

Three Gorges Water Control Project Feasibility Study

People's Republic of China

**Volume 1
Feasibility Report
Appendix A**

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CIPM Yangtze Joint Venture

VOLUME 1 – FEASIBILITY REPORT

APPENDIX 1A – FEASIBILITY REPORT MISCELLANEOUS

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TERMS OF REFERENCE

16 June 1986 *

1.0 BACKGROUND

- 1.1 The Three Gorges Project (TGP) is a multiple purpose project intended to provide flood protection to regions of the middle reaches of the Yangtze valley, generate a large block of hydroelectric power and improve navigation in the Yangtze River. It involves construction of a dam, about 165 m high, at Sandouping on the middle section of the Xiling Gorge, 40 km upstream of Yichang.
- 1.2 Studies of the potential of the Three Gorges stretch of the Yangtze were initiated in the late 40s. In the late 60s, a decision was taken to construct a 45 m high dam under the Gezhouba project, 34 km downstream of Sandouping (6 km upstream of Yichang) as a forerunner of the TGP for power generation and improvement of navigation. Construction began in 1971. The first power station (965 MW) was commissioned in 1981 and completed in 1985. The second power station (1 750 MW) was commissioned early in 1986 and is expected to be completed in 1988. Two navigation locks are in operation and a third will be commissioned in 1988.
- 1.3 In 1983, the Yangtze Valley Planning Office (YVPO) prepared a feasibility report on the TGP project, with a dam crest of 165 m, a normal reservoir level of +150 m, an installed generating capacity of 13 000 MW and a twin-lane permanent four-lift navigation lock adequate to pass 10 000 ton tows. It was approved by the People's Republic of China (PRC) State Council with the proviso that the dam crest be increased to 175.0 m. In March 1985, a preliminary design report on this project was completed. Preparation of designs continued. Construction of preparatory works, such as access roads etc. started in 1985. At this stage, requests were received from some quarters, particularly from the Ministry of Communications and Chongqing port authorities, that the normal water level be raised for better navigation benefits. In March 1986, the Ministry of Water Resources and Electric Power (MWREP) prepared a revised report recommending a level of +160 m, with the original dam crest level of +175 m, and an installed generating capacity of 14 800 MW, other features remaining unchanged. This recommendation is under consideration by Government.

* Additions or modifications subsequent to 16 June 1986 are indicated in bold.

- 1.4 A number of detailed investigations of the project have been carried out since 1983 on various aspects, e.g., sedimentation, landslides, environmental impact, resettlement, power planning, construction planning, cost estimating, etc..Some of those have been completed whereas others are continuing. Government intends to start construction of the main works of the TGP in the near future and is considering the possible arrangement of international financing for this project. For this purpose, MWREP has decided to use a Consultant to prepare a feasibility report which will form the basis for securing assistance from international financial institutions; in addition it will form an input to Government in its decision-making process. On technical issues and plan for resettlement extensive studies have been undertaken by the Chinese agencies. The Consultant in arriving at his conclusions and/or judgement will, as necessary, use the results of these studies. The Consultant should collate and effectively present the results of all studies carried out so far and establish technical and economic feasibility and financial soundness of the TGP.
- 1.5 The Canadian International Development Agency (CIDA) has agreed to assist MWREP in the preparation of such a feasibility study and in its financing. MWREP has also decided that the International Bank for Reconstruction and Development (IBRD), functioning as MWREP'S advisor, will play lead role in assisting MWREP in coordinating and supervising the study, and in reviewing the findings. For this purpose, MWREP will, in consultation with IBRD, appoint a panel of international experts.
- 1.6 These terms of reference have been prepared by MWREP, and accepted by CIDA and IBRD, on the basis set out above.

2.0 PURPOSE OF THE FEASIBILITY STUDY

- 2.1 The purpose of the feasibility study is to firmly establish, on bases acceptable to international financial institutions, the technical and economic feasibility of TGP project, and viability of the financial investment, in the context of various outstanding issues mentioned in Para 1.4 above. It will be a study aimed at settling open technical questions with an accent on the feasibility of the large investments involved.

