Basin Development Plan 2nd Regional Stakeholder Consultation and Dialogue
15-16 October 2009, Chiang Rai, Thailand

Hydrological Assessment of Basin-Wide Development Scenarios:

Tools and Preliminary Results
(Work in Progress)

Dr. Thanapon Piman

Basin Development Plan, MRCS

Outline of the Presentation

1. The approach
2. Description of basin-wide development scenarios
3. Tools for modelling
4. Preliminary results
   - Changes in flows and water levels
   - Changes in floodplain in Mekong Delta
   - Changes in salinity intrusion in Viet Nam Delta
5. In Summary
6. Proposed Next Steps

The Approach

- **All eight water and related sectors** are considered
- Nine basin-wide development scenarios are defined, some of which comprise sub-scenarios, under four situation situations: **1) Baseline, 2) Definite Future , 3) Foreseeable Future (next 20 years), 4) Long-Term Future (next 50 years)**
- **Stakeholder Participation is carried out along the whole process** at regional, national and sub-areas levels
- **Use of proven models and impact analytical tools** (the MRC-Decision Support Framework) for hydrological simulations
- First the scenarios will be assessed on **a range of hydrological impact indicators** The results are then fed into the assessment of the transboundary economic, social and environmental impacts

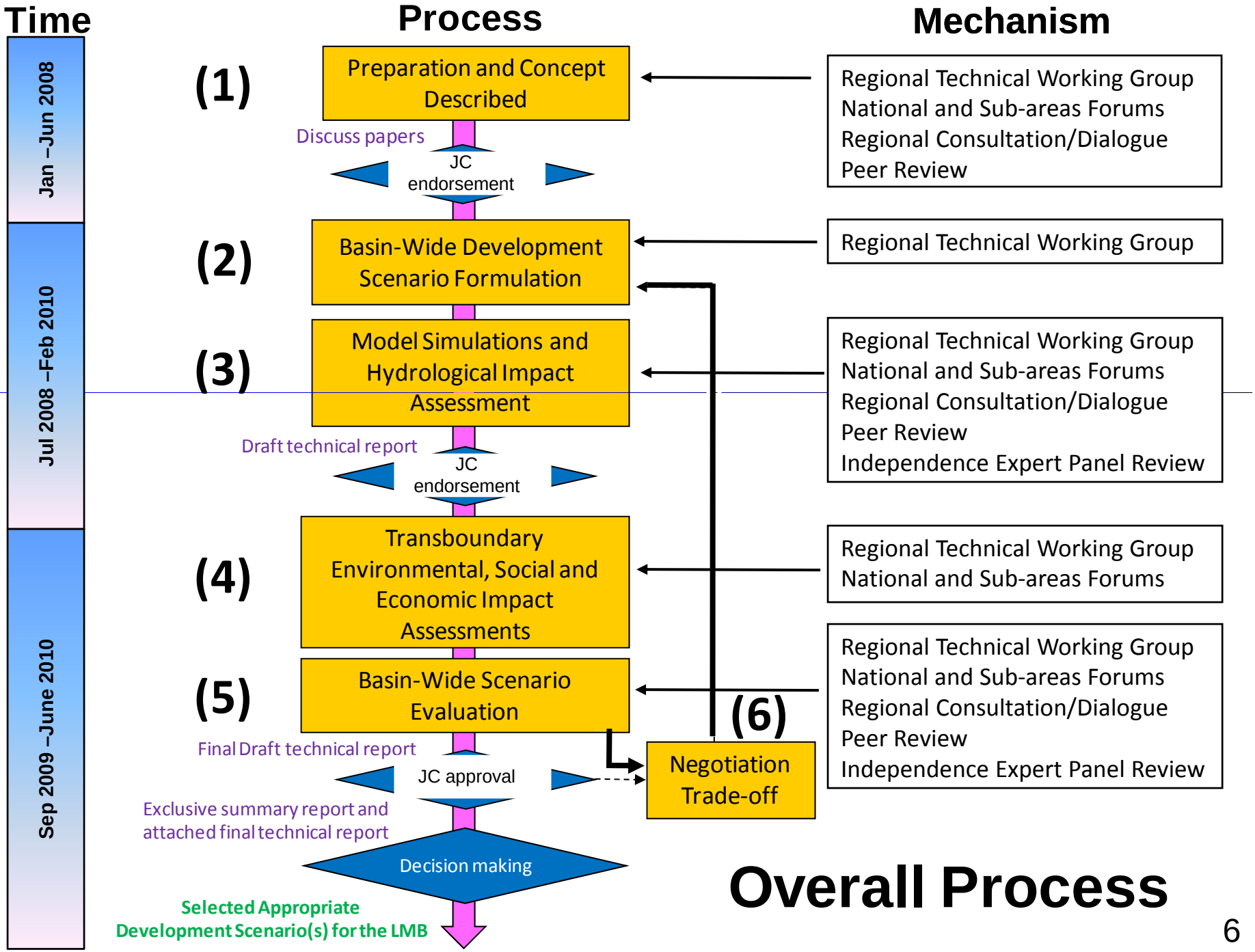
Sectors considered

- Water supplies (domestic and industrial uses)
- Irrigated agriculture
- Hydropower
- Flood management and mitigation
- Fisheries
- Navigation, transport, river works
- Tourism and recreation (water-related)
- Environment, including water demand of ecosystem

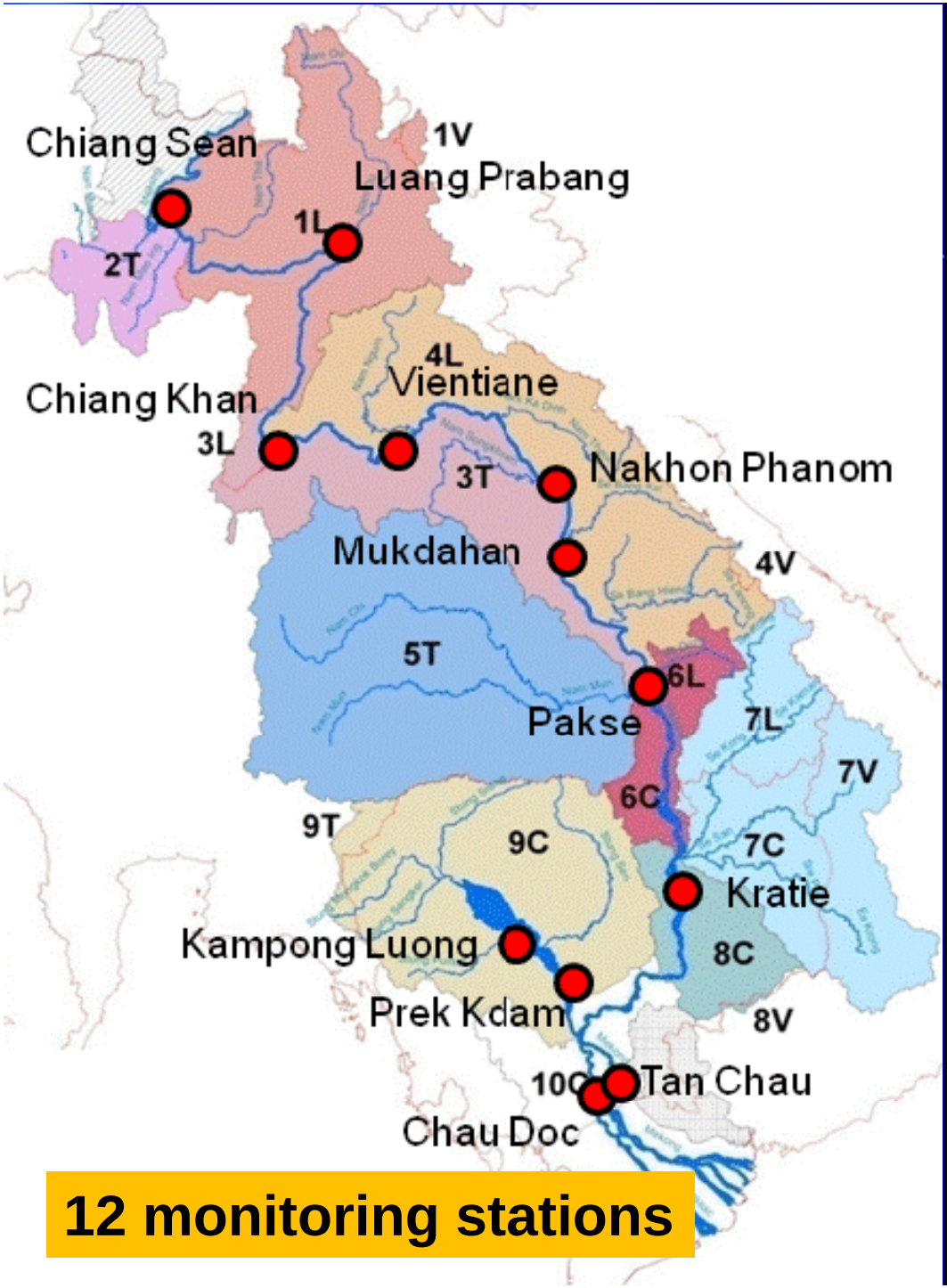
Considered Basin-Wide Development Scenarios

Baseline situation	Definite future situation	Foreseeable future situation (20 years)	Longer-term future (50 years)
1. Baseline line scenario in year 2000	2. Upper Mekong Dam Scenario 3. Definite Future Scenario	4. LMB 20-Year Plan Scenario (National perspectives) <u>Alternative perspectives</u> 5. LMB 20-Year Plan Scenario without Mainstream Dams 6. LMB 20-Year Plan Scenario with different configuration of Mainstream Dams in the LMB 7. Mekong Delta Flood Management Scenario	8. LMB Long-term Development Scenario 9. LMB Very High Development Scenario

Foreseeable Future* and *Longer Term Future Scenarios* will be assessed with and without *climate change



Overall Process



12 monitoring stations

Key Indicators

Changes in flow and water level:

- Average seasonal flow and water level
- Average monthly flow and water level
- Reverse flow to Tonle Sap at Prek Kdam, Cambodia
- Water levels in the Tonle Sap Lake, Cambodia

Changes in the floodplain of Tonle Sap and Mekong Delta (> 0.5 m water depth)

- Flood inundation area
- Flood duration
- Flood volume

Changes in salinity intrusion in the Vietnam Delta (> 4 g/l)

