Namoi Source Model – Stakeholder engagement

Workshop 4
Evaluation and Reference Scenarios

7 November 2022

NSW GOVERNMENT

Acknowledgement of Country

As we are meeting across the state in this virtual space, each of us stands upon the lands of many different Nations.

I acknowledge the Traditional Custodians of all the Nations we are meeting from.

I pay my respect to all Elders; past, present and emerging and extend that respect to other Aboriginal and/or Torres Strait Islander Peoples joining us today.

Nikita Ridgeway

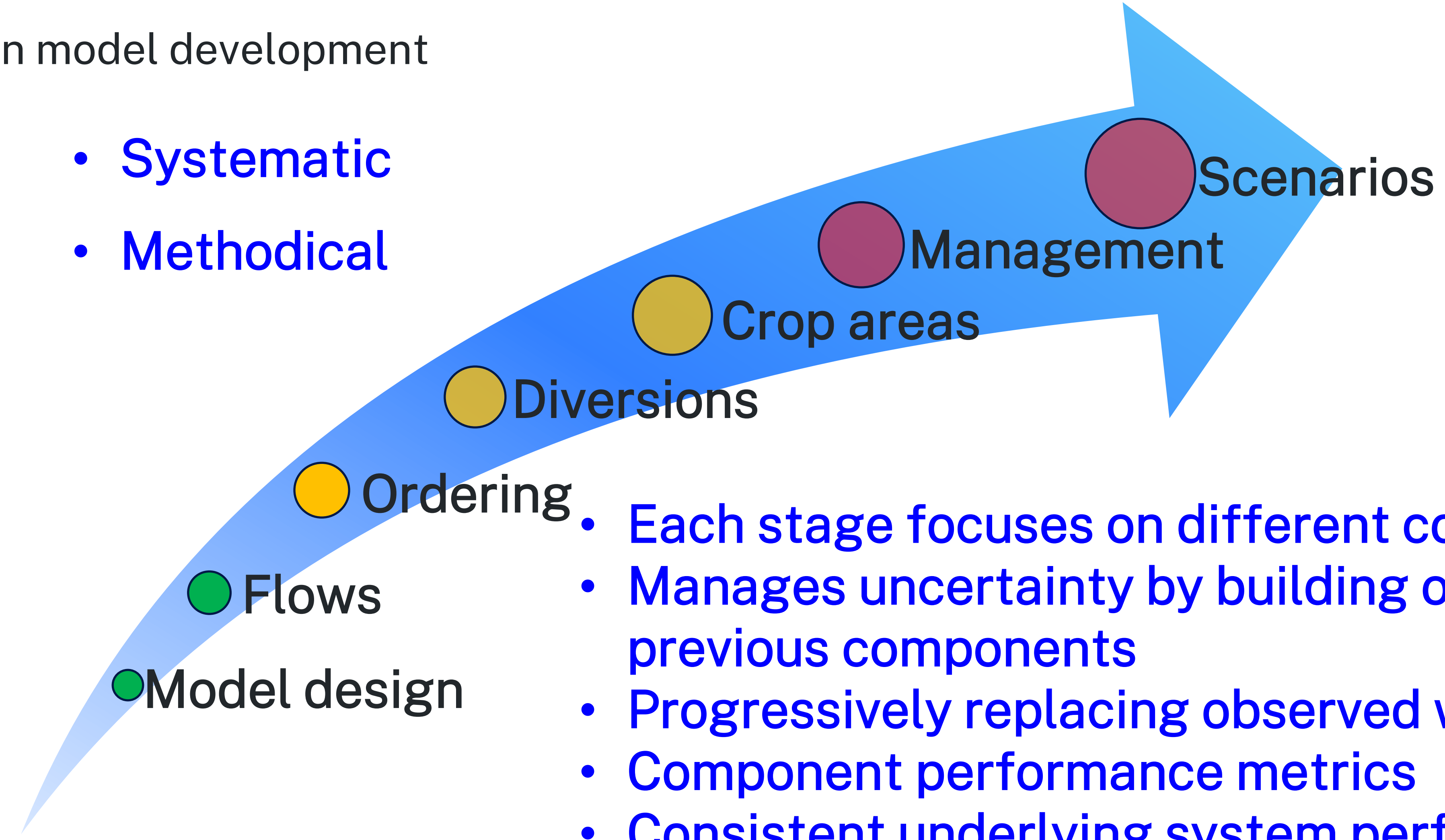
Series of workshops

1. Modelling principles — 25/10/2021
2. Flows (Availability) — 02/11/2021
3. Demands (Use) — 31/05/2022
4. Evaluation & reference scenarios — 7/11/2022

Review

Stages in model development

- Systematic
- Methodical



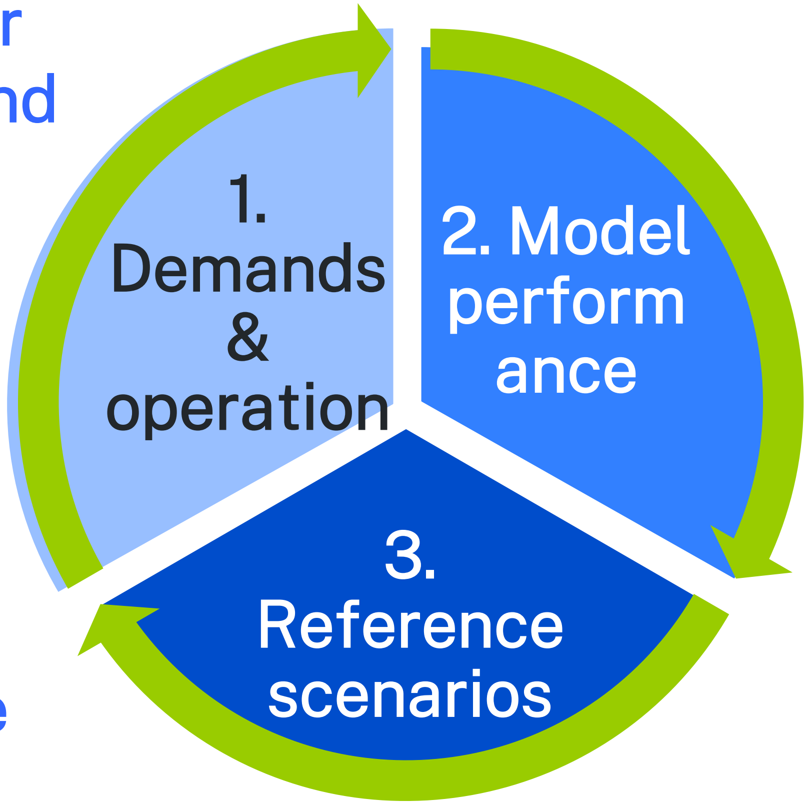
- Each stage focuses on different components
- Manages uncertainty by building on previous components
- Progressively replacing observed with modelle
- Component performance metrics
- Consistent underlying system performance me

Sessions within Workshop 4

Configuring other model demands and operations

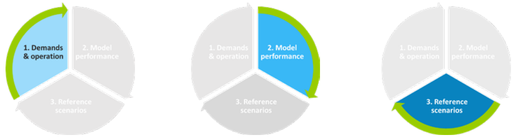
Evaluate the model against objectives

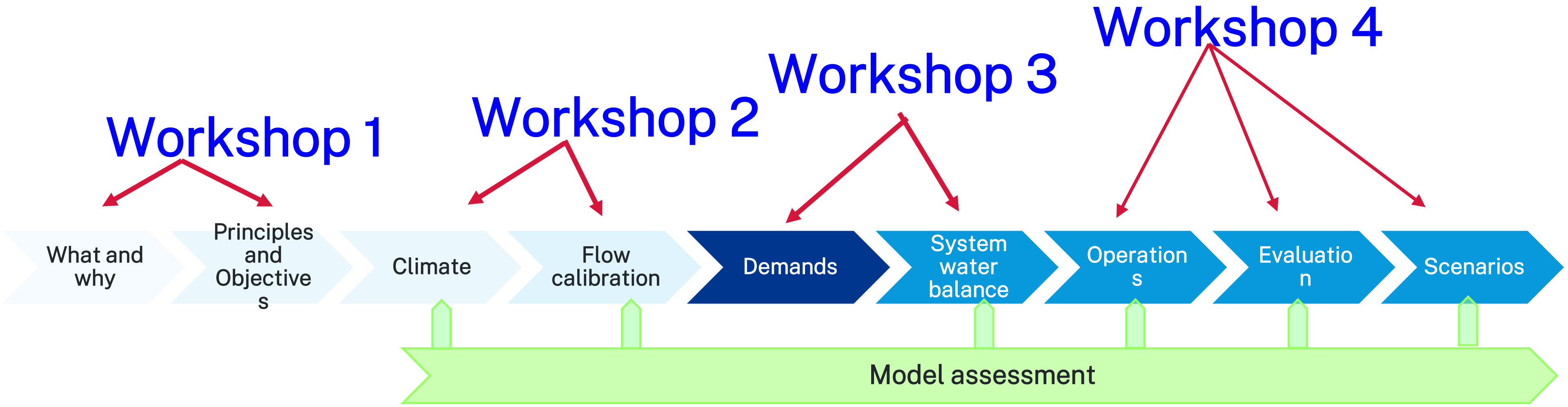
Configure and validate reference scenarios



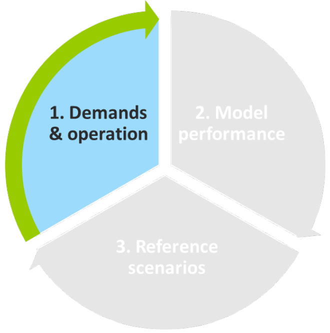
Model implementation processes

Overview





Session 1: Demand and operation



Overview

- Several key elements not previously reported.
- Non-irrigation demands
- River operation
- Resource availability
- Non-regulated diversions

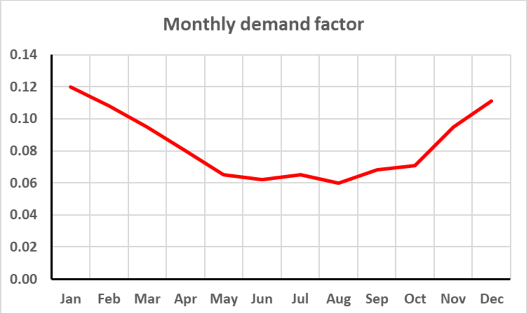
1. Local water utilities
2. Regulator operation and replenishments
3. Storage transfers
4. Supplementary access
5. Overbank flow thresholds
6. Resource assessments