3.0 SCOPE OF WORK

- 3.1 The feasibility study shall be comprehensive covering costs and benefits of the main aspects of power generation and associated transmission, navigation, flood control, and resettlement. It should demonstrate that the project represents the least-cost solution for deriving the planned benefits, and show how project features have been optimized within the range of variants deemed acceptable by the Government of China (GOC). For the purpose of the study, the variants will be defined by four normal water levels (NWL) within the 150 – 180 m⁽¹⁾ range (at the higher limits of the range, some changes in the presently contemplated dam design may be necessary.)
- 3.2 For each variant outstanding issues to be studied are;
- (a) review of plan for resettlement, particularly of affected rural population;
 - (b) review of effect of sedimentation on navigation, reservoir storage, and plant operation;
 - (c) optimization of costs associated with both temporary and permanent navigation;
 - (d) preparation of a realistic construction program, based on detailed assessment of categories of work, their timing, choice of equipment and procurement method (domestic or offshore as provided by GOC), for all goods, works and services;
 - (e) based on (d) above, an updated estimate of local and foreign costs; and
 - (f) analysis of economic viability.
- 3.3 The study will focus on, but not be limited to the following points:

(1) added 180 at SC2

GEOLOGY OF DAMSITE AND PROJECT LAYOUT

- (i) No additional site exploration or investigations are required prior to construction. The plan for excavations of the dam and spillway foundations should be reviewed so that only the totally decomposed (weathered) granite is removed, and the underlying partly weathered, but hard, rock be grouted and left in place. This should result in major cost and time savings.
- (ii) Review plans for (a) removal of weathered rock at the top of permanent rock excavations, e.g., at the shiplock so that distance from the top of excavation is satisfactory and (b) for stabilisation of permanent steep rock walls, during construction and later.
- (iii) Consider the possibility of moving the shiplock channel, and possibly the shiplift channel as well, closer to the river, as this would result in major reductions in rock excavation and support, corresponding reduction in construction time and in future maintenance.

SEDIMENTATION

- (iv) Obtain from the Chinese and any other concerned agencies, all reports on sediment studies conducted in connection with TGP and, at least, summaries of the data used. Evaluate the reports and their conclusions.
- (v) Review the reservoir—sedimentation analysis carried out by YVPO for the permanent backwater reach of the TGP reservoir. Evaluate the formulations incorporated into the model for completeness, relevance, verification and accuracy; and check the predictions for completeness and accuracy. If necessary, the Consultant may use an alternative model and carry out an independent analysis.
- (vi) carry out on independent one—dimensional flow and sediment—routing analysis for the fluctuating backwater reach, extending upstream of Chongqing, of the Three Gorges Project reservoir based on an established or specially developed mathematical model to verify and complement the mathematical and physical model studies already conducted in China and to ascertain the sedimentation impacts on navigation in this reach.
- (vii)⁽²⁾ Prepare, input and analyse sedimentation data to provide an assessment comparable to that of the Chinese sedimentation program.**

(2) Added at SC2

NAVIGATION

(viii) Reconcile the existing projections for freight volume, particularly through the closure period and to the year 2030. This is needed to address the demand for temporary navigation facilities through closure, to compute navigation benefits for various operating levels, and to optimize treatment of navigation in the fluctuating upper reaches of the reservoir.

(ix) Assess navigation benefits and/or disbenefits created at various operating levels. This involves assessing port facilities, fleet modernization, morphological changes, growth, transportation costs and/or savings with and without the project.

(x) Review impacts of fluctuating pool area downstream of Chongqing harbour, to include alternative methods for achieving required navigation depths such as tow configuration, lightering, augmented flows, fleeting area, dredging and channelization.

(xi) Considering the potential of operating the Gezhouba and/or Three Gorges power plant with rapid and high magnitude changes in release patterns, an analysis of the hourly fluctuations created by such unsteady flow should be performed to determine the adverse impacts on navigation.

(xii) After completion of the Three Gorges Project, additional degradation of the river bottom resulting from a lesser sediment load can be expected downstream of Gezhouba. This degradation will lower the tailwater elevation which could create problems in passing some vessels over the lock sill in Gezhouba. Higher minimum flow releases will overcome part of the tailwater drop. Assess potential impacts and assure that an alternative exists for resolving the issue should degradation reach an adverse level.

