Flood Risk Modelling and Mapping

Claus Skotner
Head of Projects, Water Resources, DHI

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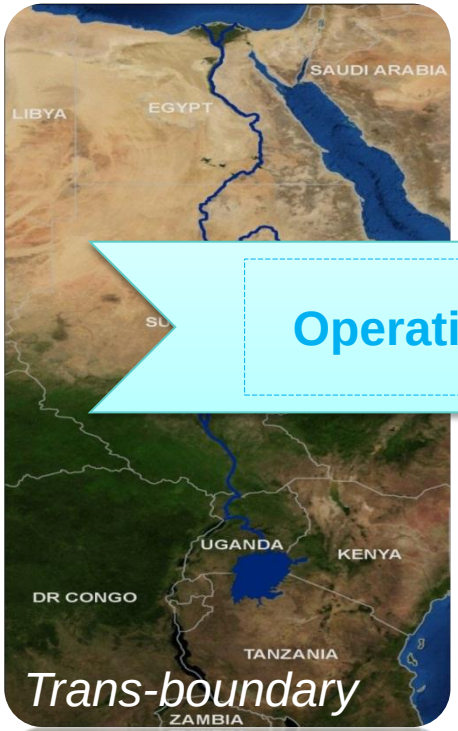
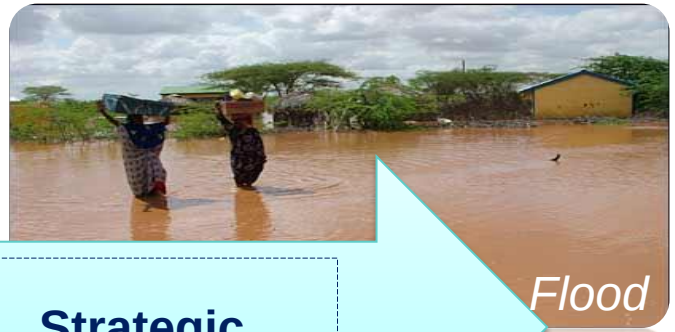
Challenges and Technology Requirements

Challenges

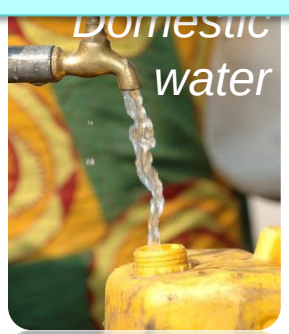


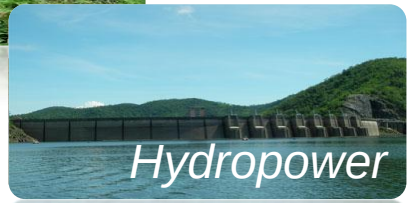


Operational

Seasonal

Strategic





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Technology Requirements

Integrated – From planning to operation – from information management, analyses, modelling, impact assessment, and mitigation to c

Open – Data – r

Robust – Resilie

Expandable – S

Supported – Important for any mission critical system

Accepted
Trusted
Sustainable

Solutions

Modern solutions help you…

…get the full benefit of real-time **monitoring** and early warning systems

…manage, organise and analyse large amounts of **data**

…optimise **operations** and planning

…make wise and robust water management **decisions**

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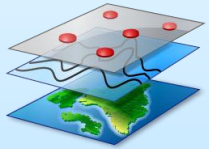
Modelling the world of water

1D – River modelling

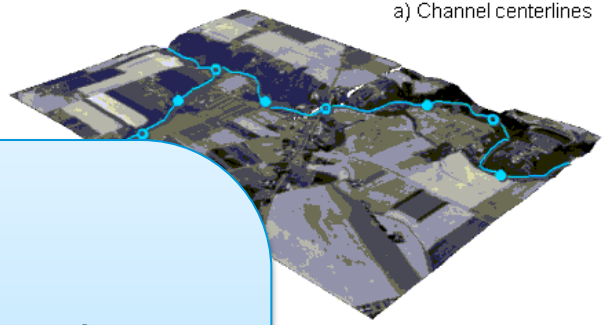
- Flood anal
- Design of
- Dam breal
- Analysis a
- Drainage a
- Water qua
- Sediment
- Optimisati
- Real-time
- …

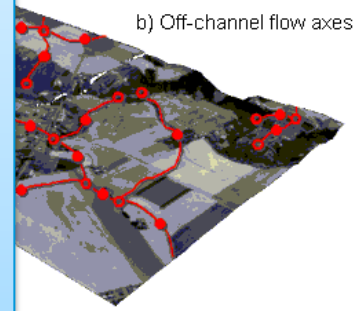


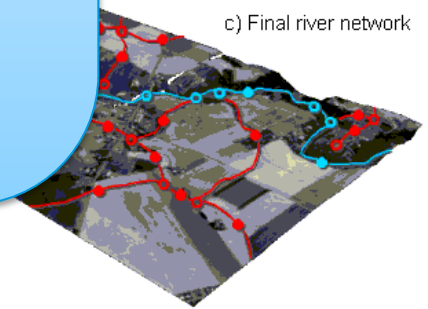
- Soil and land use maps
- Basin topography
- River alignment and cross-sections
- Embankments

- Structure geometry
- Rule curves

- Precipitation
- Potential evapotranspiration
- River flow and water level







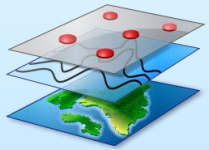
1D - Urban modelling

- **Water di**

  Water
  and w
  Includ

- **Collecti**

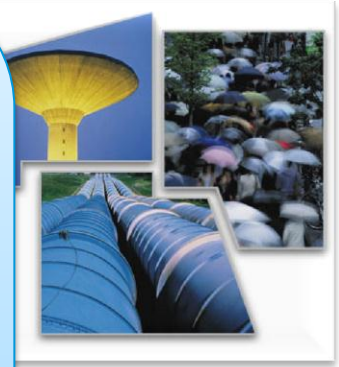
  Waste
  pollut
  time c



- Drainage and suply network
- Pipe information
- Embankments

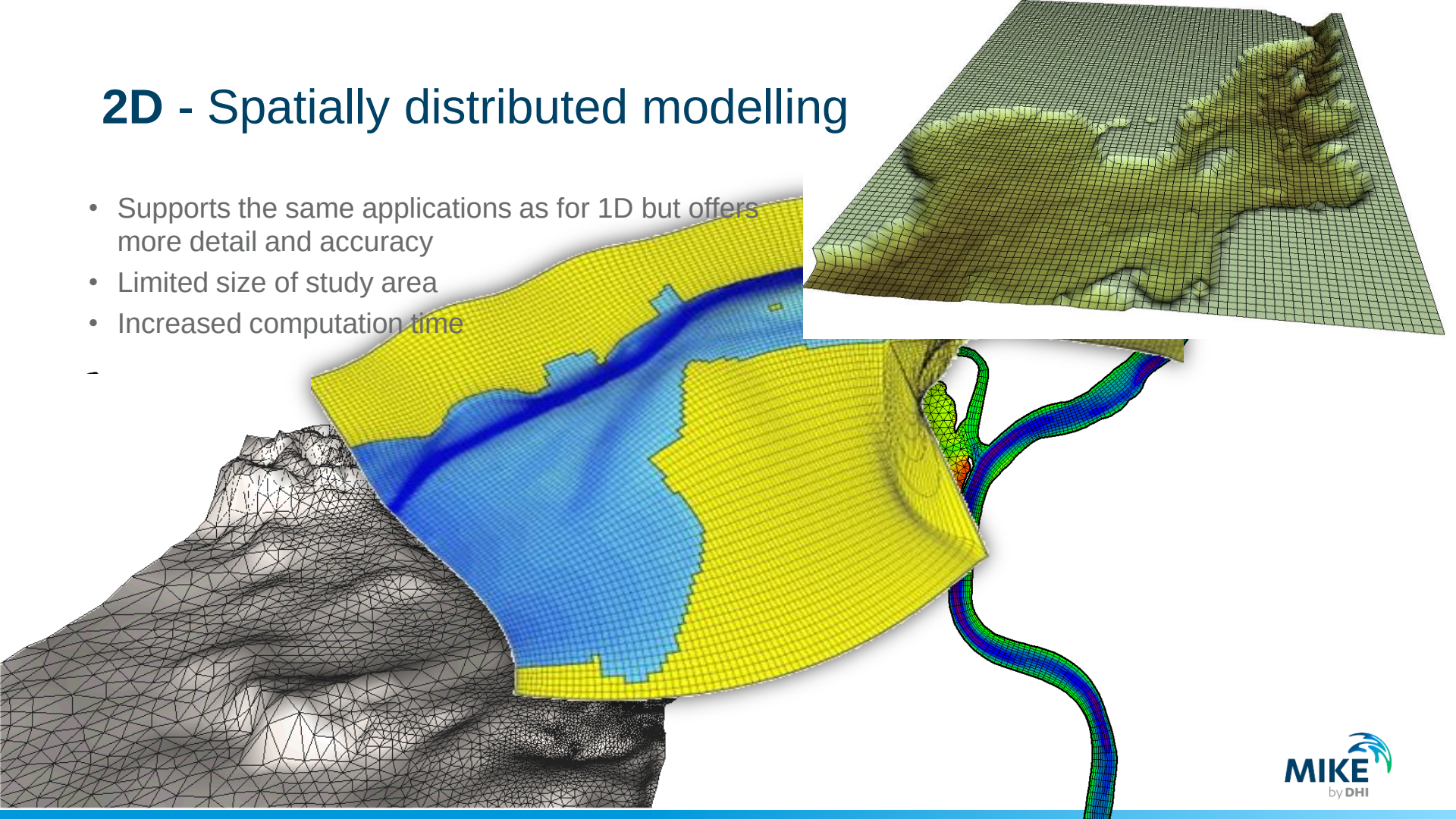
- Pump charateristics
- Operational rules