Demands and operation

Local water utilities

Demand model

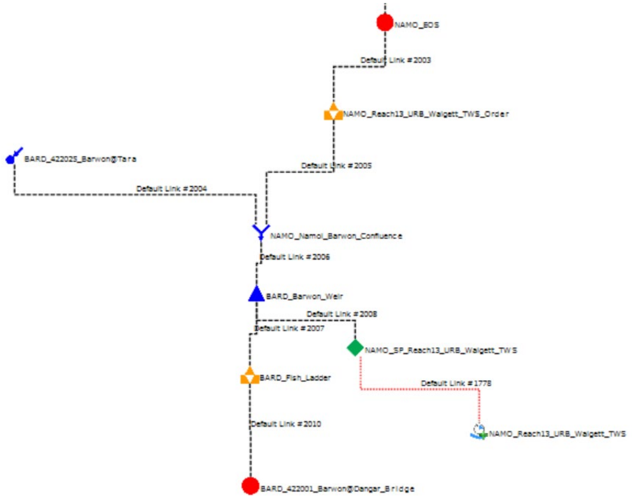
- Seasonal pattern
- Adjusted for climate & population
- Based on observed data



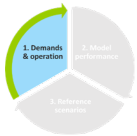
Town	Population	Annual usage (ML/person)
Manilla	2,550	0.13
Walgett	2,145	0.39

Walgett

- Extracts from a 2.9 GL weir pool
- Supplied by B-D and Namoi flows
- Topped up by Namoi orders

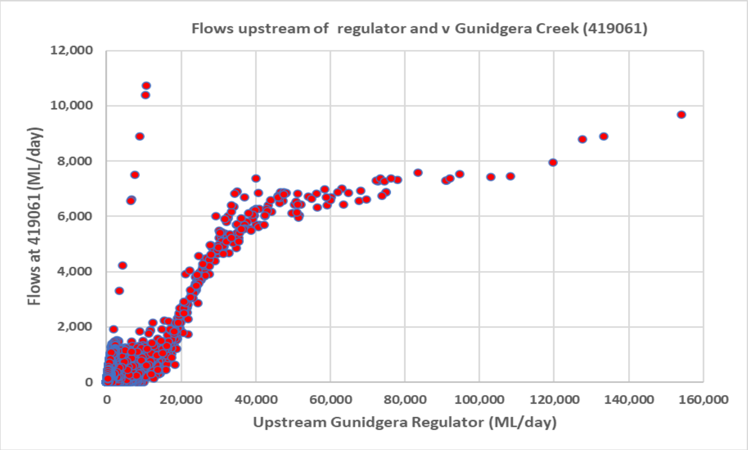


Demands and operation



Gunidgera regulator configuration

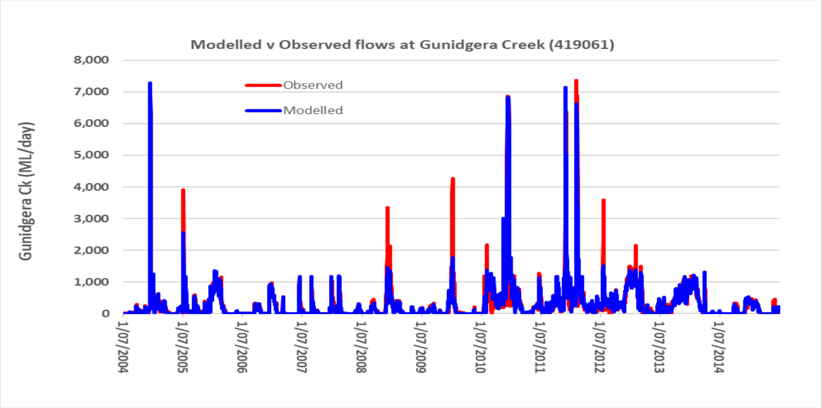
Based on discussions with WaterNSW and calibrated against observed behaviour



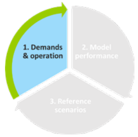
Good pattern match

Volume bias

- Gunidgera Ck -0.8%
- Namoi River 0.3%

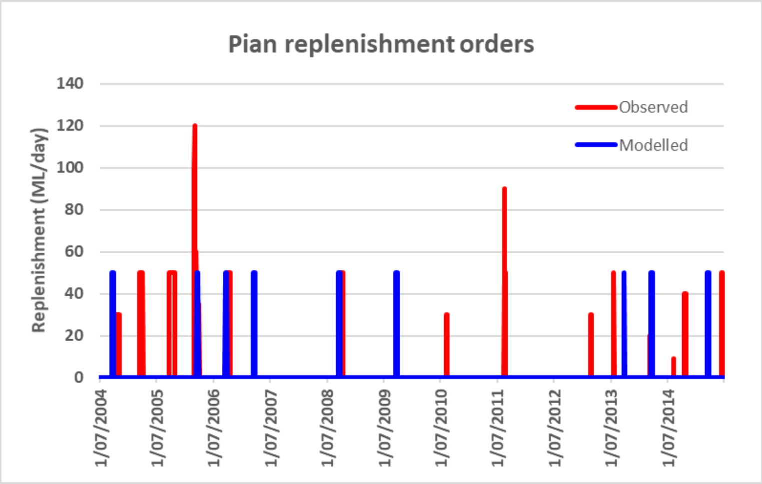


Demands and operation



Pian replenishment orders

- WSP if 180 day prior flow <= 1,000 ML
- **Two replenishment opportunities: Oct and March**
- **WSP requirement for 14 GL in storage reserve**



Note apparent underestimate of orders, in practice observed orders were met by surplus flows regulated by Gunidgera Weir

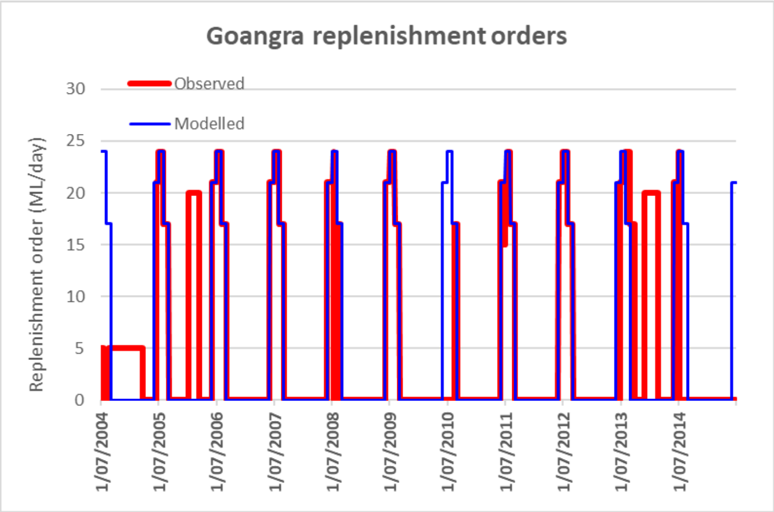
Demands and operation

End of system demands at Goangra

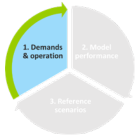
WSP - daily flow target in winter months

Month	Daily target (ML/d)
June	21
July	24
August	17

Results



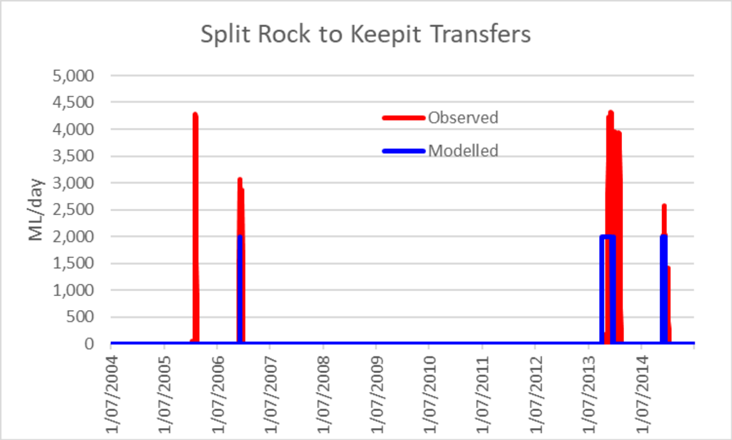
Demands and operation



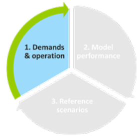
Split Rock to Keepit transfer

- Maintain a reserve in Split Rock (GL)

  19.4 + Upper Namoi GS Balance*1.6
- When expected usage (GS + HS + TWS + S&D Balance) exceeds available water in Keepit Dam
- Order shortfall from Split Rock at 2000 ML/day over Sep-Feb



Occurrences met in 3 of 4 – operational decisions and model bias account for differences



Demands and operation

Modelling supplementary access rules

WSP rules modelled

	River Section		Month		Threshold (ML/d)		Gauge
	US	DS			Start	End	
if GS <=90 GL	Keepit	Weeta Weir	Jul	Jun	500	500	Narrabri
	Weeta Weir	Walgett	Jul	Jun	10	10	Walgett
if GS > 90 GL	Keepit	Narrabri	Aug	Dec	5000	3000	Narrabri
			Jan	Jan	4000	2000	Narrabri
			Feb	July	2000	1000	Narrabri
	Narrabri	Mollee	Aug	Dec	5000	3000	Narrabri
			Jan	Jan	4000	2000	Narrabri
			Feb	July	2000	1000	Narrabri
	Mollee	Gunidgera Weir	Aug	Dec	4000	2500	Mollee
			Jan	Jan	3000	2000	Mollee
			Feb	July	2000	1000	Mollee
	Gunidgera Weir	Weeta Weir	Aug	Dec	3000	2000	Gunidgera Weir
			Jan	Jan	2000	1500	Gunidgera Weir
			Feb	July	1500	1000	Gunidgera Weir
	Weeta Weir	Walgett	Jul	Jun	500 for 5 days	500 for 5 days	Walgett
	Gunidgera	Gunidgera DS Cutting	Jul	Jun	MIN(50,local residual)	MIN(50,local residual)	Pian@Dempsey
	Gunidgera	Dempsey	Jul	Jun	MIN(50,local residual)	MIN(50,local residual)	Pian@Dempsey

