Three Gorges Water Control Project
Feasibility Study

People's Republic of China

Volume 11
Regional Economic Impacts

March 1988

Sponsored by
Canadian International Development Agency

CIPM Yangtze Joint Venture
# THREE GORGES PROJECT FEASIBILITY STUDY

## LIST OF VOLUMES

<table>
<thead>
<tr>
<th>Volume</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive Summary</td>
<td></td>
</tr>
<tr>
<td>Volume 1</td>
<td>Feasibility Report</td>
</tr>
<tr>
<td>Volume 2</td>
<td>Construction Planning, Scheduling &amp; Estimating</td>
</tr>
<tr>
<td>Volume 3</td>
<td>Economic and Financial</td>
</tr>
<tr>
<td>Volume 4</td>
<td>Design</td>
</tr>
<tr>
<td>Volume 5</td>
<td>Sediment</td>
</tr>
<tr>
<td>Volume 6</td>
<td>Navigation</td>
</tr>
<tr>
<td>Volume 7</td>
<td>Flood Control</td>
</tr>
<tr>
<td>Volume 8</td>
<td>Environment</td>
</tr>
<tr>
<td>Volume 9</td>
<td>Resettlement</td>
</tr>
<tr>
<td>Volume 10</td>
<td>Power Benefits</td>
</tr>
<tr>
<td></td>
<td>Part 1 — Least Cost Expansion</td>
</tr>
<tr>
<td></td>
<td>Part 2 — Transmission</td>
</tr>
<tr>
<td>Volume 11</td>
<td>Regional Economic Impacts</td>
</tr>
</tbody>
</table>
# VOLUME 11 - REGIONAL ECONOMIC IMPACTS

## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table of Contents</td>
<td>i</td>
</tr>
<tr>
<td>List of Tables</td>
<td>iv</td>
</tr>
<tr>
<td>List of Figures</td>
<td>v</td>
</tr>
<tr>
<td>List of Plates</td>
<td>vi</td>
</tr>
<tr>
<td>List of Appendices</td>
<td>vii</td>
</tr>
<tr>
<td>List of Abbreviations</td>
<td>viii</td>
</tr>
<tr>
<td>Glossary of Chinese Terms</td>
<td>ix</td>
</tr>
<tr>
<td>Definitions</td>
<td>ix</td>
</tr>
<tr>
<td>PREFACE</td>
<td></td>
</tr>
<tr>
<td>1. SUMMARY</td>
<td>1–1</td>
</tr>
<tr>
<td>1.1 Project Development Benefits</td>
<td>1–1</td>
</tr>
<tr>
<td>1.2 The Distribution of Benefits</td>
<td>1–2</td>
</tr>
<tr>
<td>1.2.1 Employment</td>
<td>1–2</td>
</tr>
<tr>
<td>1.2.2 Power Generation</td>
<td>1–5</td>
</tr>
<tr>
<td>1.2.3 Flood Control</td>
<td>1–5</td>
</tr>
<tr>
<td>1.2.4 Navigation</td>
<td>1–5</td>
</tr>
<tr>
<td>1.2.5 Other Effects</td>
<td>1–5</td>
</tr>
<tr>
<td>1.3 Conclusions</td>
<td>1–5</td>
</tr>
<tr>
<td>2. INTRODUCTION</td>
<td>2–1</td>
</tr>
<tr>
<td>2.1 Purpose of the Regional Analysis</td>
<td>2–1</td>
</tr>
<tr>
<td>2.2 Scope and Limitations</td>
<td>2–1</td>
</tr>
<tr>
<td>2.3 Approach and Report Organization</td>
<td>2–2</td>
</tr>
<tr>
<td>3. REGIONAL OVERVIEW</td>
<td>3–1</td>
</tr>
<tr>
<td>3.1 The National Context</td>
<td>3–1</td>
</tr>
<tr>
<td>3.2 The Economies of the Three Provinces</td>
<td>3–4</td>
</tr>
<tr>
<td>3.2.1 Hunan</td>
<td>3–4</td>
</tr>
</tbody>
</table>
3.2.2 Hubei ................................................................. 3–7
3.2.3 Sichuan ............................................................... 3–7
3.3 Summary of the Effects in the Regions Within the Provinces . 3–7
4. IMPACT OF PROJECT BENEFITS .............................. 4–1
  4.1 Power Benefits Distribution ...................................... 4–1
  4.2 Flood Protection Benefits ................................ ........ 4–1
    4.2.1 The Distribution of Flood Benefits ......................... 4–3
    4.2.2 Project and Development Benefits ......................... 4–3
  4.3 Navigation Benefits ............................................... 4–11
    4.3.1 General ......................................................... 4–11
    4.3.2 Distribution of Benefits ...................................... 4–12
    4.3.3 Project and Development Benefits ......................... 4–13
5. PROJECT COST IMPACTS ............................................ 5–1
  5.1 Three Gorges Project and Mixed Hydro—Thermal Alternative Inputs ......................... 5–1
  5.2 Input Sources ..................................................... 5–6
    5.2.1 Materials ...................................................... 5–9
    5.2.2 Construction Equipment ....................................... 5–9
    5.2.3 Permanent Equipment .......................................... 5–10
    5.2.4 Labour .......................................................... 5–10
    5.2.5 Other Items (the Three Gorges Project) ................. 5–10
    5.2.6 Coal (Mixed Hydro—Thermal Alternative) ................ 5–11
  5.3 Regional Employment Impacts .................................... 5–11
  5.4 Impact on Yichang ............................................... 5–14
    5.4.1 Yichang’s Economic Base ...................................... 5–14
    5.4.2 Gezhouba Construction Bureau Employment ............... 5–16
    5.4.3 Effects of Gezhouba Construction Bureau Wages and Expenditures ......................... 5–18
    5.4.4 The Effect of the Three Gorges Project on the Yichang Area Economy .................. 5–18
    5.4.5 Summary of Impacts on the Yichang Area ................ 5–21
5.5 Other Project Benefits ........................................... 5–22
   5.5.1 Technology Transfer ......................................... 5–22
   5.5.2 Air Quality .................................................. 5–23

6. THE RESERVOIR REGION AND THE RESETTLEMENT PROGRAM 6–1
   6.1 The Resettlement Program ...................................... 6–1
   6.2 The Economy of the Reservoir Area ......................... 6–1
      6.2.1 Population and Labour Force .......................... 6–3
      6.2.2 Agriculture ................................................ 6–5
      6.2.3 Industry .................................................... 6–5
      6.2.4 The Third Estate ......................................... 6–6
      6.2.5 Incomes ...................................................... 6–6
      6.2.6 Outlook ...................................................... 6–7
   6.3 The Three Gorges Project as a Constraint on Investment 6–8
   6.4 The Resettlement Impact ...................................... 6–9
      6.4.1 Resettlement With Development ....................... 6–9
      6.4.2 The Need for Regional Planning ....................... 6–12
   6.5 Development Issues and Conclusions ....................... 6–13

7. CHONGQING ....................................................... 7–1

LITERATURE CITED
LIST OF TABLES

1.1 Summary Table of Regional, Social and Economic Effects of the Three Gorges Project in Comparison to the Mixed Hydro-Thermal Alternative ........................................ 1–3

3.1 Selected Indicators of the Chinese Economy .................................. 3–2

3.2 Rural Urban Distribution of Population ........................................ 3–3

4.1 Power Benefits Distribution ...................................................... 4–2

4.2 Distribution of Flood Control Benefits in the Flood Plain ............ 4–4

4.3 An Example of the Land Use Change Potential in the Flood Plain ......................................................... 4–5

4.4 Average Yields of Selected Crops in the Flood Plain Compared to International Yields ......................................................... 4–7

5.1 Generation Plan Without the Three Gorges Project .................... 5–3

5.2 Transmission Inputs to the Three Gorges Project and the Mixed Hydro-Thermal Alternative ................................. 5–5

5.3 Value of Domestic Inputs to the Three Gorges Project and the Mixed Hydro-Thermal Alternative ................................. 5–7

5.4 Coal Savings Attributable to Three Gorges ................................. 5–8

5.5 Comparison of Total Employment (Direct and Indirect) Created by Construction and Transmission Work by the Three Gorges Project and the Mixed Hydro-Thermal Alternative 5–12

5.6 Yichang Area: Employment and Expenditure Summary – Alternative Scenarios ................................................................. 5–20

6.1 Average County Incomes in the Reservoir Region in 1985 ............ 6–2

6.2 Labour Force Distribution in the Reservoir Area .......................... 6–4
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Selected Provincial Indicators: Gross Output Value of Agriculture and Industry, 1985</td>
<td>3–5</td>
</tr>
<tr>
<td>5.1</td>
<td>Transmission With and Without the Three Gorges Project</td>
<td>5–2</td>
</tr>
<tr>
<td>5.2</td>
<td>Estimated Employment Distribution, Three Gorges Project and Mixed Hydro–Thermal Alternative</td>
<td>5–13</td>
</tr>
<tr>
<td>5.3</td>
<td>Yichang Area Sectoral Employment</td>
<td>5–15</td>
</tr>
<tr>
<td>5.4</td>
<td>Selected Cities: Sectoral Industrial Output Values per Capita, 1985</td>
<td>5–17</td>
</tr>
<tr>
<td>5.5</td>
<td>Yichang Area: Total Wages by Sector, 1985</td>
<td>5–19</td>
</tr>
<tr>
<td>6.1</td>
<td>Income Growth Scenarios of the Resettlement Population</td>
<td>6–10</td>
</tr>
</tbody>
</table>
LIST OF PLATES