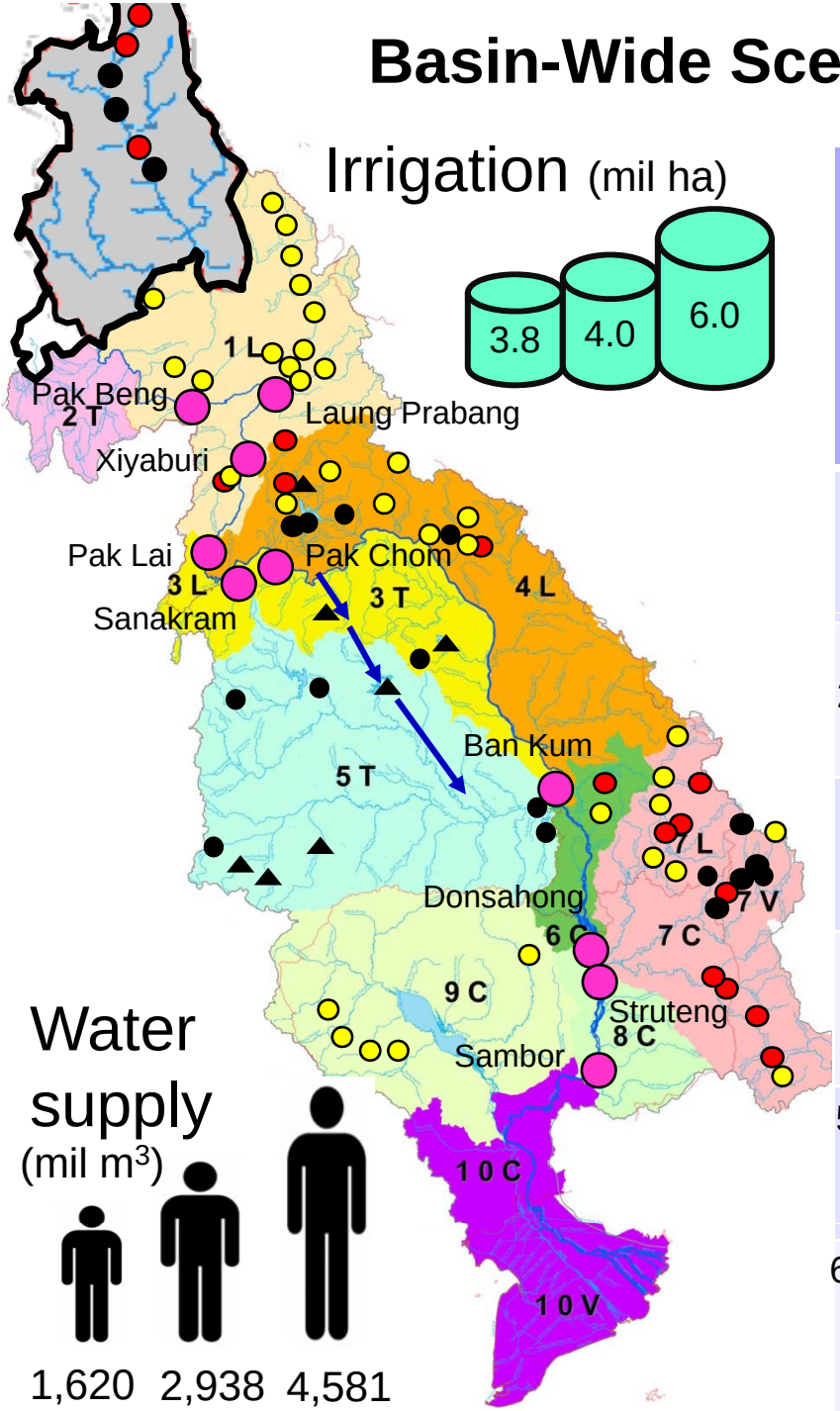
- Salinity intrusion areal extent
- Salinity intrusion duration
- Salinity intrusion concentration

Other hydrology-related changes

- Sediment transport
- Water quality

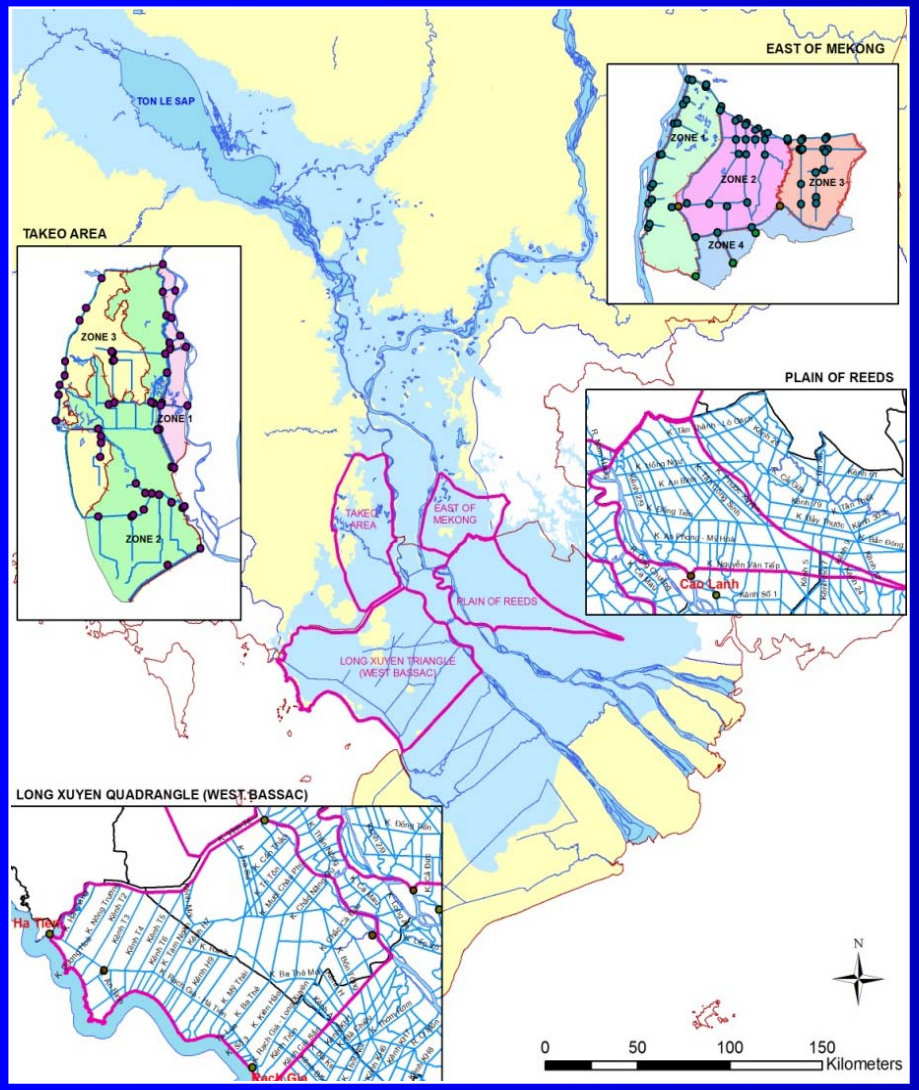
Description of Basin-Wide Development Scenarios

Basin-Wide Scenario Formulation and Input Data



Scenarios	No. Dams Install Capacity (MW)	Irrigable area (10^6 ha)	Water supply (10^6 m3)
1) Baseline 2000	11 (1,533)	3.8	1,620
2) Upper Mekong Dams	17 (16,983)	3.8	1,620
3) Definite Future	35 (21,053)	4.0	2,938
4) LMB 20-Year Plan	79 (40,753)	6.0	4,581
5) LMB 20-Year Plan without mainstream dams	69 (26,674)	6.0	4,581
6) LMB 20-Year Plan with 6 mainstream dams in north LMB	75 (34,242)	6.0	4,581

Mekong Delta Flood Management Scenario



Foreseeable Future scenario, up to the year 2030, in which the existing agreed plan for flood protection in the Mekong Delta in Vietnam is expected to be completed, and a mix of early and full flood protection in the Cambodia part of the delta is considered (FMMP C2).

Sub-Scenario 1: Early flood protection and full flood protection in Cambodia

- Takeo
- Prey Veng

Sub-Scenario 2: Early flood protection and full flood protection in Vietnam

- Long Xuyen Quidrangle
- Trans Bassac
- Plain of Reeds

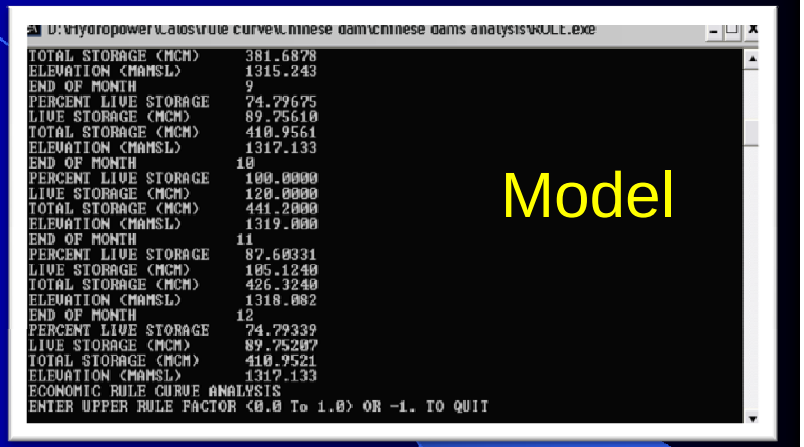
Sub-Scenario 3: Flood protection in Cambodia and Vietnam

Tools for Modelling

The Tools (1)

Hydropower Operation Rule Model

- Single dam
- Dam cascade



Model

Input

MANWAN (Cascade)

RATED NET HEAD M	INSTALLED CAPACITY MW	PLANT EFFICIENCY	FULL SUPPLY LEVEL MAMSL	LOW SUPPLY LEVEL MAMSL	TAILWATER LEVEL MAMSL	DESIGN DISCHARGE M3/S	LIVE STORAGE MCM
99.0	1500.0	0.9	994.0	982.0	891.0	1716.1	257.0

RESERVOIR CHARACTERISTICS — NUMBER OF POINTS IN TABLE (MAX. 20): 9

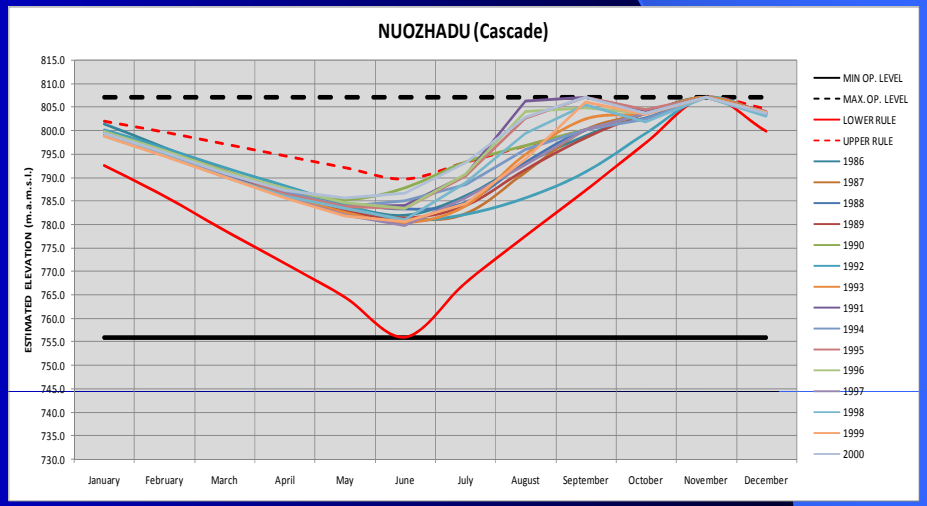
RIVER SLOPE % 2.0950 — VALLEY SLOPE % 2.1000 — Adjust Slopes to Match Storage Data — Live Storage: 257.0 — Match: 0.999866