Month		Share (%)	
Start	End	Environment	Consumptive
Jul	Oct	90	10
Nov	Jun	50	50

Start and end thresholds vary by

- GS balance
- River section
- Month

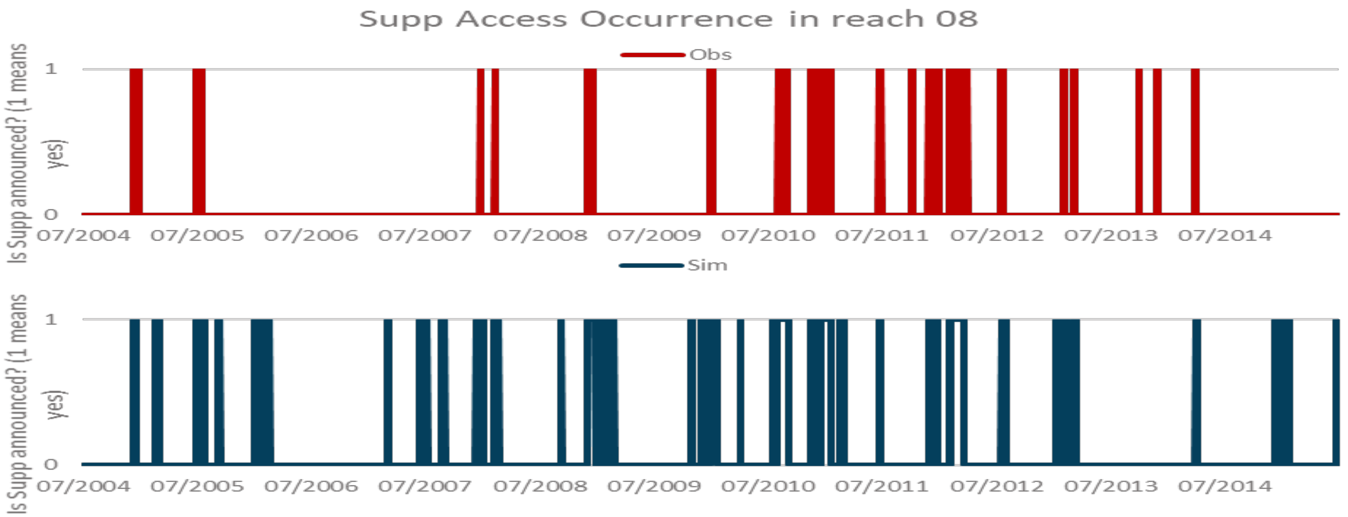
Also seasonal environmental share

Demands and operation

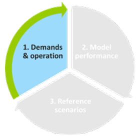
Frequency of access – observed v modelled

Model represents WSP rules and operations differ

Increased frequency in model, however, supplementary take bias is -6% overall



Demands and operation



Overbank flow frequency

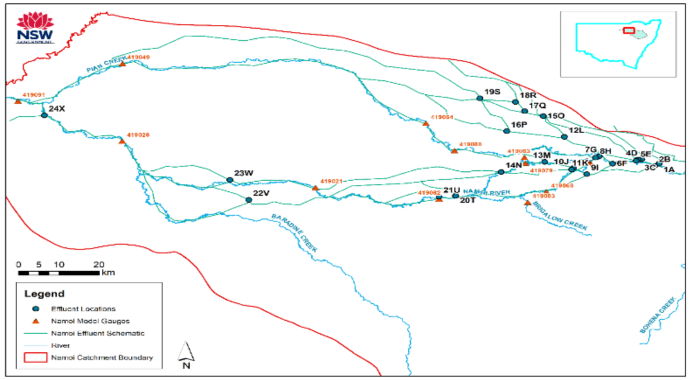
Breakouts determined from hydraulic model and observed data

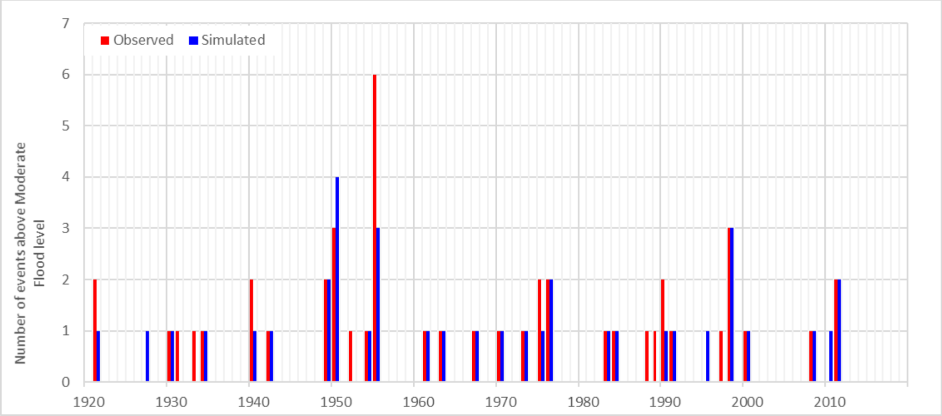
Basis of water for overbank flow harvesting

6 major floods in calibration period 2004-2015

6 significant events during calibration period matched at nearly all breakout locations

Event frequency @Gunnedah over long period has good occurrence match





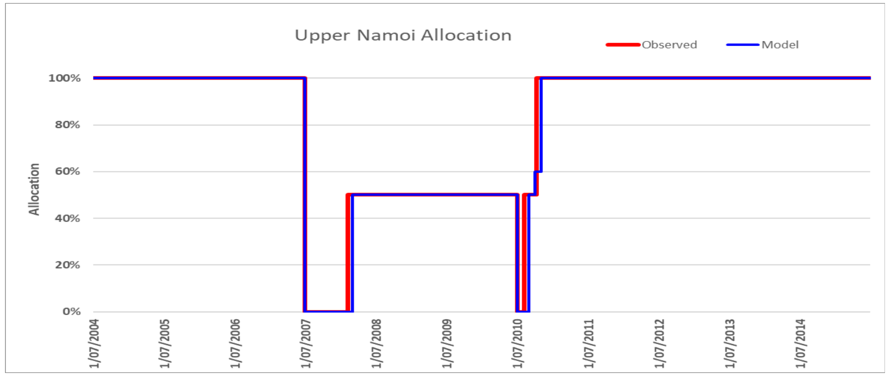
Demands and operation

Upper Namoi resource assessment

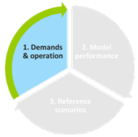
Per 2016 WSP

- Annual accounting
- Order debit
- GS= f(volume in Split Rock)
  - <5% : 0% allocation
  - 5<=x<8% : 50% allocation
  - 8<=x<10% : 60% allocation
  - >=10% :100% allocation
- **Updated monthly**

Entitlement type	Shares	Max allocation (%)	Carry over (%)
S&D	46	100	0
LWU	150	100	0
HS	80	100	0
GS	9,729	100	50



Demands and operation



Lower Namoi Resource Assessment

Based on 2016 WSP

- Continuous accounting – daily update
- **Storage volume (Split Rock + Keepit)**

Entitlement type	Shares	Max account balance (%)
S&D	1,967	100
LWU	2,271	100
HS	3,418	100
GS	246,618	200

Losses

- Forecast net evaporation
- Upper Namoi GS balance plus 30%
- Lower Namoi GS balance plus 30%

2 years reserves (maximum 67 GL) essential supplies including operational losses

d/s Keepit min flow

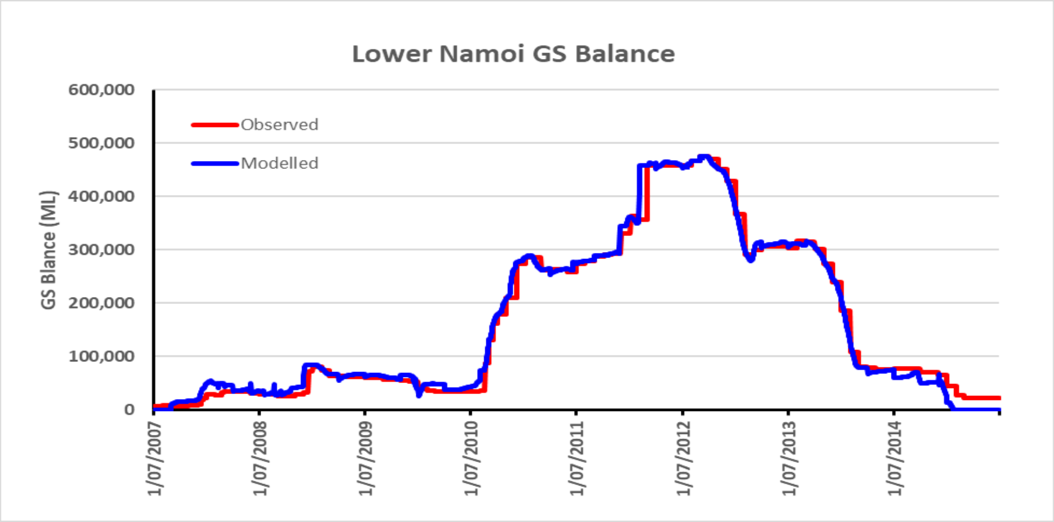
- S&D + LWU + HS
- Transfer loss
- Replenishment
- End-of-system if storage vol > 120 GL

- Gunidgera replenishment reduced by 7 GL if first replenishment met
- Delivery loss assumed to be 60%
- 18 month min inflow (1892-2000)

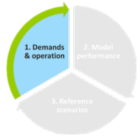
Demands and operation

Lower Namoi Resource Assessment

Results of resource assessment compared to observed - using observed storage volumes and downstream demands.