11.1 Regions in Study Area

11.2 Changes in Flood Frequency in Flood Plan Areas

11.3 Potential Input Sources

11.4 Reservoir Area Administrative Boundaries
LIST OF APPENDICES

11A — THE ECONOMICS OF SICHUAN, HUBEI AND HUNAN

11B — EMPLOYMENT ESTIMATES, MIXED HYDRO–THERMAL ALTERNATIVE AND COAL TRANSPORTATION

11C — DIRECT AND INDIRECT EMPLOYMENT, THREE GORGES PROJECT AND MIXED HYDRO–THERMAL ALTERNATIVE
**LIST OF ABBREVIATIONS**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>Cohesion</td>
</tr>
<tr>
<td>CAAS</td>
<td>Chinese Academy of Agricultural Sciences</td>
</tr>
<tr>
<td>CIDA</td>
<td>Canadian International Development Agency</td>
</tr>
<tr>
<td>CPE</td>
<td>Chinese Panel of Experts (under leading group for Three Gorges Project studies)</td>
</tr>
<tr>
<td>Cs</td>
<td>Coefficient of Skewness</td>
</tr>
<tr>
<td>Cv</td>
<td>Coefficient of Variation</td>
</tr>
<tr>
<td>CYJV</td>
<td>CIPM—Yangtze Joint Venture</td>
</tr>
<tr>
<td>CSICSC</td>
<td>China Statistical Information and Consultancy Service Center</td>
</tr>
<tr>
<td>DBE</td>
<td>Design Basis Earthquake</td>
</tr>
<tr>
<td>DCL</td>
<td>Dam Crest Level</td>
</tr>
<tr>
<td>DEM</td>
<td>Dong Fang Electrical Machine Works (China)</td>
</tr>
<tr>
<td>ECEPDI</td>
<td>East China Electric Power Design Institute (China)</td>
</tr>
<tr>
<td>EIA</td>
<td>Environmental Impact Assessment</td>
</tr>
<tr>
<td>EIS</td>
<td>Environmental Impact Statement</td>
</tr>
<tr>
<td>El</td>
<td>Elevation</td>
</tr>
<tr>
<td>EPPEI</td>
<td>Electrical Power Planning and Engineering Institute (China)</td>
</tr>
<tr>
<td>EPRI</td>
<td>Electrical Power Research Institute</td>
</tr>
<tr>
<td>f</td>
<td>Coefficient of Friction</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization (United Nations)</td>
</tr>
<tr>
<td>f'c</td>
<td>Concrete Compressive Strength as measured by Standard Tests</td>
</tr>
<tr>
<td>FJHM</td>
<td>Fu Chun Jiang Hydraulic Machining Works (China)</td>
</tr>
<tr>
<td>FCL</td>
<td>Flood Control Level</td>
</tr>
<tr>
<td>GIS</td>
<td>Gas Insulated Switchgear</td>
</tr>
<tr>
<td>HEM</td>
<td>Harbin Electric Machine Works (China)</td>
</tr>
<tr>
<td>HPPEI</td>
<td>Hydro Power Planning and Engineering Institute (China)</td>
</tr>
<tr>
<td>IBRD</td>
<td>International Bank for Reconstruction and Development (World Bank)</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
</tr>
<tr>
<td>IWHR</td>
<td>Institute of Water Conservancy and Hydroelectric Power Research (Beijing)</td>
</tr>
<tr>
<td>MAAF</td>
<td>Ministry of Agriculture, Animal Husbandry and Fisheries (China)</td>
</tr>
</tbody>
</table>
LIST OF ABBREVIATIONS (Cont’d.)

MCE — Maximum Credible Earthquake
MFL — Maximum Flood Control Operating Level
MOC — Ministry of Communications (China)
MOFERT — Ministry of Foreign Economic Relations and Trade (China)
Ms — Earthquake Magnitude as Indicated by the Surface Wave
MURCEP — Ministry of Urban and Rural Construction and Environmental Protection (China)
MWREP — Ministry of Water Resources and Electric Power (China)
NEPA — National Environmental Protection Agency (China)
NPL — Normal Pool Level
PDL — Power and Navigation Drawdown Limit
PMF — Probable Maximum Flood
PRC — People’s Republic of China
RCC — Roller Compacted Concrete
SF6 — Sulphur Hexafluoride (the gas used for insulating GIS)
TGPDC — Preparation Office for Three Gorges Project Development Corporation (China)
TGDEO — Three Gorges Economic Development Office (China)
TGM — Chinese Three Gorges mathematical model
TWL — Tail Water Level
UNDP — United Nations Development Program
USBR — United States Bureau of Reclamation
USCE — United States Corps of Engineers
YSRI — Yangtze Scientific Research Institute (China)
YVPO — Yangtze Valley Planning Office (China)
YWRPB — Yangtze Water Resources Protection Bureau (China)
ZEPDI — Zhongnan (South Central) Electric Power Design Institute (China)
GLOSSARY OF CHINESE TERMS

cheng/shi  city
    cun  village
    danwei  work unit
    diqu  prefecture
    he  river
    hu  lake
    jiang  river
    jin  unit of weight  = 0.5 kg
    mu  unit of area  = 0.067 ha
    Sanxia  Three Gorges
    xiang  township/county
    yuan  monetary unit  = 0.3545 Canadian dollars
           = 0.2703 U.S. dollars

DEFINITIONS

Requisition Level: Elevation below which compensation is paid for farmland, woodland, buildings and infrastructures in the reservoir study area. For most structures this level corresponds to NPL + 2 m or the 1:20 flood level, whichever is higher (Volume 9, Figure 5.1).

Relocation Level: Elevation above which people and structures are resettled. For most structures, this level corresponds to EL 182 for the CYJV Recommended Project or the 1:20 flood level, whichever is higher (Volume 9, Figure 5.1).

Steering Committee (SC): A committee established to oversee the feasibility study, assure its quality and provide overall direction to the Consultant and MWREP resources assigned to the conduct of the study. It consisted of nominees from MWREP, IBRD and CIDA plus eminent Chinese and international experts serving as ex-officio members.
PREFACE

I. BACKGROUND

The Chang Jiang or Yangtze, the largest river in China, carries nearly 40% of the country's annual runoff. From the grassy plains of Qinghai province, the river flows eastward, cutting through successive mountain ranges and ridges before meandering across the Central China plains.

The Three Gorges Water Control Project, located near the mouth of the Three Gorges, can provide flood protection to approximately 1 million km² in the middle reaches of the Yangtze Valley, generate a large amount of hydroelectric power and improve navigation in the Yangtze River between Chongqing and Shanghai. It involves construction of a dam, about 175 m high, at Sangouping in the middle section of the Xiling Gorge, 40 km upstream of Yichang and the relocation of a large population from the affected reservoir area.

In 1983, the Yangtze Valley Planning Office, an agency of the Ministry of Water Resources and Electric Power prepared a feasibility report for the Three Gorges Project, with a dam crest level of 165 m, a Normal Pool Level of 150 m, an installed generating capacity of 13 000 MW and permanent navigation locks adequate to pass 10 000 t tows. It was subsequently approved by the State Council of the People's Republic of China with the provision that the dam crest be increased to 175 m. In March 1985, a Preliminary Design Report for this project was completed.

Requests were made by the Ministry of Communications (MOC) and the city of Chongqing, that levels be raised to further improve navigation. In March 1986, the Ministry of Water Resources and Electric Power (MWREP) prepared a revised report recommending a Normal Pool Level of 160 m, a dam crest level of 175 m, and an installed generating capacity of 14 800 MW, other features remaining unchanged.

A number of detailed investigations on various aspects of the project have been continued since 1983, including engineering, sedimentation, landslides, environmental impact, resettlement, power planning, construction planning and cost estimating.
II. PURPOSE OF THE FEASIBILITY STUDY

The purpose of the Feasibility Study is to evaluate on a basis acceptable to international financial institutions, the technical and economic feasibility of the Three Gorges Project and the viability of the financial investment.

For this purpose the Ministry of Water Resources and Electric Power and the Canadian International Development Agency engaged CIPM Yangtze Joint Venture to prepare a Feasibility Report that would provide an impartial technical input to the Government of China in its decision-making process, and could form a basis for securing funding from international institutions.

The Feasibility Report was to be comprehensive, covering costs and benefits of the main aspects of flood control, power generation and transmission, navigation, resettlement and environment. The Report was to assess whether the Project represents the least cost solution for deriving the planned benefits and how project features have been optimized. For this Study, CIPM Yangtze Joint Venture was requested to study a full range of schemes defined by four normal pool levels at El 150, 160, 170, and 180. This range of levels primarily affects the project operation, the extent of resettlement, and the benefits for flood control, power and navigation.

III. ORGANIZATION OF THE FEASIBILITY REPORT

The results of the Feasibility Study are presented in an Executive Summary and 11 Volumes as listed below. Volumes 1 and 3 are general volumes dealing with the entire project. Volume 2 is a general volume providing the construction cost estimate and schedule. Volumes 4 through 11 are supporting volumes, each dealing with its designated subject.

