

LAO PEOPLE'S DEMOCRATIC REPUBLIC
PAKLAY HYDROPOWER PROJECT

Feasibility Study Report

FINAL

(Chapter 8 - 11)



DEVELOPER:



中国电建集团海外投资有限公司
POWERCHINA RESOURCES LTD.

CEIEC

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Contents

NO.	CHAPTER
1	Executive Summary
2	Hydrology
3	Engineering Geology
4	Project Planning
5	Project Layout and Main Structures
6	M&E Equipment and Hydraulic Steel Structures
7	Construction Organization Design
8	Project Management Plan
9	Environmental and Social Impact Assessment
10	Project Cost Estimation
11	Economic Evaluation

8 Project Management Plan

Contents

8	Project Management Plan	1
8.1	Project Construction Supervision and Quality Assurance	1
8.1.1	Management Organization during Construction Period.....	1
8.1.2	Construction Supervision and Quality Assurance Plan.....	2
8.2	Project Operation Management	21
8.2.1	Operation and Maintenance Management Mode	22
8.2.2	Organizational Structure	22
8.2.3	Personnel Allocation Plan.....	23
8.2.4	Personnel Training Plan	26
8.2.5	Standardized Management.....	27
8.2.6	Management of Spare Parts	27
8.2.7	Main Management Scope and Work Contents.....	27
8.2.8	Project Management and Operation.....	30
8.2.9	Management during Flood Discharge and Storage Period.....	49
8.2.10	Project Management Systems	50
8.2.11	Dam Safety Management.....	52
8.2.12	Updating of Notices related to Dam Safety Management.....	53
8.2.13	Related Cost on Dam Safety Management	54
8.2.14	Negotiation on Dam Safety Management.....	54
8.3	Emergency Preparedness Plan	54
8.3.1	Basic Principles for Formulation of Emergency Preparedness Plan.....	54
8.3.2	Formulation of Emergency Preparedness Plan	55

8 Project Management Plan

8.1 Project Construction Supervision and Quality Assurance

8.1.1 Management Organization during Construction Period

The Paklay Hydropower Project (Paklay HPP), as the 4th cascade hydropower project on the main steam of the Mekong River in Laos, is invested and developed by POWERCHINA RESOURCES LIMITED and CEIEC in a form of BOT. Refer to Fig. 8.1-1 for the management organization during the construction period.

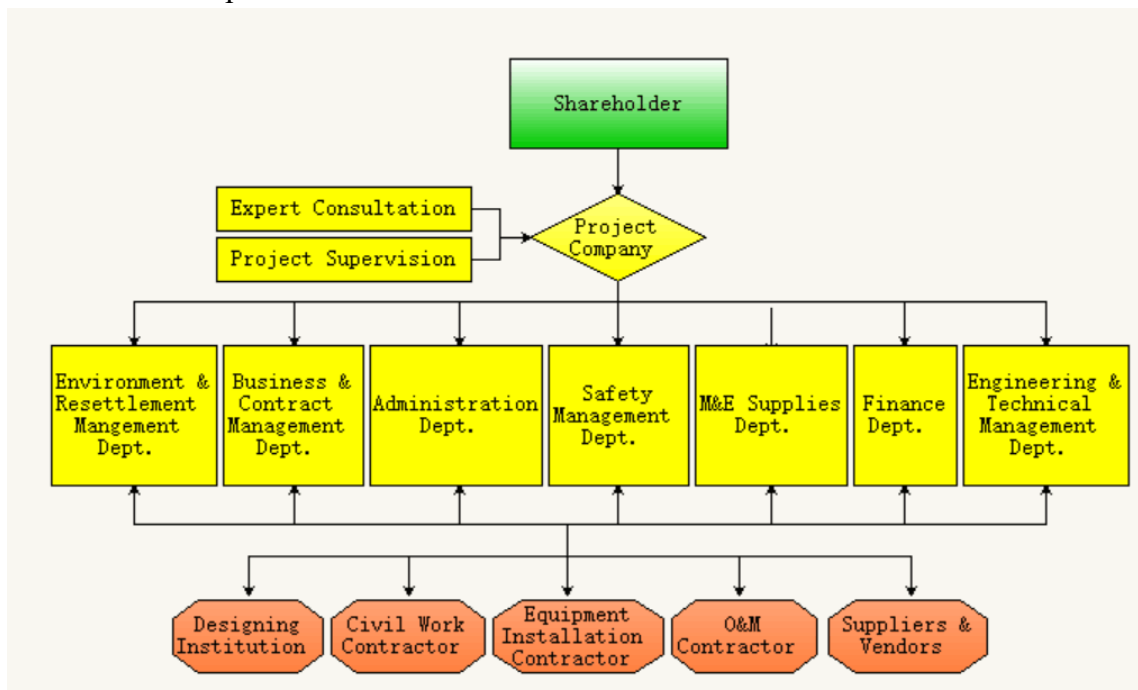


Fig. 8.1-1 Overall Structure of Project Organization Management

The Pak Lay project will be implemented through a project company established in Laos. The project company will engage consultants and supervising company to facilitate the management and implementation of the project. Within the project company, there are 7 functional departments, including Environment & Resettlement Management Department, Business & Contract Management Department, Administration Department, M&E Supplies

Department, Finance Department, Engineering & Technical Management Department etc. The project company will select designer, contractor and vendor through bidding process during different project stage to conduct the designing, construction, E&M equipment installation and O&M.

8.1.2 Construction Supervision and Quality Assurance Plan

The quality of a project is the most important guarantee to achieve the project's use value, reach the project's design productivity, gain economic benefits, achieve the Employer's investment purpose, and ensure the project's safety. Therefore, the quality control of a project is the primary task of "quality, progress, cost and safety control, contract and information management, and organization coordination" during construction supervision, as well as a key factor of project construction objective control. During quality control activities of the Project, the Supervision Engineer will adopt a series of practicable and effective operation technologies and carry out corresponding activities, determine controlled objects, specify control standards, formulate control methods and identify inspection measures according to established principles, to carry out inspection for the quality of all raw materials, construction procedures, technology, semi-finished and finished products in the construction process, and find out the differences of non-conforming items, analyze the causes, develop corresponding countermeasures and implement control, such that project construction products can completely meet the quality requirements as specified in relevant national standards and construction contract documents.

8.1.2.1 Supervision Qualification

All supervision personnel shall have Class A national qualifications for supervision of water conservancy and hydropower projects or Class A qualifications for construction supervision of water conservancy projects, and pass ISO9001 quality system certification.

8.1.2.2 Level of Personnel

Both the quantity and the structure of supervision personnel in the supervision

organization shall be determined based on the principle of ensuring effective project monitoring according to such factors of the Project as scale, contract period, and engineering conditions.

8.1.2.3 Equipment

The supervision organization shall, as agreed in the contract, provide necessary quality detection equipment such as measuring, test and detection equipment. Such equipment shall meet the contract requirements in terms of quantity and quality, pass calibration, and be within the period of validity.

8.1.2.4 Project Quality Control Procedures

a) Project quality control principles

The Supervision Engineer shall strictly follow the following principles during quality control, such that the Project's quality can meet the requirements as specified in relevant national standards and construction contract documents:

(1) Adhering to the principle of "quality first"

The Supervision Engineer shall, throughout the Project, take "quality first" as the basic principle of project quality control and the highest principle of project construction objective control, and shall never sacrifice project quality or reduce basic quality requirements for expediting project progress or saving project cost, to avoid quality defects and even quality accidents.

(2) Adhering to the principle of "people-centered control"

Since people is the creator of project quality, the quality control must adhere to the principle of "people centered" and take people as the impetus of quality control, bring people's initiative and creativity into play during supervision, enhance people's sense of responsibility, make all workers related to the Project's construction establish the idea of "quality first", improve people's quality and avoid people's faults, to guarantee the quality of working procedures and the Project by people's work quality.

(3) Adhering to the principle of "prevention crucial"

Considering the invisibility of project quality and the limitation of final inspection, during quality control, the Supervision Engineer shall put an emphasis on feed forward control and in-process control, and conduct review before commencement seriously and carefully and strict quality inspection for work, working procedures and intermediate products, to ensure project quality by the control of process quality and working procedure quality.

(4) Adhering to the principle of "quality standard"

Quality standard is a measure for project quality evaluation, a basic requirement for project quality and structure safety guarantee, and a basis for progress payment. Therefore, the Supervision Engineer must conduct strict inspection in accordance with relevant national standards and construction contract documents while controlling project quality, to evaluate quality conditions based on inspection data and with reference to relevant quality standards. Either lowering of quality standards which will cause potential safety hazards left, or unprincipled improvement of quality standards which will increase project cost or affect construction duration shall never be permitted.

(5) Adhering to the principle of "scientificity and fairness"

During supervision, control and treatment of quality problems, supervision personnel shall, on the basis of respect for objective fact and science, conduct quality inspection using a scientific and objective inspection method, and quality evaluation based on inspection data, to find out the cause of quality problems through serious and careful analysis, and thereby control various factors affecting quality by taking scientific and pertinent measures.

b) Project quality control procedures

During supervision service of contract works, the Supervision Engineer will conduct whole-process and all-round supervision, inspection and

control for all construction operations of the Project.

(1) Review and signing of design documents

For design documents provided by the design institute, review shall mainly focus on changes of bidding design documents and design documents at construction stage, conventional errors of design documents at construction stage, structural relationship among difference disciplines, and impacts of construction design documents on construction.

For design documents which shall be provided by the Contractor as specified in contract documents, review shall be conducted for the rationality, feasibility and reliability of design scheme, and the impacts of design scheme on project contract payment in accordance with project construction contract documents and relevant project specifications. The supervision organization and the technical supervision engineer shall participate in design disclosure meeting organized by the Employer. In case of any problems or unclear design intention, the site design representative shall conduct design disclosure or give an explanation in time.

If the Contractor requires local modification or optimization of design documents according to site construction conditions and construction progress, a written report shall be submitted to the Employer and the supervision organization for review in advance, and then a notice on design modification shall be issued by the design institute, reviewed by the supervision organization, submitted to the Employer for signing, and finally issued to the Contractor for implementation.

(2) Review of construction documents

Prior to the commencement of each individual works, the Supervision Engineer shall review the commencement application report submitted by the Contractor, and review the construction schedule, arrangement of working procedures, and construction technology of corresponding works, particularly the impacts of construction procedures, technology and scheme

of the works on construction progress, quality and contract payment of the works. The Supervision Engineer shall also conduct inspection for allocation of personnel and mechanical equipment, preparation of materials and site conditions on site, and approve the commencement of conforming works, put forward corresponding improvement measures for non-conforming works, and conduct review once again for the above-mentioned items. The supervision organization shall urge the Contractor to establish and improve a guarantee system related to construction quality, construction safety and environmental protection in construction area, and check implementation measures of such a guarantee system.

