CLIMATE RISK & VULNERABILITY ASSESSMENT (CRVA):

CENTRAL MEKONG DELTA CONNECTIVITY PROJECT

ADB & APAN Workshop

Climate Risk Management in Planning & Investment projects

Manila, 9-10 February, 2015

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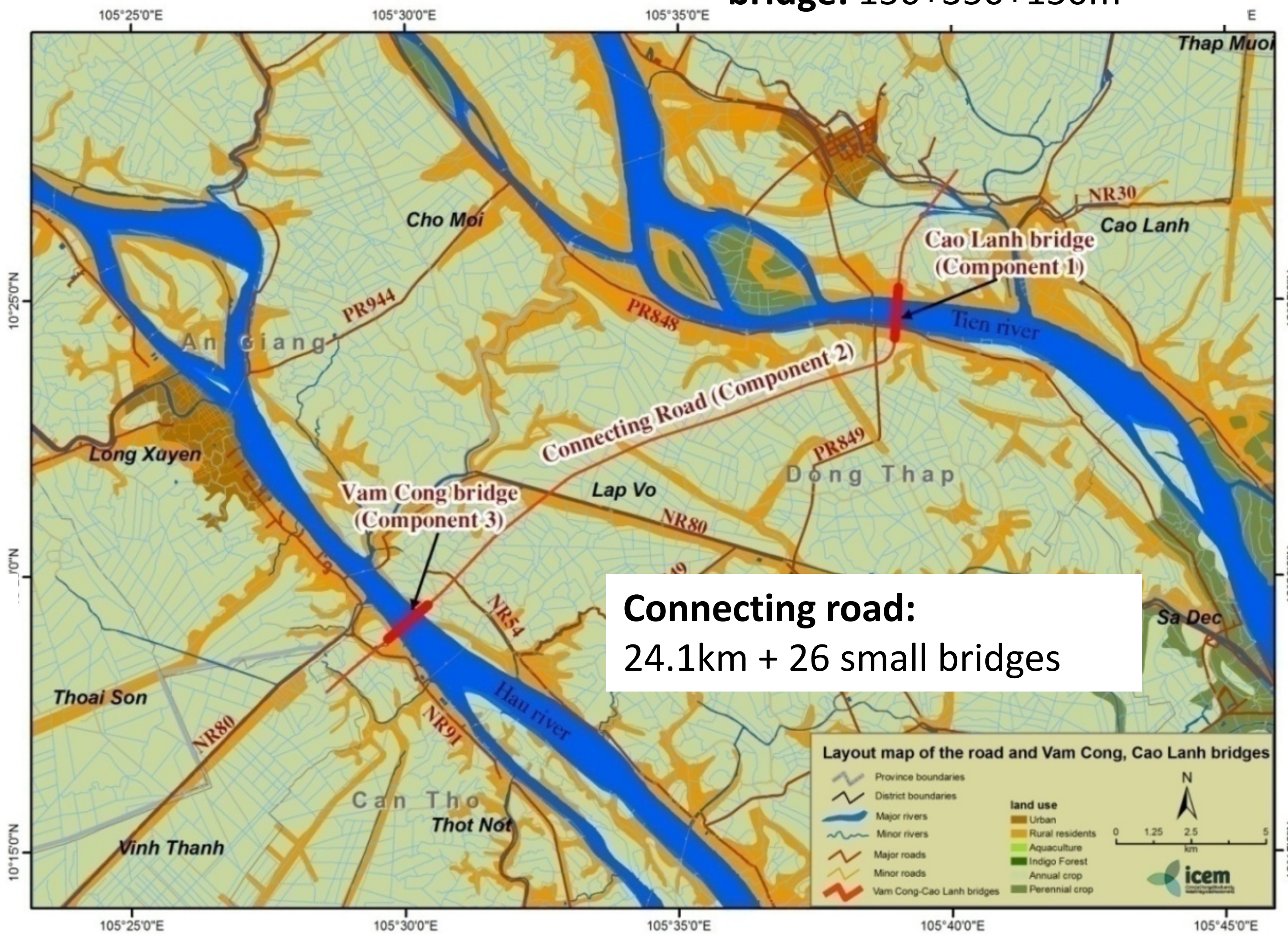
Central Mekong Delta Connectivity project (CMDCP)

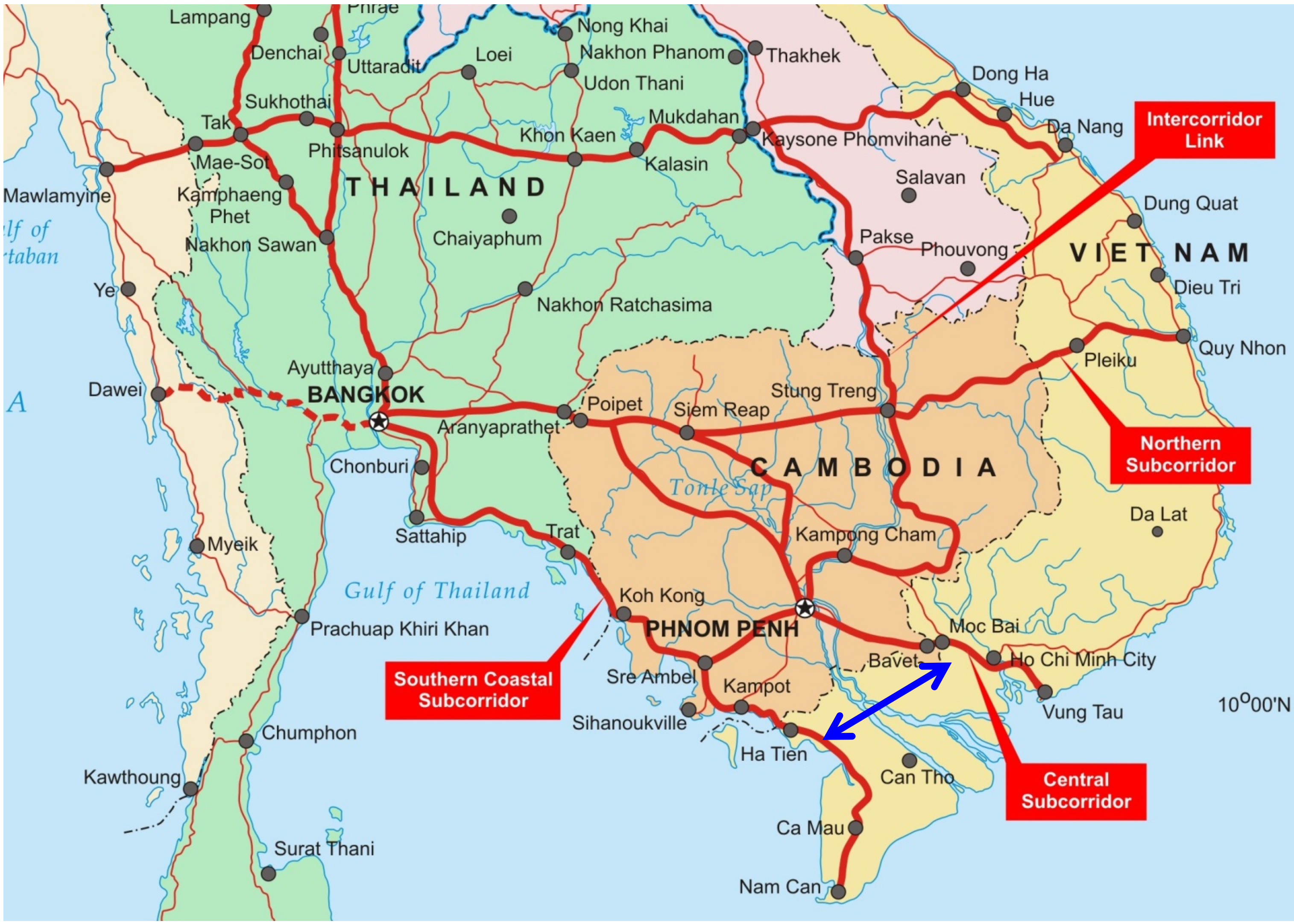
Cao Lanh: Cable-stayed bridge: 150+350+150m