The list of volumes is as follows:

General Volumes:

Executive Summary

1. Feasibility Report
2. Construction Planning, Scheduling and Estimating
3. Economic and Financial
Supporting Volumes:

4. Design
5. Sediment
6. Navigation
7. Flood Control
8. Environment
9. Resettlement
10. Power Benefits
11. Regional Economic Impacts.

IV. BASIC DEFINITIONS FOR THE FEASIBILITY REPORT

A number of concepts and assumptions which are common throughout the study are presented below.

Operating Water Levels:

— Winter Dry Season

During October, at the end of the wet season, the reservoir will be filled to Normal Pool Level. This is the highest normal operating level of the reservoir. Water levels will be maintained at Normal Pool Level until stored water is needed during critical dry periods to increase outflows for navigation and power.

In winter, the lowest level of drawdown which will occur only occasionally, is called the Power and Navigation Drawdown Limit. Winter operating storage is defined as the volume between Normal Pool Level and Power and Navigation Drawdown Limit.

During the winter season, the power plant will operate at full head when at the Normal Pool Level but with reduced output depending on the dry season inflows. Daily peaking operations will be possible with reregulation in the Gezhouba reservoir to ensure steady flows downstream.

— Summer Flood Season

During the month of May, power generation is increased to draw down the reservoir to its Flood Control Level for sediment control and increased flood storage. This is the lowest normal operating level of the reservoir.
in the period June through September. During this period, reservoir inflows are used for power generation while attempting to hold the reservoir at the Flood Control Level. Excess inflows are released to flush sediment through the reservoir and past the structures by means of submerged spillway bays.

Flood control storage is provided above the Flood Control Level. For moderate floods, up to the 1:50 year occurrence, flood control is provided without the reservoir exceeding the Normal Pool Level. For greater floods, levels will rise higher depending on the magnitude of the inflows.

Development Dates:

The following schedule dates were assumed:

- Government of China decision to proceed July 1988
- Start of construction support facilities and Year 1 of Project schedule January 1989
- Approval of Stage 1 Construction January 1990
- Start of Construction, Stage I Cofferdam October 1990
- Start of Resettlement January 1991
- First power on line, Units No. 1 & 2 August 2000
- Completion of Resettlement January 2003
- Completion of last unit December 2006

Costs and Benefits:

All costs and benefits in the report are calculated at January 1987 price levels. Net present values of annual cost and benefit streams are computed using a discount rate of 10% per annum.
V. DESCRIPTION OF THE RECOMMENDED PROJECT

The recommended project which results from this Feasibility Study consists of:

- **A Concrete Gravity Dam** 2.5 km long with crest level at El 185. The dam is made up of a central spillway flanked by gravity dams on each side.

- **Navigation Structures** on the left bank made up of a single temporary lock and twin five-flight locks as permanent facilities.

- **Two Powerhouses** downstream of the left and right bank intake blocks. Each powerhouse has 11 units and 2 service bays.

And is based on:

- **Reservoir Land Requisition Level** – the 1:20-year flood level for permanent residences and the 1:100-year flood level for large factories. All displaced structures are to be relocated above El 182, which corresponds with the 1:1000-year flood level at the dam.

- **Resettlement Planning Criteria** which improve living conditions of the affected population ("resettlement with development").

- **Environmental Planning Criteria** which protect rare and endangered species and provide improved facilities to mitigate other effects.

Salient data for the recommended project are given below.

**SALIENT DATA FOR CYJV RECOMMENDED PROJECT**

1. **Reservoir Data and Discharges**

<table>
<thead>
<tr>
<th></th>
<th>Elevation (m)</th>
<th>Volume (m³)</th>
<th>Discharge (m³/s)</th>
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<tbody>
<tr>
<td>Normal Pool Level (NPL)</td>
<td>160</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flood Control Level (FCL)</td>
<td>140</td>
<td></td>
<td></td>
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<tr>
<td>Power and Navigation Drawdown Limit (PDL)</td>
<td>140</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Flood Control Operating Level (MFL) and Discharge</td>
<td>181</td>
<td>80 000</td>
<td></td>
</tr>
<tr>
<td>Check Flood Level (PMF) and Discharge</td>
<td>183</td>
<td>116 000</td>
<td></td>
</tr>
<tr>
<td>Total Storage</td>
<td>48.1 x 10⁹</td>
<td></td>
<td></td>
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<tr>
<td>Flood Control Storage</td>
<td>31.0 x 10⁹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Annual Runoff Volume</td>
<td>451 x 10⁹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Annual Discharge</td>
<td>14 300</td>
<td></td>
<td></td>
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<tr>
<td>Regulated Discharge during Dry Season</td>
<td>5 120</td>
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</tr>
</tbody>
</table>
2. Project Effects

Flood Protection Provided for Downstream Area:

- 1:100—year flood, without diversion into Jingjiang Region, water level at Shashi not to exceed El 44.5.

- 1:1000—year flood, with diversion into Jingjiang Region, water level at Shashi not to exceed El 45.0.

Flood Protection Provided for the Reservoir Area:

- to El 160: 1:45 year flood

- to El 181: 1:1700 year flood

Total Installed Capacity 16 750 MW
Long—term Average Annual Energy 76.2 TWh
Improved Navigation Distance in the Reservoir 500—600 km
Inundated Cultivated Land 300 000 mu (20 000 ha)
Affected Population to be Resettled to above El 182. 727 000
Length of roads and highways to be relocated 650 km
County seats affected 11
Towns affected 104

3. Main Structures and Facilities

Concrete gravity intake dam and spillway:

- Crest Elevation 185 m
- Maximum Height 175 m
- Crest Length 2 150 m
- Submerged Spillway Bays 27 — 7 m wide x 9 m high
- Overflow Bays 26 — 8 m wide

Powerhouses:

- Left Powerhouse, 11 units at 761 MW
- Right Powerhouse, 11 units at 761 MW
- Turbines — Nominal Rated Output 695 MW
- Generators — Nominal Rated 845 MVA at 0.9 power Capacity factor
- Main Transformers 3 single phase/unit
- Switchyard 500 kV, Metal clad SF6 GIS
Transmission
Temporary Navigation Lock
Permanent Navigation Locks

12 circuits, 500 kV AC
Single stage 33 m maximum lift
Twin five stage flight locks, 20 m lift per stage

4. **Construction Work**

Excavation
Embankment fill (soil and rock)
Plain and Reinforced Concrete
Steel Reinforcement
Structural Steel
Total Time of Construction
Construction Time to First Generation

87 100 000 m³
34 100 000 m³
25 300 000 m³
290 000 t
210 000 t
18 years
140 months (11.7 yr)

5. **Manpower Requirements**

Total manpower for construction, manufacturing and material supply

942 000 man yr
1. SUMMARY

The regional analysis has two main themes: the identification of development benefits and their distribution throughout the country. The benefits are measured against what would have happened if, instead of the Three Gorges Project, a mixed hydro-thermal system were built. This volume presents the regional point of view as opposed to the national point of view which is contained in the Economic Analysis in Volume 3.

The analysis also examines the impact of structural and institutional factors on both the realization of and distribution of project benefits. The area covered by the regional analysis extends from the floodplain below the dam to the head waters of the reservoir, and includes portions of three provinces: Hubei, Hunan and Sichuan.

1.1 Project Development Benefits

The first theme reflects the findings of other reports which deal with the direct economic benefits associated with the Three Gorges Project. The project will generate inexpensive power compared to the least cost alternative, offer greater flood protection than exists now, and provide improved and lower cost navigation. In addition to these direct benefits, there are several other important and related benefits which, though not entirely quantifiable, could be very substantial. Among them are:

- increased opportunities for more profitable agricultural land uses in the floodplain;
- a reduction of flood risk in the floodplain which should improve the opportunities for local investors;
- opportunities to transfer new technology;
- improved air quality, particularly around Shanghai and Wuhan, as compared with what would have happened if the Three Gorges Project were not built; and
- opportunities to raise incomes in the reservoir area above what they would have been without Three Gorges Project, and to move the reservoir area into the mainstream of the economy. In general, incomes should rise by 3–8% in the reservoir area and could rise even further if proper regional planning approaches are taken.
1.2 The Distribution of Benefits

The second theme is concerned with the distribution of benefits. These have been assigned to five areas:

- the Floodplain;
- Yichang;
- the Reservoir Area;
- Chongqing;
- the rest of China.

Table 1.1 summarizes the distribution of benefits on a provincial basis. These benefits in turn are divided into five main categories: employment, power generation, flood control, navigation, and other.

1.2.1 Employment

The construction of the generation and transmission facilities for the Three Gorges Project will create some 668,000 direct man years of work and 274,000 indirect man years of work for a total of 942,000 man years. Over half of the employment created will go to the three provinces of Sichuan, Hubei and Hunan with Hubei benefiting to the extent of 390,600 direct and indirect man years or 41.5% of the total. Within Hubei province Yichang city receives the greatest impact with an additional 20,000 full time jobs.

Northeast China, where many of the manufacturing plants are located, would benefit to the extent of 136,500 person years of work of 14.5% of the total while various other provinces would gain 290,000 man years or 31% of the total.

Quite apart from the jobs created by the supply of inputs to, and construction of Three Gorges Project, there will be some 600,000 man years of work involved in the reconstruction of buildings and infrastructure around the perimeter of the reservoir. These jobs, however, are essentially replacements for jobs eliminated by inundation and resettlement.