Demands and operation

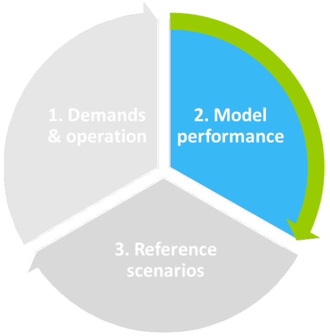


Summary

- The model has been configured to represent Water Sharing Plan rules. Observed operations may differ from this:
    - Timing of replenishments
    - Supplementary access
    - Resource assessment
- The implementation of Walgett TWS better reflects how it is operated
- Getting the operation of Gunidgera regulator right is extremely important in terms of model performance – well matched
- Frequency (and duration) of access to floodplain water matched well
- Resource assessment calculated correctly

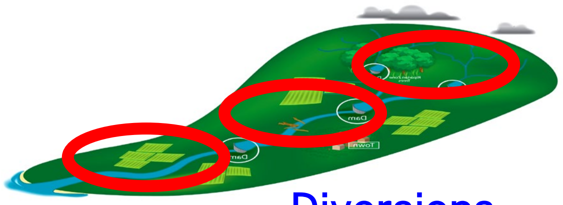
Questions

Session 2: Model Performance & Evaluation

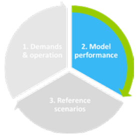


Overview

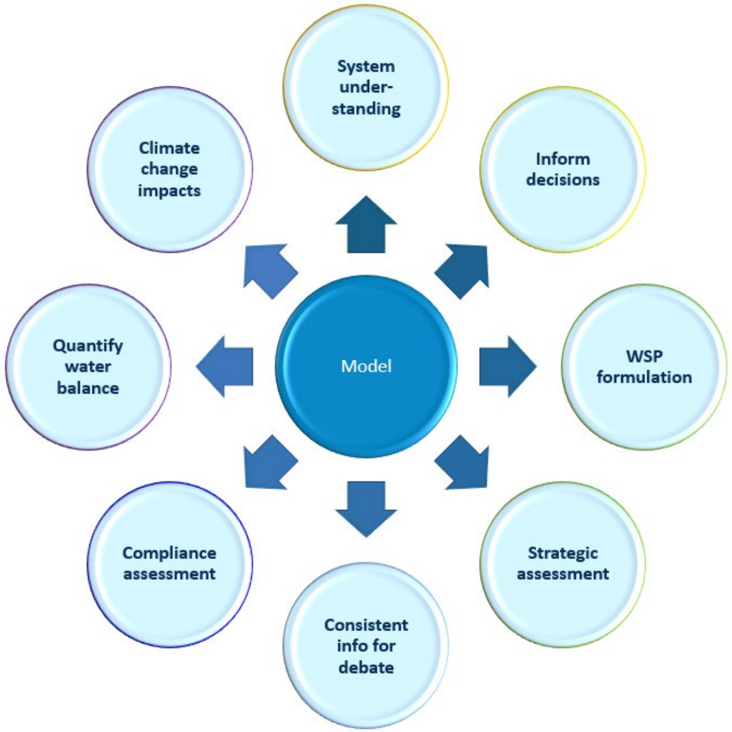
- Modelling objectives.
- Model performance – following system water balance discussion in workshop 3
  - Different stages of calibration
  - Reach irrigation performance
  - System irrigation performance
  - Storage performance
  - End of system performance
- Comparison with previous model
- Conclusion



Model use and objectives

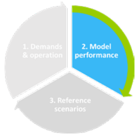


Model usage (from WS1)



Objectives for model build

1. Represent key water availability and sharing processes relevant to extractions and flows
2. Works for wet and dry climate periods
3. Report at multiple spatial scales (farm → valley)
4. Report at multiple temporal scales (daily → annual → average annual)
5. Capture historical extractions and flows on seasonal basis at reach and valley scale
6. Be update-able and extensible



Model performance

Model configuration, period, metrics

- **Calibration based on 2008/2009 infrastructure**
- **Evaluation period 1/7/2004 to 30/06/2015**
- **Performance metrics**
  - Considered at different stages of the calibration
  - Diversions on temporal reach and system basis
  - Keepit storage behaviour
  - End of system flows
- **Comparison with existing model**

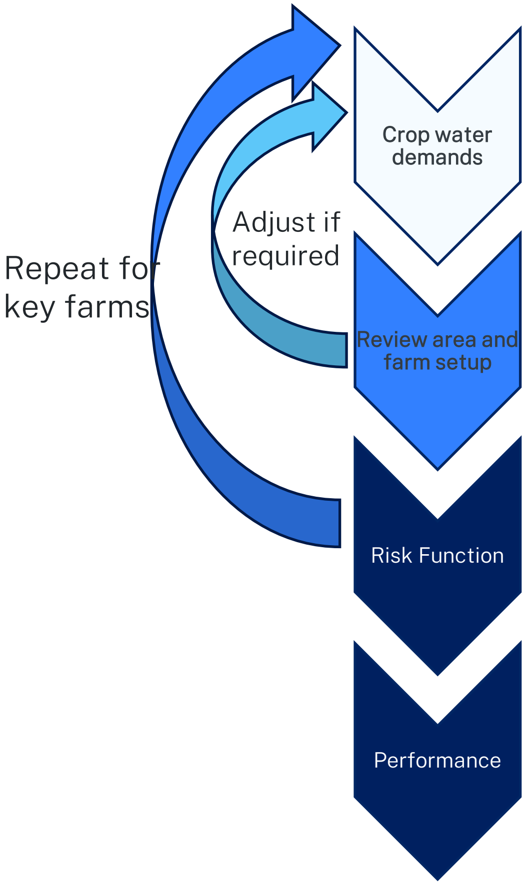
Model performance

Recap – sources of water for farms

- Mass balance approach - matching **demand** and **supply**
- **Demand** = area * application rate, on-farm losses
- **Supply**
  - Metered [GS, SA, groundwater, trade]
  - Unmetered
    - Effective rainfall
    - Overbank flow harvesting
    - Rainfall runoff harvesting
    - Unregulated

Model performance

Recap: Staged approach to calibrate irrigated area & diversions



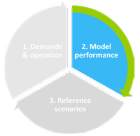
- Standardise crop parameters: defensible crop demand
- Standardise soil parameters, efficiency and undeveloped area: rainfall-runoff harvesting
- Farm infrastructure: Farm water harvesting and efficiency
- Estimate crop area that could have been planted every year – **knowing regulated diversion**

- Compare estimated area against Remote Sensing / Survey: Multiple lines of evidence
- Review efficiencies / unmetered water sources
- Review farm set-up (capacities)

- Crop area planting decisions: Develop available resource vs crop area functions

- Regionalise parameters for farms with limited data
- Assess key variables such as storage behaviour and end of system flow

Model performance



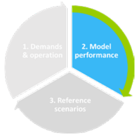
Staged method development

Approach is to methodically calibrate on-farm demand model parameters by holding certain inputs as observed

Then replacing those observed with modelled, while holding other inputs as observed

Ultimately, everything is modelled, with only climate observed

Run description	Observed?		
	Area	AWD	Keepit inflow
Irrigation demand	Y	Y	Y
Area risk	N	Y	Y
AWD	N	N	Y
Fully simulated	N	N	N



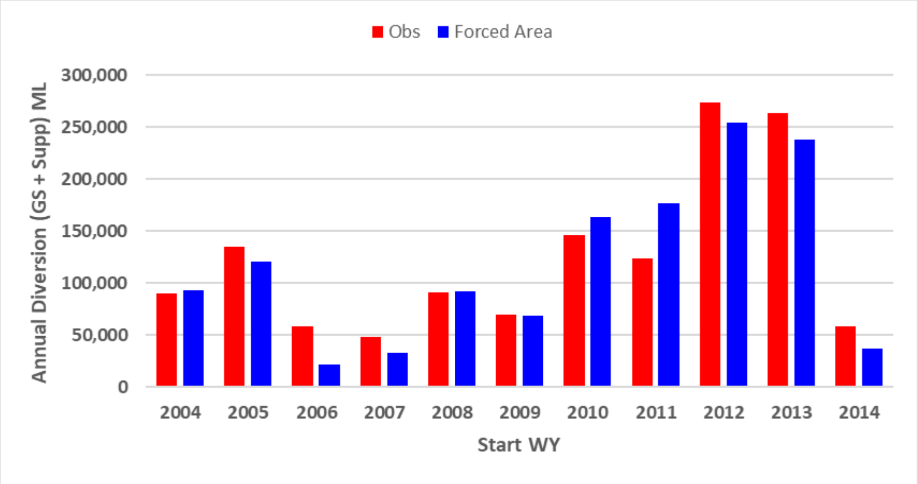
Model performance

Irrigation extraction from river

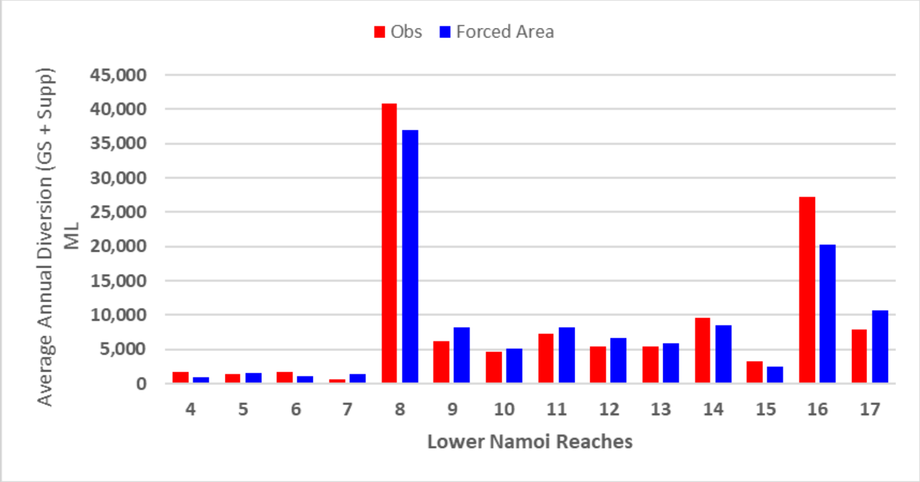
Run description	Forcing		
	Area	AWD	Keepit inflow
Irrigation demand			

Run	GS	SA	GS + SA
Irrigation demand	-4%	-6%	-4%

Temporal Performance



Spatial Performance



Recap: Remotely sensed areas

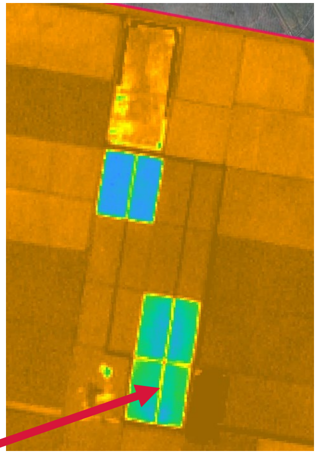
Managing crop area uncertainties

Based on energy balance algorithm to minimise noise from typical NDVI (greenness index)

Is an important data source but needs to be carefully quality assured from multiple lines of evidence

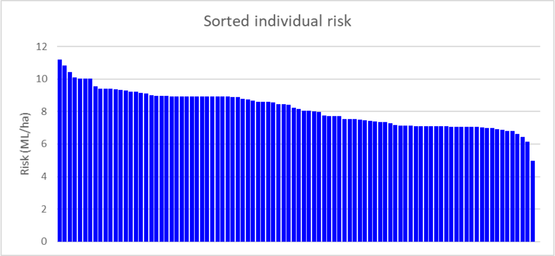
Issues:

- Does not work well when it wet
- Does not identify crop types
- Can pick riparian areas that are not irrigated
- Associating with the correct property
- Water practices (skip row)
- Cloud cover



Model performance

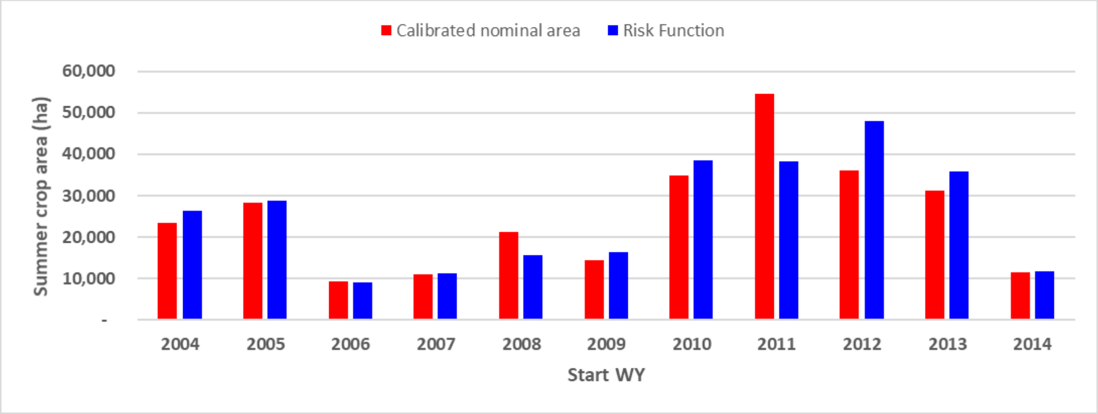
Calibrating crop areas with a risk function



Vary spatially

Crop area checks:

- Compared against remote sensing and IrriSAT area data
- Evidence of under-irrigation, short cropping season
- Calibrated area is slightly lower than raw survey data / Remote Sensing, especially in dry years



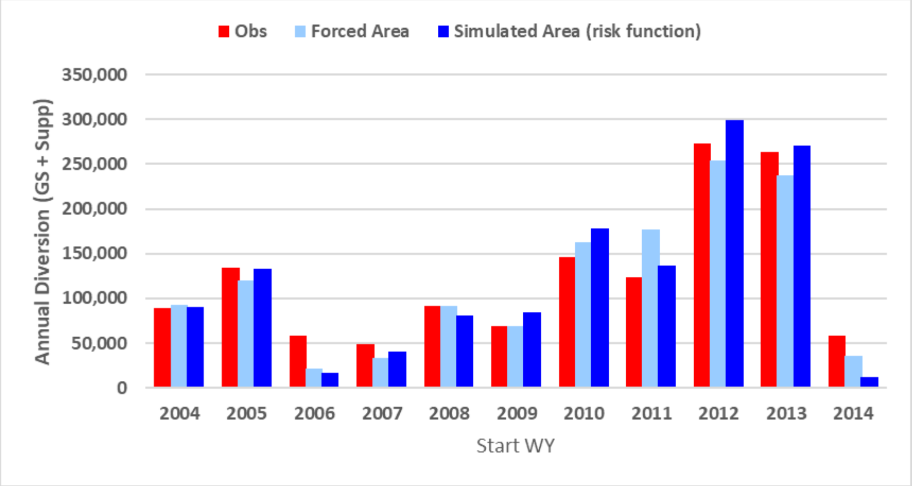
Model performance

Extractions from area risk

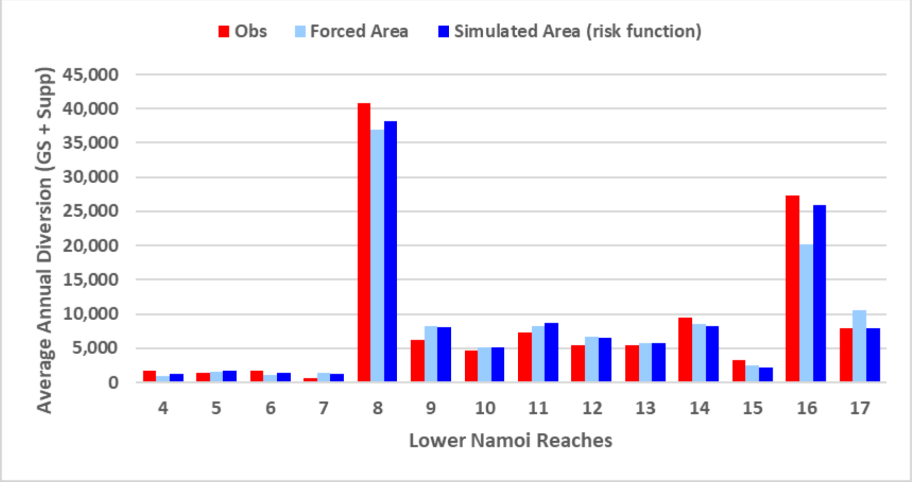
Run description	Forcing		
	Area	AWD	Keepit inflow
Area risk			

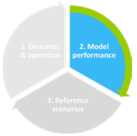
Run	GS	SA	GS + SA
Irrigation demand	-4%	-6%	-4%
Area Risk	-2%	9%	-1%

Temporal Performance



Spatial Performance





Model performance

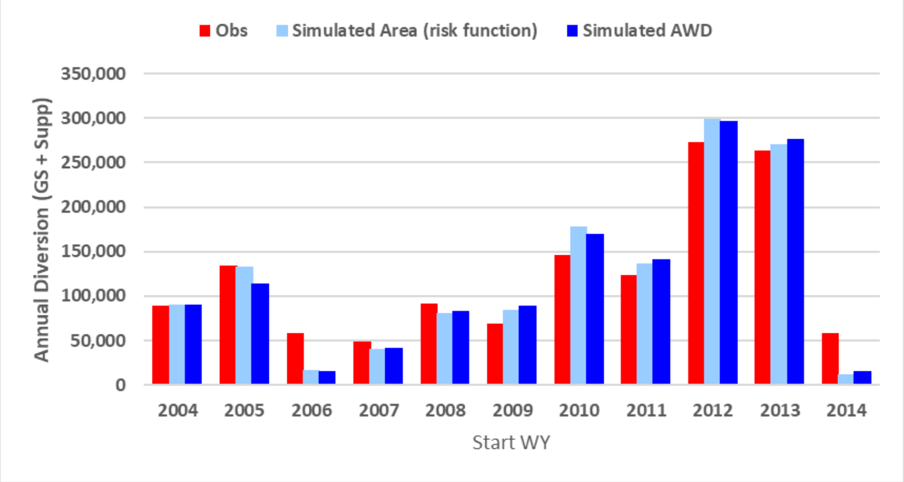
Extractions with simulated AWD

Run description	Forcing		
	Area	AWD	Keepit inflow
AWD			

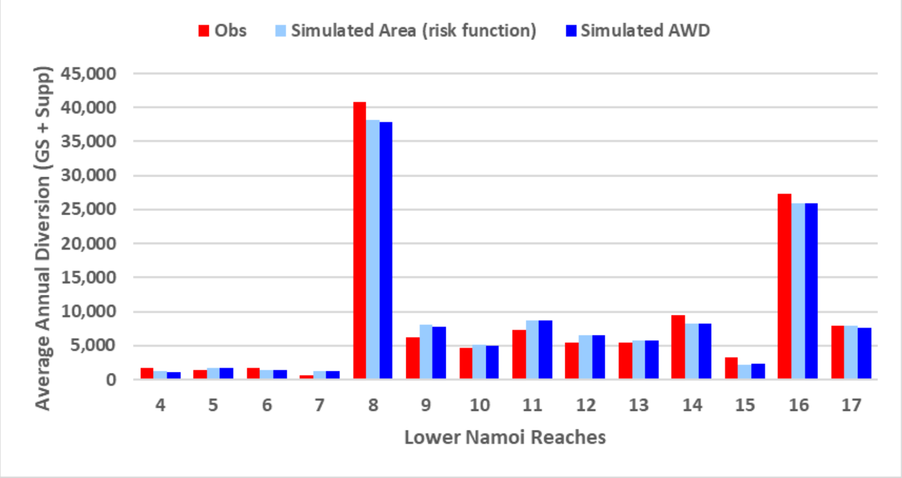
Note: 2006/07 and 2014/15 model favours essential requirements over GS AWD

Run	GS	SA	GS + SA
Irrigation demand	-4%	-6%	-4%
Area Risk	-2%	9%	-1%
Simulated AWD	**1%**	**-9%**	**-2%**

Temporal Performance



Spatial Performance



Model performance

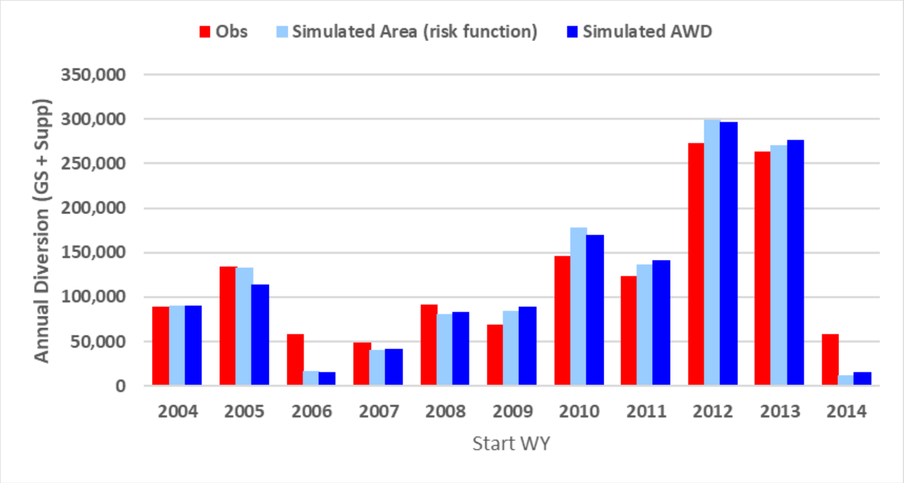
Extractions with simulated AWD

Run description	Forcing		
	Area	AWD	Keepit inflow
AWD			

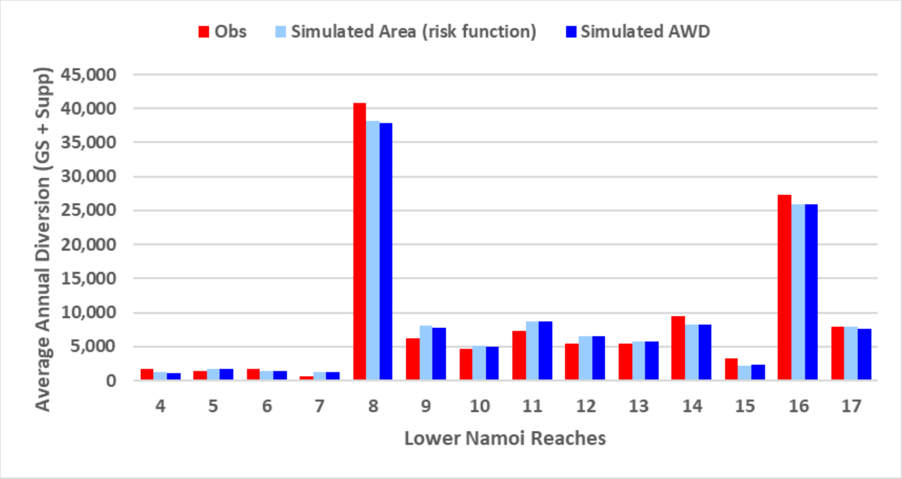
Note: 2006/07 and 2014/15 model favours essential requirements over GS AWD