Connecting road:
24.1km + 26 small bridges

Vam Cong: Cable-stayed bridge:
190+450+190m

Enhancing regional connectivity of the Delta rice bowl to the regional economy

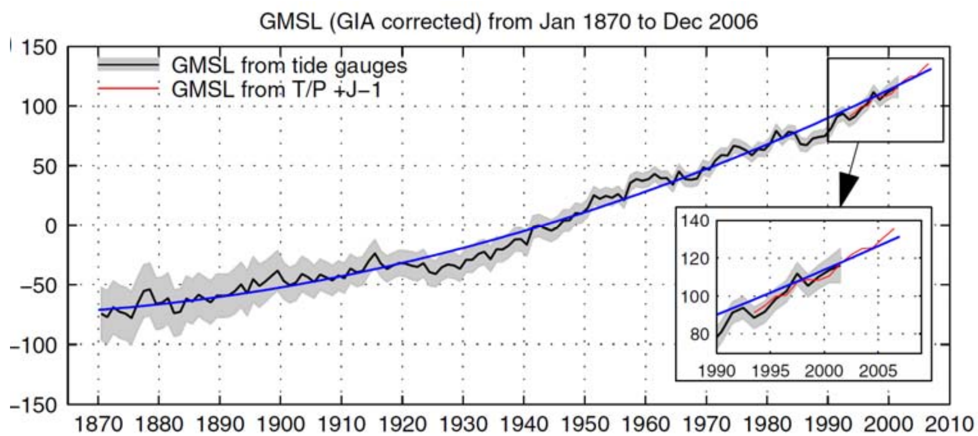


Existing issues for roads in the delta floodplain

Infrastructure design: a moving target

- *"…the idea that natural systems fluctuate within an unchanging envelope of variability, can no longer serve as the central, default assumption for water management in an era of climate change". – Milly et al, 2008*

- *All key hydromet design variables are changing*
  - Sea levels,
  - flood water levels,
  - river discharges,
  - precipitation intensity,
  - Average and peak temperatures



Source: Church et al, 2008

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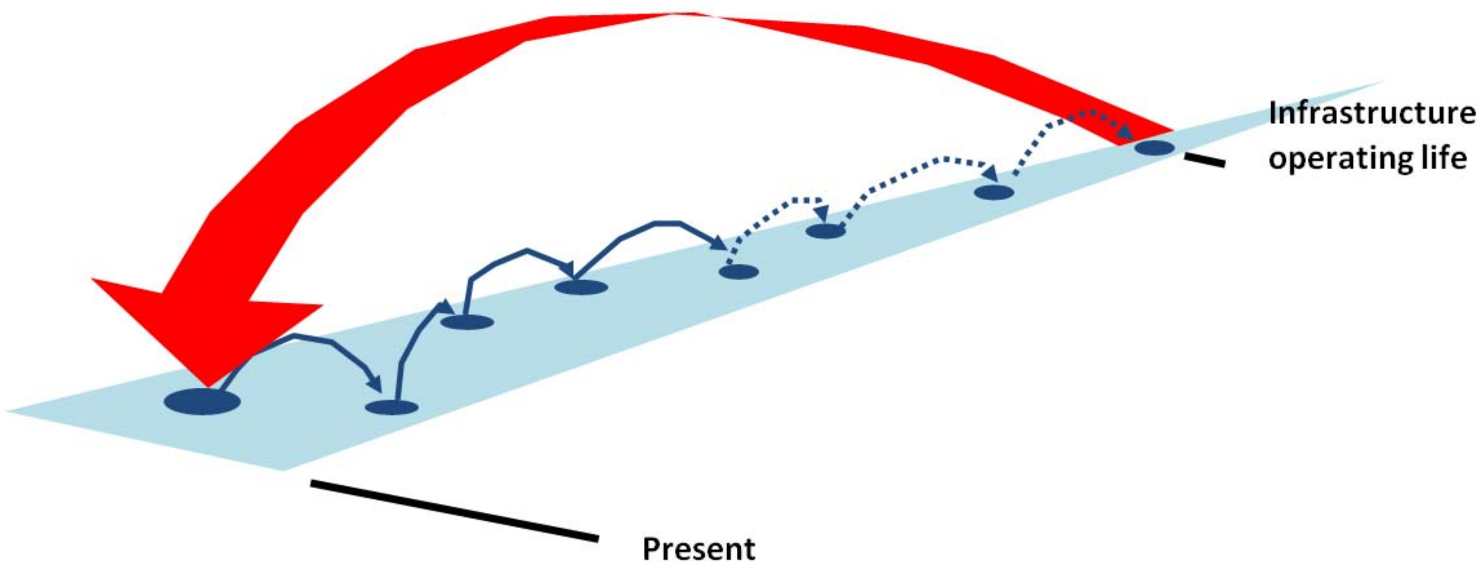
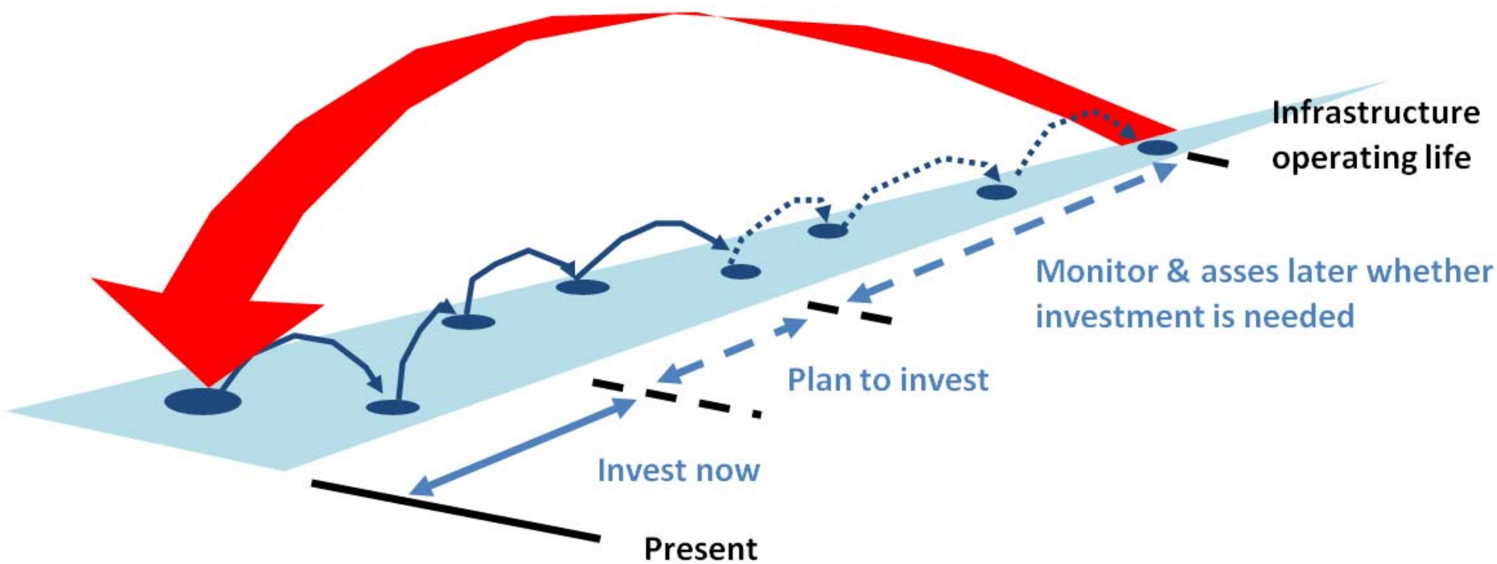
Purpose of the CRVA

- Integrate changing and future risk profile into the design, operations, and maintenance of infrastructure



Setting an "adaptation pathway"

- What do we need to do today to safeguard against this risk?
  - *What do we need to do at the design phase?*
  - *What can be addressed later as part of refurbishment, maintenance and upgrades?*
  - *What should we wait and re-assess later?*