POINT	ELEVATION MAMSL	VOLUME MCM	DEPTH M	LENGTH M	WIDTH M	AREA KM2	VOLUME MCM
1	891.0	0.0	0	0	0	0	0
2	982.0	571.0	91.0	4343.7	8666.7	18.8	571.0
3	983.0	590.0	92.0	4391.4	8761.9	19.2	590.0
4	984.0	609.4	93.0	4439.1	8857.1	19.7	609.4
5	985.0	629.3	94.0	4486.9	8952.4	20.1	629.3
6	986.0	649.6	95.0	4534.6	9047.6	20.5	649.6
7	987.0	670.3	96.0	4582.3	9142.9	20.9	670.3
8	988.0	691.5	97.0	4630.1	9238.1	21.4	691.5
9	994.0	827.9	103.0	4916.5	9809.5	24.1	827.9

START YEAR	END YEAR	INITIAL ELEVATION
1986	2000	994.0

DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	31	28	31	30	31	30	31	31	30	31	30	31
MONTHLY FLOWS												
1986	1282.8	879.5	759.6	725.2	777.8	886.0	1060.3	1343.6	1531.2	1694.4	1233.0	1017.4
1987	899.3	831.6	774.3	749.2	753.9	839.4	865.4	1155.7	2120.5	1719.9	1311.2	1031.7
1988	863.3	774.6	734.3	731.6	816.0	956.6	997.3	1305.3	1794.7	1423.5	1065.2	924.0
1989	807.9	735.1	694.3	678.1	718.0	851.8	960.1	1219.3	1509.1	2060.6	1276.1	1029.3
1990	875.8	801.0	763.4	747.3	852.2	1170.8	1710.8	2173.1	1911.8	1810.7	1193.4	973.9
1991	837.7	760.3	714.1	720.0	780.2	991.6	1330.1	2976.8	2544.2	1953.1	1499.0	1148.2
1992	966.0	878.6	831.1	815.9	809.7	827.5	838.8	795.3	727.4	799.6	1095.7	919.5
1993	797.3	736.3	698.4	681.6	710.9	805.6	946.0	1465.5	2581.0	1688.4	1260.4	1037.4
1994	846.9	750.5	713.0	723.4	775.2	1015.9	1241.9	1527.7	1733.9	1339.8	1000.2	963.4
1995	854.5	763.2	744.2	697.4	765.1	967.6	1311.5	2734.3	2754.0	1965.4	1438.2	1158.0
1996	933.5	812.1	758.2	768.3	827.5	951.3	1302.8	2835.6	2195.6	1745.0	1309.7	1054.2
1997	851.2	731.6	672.5	652.5	677.6	775.9	1043.0	1356.8	1676.6	1846.0	1034.5	858.3
1998	754.3	688.4	644.1	658.0	752.8	850.0	1196.1	2492.9	2541.5	1200.7	992.1	817.9
1999	732.2	677.9	646.6	630.2	664.2	816.2	991.5	1406.7	2823.7	1516.7	1619.7	1118.3
2000	862.3	773.9	736.0	747.6	881.4	1135.5	1737.5	2796.3	3277.2	1705.3	1260.8	999.4

Output



The Tools (2)

MRC Decision Support Framework (DSF)

Knowledge Base

Planning and monitoring data such as:

- hydrological records
- physical data
- socio-economic and environmental data
- scenario description data
- simulation model input data
- simulation model results

