

# PDG 2023 Section 5 - Aquatic Ecology



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# Aquatic Ecosystem Health: **outline**

- PDG Objectives
- Understanding Aquatic Ecosystem Health perspectives
- Outline of risks to Aquatic Ecosystem Health from HPP developments
  - Understanding risks during construction and operational phases
- Monitoring requirements during all phases of development
- Mitigation options
- Lessons learnt from previous PNPAs



## Section 5.1: Aquatic Ecosystem Health Objectives

**Overall Objective:** To understand the intensity and extent of the proposed impact of proposed HPPs on the ecological health of the main stream of the lower Mekong

**Design guidelines intended to:**

- i. To protect and conserve aquatic habitats, as far as possible, during construction and operation of mainstream dams
- ii. To minimise the impacts of construction and operation of hydropower dams on the **aquatic ecology and ecosystems** of the lower Mekong River system.
- iii. To reduce risks of pests, parasites of diseases in impoundments **to people, local ecosystems or the hydropower system**.
- iv. Protect and sustain aquatic ecosystems reliant on natural river flow regimes



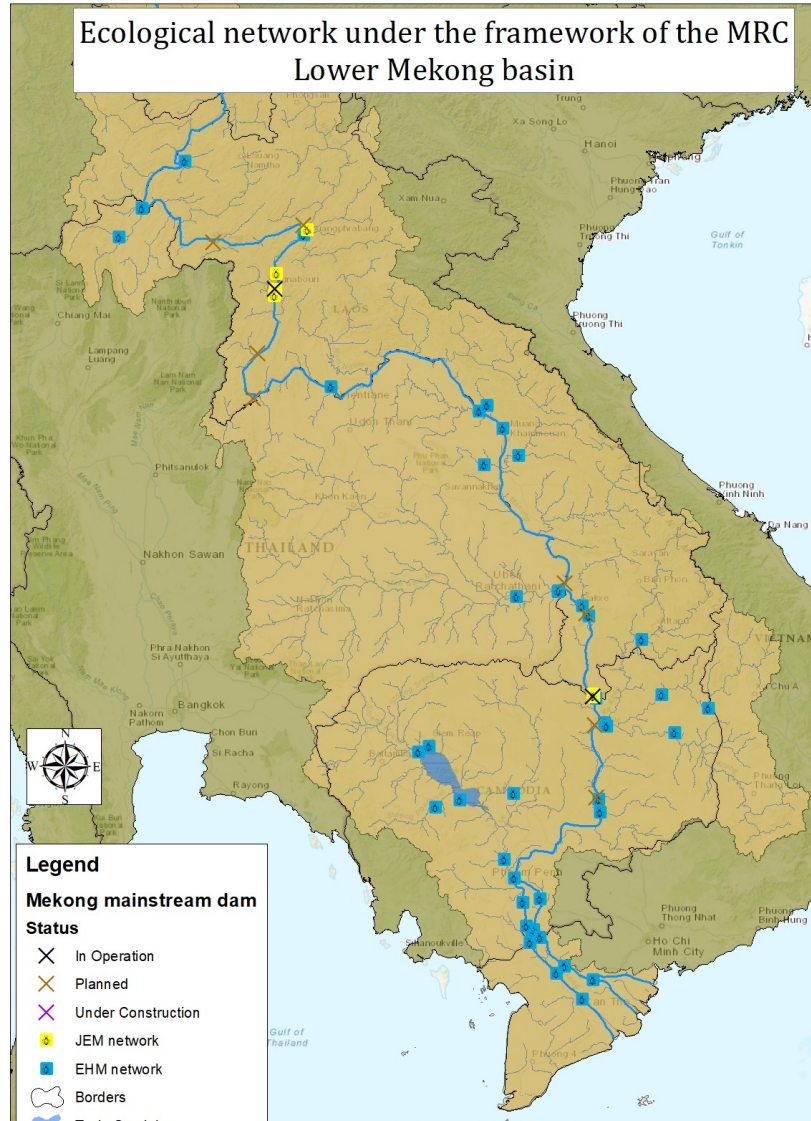
## Changes from 2009 Version

- Aquatic Ecology a stand alone section
- Extended section with more explicit monitoring requirements
- Risk-based approach
- Environmental flows using the existing Mekong DRIFT model



# Aquatic Ecosystem Health: **perspectives**

## Existing MRC Aquatic Ecosystem Health monitoring

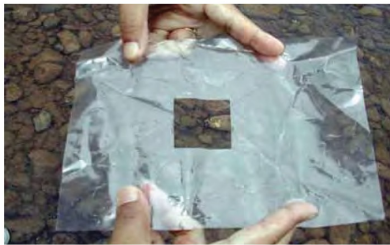


| Monitoring aspects            | Main characteristics of AEH                                                                                                                                                                     |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Location                      | <ul style="list-style-type: none"><li>• 14 on the Mekong mainstream.</li><li>• 27 on the tributaries</li></ul>                                                                                  |
| Parameters                    | <ul style="list-style-type: none"><li>• Benthic diatoms, zooplankton, littoral invertebrates and benthic macroinvertebrates</li><li>• Indices of species abundance, richness and ASPT</li></ul> |
| Frequency of data acquisition | <ul style="list-style-type: none"><li>• Standard methodologies</li><li>• Every two years</li></ul>                                                                                              |

# Aquatic Ecosystem Health perspectives: *Benthic diatoms*



Step 1. Benthic diatoms on the surface of a substrate.



Step 2. Plastic sheets, each with a 10 cm<sup>2</sup> (3.16 x 3.16 cm) square cut-out used to cover the substrate and delineate the sampling area



Step 3. Toothbrushes, plastic bowl, plastic containers with sealable lids, Lugol's Solution, labels and a marker pen used for sampling.



Step 4. A plastic sheet with a 10 cm<sup>2</sup> cut-out is placed on the upper surface of the selected stone.



Step 5. Benthic diatoms on the surface of the selected stone are brushed off.