Run	GS	SA	GS + SA
Irrigation demand	-4%	-6%	-4%
Area Risk	-2%	9%	-1%
Simulated AWD	1%	-9%	-2%
Full simulating	**-4%**	**-9%**	**-5%**

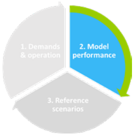
Temporal Performance



Spatial Performance



Fully simulated performance



All components simulated

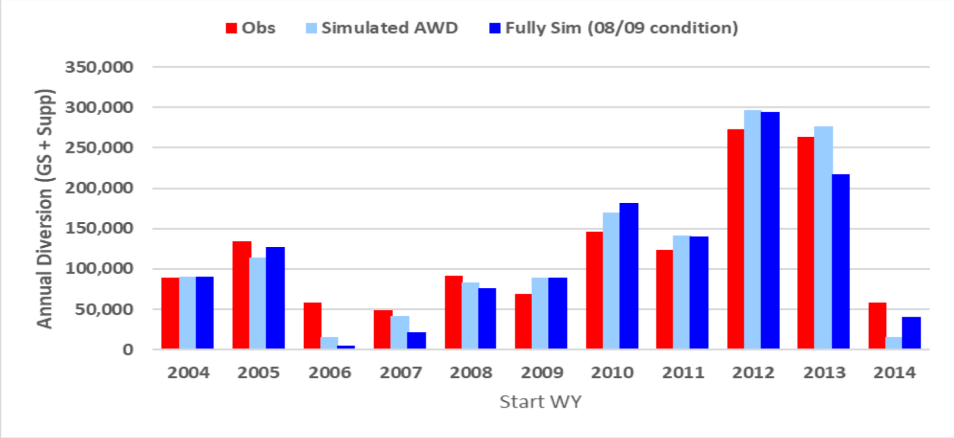
Run description	Forcing		
	Area	AWD	Keepit inflow
AWD			

Shows progressive degradation as more things are simulated

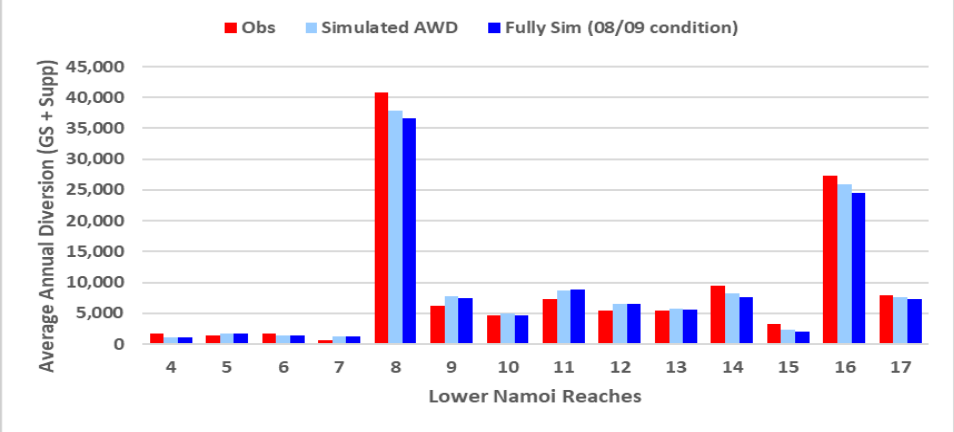
Reproduces average behaviour rather than unique decisions

Run	GS	SA	GS + SA
Irrigation demand	-4%	-6%	-4%
Area Risk	-2%	9%	-1%
Simulated AWD	1%	-9%	-2%
Full simulating	**-4%**	**-9%**	**-5%**

Temporal Performance



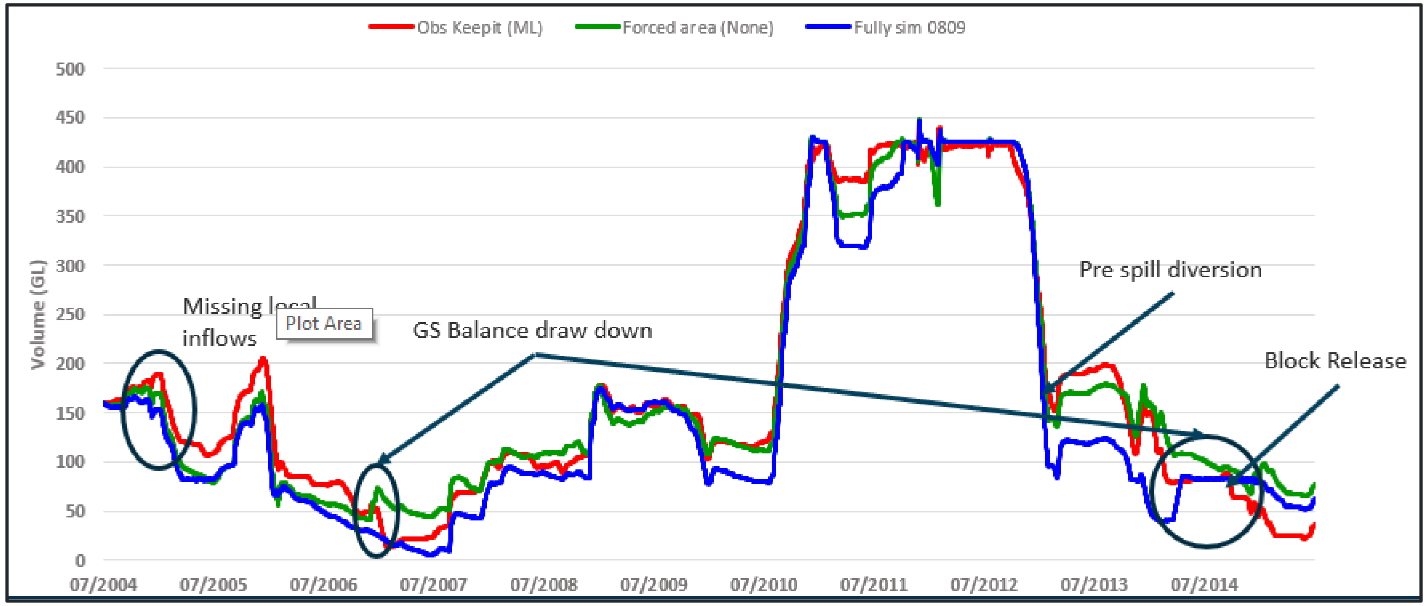
Spatial Performance



Model performance

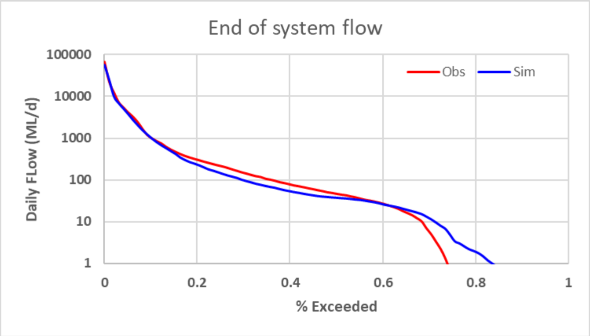
Keepit storage volume

- Biggest degradation when simulating crop area (average risk function)
- 2011/12 event came around Nov/Dec – model is configured with planting decision around mid October

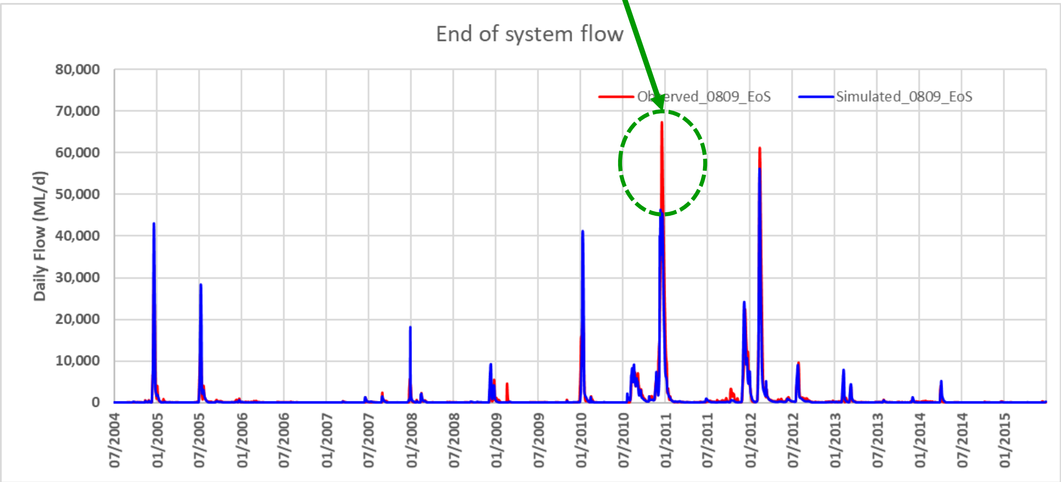


Model performance

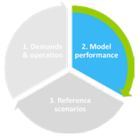
End of system flows



Fully simulated model has lower spill in 2011.
Excluding this, EOS bias is -2%



Model performance

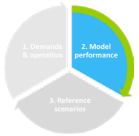


Comments

- Aim to minimise bias, but main focus on robust parameterisation and behaviour
- Performance is limited by uncertainties in observed data
- Where significant differences we can identify cause
- Fixed rules in WSP not always replicated operationally, e.g.
  - **Block transfers: affects Keepit behaviour during dry periods**
  - **2006/07 and 2014/15 reserve management in model constrained diversions**

- Fixed level of infrastructure assumed where we know changed over time
- Crop planting decisions based on available resource whereas other factors affect decisions
- Reproduces behaviour well across range of climatic conditions.