(xiii) Review the physical configuration of the navigation structures (both permanent and temporary) with a view toward moving the structures toward the river so as to decrease excavation costs and the time for construction. (item iii above). This should be done in a manner which results in sufficiently safe entrances for vessels.

(xiv) Review the temporary shiplock and the shiplift provided for maintaining navigation during construction. The need for both structures in conjunction with an improved diversion channel is questioned and should be analyzed from an economic and a traffic handling standpoint. While the shiplift is a permanent feature its operational reliability should be reviewed in view of the fact that similar structures of lesser height have experienced problems. Elimination of one of the structures should allow for moving the navigation system closer to the river system closer to the river.

(xv) Study the potential for advancing the construction of the shiplift to provide earlier availability for operational check-out and for aiding navigation passage during high velocity periods through the diversion channel.

(xvi) Using continuous lock chambers for permanent navigation passage, analyze the rock dividing wall between the parallel runs to decrease the width to a minimum to save excavation.

(xvii)⁽³⁾ Prepare a request for, and carry out an evaluation of the results of, hydraulic model testing in China of the upstream entrance conditions for the flight locks.

(xviii)⁽³⁾ Provide a report, on the results of a study of single lock alternatives, to the Steering Committee Panel of Experts.

(xix)⁽³⁾ Carry out qualitative evaluation of specialized technologies for overcoming existing navigational problems between Chongqing and the dam site.

(xx)⁽³⁾ Carry out a detailed regional economic impact assessment.

FLOOD CONTROL

(xxi) Review, and as necessary, study:

- (a) the historic floods, the design floods, as well as the characteristics of rainstorms in the Yangtze valley
- (b) planned implementation, with and without the project, of the strengthening of embankments and other measures, in the middle and lower reaches of the Yangtze basin concerned that can be implemented in the near future
- (c) alternatives of NWL within the 150 to 180 m range and respective reservoir operational strategies and
- (d) the benefits of the project from flood damage avoidance, taking into account population growth and increase in regional economic growth
- (e) the possible effects on project benefits of the 19 reservoirs studied for upstream and tributary developments

⁽³⁾ added at SC2

(f)⁽⁴⁾ flood damages for additional, smaller historic flood for the case with Three Gorges Project and improved dyking

(g)⁽⁴⁾ YVPO's derivation of the Probable Maximum Flood to establish its conformance with international hydrological methodology

(h)⁽⁴⁾ the effect of construction of a flood channel paralleling the Yangtze River from Yichang to the East China Sea.

ENVIRONMENT

(xxii) For the 150 m to 180 m schemes to be addressed in the feasibility report, prepare **two separate feasibility assessments, one for environmental, the second for resettlement⁽⁴⁾** which, inter-alia, will review, evaluate and recommend on the following subjects:

- (a) the technical and social feasibility of plans for resettlement of inhabitants and relocation of municipalities, industry, transportation, utilities, from all project areas.
- (b) the compatibility of the resettlement and relocation plans with overall project requirements and schedules.
- (c) the adequacy of the cost estimates for compensation, resettlement and relocation, including the management of cultural property.
- (d) the adequacy of institutional arrangements for implementing the above plans on schedule, within budget, and according to specifications.
- (e) the adequacy of socio-economic impact and evaluation of the above plans, including arrangements for any ethnic minorities.
- (f) the adequacy of fisheries and water quality information in the reservoir area for the purpose of evaluating the potential of reservoir fisheries and agriculture, and of approaches for linking reservoir fisheries with resettlement.
- (g) the feasibility report should review other environmental aspects such as: endangered species and habitats, health and disease, esthetics and downstream effects.
- (h) **review, with special consideration, the environmental problems in the Daning River Valley are to Shennongjia forest area "trade offs".⁽⁵⁾**

⁽⁴⁾ Added at SC2

⁽⁵⁾ Added at SC2

DESIGN AND CONSTRUCTION

(xxiii) Revise concepts adopted for design of the structures on the basis of recommendations on geology and navigation. This revision should be carried out also considering other changes that may be deemed advisable on the location of structures, especially as regards location of permanent equipment, including turbines, generators, cranes, gates, governors, pumps and all other auxiliary equipment of the power plant, spillways, erection bays. **Additional space might be necessary at the erection bays, to cope with the rapid rate of erection of the generating equipment.**⁽⁵⁾ Space for pre-erection of large components of equipments such as sub assemblies must be reserved and the connection between pre-erection areas and erection bays for heavy transportation of sub assemblies should be incorporated on the layout of construction plant.

