SEDIMENT TRANSPORT IN THE LMB AND IMPLICATIONS FOR HYDROPOWER DEVELOPMENT AND MANAGEMENT

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Vientiane

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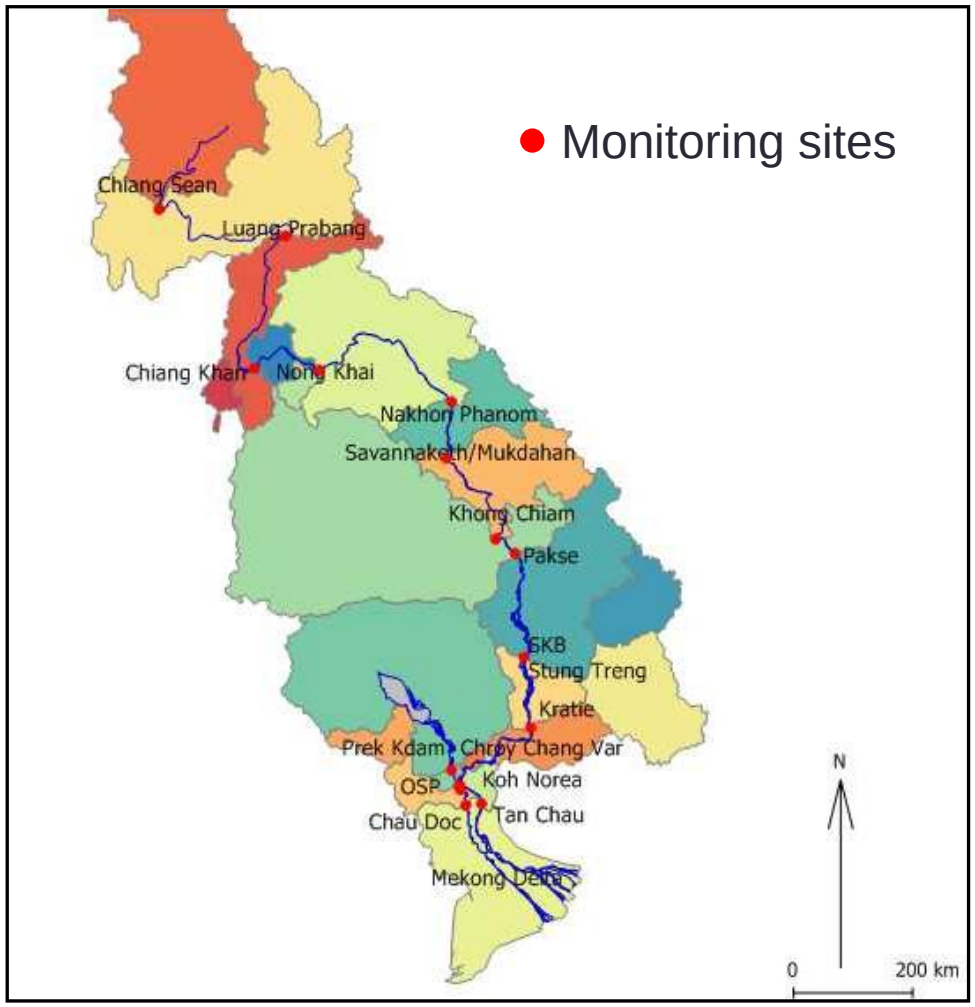
Overview of Presentation

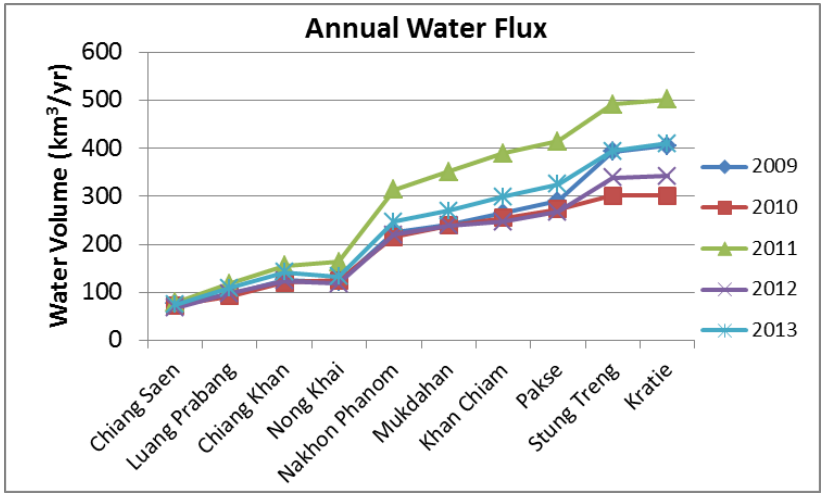
- Sediment transport in the LMB
  - 2009 – 2013 MRC Discharge & Sediment Monitoring Project
  - Sediment loads & timing
  - Changes associated with UMB development
- Risks associated with HP development
  - Geomorphic characteristics & vulnerabilities
- Mitigation approaches
  - Targets & objectives
  - Detailed hydrodynamic & sediment modelling through Initiative for Sustainable Hydropower
  - Modelling scenarios
  - Challenges