By comparison, the higher cost Mixed Hydro-Thermal Alternative would create about 1/3 more direct employment with 888,000 man years and, because of the larger domestic component and lower capital intensity, this alternative would create more indirect employment with 608,000 person-years for a total of 1,496,000 man years or about 60% more employment overall than the Three Gorges Project. These numbers exclude employment in coal mining and generation plant operation, the former of which could create some 18,000 jobs.
<table>
<thead>
<tr>
<th>Province or Region</th>
<th>Direct and Indirect Employment (Man Years x 10^3)</th>
<th>Power Generation Effects</th>
<th>Flood Control Effects</th>
<th>Navigation Effects</th>
<th>Other Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hubei</td>
<td>296.64</td>
<td>273.16</td>
<td>receives 15.3% of Power Benefits of TGP</td>
<td>- receives 82% of benefits, 2.4910^6 Yuan</td>
<td>- Jiezhang and Honghu Div. areas are main recipients.</td>
</tr>
<tr>
<td>(%) of Total</td>
<td>41.51%</td>
<td>18.32%</td>
<td></td>
<td>little change in agriculture</td>
<td>- small industry aided only in Honghu</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- no change in State-owned industry</td>
<td>- some benefit from reduced diesel maintenance and expansion costs.</td>
</tr>
<tr>
<td>Huaian</td>
<td>67.87</td>
<td>197.13</td>
<td>receives 10.1% of Power Benefits of TGP</td>
<td>- receives 17% of benefits, 4.9310^6 Yuan</td>
<td>- Dongting Lake Div. area main recipient</td>
</tr>
<tr>
<td>(%) of Total</td>
<td>7.21%</td>
<td>9.83%</td>
<td></td>
<td></td>
<td>- some benefit to 8.7.1.3 Protected areas</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- some benefit from reduced diele maintenance and expansion costs.</td>
</tr>
<tr>
<td>Sichuan</td>
<td>55.87</td>
<td>122.51</td>
<td>receives minor Power Benefits from TGP</td>
<td>- receives 8.2% of Power Benefits of TGP</td>
<td>- some indirect benefit to trade and industry</td>
</tr>
<tr>
<td>(%) of Total</td>
<td>5.91%</td>
<td>8.25%</td>
<td></td>
<td></td>
<td>- increased barge and tug building</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- likely receivers of direct economic benefits unknown.</td>
</tr>
<tr>
<td>Shanghai</td>
<td>29.64</td>
<td>252.19</td>
<td>receives no Power Benefits from TGP</td>
<td>- receives 56.2% of Power Benefits of TGP</td>
<td>- Power benefits will be received by all provinces in Central and East China</td>
</tr>
<tr>
<td>(%) of Total</td>
<td>3.11%</td>
<td>16.51%</td>
<td></td>
<td></td>
<td>- flood protection insignificant downstream of Wuhan.</td>
</tr>
<tr>
<td>Northeast China</td>
<td>136.52</td>
<td>268.79</td>
<td>receives 56.2% of Power Benefits of TGP</td>
<td>- Power benefits will be received by all provinces in Central and East China</td>
<td>- improved navigation may have benefits for trade all along the Yangtze, but of unknown magnitude and distribution.</td>
</tr>
<tr>
<td>(%) of Total</td>
<td>14.51%</td>
<td>17.43%</td>
<td></td>
<td></td>
<td>- TGP avoids air pollution from coal and gas turbine plants proposed for some East and Central China Provinces under MTA.</td>
</tr>
<tr>
<td>Rest of China</td>
<td>261.21</td>
<td>440.54</td>
<td>receives 15% of Power Benefits of TGP</td>
<td>- receives 18.2% of Power Benefits of TGP</td>
<td>- technology transfer to centres of electrical manufacturing may be large.</td>
</tr>
<tr>
<td>(%) of Total</td>
<td>27.71%</td>
<td>29.45%</td>
<td></td>
<td></td>
<td>- MTA avoids air pollution by the 1000 MW coal plant proposed under MTA.</td>
</tr>
<tr>
<td>Total</td>
<td>941.85</td>
<td>2,146.42</td>
<td>receives 15% of Power Benefits of TGP</td>
<td>- receives 18.2% of Power Benefits of TGP</td>
<td>- possible technology transfer due to construction of turbines and generators.</td>
</tr>
<tr>
<td>(% of Total)</td>
<td>100.02%</td>
<td>100.02%</td>
<td></td>
<td></td>
<td>- TGP avoids air pollution by the 1000 MW coal plant proposed under MTA.</td>
</tr>
</tbody>
</table>

Note:
- Includes only labor used in construction of rolling stock for coal transportation.
- Mining of coal involves an estimated 152,600 miners.
<table>
<thead>
<tr>
<th>Province or Region</th>
<th>Direct and Indirect Employment (Rmb Years x 10³)</th>
<th>Power Generation Effects</th>
<th>Flood Control Effects</th>
<th>Navigation Effects</th>
<th>Other Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floodplain</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Floodplain areas will receive a share of Power Benefits to Hubei and Hunan.</td>
<td>2300+10% Yuan benefits to floodplain, 9% to Hubei, 9% to Hunan; flood probabilities reduced in all areas due to reduced dyke maintenance and expansion costs.</td>
</tr>
<tr>
<td>Yichang</td>
<td>New Workers: 30</td>
<td>Underemployed: 14</td>
<td>Increase in T&amp;F employment: 200</td>
<td>Yichang will receive a share of the Power benefits to Hubei.</td>
<td>Possibly slight benefit due to increased river activity.</td>
</tr>
<tr>
<td>Reservoir Area</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Power Benefits will be received (600+)</td>
<td>Inundation requires relocation of approximately 740000 persons.</td>
</tr>
<tr>
<td>Chongqing</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>No Power Benefits will be received</td>
<td>Slight increase in maximum river stage, likely to cause increased flooding of low-lying areas during floods larger than 1:100 years.</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>15</td>
<td>600+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* These jobs constitute only the replacement of employment displaced by the formation of the reservoir.
Because the employment figures are significantly larger with the Mixed Hydro—Thermal alternative, all provinces, with the exception of Hubei, would secure more employment. In Hubei province only 273,000 man years of work would be created, some 118,000 less than with Three Gorges, Yichang city would suffer the greatest loss with some 35,000 fewer full—time jobs.

1.2.2 Power Generation

The power produced from the Three Gorges Project will be distributed among consumers in eastern Sichuan and the East and Central China Power Regions. Presumably, any cost savings will be distributed accordingly, although it is possible that the Central Government would keep all, or a portion, of those savings and apply them to the national system. Assuming the benefits are applied to load areas, benefits will be fairly evenly distributed with Hubei receiving 16%, the Shanghai area 18%, Hunan 14%, and the other provinces of the regions receiving the remaining 56%. In Sichuan, the reservoir area will receive a small amount of power benefit.

1.2.3 Flood Control

Flood control benefits naturally flow to the floodplain and to Hubei and Hunan provinces who receive 83% and 17% of the benefits, respectively.

1.2.4 Navigation

The incidence of navigation benefits was difficult to determine given that origin and destination and commodity data forecasts were not provided. Generally, there did not seem to be any reason why one particular area would benefit from improved navigation other than Chongqing.

1.2.5 Other Effects

Two other effects were noted: technology transfer and air quality. Technology transfer would tend to favour the areas where more high technology products would be manufactured. This would suggest that benefits would tend to be concentrated in the manufacturing areas of Shanghai and the northeast.

The Three Gorges Project results in annual reduction of coal usage of some 25 million tonnes. This represents a reduction in sulfur dioxide emissions of $143 \times 10^3$ per annum.

1.3 Conclusions

The chief beneficiaries of the Three Gorges Project will be the people of the floodplain, the electricity consumers of the East and Central China power regions, machinery manufactures in the northeast, the employees of the Gezhouba Construction Bureau in Yichang and people concerned with
air quality around thermal stations in Anhui, Jiangsu, Henan and Shanghai. In general, the benefits flow largely to Hubei province.

Resettlement (Volume 9) has indicated that the people of the reservoir area should be at least as well off as they would have been without the Project and should experience an overall income increase. There will be substantial employment in the reconstruction process but on a net basis no new jobs will be created. While there is a strong possibility that the Three Gorges Project will increase the chances of economic prosperity in the reservoir area, the degree to which reservoir area populations benefit above the level of compensation for the inconveniences associated with the project very much depends on the quality of the economic development planning that occurs in the area.

With the Mixed Hydro–Thermal Alternative, there is a more even distribution of benefits.

The distribution of benefits described in this report depends, to a large extent, on the degree to which China adopts pricing policies and flood management policies which will allow the forecast benefits to materialize.
2. INTRODUCTION

2.1 Purpose of the Regional Analysis

This report has two main objectives. The first is to determine the extent of economic development opportunities arising from the implementation of the project. The second is to estimate the impact of the Three Gorges Project on various regions of China. The regional impact analysis is an extension of the financial and economic analysis.

The financial analysis deals with money that is actually spent on the various aspects of the project; the cost to build the project and the actual revenues that the project will generate. The financial analysis is seen from the perspective of the ultimate owner or operator of the project.

The economic analysis examines the project from a national point of view. Resources (commodities and labour) are priced in a way that represents their real worth to the country. The economic analysis ignores taxes and subsidies and adjusts prices so that they reflect what China would have to pay for the resource if it were free to find its own value on the market. Economic analysis is the primary method used to evaluate the feasibility of the Three Gorges Project.