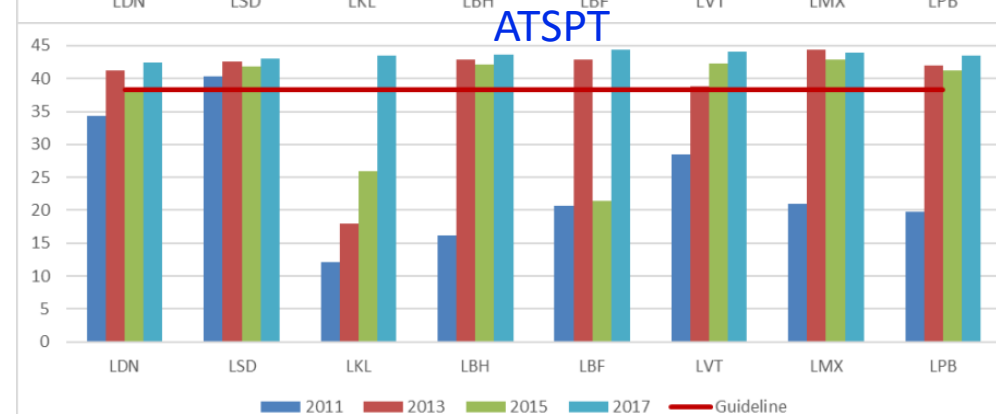
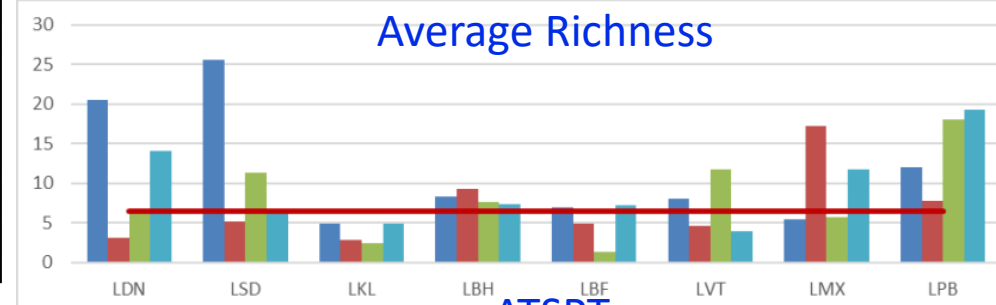
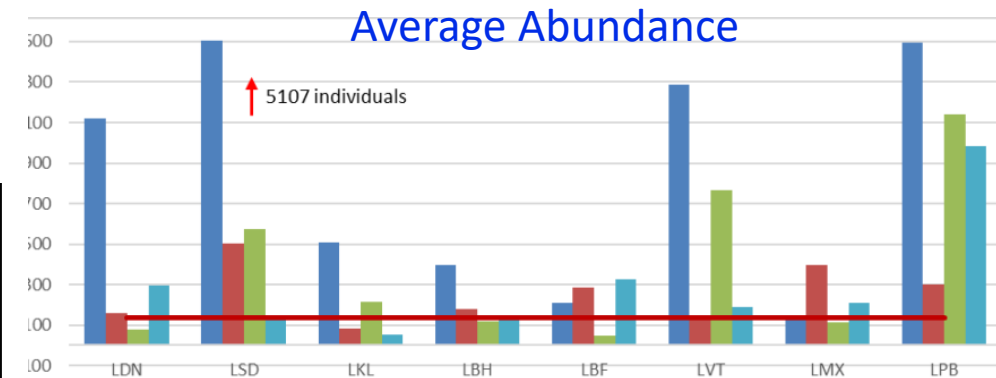
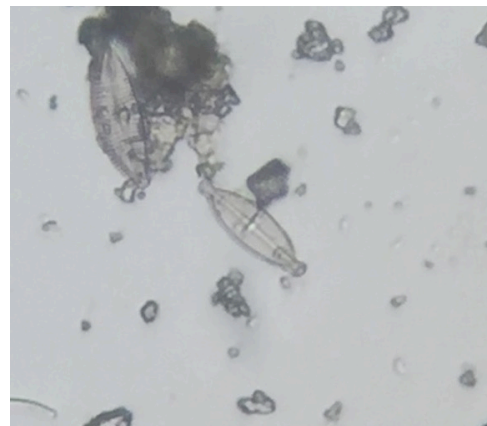
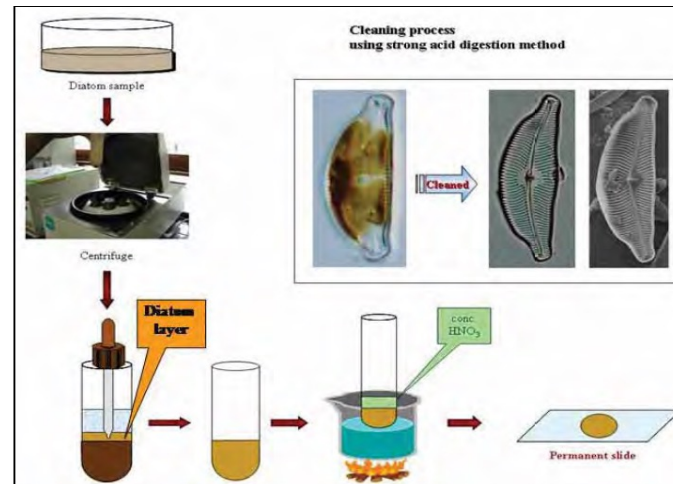
Step 6. The scraped area is rinsed with water until the cut-out area is completely clear.



Step 7. Each sample is poured into a plastic bowl and then into a plastic container.



Step 8. The label includes the site name, the site code, the date, and the replicate number, written on the plastic container.



Comparison of **Benthic Diatom** results in Lao PDR (2011, 2013, 2015 and 2017)

# Aquatic Ecosystem Health perspectives: *Zooplankton*



Step 1. A plankton net.



Step 2. Collect 10L of water and filter it slowly through the plankton net.



Step 3. Wash the net by splashing water on the outside.



Step 4. Rinse the bottom of the net to result in a water volume of about 150mL.



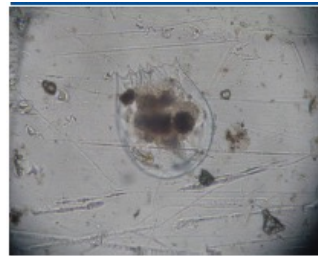
Step 5. Transfer the sample to a 250mL jar.



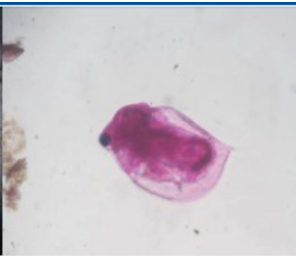
Step 4. Transfer the sample to a Petri dish and examine it under a stereo-microscope at a magnification of 40x to identify the larger specimens of zooplankton.



Step 5. The smaller species and morphological details of large species are examined with a compound microscope at a magnification of 100 – 400x.