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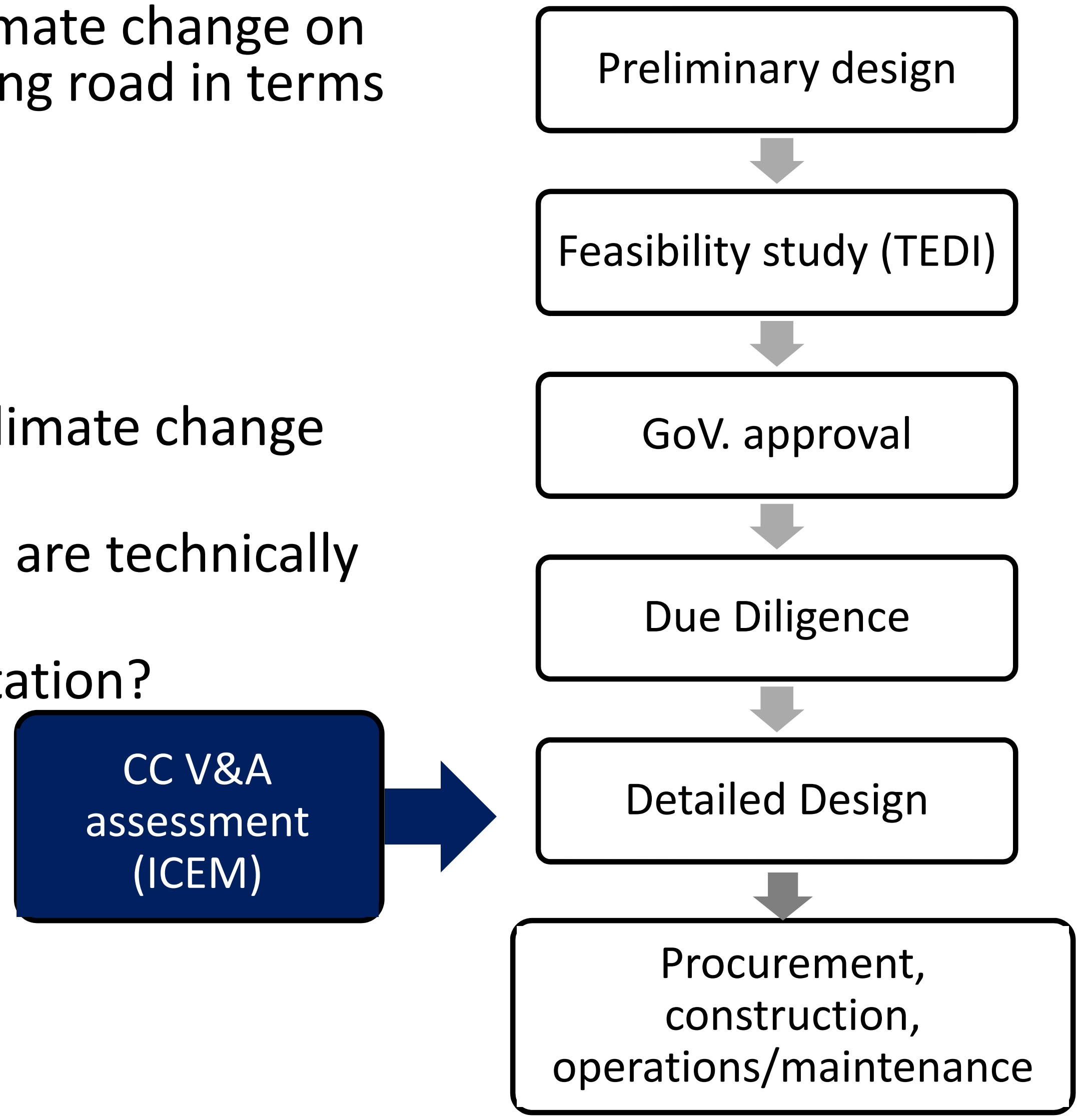
CMDCP CRVA: objective

1. What is the impact of climate change on the bridges and connecting road in terms of:
    1. *Assets*
    2. *Performance/use*
    3. *Maintenance*
    4. *Legal compliance*
2. What is the cost of this climate change impact?
3. What adaptation options are technically and realistically feasible?
4. What is the cost of adaptation?



CMDCP CRVA: scope

Climate and hydrological system

- mean daily temperature and temperature range
- daily/seasonal extreme temperatures
- Wind speeds
- Extreme gusts, cyclones
- wind-induced wave energy
- rainfall intensity
- rainfall volume
- flood frequency and intensity
- sea level rise
- floodplain and in-channel flow velocities
- sediment load and composition

Bridge & road structures

- Expansion joints
- free-sliding bearings
- bridge deck
- stay cables
- pylons and bridge foundations
- approach bridge support piles
- drainage system & road culverts
- Road/river embankments & river bank stability
- Road foundation
- road surface

CMDCP CRVA: scope

CLIMATE CHANGE THREATS

BRIDGE AND ROAD SENSITIVITY

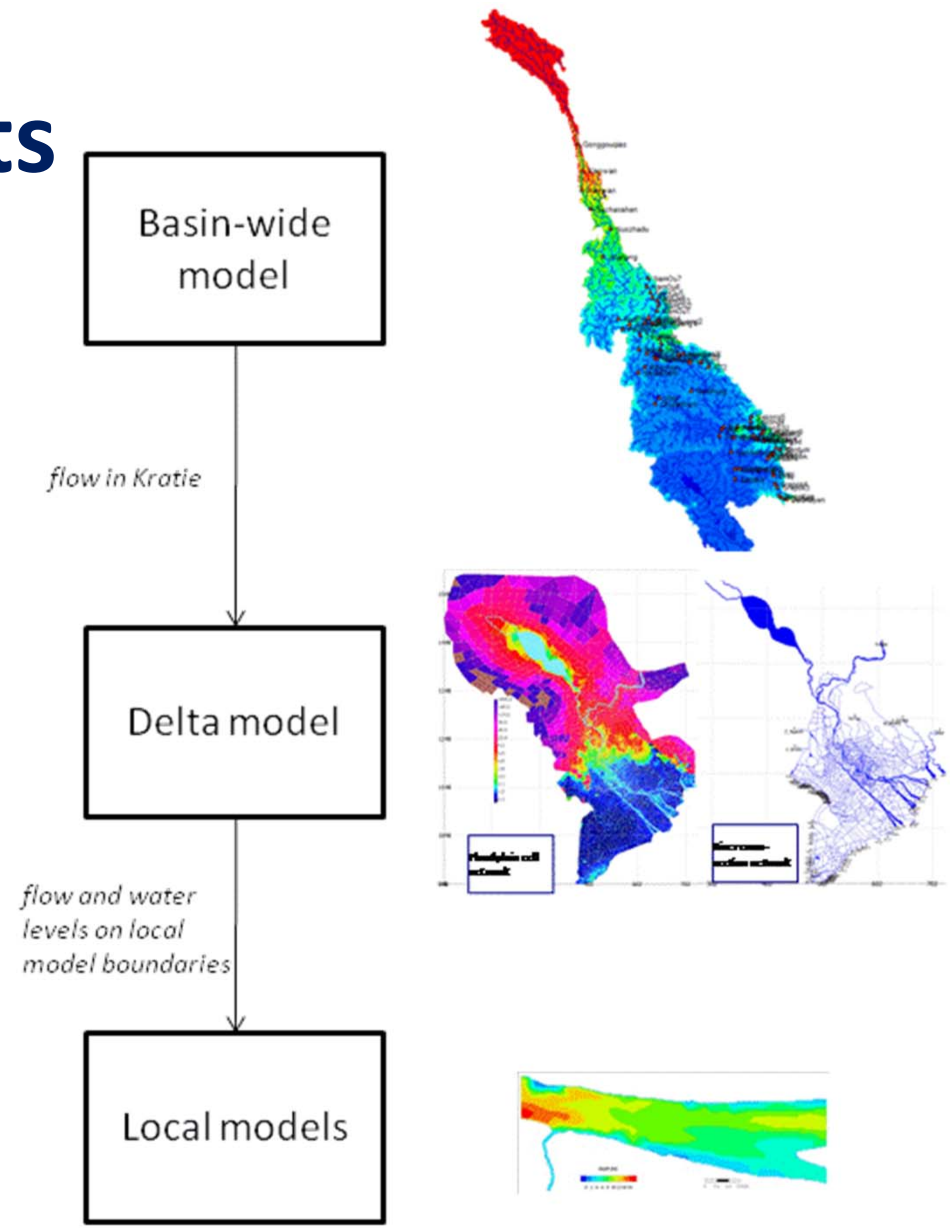
	TEMPERATURE			WIND			RAINFALL		FLOOD	WATER LEVEL		SEDIMENT		WATER QUALITY
	Change in mean daily temperature	Changes in daily, range in temp	Change in daily/seasonal extreme temperatures	Mean wind speed (10min winds)	Extreme gusts, thunderstorm, cyclones	Wind induced wave energy	Rainfall intensity	Rainfall volume	Changes in frequency & intensity of flood events	Sea and river level rise	Changes in flow velocities	Changes in sediment load	Changes in sediment composition	Changes in pH, salinity, sulphates, chlorine
EXPANSION JOINTS **Description:** *designed to accommodate expansion and contraction of bridge infrastructure in response to the daily and seasonal range in temperature.* **Design life:** *20 – 25yrs* **Maintenance:** *10 yrs*	ISSUE: *shift in mean temperature could (1) accelerate ageing through hardening, UV/solar deterioration, (2)*	ISSUE: *If upper temperature limit is exceeded (i.e. hotter temperatures than in current design range) could cause collision between bridge and approach roads. If lower temperature limit is breached, could*												
FREE SLIDING BEARINGS **Description:** *allows for relative movement between the bridge substructure and superstructure due to thermal expansion, and wind and traffic vibratio* **Design life:** *>50 yrs* **Maintenance:** *20-25yrs*														
BRIDGE DECK **Description:** *allows for relative movement between the bridge substructure and superstructure due to thermal expansion, and wind and traffic vibration* **Design life:** *10-25 yrs(for road surfacing)* **Maintenance:** *as needed (for road surfacing)*														
STAY CABLES **Design life:** *(30-50years)* **Maintenance:** *>25yrs*														
Pylons and bridge foundations including metal reinforcements) **Design life:** *=>100yrs yrs* **Maintenance:** *yrs*				reduced safety (2) increased vibrational forcing from wind		*support piles which are currently not designed to be*	*uplift, and scour at foundations* **IMPACT:** (1) reduced integrity/safety, (2)				*size and load of sediment inputs combined with increased sediment transport capacity of the river channel* **IMPACT:** (1) accelerate scour at the foot of bridge			concrete erosion of pylons and bridge foundations, (2) accelerated corrosion of metal reinforcements, (3)