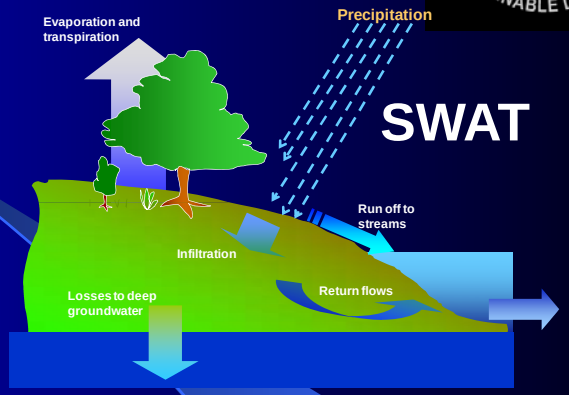
DSF User Interface and Tools

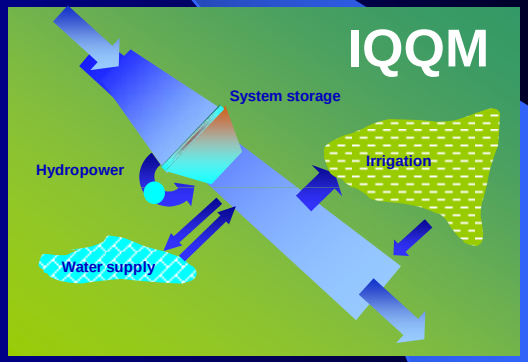
Basin Simulation Modelling Package

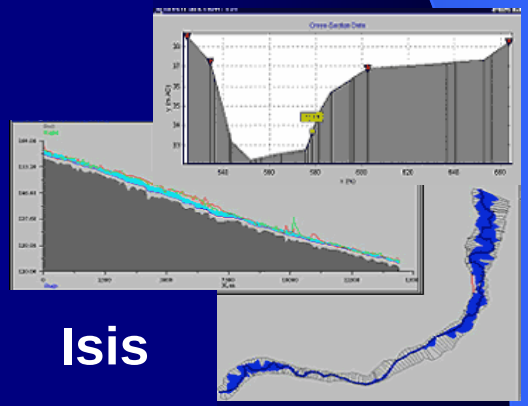
- *SWAT*
- *IQQM*
- *ISIS*

Impact Analysis Tools

Reporting Tools

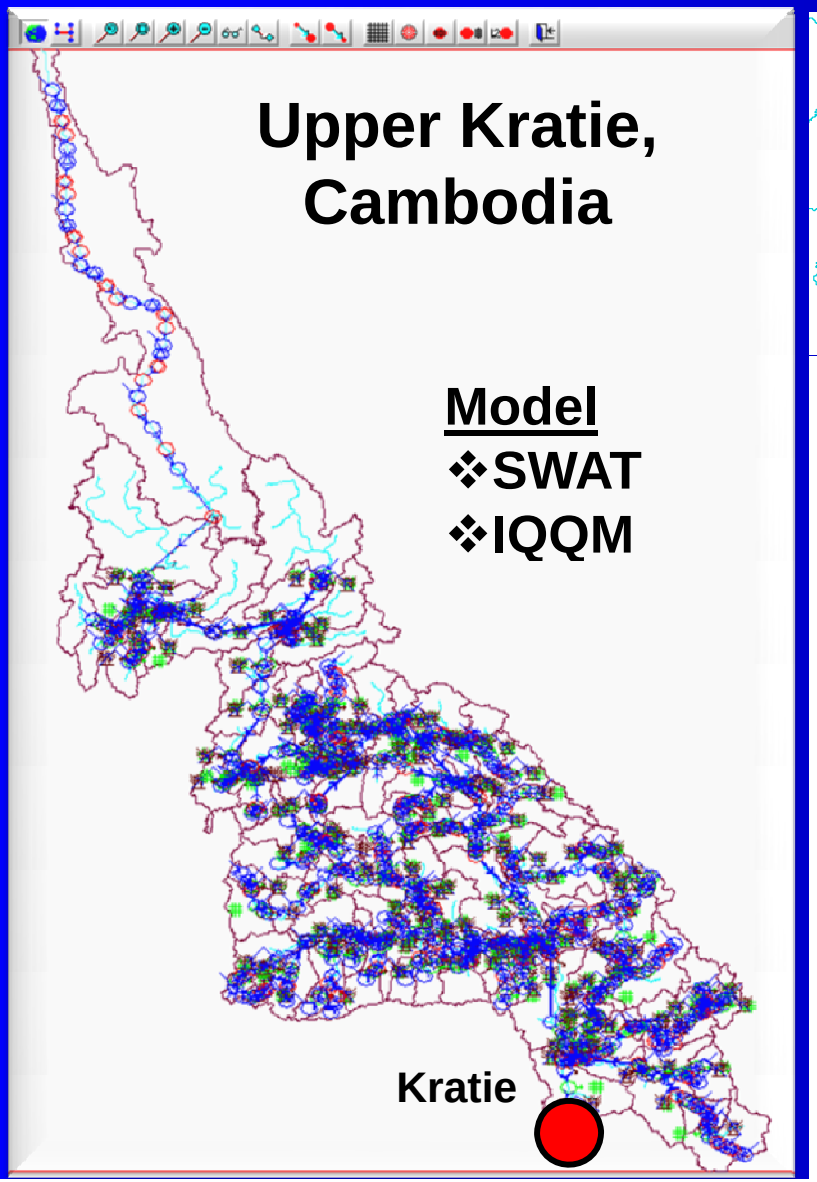


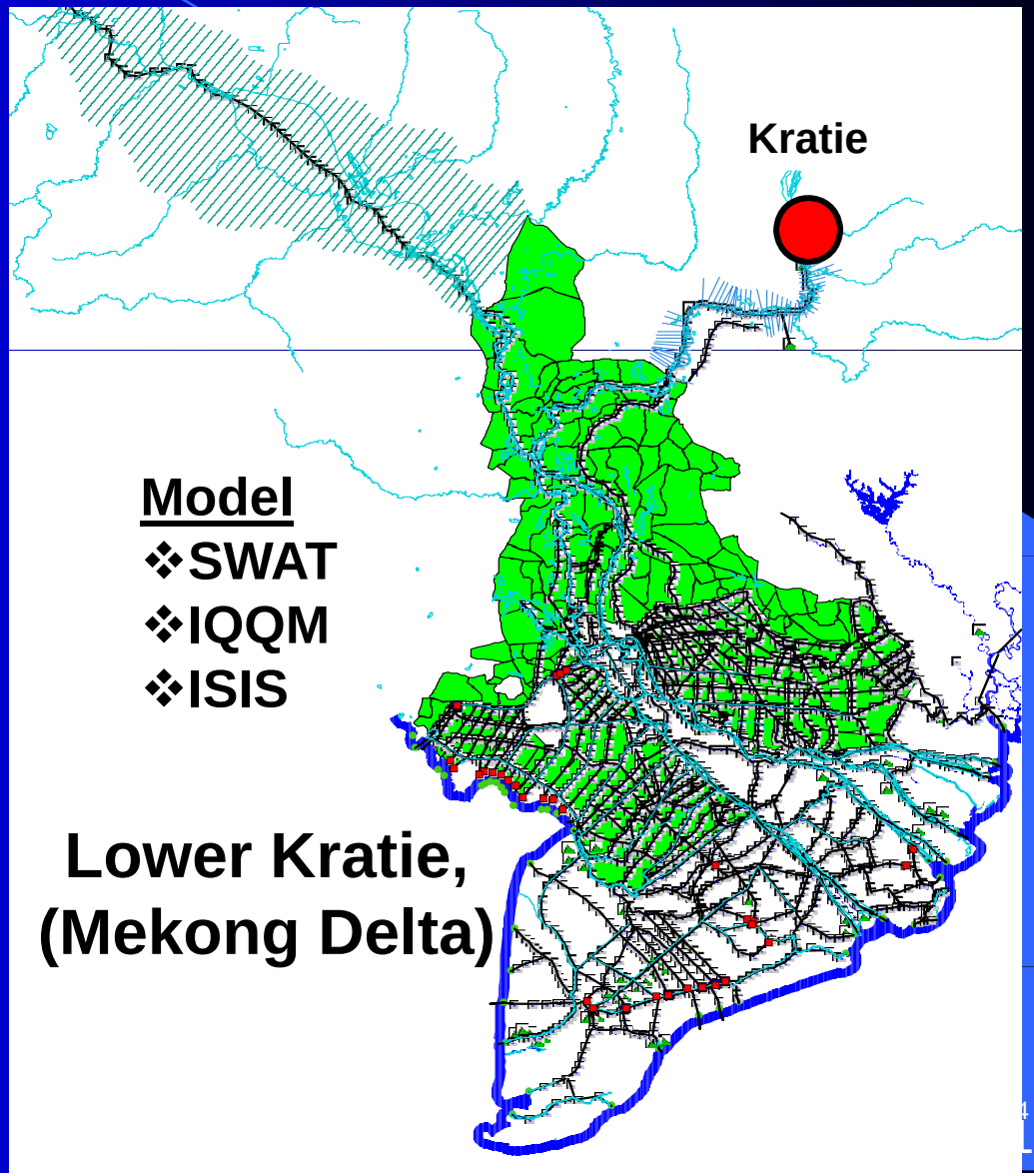




Isis

Models


Upper Kratie,
Cambodia
Model
❖SWAT
❖IQQM
Kratie

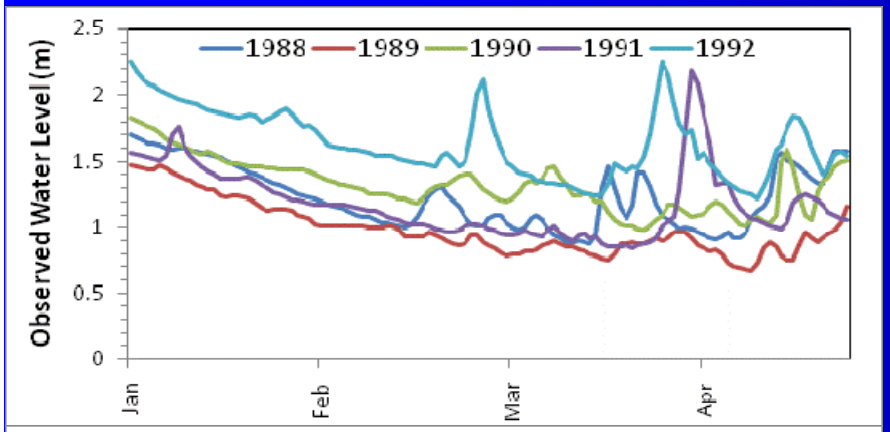

Kratie
Model
❖SWAT
❖IQQM
❖ISIS
Lower Kratie,
(Mekong Delta)

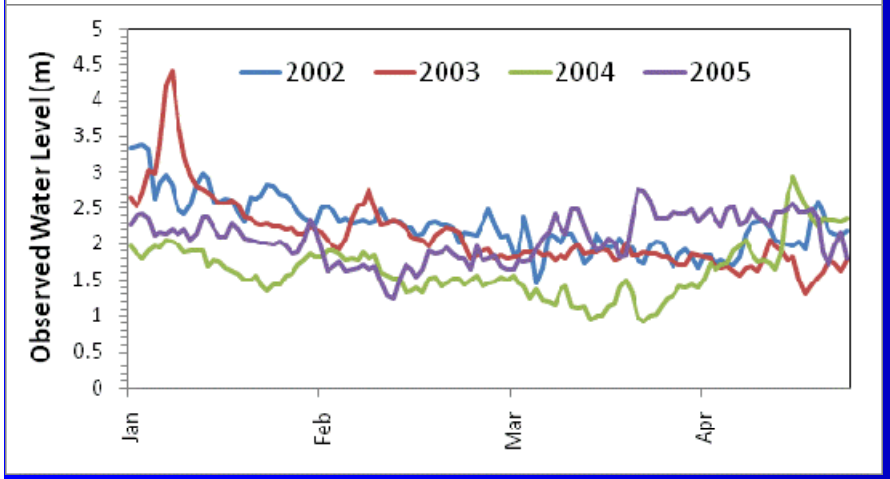
Some Preliminary Results

Changes in Flows and Water Levels

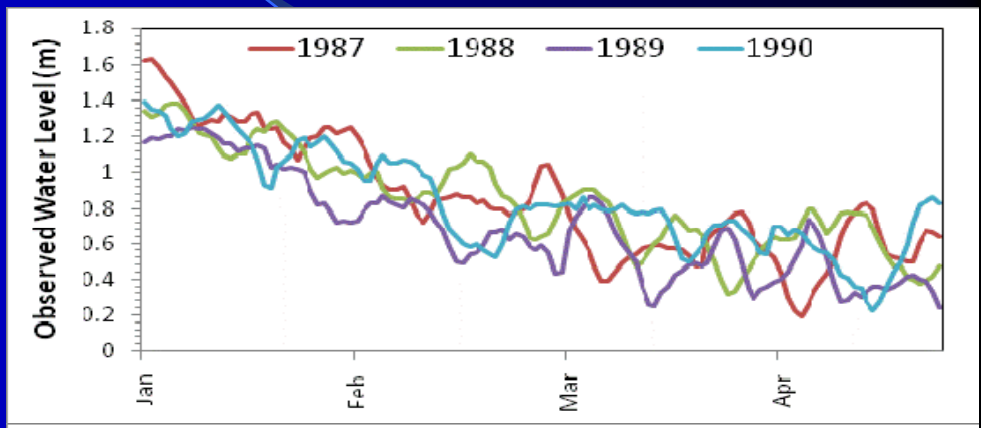
Variation in Observed Daily Water Levels

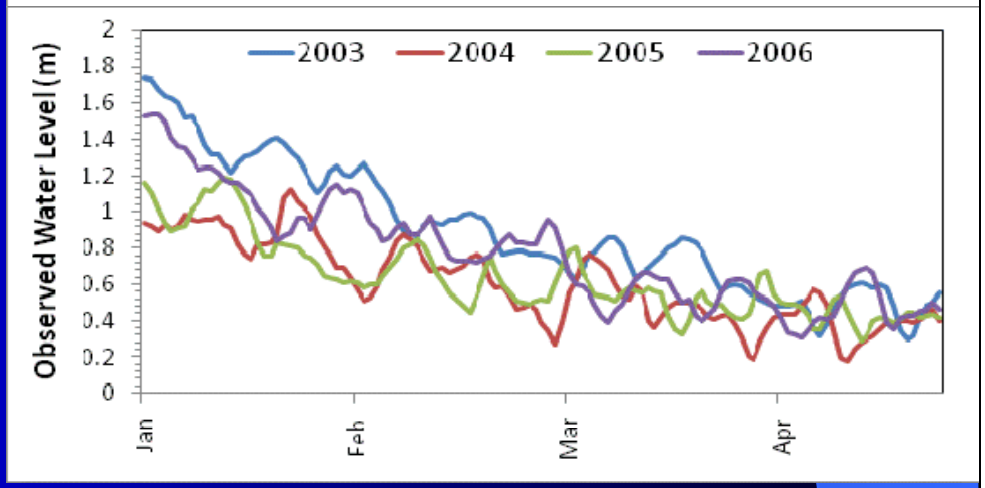
Chiang Saen Station (Upper part of LMB)



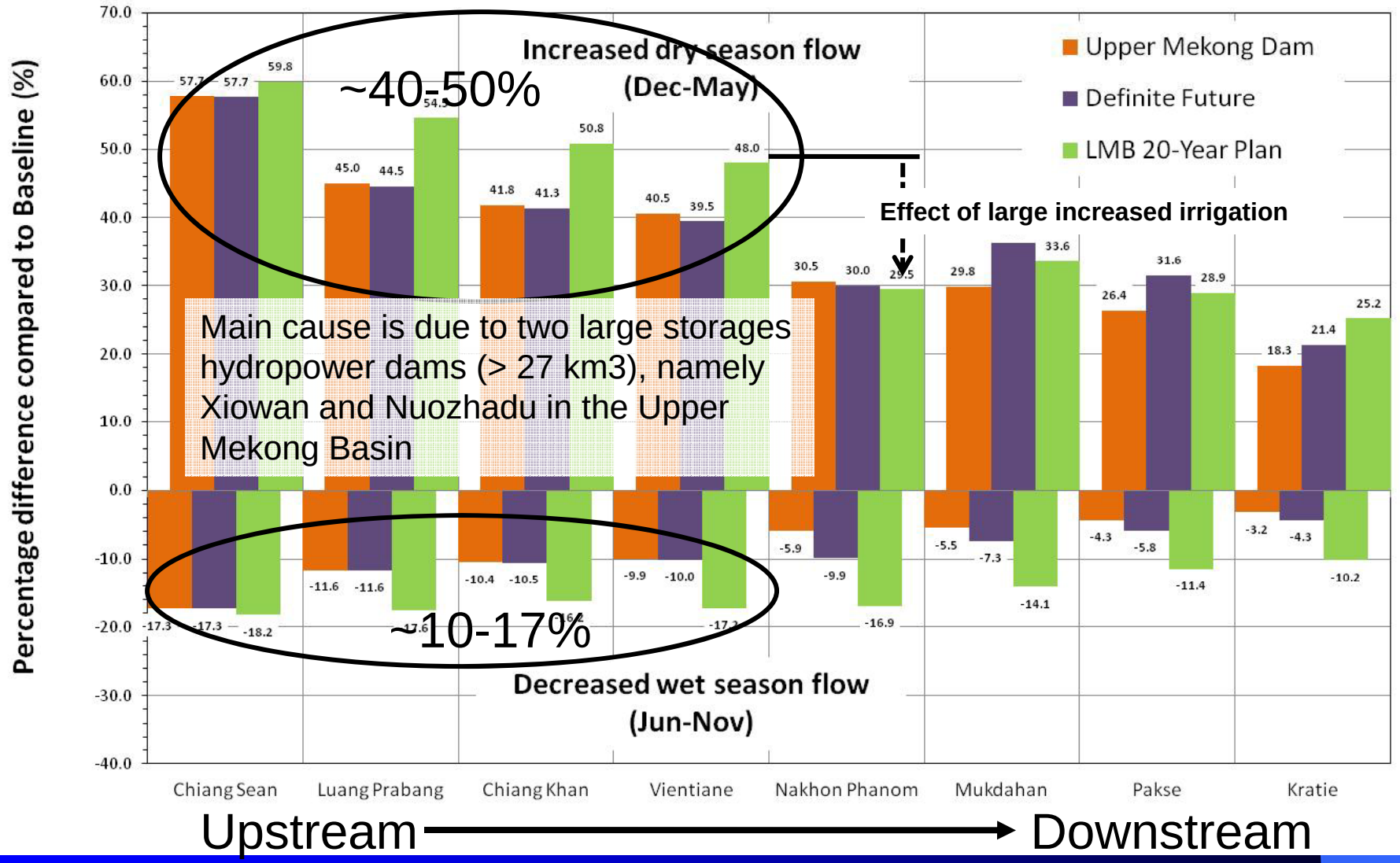


Tan Chau Station (Viet Nam Delta)