- Pipe flow
- Pumping
- Water supply and use



2D - Spatially distributed modelling

- Supports the same applications as for 1D but offers more detail and accuracy
- Limited size of study area
- Increased computation time



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2D - Building the topographical model basis

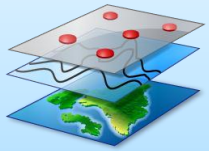
Final grid with streets and buildings

Raising
there ar

Grid with

Lowering
where there are streets

Initial elevation grid



- Digital terrain model
- Infrastructure maps

… plus relevant forcing terms

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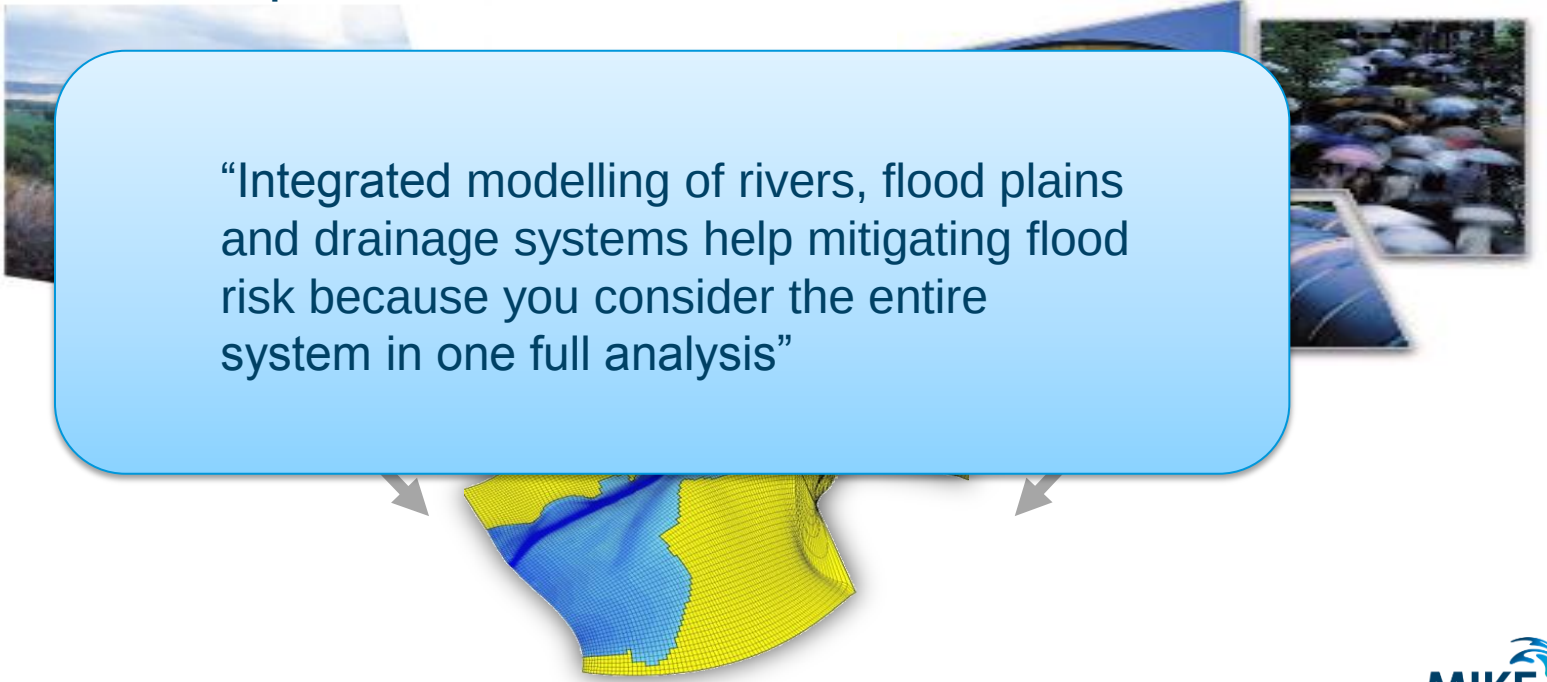
1D-2D – Dynamic model coupling

1D rural flow component

1D urban flow component



"Integrated modelling of rivers, flood plains and drainage systems help mitigating flood risk because you consider the entire system in one full analysis"

2D surface flow component

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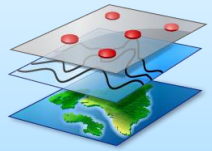
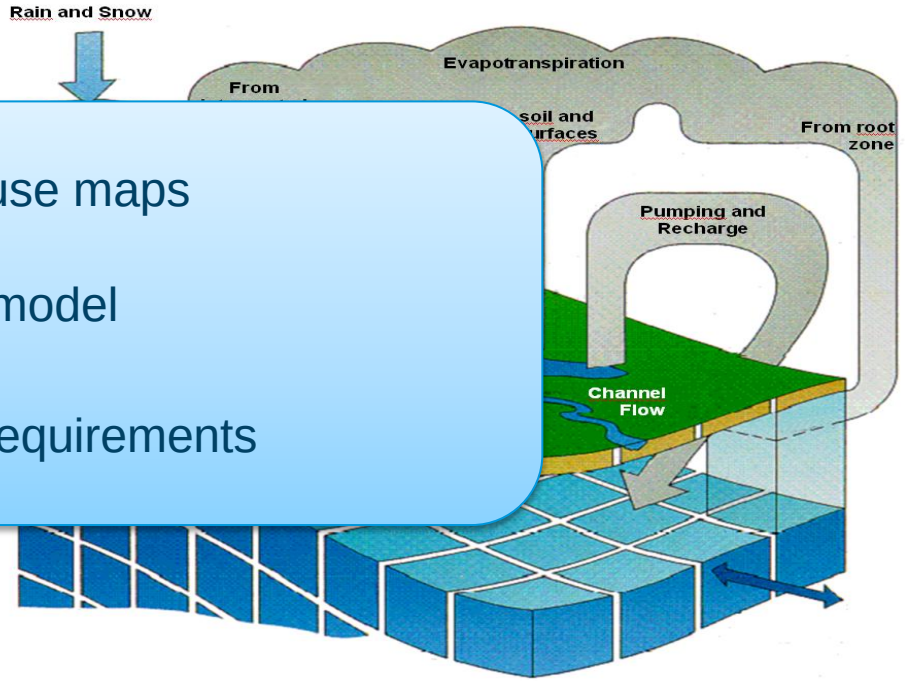
Integrated catchment modelling

- Groundwater management and planning
- Surface water impact from groundwater withdrawal
- Conjunctiv
  surface wa
- Wetland m
- Aquifer vu
  dynamic re
  boundarie
- Impact stu
  and climate
- Impact studies of agricultural practices including irrigation, drainage and nutrient and pesticide management