*Brachionus urceolaris*



*Ceriodaphnia rigaudi*



*Keratella lenzi*



*Lecane arcuata*



*Testudinella patina*



*Lecane curvirostris*



Comparison of **Zooplankton** results in Lao PDR  
(2011, 2013, 2015 and 2017)

# Aquatic Ecosystem Health perspectives: *Littoral macroinvertebrates*



Step 1a. In shallow water, the collector stands in the river about 1 - 1.5m from the water's edge and sweeps the net towards the bank, near the substrate surface OR



Step 1b. In deep water, the collector stands on a boat about 1 - 1.5 m from the water's edge and sweeps the net towards the bank, near the substrate surface.



Step 2. The D-frame net is then inverted and its contents emptied into a hand net or sieve.



Step 4. The net is then inverted and its contents emptied into a metal or plastic sorting tray.



Step 6. Small invertebrates can be picked with plastic pipette.



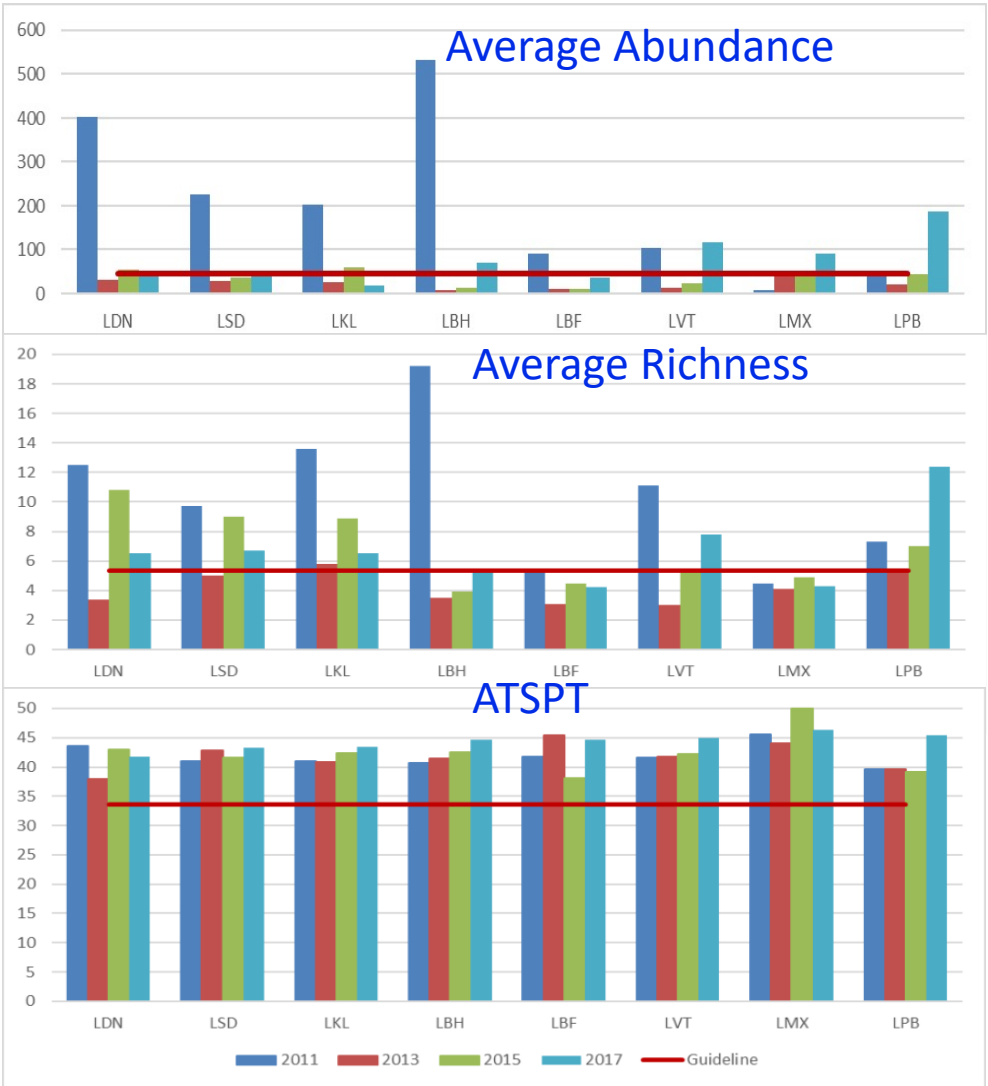
Step 3. The material adhering to the net is washed off with clean water.



Step 5. Invertebrates can be sorted in the field with forceps and plastic pipette.



Step 7. The sample jar is labelled with the site name, site code, date, and sample replicate number.



Comparison of **Littoral Macroinvertebrate** results in Lao PDR (2011, 2013, 2015 and 2017)

# Aquatic Ecosystem Health perspectives: *Benthic macroinvertebrates*



Step1. Check the operation of the Petersen grab sampler.



Step 2. Lower the grab into the water making sure that it catches on the river bottom.



Step 3. Release the contents from the grab into a stack of sieves with



Step 4. Wash the sample, aquatic plants, and substrate, etc. by shaking the sample. Repeat many times