ACCESS TO SITE

(xxiv) Evaluate current plans for access to site through the existing river navigation, the highway system under construction, and the proposed branch railroad (yet to be authorized for construction), and any combination thereof. Analyse the time schedules for these alternative transportation methods and assess construction, operation and transportation costs especially of heavy loads to be moved to site and movement of personnel.

CONSTRUCTION PLAN AND SCHEDULE

(xxv) Evaluate and review, if necessary, the detailed plan for construction activities starting from the planning of construction plant, equipment requirements, study of excavation, use of excavated material, stockpiling when necessary or otherwise disposing of same. The primary object is the earliest possible commissioning and completion of the power stations through a timely start-up and appropriate construction methods. In this context, special emphasis should be placed on the plan for concreting structures of the project including handling of concrete from batch plant to pouring sites.

(5) Added at SC2

(xxvi) Adjust the construction schedule to the revised construction plan, using the Critical Path Method in sufficient detail to permit an accurate estimation of time required for procurement, purchase, transportation and installation of mechanical and electrical equipment. Graphic elaboration should be used to give visual information about concurrent computer base follow up and revision as required. Review and revise the list of construction equipment and prepare a procurement schedule compatible with the construction schedule.

POWER SYSTEM ANALYSIS

(xxvii) Prepare a technical and economic analysis of the conditions under which the project can be incorporated into and benefit the power systems of the Central, East China and East Sichuan Regions. This work includes interalia:

- (a) Optimize the project rated power capacity and maximize daily output subject to the constraints imposed by navigation and by the reregulating capability of the Gezhouba reservoir;
- (b) Preparing least cost expansion plans both with and without the TGP; **utilize the WASP III computer simulation to support the determination of the least cost power system expansion plan and train Chinese counterpart staff in the use of personal computers;**⁽⁶⁾
- (c) Preparing separately a development plan for the hydropotential in the Yangtze catchment area upstream of the TGP and assessing its impact on downstream power generation and navigation.

For the planning period extending until 2005, the analysis under (b) must identify plant sites, and be based on unit prices consistent with the one adopted for the TGP. Network studies will exclusively make use of the voltage levels under development at this time. For the rest of the study period extending from 2005 to 2025 the optimization will be done for the generating system only on the basis of notional alternatives for peak and baseload duty.

(6) Added at SC2

COST ESTIMATE

(xxviii) Complete cost estimates should be prepared, to feasibility grade, and should include separate costs by item of the dam, power plants, permanent and temporary navigation facilities, structures for water control during construction, construction plant and internal roads. Quantities should be reviewed and unit prices formulated for local conditions of construction.

ECONOMIC EVALUATION

(xxix) Prepare an overall evaluation of the project variants defined in the foregoing works and assess the economic and financial impact of a few selected variants. This work involves the following:

- (a) Preparing a matrix of the monetary and non monetary costs and benefits for each variant with a possible range of variation with respect to key parameters such as discount rate, labour wages, exchange rates and construction leadtime.
- (b) For selected variants calculating the rate of return on the basis of all monetary costs and benefits and assessing the project impact on the local economy, the financial requirements of the power sector and the long run cost of power in the Central and East China Regions.

SUPPLEMENTAL TERMS OF REFERENCE

FOR

**Review of Resettlement Planning Information:
Land Availability and Non-agricultural Employment Potential**

1. BACKGROUND

Two aspects of rural resettlement have been documented by the Chinese and now require to be reviewed by CYJV to establish the feasibility of the rural resettlement component of the Three Gorges Project:

- i) the availability of suitable land to replace the cultivated land inundated by the Three Gorges Project, and

- ii) the potential for creating non-agricultural employment for farmers for whom alternative land cannot be provided.

YVPO/CPE has assembled the resettlement plan documents prepared by the counties for an NPL 175 project. These plans were prepared in response to CPE's May, 1987 guidelines. The Chinese review of the county resettlement plans concludes that the plans could be used for the purpose of demonstrating rural resettlement feasibility. Further coordination of the plans between counties and the provinces will be made.