For **model v model** use cases where we compare results based on the same calibration, model biases are less consequential.

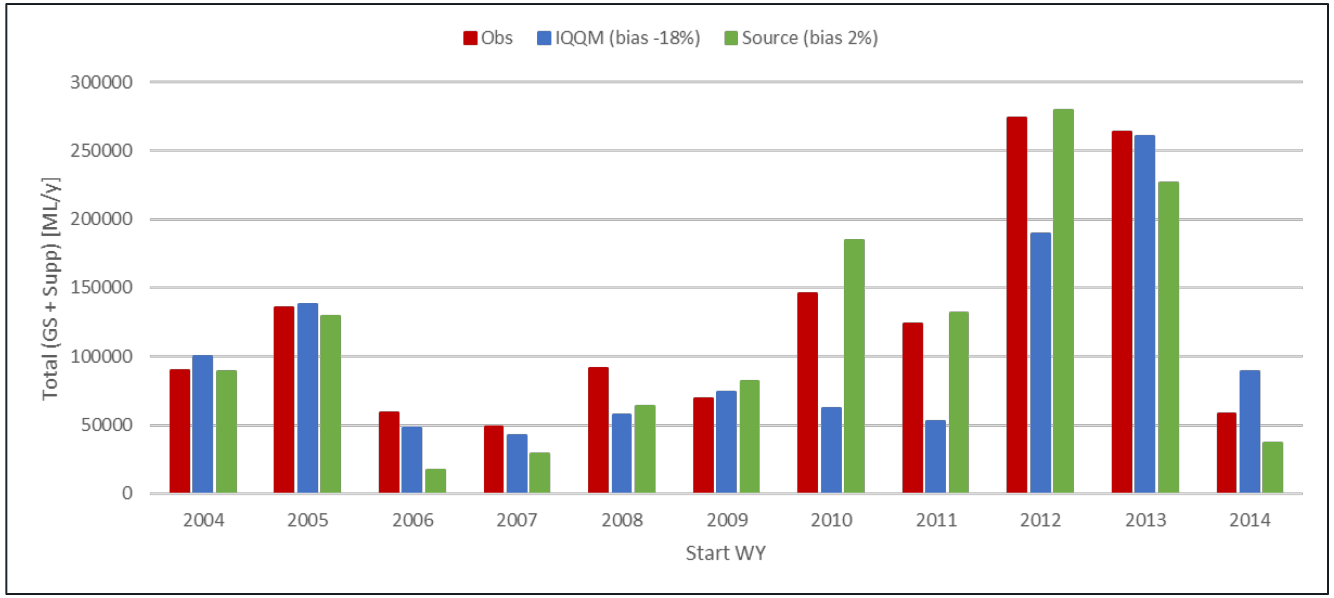


Model performance

Source diversion comparison to IQQM with similar conditions

Diversion comparison compared to existing model (similar infrastructure)

- IQQM bias -18%
- Source bias 2%



Conclusion

Overall performance is limited by available data

Not all operational decisions can or should be included in the model. This creates defensible differences compared to observed

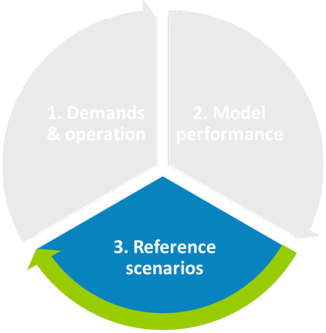
- **Source is calibrated over a long climatic period (dry and wet)**
- **Source model performance is good both spatially and temporally**
- **Source model loss and inflow is defensible**
- **Source model conceptualisation is detailed**
    - Represents key water availability and sharing process
    - Conceptualised at farm scale
    - Realistic TWS conceptualisation and demand model
    - Includes floodplain processes
    - Defensible parameters (ML/ha, efficiency, OFS operations, runoff and FPH)

Meets the required objectives and is an improvement on the existing model

This is currently the best available model of the Namoi regulated system (subject to confirmation by external peer reviews)

Questions

Session 3: Reference scenarios



Overview

- Model as built is suitable for <u>model v model</u> comparisons
- Cap, Water Sharing Plan, Eligible Works, Current Conditions
- Development configuration
- Performance in respective reference periods
- *Long Term Annual Average Extraction Limit* (LTAAEL) selection - comparison to Current Conditions
- Compliance scenario

Reference scenarios

Purpose	Scenario
LTAAEL lesser of:	• Cap • Water sharing Plan
FPH share	• 08/09 eligible works
LTAAEL compliance assessment	• Current conditions
Valley scale compliance	• FPH entitlements • Growth in use actions

Reference scenarios

Definitions

Scenario	Level of development	Rules	Management
Cap	1993/1994	1993/4	1993/1994
Water sharing plan	1999/2000	WSP	1999/2000
Eligible development	2008/2009	WSP	2008/2009
Current conditions	2018/2019	WSP	2018/2019

Reference scenarios

Key model configuration changes

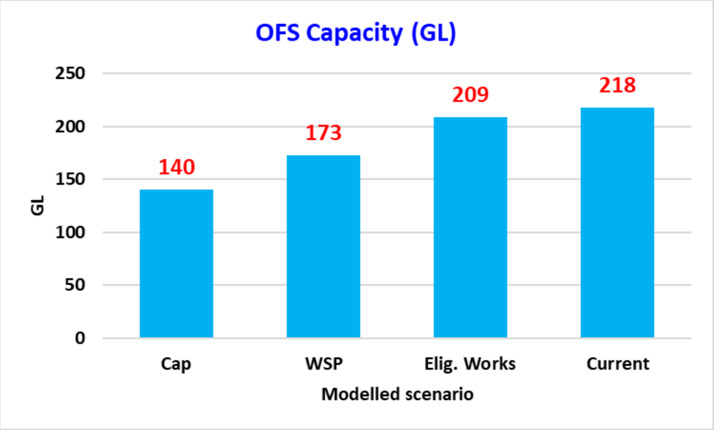
- Farm infrastructure
  - On-farm storage (OFS) volume
  - River pump capacity
  - OFS pump capacity
  - Developed area
  - Undeveloped area
- Resource assessment
  - Annual accounting (Cap)
  - Continuous accounting (others)
- Supplementary Access
- Entitlement spatial distribution

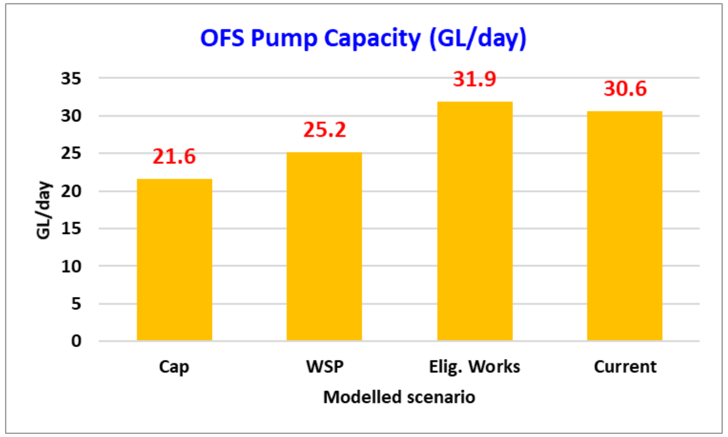
Management changes

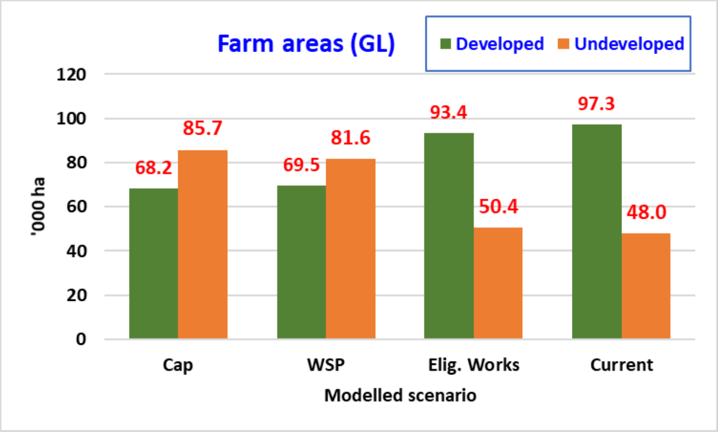
- Cap scenario
  - Annual accounting without carry-over
- Current condition scenario
  - Held Environmental Water (HEW)
  - HEW configured with 'typical' irrigator demand characteristics in reach 08 (Mollee to Gunidgera)