- Soil and land use maps
- Acquifer maps
- Digital terrain model

… plus 1D data requirements



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Sample Applications

Nile Basin Decision Support System

Accepted tools
Sharing of data and knowledge
Cross boundary cooperation

> The Nile Basin Decision Support System will provide the basis for agreement on and development of sustainable water resources projects in the Nile Basin”

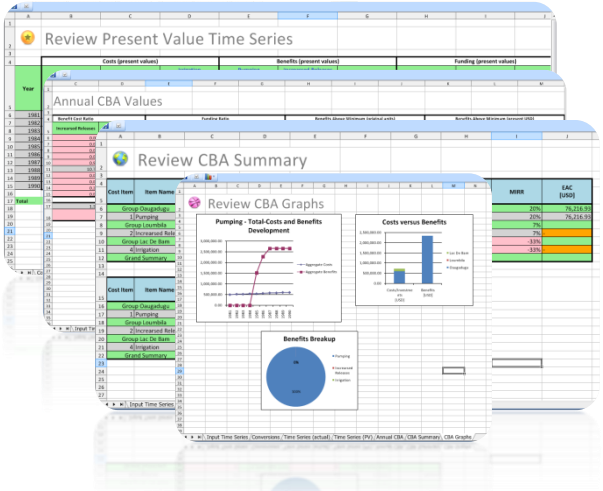
Dr. Abdulkarim H. Seid, Head, Water Resources Management, Nile-Sec

Nile Basin Decision Support System

NB DSS

- Time series
- Spread-sheets
- GIS
- MCA/CBA
- Scenarios
- Dashboard (web publishing)
- Optimisation
- Work spaces
- Ensembles
- Meta data
- Scripting
- Indicators

Data base



Computer Aided River Management System

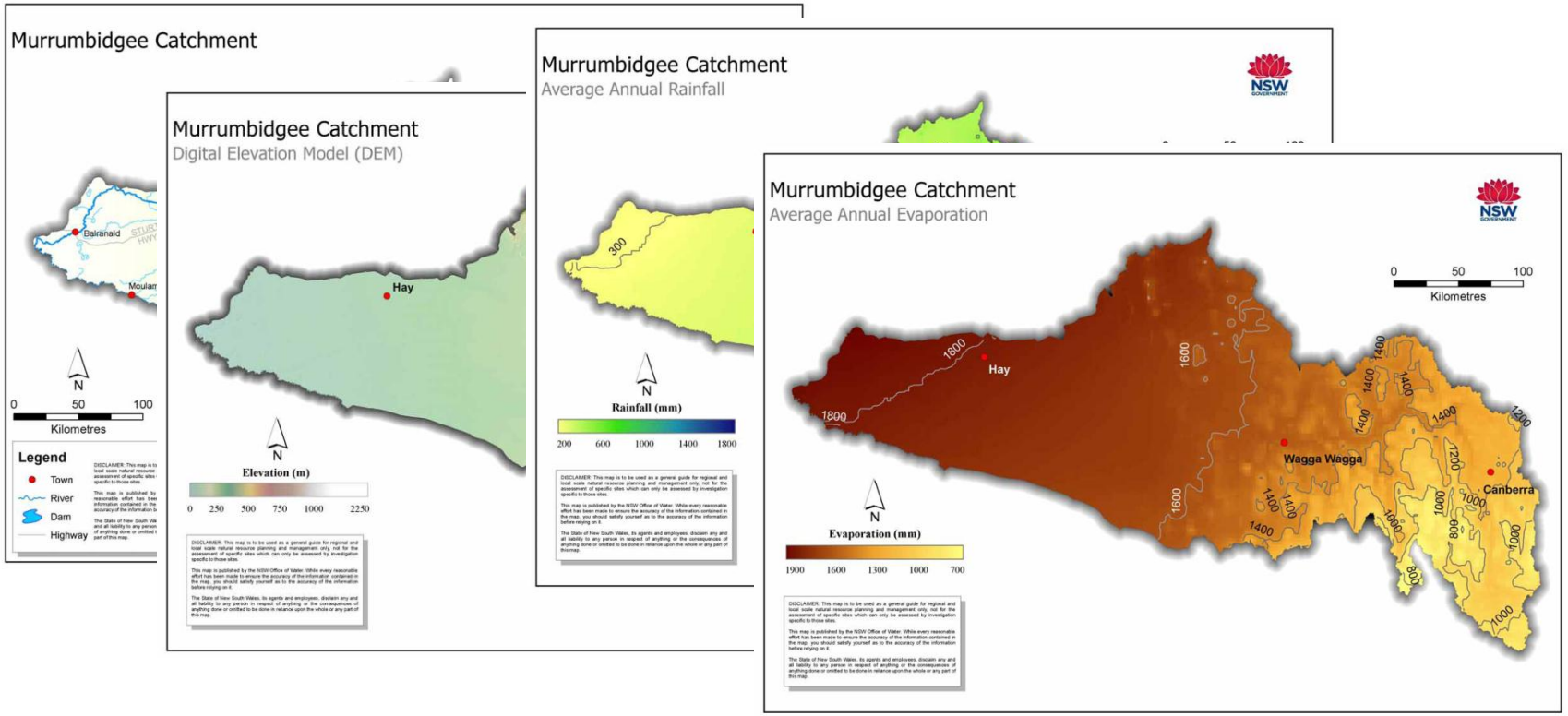
New South Wales, Australia

Over 1,600km of river with two dams and thousands of water users. **One** river management system.

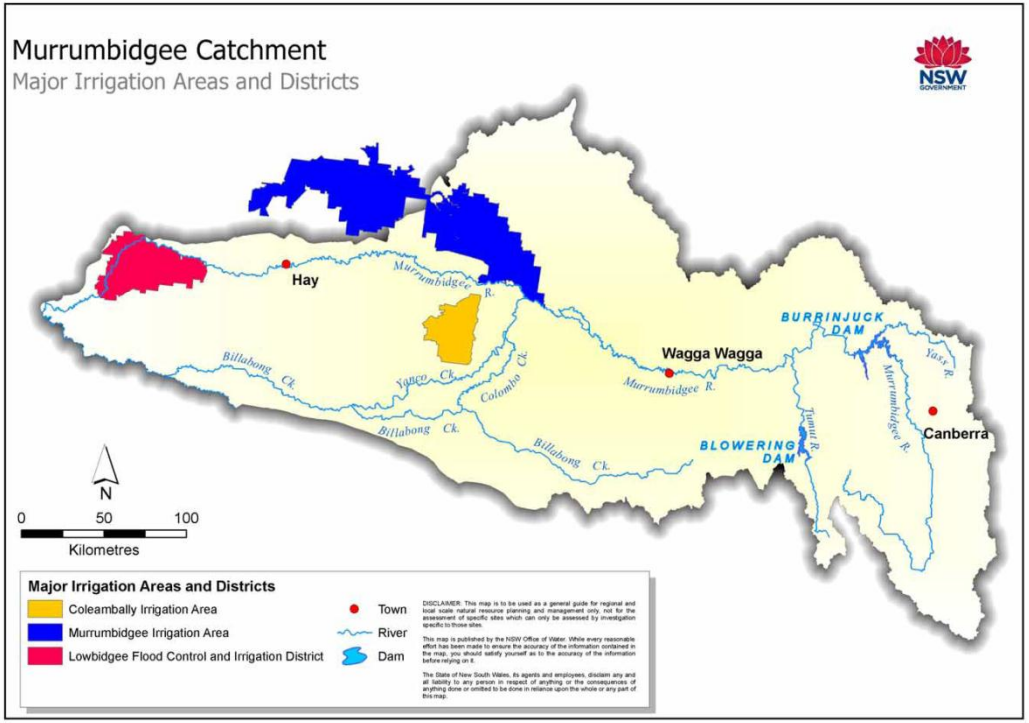
Precision releases to deliver the right flows at the right time

> CARM is a world class development designed to maximise the efficiency of the Murrumbidgee River system.”
>
> *Brett Tucker, Chief Executive Officer, State Water Corporation, New South Wales, Australia*

Murrumbidgee Catchment



Irrigation



- Irrigation and environment are biggest water users
- Murrumbidgee and Coleambally use 50% and 20% of all irrigation water.

