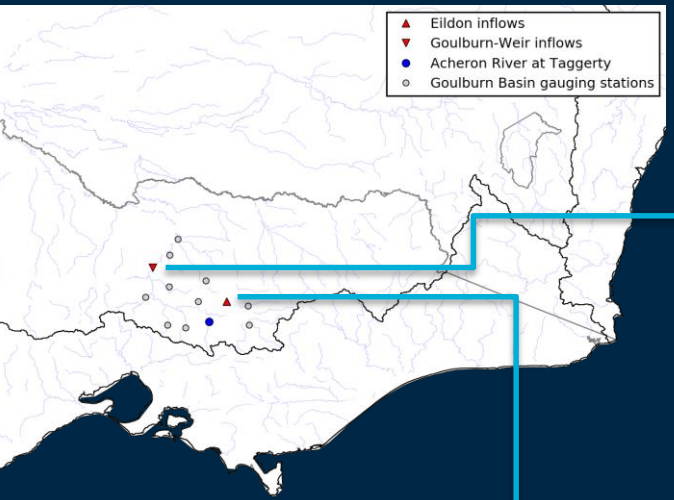
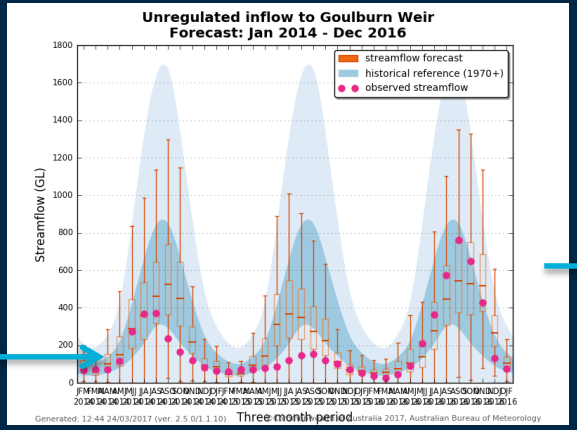
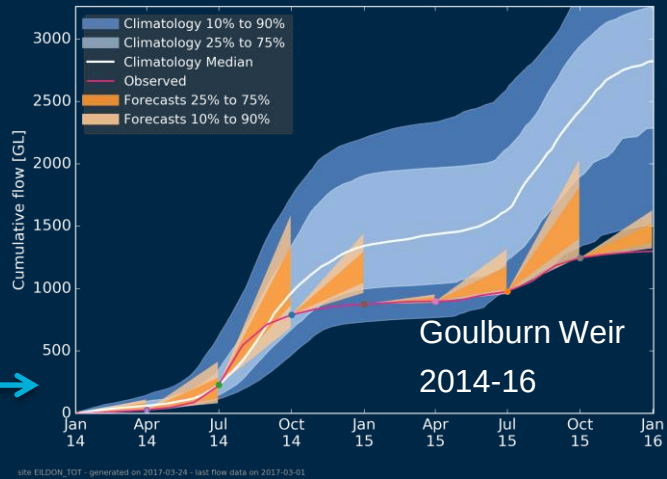
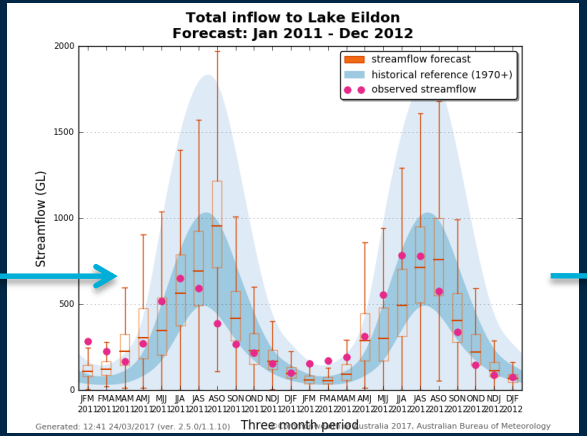
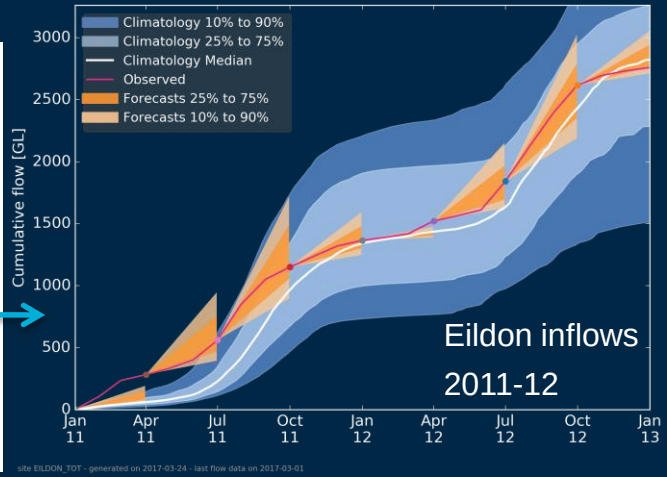
Streamflow forecast examples from MDB











