LUANG PRABANG HPP
Fish Passage

December 2019
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Overview and Requirements
FISH MIGRATION

Requirements and Design Philosophy

• Xayaburi as Basis for the Design
  – Fish Migration System in operation since 2019
  – Reference to Xayaburi system made in PNPCA for Pak Beng and Pak Lay
  – „99% of MRC comments incorporated” in Xayaburi design
  – Adjusted and optimised for Luang Prabang
    – No fish migration through NL required
    – No pumping stations, but 3 auxiliary units
    – No fish ladder: Less fluctuations in tailwater

• Requirements
  – U/S and D/S Migration required
  – NL can be used as additional passage
  – Operation up to 1-yr flood
  – Minimum for attraction:
    – 10% of min flow ($Q_{95}$)
    – 1% of 1-yr flood
  – Max. water velocities:
    – 0.5 m/s in general, 1.2 m/s for < 0.2m
  – Minimum depth:
    – 3.0 m under all flows
  – Fish friendly turbine technology
FISH MIGRATION - OVERVIEW

Auxiliary Powerhouse
- Use of water flow from d/s migration for u/s migration
- Additional water for upstream attraction flow

Right Bank Fish Migration
- Separated from Navigation Lock
- Fish Lock and open channel

U/S Migration
- Multiple Entrances along PH
- 2 fish locks

D/S Migration
- Entrances above power intakes
- Fish-friendly turbines
Fish Migration at Powerhouse
FISH MIGRATION

U/S Migration System at Powerhouse

- **Entrances**
  - 2 x 7 entrances along d/s face of Powerhouse (2x3m each) at different levels
  - 2 openings on right side entrance, at different levels
  - 3 openings on left side entrance different levels
  - Spillway entrance, two openings (for wet season)

- **Attraction Flow**
  - Between 80 m³/s and 225 m³/s

- **Fish Collecting Galleries**
  - Along the entire length of the powerhouse
  - Connects all entrances
  - Leads to the fish locks at the left pier

- **Fish Locks**
  - Two fish locks, 6x6m each
  - Moveable screen floor
  - Fish crowder to «move» fish into the fish lock

- **Fish Monitoring station**
  - Fish monitoring station at the outfall structure towards the reservoir
FISH MIGRATION

D/S Migration System at Powerhouse

- **Entrances**
  - 14 entrances along u/s face of Powerhouse above power intakes
  - Size: 2.5 x 3.0 m

- **Attraction Flow**
  - Between 100 m³/s and 140 m³/s
  - Excess water used for auxiliary turbines

- **Fish Collecting Galleries**
  - Along the entire length of the powerhouse
  - Connects all entrances
  - Leads to the downstream chute at right pier

- **Downstream Chute**
  - Continuous operation of d/s chute
  - Constant flow of 20 m³/s
FISH MIGRATION

Fish Friendly Turbines

- Hydraulic Design
  - Minimized number of runner blades
  - Reduced runner speed
  - Smooth pressure changes
  - Low level of cavitation and turbulences

- Design adjustments
  - Minimized size of gaps between stationary and parts
  - Leading edge thickness (blunt)

- Environmental
  - Water filled hub (no oil leakages)
  - Leads to the downstream chute at right pier

- Fish Survival Calculations
  - Done by supplier acc. to G.F. Franke (1997)
  - CFD based Fish Trajectory Model by Streamlines will be done during basic design

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<th>Average Thickness</th>
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FISH MIGRATION

Attraction Flow – Feeding System

- **Attraction Flow - demand**
  - 80 to 225 m$^3$/s for u/s migration
  - 80 to 120 m$^3$/s for d/s migration
- **Concept**
  - Use of attraction flow for d/s migration for u/s migration
  - Remaining water taken from reservoir
  - Water used for energy generation (auxiliary units)
- **Auxiliary Units**
  - In total 3 units, 60 m$^3$/s each
  - 2 units fed by d/s migration system
  - 1 unit fed from reservoir
  - All water released into Feeding Pond
- **Feeding Pond**
  - Centralized distribution for u/s migration system
  - Collects all water from aux. units
  - Add. Bypass when capacity of aux. Units is reached

- **Intakes from d/s migration**
  - 80 m$^3$/s to 120 m$^3$/s
- **Intakes from reservoir**
  - 60 m$^3$/s for aux. unit #3
- **Bypass**
  - Up to 60 m$^3$/s
- **Feeding Galleries**
  - For u/s migration
FISH MIGRATION

Attraction Flow – Feeding System

Feeding Galleries
- Water from Feeding Pond
- 80 m³/s to 225 m³/s

Entrances
- Above Turbine Draft Tubes
- At different Elevations

Collection Gallery
- Leading towards Fish Locks
Fish Migration at Right Bank
FISH MIGRATION

Fish Migration System at Right Bank

**Fish Lock**
- One fish Lock foreseen
- Operational during entire year

**Open Approach Channel**
- Flow of 5 m³/s
- Also for attraction flow for entrances to fish locks

**Entrances**
- One at Spillway
  When water is spilled (flood season)
- One at Navigation Lock (permanent operation)
Fish Migration at Spillway
FISH MIGRATION

D/S Fish Migration System at Spillway

Spillway
- D/S migration possible through Spillway when in operation
- Usually for wet season
125 Years of Hydropower