The regional analysis recognizes that cost and benefits have a spatial dimension and that different parts of China are affected in different ways. It also recognizes that perceptions of costs and benefits vary. A project cost incurred by the country could be perceived as a benefit to an individual for whom a job is created. However, it is important to realise that not all of the people will benefit directly through creation of employment, even though the project as a whole is of worth to the country. The policy makers need to assess carefully the benefits and costs to the people when allocating resources to the project. For example, the use of foreign exchange to purchase heavy construction equipment may carry the benefit of expedience in completion of the project, but may deprive certain centres of employment opportunities. In this case it must be shown that the benefits outweigh the costs.

2.2 Scope and Limitations

Each benefit and cost category is reviewed to determine potential project benefits related to economic development and the distribution of the impacts. Project benefits include power, flood protection, and navigation. Project costs comprise the construction of the dam, the navigation facilities, the resettlement program and environmental mitigation. Other costs such as dredging are smaller and are not dealt with in this report. The review compares the effect of the Three Gorges Project with an alternative scheme producing an equivalent amount of power (Section 4).
2.3 Approach and Report Organization

This report analyses how the CYJV Recommended Project for Three Gorges will change the economies of the areas it affects. The outlook for the regional economies is discussed in Section 3. Sections 4 to 7 discuss the impact of project costs and benefits in terms of their spatial dimensions and the development opportunities created.

The impacts are assigned to five regions (Plate 11.1) as follows:

- the flood plain, the low-lying area downstream of Yichang in the Provinces of Hubei and Hunan;
- the Yichang area in Hubei province;
- the reservoir region the counties surrounding the reservoir. This area encompasses the "Resettlement Area" in which resettlement will occur. The reservoir region lies in Hubei and Sichuan provinces;
- Chongqing City; and,
- the rest of China.

Impacts which cannot be assigned directly to a particular region are also discussed.

The distribution of impacts are measured in the report in most cases, in financial rather than economic terms. This is because the focus of the report is on how people in different areas perceive themselves to be affected by the Three Gorges Project. As financial prices measure the actual money received or spent, while economic prices weigh expenditures and receipts in terms of their value to the country, most people will understand the concept of financial prices better than economic prices.

While impacts are quantified wherever it is possible and useful, data availability and uncertainties require that in some cases only the general scale and direction of the impact can be indicated.
3. REGIONAL OVERVIEW

3.1 The National Context

Some of the major economic indicators of the Chinese economy in 1985 are summarized in Table 3.1.

Six main factors are expected to shape the Chinese economy and hence the economies of the regions over the coming decades. (See Volume 3, Appendix A for further discussion).

1. Population Growth: The population of the country is expected to grow at a rate of around 1.2% per annum. At this rate China's population will reach 1.25 x 10^9 by the turn of the century. (Table 3.2)

2. Rural/Urban Population: Increasing productivity in agriculture will mean fewer (although higher paying) jobs in farming. This implies that the farm will support fewer people and that population increases which are higher in the rural than in the urban areas will occur off the farm, either in adjacent villages or in the major cities. At the same time, the high cost of adding to China's already crowded largest urban centers will lead to policy developments which will encourage the growth of the larger centers in the countryside.

3. Economic Growth: A quadrupling of Gross Output Value of Agriculture and Industry (GOVIA) is expected by the year 2000. This implies a growth rate of around 7% per annum – a per capita growth of between 5% and 6% per annum when expected population increases are taken into account.

4. Sectoral Change: The next two decades should see a major shift in employment away from agriculture to industry (especially light industry) and the service sector. Therefore, little or no growth in the number of farm workers is expected, although there may be a substantial increase in employment in agriculture related industries.

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1 GOVIA refers to the cumulative value of all output in the agricultural and industrial sectors at each production phase. It is not equivalent to GNP or GDP which measure only value added at each stage of production and includes the output of other sectors such as services and education.
THREE GORGES PROJECT FEASIBILITY REPORT

TABLE 3.1 - SELECTED INDICATORS OF THE CHINESE ECONOMY

<table>
<thead>
<tr>
<th></th>
<th>Average Annual Growth Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1985</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Population (10^6)</td>
<td>0.45</td>
</tr>
<tr>
<td>Labour Force (10^6)</td>
<td>1.2</td>
</tr>
<tr>
<td>Total Product of Society (yuan x 10^9)</td>
<td>10.3</td>
</tr>
<tr>
<td>of which GOVAI</td>
<td>10.1</td>
</tr>
<tr>
<td>of which GOVA:</td>
<td>10.1</td>
</tr>
<tr>
<td>GOVI:</td>
<td>10.1</td>
</tr>
<tr>
<td>National Income (yuan x 10^9)</td>
<td>6.8</td>
</tr>
<tr>
<td>(Net Material Product)</td>
<td>NA</td>
</tr>
<tr>
<td>GNP (yuan x 10^9)</td>
<td>7.8</td>
</tr>
<tr>
<td>GDP* (yuan x 10^9)</td>
<td>7.8</td>
</tr>
<tr>
<td>GNP** per capita, 1984 (US $)</td>
<td>3.1</td>
</tr>
</tbody>
</table>

GOVAI - Gross output value of agriculture and industry. It is the cumulative value of all output at each production phase. It does not measure value added, and so is not equivalent to GNP. It is the most commonly used output measure in China.

GOVA - as above, but for agricultural sector only.

GOVI - as above, but for industrial sector only.

Total Product of Society - includes not only the productive sectors but non-productive sectors also. It also involves substantial double-counting.

Net Material Product (National Income) - closest approximation to the western definition of National Income from the material sectors, and involves no double-counting.


THREE GORGES PROJECT FEASIBILITY REPORT

TABLE 3.2 - RURAL URBAN DISTRIBUTION OF POPULATION

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Population (10^6)</th>
<th>Rural Proportion</th>
<th>Urban Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>1007.0</td>
<td>79.8%</td>
<td>20.2%</td>
</tr>
<tr>
<td>1983</td>
<td>1025.0</td>
<td>76.5%</td>
<td>23.5%</td>
</tr>
<tr>
<td>1985</td>
<td>1045.3</td>
<td>63.4%</td>
<td>36.6%</td>
</tr>
<tr>
<td>2000</td>
<td>1250.0*</td>
<td>42.7%**</td>
<td>57.3%2</td>
</tr>
</tbody>
</table>


Some of the shift to urban residence is a result of enlarging the definition of "urban centres".

* Assuming 1.2% growth rate per year.

**Rock Creek Research projections based on average 1.1% p.a. population growth, China Economic Trends, p. 10.
5. National Regional Development Policy: The need to allocate resources in an efficient manner has led to the adoption of a Central Government policy of encouraging greater specialization by various areas within the country. This is a change from the concept that each Province should be a separate autonomous economic unit. Recent policy has also stressed renovation and expansion of industry around existing centers rather than the development of new sites. Both forces will encourage the development of already heavily industrialized areas, such as Shanghai, and the maintenance of already specialized areas in the country; for example, heavy machinery production in northeast China will receive less emphasis than under older concepts of "equally" distributed development. This implies that there will be few funds available to specifically change current economic roles. This specialization policy implies improved links between manufacturing and resource centers. Given capital shortages, water based transportation systems may well be favored, and less emphasis be given to more expensive road and rail systems for bulk commodity transportation.

6. Investment: With state investment likely to focus more on infrastructure and related heavy industrial goods, light industry will have to rely increasingly on capital generated either internally or from collectives, individuals, and non-state owned operations.

Price reform and the associated prosperity of the agricultural communities has meant that a pool of capital has been created in the rural areas. This capital has been used for reinvestment in agriculture, in small private or collective industries and for the unofficial "purchasing" of jobs in larger industries. Continued prosperity in the light industrial sector will require that this capital should not be hoarded but reinvested in productive activities to further a secure investment climate for the rural communities.

3.2 The Economies of the Three Provinces

Four out of the five regions considered in this report are located in the Provinces of Hunan, Hubei and Sichuan. Figures 3.1 and 3.2 illustrate the production and employment structure of these three provinces.

3.2.1 Hunan

The province of Hunan has a population of $56 \times 10^6$, 70% of which is rural. By the year 2000 the population is estimated to reach $67 \times 10^6$ assuming a 1.2% p.a. growth rate. At 44% of GOVAI, agriculture in Hunan contributes more to the provincial economy than does the agricultural sector of either of the other two provinces. Farm incomes are also higher here than in the other two provinces. Hunan, and the Dongting Lake area in particular, are naturally suited to rice farming. In fact, the Dongting Lake area makes a vital contribution to China's grain supply.
THREE GORGES PROJECT FEASIBILITY REPORT

![Bar Chart: Agriculture & Industry](chart1)

![Bar Chart: Agriculture](chart2)

![Bar Chart: Industry](chart3)

**Source:** Statistical Yearbook of China, 1986

**Note:** The figures are based on the old classification. They include village and sub-village industrial input in gross output value of agriculture.

**Selected Provincial Indicators:**
Gross Output Value of Agriculture and Industry, 1985

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Volume 11
Figure 3.1

- 3-5 -
THREE GORGES PROJECT FEASIBILITY REPORT

HUBEI
POPULATION: 40 million
LABOUR FORCE: 23 million

SICHUAN
POPULATION: 102 million
LABOUR FORCE: 51 million

TRANSPORT & COMMUNICATIONS

COMMERCE

INDUSTRY

AGRICULTURE

HUNAN
POPULATION: 58 million
LABOUR FORCE: 27 million

SOURCE: Statistical Yearbook of China, 1986

NOTE: Industry includes geol., survey and construction.
Commerce includes non-material sectors.