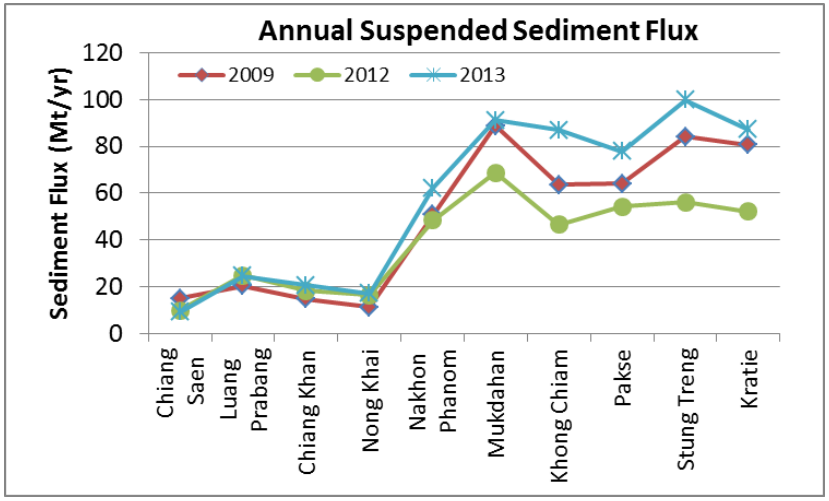
Sediment Monitoring 2009 - 2013

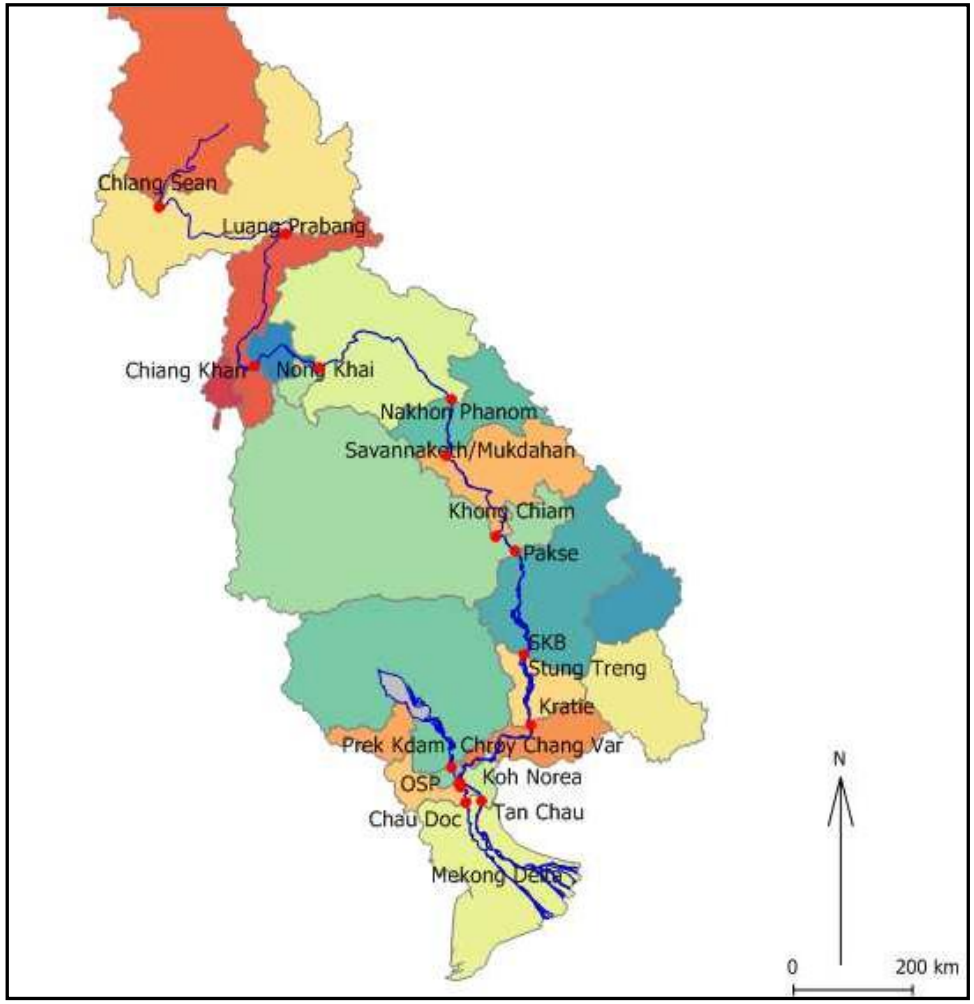
- Cooperative monitoring by LMB countries
  - Cambodia, Lao PDR, Thailand, Viet Nam
- Discharge & suspended sediment
  - 17 sites; 28 – 34 samples/yr
- Bedload, grain-size distribution
  - Subset of sites
- Bed Material surveys
- Includes wet & dry years