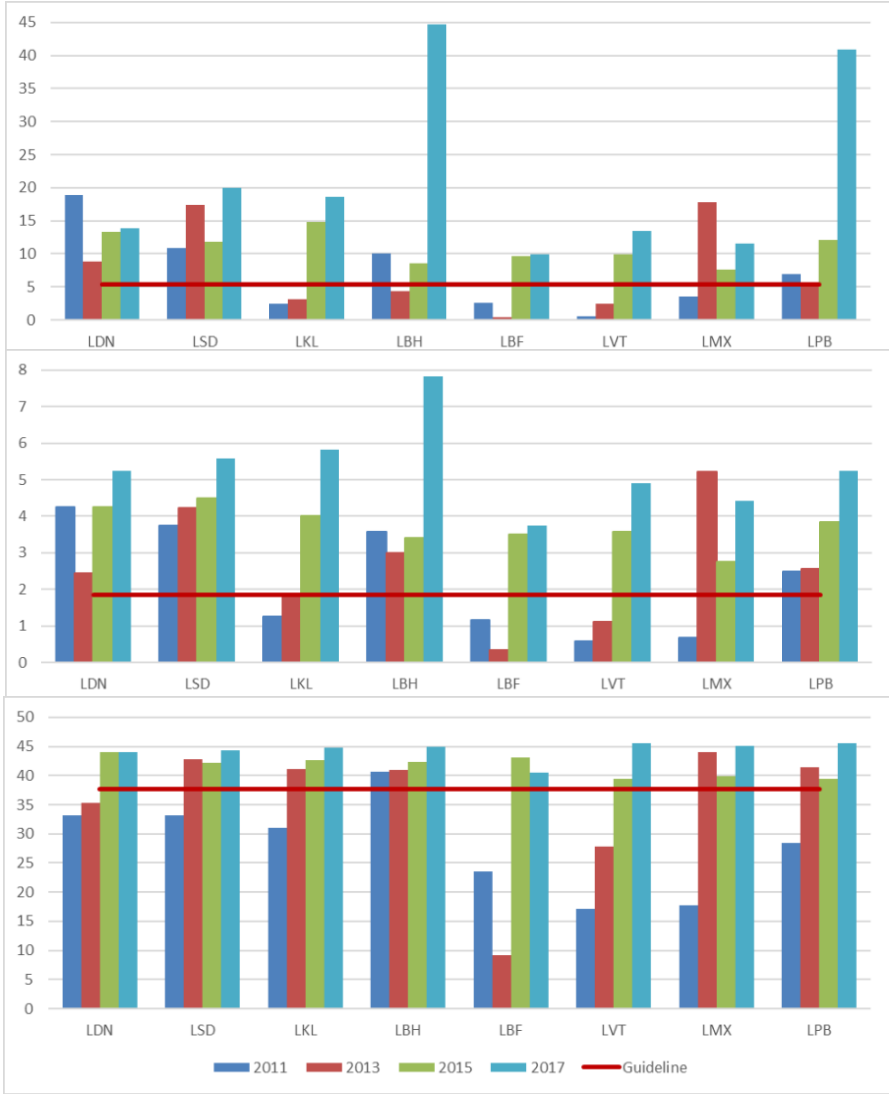
Step 5. Remove some of the sample and place it in a smaller-sized sieve with a 0.3mm mesh for further washing.



Step 6. Invertebrates can be sorted in the field with forceps.

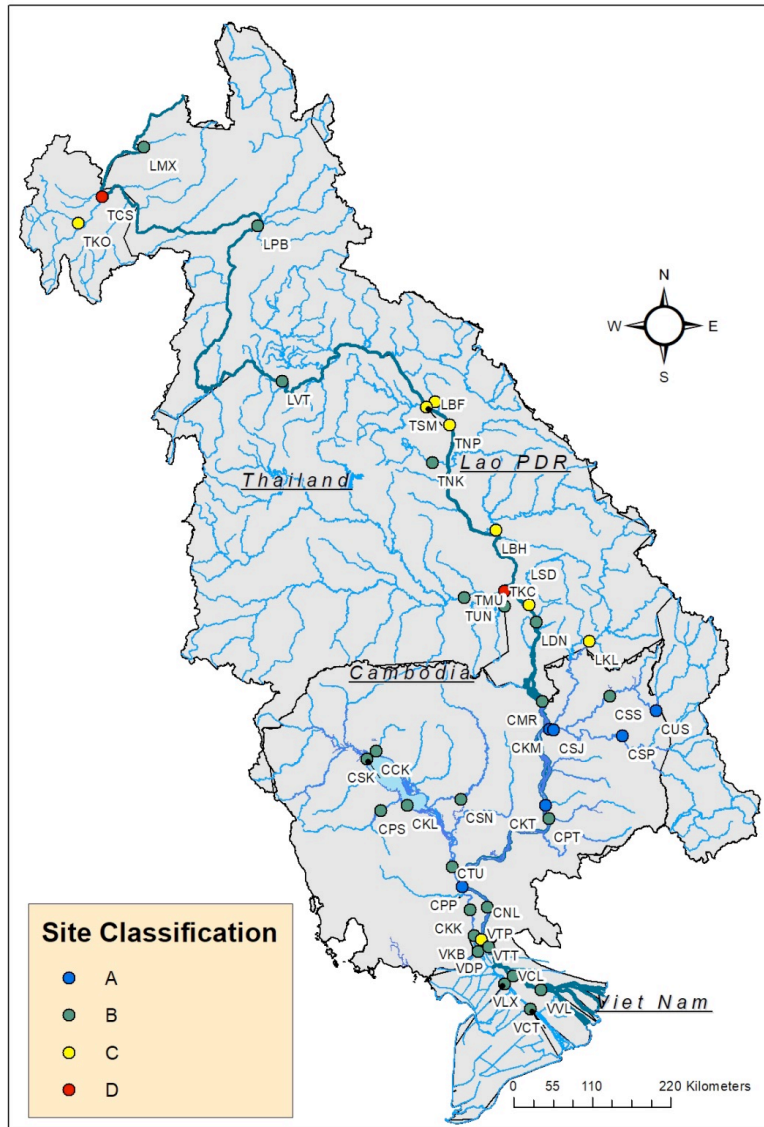


Step 7. The sample jar is labelled with the site name, site code, date, and sample replicate number



Comparison of Benthic Macroinvertebrate results in Lao PDR (2011, 2013, 2015 and 2017)

# Aquatic Ecosystem Health perspectives: **status and trends**



## Site Assessment between 2007 and 2017

| Site code | Location                                    | Year |            |            |            |      |      |
|-----------|---------------------------------------------|------|------------|------------|------------|------|------|
|           |                                             | 2007 | 2008       | 2011       | 2013       | 2015 | 2017 |
| Lao PDR   |                                             |      |            |            |            |      |      |
| LMX       | Mekong River, Ban Xiengkok, Luangnamtha     |      | D Abnormal | D Abnormal | C          | C    | B    |
| LPB       | Mekong River, Done Chor, Luang Prabang      |      | B          | A          | C          | B    | B    |
| LVT       | Mekong River, Ban Huayhome, Vientiane       | B    | C          | C          | D Abnormal | B    | B    |
| LBF       | Se Bang Fai River, Se Bang Fai, Khammouan   | B    | B          | C          | D Abnormal | C    | C    |
| LBH       | Se Bang Hleng River, Songkhone, Savannakhet | A    | C          | B          | D Abnormal | C    | C    |
| LSD       | Sedone River, Ban Hae, Pakse                | B    | B          | B          | D Abnormal | C    | C    |
| LKL       | Se Kong River, Ban Somsanouk, Attapeu       | B    | C          | C          | D Abnormal | C    | C    |
| LDN       | Mekong River, Done Nglew , Champasak        | A    | B          | A          | D Abnormal | B    | B    |

Source: MRC (2019). Report on the 2017 Biomonitoring Survey of the Lower Mekong River and Selected Tributaries. Mekong River Commission, Vientiane, Lao PDR.