(3) Inspection of construction preparation

To ensure smooth project construction, prior to the commencement of each divisional works, the Contractor must report construction preparation to the Supervision Engineer for inspection, and can commence the works only after the construction preparation is qualified.

Inspection for construction preparation made by the construction organization shall mainly focus on disclosure of construction technical measures and design documents; arrangement of main construction equipment and machinery in place; proper implementation of measures related to construction safety, project management and quality assurance; construction materials, finished or semi-finished products passing relevant inspection; completion of labor organization and personnel arrangement; arrangement of water and power supply and other auxiliary production facilities in place; completion of site leveling, and arrangement of transportation roads and temporary facilities in place.

(4) Construction process management

During construction quality control, the mode of "complete and whole-process standardized, programmed and quantitative management

based on item works by taking working procedure control as a link and conducting on-the-spot supervision for major parts" shall be applied.

In the construction process, supervision shall be carried out, such that the Contractor can strengthen internal quality management, and carry out construction in strict accordance with the technology and technical requirements as specified in the relevant national standards and technical specifications. Prior to the commencement of each item works or each major working procedure, a report must be submitted to the supervision organization for confirmation based on qualified three-level self-inspection conducted by the Contractor, and then a construction permit shall be issued. The Supervision Engineer shall conduct whole-process tracking inspection and supervision on construction site, and timely require the Contractor to correct any problems found. After each working procedure is completed and passes self-inspection conducted by the Contractor, the Contractor shall notify the Supervision Engineer of inspection and acceptance on site, and the Supervision Engineer shall conduct inspection and acceptance within the fixed time, and write comments on qualified working procedures for confirmation with a signature.

In case of any activities unsatisfactory to design requirements and violating construction specifications during construction, the supervision organization shall give verbal and written warnings on violation, or even issue instructions of reworking and stand-down for rectification. The Contractor shall conduct inspection once again upon the completion of rectification, until the Supervision Engineer considers activities rectified are acceptable. The construction of next working procedure shall not be commenced until the previous working procedure passes inspection.

(5) Construction quality inspection and acceptance

Construction quality inspection shall be subject to a five-level item inspection and commencement permit system of "unit works, divisional

works, subdivisional works, item works and construction procedures" based on item works, and a dual control system combining the Contractor's three-level inspection with the supervision organization's inspection and confirmation based on item works and major working procedures.

Upon the approval of the Supervision Engineer after all working procedures of one individual works are completed and the last working procedure passes inspection, the Contractor shall submit to the Supervision Engineer a "commencement application report" accompanied with completion data of the individual works. The Supervision Engineer will, after reviewing completion data and considering such data qualified, issue a "handover certificate of individual works" to the Contractor, and the Contractor shall go through the procedures of final settlement of the individual works according to the "handover certificate of individual works".

Each individual works shall be subject to control using the same procedures.

c) Project quality control methods

The Supervision Engineer will control the quality of contract project mainly through the following three methods: review of relevant technical documents, reports or statements submitted by the construction contractor; supervision and inspection for working procedures possibly affecting project quality; test for materials, components and accessories, semi-finished and finished products.

(1) Review of construction technical measures and quality assurance documents

The construction contractor's construction procedures and quality assurance documents are main basis documents for construction operation and control of the construction contractor, so review and approval of these documents are important ways for comprehensive supervision, inspection and control

of project quality. In the construction process of contract project, the Supervision Engineer will:

- Review quality assurance measures submitted by the construction contractor, and supervise the construction contractor to establish a quality assurance system;
- Review subcontractors' qualification certificates and control the quality of subcontracting items;
- Review construction planning, construction procedures and description of construction technology submitted by the construction contractor, to ensure reliable technical guarantee for project construction quality;
- Review commencement application report of unit works submitted by the construction contractor;
- Review quality certificates of raw materials, semi-finished products, components and accessories submitted by the construction contractor, to ensure a reliable material basis for project quality;
- Review or check post qualifications of field operation personnel, and prohibit unqualified personnel from participating in construction operation, to control the quality of working procedures through the control of operators' quality;
- Review statistical data related to the quality of working procedures, semi-finished and finished products submitted by the construction contractor, and summarize and analyze these data using a mathematical statistical method;
- Review technical evaluation documents related to new technologies, new processes and new materials, review application reports on use of these technologies, processes and materials in contract project, and approve the use after reporting to the Employer for approval according to specific conditions, to ensure use quality;
- Review investigation reports, treatment measures and treatment reports

of project quality defects or quality accidents, to ensure satisfactory treatment of quality defects or quality accidents.

(2) Tracking inspection for quality of working procedures

- Prior to the commencement of divisional, subdivisional or item works, check construction preparation on site;
- In the construction process, conduct in-process check on site constantly, and in case of any violations which will affect quality, immediately issue instructions to the construction contractor for rectification;
- Check materials, components and accessories used in each working procedure;
- Check the qualifications of operators engaged in special types of work;
- Conduct whole-process tracking inspection for working procedures which will seriously affect the quality of finished products or fails in final inspection of the quality of finished products;
- Set hold points in the control process of construction procedures and activities, to commence the construction of next working procedure after the Supervision Engineer's inspection and acceptance;
- Check semi-finished products of working procedures and activities;
- After stand-down, conduct inspection before resumption of work according to requirements of preparation or hold points;
- Conduct full inspection for finished products after the completion of item, subdivisional or divisional works.

During tracking inspection for the quality of working procedures, the Supervision Engineer will check the shape, position, status, surface characteristics and quality of semi-finished or finished products through careful visual inspection, touching by hands or loading, knocking by geological hammer or hammerhead, or measuring using measuring tools, and conduct test and detection in case of any doubts or uncertainties.

(3) Test

The Supervision Engineer will test the quality of technological process, raw materials, components and accessories, semi-finished and finished products through field sampling, and comprehensive evaluate quality conditions of these items through data and mathematical statistics.

- Supervise the construction contractor to conduct process test, and evaluate the level of quality assurance in terms of processes;
- Conduct physical and chemical tests or destructive test for raw materials, components and accessories, semi-finished or finished products through sampling;
- Conduct nondestructive testing for all important raw materials, working procedures, semi-finished or finished products.

To ensure the reliability and authenticity of test results, the Supervision Engineer will conduct whole-process tracking inspection for the construction contractor's test technical strength, test equipment or measures, and management system, test conditions and test methods. The Supervision Engineer will also, if necessary, conduct synchronous parallel test.

(4) In-process check and on-the-spot supervision

Through field observation, supervision and inspection of the whole construction process, pay attention to and timely find any potential quality accidents, potential quality hazards, development and changes of adverse factors affecting quality, and any existing quality problems, to control quality in time.

- Conduct patrol supervision for the construction of intermediate processes which are in normal conditions during construction without any quality accidents occurring easily;
- Conduct on-the-spot supervision for major parts or major working procedures of works, and concealed works, and conduct necessary whole-process tracking supervision for the construction process by supervision personnel;

- Supervision personnel shall properly keep inspection and in-process check records and personal diaries.

(5) Payment control measures

If the Contractor's project quality cannot meet required standards, and the Contractor fails to carry out corresponding treatment to meet required standards according to instructions given by the Supervision Engineer, the Supervision Engineer shall be entitled to stop partial or full payment by refusing the issuance of payment certificate. If the Contractor refuses to or fails to timely and effectively treat quality accidents or defects for other reasons, the Supervision Engineer will advise the Employer to entrust other contractor with treatment, and corresponding cost will be deducted from the Contractor's recent payment or quality bond.

d) Construction quality control measures

(1) Supervision and control of construction quality by various measures

- During construction of working procedures having serious impacts on construction quality, working procedures with extremely large difficulties in treatment of quality defects, or working procedures of concealed works, the Supervision Engineer shall timely find unfavorable development and changes affecting quality, potential quality hazards, and any existing quality problems through field observation, supervision and inspection, to immediately develop measures and implement control to nip possible quality defects and quality accidents in the bud;
- Conduct inspection and strict control for construction setting-out through measuring, immediately correct any deviations found; during inspection and acceptance of working procedures, give instructions to the Contractor for correction of any deviations in locations and geometric dimensions, and then sign an acceptance certificate;
- Conduct test for the following items using a test method: performance

and quality of raw materials, mix proportion, and physical and mechanical properties of semi-finished and finished products used in each working procedure, to evaluate and confirm the inherent quality of all materials and finished products of works through specific test data;

- For the Contractor's violations during operation, quality problems found during field inspection, and problems related to working procedures or process control measures, the Supervision Engineer will give instructions to point out problems existing in construction to draw the Contractor's attention to such problems, and urge the Contractor to rectify such problems timely, or put forward requirements or give instructions to the Contractor. For general problems, the Supervision Engineer will give verbal instructions on site to require immediate rectification, and supervise such rectification; for major problems, the Supervision Engineer will give written instructions on site, and such written instructions will be filed as technical documents. For major problems, in case of time urgency, the Supervision Engineer may give verbal instructions to the Contractor, and then give additional written instructions within 24h for confirmation of the verbal instructions.
- It is strictly required that the Contractor shall conduct inspection and acceptance for the quality of working procedures according to specified quality monitoring procedures, to ensure that the quality of each working procedure is under the Supervision Engineer's control.
- If the Contractor's construction quality cannot meet specified standards, and the Contractor is unwilling to undertake responsibility for treatment of quality defects and carry out effective treatment to meet standard requirements according to instructions given by the Supervision Engineer, the Supervision Engineer will stop partial or full payment to the Contractor by refusing the issuance of payment

certificates for non-conforming works or works with quality defects, and any losses caused thereby shall be borne by the Contractor.