- **Evaluated 14 specific hydro-climate threats**
- **13 structural components of the project:**
  - Bridge sub/superstructure,
  - Approach & connecting roads,
  - Embankments & road foundations
  - Flood protection/drainage infrastructure
- **The most critical impact (vulnerability) was found to be the likely changes in design flood elevations relative to road embankment design elevations**

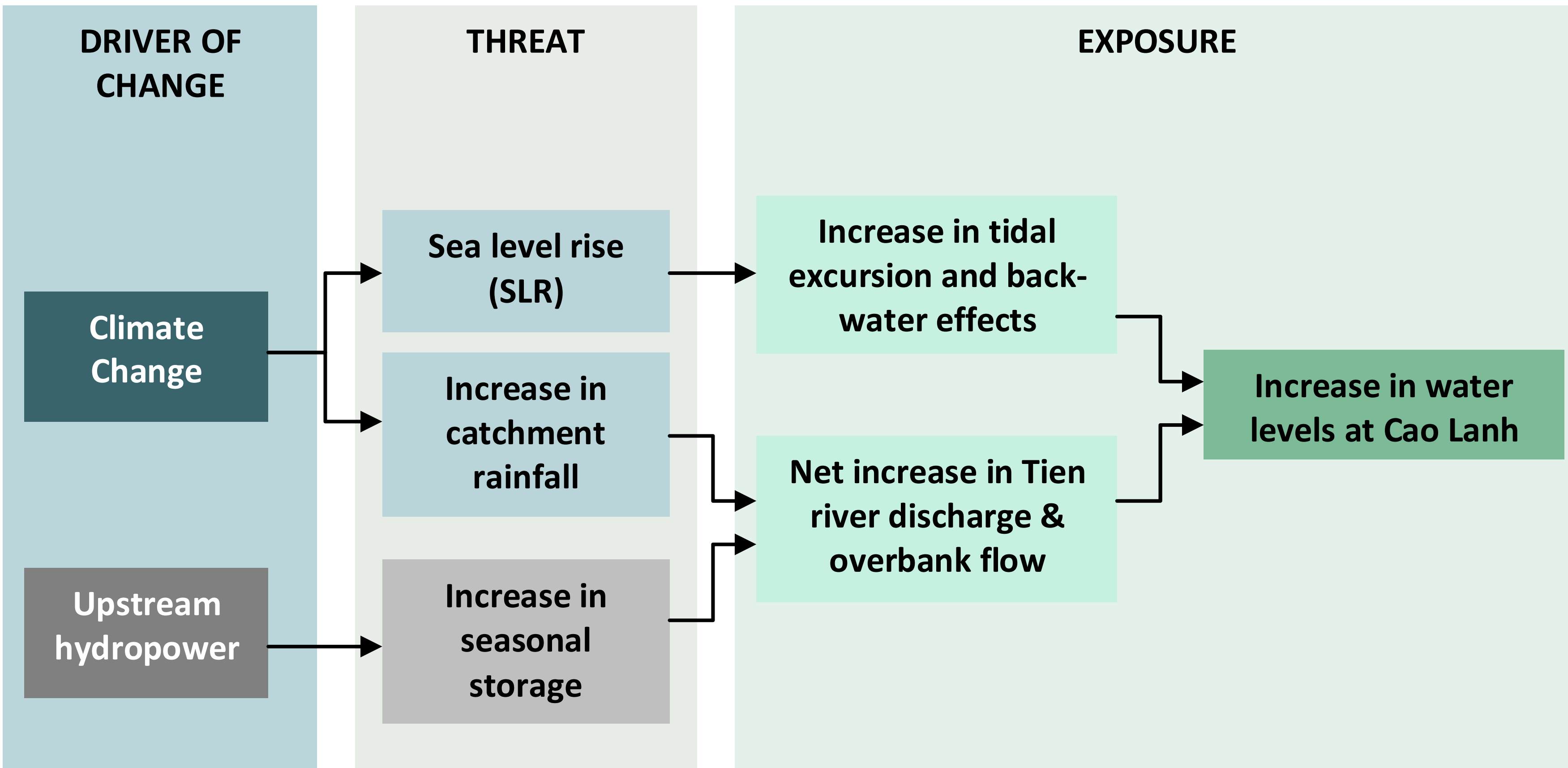
Likely severity of impact					
	Low		Medium		High