SELECTED PROVINCIAL INDICATORS:
POPULATION AND LABOUR FORCE, 1985

Volume 11
FIGURE 3.2
3.2.2 Hubei

Hubei is more industrialized, in terms of GOVAI, than the other two provinces; agriculture accounts for 34% of output values, industry for 66%. Its current population is $49 \times 10^6$ and may reach $55 \times 10^6$ by the year 2000. Three areas in Hubei are affected by the project:

- the flood plain, which is largely agricultural but contains major industrial centers such as Shashi and Wuhan,
- the Yichang Area, home of the Gezhouba Construction Bureau, is a major regional industrial and economic center, the site of the Gezhouba Dam and the location of the proposed site for the Three Gorges Project,
- a portion of the area to be flooded by the creation of the reservoir.

3.2.3 Sichuan

Sichuan has a population of $102 \times 10^6$, forecast to reach $116 \times 10^6$ by the year 2000, and has 42% of the total GOVAI of the three provinces. Sichuan includes two major industrial centers, Chongqing and Chengdu. Chongqing has a population of $14 \times 10^6$ and produces a wide range of light and heavy industrial goods ranging from armaments to steel and motorbikes. It is the commercial center of Sichuan and, because of its location on the Yangtze, it is the gateway to the Sichuan interior. Chengdu also produces heavy industrial goods including turbines, generators and transformers.

Many of the people of this resource rich province live in almost inaccessible areas such as the mountainous xiangs of the reservoir counties. Thus, although Sichuan is resource rich it has large areas, including the reservoir area, with incomes well below the national average.

Further discussion of the economies of the provinces affected by the Three Gorges Project is contained in Appendix A.

3.3 Summary of the Effects in the Regions Within the Provinces

The Three Gorges Project will affect four regions within the three provinces: the flood plain, the Yichang Area, the Reservoir Region, and Chongqing.

- The major effect on the flood plain will be to reduce the flood risk. The project will open up larger areas to economic development thereby creating a more favorable investment climate. This could be important given that the population of the flood plain is expected to grow from $3 \times 10^6$ to $6 \times 10^6$ over the life of the project, and the increasing importance of collectives and non-state enterprises for job creation.
- In the Yichang area the main impact will be the jobs associated with the construction of the project.

- The CYJV Recommended Project involves a resettlement program in the Reservoir Region which could directly affect about 748,000 persons by the year 2003. The resettlement provides a potential for raising incomes, creating new jobs and bringing the reservoir region more into the mainstream of the country's economic life.

- The Three Gorges Project's main effect on Chongqing will be to improve navigation conditions downstream of Chongqing. This is expected to produce increased port usage and improve the city's competitiveness.
4. IMPACT OF PROJECT BENEFITS

4.1 Power Benefits Distribution

The Three Gorges Project will provide an average of 76.2 terawatt hours of energy annually to the Central and East China, and eastern Sichuan Power Regions. The first power could be available in 2000 with full power available in 2006. If the Three Gorges Project is not built an equivalent amount of energy would be provided over a similar time period to the same areas, partly from hydro projects, but mostly from coal fired thermal plants. The economic analysis has shown that the project would produce power more economically than the alternative generation sources.

The distribution of the benefits of lower power costs depends on how power is priced in China. For many years, the rates charged to the power users have remained unchanged and are below the full accounting cost of supplying the power. If this policy is maintained all benefits will accrue to the government. In effect, the government will not have to subsidize the production of power as much as if the alternative generation sources were built.

Alternatively, China could adopt an approach by which power rates were either equated to the cost of production or, at least, related to changes in overall production costs. Under this system, some of the benefits might be passed to the end users. Indications are that costs, and thus savings, would be assigned in proportion to the consumption of power from the Three Gorges Project in the receiving systems. On a geographic basis Table 4.1 representing energy consumption in 1985, shows that the main beneficiaries will be consumers in the Shanghai/Jiangsu areas, who will receive approximately 35% of the total annual savings.

4.2 Flood Protection Benefits

The reservoir of the Recommended Project will contain $31 \times 10^9$ m$^3$ to mitigate the effect of floods. Through careful management of the outflows during a major flood event, flood damages throughout the middle reaches of the Yangtze river can be minimized although not entirely eliminated. The control of flood damages requires the combined use of the Three Gorges reservoir and the designated flood diversion areas on both sides of the river along the middle reaches. In addition, critical water levels at which areas are flooded vary and the existing dykes which surround them have been built to different elevations. Accordingly, different degrees of flood protection are available currently and this situation will continue if the Three Gorges Project is built. Plate 11.2 shows the approximate frequency of flooding which may be expected before and after the project is completed in the several areas of the middle reaches of the Yangtze.
TABLE 4.1 - POWER BENEFITS DISTRIBUTION

<table>
<thead>
<tr>
<th></th>
<th>1985 TWh</th>
<th>% of Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Region</td>
<td>75.7</td>
<td>53.84</td>
</tr>
<tr>
<td>Shanghai</td>
<td>25.6</td>
<td>18.21</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>23.4</td>
<td>16.64</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>13.2</td>
<td>9.39</td>
</tr>
<tr>
<td>Anhui</td>
<td>13.5</td>
<td>9.60</td>
</tr>
<tr>
<td>Central Region</td>
<td>64.9</td>
<td>46.16</td>
</tr>
<tr>
<td>Henan</td>
<td>20.9</td>
<td>14.86</td>
</tr>
<tr>
<td>Hubei</td>
<td>21.8</td>
<td>15.50</td>
</tr>
<tr>
<td>Hunan</td>
<td>14.2</td>
<td>10.10</td>
</tr>
<tr>
<td>Jiangxi</td>
<td>8.0</td>
<td>5.59</td>
</tr>
<tr>
<td>Central+Eastern</td>
<td>140.6</td>
<td>100.00</td>
</tr>
</tbody>
</table>

4.2.1 The Distribution of Flood Benefits

The distribution of benefits from increased flood protection arising from the construction of the Three Gorges Project is shown in Table 4.2. These benefits constitute the economic value of the potential flood damages avoided by the construction of the project and are similar to the financial values that would apply.

In a spatial sense the bulk of the flood protection benefits of $3506 \times 10^6$ yuan, using the reservoir operating guidelines described in Volume 7, go to Hubei Province and particularly to the Jingjiang and Honghu Diversion Areas and the Jingjiang and Chenglingji low level areas. These three areas secure 62% of total flood protection benefits while Hubei itself receives 83% of the benefits from flood protection. The remaining 17% goes to areas in Hunan Province.

Because of the division of responsibilities among local, provincial and national authorities, these benefits have a wider distribution. CYJV investigations indicated that residents and local authorities bear about one half of the cost of a flood while provincial and national authorities each contribute about 25% of the value of the losses. This implies that the Central Government will receive benefits of some $875 \times 10^6$ yuan from improved flood protection and the Provinces of Hubei and Hunan will receive $725 \times 10^6$ and $150 \times 10^6$ respectively.

4.2.2 Project and Development Benefits

The benefits described above relate strictly to losses avoided from reduced flood frequency. There are other potential benefits as well. These would come from two sources — a change to more productive agricultural land uses and changes to land uses more productive than agriculture. These benefits are difficult to quantify. They are discussed below but no attempt has been made to include them in the overall cost/benefit analysis of the project.

The suitability of an area for a particular enterprise is keyed in part to the frequency of flooding. In areas of high flooding frequency, seasonal agriculture will be pursued as the loss if a flood occurs will only be that season's crops. In areas where flooding is less frequent, crops which take longer to mature such as fruit might be cultivated. Hence, as the frequency of flooding would be decreased with the project, some changes in the land use could occur. Table 4.3 summarizes the change in expected flood frequency after construction of the Three Gorges Project.
TABLE 4.2 — DISTRIBUTION OF FLOOD CONTROL BENEFITS IN THE FLOOD PLAIN

(10^6 yuan, discounted to mid 1987 at 10%)

(Percentages may not add properly due to rounding)

<table>
<thead>
<tr>
<th>Area</th>
<th>Benefits</th>
<th>Share of Total Benefits</th>
<th>Local Benefits</th>
<th>Provincial Benefits</th>
<th>National Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hubei</td>
<td>2 903</td>
<td>83%</td>
<td>1 453</td>
<td>725</td>
<td>725</td>
</tr>
<tr>
<td>Jingjiang</td>
<td>756</td>
<td>22%</td>
<td>378</td>
<td>189</td>
<td>189</td>
</tr>
<tr>
<td>Jingjiang &amp; Chenglingji</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Level Areas</td>
<td>776</td>
<td>22%</td>
<td>388</td>
<td>194</td>
<td>194</td>
</tr>
<tr>
<td>Honghu</td>
<td>641</td>
<td>18%</td>
<td>321</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>Shangbailizhou</td>
<td>57</td>
<td>2%</td>
<td>29</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Jingnan Region</td>
<td>320</td>
<td>9%</td>
<td>160</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Renmindayuan</td>
<td>233</td>
<td>7%</td>
<td>117</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td>Sanzhoulian</td>
<td>15</td>
<td>0%</td>
<td>7</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Jingjiang Extension</td>
<td>8</td>
<td>0%</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Huxisangan</td>
<td>9</td>
<td>0%</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Jingbei Plain</td>
<td>9</td>
<td>2%</td>
<td>39</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Xilianghu</td>
<td>9</td>
<td>0%</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Hunan</td>
<td>603</td>
<td>17%</td>
<td>301</td>
<td>151</td>
<td>151</td>
</tr>
<tr>
<td>Dongting Hu (PA)</td>
<td>96</td>
<td>3%</td>
<td>48</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Dongting Hu (DA)</td>
<td>192</td>
<td>5%</td>
<td>96</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Jingjiang (DA)</td>
<td>84</td>
<td>2%</td>
<td>42</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Jingnan</td>
<td>144</td>
<td>4%</td>
<td>72</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>J&amp;C LL Fields</td>
<td>87</td>
<td>2%</td>
<td>43</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>3 506</td>
<td>100%</td>
<td>1 754</td>
<td>876</td>
<td>876</td>
</tr>
</tbody>
</table>