(2) Dynamic tracking control for working procedure activities

For major working procedures, the Supervision Engineer will conduct continuous tracking control in the whole working procedure activities, to judge the quality fluctuation of working procedures through quality inspection of working procedures, and find the cause of quality impacts for abnormal working procedure activities and take corresponding measures to eliminate interference factors. In this way, working procedure activities can return to normal conditions, to ensure the quality of working procedure activities and finished products. Tracking control procedures of working procedure activities are as follows:

- Determine a quality control plan of working procedures on the basis of construction measures of individual works, construction technology of subdivisional works, quality assurance measures and quality inspection system approved by the Supervision Engineer;
- Analyze working procedures, to identify priorities and key control points. For major and critical working procedures selected, or working procedures confirmed to always have quality problems according to experience in quality control gained during supervision of other projects, master the conditions and possible problems of these working procedures, determine quality objectives of working procedures, analyze the factors affecting the quality of working procedures, clearly define dominant elements, formulate and verify corresponding countermeasures and plans for the dominant elements, and on this basis, incorporate the verified dominant elements into the working procedure quality table and regard these elements as key control points, and implement management for these critical control points according to relevant standards;

— Conduct whole-process tracking inspection for working procedures during construction, to supervise the Contractor's operation activities, and pay close attention to changes of the Contractor's construction procedures and technology at any time, and timely correct problems (if found) to the Supervision Engineer's satisfaction. If the Contractor fails to take effective measures to solve existing problems, the Supervision Engineer will give a stand-down instruction for solving problems. Upon the completion of each working procedure, conduct strict inspection for handover between working procedures, and commence the construction of next working procedure and cover concealed works only after the Supervision Engineer confirms that the previous working procedure is qualified through inspection. The Supervision Engineer will establish a construction quality tracking file for each working procedure, to completely and fully record quality control activities carried out during construction and by the Supervision Engineer. The record shall include the following contents: documents and drawings regarded as construction basis, the Supervision Engineer's comments on quality control activities, and the Contractor's replies or feedback to such comments, and test reports, quality certificates, and quality inspection, acceptance and certificate issuance sheet, report of non-conforming items, rectification instructions, treatment of non-conforming items. Construction tracking files will be kept as project files, to serve as data and information for evaluation, inquiry and understanding of working procedure quality as well as project maintenance and management.

(3) Pre-control for project quality by setting quality control points

To ensure the quality of working procedures, the Supervision Engineer will determine some key control objects, key parts and weak links as main quality control points, and will also analyze the causes of possible quality

problems in advance, to establish corresponding countermeasures for pre-control. Main quality control points shall be set according to characteristics of each individual works, to focus on main factors affecting the quality of working procedures. During quality control of the Project, the following objects will be selected as main quality control points:

- Key working procedures, links or concealed works in the construction process;
- Weak links during construction, or working procedures, parts or objects with unstable quality, particularly working procedures susceptible to air temperature;
- Working procedures, parts or objects with significant impacts on construction of subsequent works, or quality or safety of subsequent works;
- Parts or links to which new technologies, new processes and new materials are applied;
- Working procedures or links with insufficient construction guarantee, difficult construction conditions or substantially difficult technologies.

For quality control of the Project, the supervision organization will select the following factors as main quality control points: quality and performance of materials, key operation, construction technical parameters, construction procedures, easily occurring or common construction quality problems, application of new processes, new technologies and new materials, working procedures with unstable construction quality or high rejection ratio, and structures and constructions which can easily cause serious impacts on project quality and are under unfavorable geological conditions.

(4) Strict quality inspection of construction process

In the construction process of the Project, the Supervision Engineer will constantly conduct patrol inspection on site to enhance field supervision

and inspection, and conduct whole-process tracking inspection for major working procedures, to ensure that any objects in the construction process are always under the Supervision Engineer's full control, and thereby ensure project quality and avoid project quality defects or accidents. The Supervision Engineer shall conduct strict re-inspection in the construction process:

- Before concealing or covering, each concealed works must be subject to the Supervision Engineer's inspection and acceptance, and can be covered only after it is confirmed as qualified. This is an important measure to avoid potential quality hazards and potential quality accidents;
- Upon the completion of each working procedure, the construction of next working procedure can be commenced only after the Supervision Engineer considers the previous working procedure as qualified through inspection with corresponding signature for confirmation. Such handover inspection of working procedures is carried out for all working procedures one by one without any omission, to fully ensure the quality in the whole construction process;
- Before construction of each subdivisional works, both the quality and the correctness of work which has been done previously and is closely related to the subdivisional works shall be reviewed and pass inspection, and then the Supervision Engineer can make a written confirmation; if the previous subdivisional works is not subject to inspection or fails in review or inspection, the construction of next subdivisional works shall not be commenced;
- During re-inspection, the Contractor shall submit relevant quality data, including quality self-inspection records of working procedures or concealed works; the Supervision Engineer shall conduct review, such as inspection, measuring or test, with reference to the quality data

submitted by the Contractor, make a written confirmation if the quality requirements are met, and give verbal or written instructions to the Contractor for rectification or reworking according to severity of problems if found;

- Upon the completion of each works, the Supervision Engineer shall supervise the Contractor to take proper measures to protect the works completed, and shall also conduct frequent inspection for the quality and effects of finished product protection provided by the Contractor, to avoid affecting the overall project quality due to damage or contamination caused by lack of protection or improper protection of finished products.

(5) Control of construction quality by exercising quality supervision rights

Under the following conditions during project construction, the Supervision Engineer will exercise quality supervision and control rights, to issue stand-down and rectification instructions to control project quality timely:

- For quality abnormalities during construction proposed by the Supervision Engineer, the Contractor's failure to take effective measures for rectification or failure to completely change quality conditions due to ineffective rectification measures;
- Unauthorized covering of concealed works by the Contractor without the Supervision Engineer's inspection, acceptance and confirmation;
- Delay in treatment of quality defects or accidents occurred already as required by the Supervision Engineer, or constant development of quality defects or accidents occurred already, or severe harms of such quality defects or accidents to the safety of construction personnel, equipment or works itself;
- Unauthorized design change or drawing modification for construction without the Supervision Engineer's review and approval;
- Site construction by personnel without receiving technical qualification

examination or personnel without operation qualifications;

- Use of unqualified raw materials, components and accessories or use without inspection and confirmation, or unauthorized use of alternate materials without review and approval;
- Construction by subcontractors without the Supervision Engineer's review and approval.

After the issuance of stand-down instructions under the above-mentioned conditions, the Supervision Engineer shall supervise the Contractor to conduct rectification, and shall conduct tracking inspection for rectification, and verify rectification effects. Upon the completion of rectification to the Supervision Engineer's satisfaction, the Contractor shall, before resumption of work, submit an application of resumption of work to the Supervision Engineer for approval.

(6) Inspection and certificate issuance

- After each working procedure requiring inspection or test is completed and passes self-inspection, or operation requiring inspection or sampling inspection in the operation process is commenced, the Contractor shall apply to the Supervision Engineer for acceptance and certificate issuance. Upon receipt of application for acceptance, the Supervision Engineer shall, within the time as specified in the contract, review data of application for acceptance and conduct re-inspection or sampling test on site.
- If the Supervision Engineer finds any non-conforming quality items during inspection of works, or any non-conformances between the contents shown in the sheet of application for acceptance and actual conditions, the Supervision Engineer shall be entitled to refuse certificate issuance, and can issue a certificate only after non-conforming items or non-conformances are rectified and pass re-inspection;

— The Supervision Engineer shall notify the Contractor of rectifying general quality problems found during inspection of works, and record existing problems in the supervision journal and the sheet of application for acceptance. In case of any non-conforming items found during inspection, the Supervision Engineer may issue a "notice on non-conforming items", to point out the locations of non-conforming items, existing problems, and corresponding rectification requirements. The Contractor shall apply to the Supervision Engineer for acceptance once again after rectification.

e) Quality control process

Refer to Fig. 8.1-2 for quality control process.

Quality Control Process

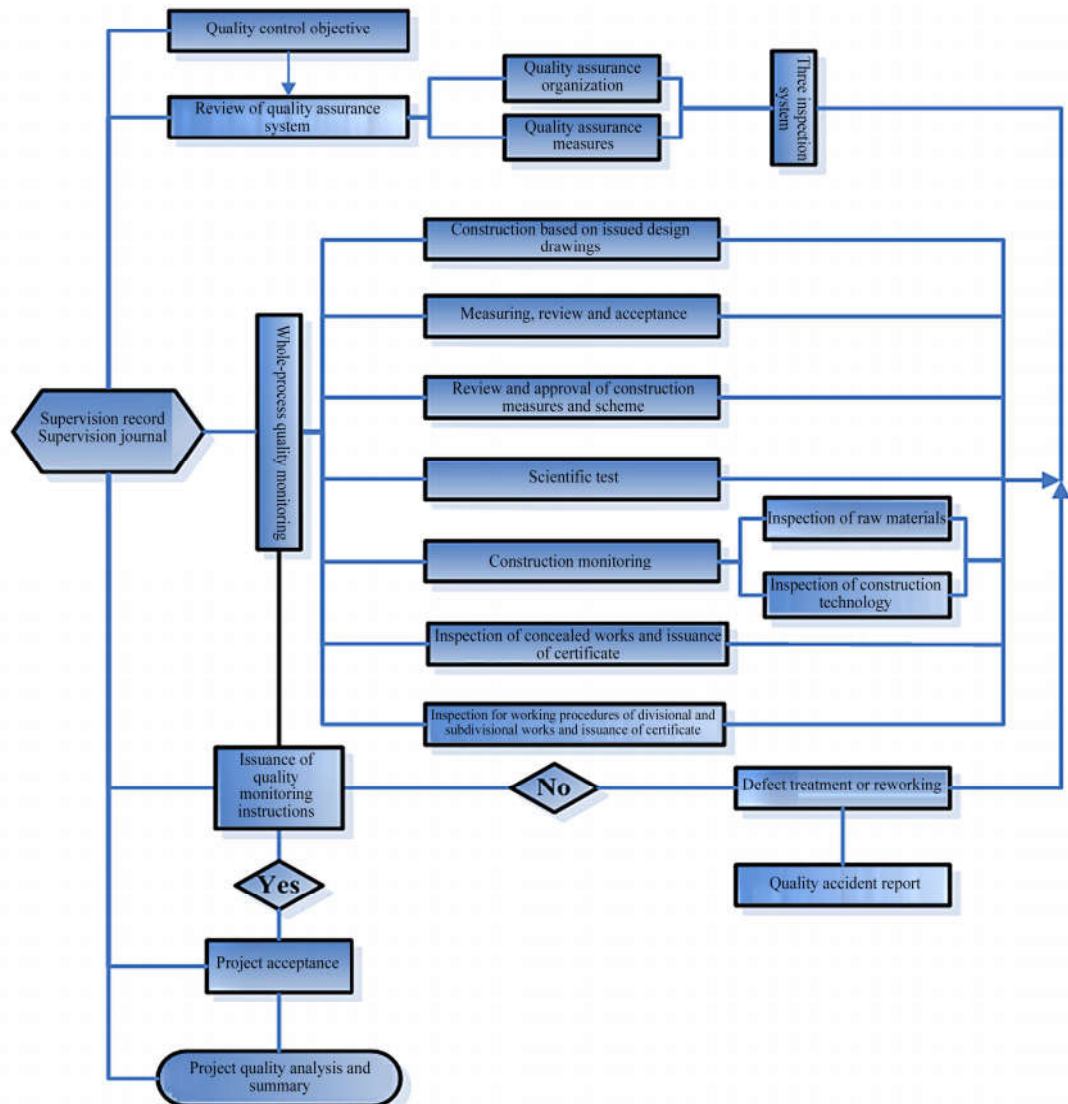


Fig. 8.1-2 Quality Control Process Chart

8.2 Project Operation Management

POWERCHINA RESOURCES LIMITED and CEIEC will establish and improve standard systems, and establish a specialized operation and maintenance management team according to hydropower industry standards of Laos, with reference to relevant Chinese and international hydropower industry standards, and in combination with the characteristics of the Paklay HPP, to conduct operation and maintenance for the HPP based on a management mode

of "attended operation with a few personnel at initial stage and unattended operation for a long term", and thereby achieve standardized operation and maintenance management, and ensure safe and stable operation of the HPP.