CMDCP CRVA: modelling CC threats

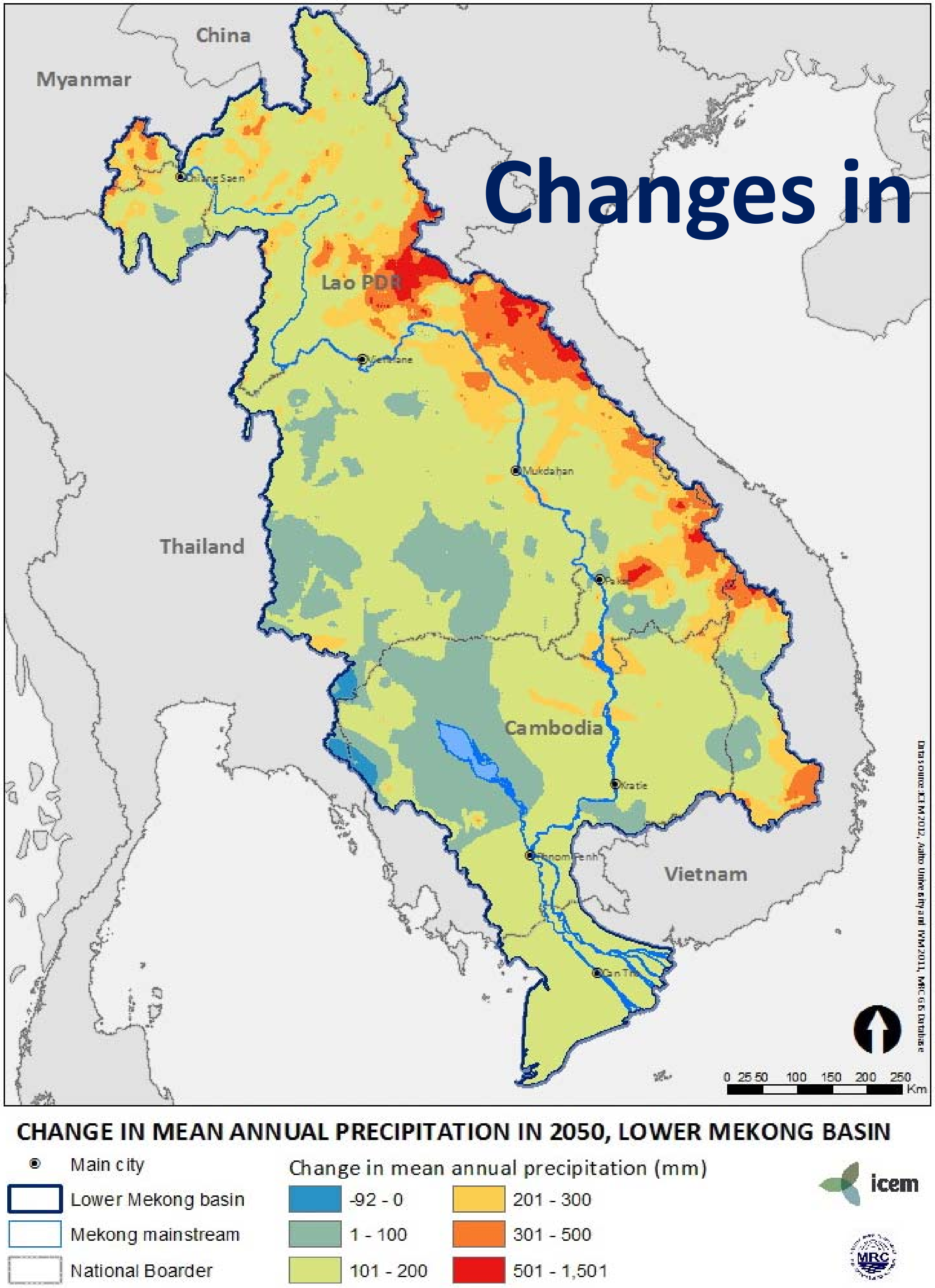
- 2 IPCC scenarios (A1b & B2)
- 6 GCMs
- 25yr baseline (1980-2005)
- 166 temp and precipitation monitoring stations
- Simulations to 2088
- ~500years of future daily data with climate change:
  - Flow/water levels
  - Rainfall
  - temperature



Drivers of change to water levels

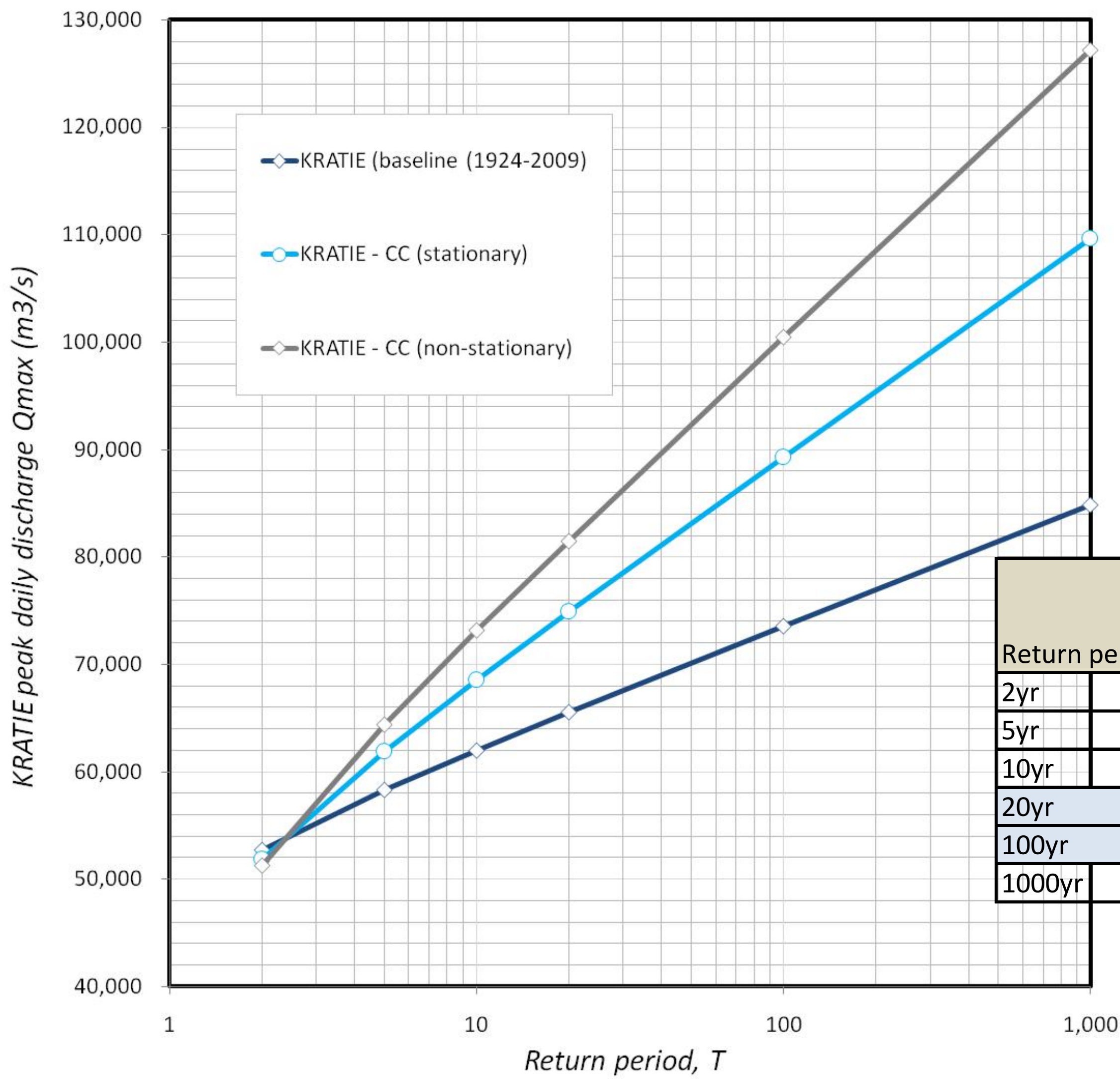


Changes in catchment rainfall



- Increase throughout the basin
  - *Except Cardamon mountains*
- >500mm/yr increase along Annamites