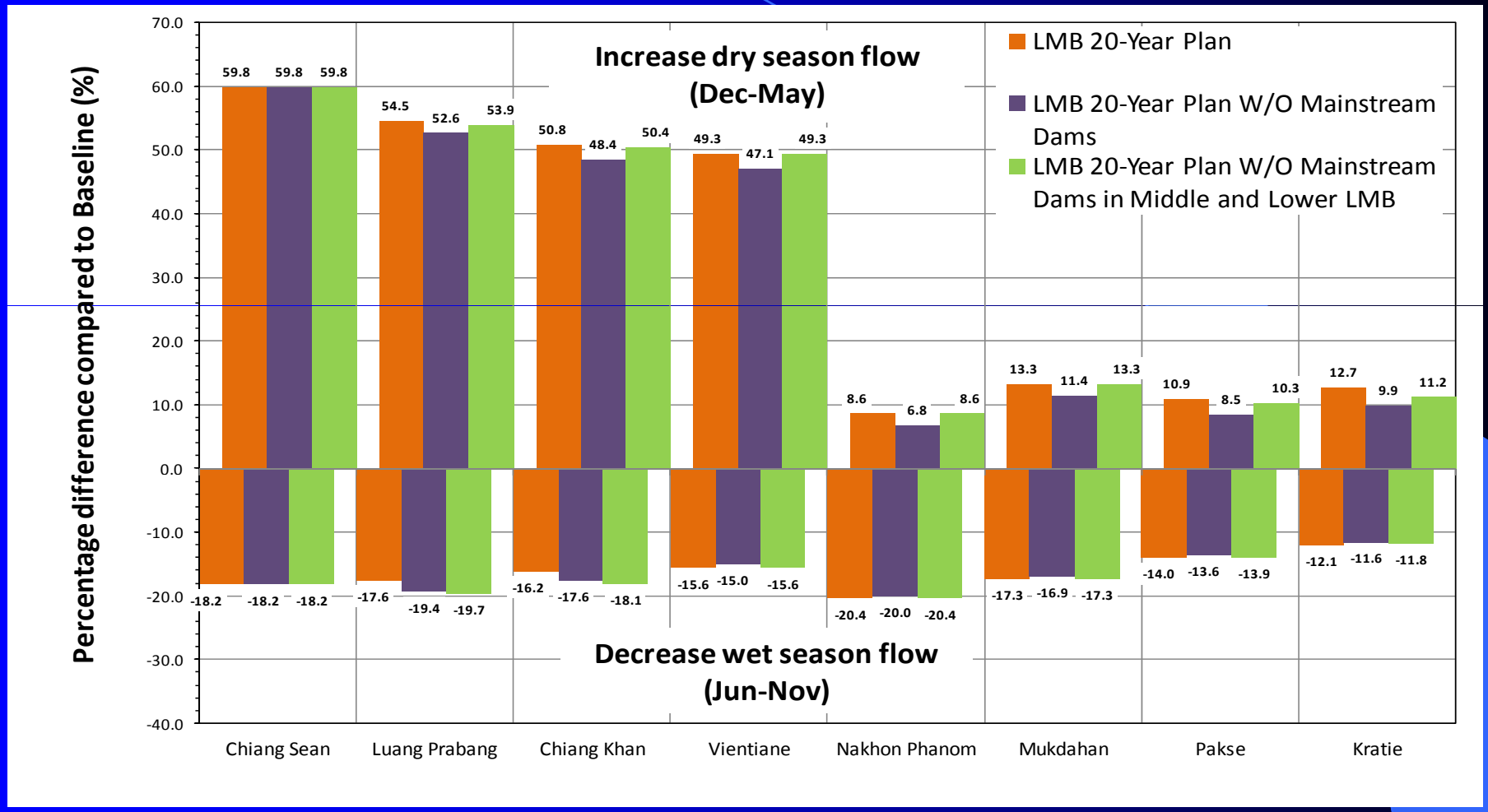




Changes in Simulated Flows in Wet and Dry Seasons

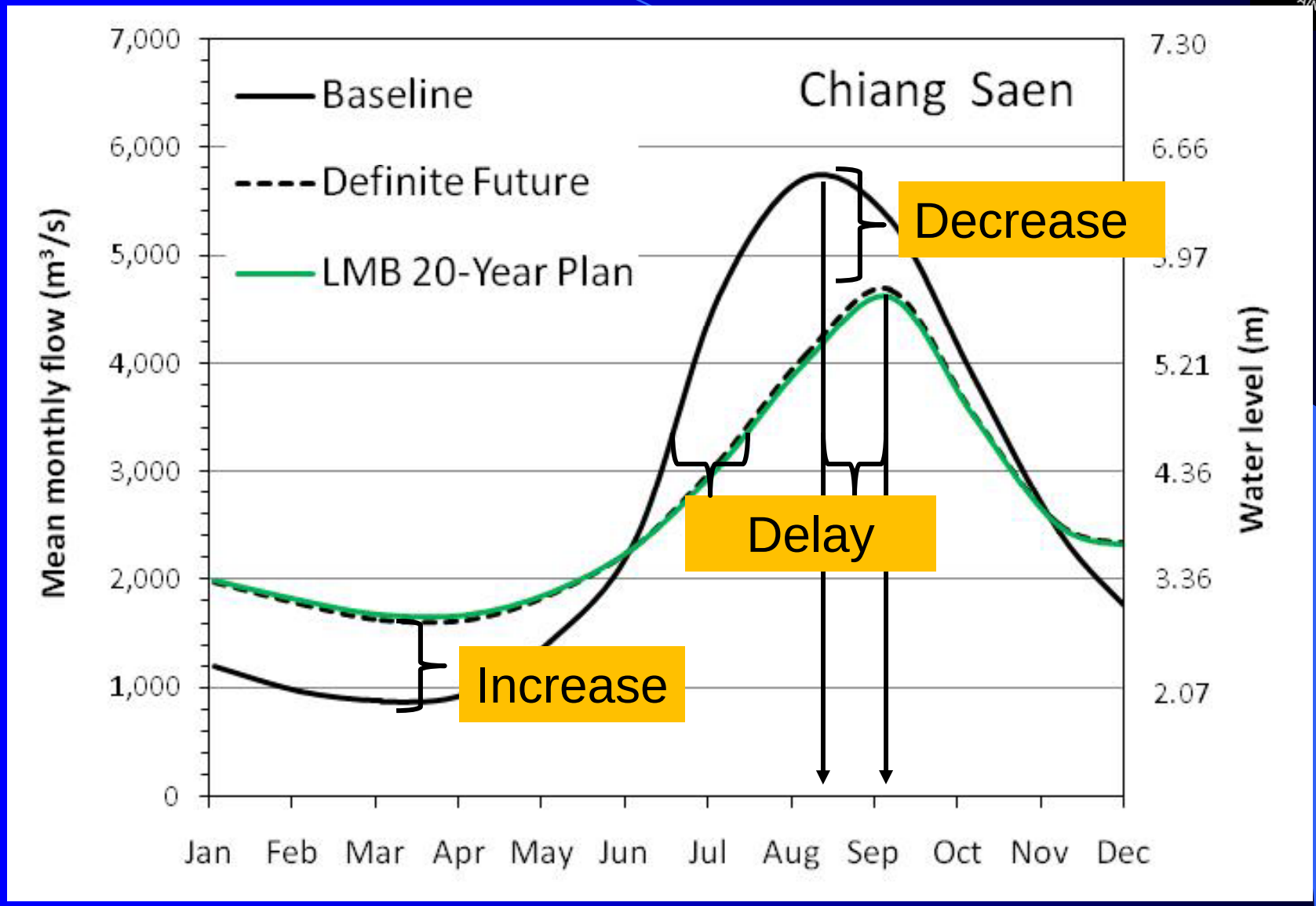


Changes in Simulated Flows in Wet and Dry Seasons (Mainstream LMB Dam Options)



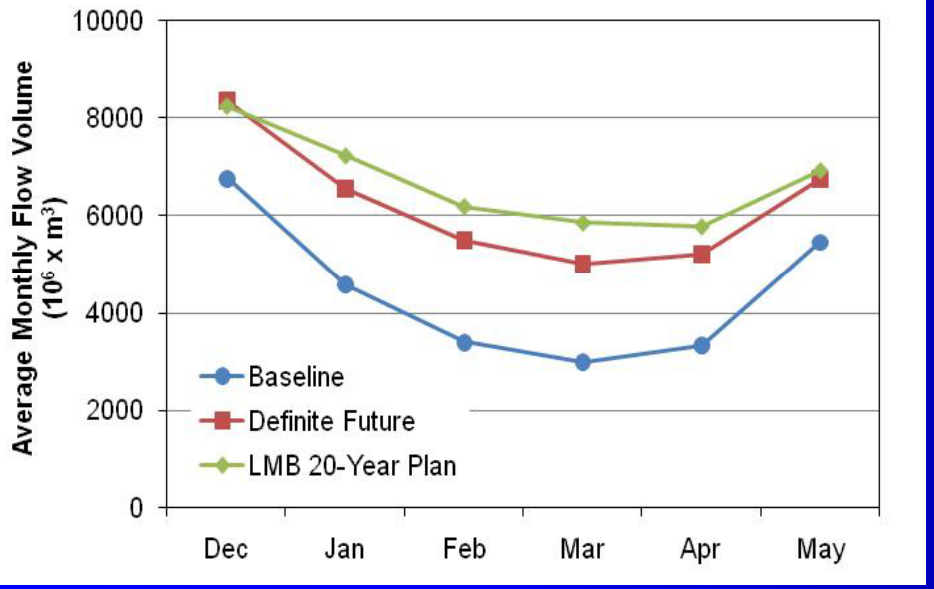
The proposed 11 run-of-river LMB mainstream dams would not cause flow changes beyond a daily timeframe