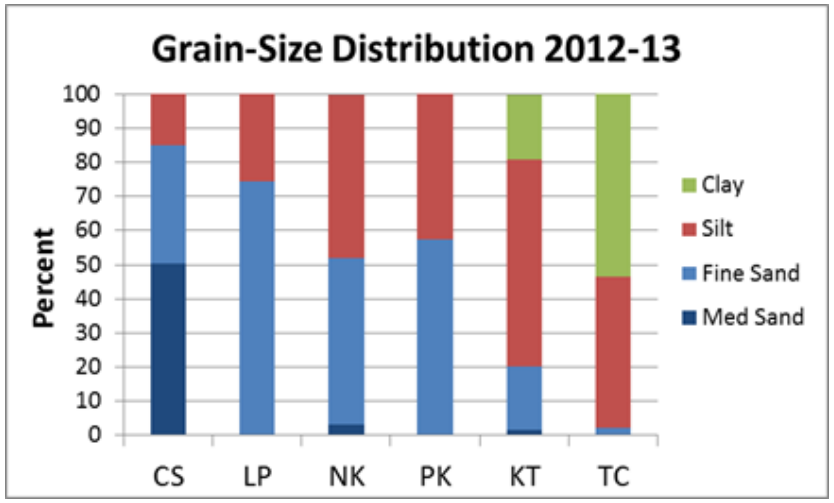
Sediment Loads & Timing

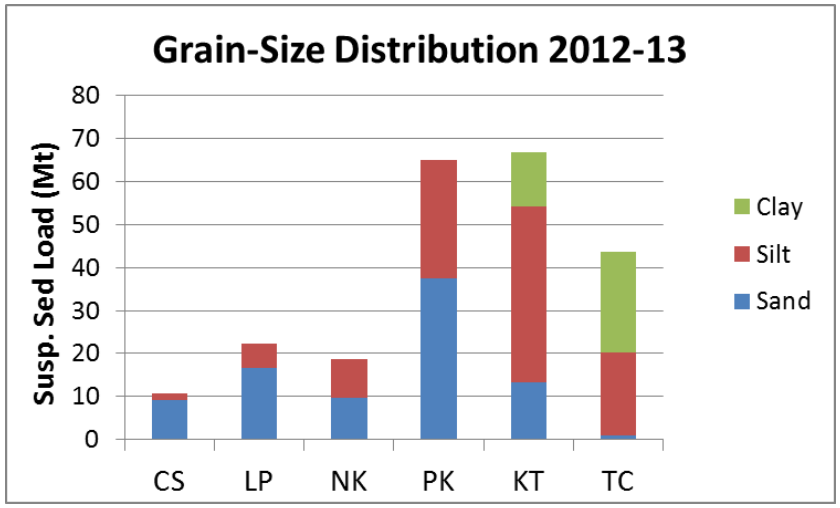


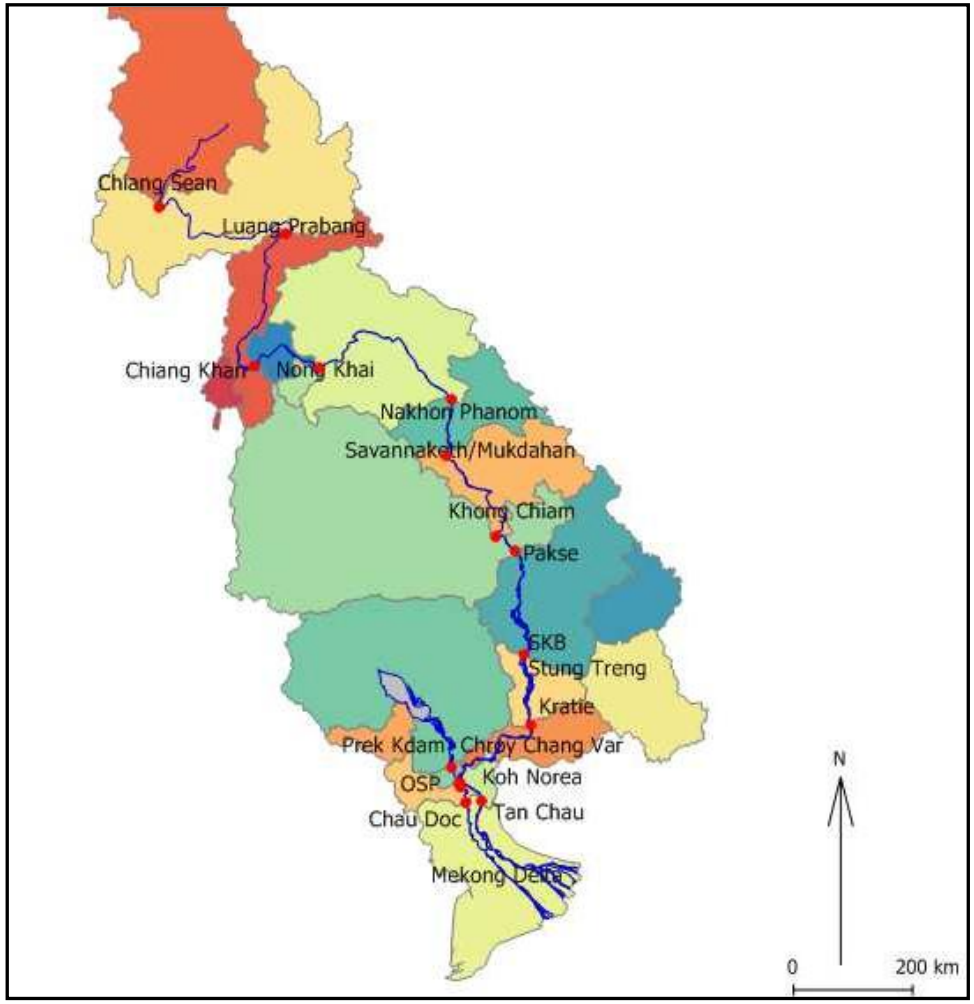




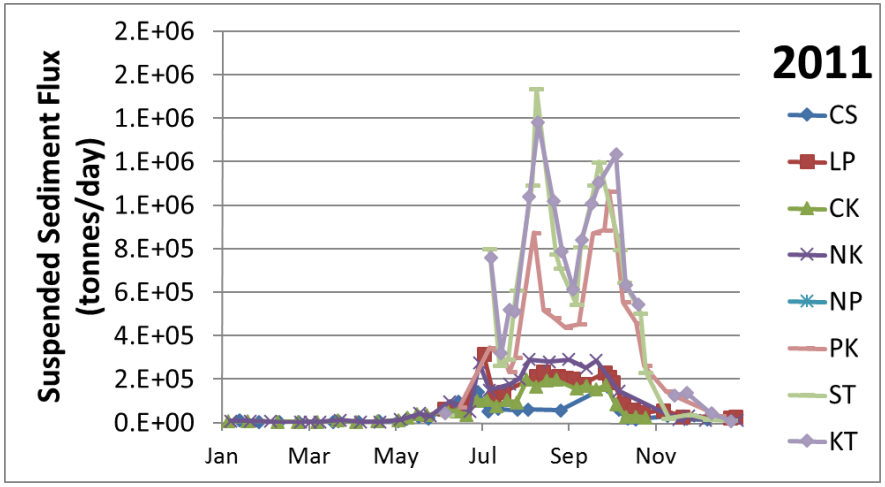
Sediment Loads & Timing



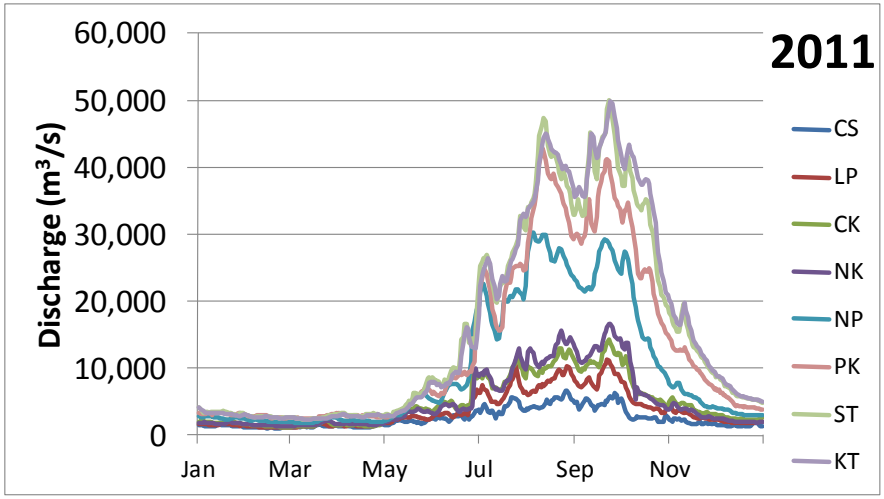


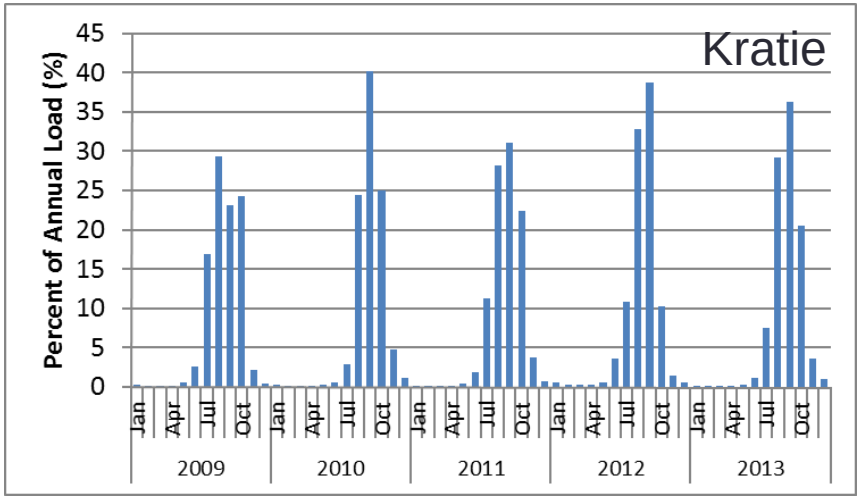


Sediment Loads & Timing = Pulse



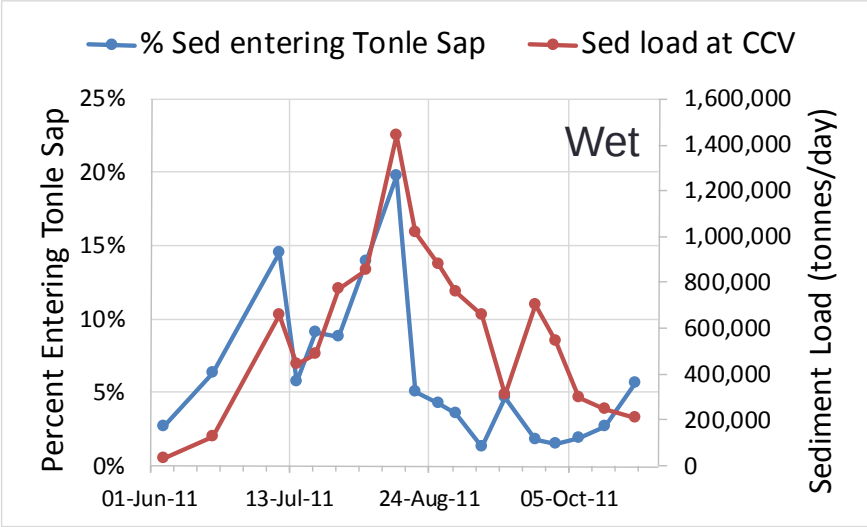
- 60% of sediment transported in 2 months