Since the 4th Steering Committee Meeting, YVPO/CPE has also developed, with the assistance from the Academy of Science, Remote Sensing Centre of MWREP and National Survey Department, information on land availability and non-agricultural job creation potential:

- a) Air photo interpretation (API) was used to measure land availability by xiang over a resettlement area covering 627 xiangs, including 325 xiangs affected by an NPL 175 scheme. The API results have not yet been verified by field work.
- b) YVPO/CPE reviewed the counties' proposals for the establishment of some 3 000 enterprises which are to provide employment for both rural relocatees and host population. The review and analysis selected 522 of the proposed enterprises as suitable.

The work and results of these two efforts are to be examined.

2. OBJECTIVE

In order to further the process of clearly demonstrating the feasibility of resettlement of the Three Gorges Project, the following questions are to be answered:

1. What amount of cultivatable land exists for new agricultural development within the resettlement area as defined by the limits of API work carried out.
2. What proportion of inundated land could be replaced in each county in the presently defined resettlement area?
3. Is the mechanism in place, or will the mechanism be in place required for resettlement planning at the macro and micro levels, on an integrated regional basis.

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- * 4. Are the anticipated effects of resettlement on the host population acceptable?
- 5. Are the expectations for the transfer of farmers to non-agricultural employment realistic in socio-economic terms and from the point of view of business viability?

3. SCOPE OF WORK

a. Land Availability

The Air Photo Interpretation under CPE's direction surveyed 627 xiangs of which 325 are affected xiangs at NPL 175. CYJV will review the recorded land availability (on 1:10 000 topographic maps) and the air photos used for interpretation in 6 of the 19 counties surveyed.

Initially all maps in the 6 counties will be examined for selection of some xiangs, both affected and unaffected, for checking of the original photo interpretation. The six counties are:

<u>County</u>	<u>No. of Xiangs surveyed</u>
Fengdu	45
Zhongxian	44
Yunyang	53
Fengjie	53
Wushan	67
Zigui	52
	314

Land availability identified will be reviewed in 60 xiangs, on average 10 per county; starting with the six xiangs (3 in Fengdu and 3 in Yunyang) previously surveyed by API by CYJV in April, 1987. This will constitute a review of under 20 percent of the xiangs surveyed in the 6 selected counties.

b. Non-Agricultural Job Creation

The review of the presently proposed enterprises will focus on the same six counties as the review of land availability.

The available information and selection criteria used by YVPO will be documented to the extent possible as a result of interviews with the staff involved in making the selection of the suitable enterprises. Specifically, answers will be sought to the following questions:

- i) Technological –
 - are enterprises technically simple or complex?
 - do they constitute new factories, expansion of existing factories or expansion of relocated plants?
- ii) Costs –
 - what are costs of equipment and buildings?
- iii) Management –
 - what level of management if required, is available, needs training?
- iv) Workers Skills –
 - what are required levels of education, age and skills, and are they available among the rural relocatees?
- v) Material Supply –
 - is the raw material needed readily available in the quantities required?
- vi) Markets –
 - what evidence has been assembled to identify a market for the products?
- vii) Construction –
 - has construction, in terms of labour and materials, been examined in relation to other construction needs?
- viii) Funding –
 - has the funding for establishment of enterprises been identified in terms of sources and amounts?

4. DATA, MAPS AND AIR PHOTOS TO BE PROVIDED

For the six selected counties:

- a. 1:10 000 topographic maps showing available land identified by API, including boundaries and names of xiangs.

For 60 selected xiangs:

- b. Air photos used by API
- c. Tabulated data by xiang for the 6 selected counties:
 - i) amount of available land identified by API,
 - ii) amount of cultivated land and orchards inundated at NPL 160,
 - iii) agricultural population,
 - iv) affected agricultural population,
 - v) total amount of cultivated land and orchard land.

FINAL REPORT

PANEL OF INTERNATIONAL EXPERTS

THREE GORGES PROJECT

Montreal, Canada
January 22, 1988

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1. PREFACE

The Panel of International Experts for the TGP feasibility study reviewed the CYJV draft Feasibility Report at the 5th Steering Committee meeting held Jan. 18 through 23 in Montreal, Canada. The principal purpose of this review has been to evaluate the Report's compliance with the Terms of Reference of June 16, 1986.