# Aquatic Ecosystem Health: **Recommendations from JEM**

- Indicators: littoral inverts, benthic inverts, zooplankton, attached diatoms, phytoplankton
- Add phytoplankton indicator (chlorophyll or counts and identification)
- Increase frequency to annual monitoring
- Minimum of three samples per site
- Sampling locations to determine intensity and extent of the impact of HPPs on the ecological health of the main stream of the lower Mekong River

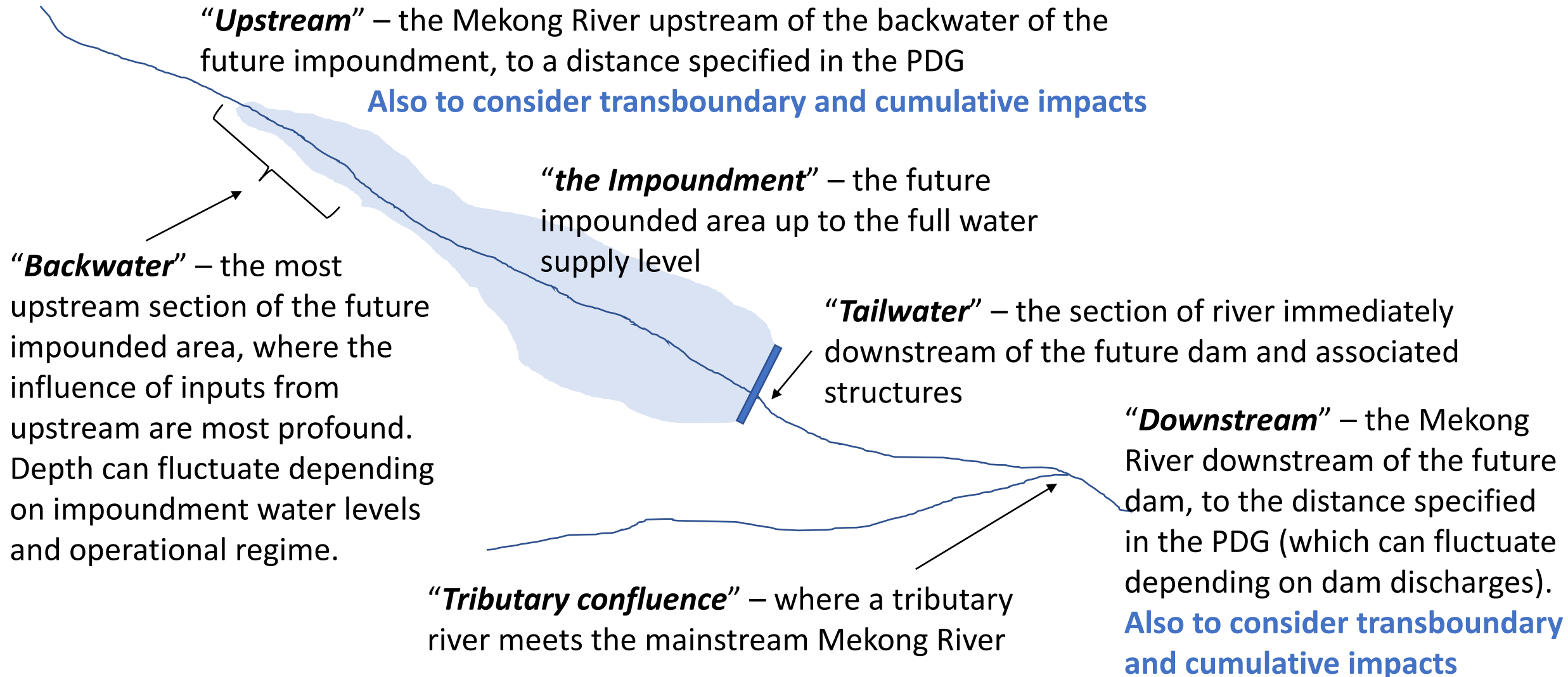


## Section 5.2 : Risks

- Major impacts on aquatic ecological health likely largely due to in habitat both in the impoundment and downstream, including some species and declines in harvesting of other aquatic animals plants and animals, with impacts on food security, nutrition, livelihoods, biodiversity and ecosystem resilience.
- Risks are from:
  - **Changes in habitat topography in the impoundment**
  - **Changes in habitat downstream of the dam**
  - **Changes in downstream flows**
  - **Changes in downstream floodplain functioning**



## Section 5.2: Risks



**Main risks:** Change in habitat and species diversity due to impoundment and flow regulation



# Risks: **downstream of impoundment**

## Downstream of the Impoundment

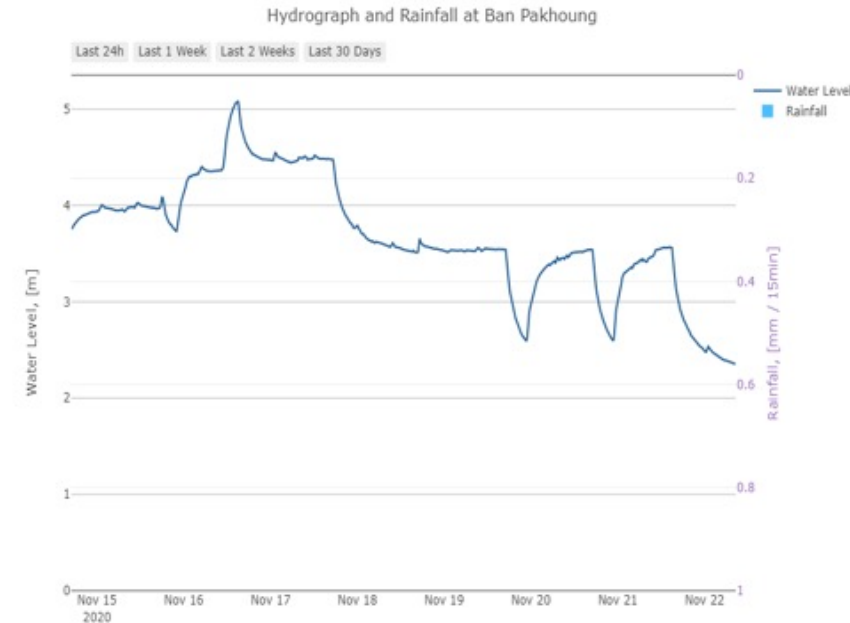
- Barrier to nutrients, carbon and biota (such as prawns)
- Changes to downstream channel morphology
- Reduced nutrient levels and continuous flow changes will likely flush algal growth and **reduce primary production in the area.**
- Benthic community degraded to next tributary
- Altered water temperature – may be warmer or colder
- Poor water quality – may alter habitat or kill biota or trigger loss through drift