8.2.1 Operation and Maintenance Management Mode

The scope of operation and maintenance management shall cover: the HPP's reservoir and dam systems, powerhouse system, navigation lock system, and fish way and other all hydraulic structures completed, hydraulic generator units, regulating and control equipment, power transformation and distribution system, auxiliary equipment, and other all operation equipment of the HPP.

The Company will establish an independent operation and maintenance management team based on technologies and personnel of POWERCHINA RESOURCES LIMITED and CEIEC, or entrust specialized teams having experience in operation and maintenance management with operation and maintenance management. Operation personnel shall be responsible for operation and daily maintenance of the HPP. Before operation of the Paklay HPP, personnel engaged in operation and maintenance shall receive two-year specialized training, and can participate in operation and maintenance only after passing examination. During operation and maintenance of the HPP, operation and maintenance personnel shall regularly receive examination and training, to ensure that their technical skills are always under good conditions.

8.2.2 Organizational Structure

In view of organization of the Paklay HPP, eight major departments and one expert team will be established according to conventional and peak work quantities and full-load work method, and in combination with emergency requirements of the HPP:

- (1) Work Safety Department: an operation team and a maintenance team are established and subordinated to the Work Safety Department. The operation team shall be mainly responsible for operation, technology, equipment and safety management of the HPP; the maintenance team shall be mainly

- responsible for equipment maintenance of the HPP;
- (2) Engineering Technical Department: responsible for management of hydraulic structures and facilities, reservoir management, and hydrologic data collection and transmission;
 - (3) Planning and Contract Department: responsible for the HPP's operation, contract, and planning and statistics management;
 - (4) Resettlement & Environmental Protection Department: responsible for resettlement and environmental protection;
 - (5) Finance Department: responsible for financial management of the HPP;
 - (6) General Manager Service Department: responsible for management of administrative affairs of the HPP;
 - (7) Human Resources Department: responsible for personnel and wage, performance assessment and training management of the HPP;
 - (8) Equipment Supply Department: responsible for purchasing and management of equipment and materials of the HPP;
 - (9) Expert team: responsible for consultation of major issues during operation and maintenance of the HPP.

8.2.3 Personnel Allocation Plan

The staffing of the Paklay HPP shall conform to the *Notice on Issuing Standard of Staffing for Power Supply (trial) and Standard of Staffing for Hydropower Stations (trial) (GDRZ [2000] No. 499) issued by the Department of Human Resources of SGCC*. The staffing shall only cover stationary staff and contract staff, excluding temporary workers and employees not covered by the plan.

For the HPP, based on the principle of "unattended operation (or operation with a few personnel)", the personnel quota is 242 in total, including 187 production personnel, 50 management personnel, and 5 others. Refer to Table 8.2.3-1 for details.

Table 8.2.3-1 Staffing of the HPP

S/N	Item	Number of People	Scope of Work
1	Production personnel	187	
1.1	Personnel quota for unit operation	96	
1.1.1	Remote monitoring	17	Guard, patrol inspection, and accident treatment of main and auxiliary equipment (including firefighting and ventilation equipment in the powerhouse) of turbines and generators.
1.1.2	Centralized monitoring	20	Monitoring, patrol inspection, metering record, accident treatment of main and auxiliary equipment (including firefighting and ventilation equipment in the powerhouse) of turbines and generators.
1.1.3	Conventional monitoring	50	Monitoring, patrol inspection, metering record, accident treatment of main and auxiliary equipment (including firefighting and ventilation equipment in the powerhouse) of turbines and generators.
1.1.4	Backup person	9	
1.2	Personnel quota for unit maintenance	39	
1.2.1	Mechanical maintenance	17	Daily, temporary and emergency maintenance of turbines and generators (excluding electrical parts), and their accessory equipment, oil, water and air systems and auxiliary equipment, and hoisting equipment in the powerhouse; technical supervision management; maintenance planning, budgeting, quality inspection and acceptance, etc.
1.2.2	Electrical maintenance	22	Daily, temporary and emergency maintenance of generators (electrical parts) and their accessory equipment, power transformation

			and distribution equipment, and other electrical equipment and industrial televisions; point inspection and commissioning of computer monitoring system; maintenance of instruments and meters, automatic devices, and relay protection devices; HV test and laboratory test; technical supervision management; maintenance planning, budgeting, quality inspection and acceptance.
1.3	Personnel quota for hydraulic structures	27	
1.3.1	Operation and maintenance of M&E equipment of hydraulic structures	5	Monitoring, patrol inspection and daily maintenance of M&E equipment of hydraulic structures; temporary and emergency maintenance, and clearing of intake; maintenance planning, budgeting, quality inspection and acceptance, etc.
1.3.2	Hydraulic observation	14	External and internal observation of hydraulic structures, and observation of triangulation network and leveling network in dam site area; reservoir survey, observation of upstream and downstream riverbeds, sediment measuring, observation of hydraulic characteristics, earthquake observation and management, and collation and analysis of observation data.
1.3.3	Water related affairs	8	Patrol inspection and maintenance of hydrological telemetry and forecast system, hydrologic forecasting and reservoir operation, watching for flood prevention and reporting, meteorological observation, environmental protection monitoring, and collection and collation of information.
1.4	Other personnel quota	25	
1.4.1	Communication	5	Management for operation and maintenance of various communication lines and equipment, and relevant technical data.

1.4.2	Warehouse	8	Acceptance, registration, keeping, maintenance and distribution of warehoused materials.
1.4.3	Vehicle	12	Dispatching, driving and safety management of vehicles for production and management.
2	Management personnel	50	Production, operation and service management.
3	Others	5	
4	Total personnel quota of the HPP	242	

The HPP will be subject to the operation management mode of 4 (or 6) shifts with 3 shifts a day. In other words, 4 (or 6) operation teams will be established for the HPP, and each team has a foreman and several specialized management personnel to participate in operation of the HPP, and these teams will take turns once every 8 hours.

8.2.4 Personnel Training Plan

To ensure safe and stable operation of the Paklay HPP, the Company will adopt a scientific personnel management mode for the HPP, to conduct intensive training for operation and maintenance personnel by two stages. All operation and maintenance personnel can participate in work only after passing skill examination.

Personnel training at the first stage: Personnel engaged in operation and maintenance will be sent to a specialized Chinese hydroelectric occupational college or an institute with experience in operation training, to receive training related to professional management of hydropower projects, and thereby establish a human resources basis. The duration at this stage is 6-12 months.

Mentoring by special persons at the second stage: Personnel engaged in operation and maintenance will be sent to hydropower stations which have been put into operation and have similar unit types to the Paklay HPP, such that these personnel can be familiar with field equipment locations and equipment

characteristics, as well as various parameters and functions under the guidance of special persons from the hydropower stations which have been put into operation. The duration at this stage is 1 year.

8.2.5 Standardized Management

Prior to the operation of the HPP, to ensure operation safety of equipment, personnel participate in operation and maintenance will formulate and strictly implement corresponding working, management and technical standards in accordance with relevant Laos' and international industrial laws, regulations, technical standards, codes and specifications related to electric power production, and in combination with specific conditions of the Paklay HPP.

8.2.6 Management of Spare Parts

Considering transportation inconvenience, and long purchasing and transportation period of spare parts of the Paklay HPP, to ensure safe operation of the HPP, the Company will increase the reserve of spare parts, increase management functions according to a scientific management method, establish a recording system, and conduct statistics and analysis using computer technology, to ensure the completeness, accuracy and timeliness of equipment management record, and to provide guidance and make decisions for equipment operation and maintenance. Meanwhile, spare parts will be subject to dynamic management, and supplemented regularly, to ensure the adequacy of spare parts.

8.2.7 Main Management Scope and Work Contents

8.2.7.1 Scope of Management and Protection Areas of the Project

The management area generally refers to the site of structures or relevant facilities and its proper expansion. Land within this area has already been requisitioned by the HPP which is entitled to management and use of the land. The protection area of the Project refers to the area formed through further expansion beyond the management area, to ensure normal and safe operation of the HPP. Land within the projection area is owned by the Government of Laos.

Some unfavorable production activities within the protection area will be restricted, as they may endanger normal operation of the HPP or cause adverse impacts.

a) Extent of management area

Project management is intended to ensure safety and reliability of structures and normal operation of reservoir, and improve economic benefits. The range of management area mainly covers: dam, powerhouse, navigation lock, fish way, flood discharge and energy dissipation area, switchyard, mixing system, aggregate storage area on the left bank, processing yard, construction camps, power supply and communication lines, and the Employer's camp.

- 1) About 9 km long along the river flow direction, including 2 km extending upstream and 7 km extending downstream from the dam site;
- 2) In the direction vertical to the river flow direction, a range of 500 m extending outwards by taking both ends of the following land requisitioned for construction as boundaries: camps on left and right banks, processing yard, warehouse, oil depot, parking lot, roads in powerhouse and dam site areas on left and right banks, concrete mixing systems on left and right banks, upstream and downstream spoil areas;
- 3) At sections without structures, a range of about 500 m extending outwards based on the maximum water level line on the bank.

The above-mentioned management area is basically within the range of land requisition for construction, and can be directly handed over to the HPP for use upon the completion of the Project. In case of inadequacy, additional land requisition is required, or extra land requisitioned is transferred to compensate new land requisitioned.

Within the management area of the Project, production activities conducted by any organizations shall be reported to the project management organization and the local government for approval, to avoid polluting water sources, causing

damage to the project and affecting the project.

b) Extent of protection area

- 1) On left and right banks, the range beyond the management area, extending to the top of slope or the exterior boundary line of terrace;
- 2) The range of about 2 km beyond the maximum water level lines on both banks in the reservoir area.

8.2.7.2 Engineering Protection Measures

Engineering protection measures shall vary with different parts and different facilities. To be specific, the level of protection can be divided based on the extent of hazard to the normal operation of the entire project. Generally, there are three levels of protection: primary protection, secondary protection and general protection, and corresponding safety monitoring, alarming system and preventive measures are set based on different levels of protection, to minimize potential safety hazard, and thereby ensure normal operation of the HPP, protect the Employer's benefits and accelerate local economic development.