The Panel has concluded that the draft report basically satisfies the Terms of Reference and instructions given to CYJV at the previous SC meetings. The analytical methods used in the CYJV study are sound and most of the project issues are addressed and resolved. The completion by CYJV of this study in 15 months, with the help of Chinese Government, is an impressive professional achievement.

The draft report incorporates discussion on all of the significant findings that CYJV obtained from its well-organized and comprehensive studies. These findings serve as a solid base for the TGP's technical and economical feasibility as well as for its financial viability; however, due to the restricted time for the feasibility study, some sections of the draft report do not effectively address all of the work that was carried out for those sections. Thus, because of omissions, or misinterpretation of some of the guidelines established and/or inconsistency between different parts of the report, some refinement is still to be done to produce the Final Report. Most of these weaknesses can be remedied by additional analyses, reorganization and editorial work.

The principal present deficiency in the draft report concerns the resettlement of the affected population in the reservoir area, which is one of the most critical components of the TGP feasibility study. CYJV has performed a commendable amount of work on this matter and has been able to verify many aspects of acceptability of resettlement from inundated areas up to NPL 160 meters. Recent information on land availability and job creation presented by the Chinese delegates at this meeting is encouraging. Therefore, the Panel recommends that CYJV carries out more fieldwork and on this basis rewrites Volume 9 and parts of Volumes 1, 3 and 8 of the draft report, incorporating all of the new information, with relevant analyses and conclusions, to further strengthen the database defining the critical aspects such as the land availability, the impacts on the host population, and the job creation opportunities in order to more fully demonstrate the feasibility of the proposed resettlement.

The Panel recommends that CYJV make the necessary corrections and modifications to the draft report in line with the comments and suggestions presented in the following portions of this Panel report. Based on the evaluation of the quantity of the work to be completed, it is suggested that all volumes, except numbers 1, 3, 8 and 9, of the Final Feasibility Report be completed and submitted to the Chinese Government in March 1988 and that those four volumes be completed and submitted at the end of June 1988, provided CYJV can begin the effort by March 1, 1988.

The Panel believes that the complete set of the Final Feasibility Report, incorporating the recommended refinements and modifications, can serve as an adequate base to the Chinese Government in its decision making for TGP.

2. DESIGN AND CONSTRUCTION

2.1 Compliance with the Terms of Reference

The Panel considers the design and construction portion of the CYJV report to be in compliance with the Terms of Reference and with the supplementary instructions of the Steering Committee. CYJV has addressed all of the major issues that influence technical feasibility in a balanced manner and has employed internationally accepted methodology in its analyses. The Panel therefore believes that CYJV has adequately established the technical feasibility of the proposed Three Gorges Project and that there are no technical problems which cannot be resolved within the necessary standards of quality and safety.

In the following paragraphs the Panel presents comments on a number of important technical items in the report which, if modified in the text, would further enhance the feasibility report for the Project.

2.2 Technical Feasibility and Design Refinements

In its technical feasibility studies, CYJV has generally adopted conservative assumptions and criteria for layout and design of project structures. The Panel agrees that it is prudent to use such conservative criteria at the feasibility stage. It is recognized and recommended in the feasibility study that several refinements be carried out during the design stage. It is possible that they would reduce costs and improve technical and economic feasibility.

2.3 PMF and Spillway Capacity

CYJV has developed a PMF hydrograph by independent correlations and a thorough review of the extensive studies performed by YVPO using the deterministic approach. The Panel considers that CYJV has complied with the TOR in this regard, as recommended during the 4th SC meeting. The spillway should be capable of passing the PMF without overtopping the dam, assuming that there is no discharge through the powerhouse. The final decision regarding the PMF and spillway configuration should be made during the design stage.

2.4 Reservoir Operating Levels and DCL

The Panel endorses the adoption of the CYJV recommended project with the DCL/NPL/FCL combination of 185/160/140 m for demonstrating the technical and economic feasibility of the project.