# Risks: **downstream flow regime**

## Changes to Discharge and Flow Regime in the river

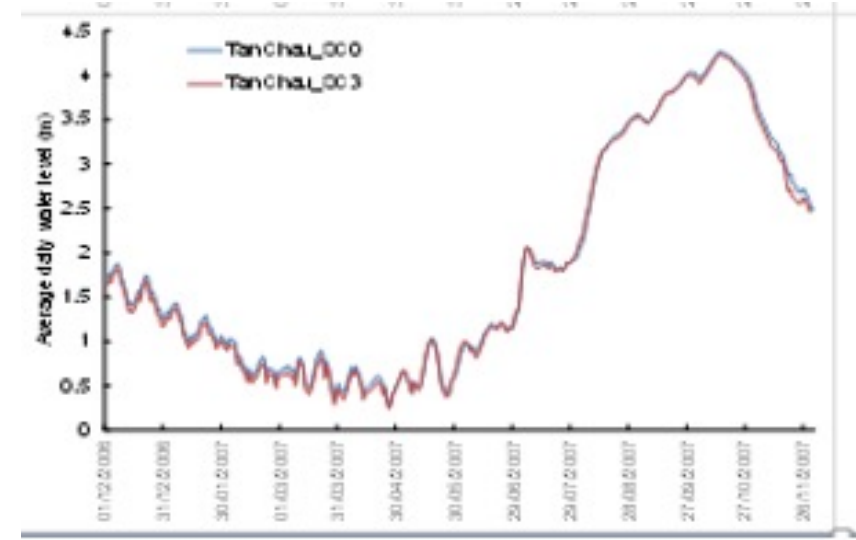
- Increased short-term rapid variation in river levels - **hydropeaking**
- Decreased wet season and increased dry season flows
- Delays to flood and dry season flows
  - unlikely in RoR HPPS
- Rapid fluctuations in discharge will likely **flush plant propagules out of the reach: bankside and instream vegetation on rocky outcrops will eventually be lost**
- **Benthic macroinvertebrates prone to flushing or drifting** in water column if discharge increases rapidly



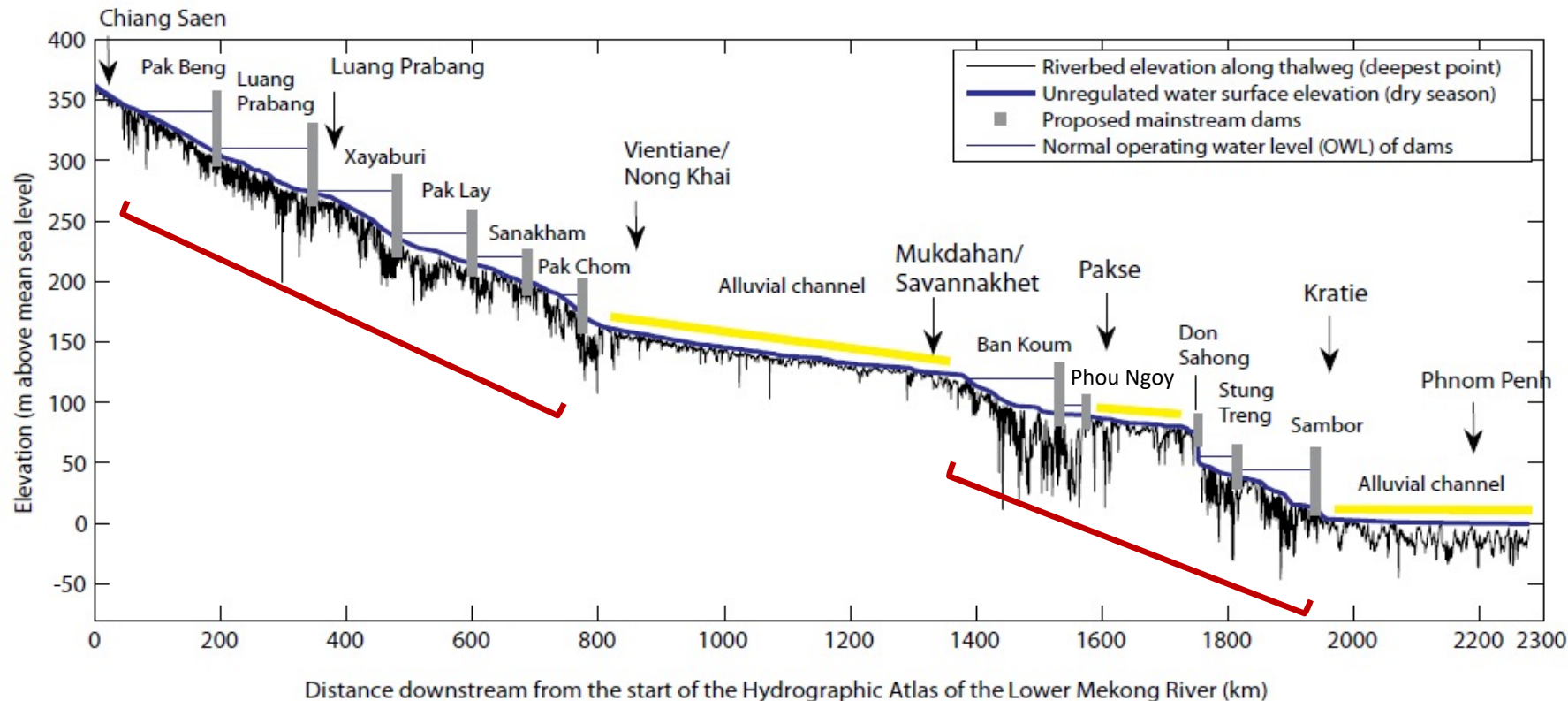
# Risks: **Impact on floodplains**

## Changes to Discharge and Flow Regime on the floodplain

- Reduction in area of riparian flooded
- Reduction in length of time of flooding  
(marginal with RoR HPPs)
- Change in timing of flooding  
(marginal with RoR HPPs)
- Reduction in nutrient load to floodplain
- Disruption of primary and secondary production