Murrumbidgee River
Efficiency Project

Improved

- Extraction and usage information
- Forecasting of Tributary Inflows
- Optimisation of Dam Releases

Central River Management

- modeling
- forecasting
- water ordering
- surveillance
- control based on real time conditions and customer needs

Improved management & measurement of Irrigation Corp offtake meters/real-time

Protection of environmental flows

MIA

Lachlan River

Swamp

Maude Weir

Hay

Gogelderie Weir

Redbank Weir

Murrumbidgee River

Balranald

Lowbidgee

Murray River

CICL

Yanco Weir

Berembed Weir

River gauge measurement in real-time

Wagga Wagga

Tumut River

Burrinjuck Dam

Blowering Dam

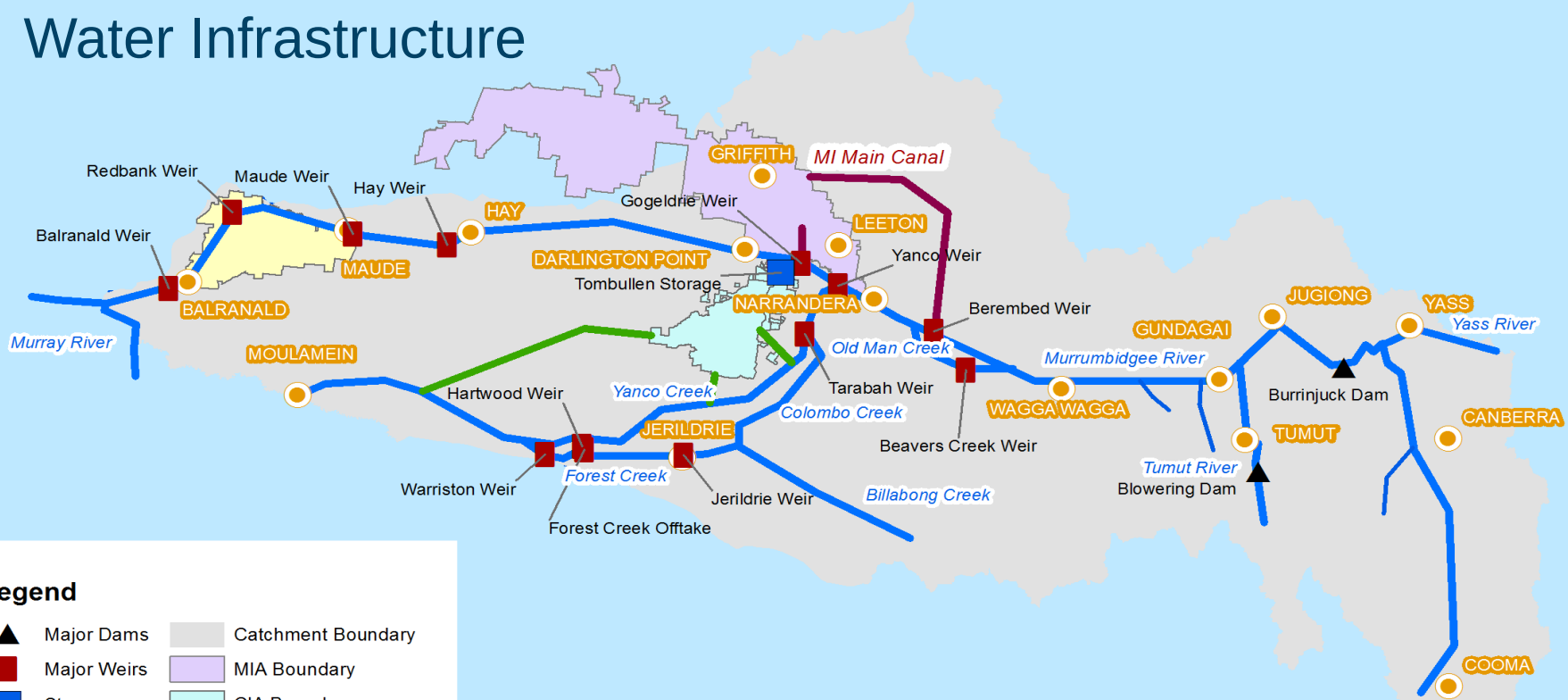
Accurate real-time metering

Modeling & forecasting of tributary inflows to manage dam release

Improved forecasting of flood flows into Burrinjuck

MIA - Murrumbidgee Irrigation Area CICL - Coleambally Irrigation

Water Infrastructure

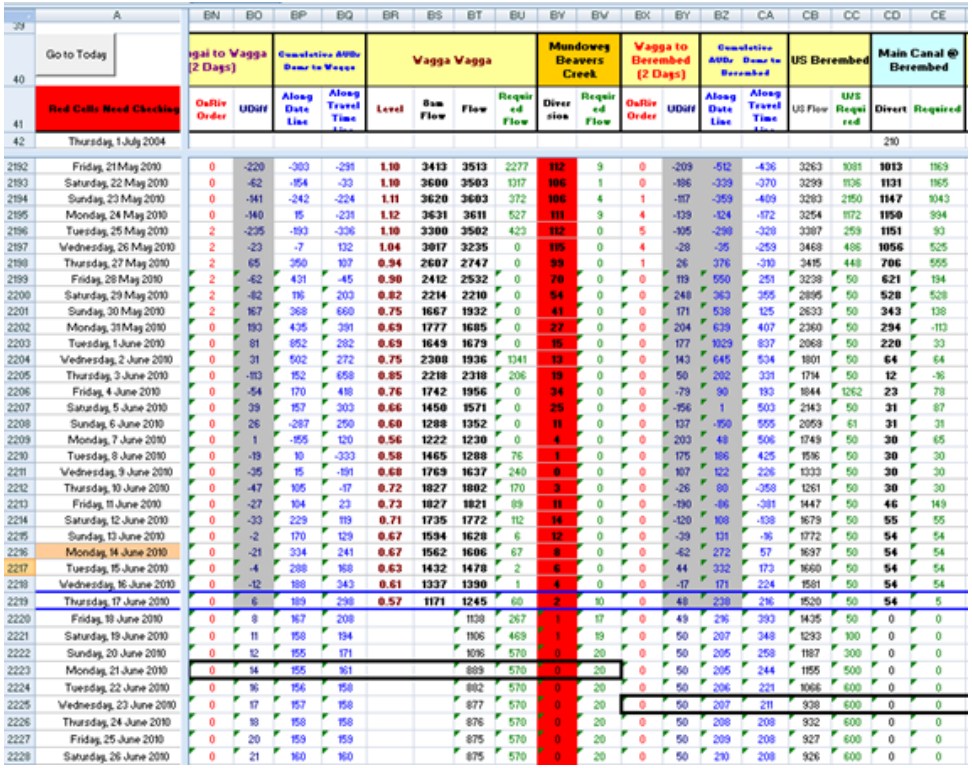


Legend

- Major Dams
- Major Weirs
- Storage
- River System
- Canals
- Drains
- Catchment Boundary
- MIA Boundary
- CIA Boundary
- Lowbidgee Boundary
- Major Towns