With the DCL at 185 m, the project structures and the generating units will also be able to accommodate NPLs up to 175 m, with appropriate modifications in the spillway, powerplants, generating units and navigation locks.

If it is decided to operate the reservoir by increasing the NPL from about 150 m to 175 m in steps, the technical modifications which would be necessary should be incorporated in the project design before the decision is made to proceed with the Project.

The Panel does not endorse the adoption of a minimum normal operating level of 130 m. The reservoir is to be operated at this level only when necessary, and for short duration, to flush out accumulated sediment. The exception to this is the early operation of 11 units for the initial 2 to 5 years, when the minimum operating level is to be 130 m. At this operating level, reduced unit efficiency and increased risk of cavitation will be expected.

The Panel agrees that raising the DCL from 175 m to 185 m, in combination with FCL of 140 m is justified on the basis of substantial incremental flood control benefits and that this increase does not substantially affect the construction schedule risks. It is likely that any further increase in the height of the dam would impair the proposed construction schedule.

2.5 Generating Units

Since CYJV has demonstrated the technical feasibility of the 761 MW units on the basis of international experience in design and manufacture, the Panel agreed at the 4th SC meeting that it is appropriate to use twenty-two 761 MW units for the feasibility study. Therefore, the TOR have been satisfied on this issue.

CYJV has prepared estimates based on the initial four generating units being provided by international manufacturers and with major portions of the remaining units being supplied by Chinese manufacturers. This is in accordance with instructions given to CYJV, and this scenario fits with the YVPO plan of using 575 MW units. However, with the 761 MW rating recommended by CYJV, the Panel believes that, when policy decisions are made concerning the units, consideration should be given to increasing the number of units provided by international manufacturers to allow additional time for Chinese capacity to expand.

Since the physical size of these units will be 20 to 30 percent larger than the existing units of comparable capacity (Grand Coulee, Itaipu, and Guri), the Panel recommends that an independent verification of unit parameters and capacity be made before selection of the final unit capacity and size. Any change in unit capacity would affect the spillway size and other features. The purpose of such an independent study would be to establish the most suitable size of the units considering the following:

- The Chinese procurement policies for import of technology, materials and equipment components.
- The Chinese plans for expanding the national manufacturing capability for large turbines, generators and their components.
- International capability to manufacture the very large thrust bearings, and to assure rotor and stator stability.
- Turbine performance at the minimum reservoir level of 130 – 135 m which will be required of the first 11 units for 2 to 5 years.

A design head of 83 m was used for the turbines for the recommended project in the CYJV study. This is appropriate for the Feasibility Study. The Panel agrees with CYJV that with this design head the turbines would operate with minimum cavitation in the FCL 140 m and the NPL 160 m range. It would be necessary to assure that the turbine would also operate at the 130 m reservoir level without excessive cavitation if other operating levels are considered in final design.

2.6 Construction Management Planning and Schedule

In order to assure timely start and completion of the TGP, the Panel emphasizes the importance of early and detailed planning for critical actions and policy decisions regarding international bidding, contract packages, and procurement of construction and permanent equipment. The Panel strongly endorses the intention of CYJV to address this in the Feasibility Report.

The Panel recommends that alternative methods of procurement for design, construction and equipment be addressed prior to final design.

The Panel emphasizes that a competent and efficient project management organization, including the participation of international experts, must be established and be in operation before the start of construction. Such an organization must have requisite authority for design, procurement, expediting, and construction scheduling, financial control and for contingency planning. Only with such an organization in place and operating effectively can the schedule proposed by CYJV be realized.

The Panel concludes that the CYJV schedule, with the first generation of power in the 12th year, is appropriate for feasibility analysis, provided the work is awarded by international competitive bidding. However, the Panel believes that refined preplanning, acceleration of the preparatory work and early procurement of critical construction plant, is necessary to improve the probability of the schedule being maintained.

CYJV has indicated the following activities to be the most critical to the success of the schedule:

- 1) Stage II Cofferdams, particularly the cut-off walls.
- 2) Stage III RCC Cofferdam.
- 3) Concrete placement in the spillway.
- 4) First closure of diversion gates from the top of the dam.

The Panel recommends that detailed studies be made of alternatives and of additional measures which may be necessary to overcome the risk of delays during the critical activities.