# Cumulative impacts



Upper and lower cascades transform river into series of impoundments

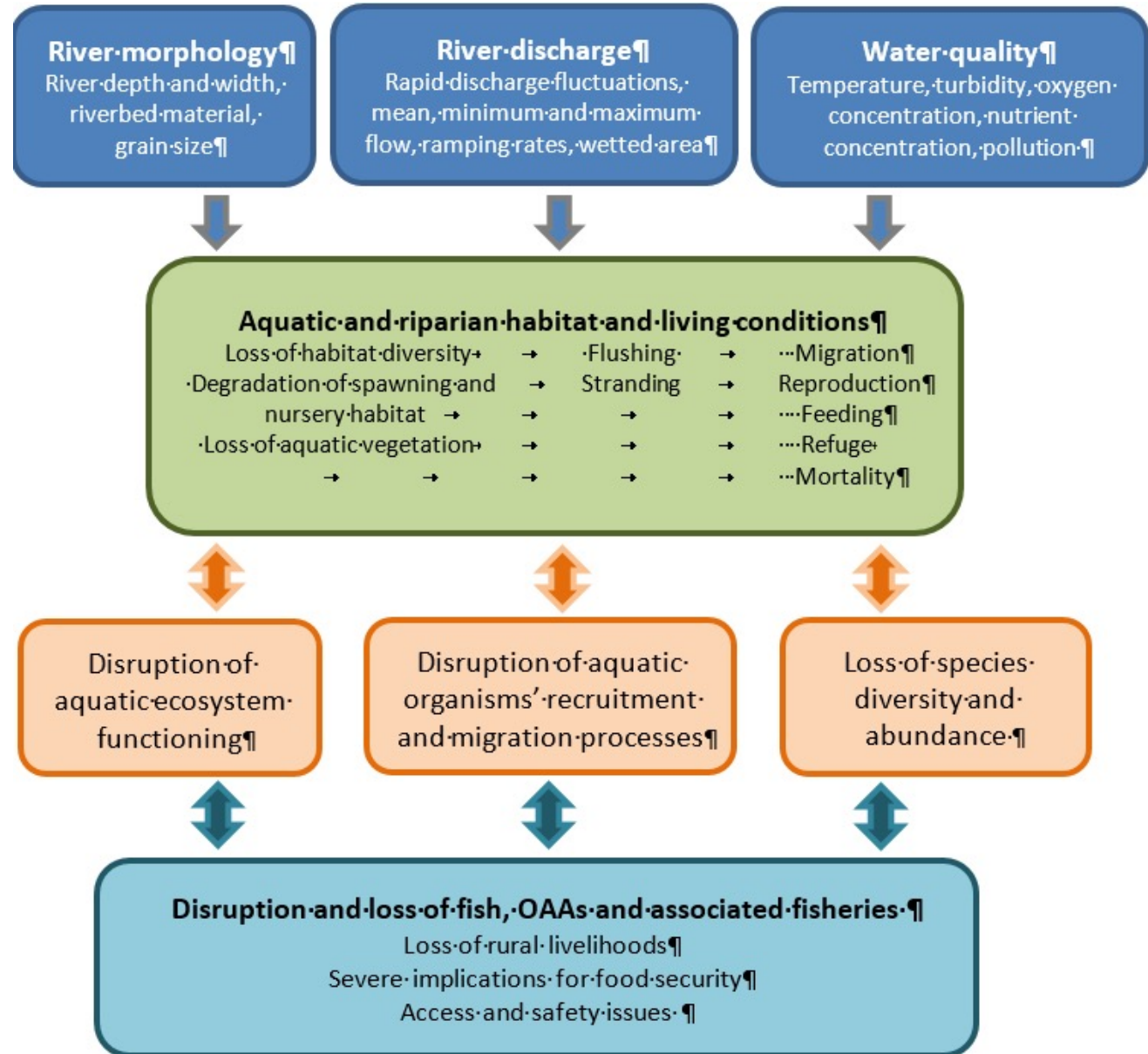
## Cumulative impact of multiple consecutive barriers

- Upper cascade: only 25 km of free-flowing river above headwaters of Xayaburi remain
- Complete drowning out of deep pools
- Loss of critical habitats for riverine benthic macroinvertebrates
- Disruption to drift of aquatic animals

# Transboundary impacts

Potential effects of rapid flow and water level fluctuations and reduction of sediment on aquatic ecosystem functioning and implications for ecosystem services from aquatic biota and fisheries

- Reduction in nutrient delivery and primary productivity
- Disruption of flows and zoobiota breeding cycles
- Collapse in biological productivity leading to loss of fisheries



## Section 5.4 – Specific Design Guidance: **mitigation options**

Mitigation options to address identified risks.

- Array of option to address risks to AEH
- AEH mitigation measures additional to those identified for hydrology, hydraulics, sediment transport, geomorphology and water quality
  - Mitigation measures for other disciplines will also benefit aquatic ecology objectives
- Not all mitigation measures expected to be delivered by the developer
  - Some (e.g. catchment protection) need to be undertaken by National or Provincial Agencies
  - All require a cooperative approach between the project and other institutions.



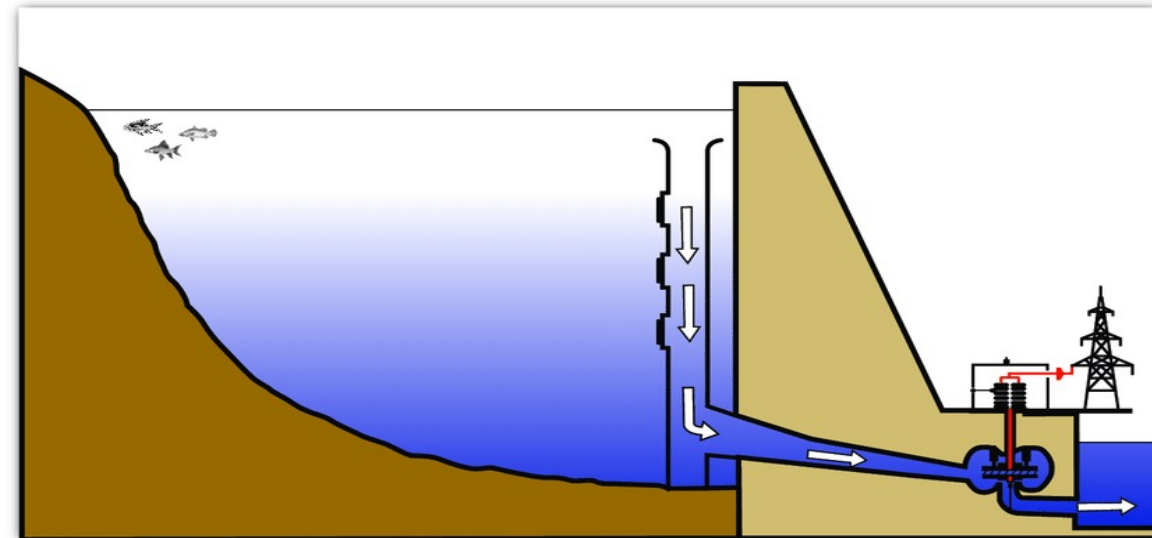
# Mitigation options: **within impoundment**