4 November, 2013

Previous River Operations



	A	BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY	BZ	CA	CB	CC	CD	CE
39																			
40	Go to Today	gai to Vagga (2 Days)		Cumulative AUDc Down to Wagga		Vagga Vagga				Mundoweg Beavers Creek		Vagga to Berembed (2 Days)		Cumulative AUDc Down to Berembed		US Berembed		Main Canal @ Berembed	
41	Red Cells Need Checking	OnRiv Order	UDiff	Along Date Line	Along Travel Time Line	Level	8am Flow	Flow	Required Flow	Diversion	Required Flow	OnRiv Order	UDiff	Along Date Line	Along Travel Time Line	US Flow	US Required	Divert	Required
42	Thursday, 1 July 2004																	210	
2192	Friday, 21 May 2010	0	-220	-303	-291	1.10	3413	3513	2277	112	9	0	-209	-512	-436	3263	1081	1013	1169
2193	Saturday, 22 May 2010	0	-62	-154	-33	1.10	3600	3503	1317	106	1	0	-186	-339	-370	3299	1136	1131	1165
2194	Sunday, 23 May 2010	0	-141	-242	-224	1.11	3620	3603	372	106	4	1	-117	-359	-409	3283	2150	1147	1043
2195	Monday, 24 May 2010	0	-140	15	-231	1.12	3631	3611	527	111	9	4	-139	-124	-172	3254	1172	1150	994
2196	Tuesday, 25 May 2010	2	-235	-193	-336	1.10	3300	3502	423	112	0	5	-105	-298	-328	3387	259	1151	93
2197	Wednesday, 26 May 2010	2	-23	-7	132	1.04	3017	3235	0	115	0	4	-28	-35	-259	3468	486	1056	525
2198	Thursday, 27 May 2010	2	65	350	107	0.94	2607	2747	0	99	0	1	26	376	-310	3415	448	706	555
2199	Friday, 28 May 2010	2	-62	431	-45	0.90	2412	2532	0	78	0	0	119	550	251	3238	50	621	194
2200	Saturday, 29 May 2010	2	-82	116	203	0.82	2214	2210	0	54	0	0	248	363	355	2895	50	528	528
2201	Sunday, 30 May 2010	2	167	368	660	0.75	1667	1932	0	41	0	0	171	538	125	2633	50	343	138
2202	Monday, 31 May 2010	0	193	435	391	0.69	1777	1685	0	27	0	0	204	639	407	2360	50	294	-113
2203	Tuesday, 1 June 2010	0	81	852	282	0.69	1649	1679	0	15	0	0	177	1029	837	2068	50	220	33
2204	Wednesday, 2 June 2010	0	31	502	272	0.75	2308	1936	1341	13	0	0	143	645	534	1801	50	64	64
2205	Thursday, 3 June 2010	0	-113	152	658	0.85	2218	2318	206	19	0	0	50	202	331	1714	50	12	-16
2206	Friday, 4 June 2010	0	-54	170	418	0.76	1742	1956	0	34	0	0	-79	90	193	1644	1262	23	78
2207	Saturday, 5 June 2010	0	39	157	303	0.66	1450	1571	0	25	0	0	-156	1	503	2143	50	31	87
2208	Sunday, 6 June 2010	0	26	-287	250	0.60	1288	1352	0	11	0	0	137	-150	555	2059	61	31	31
2209	Monday, 7 June 2010	0	1	-155	120	0.56	1222	1230	0	4	0	0	203	48	506	1749	50	30	65
2210	Tuesday, 8 June 2010	0	-19	10	-333	0.58	1465	1288	76	1	0	0	175	186	425	1516	50	30	30
2211	Wednesday, 9 June 2010	0	-35	15	-191	0.68	1769	1637	240	0	0	0	107	122	226	1333	50	30	30
2212	Thursday, 10 June 2010	0	-47	105	-17	0.72	1827	1802	170	3	0	0	-26	80	-358	1261	50	30	30
2213	Friday, 11 June 2010	0	-27	104	23	0.73	1827	1821	89	11	0	0	-190	-86	-381	1447	50	46	149
2214	Saturday, 12 June 2010	0	-33	229	119	0.71	1735	1772	112	14	0	0	-120	108	-138	1679	50	55	55
2215	Sunday, 13 June 2010	0	-2	170	129	0.67	1594	1628	6	12	0	0	-39	131	-16	1772	50	54	54
2216	Monday, 14 June 2010	0	-21	334	241	0.67	1562	1606	67	8	0	0	-62	272	57	1697	50	54	54
2217	Tuesday, 15 June 2010	0	-4	288	168	0.63	1432	1478	2	6	0	0	44	332	173	1660	50	54	54
2218	Wednesday, 16 June 2010	0	-12	188	343	0.61	1337	1390	1	4	0	0	-17	171	224	1581	50	54	54
2219	Thursday, 17 June 2010	0	6	189	298	0.57	1171	1245	60	2	10	0	48	238	216	1520	50	54	5
2220	Friday, 18 June 2010	0	9	167	208			1138	267	1	17	0	49	216	393	1435	50	0	0
2221	Saturday, 19 June 2010	0	11	158	194			1106	469	1	19	0	50	207	348	1293	100	0	0
2222	Sunday, 20 June 2010	0	12	155	171			1096	570	0	20	0	50	205	258	1187	300	0	0
2223	Monday, 21 June 2010	0	14	155	161			889	570	0	20	0	50	205	244	1155	500	0	0
2224	Tuesday, 22 June 2010	0	16	156	158			882	570	0	20	0	50	206	221	1066	600	0	0
2225	Wednesday, 23 June 2010	0	17	157	158			877	570	0	20	0	50	207	211	938	600	0	0
2226	Thursday, 24 June 2010	0	18	158	158			876	570	0	20	0	50	208	208	932	600	0	0
2227	Friday, 25 June 2010	0	20	159	159			875	570	0	20	0	50	209	208	927	600	0	0
2228	Saturday, 26 June 2010	0	21	160	160			875	570	0	20	0	50	210	208	926	600	0	0

- Water orders aggregated upstream to dams
- Assumes water moves as parcels between gauges at fixed daily travel times
- Limited use of real time and forecast data (flows, rainfall, demands)
- Manual daily operation requires extensive operator experience and judgement
- Aging technology