Source: CYJV, Volume 7, Flood Control
<table>
<thead>
<tr>
<th>Area</th>
<th>Natural Conditions</th>
<th>With Three Gorges Project</th>
<th>Possibility of Land-Use Change</th>
<th>Total Area</th>
<th>Cultivated Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flooding Frequency Greater Than Years</td>
<td>Flooding Frequency Less Than Years</td>
<td>Industry</td>
<td>Agric.</td>
<td>km²</td>
</tr>
<tr>
<td>Jingjiang</td>
<td>10</td>
<td>200</td>
<td>Yes</td>
<td>Yes</td>
<td>920</td>
</tr>
<tr>
<td>Dongting Lake Diversion area</td>
<td>20</td>
<td>20</td>
<td>No</td>
<td>No</td>
<td>2 825</td>
</tr>
<tr>
<td>Honghu</td>
<td>20</td>
<td>50</td>
<td>Yes</td>
<td>Yes</td>
<td>2 733</td>
</tr>
<tr>
<td>Shanghailizhou</td>
<td>100</td>
<td>200</td>
<td>Yes</td>
<td>-</td>
<td>170</td>
</tr>
<tr>
<td>Jingnan Region</td>
<td>500</td>
<td>1 000</td>
<td>-</td>
<td>-</td>
<td>2 500</td>
</tr>
<tr>
<td>Renmindayuan</td>
<td>20</td>
<td>200</td>
<td>Yes</td>
<td>Yes</td>
<td>344</td>
</tr>
<tr>
<td>Sanzhoulian</td>
<td>10</td>
<td>20</td>
<td>No</td>
<td>No</td>
<td>175</td>
</tr>
<tr>
<td>Jingjiang Extension</td>
<td>100</td>
<td>1 000</td>
<td>Yes</td>
<td>-</td>
<td>96</td>
</tr>
<tr>
<td>Huxisangan</td>
<td>200</td>
<td>500</td>
<td>-</td>
<td>-</td>
<td>86</td>
</tr>
<tr>
<td>Jingbai Plain</td>
<td>1 000</td>
<td>1 000</td>
<td>-</td>
<td>-</td>
<td>4 200</td>
</tr>
<tr>
<td>Dongting Lake Protected Areas</td>
<td>1 000</td>
<td>1 000</td>
<td>-</td>
<td>-</td>
<td>3 500</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17 599</td>
</tr>
</tbody>
</table>

Source: Volume 7, Flood Control

*Flood frequencies for the 1983 flood hydrograph shape.
Certain threshold levels of flood protection for land use change can be postulated. Improvements to agricultural land use, such as conversion to fruit cultivation and upgrading of irrigation systems are assumed to require a minimum flood protection level of 1:25 years. For industrial activities, a minimum flood protection level of 1:50 to 1:100 years is assumed. For residential land uses, the minimum flood protection level assumed is 1:100 years. The potential for changes in industrial and agricultural land uses according to these criteria is shown in Table 4.3. The amount of change is difficult to quantify, but the following discussion points to the likely direction of these changes.

- Agricultural Opportunities

The flood protection provided by the Three Gorges Project would affect the potential agricultural land use in the three areas; Jingjiang, Honghu and Renmindayuan. Together, the cultivated land in these areas is 1 423 km² or 15.2% of all cultivated land affected. However, it is doubtful whether much of the agricultural land use in these areas will change.

Land is intensively cultivated on the flood plain and, in general, an agricultural system exists which does not easily adapt to change. Yields are high by both Chinese and international standards (Table 4.4). Crops are well suited to the soil and climatic conditions. In the specific case of the Dongting Lake areas, national directives require a concentration on rice production. With the possible exception of fruit, there is little evidence that cropping patterns would be any different with lower flood risks.

Fruit cultivation of peaches, pears, or cherries could more than double the net return over that obtained from present crops. In addition labour requirements would be halved implying from the standpoint of a given piece of land that fruit farming might free labour for other farming or employment opportunities. Nevertheless, the opportunities are limited.

Because fruit is perishable and storage facilities are underdeveloped, it has to be grown near its main markets (urban centres such as Wuhan) or near good transportation facilities. Fruit is already grown around Wuhan and it is unlikely that any more would be grown there simply because the probability of flooding is reduced. It is likely that small fruit growing zones may develop near other major towns, but their significance relative to the total cultivated land area would be minor. Transportation improvements could broaden the area affected but such major changes are unlikely in the short term. It is
### Table 4.4 - Average Yields of Selected Crops in the Floodplain Compared to International Yields

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/h</td>
<td>kg/mu</td>
<td>kg/h</td>
<td>kg/mu</td>
</tr>
<tr>
<td>Rice (paddy)</td>
<td>5973</td>
<td>398.2</td>
<td>3106</td>
<td>207.0</td>
</tr>
<tr>
<td>Wheat</td>
<td>1576</td>
<td>105.1</td>
<td>2056</td>
<td>137.1</td>
</tr>
<tr>
<td>Corn</td>
<td>3818</td>
<td>259.5</td>
<td>2121</td>
<td>141.4</td>
</tr>
<tr>
<td>Soybeans</td>
<td>2005</td>
<td>133.7</td>
<td>1564</td>
<td>104.3</td>
</tr>
</tbody>
</table>

Source:

1. Chinese yield from CSICSC compilation of economic data for CYJV.
2. International yield from FAO, Production Yearbook, 1984
therefore difficult to forecast any major changes in agricultural land use due to increased flood protection.

--- Industrial Opportunities: Large Installations

Benefits are possible from making land available for industrial, urban and other non-farm related uses. The extent of the benefits depends on the degree to which current policy restricts such uses and on the general demand for land.

National policy requires that state enterprises (70% of all factories) have protection from a 1:100 year flood either through independent protection measures such as the construction of dykes around the enterprise, or through more general community or state initiated measures. "Self-protection" is expensive and occurs only in industries for whom the protection cost is low relative to total capital costs.¹

YVPO bears the responsibility for advising the State on the level of flood frequency and the adequacy of self-protection.

Provincial policy seems to be based partly on avoidance of flood risk and partly on the maintenance of the flood plain in agricultural uses. In Hubei the policy is to place industries in protected urban areas even though not all urban areas are protected to the 1:100 year level. At the county, xiang, and lower administrative levels the policy is not defined but appears to be similar. However, at these lower administrative levels there is more local input in the decision process and it appears that often when collectives propose to build plants in flood prone areas, they are allowed to do so even though they are encouraged to build in less risky urban areas.

The Three Gorges Project raises four areas, Jingjiang, Jingjiang Extension, Shangbailizhou, and Renmindayuan, to a minimum flood protection level of 1:100 years (Table 4.3). Only the Jingjiang Area is of appreciable size. In total, these areas account for 8.7 percent of the total land area of the flood plain, or about 1530 km².

Lowering the standard to a level requiring a minimum flood protection level of 1:50 years almost triples the amount of land potentially suitable for industrial development. This increase is entirely due to the addition of the Honghu Diversion Area. An additional 15.8 percent of the total land area (2 783 km²) is included.

¹ One such example is the Hanchuang thermal generating station near Wuhan. YVPO, asked for its comments, caused the project to be delayed until such time as it was agreed that a levee that could protect against a 1:100 year flood could be built.
giving a net total of suitable land of about 23 percent of the total land area of the flood plain, or some 4047 km².

The Honghu area has experienced relatively rapid industrial development and may be able to take advantage of the additional land made suitable by increased flood protection. While this area is apparently unsuitable for major state owned industries, it is suitable for other types of industrial growth.

By comparison, the Jingjiang Area is unlikely to see any industrial growth due to better flood control. The possibility remains that a severe flood might require that this area be deliberately flooded. Since YVPO must pay compensation for any deliberate flooding, it is therefore likely to discourage any development which would increase this cost. Industrial location in areas outside the 'refuge areas' would likely be strongly opposed.

Though its flood protection levels after the Three Gorges Project are estimated to exceed 1:200, the relative isolation of the Renmindayuan Diversion Area from any major urban centres would likely restrict its attractiveness for industrial development. The same constraint affects the Shangbailizhou Diversion Area.

While the Three Gorges Project will provide protection to as much as 25 percent of the flood plain for industrial land use, it is expected that little change will occur given the present policies and patterns of industrialization. However, it is believed that the Honghu Diversion Area will be an exception and will undergo changes in industrial land use.

— Industrial Opportunities: Small Installations

In the protected cities the flood threat will not change and there is no reason to believe that the investment pattern would change. In the smaller urban centres there could be changes even though the flood risk would still be higher than state policy would accept.