- 80% transported in 4 months
- Onset coincides with major 'flush' from upper catchment

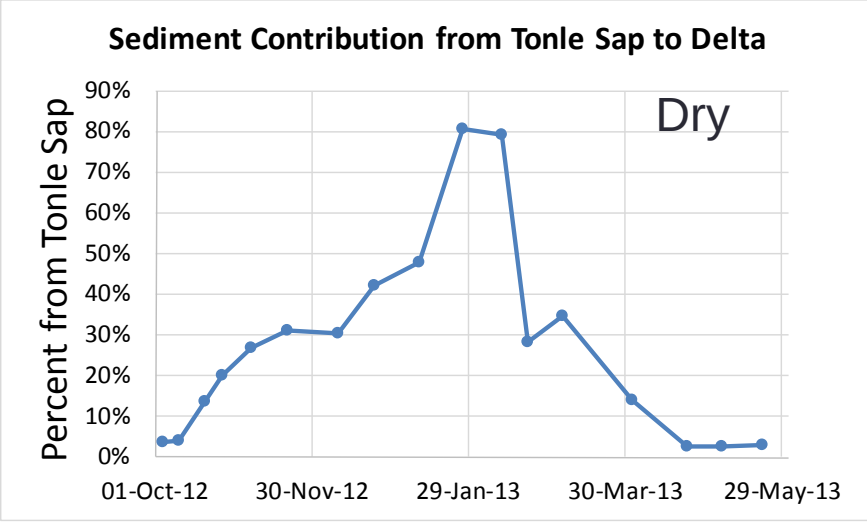




Mekong is a Sediment Pulse System

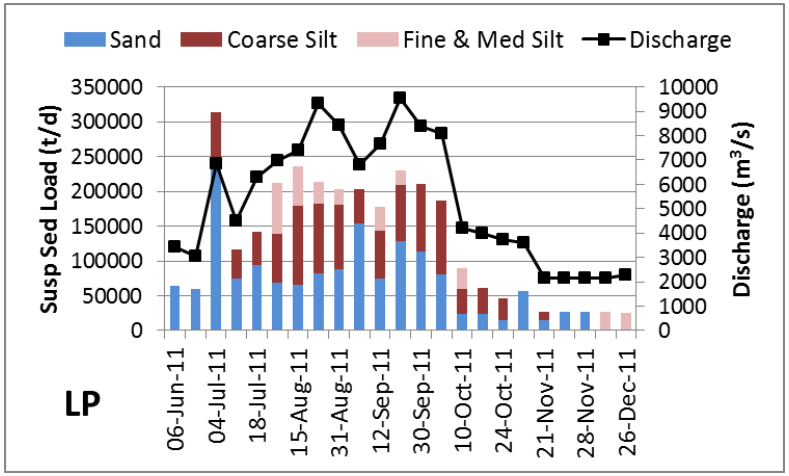
- Long recognised as a ‘Flood-pulse’ system
- Also a ‘Sediment-pulse’ system
- ‘Pulse’ drives sediment inflow to Tonle Sap in Wet season
- Tonle Sap outflow feeds delta during Dry season