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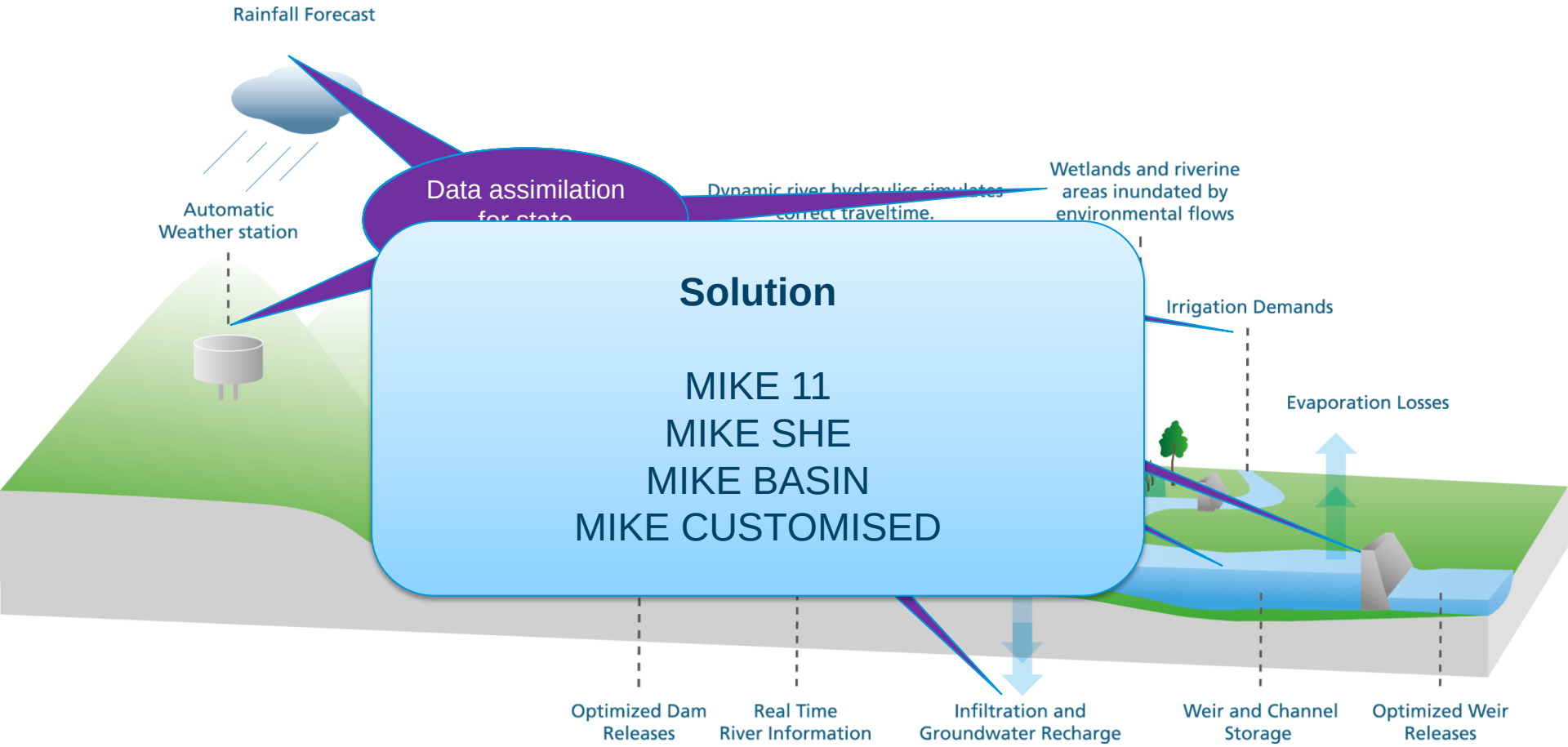
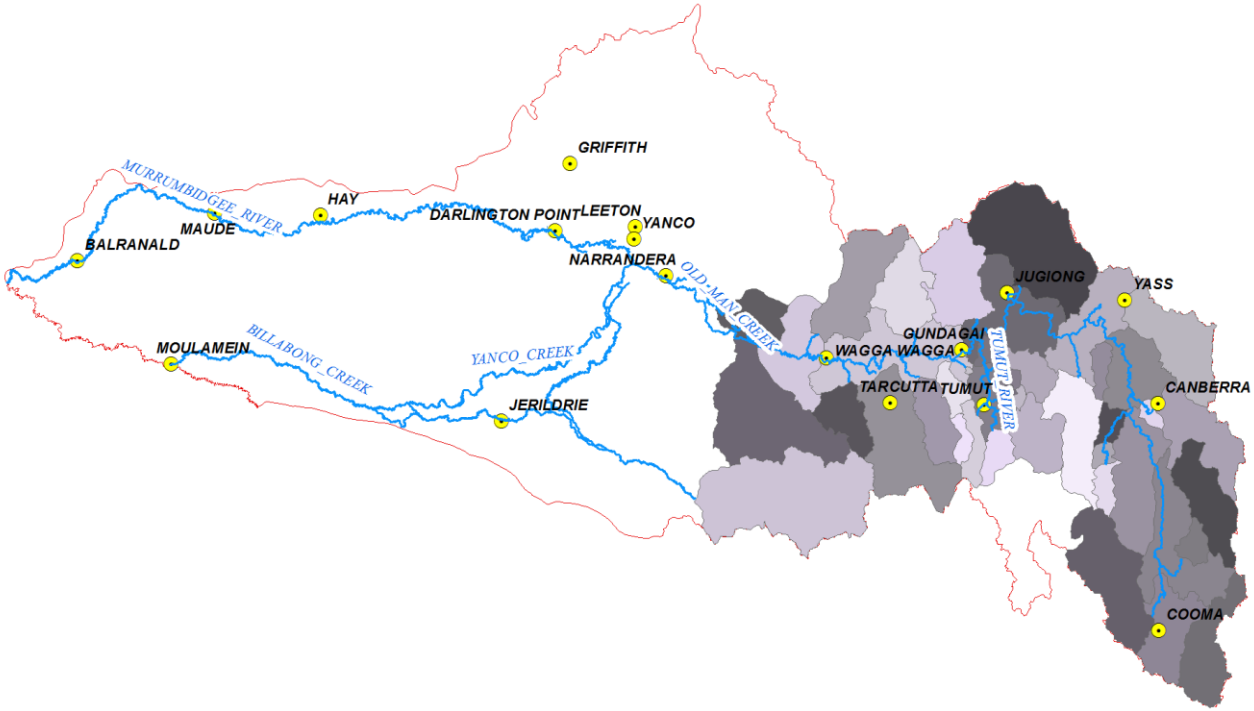
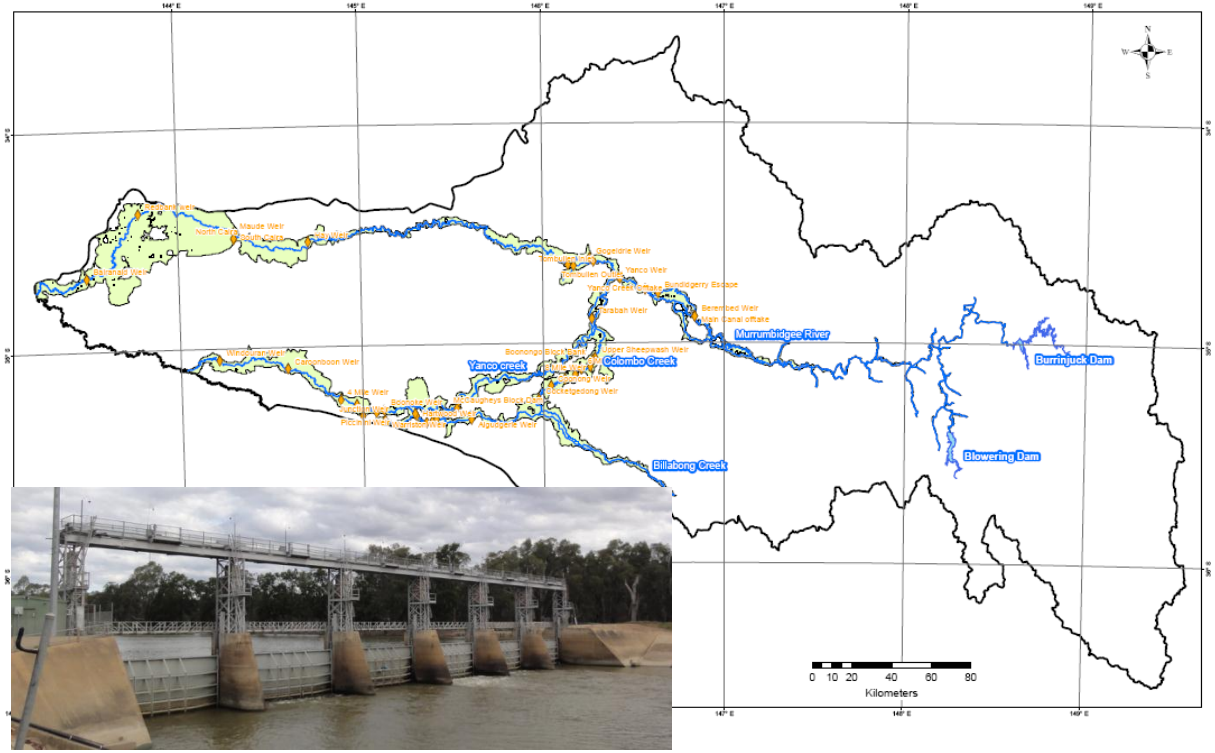

Rainfall Forecast
Automatic
Weather station
Data assimilation
Dynamic river hydraulics simulates
correct traveltime.
Wetlands and riverine
areas inundated by
environmental flows
Solution
MIKE 11
MIKE SHE
MIKE BASIN
MIKE CUSTOMISED
Irrigation Demands
Evaporation Losses
Optimized Dam
Releases
Real Time
River Information
Infiltration and
Groundwater Recharge
Weir and Channel
Storage
Optimized Weir
Releases

Catchment Inflow Forecasting – MIKE 11 RR



- Continuous, hourly timestep
- Auto-calibration
- 25 catchment models established and calibrated
- Utilises real time rainfall observations and grid based forecasts from Bureau of Meteorology