Changes in Simulated Monthly Flows

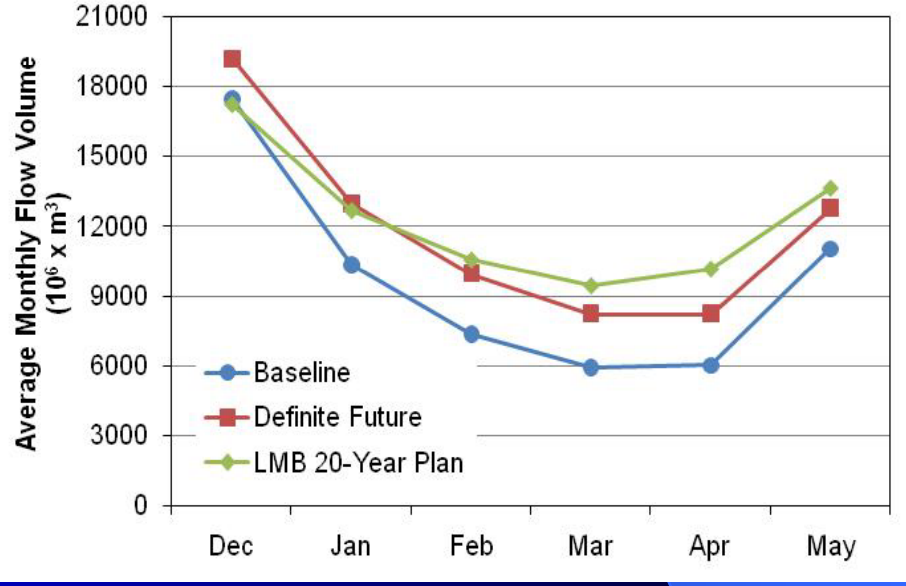


Changes in Simulated Monthly Flows Volume in Dry Season

Vientiane



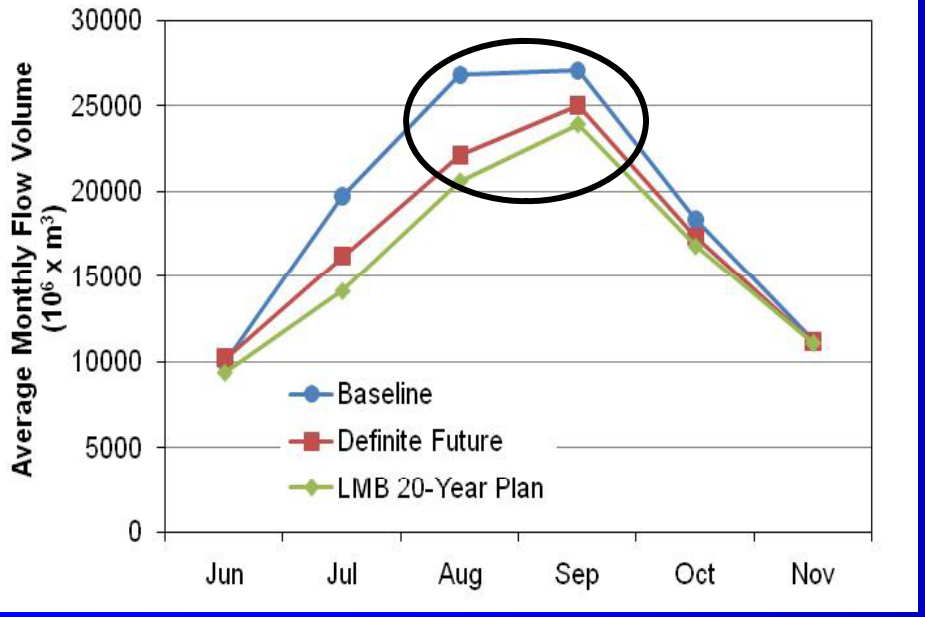
Kratie



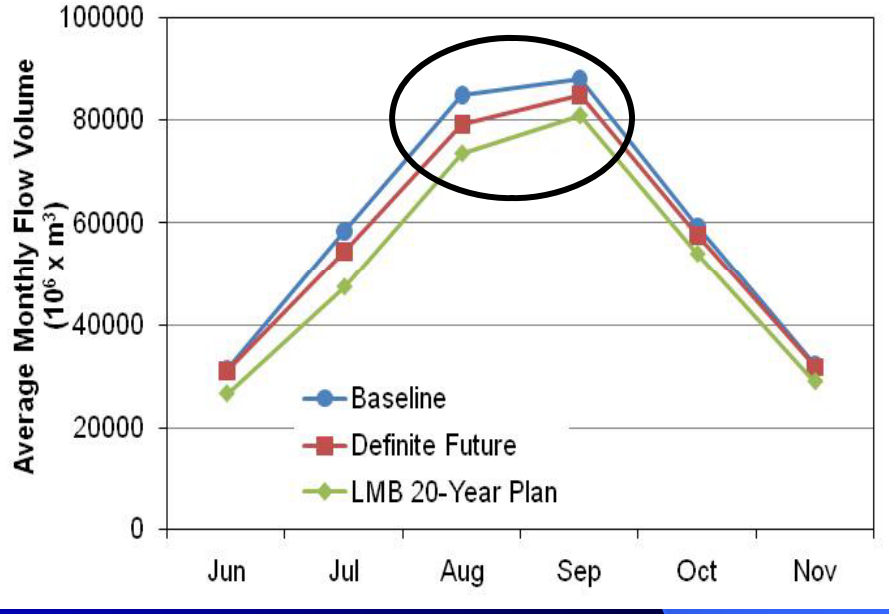
Dry season flow increases significantly (10-65%) over the Baseline in the mainstream in the Definite Future scenario which provide the opportunity for major increases in irrigation

Changes in Simulated Monthly Flows Volume in Wet Season

Vientiane



Kratie



- The Definite Future Scenario will reduce flows during the wettest months by 15% in the northern part of the LMB and by 5% in the lower part of the LMB
- The LMB 20-Year Plan Scenario causes relatively small flow changes in the mainstream over the Definite Future Scenario

Relative Changes in Simulated Water Levels in Dry and Wet Seasons Compared with Baseline

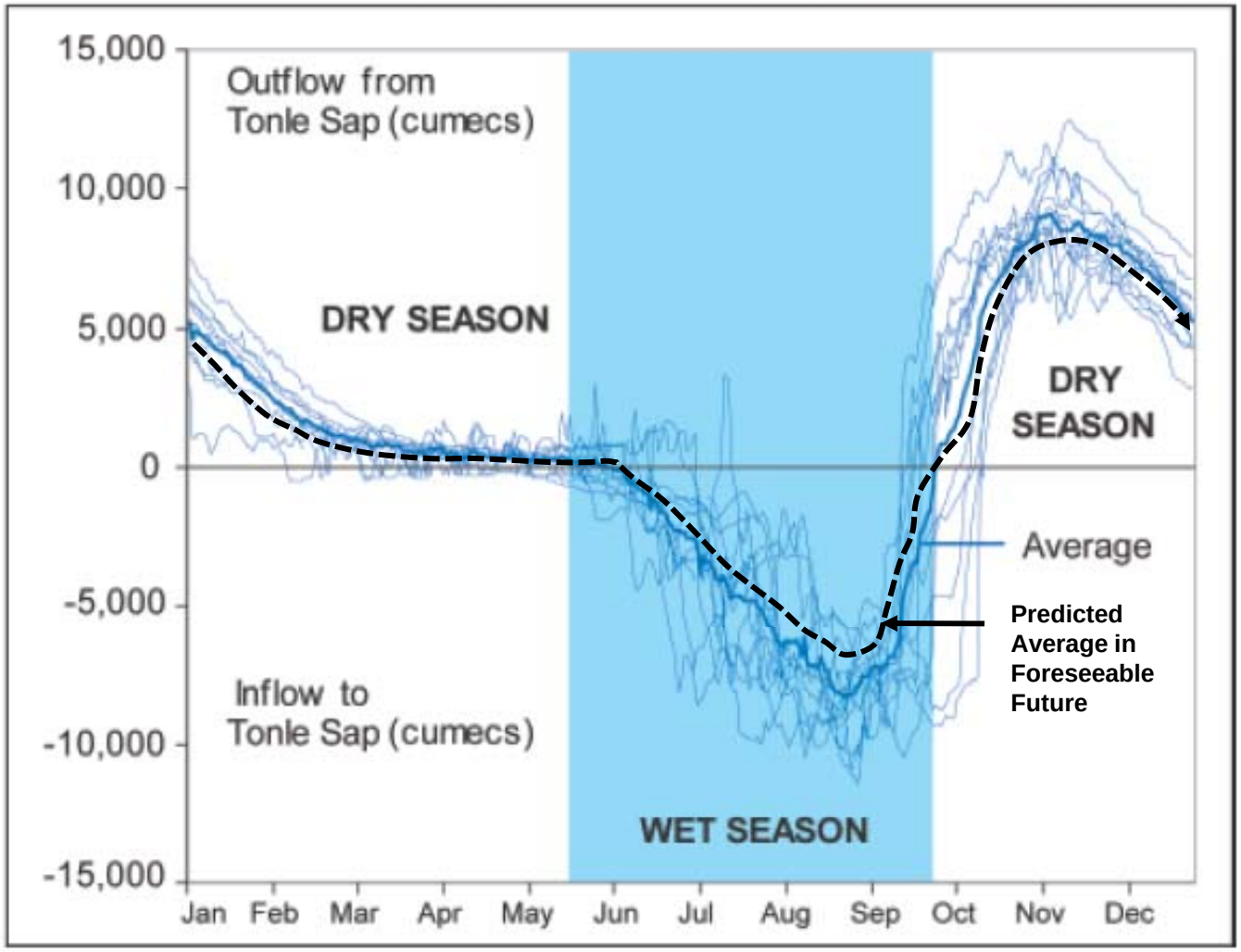
Unit: meter

Station	Upper Mekong Dam		Definite Future		LMB 20-Year Plan		LMB 20-Year Plan without Mainstream Dams		LMB 20-Year Plan without Mainstream Dams in Middle and Lower LMB	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Chiang Sean	0.87	-0.58	0.87	-0.58	0.90	-0.62	0.90	-0.62	0.90	-0.62
Luang Prabang	1.16	-0.65	1.15	-0.65	1.38	-1.00	1.34	-1.11	1.37	-1.13
Chiang Khan	1.13	-0.50	1.12	-0.50	1.34	-0.79	1.28	-0.86	1.33	-0.89
Vientiane	1.00	-0.48	0.97	-0.48	1.19	-0.76	1.14	-0.73	1.19	-0.76
Nakhon Phanom	0.47	-0.28	0.46	-0.48	0.14	-1.01	0.11	-0.99	0.14	-1.01
Mukdahan	0.51	-0.26	0.61	-0.35	0.23	-0.84	0.20	-0.82	0.23	-0.84
Pakse	0.41	-0.21	0.49	-0.28	0.18	-0.70	0.14	-0.68	0.17	-0.69
Kratie	0.51	-0.22	0.60	-0.30	0.36	-0.85	0.28	-0.82	0.32	-0.83