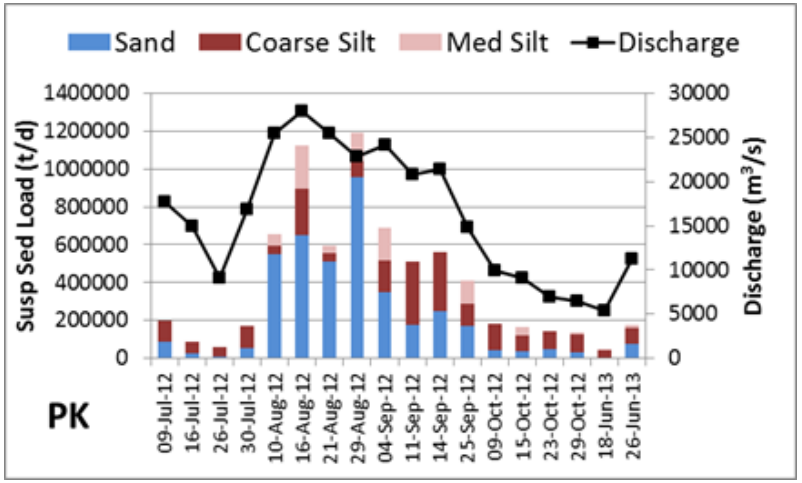
Mekong is a *Sand* pulse system

Luang Prabang suspended sediment

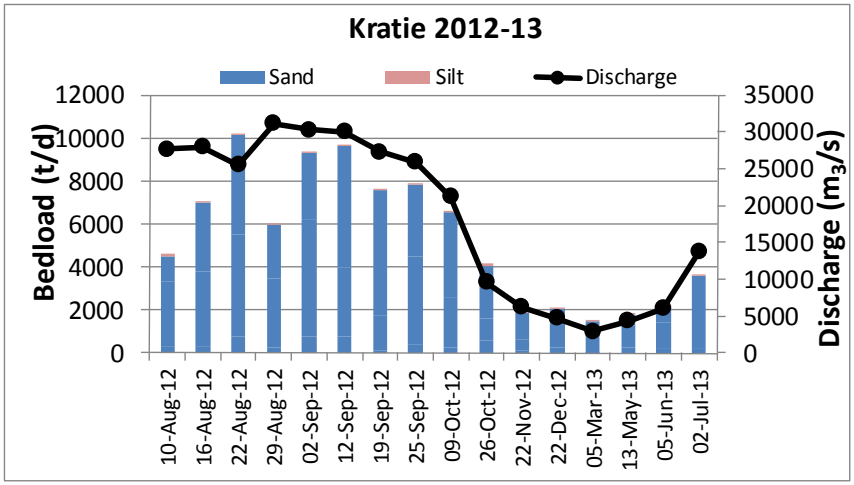


- Sand is predominant suspended grain-size during 'peak' flows upstream of Kratie
  - Bedload at all sites
- Sand is susceptible to reservoir trapping