8.2.7.3 Main Work Contents

- (1) Implement relevant policies of Laos, and instructions issued by POWERCHINA RESOURCES LIMITED and CEIEC;
- (2) Know well data related to planning, design, construction, management and operation of the Project, and operation conditions of downstream river channel and reservoir;
- (3) Conduct observation, inspection, maintenance and repair; keep abreast of information related to the Project, and eliminate project defects;
- (4) Properly conduct hydrologic forecasting, to keep abreast of hydrologic and rainfall data; properly conduct regulation and operation, and flood control of the Project;
- (5) Properly conduct water quality monitoring, and greening in the reservoir area;
- (6) Properly conduct protection of the Project;

- (7) Improve files of the Project, and record major operation events;
- (8) Formulate and revise project management measures and relevant regulations, and faithfully implement these measures and regulations.

8.2.8 Project Management and Operation

8.2.8.1 Project Operation Mode

The Paklay HPP is of a low-head run-of-river type. To reduce reservoir inundation impacts and facilitate sediment flushing of reservoir, natural water flow conditions shall be restored as far as possible in flood season, and the reservoir level shall be as close to the natural water level as possible. Based on this principle, considering inflow characteristics of the Paklay HPP, the following reservoir operation mode is proposed at this stage.

a) For power generation

When the forecasted inflow is less than the discharge (i.e. 6,100 m³/s) at full load of unit, the HPP will operate under a normal power generation mode. Meanwhile, necessary daily regulation is required according to daily electrical load change, and the reservoir level may vary between the minimum pool level (i.e. 239 m) and the normal pool level (i.e. 240 m).

If the HPP directly supplies power to Thailand according to method I as specified in 4.2.2, according to EGAT's power purchase policies, the reservoir shall operate to maximize the annual energy value (i.e. equivalent energy). On condition that the minimum discharge flow requirement is met, the highest priority shall be given to the power energy, followed by the secondary energy and then the excess energy. The reservoir of the Paklay HPP is of a typical low-head river channel type. Due to restrictions of reservoir storage, the mode of run-of-river power generation is adopted at a large discharge in flood season, and the reservoir level is maintained at the normal pool level, to obtain a higher head for power generation, reduce disabled capacity and increase power generation benefits. At a small discharge in dry season, limited regulating storage can be utilized for daily

discharge regulation and storage, and during the periods of excess energy and secondary energy, priority is given to water storage, and the stored water is used for power generation during the period of power energy, to increase equivalent energy and power generation benefits of the HPP.

If the method II as specified in 4.2.2 is adopted by the HPP, the HPP will sell power to EDL and EDL will then sell power to EGAT. As EDL purchases power at a single price, the reservoir shall operate to maximize the annual energy output and be maintained at the normal pool level as far as possible, without daily regulation. Meanwhile, the mode of run-of-river power generation shall be adopted.

b) For flood control

In flood season, if the forecasted inflow is larger than the discharge (i.e. 6,100 m³/s) at full load of unit and less than 16,700 m³/s, the outflow is equal to inflow for discharge control, units will operate for power generation at a discharge under the full load, extra flow will be discharged by opening flood discharge facilities, and the reservoir will operate at the normal pool level (i.e. 240 m). If the inflow is larger than 16,700 m³/s and will continuously increase according to forecasting, flood discharge facilities will be fully opened gradually and orderly, the project will be opened for discharge according to discharge capacity, the reservoir level will drop naturally, and the HPP will stop operation. At flood recession limb, if the inflow is less than 16,700 m³/s and will continuously decrease according to forecasting, flood discharge facilities will be closed gradually until the reservoir level returns to the normal pool level (i.e. 240 m), and the HPP will resume power generation.

In flood season, if the inflow is larger than 16,700 m³/s and will continuously increase according to forecasting, flood discharge facilities will be fully opened gradually for emptying the reservoir, to gradually reduce the reservoir level from 240 m. In this process, the opening speed

and the opening of flood gate shall be reasonably adjusted according to flood forecasting, to control the change speed of discharge flow of project. Similarly, at flood recession limb, if the inflow is less than $16,700 \text{ m}^3/\text{s}$ and will continuously decrease according to forecasting, flood discharge facilities will be closed gradually, to gradually restore the reservoir level to the normal pool level (i.e. 240 m). In this process, the change speed of discharge flow of project shall be controlled.

The control principles of discharge flow in the process of reservoir emptying and impoundment in flood season are as follows:

- 1) Ensure that the reservoir level varies at a relatively slow speed, to avoid affecting the stability of reservoir banks;
- 2) Ensure that the variation amplitude of downstream water level caused by unsteady flow is not relatively small, to avoid affecting the stability of downstream embankment, navigation and other water;
- 3) Avoid inundation of downstream banks due to increase of discharge flow, particularly avoid affecting the Paklay District.

At this stage, according to the above-mentioned control principles, considering reservoir and inflow characteristics of the Paklay HPP, it is preliminarily proposed that the discharge flow will be controlled at a flow rate larger than the inflow by $1,600 \text{ m}^3/\text{s}$ during reservoir emptying, until gates are fully opened for discharging; during reservoir impoundment, the discharge flow will be controlled at a flow rate smaller than the inflow by $1,600 \text{ m}^3/\text{s}$, until the reservoir level returns to the normal pool level (i.e. 240 m). According to flood regulation calculation for design floods at all frequencies, we can know that through control of discharge flow in this way, the maximum daily variation amplitude of reservoir level can be controlled within 3 m/d and that of downstream water level can be controlled within 2.2 m/d.

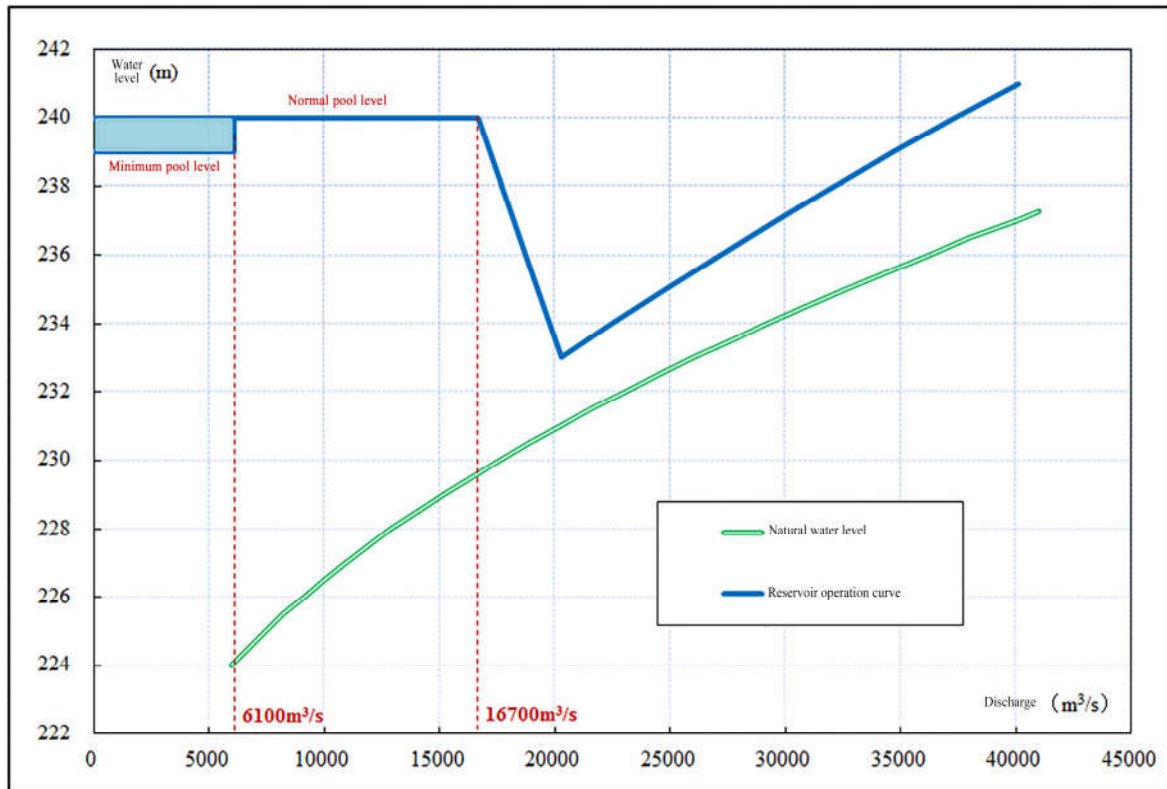


Fig. 8.2-1 Schematic Diagram of Reservoir Operation Mode

c) For sediment control and management

Upon the completion of the Paklay HPP, along with the rise of reservoir level, the flow conditions of river channel will change, affecting river sediment transport to a certain extent. To reduce the impacts of reservoir construction on river sediment transport and river form, the following reservoir sediment regulation mode and management measures are proposed at this stage according to water and sediment inflow conditions of the Paklay reservoir.

- 1) In flood season, if the inflow is larger than 16,700 m³/s and will continuously increase according to forecasting, flood discharge facilities will be fully opened gradually and orderly, the project will be opened for discharge according to discharge capacity, and the reservoir level will drop naturally to the water level close to the river water level under natural conditions, to facilitate sediment flushing of the reservoir.
- 2) In case of relatively high sediment concentration and sediment load found during monitoring, even if the inflow is less than 16,700 m³/s in flood

season, sediment flushing may be achieved by opening flood gates and reducing reservoir level.

- 3) To discharge coarse-grained bed materials deposited in the reservoir more effectively, it is recommended that the reservoir level be reduced to the minimum water level for sediment flushing at intervals of 2 ~ 5 years. The specific sediment flushing frequency may be determined according to hydrologic and sediment monitoring results. Sediment flushing should be carried out concurrently with upstream and downstream cascade hydropower projects.
- 4) The bottom sediment flushing orifices shall, as required, be opened and closed for test purpose, to avoid endangering structure stability due to direct sedimentation behind the gates, avoid possible equipment corrosion and aging due to long-time shutdown, and ensure that the gates at the bottom sediment flushing orifices can be opened in case of emergencies.
- 5) Considering poor sediment flushing effects of the above-mentioned sediment flushing modes in some zones of the reservoir, sediment in these zones may be removed by grit chamber, mechanical desilting and other modes.
- 6) According to water and sediment inflow characteristics, and operation characteristics of the Paklay reservoir, a hydrologic and sediment observation and monitoring plan of the reservoir shall be formulated, and corresponding sediment observation and monitoring shall be carried out, including: water and sediment inflow measuring, fixed section observation in the reservoir area, observation of section downstream of the dam, water level observation in the reservoir area, sedimentation sampling in the reservoir area, and gradation and test.
- 7) Hydrologic and sediment observation and monitoring data of the reservoir shall be collated regularly, and analyzed according to reservoir operation characteristics, to optimize and adjust the sediment regulation mode of

reservoir according to analysis results.