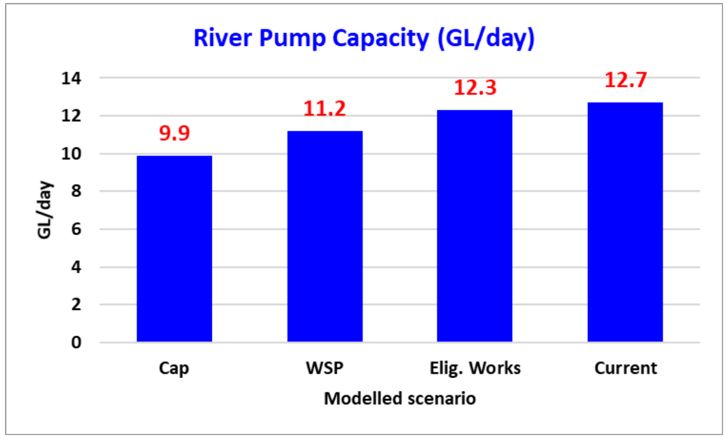
Reference scenarios

Development levels









Reference scenarios

Scenario model performance

Important to assess reference scenario for the corresponding period

Provides confidence in diversion estimates

Gradual changes to development etc, so overlap in periods

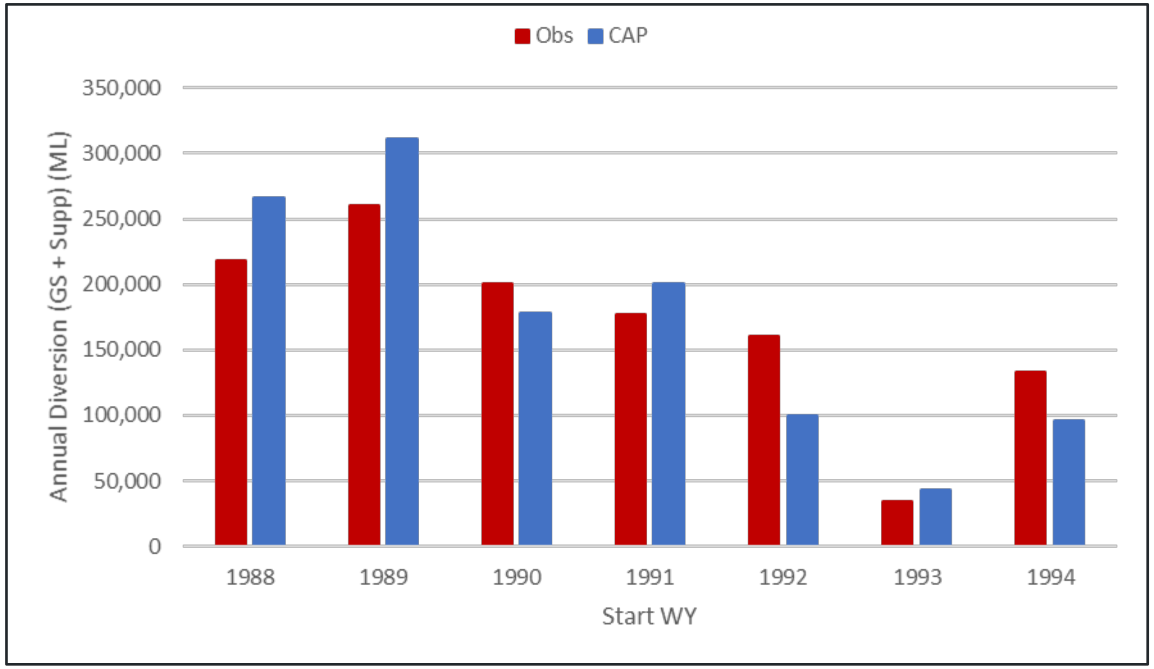
- Cap evaluated over period 1988/1989 - 1994/1995
- WSP evaluated over period 1997/1998 – 2012/2013
- Current conditions evaluated over period 2004/2005 – 2018/2019

Just by changing infrastructure the following slides demonstrate biases in all scenarios comparable with performance in calibrated model, and pattern matches are strong.

These indicate the results from the scenario v scenario comparison are valid.

Reference scenarios

Cap scenario model performance

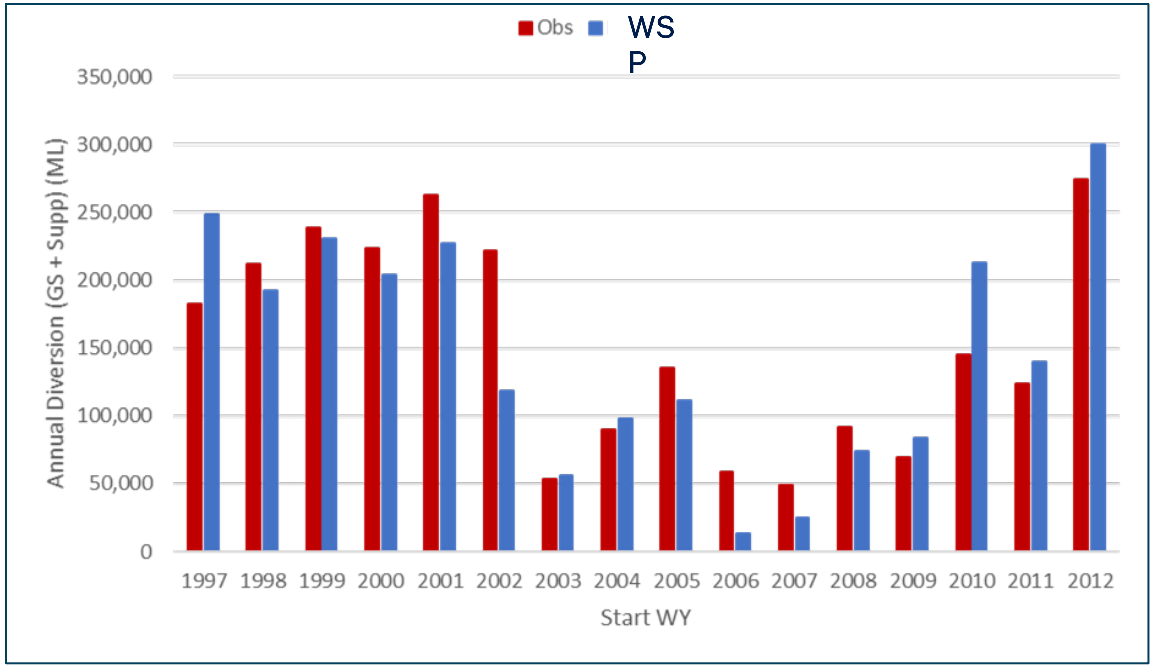


Bias = + 1%

$R^2 = 0.96$

Reference scenarios

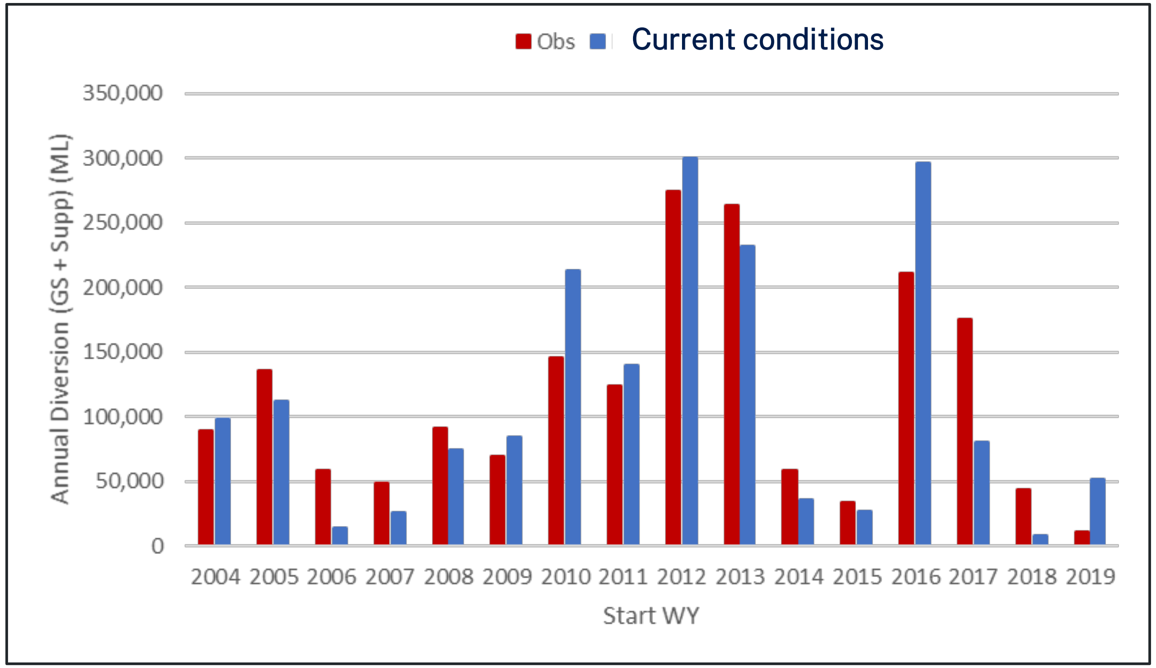
WSP scenario model performance



Bias = -4%
R^2 = 0.94

Reference scenarios

Current conditions scenario model performance



Bias = -2%
R^2 = 0.91

Reference scenarios

FPH entitlements

V

LTAAEL scenario	Assess growth	Size entitlements to remove growth	Demonstrate LTAAEL compliance
LTAAEL = min (Cap, WSP) based on total diversions	Estimate reduction to FPH needed to restore to LTAAEL levels	Eligible development used to design entitlements with equitable impacts	FPH entitlements + rules + AWD remove growth in use

Proposed accounting rules for each entitlement:

- 100% of an entitlement to be credited annually
- Maximum account balance 500% (over 5 years)
- Any unused balance can be carried over into the next water year subject to the 500% account limit.

Reference scenarios

Modelled long term averages (GL/y) for 1895-2009 climate

Entitlement type	Cap	WSP (LTAAEL)	Current condition s	Valley complian ce
Local water utility	0.8	0.8	0.8	0.8
Stock and domestic	1.5	1.5	1.5	1.5
High security	0.3	0.3	0.3	0.3
General security	135.3	142.0	135.4	137.4
HEW	-	-	6.8	6.8
Supplementary	68.5	34.4	42.1	32.3
FPH	33.9	46.5	51.3	46.0
Overbank flow	*16.9*	*25.2*	*30.6*	*24.9*
Non-exempt RRH	*17.0*	*21.3*	*20.7*	*21.1*
TOTAL	**240.3**	**225.6**	**238.3**	**225.2**
RRH (exempt)	12.6	16.2	21.0	23.4
Growth			5.6%	-0.2%

Reduce SA by AWD

Reduce FPH by entitlements

Reduce total to LTAAEL

Questions

Next steps - target timeframes

Stakeholder input into peer review process: floodplain.harvesting@dpi.nsw.gov.au

	December	January	February
WSP public exhibition period			
Peer review			
Draft entitlement – submission period			
WWH report published			
WSP amendments			
Entitlement determination			

Key dependencies

- WSP submissions
- Peer review outcomes
- Draft entitlement submissions
- WSP concurrence

Next steps – both WSP and entitlement process delays

	December	January	February	March	April	May	June
WSP public exhibition period							
Peer review							
Draft entitlements – submission period							
WWH report published							
WSP amendments							
Entitlement determination							

Next steps – entitlement process delays only

	December	January	February	March	April
WSP public exhibition period	✓	✓			
Peer review	✓	✓	✓		
Draft entitlements – submission period			✓	✓	
WWH report published			✓		
WSP amendments			✓		
Entitlement determination					✓