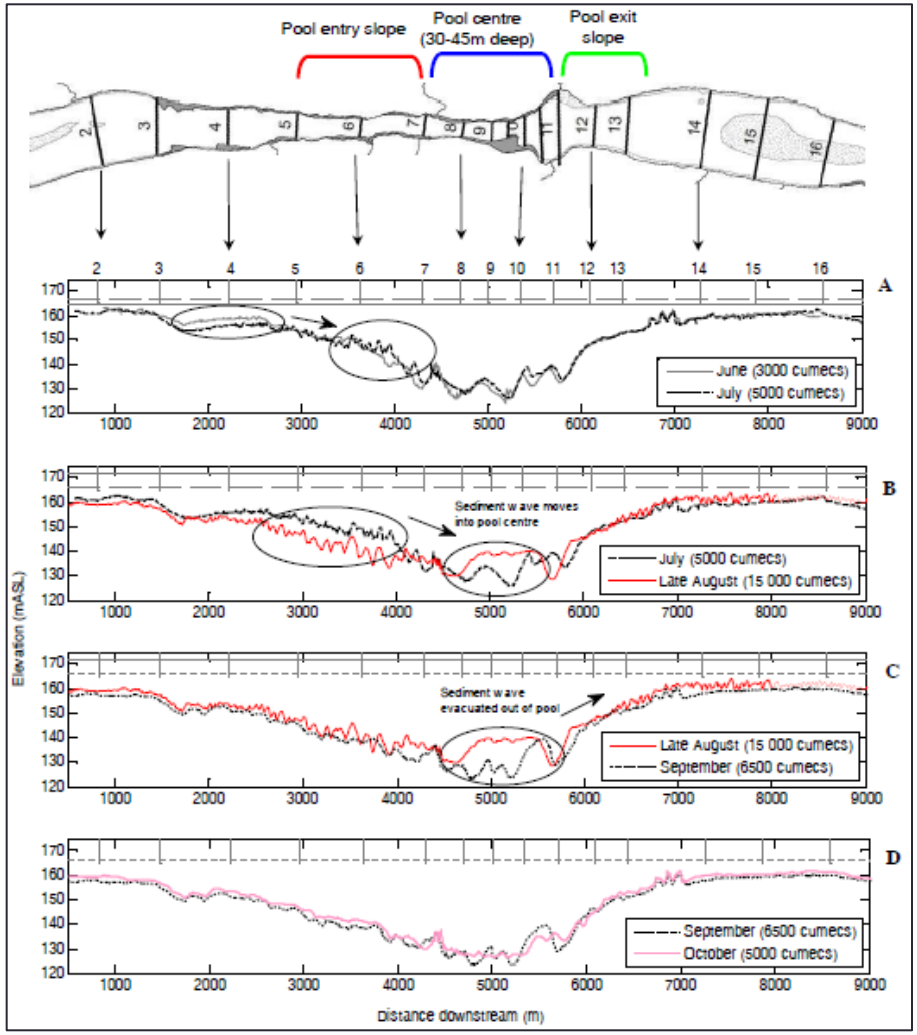
Pakse suspended sediment



Kratie bedload sediment

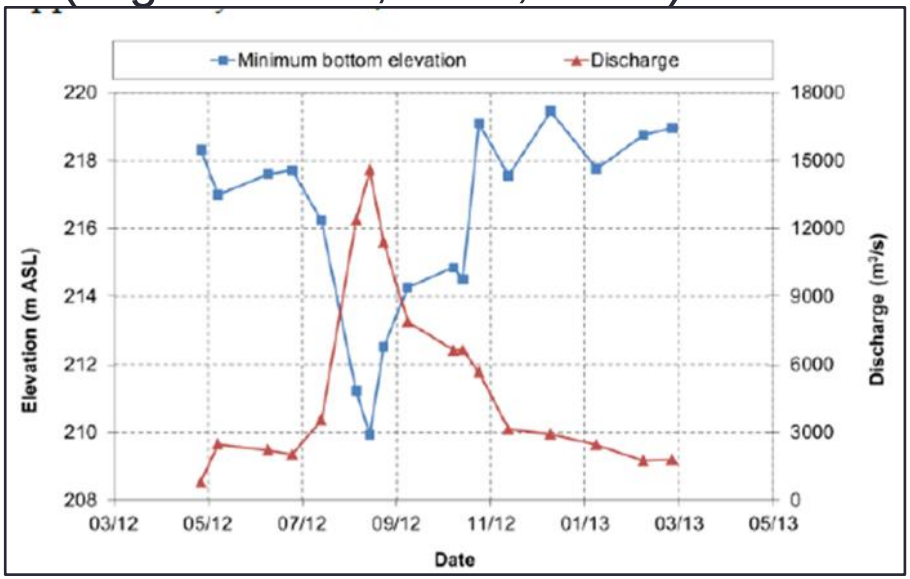


Mekong is a *Sand* pulse system



Conlan *et al.,* 2008

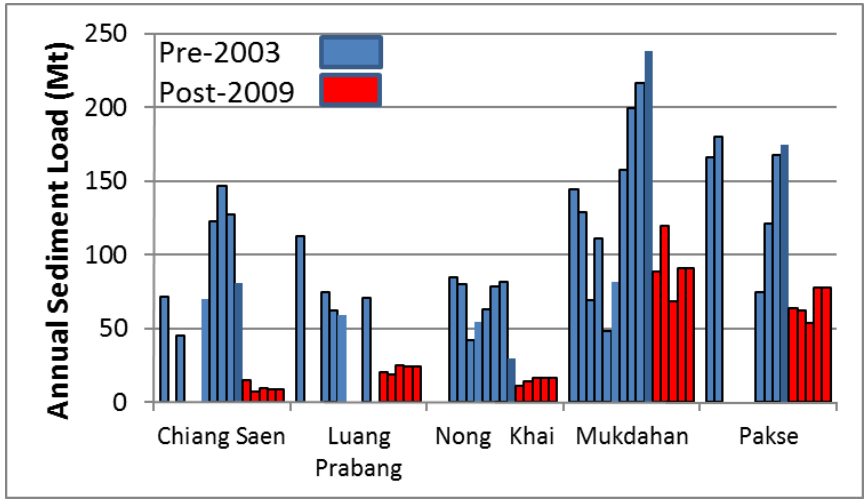
- Sand pulse observed moving through deep pools
- Channel fill moved & replenished on annual basis
- Sufficient energy to move sand in suspension at all river sites (E.g. Bravard, *et al.,* 2014)

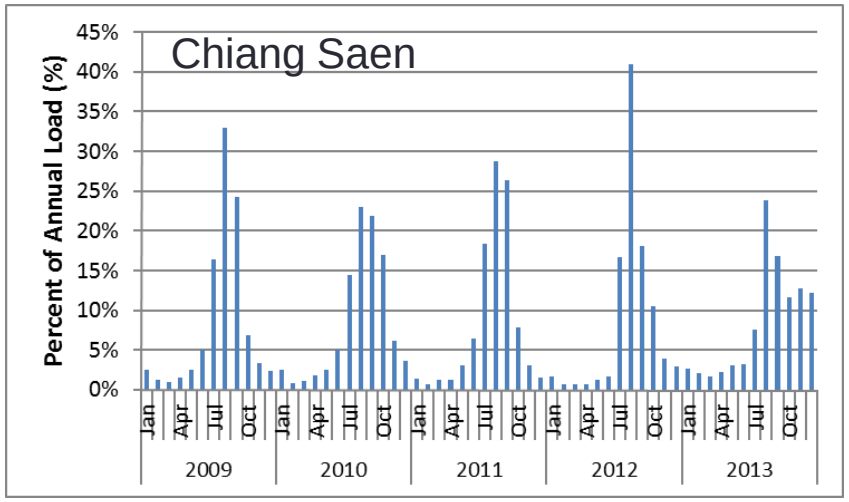


Peteuil, *et al.,* 2014

Changes from Lancang Cascade

- Reduction in suspended sed loads
  - 60 to 10 Mt at Chiang Saen
  - 160 to 90 Mt at Kratie
- Changes to timing of sediment delivery at CS
  - Reduction of ‘pulse’
  - Increase in dry season

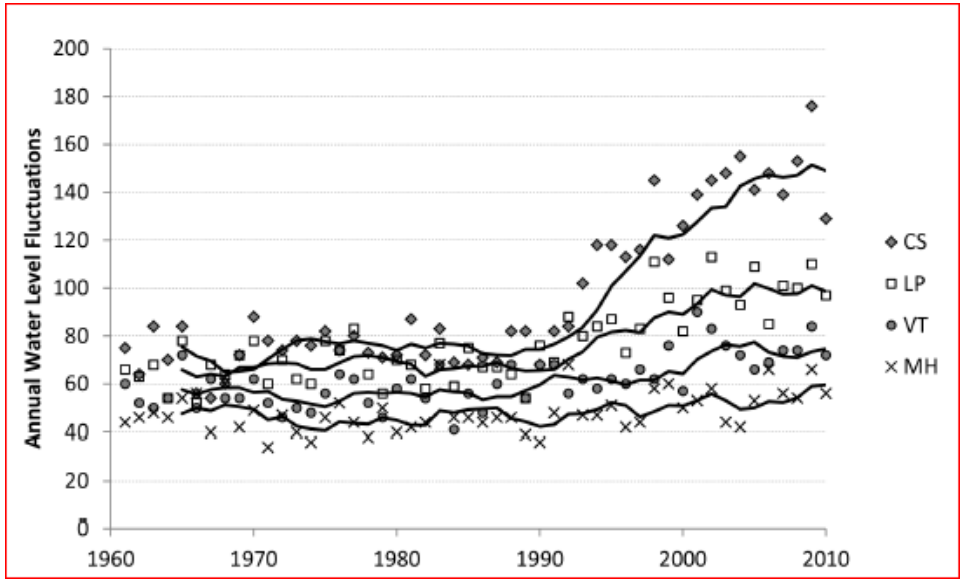




Change reduces with distance downstream

Flow changes

- Delayed onset of flood
- Increased frequency of water level fluctuations
- Most pronounced at Chiang Saen
- Reduces with distance downstream