Kratie Return period



Extreme Value Type I distribution

Kratie Baseline

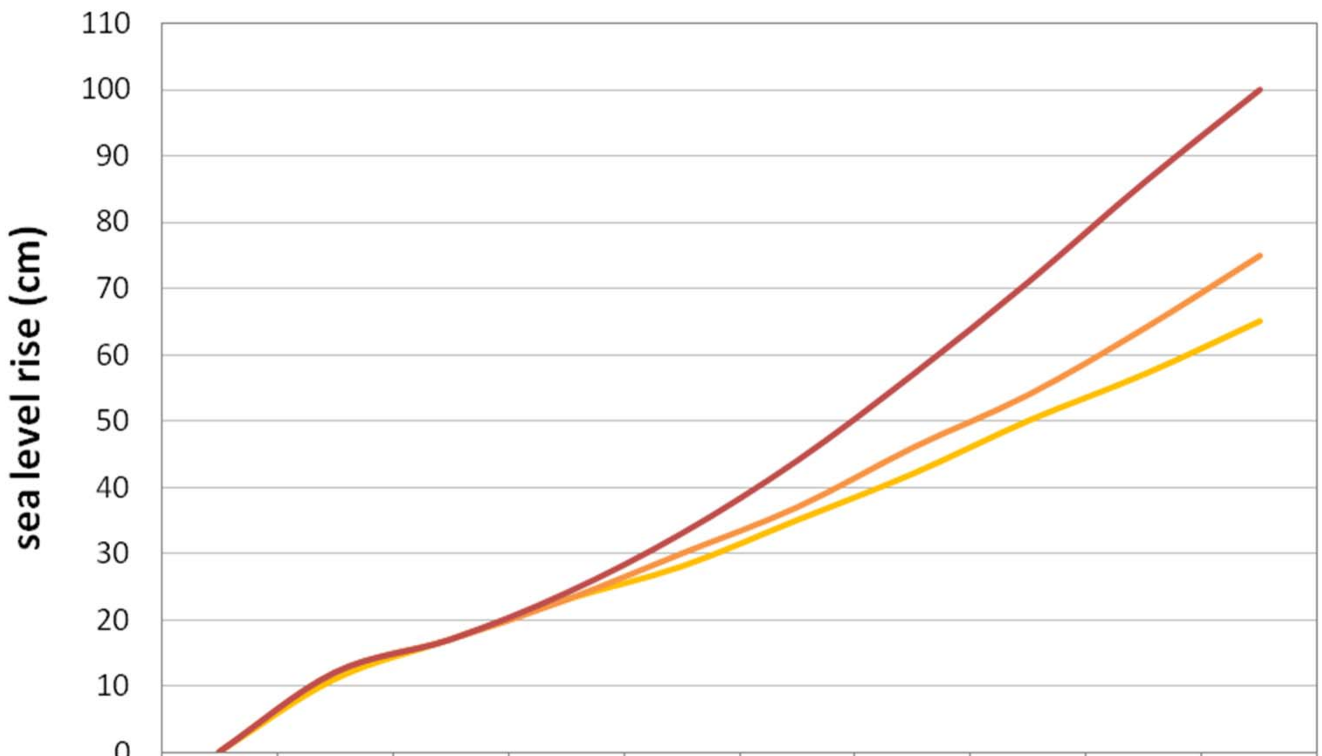
- 1924 – 1970
- 1981 - 2009

GCM series

- 2030 - 2087

Return period	KRATIE (baseline (1924-2009)	KRATIE - CC (stationary)	KRATIE - CC (non-stationary)
2yr	52,745	51,885	51,266
5yr	58,309	61,899	64,427
10yr	61,992	68,529	73,141
20yr	65,526	74,889	81,500
100yr	73,527	89,290	100,427
1000yr	84,852	109,673	127,217

Official Government of Vietnam Sea Level Rise projections



	1980-1999	2020	2030	2040	2050	2060	2070	2080	2090	2100
B1	0	11	17	23	28	35	42	50	57	65
B2	0	12	17	23	30	37	46	54	64	75
A1F1	0	12	17	24	33	44	57	71	86	100

2050 = 0.3m

2100 = 1.0m

At bridge site:

1m SLR = +0.55m peak WL

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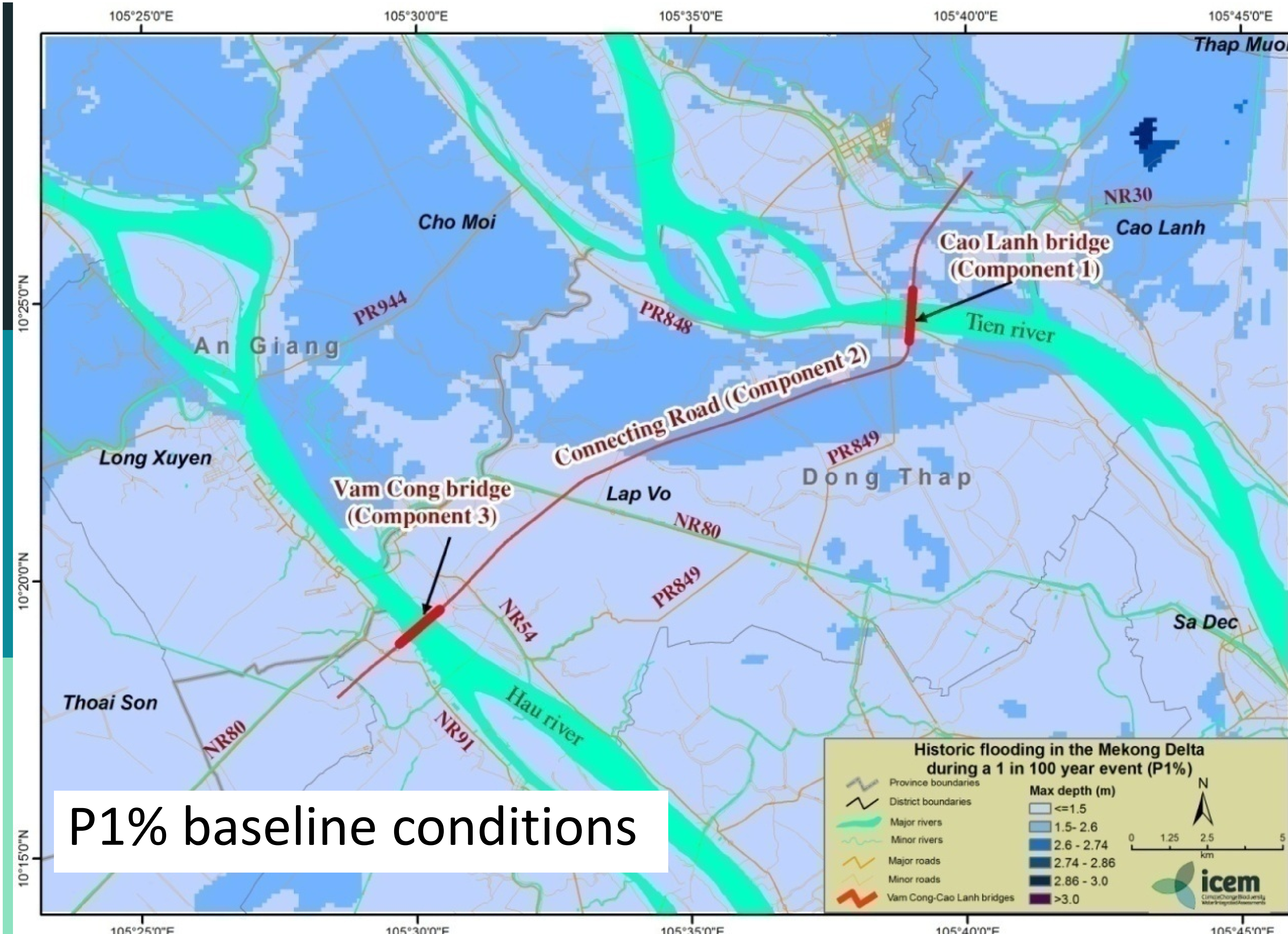
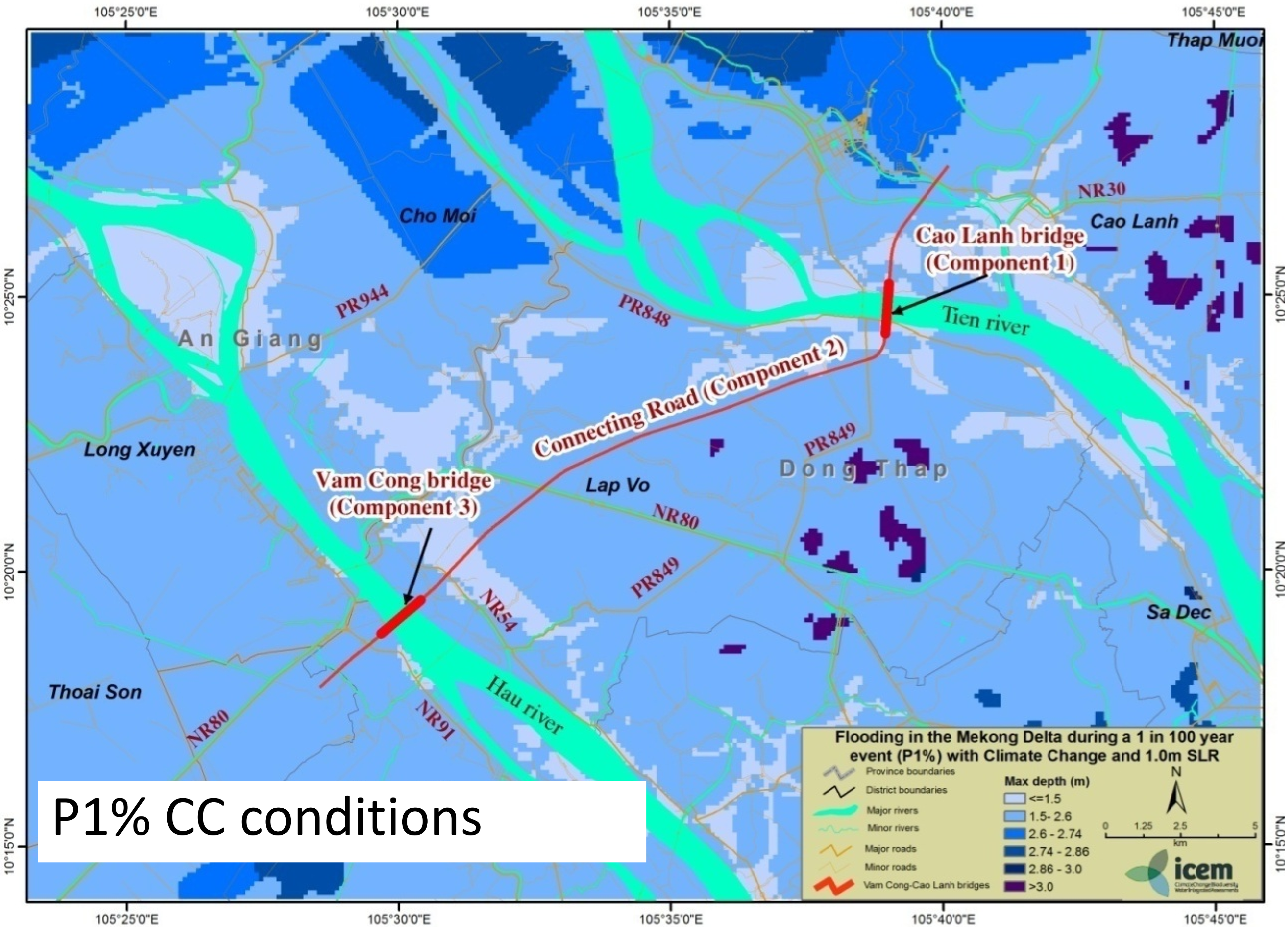
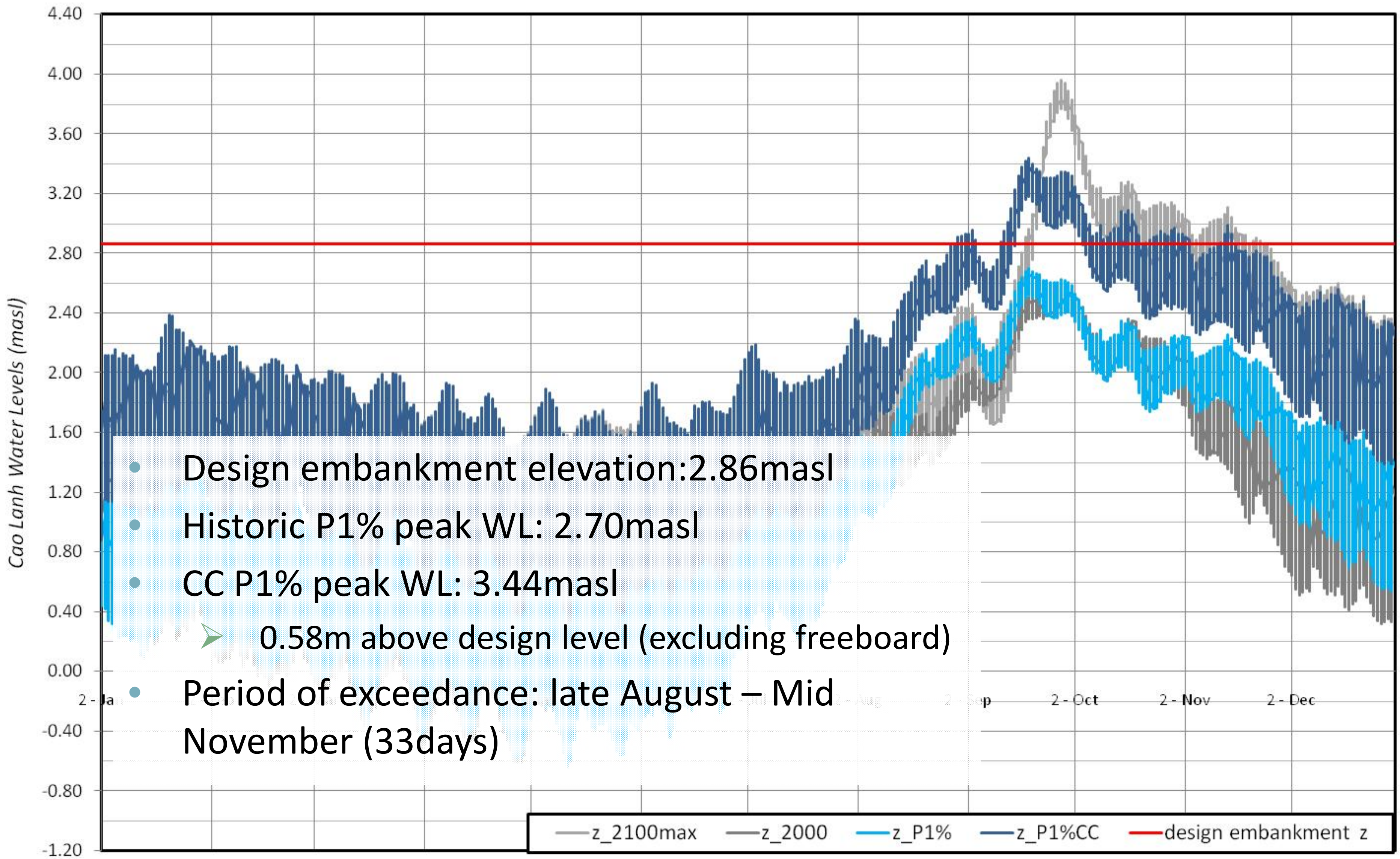