River Hydraulics – MIKE 11 HD, SO, DA

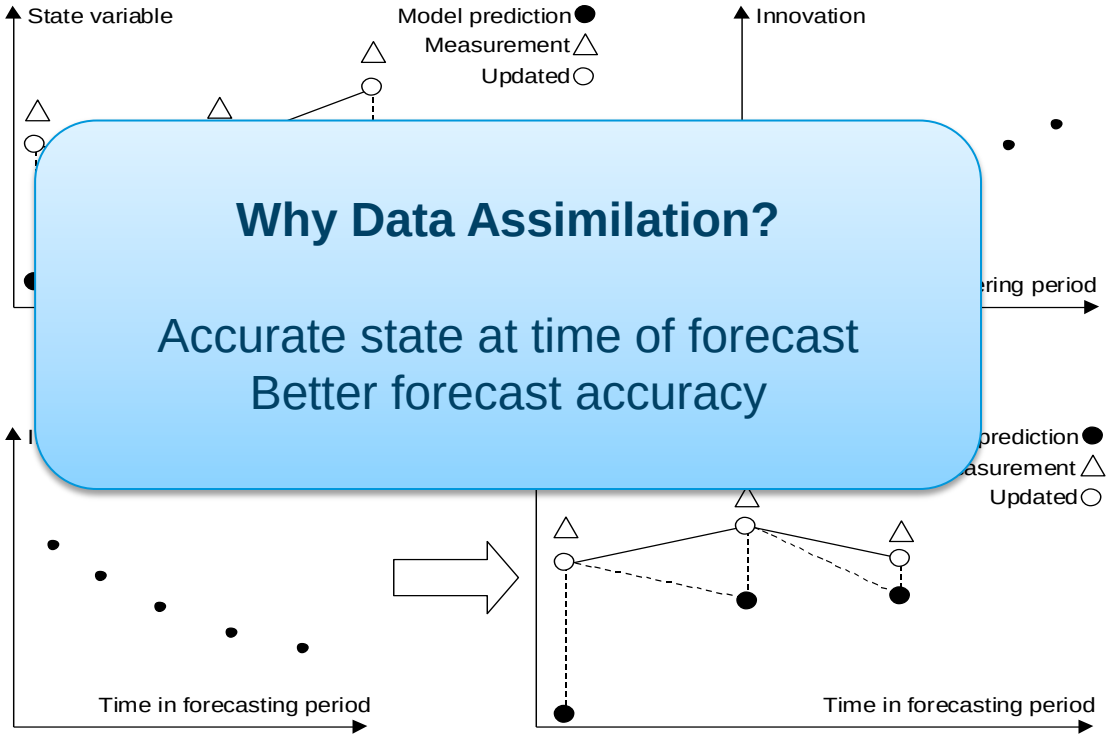


- 3000 km river
- 200 wetlands
- 17 controllable structures, 25 fixed crest weirs

Data Assimilation

Hindcast period:

Forecast period:

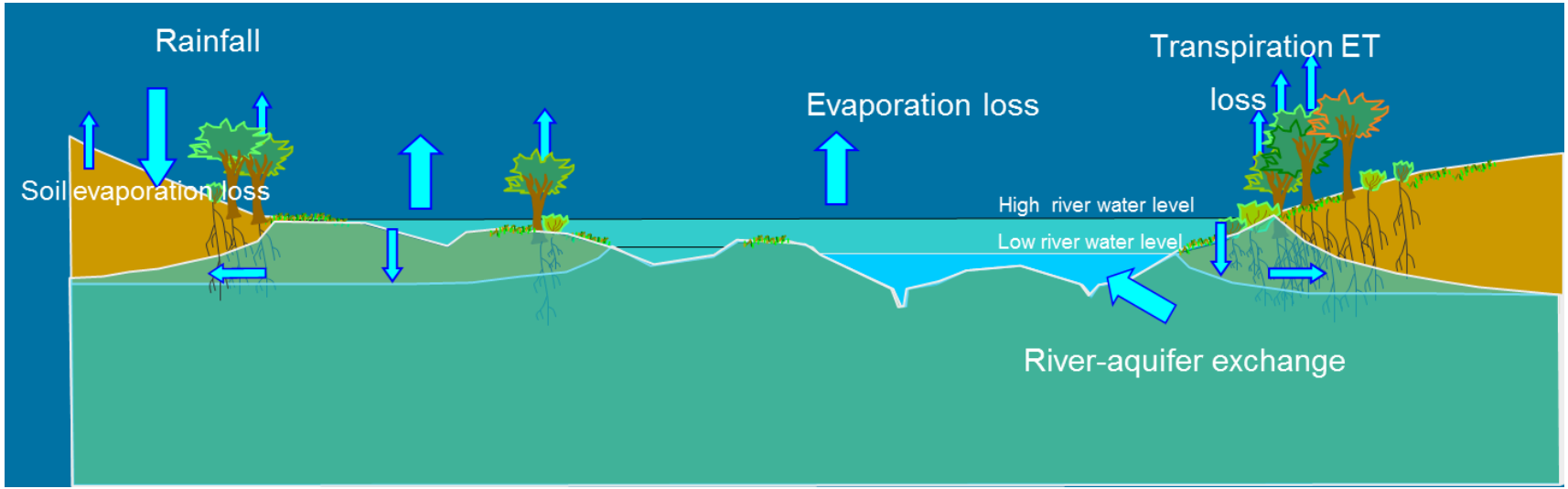


Why Data Assimilation?

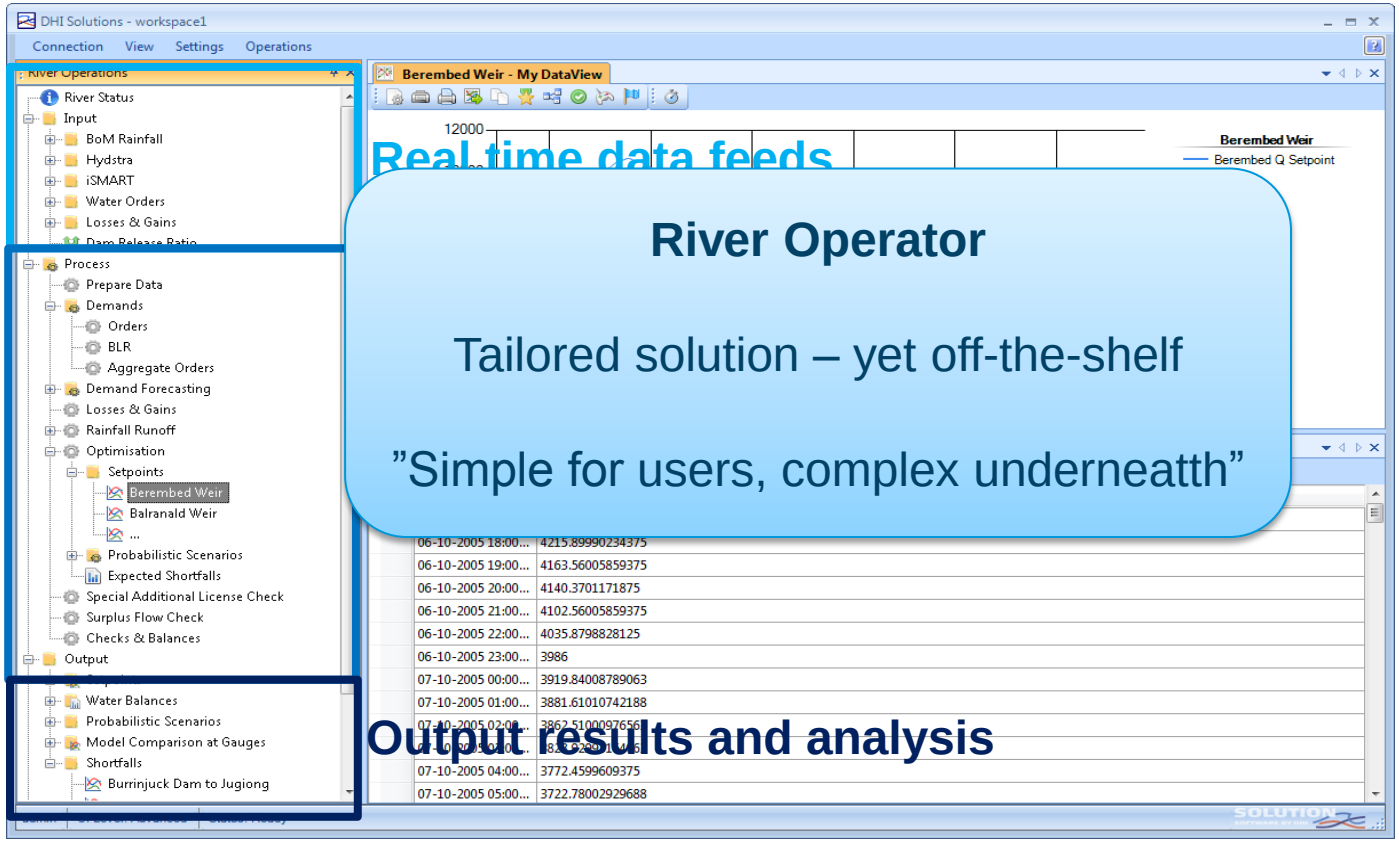
Accurate state at time of forecast
Better forecast accuracy