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Linkages with water allocation planning (Wyangala, NSW)

Department of Primary Industries Water

Water Allocation Statement

16 March 2017

Lachlan Valley

Water availability and allocation update

Allocations

The total allocation for general security licence holders in the Lachlan Regulated River for 2016/17 water year **remains unchanged at 124 per cent of entitlement.**

Wyangala Dam received just 45,000 megalitres of inflow during the period November 2016 to February 2017. Storage levels have reduced from full capacity in late October 2016 to approximately 88 per cent at present.

There is an assessed **deficit of 32,000 megalitres** this month before further allocation can be made. Inflows to Wyangala Dam so far in March have been negligible.

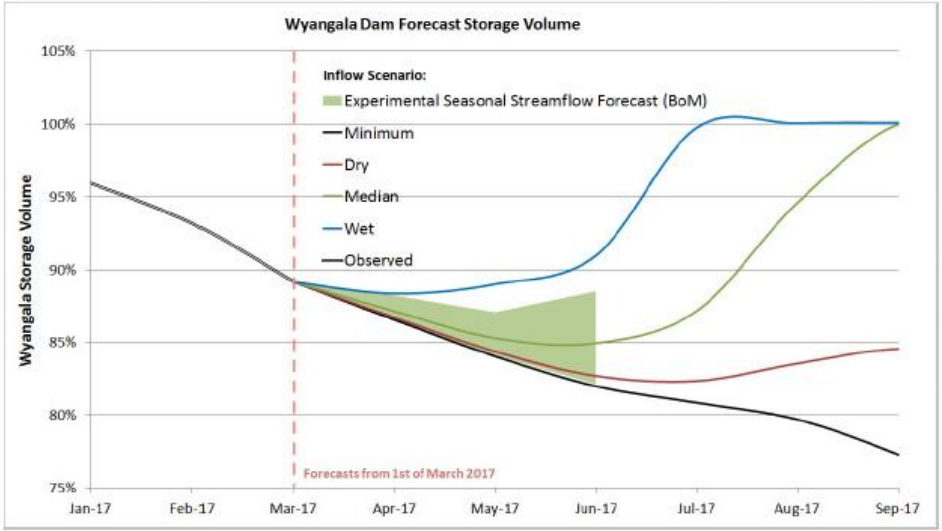
General security water users are advised that the **Annual Use Limit** that will apply in the 2017/18 water year will be a volume equivalent to **100 per cent of entitlement,** plus any adjustments up or down for trade.

	High Security	General Security	Average Carryover
Lachlan valley	100%	124%	0%

Department of Primary Industries Water

Water Allocation Statement

Forecast storage volume



In summary…..

- Understanding risks from natural hazards is pivotal to building resilient communities, sustaining industry and protecting critical infrastructure

- Hydrological ensembles are centric to driving many DSS

- Institutional challenges include adoption of scientific advances
  - Collaborative case studies are breaking barriers

- Public challenges include communicating risks and avoiding misuse
  - User centric design requires deep understanding of the customer

Thank you

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