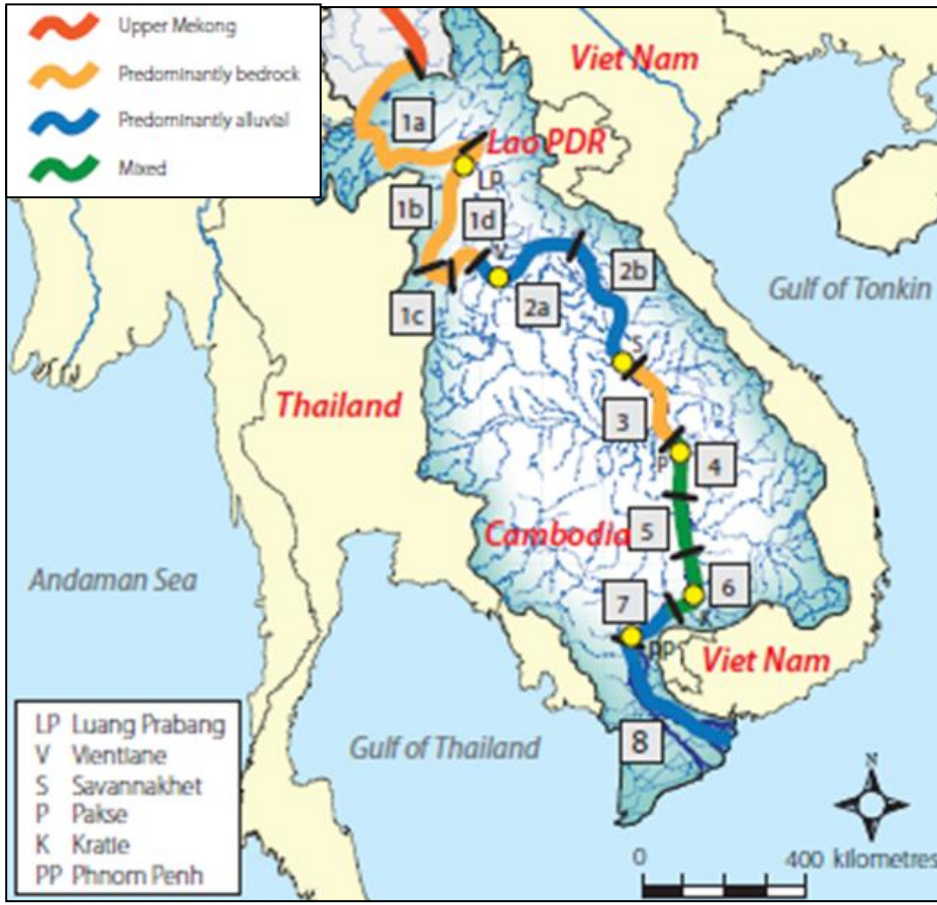


Cochrane, *et al.,* 2014

- **Developing HPs in LMB likely to lead to similar changes downstream**
  - Transboundary issues
  - Guide mitigation measures & strategies

Risks associated with HP development in the LMB

- Reduced sediment loads
- Alteration to sediment timing
- Increased flow fluctuations
- *Already happening in upper LMB*
- Risks vary by geomorphic characteristic
  - **Bedrock reaches**
  - **Alluvial reaches**
  - **Mixed**



(After Gupta 2004)

Bedrock Reaches

Characteristics

- Channel form controlled at large scale
- Alluvial insets
  - Widespread
  - Support a range of habitats
  - Provide channel fill
- Tributary inflows
  - Alluvial valleys & confluences

Risks

- Reduced sediment load and altered timing can remove sandy insets
  - Loss of vegetation & riparian zone
- Affect channel depth & fill
- Promote tributary ‘rejuvenation’

Alluvial Reaches

Characteristics

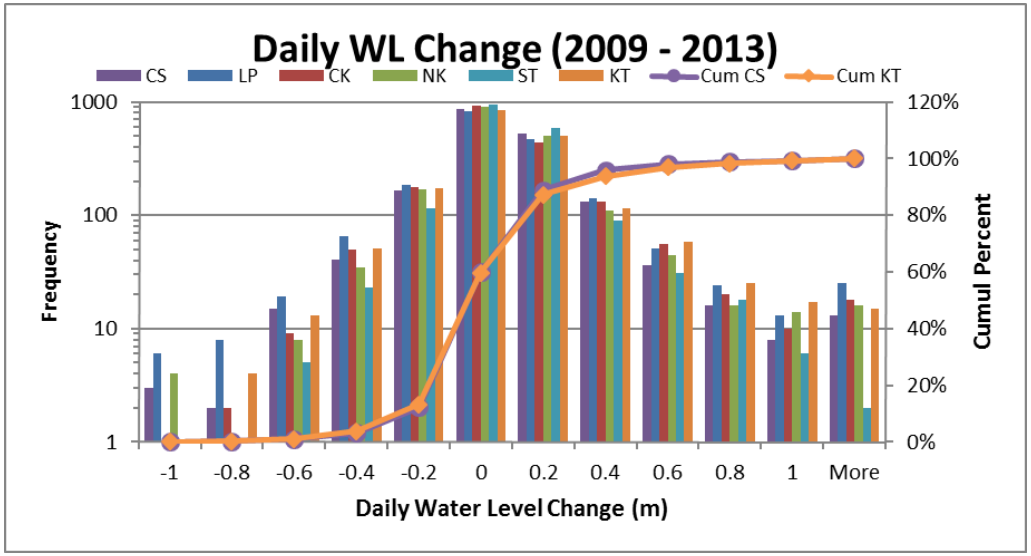
- Lack of large-scale channel control
- Alluvial deposits of variable age
  - ‘Recent’ sands
  - Older ‘terraces’ & floodplains
- Susceptible to scour & ‘seepage’ processes

Risks

- Large scale channel changes
  - Deepening
  - Widening
  - Continue until ‘adjusted’ to new flow regime
- Bank erosion
  - Loss of habitats
  - Loss of riparian zone & uses
  - Risk to infrastructure
- Tributary rejuvenation
- Continue to ‘adjust’ with each change to flow regime