- 8) During sediment flushing, the sediment concentration of discharge flow shall be monitored and controlled, to avoid adverse impacts on downstream ecological environment. According to reservoir operation conditions, evaluation shall be conducted for downstream ecological conditions, to propose a maximum allowable sediment concentration at the lower reaches to serve as a control index for ecological regulation of sediment.

8.2.8.2 Structure Management

- a) Flood discharge and water retaining structures

The flood discharge structure of the Paklay HPP is arranged on the bottomland on the right side of the powerhouse section, consisting of 11 crest orifices, 3 deep crest orifices, and 2 bottom sediment flushing orifices. To ensure operation safety during flood discharge and energy dissipation, comprehensive and strict inspection shall be carried out for flood discharge and energy dissipation facilities (gates and their hoisting equipment, and flood discharge orifices) before flood season, such that these facilities are in good conditions for use. In addition, operation in flood season shall also be in strict accordance with flood discharge regulation codes, and corresponding management principles are preliminarily proposed below:

- 1) Correctly handle the relationships between power generation and flood discharge, and between power generation and joint operation of adjacent cascade hydropower projects; make a correct arrangement for operation and maintenance, and formulate correct desilting plan of downstream river channel and other work plans, to ensure safe operation of the Project and fully create benefits of the Projects.
- 2) The Paklay HPP, and four cascade hydropower projects (PakBeng, LuangPrabang, Sayaburi, Sanakham) upstream of the Paklay HPP are of a water flush type, and their reservoirs are incapable of regulation, with a relatively small reservoir storage. The flood gates of the Paklay

HPP shall be opened orderly and reasonably according to reservoir inflow of the Paklay HPP obtained based on the hydrologic data provided by the hydrological telemetry and forecast system, and by paying close attention to the operation conditions of flood discharge structures of the Pak Beng HPP.

- 3) Since the state of flow in basin is a key factor affecting the safety of flood discharge and energy dissipation structures, the flow shall basically be symmetrical and stable, and the flowing water pressure shall be distributed uniformly as far as possible. For this purpose, flood gates shall be opened symmetrically and closed uniformly as required.
- 4) River channels on both banks shall be subject to strict monitoring and management, to ensure that the river channels are always in stable and safe conditions. Dangerous rocks and unstable blocks along river channels on both banks shall be removed timely, to avoid falling into the basin. After each flood discharge, the water pool shall be subject to diving inspection, and cleared. Careful inspection shall be conducted for the bottom plate of water pool, and in case of any severe wear and damage, measures shall be taken in time to repair the bottom plate.
- 5) After flood discharge, the river channel within the range of influence of flood discharge shall be subject to inspection and maintenance.
- 6) Gate operation management
 - ① Regular inspection and maintenance shall be conducted for all gates and their hoisting equipment, to ensure that the gates are in good operation conditions.
 - ② During initial operation of radial main gate, attention shall be paid to vibration at different openings of the gate, and the regulation scheme shall be formulated to avoid long-time water release under the conditions of small opening and large vibration.
 - ③ During gate operation, one person shall be responsible for operation

and one for monitoring. In case of any faulty operation, the monitoring personnel shall immediately order to stop operation for rectification.

- ④ During gate opening and closing, attention shall be frequently paid to normal operation of electrical parts. For example, single element and equipment in an electrical circuit shall run normally.
- ⑤ During gate opening and closing, attention shall be frequently paid to operation conditions of rotating parts, for example, whether motor, reduction gear box, bearing and electromagnetic brake are heated, there are abnormal sound during gear engagement, and the reduction gear box suffers from oil leakage. In case of any abnormalities, immediate shutdown for inspection shall be required, to eliminate abnormalities.
- ⑥ During gate opening and closing, monitoring shall particularly be carried out when the gates are lifted up and down to extreme positions, to check whether machines stop operation immediately; otherwise, power supply shall be cut off immediately, to check circuits and limit switches of controllers.
- ⑦ A special person shall be assigned to command the operation of gantry crane at dam crest, and overloading of hoists shall be prohibited during operation of gantry crane and other hoisting equipment. If gates are stuck, power supply shall be cut off immediately for shutdown and inspection.

b) Powerhouse

- 1) During power generation of the HPP, the maximum head is 20.0 m, the rated head is 14.5 m and the minimum head is 7.5 m. Without approval of the superior authority, units shall not operate with values exceeding those on the nameplates.
- 2) A check flood standard of 0.01% and a design flood standard of 0.05% shall be applied to the powerhouse of the HPP, the same as the flood control standards of dam. If the peak discharge is larger than 16,700

m³/s, all flood gates shall be opened for flood discharge, and the HPP shall stop operation.

- 3) Two gates, a trash rack and a bulkhead gate shall be set at the intake of the HPP; a tailrace emergency gate shall be set at the outlet. One emergency gate and one main gate shall be set at the inlet of sediment flushing orifice, with one bulkhead gate at the outlet.
- 4) Deposits in front of the trash rack at the intake shall be removed in time, to minimize head loss at the intake. Relatively large floats shall be intercepted as far as possible to avoid entering the head canal and causing overloading of the trash rack.
- 5) Maintenance and trial operation shall be carried out for the sediment flushing orifice at the lower part of the intake of the HPP before each flood season; the gate at the sediment flushing orifice shall be opened in flood season, and irregularly opened in dry season according to sediment monitoring data. In this way, suspended load in front of the intake of the HPP can be transported regularly through reasonable operation of sediment flushing orifice, to ensure the intake of the HPP "clear without deposit".
- 6) Operation management of gates and trash rack
 - ① Regular inspection and maintenance shall be conducted for all gates and their hoisting equipment, to ensure that the gates are in good operation conditions.
 - ② During gate operation, one person shall be responsible for operation and one for monitoring. In case of any faulty operation, the monitoring personnel shall immediately order to stop operation for rectification.
 - ③ During gate opening and closing, attention shall be frequently paid to normal operation of electrical parts. For example, single element and equipment in an electrical circuit shall run normally.
 - ④ During gate opening and closing, attention shall be frequently paid to

operation conditions of rotating parts, for example, whether motor, reduction gear box, bearing and electromagnetic brake are heated, there are abnormal sound during gear engagement, and the reduction gear box suffers from oil leakage. In case of any abnormalities, immediate shutdown for inspection shall be required, to eliminate abnormalities.

- ⑤ During gate opening and closing, monitoring shall particularly be carried out when the gates are lifted up and down to extreme positions, to check whether machines stop operation immediately; otherwise, power supply shall be cut off immediately, to check circuits and limit switches of controllers.
- ⑥ A special person shall be assigned to command the operation of gantry crane at dam crest, and overloading of hoists shall be prohibited during operation of gantry crane and other hoisting equipment. If gates are stuck, power supply shall be cut off immediately for shutdown and inspection.
- ⑦ During operation, inspection shall be conducted for floats and deposits in front of the trash rack at the intake, to avoid pollutants in front of the trash rack as far as possible, ensure clean water for turbines and reduce head loss.
- ⑧ In case that the trash rack is choked with silt or broken and does not work, units shall stop operation immediately for desilting, or the damaged trash rack shall be lifted out for treatment.
- ⑨ Operation of trash rack or desilting must be carried out only after shutdown of units.
- ⑩ Before operation of trash rack or desilting, comprehensive inspection shall be conducted for power distribution system, hoisting system and hoisting tools, as well as safety measures on site, and corresponding operation can be carried out according to specified scheme after all the items pass inspection. Pollutants gathered in front of the trash rack

shall be removed manually using a wastes cleaning boat. Regular inspection and maintenance shall be conducted, to ensure that the trash rack is in good operation conditions.

c) Shiplock

For the Paklay HPP, the navigation lock is arranged on the right bank close to the sluice gate. The scale of the navigation lock is determined in accordance with the *Design Guideline for Hydropower Development of the Mekong River*, with the effective dimension of lock chamber being 120 m x 12 m x 4 m. The navigation lock is passable for 1+2x500t pusher fleets (two rows and one line) and the maximum navigation clearance is 8.0 m. The weight of ships passing through the navigation lock shall be controlled, to avoid overloading.

- 1) The maximum and minimum navigable water levels are 240.0 m and 239.0 m respectively upstream of the navigation lock, and 229.6 m and 219.0 m respectively downstream of the navigation lock.
- 2) A check flood standard of 0.01% and a design flood standard of 0.05% shall be applied to the navigation lock of the HPP, the same as the flood control standards of dam. If the peak discharge is larger than 16,700 m³/s, all flood gates shall be opened for flood discharge, and the navigation lock shall stop operation.
- 3) The flushing and drainage time of lock chamber shall be selected reasonably, to ensure berthing stability of the navigation lock in the lock chamber.
- 4) River channels on both banks shall be subject to strict monitoring and management, to ensure that the river channels are always in stable and safe conditions. Dangerous rocks and unstable blocks along river channels on both banks shall be removed timely, to avoid falling into the basin. After each flood discharge, the water pool shall be subject to diving inspection, and cleared. Careful inspection shall be conducted

for the bottom plate of water pool, and in case of any severe wear and damage, measures shall be taken in time to repair the bottom plate.

4) Gate operation management

- ① Regular inspection and maintenance shall be conducted for all gates and their hoisting equipment, to ensure that the gates are in good operation conditions.
- ② During gate operation, one person shall be responsible for operation and one for monitoring. In case of any faulty operation, the monitoring personnel shall immediately order to stop operation for rectification.
- ③ During gate opening and closing, attention shall be frequently paid to normal operation of electrical parts. For example, single element and equipment in an electrical circuit shall run normally.
- ④ During gate opening and closing, attention shall be frequently paid to operation conditions of rotating parts, for example, whether motor, reduction gear box, bearing and electromagnetic brake are heated, there are abnormal sound during gear engagement, and the reduction gear box suffers from oil leakage. In case of any abnormalities, immediate shutdown for inspection shall be required, to eliminate abnormalities.
- ⑤ During gate opening and closing, monitoring shall particularly be carried out when the gates are lifted up and down to extreme positions, to check whether machines stop operation immediately; otherwise, power supply shall be cut off immediately, to check circuits and limit switches of controllers.
- ⑥ A special person shall be assigned to command the operation of platform crane at dam crest, and overloading of hoists shall be prohibited during operation of platform crane and other hoisting equipment. If gates are stuck, power supply shall be cut off immediately for shutdown and inspection.
- ⑦ During operation of miter main gate of the navigation lock system, continuous lubrication and maintenance shall be conducted for the

bottom pivot, and regular inspection shall be conducted for the jumping capacity of miter gate, the spacing between support pillow spacers and the distance between pull rods, to judge the operation conditions of bottom pivot and take corresponding treatment measures.