Dry season: WL increases ~0.9-1.4 m in the northern part of LMB
WL increases ~0.1-0.6 m in the lower part of LMB

Wet season: WL decreases ~0.5-1.1 m in the northern part of LMB
WL decreases ~0.2-0.8 m in the lower part of LMB

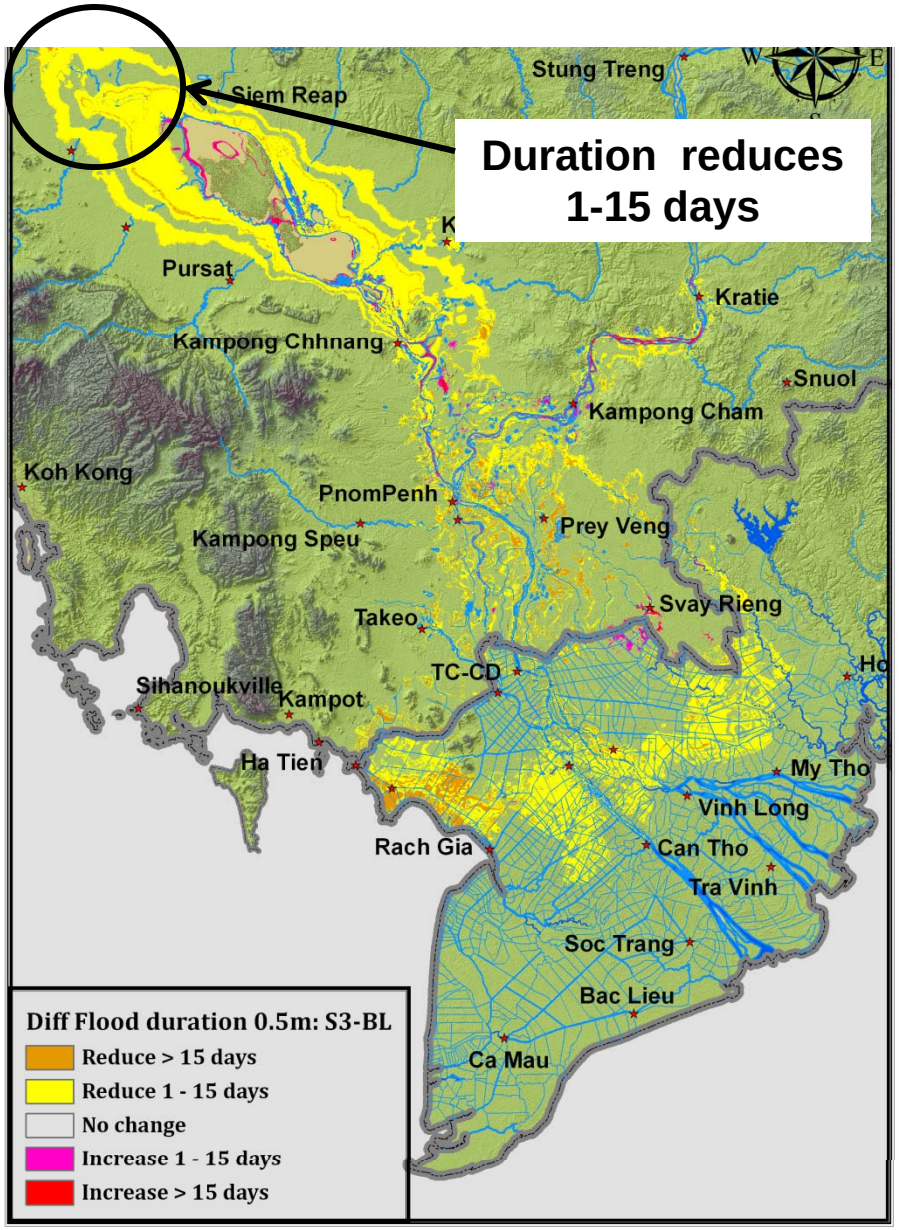
Annual inflow and outflow hydrographs to and from the Tonle Sap based on data observed at Prek Dam between July 1960 and June 1973



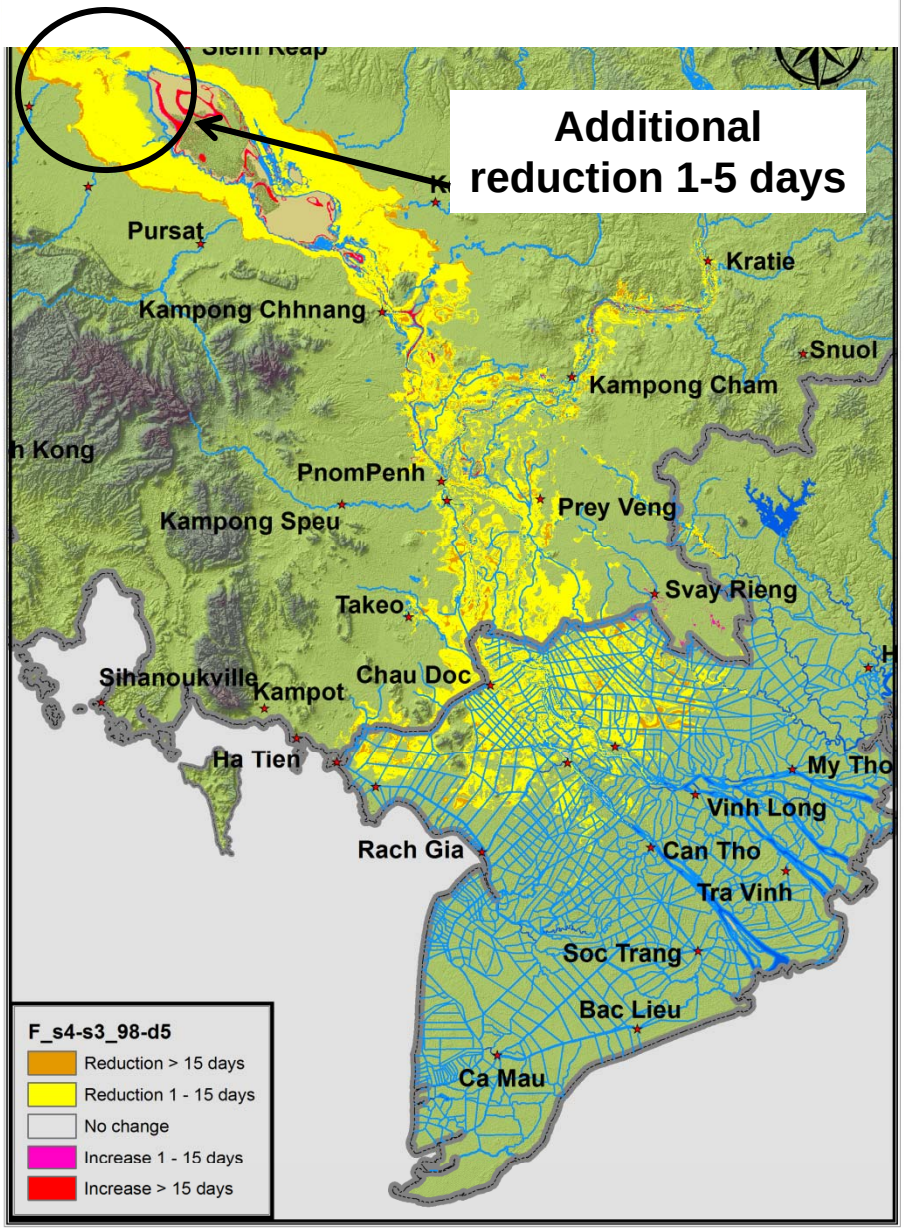
Flow changes caused by the considered scenarios for the foreseeable future constitute a small fraction of the historically observed natural year-to-year variability