- **Occurrence of toxic algal blooms**
  - limit nutrient inputs, destratify if necessary
- **Infestations of invasive plants and animals**
  - specific control measures
- **Increases in human parasites and disease**
  - monitoring, provision of sanitation, treatment and education
- **Loss of deep pools**
  - locate impoundments at sites without deep holes



# Mitigation options: **downstream of impoundment**

- **Barrier to movement of sediments and nutrients**
  - impoundment bypass, flushing systems
- **Benthic community degraded**
  - locate dams upstream of tributaries
- **Poor water quality**
  - appropriate operational rules, destratification if necessary
- **Altered water temperature**
  - operational rules, destratification, multi-level offtakes
  - mix epilimnetic and hypolimnetic waters.



# Mitigation options: **downstream of impoundment**

Changes to discharge and flow regime – *river impacts*

- **Increased short-term rapid variation in levels**
  - appropriate ramping rates, a downstream pondage if necessary
- **Increased dry season flow, decreased wet season flow, changes in time of high and low flows**
  - use the environmental flows model to predict consequences and adjust operational rules as necessary



# Mitigation options: **downstream of impoundment**

Changes to discharge and flow regime – *floodplain impacts*

- **Reduction in flooded area or period of flooding, reduction in nutrient load**
  - use environmental flows model to predict consequences and consider :
    - Adjusting operational rules as necessary
    - Constructing floodways
    - Pumping water from the river
    - Building bunds to retain water



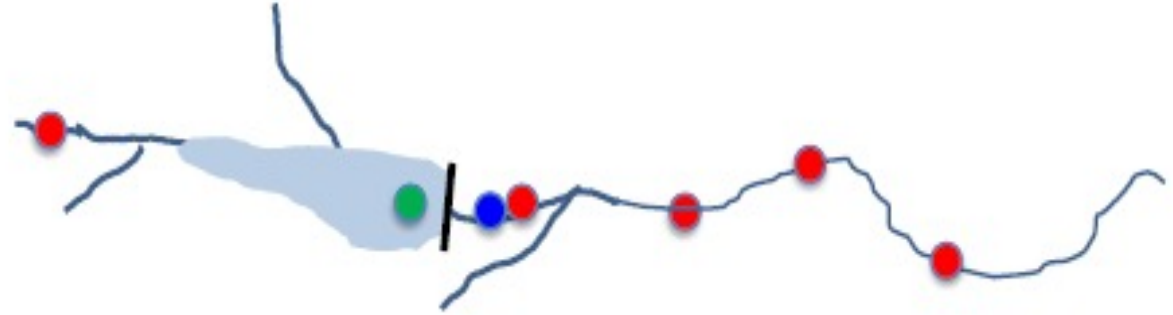
## Section 5.3 – Monitoring

- PDG contains details of **monitoring objectives** and methods for governments/developers
- Monitoring should **provide baseline status** before PNPCA submitted
- **Focus on informing decisions: for design, operations, mitigation and compensation**
- Outputs of monitoring should be **made publicly available**, to ensure transparency
- Monitoring programme should be **funded by the developer** during construction and operational phases

# Monitoring: **site location**

## Data Collection

- Monitoring locations as defined by JEM, up and downstream of impoundment
- Multiple sites upstream and downstream of dam site
- The number of downstream sites necessary depends on the nature of the river downstream (e.g. size and location of tributaries)
- Multiple samples per site, to allow statistical analysis of data



# Monitoring: **parameters**

**Parameters as defined by JEM** but include additional parameters

**Environmental (physical and chemical) indicators:**

- Altitude
- River width
- Depth
- Secchi depth (water transparency)
- Water temperature
- Dissolved oxygen (DO)
- pH
- Electrical conductivity

**Biological indicators:**

- Diatoms
- **Phytoplankton**
- Zooplankton
- **Littoral macroinvertebrates**
- Benthic macroinvertebrates



# Monitoring: **sampling methodologies**

## Methodologies

conducted using the standard methods established by the MRC EHM protocols for each parameter, including **at least three replicates per site per occasion**

## Frequency

- macroinvertebrates and plankton twice per year in dry season
- Algae: weekly chlorophyll measurements, especially in impoundment



# Monitoring: **Impact Analysis**

## Impact Analysis

- Adopt MRC river health indices: Abundance, Average Taxon Richness, and Average Tolerance Score Per Taxon
- Data analysed using BACI designs (upstream and downstream) with ANOVA (for index data) and ANOSIM (for multivariate data)
- Compare data from upstream and downstream for statistical and ecologically important differences
- Compare PNPCA results to MRC river health indices.



# Monitoring: **Roles and responsibilities**

- **Responsibilities of Developers**

- Share information about monitoring design and strategy
  - Locations, parameters, frequency, methods
- Adopt MRC standard methods where applicable
  - Or contract same line-agency
- Share monitoring results relevant to aquatic ecosystem health with Notifying Country and MRC

- **Responsibilities of MRCS**

- Manage and maintain AEH database and management system
- Provide QA/QC of reported data sets
- Organise workshops to analyse, integrate and understand results in context of WQN results
- Prepare reports summarizing findings at local and catchment level

## Lessons learnt from previous PNPAs: **ecological monitoring**

- Intensity, coverage and methods used **do not follow international or JEM standards**
  - Need to provide more robust (using standard methodologies and replication) and timely information on phytoplankton, zooplankton and benthic macroinvertebrates in the **affected region**
- Developers propose **monitoring programmes** for aquatic biota during the construction and operational phases but **details of the methodologies generally lacking and budgets modest at best.**
- Little consideration given of **biodiversity and food security importance of aquatic biota** (both plants and animals)
- Needs **wider consideration of other animal and plant groups**

## Lessons learnt from previous PNPAs: **habitat degradation**

- Potential **loss of habitats** has not been effectively addressed
- No consideration or assessment and identification of the **remaining free flowing river reaches**, particularly downstream of HPPs, for protection of key habitats of important aquatic biota
- No specific provisions to avoid, minimise or mitigate against the loss of critically endangered or endangered species, or to monitor these impacts
- **No comprehensive EFA** is considered regarding the river flows required for **all water uses**, expressed in terms of **sufficient quality, quantity, timing and duration** of river flows

# Thank you