- ⑧ For the ogee gate of main gate for the water conveyance gallery of navigation lock system, the trunnion is the most crucial rotating and stressed component, so regular lubrication, inspection and maintenance shall be conducted for the trunnion of the ogee gate.

8.2.8.3 Project Monitoring

Project safety monitoring is an important link of project management, and a basic task to ensure project safety and fully create project benefits. During dam management, relevant laws and regulations, and the policy of "safety first" shall be faithfully implemented, and great importance shall be attached to safety monitoring.

Project safety monitoring mainly consists of: patrol inspection, daily observation and data analysis, regular safety evaluation, and daily maintenance of monitoring system.

a) Monitoring items and key monitoring areas

According to geological conditions of the Paklay HPP, and structure and operation characteristics of structures, safety monitoring mainly covers concrete dam and powerhouse, navigation lock, slopes and other items. Monitoring items and contents are described below:

- 1) Patrol inspection;
- 2) Deformation monitoring: horizontal displacement monitoring, vertical displacement, and tilt and deflection monitoring of dam body, deformation monitoring of dam foundation and gate foundation, and monitoring of structural and construction joints.
- 3) Seepage monitoring: uplift pressure monitoring of dam foundation, seepage pressure monitoring, bypassing seepage monitoring, overall

leakage monitoring, and groundwater level monitoring.

- 4) Stress-strain and temperature monitoring: stress-strain monitoring of concrete and reinforced concrete structures, temperature monitoring, and stress monitoring of reinforcement, pre-stressed anchor cable and support structure of excavation slope.
- 5) Vibration monitoring: vibration velocity and acceleration.
- 6) Monitoring of environmental factors: water level, reservoir water temperature, air temperature, rainfall, and sedimentation in front of the dam.

The water retaining dam consists of non-overflow section on the right bank, navigation lock section, overflow section, powerhouse section, and non-overflow section on the left bank. According to scale, characteristics and hydrogeological conditions of all structures of the Project, the monitoring during operation period mainly focuses on navigation lock section, overflow section, powerhouse section, and non-overflow sections on the left and right banks.

During operation period of the water retaining dam, the monitoring mainly focuses on deformation and seepage, including horizontal and vertical displacement of dam body, uplift pressure of dam foundation, seepage discharge of dam body, and groundwater levels on both banks.

Any abnormalities found at other areas of the project during daily observation shall be analyzed and reported in time, and included in the range of key monitoring items.

b) Requirements on monitoring personnel

- 1) Observation personnel
 - ① Observation personnel shall master technologies related to observation, and have some experience;
 - ② Observation personnel shall work with chariness and responsibility based on the principle of being practical and realistic;

- ③ Observation personnel shall be familiar with monitoring design and construction conditions;
- ④ Observation personnel shall be permanent.

2) Observation instrument

Before use of observation instruments, relevant personnel must carefully read manufacturers' operation instructions, and grasp correct use methods of observation instruments and calculation methods of observation data. Measuring instruments and secondary instruments shall be subject to periodic inspection according to relevant specifications.

c) Requirements on instrumental monitoring frequency

The monitoring frequency of all monitoring items shall conform to the *Technical Specification for Concrete Dam Safety Monitoring* (DL/T5178-2003). Refer to Table 8.2.8-1 for details.

Table 8.2.8-1 Monitoring Frequency of Monitoring Items

Monitoring Item	Operation Period
Displacement	Once / month
Dam joint and crack	Once / month
Osmometer and piezometer	Once / ten days ~ twice / month
Bypassing seepage	Once / ten days ~ twice / month
Seepage discharge	Once / ten days ~ twice / month
Stress and strain	Once / month ~ once / quarter
Dam and dam foundation temperature	Once / month ~ once / quarter
Upstream and downstream water levels	Twice / day ~ 4 times / day
Reservoir water temperature	Once / month
Temperature	Daily
Rainfall	Daily
Monitoring control network in dam site area	Once / year
Sedimentation in front of dam	As required

The monitoring frequencies of monitoring items listed in the table above are minimum requirements of manual measuring under normal conditions, and shall be increased in special cases (such as flood, earthquake). The

frequency of automatic monitoring shall be "once / day".

According to actual patrol inspection conditions, in case of obvious increase in change speed of deformation, seepage and other properties, or rainstorm, felt earthquake and continuous high water level, or any abnormalities, the observation frequencies of relevant observation items and instruments at specific parts shall be increased, and continuous observation, if necessary, may be carried out.

d) Technical requirements on monitoring

Safety monitoring shall be carried out in accordance with relevant international standards and electric power standards of Laos, and with reference with relevant Chinese specification. Meanwhile, according to characteristics of the Project, safety monitoring rules shall be formulated, including reporting procedures of observation items, frequency and methods, calculation methods and observation results, reporting procedures of hazard warning, and responsible persons of all items.

In addition, safety monitoring items during construction period shall be combined with permanent monitoring as far as possible, to maintain the continuity and completeness of monitoring data.

1) Patrol inspection

Patrol inspection includes: daily patrol inspection, annual patrol inspection and special patrol inspection. Routine inspection shall be carried out for the following items within the safety monitoring range of dam-reservoir area: dam body, dam foundation, slopes at dam abutments, powerhouse, and other structures and equipment directly related to dam safety. The main inspection contents are as follows:

- ① Patrol inspection for dam, navigation lock and powerhouse
 - Dislocation between adjacent dam sections;
 - Opening and closing of expansion joints, and working conditions of waterstop;

- Cracks on the upstream and downstream dam faces, and leakage of cracks;
 - Breakage, corrosion or water erosion on concrete surface;
 - Working conditions of drainage holes of the dam body, and significant changes in water leakage and water quality;
 - Sounds in galleries and vibration of dam body in case of earthquake and other special conditions.
- ② Structure foundation and dam abutment
- Extrusion, dislocation, loosening and bulging of foundation rock mass;
 - Dislocation, cracking, disconnection and leakage at connections between all structures and bedrocks (or bank slopes);
 - Cracks, landslide, corrosion and bypassing seepage in the dam abutment areas on both banks;
 - Working conditions of foundation drainage facilities, and changes in water leakage and turbidity.
- ③ Bank slopes at dam abutments
- Extrusion, dislocation, loosening and bulging of excavation slope surfaces; location, scale, extension direction and change conditions of crack; dislocation of hanging and heading sides at the places where faults crop out;
 - Abnormal lifting deformation and sliding of slope surfaces, and occurrence time, location, form and range of lifting deformation and sliding;
 - Sliding of local wedges; occurrence time, location, form and volume of collapse or landslide;
 - Smoothness of surface intercepting ditches and drainage ditches, normal operation of drainage system, and changes in water seepage and turbidity;
 - Change conditions and physical and chemical characteristics of

groundwater outcrop;

- Completeness of safety monitoring facilities, and traces of blasting or other man-made damage.
- ④ Patrol inspection of monitoring facilities
- Completeness of protection devices of safety monitoring facilities, and damage to instrument cables, communication cables and power lines;
- Normal operation of monitoring instruments, and completeness, looseness and instability of all surface monitoring networks, measuring piers, scale plates and gauge points, need of maintenance or replacement;
- Completeness of safety monitoring facilities, and traces of blasting or other man-made damage.

Inspection shall be carried out for the above-mentioned items at least once a month, and the inspection frequency shall be increased in flood season. When the reservoir level is approximately at the design water level, the inspection shall be conducted at least once a day. The patrol inspection shall be carried out immediately in case of felt earthquake or flood in the dam site area, or other special conditions.

Patrol inspection shall be recorded properly, and if necessary, drawings shall be drafted for detailed description. Problems found during inspection shall be reported in time, and necessary measures shall be taken.

2) Deformation monitoring

For vertical and horizontal displacement monitoring networks, observation shall be conducted once a year by an organization with second-order leveling and triangulation network observation qualifications.

Observed values obtained at all measuring points shall be timely converted into horizontal or vertical displacement corresponding to datum point.

The observation frequency of horizontal and vertical displacement at each part shall meet the specification requirements.

3) Seepage monitoring

For piezometer without leakage water in the orifice, a water level indicator or osmometer shall be adopted for measuring water level in the orifice; for piezometer with piezometric pressure in the orifice, a proper pressure gauge with the reading within $1/3 \sim 2/3$ of the range limit shall be adopted for measuring in general. The accuracy class of pressure gauge shall not be less than 1.5. The observed piezometric pressure of piezometer shall be converted into water level of piezometer in time.

Leakage shall be observed using a measuring weir.

During water quality analysis, sampling location, date and time, and inspection purpose and analysis items shall be clearly indicated.

The observation frequency of piezometric pressure and leakage shall meet the specification requirements. In the first five years of operation, bypassing groundwater leakage on both banks shall be observed at a frequency of once / ten days or once / month generally, and total analysis of water quality shall be carried out once a year generally.

4) Stress and strain monitoring

For this item, observation shall be carried out at a frequency of once / week in general in the first five years of operation, and thereafter, a few instruments may be adopted for observation at a frequency of once / month or quarter according to actual observation results.

5) Environmental variable monitoring

Reservoir level, downstream water level of dam, air temperature, rainfall, flood discharge and other data shall be collected, and observation shall be carried out regularly for reservoir water temperature and sedimentation in front of the dam.

6) Collation and analysis of data

Collation and analysis of monitoring data shall be carried out using computers and corresponding database shall be established. Data analysis

personnel shall carefully collect and collate data, and conduct analysis as below:

- Analyze the temporal or spatial variation rules of physical quantities monitored;
- Conduct statistics for characteristic values of all physical quantities;
- Determine abnormal values of physical quantities monitored;
- Analyze the correlation among all physical quantities using a mathematical model;
- Analyze the anti-seepage and drainage effects of foundation;
- Judge structure stability;
- Comprehensively analyze all physical quantities monitored and patrol inspection data, and evaluate the work and safety conditions of all structures.

8.2.9 Management during Flood Discharge and Storage Period

Upon the completion of the Paklay HPP and formation of reservoir, the hydrologic data collection and transmission in the basin will change to a certain extent, and the flood travel time between the LuangPrabang Hydrometrical Station and the Paklay dam site will be further shortened. In this case, in case of a flood, a severe damage will be caused to the Paklay HPP.