P1% baseline conditions

P1% CC conditions

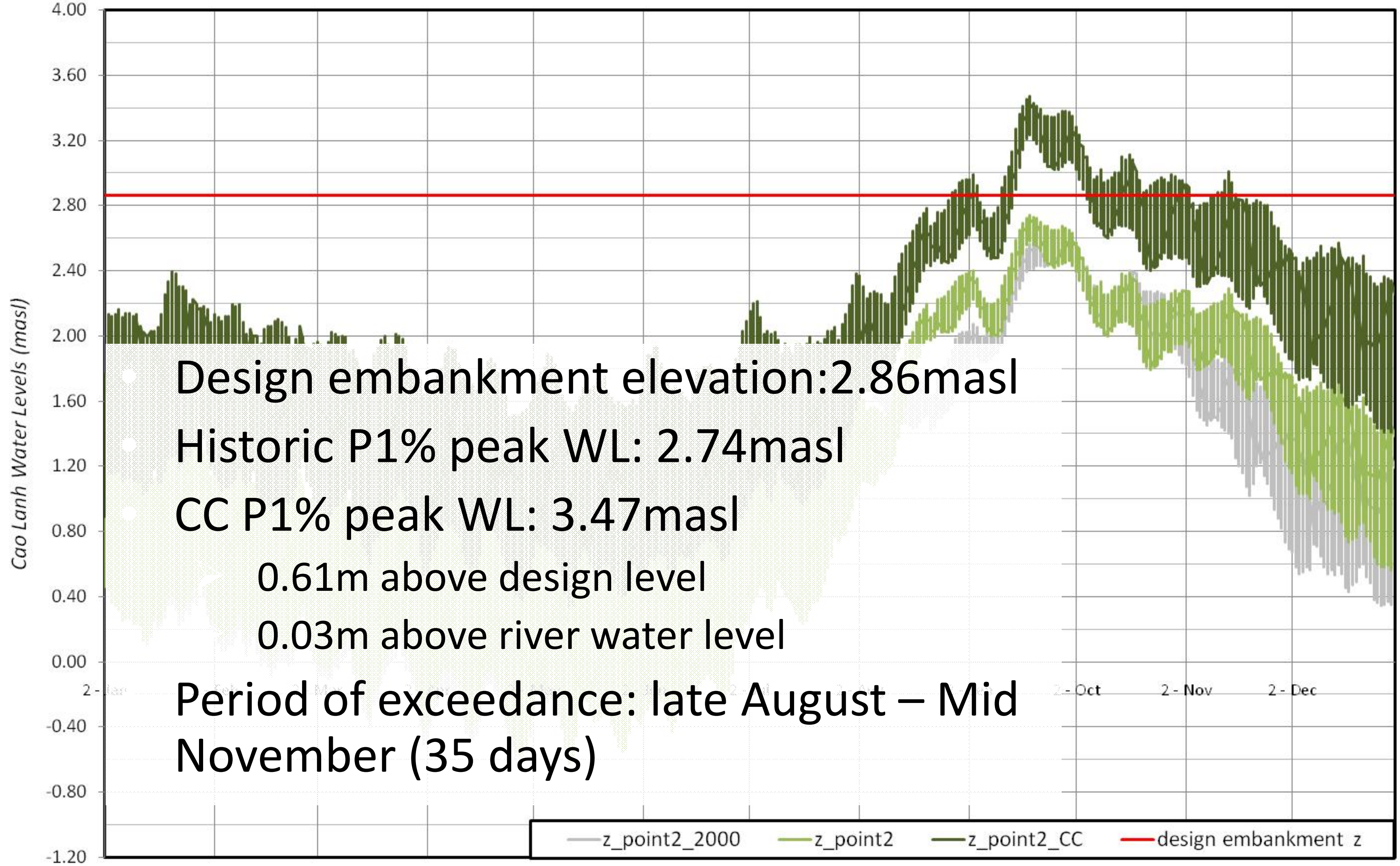


P1% Water Levels at bridge site (Delta model)



- Design embankment elevation:2.86masl
- Historic P1% peak WL: 2.70masl
- CC P1% peak WL: 3.44masl
  - 0.58m above design level (excluding freeboard)
- Period of exceedance: late August – Mid November (33days)

P1% Water Levels in Floodplain (Delta model)



- Design embankment elevation:2.86masl
- Historic P1% peak WL: 2.74masl
- CC P1% peak WL: 3.47masl
  - 0.61m above design level
  - 0.03m above river water level
- Period of exceedance: late August – Mid November (35 days)

Summary changes in water levels

		Baseline	CC (1D model)	CC (3D model)	Increase in WL(m)
Floodplain	P1% Water Level (masl)	2.74	3.47	3.1 – 3.6*	+0.6
Cao Lanh		2.7	3.44	3.4	+ 0.7

** Range reflects the variability in WL along the length of connecting road traversing the floodplain (highest in the centre and lowest near the Hau River)*

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Main Findings

- **P1% floodplain** water level will increase by 0.6m over a 100-year design life.
- **Navigation clearance** should not be significantly affected by the P5% water level in the future.
- **Maximum daily temperature** by 2050 is projected to increase by an average of 2.3°C, with 15-45% increase in the proportion of an average year > 35°C.
- **Scour/Erosion potential:** Left-bank of the Cao Lanh bridge site will see a significant increase in bed and bank velocities during large flood events.

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Main Findings

- **CC impact on road embankments represents the critical issue requiring adaptation response**
  - (0.1m above existing free board)
- Impacts include:
  - Non-compliance with design standard
  - erosion of road embankments and scour of road foundations,
  - water logging of road foundations, pore pressure induced collapse and road subsidence
  - reduced macro-stability of infrastructure
  - associated increase in maintenance effort

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Key Recommendations

1. **The design height for embankments should be raised by 0.6m to 3.46masl**
    - Cost of raising embankments = USD 4.5million
    - Post-construction elevation of the embankment in the future will be more costly
2. **Funding for the incremental cost of raising the embankments should be sought from global climate funds**.
    - Robust and credible evidence base has been developed.
3. **Navigation clearance, though impinged by larger magnitude P5% events should be sufficient for most vessel passage**.
4. **Climate change should be incorporated into detailed design technical investigations**:
    - Modelling of culvert sizing and alignment
    - determination of expansion joint, stay cable and bearing design (vis-a-vis temperature ranges)
    - Riverbank erosion studies at the bridge sites

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Key Recommendations (cont)

5. **Additional study is required to improve understanding of overland flood flow dynamics.** Rapid expansion of agricultural and transport infrastructure in the delta is suspected to have changed the floodplain dynamics of the delta-system over past decade.
6. **The climate change assessment should be expanded to cover provincial feeder roads**
7. **Need for the Government of Vietnam and ADB to assess climate change implications for other key transport infrastructure in the Delta.**
   - should be implemented as part of the Ministry of Transport's National Target Plan for Climate Change Response.

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CMDCP CRVA: lessons learnt

1. Integrate CRVA as early as possible into the investment planning process
2. Foster links between the design team and the CRVA team
3. Be careful not to proscribe the scope of the CRVA at the outset (some CC issues are non-obvious and only emerge as the study unfolds)
4. Take a wider integrated approach to resilience that considers the infrastructure investment in its surrounding environment

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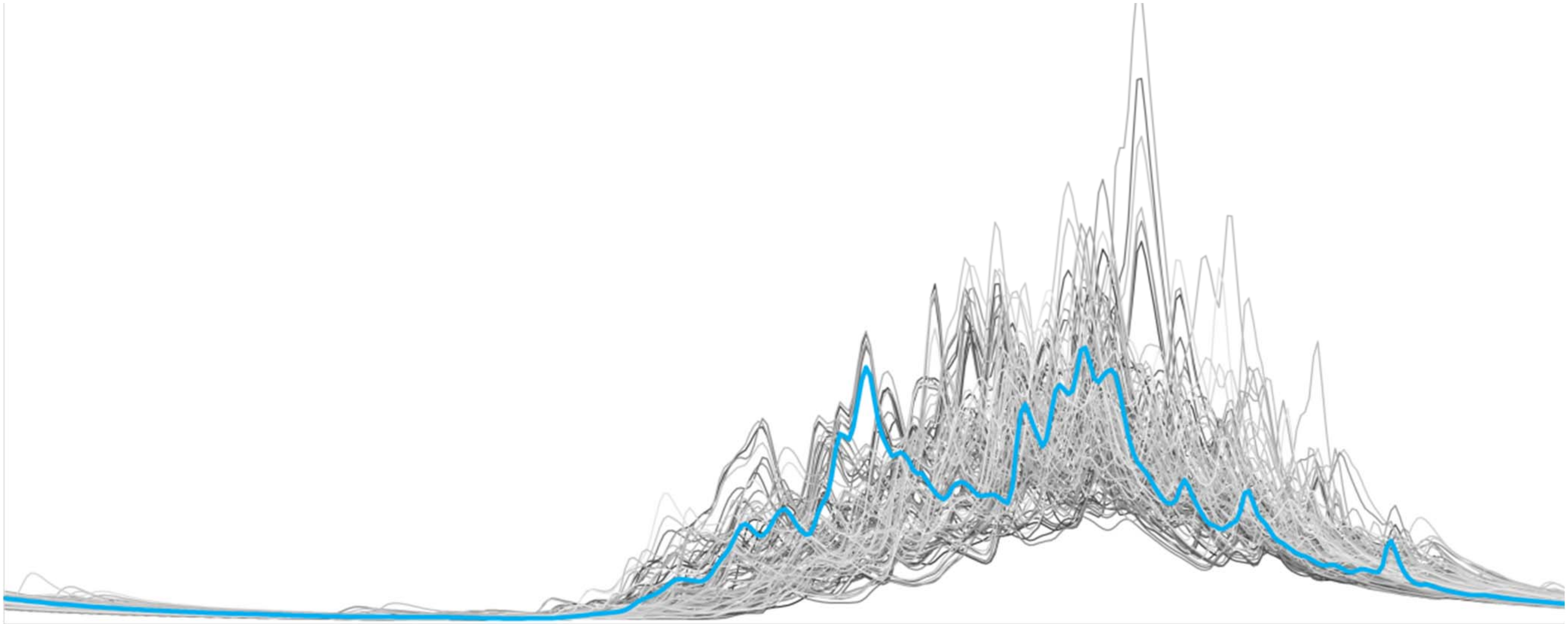

Thank you for your attention!

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