Daily Water Level Changes in the LMB

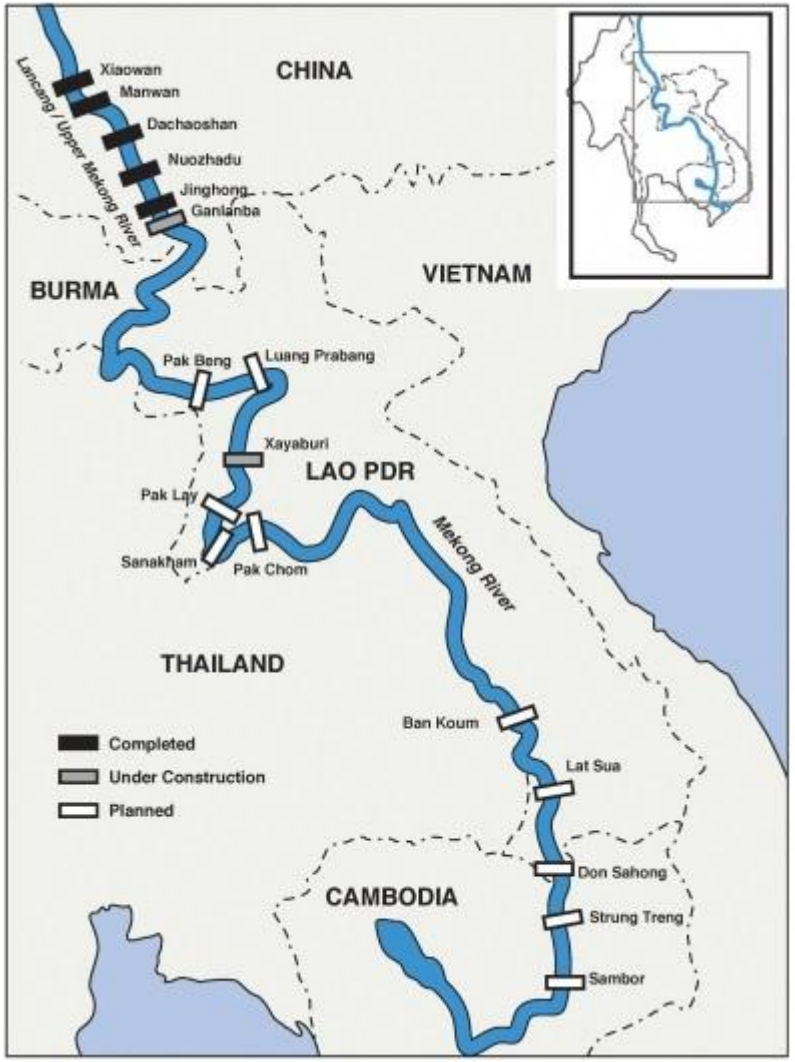
- Reflects Lancang & existing tributary developments
- 75% of days WL change <0.2 m/day
- 90% of days WL change <0.4 m/day



- HP operations can change WL by m/hr
  - Frequency increased under peaking regimes
  - Step changes associated with increasing / reducing number of turbines operating
  - Increase risk of ‘seepage’ erosion during drawdown

Mitigation approaches being considered by Initiative Sustainable Hydropower

- Focus on cascade in Northern Lao PDR (5-stations)
- Model sediment management and power station operation to:
  - Maintain sediment connectivity
  - Maintain seasonal sediment pulse
  - Maintain relationship between flow & sediment delivery
  - Minimise erosion associated with water level fluctuations
  - Maximise operational flexibility
- Will also consider water quality, fish aquatic ecology, & energy

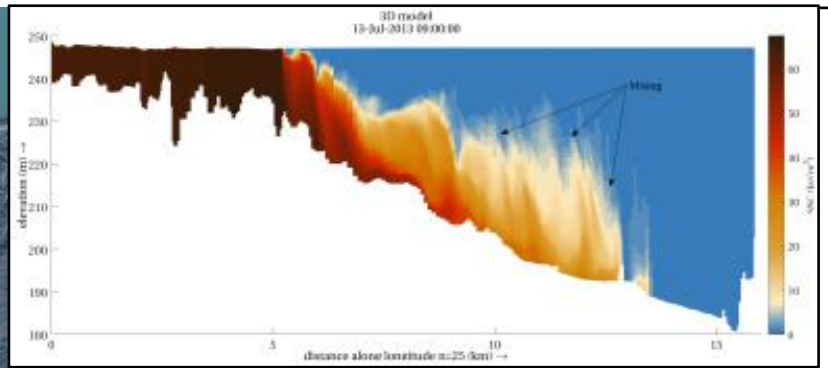


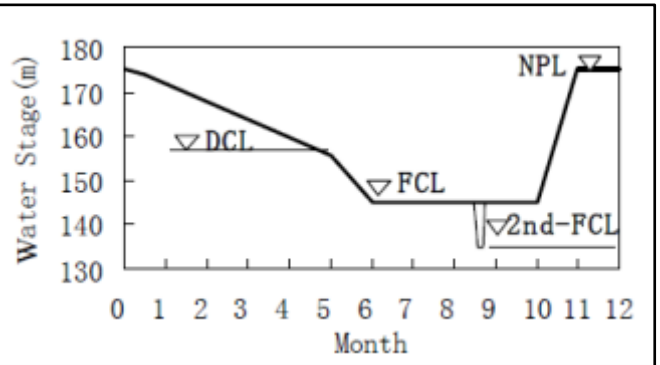
Sediment ‘Scenarios’ to be Modelled

- All scenarios include 2040 tributary and UMB developments to allow appropriate comparisons
- 5 Stations
  - Sediment sluicing / flushing during 1:2 year high flow events
  - Drawdown and sediment sluicing during peak flows (2 / year)
  - Limited ‘hydropeaking’ with ramping rules
  - Coordinated operation of cascades
- 3 Stations (Xayabouri most downstream)
  - Similar scenario(s) with fewer mainstream projects
- Qualitative assessment of potential for ‘catchment’ based mitigation
  - Extraction of sediments from HP storages
  - Reduction in sediment mining downstream
  - Alteration of locations of mainstream projects wrt tributaries

Results will inform Mitigation Guidelines

- Feasibility of mitigation in context of UMB developments
- Mitigation effectiveness v investment
  - Include power modelling
- Infrastructure design & specifications
  - *E.g.,* Gate sizes required to provide flow velocities
- Recommendations for operating rules
  - Ramping rates
  - Seasonal flow & sediment targets





Sediment Mitigation Challenges

- Magnitude & timing of sediment delivery is already altered
  - Difficult to adopt ‘annual’ approach to operations
  - Requires operational flexibility
- Mekong is in state of change due to existing developments
  - Difficult to identify ‘baseline’ for mitigation targets
  - Modelling ‘base case’ will assist
- Large number of new developments (HP & others) will induce additional change & increase complexity of the system
- Impact of sand mining on channel needs to be considered in *any* sediment mitigation / management scenario
  - Requires a catchment approach

THANK YOU!