CYJV's field visits indicated that smaller communities in the diversion areas had less modern machinery than factories in the larger towns outside the diversion areas. Until recently, such communities received little Central Government money for capital investment and had little cash of their own to invest. With agricultural reform, earnings have risen with citizens and collectives taking advantage of investment opportunities and can be expected to continue doing so.

CYJV visited several communities where it appeared that agricultural reform had led to prosperity which in turn was leading to increased local investment. One was in the City of Honghu, a community of some $77 \times 10^3$ people with protection against a flood magnitude of 1:10 to 1:20 years. The community included a vertically integrated
cotton collective which grew and processed cotton. This collective was using its gains to invest in new houses and to hire workers to run its small cotton and textile mills. The homes were built to western space standards (at least one room per person plus common quarters) and equipped with three piece baths, full kitchens, and an impressive variety of appliances.

The small factory was old and equipped with fifty year old machinery which was nevertheless well maintained and operating at full capacity. The collective employed a total of 1,700 people and paid above average wages. The group had bought trucks and tractors, and had plans to expand their operations. Similar success stories of such groups were also observed in other areas such as Yumen Xing Chuen near Yichang and the New Sky village near Wuhan.

The important point is these collective developments use retained earnings for investment. They do this partly because they see direct benefits and partly because there are few other sources of capital. State enterprises tend to be larger and are increasingly less involved in light industry. They also shun areas without protection against 1:100 year floods. In addition, there is a general shortage of official capital. Some analysts believe that in the coming years it will be groups such as the Honghu Textile Collectives and similar entrepreneurial groups who will provide the thrust for light industrial growth.

The 1986 Statistical Yearbook of China indicates that savings deposits of rural households have been increasing rapidly since 1979, the average increase has been approximately 39 percent per year. Individual households may also become important in funding local light industry. It can be assumed, however, that these groups will also be aware of alternative investments.

If flood risks are high, these rural households may choose not to make these local investments. This could mean that small scale investment in high risk areas would be curtailed and fed into larger scale activities or simply hoarded away from the investment stream. Overall, it may be presumed that the reduction of flood risk from between 1:10 and 1:20 years to greater than 1:50 years would encourage local investment.

While there may be industrial investment opportunities at the provincial and non-state levels, the opportunities for state plants may not be enhanced by the limited improvement in flood protection. In the past there have been very few applications for the construction of major facilities in the flood plain. There is no evidence that existing plants are poorly located or fail to serve their hinterland. Shashi and Jiangling, for example, contain steel mills, medical, and chemical plants in addition to the usual agricultural businesses. Such areas are within reasonable distances of agricultural production areas.
and can certainly be seen as potential employment areas for any labour surpluses emerging from the agricultural community.

The conclusion is that greater flood protection is unlikely to lead to transfers of industry from other areas on the basis of improved competitive locational advantages. It will, however, create greater opportunities for retaining local investment.

- Residential Development Opportunities

Present demographic patterns indicate not only growth in all areas generally, but also a substantial shift from rural to urban population. Overall, China’s population is expected to grow at the rate of 1.2% per annum. Urban areas will grow faster as new jobs will tend to be created in urban areas. Part of this population growth will be accommodated through increased urban densities and redevelopment of existing neighborhoods. Nonetheless more land will be needed for urban uses. A 1.2% growth rate over the next 20 years will mean an increase in the population exposed to flood risk of approximately $1.44 \times 10^6$ persons. It can be expected that given the likelihood for reduced agricultural labour requirements and the shift from agricultural to rural industrial employment, many of these people will migrate to towns in the flood plain area. This trend would require additional flood protection for these relatively more urban areas.

At a population density of $15 \times 10^3$ per km$^2$, this represents a requirement for some 96 km$^2$ of land. The Three Gorges Project adds a total of 1434 km$^2$ to the amount of land having a minimum flood protection level of 1:100 years. If only non-agricultural land is considered, 784 km$^2$ are added. Therefore, there appears to be adequate land in the flood plain to absorb an increase in the urban population. If the 96 km$^2$ required as residential land were gathered in one place and protected by a dyke, it is estimated that the dyke would cost in the order of $3.5 \times 10^6$ yuan. This figure represents an additional benefit of the project although it is almost impossible to predict when it would be realized.

4.3 Navigation Benefits

4.3.1 General

The Three Gorges Project will significantly reduce the cost of navigation above Yichang. Reduced trip times, combined with the opportunity to use larger tows, should translate into a 2.4 fen per tonne-kilometre drop in the economic cost of shipping between Wuhan and Chongqing.\(^2\)

\(^2\) Economic cost is the full cost to the nation of this operation. "Tariff", in its transportation usage, indicates the rate charged by the carrier.
The estimated present economic cost of water transportation between Chongqing and Wuhan is 3.7 fen per tonne-kilometre, virtually equal to the 3.8 fen per tonne-kilometre cost of rail transport over the same distance (Volume 6, Section 3). Present transportation rates or "tariffs" do not reflect the long run economic costs of transportation. The present tariffs are 1.3 to 1.7 fen per tonne-kilometre for rail and 2.2 fen per tonne-kilometre for water.

If a tariff structure based on economic costs is instituted, the tariff for water transport would drop to 1.3 fen per tonne-kilometre, while rail tariffs would rise to 3.8 fen per tonne-kilometre. This 3 to 1 ratio represents a reasonable tariff differential given the longer transit time involved with water transport.

If changes to the tariff structure are implemented only for water transport, the rail and water tariffs would be roughly equal i.e. about 1.3 fen per tonne-kilometre. As a result, rail would probably continue to be the favoured mode because of its shorter transit time.

The estimated distribution of benefits assumes the implementation of a tariff structure which reflects the full economic costs of transportation in both modes. Unless such a change is implemented, at least a portion of the traffic which has been forecast to use the water mode would use rail instead, and the benefits obtained through navigation improvements caused by the Three Gorges Project would be reduced.

4.3.2 Distribution of Benefits

Six groups are potentially affected by navigation improvements:

- the shippers and receivers of goods;
- the shipping companies;
- the railways;
- the State;
- the suppliers of vessels; and,
- the suppliers of port facilities.

In the case of the first three, the effect of the improvements depends on the degree to which lower water costs are passed on to users in the form of reduced tariffs. If tariffs stay approximately the same, benefits will flow to the shipping companies and their owners, generally the State, in the form of higher profits. If the water tariffs fall, the shippers and receivers will benefit. At the same time, the rail traffic would increase less rapidly although the associated loss of rail revenue would be offset by reduced requirements for expansion in the long term.
If cost savings are passed on to users, the benefits would be distributed between the senders and receivers in proportion to their share of total payments for river shipping. No attempt has been made to quantify the distribution of these benefits because of the many assumptions that would have to be made about commodity origins and destinations and differential rates between commodities as well as the uncertainties associated with the actual traffic volumes themselves.

Shipbuilders and port operators will benefit from improved navigation. CYJV estimates indicate that the two way capacity of the Yangtze will be increased from less than $20 \times 10^6$ t to between 40 and $50 \times 10^6$ t, both ways, due to the Three Gorges Project (Volume 6, Section 6). Discounting existing spare capacity and the need to replace equipment, this additional 20 to $30 \times 10^6$ t represents an opportunity to employ approximately 2200 tows of 9000 t each. Assuming 50 trips per year, this is an additional 44 tow transits, 44 tugs and 396 barges, many of which will be built in either Chongqing or Wuhan.

An important point to note is that the character of bulk water transport may change dramatically due to the Three Gorges Project. YuVPO estimates that the present average tow size is well under 1000 t, due to the large number of very small vessels on the river. The Three Gorges Project may encourage the development of larger barges, larger tows, and more sophisticated traffic control and navigation systems. These and other improvements should benefit the area's shipbuilding industry by increasing its sophistication and ability to provide better equipment to other markets. Again, this is a difficult impact to quantify.

Shipping companies and port operators will be likely to benefit directly from the trend as new vessels are put into service and existing port systems renovated or replaced. This is augmented by the likely higher volumes of freight in transit.

While traffic forecasts have been prepared for the river system, no estimates have been made of the volumes that would be handled through all the ports of Chongqing. Currently the ports handle $5 \times 10^6$ t of long distance freight and another $12 \times 10^6$ t of short distance freight. Total employment at all the ports is not known, but the recently built facility at Jiulongpo employs approximately 1600 people and has handled $1.7 \times 10^6$ t per year or roughly 1000 t per employee. This is a relatively low number and improvements will likely be made. In fact increased traffic should result in employment increases, but the amount will depend on the degree of associated mechanization.

### 4.3.3 Project and Development Benefits

The estimate of navigation benefits specifically excludes any benefits derived from "induced" traffic; i.e. new commodity movements which arise due to the availability of lower cost transportation. Similarly, it does not include other benefits associated with new development opportunities that
may arise because it is possible to move goods more easily and more cheaply. For example, the reservoir will mean that access to other regions via the Yangtze will improve for a number of communities which have hitherto only been able to get their goods to the market by foot. This could be important to farmers who decide to grow citrus crops and would otherwise have difficulty getting their produce to market.

Again, with lower transportation costs, the cost of inputs to products made in Chongqing should fall which should reduce overall costs of production. If this occurs to the point where it becomes possible to make goods not previously made or to export goods which were not previously competitive, then additional economic activity would be generated. On the other hand, the lowering of the transportation costs could lower the cost of goods imported from other areas which might replace locally made goods.