Changes in Floodplain in Mekong Delta

Definite Future vs. Baseline

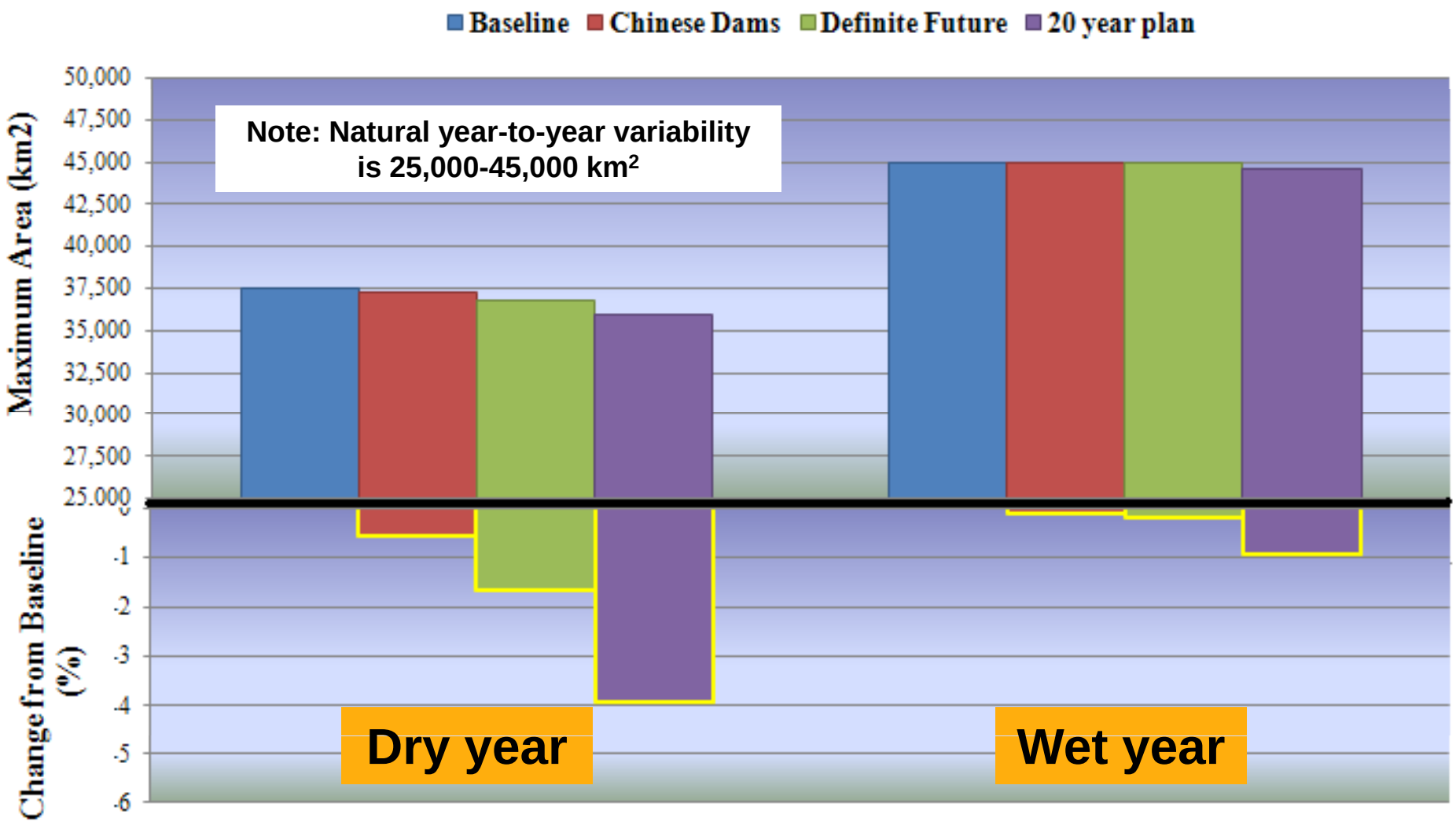


LMB-20 Year Plan vs. Definite Future



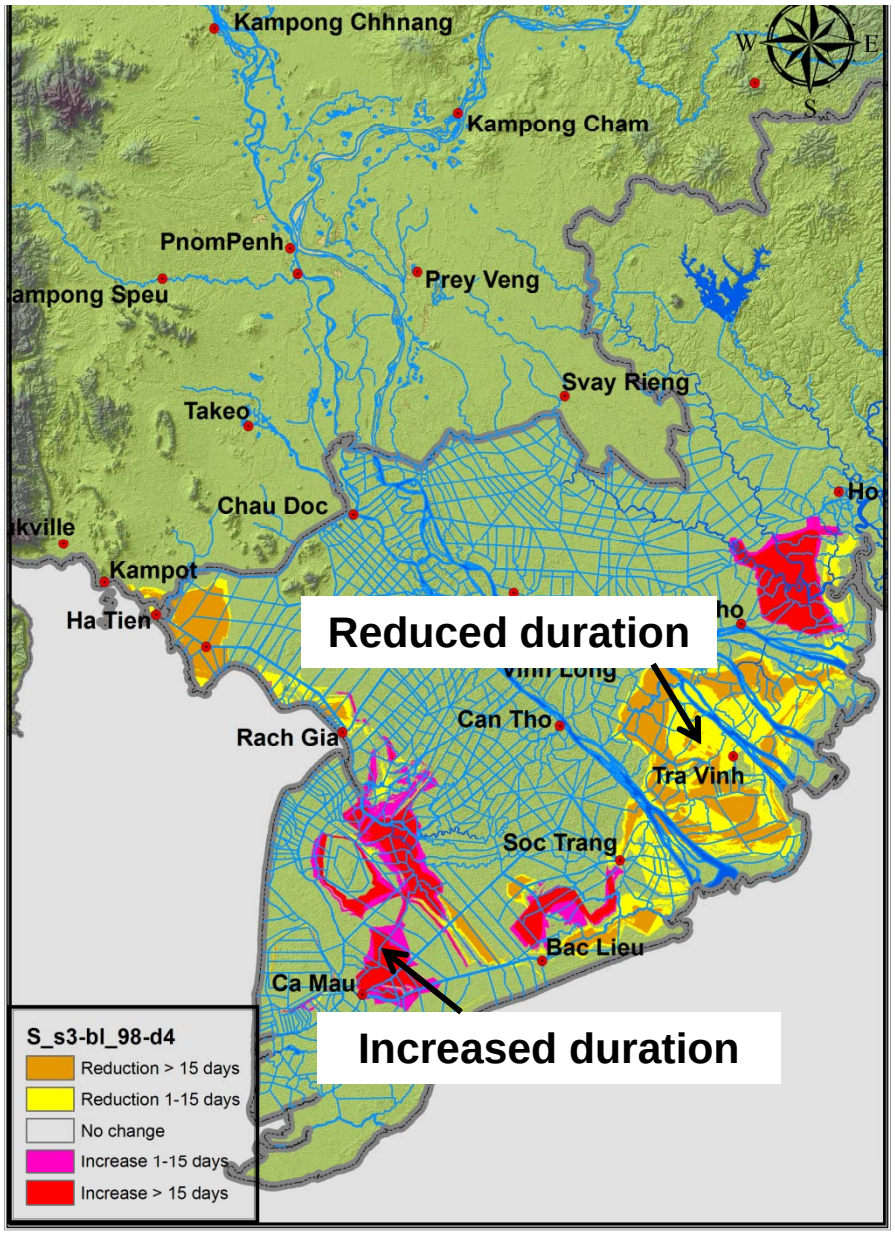
Change in Simulated Flood Duration in Dry Year

Change in Simulated Maximum Flood Inundation Areas in Mekong Delta

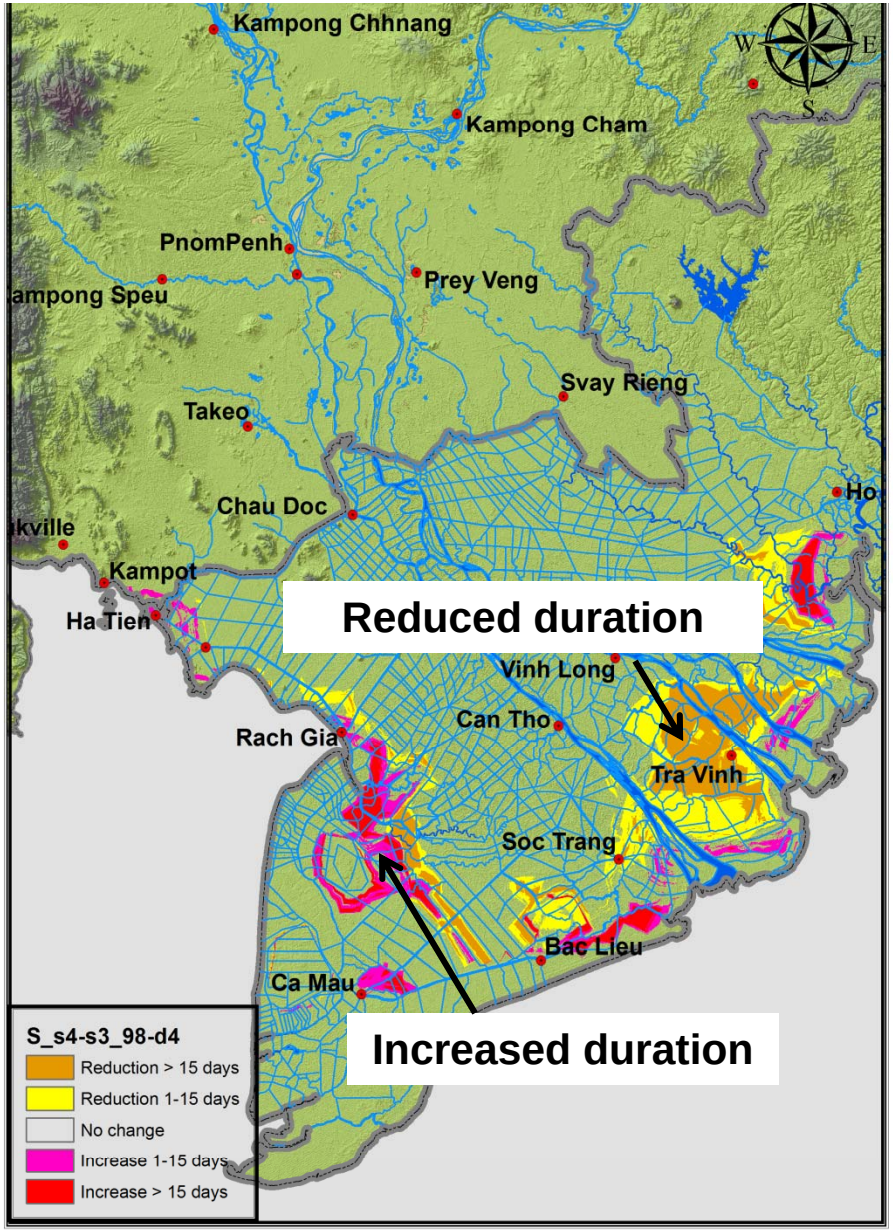


Changes in Salinity Intrusion in Viet Nam Delta

Definite Future vs. Baseline 2000



LMB-20 Year Plan vs. Definite Future



Change in Simulated Salinity Duration in Dry Year

In Summary

Initial Conclusions (1)

- **Certainties**
  - *Use of peer reviewed tools, approved by the LMB countries*
  - *Use of quality assured and verified input data with countries and line agencies*
  - *Use of existing plans and development options agreed with the responsible agencies*

- **Uncertainties** in the longer term will be revisited in subsequent 5 year planning reviews:
  - *Water uses in the Upper Mekong Basin particularly hydropower dam operations*
  - *Climate change*

Initial Conclusions (2)

….Subject to the assessment of uncertainties…..

- The Baseline Condition

  "*The mainstream can be considered to be very close to, its natural state. This is an important river flow hydrograph condition in maintaining a wide range of environmental and ecological values*"

- The Definite Future Situation

  "*The dry season flow increases significantly in the LMB particularly due to two large storage hydropower dams (Xiaowan and Nuozhadu) in the Upper Mekong Basin, while reduction of wet season flow is relatively small. These results might have*

  - *small positive changes in salinity intrusion in the Vietnam Delta;*
  - *small changes in flooded areas around the Tonle Sap compared to the natural year-to-year variability;*
  - *large increases in dry season flows, which opens up the possibility for major expansion of irrigation*"

Initial Conclusions (3)

- The Foreseeable Future Situation

"*The modelling results of the LMB 20-Year Plan Scenario indicate that the water quantity demands of all of the development 'packages' within the LMB 20-Year Plan Scenario (large irrigation increases, mainstream hydropower dams, tributary dams and irrigation etc.) can be met without impacting the present dry season flows, which are fully used for a range of economic, social and environmental purposes* "

"The calculated changes in flooding and salinity intrusion in the Mekong Delta constitute a small fraction of the historically observed natural year-to-year variability in these changes"

"*The main reason for this result is that there are considerable synergies between the hydropower and irrigation sectors: the increases in dry season flows caused by the many new dams in the LMB 20-Year Plan Scenario will be reduced by the large increases in irrigated agriculture*"

"*The proposed run-of-river LMB mainstream dams would not cause flow changes beyond a daily basis*"

Proposed Next Steps

- Complete the hydrological assessment of all basin-wide development scenarios without climate change situation by end 2009
- Complete the hydrological assessment of foreseeable and long-term future scenarios with climate change situation by end Jan 2010
- Arrange discussion of results at national level during Dec 2009-Feb 2010
- Additional scenario runs for uncertainties and sensitivity analysis by Feb 2010
- Future regional stakeholder consultation before finalization

Thank You