To achieve comprehensive utilization of the HPP and safety management by taking preventive measures, an hydrological telemetry and forecast system is required for the Paklay HPP.

The hydrological telemetry and forecast system is an automatic system intended to complete real-time collection, transmission and processing of parameters concerning hydrology, meteorology, flood situation and hydraulic structure conditions in the basin or measuring area by use of telemetry, communication, computer, network and other advanced technologies, to provide services for flood control, beneficial use and optimal operation of the Project. The hydrological telemetry and forecast system of the Paklay HPP, upon its

completion, can complete quick and accurate collection, transmission and processing of water and rainfall information in the basin, and make accurate and timely flood forecasting, to reserve time for the discharge of reservoir. Moreover, the system can also provide decision-making support for flood control regulation according to flood forecasting results, to improve the flood control capacity of the HPP and ensure operation safety of the HPP and the reservoir area.

8.2.10 Project Management Systems

According to equipment system, operation mode, geographic position and natural environment, as well as actual conditions of the HPP, the following project management system is proposed.

a) Safety management (safety, transportation, firefighting, environmental protection)

- Safety management system of outsourced items;
- Implementation rules for supervision management of work safety;
- Supervision and settlement system of work safety problems;
- Fire safety management system;
- Implementation rules for safety evaluation;
- Work safety responsibility management system;
- Management system of violations of rules and regulations;
- Provisions on safety supervision management of major hazardous sources;
- Fire safety inspection system;
- Management measures of information resources;
- Management system of flammable and combustible materials.

b) Production management (operation, equipment)

- Operation management measures of the HPP;
- Provisions on leading phase operation of unit;
- Operation instructions for flood discharge of reservoir;
- Operation instructions of navigation lock;

- Protection regulation of fish;
- Protection setting of auxiliary equipment;
- Reservoir operation regulation;
- Collection of typical habitual violations;
- Quota of spare parts;
- Technical regulation for observation of hydraulic structures;
- Equipment maintenance management regulation;
- Management measures for safety protection of secondary system;
- Management rules of technical monitoring and supervision;
- Management system of equipment defects;
- Management system of relay protection, activation and deactivation of automatic device, and setting;
- Provisions on computer management of production system;
- Management system of access to powerhouse and dam;
- Management system of special equipment;
- Management measures of major and minor repairs and technical retrofit;
- Implementation rules of key requirements for prevention of major accidents during power generation.

c) Flood control management

- On-duty working system during flood control;
- Management measures of reservoir safety;
- Implementation rules of flood control;
- Implementation rules for grading of hydraulic structures.

The above-mentioned management planning shall be formulated during construction of the Project, completed at least half a year before reservoir impoundment, and filed by the operation management organization. Meanwhile, roles and responsibilities of parties concerned shall be clearly defined in the management planning according to requirements of management system.

8.2.11 Dam Safety Management

8.2.11.1 Identification and Analysis of Hazardous Factors of Project Layout, Main Structures and Equipment

- a) Reservoir leakage(of higher priority)
- b) Reservoir inundation and immersion
- c) Instability of reservoir banks(of higher priority)
- d) Dam failure(of higher priority)
- e) Defect risk analysis of flood discharge and energy dissipation facilities
- f) Slope instability
- g) Dam foundation leakage and bypassing leakage

8.2.11.2 Identification and Analysis of Natural Disaster Risks and Hazardous Factors

- a) Earthquake; (of higher priority)
- b) Reservoir induced earthquake (of higher priority)
- c) Lightning stroke
- d) Severe convection weather
- e) Over-level flood (of higher priority)
- f) Debris flow (of higher priority)

8.2.11.3 Identification and Analysis of Risks and Hazardous Factors during Production

- a) Epidemic disease
- b) Drowning accident
- c) Fire and explosion
- d) Electric injury
- e) Mechanical injury
- f) Falling accident and object striking
- g) Defect risk analysis of safety mark setting
- h) Failure risk analysis of safety monitoring system

8.2.11.4 Identification and Analysis of Main Risks and Hazardous Factors during Construction

- a) Fire and explosion

- b) Blasting accident
- c) Electric injury
- d) Falling accident and object striking
- e) Mechanical injury
- f) Risk analysis of diversion and interception during construction
- g) Vehicle injury
- h) Instability of spoil area

8.2.11.5 Identification and Analysis of Hazardous Factors at Workplace

- a) Hazard analysis of noise and vibration
- b) Hazard analysis of abnormal temperature and humidity
- c) Hazard analysis of poor lighting
- d) Hazard analysis of dust and toxic and harmful substances
- e) Hazard analysis of slippery floor
- f) Hazard analysis of operation in confined spaces

8.2.11.6 Corresponding Countermeasures

According to characteristics of the Project, conduct investigation and inspection for possible hazardous sources one by one. Strengthen observation during construction and operation, analyze main hazardous factors in different periods, mark main hazardous sources and formulate special countermeasures.

Formulate an annual dam safety report during construction and operation. The report shall be submitted to relevant government authorities and released to the public.

8.2.12 Updating of Notices related to Dam Safety Management

During formulation of annual dam safety report, the developer and the owner / operator shall check whether technical notices related to dam safety are regularly updated in the *World Bank's Business Policy* (OD/GP 4.37) or are newly issued by the International Commission on Large Dams (ICOLD). The dam safety report shall be formulated according to the latest notice.

8.2.13 Related Cost on Dam Safety Management

According to Guide on Dam Safety Management of this project, the related cost is borne by the Developer and the Employer.

During the project construction period, the cost on dam safety management is USD 3 million and the cost will be USD 1 million during the operation period.

8.2.14 Negotiation on Dam Safety Management

Friendly negotiation on dam safety management should be carried out with local environmental management agencies and communities so that work is carried out based on the opinions from different parties.

8.3 Emergency Preparedness Plan

8.3.1 Basic Principles for Formulation of Emergency Preparedness Plan

The operator of the HPP must formulate an emergency preparedness plan, to practically strengthen reservoir and dam safety management, improve the capability of response to emergencies, ensure reservoir and dam safety, and reduce personal casualties and property losses.

Emergencies related to reservoir and dam may be caused by natural disasters, accident disasters and social security incidents. The emergency preparedness plan shall be formulated according to the following principles:

- a) Adhere to the principle of people oriented and present risk management concepts, to avoid or minimize life and property losses, and ensure public security;
- b) Based on the principle of graded responsibility, conduct level-to-level management and clearly define responsibilities and responsibility investigation system;
- c) By adhering to the principle of prevention crucial, conduct in-depth analysis for possible emergencies related to reservoir and dam, and formulate countermeasures for reducing and responding to public emergencies in advance.

- d) By adhering to the principle of operability, formulate the emergency preparedness plan in a form of text and icons to form a written document;
- e) By adhering to the principle of coordination and consistency, coordinate the emergency preparedness plan with other related emergency preparedness plans of the area and the related department.
- f) By adhering to the principle of dynamic management, properly revise, and continuously supplement and improve the emergency preparedness plan according to changes of actual conditions.

8.3.2 Formulation of Emergency Preparedness Plan

Emergencies related to reservoir and dam may be caused by natural disasters, accident disasters and social security incidents. The operation and management organization shall formulate an emergency preparedness plan for possible emergencies by careful analysis of existing hazardous factors in combination with equipment system, operation mode, geographic position and natural environment. According to actual conditions of the HPP, the following emergency preparedness plans are proposed, to improve the operation and management personnel's capabilities of responding to emergencies, ensure reservoir and dam safety, and reduce personal casualties and property losses.

- a) Emergency preparedness plan of dam failure (of higher priority)

The emergency preparedness plan of dam failure shall clearly define roles and responsibilities of parties concerned in case that dam failure will occur or flood discharge endangers downstream residents' life, properties and economic activities. The plan will be formulated during construction of the Project, and shall be submitted to the expert team for review at least 1 year before reservoir impoundment.

- b) Emergency preparedness plan of natural disasters

There are emergency preparedness plan of rainstorm, flood and heavy fog, emergency preparedness plan of earthquake disasters, and emergency preparedness plan of geological disasters.

c) Emergency preparedness plan of accident disasters

There are emergency preparedness plan of personal accidents, emergency preparedness plan of plant-wide power failure, emergency preparedness plan of black start of power plant, emergency preparedness plan of electrical equipment accidents, emergency preparedness plan of major mechanical accidents, emergency preparedness plan of safety accidents of power network information system, emergency preparedness plan of fire accidents, emergency preparedness plan of traffic accidents, and emergency preparedness plan of environmental pollution accidents.

d) Emergency preparedness plan of public health incidents

There are emergency preparedness plan of epidemic infectious diseases, emergency preparedness plan of unexplained mass diseases, and emergency preparedness plan of food poisoning.

e) Emergency preparedness plan of social security incidents (of higher priority)

There are emergency preparedness plan of mass unexpected social security incidents, and emergency preparedness plan of antiterrorism.

The emergency preparedness plans in (b) ~ (d) shall be formulated during construction of the Project, completed at least half a year before reservoir impoundment, and filed by the operation management organization. Meanwhile, an emergency preparedness plan team shall be established, and roles and responsibilities of parties concerned shall be clearly defined in the emergency preparedness plans according to requirements of emergency preparedness plan.

f) Identify the responsibility for dam operation and related emergency communications.

The Employer and the Operator are the main bodies to organize and implement the emergency plan and the other departments concerned should coordinate with or provide guidance to the Employer and the Operator for

related works. During the work, a certain quantity of communication equipment and its smooth operation need to be ensured.

g) Flood standards for various emergency situations

The early warning is classified into 4 levels with regard to the levels of emergencies and the possibility of the events of dam failure and the four levels are indicated by blue, yellow, orange and red colors. The blue early warning is triggered when the upstream water level exceeds normal pool level and the level is raised up one by one with every 1m increase in the upstream water level.

h) Characteristics of flood warning system

The flood inflow volume or the upstream water level is taken as the indicators of early warning. During the flood period, the system follows the latest flooding information closely.

i) Procedures for evacuating threatened areas and mobilizing emergency forces and equipment

A certain number of emergency personnel and a certain quantity of equipment should be equipped to ensure the smoothness of the evacuation passage.

j) To complete EPP with necessary funds

The cost necessary for EPP has already been listed in the construction and operation cost of Paklay HPP and such related cost is borne by the Developer. According to the preliminary estimated, the cost on EPP during project construction period is USD 2 million and the cost during the operation period is USD 800,000 per year.

For the emergency plans (b) to (d), they will be prepared during the project construction period and shall be finished at least a half year earlier than reservoir impoundment. The plans will then be filed by the operation and management organization, who, according to the requirements of the emergency plan, should establish an emergency response team and identify the roles and responsibilities of parties concerned.