Losses and Gains – MIKE SHE

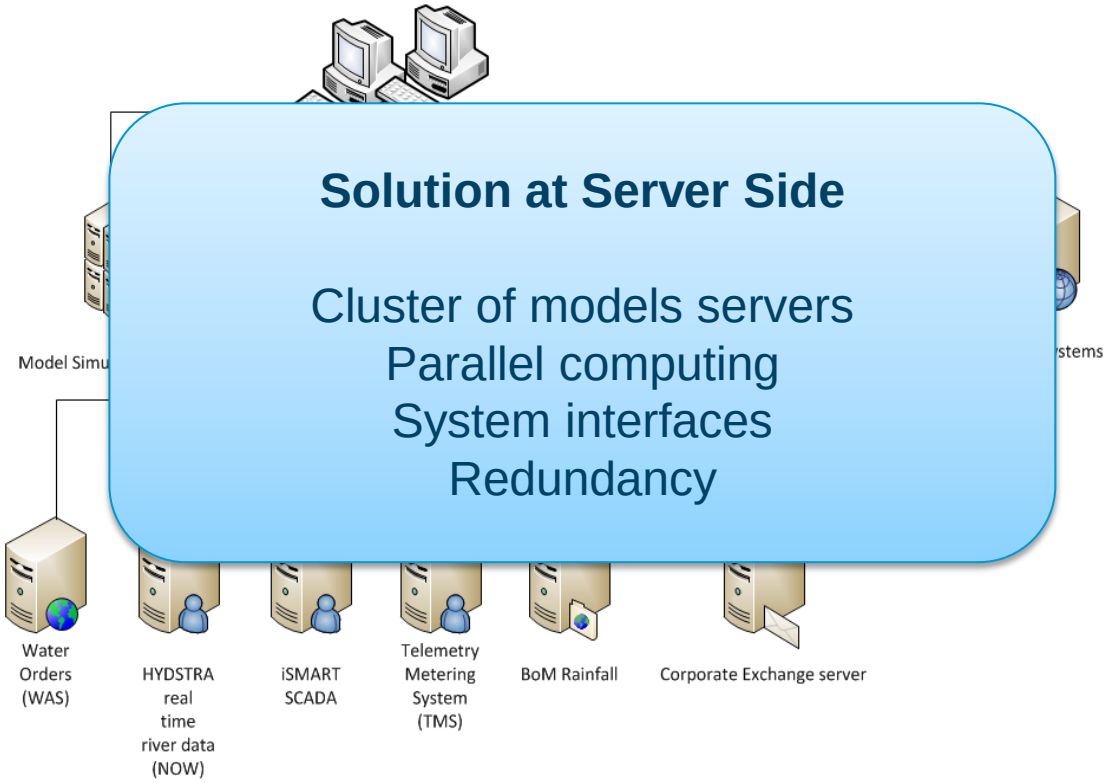
- Integrated hydrology
- Near bank ET, bank storage and groundwater inflows/outflows



River Operator – MIKE CUSTOMISED



Solution at Server Side



Solution at Server Side

Cluster of models servers
Parallel computing
System interfaces
Redundancy

Approach to Optimisation

Objectives:
- Schedule releases to match demands
- Meet environmental flow requirements
- Flood protection

Constraints:
- Minimum-maximum river flows
- Minimum operating levels at regulators
- ws

Result

Regulator set points for the next 6 hours communicated through OPC

Step 1a Dynamic la ins

Step 1b Assimilation ecast period

Step 2 Optimisation based on initial solution

Early forecast and warning systems

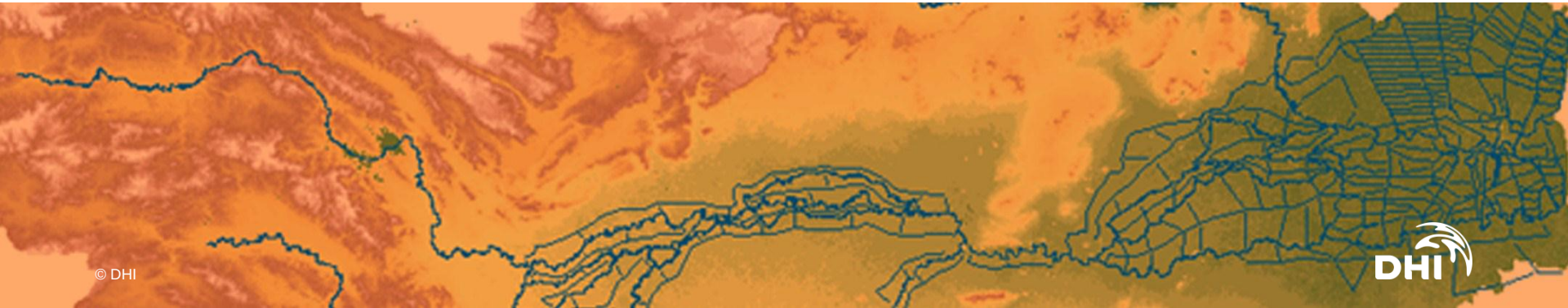
Chao Phraya, Thailand

The Chao Phraya River Basin. 160,000km2. **One** Decision Support System to protect against devastating flooding.

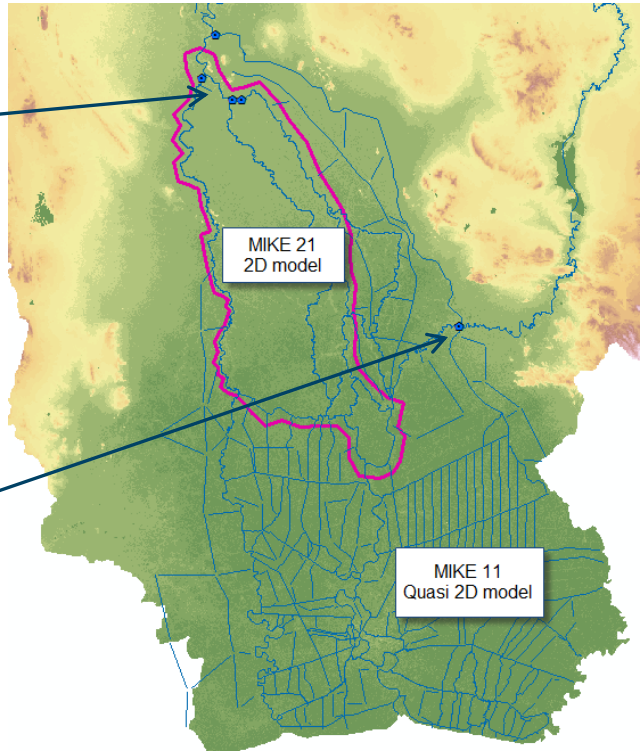
You can too – with our software platform

“HAII highly appreciates DHI for their excellent job, especially on the close collaboration and hands on experience that made us become a good partner.”

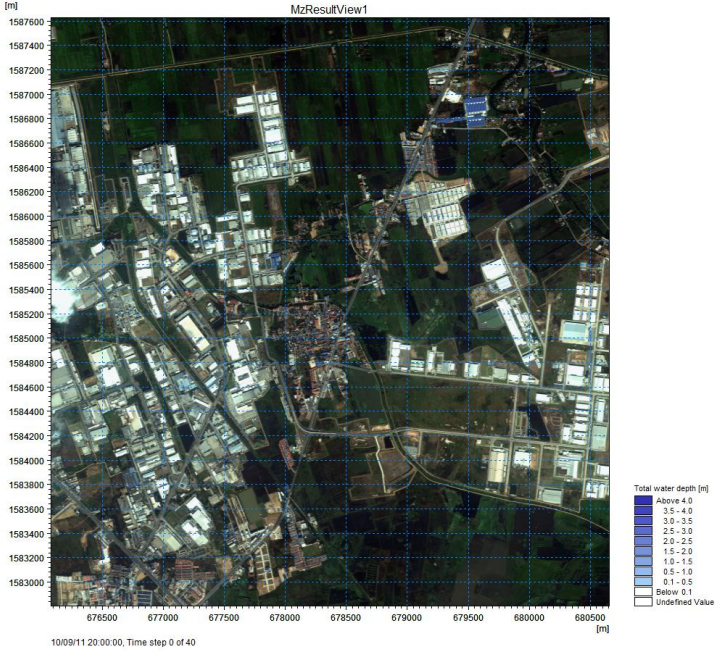
Dr. Piyamarn Sisomphon, Project Leader, Hydro and Agro Informatics Institute



Early forecast and warning systems



Chao Phraya, Thailand



MIKE by DHI

Thank you for listening!

Claus Skotner
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For info or further questions on this presentation, or on the activities of the JASPERS Networking Platform please contact:

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